DISTRIBUTION AND MOVEMENTS OF CARIBOU IN RELATION TO THE KUPARUK DEVELOPMENT AREA

SECOND INTERIM REPORT

by

Raymond D. Cameron and Kenneth R. Whitten
Alaska Department of Fish and Game

May 1980

SUMMARY

1. The calving grounds of the Central Arctic Herd were surveyed systematically by helicopter in June 1979, and periodic surveys along the West Sak Road were conducted by light truck during midsummer 1979.

2. The total number of caribou observed during calving in 1979 was approximately double that in 1978, apparently due to natural variation in the number of parturient cows entering the area. As in the previous year, the overall density of calving caribou was highest west of the Kuparuk River, with a particularly dense calving aggregation between the West Sak Road and the Arctic Coast.

3. Relatively low numbers of calving caribou were observed within or near the Prudhoe Bay Complex, reflecting continued avoidance of that area. However, no abnormalities in sex and age representation were detectable among caribou in the vicinity of the West Sak Road.

4. Mean calf percentage observed from the West Sak Road between mid-June and mid-August was representative of caribou in the general region.

5. Specific intervals along the West Sak Road (0-4, 16-20 km) were identified as areas of relatively high caribou occupancy. Between-year shifts in the location of such "nodes" of occupancy are thought to be partly attributable to changes in the distribution of construction activity. In general, the principal areas of caribou occupancy in both 1978 and 1979 corresponded to sites of road crossings; both tended to occur near or within river drainages.

6. Temporal patterns of caribou occurrence along the West Sak Road were attributed to weather-related changes in insect density.

7. Recommendations include minimizing local disturbance during the calving and insect periods, and maximizing crossing success through strategic design of production pipelines.

BACKGROUND

Since the discovery of oil at Prudhoe Bay in 1967, much attention has been focused on the effects of oilfield and industrial development on fish and wildlife resources, and on barren-ground caribou (*Rangifer tarandus granti*) in particular. Wildlife surveys of the Central Arctic Slope conducted in the late 1960's and early 1970's indicated that the Prudhoe Bay region was probably within the peripheral ranges of both the Western Arctic and Porcupine Herds, and that some 20-30,000 caribou might occupy the general area during summer (Hemming 1971, Gavin 1973). After 1970, however, the number of caribou using this area declined rapidly, to an estimated 2,500 in 1972 (Gavin 1973). This apparent withdrawal paralleled a decrease in the size of the Western Arctic Herd, from 242,000 in 1970 (Hemming 1971) to 64,000 in 1976 (Davis and Valkenburg 1978). Since 1975 no large influxes from adjacent herds have been observed and it has become clear that caribou presently ranging in the vicinity of Prudhoe Bay and along the North Slope route of the Trans-Alaska Pipeline (TAP) constitute a separate subpopulation, now known as the Central Arctic Herd (CAH) (Cameron

and Whitten 1979a). Although this herd has not been accurately censused, it undoubtedly exceeds 5,000 head and has likely been increasing slowly since at least 1977 (Cameron and Whitten 1979b).

Caribou occupancy of the Prudhoe oilfield and TAP corridor has declined with sustained petroleum development. This response is primarily a reflection of local avoidance of the area by cows and calves (Cameron et al. 1979, Cameron and Whitten 1980). In spite of this displacement from previously occupied units of range, the herd remains moderately productive. Nevertheless, existing conflicts with industrial development and the potential for progressive disruption elicit a number of concerns for the future well-being of the CAH and other caribou subpopulations on the Arctic Slope as well. Among these possible consequences is reduced survival of neonatal calves resulting from disturbance-induced displacement of parturient cows from traditional calving grounds. A second major concern involves the potential restriction of summer movements in response to insect harassment, specifically the bioenergetic ramifications of reduced access to coastal insect relief areas. The successful mitigation of these and other possible conflicts depends on the ultimate development of a basic understanding of disturbance mechanisms, including the types and intensities of development that constitute negative stimuli, the threshold levels of disturbance that trigger range abandonment, the amount of displacement tolerable before overuse of remaining range occurs, and whether caribou will accommodate to local disturbance over time. Despite our present dearth of knowledge regarding these fundamental concepts, practical short-term mitigation of existing or imminent problems will become possible as relevant site-specific data are accumulated. Thus, general criteria developed for pipeline design and placement will hopefully maximize physical passage of caribou, and strategic scheduling of construction activity should minimize disturbance-induced displacement. Continued coordinated study, both basic and applied, will likely result in more specific--and perhaps more liberal--guidelines for petroleum development on the Arctic Slope.

The present research program was initiated in 1978 to address some of these needs in the Kuparuk Development Area (KDA), located immediately west of the main Prudhoe Bay oilfield (Figs. 1 and 2). This new development unit was known to lie within an active calving area and important component of summer range. We believed that detailed knowledge of regional caribou distribution and movements would assist in the formulation of development practices which would accommodate caribou, hopefully within established geotechnical constraints. It would also provide an opportunity to identify and quantify the sources and chronology of local disturbance and the reactions of caribou to known stimuli. Finally, in conjunction with continued monitoring of CAH status, the present program represents an opportunity to document any related effects on population productivity.

Results of the first year of study showed that the majority of CAH calving occurred within a 40-km band along the Arctic Coast. The density of calving caribou was highest north of the KDA and was generally lower between Prudhoe Bay and Bullen Point. The incidence of calving was extremely low in the active oilfield near Prudhoe Bay, although parturient cows and neonates were observed south of the main complex. The percentage of calves among caribou within 8 km of the West Sak Road was significantly

lower than the same percentage calculated for caribou observed at greater distances, suggesting avoidance of the road during the calving period.

During midsummer, mean calf percentage observed from the West Sak Road was similar to that in the surrounding region. Numerical changes in caribou sightings were consistent with observed or predicted variations in insect activity. Areas of highest overall carihou occupancy along the road also accounted for the overwhelming majority of road crossings; these "nodes" of caribou activity were all associated with stream or river systems.

This report describes the results of continued surveys of the CAH calving grounds and observations along the West Sak Road in 1979. These findings and various between-year comparisons are considered in relation to weather-related variables and local disturbance.

OBJECTIVES

Acceptable baseline data were obtained in 1978, and major study objectives for 1979 were to identify and assess changes in:

1. the distribution and density of caribou calving in the vicinity of the Kuparuk Development Area;

2. the distribution, group composition, and movement patterns of caribou within the Kuparuk Development Area during summer; and

3. the overall trends in summer distribution of caribou west of the Kuparuk River.

METHODS

The calving grounds of the CAH were surveyed by helicopter on 11-13 June 1979 using a series of north-south transects (Fig 1). Except for minor differences in coverage (described below), sampling methodology was identical to that used in 1978 (Cameron and Whitten 1979c).

Caribou survey data from the West Sak Road between 26 June and 21 August, Deadhorse weather records from June through August, and estimates of local vehicular traffic were also obtained as in the previous year (Cameron and Whitten 1979c).

Area-wide sex and age composition of caribou was determined by systematic fixed-wing surveys (Cameron and Whitten 1979a) on 25 August.

Statistical differences between expected and observed variations in caribou group composition were tested by Chi-square contingency analysis; significance was evaluated at the 95 percent confidence level.

Comparisons of 1979 data with 1978 results are based on the findings of the First Interim Report (Cameron and Whitten 1979c).

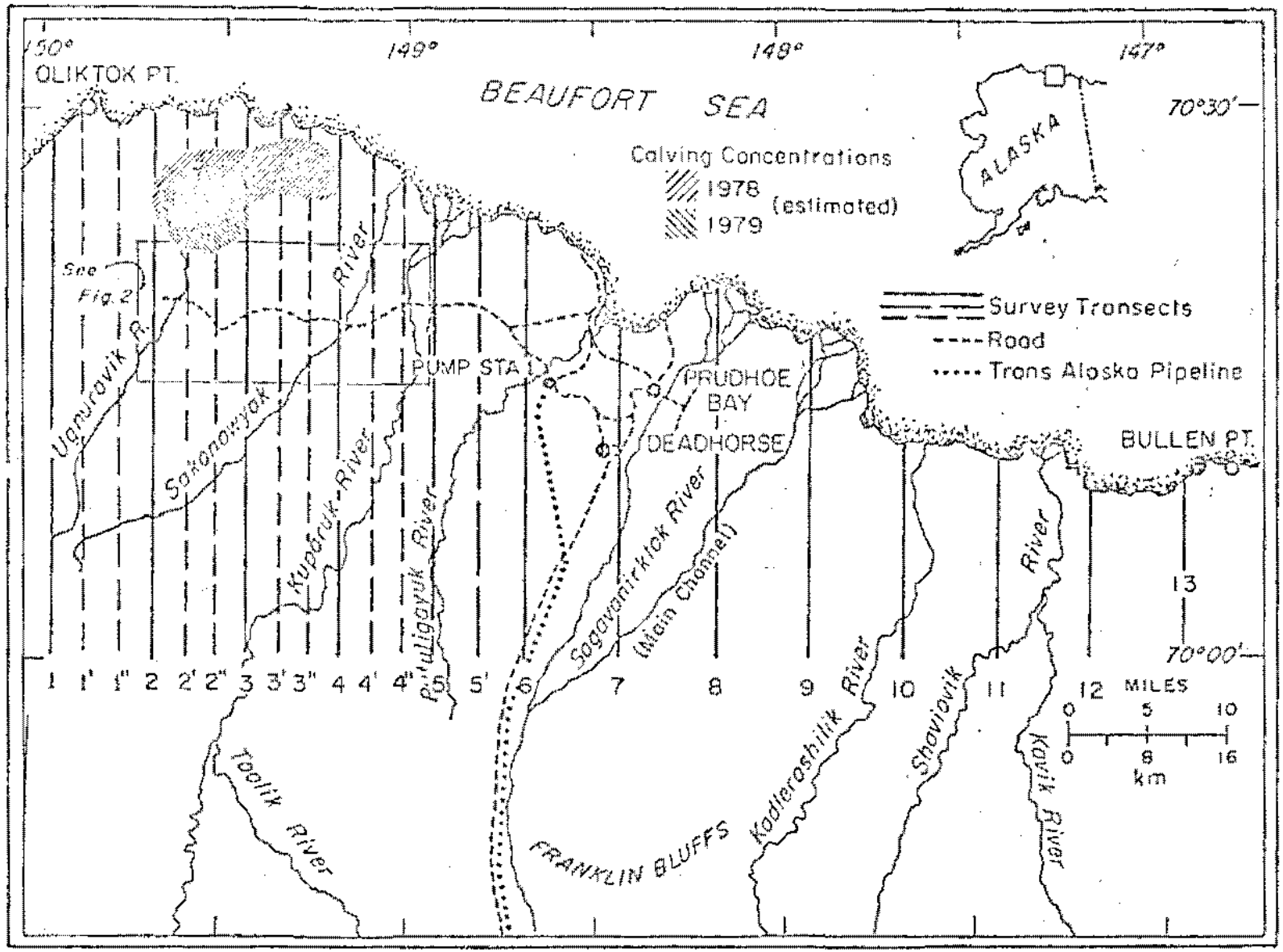


Fig. 1. Aerial survey transects, observed calving concentrations, and the route of the West Sak Road.

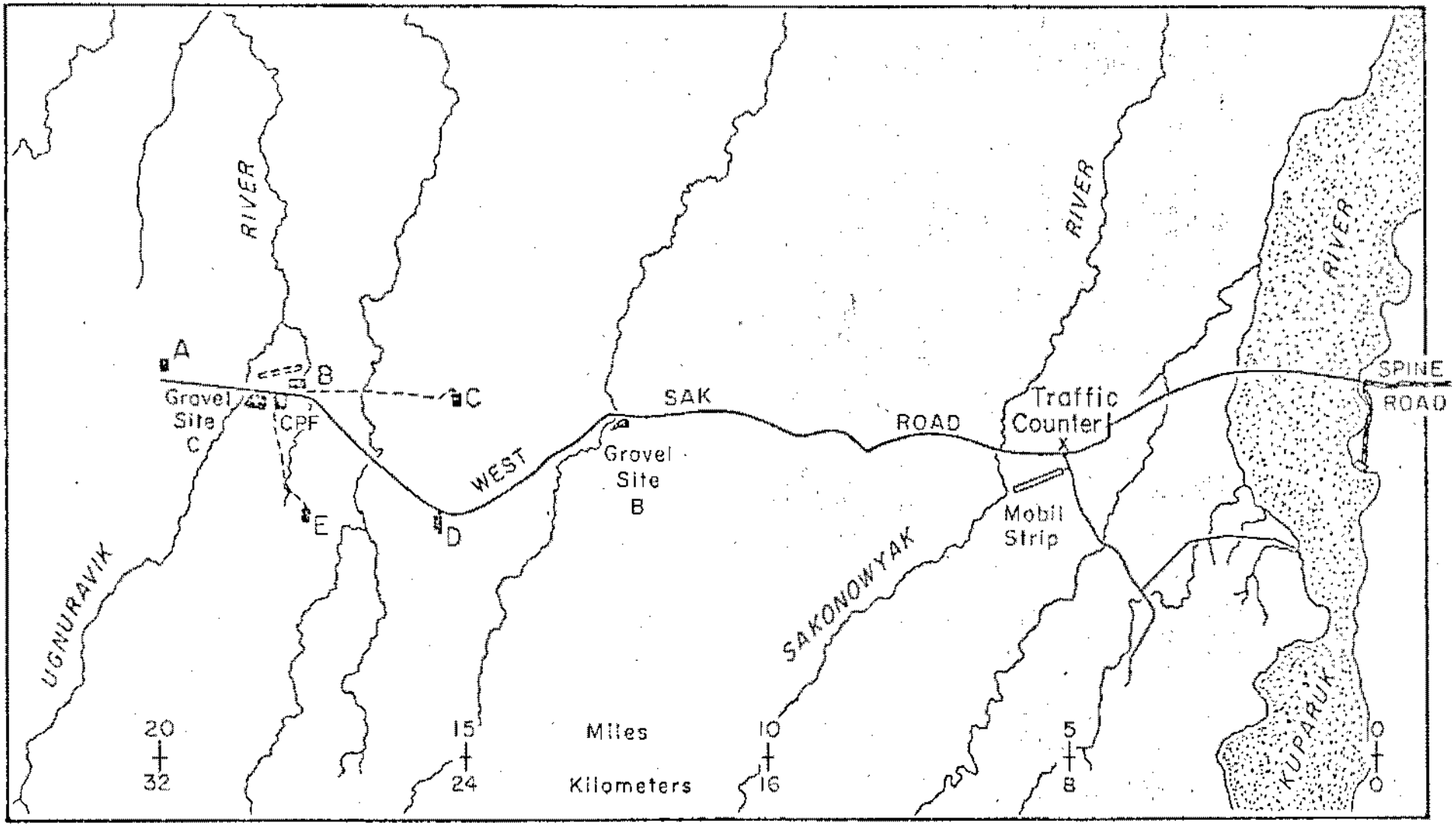


Fig. 2. Route of the West Sak Road (see Fig. 1), and the location of various associated facilities.

FINDINGS AND DISCUSSION

Distribution and Composition During Calving

During 1979 calving ground surveys 1,923 caribou were counted; composition figures are listed by observation number in Appendix I. By comparison, only 964 caribou were observed during calving surveys in 1978. Minor between-year differences in survey coverage may account, in part, for these differences in numbers. Fig. 3 shows numbers of adults and calves for each survey line flown in 1979, as well as sighting rates (caribou per km) for those transects spaced at regular 9.7-km intervals. The 1979 survey included two additional transects (1' and 1") through an area of high density calving and excluded one transect (1) which in 1978 was within an area of relatively low density (see Fig. 1). Nevertheless, Table 1 indicates that the mean sighting rate and estimated density increased for all areas surveyed in 1979, with greatest proportional increases occurring west of the Kuparuk River, the same general region which also supported the highest density calving in 1978. It is also likely that improved visibility contributed to the higher survey totals in 1979. The coastal plain was snow-free in 1979, whereas survey conditions were poorer in 1978 because of partial snow cover. However, it is inconceivable that known survey inconsistencies alone could have more than doubled the total count, and thus the 1979 results likely reflect a real increase in caribou density within the survey area.

Calves comprised 37 percent of the caribou observed on the calving grounds in 1979 and 36 percent in 1978; initial calf:cow ratios were similar at 85/100 and 82/100, respectively. However, proportionally more bulls and fewer yearlings were present in 1979 (7 bulls and 26 yearlings per 100 cows) than in 1978 (3 bulls and 39 yearlings per 100 cows). In

Table 1. Comparison of mean sighting rate and density of caribou on the Central Arctic Herd calving grounds in 1978 and 1979.

Area	Year	Mean Sighting Rate (number/100km)		Mean Density (number/100km^2)	
		Total Caribou	Calves	Total Caribou	Calves
West of Kuparuk River	1978	124	44	38	14
	1979	380	152	119	47
Between Kuparuk River and Sagavanirktok River	1978	62	19	19	6
	1979	75	30	23	9
East of Sagavanirktok River	1978	34	15	11	5
	1979	58	16	18	5
Total	1978	80	29	25	9
	1979	183	71	57	22

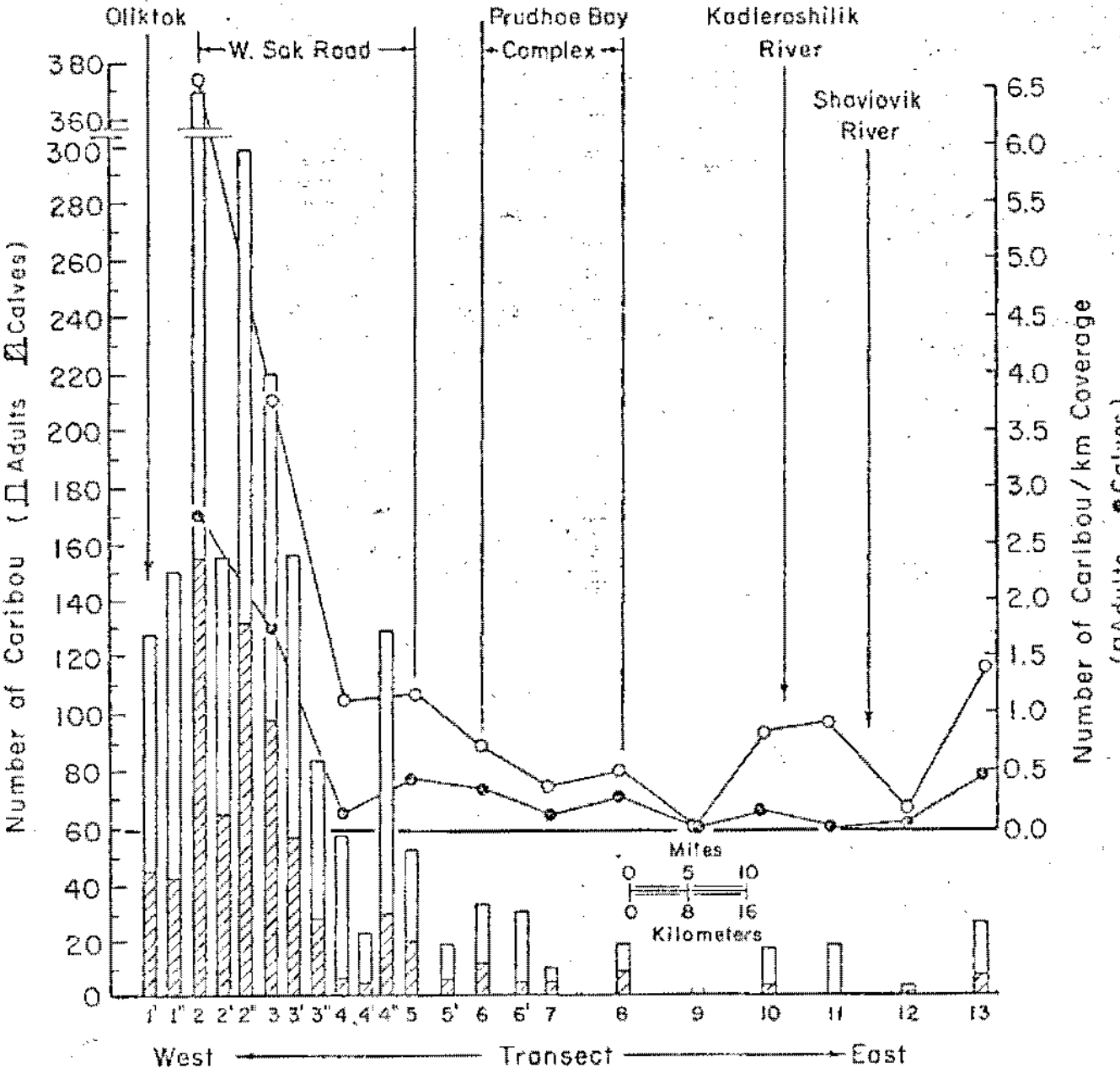


Fig. 3. East-west distribution of caribou (N of 70° lat.) during calving, and the corresponding sighting rates for each whole-number transect (see Fig. 1), 11-13 June 1979.

1979 calf percentages differed significantly among the regions surveyed. Calves were relatively more numerous west of the Kuparuk River (39%) than between the Kuparuk and the Sagavanirktok Rivers (26%) or east of the Sagavanirktok River (27%). Thus, the region of highest caribou density during calving was also characterized by the greatest increase in use and the highest initial calf production.

An analysis of caribou distribution relative to the Arctic Coast in 1979 (Fig. 4) indicates that calving west of the Kuparuk River was again concentrated toward the coast but had shifted slightly farther inland compared to 1978; 69 percent of total caribou and 73 percent of calves were between 8 and 24 km from the coast. As in the previous year, caribou between the Kuparuk and Sagavanirktok Rivers exhibited a definite inland distribution; 86 percent of all caribou and 87 percent of calves were located 24 to 40 km from the coast, and no calves were observed in the 8-16 km interval. Presumably, structures and activity associated with the Prudhoe Bay oilfield discouraged use of the coastal plain in that region.

Caribou distribution relative to the West Sak Road during calving is depicted in Fig. 5. A distinct peak in both calf and adult numbers is shown for the interval 4-12 km north of the road, slightly farther south than the peak in 1978; both peaks correspond to the respective areas of calving concentration shown in Fig. 1. Estimated minimum density of this calving "pod" in 1979 was 630 caribou/100 km^2 or 279 cow-calf pairs/100 km^2. Comparable figures for 1978 were substantially lower at 281 caribou/100 km^2 and 112 cow-calf pairs/100 km^2. There was no detectable avoidance of the road by cows and calves in 1979.

Summer Use of of the KDA by Caribou

The distribution of caribou sightings along the West Sak Road during midsummer 1979 is depicted in Fig. 6; all pertinent data are listed in Appendix II. A total of 2,695 caribou in 438 groups were observed from the road, substantially higher than the 1,667 individuals in 184 groups observed in 1978. This increase is partially attributable to a greater number of surveys, although other factors were also involved (see below). In 1979, 67 percent of the caribou observed were north of the road, 31 percent were south, and 1 percent were west of the road terminus (the remaining 1 percent were either on the road when first sighted, or no position was recorded). Thus, relatively more caribou were sighted north of the road, with fewer to the south or west than in 1978 (57, 39, and 4%, respectively).

Two thousand nineteen caribou (75%) in 425 groups (97%) were classified in 1979, a somewhat higher proportion than in 1978. However, sex and age identification among adults is subject to known errors, and the percentage of calves is considered the only reliable parameter for comparison (Cameron and Whitten 1979c). In 1979, 23 percent of the caribou observed from the road were calves, and percentages for groups seen north and south of the road were not significantly different.

In 1978 the mean percentage of calves observed along the West Sak Road did not differ significantly from the percentage of post-calving aggregations in the surrounding area (Cameron and Whitten 1979c).

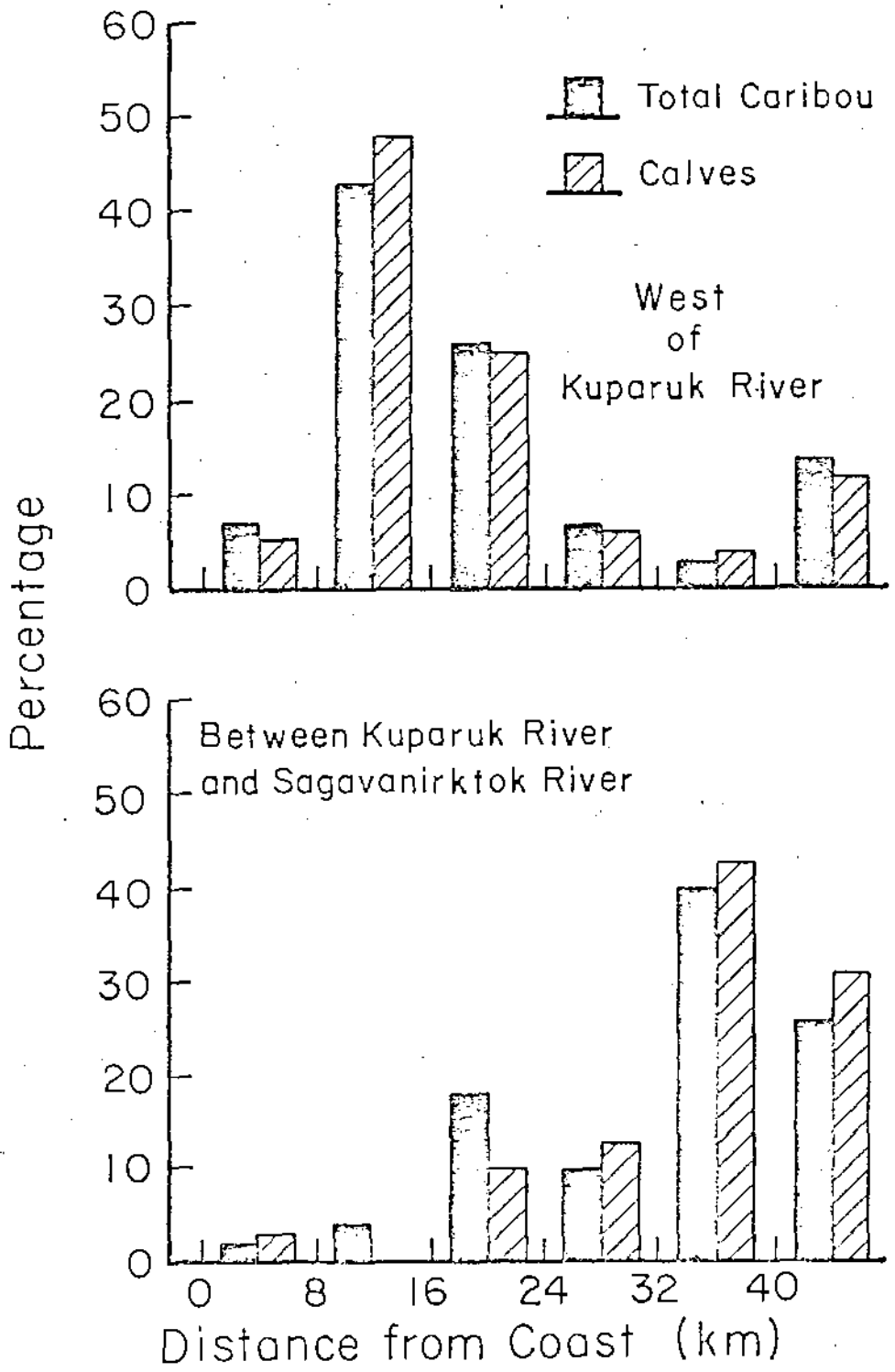


Fig. 4. Distribution of caribou in relation to the arctic coast, 11-13 June 1979.

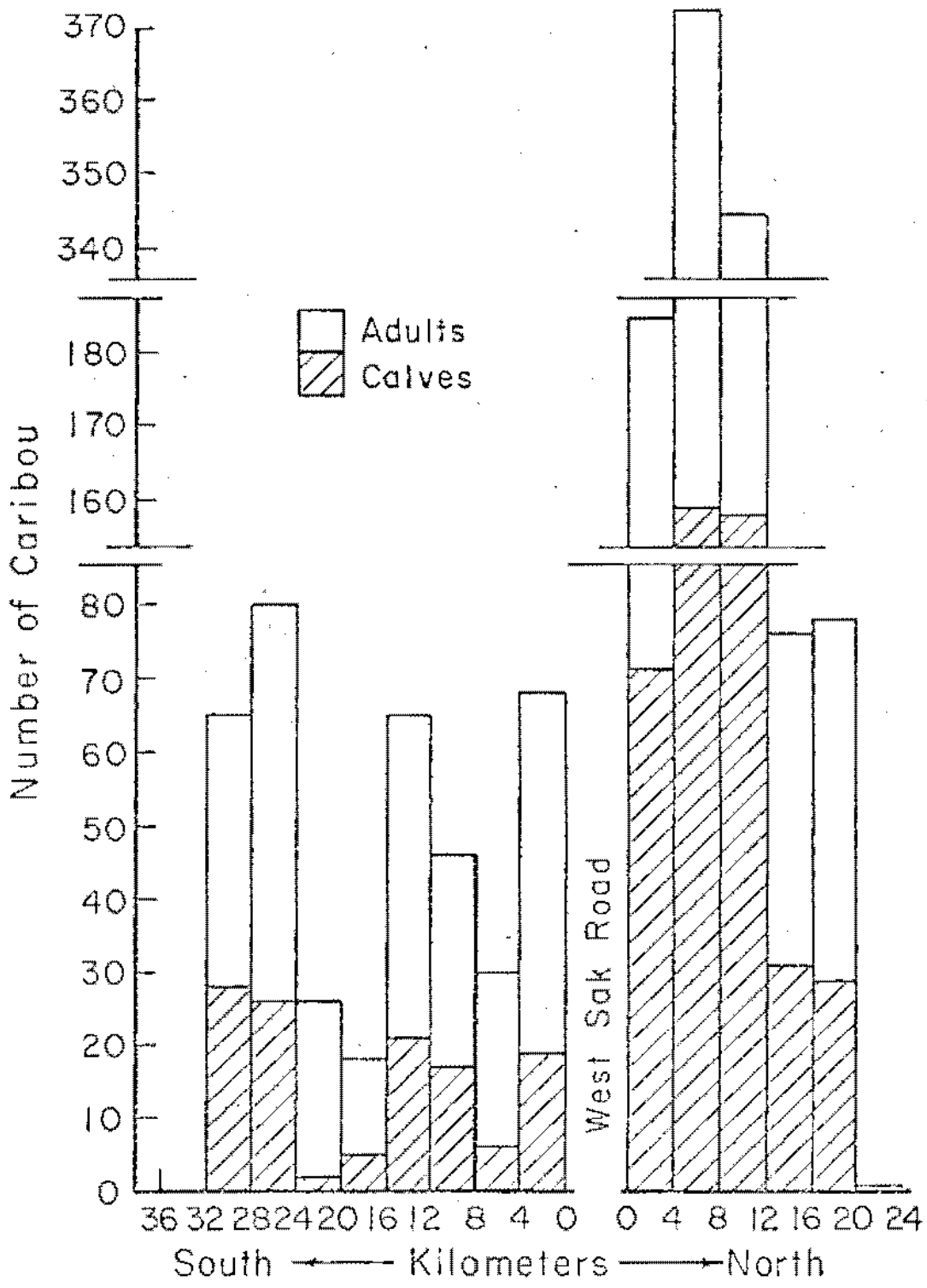


Fig. 5. Distribution of caribou in relation to the West Sak Road, 11-13 June 1979.

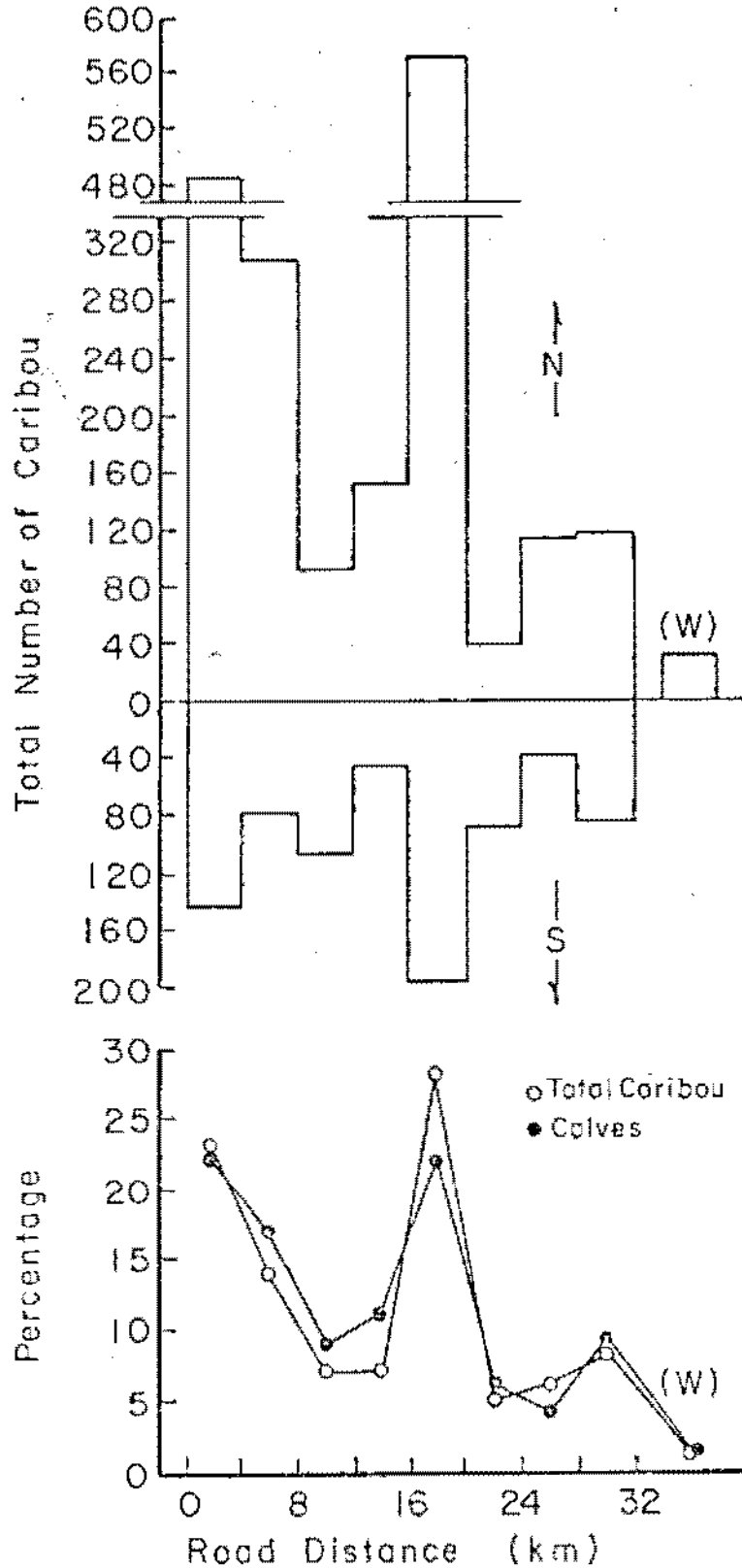


Fig. 6. Overall distribution of caribou observed along the West Sak Road, 26 June-21 August 1979.

Unfortunately, no comparable area-wide survey was done in 1979, although initial calf production (85 calves/100 cows) was very similar to that in 1978 (82 calves/100 cows), when an estimate of 25-26 percent calves was obtained in midsummer. The high overwinter calf survival in 1978-1979 (Cameron and Whitten, unpubl.) and the subsequent addition of a large cohort of nonreproductive yearlings would reasonably result in a lower overall calf percentage in 1979. In addition, an aerial survey in late August 1979, which included the foothill areas farther south where bulls normally predominate (Cameron and Whitten 1979a), yielded a minimum of 20 percent calves. Thus, it appears probable that the value of 23 percent calves obtained by road survey in 1979 was representative of caribou in the general area. Similarly, calf percentages determined for caribou observed within three intervals of distance from the road (0-500, 600-1,000, and more than 1,000 m) varied between 21 and 26 percent, but differences were not significant. Hence, there was no detectable cow/calf avoidance of the West Sak Road in 1979.

As in 1978, caribou were not distributed uniformly along the West Sak Road, but were concentrated within several "nodes" of occupancy. Fig. 6 shows that 52 percent of caribou sightings were within the 0-4 and 16-20 km intervals, which collectively make up only 25 percent of the road length.

In 1979, 225 caribou in 52 separate groups were observed crossing the road during routine surveys, fewer caribou but more groups than in 1978 (281 caribou in 23 groups). Twenty-two groups totaling 38 caribou either remained on the road shoulder as the survey vehicle passed (i.e. counted as "crossings" with direction unknown) or the direction of movement was inadvertently not recorded. Otherwise, crossing direction was overwhelmingly to the north (174 caribou in 23 groups, representing 93 percent of all caribou and 77 percent of the groups observed crossing the road). Of 214 caribou classified in crossing groups, 29 percent were calves, a significantly higher proportion than for the aggregate number of caribou observed. This, and the preponderance of northerly crossings, could reflect a strong tendency for cow/calf groups to move toward insect relief habitats near the coast. CAH bulls are typically distributed farther inland during summer (Cameron and Whitten 1979a).

Fifty-eight percent of observed crossings were within the 16-20 km road interval (a node of occupancy), with an additional 17 percent within the adjacent 20-24 km interval; a small drainage system crosses the road in this area. This corroborates the tendency noted in 1978 for insect-induced movements to be channeled along rivers (Cameron and Whitten 1979c). The relative paucity of southward crossings in both years raises several questions. Cameron and Whitten (1979c) suggested that continuously severe insect harassment in 1978 reduced the amplitude of oscillatory movements within the coastal zone; that is, temporary abatement of harassment brought caribou inland within sight of the road, but not southward across it. In 1979, however, some of these movements apparently did continue across the road (see below), but southward crossings were not detected during routine road surveys. It may be that weather conditions favoring insect activity and inducing coastal movements of caribou occurred near midday, when most surveys were conducted. Inland dispersal of caribou was probably more common during the late night or early morning hours when lower temperatures resulted in decreased insect activity. However, with the arrival of a

storm front on the late afternoon of 25 July we observed several hundred caribou moving southwest from the general area of Point McIntyre and crossing the West Sak Road just west of the Kuparuk River. Because of deteriorating weather a road survey could not be completed; consequently, this observation does not appear in the tabulated survey results. Thus, although crossing observations made during routine road surveys may be good indicators of preferred crossing locations (i.e. drainages), they may not accurately reflect the chronological patterns of local movement or the magnitude of total crossing activity.

The Effect of Insects on the Daily Patterns of Caribou Occupancy Along the West Sak Road

Caribou in the Prudhoe Bay area may be periodically subjected to insect harassment from as early as 25 June to approximately 15 August (White et al. 1975, Cameron and Whitten 1979c). Mosquitoes predominate until about 5 August but are subsequently replaced by oestrid flies. However, both are present in late July and early August, and the resultant harassment on warm, still days may be extreme. Large, dense aggregations of caribou may form on habitats on or near the coast where lower temperatures and sea breezes provide relief from insects. When cooler temperatures and/or higher winds reduce insect activity farther inland, caribou disperse to preferred feeding areas. These movements in response to changing weather and insect activity can be extensive and rapid--up to 40 km in a 24-hour period (Cameron and Whitten 1979c, unpubl.).

Levels of insect harassment estimated from 1979 weather data (see White et al. 1975, Cameron and Whitten 1979c) are shown in Fig. 7 along with corresponding observations of caribou distribution along the West Sak Road area. Conditions did not favor insect activity until late on 29 June, when severe harassment developed rapidly and continued through 3 July. Very few caribou were present near the road. Although no aerial survey data from the Kuparuk region are available for that period, flights farther east along the coast between the Sagavanirktok and Canning Rivers showed that caribou were concentrated on coastal insect relief habitat (Cameron and Whitten, unpubl.). Moderate harassment continued through 5 July, and the majority of caribou in the area probably remained well north of the road. Lower levels of harassment on 7 July brought large numbers of caribou inland to the north side of the road. Low to moderate insect levels prevailed through 11 July, followed by severe harassment between 12 and 15 July and moderate harassment on 16 and 17 July. These conditions should have favored continued southward movement across the road after 7 July and a rapid reversal to the coast after 12 July. Aerial surveys and radiocollar relocations confirmed that caribou were concentrated near the coast on 18 July, but unfortunately both aerial and road surveys were too infrequent to confirm expected movements across the road from 7 to 12 July. Caribou returned to the north side of the road on 20 July following 3 days of generally light harassment. Continued movement southward across the road likely occurred, as moderate harassment on 21 and 22 July caused substantial numbers of caribou to cross the road northbound. With severe harassment on 23 and 24 July few caribou were found near the road, although some additional northward crossings were observed. Aerial surveys confirmed that caribou were again concentrated on coastal relief habitats. Insect activity declined on the morning of 25 July, and large numbers of

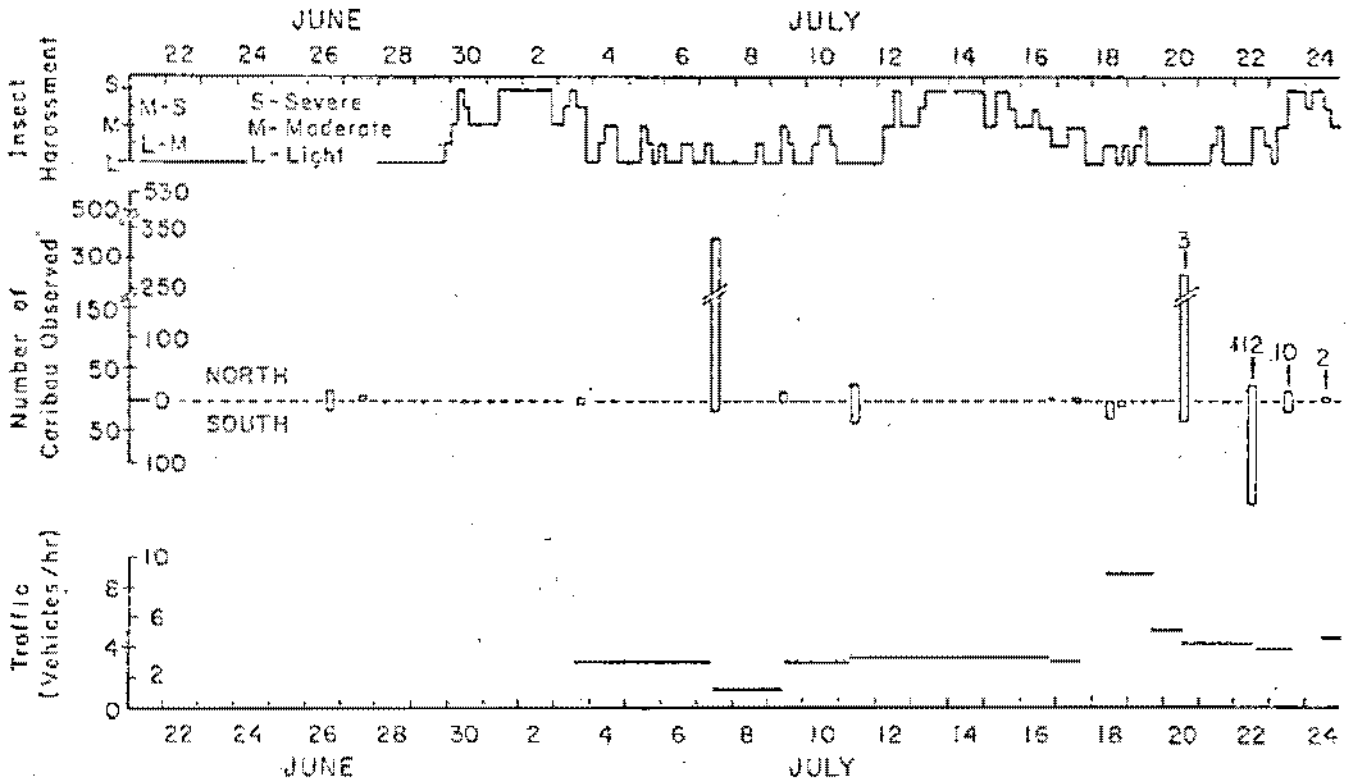
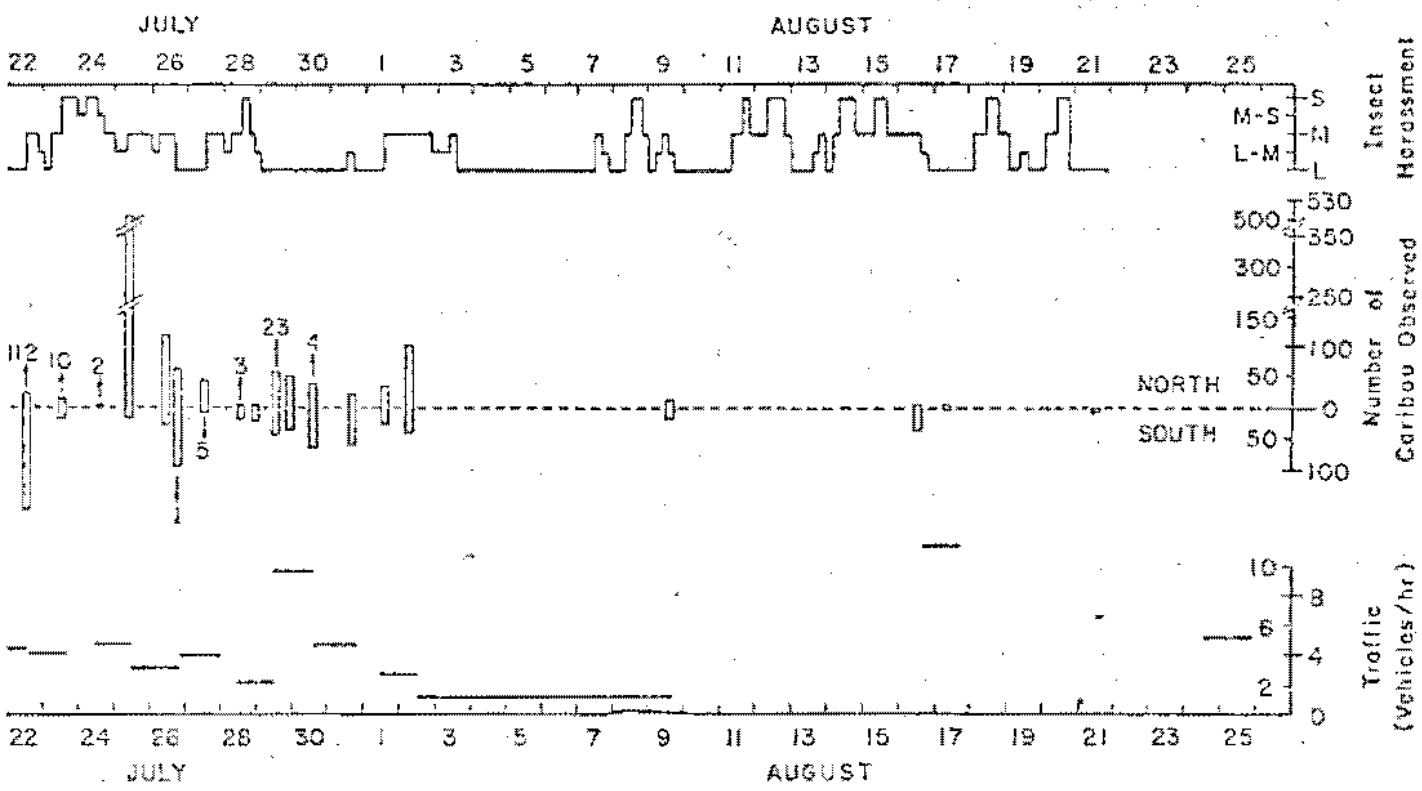


Fig. 7. Caribou sightings/crossings along the West Sak Road in



relation to insect harassment and local traffic, 26 June-21 August 1979.

caribou returned to the road. Several hundred caribou crossed the road southward that evening (see above) and remained to the south through 26 July. A brief period of severe harassment on 28 July may explain the low number of sightings on that date and early on 29 July; most caribou had presumably moved back to the coast. Only light to moderate harassment occurred thereafter through 7 August, which is normally beyond the end of the mosquito season. Caribou were dispersed on both sides of the road in moderate numbers during this entire period. Severe harassment by oestrid flies prevailed on most days between 8 and 21 August, and caribou responded by dispersing inland in small, scattered groups. Very few caribou were present along the West Sak Road and aerial and haul road surveys confirmed that most caribou had moved some distance to the south.

The foregoing discussion indicates that patterns of weather/insect harassment offer a reasonable explanation for midsummer caribou movements and occupancy in the vicinity of the West Sak Road. Severe insect harassment drives caribou northward away from the road, while light to moderate harassment brings caribou inland to or across the road. A similar interrelated pattern was noted in 1978 (Cameron and Whitten 1979c) for the KDA. In both 1978 and 1979 road surveys were conducted almost daily between 18 July and 5 August. During this period in 1978 there were 8 days of severe, 9 of moderate, and only 2 of light harassment. In contrast, the 1979 data indicated 3 days of severe, 9 of moderate, and 7 of light harassment. The predominance of moderate and severe insect harassment in 1978 resulted in a mean caribou sighting rate of 2.7 per road km, while surveys during the predominantly light-to-moderate conditions of 1979 yielded an overall sighting rate of 3.5 caribou per km. Thus, higher total numbers of caribou along the West Sak Road in 1979 may be mainly a function of between-year weather differences as manifested by variations in insect harassment.

Effects of Road Traffic and Construction Activity on Caribou Use of the KDA

As in 1978, changes in caribou occupancy along the West Sak Road showed little relation to traffic levels. Any effects were presumably masked by the stronger influence of insects on caribou movements. In general, however, traffic rates in 1979 ($x = 3.6$ vehicles/hr) were lower than in 1978 ($x = 10.1$ vehicles/hr), even though considerably more local construction activity occurred during the latter year. In 1979 restrictions on unnecessary or unauthorized travel were implemented and, in addition, midsummer flooding of the Kuparuk River halted most traffic for nearly a week. Whether lower traffic rates in 1979 had a separate, moderating effect on sighting rate is highly conjectural.

In 1978 the majority of caribou sightings and crossings occurred within three sections of the West Sak Road (intervals 0-4 km, 8-12 km, and 28-32 km. These areas corresponded to intersections of the road with the Kuparuk, Sakonowyak, and Ugnuravik Rivers, respectively (Fig. 2). It was suggested that such drainages may be preferred routes of movement between inland feeding areas and insect relief habitat on the coast. Two additional drainages, both unnamed on USGS maps, intersect the West Sak Road: the so-called West Fork of the Kuparuk River (road interval 4-8 km) and a small stream near Gravel Site B (road interval 16-20 km). Nodes of caribou occupancy in 1979 were again associated with drainage

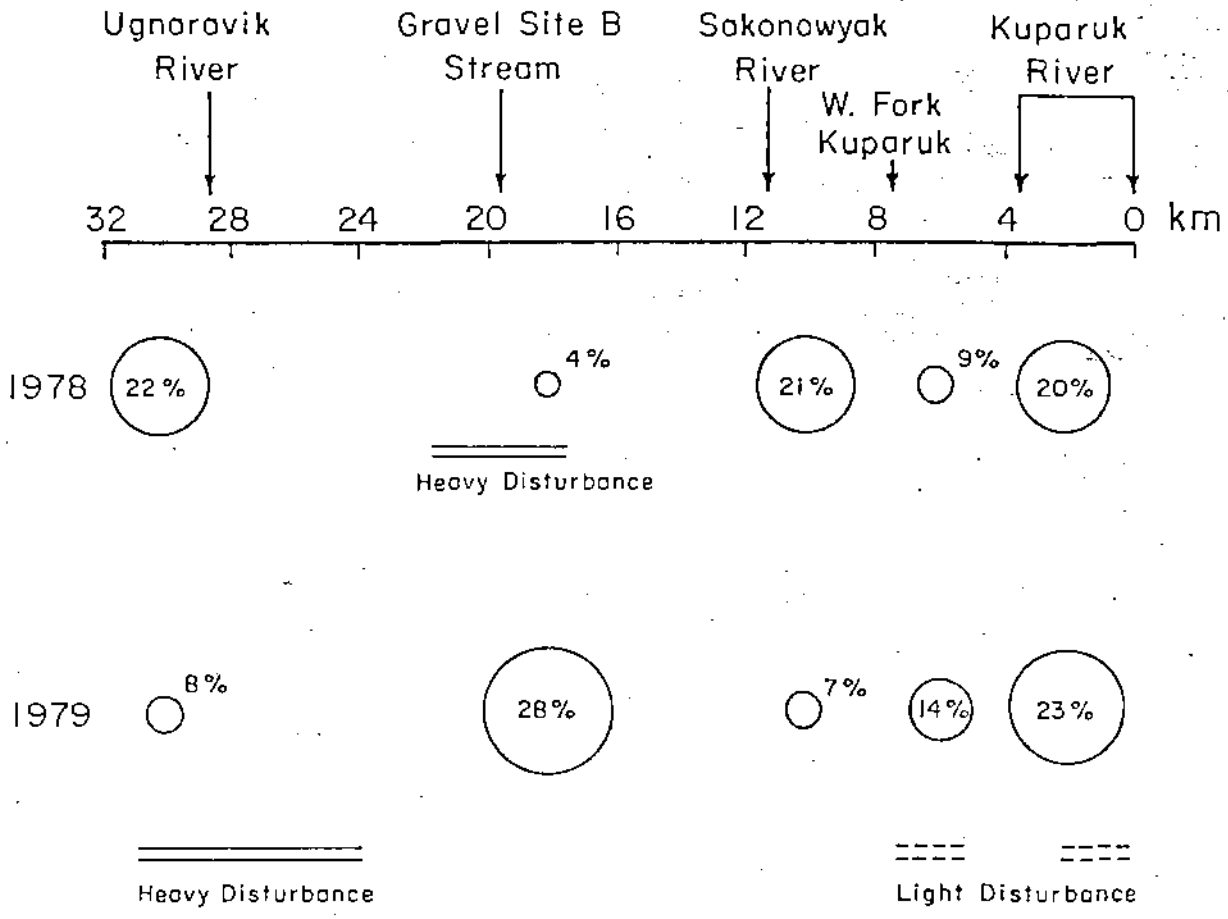


Fig. 8. Schematic summary of summer caribou distribution along the West Sak Road for 1978 and 1979.

systems. The Kuparuk remained an area of heavy use, but there were major decreases in relative sightings near the Ugnuravik and Sakonowyak Rivers, a slight increase in use of the West Fork of the Kuparuk, and a marked increase in use of the stream channel near Gravel Site B. These changes are illustrated schematically in Fig. 8.

Construction activity in 1978 was heaviest around Gravel Site B, possibly accounting for the scarcity of caribou sightings in that location. The CPF area (see Fig. 2), where little activity occurred during summer 1978, was the site of continuous heavy construction throughout the survey period in 1979. Up to 29 pieces of heavy equipment and 6 job-related pickups were in use daily on the West Sak Road, two well pad access roads, an airstrip and the CPF site itself (Fig. 2); the 28-32 km and most of the adjacent 24-28 km road intervals were affected (Fig. 8). Again, this level of intensive disturbance could account for the observed decrease in caribou use locally. Furthermore, any displacement of caribou from the vicinity of the Ugnuravik drainage could have contributed to the observed increase in occupancy of the adjacent drainage near Gravel Site B.

Some minor construction-related activity was present in the Kuparuk River as a result of flooding in early August 1979. Ferrying men and equipment across the river and subsequent road repairs resulted in some additional disturbance. However, this activity was little more than normal traffic and had no apparent effect on caribou summer use of the immediate area. In addition, culvert installation in the West Fork of the Kuparuk occasionally involved intense activity, but began late in the 1979 survey season (4 August) when caribou dispersal was already in progress. No adverse effects were discernible; in fact, caribou use of the corresponding road increased slightly relative to 1978 (Fig. 8).

Thus, it appears that changes in the intensity of construction activity associated with a given drainage had an inverse effect on caribou occupancy in that area. Other areas characterized by relatively little change in betweeen-year construction activity showed correspondingly little change in caribou use. The apparent exception to this pattern is the Sakonowyak River where construction activity was low in both years; it was identified as a node of caribou occupancy in 1978 but had relatively little use in 1979.

In summary, drainages appear to be the most important avenues of caribou movement, although the results suggest considerable natural and disturbance-induced variation in the year-to-year use of a given drainage. The levels and duration of disturbance within and among these specific areas of preferred habitat may be a critical consideration in avoiding displacement of caribou during oilfield development.

RECOMMENDATIONS

To date no major abnormalities in caribou summer distribution have been identified in the vicinity of the Kuparuk Development Area. It appears that recent levels of exploration and construction-related activity have remained below the cumulative threshold of disturbance; but it is also conceivable that exposure of resident caribou to these stimuli has been of insufficient duration to elicit an adverse response. Studies near Prudhoe

Bay and along the Trans-Alaska Pipeline Corridor clearly demonstrate that caribou will be displaced at some level of local disturbance within calving and summer range. These "critical" conditions have not been defined, and caution should continue to be exercised in terms of human and vehicular activity, particularly during construction, and through the appropriate design and placement of production facilities. The following recommendations are intended to minimize disturbance to caribou during the progress of oilfield development.

A. Activities

1. 15-30 May (pre-partum staging of parturient females). No construction; only essential road maintenance and preparations for spring breakup.

2. 1-20 June (calving period). No construction; minimal road maintenance.

3. 21 June-7 July (post-calving dispersal, no insects). Summer road repairs, equipment transfers, moderate construction.

4. 8 July-5 August (insect-induced movements). No construction, except at or near permanent facilities; only essential road maintenance; minimum road traffic.

5. 6-15 August (insect-induced movements continued). Continuation of recommendations under 4 above, highly desirable; otherwise, road maintenance and minor construction.

6. 16 August-15 September (inland dispersal). Road upgrading and repairs; equipment/facilities transfer; moderate construction.

7. 16 September-14 May (minimum conflict with caribou). Major construction, no restrictions.

B. Structures and Facilities

1. Permanent facilities should include only those absolutely essential to oil production. Temporary facilities should be similarly minimal and restricted to sites of permanent development.

2. Facilities should not be located in areas regularly occupied by large numbers of caribou and/or where caribou crossings are known to be frequent. Accordingly, placement of facilities adjacent to streams or rivers should be avoided.

3. Production lines should be buried and consolidated wherever possible. Compulsory above-ground sections should be located in nonsensitive areas, if possible. Appropriate crossing provisions should be located in areas of high caribou occupancy.

C. General

At no time during the spring and summer months should road or air traffic within the Kuparuk Development Area exceed the minimum required for specific maintenance, restoration, relocation, and/or production functions. Road traffic should be screened carefully to avoid unauthorized and unnecessary use, and authorized trips should be scheduled as infrequently as practicable, using vehicle convoys if appropriate. Low-level flights (i.e. less than 500 ft) should be prohibited, and the frequency of helicopter and fixed-wing operations reduced to the greatest extent possible. In general, transport activities from midday through late afternoon are less likely to conflict with caribou during the insect season.

ACKNOWLEDGMENTS

This study was supported primarily through a grant from ARCO, SOHIO/BP, and EXXON. Additional support was obtained through Federal Aid in Wildlife Restoration and from the Alaska Department of Fish and Game. Thanks are extended to Arctic Slope Alaska General, Inc. for logistic assistance. Technical assistance by W. T. Smith is gratefully acknowledged.

LITERATURE CITED

Cameron, R. D. and K. R. Whitten. 1979a. Seasonal movements and sexual segregation of carihou determined by aerial survey. J. Wildl. Manage. 43:626-633.

_____ and _____. 1979b. Effects of the Trans-Alaska Pipeline on caribou movements. Alaska Dept. Fish and Game, Fed. Aid Wildl. Rest. Proj. W-17-10 and W-17-11. Juneau. 36pp.

_____ and _____. 1979c. Distribution and movements of caribou in relation to the Kuparuk Development Area. First Interim Rept. to ARCO, EXXON, and SOHIO. Alaska Dept. Fish and Game, Fairbanks. 32pp.

_____ and _____. 1980. Influence of the Trans-Alaska Pipeline corridor on the local distribution of caribou. Proc. Second Int. Reindeer/Caribou Symp., September 1979, Røros, Norway. (in press)

_____, _____, W. T. Smith and D. D. Roby. 1979. Caribou distribution and group composition associated with construction of the Trans-Alaska Pipeline. Can. Field-Nat. 93:155-162.

Davis, J. L. and P. Valkenburg. 1978. Western Arctic caribou studies. Alaska Dept. Fish and Game, Fed. Aid Wildl. Rest. Proj. W-17-8 and W-17-9. Juneau. 95pp.

Gavin, A. 1973. 1972 wildlife survey, Prudhoe Bay area of Alaska. Rep. publ. by Atlantic-Richfield Co.

Hemming, J. E. 1971. The distribution and movement patterns of caribou in Alaska. Alaska Dept. Fish and Game, Wildl. Tech. Bull. No. 1.

White, R. G., B. R. Thomson, T. Skogland, S. J. Person, D. E. Russell, D. F. Holleman and J. R. Luick. 1975. Ecology of caribou at Prudhoe Bay, Alaska. In Ecological investigations of the tundra biome in the Prudhoe Bay region, Alaska. Biol. Pap., Univ. of Alaska, Fairbanks, Spec. Rep. No. 2.

Appendix I. Survey observations on the calving grounds, 11-13 June 1979.

Obs. No.	Total No.	B	C	Ca	Y	A	Obs. No.	Total No.	B	C	ca	Y	A
1	2					2	46	2	1	1			
2	6		3	3			47	6		3	3		
3	2		1	1			48	1			1		
4	19		13	6			49	6	2			2	2
5	2		1	1			50	2		1	1		
6	1		1				51	6	2			4	
7	8				1	7	52	6	6				
8	4					4	53	1			1		
9	7				5	2	54	3	2			1	
10	1					1	55	1				1	
11	4					4	56	2				1	1
12	3		1	1	1		57	6		2	2	2	
13	4				2	2	58	4		2	2		
14	8		3	3	2		59	2				1	1
15	4		2	2			60	2		1	1		
16	2		1	1			61	2				2	
17	4		2	2			62	2		1	1		
18	2		1	1			63	1					1
19	2		1	1			64	1				1	
20	6		3	3			65	3	1			2	
21	8		4	4			66	8				6	2
22	1					1	67	2		1	1		
23	2		1	1			68	2	1				1
24	6	2				4	69	6	5			1	
25	2		1	1			70	10	4			6	
26	2		1	1			71	1	1				
27	5	5					72	2				2	
28	6				4	2	73	7	1	1	1	3	1
29	7	1	2		4		74	1					1
30	4		2	2			75	9	1			8	
31	5	1			4		76	1				1	
32	2				2		77	6				5	1
33	8		4	4			78	15		6	6		3
34	18		9	9			79	4		2	2		
35	3		2		1		80	27		13	12	1	1
36	2		1	1			81	11		5	5	1	
37	6		3	3			82	11				10	1
38	7		4	1		2	83	3				2	1
39	2		1	1			84	3	2			1	
40	2		1	1			85	5		2	2	1	
41	4	3			1		86	9		4	4		1
42	1	1					87	9		4	4		1
43	19		8	8		3	88	3	1			1	1
44	2				2		89	4	3			1	
45	17		8	8	1		90	4		2		2	

Appendix I. Continued.

Obs. No.	Total No.	B	C	Ca	Y	A	Obs. No.	Total No.	B	C	ca	Y	A
91	10		5	5			136	12		2	2	7	1
92	2		2				137	1		1			
93	6		2	2	2		138	12		6	6		
94	8		4	4			139	6		3	3		
95	2				1	1	140	10		5	5		
96	34		15	9	3	7	141	38		19	18	1	
97	9		3	2	3	1	142	29		15	12	2	
98	5		2	2	1		143	16		8	8		
99	6		3	3			144	18		9	8	1	
100	1				1		145	5				3	2
101	19		9	9		1	146	3		1	1	1	
102	4		2	2			147	2		1	1		
103	2		1	1			148	3		1	1	1	
104	12		5	5	2		149	35		17	15	3	
105	9		4	4	1		150	23		12	9	2	
106	6		3	3			151	14		7	7		
107	8		4	4			152	4		1	1	2	
108	5		2	2		1	153	12		6	5		
109	1				1		154	2		1	1		
110	12		6	4	1	1	155	9		4	4		1
111	8		4	4			156	5		2	2		1
112	10		5	5			157	10		5	3	2	
113	52		27	25			158	25		12	12	1	
114	33		17	16			159	18		8	7	3	
115	68		39	27	2		160	94		55	39		
116	2		1	1			161	30		14	14	2	
117	8		4	4			162	18		9	9		
118	2		1	1			163	43		23	20		
119	6		2	2	2		164	18		9	7	2	
120	1				1		165	1					1
121	1				1		166	9	4			5	
122	4		2	2			167	1	1				
123	13		6	6	1		168	2				2	
124	4				2	2	169	3				2	1
125	3		1	1	1		170	20		8	5	7	
126	14		7	6	1		171	2				1	1
127	4		1	1	1	1	172	42		26	11	5	
128	14	1	3	3	3	4	173	20		11	9		
129	95		51	43	1		174	6	1				5
130	87		46	41			175	1				1	
131	33		16	16	1		176	15		6	6		3
132	10		5	5			177	4		2	2		
133	4		2	2			178	1				1	
134	27		14	12	1		179	21		6	6	3	6
135	2		1	1			180	3				2	1

Appendix I. Continued.

Obs. No.	Total No.	B	C	Ca	Y	A	Obs. No.	Total No.	B	C	ca	Y	A
181	4		2	2									
182	2		1	1									
183	3					3							
184	1					1							
185	2		1	1									
186	2		1	1									
187	40		16	16	4	4							
188	2				1	1							
189	2					2							
190	4		1	1	1	1							
191	51		29	20		2							
192	5		2	2		1							
193	6		3	3									
194	3				1	2							
195	1				1								
196	7		2	2	1	2							
197	2					2							
Totals	1923	56	833	710	216	108							

B = bulls, C = cows, ca = calves, Y = yearlings, and A = adults.

Note: Some observations include more than one group of caribou.

Appendix II. Survey observations from the West Sak Road, 26 June-21 August 1979.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[1] (mi)	I.O.D.[2] (yd)	N/S[3]
26 June	1415-1615	1	1	1						2.0	500	N
		2	2		1		1			2.1	300	N
		3	4					4		2.4	1000+	N
		4	3					3		2.1	1000+	S
		5	2	1				1		7.1	1000+	N
		6	1	1						7.8	600	N
		7	7		2	2	1	2		20.0	800	S
		8	5	1	2	1		1		20.0	600	N
		9	5	1	1	1	1	1		12.4	1000+	S
		10	1					1		6.7	800	N
27 June	1200-1400	1	4	2			2			0.5	200	N
		2	1	1						1.1	100	N
Survey terminated		3	1	1						3.6	1000+	S
at Mi 18.0		4	2	1				1		3.6	1000+	N
		5	2	1		1				3.9	250	S
3 July	1445-1645	1	2	1				1		11.4	1000	S
		2	1	1						14.1	1000+	S
		3	3	3						14.9	1000+	S
		4	1			1				18.6	1000+	N
7 July	1100-1300	1	3		1	1		1		13.0	1000+	S
		2	255						255	10.8	1000+	N
		3	5	5						6.0	350	N
		4	72	6	25	19	5	17		3.9	600	N
		5	13	4	4	3	1	1		3.3	800	S
		6	2	1				1		2.3	1000+	S
9 July	0915-1115	1	3					3		15.8	1000+	S
		2	1	1						6.9	0	~(X)
		3	12	2	2	2		6		4.4	1000+	N
		4	1	1						1.6	50	N
11 July	0800-1000	1	1					1		19.9	1000+	S
		2	20		3	3		12	2	20.0	1000+	S
		3	25	2	4	4		15		20.0	1000+	N
		4	9		2	2		5		20.0	1000+	W
		5	12	12						18.4	1000+	S
16 July	2030-2200	1	1				1			2.6	500	N
17 July	1325-1555	1	1	1						0.1	150	N
		2	1				1			3.7	200	S
		3	1	1						1.7	50	S

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[1] (mi)	I.O.D.[2] (yd)	N/S[3]
18 July	1010-1240	1	15	13			2			0.5	900	S
		2	3	3						0.5	400	S
Survey terminated		3	10	10						1.6	400	S
at Mi 18.0		4	1	1						1.9	400	S
	1640-1840	1	5	5						0.2	200	S
		2	1	1						1.0	800	N
Survey terminated		3	1	1						1.2	75	N
at Mi 18.0		4	1	1						9.9	150	S
19 July	1400-1522	1	1	1						12.1	600	S
20 July	1000-1200	1	11	3	2	2	2	2		3.4	500	N
		2	4		2	2				8.9	1000+	N
		3	3	1				2		9.2	700	N
		4	23	2	11	8		2		10.4	400	S
		5	175						175	12.4	800	N
		6	20						20	16.0	1000+	N
		7	38						38	15.8	1000	N
		8	5		3	1	1			12.4	150	S
		9	3		1	1	1			11.9	0	(S)X
		10	9	1	4	3	1			9.4	150	N
		11	5			2		3		8.4	800	N
		12	9			2		7		7.3	800	N
		13	5		3	2				2.9	400	N
22 July	1130-1330	1	1	1						3.3	600	N
		2	8		1	1		6		3.3	1000+	N
		3	8	1	4	3				4.9	1000+	N(X)[4]
		4	13		5	5		3		4.6	1000	S
		5	1			1				8.0	1000	S
		6	77	4	40	27	5	1		10.8	1000	S(X)
		7	30	3	9	9		9		11.6	1000+	S
		8	1						1	12.2	0	S(X)
		9	33	3	12	12	3	3		12.4	1000+	S(X)
		10	2	2						13.2	--	S(X)
		11	17	5					12	20.0	1000+	W
		12	2		1	1				2.6	0	S(X)
		13	1					1		2.1	100	S
23 July	1045-1245	1	1	1						0.3	400	N
		2	1		1					1.1	200	N
		3	1	1						1.5	50	S(X)
		4	1	1						4.1	0	S(X)

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[1] (mi)	I.O.D.[2] (yd)	N/S[3]
		5	1		1					5.2	50	S
		6	1					1		5.9	1000+	S
		7	1				1			9.5	50	S(X)
		8	2		1	1				9.5	100	N
		9	3		1	1		1		10.8	1000+	S(X)
		10	2		1	1				11.9	0	-(X)
		11	1	1						9.5	1000+	N
		12	1	1						10.8	400	S
		13	1					1		13.8	800	N
		14	1		1					14.0	1000+	S
		15	1		1					14.3	1000+	S
		16	1			1				16.0	1000+	S
		17	1	1						17.9	75	N
		18	2				1	1		19.9	1000+	N
		19	1	1						18.0	50	S(X)
		20	1					1		15.3	1000+	N
		21	1		1					14.6	300	N(X)
		22	2		1	1				5.5	50	S(X)
		23	3	3						3.0	1000+	N
24 July	1230-1430	1	1	1						1.2	400	N
		2	1		1					4.6	200	S(X)
		3	2		1	1				10.5	50	N
		4	1					1		19.4	1000+	N
		5	2		1	1				7.3	1000+	N
25 July	1000-1200	1	17	14				3		0.8	400	S
		2	170	65	34	29	3	39		1.7	1000+	N
		3	64	16	9	9		30		1.9	1000+	N
		4	134	21	54	37	12	10		2.4	700	N
		5	82	10	16	16		30	10	2.7	1000+	N
		6	53	4	14	14		21		3.2	1000+	N
		7	1	1						10.2	600	S
26 July	0840-1040	1	3	1	1	1				1.9	300	N
		2	6	1	2	2	1			2.6	800	N
		3	4	1	1		2			5.5	1000+	S
		4	5		2	2	1			5.8	1000+	S
		5	10					10		7.6	1000+	S
		6	20	1	8	6	1	4		8.9	1000+	N
		7	44		17	10	3	6	8	8.9	1000+	N
		8	7		3	3	1			9.6	700	N
		9	2		1	1				9.8	1000	S
		10	40		16	14	3	7		10.9	1000+	N
		11	5		3	1		1		11.5	1000+	S
		12	2	2						12.9	400	S

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[1] (mi)	I.O.D.[2] (yd)	N/S[3]
26 July	1700-1910	1	2	1	1					0.2	350	S
		2	1					1		0.3	800	S
		3	2		1	1				1.0	50	S
		4	1		1					1.2	500	S
		5	2					2		1.3	1000	S
		6	1	1						1.5	600	S
		7	2		1	1				2.1	75	N
		8	2	1						2.1	1000+	S
		9	2		1	1				2.1	1000+	S
		10	2					2		2.1	1000+	S
		11	1	1						2.1	1000+	S
		12	2		1	1				2.1	1000+	S
		13	9	1	5	1	2			2.5	800	S
		14	1				1			2.6	30	S
		15	2		1		1			3.0	200	N
		16	8			2		6		3.0	1000+	N
		17	3	1	1		1			3.8	800	S
		18	2				2			4.0	300	S
		19	2		1	1				4.2	400	N
		20	2	2						4.2	800	N
		21	2						2	4.2	1000+	N
		22	8	1		1		3	3	4.2	1000+	N
		23	2		1		1			4.3	200	S
		24	1					1		4.6	600	S
		25	2		1	1				5.1	100	S
		26	1					1		5.1	1000+	S
		27	7		2	2	3			5.1	300	N
		28	4	2				2		5.1	1000+	S
		29	1	1						5.1	1000+	S
		30	2					2		5.2	900	S
		31	2		1	1				5.2	300	S
		32	5	2				3		5.2	1000+	S
		33	1		1					5.7	300	S
		34	1					1		5.7	1000+	S
		35	15	2	5	4		4		5.7	100	N
		36	1			1				5.5	400	N
		37	2		1	1				5.9	300	S
		38	2		1	1				6.1	1000+	S
		39	1		1					6.1	600	N
		40	4		1	1	1	1		6.2	1000+	S
		41	1				1			6.6	600	S
		42	2		1	1				6.6	900	S
		43	9					9		6.6	1000+	S
		44	1				1			6.8	400	N
		45	1		1					6.9	0	-(X)
		46	1				1			6.9	400	S

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[1] (mi)	I.O.D.[2] (yd)	N/S[3]
		47	1		1					8.0	150	N
		48	6		2	2		2		9.4	1000+	S
		49	9	1	2	1	1	4		10.0	1000+	N
		50	2				1	1		12.2	1000+	S
		51	1					1		12.2	1000+	S
		52	2	2						13.1	800	S
		53	1					1		14.0	1000+	S
		54	3		1	1	1			14.4	600	S
		55	2		1	1				14.5	600	S
		56	5	1	2	1	1			15.1	400	N
		57	2		1	1				17.4	70	S
27 July	1530-1730	1	4	-	2	2				5.0	600	S
		2	4		2	2				9.7	200	N
		3	4		2	2				9.7	1000	N
		4	5		2	3				10.6	1000	N
		5	8		4	4				11.4	300	N
		6	2		1	1				13.1	800	N(X)
		7	1		1					14.5	600	S
		8	3		2	1				16.1	400	N(X)
		9	3		1	1		1		20.0	1000+	W
		10	1					1		20.0	1000+	S
		11	19	3	5	6		5		20.0	1000+	N
28 July	1030-1250	1	1	1						0.3	0	-(X)
		2	1				1			0.5	500	S
		3	4		2	2				6.8	50	S
		4	1		1					9.8	600	S
		5	1		1					11.2	1000+	S
		6	2		1	1				11.3	0	-(X)
		7	1	1						12.0	0	S(X)
		8	1				1			13.2	0	-(X)
		9	2		1	1				14.8	300	S
		10	1				1			16.1	400	N
		11	1	1						17.1	0	-(X)
		12	2		1	1				17.2	1000+	N
		13	1		1					20.0	0	-(X)
		14	3		1	1	1			18.2	0	-(X)
		15	1	1						18.2	50	S
		16	1	1						12.3	0	-(X)
		17	2		1	1				12.5	200	S
	2145-2330	1	2	2						0.1	400	S
		2	2	2						0.6	400	S
		3	2	2						1.9	1000+	S

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[1] (mi)	I.O.D.[2] (yd)	N/S[3]
		4	1	1						6.5	1000+	S
		5	2		1	1				11.2	200	S
		6	1	1						11.3	500	S
		7	1					1		11.2	1000+	S
		8	1					1		12.8	1000+	S
		9	1		1					12.9	500	S
		10	1	1						14.0	1000+	S
		11	2		1			1		14.6	900	S
		12	1	1						14.8	500	S
		13	1	1						15.6	500	N
		14	1	1						16.4	300	S
		15	1	1						16.6	500	N
		16	2		1	1				20.0	1000+	W
		17	1					1		20.0	800	W
		18	1					1		17.4	1000+	N
		19	3		2	1				9.6	500	N
		20	1					1		1.8	800	N
29 July	1010-1210	1	1	1						0.1	50	N
		2	2		1	1				4.7	700	N
		3	1		1					4.8	400	S
		4	8	1	4	3				6.6	150	S
		5	3						3	8.3	1000+	N
		6	5	1	2	1	1			9.0	0	-(X)
		7	4		2	2				9.8	1000+	N
		8	1	1						12.3	400	N
		9	1		1					13.3	200	N
		10	2					2		14.0	1000+	S
		11	1		1					14.0	250	N
		12	1	1						14.2	0	-(X)
		13	26	3	12	8	3			14.5	200	S(X)
		14	2	1	1					16.5	100	N(X)
		15	1			1				16.6	400	S
		16	1					1		16.6	1000+	N
		17	4	1	1	1		1		17.4	1000+	N
		18	3		1	1		1		17.8	1000+	N
		19	4	2	1	1				17.8	200	S
		20	24	1	8	8		7		17.9	1000+	N
		21	8		4	4				20.0	50	N
	2110-2310	1	2		1	1				1.1	600	S
		2	5	1	2	2				1.7	600	S
		3	1		1					3.0	500	S
		4	2					2		3.5	1000+	S
		5	5	1	2	2				6.4	800	S

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[1] (mi)	I.O.D.[2] (yd)	N/S[3]
		6	2		1	1				6.5	200	N
		7	3		2	1				11.7	1000+	S
		8	7		3	3	1			12.1	1000+	S
		9	4		2	2				14.0	700	S
		10	2	2						15.6	1000	S
		11	7		4	3				15.7	350	N
		12	3		2	1				16.3	1000+	S
		13	1					1		20.0	200	N
		14	1	1						20.0	1000+	S
		15	3		3					18.5	1000+	N
		16	4		2	1	1			17.2	1000+	N
		17	1	1						16.5	600	N
		18	18	-	5	5		8		16.1	1000+	N
		19	2				2			13.2	0	S(X)
		20	1	1						11.7	900	N
		21	15	15						0.9	400	N
30 July	1300-1500	1	8	8						0.3	50	N & S
		2	2	2						0.3	500	S
		3	2		1	1				2.3	250	S
		4	10	1	3	3		3		2.4	1000+	N
		5	2	2						4.0	1000+	N
		6	1		1					4.5	600	S
		7	1				1			5.7	50	N
		8	5		2	2		1		9.0	1000+	S
		9	1					1		9.2	1000+	S
		10	1	1						9.9	500	N
		11	4		3	1				10.6	600	S(X)
		12	3		2	1				10.6	1000+	S
		13	3		1	1	1			12.9	0	-(X)
		14	13	1	5	5		2		14.9	200	S
		15	1	1						18.1	300	S
		16	1					1		19.9	1000+	S
		17	4	2	1		1			20.0	400	S
		18	1	1						20.0	50	N
		19	4		2	1	1			20.0	700	S
		20	2					2		20.0	1000+	S
		21	1			1				18.0	700	N
		22	2		1	1				17.2	800	N
		23	1		1					16.2	1000+	N
		24	4		2	1		1		9.9	1000+	N
		25	3	1	1	1				3.5	200	N
		26	1	1						3.4	1000+	N
		27	8	1	3	1	2	1		2.3	200	N
		28	18	5	7	2	3	1		2.2	300	S

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[1] (mi)	I.O.D.[2] (yd)	N/S[3]
31 July	1430-1630	1	1	1						2.6	100	N(X)
		2	1	1						2.7	1000+	N
		3	1			1				5.9	150	N
		4	3		2	1				6.1	0	-(X)
		5	14	4	5	4	1			6.7	0	S(X)[5]
		6	2		1			1		8.2	900	S
		7	8	1	5	2				9.4	0-25	N
		8	4	1	1	1		1		10.4	1000+	N
		9	1		1					10.4	200	N
		10	1					1		10.5	0	-(X)
		11	16		4	4		8		10.6	1000+	S
		12	2		1	1				11.2	1000+	S
		13	3		1	1		1		11.4	1000+	S
		14	1		1					11.3	1000	S
		15	2					2		12.2	1000+	S
		16	1		1					13.6	1000+	N
		17	1	1						14.7	1000+	S
		18	2	1	1					15.2	400	S
		19	1	1						16.0	1000+	S
		20	2		1	1				16.1	100	S
		21	3					3		16.1	1000+	S
		22	2		1	1				16.4	600	S(X)
		23	2	1	1					18.0	200	S
		24	2	1	1					17.9	100	N
		25	1	1						18.7	300	N
		26	1					1		19.4	1000+	S
		27	1					1		19.9	1000+	S
		28	5	1	3	1				1.0	50	S
1 Aug	1240-1440	1	1	1						1.4	1000+	S
		2	3		1	1	1			1.7	250	N
		3	2		1	1				1.7	100	N
		4	1	1						1.8	1000	S
		5	1	1						1.9	100	S
		6	1					1		1.8	1000+	S
		7	1				1			2.1	250	N
		8	1	1						3.3	700	S
		9	2		1	1				4.8	1000+	N
		10	1	1						6.4	0	-(X)
		11	2	2						6.8	25	N
		12	3		1	1	1			6.9	50	S
		13	2		1	1				6.9	200	S
		14	1		1					6.9	600	N
		15	4		2	2				9.9	200	N

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[1] (mi)	I.O.D.[2] (yd)	N/S[3]
		16	1		1					10.4	200	N
		17	1	1						10.5	50	S(X)
		18	1					1		10.5	500	S
		19	3		1	1		1		11.1	1000+	S
		20	1		1					11.2	700	N
		21	2		1	1				11.2	1000+	N
		22	2	1				1		11.3	900	N
		23	1	1						11.2	1000+	S
		24	1		1					11.3	1000+	S
		25	1	1						11.4	1000+	N
		26	1	1						11.4	200	N
		27	2		1	1				12.4	300	S
		28	1		1					12.2	400	N
		29	1		1					12.3	600	N
		30	3	2				1		12.4	1000+	N
		31	4		2	1		1		13.7	1000+	N
		32	1	1						13.7	300	N
		33	1	1						15.5	50	S
		34	1					1		16.1	1000	S
		35	3		1	1		1		17.9	1000+	S
		36	1					1		18.0	500	S
		37	1					1		18.1	50	N
		38	2		1	1				19.3	0	-(X)
		39	1					1		20.0	1000+	S
		40	1	1						18.9	50	N
2 Aug	0800-1000	1	1	1						1.8	500	S
		2	2		1	1				1.9	1000+	N
		3	2		2					2.0	1000+	S
		4	6	6						3.0	1000	S
		5	4	2	1	1				5.9	25	N
		6	2	2						6.5	200	S
		7	3	1	1	1				7.4	300	N
		8	1					1		8.0	1000+	S
		9	2		1	1				8.2	600	S
		10	6		2	2		2		8.4	1000+	N
		11	2		1	1				8.9	400	S
		12	2		1	1				13.3	1000+	S
		13	5	1	1	1		2		13.7	1000+	S
		14	8	1	1	1		5		13.9	1000+	S
		15	2		1	1				16.2	900	S
		16	1	1						17.2	50	S
		17	1					1		17.8	800	S
		18	4		2	2				19.0	1000+	S
		19	3		2	1				19.2	50	S

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[1] (mi)	I.O.D.[2] (yd)	N/S[3]
		20	10	3	2	2		3		20.0	1000+	N
		21	3					3		20.0	1000+	N
		22	2		1	1				19.5	1000+	S
		23	2					2		15.5	1000+	N
		24	4	3				1		14.0	1000+	N
		25	9		2	2		5		13.8	1000+	N
		26	16	5	4	4		3		6.5	1000+	N
		27	5		2	2		1		3.2	200	N
		28	2	2						1.9	0	-(X)
		29	39	5	12	12	4	6		1.7	600	N
		30	3	3						0.5	0	-(X)
9 Aug	1200-1300	1	1	1						1.0	200	N
		2	2					2		1.5	300	S
		3	1					1		2.0	200	N
		4	2	2						2.0	300	N
		5	1	1						3.7	800	N
		6	1		1					3.8	70	N
		7	1					1		3.9	600	N
		8	1					1		4.0	800	N
		9	2		1	1				5.0	40	S
		10	3		1	1	1			6.8	30	S
		11	1		1					6.7	400	N
		12	2					2		6.9	900	N
		13	1				1			7.8	100	S
		14	1		1					8.0	0-60	S
		15	1		1					11.8	150	S
		16	1	1						12.0	0	S(X)
		17	3		1	1		1		12.0	300	S
		18	2					2		12.1	900	N
		19	1		1					14.7	200	S
		20	3		2	1				15.0	300	S
		21	1		1					15.4	0	-(X)
		22	1		1					17.8	0	-(X)
		23	1					1		18.5	1000+	S
		24	1	1						19.5	0	-(X)
16 Aug	1305-1530	1	1				1			3.6	100	S
		2	4	2			2			3.7	400	S
		3	6	6						3.8	1000	S
		4	1	1						4.0	400	N(X)
		5	1		1					4.1	50	N(X) S(X)
		6	5	3	1	1				5.2	50	S
		7	1	1						5.8	10	S(X)

Appendix II. Continued.

Date	Time	Obs. No.	Total No.	B	C	ca	Y	A	U	Location[1] (mi)	I.O.D.[2] (yd)	N/S[3]
		8	2		1	1				6.8	1000+	N
		9	3	3						6.9	200	S
		10	4					4		6.9	1000+	S
		11	1	1						11.6	30	S
		12	6			2		4		15.4	600	S
		13	1	1						16.9	600	S
		14	1					1		18.6	1000+	N
		15	1		1					16.9	300	S
17 Aug	0815-0950	1	1	1						16.6	1000+	N
		2	2		1	1				9.2	1000+	N
		3	3						3	4.4	1000+	N
		4	2					2		4.4	1000+	S
21 Aug	1200-1300	1	4		1	1		2		6.7	150	S
Survey terminated at Mi 14.8		2	3	3						9.7	600	S

[1] Road mileage (see Fig. 2).
[2] Initial observation distance (1000+ = more than 1000 yd).
[3] Initial sighting north (N) or south (S) of road; X = eventual crossing; W = west of end of road; - = on road, or position not crossed.
[4] Only three crossed.
[5] Only seven crossed.

B = bulls, C = cows, ca = calves, Y = yearlings, A = adults, U = unknowns.