EFFECTS OF ARCTIC FOX REMOVAL ON PRODUCTION OF GEESE AT MANOKINAK RIVER, YUKON-KUSKOKWIM DELTA, ALASKA.

1988 PROGRESS REPORT

by

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EXECUTIVE SUMMARY

In 1985 the Alaska Fish and Wildlife Research Center initiated studies to understand the relationship between foxes and productivity of geese in coastal tundra habitats of the Yukon-Kuskokwim Delta (YKD). The work was begun due to apparent high predation on nests of geese, which resulted in undesirably low reproductive rates of severely diminished goose populations. Before 1988 arctic fox studies were conducted at Kokechik Bay where radio telemetry, observations from blinds, and systematic searches were used to determine movement, activity patterns, productivity, den use, and prey abundance.

In 1988 we began studies of arctic foxes along the Manokinak River, an area considered more representative of coastal wet tundra of the YKD than Kokechik Bay. Our objectives were to determine the efficacy of trapping and shooting to remove foxes and the effects of removing foxes on goose production in localized areas of coastal goose nesting habitats. To meet the objectives, we compared fox activities, predation rates, nesting success, and prey abundance in a removal area (where foxes were removed by trapping and shooting) and a check area (where foxes were live-trapped and radio-collared). The two areas were separated by the Manokinak River.

Five male and 2 female arctic foxes were captured and fitted with radio collars. One male was subsequently shot after removal began. Both females were gravid at capture, but later presence of kits was never confirmed. A mated pair that was captured in the removal area was collared and released in the check area, but swam the Manokinak River and returned to the vicinity of their capture site.

From 6-25 May, 18 male and 15 female arctic foxes were taken from the removal area. Sixteen of 17 were shot from 6-14 May and 15 of 16 were trapped from 15-25 May. Six of the 15 females were gravid with an average of 11.7 embryos (range 8-18).

From 16 May to 29 June we observed arctic foxes on 29 occasions during 37 days (18.6 observation hours) in the removal area and on 46 occasions during 41 days (20.4 observation hours) in the check area. Overall predation rates were 1.9 items/hr, 1.4 eggs/hr, 0.36 goose eggs/hr, and 0.33 duck eggs/hr of observation. Arctic foxes successfully preyed upon goose nests an average of once every 7.8 hr.

We searched 8 0.6-km^2 nesting plots both in the removal and check areas. Overall goose nesting success was 90%; emperors (96%) and white-fronts (95%) fared slightly better than cacklers (87%). Nest success on the removal and check areas respectively was 98% vs 94% for emperors, 91% vs 79% for cacklers, and 98% vs 79% for white-fronts. Nest success of ducks (62% vs 71%) and eiders (78% vs 70%) were lower than geese in both the removal and check areas. Goose nests failed due to unknown causes (57%), mammalian predators, avian predators, and desertion/other causes (14% each).

Microtine activity (nests, fecal deposits, casts, runways, and live animals) observed after snowmelt and summer trapping success indicated that small mammals were abundant in areas of suitable habitat. Stomach contents of foxes indicated mice were the primary food before nesting by geese began.

Interpretation of the effects of fox removal was confounded by high microtine populations, variability in habitats and goose densities between and within the removal and check areas, and unmonitored movements of unmarked foxes in the removal area. Removal of foxes at Manokinak River was less beneficial to nesting geese than fox control at the Tutakoke River brant colony in 1986 and 1987. Control there was more efficient because the area was smaller, brant nest more densely than the geese at Manokinak River, and brant are more vulnerable predation than other geese nesting on the YKD. Studies to understand the effects of fox predation on duck and eider production should be considered.

INTRODUCTION

Investigations of the ecology of arctic foxes (*Alopex lagopus*) have been conducted in the coastal region of the Yukon-Kuskokwim Delta (YKD) since 1985. These studies were initiated because of decreased populations of geese nesting on the YKD and the apparent high predation rate on goose nests by foxes (Sedinger 1986, Stehn 1986). Studies have focused on foraging behavior, movements, den ecology, predation rates on nests, productivity of arctic foxes, and effects of fox removal in a black brant (*Branta bernicla nigricans*) colony.

Because of undesirably low reproductive rates among the YKD goose populations, research in 1988 was directed toward fox removal as a means of increasing production of geese other than brant, primarily that of cackling Canada geese (*Branta canadensis minima*). We had two primary objectives in 1988: (1) determine the efficacy of removing foxes by trapping and shooting in coastal nesting areas and (2) evaluate removal of foxes for improving nesting success of geese. To meet these objectives we compared fox activities, nesting success, and prey abundance between two areas, one of which was trapped and hunted to remove foxes before incubation by geese began. This report summarizes our efforts during the 1988 field season.

In addition, we continued marking adult foxes in other areas of the YKD to monitor winter movements and survivorship. We also began developing methods to capture and mark arctic fox kits to gather information on dispersal and survivorship. This work is discussed in the Appendix.

METHODS

Study Area

The study was conducted on the Bering Sea coast along the lower Manokinak River near its confluence with Hazen Bay (Figure 1). The flat, low, coastal wet tundra contains large grass and sedge meadows, wetter areas of mosses and grasses, and 1-4 m high pingos with covered with *Empetrum nigrum* and *Salix spp.* Intertidal sloughs transverse the area and shallow brackish ponds and lakes are numerous. Mudflats along sloughs and shallower ponds are common. Complete information on vegetative and physiographic characteristics near the Manokinak River and the YKD proper are presented by Tande and Jennings (1986).

The study area contained high numbers of nesting emperor geese (*Anser canagicus*), cackling Canada geese, and white-fronted geese (*Anser albifrons*), but few black brant. Nesting tundra swans (*Cygnus colombianus*), sandhill cranes (*Grus canadensis*), willow ptarmigan (*Lagopus lagopus*), and various species of ducks, eiders, shorebirds, and passerines were common. Several hundred non-breeding tundra swans also were present throughout the study. Mammals found in the area included arctic foxes, mink (*Mustela vison*), tundra hares (*Lepus othus*), beavers (*Castor canadensis*), muskrats (*Ondatra zibethicus*), river otters (*Lutra canadensis*), tundra voles (*Microtus oeconomus*), masked shrews (*Sorex cinereus*), and brown lemmings (*Lemmus sibiricus*).

The study area, bisected by the Manokinak River, was divided into a removal area to the east (where foxes were removed by hunting and trapping) and a check area to the west (where foxes were live-trapped and fitted with radio collars). Except for the Manokinak River, the boundaries of the two areas were loosely defined. The size of sample areas was dictated by the viewing range from observation towers--about 1.6 km. The actual area in which we removed foxes was enlarged due to required routes of travel, methods of fox removal, and as an attempt to keep all foxes from the actual sample areas. The removal and check areas were approximately 70 and 37 km^2, respectively. The check area had more pingo habitat and contained fewer sloughs.

Fox Capture and Removal

Procedures and equipment used to capture and mark adult foxes were identical to those used in previous years on the YKD (Anthony et al. 1986, 1987, 1988). Cage traps were ineffective, so we discontinued their use after the first two weeks.

To remove foxes, we hunted with a .22-250 caliber rifle and trapped with No. 1.5 leghold traps. Foxes were sexed, weighed, and measured. Skulls, reproductive tracts, gastro-intestinal tracts, and kidneys were collected for later analysis to determine age, reproductive status, food items, and physical condition.

Fox Observations

Four, 2.4-m tall towers with canvas blinds on top were erected in both the removal and control areas (Figure 2). Towers were located in areas known from previous surveys to contain sufficient numbers of nesting geese to allow observation of predation by foxes. Towers were 2.5-5.0 km apart and effective observation range was approximately 1.6 km.

Observations with 20x spotting scopes and 8x40 binoculars occurred at two towers in both areas every other day from 2200-2400 hr during goose nesting. Observers generally entered blinds 30 min. before beginning observations to reduce human influence on movements of foxes. Observations began from a randomly selected window and proceeded clockwise with 15 min. observation periods at each of four windows. If a fox was sighted, it was observed until out of sight or until its activities could not be determined. During observations we recorded initial direction and distance of the fox from the tower, start and end time of fox observations, all predation attempts and their time, type of prey, fate of prey, interactions with other species, and identity of the fox if known.

Nest Plots

Two 0.4-by-1.6-km plots were randomly located 0.8 km from each tower (Figure 2). Once incubation was underway, each plot was thoroughly searched for nests. Nests were examined during incubation from 1-7 times, but mostly from 3-4 times, to determine cause and timing of nest failure. Time between examinations was varied for each plot to test for effect of visitations on nest success. Each nest was located on an aerial photograph and marked with a wire flag about 2 m away. Information on habitat and nest status were recorded on standardized "nest cards" (Stehn 1986) used by survey crews on the YKD.

Small Mammal Abundance

Two methods were used to index small mammal abundance: amount of sign (casts, fecal deposits, nests, runways, and live animals) observed just after snowmelt and rate of capture in snap traps during summer along 100-m transects. From 1-10 transects (depending on presence of sign) were located within 1.6-km radius of each tower at areas with small mammal sign. Each transect was paced off and each meter was given a qualitative score from 0-5 based on type and abundance of sign: 0 = no sign; 1 = very faint sign of runway, uncertain; 2 = runway apparent; 3 = multiple runways, nest, fecal pellets, or fresh diggings; 4 = active runways and fresh grass clippings; 5 = abundant, fresh sign - diggings, grass clippings, runways, fresh fecal pellets, observation of small mammals. Examination of transects occured from 20-29 May. Museum Special snap traps baited with peanut butter and rolled oats were set every 10 m along a random selection of 30 of the transects from 30 June to 3 July. Traps were checked daily and maintained for 3 days. Captured animals were weighed, measured, sexed, aged according to weight (Whitney 1976), and examined for reproductive status.

Data Analysis

Difference between nest densities of removal and check areas was tested with the t-test. Analysis of covariance was used to test homogeneity of regresion lines of observed predation rate and nest success of plots near tower locations. Chi-square test was used to test difference of nest success between removal and check areas. Tests were conducted on a Data General MV-8000 computer system with SPSSx (1983) programs. Individual test statistics are presented with the results.

RESULTS

Fox Capture and Removal

Live-trapping of foxes was conducted during 24 April - 5 May. Three arctic foxes (2 males and 1 female) were equipped with radio collars and released during this time (Table 1). One of these radio-equipped males was subsequently shot in the removal area after fox control was initiated on 6 May. Four additional foxes (3 male and 1 female) were captured later, fitted with radio collars, and released. Both captured females were gravid at capture but later presence of kits was never confirmed. One pair of collared foxes that was trapped in the removal area was released in the check area. They subsequently swam the Manokinak River and returned to the vicinity of their capture site.

A total of 33 foxes (18 males and 15 females) was taken from the removal area from 6-25 May. Sixteen of 17 foxes were shot from 6-14 May and 15 of 16 were trapped from 15-25 May. Bait sets accounted for 5 foxes and scent post sets took 10 foxes. Six of the 15 females were gravid with an average of 11.7 embryos (range 8-18).

We were unable to exclude all foxes from the removal area during the goose incubation period. Although the exact number is unknown, from 4-8 foxes commonly ranged into the removal area near the towers and plots, but their centers of activity were probably outside of the study area.

Fox Observations

We observed foxes from 16 May - 29 June, the period including peak goose incubation and hatch. Number of observation days, duration of observation, and percent of time foxes were observed were similar for both the removal and check areas, but frequency of fox sightings was greater in the check area (Table 2). The occurance of two pairs of foxes at dens in the vicinity of towers C-1 and C-3 accounted for the majority of observations in the check area and the large difference between the check and removal areas. Foxes observed in the check area were usually in pingos, which resulted in shorter observation bouts.

Overall predation rates by arctic foxes was 1.9 items/hr of fox observation (Table 3). Predation rates were highest for goose and duck eggs (0.36 and 0.33 eggs/hr of fox observation, respectively). Goose and duck nests were successfully preyed upon once every 7.8 and 12.5 hr, respectively. The predation rate on eggs of all species except geese, 65% of which were ducks and gulls, was about twice that suffered by geese. Egg predation rates were generally higher in the check area. Foxes cached 85% of all eggs taken, but ate all 19 other prey items that they obtained while under observation.

Nest Plots

A total of 397 nests of all species was found in 16 plots. Of these 71.5% were goose nests. Nests of ducks, eiders, sandhill cranes, and tundra swans each comprised 3.8-5.3% of the total. Nesting densities ranged from 10.9-71.9 nests/km^2 on sample plots. Overall nest success was 89.6% and nest success in the removal area (92.5%) was significantly higher than the check area (85.4%) ($X^2 = 4.80$, $P < 0.05$) (Table 4). Causes of nest failure were 58% unknown, 17% mammalian predators, 10% avian predators, and 15% desertion/other causes.

Among goose species, emperor and cackler nests occurred more frequently than white-front nests in the plots. A group of brant nests near tower R1 accounted for 7 of the 8 brant nests found. Nests of all 4 species of geese were more abundant in the removal area, although because of high variability among plots in the same treatment area, densities did not differ significantly between the removal and check areas ($t = 1.79$, $0.10 < P < 0.20$).

Nest success of all geese was 89.8%. Emperors (96.5%) and white-fronts (94.7%) fared better than cacklers (86.6%). Overall nest success of geese was signficantly greater in the removal area ($X^2 = 6.03$, $P < 0.05$). Successof emperor nests was similar for both the removal and check areas, but cacklers and white-fronts had better success in the removal area. Only values for white-fronts were significantly different ($X^2 = 5.99$, $P < 0.05$); however, sample sizes were small. Causes of nest failure for geese was 57% unknown and 14% each for mammalian predators, avian predators, and desertion/other causes.

No sandhill crane, tundra swan, or loon nests failed in any plot for any reason. Duck and eider nests had relatively low success. Although cause of failure was unknown in most cases, the relatively high frequency of duck nests depredated during our fox observations points to foxes as the major cause.

Time between visits to goose nests ranged from 1 to 25 days, and 87% of the visits occurred from 4 to 11 days apart. Timing between visits appeared to have no effect on success of nests, in part because few nests were destroyed.

Small Mammal Abundance

Small mammal sign was abundant in suitable habitats particularly those ecotones with obvious changes in relief; e.g., pingo sides, troughs between pingos, some slough banks, and some pond shores. Towers C-2 and C-4 were essentially void of sign, and R-3 and R-4 had sign only on a few isolated pingos. Abundance scores (Table 5) are not directly comparable to any previous data collected on the YKD, but will be used to follow population trends in future years. General observations of sign and animals in 1988 indicated that the tundra vole population far exceeded levels observed in the past decade. A total of 154 small mammals (17.7/100 trap nights) were trapped: 144 tundra voles, 5 brown lemmings, and 5 masked shrews. There appeared to be an isolated population of brown lemmings as all 5 were trapped on 3 transects near tower R-1. We classified 102 microtines as adults, 32 as sub-adults, and 6 as juveniles. All but 4 of the 72 adult females were reproductively active with an average of 8.3 ± 0.5 ($C.I._{95}$) embryos or 11.4 ± 1.2 placental scars. Trapping success was almost twice as great in the check area (23.8 animals/100 trap nights) as the removal area (12.0 animals/100 trap nights) due to more suitable habitat. As in previous years (Anthony et al. 1987, 1988), summer trapping success was not related to subnivean sign observed on individual transects in spring.

DISCUSSION

Efficacy of Fox Removal

Shooting foxes was successful until lack of snow prevented extensive coverage of the area by snow machine. Foxes did not respond to trap sets until May 15, a time when terrritory boundaries were probably being established and increased scent marking activity made foxes more susceptible to trap sets, especially scent post sets. Abundance and availability of natural prey may have contributed to low trapping success at bait sets. Despite success in previous years, trapping at two other locations on the YKD (Kokechik Bay and the Tutakoke River) during this time also was ineffective.

We could not positively discern whether the foxes we observed in the removal area were occupying part of their original territory, expanding their territory size in response to removal of other foxes, or reoccupying the voids created by removal of foxes. Additional efforts to mark foxes before removal is neccessary to answer this question.

Effects of Fox Removal

Interpretation of the effects of fox removal was confounded by high microtine populations, variability in habitats and goose densities between and within the removal and check areas, and unchecked movements of unmarked foxes as mentioned above. Removing foxes had less effect on goose production than was observed in a brant colony near the Tutakoke River in 1986 and 1987 (Anthony and Youkey 1987, Flint and Anthony 1988). However, in the Manokinak River area, goose nests were more dispersed and the primary species--emperors, cacklers and white-fronts--defend their nests more aggressively than nesting brant. The relationship between observed predation rate and nest success in plots at each tower location for all species combined shows an inverse relationship as expected, but the rate of decrease is significantly lower for the removal area ($P = 0.036$) (Figure 3). This would occur if, given similar predation rates for individual foxes, fox removal were effective in reducing overall predation in the area by reducing numbers of foxes. The relatively high predation rates on duck eggs and low nesting success of ducks and eiders raises questions about relationships between arctic foxes and these species.

Small Mammal Abundance

Small mammals, principally tundra voles, have been increasing since 1986 based on observations at Kokechik Bay (Anthony et al. 1987, 1988;

Wotawa, pers. obs.) and other locations on the YKD (Stehn, 1987). Fox abundance was positively correlated to small mammal abundance elsewhere (Lack 1954, Chesemore 1968) and may be true of the YKD. The contents of fox stomachs we collected at Manokinak River indicated that small mammals were the primary prey before nesting by geese began. The relationship between small mammal abundance and nesting success of dark-bellied brent geese (*Branta bernicla bernicla*) and other tundra nesting birds in Europe has been considered (Summers 1986, Boyd 1987, Dhondt 1987, Owen 1987, Summers and Underhill 1987). Our previous work on the YKD suggests that abundance of small mammals directly or indirectly influences nest predation by foxes (Anthony et al. 1987, 1988).

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LITERATURE CITED

Anthony, R. M., P. E. Seiser, and M. A. Wotawa. 1988. Fox ecology in a coastal tundra habitat. U. S. Fish Wildl. Serv. Rep., Anchorage, Alaska. 12 pp.

______, P. E. Seiser, and M. A. Wotawa. 1987. Fox ecology in a coastal tundra habitat. U. S. Fish Wildl. Serv. Rep., Anchorage, Alaska. 22pp.

______, A. A. Stickney, and K. Kertell. 1986. Den ecology, distribution, and productivity of foxes at Kokechik Bay, Alaska. U. S. Fish Wildl. Serv. Rep., Anchorage, Alaska. 15 pp.

______ and D. E. Youkey. 1987. Effect of fox trapping on productivity of brant at Tutakoke River. U. S. Fish Wildl. Serv. Rep., Anchorage, Alaska. 33 pp.

Boyd, H. 1987. Do June temperatures affect the breeding success of dark-bellied brent geese? Bird Study 34: 155-159.

Chesemore, D. L. 1968. Distribution and movements of white foxes in northern and western Alaska. Can. J. Zool. 46:851-854.

Dhondt, A. A. 1987. Cycles of lemmings and brent geese *Branta b. bernicla*: a comment on the hypothesis of Roselaar and Summers. Bird Study 34: 151-154.

Eberhardt, L. E., R. A. Garrott, and W. C. Hanson. 1983. Den use by arctic foxes in northern Alaska. J. Mamm. 64:97-102.

Flint, P. L. and R. M. Anthony. 1988. Effect of fox control on productivity of brant at Tutakoke River in 1987. U. S. Fish Wildl. Serv. Rep., Anchorage, Alaska. 13 pp.

Johnson, D. H., A. B. Sargeant, and S. H. Allen. 1975. Fitting Richardson's curve to data of diverse origins. Growth 39: 315-330.

Lack, D. 1954. Symposium on cycles in animal populations. J. Wildl. Manage. 18:25-37.

Owen, M. 1987. Brent goose breeding and lemmings-a re-examination. Bird Study 34: 147-149.

Sargeant, A. B., S. H. Allen, and D. H. Johnson. 1981. Determination of age and whelping dates of live red fox pups. J. Wildl. Manage. 45: 760-765.

Sedinger, J. S. 1986. The status and biology of geese nesting at Tutakoke, 1986: a progress report. Unpubl. rep. Univ. of Alaska, Fairbanks.

SPSSx User's Guide. 1983. SPSS Inc. Chicago, IL. 806 pp.

Stehn, R. 1986. Sampling plan for estimating production of geese on the Yukon-Kuskokwim Delta. U. S. Fish and Wildl. Serv. Rep., Anchorage, Alaska. 11 pp.

______. 1987. Nesting success of geese in the coastal tundra region of the Yukon-Kuskokwim Delta. U. S. Fish Wildl. Serv. Rep., Anchorage, Alaska. 13 pp.

Storm, G. L. and K. P. Dauphin. 1965. A wire ferret for use in studies of foxes and skunks. J. Wildl. Manage. 29:625-626.

Summers, R. W. 1986. Breeding production of dark-bellied brent geese *Branta bernicla bernicla* in relation to lemming cycles. Bird Study 33: 105-108.

_____ and L. G. Underhill. 1987. Factors related to the breeding production of brent geese and waders on the Taimyr peninsula. Bird Study 34: 161-171.

Tande, G. F., and T. W. Jennings. 1986. Classification and mapping of tundra near Hazen Bay, Yukon Delta National Wildlife Refuge, Alaska. U. S. Fish Wildl. Serv. Rep., Anchorage, Alaska. 187 pp.

Whitney, P. 1976. Population ecology of two sympatric species of subarctic microtine rodents. Ecol. Monog. 46:85-104.

APPENDIX - MARKING FOXES IN 1988

Since 1985, while conducting other studies, we have fitted radio collars on foxes at Kokechik Bay, YKD and subsequently monitored their movements throughout the following winters. In 1988 we repeated this activity to maintain a consistent, long term data set on distribution, abundance, winter movements, and survival of arctic foxes. Additionally, we began developing methods to capture and mark arctic fox kits to determine dispersal and survival of this cohort.

Adults were captured with leghold traps and marked as previously described. Several approaches to capturing kits were tried. Kits were captured with leghold traps and with a remotely-triggered device that blocked den entrances once kits left their underground shelter. A "wire ferret" described by Storm and Dauphin (1965) also was used unsuccessfully to flush kits from dens. Kits were sexed, weighed, measured, marked with ear tags, and released into their den. Whelping dates were estimated with a growth curve for hind-foot length of kits (Johnson et al. 1975, Sargeant et al. 1981) modified for arctic foxes (Anthony et al. 1985).

We visited Kokechik Bay during spring (25 April - 6 May) and summer (6-18 July) to capture and mark arctic foxes. During spring, 2 female arctic and 3 red foxes (Vulpes vulpes) were captured (Table 1). One arctic fox was a recapture from 1987 that remained paired with its radio-collared mate from 1987 and subsequently denned at the same den. The second arctic fox also paired with an animal that was radio-collared in 1987--a male that was unpaired the previous year. Two red foxes were marked with ear tags but not with collars, and the third was shot in the trap by an unidentified party.

During the summer period, 3 female and 2 male adult arctic foxes were captured at 4 den sites and fitted with radio collars. One other died during trapping (Table 1). Also during the summer period 3, 4, and 6 kits were captured at 3 den sites at Kokechik Bay (Table 6, Figure 4). No red foxes were captured although one with silver-phase coloration was seen. In addition to foxes marked at Kokechik Bay, a pair of arctic foxes was fitted with radio collars and 1 kit was ear-tagged at a den along the Tutakoke River.

Estimated whelping dates ranged among litters from before 2 May to 30 May. Litter size varied from 4-9 kits. Two family groups changed dens, probably in response to our disturbance, though it is also a common natural occurance among foxes (Eberhardt et al. 1983, Anthony et al. 1986).

Padded leghold traps set at dens took 5 kits incidental to trapping adults but were not used specifically to capture kits because of high risk of injury to kits, a low rate of success, prolonged disturbance at dens, inefficency due to required continual monitoring of traps, and capture of only part of a litter. The "wire ferret" was used on 3 dens that contained at least 1 adult and kits, but only flushed an adult from its den. This device would probably work well when kits are older and foraging on their own but still returning to the den site. However, the method is labor-intensive requiring 2 people to operate the ferret and several others to capture kits with nets. The remotely-triggered trap worked well allowing us to capture 8 kits. It will be refined and used again in 1989.

Unlike the previous two years, in 1988 the Kokechik Bay area was occupied by several pairs of reproducing foxes and a large microtine population. To understand the dynamic and possibly cyclic nature of foxes and microtines and their effect on goose production on the YKD, efforts should continue to monitor the fox population and collect a long-term data base at Kokechik Bay.

Table 1. Measurements of adult arctic foxes fitted with radio collars at 3 locations on the Yukon-Kuskokwim Delta, Alaska in 1988.

Frequency (MHz)	Date	Den*	Sex	Weight (g)	Total Length (mm)	Tail Length (mm)	Hind Foot (mm)	Ear Notch (mm)	Neck (mm)
Manokinak River									
164.688	4-30	1	F	3190	605	250	140	55	200
164.495	6-6	1	M	3270	900	300	140	60	185
164.487	5-6	2	M	3430	910	320	145	56	-
164.512	6-7	2	F	4100**	880	300	135	57	175
164.638	6-26		M	3450	860	320	137	61	195
164.449	6-28		M	3150	990	340	142	61	175
Kokechik Bay									
164.714	5-1	A	F	3250	-	-	-	-	-
164.439	5-3	F	F	4450**	881	308	137	56	-
164.563	7-7	E	M	2700	940	305	130	57	170
166.762	7-8	D	F	3050	930	325	133	59	175
166.937	7-9	D	M	3350	910	335	136	61	180
166.988	7-13	C	F	3310	900	295	144	62	170
164.611	7-17	B	M	3750	920	310	147	68	185
Tutakoke River									
166.962	7-21	3	M	3200	860	290	145	57	195
166.738	7-21	3	F	2680	785	290	133	53	160

* Foxes with the same den code are paired.

** Parous female

Table 2. Fox observations made from 8 towers from 16 May - 29 June, 1988 at Manokinak River, Yukon-Kuskokwim Delta, Alaska.

Tower	No. Observation Days	Total No. Observations	No. Observation Hours	Fox Observation Hours	Percent Time Foxes Observed
R 1	9	8	17.9	6.4	36
R 2	9	7	18.6	4.5	24
R 3	10	6	20.2	4.9	24
R 4	9	8	16.6	2.7	16
Subtotal	37	29	73.3	18.6	25
C 1	11	11	23.5	5.8	25
C 2	10	5	19.3	1.5	7
C 3	10	22	19.3	9.6	50
C 4	10	8	20.0	3.5	17
Subtotal	41	46	82.2	20.4	25
Total	78	75	155.5	39.0	25

Table 3. Fox predation rates--items/hr of fox observation-- during observations from 16 May - 29 June 1988 in the removal (18.6 hr total) and check (20.4 hr total) areas at Manokinak River, Yukon-Kuskokwim Delta, Alaska.

Prey	Removal		Check		Total	
Eggs (Nests):						
Cacklers	.05	(.05)	-		.02	(.02)
Emperors	.16	(.05)	-		.08	(.02)
Unknown Geese	.11	(.05)	.39	(.10)	.26	(.08)
Ducks	.27	(.11)	.39	(.05)	.33	(.08)
Swans	.16	(.11)	-		.08	(.05)
Cranes	.05	(.05)	-		.02	(.02)
Gulls	.16	(.11)	.10	(.05)	.13	(.08)
Loons	-		.10	(.05)	.05	(.02)
Shorebirds	-		.10	(.05)	.05	(.02)
Unknown	.16	(.16)	.54	(.10)	.36	(.13)
All Birds	1.1	(.70)	1.6	(.54)	1.4	(.54)
All Geese	.32	(.16)	.54	(.10)	.36	(.13)
Small Mammals	.16		.10		.13	
Birds	.05		-		.02	
Recovered Caches	.11		.10		.10	
Unknown	.38		.10		.23	
All Prey	1.8		1.9		1.9	

Table 4. Percent nest success (number of nests) within 8 0.64-km^2 plots each in the fox removal and check areas at Manokinak River, Yukon-Kuskokwim Delta, Alaska in 1988.

Species	Removal		Check		Total	
Emperors	98	(60)	94	(55)	96	(115)
Cacklers	91	(58)	79	(39)	87	(97)
White-Fronts	98	(48)	78	(9)	95	(57)
Black Brant	71	(7)	0	(1)	62	(8)
Unknown Geese	0	(2)	40	(5)	29	(7)
All Geese	94	(175)	84	(109)	90	(284)
Swans	100	(7)	100	(11)	100	(18)
Cranes	100	(11)	100	(10)	100	(21)
Ducks	62	(8)	71	(7)	67	(15)
Eiders	78	(9)	70	(10)	74	(19)
Gulls	86	(14)	100	(7)	90	(21)
Loons	100	(6)	100	(2)	100	(8)
Other	100	(9)	50	(2)	91	(11)
Total	92	(239)	85	(158)	90	(397)

Table 5. Number of meters of small mammal sign (qualitative abundance scores[1]) intersected along 100-m transects examined from 20-29 May 1988 near 8 towers (see Figure 1 for locations) at Manokinak River, Yukon Kuskokwim Delta, Alaska.

	Check Area				Removal Area			
Transect No.	C1	C2	C3	C4	R1	R2	R3	R4
1	67 (145)	9 (27)	100 (300)	1 (2)	84 (197)	100 (308)	8 (17)	100 (398)
2	53 (95)	-	48 (147)	1 (1)	77 (165)	99 (213)	46 (175)	100 (385)
3	18 (52)	-	12 (30)	-	100 (346)	98 (242)	2 (3)	95 (340)
4	35 (103)	-	22 (65)	-	26 (77)	79 (143)	11 (27)	-
5	47 (134)	-	66 (234)	-	19 (55)	82 (148)	2 (4)	-
6	10 (28)	-	32 (82)	-	7 (17)	100 (305)	-	-
7	18 (45)	-	100 (295)	-	3 (9)	-	-	-
8	93 (293)	-	91 (246)	-	44 (142)	-	-	-
9	19 (48)	-	100 (292)	-	40 (107)	-	-	-
10	11 (39)	-	93 (231)	-	79 (292)	-	-	-
Total	371 (982)	9 (27)	664 (1922)	2 (3)	519 (1407)	558 (1359)	69 (226)	295 (1123)
Mean	37 (98)	9 (27)	66 (192)	1 (1)	48 (141)	93 (226)	14 (48)	98 (374)

[1]See text for description of methods.

Table 6. Measurements and estimated whelping dates of arctic fox kits captured on the Yukon-Kuskokwim Delta in July 1988.

Date	Sex	Weight (g)	Total Length (mm)	Tail Length (mm)	Hind Foot (mm)	Ear Notch (mm)	Neck (mm)
<u>Kokechik Bay, Den C</u>: Whelping Date - 12 May							
7-10	M	1070	515	114	100	45	150
7-10	F	1010	505	140	96	45	125
7-12	F	1110	560	170	101	48	135
7-13	F	1260	585	175	105	44	135
<u>Kokechik Bay, Den D</u>: Whelping Date - 30 May							
7-13	M	690	470	140	89	44	130
7-15	M	690	490	150	86	37	130
7-15	F	760	560	145	81	46	120
<u>Kokechik Bay, Den B</u>: Whelping Date - 13 May							
7-16	F	1430	560	195	108	48	145
7-16	M	1340	555	180	108	44	145
7-16	M	1490	570	185	108	52	160
7-16	F	1310	580	180	99	48	145
7-16	F	1310	595	190	107	49	140
7-17	F	1210	-	-	-	-	-
<u>Tutakoke River Den</u>: Whelping Date - before 2 May							
7-21	F	1550	710	240	125	470	145
7-21	F	1750	660	230	130	50	160

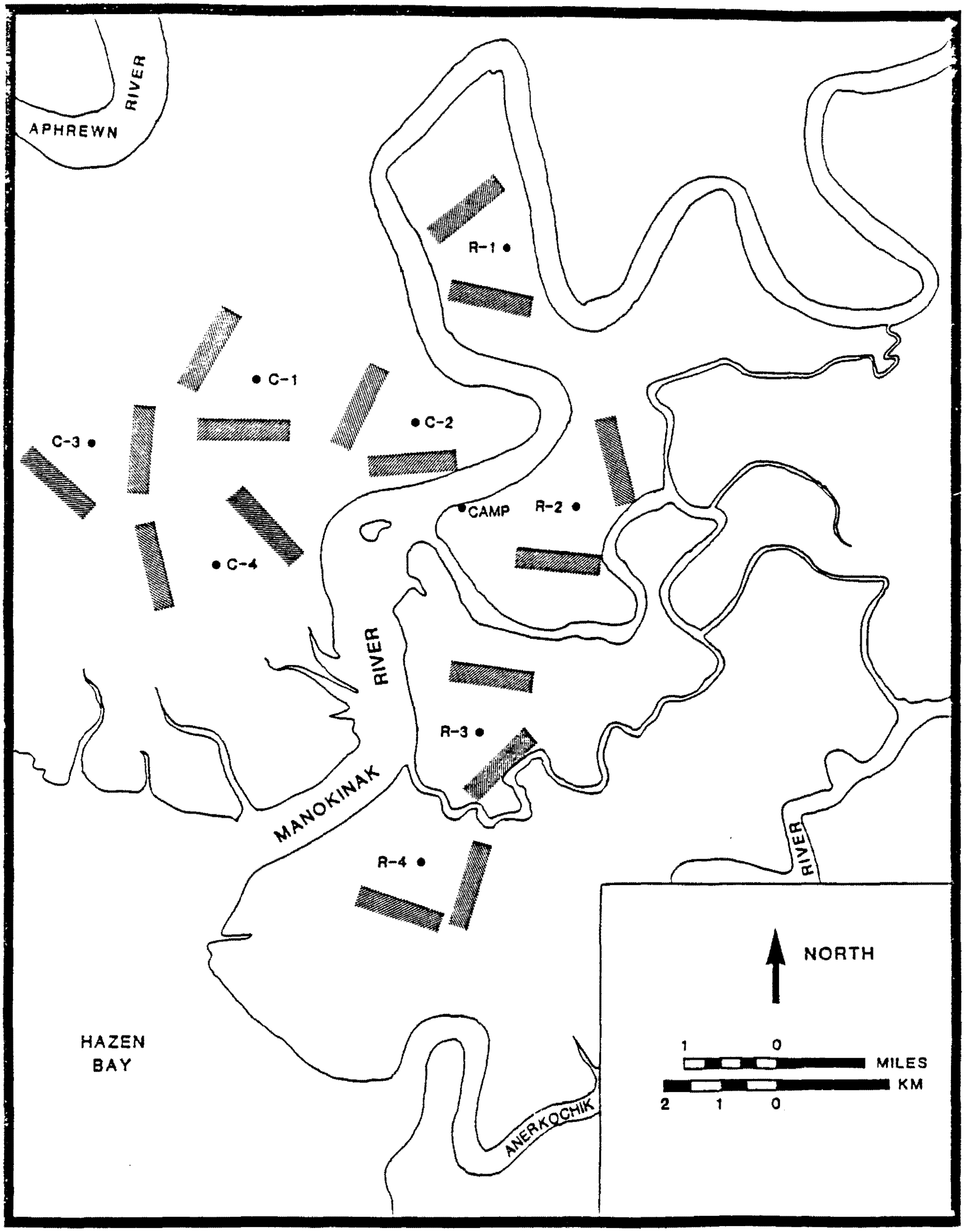

Figure 1. Locations of camp, observation towers, and goose nesting plots associated with arctic fox studies along the Manokinak River, Yukon-Kuskokwim Delta, Alaska in 1988.

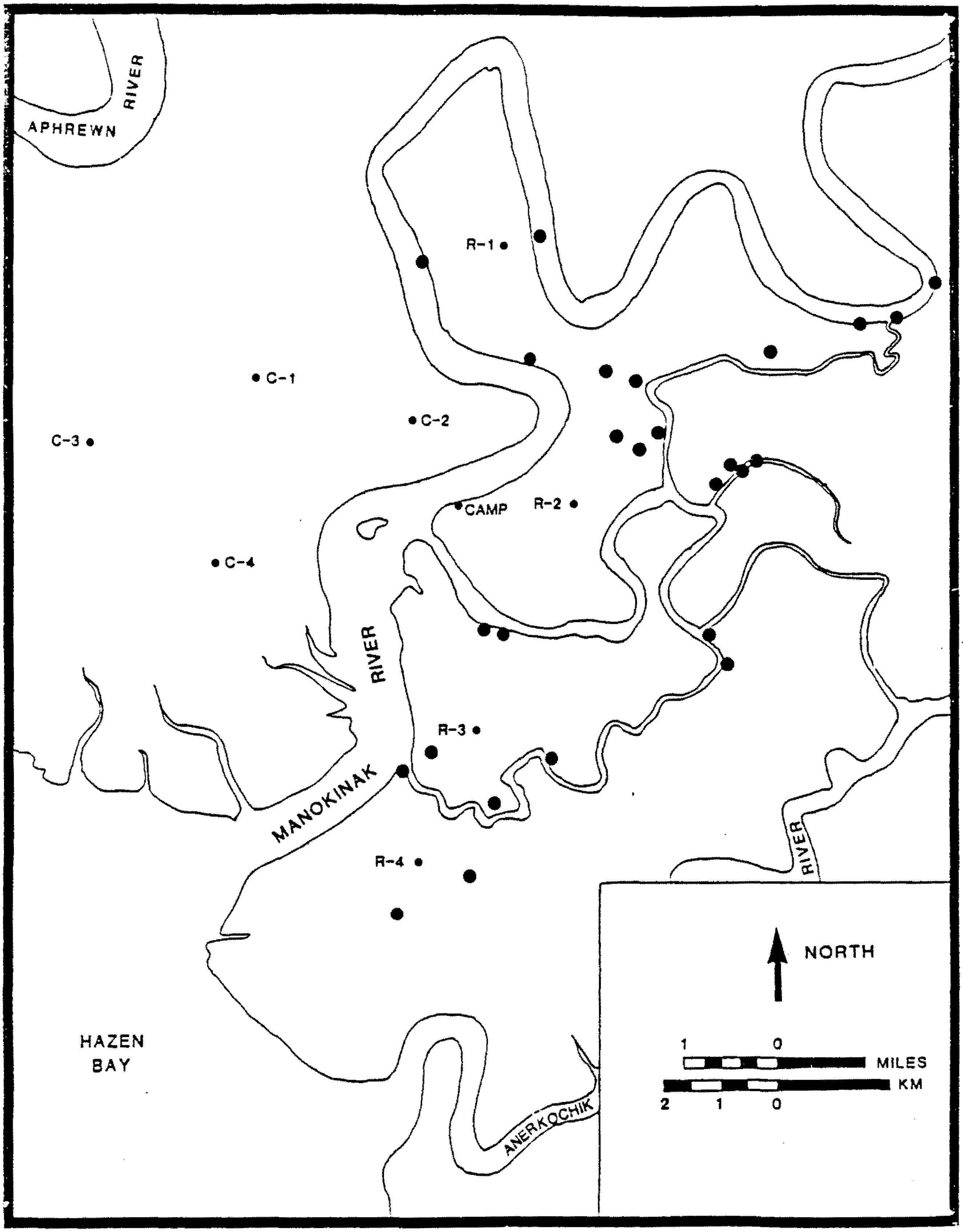

Figure 2. Locations of observation towers, camp, and 26 arctic foxes trapped or shot from 6-25 May 1988 in the removal area east of the Manokinak River, Yukon-Kuskokwim Delta, Alaska.

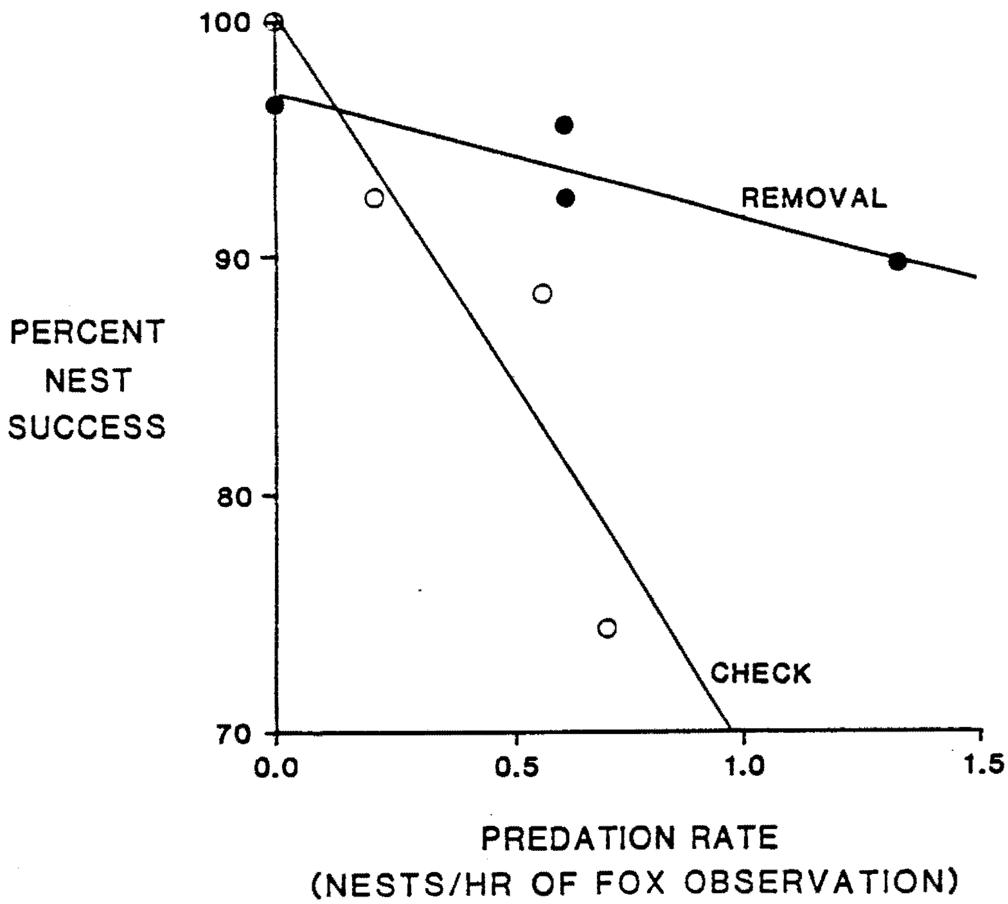

Figure 3. Regression of nest success on observed predation rate of all birds around 4 observation towers each in the removal and check areas along the Manokinak River, Yukon-Kuskokwim Delta, Alaska in 1988.

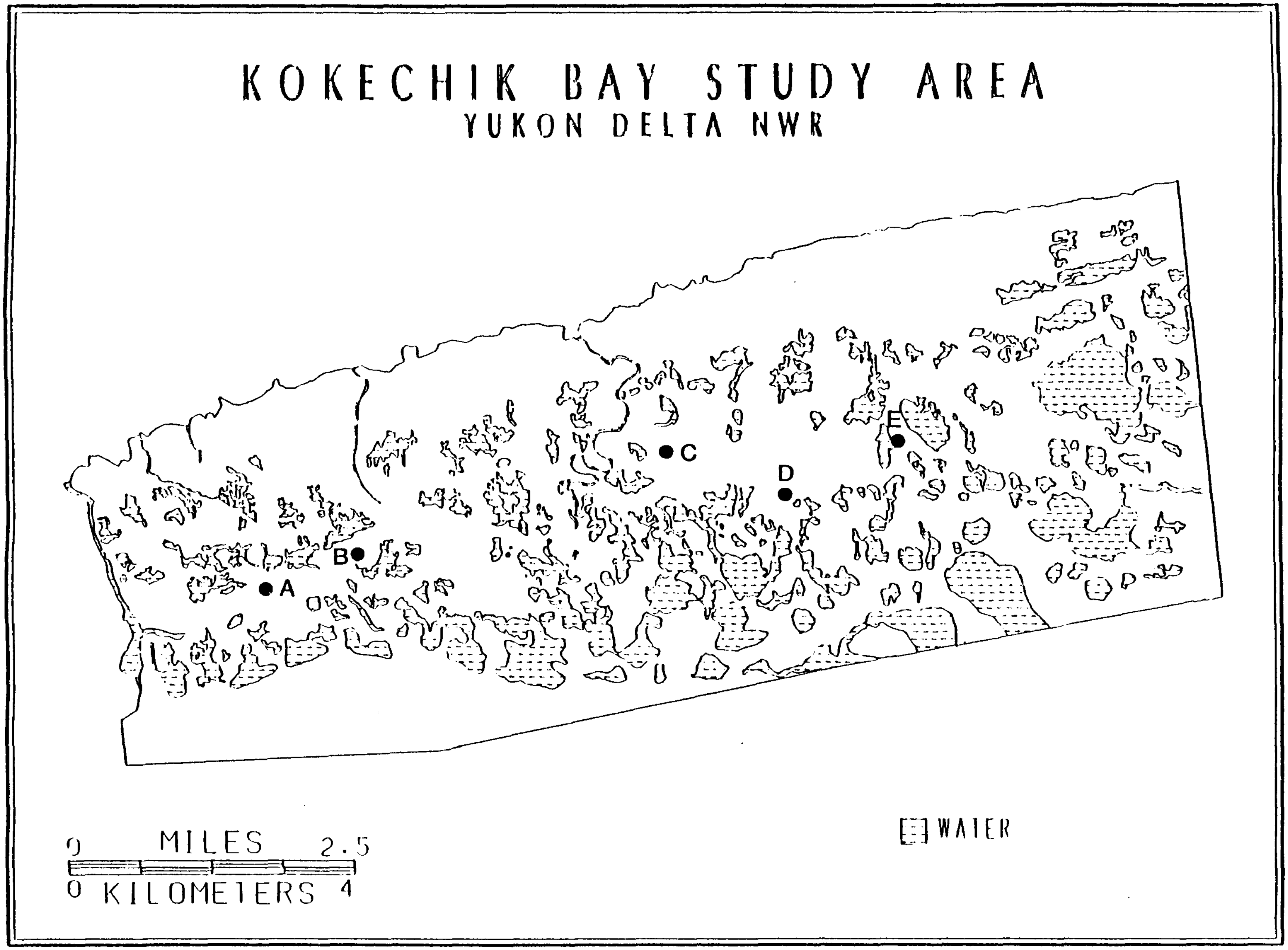

Figure 4. Locations of dens occupied by arctic foxes which were fitted with radio collars in 1988. Den "F" is located out of the study area by approximately 4.3 km to the east.