Joint State/Federal Fish & Wildlife Advisory Team

THIRD INTERIM REPORT OF THE EFFECTS OF THE TRANS-ALASKA PIPELINE ON CARIBOU MOVEMENTS

BY:

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SUMMARY

The results of continued road and aerial surveys along the Trans-Alaska Pipeline (TAP) route are presented and compared with similar data obtained in 1975 and 1976.

In 1977 a greater portion of the Central Arctic Herd (CAH) wintered on the coastal plain than during the previous 2 years. Other differences in the timing of seasonal movements were noted, but the centers of caribou occupancy within the study area have remained within roughly the same distance range from the TAP corridor, irrespective of season; thus, no major shifts in overall range occupancy have been identified.

The results of aerial surveys conducted in June 1977 indicate that the peak of calving was between 6 and 8 June and that virtually all calving activity occurred between Point Oliktok and Bullen Point, extending inland from the coast to approximately 70°N latitude. As for the past 2 years, survey observations indicate that little if any calving took place within the Prudhoe Bay oilfield, while elsewhere within the above boundaries calving activity appeared to be fairly uniform. Thus, structures and/or human activity near Prudhoe Bay continue to elicit a local avoidance response by parturient/maternal cows and neonatal calves.

A comparison of group composition determined through aerial and haul road surveys for 1975-1977 indicates that calves are underrepresented along the TAP corridor. During summer 1975, 1976 and 1977 mean calf percentages determined from haul road surveys were, respectively, 38, 65 and 87 percent lower than those determined by air.

A comparison of latitudinal distribution of caribou determined from corresponding aerial and haul road surveys demonstrates some abnormalities in caribou occupancy immediately adjacent to the Pipeline corridor, particularly in the vicinity of Prudhoe Bay. During summer in all 3 years relatively fewer caribou were present in the coastal region of the corridor than observed during comparable surveys by air. This reflects perturbed distribution resulting from local avoidance of structures and/or activities. In November 1975 some decrease in this avoidance tendency was noted, but in 1976 and 1977 sensitivity appears to have continued into fall.

During spring 1976 and 1977 the frequency of caribou sightings along the haul road (no. of caribou/100 km coverage) was substantially higher than in 1975, but summer and fall values for 1976 and 1977 remained consistently lower than for 1975; however, sighting frequency in fall 1977 was higher than in fall 1976. Crossing frequencies (no. of observed road or pipe crossings/100 caribou sightings) obtained in spring, summer and fall 1976 were all lower than those in 1975. In 1977 the spring value continued to decline while little change was noted in summer; however, the crossing frequency in fall increased above that obtained in either previous year. Thus, both sighting and crossing frequencies showed increases by late 1977. These changes, together with some indication

of a more representative sex/age composition along the TAP corridor, suggest a slight reversal of the previous downward trend in local occupancy and crossing success.

Transects were flown in the vicinity of the corridor to further characterize the avoidance response of caribou. The results demonstrate a distinct local pattern of distribution in relation to group composition. Caribou in groups with calves were present in low numbers near the corridor, but were progressively more numerous as distance increased. In contrast, groups without calves exhibit the opposite tendency and may even be attracted to the corridor.

Movements of collared caribou are in general agreement with CAH movements described using aerial survey data. In addition, sighting location and frequency of collared caribou support other indications of corridor avoidance by cows and calves. Proportionately more collared bulls were observed after collaring and were resighted more frequently than collared cows; 77 percent of all sightings of collared bulls were from the road, whereas only 45 percent of the cow sightings were from the road.

Infrequent contact of caribou with the corridor continues to limit an evaluation of the behavioral responses associated with Pipeline encounters and precludes any assessment of the effectiveness of Pipeline crossing structures.

The minimum total size of the CAH in July 1977 was estimated at 4,756 caribou (3,805 adults), and likely did not exceed 6,000. Overwinter survival of 1976 and 1977 calf cohorts was approximately 70 percent; thus steady herd growth appears probable.

CONTENTS

BACKGROUND

Identification and assessment of the effects of the Trans-Alaska Pipeline (TAP) on caribou (*Rangifer tarandus granti*) movements, now in the fourth year of study, have been directed almost exclusively to Alaska's Arctic Slope. Because of a dearth of background information on local caribou activities and the probable influence of pipelines, initial concerns were very general and highly speculative. Consequently, much of the early work was directed toward caribou inventory, a description of herd movements and the identification of potential problems. Specific concerns have now been identified, and project efforts now focus on two or three aspects of caribou-pipeline interaction; other interests have been de-emphasized or discarded.

It is now clear that the Arctic Slope route of the TAP traverses the range of a distinct subpopulation of about 5,000 caribou, the Central Arctic herd (CAH). Seasonal movements are primarily north-south, between calving grounds near the coast and wintering areas in the northern foothills of the Brooks Range. In 1975 and 1976 such movements were described through a series of aerial surveys (Cameron and Whitten 1976, 1977) and have since been verified through the known movements of collared caribou (unpubl. data).

A comparison of the results of aerial and haul road surveys conducted in 1975 revealed local abnormalities in caribou distribution and group composition (Cameron and Whitten 1976, 1977). During both summer and fall, fewer caribou were observed along the corridor near Prudhoe Bay than expected on the basis of aerial survey results. Also, calf percentages calculated for groups observed along the haul road in summer were consistently lower than for those classified through aerial survey of a more representative area extending east and west of the corridor; comparable percentages obtained in fall, however, did not differ appreciably. These observations indicated caribou avoidance of the Pipeline corridor and associated areas of oil development, a response which appears to be strongest for cows and neonatal calves.

In 1976 the level of avoidance increased (Cameron and Whitten 1977). Calf percentages determined from haul road surveys continued to be lower than those obtained from comparable aerial surveys, particularly during spring and summer, and sustained avoidance of the Prudhoe Bay area was noted. In addition, caribou sighting frequency along the haul road and the observed rate of corridor crossings were generally lower in 1976 than in 1975; contact with, and crossings of, elevated pipe were infrequent for both years. The current trend appears to be toward separation of the herd into eastern and western components, each with largely independent north-south movements.

The extent to which the elevated pipe alone might restrict caribou movements was a major concern at the inception of this project. In retrospect, the question of crossing success of caribou in relation to <u>any</u> pipe mode has proven to be somewhat irrelevant due to avoidance of corridor activities and/or structures. Given the choice of crossing location, approaching caribou appear to select areas of buried pipe, or--where continuous elevated mode is present, greater surface-to-pipe clearance (Cameron and Whitten 1976). However, local traffic and human activity apparently represent an equally serious or overriding impediment to movement, since avoidance of the corridor occurs irrespective of the pipe mode which would otherwise be encountered. In fact, even caribou approaching or successfuly crossing the Pipeline, and/or haul road, frequently exhibit outward signs of disturbance. Further, little use of big game crossings (i.e. short elevated or buried sections of the Pipeline) has been noted. Previous reports and our own observations indicate that these should be preferred crossing sites, and non-use of special structures is probably more a reflection of the low numbers of caribou approaching the corridor than an indication of unsuitable design.

In the absence of human influence, sections of buried pipe and low road berms do not appear to pose a serious barrier to caribou movements. Fortunately, the placement of buried pipe between Deadhorse and Pump Station 2 and near the mouth of the Ribdon River coincides roughly with two known areas of caribou movement. This suggests possible accommodation in the future, should a moderation of the avoidance response occur. Similarly, special crossings have been located in previous movement areas, and may become more functional if the sensitivity of caribou to human activity decreases. The crucial question is whether caribou will continue to demonstrate an avoidance of the corridor, or if a reversal of the current trend will occur.

Caribou movement data obtained in 1976 indicated that no appreciable changes in migration between, and general use of, seasonal ranges had occurred compared to 1975. It was therefore concluded that observed avoidance of the corridor was a local phenomenon and not due to a lateral shift in range occupancy (Cameron and Whitten 1977). Quantitative information on seasonal movements of the CAH is now available for 1977, and these studies should continue as a means of identifying any disturbance-related changes in range utilization.

Despite a strong negative response of caribou to the TAP corridor and related structures/activities, initial calf production in 1976 was moderate (ca: 44 calves per 100 cows) and survival of calves to 4 months of age nearly 100 percent. Unfortunately, however, calf mortality during the previous winter was estimated at 70 percent (Cameron and Whitten 1977), indicating a low rate of yearling recruitment. These are the only such data available for the CAH, data which may or may not reflect the "normal" dynamics of the subpopulation. Only by regular monitoring of herd status can trends of productivity and mortality be established. This type of information has direct management application and, in addition, is required for identification of any future decline of the CAH which might be linked to disturbance within its range.

The present report summarizes progress on studies conducted during the 1977 field season, and includes data on: 1) seasonal movements and sex/age composition of the CAH, 2) caribou distribution and group composition along the TAP haul road, 3) changes in the status of corridor avoidance, 4) Pipeline crossings, and 5) productivity/mortality of the CAH.

OBJECTIVES

In accordance with stipulations 2.5.4.1* and 2.5.3.1 of the Stipulations for the Agreement and Grant of Right of Way for the Trans-Alaska Pipeline, this project is designed to accomplish the following objectives:

To determine herd identity, general numbers, productivity and seasonal movement patterns of caribou which range in the vicinity of the pipeline corridor.

To characterize movement behavior of caribou which encounter the haul road, pipeline and construction-related activities.

To assess the effectiveness of special crossings in allowing for unrestricted movement.

PROCEDURES

Aerial surveillance within the Arctic Slope study area and ground surveys along the TAP haul road (see Fig. 1) were conducted as described

*"Leasees shall construct and maintain the pipeline, both buried and above ground sections, so as to assure free passage and movement of big game animals."

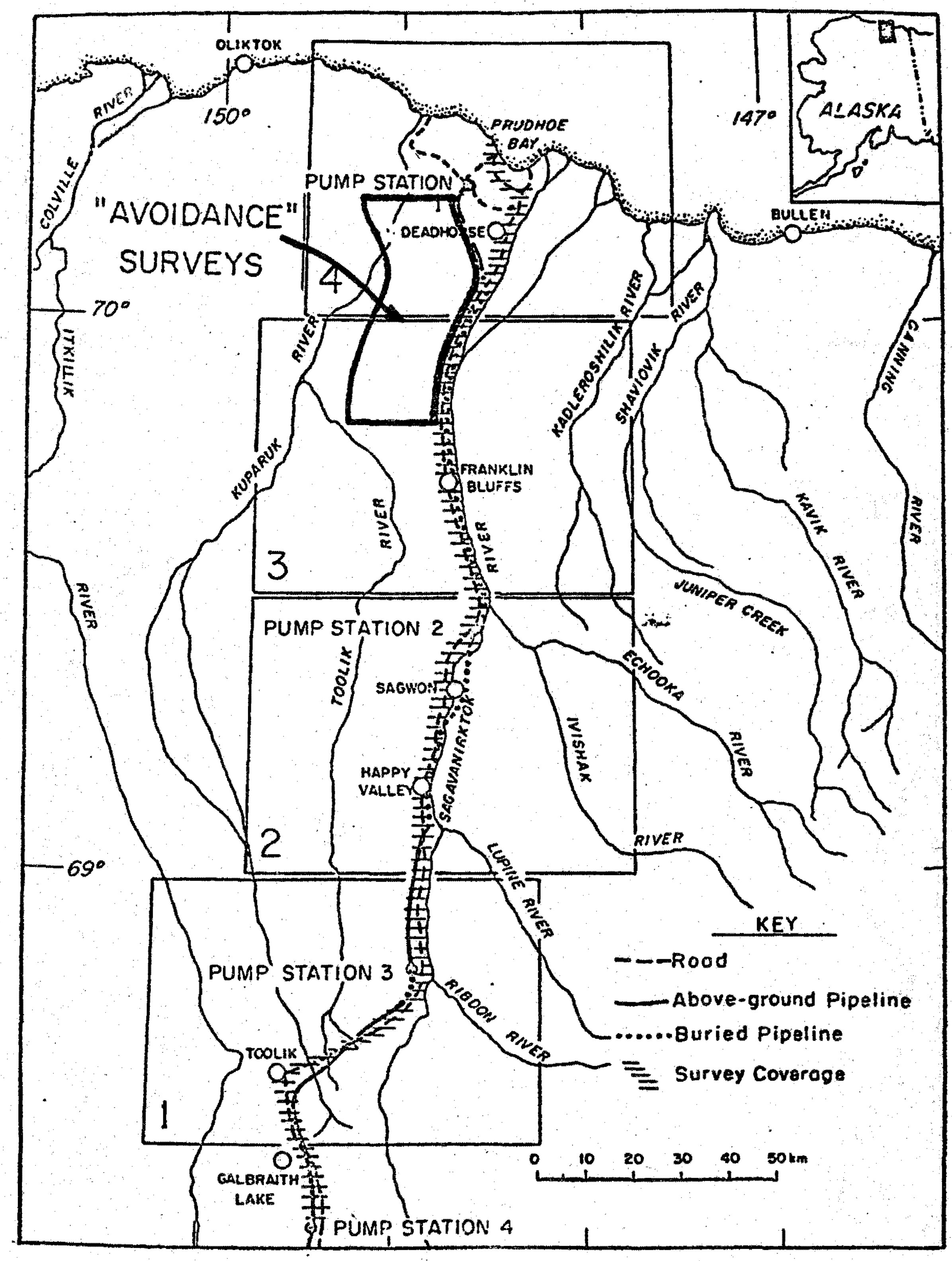

Fig. 1. Map of the study area depicting road survey coverage, the regions established for comparison of aerial and road survey data, and the site selected for determining avoidance distance of caribou.

previously (Cameron and Whitten 1977). Observations of caribou-pipeline or caribou-road interaction, including evidence from tracks, were made incidental to haul road surveys and during unscheduled trips between camps; the information recorded for each observation is given in a previous report (Cameron and Whitten 1976).

Sex and age composition of the CAH was determined with the aid of a helicopter. Caribou were identified as bulls, cows, calves or yearlings on the basis of external genitalia, body size and/or antler development. Generally, the composition of groups of less than 30 individuals could be ascertained by hovering briefly at low level (ca: 10-20m), whereas for larger groups, a landing was made nearby (ca: 100-300m) and caribou were classified using a spotting scope or binoculars. Initial calf production was estimated during post-calving aggregation in late July. Size and composition were determined for all groups located (with fixed-wing assistance) on the coastal plain between Point Oliktok and the Canning River (Fig. 1). Rates of calf survival over the previous winter and through 4 months in the current year were determined in early May and early October, respectively, by classifying all caribou observed along a standard, preestablished survey route (Cameron and Whitten 1976, 1977).

The peak of calving (i.e. date of highest calf:adult cow ratio) was determined through the results of four successive helicopter surveys within the known calving grounds of the CAH. On 3, 5, 7, and 9 June transects were flown along the coast between Point Oliktok and Bullen Point; and over the same straight-line distance inland along transects corresponding approximately to 70°05' and 70°15'N latitude on the east and west sides of the Sagavanirktok River, respectively (Fig. 1). Sex and age composition was determined, as described above, for all groups sighted. During the last three surveys, the number of antlered cows in each group was recorded.

On 28 June a fixed-wing grid survey was conducted between the Colville and Canning Rivers to delineate the calving area of the CAH, the assumption being that little redistribution had occurred since the peak of calving. An initial flight line along the Arctic coast was followed by an inland series of parallel east-west transects (true course), approximately 10 km apart. Except for low passes to count and classify caribou, airspeed was maintained between 190 and 210 km per hour, and altitude was adjusted to approximately 50 m above terrain. Total caribou and the number of calves were recorded for each group observed; locations were noted on a 1:500,000 aeronautical chart. The survey was terminated to the south when no calves were sighted during two successive transects.

On 30 June an attempt was made to verify and further quantify differential avoidance of the TAP corridor by caribou. The area selected for study is bounded on the east by a 45-km section of the corridor, just south of Pump Station 1, and extends west approximately 20 km (Fig. 2). Ten east-west (true course) transects, 5 km apart, were flown in fixed-wing aircraft about 50 m above ground level and at an airspeed of approximately 190 km per hour. Group size, number of calves and location were recorded

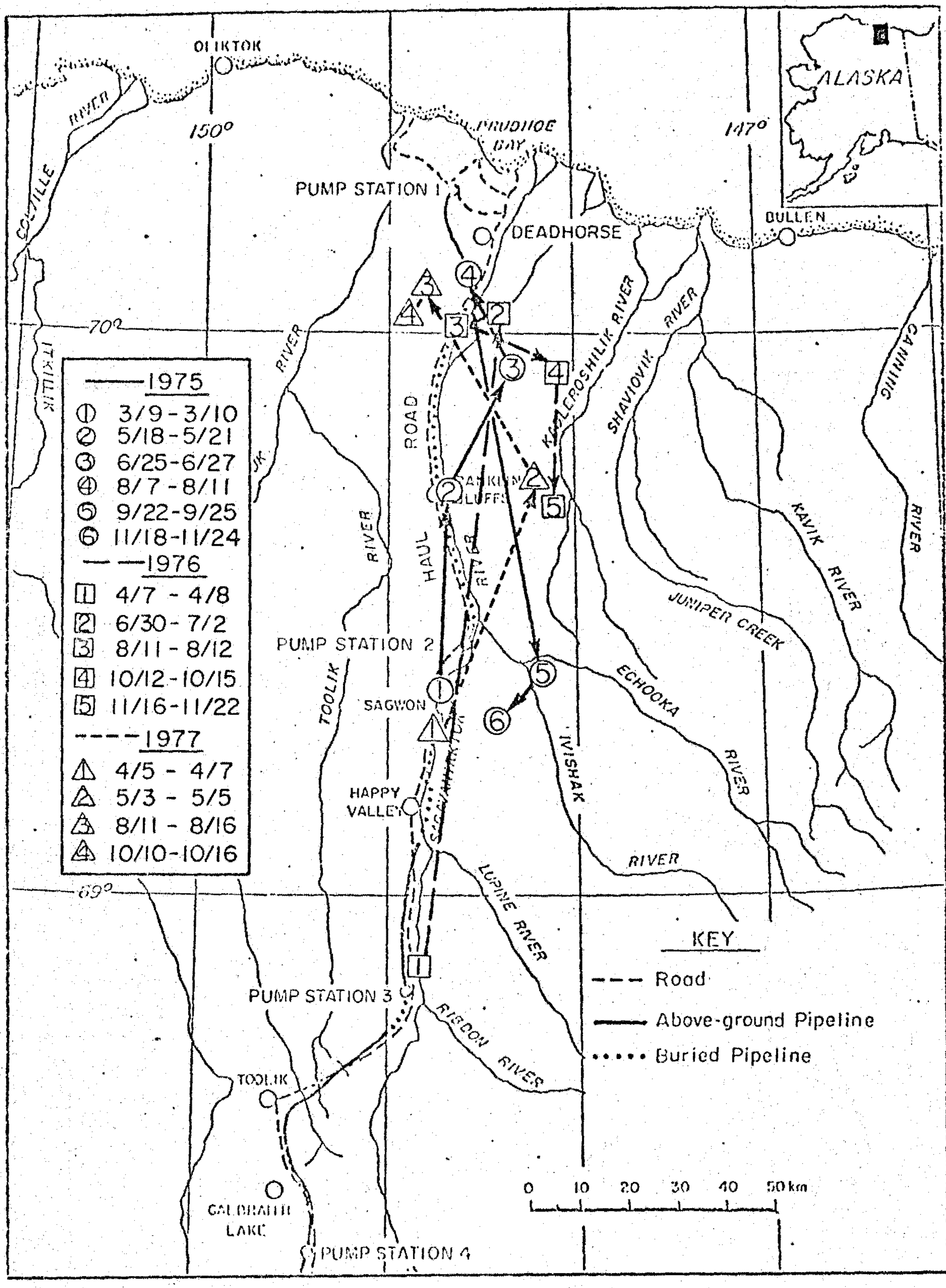

Fig. 2. Seasonal shifts in the center of caribou occupancy, 1975–1977.

on a 1:250,000 USGS map. Distance of each group from the corridor was determined as a straight-line measurement due east (true) to either haul road or Pipeline.

Caribou collaring operations were conducted within 30 km of the Pipeline corridor between Galbraith Lake and the northern end of Franklin Bluffs. Fifty-one adult caribou were collared (including two replacement collars) in this region between 19 April and 7 May: 13 radio collars (all on females) and 38 numbered collars (24 on females, 14 on males). Immobilization and relocation procedures are described in a previous report (Cameron and Whitten 1976).

FINDINGS AND DISCUSSION

Seasonal Movements and Group Composition Determined by Aerial Survey

Shifts in the center of caribou occupancy (Cameron and Whitten 1976, 1977) within the study area are shown in Figure 2 for 1975, 1976 and 1977. In all 3 years northward spring migration was in progress by early May, and the majority of the CAH remained near the coast from June through August. In general, the results demonstrate that little change in summer range occupancy has occurred over the past 3 years. Fall movements in 1975 occurred earlier than in either succeeding year and, by the rutting period, most caribou had penetrated farther south than in either 1976 or 1977. In fact, the majority of the CAH appears to have wintered on the coastal plain in 1977-78. A survey was attempted in November 1977, but bad weather prevented coverage of the coastal plain. Nonetheless, as in October, very few caribou were observed south of Franklin Bluffs within the study area. Additional observations in early spring 1978 suggested continued use of the coastal plain as primary winter range.

It is noteworthy that, since 1975, progressively greater numbers of caribou have wintered in the northern half of the study area, correspondingly fewer migrating to and through the foothills of the Brooks Range. This tendency correlates roughly with the timing of initial snowfall and the overwinter accumulation of snow. In 1975 major snowstorms first occurred in late September whereas in 1976 and 1977 little snow accumulated until November. Also, snow depths on the coastal plain remained low (ca. 10-15cm) throughout the winter of 1977-1978, while those inland on more "typical" winter range were clearly greater. Perhaps the relative ease of access to forage near the coast compensates for the energy expenditures of southward migration and cratering in deeper snow, albeit for more abundant forage of higher quality.

Aside from between-year differences in the timing of seasonal movements, presumably due to weather phenomena, centers of occupancy have remained within roughly the same range of distances from the Pipeline corridor (ca. 0-25 km, see Fig. 2). Thus, no major disturbance-related changes in overall range occupancy have been identified to date; adverse effects on caribou have been primarily of a local nature.

Table 1 gives caribou numbers and overall group composition observed during aerial surveys in 1977. The aggregate percentage of calves in the herd (i.e. short yearlings) in April and May was in general agreement at 13 and 15 percent, respectively. However, calf percentages calculated for groups with calves declined slightly, from 28 percent in April to 23 percent in May, indicating a reshuffling of caribou between group types. The percentage of caribou observed in groups with calves increased from 46 to 68 percent, while the mean size of such groups without calves declined from 6.5 to 6.0 during the same period (Table 1). Thus, the spring decrease in the percentage of calves in groups with calves was due, in part, to the addition of bulls, juveniles, and/or non-maternal cows from groups without calves. Although not detectable from the present data, the above changes in group composition may also reflect an early tendency for cow-calf separation prior to calving.

Calf percentages obtained in August (Table 1) reflect the addition of current-year neonates, surviving yearlings having been recruited into the adult base of the herd. Despite a 15-percent increase in total caribou numbers due to calf production (less early mortality), mean group size declined to 5.8 and 1.9 for with- and without-calf groups, respectively (Table 1). The wide dispersal of small groups in late summer is thought to be a response to oestrid flies (Curatolo 1975, Roby 1978).

During the rut in October approximately 80 percent of the caribou observed were in groups with calves. Mean size of these breeding bands was seven individuals, collectively representing the majority of cows, calves and bulls in the herd. The remaining smaller groups were predominated by nonbreeding bulls (Table 1).

Aside from the productivity/mortality parameters obtained from aerial survey results (see subsequent section), these data on presumed normal group composition represent a reference for corresponding observations along the Pipeline corridor. Such comparisons, presented below, represent the basis for the identification and assessment of corridor-related abnormalities in caribou group structure.

Calving

Results of survey transects conducted during calving are presented in Table 2. The aggregate number of calves per 100 cows increased from nine on 3 June to 26 on 5 June and stabilized at 52-53 on 7 and 9 June. After 7 June the percentage of antlered cows declined to nearly half of the earlier estimates, indicating postpartum antler shedding. Further, the ratio of calves to antlered cows, relatively low on 5 June when few new calves were present, increased to a peak value on 7 June and subsequently declined by about 50 percent on 9 June as the rate of antler shedding increased. This accelerated antler loss by cows with stabilization of relative calf numbers suggests that calving reached its maximum prior to 9 June. Peak of calving for the CAH is estimated to be between 6 and 8 June, slightly after the estimated peak for the Porcupine Herd (Roseneau, pers. comm.) and a few days earlier than that for the Western Arctic Herd (Davis, pers. comm.).

Table 1. Aerial surveys: caribou numbers and group composition, April-October 1977.

Survey Number	Incl. Dates	Total Obs.		Total Classified[1]					Groups w/Calves[2]					Groups w/o Calves[3]			
		N	G	N	G	%B	%ca	%A	N	G	%B	%ca	%A	N	G	%B	%A
1	4/5-7	800	105	626	94	(4)	13	82	287	42	(0)	28	69	339	52	(7)	93
2	5/3-5	889[4]	123	889	123	35	15	0	602	75	20	23	0	287	48	69	0
3	8/11-16	520	190	512	189	(44)	15	34	231	40	(10)	33	43	281	149	(73)	26
4	10/10-16	656[4]	151	624	145	38	20	0	497	71	27	26	0	125	74	80	0

1 Excludes "unknowns" (unclassified as to sex or age).
2 Total caribou in groups with one or more calves present.
3 Total caribou in groups with no calves.
4 Composition counts by helicopter.

Note: N = number of caribou, G = number of groups, B = bulls, ca = calves, A = adults; values in parentheses include only obvious adult bulls (see Cameron and Whitten 1977) and are minimum percentages.

Table 2. Changes in caribou group composition during calving, 1977.

	Survey Date			
	3 June	5 June	7 June	9 June
No. of caribou observed	189	182	189	130
No. of calves/100 cows	9	26	52	53
Percent cows w/antlers	--	65	64	37
No. of calves/100 antlered cows	--	33	50	28

Survey observations from transects flown by fixed-wing on 28 June indicate that virtually all calving by the CAH occurred between Point Oliktok and Bullen Point, extending inland from the coast to approximately 70°N latitude (Fig. 1). This is the same area in which surveys were conducted for determining the peak of calving. General impressions of caribou density were similar during the two surveys and no appreciable differences in distribution were apparent. More than 500 caribou were observed, of which approximately 150 were calves. Groups with calves were distributed more or less uniformly within the area described above, and no distinct regional concentrations were evident. In past years, however, Gavin (1973; pers. comm.) noted calving concentrations in the White Hills (110 km southwest of Prudhoe Bay), in the Ugnu area (15 km east-southeast of Point Oliktok) and in the vicinity of the Canning River Delta (Fig. 1).

Results of both June surveys indicate that neonatal calves were absent or extremely scarce within the Prudhoe Bay oilfield. Except for the immediate coastal region between the mouth of the Kuparuk River and Prudhoe Bay itself (where little development has occurred), no calves were observed from the air between the Kuparuk River and the west channel of the Sagavanirktok River. Gavin (pers. comm.), while acknowledging that calving activity within the oilfield is and has been relatively low, argues that the area is normally not preferred as calving habitat. He attributes annual variations in local calving activity to between-year differences in the total number of caribou occupying the central Arctic Slope. This explanation would be irrefutable in years when distinct concentrations of calving caribou are found elsewhere within the coastal plain. However, the absence of neonatal calves near Prudhoe Bay, within an area of otherwise uniform distribution of calf groups, strongly suggests an avoidance of that area by calving caribou. The known sensitivity of parturient and postpartum cows to disturbance and the scarcity of new calf observations during road surveys (Cameron and Whitten 1977, and below), support this conclusion. In our opinion the structures and human activity associated with oil development have resulted in a local displacement of calving activity of the CAH.

Group Composition along the Pipeline Corridor

A detailed breakdown of caribou counts and group composition obtained from 1977 surveys along the TAP haul road is given in Table 3, and a summary comparison of composition data based on the results of aerial and road surveys is shown in Table 4 for 1975-1977. In all 3 years the overall mean percentages of calves determined from haul road surveys in spring (where appropriate), summer and fall were lower than the corresponding percentages obtained from the results of comparable aerial surveys. In 1975, 1976 and 1977 mean calf percentages obtained from haul road surveys in summer were, respectively, 38, 65 and 87 percent lower than those from comparable aerial surveys of the general study area; fall values did not differ in 1975 but were 41 percent lower in 1976 and 50 percent lower in 1977. In contrast, bull percentages derived from the results of haul road surveys were often substantially higher than those determined by air.

Table 3. Haul road surveys: caribou numbers and group composition, March-November 1977.

Survey dates	Total Obs.		Total Classified[1]							Groups with Calves[2]							Groups w/o Calves[3]					
	N	G	N	G	%B	%C	%Y	%ca	%A	N	G	%B	%C	%Y	%ca	%A	N	G	%B	%C	%Y	%A
1/29-30	74	6	74	6	45	34	0	16	45	53	3	36	40	0	23	2	21	3	67	19	0	14
3/15-16	160	7	69	6	62	3	0	9	26	23	2	9	9	0	26	57	46	4	0	89	0	11
5/11-12	98	8	88	7	78	7	2	13	0	74	4	74	8	2	15	0	14	3	100	0	0	0
5/24-25	242	29	161	23	94	4	0	2	0	28	3	71	14	0	14	0	133	20	98	2	0	0
			Spring Mean		83	4	1	7	6			62	10	2	17	10			75	22	0	3
6/8-10	150	39	139	36	95	2	2	0	1	0	0	0	0	0	0	0	139	36	95	2	2	1
6/22-29	297	45	245	41	81	4	8	3	3	22	2	5	4	4	36	0	223	39	89	1	7	4
7/11-14	102	23	102	23	78	4	1	4	13	9	1	0	44	0	44	11	93	22	86	0	1	13
7/26-29	180	43	180	43	84	5	1	3	7	16	2	0	44	0	31	25	164	41	93	1	1	5
8/9-11	143	35	143	35	92	3	0	1	5	3	1	33	33	0	33	0	140	34	93	2	0	5
8/25-28	122	33	122	33	87	6	1	4	4	27	5	11	33	1	26	26	95	28	99	1	0	0
			Summer Mean		85	5	3	2	5			6	39	6	32	16			93	1	2	4
9/9-12	110	30	110	30	95	2	1	1	2	4	1	25	50	0	25	0	106	29	97	0	1	2
10/10-15	88	25	88	25	40	23	5	18	15	70	14	33	24	3	23	16	18	11	67	17	6	11
10/25-26	24	7	24	7	88	8	0	4	0	3	1	33	33	0	33	0	21	6	95	5	0	0
11/14-15	87	18	87	18	46	11	8	9	25	41	7	34	22	5	20	10	46	11	54	1	15	39
11/25-26	82	9	46	7	65	17	2	9	7	19	3	32	32	1	21	11	27	4	89	7	0	4
			Fall Mean		65	12	4	10	8			34	26	7	22	12			85	3	2	10

1 Excludes "unknowns" (unclassified as to sex or age).
2 Total caribou in groups with one or more calves present.
3 Total caribou in groups with no calves.

Note: N = number of caribou, G = number of groups, B = bulls, C = cows, Y = yearlings, ca = calves, A = adults

Table 4. Summary of major differences in group composition determined by haul road and aerial survey, 1975-1977.

	1975					1976					1977				
	Total classified		Groups w/calves		Groups w/o calves	Total classified		Groups w/calves		Groups w/o calves	Total classified		Groups w/calves		Groups w/o calves
	%ca	%B	%ca	%B	%B	%ca	%B	%ca	%B	%B	%ca	%B	%ca	%B	%B
Spring															
Road	-	-	-	-	-	5	67	19	33	78	7	83	17	62	75
Air	-	-	-	-	-	-	-	-	-	-	14[1]	35[2]	26[1]	20[2]	69[2]
Summer															
Road	13	65	40	31	94	6	79	34	10	94	2	85	32	6	93
Air	21	(35)	35	(2)	(84)	17	(27)	33	(1)	(54)	15	(44)	33	(10)	(73)
Fall															
Road	17	43	23	29	92	10	64	29	21	86	10	65	22	34	85
Air	17	(29)	21	(20)	(64)	17	44	21	34	81	20	38	26	27	80

[1] Mean of April and May percentages (see Table 1).
[2] May percentage (see Table 1).

Note: ca = calves, B = bulls; values in parentheses include only obvious adult bulls (see Cameron and Whitten 1977) and are minimum percentages.

Cameron and Whitten (1977) reported previously that low calf percentages noted along the haul road during summer 1975 were due primarily to the presence of fewer groups with calves, rather than to a lower percentage of calves in such groups. This suggests that the presence within the corridor of a representative proportion of calves during that fall occurred because the relative abundance of group types reflected that of caribou in the study area as a whole. This indeed appears to be the case. Figure 3 is an updated summary of the seasonal percentages of total caribou observed in groups with calves during both aerial and road surveys. In summer 1975 total caribou sighted along the haul road in groups with calves was only about half of that determined by air. This corresponds to the corridor avoidance phenomenon described previously for that year (Cameron and Whitten 1976, 1977). However, caribou percentages by group classification were nearly equal during fall 1975 (Fig. 3), as were calf proportions (Table 4), confirming an abatement of avoidance (Cameron and Whitten 1976, 1977). After 1975 the disparity between relative "expected" and "observed" numbers of caribou in calf groups increased. Summer ratios (calculated from Fig. 3) declined from 0.55 in 1975 to 0.34 in 1976, and to 0.18 in 1977, paralleling the progressive divergence of calf percentages noted above. Fall ratios decreased from 0.95 in 1975 (i.e. no detectable avoidance) to 0.42 in 1976, and increased slightly to 0.49 in 1977. In 1976 the lower calf percentage for the corridor (Table 4) reflects this abnormally low representation by groups with calves, whereas a continued decline in the calf percentage in 1977 (Table 4) is associated with a slight increase in the aforementioned ratio. This inconsistency is difficult to explain and may be an artifact resulting from the particularly small sample size obtained from the haul road in fall 1976 (N=42; Table 2, Cameron and Whitten 1977).

Latitudinal Distribution of Caribou along the Pipeline Corridor

The relative distribution of caribou among four regions centered on the Pipeline corridor (Fig. 1) is shown in Figure 4 for comparable results of aerial and road surveys. In general, shifts in regional occupancy determined by aerial survey reflect the north-south movements described earlier in this report (Fig. 2). Thus, in 1975 some additional northern movement occurred between June and August, but southward migration was in progress by September and continued into November. During summer 1976 caribou redistributed between Regions 3 and 4 (Fig. 4) such that a slight southward relocation occurred (Fig. 2). Fall migration in 1976 was atypical. By October most caribou had abandoned Region 3; some returned to coastal areas while others moved southward into the lower half of the study area (Fig. 4). As of May 1977 little redistribution was detectable, suggesting that caribou remained on the same range throughout the winter. By August 1977 virtually all caribou were located within the northern two regions, while in October relative numbers were higher in Region 4. Apparently the latter shift was rather localized as it was not reflected in the net movement of caribou in the study area as a whole (Fig. 2). Additional observations in winter 1977-1978 suggest that little southward migration occurred and that most of the CAH wintered on the coastal plain.

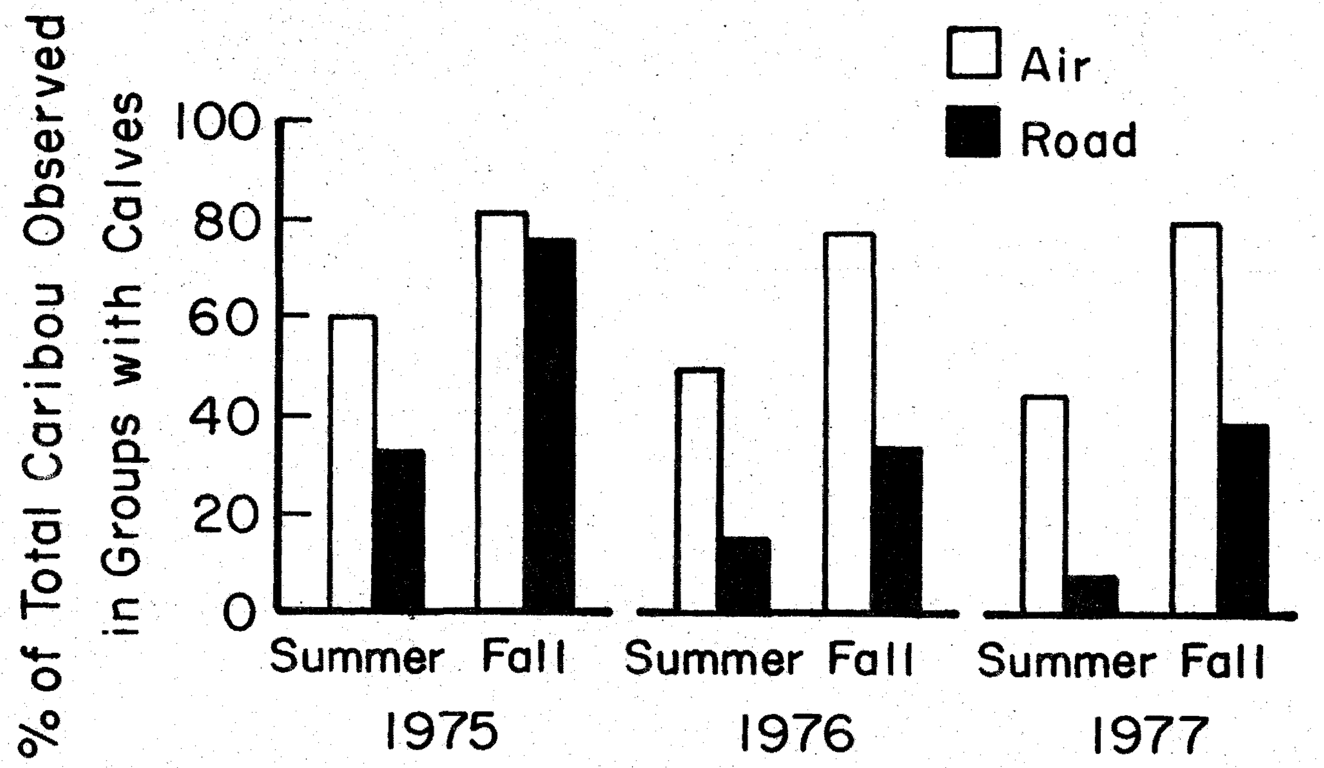

Fig. 3. Seasonal comparison of the relative numbers of caribou observed in groups with calves during aerial and haul road surveys.

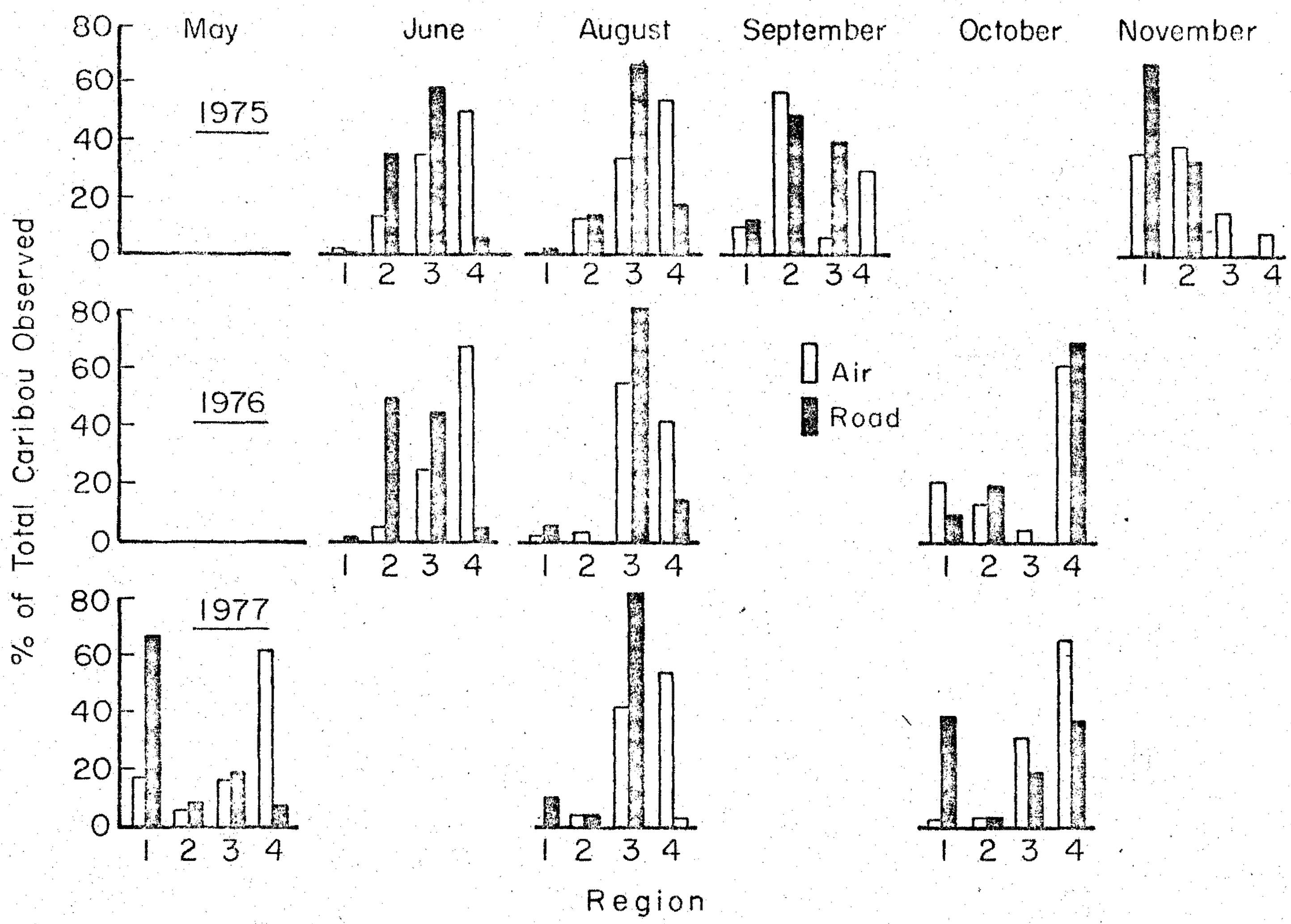

Fig. 4. Regional distribution (see Fig. 1) of caribou determined from corresponding aerial and haul road surveys, 1975-1977.

A comparison of regional caribou distribution determined from corresponding aerial and haul road surveys demonstrates some abnormalities in occupancy along the Pipeline corridor. During summer, in all 3 years, relatively fewer caribou were present along the corridor in Region 4 than were observed during comparable surveys by air; relatively greater numbers were present along the corridor in Region 3. This displacement of peak percentages does not indicate a preference for the corridor within Region 3, but rather reflects perturbed distribution resulting from avoidance of the development area near Prudhoe Bay. Cameron and Whitten (1977), in presenting these data for 1975, discussed the evidence for, and nature of, this response. Briefly, groups with calves generally predominate in the coastal region during summer, and tend to avoid the Prudhoe Bay area. Thus, the more southerly distribution of caribou along the haul road is due primarily to the absence of these groups along northern segments of the corridor, an interpretation supported by differences in group composition (see previous section). Sensitivity of cows and young calves to established structures and/or human activity is thought to stimulate and sustain this avoidance response. In general then, it appears that the summer pattern described for 1975 also applies to 1976 and 1977.

In November 1975 avoidance of the Prudhoe Bay area appears to have continued. However, aerial surveys established that relatively few caribou were occupying the coastal region, and the apparent absence of caribou along the northern half of the corridor may be inconsequential. Further, data on group composition indicate that a more representative portion of the herd was observed within the Pipeline corridor (Table 4, Fig. 3) and, therefore, that no differential avoidance by groups with calves had occurred.

The sample obtained from haul road surveys in October 1976 was extremely small (Cameron and Whitten 1977). However, distribution of those few caribou observed along the corridor resembled that determined by aerial survey (Fig. 4), and no specific avoidance of the Prudhoe Bay area was apparent. On the other hand, data on group composition indicate that calves were underrepresented in the vicinity of the corridor (Table 4, Fig. 3). Thus, from the limited data available it appears that a local reshuffling of group types occurred in fall such that the "expected" latitudinal distribution of caribou was maintained locally.

Comparable data for fall 1977 suggest a general avoidance by caribou in the northern two regions (Fig. 4), although the skewed distribution may be a function of the unexpected, and possibly fortuitous, appearance of numerous caribou in Region 1 of the haul road (ca. 40% of total sightings). As in 1976, fall calf percentages along the corridor were abnormally low (Table 4), indicating a continuation of the avoidance response described previously.

To summarize, summer data for all 3 years demonstrate a distinct local avoidance of the Pipeline corridor near Prudhoe Bay, particularly by cows and young calves. During fall 1975 some lessening of this tendency may have occurred; group composition and latitudinal distribution along the haul road were similar to comparable results obtained by aerial survey. In 1976 and 1977, however, avoidance may have continued into October, although conclusions as to abnormalities of distribution or group composition are equivocal because of small sample sizes (Table 4; Table 2, Cameron and Whitten 1977).

Seasonal and Annual Changes in Caribou Occupancy and Crossings of the Pipeline Corridor

In previous reports the frequency of caribou sightings along the haul road has been used as a general index of local occupancy. This approach permits comparison of relative abundance of caribou within the corridor for each season and comparison of annual trends. Since caribou distribution is often skewed toward the north or south limit of the study area (Fig. 4), the sighting frequency for a given season was calculated using aggregate observations obtained from road surveys completed on a single day and from paired north/south survey segments (Cameron and Whitten 1977). Seasonal changes in caribou sighting frequency are shown in Figure 5 for 1975, 1976 and 1977.

In 1975 sighting frequency increased between spring and summer, but declined to an intermediate value during fall. In spring 1976 sighting frequency was higher than the corresponding 1975 value, but decreased in summer to well below the comparable rate in 1975, and declined further in fall when lowest values were obtained (ca. 5 sightings/100 km coverage). Sighting frequencies were consistently higher in 1977 than in 1976, but the seasonal trends were similar; however, 1976 and 1977 rates for both summer and fall remained substantially lower than the initial 1975 values. The relatively low sighting frequency for spring 1975 may reflect initially greater sensitivity of caribou to disturbance during the early stages of Pipeline construction, with a moderation of the avoidance response later the same year and during the subsequent spring periods.

Crossing frequencies (Fig. 5) indicate the proportion of all caribou sighted that were observed crossing either the road or the Pipeline (i.e. it was assumed that caribou crossing one structure would cross--or had crossed--the other). All values obtained in 1976 were lower than those for 1975. In 1977 the spring crossing frequency continued a decline to near zero, while that for summer changed little relative to 1976. However, crossing frequency in fall increased above the value obtained for either previous year.

The post-1975 changes in sighting and crossing frequencies during summer and fall may be behaviorally significant. Following an initial decline in 1976, these levels increased, particularly during fall 1977 when sighting frequency was approximately four-fold higher than in 1976 and crossing frequency increased above that recorded for either previous year (Fig. 5). These observations and some data on group composition shown for fall 1977 (Fig. 3) suggest a slight reversal of the previous downward trend in caribou occupancy and crossings. It is noteworthy that this apparent decrease in caribou sensitivity corresponds to a

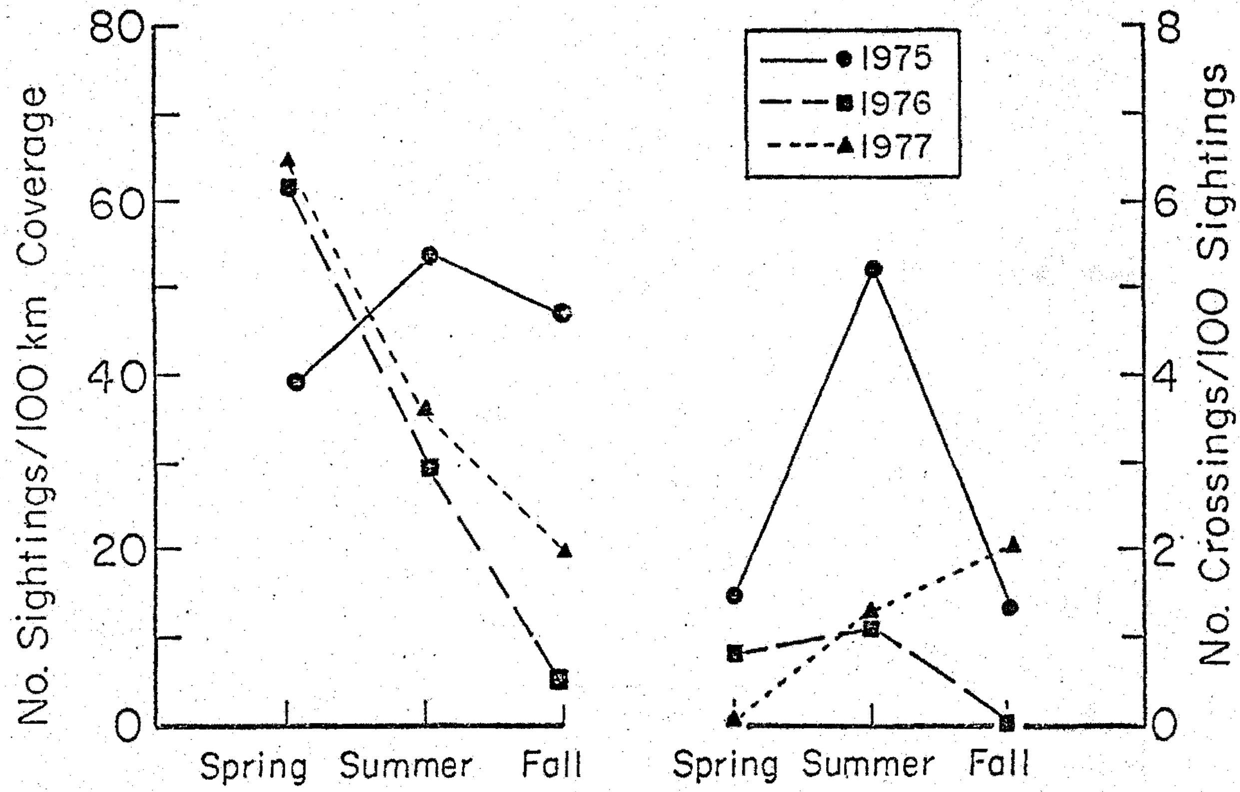

Fig. 5. Seasonal changes in caribou sighting frequency and corridor crossing rate, 1975-1977.

transition from considerable construction/restoration efforts along the corridor to the greatly reduced level of activity associated with Pipeline startup and operation. Although the sample base for these results may be insufficient for definitive conclusions, it is interesting that two independent calculations show the same general trend.

We suspect that vehicular and human activities represent a relatively greater source of disturbance to caribou than road and pipe structures per se. Seasonal and annual records of road traffic are presently being compiled and analyzed as a means of calculating indices of human activity within the corridor. These will hopefully assist in establishing a causal relationship between human activity and the observed abnormalities in caribou occupancy and group composition.

Distance of Caribou from the Pipeline Corridor in Relation to Group Composition

Survey results from lateral transects flown west of the Pipeline and/or haul road (Fig. 1) are presented as a frequency distribution in Figure 6. Numbers of caribou in each of three separate categories (i.e. total sightings, groups with calves, groups without calves) are shown for three distance intervals. Within 5.9 km of the corridor more than twice as many caribou were observed in groups without calves than in groups with calves. At intermediate distances of between 6.0 and 11.9 km, nearly all caribou were observed in calf groups, with those in groups without calves representing only 10 percent of the total. More than 60 percent of all caribou sightings were within the farthest distance interval (i.e. 12.0-17.9 km), of which approximately 90 percent were in groups with calves. Overall mean distances for caribou in groups with and without calves were, respectively, 11.3 and 6.9 km.

These data support separate observations of abnormal group composition along the corridor. Within 5.9 km of the corridor calves constituted 11 percent of the total, well within the range of calf percentages recorded from the haul road in summer during 1975 through 1977 (Table 4). This comparison is particularly relevant, as caribou sighted from the haul road are at distances which seldom exceed 1 km. Further, there is no sampling bias due to low relative abundance of calves which, on the contrary, were twice as numerous as in counts made during general surveys in August 1977 (Table 4).

The results demonstrate a local redistribution of caribou in relation to group composition. Caribou in groups with calves are present in low numbers near the corridor, but become progressively more numerous with distance. It is possible that calf groups, in undergoing outward displacement, become more dense at a certain minimum distance, but the present data are insufficient to examine this possibility. In contrast, bull groups exhibit the opposite tendency and actually appear to be attracted to the corridor, although, again, samples sizes are too small and the range of distances surveyed is too limited for a more detailed analysis. Nevertheless, the data trend clearly supports other observations of local changes in caribou distribution and group composition.

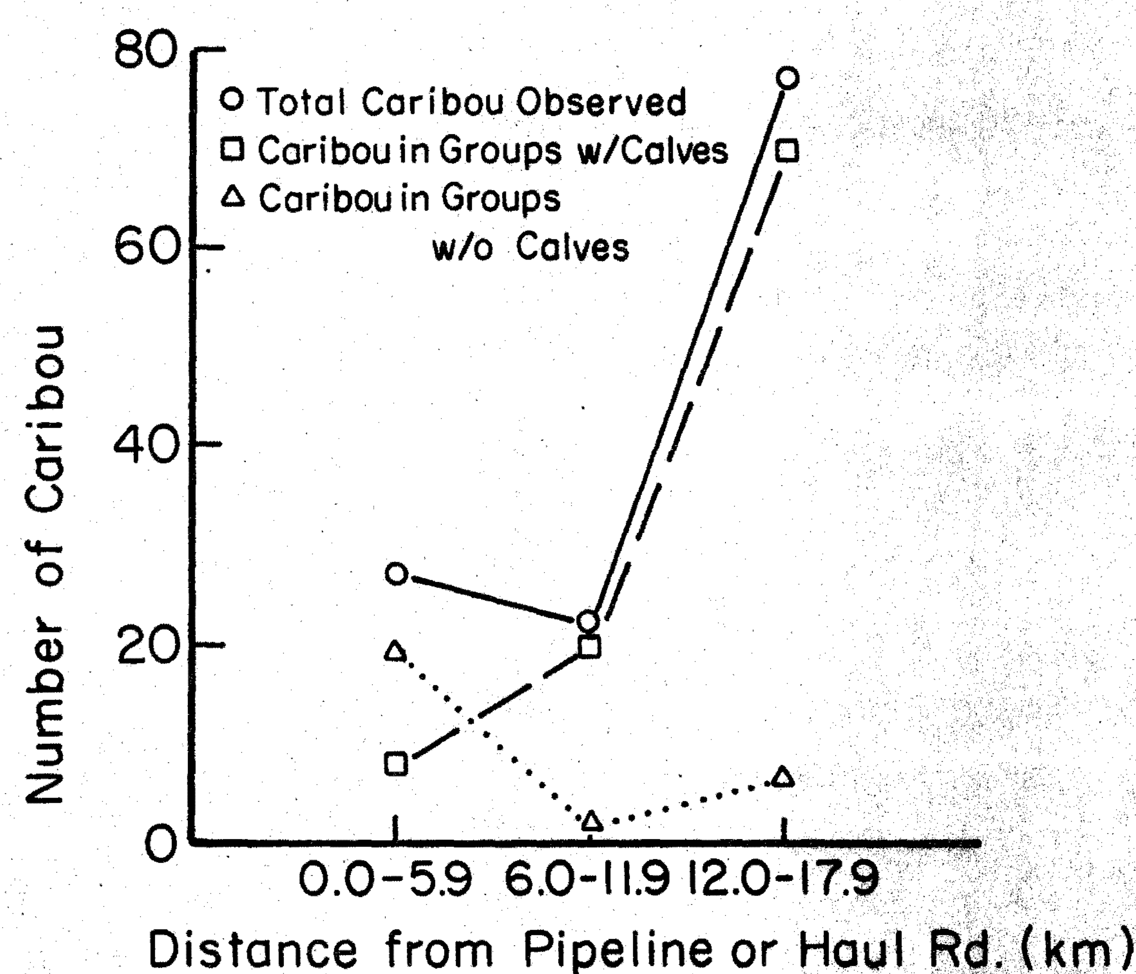

Fig. 6. Influence of group composition on caribou distribution in relation to the Pipeline corridor.

Movements of Collared Caribou

Since 1975, 109 caribou have been equipped with numbered collars on the North Slope. Sixty-eight of those caribou, nearly two-thirds of all those tagged, have been resighted a total of 228 times. Most sightings were either from the haul road or during sex and age classification of post-calving aggregations. Between the summer of 1975 and the end of 1977, 29 collared caribou are known to have crossed the Pipeline corridor a total of 70 times.

Radio transmitters have been placed on 30 adult female caribou to date. The first nine radio collars were color coded and the remainder were attached to numbered collars. One of the latter transmitters failed shortly after installation, but several collar resightings have been made and movements are included in the data compiled for caribou with numbered collars. Three of the radio-collared caribou have never been resighted; transmitter malfunction is suspect, although one is now known to have emigrated to the Western Arctic Herd. The remaining 26 radio-collared cows have been successfully tracked. However, since frequency of relocation is not random and largely a function of the effort expended in tracking, the number of resightings is rather meaningless and will not be discussed here. Of the 26 animals tracked, nine crossed the Pipeline corridor a total of 14 times (aggregate).

Ninety percent of the radio-collared caribou have been relocated within the study area. Known emigration accounts for 3 percent, and the remaining loss likely can be attributed to emigration or transmitter malfunction. Mortality of radio-collared caribou has been at least 10 percent within 2 years after tagging. An additional 7 percent mortality is suspected, although carcasses were never located, and the collars may have been shed. No mortality estimate for number-collared animals is available, but two probable instances of tagging-induced mortality (dead within 10 days of capture) have been recorded. There is one known instance of collar shedding and two others are suspect (collars found, but no carcass nearby).

Although 6 percent of the caribou with numbered collars are known to have emigrated to other herds (5% to the Western Arctic Herd, 1% to the Porcupine Herd), 62 percent have been relocated within the study area, and many have been sighted repeatedly over 2 years or more. Considering the known mortality and shedding losses, resighting rates of both numbered and radio-collared animals appear sufficient to substantiate the integrity of the CAH. The few cases of known relocation of CAH caribou to another herd support Skoog's (1968) contention that, while Alaskan caribou occur in discrete herds, interchange is frequent enough to consider all caribou in the state as constituting a single breeding population. To our knowledge, our's is the first documented case of inter-herd movement in Alaska.

Movement patterns of both numbered and radio-collared caribou, based on successive relocations, are in general agreement with CAH movements described through systematic surveys of the study area (Cameron and Whitten 1976, 1977). The time interval between collar resightings was often too long to determine precise movement schedules, but it appears that most crossings of the Pipeline corridor occurred in spring and late summer. Many of the crossings occurred during northward spring migration along the Sagavanirktok River/Pipeline corridor and reflect the multiple recrossings which often accompanied such parallel movements. The location of most corridor crossings was between Sagwon and the Security checkpoint just south of Deadhorse. This is based both on actual crossing observations and on crossing locations projected from seasonal changes in position of the center of caribou occupancy (see Cameron and Whitten 1976, 1977; above). Little if any movement through the Prudhoe oilfield can be inferred from any of the collared caribou data.

Earlier indications of avoidance of the Pipeline corridor/Prudhoe Bay area by cows and calves (Cameron and Whitten 1976, 1977; above) are supported by data on collared caribou. A breakdown of number-collar resightings by sex shows that proportionately more bulls were observed after collaring and were resighted more frequently than collared cows. Twenty-one of 30 bulls were resighted a mean of 5.0 times each, versus 46 of 78 cows with a mean resighting rate of 2.7. These differences are even more striking when sightings from the haul road are compared to those some distance from the corridor. Twenty of the 21 bulls resighted were observed from the haul road at least once, and 77 percent of all sightings of collared bulls were from the road. In contrast, only 24 of the 46 collared cows resighted were seen from the road, and only 45 percent of all collared cow sightings were from the road. Many of these cows were non-maternal, and most others were seen between fall and spring. This further substantiates earlier findings of heightened sensitivity of cows and young calves to traffic and/or construction activity (Cameron and Whitten 1977). Finally, 15 of the 21 number-collared bulls resighted (71%) accounted for 61 percent of all known crossings of the corridor by collared caribou ($\overline{x}$ = 2.9 crossings); of the 46 collared cows resighted, 14 (30%) crossed the corridor, representing only 39 percent of the crossings ($\overline{x}$ = 1.9 crossings). Crossing data for radio-collared cows are similar: nine of 26 (35%) crossed a mean of 1.6 times.

Crossings of Elevated Pipe by Caribou

Known crossings of elevated pipe in 1977 are listed in Appendix I as a continuation of similar appendices to previous reports (Cameron and Whitten 1976, 1977. Only one crossing was recorded south of Happy Valley during late spring/early summer 1977, although several were observed during the same period in 1976. However, bull caribou again grazed snow-free areas in that vicinity, and pipe crossings by these local groups may have occurred more frequently in 1977 than indicated by our observations. In general, during 1977 little additional time was spent in search of crossings, while in previous years extra surveys over certain segments of the haul road were quite common. In late summer and early fall a group of bulls crossed the elevated pipe near Galbraith Lake and a mixed group crossed just south of Pump Station 1. In November

1977, numerous crossings were recorded near Toolik Camp (Appendix I). All were inferred from tracks, and many of the caribou remained nearby. Multiple crossings by the same animals seem probable, as there was extensive cratering on the pipe work pad and few fresh tracks into or out of the immediate area. The only confirmed (i.e. through tracks) crossing of a sagbend was also noted at this time.

Infrequent contact of caribou with the corridor continues to limit an evaluation of the behavioral responses associated with direct encounters with the Pipeline and, to date, has precluded any assessment of the effectiveness of special crossing structures. Adult bulls constitute the large majority of caribou sighted from the haul road (Table 3) and recorded crossings of elevated pipe (Appendix I; Cameron and Whitten 1976, 1977), and there is some evidence for habituation to this area by males, or even attraction of males to the corridor (Fig. 6). In contrast, maternal cows and calves are present in relatively low numbers locally, and contact with elevated pipe is correspondingly infrequent. Since reproductive performance of cows and recruitment of calves to the herd are the principal factors influencing the status of caribou populations, the behavioral responses of these sex/age classes to disturbance should receive priority attention. There is little direct evidence (i.e. from the results of haul road surveys or from sightings of collared caribou) for unrestricted movements of maternal cows either across the pipeline or through the oilfield near Prudhoe Bay, and it is the effects of continued restriction of these caribou to portions of their traditional range that may be potentially detrimental.

Herd Status

A summary of the sex and age composition of the CAH between July 1976 and May 1978 is presented in Table 5. To permit calculations of overwinter calf survival and to provide a meaningful estimate of relative bull numbers, calf and bull ratios have been adjusted to a common cow base. That is, yearling counts made in summer and fall were apportioned between the bull and cow categories, and new ratios were calculated; no adjustment of spring data is necessary since "long yearlings" were classified as either adult bulls or cows.

The adjusted calf:cow ratio increased slightly between July and October in both years. This artifact probably resulted from misclassifying young bulls as cows during July, thereby decreasing the relative number of calves. Fall counts are probably more representative, since the herd approaches homogeneity during the rut, and because sex identification of adults at that time is seldom in question. Sampling inaccuracies notwithstanding, it appears that summer mortality of calves was extremely low in both years. In addition, calf:cow ratios obtained in spring indicate that overwinter survival of both 1976 and 1977 cohorts was approximately 75 percent.

Bull:cow ratios varied seasonally in both years. Consistently more bulls were observed during the rut than during post-calving aggregation or spring counts. Previous surveys indicate that bulls remain substantially

Table 5. Summary of sex/age composition of the Central Arctic herd, 1976-1977.

Cohort	Season	Observed Ratios			Adjusted Ratios[1]	
		ca/100C	Y/100C	B/100C	ca/100C	B/100C
1976	Post-calv. (July)	43	13	86	40	87
	Rut (Oct.)	46	9	125	44	124
	Spring (May)	32	-	75	32	75
1977	Post-calv. (July)	56	14	72	52	74
	Rut (Oct.)	64	32	121	54	115
	Spring (May)	40	-	37	40	37

[1] Yearlings classified as bulls or cows; when not determined directly, a sex ratio of 1 was assumed.

Note: B = bulls, ca = calves, C = cows, Y = yearlings.

farther south in summer, scattered in small groups throughout the foothills (Cameron and Whitten 1976, 1977), and are more difficult to locate and count than the dense aggregations on or near the coast. Sexual segregation in early spring tends to be similarly polarized, but may vary widely from year to year. Nevertheless, fall ratios indicate that bulls are unusually numerous, representing more than half of the adults in the CAH.

Our highest and most accurate total count of the CAH was made during post-calving aggregation in July 1977 when a minimum of 4,300 caribou were observed, of which 1,760 (41%) were cows. Applying the October figure of 37 percent cows (includes one-half of the yearlings counted) gives a July estimate of 4,756 total caribou or 3,805 adults in the herd. In April 1978 a ratio of 40 calves:100 surviving cows was obtained (Table 5). Assuming a minimum 7 percent overwinter mortality of adults (Bergerud 1978), we estimate that 655 calves were recruited as yearlings in 1978. However, overwinter adult mortality (again estimated at 7%) would theoretically reduce the number of surviving adults by 266, yielding a projected net increase of only 389 (approximately 10%) for a herd total of 4,239. Of course, at higher rates of adult mortality the annual increment would be correspondingly lower. These calculations are admittedly speculative, but are in general agreement with our recent impressions of steady herd growth. Unfortunately, the detection of minor, short-term changes is not possible using standard surveillance methods, and confirmation of herd trends must await quantitative changes of a greater magnitude. The above projections are based on a minimum population size for July 1977. At the present time we are not prepared to calculate the actual size of the CAH, but it is doubtful that it exceeded 6,000 head prior to calving in 1978.

GENERAL COMMENTS AND RECOMMENDATIONS

Analysis of the behavioral responses of caribou to the TAP and, more specifically, their success in crossing sections of elevated pipe has been complicated by an overriding avoidance of the corridor area. This general reaction has not only reduced the frequency of Pipeline contact but has also altered the local sex and age composition of groups which actually encounter pipe structures. Even these caribou often exhibit difficulty in negotiating elevated pipe, while properly buried pipe would probably have no influence on free movements in the absence of local disturbance. The haul road itself represents a significant hindrance to movements through the corridor, due principally to high levels of traffic and human activity, but also to excessive berm heights in some areas. Heavy construction activity and the attendant noise, concentrations of workers and equipment operations occurred during the first 3 years of this study, and additional cleanup/restoration work during the fourth year resulted in traffic levels well above those anticipated for long-term operation and management of the TAP. However, our data suggest a decrease in caribou avoidance during fall 1977, possibly in response to the recent reduction in traffic and construction activity. Such a recovery, if sustained, would permit a more meaningful assessment of overall crossing success as well as an evaluation of the effectiveness of special crossing structures (i.e. sagbends and special elevated sections). Gasline construction apparently won't occur for several years and this delay could provide an opportunity for continued study in the absence of massive local disturbance.

Baseline data on caribou distribution and movements on the Arctic Slope were not available prior to road and pipeline construction. Further, there was no relevant information on the anticipated responses of caribou to the general disturbance which would undoubtedly accompany the TAP project. Some preliminary research on pipeline crossing structures represents the only planned effort to accommodate caribou--clearly an inadequate basis for designing a pipeline that would permit unrestricted movements. Other considerations such as road traffic, and the size, location and scheduling of work crews were largely ignored and, in hindsight, should have been among the principal concerns. For example, more prudent planning could have eliminated a great deal of unnecessary road traffic.

Oilfield development near Prudhoe Bay is of special concern. These activities have now expanded further into the CAH calving grounds west of Prudhoe Bay, and exploration is in progress in coastal areas to the east. Feeder (production) lines from wells in these areas will not only traverse existing calving grounds but will also bisect important routes of seasonal movement. To our knowledge no oil industry scenarios for development of the Prudhoe Bay area exist in sufficient detail to allow proper planning of baseline research programs, much less to permit implementation of studies related to specific concerns. It is imperative that local expansion be considered in the context of overall field development and that plans be generated in a timely manner. Future studies of the effects of oilfield operations on caribou will be more closely integrated with ongoing pipeline research.

To date, the displacement of caribou from some units of range and the partial disruption of movements have had no measurable effect on herd productivity. Future research must address such questions as: How much disruption/displacement can caribou tolerate before productivity and recruitment are affected? Will the CAH continue to exist as a distinct unit within its present range or will it be displaced to an adjacent range and replaced by fragmented subgroups? Can caribou eventually accommodate to human activity and artificial barriers within their range? Can freer movements be encouraged by minimizing local disturbance and by providing, where necessary, more effective crossing structures? These unknowns reflect the required direction and depth of future research, which will hopefully contribute to the formulation of improved wildlife management practices and encourage cooperation from a better informed, more responsive oil industry.

Alyeska's official responsibility to support caribou/TAP research has now ended (1 July 1978), despite the fact that compliance with the stipulations for free passage and movement cannot be demonstrated, and the State of Alaska is currently sponsoring continued studies. Legal questions as to the allowable time frame for compliance with stipulations, mitigative measures and penalties for non-compliance have not yet been addressed.

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Appendix I. Elevated pipe crossings/deflections (1977).

Observ. No.	Date	Location[1]	Observ. Type[2]	Composition[3]	Dir.	Pipe Height (m)	Remarks
54	6/2	19.2 S	V	12 B	W	1.95	All 12 crossed the road, led by a large bull, and fed briefly before approaching the pipe (100 m farther W). A smaller bull then started toward the pipe pad and head-bobbed several times before walking under the pipe. The others followed quickly, single file.
55	7/14	103.8 S	V	4 B	NC	--	Deflection. First observed walking on the haul road. They left the road and walked onto the pipe pad, stood for a few minutes, and trotted back to and across the road.
56	8/10	100.2 S	V	3 B	W	--	One feeding and two standing on a steep hillside just above the pipeline; vegetation was still lush and green beneath an old snow bed. All three crossed under the pipe and continued west across the road.
57	9/9	153.6 N	V	1 C 1 B, 2 C, 1 Ca	W E	2.0 2.0	One C crossed W under a feeder line to where others were grazing. All seemed accustomed to traffic on nearby road. C with ca led group back under feeder line to the E. All trotted to some extent during the crossing, and the ca seemed alarmed while passing beneath the pipe.

Appendix I. Continued.

Observ. No.	Date	Location[1]	Observ. Type[2]	Composition[3]	Dir.	Pipe Height (m)	Remarks
58	11/14	94.0 S	T	10-15 U	--	--	Tracks and cratering were found on the revegetated pipe pad about 400 m S of a Sagbend; some tracks were present beneath the pipe, but none actually crossed. Other tracks crossed the pipe about 200 m N of the Sagbend but none were observed in the Sagbend itself.
59	11/14	91.0 S	T	few U	--	--	Tracks of a small group of caribou crossed under the pipe.
60	11/14	88.0 S	T	21 U	--	0	Tracks crossed through a Sagbend. Approximately 15 caribou, including calves, were observed just W of the pipeline and 6 more were present to the E.
61	11/14	80.0 S	T	few U	--	--	Tracks crossed under the pipe; cratering on on the work pad.
62	11/14	78.0 S	T	1 U	--	--	Tracks crossed the pipe near a Sagbend.
63	11/14	69.0 S	T	1 U	--	--	Tracks crossed under the pipe.
64	11/30	76.8 S	V	11 B	NC	--	11 B from a group of 18 B and 1 Y crossed the haul road and ran about 1 km along the pipe pad without crossing. Some turned back and one recrossed the road.

Note: Observations 1-35 appear in Cameron and Whitten 1976, and 36-53 appear in Cameron and Whitten 1977.

1 km north (N) or south (S) of Happy Valley.
2 V = visual observation, T = data from track record
3 B = bull, C = cow, Ca = calf, Y = yearling, A = adult, U = unknown
4 NC = no crossing.