JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Raymond D. Cameron and Kenneth R. Whitten

Project No.: W-17-8 Project Title: Big Game Investigations

Job. No.: 3.18 Job Title: Effects of the Trans-Alaska Pipeline on Caribou Movements

Period Covered: July 1, 1974 to December 31, 1975

SUMMARY

Studies of caribou in the vicinity of the Trans-Alaska Pipeline on the North Slope were conducted using systematic aerial surveys and ground reconnaissance.

Results indicate that this "Central Arctic" herd, estimated at 5,000 caribou, is not associated with either of the larger adjacent subpopulations by virtue of a separate calving area and distinctly different patterns of seasonal movement. For the major portion of its annual cycle the herd remains between the Colville and Canning Rivers, ranging from the northern foothills of the Brooks Range in winter to the arctic coast in mid-summer.

A comparison of mean latitudinal positions of caribou determined from road surveys with those from aerial surveys covering a larger area indicates that both total caribou and groups with calves observed along the pipeline corridor are distributed at significantly lower latitudes during summer than caribou in adjacent, but similar, regions of the North Slope. Further, the percentage of calves observed within the corridor is substantially lower than in adjacent areas. These differences suggest a pipeline-related delay in northern movements and/or an avoidance of pipeline activities by nursing pairs.

An investigation of the effects of berm height on Haul Road crossings demonstrates that caribou tend to select lower grades for crossing sites. Limited observations of caribou-pipeline interaction suggest an appreciable degree of interrupted movement; disturbance behavior was frequently associated with both deflections and successful crossings.

CONTENTS

BACKGROUND

Studies in Alaska of the reactions of reindeer and caribou (*Rangifer tarandus*) to both actual and simulated pipeline structures suggest that properly buried sections of an oil pipeline will not seriously affect movement, but that all types of above-ground construction, including underpass and ramp crossing provisions, are at least partial impediments to the free movement of *Rangifer* (Child 1973, Child and Lent 1973, Child 1975). These investigations have been criticized for their incompleteness and artificiality but, aside from similarly discouraging experiences with reindeer and pipelines in the Soviet Union (Taylor 1973, Klein 1975, Andreev, pers. comm.), represent the only significant source of information from which the reactions of caribou can be anticipated.

The nomadic instincts of caribou are consistent with the diverse character of seasonal ranges, and regular movements to or through a given area tend to coincide with optimal grazing conditions in terms of forage quality and availability (Kelsall 1968, Klein 1970). While the inaccessibility of minor habitats with relatively unimportant vegetation types may be of little significance, the loss of large areas of traditional winter or summer range might be disastrous if access to a critical forage type is effectively eliminated, particularly with high stocking rates (see Klein 1968). Further, the inability to reach a traditional range might result in excessive caribou concentrations in other areas which, with continued use, would eventually become overgrazed; this could occur most readily on winter range due to the very slow regenerative capabilities of lichens (Klein 1970). A more direct consequence may be range deterioration in the immediate vicinity of a barrier. Caribou are frequently gregarious, and large numbers assemble during the spring and fall; thus, overgrazing and trampling of vegetation may occur in areas where normal movements are restricted (Pegau 1970). Possibilities for range destruction or abandonment notwithstanding, the potential disruption or delay of seasonal movements is of equal concern, particularly with respect to timing of spring migration and arrival on the calving grounds, calf survival, recruitment to the population, and maintenance of traditional migratory patterns (Klein 1971, 1973).

The behavioral responses of caribou to a potential obstruction probably depend on a combination of several factors, including the height and shape of the barrier and its relation to the local topography. Seasonal changes in the strength of migratory instincts may also influence these responses (Child 1973). For example, winter and summer movements may be more easily deterred than those during fall and spring when the migratory drive is more pronounced (i.e., during rut and pre-calving, respectively). Weather conditions (Curatolo 1975, Gavin 1975), snow depth and hardness (Pruitt 1959, Gavin 1975), characteristics of the vegetation and terrain, presence of insects (Curatolo 1975), and group composition as it relates to leadership (Miller et al. 1972, Child 1973) are additional factors which may alter behavior when a potential restriction to movement is encountered. Lastly, the frequency of contact with the barrier is undoubtedly an important consideration in evaluating the ultimate degree of accommodation (Child 1973).

Any alteration of migratory routes and range occupancy resulting from pipeline construction may prove to be very gradual and virtually undetectable over a few years. A principal difficulty in defining cause-and-effect relationships is the unpredictable nature of caribou movements as influenced by a myriad of pipeline-unrelated variables. Hence, the separation of natural variation from pipeline-induced deviation may prove to be an extremely difficult task. Therefore, it is imperative that complete and accurate data on caribou movements be obtained prior to, during, and following pipe installation, primarily in the actual corridor, but also extending to the seasonal ranges of caribou affected by pipeline construction.

This report describes progress of field studies conducted on Alaska's North Slope between July 1974 and December 1975. Several aspects of the project are incomplete or inconclusive, and will not be considered here in detail. Among these are seasonal changes in habitat selection and forage preference, and the influence of snow conditions on local and annual movements. Observations of pipeline crossing activity and data collected on collared caribou are insufficient to warrant any specific conclusions, and are presented primarily as general support for seasonal movements determined by other means. Studies of the influence of various environmental factors on movement behavior and activity patterns of caribou are outlined in Appendix I which also contains a physiographic description of the study area, a historical account of caribou occupancy of the central Alaskan arctic, and a short review of factors known to affect caribou behavior. These studies are nearing completion and will be reported in a Masters Thesis by January 1977.

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 was designed to accomplish the following objectives:

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

2. To identify segments of the corridor featuring high or frequent use by caribou.

3. To characterize movement behavior of caribou which encounter the Haul Road, pipeline, and construction-related activities.

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

PROCEDURES

Aerial Reconnaissance

Aerial surveys were conducted periodically over a specified portion of the study area. Each survey flight followed the arctic coastline and a number of selected drainages (linear distance approximately 1480 km) so that successive surveys could be duplicated (Fig. 1). With one exception, all surveys attempted in 1974 were incomplete, due principally to time constraints and inclement weather; and in two cases, more than one separate attempt was necessary to obtain reasonable coverage. However, during 1975 all surveys were essentially complete, with only minor areas deleted.

A Cessna 180 or 185 with pilot and one observer was used for all aerial reconnaissance. Airspeed ranged from 190 to 210 km/hr, and altitudes of 60 to 120 m were maintained, depending on terrain and visibility. Following an initial sighting of caribou, one or more low passes were made to obtain total number, and in most cases, composition, i.e., bulls, cows, yearlings, calves, adults (unknown sex but older than calves), or unknown (unclassified as to sex or age); detailed sex and age classification was attempted for smaller groups, but frequently only calves and adults could be reliably distinguished. The following subjective definitions were developed for purposes of data treatment:

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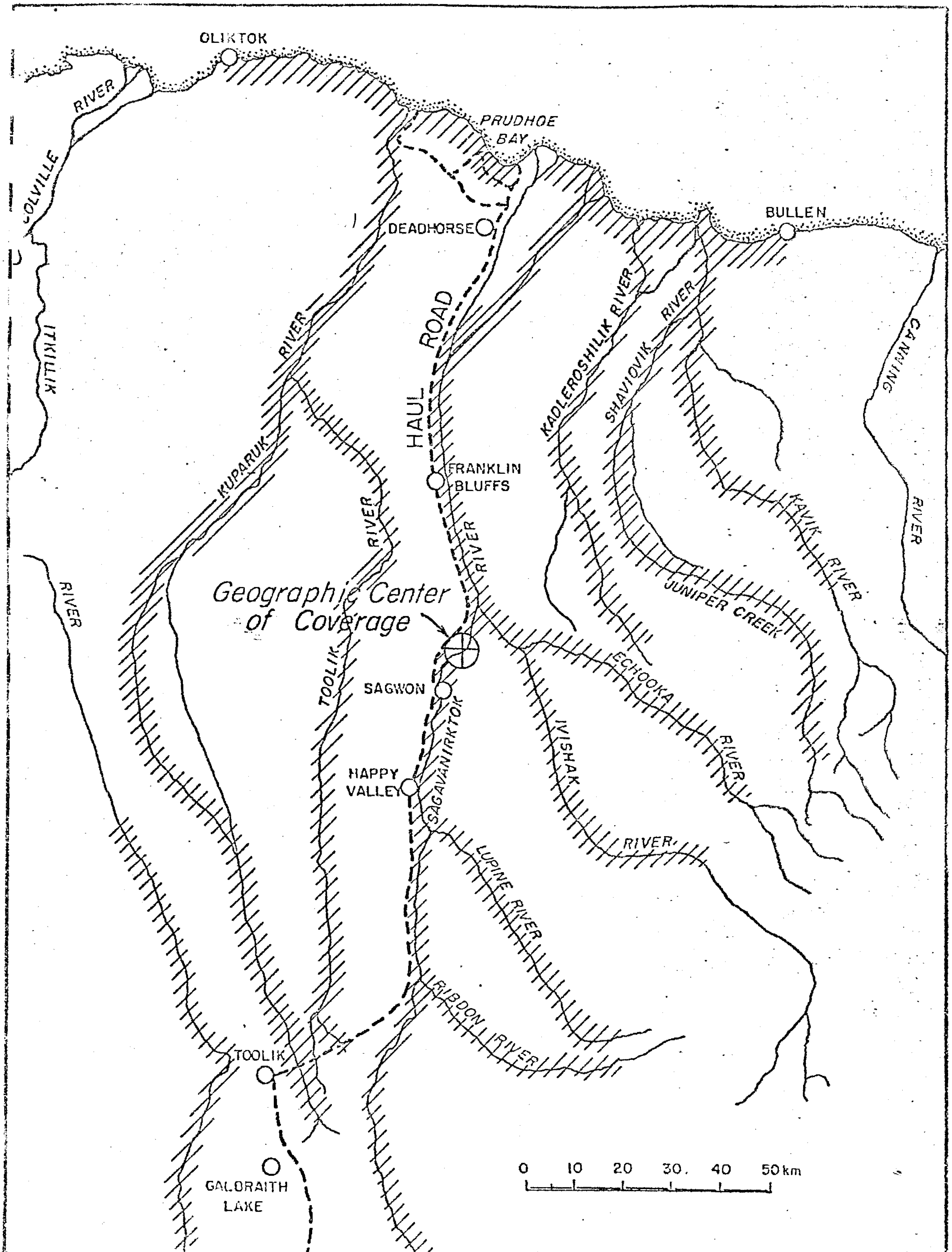
* "Lessees shall construct and maintain the Pipeline, both buried and above ground sections, so as to assure free passage and movement of big game animals."

Fig. 1 Route of coverage for aerial surveys.



OLIKTOK
COLVILLE
RIVER
PRUDHOE BAY
DEADHORSE
BULLEN
ITKILLIK
RIVER
KUPARUK
RIVER
HAUL ROAD
KADLEROSHILIK RIVER
SHAVIOVIK RIVER
CANNING RIVER
FRANKLIN BLUFFS
RIVER
KAVIK RIVER
JUNIPER CREEK
Geographic Center of Coverage
TOOLIK
RIVER
SAGWON
ECHOOKA RIVER
IVISHAK RIVER
SAGAVANIRKTOK
HAPPY VALLEY
LUPINE RIVER
RIBDON RIVER
TOOLIK
GALBRAITH LAKE
0 10 20 30 40 50 km

group – one caribou, or more than one caribou separated by less than approximately 300 m; groups were considered distinct when mean individual distance exceeded 300 m.

observation – all groups readily visible from the position of the first group sighted, and probably close enough for coalescence or exchange of individuals.

Each observation was assigned a number, and locations were recorded on a 1:500,000 aeronautical sectional chart; other data (time of day, total number, composition, activity, habitat) was referenced to this number on a portable tape recorder.

Observation points were subsequently duplicated on cellulose acetate overlays with an identifying number. A mean "center of caribou occupancy" was calculated for each set of survey observations. The geographic position of each observation was described as its latitudinal and longitudinal coordinates, estimated to the nearest 3' and 6', respectively (linear distance associated with one degree of latitude is more than double that associated with one degree of longitude). A single-digit number was assigned to each degree longitude and to each one-half degree of latitude, and each coordinate estimated to the nearest tenth of this arbitrary unit. The number of caribou associated with each observation point was multiplied by the arbitrary unit for each coordinate, and the mean and standard deviation of the resultant products calculated. The final latitudinal and longitudinal means and standard deviations were determined by dividing the respective products by the total number of caribou associated with the analysis, and reconverting to the conventional base-sixty format. The result can be depicted as a single mean with a two-dimensional standard deviation. Plotted over time, these population centers provide a method for determining the net movement of the population or, in cases of caribou movements into and/or out of the coverage region, shifts in the center of geographic preference within the study area.

As a reference for the various position means of the population, an estimated center of coverage was determined by plotting the mean coordinates of linear coverage (Fig. 1). This was calculated by averaging the products of each 15' and 30' - spaced coordinate of latitude and longitude, and the number of intersections of each with the coverage route; final coordinates were obtained by dividing product means by the respective total number of intersections. This point defines the statistical center of the population assuming uniform or normal distribution over the study area. Thus, the position of population means relative to the center of coverage indicates the degree of symmetry of distribution, and the associated standard deviations are a measure of the relative magnitude of population spread.

Caribou Collaring

Three separate collaring operations occurred during this reporting period. In each case both transmitter-equipped and numbered neck collars were installed on caribou. All collaring on the North Slope was conducted within 8 km of the pipeline Haul Road between Sagwon and Slope Mountain. One collaring operation was conducted on the south slope of the Brooks Range in the Wild River Flats, approximately 25 km north of Bettles Field and 40 km west of the pipeline corridor. Table 1 gives the inclusive dates, sexes and total numbers of caribou equipped with identifying collars. All caribou were darted from a helicopter (206B or FH-1100) using a 28 gauge shotgun and 3-cc syringes (CAP-CHUR) loaded with 12 - 20 mg of succinyl-choline chloride (Anectine); exact dosages varied with estimated body weight and season.

An effort was made to relocate radio collared caribou every 1-3 weeks during the spring, summer and fall and less frequently during winter. Radio tracking was always attempted in conjunction with general surveys (see above), but separate flights were often necessary to obtain adequate data. Utilizing a Cessna 180 or 185, equipped with a 12-channel FM receiver (AVM) and a wing strut-mounted, three-element Yagi antenna, each transmitter was located by flying a bearing which corresponded to maximum signal strength. Upon visual identification, location was recorded on a USGS 1:250,000 topography map and the following minimum information was recorded:

Collar Number
Date
Time
Group Size
Composition
Habitat

Sightings of caribou equipped with numbered neck collars were made incidental to both aerial reconnaissance (see above) and road surveys (see below). Locations were noted, and the same information was recorded as for radio-collared individuals. Position information on each collar sighting was transferred to a master overlay and all associated data were recorded in a central file.

<u>Ground Surveys</u>

Surveys along the Haul Road commenced in September of 1974. Due to the need for finalizing construction plans with respect to special big game crossings between Pump Stations 3 and 4, surveys were restricted to that section of the road through December. Ground reconnaissance recommenced in February of 1975, and beginning in June the entire length of the Haul Road north of Pump Station 4 was surveyed twice during a given two-week period; additional surveys were conducted in areas having larger concentrations of caribou. Table 2 summarizes monthly coverage over the entire route and between the various pump stations.

A pickup truck, generally with one driver/observer, was used for road reconnaissance. Survey speed ranged from 40-65 km/hr, depending on terrain and visibility, and binoculars or spotting scope were used as required. Information recorded for each caribou sighting is listed below.

Table 1. Caribou collaring, 1975

Incl. dates	Location	Total Collared	Visual Collars	Transmitter Collars	Sex M	Sex F
2/5-2/7/75	S. Slope[1]	15	13	2	4	11
4/21-4/25/75	N. Slope[2]	25	20	5	10	15
10/20-10/25/75	N. Slope[2]	11	7	4	3	8

1 Wild River Flats (25 km North of Bettles Field)
2 Along pipeline corridor between Sagwon and Slope Mountain

Table 2. Minimum estimates* of Haul Road coverage between Pump Station #1 and Pump Station #4, 9/74-12/75.

Month		One-way coverage (km) PS#1-PS#2 (109 km)	PS#2-PS#3 (82 km)	PS#3-PS#4 (72 km)	Total (263 km)
1974 - Sept				188(9)	188(2)
Oct				879(39)	879(11)
Nov				628(29)	628(8)
Dec				314(14)	314(4)
	Total			2,009	2,009
1975 - Feb			209(9)	47(2)	256(3)
Mar			219(9)	671(30)	890(11)
Apr			171(7)	553(26)	724(9)
May			228(9)	545(24)	773(9)
Jun		1,073(33)	1,004(41)	282(13)	2,359(30)
Jul		1,184(35)	463(18)	145(6)	1,792(22)
Aug		817(24)	787(31)	455(20)	2,059(25)
Sept		726(22)	631(26)	270(13)	1,627(21)
Oct		302(9)	666(26)	293(13)	1,261(15)
Nov		283(9)	681(28)	436(20)	1,400(18)
Dec		109(3)	121(5)	63(3)	293(4)
	Total	4,494	5,180	3,760	13,434

* Values are based on the distance from origin to the most distant point reached in a given day, and do not include return trips over the same area.

( ) = percentage of total coverage possible for each month, assuming one complete trip per day.

Observation number
Date
Time
Location (road distance from a known point)
Position of animals in relation to road or pipe
Estimated observation distance
Group size
Composition
Topography
Habitat

Photographs of caribou crossing the pipe, construction pad, or road were taken, when possible; additional photographs were taken from the approach side of the structure. Berm height (distance from natural terrain to road surface) or pipe elevation (distance from construction pad to lower pipe surface) was measured, and snow depth and hardness (Rammsonde index) were determined at the crossing site. Tracks approaching and/or crossing the Haul Road and construction pad supplemented the visual record during months of snow cover.

At 1.6 km intervals between Galbraith Lake and Pump Station 3 road berm heights were measured, and on four occasions (October and November, 1974; March and April, 1975) snow depth and hardness were determined at points approximately 10 m west of the road. Berm heights and snow characteristics were compared to corresponding data obtained at caribou crossing sites. However, snow data have not been fully analyzed and will not be reported here.

Statistical Methods

Standard methods were used to determine mean and standard deviation. Significance was evaluated at the 95 percent confidence level using Students t distribution.

FINDINGS

Caribou Group Structure and Seasonal Distribution in the Study Area

Mean group size and calf percentages determined from aerial surveys are shown in Table 3 together with means for spring (March-May), summer (June-August), and fall (September-November). A maximum mean group size of 98 was observed in July 1974 when several large post-calving concentrations were located near the arctic coast. Otherwise, values ranged from 7 to 26, with larger groups present in early fall prior to the peak of the breeding season. Although fall means were similar for 1974 and 1975 (15 and 17, respectively), higher group sizes remained through November in 1974, but decreased in November of 1975. Calf percentages of 15 and 11 were recorded in October and November 1974, respectively; however, November surveys excluded coastal areas which may account for the decrease in calves during that month. In 1975, the highest calf percentage was obtained in August (23%), other values ranging between 15 and 17 percent.

Table 3. Aerial Surveys: changes in mean group size and composition.

Survey	Incl. date	Total	Mean group size	No. classified	% calves
1	7/15-7/17/74 & 7/30-7/31/74	1960	98		
2	8/27-8/29/74	335	8	...	..
		Summer Mean	53		
3	10/3-10/10/74 & 10/29-10/30/74	691	14	281	15
4	11/19-11/20/74	588	16	338	11
		Fall Mean	15		13
	NO SURVEYS DURING MIDWINTER 1974-75				
5	3/9-3/10/75	629	11	...	..
6	5/18-5/21/75	716	8	...	..
		Spring Mean	10		
7	6/25-6/27/75	865	8	585	16
8	8/7-8/11/75	555	7	525	23
		Summer Mean	8		20
9	9/22-9/25/75	676	26	361	15
10	11/18-11/24/75	1029	8	921	17
		Fall Mean	17		16

Position means (± SD) of caribou distribution, based on total sightings, are listed in Table 4 and shown diagramatically in Figs. 2 and 3 for 1974 and 1975, respectively. Except for latitudinal changes between August and October of 1974, all shifts in geographic centers for successive surveys were significant (Table 5A). Due to the incompleteness of 1974 surveys, a detailed comparison with 1975 data is invalid, although certain similarities are apparent between years during summer and fall.

A July 1975 coastal survey was impossible due to inclement weather, and data are lacking for comparison with the results from July 1974. However, limited information from the road travelers and reports from helicopter pilots confirmed the presence of large concentrations of caribou between Deadhorse and the Sagavanirktok River Delta, suggesting that more northerly movements to the coast in late July probably occurred in 1975. The combined survey data indicate the onset of inland movements during mid and late August, and progressively greater occupancy of the extreme northern foothills of the Brooks Range by November. Spring movements between March and June 1975 clearly followed a northerly direction from foothill wintering areas.

Beginning with aerial surveys conducted in late June 1975 it became apparent that groups of caribou with calves were occupying higher latitudes than other groups. This segregation was most obvious between June and August when "calf" groups occupied primarily wet sedge areas of the coastal plain outside of the pipeline corridor. Other groups dominated by bulls were found toward the southern limits of wet sedge habitat, in tussock communities, and in riparian habitats along major drainages. By way of demonstrating this phenomenon, position centers (June-November 1975) were determined separately for total caribou numbers in groups* with calves and for all other groups (Table 4), and the results were plotted separately (Fig. 4). Except for latitudinal differences for June-August and September-November, position means for the two classes were significantly different within each survey (Table 5B), and between successive surveys for all three categories (Table 5A). Patterns of movement of the two classes of animals were similar, but a latitudinal separation of approximately 50 km was maintained between respective mean centers.

The proportion of total caribou found in calf groups reached a maximum of 94 percent in late September (Table 4), indicating a more thorough mixing of various cohort classes during or immediately preceding the rut, and corresponding to the formation of larger breeding groups (Table 3). Both the percentage of calf groups and mean group size (Table 3) decreased in November, presumably reflecting the fragmentation of larger, homogeneously-mixed rutting bands into smaller wintering units.

Movements of Collared Caribou

One of the five caribou equipped with transmitter collars in April 1975 (Table 1), died in late June, and the remaining four radio units

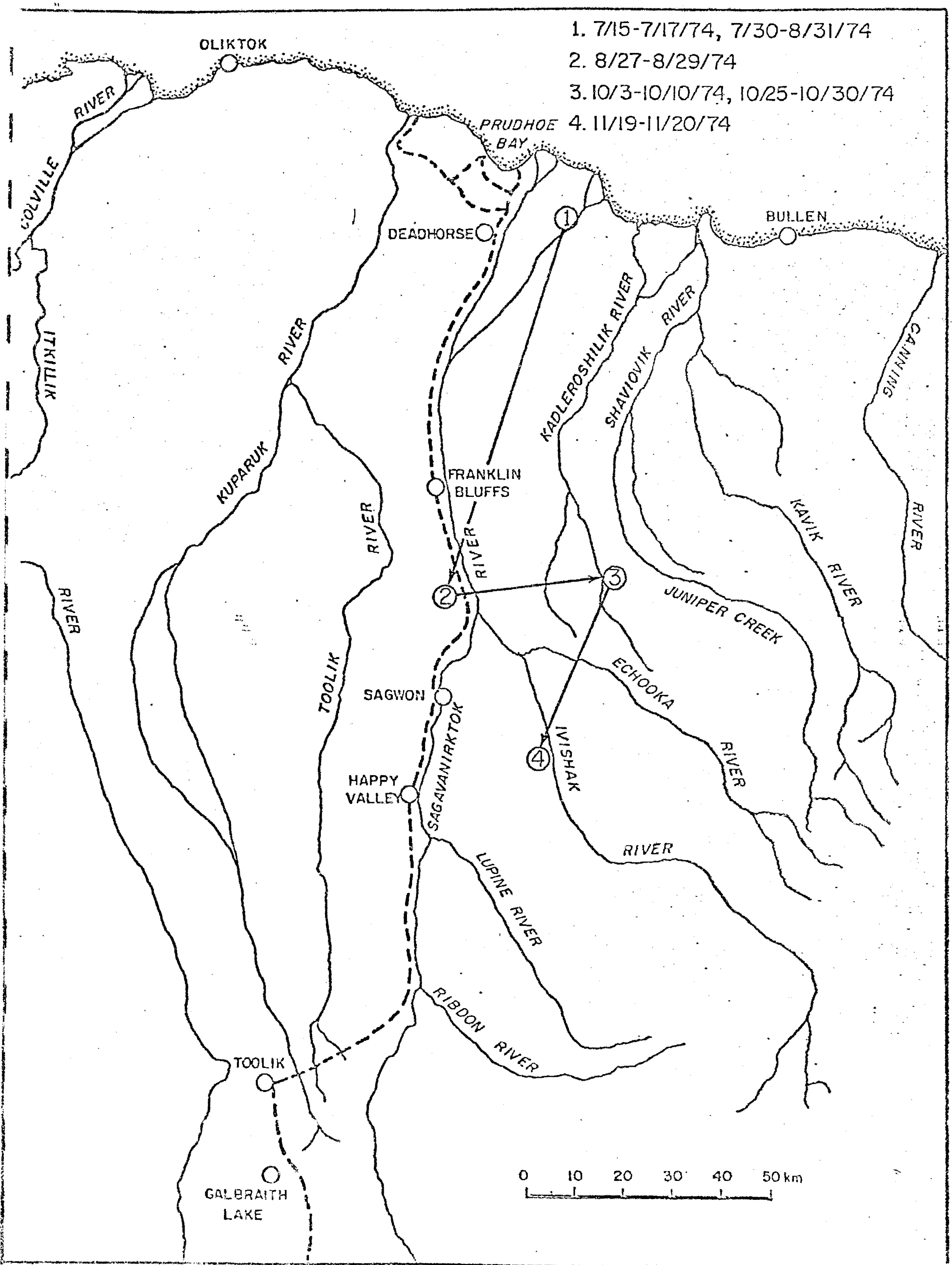
* For the purpose of these analyses "group" is synonymous with "observation" which, by previous definition, includes all caribou seemingly close enough to intermix (see PROCEDURES).

Table 4. Aerial surveys: total numbers and position means.

Survey	Incl. dates	Fraction	N	Mean Latitude (± SD)	Mean Longitude (± SD)
1	7/15-7/17/74 & 7/30-7/31/74	Total caribou[1]	1960	70°12' ± 08'	148°06' ± 48'
2	8/27-8/29/74	Total caribou	335	60°30' ± 33'	148°42' ± 71'
3	10/3-10/10/74 & 10/29-10/30/74	Total caribou	691	69°30' ± 27'	147°48' ± 57'
4	11/9-11/20/74	Total caribou	588	69°12' ± 15'	148°12' ± 54'
		NO SURVEYS DURING MIDWINTER 1974-75			
5	3/9-3/10/75	Total caribou	629	69°21' ± 27'	148°42' ± 47'
6	5/18-5/21/75	Total caribou	716	69°30' ± 42'	148°48' ± 46°
7	6/25-6/27/75	Total caribou	865	69°54' ± 26'	148°48' ± 47'
		w/ca[2]	373(52)	70°15' ± 24'	148°30' ± 45'
		w/o ca[3]	346	69°45' ± 19'	148°00' ± 49'
8	8/7-8/11/75	Total caribou	555	70°06' ± 21'	148°36' ± 46'
		w/ca	368(68)	70°18' ± 13'	148°42' ± 50'
		w/o ca	177	69°45' ± 15'	148°24' ± 33'
9	9/22-9/25/75	Total caribou	676	69°27' ± 30'	148°12' ± 50'
		w/ca	600(94)	69°30' ± 30'	148°12' ± 50'
		w/o ca	38	69°03' ± 25'	149°00' ± 30'
10	11/18-11/24/75	Total caribou	1029	69°18' ± 28'	148°30' ± 49'
		w/ca	782(82)	69°24' ± 28'	148°30' ± 48'
		w/o ca	172	69°00' ± 22'	148°24' ± 44'

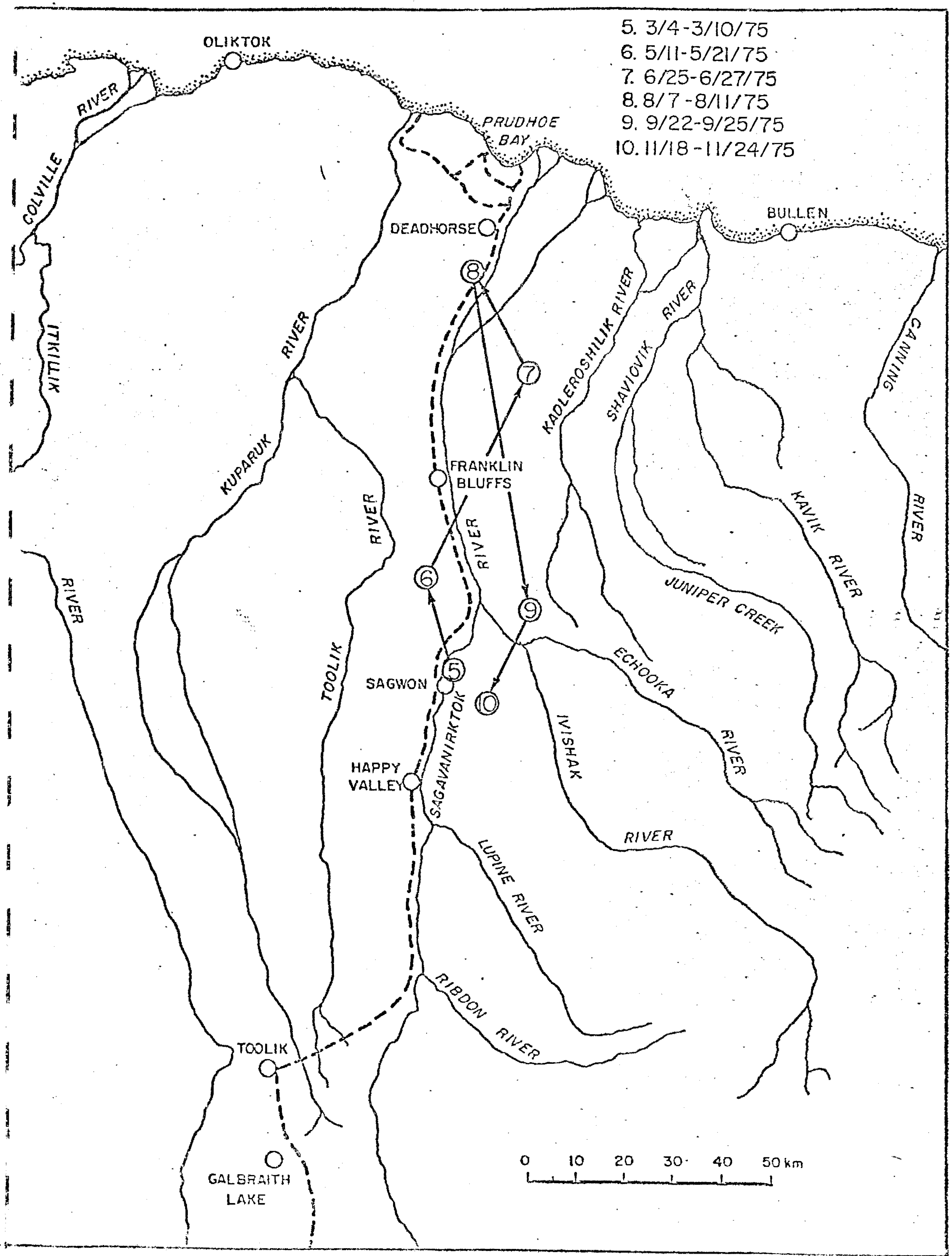
1 includes unidentified animals (i.e., "unknown" classification).
2 includes all caribou seen in groups with one or more calves present.
3 includes all caribou seen in groups which definitely contained no calves.
( ) = percentage of total classified.

Fig. 2 Position means of total caribou within the study area, 1974.



1. 7/15-7/17/74, 7/30-8/31/74
2. 8/27-8/29/74
3. 10/3-10/10/74, 10/25-10/30/74
4. 11/19-11/20/74
OLIKTOK
COLVILLE
RIVER
PRUDHOE BAY
BULLEN
DEADHORSE
ITKILLIK
KUPARUK
RIVER
KADLEROSHILIK RIVER
SHAVIOVIK
RIVER
CANNING
RIVER
FRANKLIN BLUFFS
RIVER
KAVIK
RIVER
JUNIPER CREEK
TOOLIK
RIVER
ECHOOKA
RIVER
SAGWON
SAGAVANIRKTOK
IVISHAK
RIVER
HAPPY VALLEY
LUPINE RIVER
RIBDON RIVER
TOOLIK
GALBRAITH LAKE
0 10 20 30 40 50 km

Fig. 3 Position means of total caribou within the study area, 1975.



5. 3/4-3/10/75
6. 5/11-5/21/75
7. 6/25-6/27/75
8. 8/7-8/11/75
9. 9/22-9/25/75
10. 11/18-11/24/75
OLIKTOK
COLVILLE RIVER
PRUDHOE BAY
DEADHORSE
BULLEN
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KUPARUK RIVER
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HAPPY VALLEY
IVISHAK RIVER
LUPINE RIVER
RIBDON RIVER
TOOLIK
GALBRAITH LAKE
0 10 20 30 40 50 km

Table 5. Aerial surveys: significance tests.

A.

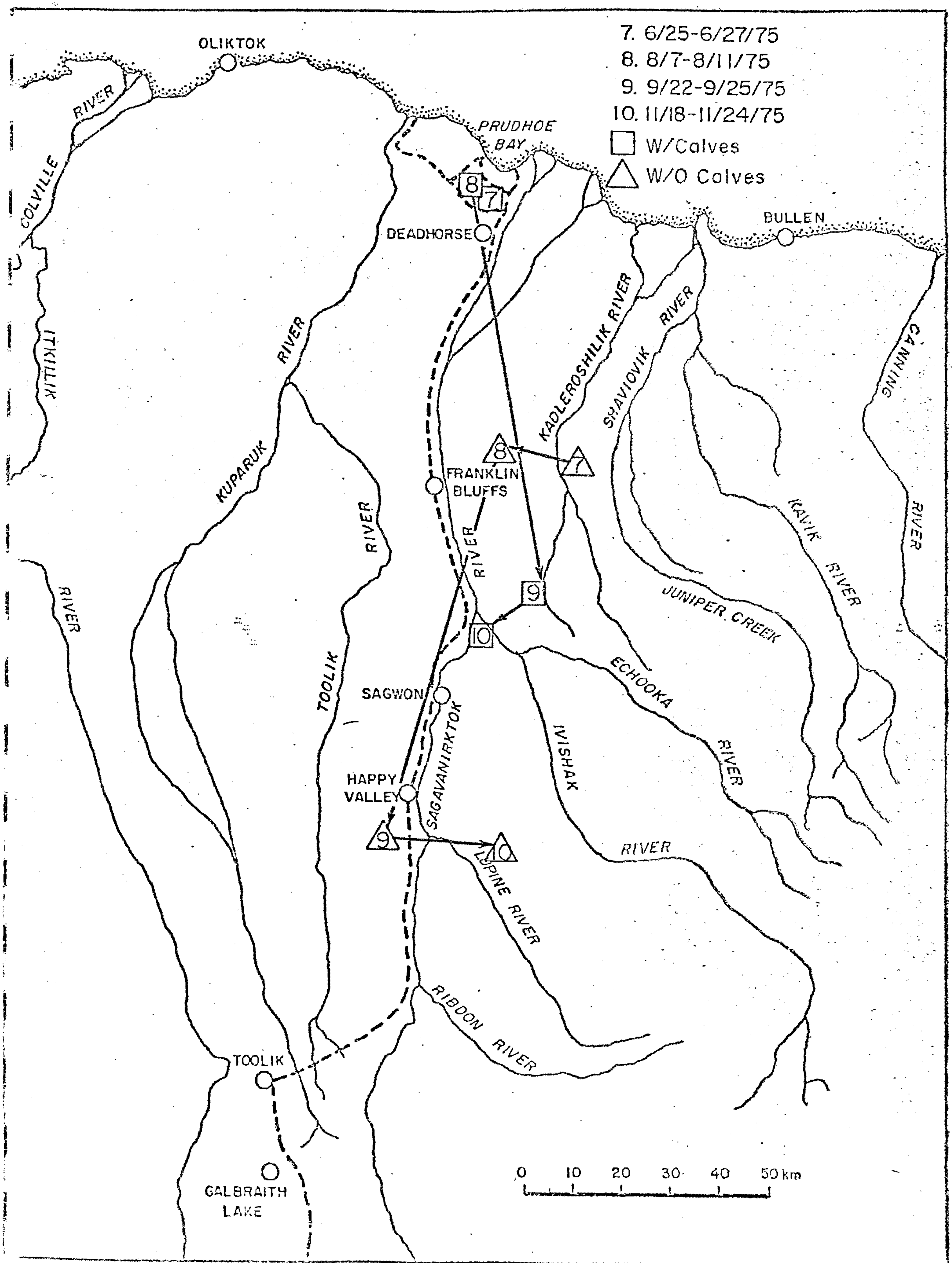
		Survey* 1974 1-2	2-3	3-4	5-6	6-7	1975 7-8	8-9	9-10
Total	lat.	S	NS	S	S	S	S	S	S
	long.	S	S	S	S	S	S	S	S
w/calves	lat.						S	S	S
	long.						S	S	S
w/o calves	lat.						NS	S	NS
	long.						S	S	S

B.

		Survey* 1975 7	8	9	10
w/calves vs. w/o calves	(lat.)	S	S	S	S
w/calves vs. w/o calves	(long.)	S	S	S	S

* Refer to Table 3 or 4 for dates

Fig. 4 Position means for groups with calves and groups without calves, 1975.



7. 6/25-6/27/75
8. 8/7-8/11/75
9. 9/22-9/25/75
10. 11/18-11/24/75
W/Calves
W/O Calves
OLIKTOK
COLVILLE
RIVER
PRUDHOE BAY
DEADHORSE
BULLEN
ITKILLIK
RIVER
KUPARUK
RIVER
KADLEROSHILIK RIVER
SHAVIOVIK
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GALBRAITH LAKE
0 10 20 30 40 50 km

failed to transmit by August or September. During the period in which transmitters were functional a total of 35 resightings were made, which was an average of 2 per caribou per month. Of the 20 numbered neck collars installed on caribou in April, one or more resightings were made on 14 animals (70%), and 65 repeat sightings were made during air and road surveys. Caribou equipped with transmitters in October have been successfully relocated only once or twice and no sightings of numbered collars have occurred.

While movement data collected from collared caribou in 1975 is insufficient to provide specific conclusions, in general the results support the population movements indicated in Figs. 3 and 4. In addition, the known movements of 14 collared caribou (4 radio, 10 numbered) permits some speculation regarding the extent and timing of summer movements of various classes of caribou. Calving occurred during the first half of June, and new calves were observed from the latitude of Happy Valley Camp north to the arctic coast. For much of the cow segment, parturition apparently takes place during the extensive northward migration occurring between early May and late June (Figs. 3 and 4). Six of eight collared females were known to calve successfully; three calves died by August, while the other three were sighted with their dams as late as October or November. The three cows which lost their calves during the summer showed summer and fall movement patterns similar to those of the "non-calf" groups, while cows which successfully reared calves through the summer and fall exhibited movements similar to those shown for the "with calf" classification (Fig. 4). Of the remaining two cows which were presumably non-pregnant, one moved north with parturient cows and the other remained at the lower latitudes characteristic of the non-calf classification; similarly, three of the six collared bulls moved north with parturient cows, while the others remained south. Thus, these data suggest that cows giving birth to weak offspring and/or unable to provide adequate early maternal care tend to remain inland, while those able to maintain healthy calves migrate to coastal areas during early summer. Bulls and barren cows select either movement strategy.

Caribou Group Structure and Seasonal Distribution within the Pipeline Corridor

Changes in mean group size and composition determined from two-week road surveys are shown in Table 6. Mean group size ranged from 2 to 15, with the collective mean for fall double that for summer; highest two-week means were observed toward the end of and immediately following the rut. Composition data show that bull percentages remained high throughout the summer, averaging 92 percent. The fall decrease to a mean of 64 percent was accompanied by more than five fold increases in the mean percentages of cows and calves. Peak calf percentages occurring in late October (Survey H), corresponded closely with the period of rut, although mean group size for that period remained low. Numbers classified during fall were generally quite small relative to summer samples, and therefore, percentages based on individual surveys are thought to be somewhat unreliable. On the other hand, means shown for the summer and fall seasons should be representative of those periods.

Table 6. Road surveys: changes in mean group size and composition.

Survey	Incl. dates	Total	Mean group size	No. classified	Composition (% of total)* Bulls	Cows	Yearl.	Calves
A	6/11-6/18/75	91	4	63	90	5	5	0
B	6/24-7/2/75	351	5	316	92	2	4	2
C	7/10-7/17/75	95	4	95	91	5	0	4
D	7/24-8/2/75	136	9	136	98	1	0	1
E	8/7-8/13/75	267	4	247	83	9	1	7
F	8/20-8/28/75	146	2	134	97	2	0	1
		Summer Mean	5		92	4	2	2
G	9/3-9/6/75	195	6	177	94	3	1	2
H	10/24-10/28/75	54	5	27	40	30	4	26
I	11/5-11/10/75	176	15	44	61	30	2	7
J	11/19-11/25/75	92	12	40	60	30	0	10
		Fall Mean	10		64	23	2	11
K	12/5-12/7/75	31	5	12	50	25	0	25

* groups with "unknown" and "adult" classifications eliminated.

Note: Results are based on one or more complete surveys between Pump Stations 1 and 4.

Using the results of each two-week road survey, mean latitude was calculated for total caribou observations, and for groups satisfying the calf or non-calf criteria (Table 7). The highest latitude for both the total and non-calf categories was attained in late July and early August (Survey D). Caribou found in groups with calves did not reach their maximum latitude until late August (Survey F); however, since calculations were generally based on very small samples, neither the exact peak latitude nor the precise survey during which such a latitude was reached can be accurately estimated. With few exceptions, mean latitudes calculated from successive surveys for all three categories were significantly different (Table 8A), and except for one survey conducted in early November (Survey I), mean latitudes of caribou found in calf and non-calf groups were significantly different within surveys A through K (Table 8B). The number of caribou found in calf groups was generally lower (Table 7) than that obtained from aerial surveys (Table 4). Peaks noted in early August, October and December did not correspond to an increased mean group size (Table 6); these observations directly contradict the results of aerial surveys (Table 3, Table 5A).

The effects of construction activity on caribou distribution along the Haul Road were evaluated. Summer and fall schedules giving the alignment sheet location(s) of construction activity at two week intervals were prepared by Alyeska Pipeline Service Company (Galbraith Lake Camp). These segments of activity were converted to road position and compared to the locations of caribou observed from the Haul Road during the corresponding time periods. Histograms were prepared showing caribou numbers totaled at 8 km intervals; for each two week record lowest values were eliminated up to five percent of the total number of sightings, and a mean (± SD) location was calculated for each discrete "pod" of caribou observed. This comparison is given in Fig. 5 and demonstrates a general absence or scarcity of caribou along segments of the road route where construction activity occurred. Combining the results for two-week intervals during which construction work was recorded indicates that means and/or standard deviations representing only about 4 percent of the total sightings overlapped road segments known to feature a construction effort. However, this consideration may be misleading since in some cases construction activity occurred in areas where caribou occupancy was not anticipated based on data trends from road surveys (Table 7). Observations of caribou away from pipeline-related construction may be similarly fortuitous. Further, the construction schedule upon which the analysis is based is a point-in-time estimate of what is a continuous and often erratic process. Hence, the variables are too numerous and the associated data too crude to permit a reliable probability analysis. However, the data strongly suggest that human activities were influencing the local distribution of caribou.

Haul Road and Pipeline Crossings

As mentioned above (see PROCEDURES), road surveys conducted during the fall of 1974 were restricted to that section of the Haul Road between Galbraith Lake and Pump Station 3. From direct observation and through track analysis, a total of 200 road crossings were recorded between

Table 7. Road surveys: total numbers and position means.

Survey	Incl. dates	Fraction	N	Mean Latitude (± SD)
A	6/11-6/18/75	Total caribou[1]	90	69°17' ± 19'
B	6/24-7/2/75	Total caribou	351	69°33' ± 16'
		w/ca[2]	19(6)	69°59' ± 01'
		w/o ca[3]	323	69°32' ± 15'
C	7/10-7/17/75	Total caribou	95	69°46' ± 36'
		w/ca	9(9)	70°02' ± 00'
		w/o ca	86	69°44' ± 38'
D	7/24-8/2/75	Total caribou	136	69°53' ± 18'
		w/ca	5(4)	70°13' ± 00'
		w/o ca	131	69°52' ± 18'
E	8/7-8/13/75	Total caribou	267	69°47' ± 21'
		w/ ca	55(21)	70°04' ± 11'
		w/o ca	212	69°42' ± 20'
F	8/20-8/28/75	Total caribou	146	69°36' ± 24'
		w/ca	11(8)	70°17' ± 00'
		w/o ca	128	69°35' ± 24'
G	9/3-9/6/75	Total caribou	195	69°25' ± 19'
		w/ca	16(8)	69°45' ± 20'
		w/o ca	177	69°23' ± 17'
H	10/24-10/28/75	Total caribou	54	69°11' ± 09'
		w/ca	25(78)	69°14' ± 10'
		w/o ca	7	69°08' ± 15'
I	11/5-11/10/75	Total caribou	176	69°02' ± 17'
		w/ca	19(51)	69°15' ± 10'
		w/o ca	18	68°56' ± 14'
J	11/19-11/25/75	Total caribou	92	68°55' ± 32'
		w/ca	25(38)	68°57' ± 35'
		w/o ca	41	68°59' ± 37'
K	12/5-12/7/75	Total caribou	31	68°47' ± 12'
		w/ca	16(80)	68°53' ± 02'
		w/o ca	4	68°59' ± 00'

1 includes unidentified animals.
2 includes all caribou seen in groups with one or more calves present.
3 includes all caribou seen in groups which definitely contained no calves.
( ) = percentage of total classified.

Table 8. Road surveys: significance tests.

A.

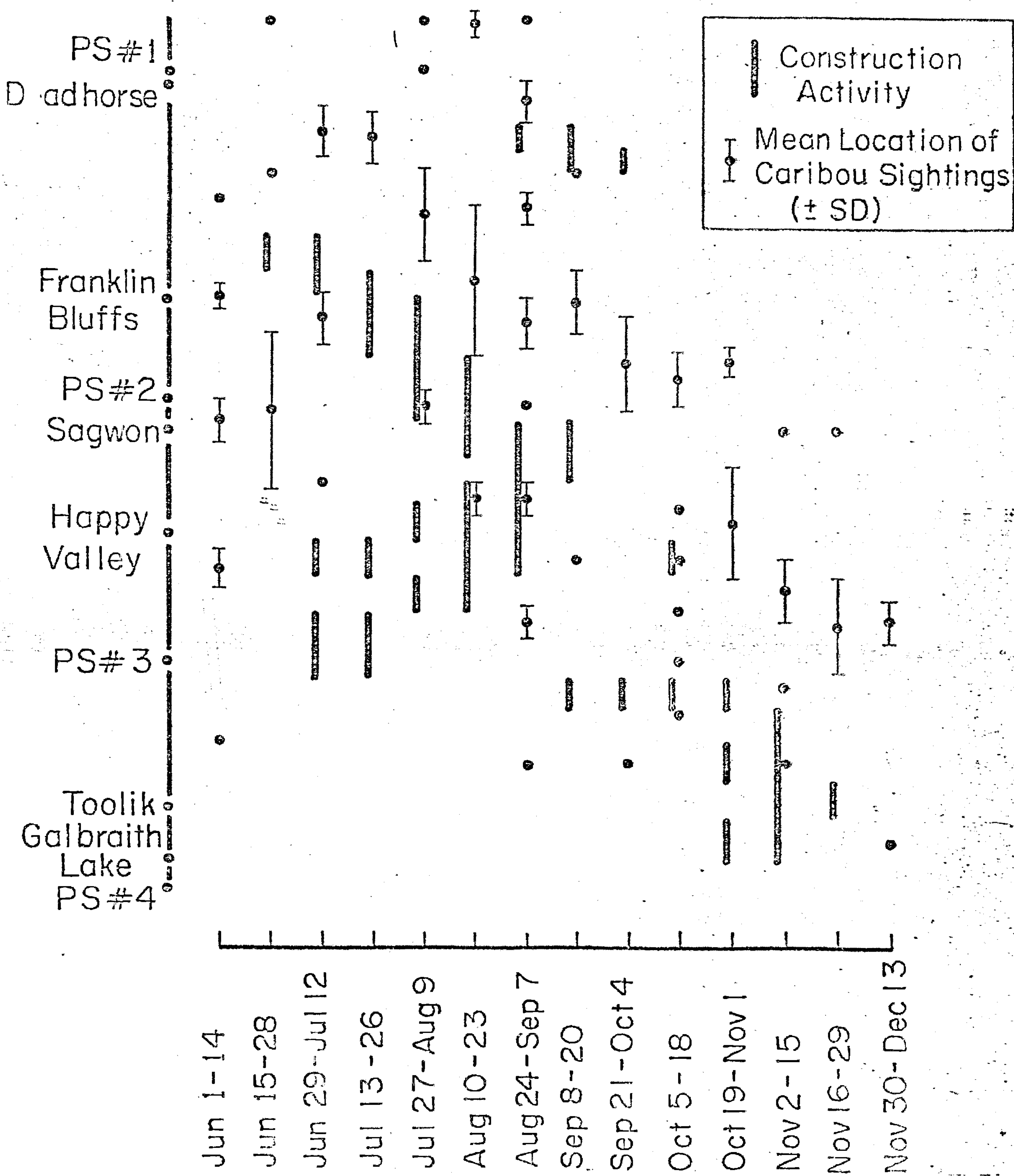
		Survey*									
		A–B	B–C	C–D	D–E	E–F	F–G	G–H	H–I	I–J	J–K
Total	lat.	S	S	S	NS	S	S	S	S	S	S
w/calves	lat.	–	S	S	S	S	S	S	NS	S	S
w/o calves	lat.	–	S	NS	S	S	S	S	NS	NS	NS

B.

	Survey*										
	A	B	C	D	E	F	G	H	I	J	K
w/calves vs. w/o calves (lat).	S	S	S	S	S	S	S	S	NS	S	S

* Refer to Table 6 or 7 for dates.

Fig. 5 Relationship between caribou distribution and construction activity.



PS#1
D adhorse
Franklin Bluffs
PS#2
Sagwon
Happy Valley
PS#3
Toolik
Galbraith Lake
PS#4
Construction Activity
Mean Location of Caribou Sightings (± SD)
Jun 1-14
Jun 15-28
Jun 29-Jul 12
Jul 13-26
Jul 27-Aug 9
Aug 10-23
Aug 24-Sep 7
Sep 8-20
Sep 21-Oct 4
Oct 5-18
Oct 19-Nov 1
Nov 2-15
Nov 16-29
Nov 30-Dec 13

September and December 1974. The location of crossings and the numbers of caribou applicable to each are given in Fig. 6. Since field efforts coincided with fall migration, road crossings were predominately east-southeasterly (77% of the total recorded). Based on the above information and operating within the geotechnical constraints of soil stability, Alyeska proposed the location of eight special "sag-bend" crossings in this region (Fig. 6). These are short sections of buried pipe designed to allow caribou movements across an otherwise totally elevated segment of the pipeline. Sag-bends should be in place by the end of the 1976 construction season, at which time the relative effectiveness of these structures can be assessed.

The influence of road berm heights on the selection of crossing sites by caribou was evaluated by statistical comparison of the mean height at actual crossings with that calculated from a measured profile between Galbraith Lake and Pump Station 3. Means of 1.43 ± 0.59m (N=33) and 1.70 ± 0.76m (N=73), for crossing sites and the road profile, respectively, were significantly different, indicating that approaching caribou tended to select the lowest berm areas for negotiating the Haul Road.

Total caribou sightings, and road or pipe/construction pad crossings observed during three-month intervals in 1975 are shown in Table 9 for each of three arbitrarily established sections of the pipeline corridor. A ratio of visual crossings to total sightings (R) was calculated as a means of evaluating relative crossing frequency, and the results for 1975 are plotted in Fig. 7. Maximum crossing rates occurred during summer (i.e. June-August) in each section of the corridor, and during each season the relative frequency decreased from north to south. High summer ratios correspond to periods of insect harassment, and may reflect a greater tendency for random movement and a higher crossing probability.

Installation of elevated pipe on the North Slope commenced in early August 1975 and continued until early December. During this 4-month period 23 group crossings of elevated pipe by 74 individual caribou were recorded (Appendix II). All caribou observed to cross the pipe were single bulls. Sixteen crossings were inferred from the track record and involved from 1 to 15 individuals; track size indicated that cows and calves were present in at least 3 of these groups. Nine of the 23 recorded crossings occurred in the 10-km section of elevated pipe near Pump Station 2, and 14 in the 35-km section between Pump Station 3 and Happy Valley camp.

Five of the seven observed crossings occurred during intense oestrid fly harassment in mid-August. Adult bull caribou were observed standing in the shade of the pipe and repeated crossings beneath elevated sections occurred at heights as low as 1.1 m. Temperatures up to 25°C and low wind velocities were noted, suggesting that thermal stress was an influencing factor. In addition to exhibiting little aversion to the elevated pipe, these bulls appeared quite tolerant of nearby heavy equipment. Such permissive behavior was not observed during any other season of the year, and therefore may be associated with weather conditions which encourage high insect activity. The other crossings observed were

Fig. 6 Caribou crossings and proposed pipeline construction between Galbraith Lake and Pump Station 3, fall 1974.

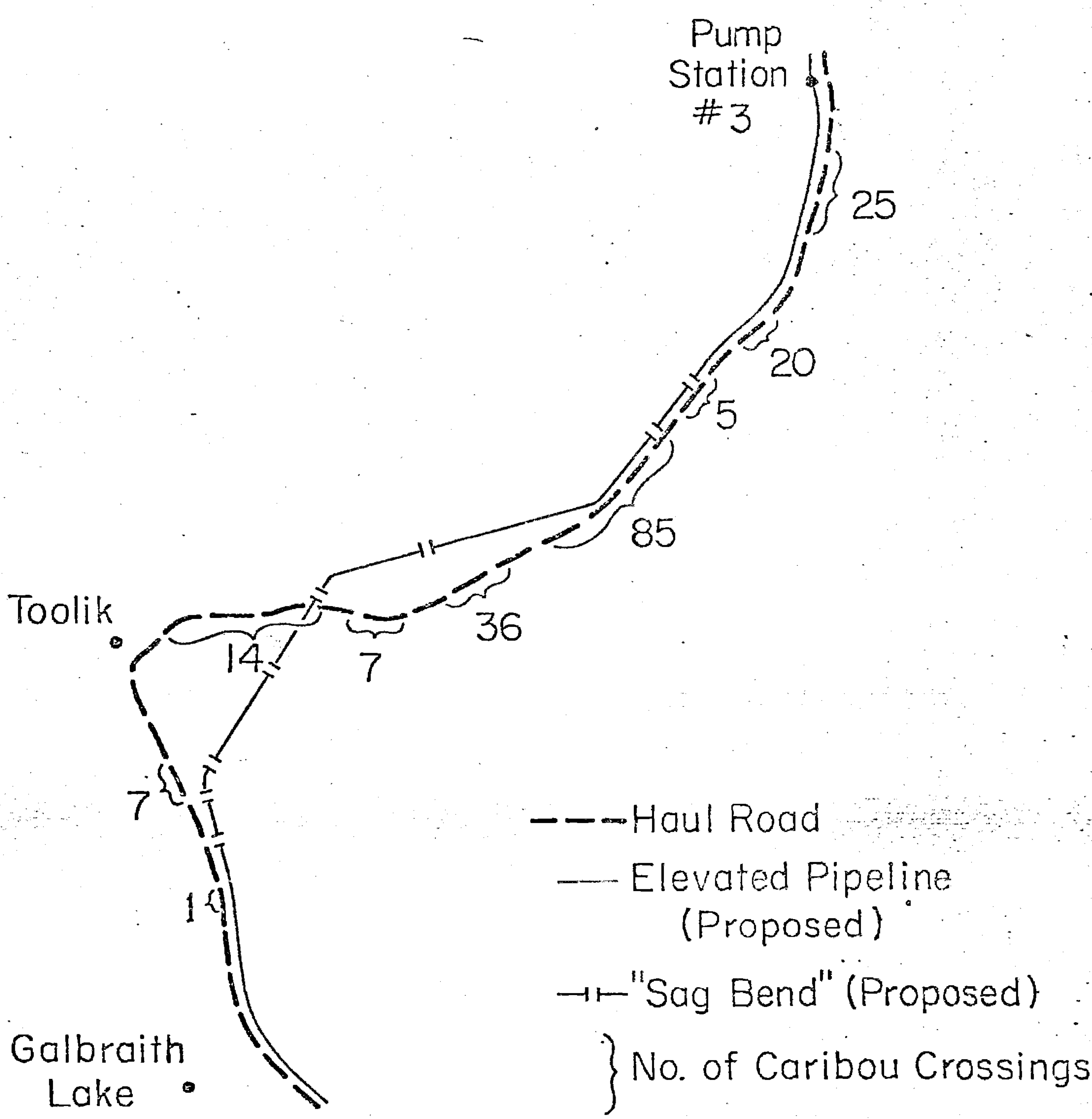
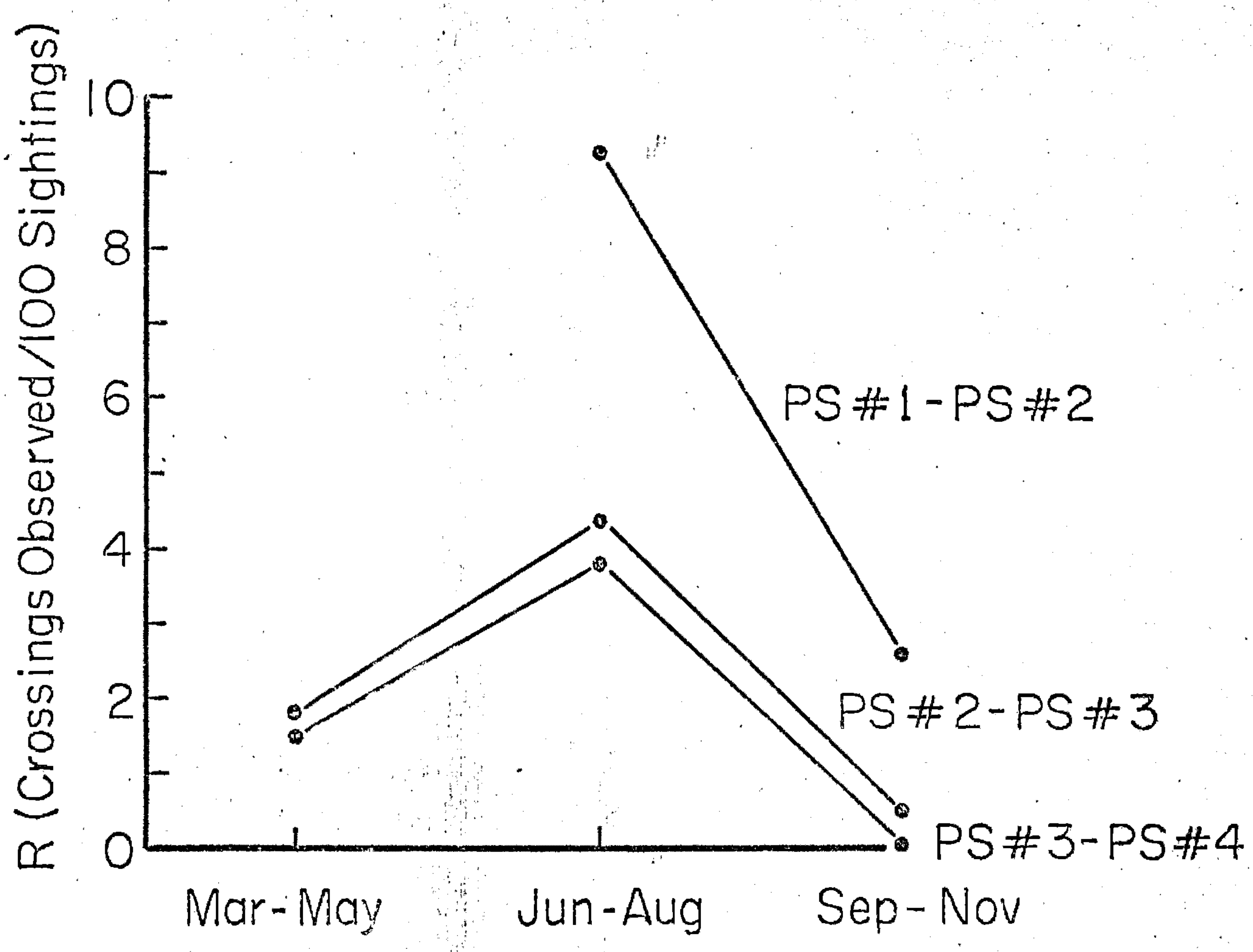

Pump Station #3
25
20
5
85
36
Toolik
14
7
7
1
Galbraith Lake
Haul Road
Elevated Pipeline (Proposed)
"Sag Bend" (Proposed)
No. of Caribou Crossings

Table 9. Frequency of road/construction pad crossings.

Months	PS#1 - PS#2 sight.	PS#1 - PS#2 cross.	PS#1 - PS#2 R[1]	PS#2 - PS#3 sight.	PS#2 - PS#3 cross.	PS#2 - PS#3 R	PS#3 - PS#4 sight.	PS#3 - PS#4 cross.	PS#3 - PS#4 R
9/74-11/74							418	2	0.5
12/74-2/75[2]				277	18	2.9	80	0	0
2/75-5/75				652	12	1.8	1038	15	1.5
6/75-8/75	3859	360	9.3	970	43	4.4	79	3	3.8
9/75-11/75[3]	1258	33	2.6	1522	8	0.5	340	0	0

1 R = no. crossings observed/100 sightings
2 includes only Feb. for PS#2 - PS#3, and only Dec. and Feb. for PS#3 - PS#4.
3 all crossings listed for PS#1 - PS#2 occurred in Sept.

Fig. 7 Seasonal and regional changes in caribou crossing rates.


R (Crossings Observed/100 Sightings)
10
8
6
4
2
0
PS #1 - PS #2
PS # 2 - PS # 3
PS # 3 - PS # 4
Mar - May
Jun - Aug
Sep - Nov

preceded by several crossing attempts and accompanied by behavior indicative of stressful conditions. The track record indicated that nearly all crossings involved some milling, running, and/or group separation on the approach side of the pipe. Only one crossing appeared to involve no disturbance reaction; tracks were observed to follow those of a group which had crossed previously.

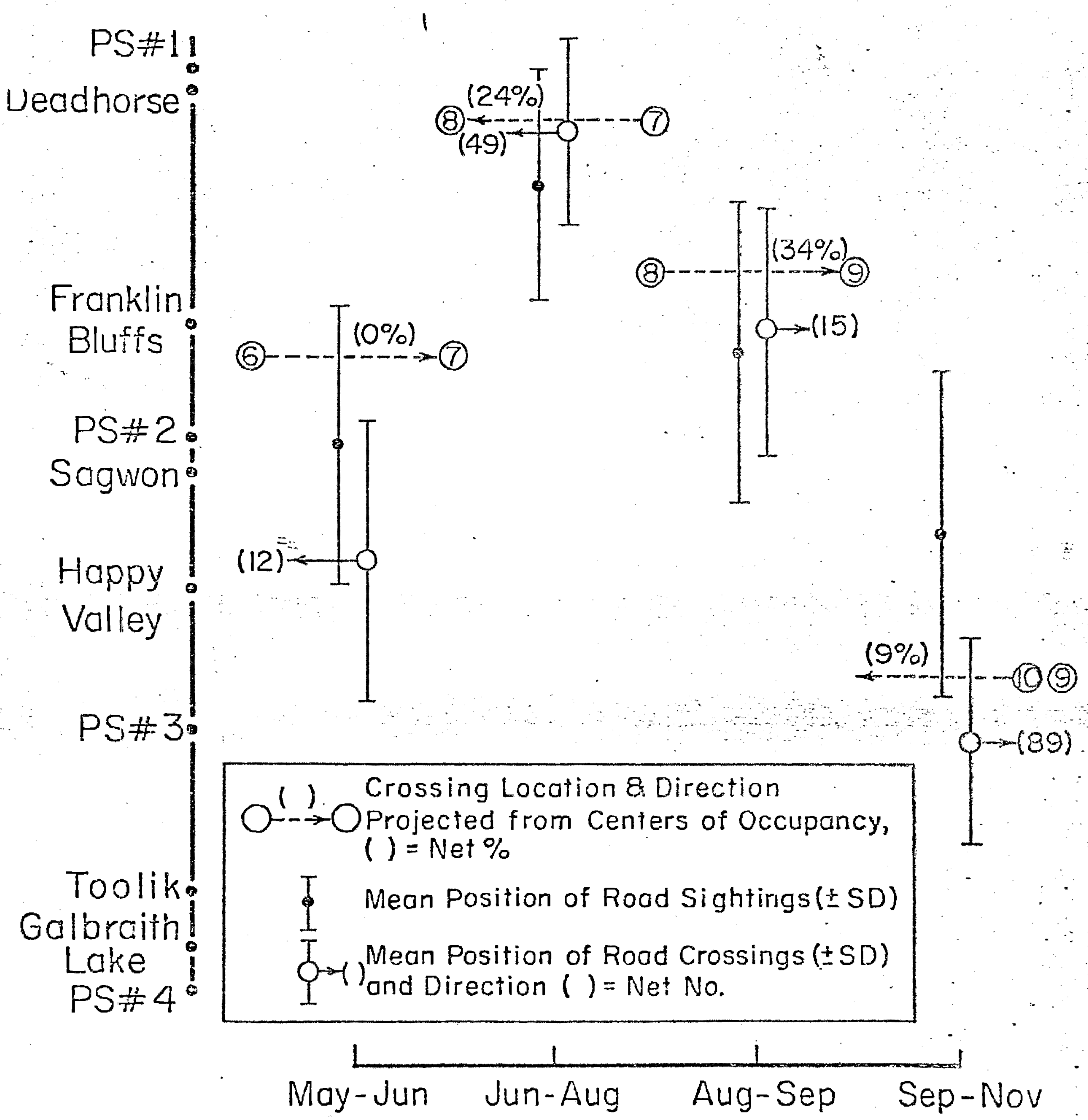
Only 12 group deflections were recorded, 3 of which were observed. However, tracks of deflected groups are much less likely to be discovered than those crossing the pipe. Further, it is nearly impossible to ascertain whether caribou under observation are behaving "normally" or responding negatively (i.e. deflecting) to the visual stimulus of the pipe.

Some caribou were diverted at least 1.5 km during attempts to cross the pipeline. Six crossings appeared to involve selection for higher pipe elevations. In one case, a lone bull was observed to parallel the elevated pipe and subsequently cross at a short section where no pipe was in place; the track record indicated two similar occurrences.

Integration of Survey Techniques

Movement data inferred from the results of aerial surveys were compared with caribou distribution and crossing locations determined from road surveys. Sites and directions of principal corridor crossings were predicted by straight line projection between consecutive position means determined for May, June, August, September and November of 1975 (Fig. 3). The directional movement tendency was expressed as the difference between the percentages of total caribou observed east or west of the pipeline corridor. A corresponding mean (± SD) location of all road sightings was calculated for the appropriate intervals. Similarly, mean (± SD) positions of all recorded crossings were determined, along with the net number of individual crossings applicable to the direction of east-west movement (Fig. 8). In all cases crossing locations estimated from the results of aerial surveys overlapped with one or both standard deviations of caribou activity calculated from ground surveys. However, predicted and observed crossing directions were not consistently in agreement. Contradictory directional results shown between May and June may reflect the absence of road coverage north of Pump Station 2 in May (Table 2), but since aerial data indicate no net lateral movement, actual east and westbound crossings were presumed to have equalized. From June to September, when road coverage was most complete (Table 2), the net direction of observed crossings corresponded closely to predicted movements. Data are again conflicting between September and November, although net movement activity to the west was relatively low (9%), and the lack of agreement appears to be of little consequence. It is noteworthy, however, that both location and direction of observed crossing activity correspond to a shift in the position mean of the non-calf segment during this period (Fig. 4). Thus, while minor descrepancies are apparent, these data demonstrate that the primary movements of caribou within the study area can be ascertained reliably through a determination of mean geographic centers over time.

Fig. 8 Interrelationships of road and aerial survey data.


PS#1
Deadhorse
Franklin Bluffs
PS#2
Sagwon
Happy Valley
PS#3
Toolik
Galbraith Lake
PS#4
(24%)
(49)
(0%)
(12)
(34%)
(15)
(9%)
(89)
Crossing Location & Direction Projected from Centers of Occupancy, ( ) = Net %
Mean Position of Road Sightings (± SD)
Mean Position of Road Crossings (± SD) and Direction ( ) = Net No.
May-Jun
Jun-Aug
Aug-Sep
Sep-Nov

DISCUSSION

Herd Identity

Skoog (1968) has defined a caribou "herd" or "sub-population" in terms of its fidelity to a relatively fixed calving area, which serves as a focal point for seasonal movements. Thus, when a group of caribou establishes a calving area distinct from that of any other, the group itself becomes distinct. Should mixing of herds occur during the year, individual identities are retained if followed by a return to respective calving grounds.

Past studies have established the existence of two major herds in northern Alaska, the Western Arctic herd and the Porcupine herd. The traditional calving area of the Western Arctic herd is described as the headwaters of the Utikok, Ketik, Meade and Colville Rivers, and known movements have extended east to the Sagavanirktok and Koyukuk Rivers during summer and winter, respectively (Hemming 1971). Major calving activity of the Porcupine herd is centered roughly south of Barter Island and extends along the arctic coast between the Canning River and the Canadian border (Hemming 1971, LeResche 1975, Roseneau and Stern 1974, Roseneau et al. 1974). Although most of this herd ranges in Canada for the balance of the year, westerly movements have included the upper Atigun and Dietrich Rivers and the Sagavanirktok River during both summer and winter (Hemming 1971). Thus, although peripheral ranges of the two herds may at times overlap, distinctly different calving areas persist and represent the single most important criterion by which each is identified.

Coincidentally, the present study is focused on this overlap zone which supports a third caribou sub-population having a calving area separate from that of either adjacent herd. In 1975, new calves were observed north of Happy Valley on June 4, and although a thorough coastal survey was not possible at the time, by June 25 calves were found throughout the northern half of the study area (Table 4, Fig. 4). Child (1973) reported the occurrence of calving in the Prudhoe Bay area; and Gavin (1972) observed calving activity within this region in 1969 and 1970, but noted that in 1971 calving occurred predominately within the Brooks Range and along the northern foothills due to heavy snow cover in late spring. While the distance between the calving area of the Western Arctic herd grounds and that within the study area precludes the possibility of similar identities, calving grounds of the Porcupine herd and the study sub-population may approach or overlap in the vicinity of the lower Canning River. However, since calving east of the Canning River commences approximately one week earlier than that observed for caribou in the study area, and considering the distinctly different movements of the respective post-calving concentrations (see below), co-identity appears unlikely.

Skoog (1968), in a historical account of caribou in the central and eastern Arctic, presents evidence for the existence of two separate herds during the 1920's and 1930's; one herd occupied areas now used by the Porcupine herd, and the other ranged between the Koyukuk and Chandalar

Rivers and the Arctic Slope. This central herd was thought to have disappeared during the 1950's, but Gavin (1971, 1972, 1973) provides evidence for its continued existence as a separate sub-population; yet despite delineation of a distinctly different calving area over four years of study, Gavin (1973) identifies these caribou as "offshoots from both the Arctic and Porcupine herds." While the latter conclusion describes the probabilities of historical origin, it does not confer herd status which, by Skoog's definition, is clearly justified. Our recent findings, together with those of Roseneau and Stern (1974) and Roseneau et al. (1974) and the collective observations of Child (1973), Gavin (1971, 1972, 1973) and White et al. (1975), indicate that the majority of caribou found within the study area represent a separate sub-population, which for the purpose of this report will be referred to as the "Central Arctic Herd."

<u>Total Numbers</u>

From observations made in 1971 and 1972, Child (1973) identified the coastal area at Prudhoe Bay as important summer range for an estimated 3,000 caribou. Gavin (1973) reported totals of 26,000 in 1969 and 1970, 15,000 in 1971, and 2,500 in 1972. Thus, either the herd has experienced a rapid decline over the last six years, or earlier estimates included caribou from either or both adjacent herds.

Since no recent attempts have been made to census the Central Arctic herd, its current size can only be estimated from the results of systematic aerial surveys conducted in 1974 and 1975. Maximum numbers were obtained during July 1974 (Table 4), but since this survey consisted of two separate attempts (Table 3), some duplication is possible. A total of about 1,700 caribou were observed on the first attempt, although some coastal areas to the west and the major portion of the inland region was not covered. In addition, a minimum of 3,000 head, thought to be part of the Central Arctic herd were observed on the Canning River Delta (see below). Because of the relatively high mean group size (Table 3) characteristic of post-calving aggregations, these observations were thought to include the majority of the cow/calf segment and, as indicated by estimates of group composition, a substantial portion of other cohort groups. This survey probably excluded only scattered bands of bulls, yearlings and barren cows remaining inland during the peak of the insect season. Unfortunately, a comparable survey was not conducted in 1975, but mean group size for August of that year approximates that obtained in August of 1974 (Table 3). Thus, post-calving aggregations, though undetected, could also have occurred in 1975. Further, the absence of a July 1975 survey makes it difficult to accurately define maximum northern movements of the herd (Fig. 3), movements which were apparently detected during the coastal survey conducted in July of the previous year (Fig. 2).

In 1975, the largest number of caribou (1,029) was observed in November (Table 3). Considering the low estimates of mean group size (Table 3) and the probable presence of similarly dispersed, but unobserved small groups within the study area, a survey sample size of less than 20 percent of the total sub-population is likely. Thus, although the total count obtained in 1974 remains unverified, 5,000 caribou is currently our minimum estimate of population size for the Central Arctic herd.

Productivity and Mortality

Although fixed wing aircraft are not entirely suitable for classifying caribou, estimates of calf percentages were obtained during six surveys conducted between October 1974 and November 1975. Between summer and fall 1975, mean values decreased from 20 to 16 percent, indicating a pre-winter calf mortality of 20 percent. Summer values are similar to those of White et al. (1975), who reported July calf percentages of 23 and 16 for 1972 and 1973, respectively. Earlier estimates of calf composition by Gavin (1972) for 1971 are substantially higher, ranging from 35 percent on June 14 in the Kavik River area, to 33 percent on August 15 in the Dietrich-Atigun region. These estimates indicate a downward trend in calf production over the last four years, roughly paralleling a herd reduction from about 15,000 to an estimated 5,000. However, decreased calf production alone could not account for such an enormous decline, and it is likely that previous estimates included animals from one or both adjacent herds. In any case, the regular occurrence of calving in the study area, together with more recent evidence for predictable, though somewhat limited seasonal movements (see below), suggests the existence of a relatively small "core" herd which periodically acquires immigrants from other sub-populations.

Current estimates of calf production are low compared to those of the Porcupine and Western Arctic herds (Roseneau and Stern 1974, Roseneau et al. 1974, Davis, pers. comm.). However, predator influence on the herd appears light, as indicated by low pre-winter mortality of calves, and human utilization in the area is negligible. Excluding the possibility of pipeline-related influence on the production and survival of calves, herd stability or growth is conceivable, but estimates of yearling recruitment are required before the status of the herd can be accurately evaluated.

Seasonal Movements and Distribution

Northerly spring movements were first detected by aerial surveys conducted in May 1975. Haul Road crossings from east to west are indicated (Fig. 3), but cannot be substantiated by ground observations. Movements paralleled progressive snow melt and the appearance of new vegetation, and continued through late June (Fig. 3) with a second road crossing suggested, but unconfirmed (Fig. 8). Thus, net movement between March and June was nearly due-north, and available evidence indicates only occasional crossings of the Haul Road during this period. Overall herd movements between June and August 1975 were northwesterly (Fig. 3), with crossing activity occurring primarily between the arctic coast and Franklin Bluffs (Fig. 8). A July 1975 survey was not conducted, but data from the previous year and reports by other investigators, suggest the regular occurrence of an extensive post-calving movement in mid-summer which could not have been detected by our 1975 surveys.

On July 17, 1974 a minimum of 3,000 caribou were observed crossing the Canning River from east to west within 20 km of the coast, and an additional total of approximately 1,400 in 5 groups were westbound along the coast between the Canning and Sagavanirktok Rivers. These groups were predominantly cows and calves, with bulls and yearlings representing less than 20 percent of the total. In early July 1973, Roseneau et al. (1974) observed an eastern crossing of the Canning River, followed by a westerly recrossing by the same caribou a few days later. Observations in 1972 indicate that this reversal continues through the Prudhoe Bay area (Child 1973) and may extend as far west as the lower Colville River (Roseneau and Stern 1974). This movement reportedly occurred in 1972, 1973 and 1974 (Roseneau, pers. comm.). Roseneau et al. (1974) speculate that these post-calving aggregations originated from the central arctic region, and our observations and those of Gavin (1971, 1972, 1973) support this hypothesis.

These observations suggest that intermingling of the Central Arctic herd and the Porcupine herd may occur in the Canning River area. In 1972 and 1973, easterly post-calving movements of the Porcupine herd toward the Canadian border were well advanced before caribou from the southwest appeared on the Canning River Delta, and no evidence of mixing was observed (Roseneau and Stern 1974, Roseneau et al. 1974). However, the formation of typical aggregations and subsequent eastern movements were delayed in 1974, and although Porcupine caribou remained east of the Canning River, they were observed further west than during either previous year (Roseneau, pers. comm.). Movements from the central region extended into this general area at approximately the same time, and some mixing could have occurred, although subsequent westerly movements noted by the author (see above) suggest that respective identities were retained.

If this large scale movement occurred undetected in 1975, caribou were probably restricted to the eastern half of the study area, since no appreciable road crossings to the west were reported (Fig. 8), and the position means of groups with calves were displaced only slightly to the west in August (Fig. 4). The biological significance of this brief movement phenomenon is unknown, but its disappearance or incompleteness in 1975 may be oil-related since it paralleled increased exploration efforts and accelerated pipeline construction in the Prudhoe Bay area.

Appreciable inland movements occurred between August and September 1975 (Fig. 3), and easterly crossings were observed in the Franklin Bluffs area (Fig. 8). The major part of southerly progress apparently occurs before the beginning of September, since mean latitudinal position in late August 1974 (Fig. 2) was similar to that for late September 1975 (Fig. 3). Centers of occupancy for calf and non-calf groups remained separated by approximately 50 km, but were closer in November (Fig. 4) as southerly movements decreased. In fact, by September the mean latitudinal position of caribou in groups with calves approached that of the total population; the number of caribou classed as "non-calf" represented only six percent of the total (Table 4), and reflects the increased homogeneity of larger bands (Table 3) characteristic of the breeding season.

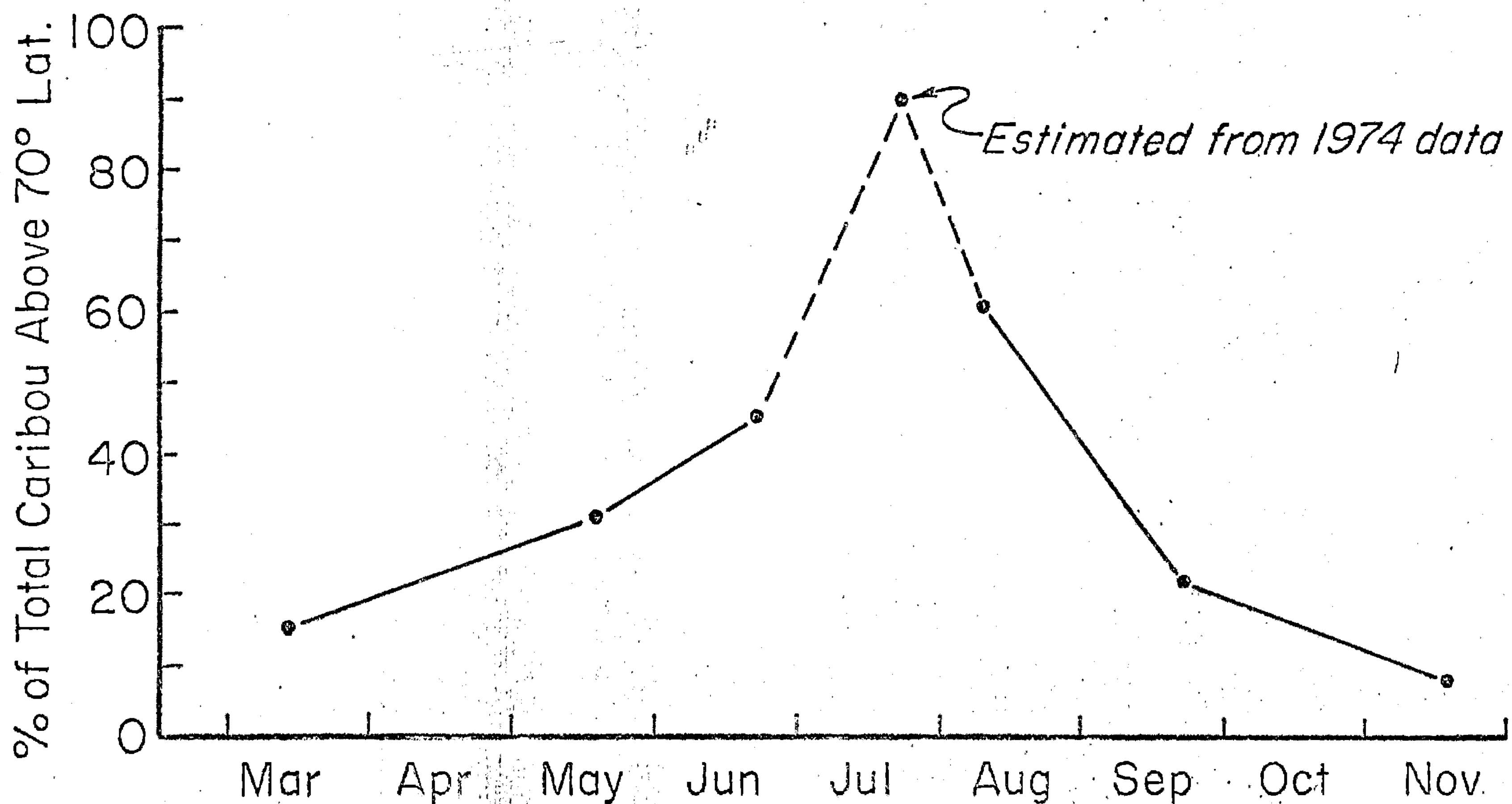
Latitudinal movements of the herd are summarized in Fig. 9 which shows a gradual northern movement in spring, a peak in mid-summer, and a fall reversal to winter range. As noted previously, the annual trends of north-south movement are similar for calf and non-calf groups but the former class remains approximately 50 km north of the latter for most of the year (Fig. 4). This phenomenon could be related to several possible factors. First, and most likely, is an instinctive behavioral response of cows associated with the protection of offspring. Young calves are particularly vulnerable to predation, and maternal cows may be selecting flat terrain where predator densities are low and increased visibility is possible. These preferred areas correspond to poorly-drained wet sedge habitat, and it is noteworthy that no wolves and only occasional grizzly bears have been sighted north of Franklin Bluffs during the last two field seasons.

The value of coastal areas for insect relief has been discussed by Child (1973) and White et al. (1975). Caribou make use of sand dunes, gravel bars, and coastal islands during periods of high insect density. Typically, these are sparsely vegetated and exposed areas which provide relief from fly and mosquito attack. In general, higher wind velocities are characteristic of coastal regions, and tend to reduce the effectiveness of insect pests. Increased energy expenditure and decreased feeding efficiency associated with insect harassment may affect summer nutrition of lactating cows and calf survival. Similarly, the selection of insect relief habitat facilitates growth and fattening of adults and yearlings remaining inland during mid-summer. Insect disturbance can be minimized by the use of alternate inland habitats (e.g. ridgetops, aufeis) and it is possible that the distribution of cohort groups is related to differential requirements for key nutrients associated with various plant communities. Although modified by various environmental factors, annual movements of caribou tend to follow plant phenology (Klein 1970). However, the subtle differences in nutrient demand by various sex and age classes are poorly understood.

The Central Arctic herd remains within the study area for the majority of its annual cycle (Figs. 2 and 3). Occasional flights along the Colville and Canning Rivers between May and September of 1974 and 1975 produced only small, scattered bands of additional caribou with one exception, noted above. However, winter range may extend south and east beyond the limits of aerial coverage, and spring movements noted previously through the upper Sagavanirktok and Atigun Rivers (Gavin 1971) indicate periodic occupation of winter range to the south and west. Hence, overlapping of winter range with that of the two larger adjacent herds is a distinct possibility and a potential opportunity for exchange between caribou sub-populations.

While the majority of the Porcupine herd traditionally winters in Canada, a portion of this sub-population is known to occupy areas of the Brooks Range in Alaska between late fall and early spring. Typical movements are westward from the Canadian border through the Arctic Village area and extending as far as Big Lake and Wiseman (Hemming 1971). If extensive southeasterly movements of wintering caribou from

Fig. 9 Latitudinal movements of caribou within the study area.


% of Total Caribou Above 70° Lat.
100
80
60
40
20
0
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov.
Estimated from 1974 data

the study area occur, the herds may intermix. Wintering bands suspected to be from both herds have been observed by Roseneau and Stern (1974) in the same general vicinity of the Brooks Range.

Observations during the winter of 1974-75 indicate that the Central Arctic herd did not overlap or mix with the Western Arctic herd. Aerial surveys conducted in January and March on both the north and south slopes of the Brooks Range revealed no instances in which caribou from the study area were closer than 90 km from those located south of the Divide. No other evidence was obtained to suggest intermingling of the two sub-populations. Tracks and cratering indicated that caribou on the south slope of the Brooks Range had approached from the northwest, apparently through Anaktuvuk Pass and drainages west of Anaktuvuk River. In addition, one female caribou collared north of Bettles in February (Table 1) was killed by a hunter near Kivalina in October. This supports our premise of Western Arctic herd identity. Further, to our knowledge, no caribou collared on the south slope appeared in the study area.

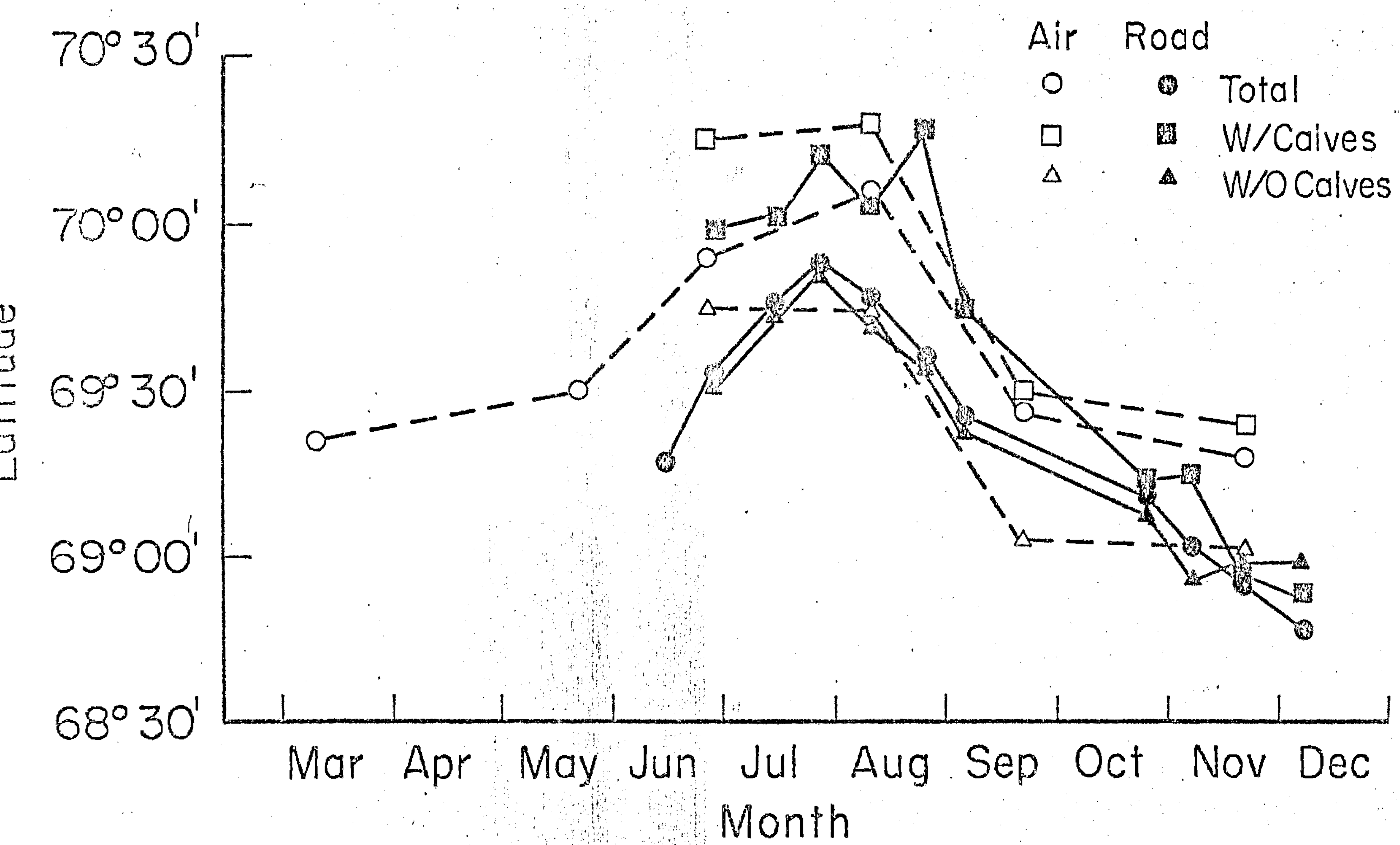
In contrast to the more typical inland occupancy of winter range, a variable number of Central Arctic caribou apparently remain on the coastal plain. Skoog (1968) and Hemming (1971) have made reference to this occurrence, and more recent observations by Gavin (1973) and White et al. (1975) indicate that up to 300 caribou may winter near the arctic coast around Prudhoe Bay. Results of the present study support these earlier data. Aerial surveys conducted in March and November of 1975 indicate that 15 and 8 percent, respectively, of the caribou within the study area were located above 70° latitude (Fig. 9) which corresponds roughly to the northern end of Franklin Bluffs. If 8 percent of the estimated 5,000 caribou comprising the Central Arctic herd winter on the coastal plain, then approximately 400 caribou are year-round residents in the area. White et al. (1975) estimate the winter carrying capacity of the Prudhoe Bay area to be low, suggesting that winter occupancy may be at or near maximum levels. The option of non-migratory activity may involve a tradeoff of forage quality for the reduced energy expenditure associated with a comparatively immobile existence.

Local Effects of Pipeline Construction on Caribou Distribution, Composition and Group Size

Changes in latitudinal means of caribou determined from both aerial and road surveys are shown in Fig. 10. Where comparisons are possible, the data show that latitudinal positions calculated for total caribou observations are consistently higher for the results of aerial surveys than for road observations. Groups without calves remained farther south than those with calves, but differences in the former due to survey procedure were not appreciable. Positions calculated for calf groups based on the two survey techniques remained separate until late summer, but showed a tendency to converge immediately prior to and during the rut, followed again by a substantial separation in late fall.

If results of aerial surveys are assumed to reflect the undisturbed pattern of caribou distribution within the study area, then the results

Fig. 10 Comparison of seasonal changes in latitudinal distribution of caribou.



Air
Road
Total
W/Calves
W/O Calves
70° 30'
70° 00'
69° 30'
69° 00'
68° 30'
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

of road surveys indicate a deviation from the normal progress of latitudinal change. Thus, while the north-south movements of groups without calves (primarily bulls) observed within the pipeline corridor follow the "expected" trend, groups with calves do not, at least during most of the summer. The latter groups are clearly in the minority of total ground observations through September (Table 7), and the general absence of maternal groups has the effect of consistently reducing the mean latitude of total road observations relative to that of aerial surveys (Fig. 10). These differences imply a pipeline-related delay in northern movements of parturient cows along the corridor, possibly in response to construction activities (Fig. 5), and a continued lag post-parturition which persists throughout most of the summer. Limited data obtained from collaring studies (see FINDINGS) have confirmed the use of inland summer range by some nursing pairs, and suggest an associated reduction in calf survival.

In addition to conceivable delays or interruption of summer movements, latitudinal differences may reflect preferential occupancy in response to visual stimuli presented by the pipeline and ongoing construction. The area north of 69°30' is predominately wet sedge habitat with little or no relief, while that to the south is typically rolling tussock tundra. Thus, due to the moderating influence of local terrain, pipeline structures and related activities within hilly areas may represent a less serious hazard to maternal cows than those occurring in flat terrain. If continued northern movement beyond the transition to wet sedge habitat occurs, it is presumably by avoiding visual contact with the corridor. Whatever variables affect the maternal response to pipeline construction, it is clear that cow-calf pairs are not "normally" represented in groups of caribou observed from the Haul Road during summer (Tables 3, 4, 6 and 7). This suggests decreased access to a portion of summer range within and near the pipeline corridor. Suboptimal use of available range could become a serious problem in the event of population growth or influx from other areas, particularly if North Slope oil development proceeds at its present rate.

The general avoidance of the corridor by cows with calves decreases the frequency of pipeline contact by these cohort groups. Of the combined road and pipeline crossings recorded only 11 percent of the groups definitely involved calves. In contrast, bulls were frequently observed on construction pads and in the shade offered by the pipe during periods of insect harassment (see cover photo), and caribou in Prudhoe Bay reportedly stand on drill pads and in the shade of buildings and equipment during periods of insect attack (White et al. 1975). Again, should the area sustain an increase in caribou numbers, this attraction to construction sites could result in local overgrazing and trampling of vegetation. Bull movements appear to be far less extensive than for other groups, and the majority of pipe crossings involving bulls seem to result from random movements associated with insect harassment. Thirty-seven percent of all road and pipe crossings definitely involved bulls, more than three times the number of group crossings in which calves were known to participate.

Due to the paucity of information on physical interactions of caribou with the pipeline, and because some related studies are incomplete, it is not yet possible to generalize on the behavioral responses of caribou, or to evaluate the influence of various environmental factors on crossing success. However, available data indicate that, taken literally, the stipulation of "free passage and movement" is not being satisfied. Crossing delays have been observed, and distribution abnormalities associated with pipeline construction are becoming apparent.

The primary goal of initial studies was to provide baseline information on seasonal movements of caribou in areas traversed by the Trans-Alaska Pipeline. Unfortunately, these investigations were conducted concurrent to the early stages of pipeline construction. Consequently, the value of the results as reference data is decreased, although this information represents the only means by which future patterns of caribou movement can be assessed. Subsequent studies will continue to monitor pipeline-related shifts in seasonal distribution and to evaluate the influence of various climatic, nutritional and human factors on movement behavior.

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APPENDIX I

GRADUATE STUDENT RESEARCH PROJECT - DAN ROBY

Factors Affecting the Activity Patterns and Related Movements of Caribou (Rangifer tarandus granti) within or near the Trans-Alaska Pipeline Corridor

BACKGROUND

Study Area

Approximate boundaries of the study area are the Beaufort Sea to the north, the continental divide (crest of the Brooks Range) to the south, the Canning River to the east and the Colville and Anaktuvuk Rivers to the west; and includes that portion of the Arctic Slope traversed by the TAPS corridor. This region has been referred to previously as the "Central Arctic Region" (Olson 1959). Although the majority of data on caribou movements and behavior is to be gathered in the pipeline corridor itself (due to logistic limitations), additional information on movements and distribution will be available for interpretation of local findings.

The study area can conveniently be divided into three major physiographic regions: coastal plain, arctic foothills and Brooks Range provinces. The coastal plain is characterized by flat, poorly drained, polygonal tundra which is dotted with thaw lakes and ponds. Maximum elevation of this region is 600 feet and the dominant vegetation is an association of moisture-loving monocots, particularly of the genera Eriophorum and Carex. In addition, several species of dwarf willow (Salix spp.) are common as are a variety of dicotyledonous herbs. More xeric conditions are found on the alluvial deposits of major rivers, on stream banks, and along the coastline. Pingoes and a few "island uplands," such as Franklin Bluffs and the White Hills break the straight horizon and reach elevations of 900 feet and 1300 feet, respectively. Vegetation in these areas is more similar to the southern foothills region than to surrounding areas within the coastal plain.

The foothills physiographic region is characterized by east-west trending hills and low mountains rising to a maximum of 4000 feet (Slope Mountain). The primary vegetation community is Eriophorum vaginatum with willows (Salix spp.) and dwarf birch (Betula nana) usually well represented. Tussock-heath tundra is also present and is dominated by various Ericaceous shrubs. River floodplains support a greater diversity of plant life, presumably partly due to increased drainage and a thicker active layer, and more variable microclimatic conditions; dense shrub willow stands, meso-xeric mountain avens (Dryas spp.) and legume associations, and wet sedge-horsetail (Equisetum variegatum) meadows all exist in close proximity.

The Brooks Range is rugged, poorly vegetated terrain mostly over 4000 feet in elevation with some glaciated peaks attaining heights of 7500 feet. The major plant community is dominated by mountain avens (Dryas spp.). Vegetation of the lower slopes may be similar to that of the foothills. Braided rivers with extensive outwash plains and highly variable discharge rates flow through U-shaped valleys frequently vegetated by riparian willow stands.

During the summer months temperatures are relatively warmer to the south and snow melt proceeds from the Brooks Range north to the coast. Winter temperatures are usually lower in the Brooks Range than on the coastal plain and strong winds are usually limited to the coastal plain and Brooks Range. Annual precipitation increases on a north-south gradient but snow accumulation tends to be highest in the foothills towards the end of the winter season. Snow cover is present in the study region at least seven months of the year.

History of Caribou Movements in the Study Area

Hemming (1971) recognizes two distinct caribou populations as occupying the Arctic slope. The summer ranges of the Arctic and Porcupine caribou herds overlap in the area of the pipeline corridor, although summer distribution of the Arctic herd occasionally includes areas as far east as the Canning River.

Olson (1957) reports a movement of about 25,000 east from the Anaktuvuk to the Canning River during the spring migration of 1956 and during August of that year a group of about 3,500 was seen at the head of the Sagavanirktok River. The following winter the majority of the caribou in the "Central Arctic Region" (well over 100,000 animals) remained on the North Slope in small widely scattered bands. Similarly, during the winter of 1958 over 150,000 caribou remained on the central North Slope. Just prior to calving that year a major movement involving about 125,000 caribou took place from the Shaviovik River toward the west. Although very little calving took place in the Central Arctic that year, 10-12,000 caribou were seen just south of Oliktok Point during the summer, and on September 11th a group of 25-30,000 was seen moving south between the upper Ivishak and Sagavanirktok Rivers.

Child (1973) points out that "very little is known of the historical importance of the Central Arctic area...to caribou as calving, summering, and wintering grounds." Skoog (1968) coined the name "Central Brooks Range Herd" to describe this subpopulation and identified its center of habitation as the Central Arctic; however, this herd was thought to have merged with the Arctic herd in the early 1950's.

In reference to the spring migration of 1972, LeResche (1972) wrote "the line of separation between the Arctic (west-turning) and Porcupine (east-turning) herds occurred at the Sagavanirktok and Atigun River drainages." LeResche noted no calving between the Porcupine herd in the Arctic National Wildlife Range and the traditional calving grounds of the Arctic herd with the exception of "a few hundred animals in the Prudhoe Bay-Kavik area." This population he describes as a "small, isolated group, probably fewer than 5,000, that uses the Prudhoe Bay area" and noted that "very few animals...(in relation to total numbers) have crossed the pipeline route during spring and fall migrations in most recent years."

The most recent information for movements and numbers of caribou in the Prudhoe Bay area comes from Gavin (1971, 1972) and Child (1973). These sources indicate some calving occurred in the oil fields during 1971 and 1972, and "considerable" calving was noted in the White Hills (Gavin 1971).

Child (1973) considered the Prudhoe Bay area as "important summer range for a small population of approximately 3,000 animals." During the summers of 1969 and 1970 Gavin estimated that there were as many as 30,000 caribou using the Central Arctic Region. His surveys for 1971 produced only about 15,000 animals and, in 1972, only about 2,500 animals. Apparently little change in caribou numbers has occurred in the area since 1972 (Cameron, pers. comm.).

Thus, available information indicates a gradual decrease in caribou numbers in this region from the mid-fifties, when over 150,000 head were thought to use the area, to the present day estimate of 2,500-3,000 animals. However, as recently as 1970, a group of approximately 20,000 crossed what is now the pipeline route on the North Slope. This and other large groups appear to wander in from adjacent areas occupied by either the Porcupine or Arctic herds.

Review of Factors Affecting Caribou Movements and Activity Patterns

Any attempt to assess the impact of the TAPS and related activities on movements and behavior of caribou is contingent upon an understanding of the effects of "normally-occurring" environmental stimuli. Several studies have either speculated on or demonstrated the relationships between certain factors and movements of caribou during a particular phase of the annual cycle. Pruitt (1959) was able to relate snow depth and density to the winter movements and distribution of barren-ground caribou and the effects of snow cover on caribou movements was further documented by Henshaw (1968) in northwestern Alaska. Snow has also been implicated in the onset (Lent 1966, Kelsall 1968) and extent (Hemming 1971) of fall migration. In addition, there is evidence which indicates that snow conditions may impede or direct spring migration (Pruitt 1959, Kelsall 1968, Lent 1966, Gavin 1972).

A few authors have mentioned the effects of wind chill on caribou movements and behavior during winter (Henshaw 1968, Thomson 1971). Wind speed and direction are known to affect caribou movements during the summer months. Level of insect harassment varies inversely with wind velocity (White, in press), and wind direction is thought to play a part in orienting local movements (Thomson, in press). The effects of insect harassment on group size and speed of movements are also pronounced. In addition, "fly harassment" has been shown to be a major factor in altering a group's activities (Thomson, in press).

Some disagreement exists as to the relative effects of various insect pests. Kelsall (1968) hypothesized that August dispersal in caribou followed release from black fly and mosquito attack, while Curatolo (1975) concluded that warble fly harassment is the major cause of dispersal.

In contrast to the above Espmark (1967) observed the reactions of semi-domestic reindeer to oestrid fly attack and concluded that oestrid fly harassment caused bunching by reducing social distance.

Temperature has not been shown to have an important effect on caribou behavior, except as it relates to insect activity (Zhigunov 1968, Thomson 1971). Similarly cloud cover seems to have little influence on caribou activity except during rut when sparring and associated behavior decreases with increasing cloudiness (Curatolo 1975).

It has been demonstrated that caribou show distinct preferences for certain vegetation types during different seasons of the year (Lent 1966, Gaare et al. 1970, Curatolo 1975, White in press). It is critical that large northern grazers select the highest quality forage available during the short growing season when dietary requirements are greatest (Klein 1970). Active selection of specific plant communities extends into winter and, to a certain degree, affects local movements during these months. However, habitat preference is complicated by snow conditions which may alter the availability of specific plant communities (Gaare et al. 1970).

It is not known to what extent predators affect regional or seasonal movements but some effects on local movements and activity patterns have been noted (Gaare et al. 1970, Thomson 1971, Curatolo 1975). In general, these effects were immediate and temporary whereas insect disturbance caused prolonged alteration in daily activity cycles. Kelsall (1968) theorized that relative scarcity of wolves may be one of the most important criteria for the selection of calving grounds since, in many other respects, such areas are some of the harshest available during the calving period.

Caribou are gregarious during the majority of the annual cycle and it is clear that changes in an individual's social environment are connected with various changes in activity patterns and reactions to environmental stimuli (Gaare et al. 1970, Curatolo 1975). Sexual differences in behavior have been observed in relation to activity budgeting in winter and during the rut. The sex of group leadership is also significant in relation to reactions to potential man-made obstructions (Child 1973).

Various man-made obstructions including roads, railroads, power lines and hydroelectric projects have been observed to affect movements of reindeer in Scandinavia (Klein 1970). Attempts to trap caribou during spring migration has added information on the effects of obstacles across traditional migration routes to that obtained from reindeer in the changing Scandinavian landscape (Miller et al. 1972). Espmark (1972) recorded the behavioral reactions of reindeer to sonic booms and observed very little disruption of activity patterns. However, conclusions drawn from observations during one period of the year and for a single group of particular size and composition are subject to error. Thomson (1972) pointed out that seasonal differences in reaction of caribou to human disturbance exists. Responses to aircraft disturbance differed in relation to group size and composition (Klein 1973).

Reindeer husbandry in the Soviet Union has added valuable information on the impact of disturbance on health and reproduction (Zhigunov 1968). Another effect of disturbance on caribou might be decreased alertness or wariness toward predators which could lead to higher predation rates (Calef 1974). Geist (1970) thought that the most critical result of increased stress in caribou would be reduced weights of calves at birth which would have a severe impact on calf survival during the first week of life. In general, unpredictable and repeated exposures to a stimulus which reinforces those fright reactions initially displayed by caribou can be expected to contribute toward lowered productivity due to stress. Such disturbances may be reflected as only a minor change in the activity budgeting of the individual.

OBJECTIVE

To assess the effects of various environmental and social factors on the activity patterns and local/seasonal movements of caribou potentially affected by construction of the Trans Alaska Pipeline.

Factors to be evaluated include:

1. temperature
2. wind, speed and direction
3. insect harassment
   a) mosquitoes (*Aedes* spp.)
   b) warble flies (*Oedemagena tarandi*)
   c) nose bots (*Cephenomyia trompe*)
4. terrain
   a) slope
   b) aspect
   c) slope shape
   d) elevation
5. time and season
6. cloud cover
7. precipitation, type and rate
8. plant community type
9. snow, depth and density
10. potential disturbance factor, type and distance

11. group characteristics
    a) size
    b) composition
    c) density (average individual distance)

In addition to examining the effects of these factors on movements and activity patterns it is expected that correlations will be demonstrated between some of the above factors. Observation on general seasonal distribution and behavior of caribou along the pipeline corridor will be discussed in light of such regional factors as plant community distribution, plant phenology, snow characteristics, insect distribution and wind chill factor.

It is important in attempting to analyze the impact of the pipeline and related activities on local movements to have an understanding of which "natural" environmental factors can affect movements and what effects can be reasonably expected. Despite the notoriously unpredictable nature of regional caribou movements, certain relationships have been identified by some investigators indicating that at least, in many cases, movements are not random. Our failure to comprehend the "purpose" behind some migrations may be due to our lack of understanding of those factors affecting movements on a local scale.

A major objective in the analysis of activity data from caribou bands in the study area is the evaluation of the impact of human-related activities and obstructions on activity patterns. The two basic activities of feeding and lying are alternated in a regular fashion which Thomson (1971) has referred to as a short-term polycyclic rhythm. It is assumed that the efficient fermentation and assimilation of forage materials is dependent on the stability of this cycle through the day and that frequent digressions from the pattern will be detrimental to the individual, particularly during that period of the year when caribou are consuming food at or below maintenance levels.

Superimposed on this basic feeding-lying rhythm are the necessary activities of walking (to locate new feeding areas), running (to escape predators), standing (to defend against insect attack), etc. Comparison of mean percents of total time engaged in each activity for caribou at various distances from potential disturbance factors should give an indication of significant disruptions of activity cycles and/or an increase in what might be referred to as "non-productive activity" (i.e. walking, running and standing). This information will be useful, particularly when examined in conjunction with qualitative descriptions of caribou reactions to pipeline related activites.

METHODS

Quantitative analysis of behavior patterns and movements is made possible through the collection of "activity data" on bands of caribou in the vicinity of the pipeline corridor. This method consists of point-in-time samples of the activity engaged in by each individual in a group under observation. Activity falls into one of eight categories:

feeding, lying, standing, walking, trotting/running, sparring, nursing, or "other." Activity is sampled every five minutes (or every 15 minutes in the case of groups larger than 50 individuals). The following environmental parameters are recorded every 15 minutes: temperature, wind, speed and direction, cloud cover, precipitation type and rate, distance and direction of caribou from observer, elevation, direction and distance of group movement, average individual distance, level of insect harassment, slope, aspect, slope shape, distance from potential disturbance factor, and number and type of vehicles passing on road or pipe pad. Average individual distances are estimated and are meant only as a rough indication of spacing in the group. All directions are in 45° intervals. Insect harassment, precipitation rate, slope and slope shape are all measured on a scale of one to five. Attempts are made to separate insect harassment levels into mosquito, warble fly and nose bot fly components. This is done on the basis of subjective impressions of the mosquito annoyance. But for the two oestrid fly species evaluation of harassment level must be based on the caribou reactions themselves since the insects are difficult to observe. Cloud cover falls into one of four categories: clear, scattered, broken and overcast.

For each caribou band observed an attempt is made to measure snow depth and density using a Ramsonde on the feeding area and to classify and briefly describe the plant community where feeding took place. Also, whenever possible, the forage species being selected is identified either by examination of feeding craters in winter or close observation in summer. Areas of intensive cratering in winter months are marked and later photographed and characterized using percent cover estimates of the various dominant species present. Stations for repeated sampling of snow depth and density through the winter will be established in representative topographic and vegetation types along the pipeline haul road from the Brooks Range to the coastal plain. It is hoped this data will provide additional insight to the relationship between caribou distribution along the haul road in winter and regional differences in snow cover. Data will also be available during the growing season for examination of the relation between the phenology of preferred forage species along the haul road and the changing distribution of caribou. This will also be accomplished by establishing sampling stations in representative stands of preferred forage species and sampling periodically for energy and/or protein content.

All aberrant behavior, reactions with potential predators and reactions to pipeline related activities are described in detail. 35mm photography is used to record behavior during road or pipe crossings and reactions to both natural and man-made environmental factors.

Because of logistical constraints most activity data, particularly in the winter months, will be collected from the haul road itself. Thus, describing such data as an indicator of "undisturbed" activity patterns or movements is open to serious question, regardless of how far the group is from the road or pipe. But if activity patterns or movements are being significantly affected by pipeline activity, then we would expect those effects to be more pronounced as the strength of the potential disturbing stimulus increases. This hypothesis can be tested by statistical comparison of activity data gathered from groups at, for example, less than 400 meters and more than 400 meters from the potential disturbance factor.

One of the greatest difficulties so far encountered in evaluating the impact of pipeline related activities on caribou is the lack of information on the role of previous experience and habituation in affecting response to disturbance. It is clear from observations to date that reactions to the haul road are extremely variable. We know also that at least some animals in the study population have had frequent and prolonged experience with some type of potential human disturbance. Despite these problems the data should indicate the existence of a behavior disruption due to pipeline related activities if it occurs in a significant portion of the population. If groups of certain sizes or compositions are avoiding areas of pipeline activity altogether then this should emerge as a result of comparing data from aerial surveys with data collected from the haul road.

General reconnaissance of the study area on the average of once a month, resighting of collared caribou, and tracking of radio-collared animals will all provide supplemental data on study area-wide movements and distribution without which much roadside data would have little meaning.

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APPENDIX II. Elevated pipe crossings/deflections (1975).

Observ. No.	Date	Location[1]	Observ. Type[2]	Composition[3]	Dir.	Pipe Height (m)	Remarks
1	8/15	47.7 N	V	1 B	E	1.9	Severe warble fly harassment; aberrant running; traffic on pad.
2	8/15	47.8 N	V	1 B	E	2.3	Severe warble fly harassment; stood in shade beneath pipe.
3	8/15	47.4 N	V	1 B	W	1.1	Severe warble fly harassment; stood in shade beneath pipe.
4	8/15	47.8 N	V	1 B	NC[4]	2.0	Severe warble fly harassment; attempted crossing to east but reversed movement after several attempts.
5	8/15	47.5 N	V	1 B	E	2.4	Severe warble fly harassment; disturbed by traffic on pipe pad.
6	8/22	43.5 N	V	1 B	W	?	Possible warble fly harassment.
7	10/3	47.2 N	T	3 A, 3 U	NC E	1.9 2.1	 One large adult deflected 175 m south and crossed 2.1 m; some milling on pipe pad prior to crossing.
8	10/3	44.8 N	T	1 U 2 U 2 U	NC NC NC	1.6 1.7 1.9	All attempted crossing to east; not clear whether the same or different individuals were involved.
9	10/3	44.3 N	T	1 ca	NC	1.9	Tracks on pipe pad; attempted crossing to east.
10	10/4	28.0 S	T	1 A	NC	?	Tracks on pipe pad; attempted crossing to west.
11	10/10	48.0 N	T	1 B	W	2.0	Two other bulls failed to cross after several attempts and deflected about 2 km to north, but crossed where pipe was buried.

Observ. No.	Date	Location[1]	Observ. Type[2]	Composition[3]	Dir.	Pipe Height (m)	Remarks
12	10/11	46.4 N	V	1 ca 1 Y	NC	?	Approached from east to within 20 m of pipe; assumed alarm stance, but didn't cross.
13	10/12	47.2 N	T	1 A	W	2.2	Some milling to east of pipe before crossing.
14	10/17	21.9 S	T	2 U	NC	0.2	Tracks paralleled pipe to south; pipe was on blocks about 0.1-0.2 m above ground; animals attempted to cross to west but deflected to northeast.
15	10/18	43.2 N	V	1 B	NC	?	Paralleled pipe to south for 1.5 km; approached to within 50 m of pipe; no crossing.
16	10/23	45.1 N	T	3 A 1 ca	W	1.8	Paralleled pipe to the south for about 0.5 km before crossing.
17	10/23	44.8 N	T	1+ U	NC	?	At least one animal milled around on pipe pad to west of pipe; no crossing.
18	10/23	12.5 S	T	3 A	NC	1.5	Crossed road to east and approached to within 30 m of pipe; reversed direction and recrossed road to west.
19	10/23	26.8 S	V	1 B	W	2.2	Attempted to negotiate pipe about 6 times; paralleled pipe to north for at least 1.5 km before crossing; pipe heights at 4 attempted crossings were: 1.9, 2.0, 2.0 and 1.8 m.
20	11/2	18.6 S	T	2 B	E	1.8	Some milling on pipe pad before crossing.
21	11/2	19.2 S	T	1 U	E	-	Adjacent pipe in place, but absent at crossing site.

APPENDIX II. Elevated pipe crossings/deflections (cont.)

Observ. No.	Date	Location[1]	Observ. Type[2]	Composition[3]	Dir.	Pipe Height (m)	Remarks
22	11/2	19.8 S	T	2 A	E	2.5	Approached twice at pipe heights of 1.6 m and 1.8 m above pad; crossed at 2.5 m.
23	11/2	20.3 S	T	1 A	E	1.95	Caribou approached 3 times before crossing; pipe was 1.7 m high at site of first attempt.
24	11/7	17.3 S	T	1 A	W	1.45	20 m north pipe height was 2.0 m above pad; 10 m further south, 1.1 m.
25	11/7	20.8 S	T	5 U	NC	?	Feeding craters within 16 m of pipe.
26	11/7	21.6 S	T	10 U	NC	?	Feeding craters within 19 m of pipe; tracks deflected to north.
27	11/7	18.4 S	T	1 U	NC	?	Caribou approached pipe from west; reversed movement to west.
28	11/10	19.2 S	V	1 B	E	-	Attempted to cross 3 times at pipe heights 2.2 m, 2.0 m, and 1.8 m; crossed pad at a gap in the pipe.
29	11/10	35.8 S	T	12 U	E	2.3	Some milling on pipe pad prior to crossing.
30	11/24	31.2 S	T	5 U	E	2.1	Some milling and running prior to crossing; one individual crossed under a 2 m gap in the elevated pipe.
31	12/5	35.2 S	T	3 U	W	2.1	No milling.
32	12/5	35.2 S	T	15 U	E	2.1	Group fragmented and crossed in several places; probably included at least 1 calf and at least 2 bulls.

APPENDIX II. Elevated pipe crossings/deflections (cont.)

Observ. No.	Date	Location[1]	Observ. Type[2]	Composition[3]	Dir.	Pipe Height (m)	Remarks
33	12/6	35.2 S	T	4 U	W	2.1	Considerable milling around and on pad prior to crossing; another group had previously crossed at this location.
34	12/6	35.2 S	T	6 U	W	2.4	Same as above.
35	12/6	35.2 S	T	3 U	E	1.7	Pipe was higher on either side of crossing site; no apparent selection for higher sections.

[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