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Research Progress Report

DISTRIBUTION AND PRODUCTIVITY OF THE CENTRAL ARCTIC CARIBOU HERD IN RELATIONSHIP TO PETROLEUM DEVELOPMENT

by
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SUMMARY

In October 1987 and July, September, and October 1988, 38 radio-collared female caribou (Rangifer tarandus granti) from the Central Arctic (CAH) and Porcupine (PCH) Herds were captured and weighed; 24 of those females were captured at least twice. During late May and early June 1988, 40 radio-collared females, including most of the above, were relocated and observed on every other day; calving success (i.e., presence or absence of a calf) and parturiton date, where applicable, were determined for each female.

Body weights of parturient and nonparturient females did not differ significantly; however, these results are questionable, because capture activities during the previous fall appear to have interfered with breeding. Among parturient females, their calving dates in June 1988 were inversely correlated with their body weights in October 1987. Fall body weights of females that subsequently lost their calves within 48 hours of calving were lower than those for other maternal females, but the difference was not significant.

Between the fall of 1987 and the summer of 1988, rates of weight loss of pregnant/lactating and nonpregnant females (41 and 40 g/day, respectively) were nearly identical. However, between the summer and fall of 1988, rates of weight gain of lactating and nonlactating females differed significantly.

In 1988 radio-collared females in contact with oil development (i.e., west of the Sagavanirktok River) calved throughout the first 2 weeks of June ($n = 8$), whereas most (12 of 13) of those under disturbance-free conditions (i.e., east of the Sagavanirktok River) calved within the first 5 days of the month.

Supplemental reports summarize 1987-88 data on population status of the CAH, calving distribution and density, distribution and movements of caribou in relation to the Kuparuk oilfield complex, and the movements of collared caribou.

Key Words: body weight, calving, caribou, Central Arctic Herd, disturbance, lactation, nutrition, oilfield, parturition.

CONTENTS

BACKGROUND

The Central Arctic Herd (CAH) is a discrete subpopulation (Whitten and Cameron 1983a, Cameron et al. 1986) of about 18,000 caribou (Rangifer tarandus granti) (ADF&G, unpubl. data) that ranges the Arctic Slope between approximately the Colville and Canning Rivers. Seasonal movements are principally north and south between wintering areas in the northern foothills of the Brooks Range and calving grounds and summer range on the Arctic Coastal Plain (Cameron and Whitten 1979).

Pregnant females and some attendant short-yearlings move onto the coastal calving grounds in May; parturition occurs during the first 2 weeks of June. Although several concentrations are apparent, notably those near Milne Point and in the vicinity of the Canning Delta, in most years the majority of calving takes place over a wide area within about 50 km of the coast (Whitten and Cameron 1985).

Nonmaternal caribou arrive in coastal areas about 2 weeks after calving, and virtually the entire herd may be found there during the insect season, which extends from late June through early August. On warm, calm days when mosquitoes (Culcidae) and oestrid flies (Oestridae) are active, groups of caribou coalesce and move rapidly northward. Because the area within 1 km of the coast is typically cooler and windier than inland regions, it is less conducive to insect activity (White et al. 1975, Roby 1978, Dau 1986). During protracted periods of insect attack, large aggregations of caribou continue moving along the coast into the prevailing northeasterly winds. With a weather-induced decline in insect activity, the groups fragment and caribou drift inland to feed. These coastal-inland oscillations may occur frequently during midsummer, lasting for several successive days. By early August of most years, insect activity declines and CAH caribou disperse southward toward wintering areas.

Oilfield development increased dramatically in the immediate Prudhoe Bay area in the late 1970's, and additional production units have recently been established west of the Kuparuk River (Shideler 1986). These complexes alter the distribution and movements of many CAH caribou present in the coastal zone during the spring and summer. Parturient and postpartum females are particularly sensitive to disturbances and tend to avoid areas of structural complexity and human activity, resulting in reduced use of some calving habitats (Whitten and Cameron 1985, Dau and Cameron 1986). In addition, access to portions of summer range has been impaired, either through avoidance of disturbed areas (Cameron et al. 1979; Cameron and Whitten 1980; Smith and Cameron 1983; Whitten and Cameron 1983a, 1986) or because of the impediments to movement posed by roads and pipelines (Smith and Cameron 1985a, 1985b; Curatolo and Murphy 1986).

To date, losses of CAH calving habitat have been limited to localized displacement from the industrial complexes near Prudhoe Bay and west of the Kuparuk River, and it appears that sufficient calving sites remain available to parturient females; indeed, the CAH has continued to grow as petroleum development has occurred within its range (Whitten and Cameron 1983b, 1985). However, because of the potential for extensive development on state lands within the central Arctic region, continued expansion of industrial activity appears likely. Large-scale losses of calving habitat, as well as the possibility of major impacts on CAH productivity, might then occur (Cameron 1983).

The various concerns regarding reduced access to preferred calving grounds are predicated on the assumption that such areas confer some advantage. The very fact that calving locations are relatively constant over time (Lent 1966a, Kelsall 1968, Skoog 1968, Hemming 1971, Fleck and Gunn 1982, Whitten and Cameron 1985, Cameron et al. 1986, Garner and Reynolds 1986, Gunn and Miller 1986) strongly suggests a long-term net benefit. Beyond the implications of traditional use per se, calving grounds tend to be relatively free of predators (Bergerud 1974, 1978, 1983, 1985), are characterized by locally advanced forage phenology (Lent 1966b, 1980; Kuropat 1984; Kuropat and Bryant 1980), and/or provide ready access to insect relief habitat (Kelsall 1968, Skoog 1968, Garner and Reynolds 1986). Given these attributes and, by inference, a survival advantage to calves, it seems more than reasonable to ensure that traditional calving grounds remain available to parturient females (Elison et al. 1986).

Likewise, insect-induced movements during midsummer probably yield a net benefit to CAH caribou. The energy cost of moving to coastal areas, where insects are less active, is presumably offset by the energy savings associated with reduced harassment; an abatement of insect attack is accompanied by a prompt return to preferred feeding areas inland. Overall, these movements are believed to reduce energy expenditure, enhance feeding and nursing opportunities, and thereby maximize energy retention (Bergerud 1974, White et al. 1975, Roby 1978, Dau 1986, Downes et al. 1986). Maintaining free access of caribou to insect relief and feeding habitats is therefore highly desirable.

It is generally acknowledged that the use of diverse habitats during the annual cycle is important to the general well-being of Rangifer, and the success of growth and fattening in summer is crucial to individual performance and, hence, herd productivity. The body condition of caribou entering the fall season may influence conception rates, gestation time, calf birth weights, and subsequent survival of calves and adults (Dauphiné 1976; Haukioja and Salovaara 1978; Skogland and Mølmen 1980; Thomas 1982; Reimers 1983a,b,c; Reimers et al. 1983; Skogland 1983a,b 1986).

This study has 2 major components: (1) a case history assessment of Central Arctic Herd population status and distribution in relation to oilfield development and (2) a specific investigation of the influence of female body condition on reproductive performance. The former is a straightforward monitoring program, while the latter involves clarifying the relationships linking body weight/composition of females with calf production and survival.

Together with ongoing complementary studies concerning the distribution and quality of various habitats (U.S. Fish and Wildlife Service), energy balance, and body composition (University of Alaska, U.S. Fish and Wildlife Service) and with the aid of pertinent data in the existing literature, we should be better equipped to trace the influence of habitat quality on the nutrition, growth and fattening, and reproductive potential of female caribou. By incorporating these relationships in a computer simulation model, one can then project the consequences to the population of a disturbance-induced change in habitat use.

OBJECTIVES

To monitor the size, productivity, and seasonal distribution and movements of the CAH.

To determine the effects of oil development on the distribution and movements of CAH caribou.

To characterize the relationships between the body condition and reproductive performance of female caribou.

a. H_o: Pregnancy and parturition rates are independent of body condition during the previous fall.

b. H_o: Calving date is independent of body condition during the previous fall and/or winter.

c. H_o: Calf survival is unrelated to maternal condition prior to parturition.

To determine seasonal changes in body condition of pregnant/lactating vs. nonreproductive female caribou.

a. H_o: Pregnancy and lactation have no effect on condition.

To compare the body condition and reproductive performance of CAH female caribou in close association with oil development with the status of those under disturbance-free conditions.

a. H_o: The variance in body condition and reproductive performance (i.e., pregnancy and parturition rates, calving date, and calf survival) is independent of exposure to oil development.

Recent progress in addressing the first 2 objectives is described in supplemental reports (Appendix A; Golden and Smith 1989) that summarize CAH productivity and harvest information, the results of helicopter surveys of the CAH calving grounds, road survey observations of caribou within the Kuparuk oilfield complex, and selected data on the distribution and movements of caribou equipped with conventional and satellite radio transmitters. This report pertains to the last 3 objectives, emphasizing data on the body condition and reproductive performance of radio-collared female caribou.

METHODS

On 24-28 October 1987, 2-4 July 1988, and 23 September-3 October 1988, we captured 29 adult CAH female caribou a total of 58 times. On 8-22 October 1987, 11 April 1988, and

23-26 September 1988, an additional 9 females from the Porcupine Caribou Herd (PCH) were captured 14 times. Of those 38 females, 24 were captured at least twice (Appendix B).

All caribou were darted from a helicopter with 7 mg of M99 (etorphine hydrochloride, Lemmon Co., Sellersville, PA) or Wildnil (carfentanil, Wildlife Lab., Fort Collins, CO) and later revived with intravenous and/or intramuscular injections with 14 mg M50-50 (diprenorphine hydrochloride, Lemmon Co., Sellersville, PA) or 150 mg of Naloxone (naloxene hydrochloride, Wildlife Lab., Fort Collins, CO). Each female was weighed with a net and spring scale suspended from a bar or tripod, blood (10-20 ml) was withdrawn by jugular venipuncture, and various body measurements were taken. Conventional FM or satellite radio collars with numbered neck bands were deployed or replaced as necessary.

During the period 29 May through 15 June 1988, 40 radio-collared CAH and PCH females were each relocated an average of 6 times (range, 2-9), or approximately every other day, using standard tracking methods by fixed-wing aircraft (Whitten and Cameron 1983a, Cameron et al. 1986). Data recorded for each sighting included the following: date and time, location (map point or LORAN coordinates), group size and gross composition, presence or absence of a calf at heel, and whether or not hard antlers had been retained. For cows without calves, an attempt was made to discern the presence or absence of a distended udder. Parturient cows were identified on the basis of antler retention and udder distension patterns, and calving dates were estimated (generally within 2 days) from successive observations. To document perinatal (i.e., early postnatal) mortality, most (all but 3) radio-collared females were relocated at least once within 3 days after they were first observed with a calf.

Body weights, rates of weight change, parturition rates, and calving dates were compared using Student's t-tests, chi-square analysis, and Spearman's rank correlation. Alpha levels <0.1 were considered statistically significant.

RESULTS AND DISCUSSION

Body Condition vs. Reproductive Performance

Parturition rate:

Of the 31 radio-collared CAH females that were tracked and relocated repeatedly in June 1988, 14 had been captured and weighed in October 1987. An additional 9 radio-collared PCH females of known reproductive status had also been weighed during the previous fall (Appendix B). Mean body weights of parturient and nonparturient females (Table 1) did not differ significantly (t-test, $\underline{P} > 0.2$) either within herds or for the combined data.

It appears that the timing of fall capture activities in the CAH may have interfered with the reproductive process, because the parturition rate of females handled previously (60%) was significantly lower (chi-square, 1 df, $\underline{P} < 0.001$)) than that of unhandled females (93%). Perhaps the stresses associated with pursuit, immobilization, and/or recovery during or immediately following the rut prevented some females from breeding successfully. In any case, this apparent bias, together with the small sample size, precludes an assessment of the relationship between parturition rate and fall body weight. The change in timing of fall capture to early October should minimize the potential for future complications.

Calving date:

Fourteen of 16 parturient CAH and PCH females that had been weighed in October 1987 were observed with sufficient frequency in June 1988 to obtain reasonable estimates of calving dates. Although the data set is small and highly variable, an inspection of the plot of calving dates against body weights (Fig. 1) reveals a weak inverse relationship; indeed, the 2 variables are significantly and negatively correlated (Spearman's rank, $\underline{n} = 14$, $0.1 > \underline{P} > 0.05$). Thus heavier females (i.e., presumably those in superior condition) tend to calve earlier, an observation consistent with much of the literature on reindeer (Reimers 1983a; Reimers et al. 1983; Skogland 1983b, 1984a).

Calf survival:

In June 1988, 5 instances of perinatal calf mortalty (3 CAH, 2 PCH) were detected among 16 females captured and weighed during the previous fall. Mean body weight of females that had lost their calves (87 kg) was lower than for other maternal females (92 kg), but the difference was not significant (t-test, 14 df, $\underline{P} > 0.1$). Possibly, the incidence of early postnatal mortality is more a function of female condition immediately before calving than of condition at conception. Skogland (1984a) concluded that undernutrition during gestation depresses fetal growth, birth weight, and offspring survival.

<u>Effects of Pregnancy and Lactation on Body Condition</u>

Body weights were obtained for 12 radio-collared females in October 1987 and July 1988 and for 15 females in July, September, and October 1988 (Appendix B). Comparisons of weight gain and loss between reproductively active and nonreproductive females permit a preliminary assessment of the costs of pregnancy and lactation.

Between fall and summer, the body weight loss for both pregnant/lactating and nonpregnant females averaged 10 kg (Table 2). The respective mean rates of weight loss of 41 and 40 g/day were not significantly different (t-test, 10 df, $P > 0.2$), indicating that gestation and early lactation had no net influence on body weight. This was unexpected, considering the substantial metabolic requirements of reproductive processes. Three possible explanations come to mind: (1) nonrepresentative samples of one or both reproductive categories of females; (2) compensatory feeding by pregnant/lactating females (Skogland 1984b); and (3) differential changes in body composition, despite similar body weight trajectories; i.e., a higher total body water content and therefore a lower protein and/or fat content among reproductive than among nonreproductive females (Cameron et al. 1975, Fancy 1986). Further study will be required to properly quantify these changes and assess their importance.

In contrast, the body weight trends of lactating and nonlactating females were distinctly different between midsummer and fall. During this approximate 90-day period, lactating females gained a mean of 11 kg, compared with 16 kg for nonlactating females (Table 2); the respective mean rates of 126 and 173 g/day differed significantly (t-test, 13 df, $0.1 > P > 0.05$). This indicates that mid- to late lactation, on average, reduced summer weight gain by 47 g/day. Put another way, the forage nutrients diverted daily to milk production were equivalent to an amount that otherwise would have been deposited as 47 g of body fat and protein (assuming no change in the body water percentage). Clearly, maternal females enter the winter at a relative disadvantage. Whether or not compensatory feeding occurs during the winter is unknown, but we hope to address the question through additional sampling in late spring.

Effects of Disturbance on Body Condition and Reproductive Performance

Data on body weight and calf survival are insufficient to evaluate the performance of females in contact with oil development (i.e., west of the Sagavanirktok River) vs. those under disturbance-free conditions (i.e., east of the Sagavanirktok River). Also, because of the possibility of capture-related effects on 1987 breeding success (*see* above), any analysis of east-west differences in parturition rate would be unreliable; however, comparative calving dates are available for 21 radio-collared females tracked within the 2 areas. On the east side, most (12 of 13) females calved within approximately the first 5 days of June, whereas calving to the west was distributed over the entire first half of the month (Table 3). This may be a reflection of different body weights among females sampled on the west and east (means: 85 and 93 kg, respectively; t-test, 6 df, $0.05 > \underline{P} > 0.02$), given the apparent influence of body weight on calving date (Fig. 1).

Thus far, the data base is small, and few inferences can be made beyond the identification of broad trends. Samples must be sufficiently large and reasonably representative of females in each area before the effects of oil development can be evaluated with confidence. Even then, caution must be exercised. One must be alert for disturbance-unrelated changes that may distort the results.

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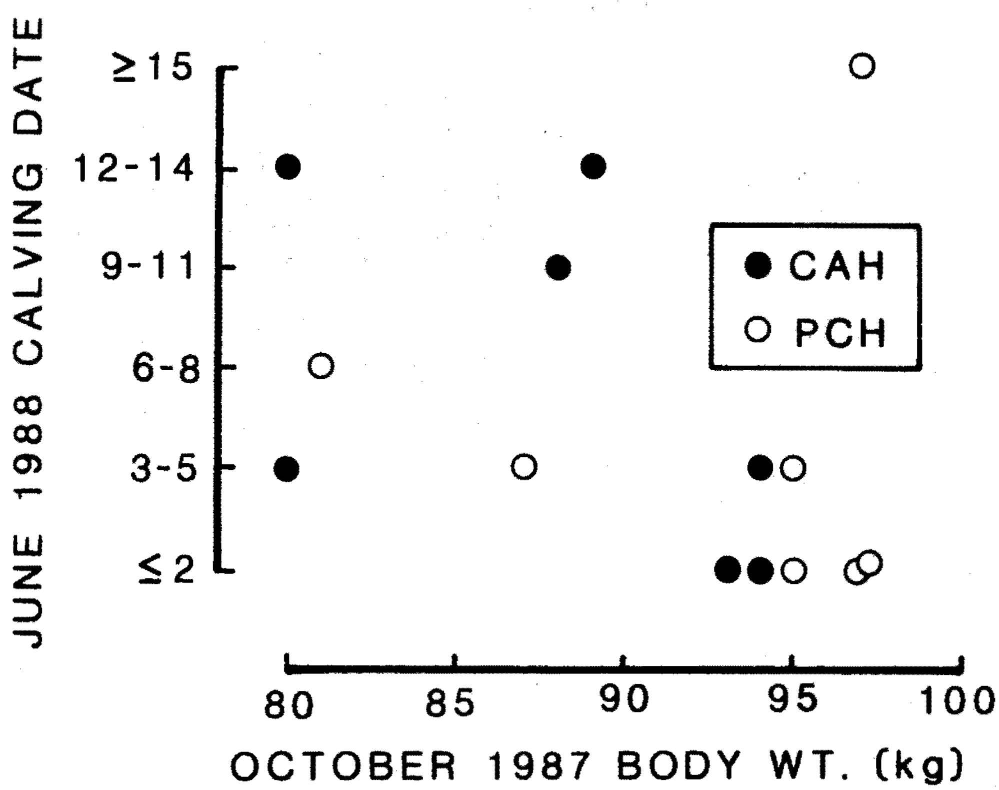

Fig. 1. Plot of June 1988 calving date against October 1987 body weight for female caribou, Central Arctic Herd (CAH) and Porcupine Herd (PCH).

Table 1. Comparative mean (±SD) body weights of radio-collared parturient and nonparturient female caribou. Central Arctic Herd (CAH), 24-28 October 1987, and Porcupine Herd (PCH), 8-22 October 1987.

Herd	Parturient[a]		Non-parturient[a]	
	Body weight (kg)	*n*	Body weight (kg)	*n*
CAH	89 (±6)	8	91 (±10)	6
PCH	92 (±6)	8	92 (±0)	1
All	90 (±6)	16	91 (±9)	7

[a] Based on observations in June 1988.

Table 2. Changes in mean (±SD) body weight of radio-collared female caribou based on serial (paired) determinations: effects of pregnancy and lactation. Central Arctic Herd, October 1987-October 1988.

	Body weight (kg)			g/day	n
Date[a]:	10/26/87	7/4/88	Change		
Pregnant/lactating	90(±5)	80(±9)	-10(±6)	-41(±22)	6
Nonpregnant	91(±10)	81(±7)	-10(±3)	-40(±14)	6
Date[a]:	7/4/88	10/1/88	Change		
Lactating	78(±8)	89(±9)	+11(±3)	+126(±35)	8
Nonlactating	81(±7)	97(±7)	+16(±5)	+173(±52)	7

[a] Mean date of capture.

Table 3. Calving dates of radio-collared female caribou, Central Arctic Herd, June 1988.

Calving location[a]	Dates:	No. of females calving ≤6/2	6/3-5	6/6-8	6/9-11	6/12-14	≥6/15
West of Sagavanirktok River		2	1	2	2	1	0
East of Sagavanirktok River		6	6	0	0	1	0
All		8	7	2	2	2	0

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APPENDIX A

DISTRIBUTION AND MOVEMENTS OF CARIBOU IN RELATION TO PETROLEUM DEVELOPMENT

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Alaska Department of Fish and Game

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STUDY AREA

The study area lies in the northern portion of Subunit 26B between the Canning and Colville Rivers; i.e., approximately 69°45' north latitude (Fig. 1). This region is within the Arctic Coastal Plain physiographic province (Wahrhaftig 1965), a low, poorly drained area of numerous thaw lakes. The Dalton Highway and associated Trans-Alaska Pipeline extend southward along the Sagavanirktok River from the Prudhoe Bay Oilfield.

The Kuparuk Development Area (KDA), approximately 50 km west of Prudhoe Bay, is linked to the Prudhoe Bay Oilfield by a 32-km extension of the Spine Road (SR) (Fig. 2) that was built in the winter of 1977-78. By 1980-81, a construction camp, permanent office/living quarters, oil/gas processing facilities, and an airport were in place at ARCO's Central Processing Facilities (CPF-1) pad. Also in 1980-81, the Kuparuk Pipeline was constructed between CPF-1 and the origin of the Trans-Alaska Pipeline, 40 km to the east. Recent additions to the regional oilfield infrastructure include Conoco's Milne Point Pipeline and production facility, a pipeline/road system from CPF-1 to Oliktok Point, and the CPF-2 and CPF-3 production networks.

BACKGROUND

The Central Arctic Herd (CAH) is a discrete subpopulation (Whitten and Cameron 1983, Cameron et al. 1986) of about 18,000 caribou (Rangifer tarandus granti) that ranges the Arctic Slope between the Colville and Canning Rivers (Fig. 1). Seasonal movements are principally north and south between wintering areas in the northern foothills of the Brooks Range and calving grounds/summer range on the Arctic Coastal Plain (Cameron and Whitten 1979).

Pregnant females and some attendant short yearlings move onto the coastal calving grounds in May; calving occurs during the first 2 weeks of June. Typically, the majority of calving occurs over a broad area within 50 km of the coast, although several concentrations are apparent, notably those near Milne Point and in the vicinity of the Canning Delta (Whitten and Cameron 1985).

Most nonmaternal caribou arrive in coastal areas about 2 weeks after calving, and virtually the entire herd may be found there during the insect season, which extends from late June through mid-August. On warm, calm days when mosquitoes (Culicidae) and oestrid flies (Oestridae) are active, groups of caribou coalesce and move rapidly northward. The area within 1 km of the coast is typically cooler and windier than inland regions and therefore less conducive to insect activity (White et al. 1975, Roby 1978, Dau 1986). During protracted periods of insect attack, large aggregations of caribou continue moving along the coast into the prevailing northeasterly winds. With a weather-induced decline in insect activity, the groups fragment and caribou move inland to feed. These coastal-inland oscillations may occur frequently during midsummer, occasionally lasting for several successive days. By mid- to late August, insect activity declines and CAH caribou disperse inland toward wintering areas.

Oilfields and other development complexes in the Prudhoe Bay area alter the distribution and movement of many CAH caribou present in the coastal zone during spring and summer. Parturient and postpartum females are particularly sensitive to disturbance and tend to avoid areas of structural complexity and human activity, resulting in local losses of CAH calving habitat (Whitten and Cameron 1985, Dau and Cameron 1986). In addition, access to portions of summer range has been impaired, either through avoidance of disturbed areas (Smith and Cameron 1983, Whitten and Cameron 1983) or because of the impediments to movement posed by roads and pipelines (Smith and Cameron 1985a, 1985b; Curatolo and Murphy 1986).

Studies of CAH calving distribution and summer movements in relation to industrial development were initiated in 1978. This report summarizes results of continued surveys conducted in late spring and summer 1988.

STUDY OBJECTIVES

To monitor the calving distribution and initial calf production of the CAH.

To describe the late spring and summer distribution and movements of CAH caribou in the Colville/Kuparuk region.

To determine the distribution and movements of CAH caribou in relation to the existing KDA road/pipeline network during calving and midsummer.

The above information will provide the basis for recommendations to the oil industry and state and federal regulatory agencies on development activity in the region so as to minimize conflicts with CAH caribou.

METHODS

On 10-15 June 1988 low-level helicopter surveys were conducted between the Colville and Canning Rivers (Cameron et al. 1985, Whitten and Cameron 1985, Dau and Cameron 1986). Caribou were counted and classified within 26 north-south transect strips; each one was 3.2 km (2 mi) wide, extending 35-73 km (56-117 mi) inland (Fig. 3). All locations were recorded on 1:63,360 USGS topographic maps; geographic coordinates were generated using an Altek digitizing table connected to a COMPAC portable and, together with the group composition data, entered on computer discs compatible with IBM PC hardware. Data on caribou distribution and density were plotted on digitized base maps.

During the periods 25 May-15 June and 28 June-31 July, systematic transect surveys were conducted once daily along the SR, Oliktok Road (OR), and Milne Point Road (MPR) (Fig. 2) (Smith and Cameron 1985a, 1986). The SR/OR survey began on the east bank of the Kuparuk floodplain (km 0.0) and terminated at Oliktok Point (km 56.0); important reference points along the transect are MPR junction, 19.2 km; CPF-1, 29.3 km; and CPF-3, 42.6 km. Surveys along the MPR extended from its origin at the SR to Conoco's northernmost well pad. One driver/observer surveyed each area by light truck at speeds ≤50 km/hr. When caribou were sighted, the vehicle was stopped at a point approximately perpendicular to the group and caribou were observed using binoculars or a spotting scope. The following criteria were recorded for each group: (1) date and time, (2) location (distance from known point), (3) observation distance, (4) group size, (5) direction of movement, (6) sex and age composition (nos. of bulls, cows, yearlings, calves, adults, unknown), (7) location of any road and/or piepeline crossing, and (8) number and composition of caribou that crossed.

In conjunction with other CAH studies, about 35 radio-collared female caribou were repeatedly tracked and relocated during June and July 1988 using standard techniques (Whitten and Cameron 1983, Cameron et al. 1986). Locations were digitized and displayed using procedures similar to those previously described.

On 24-27 October 1987, 5 adult female caribou were equipped with satellite transmitters and conventional VHF transmitters (Fancy et al. 1989). Location data were received by 2 Tiros-N series weather satellites in sun-synchronous, near-polar orbits and sent to processing centers in Alaska, Maryland, and France. Locations were obtained from the U.S. Fish and Wildlife Service (i.e., Fish and Wildlife Research Center, Fairbanks, Alaska) and depicted on base maps using an HP 7475A plotter.

RESULTS AND DISCUSSION

Aerial transect surveys (10-15 June)

During the period 10 to 15 June, northern portions of the survey area were mostly snow-covered, while the southernmost areas were snow-free. We counted and classified 4,892 caribou; the overall calf:cow ratio was 67:100 (Table 1), which is within the range of 56-91 calves:100 cows observed for the CAH between 1978 and 1986 (Cameron et al. 1988). Calf:cow ratios for the eastern (transects 11-20) and western (transects 3-10) portions of the study area were virtually identical: 66 calves:100 cows and 67 calves:100 cows, respectively.

The distribution of caribou during the calving period was similar to that observed in 1987 (Lawhead and Cameron 1988), with concentrations south of Bullen Point and southwest of the Kuparuk Oilfield (Fig. 4). Essentially no caribou were seen in the central portion of the study area, an apparent avoidance of the Dalton Highway and the road system within the Prudhoe Bay industrial complex. In the KDA, relatively few calves were within transect segments near roads (Fig. 5), an observation consistent with the avoidance response reported previously (Dau and Cameron 1986).

Road Surveys (25 May-15 June)

During 12 road surveys along the SR and OR, we observed 1,910 caribou in 492 groups (Table 2). When 1988 data were compared with those reported for 1981-85 (Smith and Cameron 1986), we noted the following:

1. The overall sighting rate was higher: 2.84 caribou/km vs. the earlier range of 0.78-1.52/km. More caribou per km were seen within 1,000 and 2,000 m of the road: 2.37 and 2.71, respectively, vs. the previous ranges of 0.23-0.74 and 0.42-1.22, respectively.

2. The mean group size of 3.9 fell within the previous range of 2.6-5.6.

3. The overall calf percentage of 1.9 was at the low end of the previous range of 1.2-7.4.

4. As in recent years, relatively more caribou were present along the OR than along the SR.

5. Twenty-three caribou were observed crossing roads and/or pipelines, compared with a previous range of 4-142.

In general, we observed more caribou closer to the road system but with fewer calves than in 1981-85. Caribou were numerous in the middle of the SR/OR transect near the main Kuparuk Complex (CPF-1), but these groups contained few calves (Fig. 6). Most caribou were feeding in the dust shadow created by the traffic and activities near CPF-1. As in previous years, small bull bands were most numerous near Oliktok Point and CPF-1.

Similarly, few caribou and relatively few calves were seen along the MPR (Table 3), even though there was little traffic or maintenance activity. Clearly, female caribou with calves continue to avoid the road transect during calving (Dau and Cameron 1986).

Radio-collared Caribou (2-14 June)

Sixteen radio-collared cows west of the Kuparuk River were located every other day from 2 June through 14 June (mean = 7 locations per caribou). By the end of the period, 9 of 17 (53%) had produced calves, one of which died of unknown causes within 24 hours of birth. Mean birth date was 7 June.

An inspection of the comparative distribution of females with and without calves reveals a tendency for the latter to be closer to the Kuparuk road system (Fig. 7). We are in the process of developing a procedure that will allow a statistical evaluation of the relative willingness of caribou to approach and cross oilfield structures.

Using area-wide survey results (i.e., 67 calves:100 cows) as a base, a comparison of calf production among radio-collared females west of the Kuparuk River with sex and age data from helicopter surveys in the vicinity of the KDA (transects 3.0-10.0, Fig. 3) indicates that radio-collared caribou had fewer calves at heel at the end of the calving period (53%) than expected. In contrast, all 14 radio-collared CAH cows east of the Sagavanirktok River had calves at heel by 14 June. It should be noted, however, that most of the radio-collared females in the Kuparuk area had been captured during the previous October, which may have reduced reproductive success.

Satellite-collared Caribou (1 May-30 June)

Female caribou OB 65, OB 66, and OB 67 were collared within 5 km of the Kuparuk road system; BY 32 was collared near the mouth of the Toolik River; and OB 62 was captured near the Dalton Highway, 150 km south of Prudhoe Bay. All had been captured in late October 1987. By late spring 1988, OB 65, OB 66, OB 67, and BY 32 had returned to the vicinity of the Kuparuk Oilfield (Figs. 8, 9, and 10; BY 32 not shown). OB 62 moved 200 km west and remained west of the Colville River for the summer. The satellite transmitter on BY 32 failed in early June.

During May, OB 65 remained about 50 km south of the coast. She calved 25 km south of the road system on 10 June and then moved to within a few kilometers of the coast by the end of June (Fig. 8).

OB 66 remained just south of the Spine Road during May. In early June, she moved north along the Oliktok Road and then east to the Milne Point calving area where she gave birth on 7 June. She stayed in this general area until late June and then moved to the coast near Oliktok Point (Fig. 9).

OB 67 spent early May in the southwest portion of the Kuparuk Oilfield, moved east of the Oliktok Road in mid-May, and stayed south of the Spine Road for most of June (Fig. 10). She did not produce a calf.

During the calving period, the daily distances traveled by satellite-collared females were more variable than those during either the precalving or postcalving periods (Table 4). Additionally, there were no consistent differences between the collared cow without a calf (OB 67) and those with calves (OB 65, OB 66).

<u>Road Surveys (28 June-31 July)</u>

During 26 road surveys along the SR and OR, we observed 23,916 caribou in 563 groups (Table 2). We noted the following trends when comparing these data with those obtained in 1981-85 (Smith and Cameron 1986):

1. The overall sighting rate was higher: 16.4 caribou/km vs. the earlier range of 4.58-13.32. More caribou per km were seen within 1,000 m and 2,000 m of the road: 12.3 and 15.8, respectively, vs. the previous ranges of 1.90-7.12 and 3.37-10.05, respectively.

2. The mean group size of 42.5 caribou was higher than the previous range of 16.9-33.5.

3. The overall calf percentage of 21.1 was within the previous range of 16.2-23.2.

4. As in recent years, relatively more caribou were sighted along the OR portion of the survey.

5. A total of 14,655 caribou were seen crossing roads and/or pipelines, compared with the previous range of 1,078-12,430.

As in recent summers, most caribou were seen near the Kuparuk River and Oliktok Point (Fig. 11). Relatively few calves were seen in the Kuparuk floodplain, and fewer total caribou, with a lower calf percentage, were seen near km 10.0. Although this may be in response to construction of SAPCO's new West Eileen Unit south of the SR between mile points 7.7 and 10.4, it is more likely due to an overall change in local distribution of caribou that we observed in 1988. That change involves the relative number of sightings along the SR and OR on insect days. In summer 1988 we saw 16,650 caribou under moderate-to-severe insect harassment (Table 2). If we include survey records on 6 July, when caribou were staging east of CPF-1 after the 1st appearance of significant numbers of mosquitoes, then more than 80% of our observations were insect-related. In 1984 and 1985, years of comparable insect conditions, 29.4% and 41.6% of all caribou were seen under insect harassment conditions. This indicates that in 1988, unlike 1984 and 1985, caribou moved away from the road system after insect harassment ceased.

As in previous years, most caribou crossed the road transect at its extremes, near the Kuparuk River and Oliktok Point (Fig. 12), and more than 98% of the crossings were observed under insect harassment. Road/pipeline crossing success by large groups (>100 individuals) increased markedly in 1988, relative to earlier observations (Smith and Cameron 1985a, 1985b; Smith and Cameron 1986). Fourteen of 16 large groups and 83.5% of 10,106 individual caribou in these groups crossed successfully. The 2 unsuccessful attempts occurred near CPF-1, while the successful crossings occurred at the north end of the Oliktok Road and in the Kuparuk floodplain.

In general, we saw the majority of caribou moving in large, insect-harassed groups. They spent little time near the road system, and most crossed the OR near the coast, as did satellite-collared cows.

Along the MPR, we observed relatively more caribou in larger groups, but with fewer calves, than along the SR and OR (Tables 2 and 3). Most caribou appeared to be in temporary residence, because only 41.2% of the observations were made on insect days, only 9.4% of the caribou were observed crossing the road and/or pipeline, and most caribou were seen initially at distances <2,000 m.

Radio-collared Caribou (1-26 July)

Forty radio-collared females were relocated 1-7 times each in July 1988. All but one were observed within 50 km of the coast, and of these, most were located within 30 km of the coast (Fig. 13).

Satellite-collared Caribou (1-31 July)

The movements of female OB 40 in July (Fig. 14) are generally representative of major movements of caribou near the Kuparuk Oilfield. We replaced her satellite collar on 3 July, south of CPF-2. During the 1st bout of moderate-to-severe insect harassment on 7 July, she moved with her calf to the coast west of Oliktok Point, staying in that area until 12 July. With the onset of a 4-day harassment period on 13 July, she moved rapidly east into the prevailing northeasterly winds to the west side of Prudhoe Bay. After crossing and recrossing roads and pipelines at the south end of Prudhoe Bay in the morning and afternoon of 14 July, she began to move west. With a westerly wind shift in the early morning of 15 July, she continued west. On 16 July we observed her crossing the OR at 1400 h in a mixed group of 3,275 caribou. She then crossed the east channel of the Colville River and stayed in the western Colville delta from 18 to 21 July. With the onset of variable winds and predominately oestrid fly harassment, subsequent movements for the remainder of July were multidirectional. OB 65, OB 66, and OB 67 moved in a similar pattern (Figs. 15, 16, and 17).

These cows more than doubled their daily distance traveled in July, relative to May or June (Table 4). Although OB 67 moved a daily distance intermediate to that of the 3 collared cows with calves, she crossed the SR and OR 8 times, compared with a mean crossing rate of 3.7 for the others.

The July satellite locations support the conclusion reached from the road survey data that caribou spent little time near the oilfield complex. In previous years, after bouts of insect harassment, caribou moved to inland feeding areas from the SR and OR. With the predominantly westerly winds during the 3rd week of July in 1988 and variable winds for the remainder of the month, caribou tended to avoid oilfield facilities when not harassed by insects.

ACKNOWLEDGMENTS

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C. S. Gewin, R. T. Shideler, D. J. Reed, D. C. Miller, K. Jouppi, and W. Lasher for technical assistance. Thanks to the Alaska Department of Transportation and Public Facilities, and to VECO (Deadhorse) for aid in field logistics.

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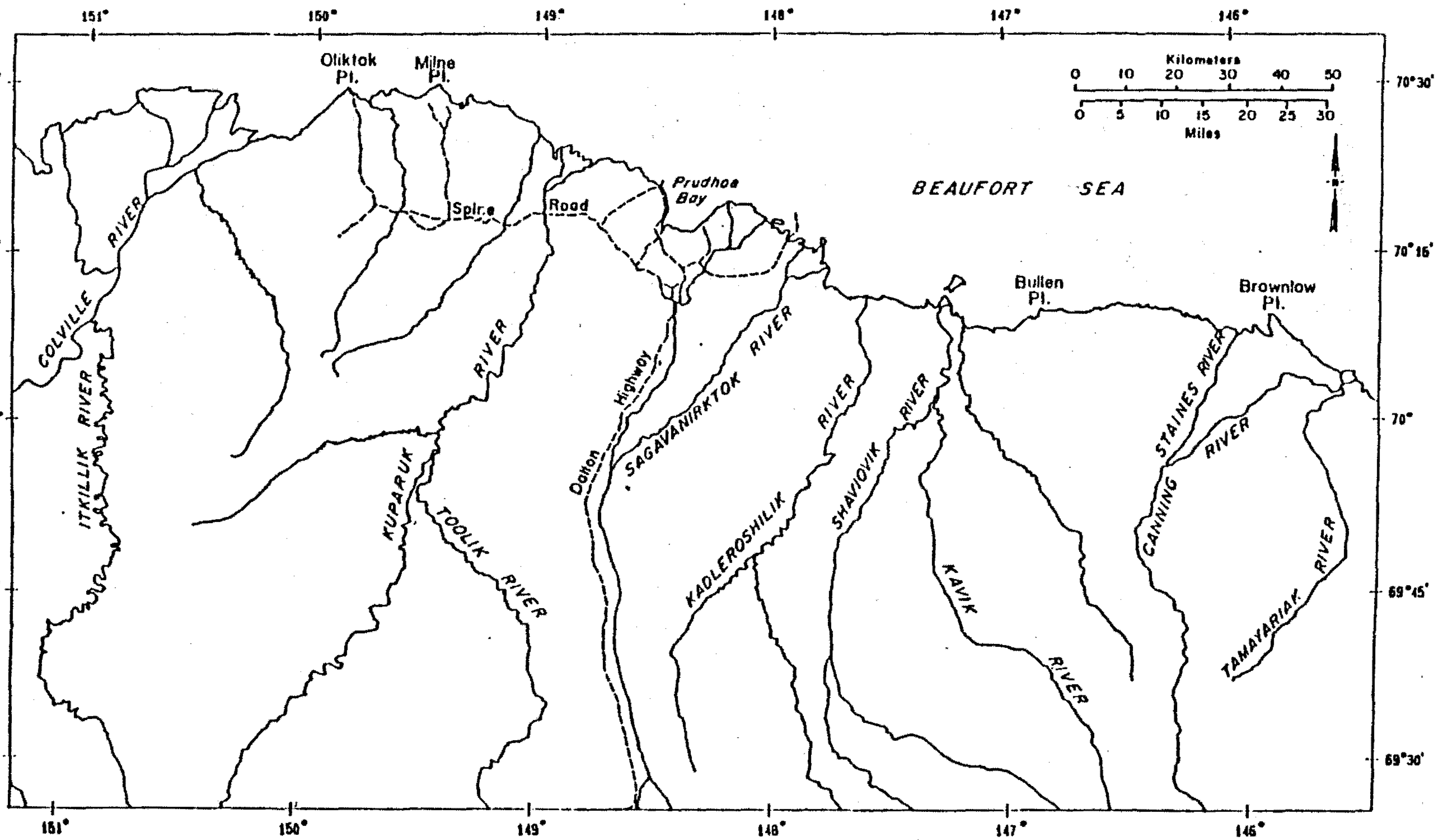

Fig. 1. Study area, Central Arctic Herd, May-July 1988.

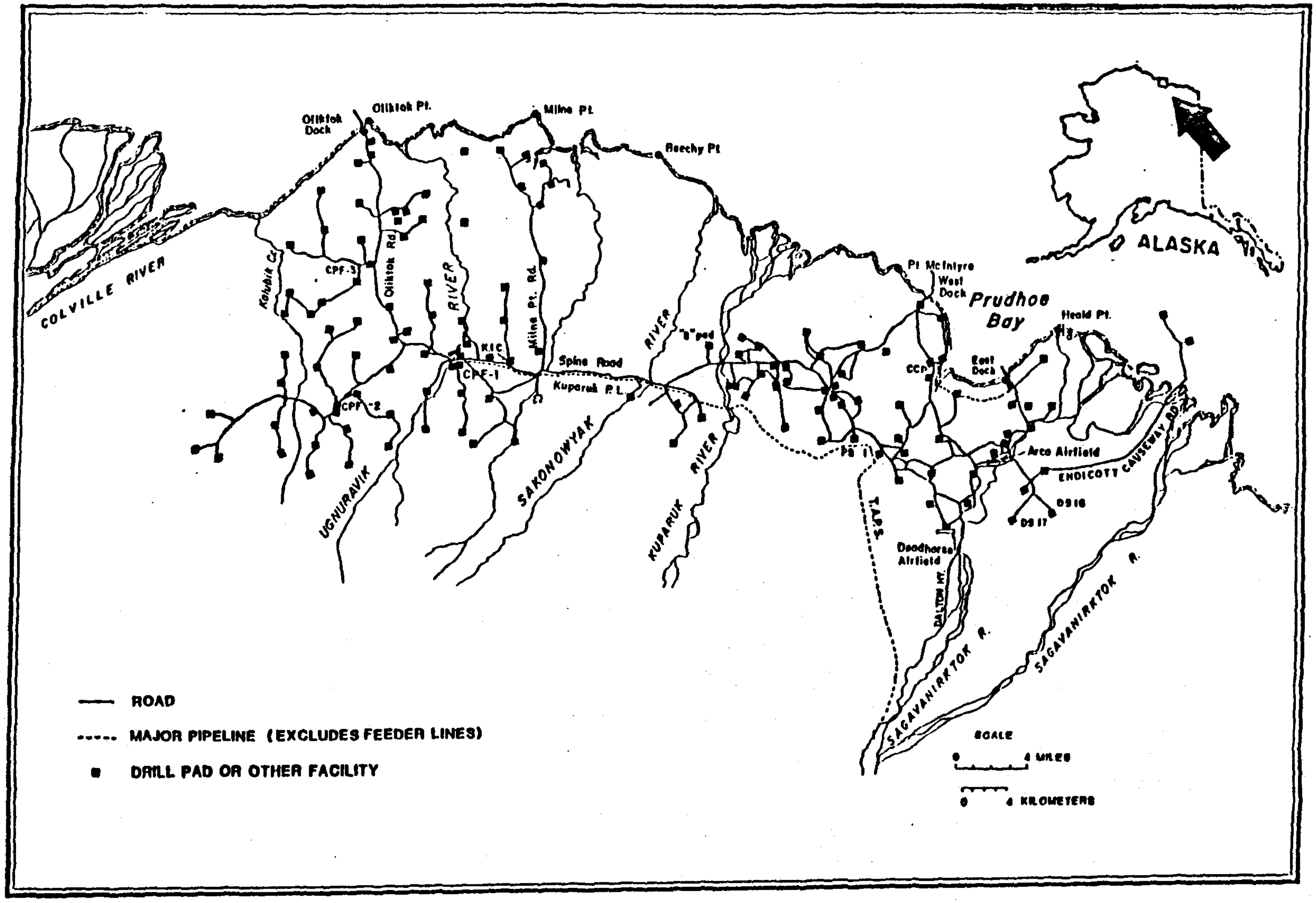

Fig. 2. Oilfield development in the Prudhoe Bay area, 1988. (Adapted from Alaska Department of Natural Resources, Northcentral District).

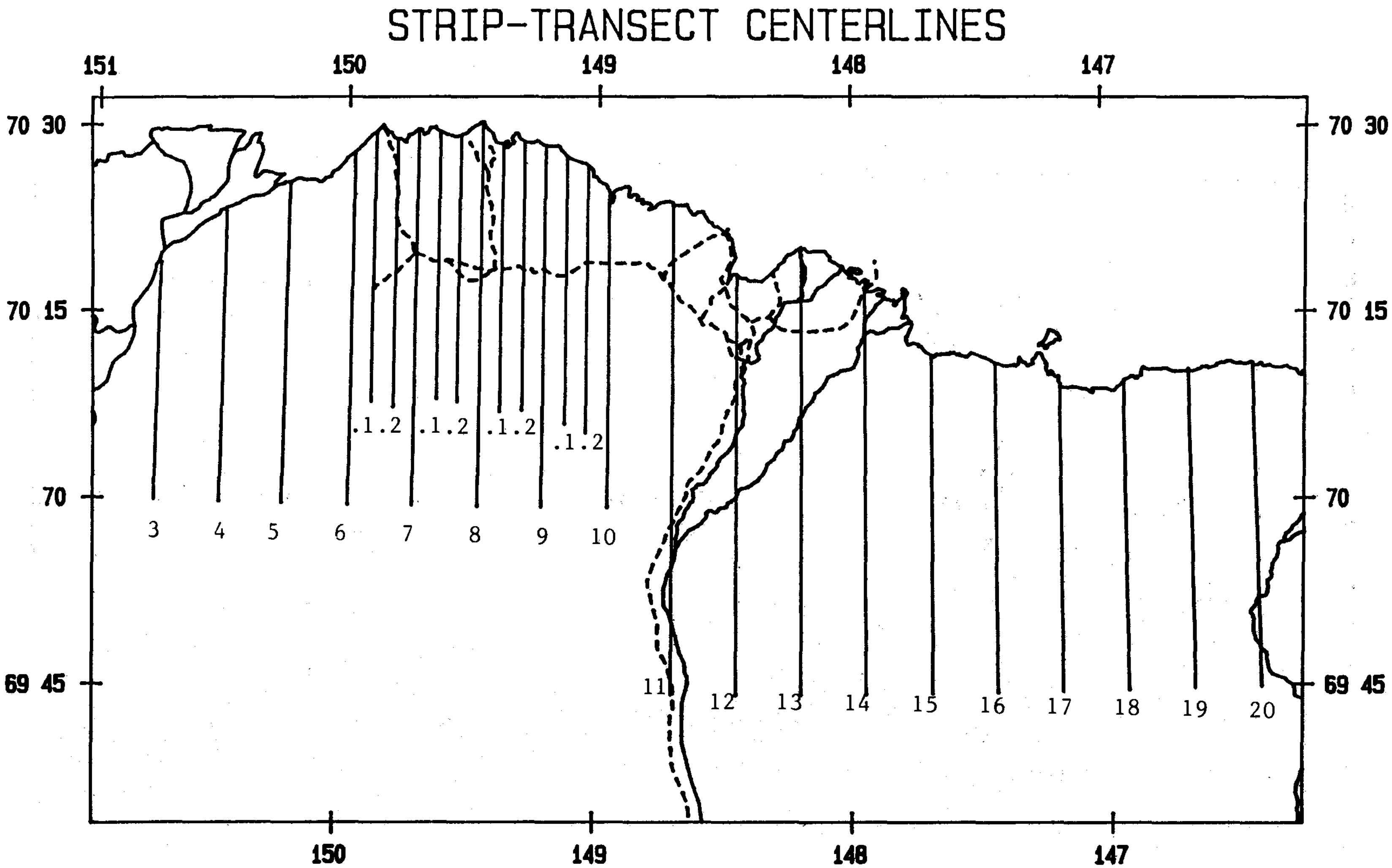

Fig. 3. Center lines of transects surveyed by helicopter, 10-15 June 1988.

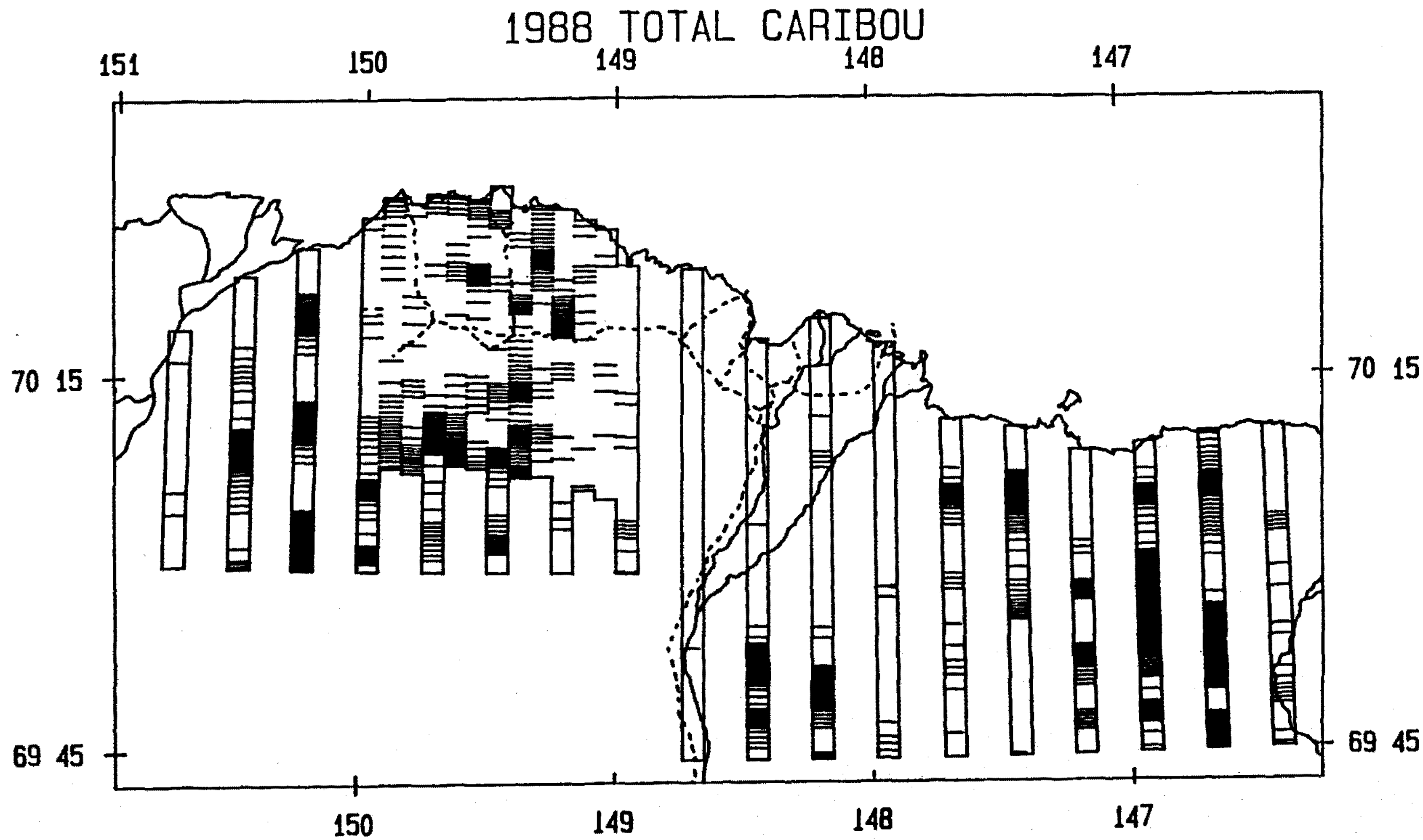

Fig. 4. Distribution and relative density of all caribou observed on helicopter surveys of the Central Arctic Herd calving grounds, 10-15 June 1988. Gradations in shading depict average densities in 10.4-km^2 transect segments from $\leq 0.4/km^2$ (open) to $\geq 7.7/km^2$ (solid).

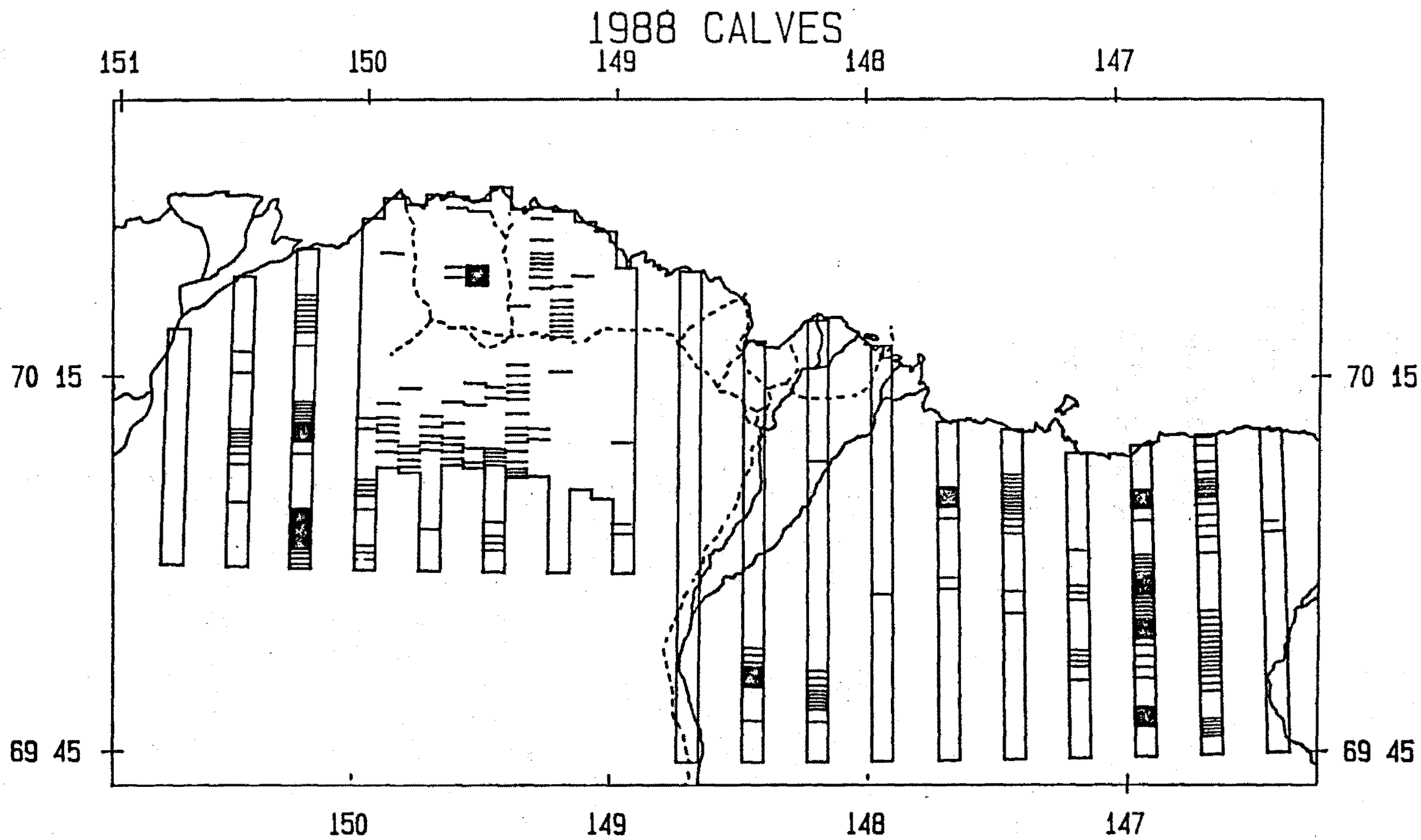

Fig. 5. Distribution and relative density of caribou calves observed on helicopter surveys of the Central Arctic Herd calving grounds, 10-15 June 1988. Gradations in shading depict average densities in 10.4-km^2 transect segments from $<0.4/km^2$ (open) to $>7.7/km^2$ (solid).

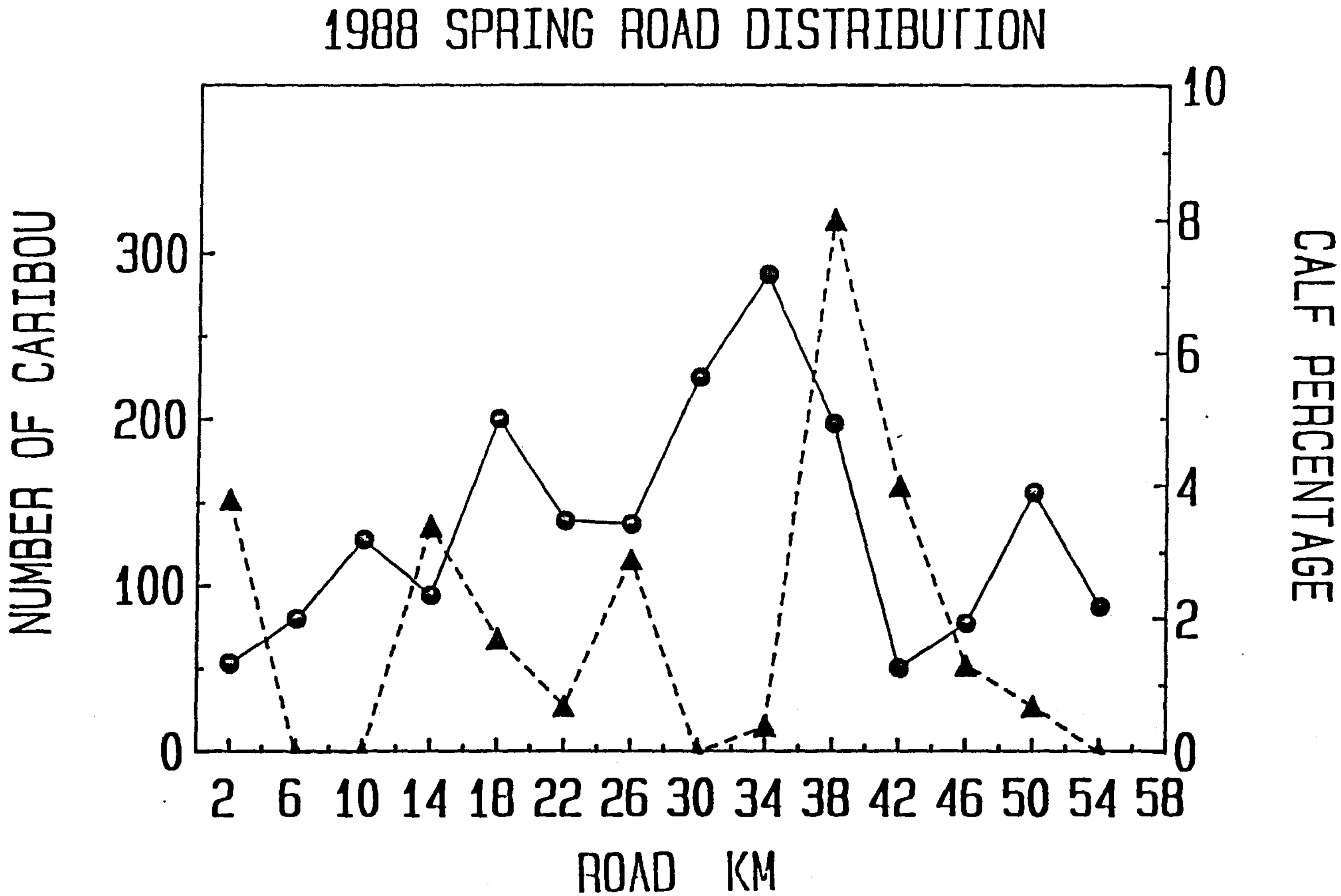

Fig. 6. Number of caribou (●) and calf percentage (▲) of groups sighted within 4-km segments of the Spine and Oliktok Roads, 25 May-15 June 1988.

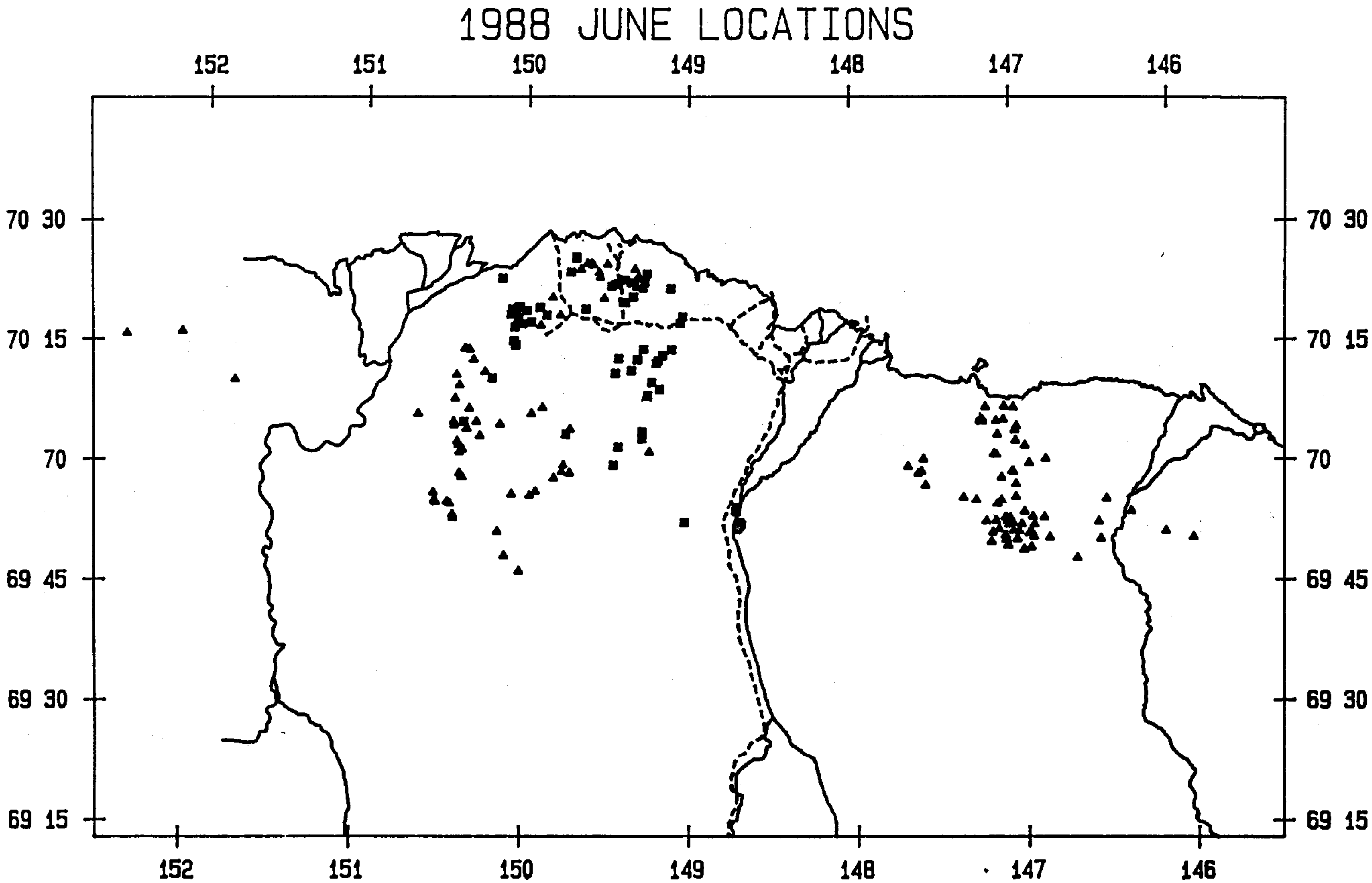

Fig. 7. Locations of radio-collared female caribou, Central Arctic Herd, 2-14 June 1988. (▲ = produced a calf; ■ = did not produce a calf).

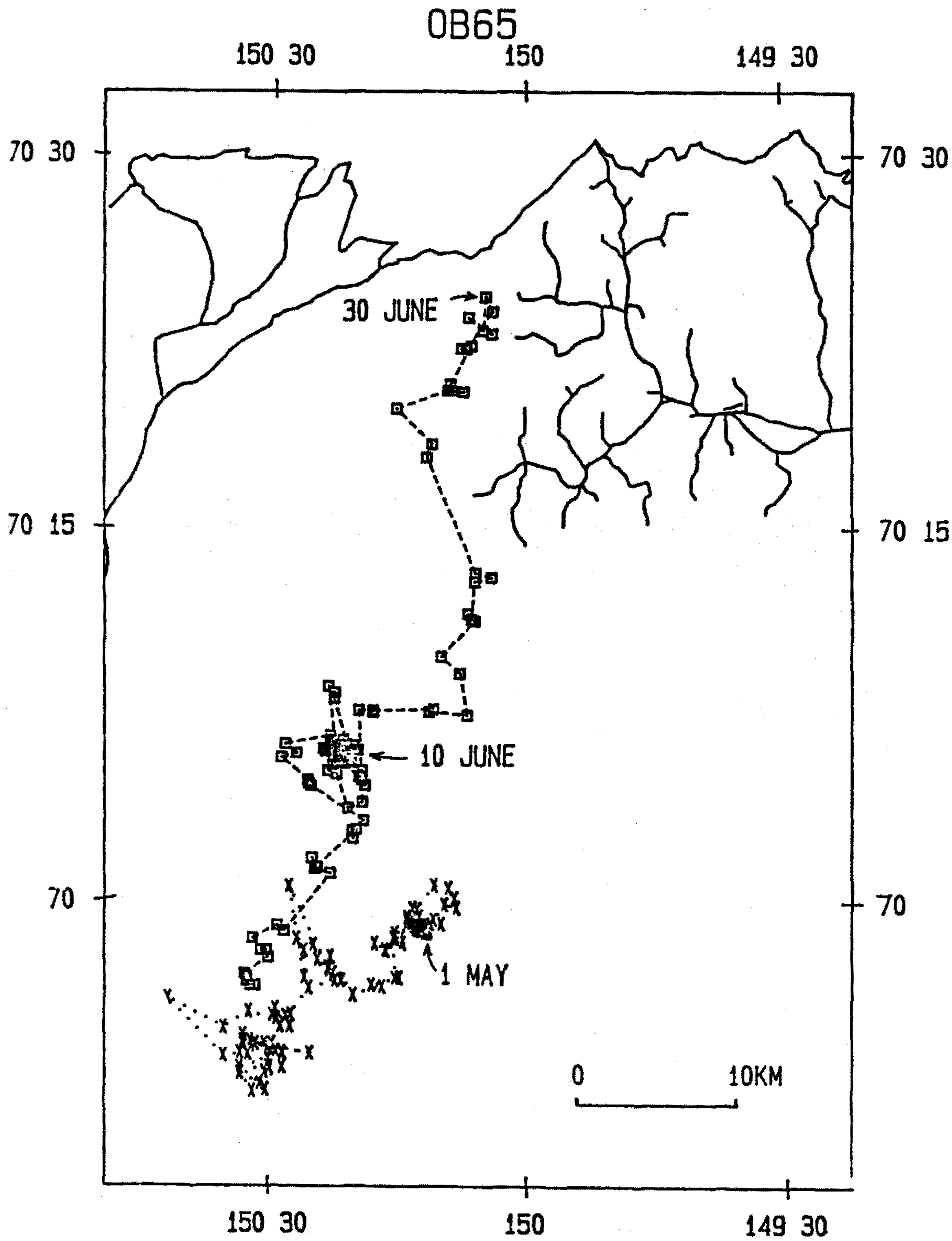

Fig. 8. Satellite locations of OB 65, May (X) and June (□) 1988. Calving date, 10 June.

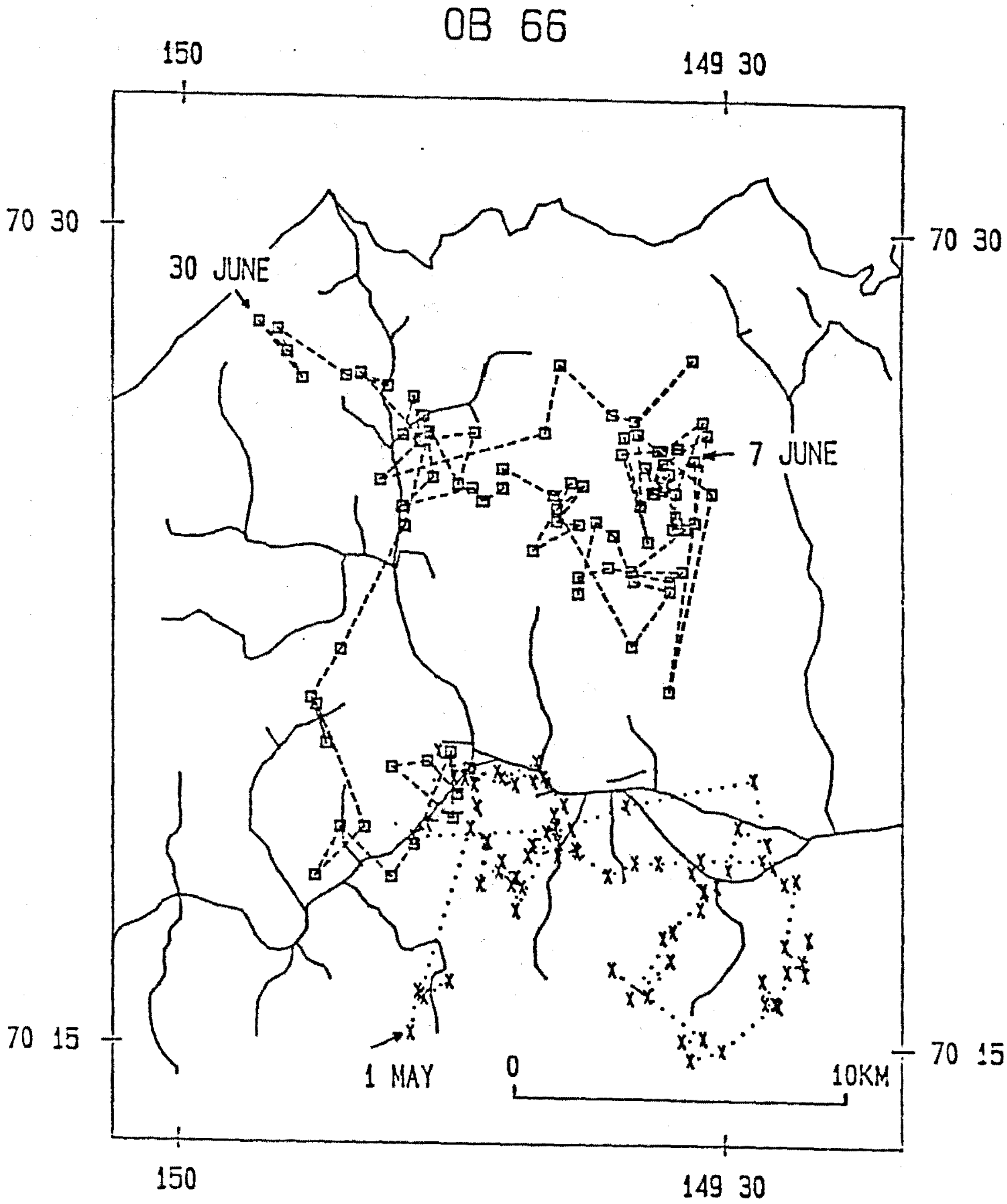

Fig. 9. Satellite locations of OB66, May (X) and June (□) 1988. Calving date, 7 June.

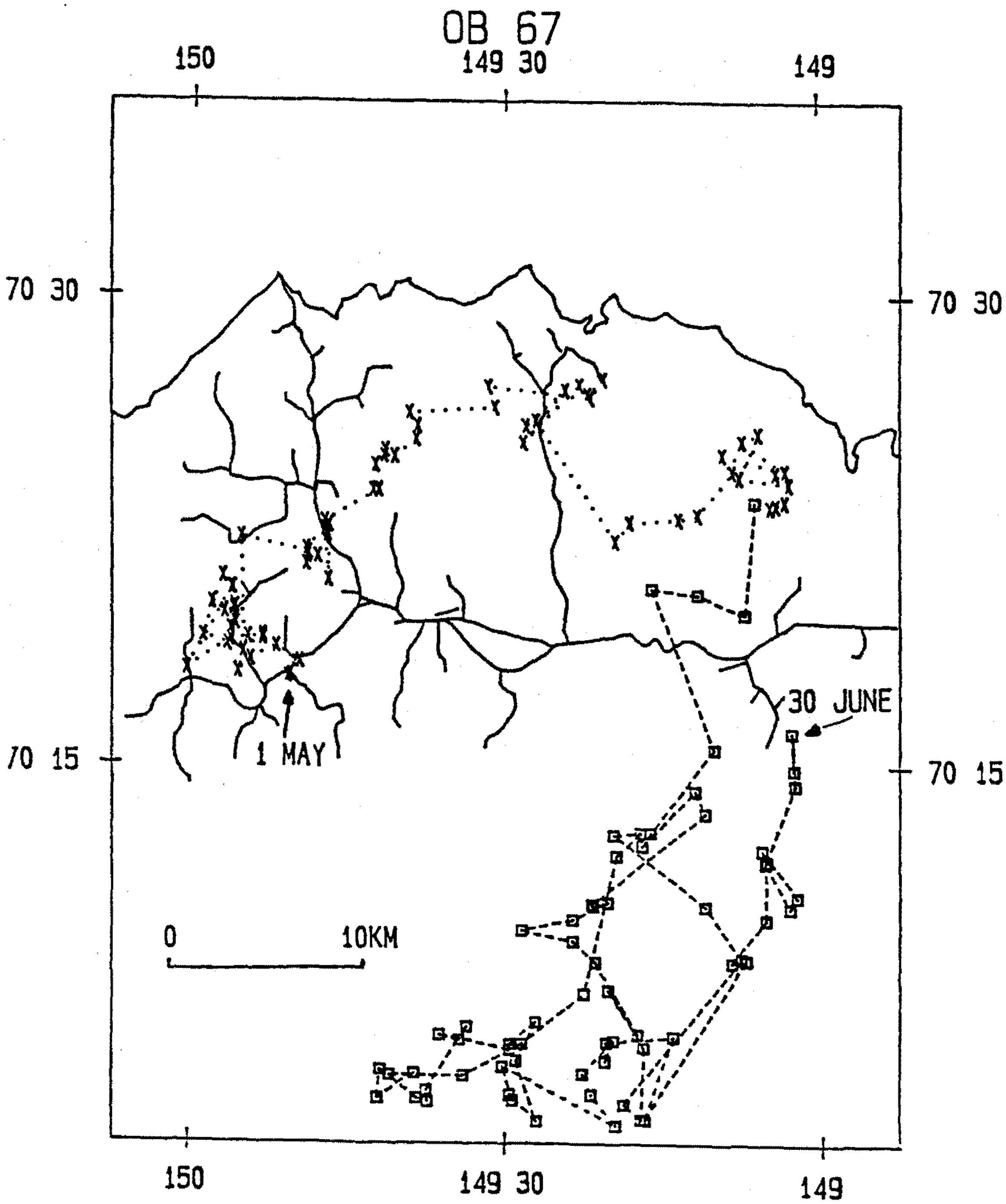

Fig. 10. Satellite locations of OB 67, May (X) and June (□) 1988. No calf produced.

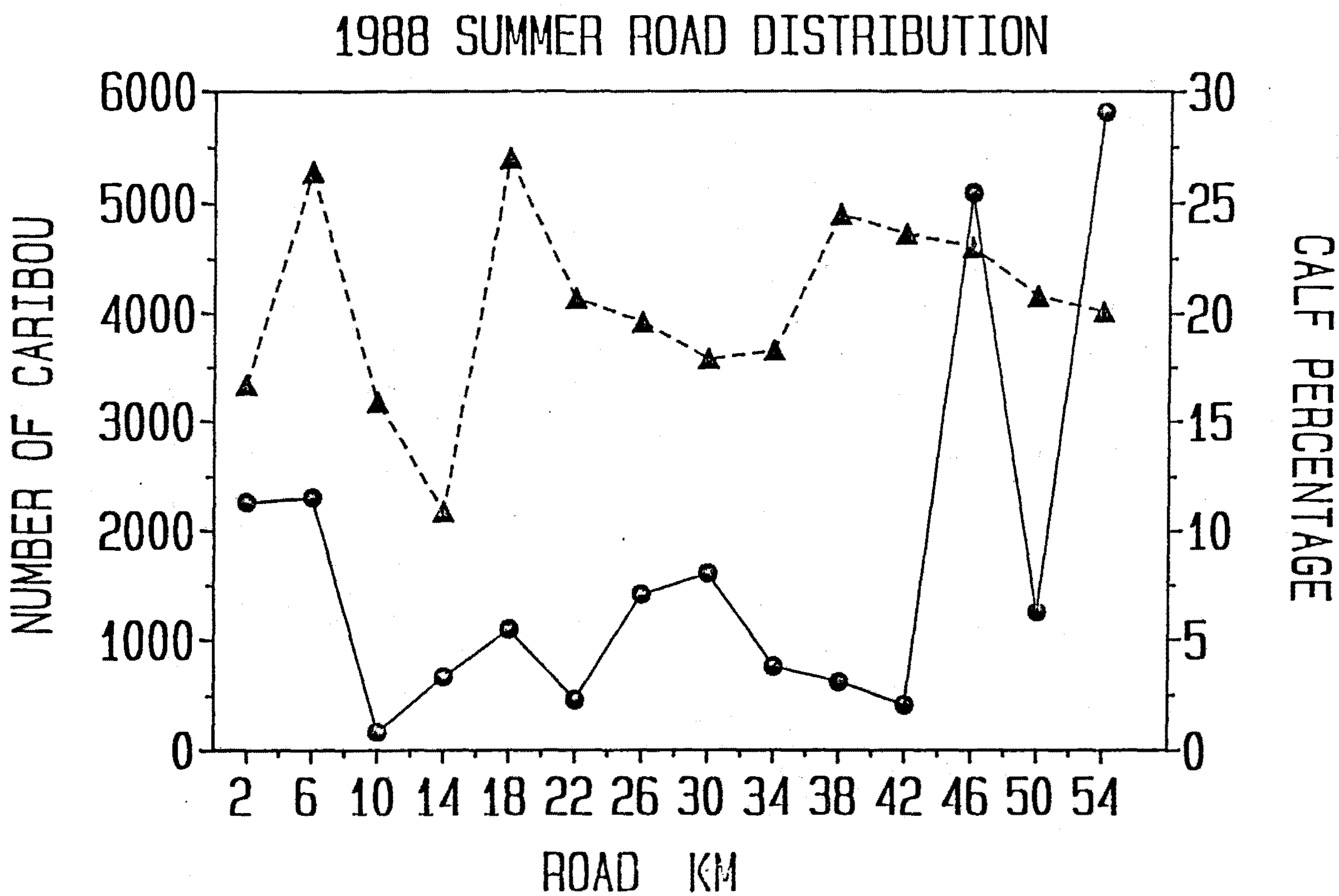

Fig. 11. Number of caribou (●) and calf percentage (▲) of groups sighted within 4-km segments of the Spine and Oliktok Roads, 28 June-31 July 1988.

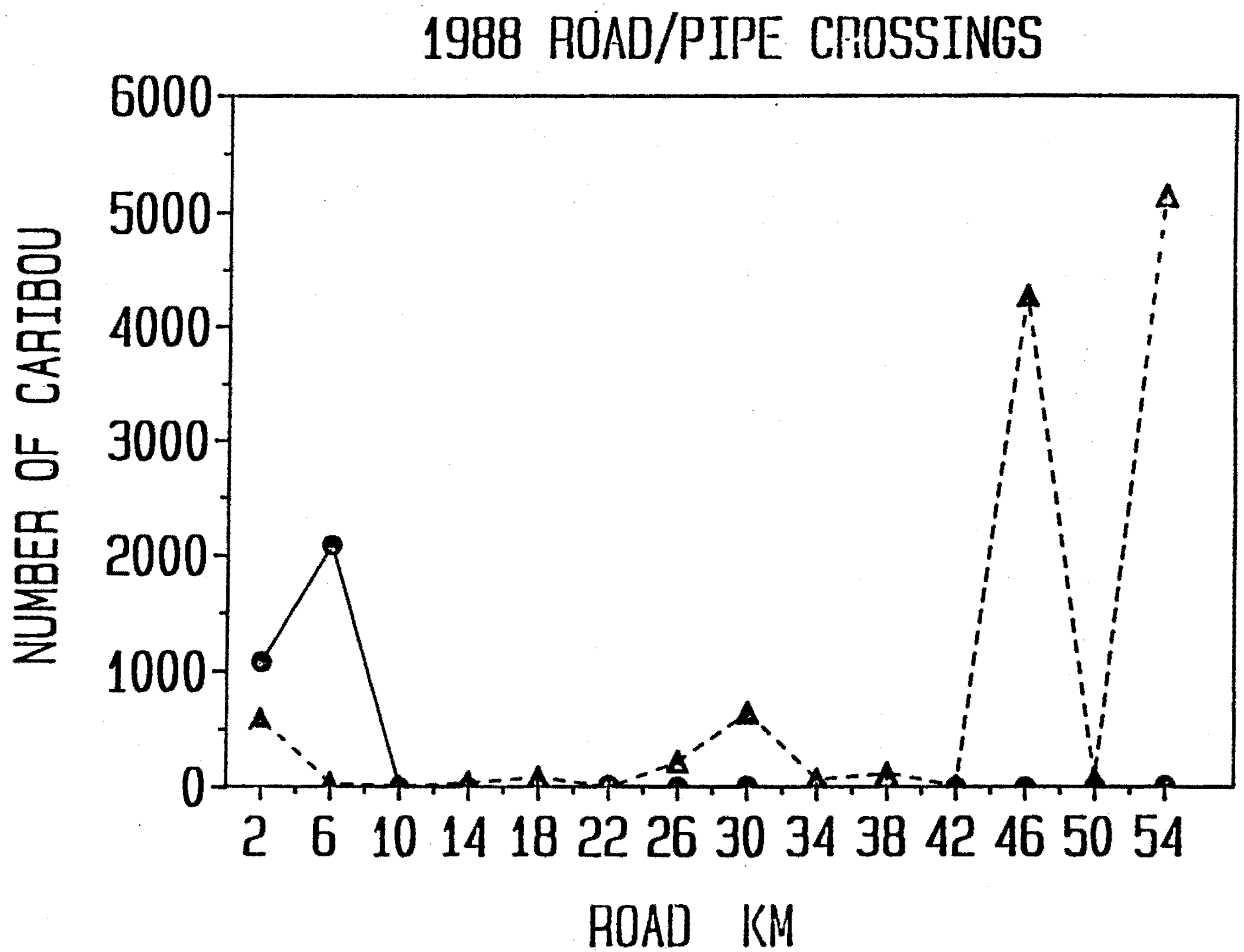

Fig. 12. Number of caribou attempting to cross roads (●) and road/pipeline complexes (▲) within 4-km segments of the Spine and Oliktok Roads, 28 June-31 July 1988.

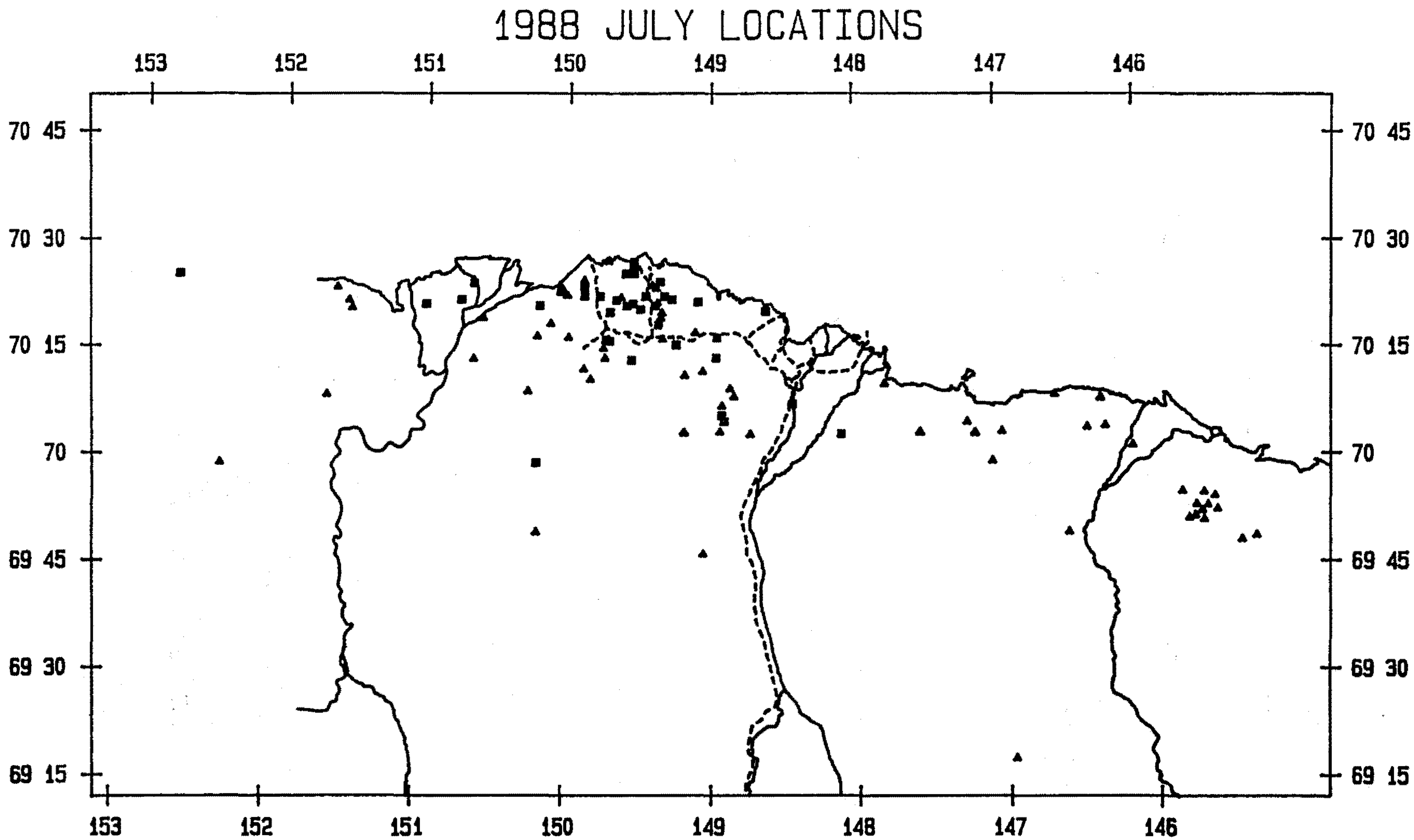

Fig. 13. Locations of radio-collared female caribou, Central Arctic Herd, 1-26 July 1988. (▲ = produced a calf; ■=did not produce a calf)

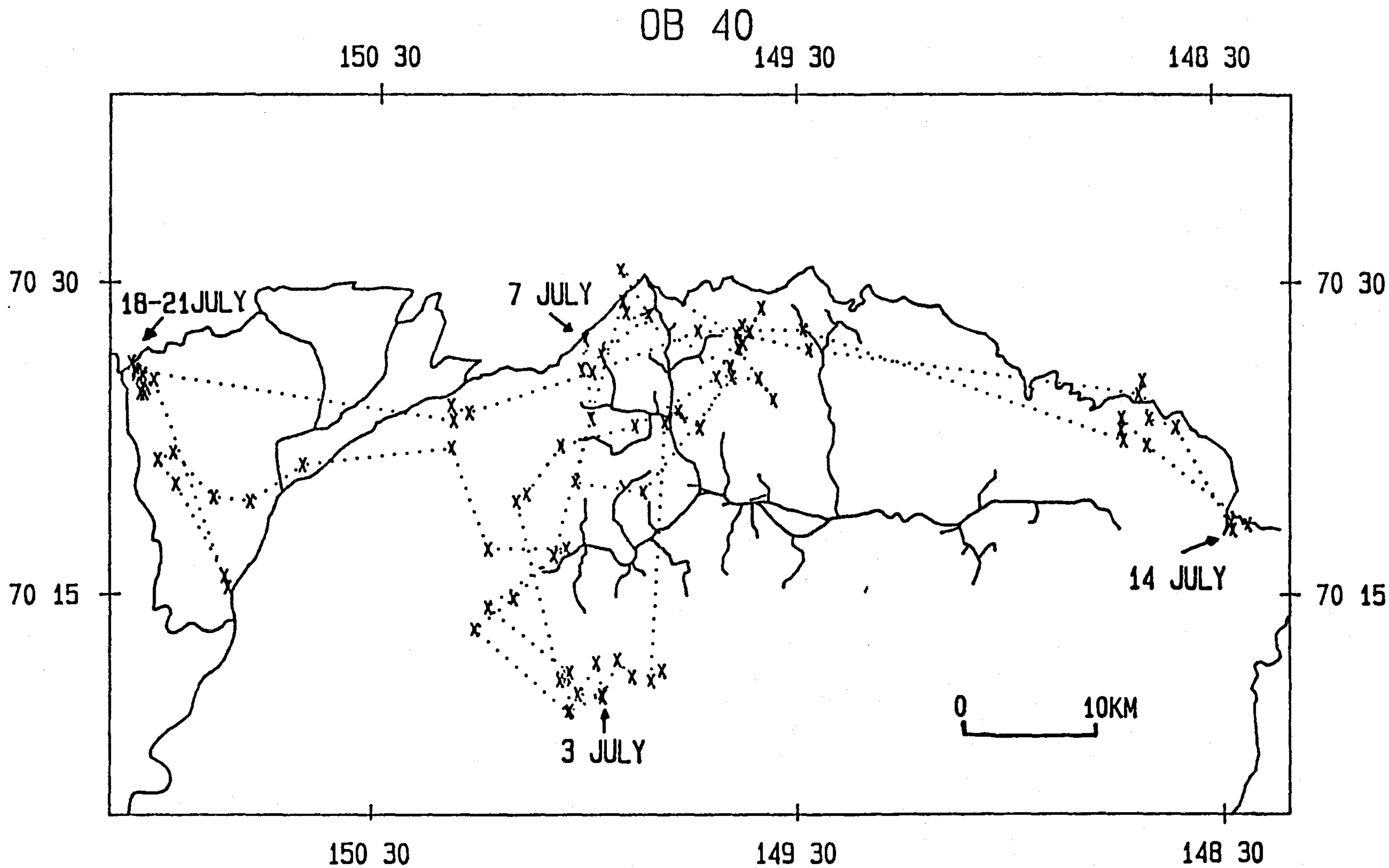

Fig. 14. Satellite locations of OB 40, July 1988.

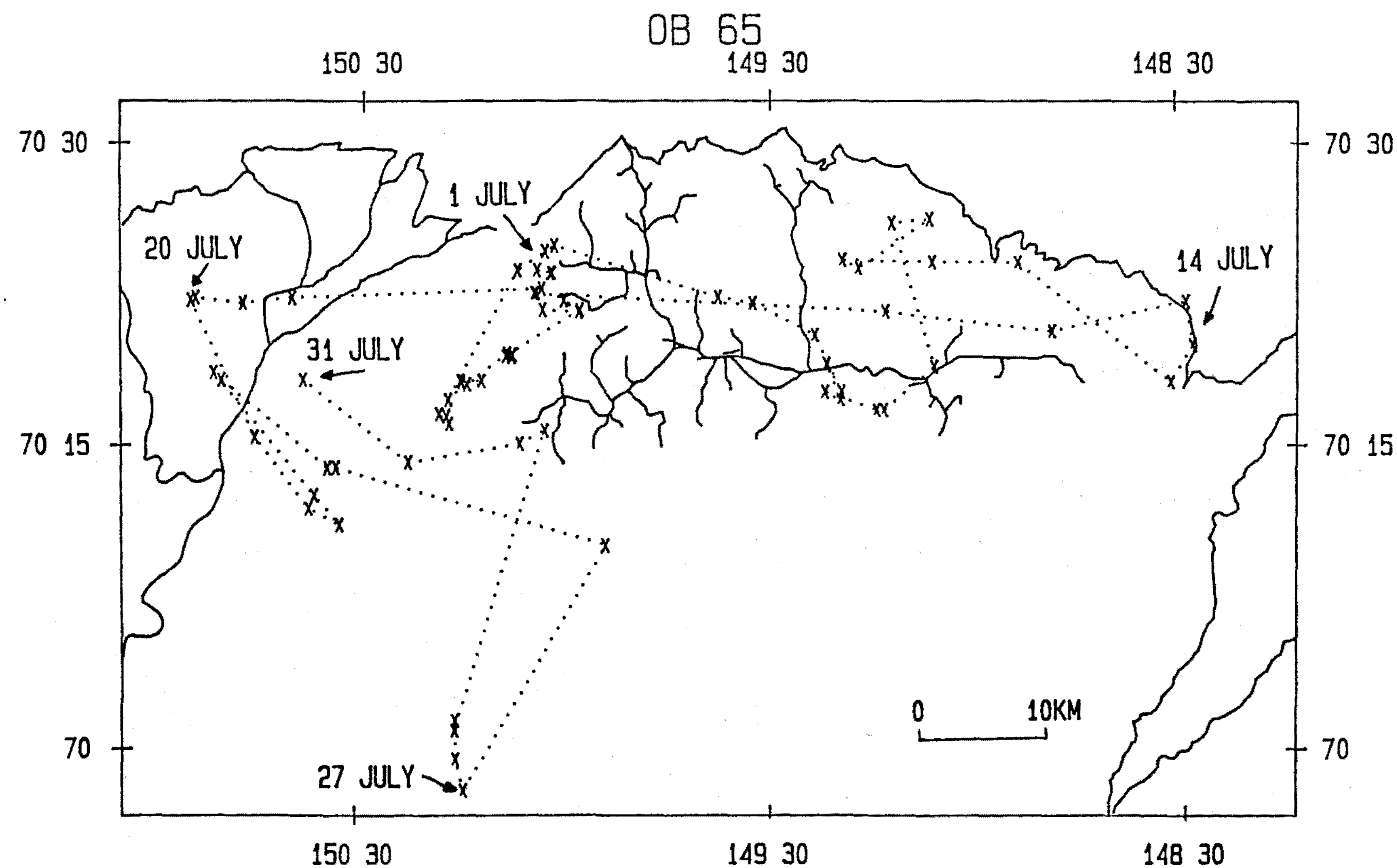

Fig. 15. Satellite locations of OB 65, July 1988.

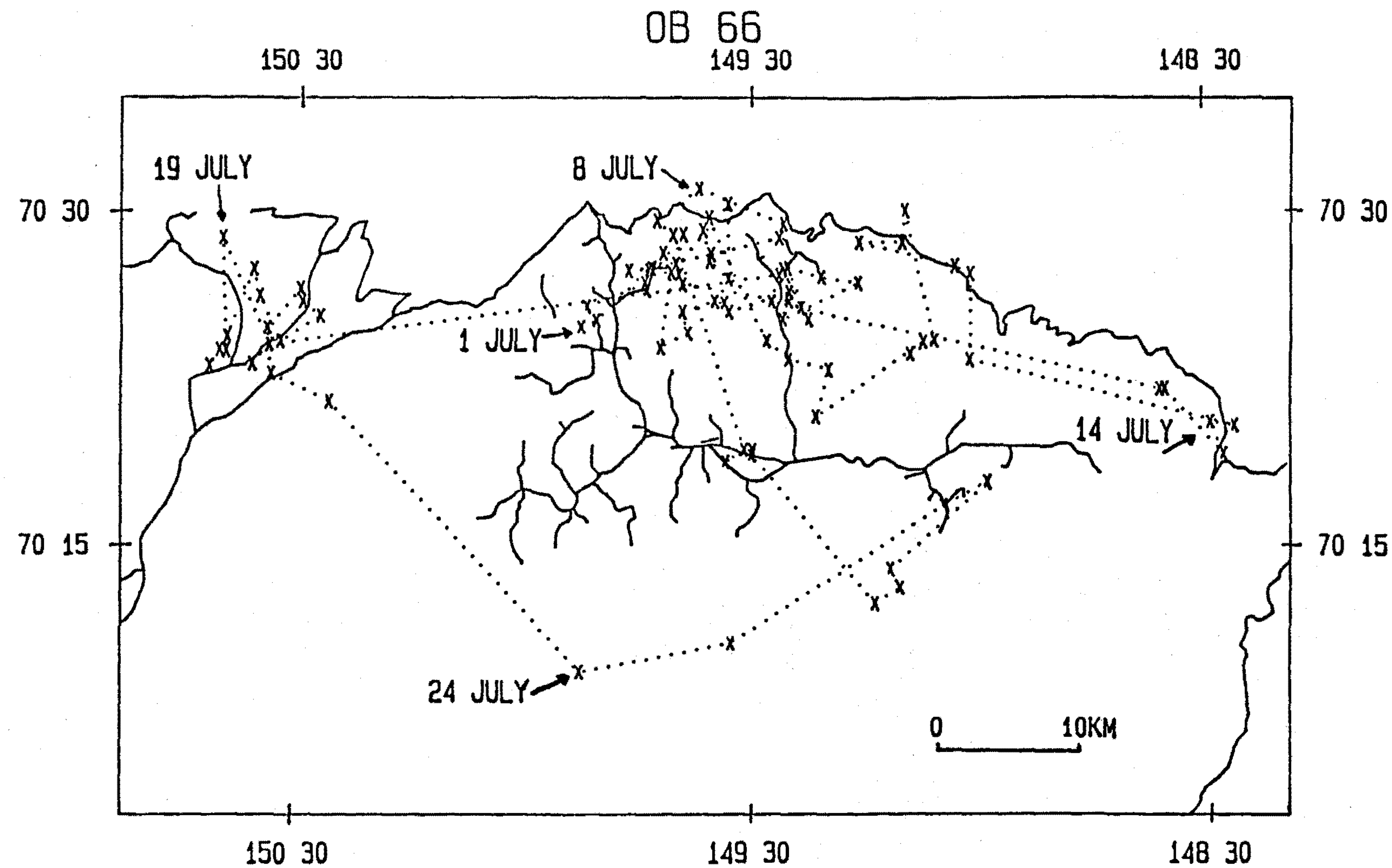

Fig. 16. Satellite locations of OB 66, July 1988.

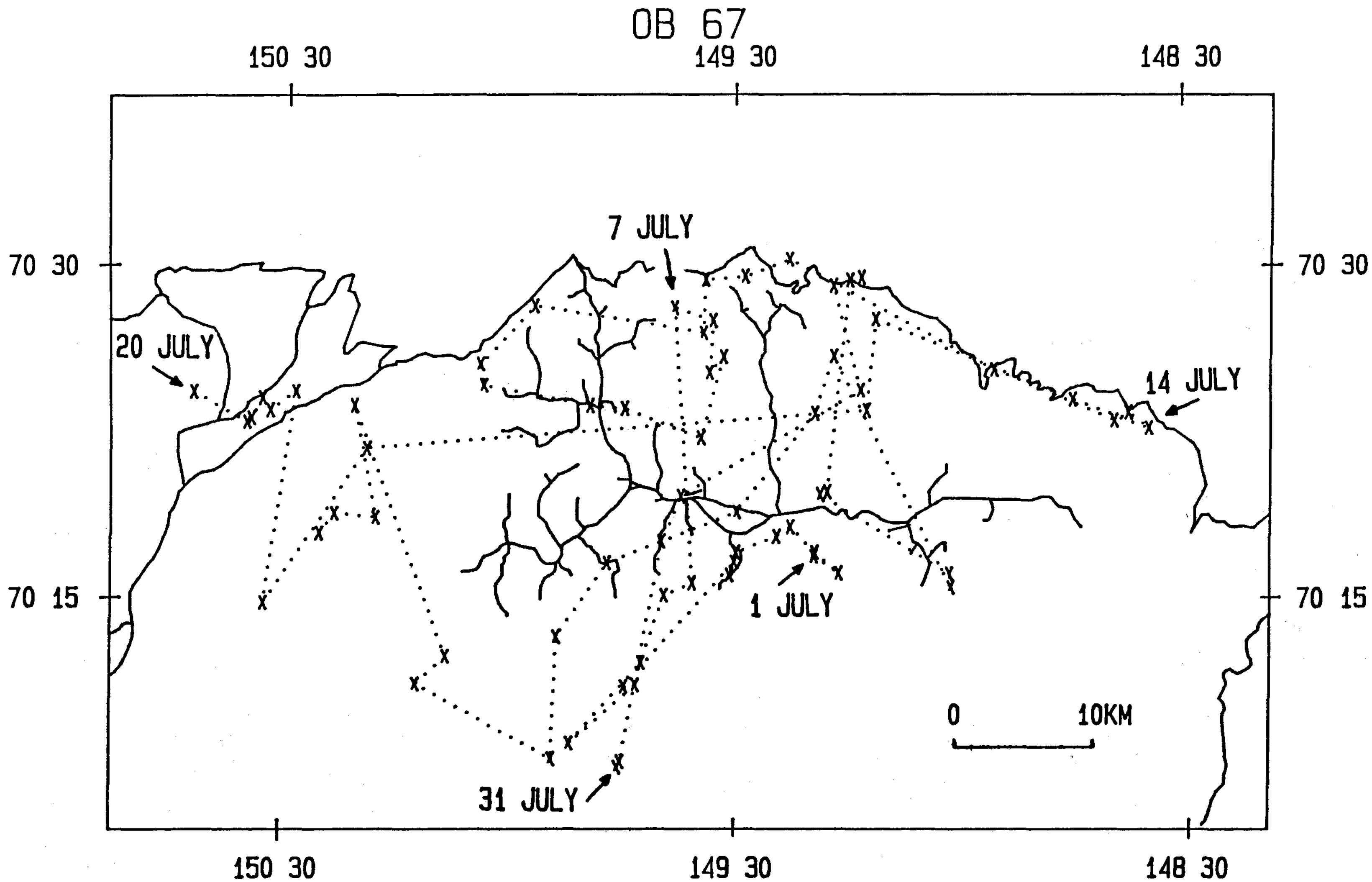

Fig. 17. Satellite locations of OB 67, July 1988.

Table 1. Sex and age composition and sighting rates of caribou observed on 3.2-km-wide strip transects during helicopter surveys of the Central Arctic Herd calving grounds, 10-15 June 1988.

Transect	No. of groups	Sex/age class				Total	% calves	Sighting rate caribou/km
		Bulls	Cows	Calves	Yearlings			
3	5	5	4	--	8	17	0.0	0.5
4	25	3	79	56	62	200	28.0	4.6
5	30	1	245	206	40	492	41.9	10.2
6	32	6	88	54	27	175	30.9	3.3
6.1	25	9	52	39	28	128	30.5	3.2
6.2	18	6	42	31	19	98	31.6	2.4
7	39	14	97	49	42	202	24.3	3.7
7.1	23	11	73	46	23	153	30.1	3.8
7.2	27	5	131	100	15	251	39.8	6.2
8	33	10	109	55	38	212	25.9	3.7
8.1	33	2	120	70	31	223	31.4	5.8
8.2	25	2	83	54	15	154	35.1	3.8
9	23	2	69	48	9	128	37.5	2.4
9.1	15	0	41	17	12	70	24.3	1.7
9.2	12	9	17	7	13	46	15.2	1.1
10	13	4	27	21	12	64	32.8	1.4
11	2	1	1	1	0	3	33.3	<0.1
12	24	13	109	66	61	249	26.5	4.0
13	22	17	94	59	36	206	28.6	3.1
14	10	8	10	5	16	39	12.8	0.6
15	22	8	103	78	23	212	36.8	4.2
16	18	2	104	77	24	207	37.2	4.2
17	15	2	76	45	50	173	26.0	3.8
18	42	11	319	221	71	622	35.5	13.5
19	29	8	242	157	80	487	32.2	10.1
20	11	4	46	18	13	81	22.2	1.7
Total	573	163	2381	1580	768	4892	32.3	4.0

Table 2. Population characteristics of caribou observed along the Spine and Oliktok Roads, 25 May-31 July 1988.

Category	Calving (25 May-15 June)					Summer (28 June-31 July)				
	No. groups	No. caribou	Mean group size	Sighting rate (caribou/km)	% calves	No. groups	No. caribou	Mean group size	Sighting rate (caribou/km)	% calves
Kuparuk Spine Road (0.0-32.0 km)	263	1,056	4.0	2.75	1.4	269	9,977	37.0	12.0	20.6
Oliktok Road (32.1-56.0 km)	229	854	3.7	2.97	2.4	294	13,939	47.4	22.3	21.4
Total (Road) (0-56.0 km)	492	1,910	3.9	2.84	1.9	563	23,916	42.5	16.4	21.1
0-1,000 m	403	1,596	4.0	2.38	1.1	475	17,845	37.5	12.3	22.0
0-2,000 m	465	1,819	3.9	2.71	1.7	543	22,941	42.2	15.8	21.2
Pipe Crossings	2	7	3.5	0.01	0.0	24	169	7.0	0.1	14.2
Road Crossings	3	7	2.3	0.01	0.0	26	3,211	123.5	2.1	24.3
Road/Pipe Crossings	3	9	3.0	0.01	0.0	50	11,275	225.5	7.5	22.2
Total (Crossing)	8	23	2.9	0.03	0.0	100	14,655	146.6	10.1	22.6
On insect days	--	--	--	--	--	158	16,650	106.0	33.0	22.0

Table 3. Population characteristics of caribou observed along the Milne Point Road, 25 May-31 July, 1988.

	Calving (25 May-15 June)					Summer (28 June-31 July)				
Category	No. groups	No. caribou	Mean group size	Sighting rate (caribou/km)	% calves	No. groups	No. caribou	Mean group size	Sighting rate (caribou/km)	% calves
Total caribou	210	630	2.9	2.43	4.2	346	16,629	48.1	29.6	16.8
0-1,000 m	145	415	2.9	1.60	3.6	271	12,067	44.5	21.5	17.0
0-2,000 m	189	542	2.9	2.09	3.5	299	13,567	45.3	24.1	17.0
Pipe crossings	0	0	0	0.0	0	7	11	1.6	0.02	18.2
Road crossings	0	0	0	0.0	0	1	1	1.0	<0.01	0
Road/Pipe crossings	1	2	2	0.01	0	16	1,548	96.8	2.8	14.3
Total crossings	1	2	2	0.01	0	24	1,560	65.0	2.8	14.4
On insect days	--	--	--	--	--	138	6,851	49.6	12.2	14.5

Table 4. Average daily distance traveled by 4 satellite-collared female caribou, Central Arctic Herd, 1 May-31 July 1988.

Period:	Pre-calving (25-31 May)		Calving (1-15 June)		Post-calving (16-30 June)		Insect season (1-31 July)	
Caribou number	No. locations	Distance (km/day)	No. locations	Distance (km/day)	No. locations	Distance (km/day)	No. locations	Distance (km/day)
OB40	--	--	--	--	--	--	84	19.38
OB65	87	4.83	45	4.77	43	6.44	67	15.27
OB66	83	3.58	40	7.90	40	5.98	87	16.66
OB67	68	4.35	32	8.99	34	6.65	70	18.53

Appendix B. Seasonal body weights of radio-collared female caribou, Central Arctic Herd (CAH) and Porcupine Herd (PCH), October 1987-October 1988.

Herd	Acc. No.	Body weight (kg)			Remarks
CAH		10/24-28/87	7/2-4/88	9/23-10/3/88	
	8702	94	83[a]	90	
	8705	104	-[b]		Dead 3/88
	8221	93	76[a]		Dead 7/88
	8701	91	81[a,c]	99	
	8704	84	-[b]		Dead 6/88
	8710	93	79[d]	101	Dead 10/88
	8709	101	88[d]	96	
	8706	74	68[d]	81	Dead 9/88
	8503	99	88[d]	104	
	8708	93	83[d]	96	
	8711	80	65[a,c]		Dead 7/88
	8716	89	83[a]	99	
	8618		79[a]	90	
	8108	89	-[b]	88	
	8715	75	-[b]		Dead 3/88
	8619	88	-[a]	88	
	8622	94	92[a]	102	
	8616	80	-[a,c]		Dead 9/88
	8713	86	80[d]	99	
	8801		81[a]		
	8802		67[a]		Dead 7/88
	8803		83[a]		Dead 7/88
	8804		86[a]		Dead 9/88
	8805		69[a]	80	
	8806		73[a]	88	
	8216		68[a]	76	Dead 10/88
	8620		75[a]	88	
	8807		-[b]	88	
	8714		74[a]		

Appendix B. Continued.

Herd	Acc. No.	Body weight (kg)			Remarks
PCH		10/8-22/87	4/11/88	9/23-26/88	
	S-11	97	96[a]		Dead 7/88
	S-13	95	-[a]	91	
	S-19	97	-[a]		Cow and calf dead 6/88
	S-20	87	-[a]	83	
	S-35	95	-[a,c]		Dead 7/88
	S-36	88	-[a,c]	95	
	S-37	92	-[d]	101	
	S-40	97	-[a]		Dead 7/88
	S-8	81	-[a]		Dead 7/88

[a] Calved, 6/88.

[b] Unknown calving status.

[c] Perinatal calf mortality (i.e., calf died of predator-unrelated causes within ca. 48 h of birth).

[d] Did not calve, 6/88.

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