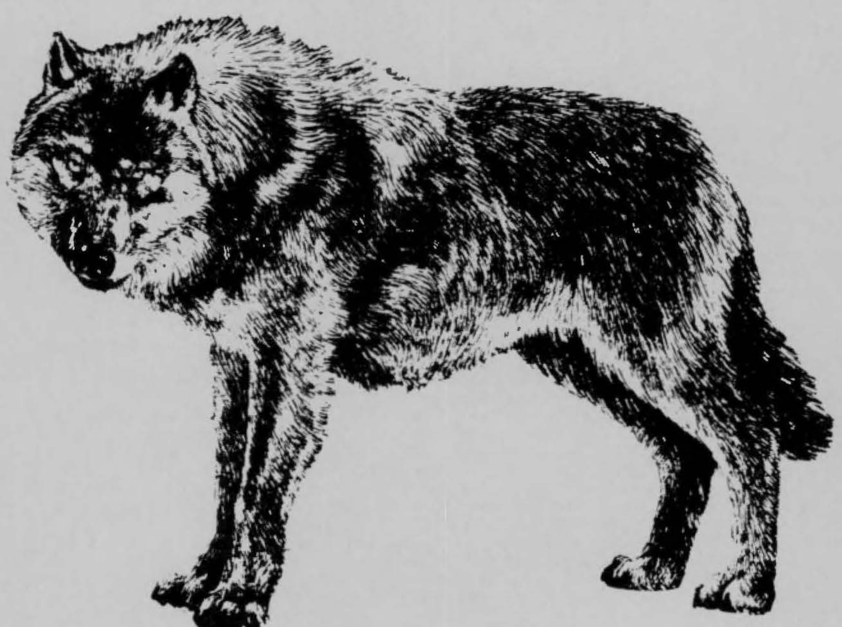
Alaska Department of Fish and Game
Division of Wildlife Conservation
Research Progress Report

DEMOGRAPHY AND MOVEMENTS OF WOLVES IN RELATION TO THE WESTERN ARCTIC CARIBOU HERD OF NORTHWEST ALASKA



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SUMMARY

During April 1987, a pilot study was initiated in northwest Alaska to determine the status of the wolf (*Canis lupus*) population and to examine the feasibility of conducting investigations of wolf demography and survey techniques. Eleven wolves in 6 packs were captured and radio-collared; one of these was fitted with a prototype satellite collar. Autumn 1987 wolf density was estimated at 4.4 wolves/1,000 km^2, and the wolf population appeared to be increasing. Consequently, a more intensive study was initiated in April 1988.

Between April 1988 and April 1989, a total of 49 wolves in 13 packs were captured and radio-collared. Sex ratios of pups were skewed in favor of females, while ratios for other ages were 50:50. From April 1987 through June 1989 the 13 packs were relocated on 1,012 occasions with conventional telemetry methods. Territory sizes of 4 packs ranged from 950 to 2,358 km^2. During the 1st year of study, all study packs maintained year-round territories. During the 2nd year of study, at least 2 of 6 packs migrated 170-230 km south, an apparent attempt to follow migrating caribou. Caribou (*Rangifer tarandus granti*) and moose (*Alces alces*) were the major prey species. When caribou were present within pack areas, they were the primary species killed. When caribou migrated out of the area and few were present, moose were the primary species killed. Wolf densities ranged from a low of 2.7/1,000 km^2 in the spring of 1987 to a high of 6.3/1,000 km^2 during the fall of 1988.

Seven satellite collars (i.e., platform transmitter terminals [PTT's]) were tested during the period 1987 to 1989, one in 1987-88, and six in 1988-89. Two of the 7 collars failed. The first collar performed flawlessly, resulting in 415 relocations and 747 sets of sensory data. During 1988-89 the 6 satellite collars transmitted for varying lengths of time, providing 1,606 relocations and at least 2,063 sets of sensory data. Wolf PTT's had an average life span of about 10 months. Transmission duty cycles were compared; PTT's transmitting 6 hours provided a greater number of useable relocations than those transmitting for only 4 hours. An average of 26 relocations per month was obtained with either a 4- or 6-hour transmission cycle. Evaluation of satellite transmitters for monitoring wolf movements will continue. Several wolf census methods will be tested in 1990.

Key Words: wolves, *Canis lupus*, movements, density, caribou, satellites, territories.

CONTENTS

INTRODUCTION AND BACKGROUND

The Western Arctic Caribou (Rangifer tarandus granti) Herd (WACH) has historically been one of the largest caribou herds in North America, and it is the largest herd that resides totally within the state of Alaska. The herd is an extremely important resource for subsistence and recreational uses, numbering between 200,000 and 300,000 (Davis et al. 1980) during the 1950's and 1960's (Fig. 1). By 1976, the herd had dramatically declined to a minimum of 64,000 to 75,000 (Davis et al. 1980). Excessive human harvest and predation by wolves (Canis lupus) were the primary causes of the decline (Doerr 1979, Davis and Valkenburg 1985).

The herd's dramatic decline in the mid-1970's precipitated a comparable reduction in the human harvests. The number of wolves also declined because of a combination of legal and illegal hunting, a rabies outbreak, and changes in the distribution of caribou (Davis et al. 1980). The caribou herd responded favorably to the reductions in total mortality; it currently numbers in excess of 330,000 (Fig. 1). In 1984 the Alaska Board of Game approved a management plan for the WACH, in which the highest management priority is to prevent the herd from declining to low numbers (ADF&G 1984). To avoid future catastrophic declines in the WACH, it is imperative that caribou harvests as well as the population levels for wolf and caribou be routinely monitored. Managers and biologists also need to improve their understanding of interspecies and intraspecies relationships.

Proper management of predators and prey requires that population status (i.e., numbers, density, or trend) be monitored accurately and regularly. Reasonably accurate and precise survey methods exist for monitoring large ungulate populations; e.g., moose (Alces alces) (Gasaway et al. 1986) and caribou (Pegau and Hemming 1972, Davis et al. 1979). Also, mark-recapture methods have been successfully used to obtain relatively accurate and precise estimates of grizzly bear (Ursus arctos) densities (Miller et al. 1987); however, statistically valid estimates of wolf densities have only been obtained through expensive and time-consuming radiotelemetry studies (Fuller and Snow 1988). In those cases, a number of wolves have been captured and radio-collared and subsequent relocations have been used to estimate territory and pack sizes over a period of several years. Density estimates within known pack areas have then been extrapolated to the larger study area or other pertinent areas. Other wolf census methods that have been used with limited degrees of success in relatively small study areas include howling surveys, ground observations, hunter observations of scats or tracks, and counting tracks and wolves from fixed-wing aircraft after a fresh snowfall (Stephenson 1978, Crete and Messier 1987, Fuller and Snow 1988).

In Alaska wolf population estimates have also been successfully obtained through use of radiotelemetry studies; however, this method has not been used widely because of its high costs and applicability to only relatively small areas. Because of the vastness of areas needing population data and the short time frame available, the most widely used method has been counting tracks and/or wolves from fixed-wing aircraft following fresh snowfall (Stephenson 1978), herein referred to as the track count method. Although this method has been regularly used with apparent success, it has not worked in other areas of North America (Crete and Messier 1987). Within Alaska, the method assumes that wolf packs are discrete and territorial during the census. Also, there is no measure of accuracy or precision, and the results are dependent on the experience and expertise of the individual doing the survey (Ballard and Bergerud 1988). Such data have lead to different interpretations among biologists (Van Ballenberghe 1981, Bergerud and Ballard 1989). The track count method also assumes that populations are closed. Violations of the latter assumption can result in large errors in final density estimates, as evidenced during a count conducted in Unit 13 during the spring of 1985. Because some wolf packs were radio-collared, numbers of wolves present in the count area were known. During that census of 8,700 km^2, the total population was overestimated by 71%, in part, because $\geq$1 wolf pack with a small portion of its territory within the study area had been given the same statistical weight as packs totally contained within the area. Another potential problem with the track count method is its increased reliability in areas of low prey density, because wolf tracks are easier to spot when the area has not been trampled by large numbers of ungulates. Lastly, unless observers are experienced at recognizing and interpreting wolf tracks, a 3-fold difference in final density estimates are possible (Stephenson 1978, ADF&G files).

If wolves preying on the WACH follow it to seasonal ranges in Canada (Kelsall 1968, Parker 1972), then wolves may not maintain territorial boundaries on the caribou winter range. Movements among packs and pack members could occur frequently, confounding attempts to map territories during track counts. This could easily result in doubling the number of wolves counted during censuses or in surveys conducted 2-3 weeks apart. James (1981, 1984) also recognized several potential problems with the track count method, but because of unfavorable snow conditions and apparent low numbers of wolves, he was unable to initiate an investigation.

As mentioned earlier, the WACH increased rapidly during the 1980's, but for unknown reasons wolf numbers did not respond to increased prey availability; this failure to respond to the increase in caribou as well as low numbers of wolves reported by members of the public (Larsen and James 1988) created interest in determining the exact status of the wolf population. Consequently, during the spring of 1987 we initiated a pilot study to evaluate the status of the wolf population and the feasibility of conducting more intensive research. Once it became clear that the wolf population size was at a sufficient level to warrant further study, the first complete year of sudy was initiated; its aim was to ultimately improve the management of WAH caribou and wolves by providing current data on predator-prey relationships, improved census techniques, and increased capabilities for modeling the dynamics of WAH caribou. We also sought to improve our capabilities of censusing other furbearers as well, particularly wolverines (Gulo gulo). The original study plan is contained in Appendix A. Plans were also developed for conducting ground counts on the Selawik National Wildlife Refuge (Appendix B). This report presents data and analyses resulting from the 1-year pilot study and the 1st full year of active research.

OBJECTIVES

To determine the number of wolves occurring within the range of the WACH.

To determine the spatial relationships among and within wolf packs on caribou winter range.

To develop and test precise and effective census methods for wolves and other furbearers.

To estimate the impacts of wolf predation on WAH caribou.

To compare the efficiency and accuracy of satellite telemetry with conventional telemetry for monitoring movements of wolves seasonally and annually.

STUDY AREA

Davis (1980) and Davis et al. (1980) defined the range of the WACH as encompassing 362,600 km^2 in northwest Alaska (Fig. 2). During the spring of 1987 management staff selected an area from within that relatively large area representative of winter ranges recently used by the WACH to serve as the core study area for the wolf project (Fig. 3). It is bounded by the Huslia River on the south, on the east along a line extending from the eastern end of the Purcell Mountains north along the eastern Zane Hills to the eastern Lockwood Hills (excludes Pah River Flats), northeast to Shungnak then to upper Miluet Creek, on the north the crest of the Baird Mountains, and on the west the ridgeline west of Akiak Creek and Hunt River southwest along a line to the western edge of the Greater Kobuk Sand Dunes to the crest of the Waring Mountains, then along a line running southeast to the upper north fork of the Huslia River. The size of the area is approximately 15,000 km^2, and it includes the eastern half of Kobuk Valley National Park, the eastern two-thirds of Selawik National Wildlife Refuge, and northern portions of the Koyukuk National Wildlife Refuge, and is contained largely within Unit 23. Portions of the range of the WACH are also found in Subunits 21D, 22A, 22B, and 26A and Unit 24.

Topography ranges from relatively flat plains along the major river systems, rolling hills (e.g., Waring Mountains) to rugged, steep mountainous terrain (e.g., Purcell and Baird Mountains). Elevations within the study area range from near sea level along the Kobuk and Selawik Rivers upwards to 1,168-1231 m.

Vegetation ranges from unvegetated sand dunes (e.g. Greater and Little Kobuk Sand Dunes), gravel bars, rock screes, and lakes to wetlands and marshes or dense white spruce (_Picea glauca_) forests along the major river systems. Willows (_Salix spp_) occur throughout the study area but are most common along riparian areas and least common in open tundra. Away from major river systems, the area includes sparse to dense taiga scrub forests of white and black spruce (_Picea mariana_) or alpine and arctic tundra. Small tundra lakes and wetlands are prominent along the Selawik River. The study area is bisected by the Kobuk, Selawik, and Huslia River systems.

The area has a maritime climate during ice-free periods and long cold periods during winter months (USDI 1987). Temperature extremes range from 90 degrees F to -60 degrees F. Summer temperatures average about 60 degrees F, and winter temperatures of 20 to -30 degrees F are common. Annual precipitation averages 6 to 8 cm and up to 12 cm in lowland and upland areas, respectively; half of it occurs during July and August. Because of severe winter winds, snow depths can range from zero in upland windblown areas to hundreds of cms in low riparian areas.

The study area is occupied by other predators such as brown bears (Ursus arctos) and black bears (Ursus americanus). Although coyotes (Canis latrans) occur in the area, none have been observed in recent years. Other important furbearers in the study area include wolverines, lynx (Felis lynx), beavers (Castor canadensis), muskrats (Ondatra zibethicus), river otters (Lutra canadensis), mink (Mustela vison), marten (Martes americana), and red foxes (Vulpes vulpes). Other wolf prey species include moose (Alces alces), Dall sheep (Ovis dalli) and muskox (Ovibos moschatus).

METHODS

Wolves were captured for radio-collaring using helicopter-darting procedures similar to those described by Ballard et al. (1982). Wolves were immobilized with either etorphine hydrochloride (M-99, D-M Pharmaceuticals, Inc., Rockville, Maryland) or with a combination of tiletamine hydrochloride and zolazepam hydrochloride (Telazol, A. H. Robins Company, Richmond, Va.). M-99 was available in a concentration of 1 mg/ml and was administered to wolves of all sex and age classes at a dose of 2.5 ml. After processing each wolf, the antagonist diprenorphine hydrochloride (M-50-50, D-M Pharmaceuticals, Inc., Rockville, Maryland) was administered at an equivalent dose; however, the concentration was 2 mg/ml. Induction and immobilization times were identical to those reported by Ballard et al. (1982). Telazol was available in 500-mg vials. We recombined 2 vials of the drug with 5 ml of sterile water, resulting in a concentration of 100 mg/ml. Both sexes and all ages were immobilized with a dose of 2 ml. Each immobilized wolf was sexed and aged to the nearest month, based on tooth eruption and wear assumption of a 1 June birthdate. In addition, each was weighed, measured, and ear-tagged; a blood sample was taken, and each wolf was equipped with either a conventional VHF or satellite transmitters, (Telonics, Inc., Mesa, AZ.) referred to herein as PTT's (i.e., platform terminal transmitters).

Wolf movements and territory sizes were determined independently, using relocations obtained from fixed-wing aircraft (Ballard et al. 1987) or satellite PTT's. Instrumented wolf packs within the core study area were relocated approximately once every 2 weeks throughout the year, except during specified periods. During March and April 1987 and 1988, radio-collared wolf packs were relocated daily to accomplish 2 objectives: (1) determine spatial relationships among packs during the time period when we normally would conduct counts or censuses, and (2) quantify food habitats and estimate rates of predation of different sized packs. Availability of caribou as prey during March and April was evaluated and rated, based upon the proportion of radio-collared caribou from the WACH located within the wolf study area. Productivity and survival of pups were monitored annually, based on counts at den sites and comparisons of counts during early autumn, midwinter, and late spring.

Using the minimum convex polygon method, territory sizes (Mohr 1947) were estimated from all relocations, excluding obvious extraterritorial forays and dispersals. Other methods will be considered as additional data become available. Spring and autumn wolf densities within the core study area were estimated by extrapolating known numbers of wolves within radio-marked packs to other portions of Unit 23 as well as other areas within the range of the WACH, if appropriate. These methods, which follow those used by Ballard et al. (1987), were recommended by Fuller and Snow (1988). To verify whether density estimates of the study area can be extrapolated to additional areas, periodic surveys using Stephenson's (1978) track count method will be conducted in areas where few or no radio-collared wolves exist. We assumed the wolf population will be composed of 10% lone or single wolves (Stephenson 1975, Ballard et al. 1988, Fuller and Snow 1987), unless study area data suggest otherwise.

Based on criteria described by Stephenson and Johnson (1972, 1973), Peterson (1977), Peterson et al. (1984), Ballard et al. (1987), and Fuller (1989), carcasses of ungulates observed while relocating instrumented wolf packs were classified as to cause of death. Causes of death were classified as wolf-killed, bear-killed, hunter-killed, scavenged, winter-killed (i.e., starvation), or unknown. When practical, active wolf dens of radio-collared packs were visited each year to describe the den sites (Ballard and Dau 1983) and collect wolf scats for assessment of summer food habits. We also examined ungulate carcasses in situ to confirm cause of death and look for obvious physical abnormalities; we collected mandibles and longbones for determining percentage of marrow fat (Neiland 1970) and age (Sergeant and Pimlott 1959; Skoog 1968). All observations made from fixed-wing aircraft and on the ground were recorded on standardized forms (Appendix C). Upon returning from the field, data were entered onto a PC microcomputer using a DBASE III format (Appendix D).

Satellite Telemetry

Recent history of the use of satellite telemetry for examining movements and habitat use of large animals such as caribou and polar bears (Ursus maritimus) has been described by Fancy et al. (1988). In Alaska, the U. S. Fish and Wildlife Service and the Department have cooperated since 1984 in a long-term project to develop, test, and refine the use of satellite telemetry for studying wildlife. The Argos Data Collection and Location System (DCLS) has been routinely used for collecting and processing data obtained from satellite collars. The Argos project is a cooperative effort among the Centre National d'Etudes Spatiales of France, the National Oceanic and Atmospheric Administration, and the National Aeronautics and Space Administration to acquire reliable environmental data on a global basis. Currently, there are 2 polar orbiting satellites that cover Alaska. The Argos system consists of a series of receiving and tracking stations and communications links that transfer data to several processing centers.

Use of satellite telemetry in this study appeared feasible, given our interest in specific movement patterns among packs when censuses might be feasible. More importantly, weather patterns in northwest Alaska frequently hamper data collection using fixed-wing aircraft and conventional VHF transmitters. Satellite transmitters appeared to offer an opportunity to obtain year-round continuous relocations, regardless of weather conditions. Until recently, however, satellite collars powered by "D" cell batteries have weighed between 1.6-2.0 kg (Fancy et al. 1988), too heavy for use on smaller mammals such as wolves. In addition to relocations, satellite transmitters provide data on canister temperatures and animal activities. Canister temperature is thought to reflect ambient air temperatures. Each PTT also contains a mercury tip switch that has proved useful in assessing activity patterns in other wildlife species such as caribou (Fancy et al. 1988).

RESULTS AND DISCUSSION

During April 1987 a pilot study was initiated to determine if wolf densities were sufficiently high within Unit 23 to warrant further investigations into wolf demography and development of census methods. An earlier attempt at initiating a study failed because of low wolf numbers and poor snow conditions (James 1984). From 14-17 April 1987, 11 wolves in 6 social units were captured and radio-collared (one with a satellite collar; <u>see</u> Appendixes E-G) on the winter range of the WACH (Table 1). Subsequent observations of pack sizes in combination with public reports indicated that the wolf population in Unit 23 was increasing and densities were sufficiently high to warrant further study. Consequently, in the spring of 1988 the 1st formal year of study was initiated.

From April 1987 through June 1989, 49 wolves were captured and radio-collared from the Anisak River south to the Kateel River (Tables 1 and 2). Of that total, 39 were captured once, eight twice, and two on three occasions. Of the 64 immobilizations, M-99 was used in 11 instances and Telazol in 53. No mortalities occurred as a result of the immobilizations; however, 1 wolf had to be killed and tested for rabies (test was negative) because it slipped its muzzle while members were attempting to weigh the animal and bit one member of the tagging crew. After results of the Telazol immobilizations have been evaluated, they will be presented in future reports. One wolverine was also collared in April 1989.

Overall, sex ratios of wolves at initial capture were 50:50 ($n = 49$, $P > 0.05$); however, pup ratios appeared skewed in favor of females (74:26, $n = 23$, $P < 0.05$). The 49 wolves were composed of 23 pups, 5 yearlings, and 21 adults (Tables 1 and 2).

The 49 radio-collared wolves from 13 different social units were relocated from fixed-wing aircraft on 1,012 occasions between 14 April 1987 and 30 June 1989. The frequency of the wolf relocations is provided in Tables 1 and 2. Of the 49 wolves collared, seven dispersed from their original pack area; of the 7 dispersers, two were shot and the status of one was unknown. Excluding 1 project-related mortality, 35% of the collared wolves have died. Excluding the 20 wolves collared in April 1989, 16 (57%) of 28 wolves have died. The 20 recently collared wolves have not yet been exposed to snow conditions, when most of the mortality attributable to hunters occurs. Known fates of the 49 collared wolves as of 30 June 1989 are as follows: 31 were alive (20 of these were first collared in April 1989); 13 and two have been killed by snowmachine- and aircraft-assisted hunters, respectively. One was killed by project staff; and the status of one was unknown.

Estimates of wolf territory sizes are often a function of the number of relocations and pack sizes (Fritts and Mech 1981; Ballard et al. 1987; Fuller 1989); territory size estimates in this study (Table 3) appear related to those variables, as well as others such as prey availability and density. Assuming that pack territories are not fully defined until numbers of pack-days are $\geq$ 60 (Ballard et al. 1987), then only 4 territories have been fully defined. These latter areas ranged from 950 to 2,358 km^2. Annual differences in territory sizes are also reflected in Table 3.

Boundaries and locations of instrumented wolf packs during 1987-88 suggest that wolves maintained year-round resident territories and did not migrate (Fig. 4). Results of Canadian studies by Kelsall (1968) and Parker (1972), earlier work by Stephenson and James (1982) and James (1983, 1984) in this area, and numerous reports from the public indicated that wolves located on caribou winter range were migratory; because these wolves were apparently not, we wondered if they had ever been migratory. If they had been migratory earlier, perhaps conditions had changed and it had been no longer necessary. Also, it was possible that migratory wolves existed outside of our study area.

The expectation that wolves would be migratory was based on several assumptions that may or may not be valid. Wolves migrating with caribou would either be primarily dependent on caribou as prey or would be migrating for other reasons. Because moose have recently colonized northwest Alaska (i.e., 1950's), alternate nonmigrating prey may now be available at high enough densities to no longer require wolves to follow caribou; or because the caribou population has greatly increased after the crash in the mid-1970's (see Fig. 1), they have become widely distributed on year-round basis throughout the range of the WACH at densities sufficiently high (or in combination with alternate prey) to sustain predation by wolves on a year-round basis. Although the bulk of the caribou herd (females, calves, and yearlings) continued to migrate, resident wolves had access to prey at densities necessary for them to survive. Although these explanations can not yet be dismissed, wolf movement patterns the following year indicated that wolf migration may not be an annual event.

Most wolf packs within the study area continued to maintain year-round territories until about December 1988 (Fig. 5). At that time members of the Rabbit Mountain and Ingruksukruk packs began traveling to areas where they had not been relocated during the preceding 20 months. Between December and March, both packs migrated 170 to 230 km south (straight line distance) to the Shaktoolik River in Subunit 22A. These packs relied heavily on caribou for prey, and during December 1988 there were very few caribou within the original pack areas. Compared with the previous period (1987-88), caribou migrated farther south during the 1988-89 period, and these 2 packs followed them. Other nonmigrating wolf packs were occupied with scattered bands of caribou and moose and did not migrate.

Both the Rabbit Mountain and Ingruksukruk wolf packs suffered heavy mortality while they were in the Shaktoolik River area. Apparently, hunters from the villages of Koyuk and Shaktoolik ran into these wolf packs while caribou hunting. At least one radio-collared member from each pack was killed; the Rabbit Mountain pack was reduced from eight to three and the Ingruksukruk pack from 14 to nine. Following their encounter with hunters, remaining members from both packs quickly returned to their original pack areas. At least one radio-collared member from the Ingruksukruk pack remained south, joined an adult male, and apparently colonized an area along the upper Kateel River. Movement patterns and other pertinent data will be presented in subsequent reports.

Data on ungulates killed by instrumented wolf packs (excluding scavenged carcasses) during this study are summarized in Table 4. A large portion of these data were collected during daily relocation flights in March and April to determine predation and movement rates. Detailed analyses of these data are not available for this report; however, annual changes in prey distribution and abundance within the study area are reflected in Table 4. During the winters of 1987 and 1988 when caribou wintered within the packs' areas, caribou composed at least 69% of the kills. During the winter of 1989 when most caribou wintered farther south, caribou composed only 33% of the kills.

Wolf densities within the study area from the fall of 1987 throug the spring of 1989 ranged from 2.7 to 6.3 wolves/1,000 km^2 (Table 5). Despite apparent heavy mortality rates among radio-collared wolves, the population is increasing. Annual finite rates of increase were estimated at 1.22 and 1.09 for the spring of 1988 and 1989, respectively. The finite rate of increase between the fall of 1987 and 1988 was 1.43. Based on densities within the study area, the wolf population in Subunit 23 ranged from 322 in the spring of 1987 to 750 in the fall of 1988. By the spring 1989, the population was 429 wolves. These estimates are preliminary and will require future refinement, because they assume uniform density.

Satellite Telemetry

Early in 1987, 2 prototype wolf PTT's were developed by Telonics. These collars were the first to utilize "C" cell lithium batteries and weigh less than 1,500 g. They had a projected life expectancy of approximately 9 months, based on a VHF transmission rate of 6 hours on and 42 hours off, (i.e. every other day). Each PTT also contained a VHF transmitter that allowed each animal to also be tracked by conventional methods. Because the VHF transmitter operates independently of the VHF satellite transmitter, the animal can still be relocated using conventional methods after the satellite transmitters have ceased operation. Although the collars were judged to be too bulky for most wolves, the units were minimally acceptable for use on adult animals. Both units were deployed on wolves in the spring of 1987; one in this study area and another in the Arctic National Wildlife Refuge. The latter unit failed, while ours performed flawlessly. Preliminary results obtained from this 1st wolf satellite collar have been presented elsewhere and are contained in Appendixes E through G.

Each PTT can be programmed to transmit for varying lengths of time, depending on the objectives. Prior to this study, VHF transmitters were programmed to transmit for a minimum of 6 hours per day, which was optimal for insuring the satellite would fix at least one relocation with reasonable accuracy during the transmission. Obviously, length and rate of transmission affect battery life as well as the life of the collar. The first prototype collar (i.e., programmed to transmit 6 hours every other day) had a theoretical life expectancy of about 6 months; however, it actually functioned for 13 months (Appendix G). Because the theoretical life expectancy was relatively short, we examined other transmission frequencies to determine if we could obtain a minimum of 1 good relocation per transmission while extending battery life to at least 1 year. Because we were interested in daily movements among adjacent wolf packs, we programmed all 6 wolf PTT's deployed in 1988 to transmit daily for a 30-day period at a transmission schedule of 6 hours on and 18 hours off. We assumed the time we deployed these collars corresponded to the time we normally counted wolves.

Satellite transmitters can be programmed for up to 4 different transmission schedules so that more or fewer relocations and activity data can be obtained during specified periods, depending upon project objectives. After the initial 30-day period, we were interested in extending the maximum life of the transmitter as well as maintaining consistent contact. Consequently, after the first 30 days of daily transmission, four of the transmitters (PTT Nos. 7909-7912) were programmed to transmit 6 hours on and 42 hours off for the duration of battery life. The remaining 2 transmitters (PTT Nos. 7913 and 7914) were programmed to transmit 4 hours on and 44 hours off for 96 hours and then 6 hours on and 42 hours off, repeating the same transmission schedule for the duration of battery life.

Five of 6 PTT's were deployed in mid-April 1988 (Tables 1 and 2). Two or 3 weeks after they had been deployed, it became evident that we were not receiving the number of relocations anticipated. We then learned that Service Argos has several different options for data processing and each option requires a special request from the user to Argos. Each relocation is given a location quality index value referred to as QQ's. We were originally placed in the normal standard processing category (QQ's 8 and 9), which meant that only the highest-quality relocations were being processed. Other processing options included nonguaranteed and special-animal processing. Nonguaranteed processing contained additional relocations, but their accuracy is not guaranteed (QQ 7). Special-animal processing (QQ's -4 through 6) provides the greatest number of relocations, but many of them are not accurate and the service costs an additional $1.25 per PTT-day. The different qualities of relocations are a function of the number and quality of signals received by the satellite. Brief descriptions of the various location index values (QQ's) are contained in Table 6.

During 1988 and 1989 the failure rate of the satellite collars was 33% (2 of 6). Of the first 5 PTT's deployed, PTT No. 7913 failed immediately, providing only 1-3 relocations. Telonics indicated that this transmitter failed because of an internal short on one of the power leads, that caused the unit to immediately discharge (Bill Berger, Telonics, pers. commun). This PTT was recovered in mid-June and replaced with PTT No. 7911. The UHF transmitter on PTT No. 7911 functioned as planned, but the VHF unit failed almost immediately after deployment. Consequently, this wolf was only visually observed when it was accompanied by other collared animals. PTT No. 7910 failed in mid-August and was recovered in November 1988. Two problems with PTT No. 7910 were identified: (1) the canister had been punctured from an apparent bite that allowed moisture to enter the unit and caused the batteries to short out (Berger, pers. commun.) and (2) the urethane material covering the sides of the canister to protect the antennae leads had been pulled from the canister. Although this 2nd problem was not the cause of the failure, it probably would have caused problems.

PTT's Nos. 7909-7914 were 2nd-generation wolf collars. Several modifications from the 1st collar design were made to reduce the size and weight. The 1st prototype units were bulky and relatively heavy, and they could only be used on adult animals (Fig 6). One of the modifications involved eliminating the urethane material encompassing most conventional wolf collars. Although this material was eliminated from the front and back of the collar, it remained on the sides to provide protection for antennae outlets. Unfortunately, this material had a tendency to separate from the canister because of wear or bites. Once separated from the canister, moisture entering the canister could cause premature failure of the unit; this may explain why the VHF transmitter failed on PTT No. 7910. To eliminate this problem, the collars were again modified by using a slightly different canister and by having both the VHF and UHF antennas exit the canister from the top rather than the sides eliminating the need for the urethane material along the sides and resulting in a slightly smaller and lighter unit. Each generation of the wolf collar has been smaller and lighter (Fig. 6).

During 1988 and 1989, 1,606 relocations with activity data were obtained from the 6 wolf PTT's (Table 7). Activity data alone were obtained on an additional 2,063 occasions when insufficient information was received by the satellite for a location to be calculated. Because we did not request special processing until June 1988, we did not obtain as many locations as were possible. We also suspect that a large number of activity and relocations have not yet been received from Service Argos. For unknown reasons, raw data received from Argos are at times incomplete and users need to be alert for missing data. Fancy et al. (1988) developed a number of data processing programs for microcomputers that not only simplify organization and analysis of data but also allow users to easily spot where data may be missing. One of the most heavily used programs is PCARGOS.

The PCARGOS program edits out unnecessary or unusable data received from Argos, summarizing the useful data into 2 files; i.e., ".AI" files (Area of interest) that provide records only when a relocation was calculated and ".All" files that provide all records regardless of whether a relocation was calculated. Another program referred to as "SP" allows data from special animal processing to be edited and organized similarly to .AI and .All files. These programs allow users easy access to the most meaningful portions of the data. A good example of the utility of these programs for discovering discrepancies in or problems with raw data received from Argos and acquiring easy access to more useable data is demonstrated by comparisons of Table 7 with Tables 8 through 14. For example, data from PTT No. 7911 in Table 7 (based on summary statistics from Argos) indicate that 417 relocations were obtained during 1988 and 1989; however, data in Table 10 (based on special processing and .AI files) indicate that 536 relocations were obtained. Reasons for these discrepancies are due, in part, to the use of relocations of unknown accuracy but also to discrepancies in the raw data provided by Argos. The number of relocations in Table 6 include many that were based on data having low QQ indices (i.e., 0-6 see Table 5). These relocations should not be used for analyses until their accuracy has been determined. Also, data appear to be missing because of the unexplained low number of relocations for the month of August.

Those PTT's that did not prematurely fail transmitted for an average of about 10 months (i.e., 4 months beyond the theoretical life span based on battery output). The shorter transmission duty cycles for PTT Nos. 7913 and 7914 did not appear to increase the life of the transmitters. During the first 2 months following deployment, the duty cycle for all transmitters was 6 hours on and 18 hours off and the transmitters averaged 22.6 high-quality (n = 6, SD = 16.4) relocations per month (Table 14). The latter is a minimum estimate; an unknown quantity of data was lost because we were not on special animal processing. Following the first 2 months of transmission when duty cycles were either 4 or 6 hours on, an average of 25.5 high-quality (QQ's > 7, n = 32 mos., SD = 12) relocations were obtained, excluding August and last partial months of transmission.

The reduced transmission duty cycle from 6 to 4 hours resulted in a reduction in the numbers of relocations obtained per month; however, because of several factors this difference may or may not be statistically significant. To insure that duty cycles were comparable, only data obtained after the first 2 months of transmission were used; data from the last month and the month of August were excluded. PTT Nos. 7913 and 7914, which had 4-hour duty cycles, averaged 20.6 (n = 9 mo, SD = 11.7) relocations per month, compared with an average of 27.4 (n = 23 mo, SD = 11.7) relocations per month for PTT transmitting for 6-hour periods. This difference was not significant (t = 1.48, P > 0.05), but because PTT No. 7913 had been refurbished, there was some question as to whether the duty cycle had been changed. If 2 months of relocations from PTT No. 7913 were excluded from the analysis, the average number of relocations per month would decline to 15.7 (SD = 7.3), a significant difference (t = -2.4, P < 0.05). We concluded that the 4-hour transmission schedule (1) resulted in fewer relocations than those obtained from a 6-hour schedule and (2) did not increase the life span of the transmitter. More experimentation with optimal duty cycles appears warranted.

Movements of 5 wolf packs, as determined with satellite telemetry from mid-April through June 1988, are shown in Figure 7. Unfortunately, most of the data collected during 1988 and 1989 were being analyzed and plotted while this report was being prepared. Movement patterns during the 1st year of this study were typical of resident nonmigratory wolves; no significant migrations occurred until early 1989. Plotted movements of the

Rabbit Mountain Pack, as determined with the first prototype satellite collar during 1987-88, were superimposed over the plotted movements from mid-April 1988 through June 1988 (Fig. 8). The movements for the Rabbit Mountain pack represent either annual changes in use patterns or differences between individuals of the same pack. PTT No. 7900 was deployed on an adult nonalpha male during 1987 and 1988, while PTT No. 7914 was deployed on the alpha female during 1988 and 1989.

Wolf movement patterns observed thus far suggest that migrations of wolf packs to the winter caribou range are inconsistent and unpredictable. During the next reporting period, (1989-90) we intend to further evaluate satellite telemetry as a tool for monitoring wolf pack movements, gather wolf and caribou demographic data, monitor predation rates, and begin testing wolf survey methods on caribou winter range. Two surveying methods may be promising: (1) a modification of a linear transect developed by Earl Becker that has been used successfully on a known population of lynx (<u>Felis canadensis</u>) (Schwartz and Becker 1988); this method has also been used on wolves and wolverines in Southcentral Alaska (ADF&G files, Becker and Van Daele 1988), but the accuracy of the estimates are unknown and have not been evaluated in areas with known densities of wolves and (2) the wolf track count method (Stephenson 1978) using an appropriate sample unit and random sampling.

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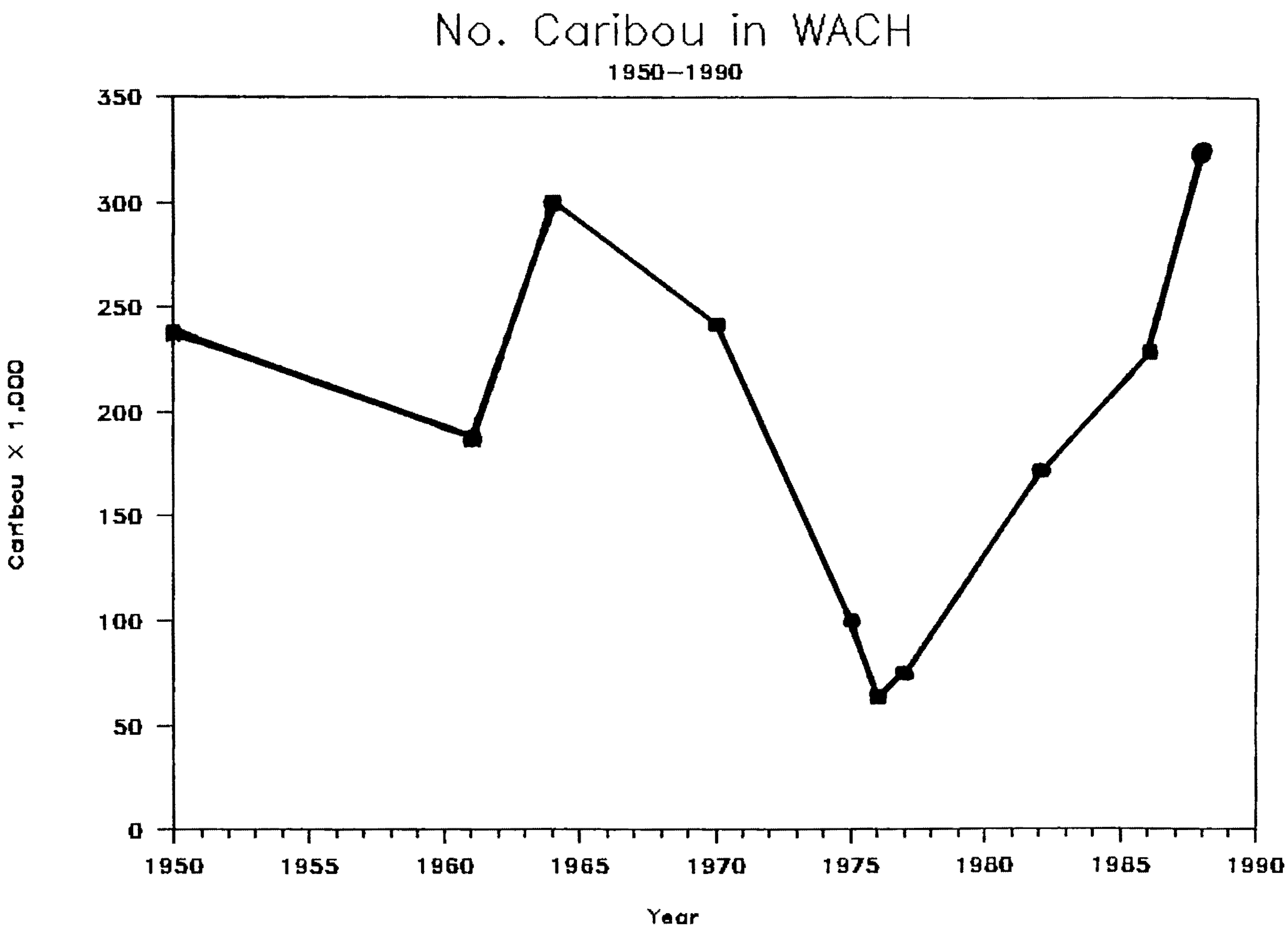

Fig. 1. Population estimates of the Western Arctic Caribou Herd in northwest Alaska from 1950-1988.

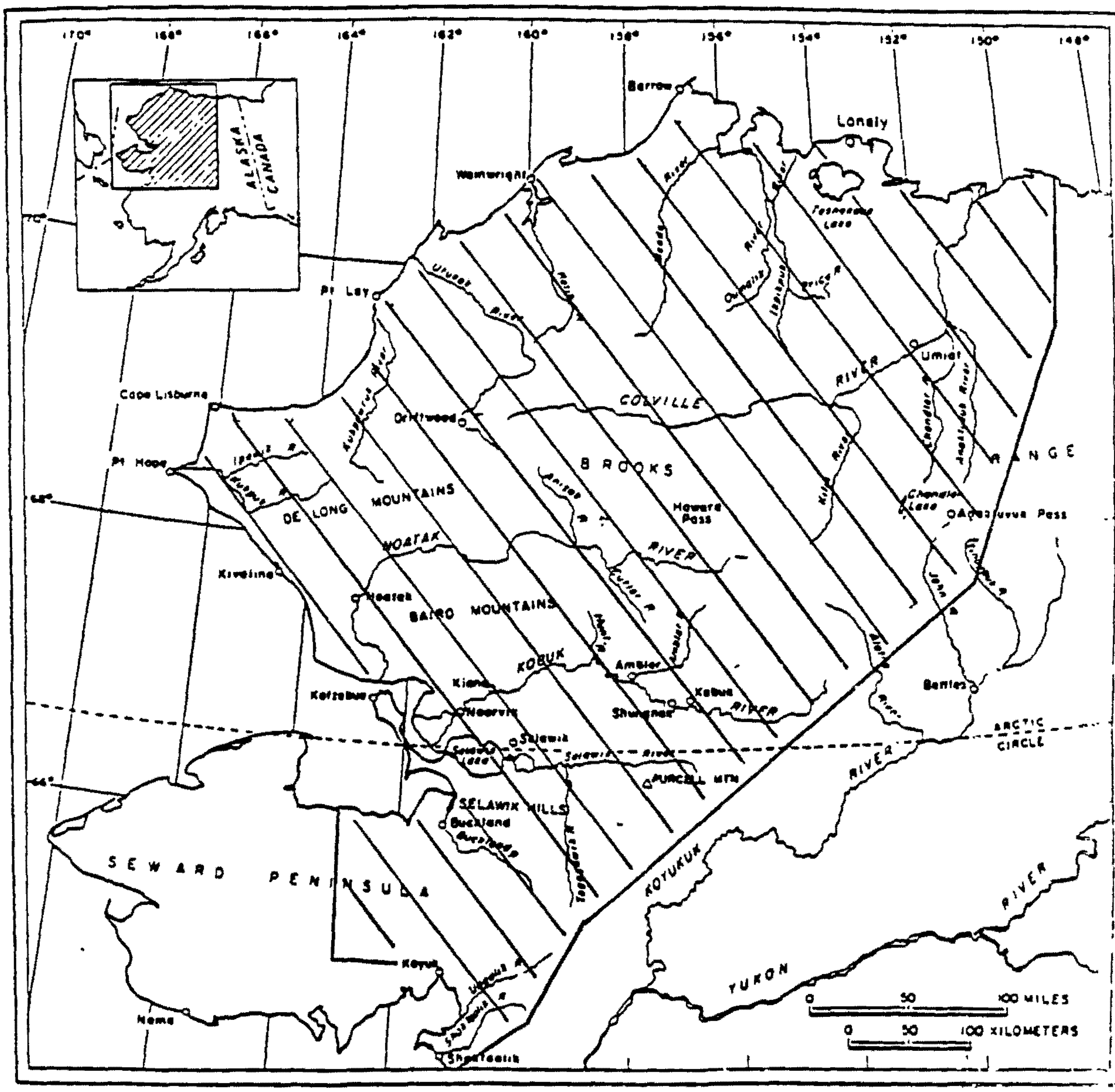

Fig. 2. Range of the Western Arctic Caribou Herd during the late 1970's and early 1980's as determined from radio telemetry (from Davis et al. 1980).

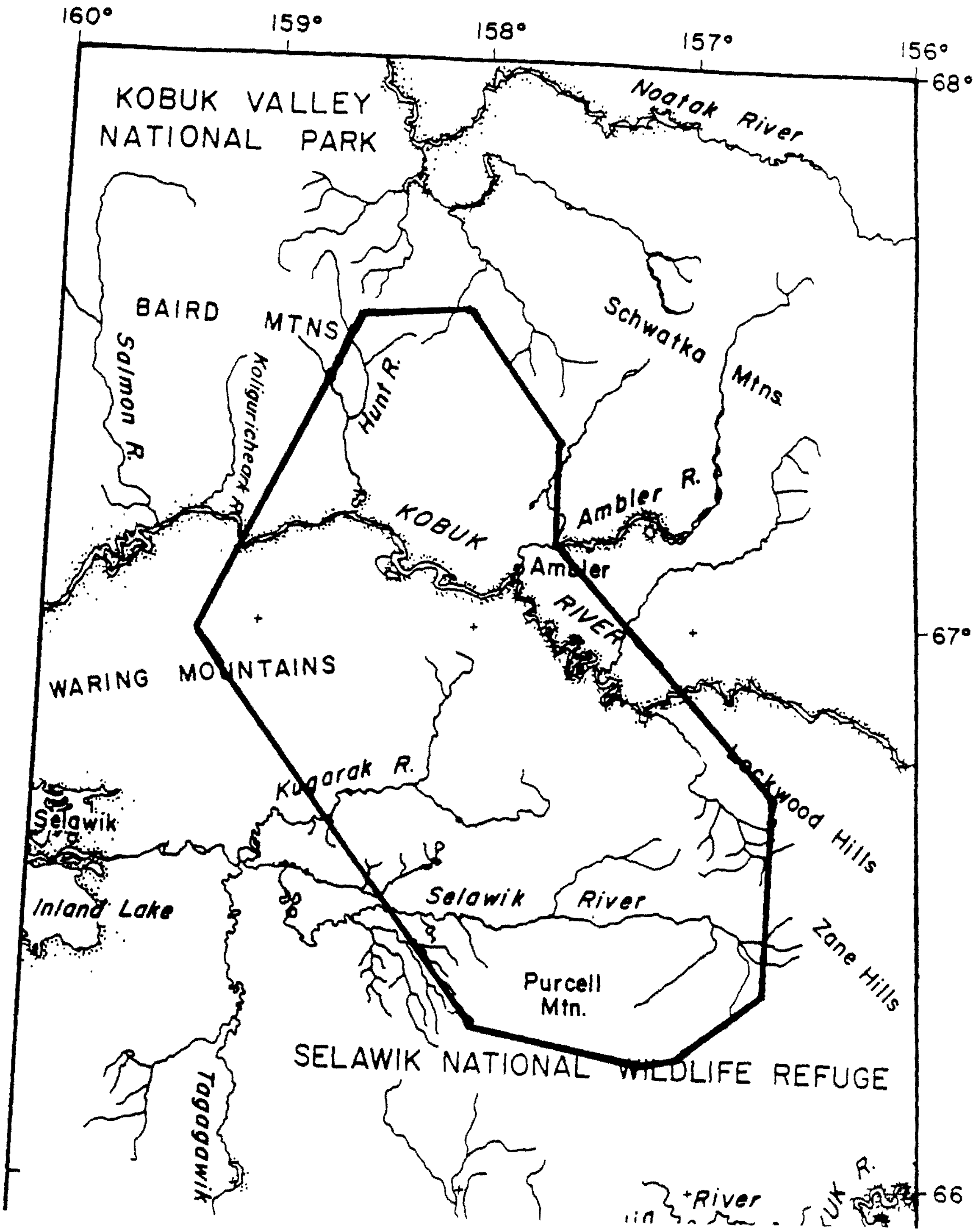

Fig. 3. Boundaries of wolf study area in northwest Alaska where wolf demography and movement patterns have been intensively studied from April 1987 through June 1989.

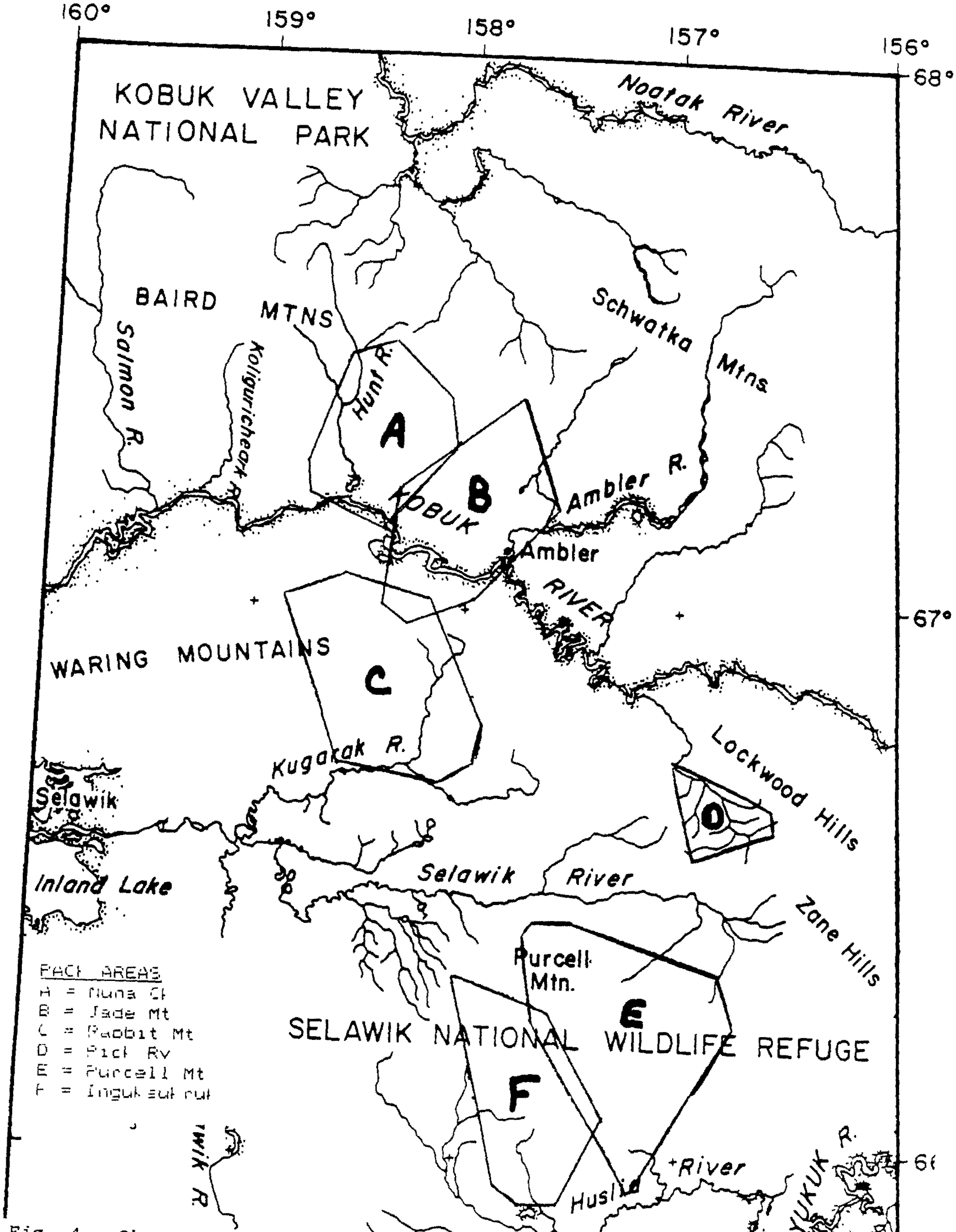

Fig. 4. Observed boundaries of wolf territories as determined from relocations of instrumented pack members in northwest Alaska from April 1987 through June 1988.

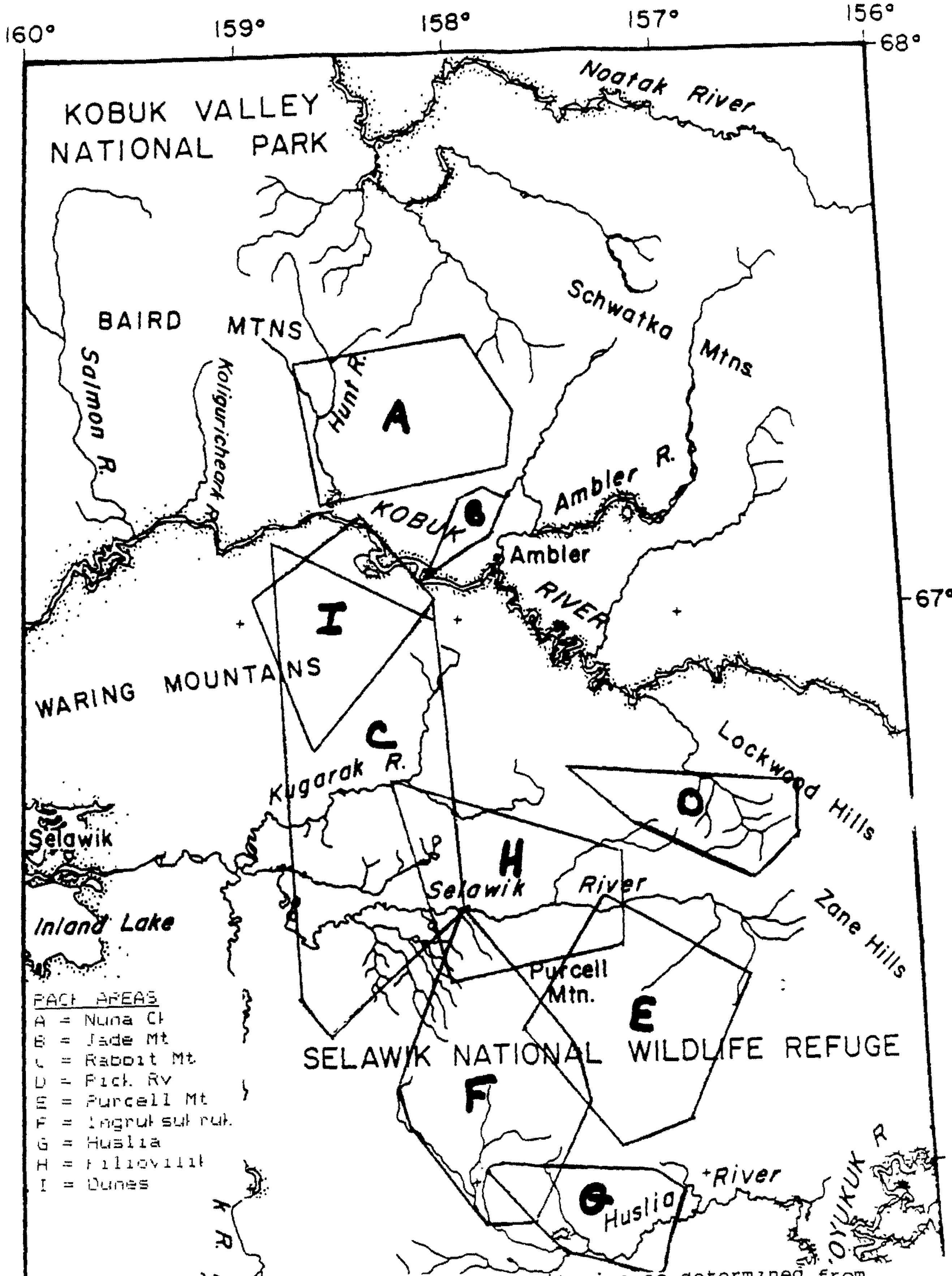

Fig. 5. Observed boundaries of wolf territories as determined from relocations of instrumented pack members in northwest Alaska from June 1988 through June 1989.

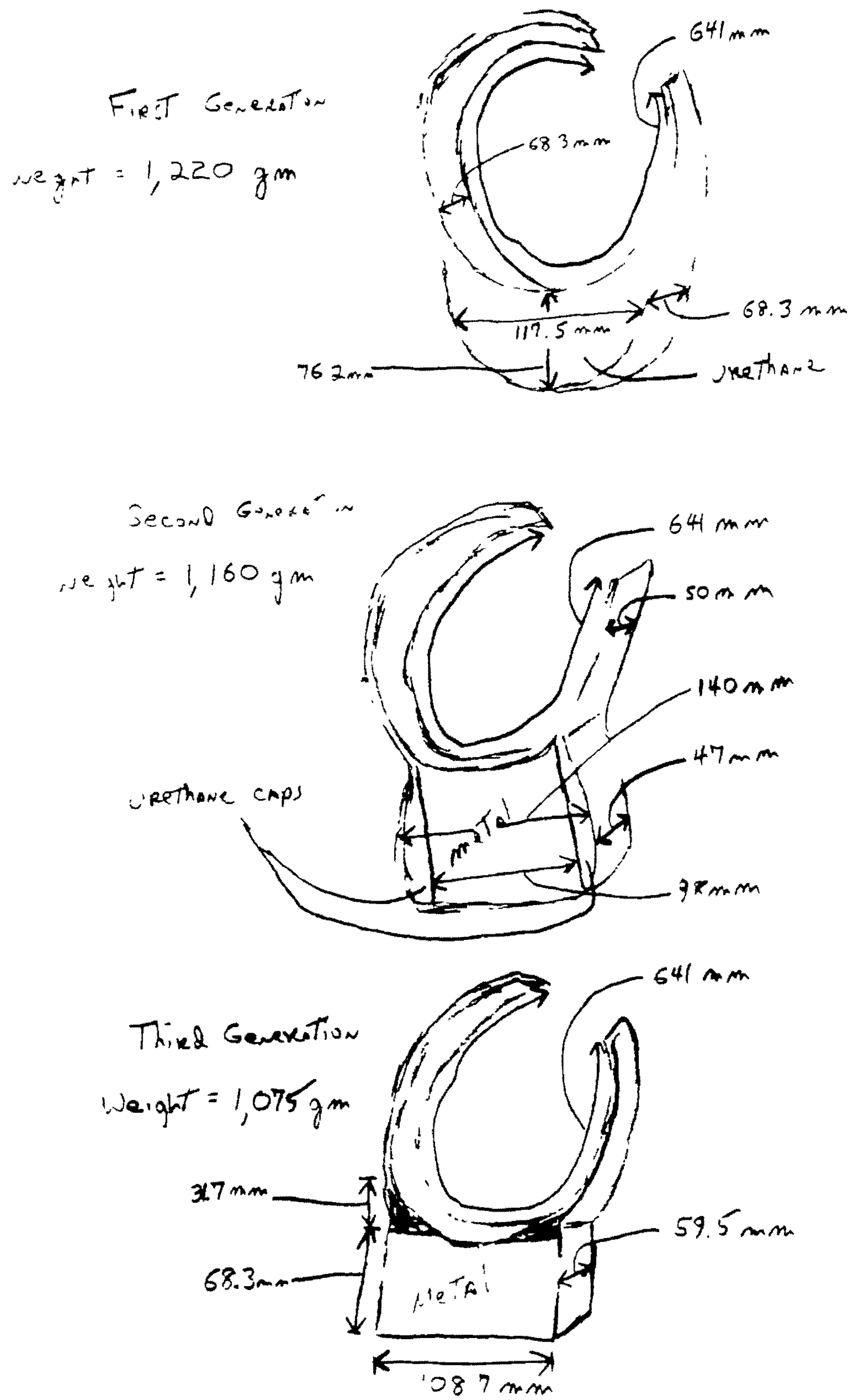

Fig. 6. Dimensions and weights of satellite transmitters used on wolves in northwest Alaska from April 1987 through June 1989.

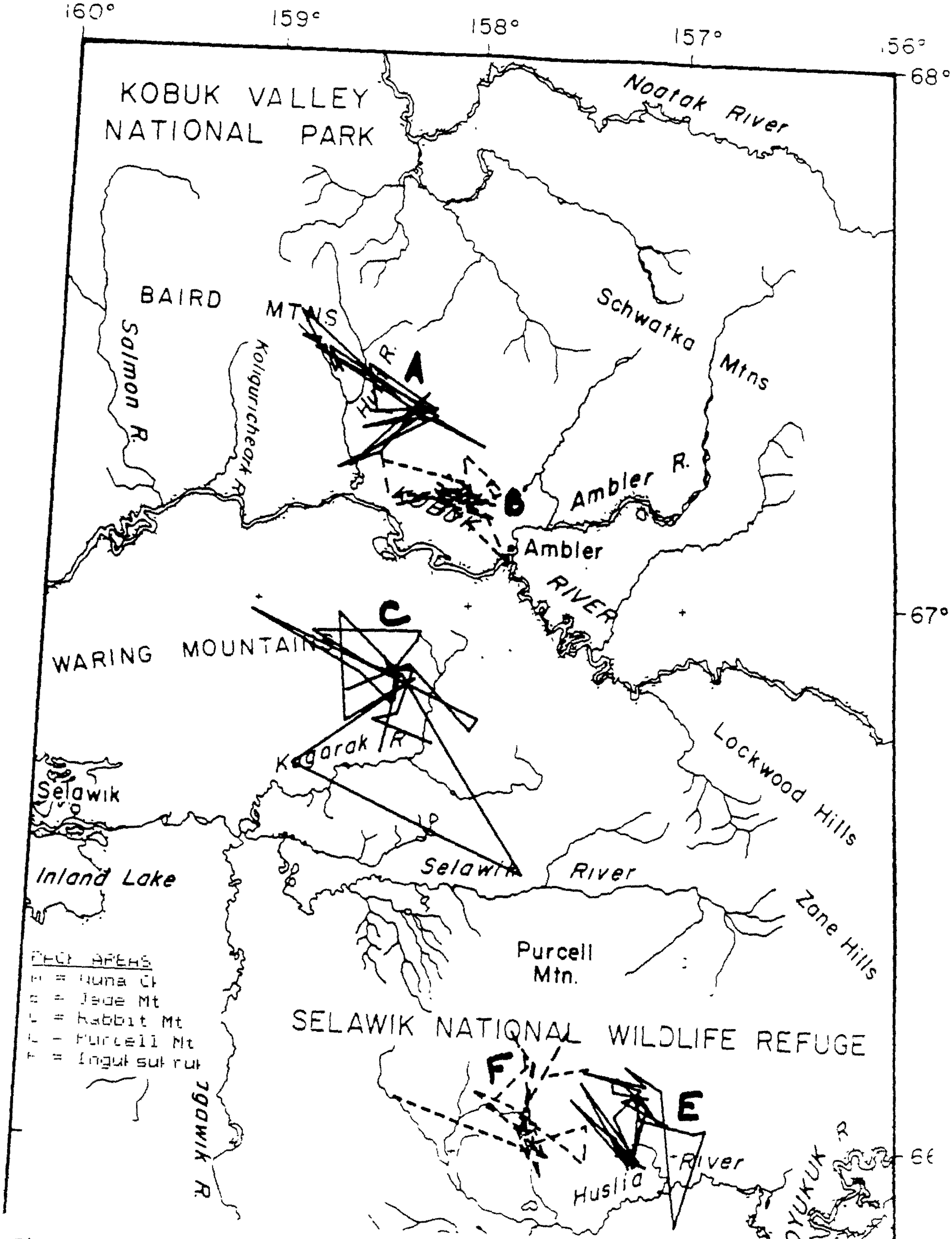

Fig. 7. Movements of 5 wolf packs from April 1988 through June 1989 as determined from satellite telementry.

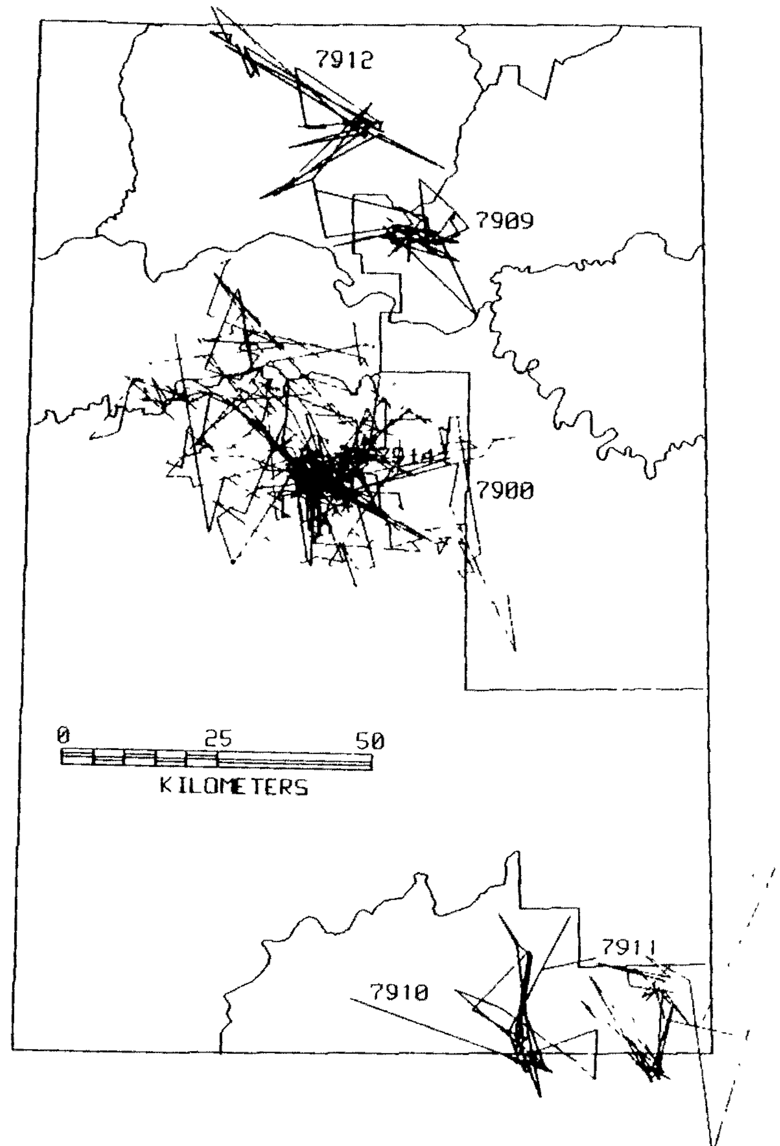

Fig. 8. Movements of 5 wolf packs as determined from satellite telemetry in northwest Alaska from April 1987 through June 1988. Individual identification numbers are listed next to movement data. Movement data for ptt 7900 and 7914 are for the same pack but in different years. Movement data for ptt 7900 are for April 1987 through February 1988. Data for other ptts are for April 1988 through June 1988.

Table 1. Summary of wolves captured and radio-collared during April 14, 1987 through June 20, 1989 in northwest Alaska.

Pack[a]	ID no.	Dates immobilized	Sex	Age (mo.)	Fate as of 06/30/89
1	1	04/15/87	M	35	Shot 02/27/88 (snowmachine)
2	2	04/15/87 04/14/89	F F	23 47	Alive
2	3	04/15/87	M	35	Alive
2	4	04/15/87	F	11	Dispersed and alive
7		04/14/89	F	35	Alive
3	5	04/16/87	F	11	Shot 01/08/88 (snowmachine)
3	6	04/16/87	M	47	Dispersed-Wulik-RV shot 11/87 (snowmachine)
4	7	04/16/87 04/24/88 04/10/89	F F F	35 47 59	Alive
4	8	04/16/87	M	47	Shot 01/88 (snowmachine)
5	9	04/17/87	M	59	Dispersed Ray Mts. (Shot 2/89 aircraft)
5	10	04/17/87 04/26/88 04/10/89	F F F	11 23 35	Alive
1	11	04/17/87	M	179	Dead 6/89 Natural

Table 1 (continued)

Pack[a]	ID no.	Dates immobilized	Sex	Age (mo.)	Fate as of 06/30/89
2	12	04/23/88 06/11/88	F	11 13	Alive
6	13	04/23/88 11/13/88	M M	23 30	Shot 03/89 (Snowmachine)
1	14	04/24/88	F	35	Shot 03/89 (Aircraft)
6	15	04/24/88	M	35	Shot 03/89 (Snowmachine)
6	16	04/24/88	F	11	Alive
6	17	04/24/88	F	11	Dispersed Kateel R. Alive
5	18	04/26/88	M	11	Dispersed Missing
5	19	04/26/88 04/10/89	M M	11 23	Alive
5	20	04/26/88 04/27/88	M M	23 23	Dead-Sacrificed
5	21	04/26/88	M	23	Dispersed -Dunes
11					Alive
12	22	08/03/88 11/12/88	F F	3 6	Shot 12/88 (Snowmachine)
1	23	11/14/88	F	6	Shot 02/89 (Snowmachine)
3	24	06/27/88 11/14/88	M M	37 42	Shot 02/89 (Snowmachine)
1	25	11/14/88	M	6	Shot 01/88 (Snowmachine)

Table 1 (continued).

Pack[a]	ID no.	Dates immobilized	Sex	Age (mo.)	Fate as of 06/30/89
4	26	11/15/88	M	42	Shot 01/89 (Snowmachine)
12	27	11/15/88	M	114	Alive
12	28	11/15/88	M	6	Shot 12/88 (Snowmachine)
1	29	04/09/89	F	11	Shot 04/89 (Snowmachine)
1	30	04/09/89	F	11	Alive
13	31	04/09/89	F	23	Alive
13	32	04/09/89	F	11	Alive
11	33	04/10/89	F	35	Alive
5	34	04/10/88	F	47	Alive
5	35	04/10/89	F	11	Alive
3	36	04/13/89	F	11	Alive
3	37	04/13/89	F	35	Alive
3	38	04/13/89	M	11	Alive
3	39	04/13/89	F	11	Alive
6	40	04/14/89	F	11	Alive
7	41	04/14/89	M	35	Alive
2	42	04/14/89	F	11	Alive
2	43	04/14/89	M	11	Alive
2	44	04/14/89	M	35	Dispersed and Alive

Table 1 (continued).

Pack[a]	ID no.	Dates immobilized	Sex	Age (mo.)	Fate as of 06/30/89
8	45	04/15/89	F	35	Alive
9	46	04/15/89	F	11	Alive
9	47	04/15/89	F	47	Alive
10	48	04/15/89	M	83	Alive
14	49	04/19/89	M	35	Alive

[a] Pack name indexed as follows: 1 = Rabbit Mtn., 2 = Purcell Mtn., 3 = Pick River, 4 = Jade Mtn., 5 = Nuna Ck., 6 = Ingruksukruk, 7 = Huslia. 8 = Lower Tag., 9 = Upper Tagagawik, 10 = Kateel River, 11 = Dunes, 12 = Kiana, 13 = Kiliovilik, and 14 = Anisak.

Table 2. Number of occasions each month that radio-collared wolves were relocated during April 14, 1987 through June 20, 1989.

Pack[a]	ID no.	1987 A	M	J	J	A	S	O	N	D	1988 J	F	M	A	M	J	J	A	S	O	N	D	1989 J	F	M	A	M	J	Totals
1	1	5	2	2	0	1	1	1	1	1	2	1																	17
2	2	3	4	2	0	1	2	2	2	1	2	1	2	21	1	4	1	3	1	1	0	0	1	1	21	8	2	1	88
2	3	3	4	2	2	1	2	2	2	1	2	1	2	21	1	5	1	3	1	1	0	0	1	1	21	8	2	1	91
2	4	3	4	2	1	2	2	2	2	1	2	1	2	22	1	4	1	3	1	1	0	0	1						
7																									4	4		1	67
3	5	4	4	2	1	1	2	1	1	1																			17
3	6	4	4	2	1	0	0	2	1																				14
4	7	4	4	2	1	1	2	2	2	1	1	1	2	25	1	4	1	3	1	1	1	0	1	0	5	7	2	3	78
4	8	4	4	2	1	1	2	2	2	1	1																		20
5	9	3	4	2	0	1	2	3	2																				17
5	10	3	4	2	1	1	2	3	2	1	1	1	2	27	1	4	1	3	1	1	1	0	2	1	18	8	3	1	95
1	11	5	3	2	1	1	2	1	11	1	2	1	2	28	1	4	1	3	1	1	1	0	1	0	22	6	3	2	106
2	12													6	1	1[b]													8
6	13													5	1	4	4	3	1	1	1	0	1	1					22
1	14													4	1	4	1	3	1	1	1	0	1	0	1				18
6	15													3	1	3	3	3	1	1	1	0	1						17
6	16													3	1	4	3	3	1	1	1	0	1	1	19	8	3	1	50
6	17													3	1	4	1	3	1	1	1		1	1					17

Table 2 (continued).

Pack[a]	ID no.	1988 J	F	M	A	M	J	J	A	S	O	N	D	1989 J	F	M	A	M	J	Totals
5	18				3	0	4	2	3	1	1	1	0	2	1	18	1			37
5	19				3	1	4	2	3	1	1	1	0	2	1	19	8	2	1	49
5	20				1															1
5	21				3	0	1	0	2	1	1									
11																18	8	2	2	38
12	22								4	1	1	2	0	1						9
1	23											1	0	1	0	1				3
3	24						2	1	3	1	1	2		1						11
1	25											1	0	0	1					2
4	26											1	0	1						2
12	27											1	0	1	0	1	3	2	3	11
12	28											1								1
1	29																1			1
1	30																1	0	1	2
13	31																6	2	2	10
13	32																4	1	1	6
11	33																3	2	0	5
5	34																3	3	2	8

Table 2 (continued).

Pack[a]	ID no.	1989 J	F	M	A	M	J	Totals
5	35				3	2	2	7
3	36				3	2	1	6
3	37				3	2	1	6
3	38				3	2	1	6
3	39				3	2	1	6
6	40				3	0	1	4
7	41				1		1	2
2	42				4	2	1	7
2	43				4	2	1	7
2	44				4[c]	1		5
8	45				2	1	2	5
9	46				2	0	1	3
9	47				2	0	1	3
10	48				2	1	1	4
14	49				1	1	1	3

Table 2 (continued).

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[a] Pack name indexed as follows: 1 = Rabbit Mtn., 2 = Purcell Mtn., 3 = Pick River, 4 = Jade Mtn., 5 = Nuna Ck., 6 = Ingruksukruk, 7 = Huslia, 8 = Lower Tagagawik, 9 = Upper Tagagawik, 10 = Kateel River, 11 = Dunes, 12 = Kiana, 13 = Kililovilik, and 14 = Anisak.

[b] Satellite VHF failed.

[c] Dispersed.

Table 3. Summary of number of pack relocations, pack days, and approximate territory sizes for instrumented wolf packs studied in northwest Alaska from April 1987 through June 1989.

Pack name	April 1987-June 1988			July 1988-June 1989		
	No. pack relocations	Number pack days[a]	Territory size (km^2)	No. pack relocations	Number pack days[a]	Territory size (km^2)
Anisak				3	3	---
Dunes				33	32	763
Huslia				13	12	385
Ingruksukruk	20	10	588	59	42	1,901
Jade Mountain	56	53	950	25	25	121
Kiana				19	17	349
Kiliovilik				15	10	1,437
Lower Tagagawik				5	5	111
Nuna Creek	74	56	1,033	58	44	790
Pick River	27	20	212	21	21	758
Purcell Mountain	73	55	1,627	48	41	1,267
Rabbit Mountain	64	54	1,572	48	42	2,358
Upper Tagagawik				4	2	47

[a] Pack day defined as 1 day when 1 or more pack members were located $\geq$ 1 occasion.

Table 4. Summary of ungulate kills found while relocating radio-collared wolf packs in northwest Alaska from mid-April 1987 through June 20, 1989

Pack	Dates	Prey species	Sex	Age	Observed pack size
Huslia	04/03/89	Moose	Unk	Adult	2
Ingruksukruk	06/28/88	Moose	M	Adult	1
	08/26/88	Caribou	M	Adult	0
	01/14/89	Caribou	Unk	Unk	14
	03/18/89	Moose	Unk	Adult	3
	04/01/89	Moose	F	Adult	1
	04/14/89	Moose	Unk	Unk	2
	04/26/89	Moose	Unk	Calf	1
	05/26/89	Moose	Unk	Calf	1
Kiana	10/20/88	Other	Unk	Unk	2
	11/15/88	Caribou	F	Yearling	8
	04/05/89	Caribou	Unk	Adult	2
	04/16/89	Moose	Unk	Adult	2
	04/27/89	Caribou	Unk	Yearling	2
Nuna Creek	03/12/89	Moose	Unk	Adult	13
	03/13/89	Moose	Unk	Adult	15
	03/14/89	Moose	Unk	Unk	13
	03/20/89	Moose	M	Adult	7
	03/22/89	Moose	F	Adult	4
	03/28/89	Moose	Unk	Adult	3
	04/02/89	Moose	M	Adult	5
	04/05/89	Moose	F	Adult	12
	04/19/89	Caribou	F	Adult	6
Pick River	12/17/87	Caribou	Unk	Unk	4
	08/17/88	Caribou	Unk	Unk	0
	08/26/88	Caribou	Unk	Yearling	8
	10/20/88	Moose	M	Adult	4
	04/13/89	Caribou	F	Adult	7
Purcell Mt.	04/29/87	Moose	Unk	Unk	4
	01/06/88	Caribou	F	Adult	11
	03/31/88	Caribou	Unk	Unk	10
	04/03/88	Caribou	F	Adult	11
	04/04/88	Caribou	F	Adult	11
	04/07/88	Caribou	F	Adult	11
	04/09/88	Caribou	M	Adult	10
	04/15/88	Caribou	Unk	Adult	11
	04/16/88	Caribou	Unk	Adult	11
	04/18/88	Caribou	F	Adult	5
	04/20/88	Moose	M	Adult	1
	04/22/88	Caribou	M	Adult	4

Table 4 (continued).

Pack	Dates	Prey species	Sex	Age	Observed pack size
Purcell Mt. (continued)					
	04/23/88	Moose	M	Adult	5
	06/28/88	Moose	Unk	Calf	3
	03/11/89	Caribou	Unk	Adult	14
	03/14/89	Moose	Unk	Adult	12
	03/17/89	Moose	Unk	Adult	8
	03/24/89	Caribou	Unk	Adult	13
	03/25/89	Moose	M	Adult	13
	03/27/89	Moose	Unk	Adult	5
	04/11/89	Moose	Unk	Calf	11
	04/14/89	Moose	F	Adult	9
	04/27/89	Caribou	Unk	Adult	10
Rabbit Mt.	06/18/87	Moose	M	Adult	1
	08/11/87	Caribou	Unk	Adult	1
	10/29/87	Caribou	M	Adult	6
	11/24/87	Unknown	Unk	Unk	5
	01/06/88	Caribou	F	Adult	4
	04/03/88	Unknown	Unk	Unk	0
	04/07/88	Caribou	F	Yearling	2
	04/13/88	Caribou	F	Adult	0
	04/24/88	Caribou	F	Adult	2
	08/26/88	Caribou	M	Adult	1
	01/13/89	Caribou	Unk	Unk	3
	03/11/89	Moose	F	Yearling	2
	04/09/89	Caribou	F	Adult	3
Upper Tag	04/15/89	Caribou	F	Adult	4

Table 5. Observed number of wolves within radio-collared wolf packs during spring and autumn 1987-1989 used to estimate wolf densities and population estimates in study area and GMU 23. Underlined pack names were used for density estimates.

Pack name	Number of wolves				
	Spring 87	Autumn 87	Spring 88	Autumn 89	Spring 89
Anisak	--	--	--	--	2
Dunes	0	0	0	1	2
Huslia	--	--	--	1	2
Ingruksukruk	4[a]	10[a]	10	14	9
Jade Mountain	2	2	1	2	1
Kiana	--	--	--	8	3
Kiliovilik	3[a]	3[a]	3[a]	3[a]	2
Lower Tagagawik	--	--	--	--	2
Nuna Creek	8	9	7	15	12
Pick River	4	6	3	8	5
Purcell Mountain	6	12	11	20	10
Rabbit Mountain	3	7	2	8	1
Upper Tagagawik	--	--	--	--	4
Subtotal	30	49	37	70	40

Table 5. (continued)

Pack name	Number of wolves Spring 87	Autumn 87	Spring 88	Autumn 89	Spring 89
No. lone wolves assumed at 10%	3	5	4	7	4
Total	33	54	41	77	44
Size of study area (km^2)	12,279	12,279	12,279	12,279	12,279
Km^2/wolf	372	227	229	159	279
Wolves/1,000 Km^2	2.7	4.4	3.3	6.3	3.6
GMU 23 population estimate (assuming 119,140 km^2)	322	524	393	750	429
Spring finite rate increase			1.22		1.09
Autumn finite rate increase				1.43	

[a] Estimates based on track counts, public observation and harvest records.

Table 6. Description of location quality index (QQ) used with locations obtained from ptts with regular, non-guaranteed, and special animal processing by Service Argos.

QQ Index	Description
9	Equivalent to NQ=3. 5 messages received and used in calculation of position over 420 second duration. Internal consistency >0.15 Hz, satellite must achieve a maximum elevation between 22-55 degrees above horizon relative to ptt. Location reportedly accurate within 150 meters or 68% of occasions.
8	Equivalent to NQ=2. At least 5 messages must be received and used in calculation of position over 420 second duration. The satellite must achieve maximum elevation of 17-78 degrees above horizon relative to ptt. Location reportedly accurate within 350 meters or 68% of occasions.
7	Equivalent to NQ=1. At least 5 messages must be received 240 second or 4 messages over 420 seconds. Provides a non-guaranteed location but not necessarily of low quality.
6	≥4 messages but a pass duration less than 240 seconds.
5	Doppler point of inflection does not belong to the pass or mid-term oscillator drift is high.
4	3 messages. Previous lcoation <12 hours old.
3	3 messages. Previous location >12 hours old.
2	2 messages. Previous location <12 hours old.
1	2 messages. Previous location >12 hours old.
0	Location impossible. Geometric initialization failed.
-1	Location rejected. Distance from ground track.
-2	Location rejected. Internal consistency of the least square fit too high.

Table 6. (continued).

QQ Index	Description
-3	Location rejected. Long term oscillator drift too high.
-4	Location rejected. Location computation failed or choice of correct solution uncertain.

Table 7. Summary of total overpasses and relocations by month for individual wolf satellite radio-collars from 1988 through March 1989 in northwest Alaska

Wolf name -	Jade Mountain-Female			Ingruksukruk-Female			Purcell Mountain-Female			Nuna Creek-Female		
PTT No. -	7909			7910			7911			7912		
Deployment dates -	04/25/88 - 04/10/89			04/23/88 - 11/13/88			06/11/88 - ?			04/26/88 - 04/10/89		
(Julian dates)	(115-100)			(111-318)			(163-?)			(117-100)		
Month	Over-passes	Fixes	Hits	Over-passes	Fixes	Hits	Over-passes	Fixes	Hits	Over-passes	Fixes	Hits
Apr	27	12	1,042	37	0	154				19	16	291
May	129	26	536	160	8	665				154	12	536
Jun	70	48	261	66	47	317	147	102	867	74	42	248
Jul	71	52	250	79	58	329	73	49	307	72	48	219
Aug	85	8	377	49	4	205	69	6	294	69	9	208
Sep	83	67	375				87	68	395	81	51	246
Oct	97	73	488				92	62	479	80	49	290
Nov	63	46	314				55	40	241	54	25	184
Dec	95	48	407				88	40	367	79	27	228
Jan	78	29	333				81	22	339	65	6	171
Feb	56	17	211				55	21	224	71	15	210
Mar							26	7	88	22	2	50
Totals	854	426	4,594	391	117	1,670	773	417	3,601	840	302	2,881

Table 7. (Continued)

Wolf name -	Pick River - Male			Rabbit Mountain - Female					
PTT No -	7912			7913					
Deployment dates -	11/14/88 - 02/18/89			04/24/88 - 03/10/89					
(Julian dates)	(313-059)			(115-074)			Totals		
Month	Over- passes	Fixes	Hits	Over- passes	Fixes	Hits	Over- passes	Fixes	Hits
Apr				29	6	172	112	34	1,659
May				107	5	331	550	51	2,068
Jun				57	32	186	414	271	1,879
Jul				73	42	236	368	249	1,341
Aug				28	1	86	300	28	1,170
Sep					17	115	284	203	1,031
Oct				26	8	64	295	192	1,321
Nov	49	45	402	6	3	27	227	159	1,158
Dec	92	58	498	51	22	242	405	195	1,742
Jan	78	33	359	67	22	248	369	112	1,450
Feb	77	42	406	38	8	98	297	103	1,149
Mar							48	9	138
Totals	296	178	1,665	515	166	1,795	3,669	1,606	16,106

Table 8. Number of relocations per month by quality of fix for satellite transmitter (PTT)-7909 which was deployed on the Jade Mountain female wolf from 25 April 1988 through February 1989 when the PTT ceased transmission. Data from ≥ 1 Jun based on special animal processing (See Fancy et al. 1988 and Argos bulletin)[a].

Quality index QQ[b]	Month											Total[c]	%
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb		
-4			0	0	0	1	0	0	2	0	4	7	1.2
-3			0	0	0	0	0	1	0	1	1	3	.5
-2			2	2	0	2	10	11	11	3	1	42	7.2
-1			3	2	0	3	3	6	7	1	4	29	5.0
0		3[d]	0	0	5[d]	0	0	0	0	16	23	39	6.7
1		3[d]	3	6	5[d]	2	3	7	4	0	0	25	4.3
2		3[d]	3	9	5[d]	7	7	2	4	0	0	32	5.5
3		3[d]	6	4	5[d]	3	2	2	1	0	0	18	3.1
4		3[d]	8	4	5[d]	9	5	0	5	0	0	31	5.3
5		3[d]	3	3	5[d]	2	4	3	3	0	0	18	3.1
6		3[d]	4	1	5[d]	7	3	1	1(13)	0	0	37	6.4
7	3	11	13	16	1	20	42	41(24)	21(23)	0(23)	0(15)	208	35.9
8	8	11	8	8	2	17	6	8(7)	7(12)	0(6)	0(2)	88	15.2
9	0	1	0	1	0	0	1	0	0	0	0	3	.5
Totals[c]	11	26	53	56	8	73	86	82	85	50	50	580	99.9

[a] Numbers in ( ) are from AI files which suggest discrepancies in processing.

[b] See definition QQ index in text.

[c] Includes data within ( ) if larger than comparative figure.

[d] Included in QQ = 6 totals.

Table 9. Number of relocations per month by quality of fix for PTT 7910 which was deployed on the Ingruksukruk yearling male wolf from 23 April 1989 through August 1989 when the PTT prematurely ceased transmission. Data for $\geq$ 1 Jun based on special animal processing (See Fancy et al 1988 and Argos bulletins).

Quality index QQ[a]	Month					Total	%
	Apr	May	Jun	Jul	Aug		
-4			0	0	0	0	0
-3			0	0	0	0	0
-2			6	2	0	8	5.1
-1			4	3	0	7	4.5
0	2[b]	7[b]	0	0	3[b]	0	0
1	2[b]	7[b]	0	3	3[b]	3	1.9
2	2[b]	7[b]	11	11	3[b]	22	14.0
3	2[b]	7[b]	2	1	3[b]	3	1.9
4	2[b]	7[b]	1	7	3[b]	8	5.1
5	2[b]	7[b]	0	0	3[b]	0	0
6	2	7	2	3	3[b]	17	10.8
7	4	11	24	23	1	63	40.1
8	0	8	6	10	0	24	15.3
9	0	0	1	1	0	2	1.3
Totals	6	26	57	64	4	157	100.0

[a] See definition QQ index in text.

[b] Included in QQ = 6 totals.

Table 10. Number of relocations per month by quality of fix for PTT 7911 which was deployed on the Purcell Mountain yearling female from 1 Jun 1988 through March 1989 when the PTT ceased transmission. All data were based on special animal processing (see Fancy et al. 1988 and Argos bulletins)[a].

Quality index QQ[b]	Month										Total[c]	%
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar		
-4	0	0	0	0	1	1	0	1	2	0	5	.9
-3	0	0	0	0	1	1	0	0	1	2	5	.9
-2	11	3	0	6	11	12	9	0	1	0	53	9.9
-1	2	3	0	1	2	4	4	4	4	3	27	5.0
0	0	0	4[d]	0	0	0	0	12	22	7	41	7.6
1	1	4	4[d]	6	0	2	4	0	0	0	17	3.2
2	7	7	4[d]	5	3	9	7	0	0	0	38	7.1
3	1	3	4[d]	1	0	0	2	0	0	0	7	1.3
4	4	6	4[d]	3	5	2	2	0	0	0	22	4.1
5	1	1	4[d]	4	7	7	3	0	0	0	23	4.3
6	6	1	4[d]	5	2	0	5(11)	0(0)	0	0(0)	29	5.4
7	29	23	2	33	37	35(22)	16(21)	0(20)	0(19)	0(7)	226	42.2
8	8	6	0	7	8	0	5(8)	0(2)	0(2)	0(0)	41	7.6
9	1	0	0	0	0	0	1(0)	0	0(0)	0(0)	2	.4
Totals	71	57	6	71	77	73	72	39	51	19	536	99.9

[a] Numbers in ( ) are from AI files which suggest discrepancies in processing.

[b] See definition QQ index in text.

[c] Includes data within ( ) if larger than comparative figure.

[d] Included in QQ = 6 totals.

Table 11. Number of relocations per month by quality of fix for PTT 7912 which was deployed on the Nuna Creek adult female wolf from 26 April 1988 through March 1989 when the PTT ceased transmission. Data ≥ 1 Jun were based on special animal processing (See Fancy et al. 1988 and Argos bulletins)[a]

Quality index QQ[b]	Month												Total[c]	%
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar		
-4			0	1	0	0	0	2	1	1	5	3	13	3.0
-3			0	0	0	0	0	3	0	0	2	1	6	1.4
-2			6	1	0	8	10	13	7	0	2	0	47	10.7
-1			1	4	0	4	3	1	4	0	3	1	21	4.8
0	3[d]	2[d]	0	0	5[d]	0	0	0	0	4	13	3	20	4.5
1	3[d]	2[d]	2	13	5[d]	7	8	5	9	0	0	0	44	10.0
2	3[d]	2[d]	6	5	5[d]	11	6	10	4	0	0	0	42	9.5
3	3[d]	2[d]	2	5	5[d]	5	4	3	0	0	0	0	19	4.3
4	3[d]	2[d]	5	2	5[d]	4	2	1	1	0	0	0	15	3.4
5	3[d]	2[d]	2	0	5[d]	1	4	4	0	0	0	0	11	2.5
6	3[d]	2[d]	6	6	5[d]	5	3	2	1(12)	0	0	0	44	10.0
7	5	10	16	15	3	17	18	14(8)	13(15)	0(6)	0(13)	0	132	30.0
8	8	2	2	1	0	1	4	1	0	0	0(1)	0(2)	22	5.0
9	1	0	1	0	0	0	1	0	0	0	0(1)	0	4	9
Totals[c]	17	14	49	53	8	63	63	59	53	11	40	10	440	100.0

[a] Numbers in ( ) are from AI files which suggest discrepancies in processing

[b] See definition QQ index in text

[c] Includes data within ( ) if larger than comparative figure

[d] Included in QQ = 6 totals.

Table 12. Number of relocations per month by quality of fix for PTT 7913 which was deployed on the Pick River adult male wolf from 14 November 1988 through 18 February 1989 when the wolf was shot. All data from special animal processing (See Fancy et al. 1988 and Argos bulletins)[a].

Quality index QQ[b]	Month				Total[c]	%
	Nov	Dec	Jan	Feb		
-4	0	0	2	2	4	1.4
-3	1	0	0	2	3	1.0
-2	15	13	2	2	32	11.0
-1	7	6	0	0	13	4.5
0	0	0	16	21	37	12.7
1	1	2	0	0	3	1.0
2	5	4	0	0	9	3.1
3	1	1	0	0	2	.7
4	4	0	0	0	4	1.4
5	0	4	0	0	4	1.4
6	1	1(3)	0	0	4	1.4
7	36	39(40)	0(29)	0(23)	128	43.8
8	10	9(14)	0(4)	0(16)	44	15.1
9	1	1(1)	0	0(3)	5	1.7
Totals[c]	82	88	53	69	292	100.2

[a] Numbers in ( ) are from .AI files which suggest discrepancies in processing.

[b] See definition QQ index in text.

[c] Includes data within ( ) if larger than comparative figure.

[d] Included in QQ = 6 totals.

Table 13. Number of relocations per month by quality of fix for PTT 7914 which was deployed on the Rabbit Mountain adult female wolf from 24 April 1988 through early February 1989 when the wolf was shot. All data from ≥ June are based on special animal processing (See Fancy et al. and Argos bulletins)[a].

Quality index QQ[b]	Month											Total[c]	%
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb		
-4			0	1		0	0	1	0	2	3	7	2.6
-3			0	0		0	0	0	0	0	0	0	0
-2			5	5		5	3	4	9	0	0	31	11.5
-1			2	4		0	1	4	5	1	0	17	6.3
0	2[d]	2[d]	0	0	0[d]	0	0	0	0	6	9	15	5.6
1	2[d]	2[d]	8	9	0[d]	1	4	4	5	0	0	31	11.5
2	2[d]	2[d]	3	8	0[d]	3	0	1	2	0	0	17	6.3
3	2[d]	2[d]	0	0	0[d]	0	0	0	0	0	0	0	0
4	2[d]	2[d]	0	0	0[d]	0	0	1	0	0	0	1	.4
5	2[d]	2[d]	2	2	0[d]	0	1	1	0	0	0	6	2.2
6	2[d]	2[d]	1	1	0[d]	0	0	0	0(2)	0	0	8	3.0
7	5	7	15	19	0	12	3	10(2)	15(18)	0(20)	0(8)	117	43.3
8	1	5	4	4	0	1	0	0	1(02)	0(1)	0	18	6.7
9	1	0	0	0	0	0	0	0	0	0(1)	0	2	.7
Totals[c]	9	14	40	53	0	22	12	26	43	31	20	270	100.1

[a] Numbers in ( ) are from AI files which suggest discrepancies in processing.

[b] See definition QQ index in text.

[c] Includes data within ( ) if larger than comparative figure.

[d] Included in QQ = 6 totals.

Table 14. Frequency of high quality relocations (QQs ≥7) obtained monthly from wolf PTT's deployed in northwest Alaska from mid-April 1988 through early February 1989.

PTT no.	QQ index	Month												
		Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
7909	7	3	11	13	16	1	20	42	41	23	23	15		208
	8	8	11	8	8	2	17	6	8	12	6	2		88
	9	0	1	0	1	0	0	1	0	0	0	0		3
Subtotal		11	23	21	25	3	37	49	49	35	29	17		299
7910	7	4	11	24	23	1								63
	8	0	8	6	10	0								24
	9	0	0	1	1	0								2
Subtotal		4	19	31	34	1								89
7911	7			29	23	2	33	37	35	21	20	19	7	226
	8			8	6	0	7	8	0	8	2	2	0	41
	9			1	0	0	0	0	0	1	0	0	0	2
Subtotal				38	29	2	40	45	35	30	22	21	7	269
7912	7	5	10	16	15	3	17	18	14	15	6	13	0	132
	8	8	2	2	1	0	1	4	1	0	0	1	2	22
	9	1	0	1	0	0	0	1	0	0	0	1	0	4
Subtotal		14	12	19	16	3	18	23	15	15	6	15	2	158

Table 14. (continued).

PTT no.	QQ index	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
		Month												
7913	7								36	40	29	23		128
	8								10	14	4	16		44
	9								1	1	0	3		5
Subtotal									47	55	33	42		177
7914	7	5	7	15	19	0	12	3	10	18	20	8		117
	8	1	5	4	4	0	1	0	0	2	1	0		18
	9	1	0	0	0	0	0	0	0	0	1	0		2
Subtotal		7	12	19	23	0	13	3	10	20	22	8		137
	7	17	39	97	96	7	82	100	136	117	98	78	7	874
	8	17	26	28	29	2	26	18	19	36	13	21	2	237
	9	2	1	3	2	0	0	2	1	2	1	4	0	18
Totals		36	66	128	127	9	108	120	156	155	112	103	9	1,129

Appendix A. Plan of study for current wolf investigations.

WILDLIFE RESEARCH STUDY PLAN

Alaska Department of Fish and Game

Division of Wildlife Conservation

STUDY TITLE: Development of wolf census methods and wolf demography in northwest Alaska, including movement patterns in relation to the Western Arctic Caribou Herd.

THE PROBLEM:

1. Statement

Doerr (1979) and Davis and Valkenburg (1985) all believed that human harvest and wolf (*Canis lupus*) predation were the most important factors contributing to the decline of the Western Arctic Caribou (*Rangifer tarandus*) herd in the 1970's. Since that time, reductions in human harvest and apparently wolf predation have allowed the caribou population to return to predecline levels. Wolf populations, however, have not recovered to historic levels. To anticipate and hopefully avoid future declines in both caribou and wolf populations, it is imperative that wolf population trends be monitored. Reasons for the apparent lack of wolf population response are not known and could involve solely or in combination excessive mortality, low productivity, or inadequate methods for detecting changes in wolf population numbers. The status of the wolf population is unknown, and census methods may not be adequate for effective management of wolves.

2. Justification

The relationships between large predator and ungulate populations have recently been redefined as a loose, slow feedback mechanism between predator and prey (Gasaway et al. 1983, Ballard and Larsen 1986). This relationship has been defined for declining ungulate populations where predator populations remain stable or decline proportionately less than that of the prey species. To properly manage a predator-prey system, it is important that timely and reliable indices of population size be available. Although accurate and precise methods exist for censusing large ungulate populations such as moose (Gasaway et al. 1981) and caribou (Pegau and Hemming 1972, Davis et al. 1979), no suitable methods exist for wolves. Other than studies by Stephenson (1978) and Miller and Russell (1977), no studies have been conducted on wolf census methods. One of the more important assumptions for conducting traditional wolf censuses as described by Stephenson (1978) is that wolf packs are territorial. This assumption may not be valid on caribou winter range where wolves follow their prey. Also the method is only as reliable as the skill of the person doing the survey, because no measure of precision is available. Because wolf predation is one of several factors altering the dynamics of the Western Arctic Caribou Herd, it is essential that reliable repeatable wolf census methods be developed for not only responsible management of the predator-prey system but also for responsible wolf management.

Two possible scenarios exist for the current status of wolf populations in Unit 23: (1) wolf populations are currently healthy and we have been unable to document population status because suitable survey conditions have not existed in recent times; (2) the wolf population is very low because of unknown factors, and when and to what degree it will recover are unknown. Both scenarios have management implications to caribou and wolf management programs.

This study will first focus on determining the status of the wolf population. If wolf numbers are low, then the study will emphasize determination of causes and recommendations for allowing the population to increase. If wolf populations are healthy or once the wolf population recovers (current pilot study suggests wolf population is high enough to warrant further study), then the study will proceed with determination of spatial relationships and movement patterns. Satellite radiotelemetry will be used to supplement standard telemetry methods. Once spatial relationships of wolf social units are understood, traditional and new survey methods containing a measure of precision will be developed and tested. The study will then focus on quantification of winter and summer predation rates and the sex, age, and physical condition of prey during summer and winter.

3. Background

Stephenson and James (1982) and James (1983a) studied the movements and food habits of two wolf packs within the western Brook's Range during 1977 and 1978. Caribou were the most important prey. Wolves appeared to be territorial during summer but not during winter, although the small numbers of packs and numbers of radio-relocations precluded firm conclusions. James (1983a) concluded that a great deal remained to be learned about seasonal distribution and abundance of wolves in northwest Alaska.

According to sealing documents, annual wolf harvests in Unit 23 have ranged from 4 to 177. If wolf harvests reflect abundance, wolves were numerous in the mid to late 1960's and in the mid-1970's. The peaks coincided with a decline in the Western Arctic caribou Herd. Within recent years annual harvests have been relatively low (range of 17-55 from 1979-1985). Public sightings and trapper reports suggest wolf numbers are low in spite of caribou being numerous (Larsen 1986). Other than harvest, incidental observations by the public, and wolf track counts after fresh snow, no methods currently exist for monitoring wolf population status.

Several estimates of wolf numbers in Unit 23 exist, but their accuracy is unknown. Stephenson (ADF&G files) estimated wolf density at 1/64 mi^2 (720 wolves unitwide) in 1977, while in 1981 Quimby (1982) estimated the density at 1/64 mi^2 and 1/150-200 mi^2 for 85% and 15% of the unit, respectively (476 wolves). James (1983_b_) thought the wolf population was increasing in 1981-82 and predicted a significant increase in future years as the caribou population continued to increase.

James (1981) recognized the potential problems with using the traditional wolf census method described by Stephenson (1975, 1978) for censusing migratory or nomadic wolves on caribou winter range. Although he attempted to evaluate the usefulness of the method in northwest Alaska, unfavorable weather conditions in addition to apparent low numbers of wolves forced cancellation of the project (James 1984). Several other factors could also influence the usefulness of the wolf track count method.

Stephenson (1978) evaluated the wolf track count method in Interior and Southcentral Alaska and concluded that reasonably accurate estimates of wolf numbers could be obtained under similar habitat and wolf densities. However, such estimates can be grossly inaccurate depending on the current experience and familiarity of the pilot and observer. Stephenson (op. cit.) found nearly a three-fold difference in numbers of wolves observed in Unit 20, according to pilot-observer experience. A similar discrepancy was found in Unit 13 (W. Ballard, ADF&G files). Many area game biologists might be considered relatively experienced but not current, if surveys were conducted once per year or once every several years when weather conditions are suitable.

Differences in wolf density and territory size could also significantly affect the results of wolf censuses. Stephenson (1978) believed that at higher wolf densities and/or smaller territory sizes than those found in either Units 13 and 20, the wolf track count method could be less useful. Since Stephenson's evaluation, several types of census methods for other furbearer species have been developed, and most have contained some measure of precision. What is needed is a method for wolves and wolverines that reduces potential differences among observers, expands the period of time when useful surveys can be conducted, is relatively inexpensive, and contains a measure of precision.

Stephenson (1978) made several recommendations for improving wolf censuses, but these remain untested. Perhaps the most applicable ones to northwest Alaska would include experimentation with conducting surveys at different seasons. Most surveys are conducted in March when breeding is in progress or just concluded. Wolf packs are the least cohesive during this period, and the possibility of not detecting a significant number of single wolves exists. Packs are most cohesive in autumn, and comparisons of surveys during this period should be made.

In order to properly manage wolves, particularly in relation to caribou populations, several wolf population characteristics need to be identified and described. The study will seek to determine the status of the Unit 23 wolf population. Home range or territory sizes, spatial relationships among adjacent social units, and daily movement patterns will be determined on representative caribou winter range. A pool of radio-collared individuals, including use of satellite collars, will be maintained in at least 5-8 packs to allow testing and comparison of wolf census methods.

Several census methods will be examined for their suitability for precisely estimating wolf population numbers under a variety of ecological circumstances. Simulation modeling will be used to investigate feasibility of different census methods for both territorial and nomadic wolves. Data from Unit 13 (Ballard et al. 1981, 1987), where territorial wolves were intensively monitored, will serve as the data base for preliminary assessment of appropriate census methods for territorial packs. Data collected during this study will serve as the data base for nomadic wolves. Field testing of census methods for territorial wolves is not part of this proposal and will have to be accomplished under a different research proposal or as a management program. A minimum of 3 methods, or some combination thereof, will be investigated for their suitability and efficiency for precisely estimating wolf and other furbearer species in northwest Alaska. The methods or some combination to be tested might include the following: (1) Stephenson's track count method, (2) modified line transects, or (3) stratified random quadrant sampling.

While census methods are being developed, other types of data concerning arctic wolf population ecology and characteristics will be gathered. This information in combination with harvest statistics will be used to model wolf population fluctuations. Wolf population models will be combined with caribou population statistics derived from other studies and used to model and update the caribou population modeling originally developed by Doerr (1979) and Davis and Valkenburg (1985).

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5. Study Goals

The proposed study will provide a basis for systematic and precise monitoring of wolf and other furbearer populations in relation to Western Arctic Herd Caribou. The study is designed to accomplish the following primary objectives: (1) To determine the number of wolves occurring within the range of the Western Arctic Caribou Herd, (2) To determine the spatial relationships among and within wolf packs on caribou winter range, (3) To develop and test precise and effective census methods for wolves and other furbearers, and (4) To estimate the impacts of wolf predation on Western Arctic Caribou. The following hypotheses will be tested:

1. Wolf populations in northwest Alaska are depressed due to excessive mortality from hunting and trapping.

2 Wolf packs maintain discrete territories on a year-round basis.

3. Membership in packs is stable particularly during periods when wolf surveys are conducted.

4. Late winter is the best season for conducting surveys of wolves.

5. Low search effort per unit area has no relationship to numbers of wolves or tracks observed.

6. The traditional method of censusing wolves is the most efficient and precise method available.

7. All wolves in the population are equally observable during surveys.

8. Wolf predation currently has no significant impact on the dynamics of the Western Arctic Caribou Herd.

9. Productivity within the wolf population is high.

10. Wolves selectively kill young and/or weak and old caribou which would die anyway.

11. Wolf pack size has no relationship to the sex, age, physical condition, or numbers of caribou killed.

6. Expected Results and Benefits

The status and dynamics of the wolf population will be known allowing for prediction of potential impacts on caribou. Development and testing of repeatable precise census methods will provide managers with the ability to confidently assess wolf population numbers. This in turn will allow better assessment of predator-prey interactions when predator population estimates are elevated to the same level of precision as those of ungulate prey. A wolf census manual and practical training sessions will serve as learning tools for biologists interested in accurately and precisely estimating wolf numbers. Feasibility of using wolf census methods on wolverines and lynx will also be investigated.

7. Study approach

The following jobs will be undertaken to accomplish the goals of this study.

Job 1.

To determine the status of wolf populations in northwest Alaska, particularly when wolves are located on caribou winter range. Preliminary wolf track counts will be conducted when weather conditions permit. Concurrently or previously, an effort will be made to capture and radio-collar 3-5 members in each of up to 8 adjacent packs or social units while on caribou winter range. One member of each pack will be fitted with a satellite radio-collar. Helicopter darting and other methods described by Ballard et al. (1982) or other potentially cheaper capture methods will be used. Results of surveys and the fates of the marked sample of wolves will be used to evaluate the status of the wolf population. Radio marked wolves will be monitored weekly during the first 2 years of study to monitor status and accomplish other job objectives. However, if satellite collars prove highly reliable the frequency of monitoring from fixed-wing aircraft may be reduced

Job 2.

To determine spatial relationships and cohesiveness of wolf packs on caribou winter range. Radio-collared members of up to 8 packs will be monitored daily from fixed-wing aircraft during March of at least the first 2 years of study and perhaps while census methods are being developed and tested.

Job 3.

To develop and test reliable sampling procedures for estimating wolf densities, particularly when wolves are concentrated on caribou winter range. Several methods will be examined for their appropriateness for censusing wolves and other furbearers. Development of census procedures will parallel the basic design approach used by Gasaway et al. (1981) for development of moose population estimates. Changes in approach may be taken if data suggest other approaches may be appropriate. A wolf census manual will be produced and training sessions conducted.

Job 4.

To determine seasonal movements, territory sizes, productivity, mortality factors, survival rates, and den site characteristics of wolves in northwest Alaska. Procedures will closely follow those described by Fritts and Mech (1981), Peterson et al. (1984), and Ballard et al. (1987).

Job 5.

To determine seasonal food habits, rates of predation, and types of prey killed by wolves in northwest Alaska. These types of information will be collected concurrently while other job objectives are accomplished. Data concerning characteristics of kills will be collected on an opportunistic basis using methods described by Stephenson and Johnson (1972,1973), Peterson et al. (1984), and Ballard et al. (1979,1987).

Job 6.

To develop wolf and caribou population models which can be used for prediction of population trends and testing of management strategies. A wolf population model incorporating the population parameters measured in this and other studies will be developed for use on ADF&G microcomputers. Following development of the wolf population model which will include food habits and rates of predation information, the wolf model will be merged with a caribou population model which will consist of modifications of the model used by Doerr (1979) and Davis and Valkenburg (1985). The caribou model will allow assessment and prediction of population trends and testing of management strategies.

Job 7.

To produce a wolf census manual and conduct staff training sessions.

Job 8.

To attend and participate in conferences and workshops.

Job 9.

To analyze and summarize data and write annual, final, and appropriate technical reports.

8. <u>Personnel-Co-investigators</u>

Warren B. Ballard, Research Game Biologist, ADF&G, Nome

Steve Fancy, U.S. Fish & Wildlife Service, Fairbanks
Douglas Larsen, GMU 23 Area Game Biologist, ADF&G, Kotzebue

Dan Reed, Region III Biometrician, ADF&G, Fairbanks

Kate Roney, Resource Specialist, Northwest Area, National Park Service, Kotzebue

Mike Spindler, Asst. Refuge Manager, Selawik National Wildlife Refuge, Kotzebue

9. <u>Cooperators</u>

John Coady, Robert Nelson, Steve Machida, and Tim Smith, all ADF&G Nome, will cooperate in the study by assisting in project design and capture of wolves and with routine monitoring.

Layne Adams, National Park Service-Anchorage, will assist with project planning and participate in capture and monitoring programs and serve as principal contact for NPS.

Scott Robinson and Robert Gal, Bureau of Land Management, Fairbanks and Kotzebue, respectively, will serve as principal agency contacts and occasionally assist with collaring and monitoring and provide lodging when available.

10. <u>Cooperator Requirements</u>

This study is designed to be a cooperative multi-agency effort involving the Alaska Department of Fish and Game, National Park Service, and Fish and Wildlife Service.

Major responsibilities of Fish and Wildlife Service Principal Investigator are as follows:

1. Take lead responsibility for development and testing of snow machine furbearer surveys for determination of population trends.

2. Assist with annual routine monitoring and late spring daily monitoring flights of radio-collared wolf packs, i.e. conduct one-third of flights.

3. Provide one fixed-wing aircraft and one pilot-survey team for 3 week period each spring to assist with capture and monitoring of wolves and to conduct intensive furbearer surveys.

4. Serve as primary agency contact and provide logistical support as needed.

5. Assist with project planning and operation of other aspects as needed.

6. Assist with data analyses, preparation of annual progress reports, and final scientific publications.

Major responsibilities of National Park Service Principal Investigator are as follows:

1. Assist with annual routine monitoring and late spring daily monitoring flights of radio-collared wolves, i.e. conduct one third of flights.

2. Provide one fixed-aircraft and one pilot-survey team for 3 week period each spring to assist with capture and monitoring of wolves and to conduct intensive furbearer surveys.

3. Assist with project planning and implementation as needed.

4. Serve as primary agency contact and provide logistical support as needed.

5. Assist with data analyses, preparation of annual progress reports, and final scientific publications.

Major responsibilities of the Alaska Department of Fish and Game Principal Investigator are as follows:

1. Take lead responsibility for design, implementation, and coordination of overall research effort. One full-time position will be allocated to the project.

2. Provide statistical backup for testing and development of aerial and ground census methods.

3. Conduct at least one-third of routine and intensive monitoring flights for radio-collared wolves.

4. Provide one aircraft and one pilot-survey team for 3 week period each spring to assist with capture and monitoring of wolves and to conduct intensive furbearer surveys.

5. Take lead responsibility for data analyses, preparation of final reports, and preparation of final scientific publications.

Appendix B. Initial plan of study for proposed ground survey.

SELAWIK NATIONAL WILDLIFE REFUGE
PROPOSED METHODS FOR A GROUND FURBEARER TREND COUNT

By
MIKE SPINDLER

We currently have very poor information on furbearer population trends on Selawik NWR. Such trends are normally monitored by examination of catch statistics and from trappers surveys and questionnaires. Catch statistics have been deemed unreliable in this region due to poor compliance with furbearer sealing and reporting requirements. A majority of locally trapped and hunted fur is used domestically. The Kotzebue ADFG biologists usually conduct an annual trappers survey or hold annual village meetings to discuss game and furbearer management. These questionnaires and meetings have proven to be useful in gauging prevailing local opinion regarding any trends, however they at times yield ambiguous or conflicting results. Another approach for trend monitoring would be to conduct standardized easily repeatable ground transects, similar in function to the now well established moose trend surveys. The objective will be to obtain furbearer trend information and not actual population data.

In March 1988 the refuge field station at Upinnigvik will be the center of activity for a wolf and wolverine collaring effort. During that month daily radio tracking of wolves and wolverines will be attempted, which should yield some fairly accurate density information to use as a benchmark. At the same time two persons from the refuge staff, probably one volunteer and one biological technician, will be detailed to spend about two weeks performing snowmobile ground transects. A pattern of several 12-18 mile long transects will be established similar to that shown in Fig. 1. It is anticipated that most if not all transects should originate from the Selawik to Ambler trail to facilitate easy access and consistent location of starting points. Additionally, an array of transects could radiate away from the Selawik River near Upinnigvik, a less travelled area, if disturbance effects of the trail are a concern. It is easy to travel along the river, but access up the river bank is limited to a few places.

Starting points will be marked at every intersection of the trail and a north-south township line. Once the starting point is established, personnel will choose a distant landmark that approximates a north-south line, and attempt to follow that course. Some deviations will undoubtedly be needed to avoid getting the snowmobile stuck. A photograph of the target landmark and a compass bearing will be taken to allow future repeat surveys of the same transect line. Transects will be run starting the second day after a new powder snowfall and proceed until 10 days after the snowfall. If high winds obliterate the powder snow, transect surveys will cease until adequate snow again falls. Any transects surveyed during the first snowfall will be surveyed in about the same sequence after the second snowfall. Track encounters will be recorded on the attached data form. Results will be standardized according to number of days since snowfall and presented as track intercepts/km/day.

It is anticipated that after the first day or two team members will discuss problems encountered in running the transects and agree on standardized sampling rules that will emphasize consistency between transect observers and ensure repeatability between seasons and between years. Initial suggestions are:

1. Survey crew will spend several days in training before actually performing transects. Training will involve snowshoe or ski surveys in powder snow areas with an expert tracker, if possible, and aerial overflights at low altitude to look at overall track and behavior pattern.

2. Transects will terminate at the first impassible terrain encountered (rather than deviate and continue).

3. Transect spacing will be about one per six miles, or about one per township.

4. The same observer will perform repeat transects on the same transect if possible.

5. Ground trackers will not be allowed prior access to radio-telemetry derived territory maps or aerial surveys on a transect they are scheduled to perform in the near future.

6. Sample size and intensity will be adjusted to allow the most easily repeatable survey year after year.

The above methods were developed after review of Howard Golden's (1987) Yukon Flats study, discussions with Selawik NWR staff; ADFG Area and Research biologists Doug Larsen, David James, and Warren Ballard; and the ADFG biometrician in Fairbanks, Dan Reed. Continued discussion and adjustment will be desirable until the transects are finally surveyed.

SELAWIK NWR FURBEARER SURVEY

GROUND TRANSECT DATA SHEET

Transect No.:__________ Survey No.:__________ Date:__________

Time start transects:______________ End time:______________

Transect Length:__________(km) Map No.:_________ Photo:_____

Observer(s):____

Date last snow:_____________ Days post-snowfall:____________

Depth last snow:_________(Cm) Average snow depth:_______(Cm)

Est. extent sastrungi (%):_________ Estimated % Powder______

Cloud cover:_____(%) Ceiling:________(ft) Visibility:____(Mi)

Wind dir.:________ Wind speed:________(Mph)

Species	No. track intercepts	Intercepts/km/day
Red Fox		
Marten		
Lynx		
Hare		
Wolf		
Otter		
Mink		

Comments:

Appendix C. Index and data form for recording observations during wolf studies in Northwest Alaska.

INDEX FOR NORTHWEST ALASKA WOLF OBSERVATION FORM

Overview: Each data sheet is for one relocation of either an entire pack, group, or if appropriate, single radio-collared or uncollared animals. One pack relocated on the same day may require several data sheets if the animals are split up and in different groupings. The following are brief descriptions of each data entry. You are encouraged to take whatever additional notes you think may be pertinent or important. The intent of this form is to standardize data collection and minimize data transfers. Each form will serve as a permanent record of a particular relocation. Self explanatory numbers were left blank.

1. Observation number: This space can be used in the aircraft or in the field to index your descriptive data to your map location. Upon returning to the office a new number will be entered which will correspond with a map number.

2. Date:

3. Time:

4. Pilot/observer: Last names of each.

5. Weather: Percent cloud cover and type of weather, e.g., snow, rain, scattered showers, avu.

6. Temperature: Usually the temperature at your take-off point or an estimate in the field.

7. Wind speed/direction:

8. Pack Name: This name should be taken from your frequency sheet.

9 through 16. Individual radio-collared wolf ID number and radio frequency: These should be taken off your radio frequency sheet. (Note - you may have to fill out several forms if the pack is split up.)

17. Observed pack size: This is the total number of wolves observed. Indicate whether you felt others were present but not observed. If just a radiolocation, say not observed. For example, for a visual: 9 wolves.

18-20. Color and Number combinations: For example 3 grays, 5 blacks and 1 white.

21-23. No. of pups by color: There will be many times when you will be unable to collect this type of data. Usually it can be collected in late summer or autumn. Don't force it. If you can not tell leave this blank.

24-26. No. of adults by color: same as above. Leave blank if you don't know.

27. Elevation: This is the elevation of where you located the animals. It is taken from the plotted relocation on the map and can be done in the office.

28. Slope: Calculated from the map when using 1 inch per mile scale maps or classified in the field using map and visual observation when using 1;250,000 scale maps. 4 categories=Flat 0 to 10 degrees (on inch to mile maps space between contour lines exceeds 4.75mm, Gentle 11 to 30 degrees (contour lines on map spaces .75 to 4.75mm), and moderate or steep 31 to 90 degrees (contour lines less than .75 mm apart).

29. Aspect: Usually done in the office with the map. Use 8 points of the compass or flat, gully, or ridgetop.

30. Habitat type: The overstory (that which you can see) vegetation within 1 full tight turn of the aircraft surrounding the animals in question. In some cases you may wish to note the micro habitat if the animals has obviously selected a place that is different from the general type. Types that I have used are as follows:

Spruce - I have attempted to classify spruce by density and height of tree and particularly paid attention if it was a riparian type situation. Spruce types are: 1. Sparse-tall, 2. Mod-tall, 3. Dense-tall (usually riparian) 4. Sparse-medium, 5. Mod-medium, 6. Dense-medium, 7. Sparse-low, 8. Medium-low, 9. Dense-low. Definitions of density are subjective while for heights use: low 0-10 ft., medium 10-20 ft., and tall >20 ft.

Shrublands - 10-. Riparian willow, 11. Upland willow or shrub, 12. Willow/birch combination (low growth form), 13. Alder.

Tundra: 14. Tussock tundra, 15. Sedge-grass tundra, 16. Alpine herbaceous, 17. Mat and cushion.

Other forest: 18. Riparian hardwood (cottonwood), 19. Mixed birch and spruce, 20. Birch.

Other: 21. Marsh, 22. Rock/ice/snow, 23. Gravel bar.

Others ???
31. Activity: Usually one of following: bedded, standing, running, traveling, feeding, sitting, others.

32. Direction of travel:

33. Reaction to aircraft: subjective. None, moderate, nervous, terror.

34. Snow depth:

35. Extend of snow: see categories.

36. Hardness: see categories.

37. Kill made: Yes or no.

38. Species killed: Check one of the blanks and add others if needed. Items to help you determine species include shape and configuration of antlers, hair coloration, texture, and length, length of bones, hooves, etc.

39. Sex of prey: Look for antler shape and configuration, presence or absence of vulval patch, presence or absence of antlers depending on season, etc.

40. Age of prey: Size, coloration, shape and size of antlers and long bones.

41. Percent of carcass consumed: Subjective estimation of percent of eatable flesh that has been consumed. If there are other scavengers present note the species and number.

42. Days since kill: Give actual time if known or estimate based on presence of blood, amount of carcass remaining.

43. Aerial description of remains: Make a description of the kill site so that others might find it if they needed to for collection of specimens. Note the position of the carcass (on sternum or on side, legs out stretched or tucked in, etc.) and attempt to recreate how the kill was made. Was there escape cover present, did they prey run along a water body. Be sure to note the presence and activity of other predator and scavenging species.

REMAINDER OF FORM ON BACKSIDE IS FOR GROUND EXAMINATION OF PREY

44. Kill examined: Yes or no
45. Disarticulated:
46. Skeletal abnormalities: Yes or no. Be sure to examine as much of the skeletal structure as possible and record anything that looks unusual. If possible collect it.
47. Attempt to collect mandibles and or paired leg bones. Ideally collect as many leg bones as possible. Collect as many other specimens as you can. Be sure all are correctly labelled with an appropriate number.
48. Measurements taken:
49. Hind foot:
50. Metatarsus:
51. Depth of wolf tracks:

52. Depth of prey tracks:
53. Snow depth:
54. Extent:
55. Snow hardness:
56. Comments: Describe the kill site. Be verbose and over describe the site and its characteristics.

NORTHWEST ALASKA WOLF OBSERVATION FORM

---

1. Observation Number___________________ 2. Date____________
3. Time__________ 4. Pilot/Observer_________________________
5. Weather_______________________ 6. Temperature____________
7. Wind Speed/Direction________________________________
8. Pack Name___________ 9. Individual Radio-collared wolf ID's & frequency:

10. ____________ 11. ______________

12. __________________ 13. ____________ 14. ______________

15. __________________ 16. ____________

17. Observed Pack Size____
(Visually observed or radio location)

18. Color and number combination____________ 19. ______________

20. _________________

21. No. of pups by color _________ 22. ___________ 23. ________

24. No. Adults by color __________ 25. ___________ 26. ________

27. Elevation _________________ 28. Slope __________________

29. Aspect ____________________ 30. Habitat type ____________

31. Activity ____

32. Direction of travel ____

33. Reaction to aircraft _______________________________________

34. Snow depth ________ 35. Extent: Bare _____ Patchy _____ Entire _________

36. Hardness: Hard ______ Soft ______

37. Kill Made: Yes_____ No_____

38. Species Killed: Caribou ______ Moose ______ Sheep ______

Hare _____ Rodent _____ Other _____

39. Sex of Prey: Male _____ Female _____ Unknown _____

40. Age of prey: Calf ___ Yearling ___ Adult ___ Unknown ___

41. Percent of carcasee consumed ______________________________

42. Days since kill ____________ (estimate or known)

43. Aerial Description of remains (including presence, number and activity of other predators)

____

____

44. Kill Examined: Yes _____ No _____ 45. Disarticulated:

Yes _____ No _____ Partial _____

46. Skeletal Abnormalities: Yes _____ No _____ Check:

Vertebrae ____ Hooves ____ Legs ____ Joints ____ Neck ____

47. Specimens Collected: Mandible __________ Femur _________

Metatarsus ___ Hair ___ Frozen Urine ___ Frozen Blood ___

Other ___

48. Measurements taken: Yes ___ No ___ 49. Hind Foot ______

50. Metatarsus _________ 51. Depth Wolf Tracks _______________

52. Depth Prey Track _____________ 53. Snow Depth __________

54. Extent: Bare ______ Patchy _____ Entire ______

55. Hardness: Hard ________ Soft _______

56. Comments ____

____

____

Appendix D. Format of DBASE program for entry of wolf relocations, food habits and observation data.

INSTRUCTIONS FOR DATA ENTRY IN WOLF.DBF

OBS. NO.	Sequential observations in chronological order. Unique numbering series for each pack.
DATE	Calendar date of observation.
TIME	24 hr military time.
PILOT-OBS	Initials of pilot/observer
WEATHER	Altitude of ceiling above ground level/100 (ex. 3,000 ft. = 30,10,000 ft. 100) Sky conditions (see attached sheet), weather, precip., obscurations to visibility (see attached sheet).
TEMP	Degrees in Fahrenheit. If no temperature was recorded enter 9999.
WIND	Direction (N, NE, E, SE, S, SW, W, NW), Speed in MPH.
PACK	Code, letter.
OBS	Was the animals sighted? Y. N. T. F.
FREQ	Last 4 digits of radio-collar frequencies present at observed location (ex. 8.140). Use comas between frequencies.
PACK SIZE	Number of wolves observed together.
NO-GRAY	Number of gray wolves observed.
NO-BLACK	Number of black wolves observed.
NO-WHITE	Number of white wolves observed.
ELEV	Elevation of site where wolf observed. From map.
SLOPE	Slope at site wolf observed (see attached sheet).
ASPECT	Compass direction of slope. Same as wind direction: Flat = F; Gully = G; Ridgetop = R.

HABITAT	Vegetation type code. (See attached sheet).
ACTIVITY	Code: Walk = W; Run = R; Lie = L; Stand = S; Feed = F.
TRAVELDIR	Compass heading (Same as wind direction).
REACTION	Code: Low = L; Moderate = M; Strong = S.
SNOWDEPTH	Inches of snow at location site.
EXTENT	Code: Bare = B; Patchy = P; Complete = C.
HARD	Is the snow hard or soft? Y. N. T. F. (ex. if hard T or Y; if soft F or N).
KILL	Was a kill made? Y. N. T. F.
PREY SPEC	Animal killed. Code: Moose = M; Caribou = C; Sheep = S; Other = O.
PREY SEX	Sex of prey animal. M. F. U. (Unknown)
PREY AGE	Years
PCTCONS	Percent of prey animal consumed.
DAYS OLD	Days since kill made.
COMMENTS	Memo
LAT.	From map.
LONG	From map.

HABITAT TYPE CODES USED IN WOLF.DBF

SPRUCE

1	Tall	SPARCE
2	Tall	MODERATE
3	Tall	DENSE
4	MEDIUM	SPARCE
5	MEDIUM	MODERATE
6	MEDIUM	DENSE
7.	SHORT	SPARCE
8	SHORT	MODERATE
9	SHORT	DENSE

FOREST

13 MIXED DECIDUOUS
23 SPRUCE/BIRCH
24 BIRCH

B BURNED

SHRUBLANDS

10 RIPARIAN WILLOW
11 UPLAND WILLOW
12 WILLOW/COTTONWOOD
16 ALDER

OTHER

15 MARSH
17 UNVEGETATED ROCK OR SOIL
22 GRAVEL BAR

TUNDRA

18 ERIOPHYORUM TUSSOCKS
19 ALPINE TUNDRA
20 SHRUB TUNDRA
26 SEDGE MEADOW
21 MOIST TUNDRA

SLOPE AND ASPECT CODES USED IN WOLF.DBF

DEGREES	SLOPE CODE
0-10	F
11-30	G
31-60	M
61-90	S
RIVERBED	R

ASPECT	
FLAT	F
GULLY	G
RIDGETOP	R
NORTH	N
NORTHEAST	NE
NORTHWEST	NW
EAST	E
SOUTHEAST	SE
SOUTH	S
SOUTHWEST	SW
WEST	W

STANDARD WEATHER OBSERVATION DESIGNATORS

Table 2-1. Summary of sky cover designators.
CAVU - Ceilings and Visibilities Unlimited 9999 - No temperature recorded

Designator	Meaning		Spoken
CLR	Clear. (Less than 0.1 sky cover.)		CLEAR
SCT	Scattered Layer Aloft. (0.1 through 0.5 sky cover.)		SCATTERED
BKN[a]	Broken Layer Aloft. (0.6 through 0.9 sky cover.)		BROKEN
OVC[a]	Overcase Layer Aloft. (More than 0.9, or 1.0 sky cover.)		OVERCAST
-SCT	Thin Scattered.	At least 1/2 of the sky cover aloft is transparent at and below the level of the layer aloft.	THIN SCATTERED
-BRKN	Thin Broken.		THIN BROKEN
-OVC	Thin Overcast.		THIN OVERCAST
X[a]	Surface Based Obstruction. (All of sky is hidden by surface based phenomena.)		SKY OBSCURED
-X	Surface Based Partial Obscuration. (0.1 or more, but not all, of sky is hidden by surface based phenomena.		SKY PARTIALLY OBSCURED

Appendix E. Abstract of paper given at IUCN/SSC Wolf Specialist Group, Univ. of Alaska. August 12-14, 1988.

SATELLITE RADIO-TRACKING OF WOLVES

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During 1987 and 1988 a total of 8 satellite radio-collars, weighing 1,160-1,220 gms each, were deployed on yearling and adult wolves in Alaska. These are the first satellite collars to weigh less than 1,500 gms and employ C Cell batteries. All collars contained VHF transmitters which were encased with the satellite transmitters. Two transmitters failed immediately and were retrieved. One collar transmitted for 13 months and provided 415 relocations and 747 sets of sensory data from April 1987 through February 1988. With a transmission duty cycle of 6 hours on and 42 hours off an average of 3.0 relocations and 5.4 sets of sensory data were obtained per transmission. The remaining 5 collars which were deployed this past spring are functioning as planned. Preliminary analysis of movements data suggest that territory sizes estimated from satellite relocations were 75% larger than those estimated from relocations obtained by conventional methods. Each satellite transmitter costs about $3,500 with about $1,400 required for annual data access fees. Consistent and frequent radio contact provided by satellite collars appear to provide superior data sets for evaluating wolf movements and home range use than those provided by conventional methods.

Appendix F. Verbal presentation at IUCN Wolf group meeting at Fairbanks, AK Aug 12-14, 1988.

SATELLITE RADIO-TRACKING OF WOLVES

By
Warren B. Ballard

My objective in making this presentation today is to summarize and provide a status report on a new wolf demography and census techniques development study which has recently been initiated in Northwest Alaska. This study is a cooperative effort by the Alaska Department of Fish and Game, National Park Service, and the Fish and Wildlife Service. Besides myself the principal participants include Kate Roney and Lee Ann Ayres of the National Park Service and Steve Fancy and Mike Spindler of the Fish and Wildlife Service. Fancy was responsible for many of the visual aids I'll be showing in a minute.

The study is being conducted within the range of the Western Arctic Caribou Herd of northwest Alaska. This herd is one of the largest herds in North America and is the largest herd that fully resides within the state. This herd numbered between 200 and 300,000 animals in the 1950's and 1960's. In the mid 1970's the herd declined drastically to a minimum of 64,000 animals. Since that time the herd has recovered and now numbers in excess of 230,000. The decline in the 1970's was thought to have been caused by excessive human harvest and wolf predation. Reduced human harvests and a coincident reduction in wolf numbers resulted in the caribou population increase. Clearly for future management of caribou and wolves both populations need to be closely monitored. Which leads us to one of the main reasons for conducting the present study.

In Alaska biologists typically estimate the numbers of wolves in an area by conducting counts of tracks and or wolves in area within one or two days following fresh snow fall. This method of estimating numbers of wolves has appeared to work in many areas of Alaska. However, the method assumes that wolf packs are territorial and that these boundaries are relatively stable during the period that counts are being conducted. It also assumes that individual membership in packs is also stable. Research by Kellsal (1964), Parker (1972), and Stephenson and James (1982) indicate that wolves which prey predominantly on caribou in arctic regions are migratory. In the case of Western Arctic Herd Caribou and other caribou herds for that matter we wondered what percent of the wolf population was migratory. When wolves concentrate on caribou winter range we wondered what type of spacing occurred among packs and whether membership within a pack was stable. Do wolves maintain territorial boundaries on caribou winter range, or do resident wolves share winter range with migratory wolves and if so what sort of spacing occurs, or are wolves totally migratory with no spacing mechanisms, and are there portions of caribou winter range where wolves only occur seasonally? Also, in Northwest Alaska we rarely get the ideal weather conditions necessary to use the traditional wolf census method. All of the above factors could seriously jeopardize the validity of the track count method.

With the above considerations in mind in spring 1987 we initiated a study with the following objectives:

1. To determine the number of wolves occurring within the range of the Western Arctic Caribou Herd.

2. To determine the spatial relationships among wolf packs on caribou winter range.

3. To develop and test precise and effective census methods for wolves on caribou winter range.

4. To estimate the impacts of wolf predation on Western Arctic Caribou.

While we were contemplating this study, the U. S. Fish and Wildlife Service in cooperation with a number of cooperating agencies in addition to Telonics and Service Argos were conducting research and development on 3rd generation satellite radio-collars. The Argos satellite system is a cooperative effort between the French government, the U. S. National Oceanic and Atmospheric Administration, and the U. S. National Aeronautics and Space Administration. There are 2 polar orbiting satellites which concern us. a series of ground receiving and tracking stations, and communications links which transfer data to several processing centers. Much of the research by the Fish and Wildlife Service has focused on polar bears and caribou, and clearly these collars were too large for use on wolves. Our proposed wolf study was a natural for extensive use of satellite telemetry if it could be made to work because it would be difficult to obtain. Fortunately they had just acquired two new prototype wolf collars which utilized "C" size batteries rather than the "D" size used in standard satellite collars. These were the first satellite collars to weigh less than 1500 grams.

Both prototype transmitters were deployed on wolves in spring 1987. One near Venetie, along the Chandalar River in northeast Alaska and the other in our study area just south of the Kobuk River referred to as the Rabbit Mountain Pack. Because of the transmitters smaller size and the extremely low winter temperatures in the study areas they were expected to transmit for only 6 months with a duty cycle of 6 hours on - 42 hours off (that is they transmitted for 6 hours every other day). Their actual weight was 1.220 grams and although not excessively heavy they were somewhat bulky particularly under the neck and so we restricted these units for use only on large adult males. The size and weight of these units is due largely to the batteries and we are told that it is not likely that the units can be made much smaller in the near future. Also each unit contains a standard VHF transmitter which is located within the canister with the satellite transmitter. The VHF transmitter allows the collar to be relocated with traditional tracking methods once the satellite collar fails so that it can be refurbished and redeployed.

Of the two prototype transmitters the one deployed at Chandalar River failed almost immediately. A few relocations were obtained along with mostly sensory data. At this point I should mention that all of the transmitters that I have dealt with provide activity and temperature data in addition to relocations because they are equipped with several sensors. The unit that failed was retrieved and sent back to Telonics and they couldn't find anything wrong with it and believed it was due to some peculiarity of the animal and/or the location that it was deployed. They refitted that particular collar and deployed it on a muskoxen and it worked perfectly.

The second wolf satellite collar worked perfectly. From April 1987 through February 1988 when the animal was shot by an Eskimo hunter, a total of 415 relocations were obtained. The transmitter continued to transmit until June 1988; a life of 13 months, or 7 months beyond that expected. An average of 3.0 relocations (plus or minus 4.8 locations) and 5.4 sets of sensory data (plus or minus 1.7) were obtained every other day during the 6 hour period of transmission. We are just now beginning to analyze portions of the data so everything presented here is very preliminary. This plot depicts the movement patterns of this male wolf from April through February. This consists of 3-5 locations for a 6 hour period every other day. At least one area of concentrated activity can be seen and as you might expect that area encompasses the den site. These transmitters can be programmed to transmit for different durations and for up to four different time periods. At the present time Telonics recommends a minimum of 6 hours of transmission to guarantee at least one relocation. The frequency of the transmission can be varied up to 4 time periods so that an investigator could get more relocations for certain selected time periods. The limiting factor of course is battery life and the more frequent you transmit the shorter the life span of the collar. With this type of technology if you were interested in spatial relationships among several packs during the time period you would normally be out there counting or estimating wolves based on tracks having several transmitters programmed to transmit daily should provide useful data to help us design a valid censusing method. In this regard satellite telemetry has direct application in this study.

We are hopeful that the sensory data will ultimately provide some useful data on wolf activity patterns and help us interpret movements and habitat use. As I mentioned earlier we have not really analyzed any of this data in detail but one initial analysis indicated that the activity data may not be easy to interpret. In this analysis we compared average distance traveled per day with the average summary of the 24 hour activity index (the latter being the number of occasions the mercury tip switch was activated). The two data sets were not correlated suggesting that the activity index was not useful in this type of analysis.

We compared territory boundaries obtained with satellite telemetry in comparison to that obtained from fixed-wing aircraft. Between April 1987 and February 1988 the two radio-collared members of the Rabbit Mountain Pack were relocated on 38 occasions from fixed-wing aircraft while the one satellite radio-collar provided 415 relocations. This level of fixed-wing monitoring was about the maximum that could be accomplished in NW Alaska given funding constraints and weather conditions. Using Mohr's minimum home range method which consists of connecting outermost points the estimated territory size based on relocations from fixed-wing aircraft was 1,515 km^2 in comparison to 2,632 km^2 or about 75% larger. A few reasons for these differences might be due to too few locations from fixed-wing aircraft and/or inaccuracies associated with the satellite data. I tend to dismiss both. First because even using the year-round territory calculated with 64 relocations still shows a very large difference in territory size (1,573 km^2 from fixed-wing vs 2,632 km^2 by satellite or 67% larger). The Argos system provides information on the quality of relocation sizes. Quality is reported in a range of 0 through 3 with the best being 3 the worse being 0 with only sensory data provided. The worst relocation index is a score of 1 which accounts for about 70% of the relocations with an average error of 800 meters. Just visually examining our simple plot in relation to this range of error in relocations does not appear to account for the large differences. I attribute the large differences to more frequent and more consistent relocations of the study animals.

While we were experimenting with this new satellite telemetry we also employed conventional radio-telemetry and have maintained contact with 5 to 7 packs during the past year within a 12,279 km^2 study area (4,741 mi^2). We have maintained a pool of about 15 radio-collars and have now captured 24 wolves using standard helicopter darting methods using either Telazol or M-99. Unfortunately, it appears we do not have any migratory wolves radio-collared. We believe this is due to a possible combination of factors including that migratory wolves may not exist in the southern range of the Western Arctic Caribou Herd, and also that we have not attempted to capture wolves during the time periods when migratory wolves would most likely occur in this area. If migratory wolves occur they either share range with territorial wolves or they only pass through existing territories.

There are large gaps between some of the territories and these are real although one small pack estimated at 3 individuals probably occurs in a mountainous area between the Rabbit Mountain Pack and the Purcell Mountains Pack. These wolves are largely limited to mountainous terrain apparently due to several factors including adequate escape cover from snowmachine hunters, lesser snow depths, and perhaps easier conditions for killing caribou. Territories for these six packs average 997 km^2, however using only those with 50 or more relocations average territory size increases to 1,296 km^2. Making allowances for one small uncollared pack of 3 animals and adding 10% for single wolves we estimate the density within this 12,300 km^2 study area at a low of 2.7 wolves/1,000 km^2 in spring (about 320 wolves in 119,000 km^2) to a high of 4.4/1,000 km^2 in autumn (about 524 wolves in 119,000 km^2). The population has been increasing with a finite rate of increase of about 1.24.

Our good luck with this first satellite transmitter and its obvious potential for providing detailed movements information led us to incorporating satellite telemetry into our study. Although admittedly at the time we were hopeful that we would locate migratory wolves. We did not get our funding approved until late in the spring and poor snow conditions didn't allow us to search for migratory wolves so we were forced to put the new satellite collars on packs which we already had radioed with conventional collars.

Telonics was able to modify the first prototype collar. We reduced the weight by 60 grams and narrowed the width of canister under the chin. This new collar is 1400mm wide (ear to ear), 47mm deep (head to tail), and hangs down 75mm. It appears to fit and look much better than the original prototype.

We purchased 6 of these new collars and were able to deploy 5 of them. One collar failed immediately and may not every have worked properly. This collar is currently being examined by Telonics. We replaced this collar and currently have 5 working collars. On one of the collars the conventional VHF radio has failed but otherwise everything appears to be working satisfactorily.

We have been experimenting with duty cycles on the transmitters. As I mentioned earlier we were interested in spatial relationships among packs during the time periods we would normally due wolf surveys. Consequently we programmed the transmitters to transmit for 6 hours daily for 30 days and then for 4 transmitters to transmit for 6 hours every other day until the batteries expire while for 2 other transmitters they were programmed to transmit for only 4 hours every other day until the batteries expire. Our idea based on the original prototype was that there would not be a significant loss in numbers of relocations between the 4 and 6 hour transmission period but that this reduction could possible greatly extend the life of the transmitter. Thus far this reduction in length of transmission appears to mean that during one month instead of receiving 35 relocations we get 28 or a loss of an average of 7 locations per month but hopefully a longer life expectancy on the radio. I might mention that varying the length of the transmission to get greater life expectancy out of the collar without losing a significant number of relocations may not work in all cases because of different satellite coverage in different geographic areas.

This figure represents about a 6 week period in May and June showing continuous relocations of the 5 wolves equipped with satellite collars. This preliminary figure I think clearly shows we have very little overlap among pack areas and at this time we do not have contact with migratory wolves. As I mentioned earlier we have not been able to mount a capture effort during the time periods when migratory wolves would most likely be present. Also they may not occur this far to the south or perhaps their occurrence is dependent on prey densities. Regardless we believe that use of satellite telemetry on wolf populations depending on project objectives can greatly extend our knowledge of wolf behavior, movements and habitat use. The biggest drawback may be the cost.

Each wolf satellite collar including the conventional VHF transmitter costs $3,500.00. Data access from Argos using the transmission frequency that we are using (that is 6 hours daily for 30 days and then 4 or 6 hours every other day for the remainder of the life of the collar which we hope will be 11 months) amounts to $1,396 per year. This equals a total cost of $29,556.00 for 6 satellite collars and data for one year or $4,926 for one collar and data acquisition for one year.

I estimated similar costs using conventional radio-collars. You can do similar analyses depending on how many collars per pack you might wish to use. Using 2 conventional VHF collars per pack at an average cost of $300/collar equals $3,600.00 for 6 packs. In our study it takes 7 hours of fixed-wing aircraft flight time to relocate all 6 packs on one occasion. At commercial charter rates to get an average of one relocation per week would require 336 hours annually at $135 per hour for an estimated cost of $45,360 for a total cost of $48,960.00. Fortunately much of our aircraft work is done with government owned or leased aircraft. Even assuming a minimum of $50/hour aircraft costs are still high at about $17,000 annually or a total of $20,400 annually in relation to $29,500 annually for satellites.

More consistent and frequent monitoring appear to provide movement and territory data of superior quantity and quality to that provided by conventional telemetry but exactly how much superior has not yet been quantified. Whether the additional data are worth the additional costs remain unanswered but will no doubt relate back to the exact objectives of the study being considered. In our case it appears justified.

Appendix G. Manuscript submitted to Canadian Journal of Zoology describing performance of two prototype wolf transmitters.

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WOLF MOVEMENTS DETERMINED BY SATELLITE

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Key Words: Alaska, *Canis lupus*, movements, satellite, telemetry, wolf.

Use of satellite transmitters to monitor movements and activities of free-ranging wildlife has expanded rapidly since 1984. The Argos Data Collection and Location System (Argos DCLS) has been used by our agencies to obtain more that 100,000 relocations of caribou (*Rangifer tarandus*), polar bear (*Ursus maritimus*), muskoxen (*Ovibos moschatus*), and several other terrestrial mammals (Fancy et al. 1988, 1989; Harris et al. 1989). Recent advances in transmitter miniaturization and power supplies have made it feasible to use satellites in studies of smaller species (e.g. walrus, swans, etc.) under a wide range of study conditions. We report on the use of a prototype satellite transmitter to determine movements, activities and ambient temperatures for two adult male wolves (*Canis lupus*) in arctic Alaska.

METHODS

Fancy et al. (1988) presented a detailed description of the Argos DCLS and its potential applications to wildlife research and management. Briefly, Argos instruments on 2 polar-orbiting satellites (NOAA-9 and NOAA-10 in this study) passed over Alaska approximately 24 times daily, received signals from transmitters, and relayed data to ground stations in Alaska. Virginia and France. Data were processed at Service Argos' computer facility in Landover, Maryland, and received monthly on computer tapes. Results could also be obtained 3-8 hours following an overpass using a telephone modem and computer links to the Argos computer (Fancy et al. 1988).

On 22 march and 15 April 1987, we deployed 1,200-g satellite transmitter packages built by Telonics, Inc. (Mesa, AZ) on 2 adult male wolves weighing approximately 43 kg. Each satellite collar was equipped with a conventional VHF radio transmitter that allowed wolves to be located from aircraft. Wolves were immobilized for collaring by darting them from a helicopter using 2.5 mg does of etorphine hydrochloride and methods similar to Ballard et al. (1982). Separate power supplies and antennas were used for the satellite and radio transmitters. Each collar cost approximately $3,500; data processing expenses were ca. $1,400 annually. Satellite transmitters were programmed to transmit once each minute during a 6-hour period (1530-2130 hour Universal Time) on alternate days. Unlike previous models of satellite transmitters that used three "D" size lithium batteries, the prototype wolf transmitters used 3 "C" size batteries. The smaller batter pack provided a theoretical life of 6 months based on 6 hours of operation every 48 hours and anticipated ambient air temperatures. Harries et al. (1989) reported a median location error of 543 m for similar transmitters deployed on large mammals.

Each message transmitted to the satellite contained measures of ambient temperature, a short-term (previous minute) index of the wolf's activity, and a long-term (previous day) index of activity (Fancy et al. 1988). The short-term activity index was a count of the number of seconds each minute that a mercury switch within the canister was activated. The index ranged from 0 to 60, with higher counts presumably associated with greater activity. The long-term index was the sum of the short-term counts for a 24-hours period (maximum value = 86,400), and was intended to indicate mortality or to reflect seasonal trends in daily activity.

Distances moved between successive locations were calculated by connecting locations with straight lines. A minimum distance travelled was estimated by summing distances between successive locations. Mean daily movement rates and mean long-term activity indices were summarized by 2-week intervals and used in subsequent comparisons by season. Statistical comparisons (SAS 1985) were evaluated at the 95% confidence interval.

RESULTS AND DISCUSSION

One wolf collared on 2 March 1987 in northeast Alaska was located by satellite only 4 times during March and April; after 26 April 1987, only temperature and activity data were received from the satellite transmitter. The wolf appeared normal when visually observed from aircraft on 25 April and 11 May. It was recaptured in late June to recover the satellite transmitter and determine why the transmitter failed. The manufacturer was unable to find any defects in the transmitter. The most plausible explanation was that the close proximity of the antenna to the wolf's body and its effect on the voltage standing wave ratio (VSWR; see Fancy et al. 1988), coupled with a relatively weak power output resulted in poor performance of this transmitter.

The second transmitter, deployed in northwestern Alaska on 15 April 1987, provided location and sensory data throughout its expected life span. The transmitter was still functioning when the wolf was shot by a hunter on 27 February 1988, and transmitted for another 2 months after retrieval. Data were received from 876 satellite overpasses between 1 April 1987 and 28 February 1988. Adequate data for calculating the wolf's location were obtained from 512 of these overpasses (Fig. 1). We obtained an average of 3.1 ± 4.7 (SD) locations/day and location was obtained on 92% of 167 days when the transmitter was active. The remaining 364 overpasses provided sensor data (e.g., canister temperature and short- and long-term indices of the wolf's activity) but no location.

The minimum distance travelled by the wolf between April 1987 and February 1988 was 2,618 km. Mean distance travelled in winter (October-April; $\underline{x}$ = 11 ± 3 (SD) km/day; Fig. 2) was greater than that in summer (May-September; $\underline{x}$ = 6 ± 1 (SD) km/day) (F = 25.84; 1 df; $\underline{P}$ = 0.0001). Highest movement rates occurred in February, when the wolf travelled 236 km during a 3-day period. This wolf was accompanied by 2 adults (1 adult male and female) when captured and apparently was not the alpha male of the pack. The pack denned during 1987 and 6 pups were raised. The concentrated overlapping movements within the territory (Fig. 1) represent the wolf's attendance at the den site during late spring and summer. This pack's principal year-round prey was caribou (Ballard et al. 1989).

There was no significant correlation ($\underline{r}$ = -0.33; n = 21; $\underline{P}$ = 0.14) between mean distances travelled during 2-week intervals, and the mean long-term activity index. The main activity index in winter ($\underline{x}$ = 13,345 ± 1498 SD) was lower than during summer mean ($\underline{x}$ = 14,930 ± 2057 SD; $\underline{F}$ = 4.13; 1 df; $\underline{P}$ = 0.056), in contrast to the higher winter movement rate. We were unable to discern between periods of rest and activity from the short-term activity counts. Fancy et al. (1989) found a high correlation for caribou between the short-term activity index and activity (e.g., lying, feeding, walking) and between the 24-hour activity index and daily movement rates. Differences between the 2 species may be related to the placement of the mercury sent in the transmitter. The mercury switch within the canister was oriented parallel to the wolf's spine and to the bottom of the canister. In captive wolf studies, the canister rested against the wolf's chest and the mercury switch was activated by even slight body movements, including breathing motions as the wolf rested (G. Garner, U. S. Fish and Wildl. Serv., pers. commun.). We attribute the apparent inability to detect activity patterns in the wolf to improper orientation of the mercury switch, and recommend that future researchers orient the anterior end of the switch +2 to +6 degrees relative to the bottom of the canister. Switches elevated at the anterior end should be less sensitive to slight body motions such as breathing but should still be activated by body movements during activity. Calibration studies using captive wolves need to be conducted to determine the best switch orientation for wolves.

Harris et al. (1989) reported that the temperature sensor within the canister of similar transmitters accurately measured ambient temperatures once the transmitter had been exposed to a relatively constant ambient temperature for $\geq$ 1 hour. Transmitted temperatures during summer were between the monthly minimum and maximum extreme temperatures recorded at Ambler, Alaska, about 40 km from wolf's territory (Fig. 3). Winter temperatures were more variable, and frequently exceeded the maximum extreme temperature. Behaviors such as curling the body to reduce heat loss and seeking relatively warm microenvironments partially explain the greater variation in winter temperature. Significant negat e correlations between temperature and daily distance travelled (Pearson correlation; n = 145; r = -0.386; P < 0.0001), and between temperature and the standard deviation of the short-term activity counts during an overpass (n = 145; r = -0.267; P = 0.001) suggested the wolf travelled less and had less variable activity in summer while attending the den site and when temperatures were relatively higher.

We are currently tracking 6-12 wolves using the Argos DCLS (Ballard et al. 1989). Preliminary analyses suggest that territory sizes estimated from satellite locations are 75% larger than those from relocations obtained by conventional methods using fixed-wing aircraft (Ballard and Fancy 1989). Larger estimates of territory size appear to be the result of greater numbers of relocations, detection of unusual movements, and more consistent coverage than that provided by conventional methods, and can only partly be explained by errors associated with locations determined by satellite. Consistent and frequent relocation of wolves using satellite collars appears to provide data sets for evaluating wolf movements and home range use that are superior to those provided by conventional methods, particularly in remote areas.

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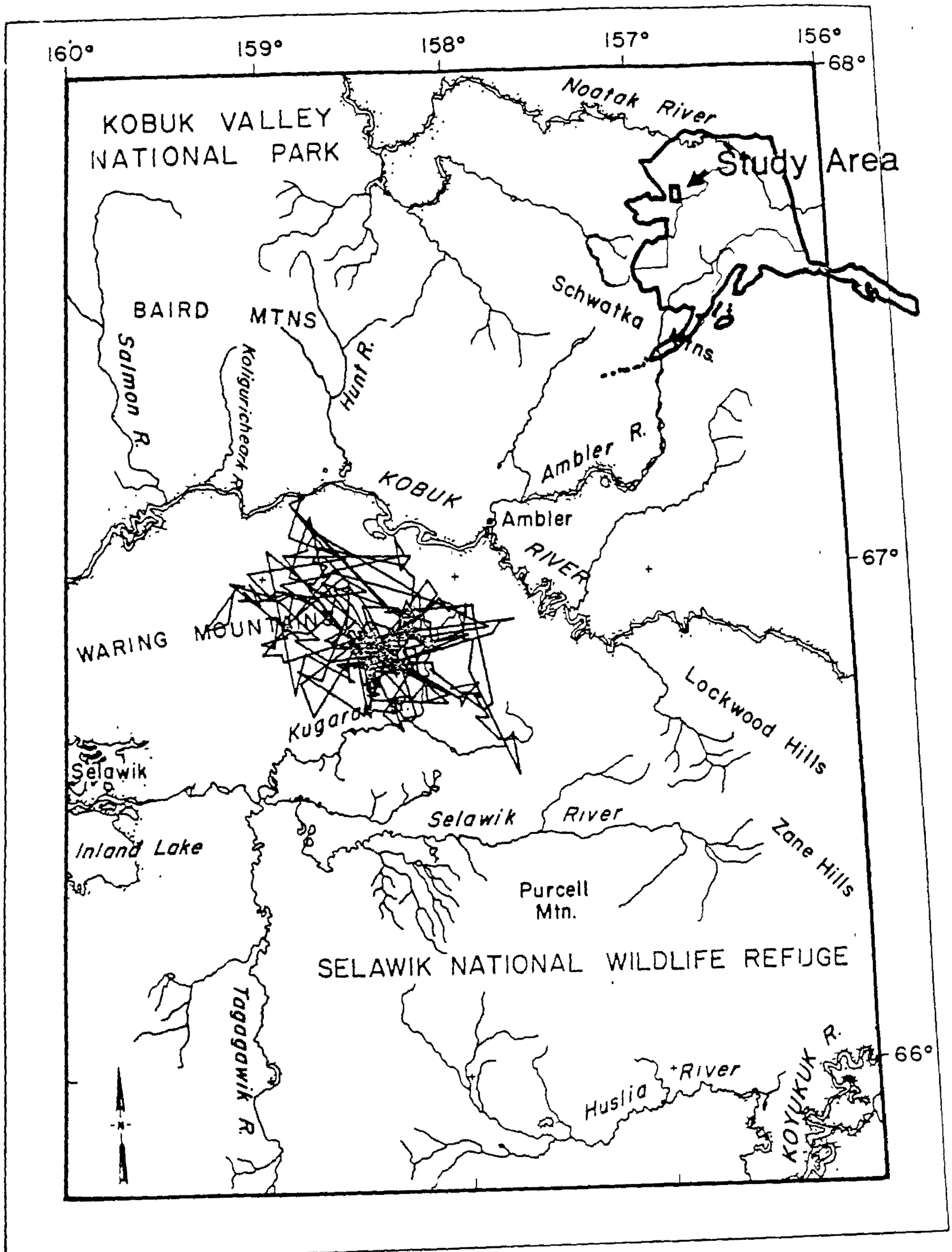

Fig. 1. Movements of an adult male wolf between April 1987 and February 1988 as determined by the Argos Data Collection and Location System.

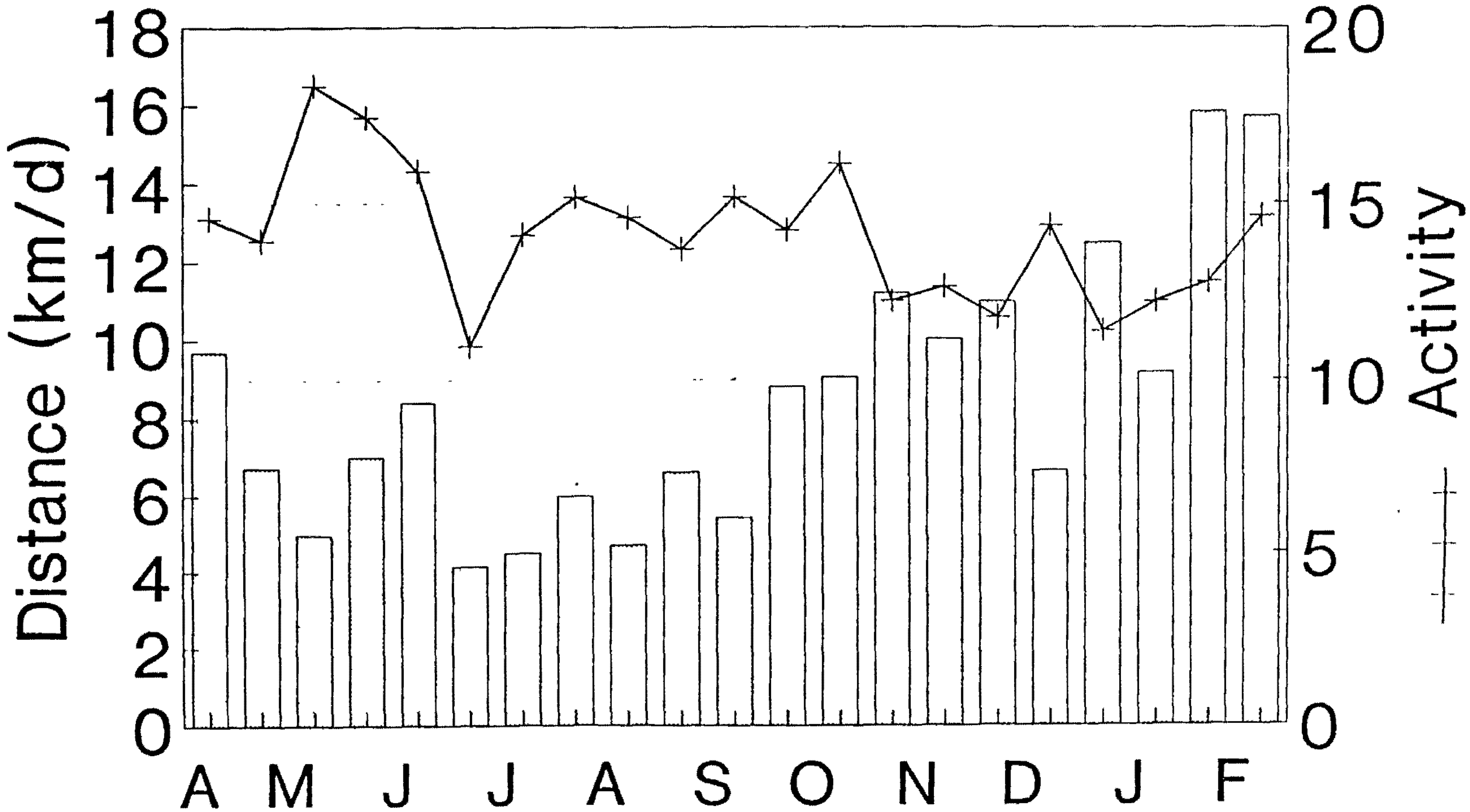

Fig. 2. Mean distance travelled (km/day) and mean long term activity indices during 2-week intervals between April 1987 and February 1988 for an adult male wolf in northwestern Alaska.

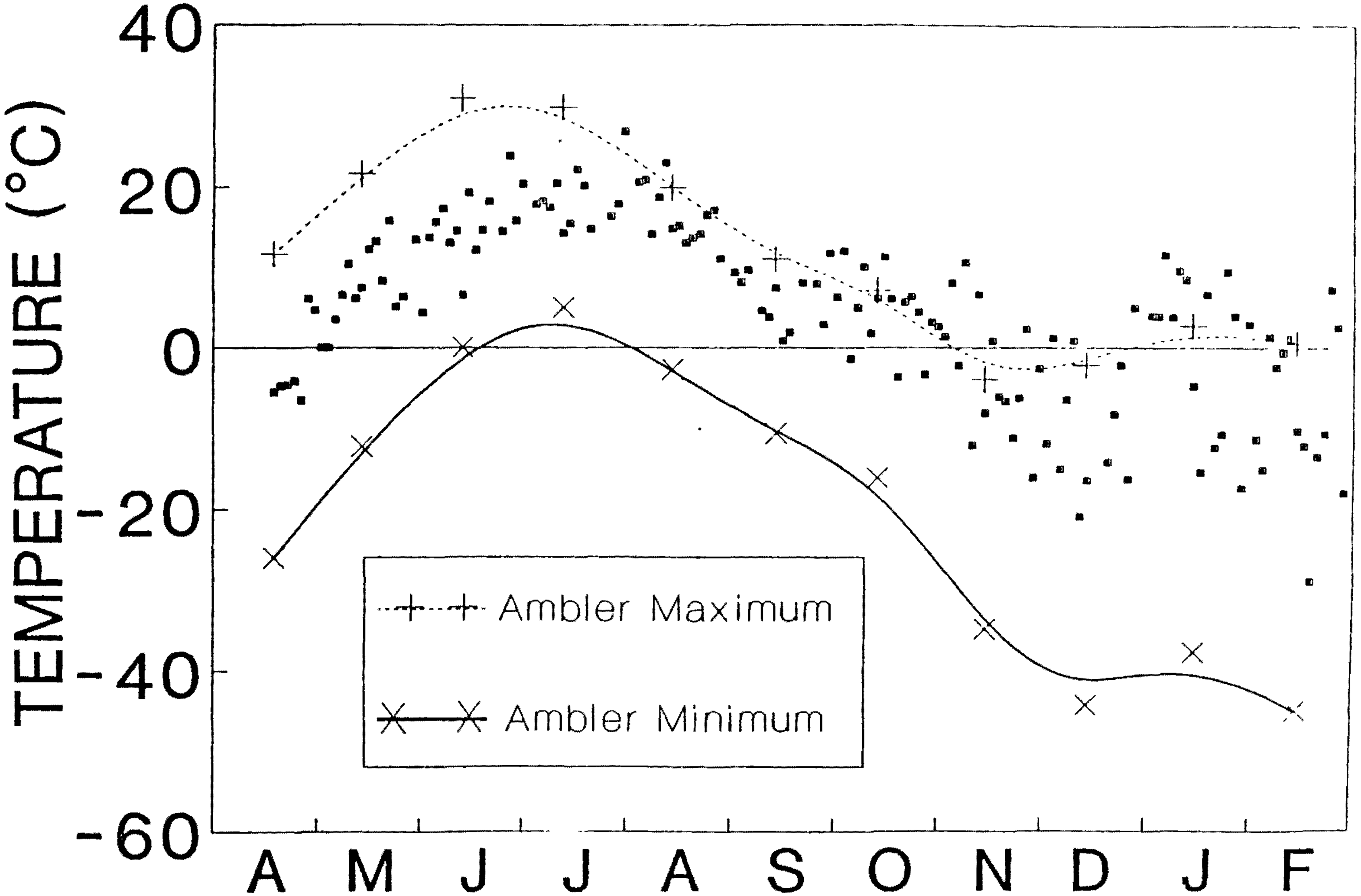

Fig. 3. Temperatures recorded by a sensor within the canister of a satellite transmitter deployed on a wolf in northwestern Alaska. Monthly extreme temperatures (minimum and maximum) recorded at Ambler, Alaska, are shown.