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RESPONSES OF CARIBOU TO PETROLEUM-RELATED DEVELOPMENT ON ALASKA'S ARCTIC SLOPE

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SUMMARY

Results of aerial surveys in 1981 indicated good overwinter survival of the 1980 cohort of the Central Arctic Herd (CAH) and high initial production/oversummer survival of the 1981 cohort. Comparison of regional estimates of calf percentage with those obtained during surveys along the Dalton Highway/Trans-Alaska Pipeline indicate continued avoidance of the corridor by cow/calf pairs.

The rationale, objectives, and experimental design of a new collaring program are outlined in detail. Between June and November 1981, 23 radio-collared cows were monitored to determine the 1st-year movements of their offspring; these same calves will be collared as short yearlings and monitored similarly for up to 3 years. It is noteworthy that during this 6-month period only 4 collared individuals crossed the pipeline corridor.

Because of mild weather and lack of snow cover in 1981, virtually all calving occurred on the coastal plain; initial calf production was high, 85 calves/100 cows. Two distinct high-density calving areas for the CAH were identified, one north of the Kuparuk Development Area (KDA) and another on the Canning River delta.

Of 10,901 caribou classified during road surveys along the West Sak Road (WSR) in summer 1981, 18% were calves, substantially lower than the estimate of 27% calves for the region west of the Kuparuk River. Caribou were most numerous along the initial and terminal portions of the WSR; the corresponding calf percentages, however, differed appreciably. The local decline in calf representation and other changes/inconsistencies in caribou distribution within the KDA may be a result of increasing traffic and construction activity. A provisional analysis, using a disturbance index, indicates that cows with calves are underrepresented near areas of heavy local disturbance; this avoidance response appears to be attenuated by insect harassment.

Present land use policies for the central Arctic Coastal Plain do not adequately address problems associated with industrial development on caribou calving grounds, insect relief habitat, and within movement zones. An analysis of existing and possible future conflicts between petroleum development and caribou is presented, together with some general recommendations for minimizing those conflicts. In the long term, we believe that planning of surface uses and selective subsurface leasing is the only rational approach to protecting caribou habitat on the Arctic Slope.

Key words: caribou, disturbance, pipelines, seasonal movements.

CONTENTS

PREFACE

Since the discovery of oil at Prudhoe Bay in 1967, much attention has been focused on the effects of oilfield and industrial development on fish and wildlife resources, and on barren-ground caribou (Rangifer tarandus granti) in particular. Wildlife surveys of the central Arctic Slope conducted in the late 1960's and early 1970's indicated that the Prudhoe Bay region was probably within the peripheral ranges of both the Western Arctic and Porcupine Herds (Hemming 1971), and that some 20,000-30,000 caribou might occupy the general area during summer (Gavin 1973). After 1970, however, the number of caribou using this area declined rapidly, to an estimated 2,500 in 1972 (Gavin 1973). This apparent withdrawal paralleled a decrease in the size of the Western Arctic Herd, from 242,000 in 1970 (Hemming 1971) to 64,000 in 1976 (Davis and Valkenburg 1978). Since 1975, no large influxes from adjacent herds have been observed, and it is now clear that caribou presently ranging in the vicinity of Prudhoe Bay and along the North Slope route of the Trans-Alaska Pipeline (TAP) constitute a separate subpopulation of about 9,000 caribou (Appendix A), the Central Arctic Herd (CAH) (Cameron and Whitten 1979a).

Caribou occupancy of the Prudhoe oilfield and TAP corridor has declined with sustained petroleum development. This response is primarily a reflection of local avoidance of the area by cows and calves (Cameron et al. 1979, 1982; Cameron and Whitten 1980a; Appendix B). In spite of displacement from previously occupied units of range, the herd is very productive (Appendix B). Nevertheless, existing conflicts with industrial development and the potential for progressive disruption raise a number of concerns for the future well-being of the CAH and other caribou subpopulations on the Arctic Slope. Among the possible consequences is reduced survival of neonatal calves resulting from disturbance-induced displacement of parturient cows from traditional calving grounds. A 2nd major concern is the potential restriction of summer movements in response to insect harassment, specifically, the bioenergetic ramifications of reduced access to coastal insect relief areas.

The mitigation of these and other conflicts will require a basic understanding of disturbance mechanisms, including the types and intensities of development that constitute negative stimuli, the threshold levels of disturbance that trigger range abandonment, the amount of displacement tolerable before overuse of remaining range occurs, and whether caribou will accommodate to local disturbance over time. Despite the present dearth of knowledge regarding these fundamental relationships, practical short-term mitigation of existing or imminent problems will become possible as relevant site-specific data are accumulated. Thus, general criteria developed for pipeline design and placement will hopefully maximize physical passage of caribou, and strategic scheduling of construction activity should minimize disturbance-induced displacement. Continued coordinated study, both basic and applied, will likely result in more specific guidelines for petroleum development on the Arctic Slope.

This project presently comprises 3 distinct research jobs that are directed toward the following goals: (1) To determine the immediate and long-term effects of petroleum development, pipeline construction/operation, and related activities on the distribution, movements, and productivity of caribou on Alaska's Arctic Slope; (2) To characterize the behavioral responses of caribou to physical and sensory disturbance associated with industrial development; and (3) To formulate mitigating standards for facilities design/placement and for the types, timing, and levels of activity within caribou habitat.

Complementary survey and inventory activities in the form of routine population monitoring are also in progress. Data on herd size, calf production, and yearling recruitment are reported as annual updates on the status of the CAH (Appendix C).

I. EFFECTS OF THE TRANS-ALASKA PIPELINE CORRIDOR ON THE DISTRIBUTION AND MOVEMENTS OF CARIBOU.

BACKGROUND

The Trans-Alaska Pipeline (TAP) traverses the range of the Central Arctic Caribou Herd (CAH) (Cameron and Whitten 1979a). Comparisons of caribou observations along the Dalton Highway with corresponding data from the surrounding region have revealed abnormalities in the distribution and group composition of caribou associated with the pipeline corridor. Calves are clearly underrepresented, indicating avoidance of the corridor area by maternal groups (Cameron and Whitten 1980a; Cameron et al. 1979, 1982).

The following is a summary of data obtained in 1981. As in past interim reports, interpretation of caribou observations along the TAP corridor/Prudhoe complex is somewhat superficial; conclusions are tentative, based primarily on unadjusted data. In 1983, we will prepare an in-depth final report for the entire 8-year study period. We will fully explore caribou distribution and group composition along the TAP corridor in relation to population dynamics, habitat selection, and a number of spatial, temporal, and disturbance variables.

OBJECTIVES

In accordance with stipulations 2.5.4.1* and 2.5.3.1 of the Grant of Right-of-Way for the TAP and in anticipation of similar stipulations for the Northwest Alaskan Gas Pipeline, this project is designed to accomplish the following principal objectives:

1) To determine seasonal/annual changes in the distribution and group sex/age composition of caribou in the vicinity of the TAP corridor, with special interest in the identification and assessment of local abnormalities.

2) To determine the location and direction of corridor crossings by caribou.

3) To characterize the behavioral responses of caribou to the Dalton Highway, pipeline(s), traffic, and human activity.

PROCEDURES

Systematic aerial surveys of caribou in the central Arctic region (Cameron and Whitten 1979a) were conducted on 27-30 April and again on 3-5 November 1981. Summer estimates of regional sex/age composition were made in conjunction with a census of the CAH (Appendix A). All surveys were conducted by Bell 206 helicopter, and caribou were classified according to standard sex and age criteria (Cameron and Whitten 1979a).

Caribou were surveyed periodically from the Dalton Highway between late February and early December, generally on or about the 10th and 25th of each month. Coverage and observation procedures are described elsewhere in detail (Cameron et al. 1979). Road survey data were entered in a computer file (Honeywell Model 20, University of Alaska).

FINDINGS AND DISCUSSION

Composition of Caribou Determined by Aerial Survey

Calves composed 13% of 998 caribou classified in April (Table 1). Composition and census data obtained in 1981 indicated an adult sex ratio of 80 bulls:100 cows, a decline from the ratio of 100 bulls:100 cows estimated in 1978 (see Appendix A). Bulls were overrepresented in the spring survey (135 bulls/100 cows). Adjusting for the estimated actual ratio of 80 bulls:100 cows yields a spring estimate of 16% calves in the herd. If a similar adjustment is made on the fall 1980 data, an estimated regional

* "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."

value of 21% calves is obtained. A comparison of fall and spring calf percentages indicates good overwinter calf survival and continued high recruitment of short yearlings into the CAH.

In late July, a summer composition survey was conducted in conjunction with a photocensus. Of 4,167 caribou classified in postcalving aggregations (Table 1), 25% were calves, with an estimated ratio of 65 calves:100 cows. Correcting the observed bull:cow ratio (70 bulls:100 cows) to our best estimate of 80 bulls:100 cows yields 26% calves in summer 1981. This equals the highest calf percentage obtained since surveys were begun in 1975 and is especially high considering the large number of immature cows recruited into the herd in 1979 and 1980 (Appendix A).

During fall 1981, calves composed 26% of the 1,712 caribou classified (Table 1). The estimate of 63 calves/100 cows indicates virtually no mortality of calves between midsummer and fall.

Composition of Caribou Along the TAP Corridor

Between March and November 1981, 8,338 caribou were seen from the Dalton Highway (Table 2), substantially more than the corresponding 1980 total (Cameron et al. 1982). This increase is primarily attributable to more frequent road coverage and a modification in our criteria for inclusion of groups in the survey records. Previously, groups too far away to be classified were not regularly included in survey totals. In 1981, all caribou visible from the road were recorded; consequently, numerous additional caribou were classified as "unknowns." This procedural change affected only the spring and fall counts, when snow cover improved sighting conditions for distant groups. A total of 5,559 caribou (67%) were classified.

Calf percentages during spring, summer, and fall were 6, 5, and 14%, respectively--all higher than the corresponding 1980 estimates, but generally consistent with the recent trend in local calf representation (Cameron et al. 1982). Fig. 1 presents a 7-year comparison of ratios of calf percentages observed from the Dalton Highway to those determined by corresponding aerial surveys of the central Arctic region. Beginning with fall 1978 data, regional calf percentages were adjusted according to bull:cow ratios extrapolated from the 1981 CAH census observations (see Appendix A). This reanalysis resulted in small revisions in the ratios reported previously (Cameron and Whitten 1980a, 1980c; Cameron et al. 1982), but interpretations and conclusions remain the same.

Two separate ratios have been plotted to describe calf representation in summer 1981 along the corridor (Fig. 1). These represent separate calculations based on different summer totals. On 29 July, a group of 296 caribou including 68 calves was observed moving south under insect harassment in the alluvial gravel south of the Prudhoe Bay Complex(PBC). This group contained 87% of the total number of calves seen along the Dalton Highway in summer 1981. These caribou (included in the total, Table 2) were clearly transient, having moved into the corridor under insect stress. Even with this group included, the calculated ratio of 0.20 indicates that only about one-fifth the expected number of calves were present in groups observed from the road in summer 1981. Deletion of this group reduces the summer calf percentage to 0.2%, the lowest value for any season in which adequate data were obtained, and results in the lowest calf ratio (0.03) for any season to date.

The ratios for 1981 are consistent with recent trends. Following a sharp decline during 1976-78, the respective summer and fall ratios stabilized at approximately 0.1 and 0.6. Spring ratios for 1979-81 are roughly intermediate. Nevertheless, it is clear that calf representation in groups observed from the Dalton Highway in 1981 remained substantially lower than the corresponding regional estimates.

The decreased incidence of calves along the Dalton Highway is a result of avoidance of the corridor by entire groups, rather than individual cow/calf pairs. Overall calf percentages for groups with calves along the Dalton Highway (Table 2) are similar to the respective regional estimates. Seasonal differences in calf percentage indicate that cows with calves are more sensitive to disturbance during summer than in fall.

Sighting rates for summer and fall 1981 were 49 and 44 caribou/100 km, respectively--slightly above those in 1980 but similar to recent values (Cameron et al. 1982). Rates were calculated on the basis of total groups classified and are therefore comparable to those reported previously. The spring rate of 78 caribou/100 km is the highest ever recorded for any season and is more than double the comparable 1980 value of 36 caribou/100 km. However, since spring values are available for only the past 2 years, it is impossible to determine whether or not this indicates a trend toward increased occupancy of the corridor.

Rates of crossing the Dalton Highway by caribou were highly variable in 1981: 0.35, 7.9, and 1.0 observed crossings/100 caribou sightings for spring, summer, and fall, respectively. Both spring and fall rates are similar to previous values (Cameron et al. 1982). The summer crossing rate, however, is the highest recorded to date and is primarily attributable to the sighting of 114 bulls (of 124 total crossings observed during summer 1981) that crossed the road during the 11 July survey. Local movements of small bull bands along and across the Dalton Highway are common during the summer insect period, but crossings by large, intact groups are rare.

Daily traffic levels on the Dalton Highway during 1981 were substantially higher than in 1980 (Table 3). In June 1981, the check station was moved 158 miles north, from the Yukon River to

Disaster Creek; therefore, 1981 summer traffic levels are not directly comparable to previous years' data. However, current estimates are more representative of the actual traffic on the Arctic Slope and indicate a net increase over the previous 3 years.

II. DEVELOPMENT AND ALTERATION OF CARIBOU MOVEMENT PATTERNS.

BACKGROUND

Past studies have established that parturient and postpartum caribou tend to avoid areas of intensive petroleum-related development. Caribou surveys conducted along the Trans-Alaska Pipeline (TAP) Corridor and within the Prudhoe Bay Complex (PBC) between 1975 and 1980 yielded overall calf percentages that, with 1 exception, were substantially lower than corresponding regional estimates (Cameron et al. 1982; Appendix B). Seasonal differences in this response pattern are apparent. During summer, calf proportions within the TAP Corridor declined sharply from 1975 to 1977 and have remained at 10-15% of estimated regional values through 1980. Fall calf proportions decreased similarly between 1975 and 1978 but increased to 60-70% of regional estimates in 1979-80. Thus, despite some indication of a trend reversal during fall, summer calf representation within the corridor continues to be abnormally low.

These 6-year trends in local calf representation are not consistent with the corresponding changes in construction-related disturbance. Given that female caribou and their calves respond negatively to increasing levels of development and human activity, it seems logical to expect improved sex/age representation during periods of reduced disturbances. In addition, repeated exposure to local disturbance might allow some individual females to accommodate to what would otherwise be negative stimuli.

The above premise is not supported by available data on annual trends in disturbance, particularly during summer. Various indices of development-related activity indicate that highest relative levels occurred in 1975 and 1976, followed by a distinct net decline thereafter through 1978 (Cameron and Whitten 1980a); estimated daily traffic on the Dalton Highway suggests a continued decrease in local activity through 1979, followed by an increase in 1980 (Cameron et al. 1982). Local disturbance has since increased over 1980 estimates but remains well below peak levels. Clearly, continued underrepresentation of maternal pairs during summer reflects sustained avoidance of the TAP Corridor/PBC despite an appreciable moderation of disturbance stimuli. On the other hand, the recent recovery during fall suggests increased accommodation, possibly in response to reduced activity following completion of the TAP. However, it remains to be seen whether this trend will continue as coastal oilfield development proceeds and with the possible initiation of gas pipeline construction.

The central point is that an increase in local calf representation has not accompanied the net decline in development activity within the TAP Corridor/PBC. Although this could reflect a response lag following diminution of adverse stimuli, it is also conceivable that altered patterns of seasonal distribution and movements of caribou tend to persist as new traditions. These changes might also be reinforced by maternal group leaders and sustained further by their female offspring. Hence, components of range and/or specific habitats once abandoned by individual or cohesive bands may not be reoccupied for many years after the withdrawal of industrial activity--and perhaps only then by a chance reinvasion.

This study was designed to examine the mechanisms by which caribou movement patterns are established and subsequently sustained or altered. An understanding of these mechanisms will assist in projecting the effects of proposed industrial or urban development, in terms of both the duration of habitat loss and the likely consequences to caribou users. The project is now in the early stages of implementation, and this report is an update of progress made during the 1981 field season.

OBJECTIVES

To evaluate the degree to which the seasonal movements of individual adult caribou are influenced by their 1st-year movements as calves.

To identify and describe any disturbance-related alteration of seasonal distribution and movements of such caribou.

To determine sexual differences in the development of caribou movement and dispersal patterns, social relationships, habitat preferences, and range fidelity.

PROCEDURES

Caribou have been, and will continue to be, radio-collared as described previously (Whitten and Cameron 1982). As of fall 1981, 25 adult females were equipped with functional transmitters. In spring 1982, additional females will be collared to provide a minimum of 30 individuals with transmitters that will remain operational for at least 1 year. Offspring of these females will be collared as short yearlings in March or April 1983.

Standard methods of tracking by fixed-wing aircraft (Whitten and Cameron 1982) will be used. Radio-collared cows and their offspring will be relocated monthly between June and September, and again in November, March, and May of the following year.

Beginning in June 1982, movements of the original adult females will be tracked for at least 1 year. Individuals radio-collared as short yearlings will be relocated for the functional life of the transmitters (ca. 3 yrs). For each resighting, location, group composition, habitat type, and any local disturbance will be recorded; when relocating collared offspring, the presence or absence of their maternal cows (visual collars will remain after transmitters expire) will be noted.

The 1st-year movements of collared cows and their calves will be compared with the subsequent activities of those same calves as yearlings and adults. Particular attention will be focused on sexual differences in distribution, movement chronology, habitat use, and group structure. This program will also provide an opportunity to examine patterns of sex- and/or age-related mortality and fecundity.

FINDINGS AND DISCUSSION

All 23 radio-collared cows were located during both June and July. However, because of frequent inclement weather, we were only able to relocate 22 individuals in September and 13 in November. Excluding cows with radio collars that are due to expire, there are 12 caribou on which we have complete 1981 data. Tracking of these cows for a 2nd full year (i.e., June 1982-May 1983) will provide useful information on between-year variation in the movements of adult females; similar data can be obtained opportunistically in subsequent years by tracking the 2- or 3-year movements of additional cows to be collared in spring 1982. This will provide a valuable reference base for interpreting any annual shifts in the movement patterns of females as calves, yearlings, and adults.

We have not yet established the format for data analysis, and the limited resighting information obtained to date is insufficient for any detailed interpretation. However, some generalizations on the seasonal movements of CAH cows are noteworthy.

During the calving period in early June, most of the radio-collared cows were found within 40 km of the coast on both sides of the TAP Corridor/PBC, 13 to the east, and 13 to the west; none were observed within the PBC itself. In addition, all but 4 collared cows were found in areas of concentrated calving activity (see Part III, this report); 4 were found in the Milne Point area, 6 were in the upper Kachemach River, 11 were in the lower Canning River/Bullen Point area, and 1 was near Franklin Bluffs. Of those remaining, 2 were located about 80 km inland on the Toolik River, 1 was at Mikkelsen Bay, and 1 was about 50 km inland near the Kavik River. All but 2 collared females had calves at heel.

During the remainder of June and throughout July, most collared individuals exhibited considerable east-west movement within the coastal zone. Despite this activity, only 1 collared cow crossed the TAP Corridor. This individual calved between the Kuparuk and Sagavanirktok Rivers, approximately 20 km south of Deadhorse airport, and subsequently moved eastward to the Franklin Bluffs area; the TAP is predominantly buried in the general region where the crossing most likely occurred. Otherwise, radio-collared cows remained either east or west of the TAP Corridor/PBC.

By mid-September, 2 additional collared caribou had crossed the corridor, both to the west and, again, in the vicinity of Franklin Bluffs; the individual that had crossed to the east in July remained on the east side. Of the 13 cows relocated in November, 1 other had crossed to the west.

To summarize, 26 collared caribou were relocated repeatedly over nearly a 6-month period, yet only 4 crossings of the TAP Corridor/PBC by different individuals were detected. This low crossing frequency complements similar data reported previously (Whitten and Cameron 1982) and is consistent with observations of continued low occupancy of developed areas by cows and calves (Part I, this report). In contrast to these conclusions, Child (1973) and White et al. (1975) observed large mixed groups of summering caribou moving through the PBC during the early 1970's. The recent cessation of such movements suggests a tendency toward relative isolation of eastern and western portions of the cow-calf component of the CAH.

During summer 1981, collared cows were also useful in describing movements of caribou that occurred in response to changing insect activity. A summary of those movements in relation to the Kuparuk Development Area (KDA) is dealt with in Part III of this report.

Data on collared cows indicate excellent oversummer survival of calves. Admittedly, some individuals were not found during fall 1981 (see above), but all collared females observed with calves at heel in June were still accompanied by calves in September and/or November. These observations reaffirm demographic evidence for recent high levels of recruitment to the CAH (Appendix A).

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

BACKGROUND

The Kuparuk Development Area (KDA) is located immediately west of the main Prudhoe Bay oilfield, within an active calving area and an important component of summer range. We believed that detailed knowledge of regional caribou distribution and movements would assist in the formulation of development practices which would accommodate caribou, hopefully within established geotechnical constraints. It would also provide an opportunity to identify and quantify the sources of local disturbance and the reactions of caribou to these stimuli. Finally, in conjunction with continued monitoring of CAH status, the present program provides an opportunity to document any related effects on herd productivity.

This report summarizes the 1981 results of continued surveys of the CAH calving grounds* and along the West Sak Road (WSR). These findings and various between-year comparisons are considered in relation to weather-related variables and local disturbance.

OBJECTIVES

To describe annual variations in the distribution of CAH caribou on their calving grounds, with special reference to calving activity in the vicinity of the KDA.

To determine between-year differences in the distribution, movements, and sex/age composition of caribou within or near the KDA during summer.

To determine the location of road/pipeline crossings.

To characterize the responses of caribou to local structures and disturbance.

PROCEDURES

Calving ground surveys were conducted between 11 and 14 June; virtually all calves were born during the previous 7-10 days. Survey observations were made during this same period in 1978, 1979, and 1980 (Cameron and Whitten 1979b, 1980b; Cameron et al. 1981). Distribution of calving caribou on the coastal plain was determined by flying a series of north-south transects, each extending 40 km inland from the coast. Primary transects were at 9.7 km (6 mi) intervals between the National Petroleum Reserve-Alaska (NPR-A) boundary on the west and Camden Bay on the east (transects E and 19, respectively; Fig. 2). Additional transects were flown at 3.2 km (2 mi) intervals in the vicinity of the Kuparuk oilfield and at 4.8 km (3 mi) intervals through the Prudhoe Bay Complex (PBC). Transect numbers and locations correspond to those used previously, except that new flight lines were added to both the east and west in 1981.

* Preliminary report submitted to the Office of Coastal Management (Alaska Coastal Management Program) and ARCO Alaska, Inc., October 1981.

All north-south transects were flown by Bell 206-B helicopter with the pilot and front-seat observer searching primarily in the direction of flight and 2 rear-seat observers searching to either side of the aircraft. USGS 1:63,360 maps were used for navigation and for recording locations of caribou groups; only groups within approximately 1.6 km (1 mi) of each transect were used in the transect data analysis, although more distant groups were often classified for additional information. Airspeeds of 110-130 km/hour and altitudes of 30-50 m were maintained until a group of caribou was sighted. Composition was ascertained by making a lower, slower pass or by hovering briefly at a distance of 50-300 m and using binoculars. Individuals were classified on the basis of genitalia, body size, and/or antler development as bulls, cows, calves, or yearlings.

The southern limit of the coastal calving area was estimated by flying east-west or southeast-northwest transects beginning roughly along the southern edge of the north-south transects (Fig. 2). These transects were flown by Cessna 180 with pilot and 1 observer. Locations of caribou were noted on 1:250,000 USGS maps; only group size and number of calves were recorded. In addition, when caribou were still in sight at the southern end of a north-south transect, helicopter surveys continued southward until caribou were no longer visible; these extended-transect data were also helpful in establishing the southern limits of calving.

Midsummer sex/age composition of caribou in the region surrounding the KDA was determined in conjunction with an aerial photo census of the CAH. All caribou observed along the coast between the ARCO West Dock and the Kalubik River were assumed to be potentially associated with the KDA. Postcalving groups were monitored until maximum aggregation occurred. Numbers of caribou were estimated from photographs of aggregations taken on 23 July. These caribou then dispersed, and new aggregations formed on 27 July, when composition was determined by landing a helicopter near each group and classifying as many caribou as possible. Composition was assumed representative of the total numbers estimated on 23 July. Numbers and composition of the remainder of the CAH were similarly estimated from aggregations found between Deadhorse and the Canning River on 27 July.

The WSR (Fig. 3) was surveyed systematically by light truck (Cameron and Whitten 1979b), generally twice daily, between 15 June and 7 August. For each survey, the level of insect harassment was estimated by direct observation as none, light, moderate, or severe, and prevailing weather was summarized. Hourly weather reports for Deadhorse airport were obtained from the Arctic Environmental Information Center, University of Alaska, Anchorage. Mean 4-hour insect levels were calculated (White et al. 1975) for each day of the survey program. Rates of vehicular traffic on the WSR were determined using an automatic infrared trail/traffic counter (Scientific Dimensions, Inc.)

(Cameron and Whitten 1979b); counter readings were taken at the beginning and end of each survey as well as during additional nonsurvey trips through the area.

An attempt was made to subjectively rate the relative disturbance magnitude of various temporary/permanent facilities, storage areas, and construction/maintenance activity occurring within an estimated 2 road km of each caribou sighting. Together with the traffic rates determined for each survey (see above), a numerical disturbance index was calculated in a manner similar to that reported for 1980 data (Cameron et al. 1981).

Caribou survey data from the WSR (including location, observation distance, group composition, direction of movement, road/pipeline crossings, insect levels, and disturbance indices) were entered in a computer file (Honeywell Model 20, University of Alaska). Selected data on total numbers and group composition were retrieved and compiled on the basis of various position, distance, insect harassment, and/or disturbance variables.

FINDINGS AND DISCUSSION

Distribution of Calving Caribou

Detailed surveys of the CAH calving grounds began in 1978. Initial emphasis was on calving distribution in relation to the active Prudhoe Bay oilfield and the developing Kuparuk oilfield, with less complete coverage of the relatively undisturbed area extending eastward to Bullen Point (Cameron and Whitten 1979b, 1980b). The area of intensive coverage was expanded slightly in 1980 but still did not encompass the entire calving grounds (Cameron et al. 1981). However, with even more extensive surveys during 1981, observations indicated that virtually all CAH calving occurred within the area of coverage. Caribou numbers declined sharply at both the eastern and western limits of the north-south transects (Fig. 4); this low density apparently extended at least 40 km beyond the survey area to the edges of the Porcupine Herd and Teshekpuk Herd calving grounds on the east and west, respectively (D. Ross and P. Reynolds, pers. commun.). A total of 3,446 caribou (2,620 on-transect) were classified. Initial productivity was 85 calves/100 cows.

Two distinct centers of calving were evident (Fig. 4). One, in the vicinity of the KDA, has been described in previous studies; the other, in the Canning River delta area, was observed during 1978 and 1979 surveys and was tentatively quantified in 1980 (Cameron and Whitten 1979b, 1980b; Cameron et al. 1981). Based on observations from primary transects, the area in the lower Canning River appears to support at least as many calving caribou as the Kuparuk area. This is consistent with counts of postcalving aggregations which have shown more caribou east of the PBC/TAPS Corridor than to the west (Cameron and Whitten, unpubl. data).

Within the 2 high-density calving areas, caribou were concentrated near the coast (Fig. 4). This pattern also characterized the relatively low-density calving area south of Mikkelsen Bay. However, low-density calving in the vicinity of Prudhoe Bay and the Colville delta was distributed somewhat farther inland (Fig. 4). The absence of calving near the coast at Prudhoe Bay has been interpreted previously as an avoidance reaction to industrial activity in the PBC (Cameron and Whitten 1979b, 1980b; Cameron et al. 1981; Appendix B). Localized avoidance of road and camp areas in the Kuparuk region has also been identified (Cameron and Whitten 1979b; Cameron et al. 1981), but the area in general remains a major component of the CAH calving grounds.

Generally, few caribou were observed on transects through the Colville delta area except for Transect A (Figs. 2, 4); a fairly large calving concentration was observed at the southern end of that transect in a well-drained, hilly area south of the coastal plain. This may reflect a preference for upland sites over the flooded and sparsely vegetated delta. A similar inland calving concentration was observed near Franklin Bluffs. Each of these areas was occupied by about 200 caribou. Isolated calving concentrations may have been present elsewhere as well, although observations by fixed-wing indicated that very little calving occurred more than 40 km from the coast. East-west flight lines closest to the southern end of the north-south transects intercepted 13 caribou groups, a total of 61 adults and 13 calves; only 9 groups with 33 adults (no calves) were observed on southernmost flight lines.

Apparently, weather patterns over the past 4 years have had a considerable effect on calving distribution. In years of mild spring weather, the coastal plain is preferred for calving. Such was the case in 1981, when snow had melted by 1 June, and the coastal areas were snow-free and well-drained. Weather conditions were similar in 1979, as was the pattern of calving distribution (Cameron and Whitten 1980b). Conversely, during years of adverse weather, at least part of the CAH did not use preferred coastal calving areas. Instead, hilly inland sites, such as Franklin Bluffs and the area south of Transect A, which were only lightly used in dry years, were occupied preferentially. Thus, during calving in 1978 and 1980, with substantial snow/ice cover and extensive flooding, relatively few caribou used the coastal plain (Cameron and Whitten 1979b; Cameron et al. 1981). In all years, however, relative distribution of caribou utilizing coastal calving areas has been similar; that is, calving caribou have been most numerous in the Kuparuk and Canning River areas near the coast, with few or none in the Prudhoe Bay area (Cameron et al. 1981).

Estimated boundaries of the Kuparuk calving concentration have remained remarkably constant since 1978 (Fig. 5). Caribou density within this area has fluctuated roughly in proportion to overall occupancy of the coastal plain (Table 4a).

Composition of caribou using the CAH calving grounds (Table 4b) shows that 1981 was another year of excellent calf production. Few adult bulls have appeared on the calving grounds in any year of study (see also Cameron and Whitten 1979b; Cameron and Whitten 1980b), while most yearlings have accompanied adult cows to these areas in the spring. An exception was noted in 1979, when, in spite of high overwinter calf survival, relatively few yearlings appeared on the calving grounds.

Summer Distribution West of the Kuparuk River

Regional Group Composition:

Counts during the 1981 photo census indicate that at least 4,067 CAH caribou summered in the KDA region. An additional 4,470 caribou were counted east of the Sagavanirktok River. Composition estimates east and west of Deadhorse yielded similar calf:cow and yearling:cow ratios, but the bull:cow ratio was substantially higher to the east (Table 5). Results of the census and composition counts are summarized in Appendix A of this report. An estimate of 27% calves was obtained in the coastal area west of the Kuparuk River (Table 5). Since there is apparently little or no movement of caribou through the PBC during the 2 months after calving (Whitten and Cameron 1982; Part II, this report), this percentage is assumed to be representative of relative calf numbers in the KDA region during summer 1981 and will be used as a basis for assessing similar data obtained along the WSR.

Distribution and Group Composition Along the (West Sak Road):

Between 15 June and 7 August, 86 complete surveys were conducted from the WSR. We observed a total of 14,966 individual caribou in 1,120 groups, approximately 3 times the respective total for 1980, but with only twice the survey effort (see Cameron et al. 1981). In part, this increase is a reflection of continued growth of the CAH, but is probably also a function of generally greater insect activity in 1981, bringing caribou in sight of the road more frequently (see below).

A total of 14,966 caribou were observed from the WSR. Excluding groups with individuals of "unknown" age, 10,741 caribou, or 72% of the total, were classified as either adults or calves; 18% were calves, substantially lower than the corresponding regional estimate of 27% calves (see above). Thus, for the 1st time in 4 years of summer surveys along the WSR, the relative number of calves observed locally was not representative of the surrounding population west of the Kuparuk River.

In 1981, we supplemented the standard road survey route with partially redundant coverage. The newly constructed Kuparuk Pipeline is routed east from the Central Processing Facility (CPF), along the access road and flowlines from Drill Site C., joining the WSR just west of Gravel Site B (see Fig. 3). This 8-km section of road was also driven on a routine basis, and survey observations were recorded in a separate file. Coverage along this road segment was added principally because, in several areas, the associated pipeline(s) restricts the northerly view from the corresponding southern portions of the main WSR. Unfortunately, these separate observations cannot simply be added to the main data bank, as effective coverage to the north would then extend well beyond the normal viewability. Legitimate between-year comparisons will require data adjustment based on a standard coverage area relative to the WSR itself, that is, including only those observations that meet specific distance criteria. In any case, 947 caribou were sighted from this section of road during summer 1981. Calves composed 14% of the total, even lower than the overall value of 18%. The following discussion of 1981 data pertains only to caribou observed from the WSR. For a summary of 1978-80 observations, the reader is referred to Fig. 7 in Cameron et al. 1981.

Fig. 6 depicts the summer 1981 distribution of caribou among 4-km segments of the WSR and the calf percentage applicable to each. Of the total caribou observed, 62% were north of the road, 27% were south, and 11% were west of the road terminus; respective calf proportions were 19, 14, and 23%. It is noteworthy that the percentage of total caribou sighted to the west was the highest recorded to date and, as in 1980, the associated calf percentage was also high relative to most other segments of the WSR--exceeded only by that for the 24.1-28.0 km interval.

In terms of the overall pattern of caribou distribution along the WSR, 1981 was quite similar to 1980. Excluding the aforementioned differences in sightings to the west, highest numbers of caribou were observed along the initial and terminal segments of the WSR in both years, although the individual peaks were more distinct in 1981. In fact, despite considerable variability in the occupancy of intermediate road segments, those portions encompassing the Kuparuk River (0-4.0 km) and Ugnuravik River (28.1-32.0 km) have been sites of high caribou use for the past 4 summers.

Peaks in caribou occupancy did not necessarily correspond to those in calf representation. Thus, although the proportion of calves among relatively numerous caribou observed in the vicinity of the Ugnuravik River was similar to the overall mean of 18%, the peak at the Kuparuk River was associated with the lowest calf percentage recorded (9%). The latter data are similar to results obtained previously. The Kuparuk drainage has been the site of consistently high occupancy, prominent among the various nodes identified, yet the corresponding calf percentages have been generally at or near the lowest recorded for any road segment. Lower calf representation in this area is thought to be a response to typically high levels of nearby construction activity, traffic, and the presence of other facilities/ disturbances in or near the floodplain (Cameron et al. 1981).

In 1978 and 1979, peaks in caribou occupancy west of the Kuparuk River coincided with the location of rivers and streams and were characterized by relatively high calf percentages. We hypothesized that cow/calf groups preferentially moved along these riparian areas, whereas nonmaternal adults were less selective. Shifts in the location and magnitude of these nodes were linked to the distribution of construction activity (Cameron and Whitten 1979b, 1980b). In 1980, a nodal pattern of occupancy was not discernible, and caribou distribution shifted generally westward, with a slight increase in relative numbers of caribou sighted beyond the road terminus; this, we believed, was a response to the increasing level of KDA-related activity (Cameron et al. 1981). By 1981, the relative numbers of caribou in the vicinity of the Ugnuravik River increased, but the associated calf percentage did not change correspondingly. Rather, the proportion of calves among caribou observed from the adjacent road interval (i.e., 24.1-28.0 km) increased to the highest value recorded for any segment (Fig. 6). The latter, however, is probably not meaningful in terms of an overall 1981 trend, but is attributable to a single group response to what may have been an unusual set of circumstances (see below).

The overwhelming majority of WSR crossings occurred within the 0-4.0 and 24.1-28.0 km segments (Table 6). Crossings at the Kuparuk floodplain coincide with an area of high caribou occupancy, but with relatively few calves, while the crossing area east of the CPF was associated with only moderate numbers of caribou with a high proportion of calves (Fig. 6). It should be noted that the latter crossing site was identified as a result of a single event: a group of 917 caribou (32% calves) crossed the road northbound, with considerable milling in the vicinity of the Kuparuk Pipeline. Calves composed 25% of the total caribou in crossing groups, a value approaching the regional estimate of 27% calves. In fact, since 1978 the overall percentage of calves in crossing groups has been consistently higher than the aggregate value for road observations (Cameron and Whitten 1979b, 1980b; Cameron et al. 1981). This indicates that, although some cows and calves are apparently reluctant to approach and cross the WSR, other maternal groups are highly motivated to do so. It is possible that bulls and nonparous females, despite a greater tolerance for disturbance, generally have a weaker natural impetus for movement. Hence, a higher percentage of calves among crossing groups may reflect only relative tendencies for movement, irrespective of disturbance considerations.

The general decline in local calf representation and other abnormalities observed in 1981 may be attributable to growth of the KDA. Among the more obvious changes were the installation of the Kuparuk Pipeline, expansion of CPF facilities, construction of additional well pads, reinstallation of a permanent Kuparuk bridge, and culvert replacement in various sections of the WSR. As a result of these and related activities, road traffic increased substantially (from 11.3 vehicles/day in 1980 to 17.8 vehicles/day in 1981). Aggregate disturbance accruing from the various component activities and structures may have exceeded the tolerance threshold of cows and calves, effectively reducing the number of options for local occupancy. In other words, some cow/calf groups may be simply avoiding the road system. The relatively high number of caribou sightings west of the WSR terminus suggests that many of these groups may be "end-running" the complex. For example, in mid-July we observed a mixed group of approximately 1,200 caribou move south to within sight of the Kuparuk bridge and then essentially parallel the WSR to the west; although some southward crossings occurred enroute, the majority continued to, or around, Drill Site A (See Fig. 3). A similar incident involved a northbound group of about 1,000 that paralleled the road/pipeline eastward for most of its length; the majority eventually crossed northward near the Kuparuk River.

These and related observations, including data on group composition, suggest an increase in local conflicts between caribou and industrial activity, although neither the precise stimuli involved nor the behavioral mechanism has been clearly defined. In fact, with rapid local and regional development, and an increase in the intensity and diversity of disturbance stimuli, it is becoming increasingly difficult to distinguish between the emergence of new patterns of caribou distribution and short-term, aberrant occurrences. Perhaps the absence of a clear trend is, in itself, symptomatic of a transition process.

Insect-Induced Movements:

As in previous years, caribou distribution along the WSR was affected by weather-induced changes in insect activity. Sudden changes in weather/mosquito activity induced rapid movements of caribou to or from the coast and through the vicinity of the WSR. Thus, relatively high numbers of caribou were seen along the road on 18-19, 22, and 27 July when severe insect harassment followed periods of low insect activity; caribou were moving across the road toward insect relief areas on the coast. On 24 July, sudden cooling temperatures brought numerous caribou inland to within sight of the road. After about 30 July, warble flies replaced mosquitoes as the dominant insect pest, resulting in general dispersal of caribou, and few were seen along the road.

Collared caribou resightings also reflected the influence of insect levels on caribou movements. All collared caribou known to be west of the Kuparuk River were north of the road near the coast on 13, 23, and 27 July when insect harassment was severe. When mosquitoes were not active, collared caribou were found farther inland. Thus, 8 of 9 collared caribou moved south on 24 July and had either crossed the road to the south or had circumvented the CPF to the west by 25 July. They remained south and west until insect levels increased on the 27th.

Chronology and direction of road crossings were also obviously influenced by insect activity. Although nearly all observed crossings were northbound (Table 6), general movement/sighting patterns and collared caribou resightings indicated that south-bound movements also took place. One possible explanation is that cool weather, low insect activity, and resulting southward movements occurred during late night or early morning hours when no road surveys were conducted. Also contributing to the preponderance of observed northbound crossings was the tendency for inland moving caribou to first parallel the road and pipe to the west before finally turning south around the CPF (see previous section).

Compared to other years, 1981 had a more even distribution of insect harassment levels during the peak mosquito season (Table 7). Frequent changes between days of moderate to severe harassment and days of little or no harassment resulted in increased caribou movements and frequent encounters with the road. Thus, the caribou sighting rate in 1981 was the highest observed since WSR surveys began (Table 7). Since 1978, the CAH has increased about 13%/year (Appendix A), and some increase in sighting rate would thus be expected. However, even with adjustments for herd growth, the sighting rates in 1979, and especially in 1981, would still be higher than in 1978 or 1980. Thus, it appears that annual changes in patterns of insect harassment as they affect the frequency of caribou movements on the coastal plain largely determine the number of caribou observed from the WSR. During years of either continuous harassment or of long periods of no harassment, relatively few caribou encounter the road. Interestingly, if sighting rates were adjusted for herd growth, the rate in 1980 (generally low harassment) would actually be lower than in 1978 (generally high harassment). In retrospect, frequent short periods of low harassment (i.e., during late night hours) regularly brought some caribou inland near the road in 1978 (see Cameron and Whitten 1980a). In contrast, the prolonged periods of low harassment in 1980 resulted in generally little movement during the summer.

Disturbance and Local Group Composition:

The disturbance indexing system reported previously (Cameron et al. 1981) has been revised to accommodate various combinations of pipelines and other structures, higher rates of vehicular traffic, and other unforeseen disturbance circumstances that emerged in 1981. As of this writing, analyses of the relationship between local calf representation and disturbance level are incomplete; as in 1980, sample sizes within a number of the disturbance/insect harassment categories are insufficient for the calculation of reliable mean values. After compiling the 1982 data, we will attempt to standardize the disturbance index and adjust the units of calf representation to permit pooling of observations from all 3 years. Hopefully, through such adjustment and reorganization we can perform some meaningful statistical comparisons.

A preliminary analysis of the 1981 data (using a slightly modified index) indicates that, under light insect harassment, the percentage of calves among caribou associated with disturbance classed as "high" (9%) was somewhat lower than under those levels designated as "low" or "medium" (16% and 14%, respectively). Calf percentages for 2 other insect/disturbance categories having sufficient sample sizes (i.e., moderate insects/medium disturbance; severe insects/high disturbance) were both higher (i.e., 22% and 24%, respectively) than those associated with light insect harassment under any degree of disturbance. This provisional analysis of limited data is consistent with our premise that cows with calves tend to progressively avoid areas of increasing disturbance, with an apparent attenuation in sensitivity to those same stimuli when subjected to the competing adverse stimulus of insect harassment. It remains to be seen, however, if we can, in fact, detect any shifts in the disturbance threshold within each of the 3 insect categories. This analysis will hopefully assist in clarifying the responses of caribou to combinations of natural and artificial stimuli, and may ultimately be useful in predicting the responses of caribou to proposed development.

RECOMMENDATIONS

The authors, with assistance from staff of the Divisions of Game and Habitat, are in the process of preparing a Department issue paper on "Caribou and Petroleum Development" (Appendix E). The draft document presents an analysis of the various concerns related to existing and probable future conflicts based on a review of relevant literature and theoretical considerations regarding the habitat requirements of caribou. Although the focus is on the calving and summer ranges of the CAH, the other Arctic herds are considered in the context of overall development on the Arctic Slope. Also included is a description of the present scope of petroleum development on State land and, more importantly, the potential for massive future development considering the large tracts of State and Federal land identified as having oil and gas potential.

Foremost among the recommendations is a plea for interagency surface use planning of the Arctic Slope to ensure that adequate and appropriate habitats remain available. Limits on the total amount of regional development should be firmly established, principally on the basis of management goals for the various caribou herds (i.e., optimal size, primary use, etc.). Protection of special use areas (e.g., calving grounds, movement corridors, insect relief habitat) should receive particular attention. This comprehensive plan would be implemented through a strategic leasing program followed by careful preplanning of individual production units, each with a set of broad development standards and lessee responsibilities.

Crucial to the ultimate success of development planning is a continuing program of basic and applied research on the behavior and habitat requirements of caribou, together with a mechanism for input to, and revision of, various policy guidelines. The overall effectiveness of any planning system requires formal interagency recognition, but with sufficient flexibility to be refined on the basis of new knowledge.

An established planning framework should greatly simplify and facilitate the routine permitting process. Given a set of development guidelines that are established prior to unitization, site-specific mitigation (e.g., road/pipeline routing and design, facilities placement, construction scheduling, traffic regulation, etc.) need involve little more than direct application through various permits and strict enforcement of the appropriate stipulations. Previously established principles of development, together with specific limitations, should leave few actions subject to industry or agency interpretation.

In direct contrast to these proposed policy changes, present and renewable subsurface leases on State lands are extremely vague in terms of habitat protection. As industry is neither bound by specific formal agreement nor inclined toward voluntary self-restriction of its activities, the present course and character of oilfield development will likely prevail in these areas. Unfortunately, technical needs, procedural philosophies, and economic pressures are frequently inconsistent with what we perceive as adequate protection of caribou and caribou habitat. Thus, with no legal or official policy base, the only regulatory option is a site-specific, case-by-case approach to mitigation; that is, reaction to individual proposals rather than implementation and enforcement of an operating framework that is formulated and accepted before the fact.

The present inefficient--and largely ineffective--approach to mitigation is exacerbated by a tendency for the burden of proof to be placed squarely on the permitting agencies rather than on the lessee. It is incongruous, to say the least, that accountability be greater for a defending agency than for the development aggressor. Renewable resource agencies are inclined to err on the conservative side, and this cautious approach to permitting is apparently unpalatable to both industry and the State land managers. Also, on most environmental issues, the Department of Fish and Game is little more than advisory to the Department of Natural Resources, lacking the authority to insist on protective measures. In practice, however, the Habitat Division, recognizing its weak position, frequently settles for unacceptable compromises before the fact rather than forcing the issue and thereby risking a complete loss of mitigation.

Because of the Department's present inability to influence oilfield planning, and despite the inadequacies of the permitting system, advisory input to permit stipulations appears to be the only regulatory option on State lands. In an attempt to inform industry of Department views on various permitting issues and to standardize stipulations pertaining to caribou (and other species) on the central Arctic Slope, staff from the Division of Habitat drafted a "North Slope Lands Guideline Document" (excerpts, Appendix F). While this document has never been accepted as Department policy, it is consulted regularly by the permitting staff as an internal reference. Seaman et al. (1981) prepared a comprehensive analysis of the coastal habitats between the Colville and Kuparuk Rivers and cited this same set of recommendations. By and large, we support the intent and substance of these guidelines. The reader is referred to these documents for specific operating principles and stipulations.

The central Arctic coastal plain (i.e., between the Colville and Canning Rivers) coincides very closely with land ownership by the State. The overwhelming majority of calving and summer range of the CAH is within this area, particularly that portion of State lands within about 50 km of the Arctic coast. Because of the magnitude of ongoing and probable future development in this region, conflicts during calving and midsummer continue to be of primary concern (see Appendix E). The following is an overview of what we perceive as chronic, recurrent problems resulting from ill-conceived development procedures and/or agency ineffectiveness. Discussion of the nature and status of each broad issue is followed by some general suggestions aimed at resolution. Admittedly, these problems will be difficult to resolve without a comprehensive planning approach, as discussed above, but should certainly be addressed by appropriate action within the existing permitting structure.

1. Oilfield Design and Development Procedures

We have repeatedly recommended that the routing of various roads and pipelines, as well as the siting of various temporary and permanent facilities, be such that total disturbance is minimized. This applies not only to individual processing/ support facilities, discrete complexes, and oilfield units, but also to contiguous and proximate production areas, irrespective of unit boundaries.

Few attempts have been made to achieve this goal. The progress of oilfield development to date demonstrates clearly that many actions are solely for the sake of convenience. Unit operators continue to request and receive permits for redundant access, new airports, additional docks, luxurious living accommodations, and temporary camps/equipment storage areas, to cite just a few examples. Similarly, surface leasing to commercial interests frequently results in additional unnecessary sources of disturbance in adjacent areas; specific examples are the recent proliferation of storage sites south of Deadhorse airport and tentative approval for a North Slope Borough "industrial park" in the Kuparuk area.

The proposed placement of any permanent road or processing/support facility should receive more careful scrutiny. The nature and extent of any potential conflict with caribou should be examined in the context of both present and future development in the area. Except in rare cases, permit applications for establishing temporary camp or storage facilities outside of existing complexes should be denied. Further, it should be the responsibility of the applicant to provide evidence for the necessity of each proposed action by assessing the alternatives. Claims of economic advantage may not, and simple convenience should not, be sufficient.

2. Linear Structures

Roads and pipelines should be designed and routed so as to maximize caribou passage. An essential element of the planning process is early implementation of an industry-funded field surveillance program to establish preferred routes of caribou movement through each area in question. Every attempt should be made to preserve these natural movement zones.

Unfortunately, the practical question of optimal pipeline design and caribou crossing success remains open, despite an assortment of useful studies conducted over the past decade. As an absolute minimum requirement, elevated pipe should be such that physical passage is assured; most caribou, considering maximum stage of antler development, can physically pass beneath a pipeline with a 150-cm (ca. 5 ft) surface-to-pipe clearance. However, special crossing provisions (e.g., buried sections, ramps, greater clearances) may be required, particularly in major movement zones and in areas where drifting snow would otherwise restrict passage.

To ensure the effectiveness of special crossing structures, it is essential that the location of existing and proposed structures/disturbances be considered in the planning process. It makes little sense to modify pipeline design in total ignorance of subsequent actions that might nullify or seriously compromise those efforts. One glaring example is the construction of an extremely expensive buried crossing in the TAP (just south of Pump Station 1), only to have a well pad appear in the immediate vicinity a few years later. There are numerous other instances where some reasonable foresight would have greatly improved both economic efficiency and mitigative effectiveness.

Mitigation may also involve strategic placement of roads and other facilities. Simply meeting the minimum criteria for physical passage of caribou has, in a number of instances, proven inadequate because of complications resulting from the presence of other adverse stimuli. Nearby roads and processing/support facilities, traffic and construction activity (see 3, below) as well as the overall character of proximal development (see 1, above) can greatly influence accommodation, irrespective of local road or pipeline design. Curatolo et al. (1982) tentatively concluded that in areas where the Kuparuk Pipeline was separated from the WSR, pipeline crossing success did not improve at clearances above 150 cm; accordingly, preliminary recommendations were for spatial separation of the pipeline and road/traffic stimuli. We agree that, although crossing success can be reduced by the presence of additional disturbance stimuli, separation of linear structures is not acceptable as a universal solution. Advantages associated with the spatial separation of stimuli must be weighed against the possibility that caribou will perceive the same stimuli collectively as a single, larger complex; that is, the association of individual stimuli such that the overall negative effect is greater than the sum of the various components. The relative desirability of a corridor vs. a network effect must be determined on a case-by-case basis, in recognition of the probable tradeoffs involved. As an example, although diverting the Kuparuk Pipeline south to a separate river crossing apparently increases crossing success of the pipeline itself, repeated encounters of the 2 separate linear structures by resident caribou may ultimately result in decreased use of the movement corridor in general. Most importantly, construction of any additional crossings may create an increasing network effect, with virtual abandonment as a possible consequence.

3. Activity

Numerous reports confirm the importance of movement stimuli as a source of disturbance to caribou (see Appendix E). Many such studies have been conducted in the Prudhoe/Kuparuk area, focusing on the responses of caribou to petroleum-related activity during spring and summer. Based on these findings and additional theoretical considerations, industry has been encouraged to restrict traffic and construction activity during calving and in midsummer (Appendix F). Unfortunately, these periods of concern coincide with the most active portion of the summer construction season. Consequently, agency attempts to restrict traffic in areas outside the established PBC have been largely unsuccessful. Industry argues that any limits on ground transportation would hinder the construction process, implying that all traffic is essential development-related activity. The fact of the matter is that considerable unproductive "touring" does occur in remote areas, not to mention totally unnecessary traffic resulting from improper planning (see below).

When approached about the possibility of traffic control through the use of security check stations, industry representatives typically argue that such measures would be unreasonably expensive and/or that they lack the authority to restrict surface travel on public lands. With respect to the latter claim, it is indeed ironic that established security systems within the PBC exercise a measure of control that is well beyond a simple checkpoint function, presuming authority reserved for law enforcement officers. More to the point, if a rudimentary security system is indeed within the legal privileges of a subsurface lessee, the checkpoint system should be designed to efficiently protect both wildlife resources and corporate interests. This issue has philosophical, legal, and biological ramifications and should be resolved promptly.

Additional unproductive traffic and construction activity also result from engineering errors in facilities design. Specifically, since 1978, many bridges and culverts along the WSR have been of insufficient size to accommodate water from spring runoff and summer storms. As a result, major road repairs and culvert/bridge replacement have become annual summer exercises. It is only recently that most of these water crossings have been finally replaced with what, hopefully, will prove to be adequate structures. Underdesigning of culverts and bridges, whether intentional or otherwise, is inexcusable. In many instances, the necessary repairs and reconstruction activity are in direct conflict with caribou, which tend to preferentially occupy, and move along, riparian systems.

Related practices with similar consequences involve the aforementioned propensity for nonessential construction. Hence, optional/redundant roads, new transportation facilities, local commercialization, and storage pads all necessitate a concomitant increase in demands on everything from gravel resources to sewage disposal. Aside from an undesirable proliferation of permanent facilities within an oilfield, the intensity of activity must also increase correspondingly. In short, any construction project, however minor in its physical characteristics, must also be viewed in terms of its indirect impact on a variety of support requirements and, ultimately, the net disturbance increment. All construction proposals require closer examination as to need, feasibility, soundness of design, and environmental tradeoffs.

To reemphasize, given the present leasing policy and permitting structure on State lands, we believe that the only rational approach to maintaining caribou habitat is a careful reexamination of current development practices. Actions that can be confirmed as procedural essentials should be streamlined, while those which are superfluous should be abandoned. In the long term, and particularly in a regional context, strategic land use planning at the leasing and unitization stages is the most viable approach to reconciling conflicts between caribou and industrial development.

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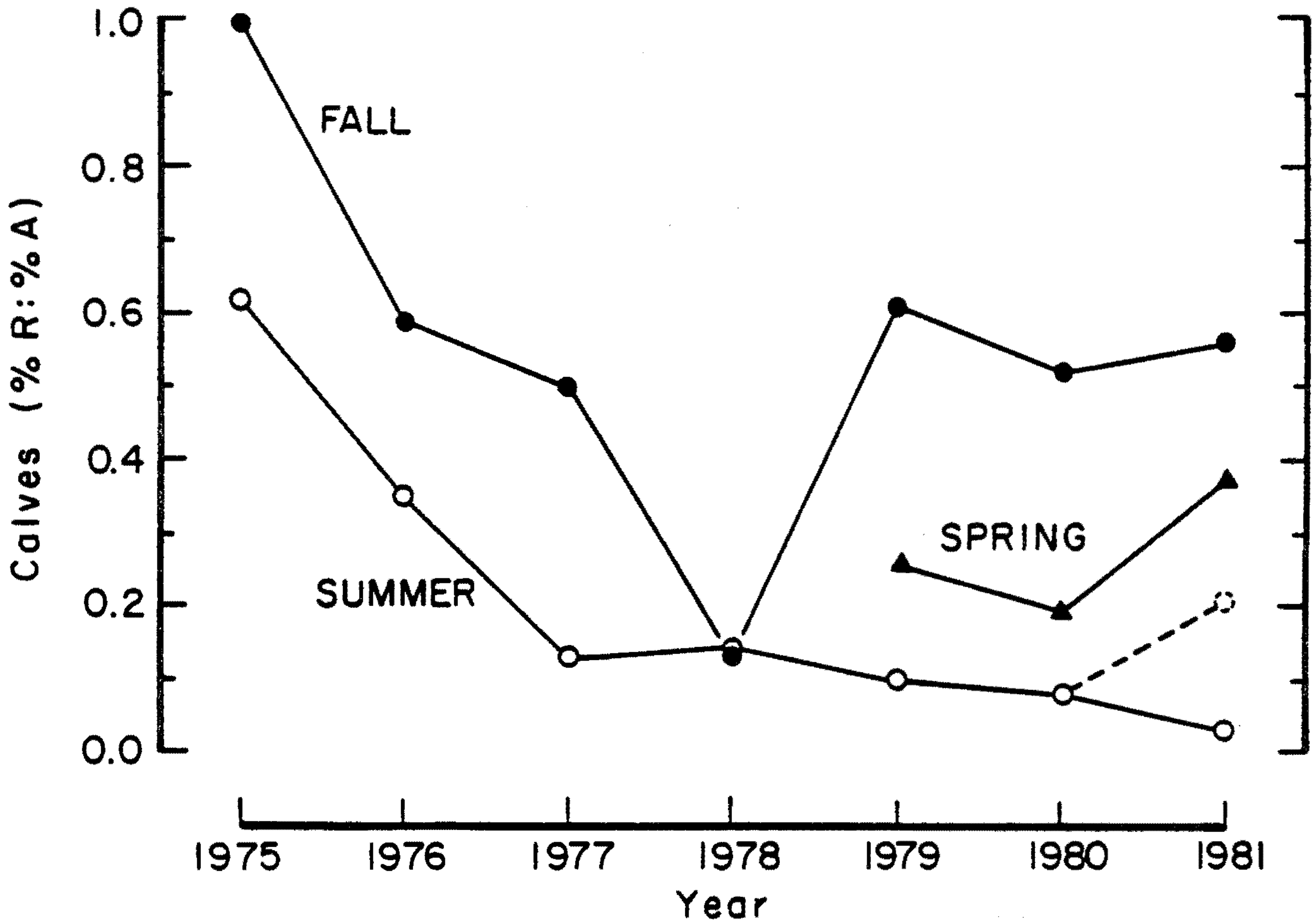

Fig. 1. Seasonal changes in relative calf representation among caribou associated with the Trans-Alaska Pipeline Corridor, 1975-1981.

NOTES: %R:%A = ratio of calf percentage observed from the Dalton Highway to that determined by aerial survey. Higher ratio for summer 1981 includes data on a large transient group (see text) and is excluded in calculation of the lower ratio.

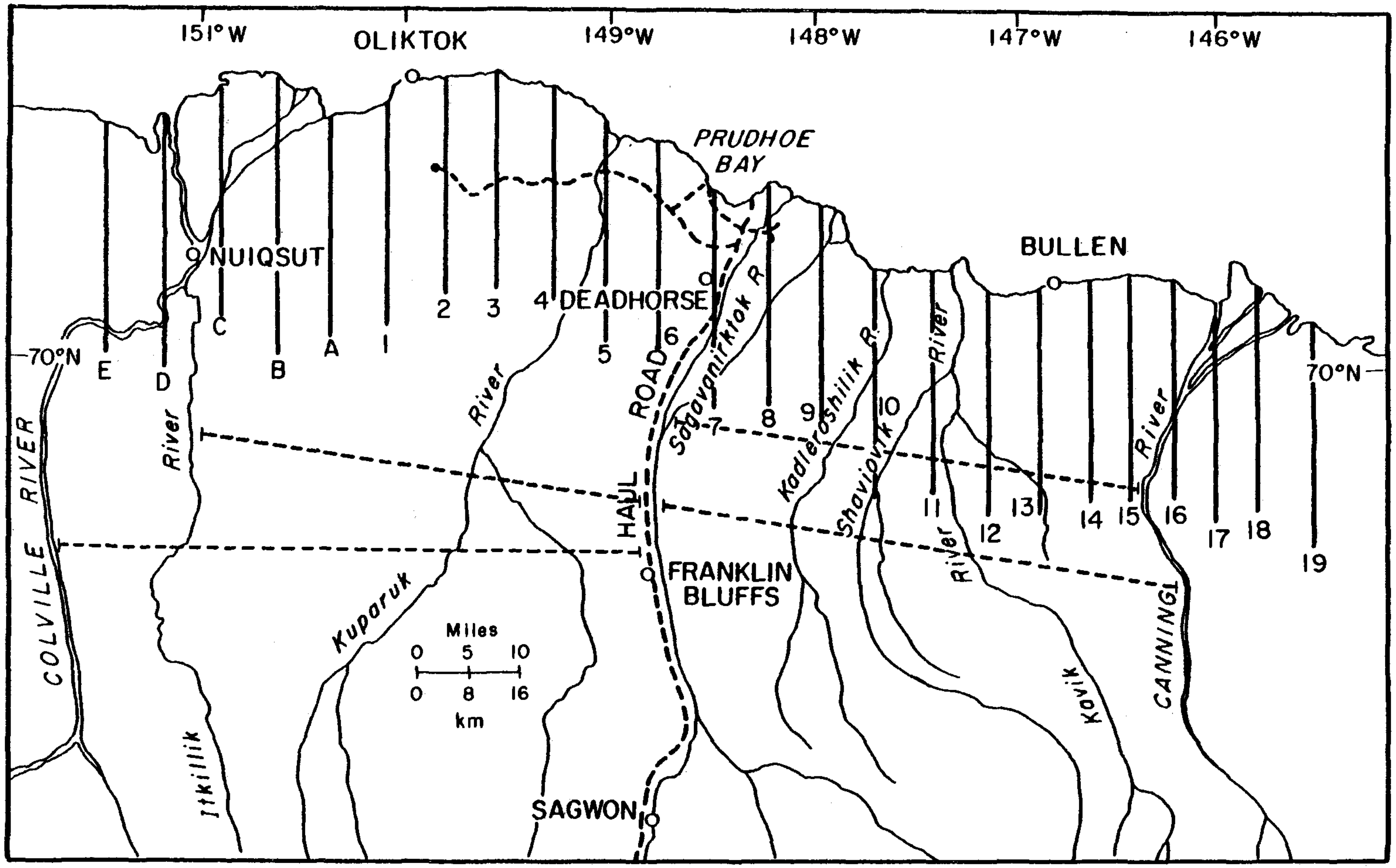

Fig. 2. Aerial survey transects, 11-14 June 1981. _____ helicopter coverage; ----- fixed-wing coverage.

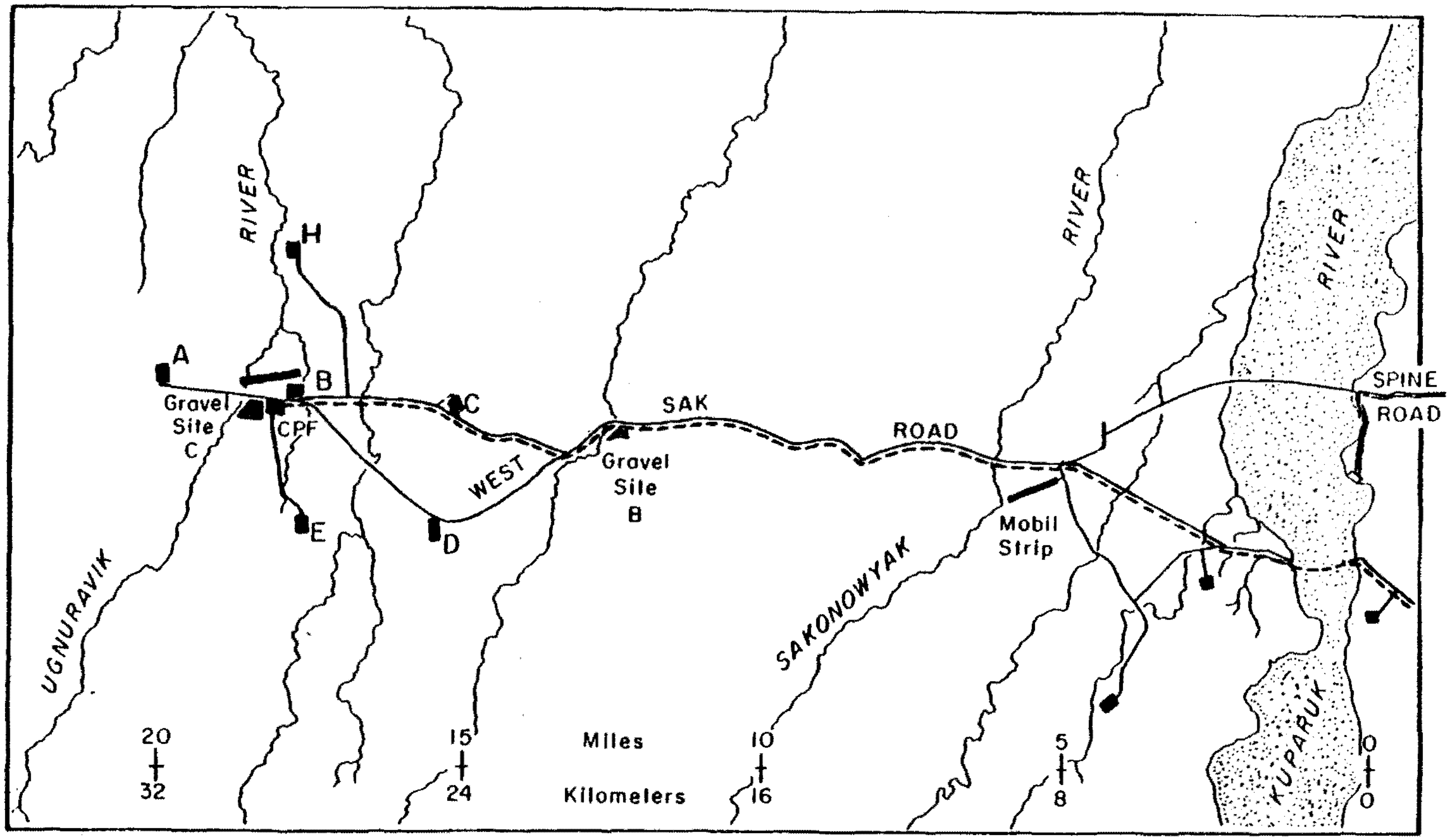

Fig. 3. The West Sak Road and associated facilities, summer 1981. _____ road; ----- Kuparuk Pipeline; ▰ drill pads or facilities.

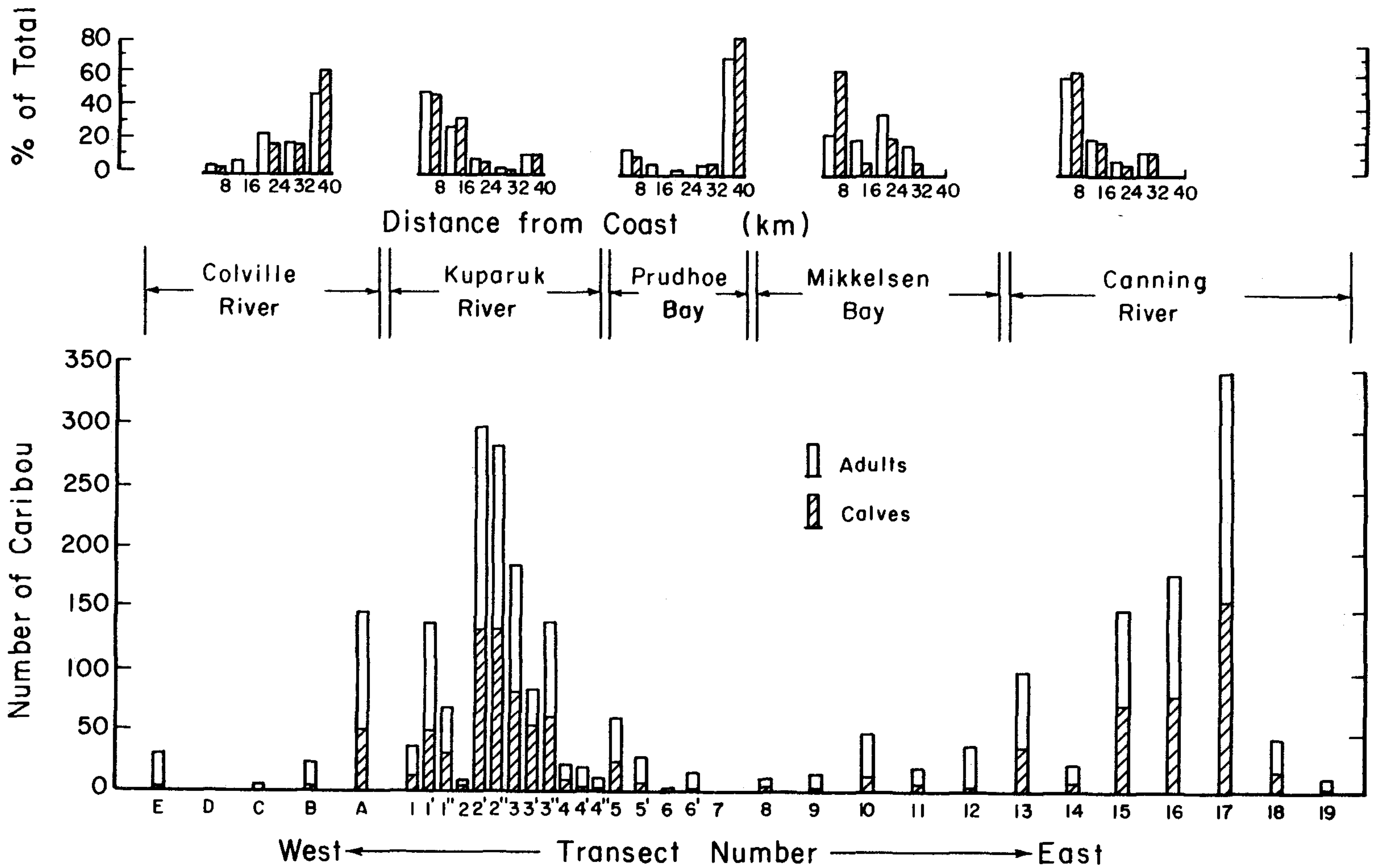

Fig. 4. Distribution of caribou on the Central Arctic Herd calving grounds, 11-14 June 1981.

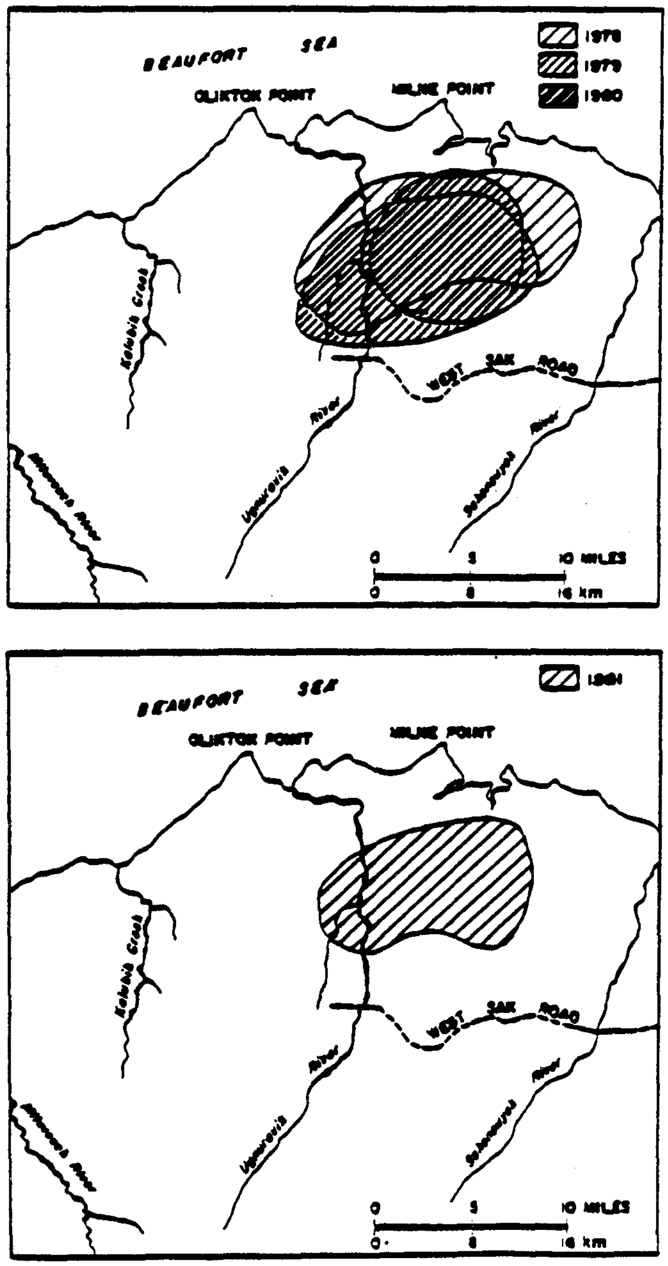

Fig. 5. Calving concentrations of the Central Arctic Herd, 1978-1981.

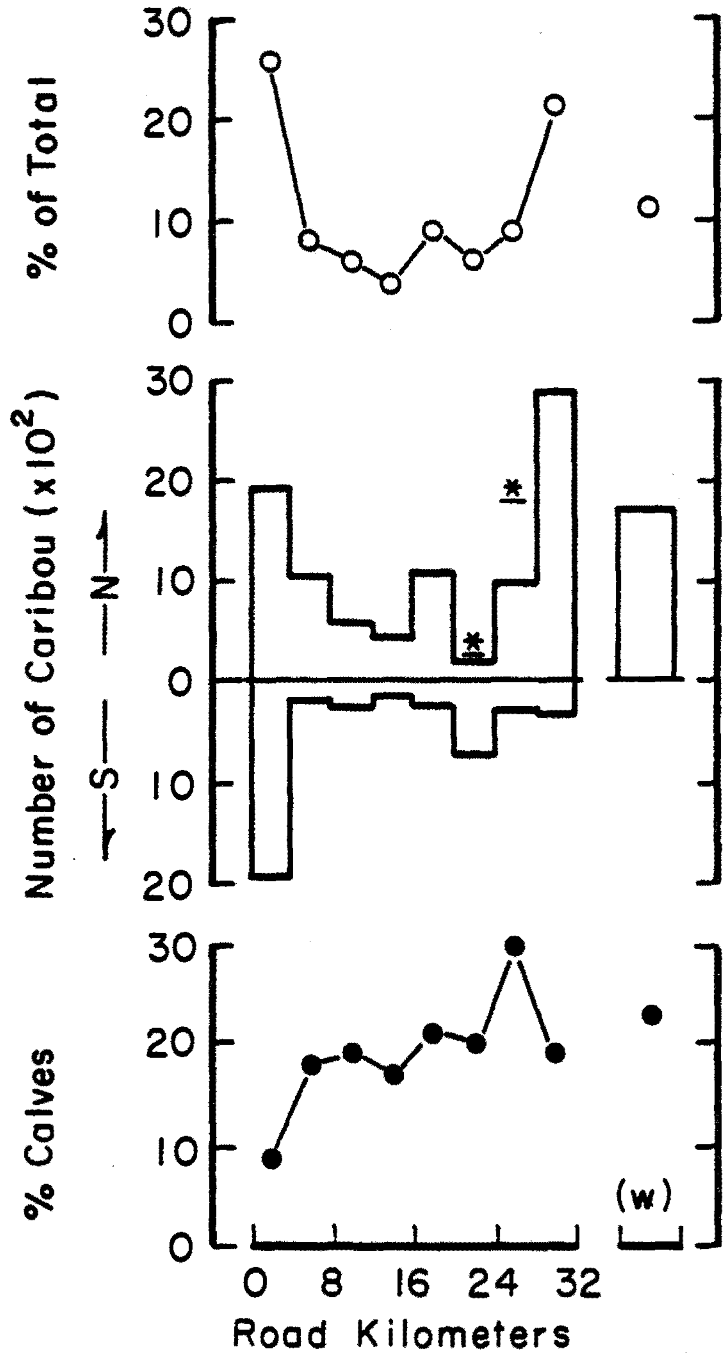

Fig. 6. Distribution of caribou observed from the West Sak Road, summer 1981. *Additional sightings from the northern access road east of the CPF (see Fig. 3).

Table 1. Numbers of caribou and group composition determined by aerial survey.

Inclusive dates	Total obs.		Total classified						Group w/calves[a]						Groups wo/calves[b]				
	N	G	N	G	%B	%C	%Ca	Y	N	G	%B	%C	%Ca	%Y	N	G	%B	%C	%Y
4/27-4/30/81	998	141	998	141	50	37	13	--	495	56	19	56	25	--	503	85	81	19	--
7/27-7/28/81																			
7/27[c]	2,059	12	2,059	12	23	42	27	7	2,059	12	23	42	27	7	--	--	--	--	--
7/28[d]	2,108	18	2,108	18	32	36	24	8	2,086	14	31	37	24	8	22	4	77	23	--
Total/Mean			4,167	30	28	39	25	8	4,145	26	27	39	26	8	22	4	77	23	--
10/25-11/7/81	1,712	145	1,712	145	33	41	26	--	1,639	119	31	42	27	--	73	26	88	12	--

[a] Total caribou in groups with 1 or more calves present.

[b] Total caribou in groups with no calves.

[c] Total west of Prudhoe Bay Complex.

[d] Total east of Prudhoe Bay Complex.

Note: N = number of caribou, G = number of groups, B = bulls, C = cows, Ca = calves, Y = yearlings.

Table 2. Number and group composition of caribou observed along the Dalton Highway, February-December 1981.

Survey dates	Total obs.		Total classified[a]							Group w/calves[b]							Group w/o calves[c]					
	N	G	N	G	%B	%C	%Ca	%Y	%A	N	G	%B	%C	%Ca	%Y	%A	N	G	%B	%C	%Y	%A
2/28 - 3/1 Winter summary[d]	579	51	383	47	14	7	7	5	67	125	8	3	21	21	13	42	258	39	19	0	1	80
3/11-3/12	962	69	539	61	3	0	5	0	92	234	19	0	2	12	0	84	305	42	6	0	0	94
3/25-3/26	825	79	456	62	3	0	5	0	92	116	11	0	2	19	0	79	340	51	4	0	0	96
4/9-4/10	839	64	433	47	1	0	10	0	89	188	12	0	0	23	0	77	245	35	2	0	0	98
4/23-4/24	350	44	308	41	58	0	9	1	33	92	7	13	0	29	0	58	216	34	77	0	1	22
5/13-5/14	622	88	612	85	54	11	5	5	25	119	17	9	34	28	3	26	493	68	65	5	5	25
5/27-5/28	209	52	205	51	45	7	0	9	39	0	0	--	--	--	--	--	205	51	45	7	9	39
Spring means[e]					25	3	6	2	64			3	6	21	1	69			34	2	3	61
6/9-6/10	182	51	182	51	78	0	1	2	19	3	1	0	0	33	0	67	179	50	79	0	2	19
6/24-6/25	269	36	269	36	80	1	1	0	18	9	2	11	33	22	0	33	260	34	83	0	0	17
7/10-7/11	491	45	453	44	89	1	0	0	10	4	2	0	0	50	0	50	449	42	89	1	0	10
7/28-7/29	452	44	452	44	49	1	15	0	35	299	3	26	0	23	0	51	153	41	94	1	1	4
8/8-8/9	168	30	168	30	96	1	1	0	2	2	1	0	50	50	0	0	166	29	98	0	0	2
8/26-8/29	45	24	45	24	82	4	4	0	9	5	1	0	40	40	0	20	40	23	93	0	0	7
Summer means[e]					75	1	5	0	19			25	3	24	0	48			88	0	1	11
9/13-9/14	63	21	63	21	54	10	11	3	22	27	6	22	18	26	4	30	36	15	77	3	3	17
9/27-9/28	197	7	151	6	32	3	11	0	54	142	5	32	3	12	0	53	9	1	22	0	0	78
10/12-10/13	1399	59	369	44	33	5	16	0	46	303	22	30	5	19	0	46	66	22	47	6	0	47
10/28-10/30	413	49	353	45	40	2	13	0	45	266	22	30	3	18	0	49	87	23	70	0	0	30
11/12-11/13	635	52	320	39	39	5	15	0	41	199	15	26	8	24	1	41	121	24	61	0	0	39
11/23-11/24	217	35	181	32	41	12	11	1	35	96	11	28	23	21	1	27	85	21	56	0	0	44
Fall means[e]					38	5	14	0	43			29	7	19	0	45			60	1	0	39
12/11-12/12[d]	252	35	179	31	30	11	8	1	51	73	9	18	26	19	1	36	106	22	38	0	0	62

[a] Excludes groups with any "unknowns" (unclassified as to sex or age).
[b] Total caribou in groups with 1 or more calves present.
[c] Total caribou in groups with no calves.
[d] One survey period only.
[e] Mean seasonal percentage for each sex/age class.

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

Table 3. Estimated daily traffic on the Dalton Highway, 1976-1981.[a]

	1976	1977	1978	1979	1980	1981
Spring[b]	287	383	102	65	78	190
Summer[c]	412	224	139	71	126	124[d]
Fall[e]	249	159	71	71	127	146
Totals	948	766	312	207	331	460

[a] Data compiled from Community Research Quarterly, Fairbanks North Star Borough, Vol. V, No. 1, April 1982, Fairbanks, Alaska. Estimates are based on enroute vehicle counts at highway check points south of the Brooks Range; additional local traffic is not included.

[b] March-May.

[c] June-August.

[d] Traffic count was taken at Disaster Creek bridge rather than the Yukon River bridge.

[e] September-November.

Table 4a. Caribou densities in the Kuparuk calving concentration area, 1978-81.

Year	Caribou/100 km^2	Cow-calf pairs/100 km^2
1978	281	112
1979	630	279
1980	276	90
1981	589	274

Table 4b. Group composition of Central Arctic Herd caribou on calving grounds, 1978-81.

Year	% calves	Calves/ 100 cows	Bulls/ 100 cows	Yearlings/ 100 cows
1978	36	82	3	39 (40)[a]
1979	37	85	7	26 (60)
1980	30	68	4	48 (50)
1981	40	85	9	22 (34)

[a] Numbers in parentheses are yearlings/100 cows estimated from overwinter calf survival counts.

Table 5. Composition of 1981 CAH postcalving aggregations east and west of the Prudhoe Bay Complex.

Region	% cows	Calves		Bulls		Yearlings		Total sampled
		%	/100 cows	%	/100 cows	%	/100 cows	
Kalubik River to West Dock	42	27	64	23	55	7	17	2,059
Deadhorse to Canning River	36	24	67	32	89	8	22	2,108

Table 6. Observed caribou crossings of the West Sak Road and/or the Kuparuk Pipeline, summer 1981.

	Road interval (km)								
From:	0.0	4.1	8.1	12.1	16.1	20.1	24.1	28.1	
To:	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	Total
No. of caribou	292	32	18	9	14	11	932	4	1,312
% of total	22	2	2	1	1	1	71	<1	100
% northbound	69	63	50	100	86	91	98	50	90
% calves	3	19	22	0	14	0	32	0	25

Table 7. Caribou sighting rates and insect harassment levels in the Kuparuk area during the period 18 July-5 August, 1978-1981.

Year	Insect harassment (no. days)			Sighting rate (caribou/km)
	Light	Moderate	Severe	
1978	2	9	8	2.7
1979	7	9	3	3.5
1980	11	6	2	3.1
1981	6	6	7	6.0

APPENDIX A

POPULATION DYNAMICS OF THE CENTRAL ARCTIC HERD, 1975-1981

K. R. Whitten and R. D. Cameron

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Population dynamics of the Central Arctic Herd, 1975-1981

Kenneth R. Whitten and Raymond D. Cameron

Whitten, K. R. & Cameron, R. D. 1982: Population dynamics of the Central Arctic Herd, 1975-1981. -- Acta Zool. Fennica 000:000-000.

The Central Arctic Caribou (Rangifer tarandus granti) Herd (CAH) ranges on Alaska's Arctic Slope in the vicinity of the Trans-Alaska Pipeline Corridor and Prudhoe Bay Oilfield. In 1975 the CAH was identified as a distinct subpopulation. By 1978, the herd numbered about 4,620 adults; the adult sex ratio was unusually high--a minimum of 1 bull per cow. A census conducted in 1981 indicated continued herd growth to an estimated 6,660 adults, with a decline in the adult sex ratio to about 80 bulls/100 cows. Yearling recruitment averaged 22% between 1978 and 1981. Actual herd growth was approximately 13% per year, implying an annual adult loss of 9%. Factors affecting this high rate of increase are discussed, as are the inherent difficulties in obtaining reliable population data, even from an intensively surveyed caribou herd.

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1. Introduction

The Central Arctic Caribou Herd (CAH) inhabits the region surrounding Prudhoe Bay and the Trans-Alaska Pipeline on Alaska's Arctic Slope (Cameron & Whitten 1979). Despite changes in range use patterns resulting from petroleum development (Cameron & Whitten 1980), ample alternative range remains available and the herd is increasing. This report deals with population dynamics of the CAH between 1975 and 1981.

2. Methods

CAH distribution and sex/age composition were examined regularly from 1975 through 1981. All surveys (Cameron & Whitten 1979, 1980) were conducted by helicopter. Groups of less than about 30 caribou were counted directly from the air. Otherwise, we landed nearby and used binoculars or a spotting scope to count and classify caribou. Sex/age classification was based on external genitalia and body size/morphology.

Minimum herd size was estimated during the postcalving period when most of the herd was aggregated in a few large, discrete groups. In 1978, the size of each aggregation was estimated from the air, followed by a direct count from the ground. In 1981, groups were either directly counted or photographed and counted later.

3. Results

3.1 Population composition and productivity

Proportions of males and females varied widely among seasons within each year, and also within a season between years (Table 1), primarily due to variable distribution of males and females among the count areas. Bulls were generally distributed farther south than cows during all seasons (Cameron & Whitten 1979). Therefore, bulls were underrepresented in surveys of the coastal calving and postcalving ranges. Attempts to obtain an accurate adult sex ratio were also frustrated by anomalies in local caribou distribution. Caribou were often evenly distributed over most of the coastal tundra during fall, but were concentrated along floodplains in the foothills and mountains. Since fall survey routes were along drainages, the southern groups were disproportionately counted; thus, bulls were overrepresented. During fall 1976, for example, 135 bulls/100 cows were observed along the survey route; however, there were 400 bulls/100 cows in the foothills and only 60 bulls/100 cows on the coastal plain. Weighting these ratios according to the estimated proportion of caribou in each area yielded a sex ratio of approximately 100 bulls/100 cows. This unusually high ratio (Bergerud 1978) could have resulted from an influx of caribou from the adjacent Western Arctic and/or Porcupine herds in the late 1960's and early 1970's. If so, the bull:cow ratio should have declined in the mid- to late 1970's as older male cohorts began to die of old age. Indeed, the preponderance of very large bulls observed in 1976 was no longer apparent by 1981. The adult sex ratio in fall 1981 was estimated at 81 bulls/100 cows, and no geographic variation was apparent.

Misclassification of yearlings and young bulls as cows probably occurred during midsummer. However, during calving, fall, and spring surveys, smaller groups were classified at close range by helicopter, and sex identification was positive. Results from those surveys provided the best estimates of calf survival. Initial productivity and oversummer survival were high for the 1977-1980 calf cohorts. Overwinter calf survival was excellent from 1977 through 1979 and moderately good in the 1976 and 1980 cohorts (Table 1).

3.2 Population size and rate of growth

The CAH numbered about 5,000 total caribou in midsummer 1975 (Cameron & Whitten 1979). During postcalving aggregation in 1978, the herd was estimated at 5,300-5,800. No census was attempted in 1979 or 1980.

The total count in summer 1981 was 8,537 caribou, substantially higher than in 1978. Neither the 1978 nor the 1981 count was an accurate census of the entire herd, however, because caribou dispersed inland were not counted. Difficulty in obtaining accurate composition data and/or the rapid dispersal of postcalving groups into peripheral areas precluded use of either standard or modified aerial photo-direct count-extrapolations (Davis et al. 1979). Thus, total population size could only be subjectively extrapolated. We conservatively estimated 6,000 caribou (4,620 adults) in 1978 and 9,000 (6,660 adults) in 1981.

The nearly 50% increase in the number of adult caribou in only 3 years can be accounted for by excellent productivity and recruitment. Assuming adult mortality of 7-13% per year in a lightly exploited population with moderate wolf predation (Bergerud 1978), recruitment would have been between 15 and 28% per year. Starting with an estimated 4,620 adults and 100 bulls/100 cows in 1978, and assuming 90 bulls/100 cows in 1979 and 80 bulls/100 cows in 1980, the 1981 adult population would have been between 5,971 and 7,294. Similarly, calculating backward from 6,660 adults in 1981 yields 4,216-5,152 adults in 1978. Both sets of calculated values bracket the actual estimates. The 13% annual increase and 22% average recruitment in the CAH between 1978 and 1981 indicate annual adult losses of about 9%.

4. Conclusions

Adult sex ratios in the CAH proved difficult to establish in spite of frequent composition counts based on 5-67% of the herd. Yearling classification was unreliable; consequently, rates of recruitment were calculated using late winter calf counts. Recruitment was undoubtedly good, and the CAH surely increased between 1975 and 1981. From 1978 to 1981, the observed growth rate of the CAH was about 13% per year. Potential increase, based on empirical values of mortality, was even higher. Emigration of individual caribou from the study area (Whitten & Cameron, unpubl. rep.) could partially account for the disparity between potential and measured growth. Clearly, accurate rates of mortality, additional data on caribou emigration, and/or more accurate censuses are required to more fully understand dynamics of the CAH.

Acknowledgments

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Table 1. Sex and age composition of the Central Arctic Caribou Herd, 1976-81.

Year	Season	Cows %	Calves %	Yrlgs %	Bulls %	Total
1976	Postcalving	41	18	6	35	1389
	Rut	36	17	3	44	1223
	Spring	48	16	--[a]	36	889
1977	Postcalving	41	23	6	30	3847
	Rut	32	20	10	38	628
	Spring	56	23	--	21	351
1978	Calving	44	36	17	1	964[b]
	Postcalving	45	25	7	23	4043
	Rut	36	23	7	34	816
	Spring	40	24	--	36	499
1979	Calving	46	37	11	3	1923[b]
	Spring	36	18	--	45	1309
1980	Calving	45	31	22	2	787
	Rut	33	17	6	44	1728
	Spring	37	13	--	50	998
1981	Calving	46	40	10	4	3337
	Postcalving	39	25	8	28	4167
	Rut	41	26	--	33	1712

[a] "Long" yearlings classified as adult cows or bulls.
[b] Total includes some unclassified adults.

APPENDIX B

RESPONSES OF CARIBOU TO INDUSTRIAL DEVELOPMENT ON ALASKA'S ARCTIC SLOPE

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Responses of caribou to industrial development
on Alaska's Arctic Slope
Walter T. Smith & Raymond D. Cameron

Smith, W. T. & Cameron, R. D. 1982: Responses of caribou to industrial development on Alaska's Arctic Slope. -- Acta Zool. Fennica 000:000-000.

Barren-ground caribou (Rangifer tarandus granti) of the Central Arctic Herd (CAH) were surveyed repeatedly from the road network of the oilfield complex near Prudhoe Bay, Alaska. Between mid-June and mid-August 1978, we observed 1,694 caribou within or adjacent to this Prudhoe Bay Complex, with an overall average of 10% calves; by comparison, corresponding aerial surveys within the general region yielded a minimum estimate of 23% calves. Data on locally depressed calf percentages complement previous findings that females with young calves tend to avoid the Trans-Alaska Pipeline Corridor and indicate greater effects in areas of industrial activity.

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1. Introduction

In 1975, studies were initiated along the Arctic Slope portion of the Dalton Highway (the supply road for the Trans-Alaska Pipeline) to monitor the effects of pipeline construction and operation on caribou distribution. Ground observations along the Dalton Highway (DH) were compared with corresponding aerial survey data obtained within the range of the Central Arctic Herd (CAH) (Cameron & Whitten 1980). The distribution and group sex/age composition of caribou in the vicinity of the pipeline corridor differed substantially from corresponding observations in the surrounding region. By 1977, the calf proportion along the corridor had declined to 13% of that in the general region, and relatively fewer caribou were observed in the coastal segment of the corridor than expected on the basis of aerial survey results.

Existing and proposed sites of petroleum development on the Central Arctic coastal plain coincide roughly with the calving grounds and summer range of the CAH. In recent years, calving activity within the Prudhoe Bay Complex (PBC) has been substantially lower than in adjacent areas to the east and west (Cameron et al. 1979, Cameron & Whitten 1980, unpubl. rep.) Such decreased local use by calving caribou has paralleled a steady increase in activity associated with oil exploration, production, and transport. Our principal concerns involve the potentially detrimental effects of further industrial expansion on caribou calving success, range occupancy, movements, and, ultimately, herd productivity.

The purpose of this study was: (1) to determine the distribution and group composition of caribou within the PBC; and (2) to compare these variables with similar data obtained in (a) that portion of the standard DH survey within the PBC, and (b) the newly initiated development within the Kuparuk Development Area (KDA).

2. Materials and methods

Systematic bimonthly surveys were conducted by light truck along the Arctic Slope portion of the DH (Cameron et al. 1979), including 23 km of road within the PBC (Fig. 1) that overlap with the more extensive PBC surveys. Only DH survey results from this northernmost segment of road are used for comparison.

At irregular intervals between June 12 and August 16, 1978, 26 surveys were conducted by light truck within the PBC along 65 km of existing roads (Fig. 1). In addition, between July 18 and August 18, 1978, 28 surveys were completed within the KDA, along the 32-km West Sak Road (WSR). Survey methods were similar to those reported previously (Cameron et al. 1979).

3. Results and discussion

Of the 1,694 caribou classified during the 26 intensive PBC surveys, 10% were calves (Table 1), which is substantially lower than estimates of 16-26% calves reported earlier by Child (1973) and White et al. (1975). By comparison, regional calf percentages determined by 3 aerial surveys on the Central Arctic coastal plain in summer 1978 ranged from 23 to 36% (Cameron & Whitten 1980, unpubl. rep.). Low calf numbers indicate avoidance of the PBC by cow/calf pairs. This conclusion is consistent with previous reports of the sensitivity of cows with neonatal calves to disturbance (Lent 1966, Bergerud 1974). Caribou group composition did not vary appreciably within the PBC. Calf proportions were 11% (N = 328) west of the Putuligayuk River, 9% (N = 784) east of the Sagavanirktok River, and 11% (N = 582) within the remainder of the PBC--all similar to the combined summer percentage.

The shaded portion of Fig. 1 defines the "core" area of intensive industrial activity. This area is almost entirely circumscribed by roads and pipelines and represents approximately 30% of PBC survey coverage. The numbers of groups, calves, and total caribou observed within this core area were all significantly lower ($P<.001$) than the respective values for the remainder of the PBC. These differences indicate the various linear structures, facilities, and related industrial activities together represent an impediment to caribou access.

The mean of 11% calves observed along the northern portion of the DH is similar to the 10% figure observed within the PBC. Both estimates are approximately one-half the average of 19% calves recorded for the previous 3 summer DH surveys within the PBC (unpubl. data). Thus, data gathered from the PBC section of the DH survey in 1978 were representative of the entire complex. Both sets of results indicate a decrease in range occupancy compared with 1975-77 estimates.

The WSR was chosen as a control site for comparison with the PBC. After its opening on July 18, 1978 construction activity and traffic intensity remained low throughout that summer. The estimate of 26% calves along the WSR was similar to that obtained by corresponding aerial survey (Cameron & Whitten 1980), indicating that caribou along the WSR were representative of the regional population. Calf percentages for groups at various distances (i.e., <500 m, 500-1,000 m, >1,000 m) from the WSR were not significantly different; the mean calf percentage of groups crossing the road was representative of regional values.

The mean calf percentage in the PBC, whether determined by the comprehensive PBC survey or the northern portion of the DH survey, was significantly lower than either the regional or WSR calf percentages. The relative density of caribou along the road system, as indicated by sighting rates (Table 1), was also lower within the PBC. These data indicate a substantial effect of industrial activity on caribou composition and distribution, and these changes are accentuated in areas of intense activity.

4. Acknowledgments

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Table 1. Composition and sighting rates of caribou during road surveys in the Prudhoe Bay Complex area during summer 1978.

	Total classified	Number of groups	Percent calves	Sighting rate* (number/km surveyed)
Prudhoe Bay Complex	1,694	216	10	1.26
Dalton Highway**	83	19	11	0.30
West Sak Road	827	154	26	1.86

* Includes caribou of unknown sex or age.
**Within the PBC.

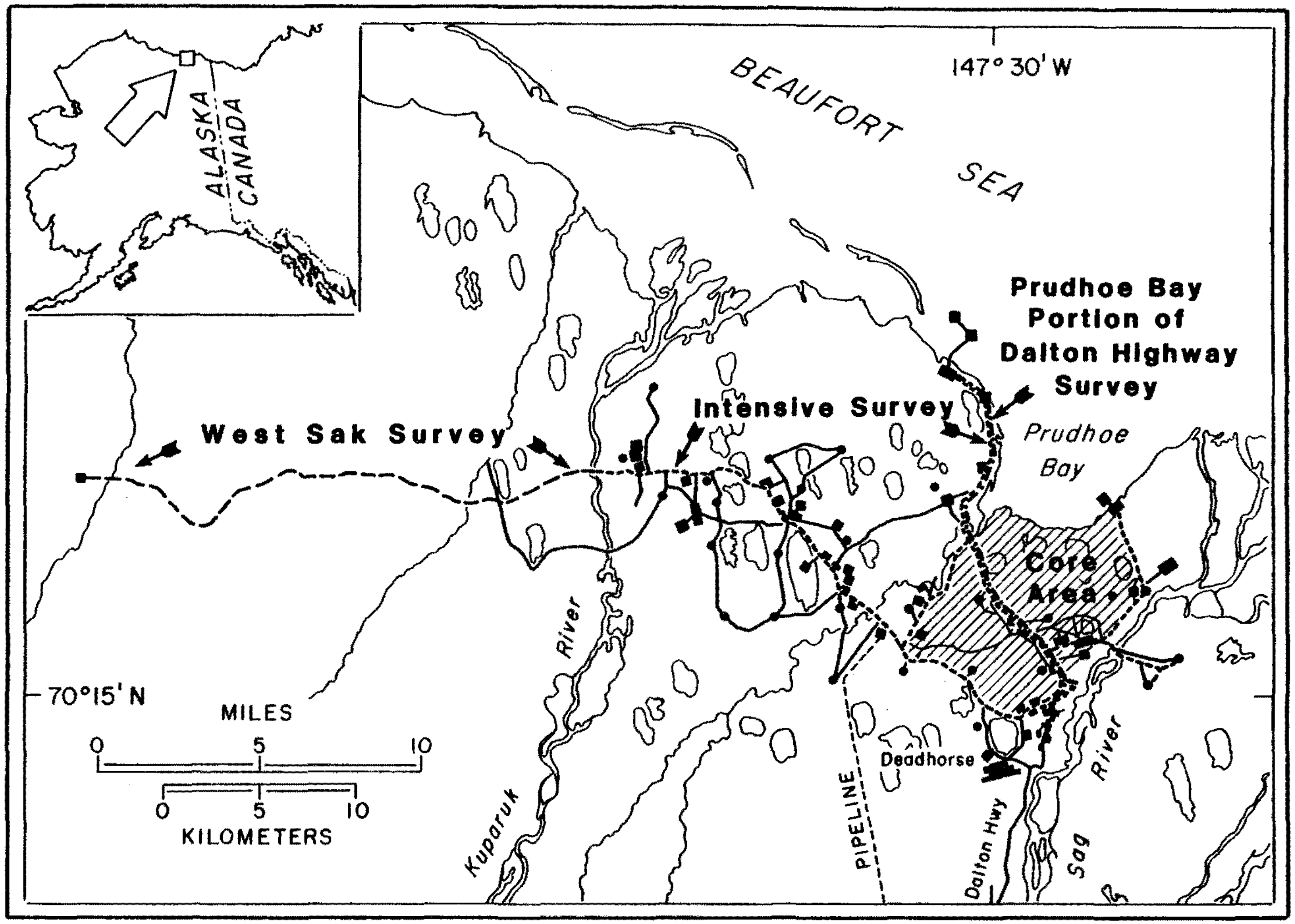

Fig. 1. Survey coverage, Prudhoe Bay area.

APPENDIX C

SURVEY-INVENTORY PROGRESS REPORT

CENTRAL ARCTIC HERD, 1981-82

K. R. Whitten and R. D. Cameron

In: Annual Report of Survey-Inventory Activities (J. A. Barnett, ed.), Vol. XIII. 1983.

CARIBOU

SURVEY-INVENTORY PROGRESS REPORT

GAME MANAGEMENT UNIT: 26B

HERD: Central Arctic

PERIOD COVERED: July 1, 1981-June 30, 1982

Seasons and Bag Limit

Aug. 10-Oct. 15 Feb. 15-Apr. 15	Three bulls

Population Status and Trend

The Central Arctic Herd (CAH) has grown continuously since it was first recognized as a distinct subpopulation in 1975. The CAH was estimated at 9,000 (6,660 adults) in July 1981, having increased at a rate of approximately 13% per year since 1978. Rapid herd growth is attributable to excellent calf production and survival and low adult mortality.

Industrial development near Prudhoe Bay and the Trans-Alaska Pipeline corridor continues to affect the local distribution of CAH caribou. Cows and calves avoid these areas of intensive activity.

Population Composition

Results of composition surveys are shown in Appendix A. Survey conditions were generally good, although a few areas of low visibility precluded complete coverage of the easternmost portion of the CAH range during fall and spring; however, earlier reconnaissance indicated that very few caribou were present in those areas.

CAH calf production and survival were excellent in 1981-82. The postcalving and fall surveys yielded reliable estimates of overall herd composition. The high bull:cow ratio obtained in spring resulted from counts of several unusually large bull groups in valleys of the Brooks Range; cows were already moving north in widely scattered bands. Nevertheless, the results clearly indicated low overwinter calf mortality and, consequently, high yearling recruitment to the herd.

Mortality

Ninety-eight people reported hunting CAH caribou during the 1981-82 season; 65 successful hunters harvested 95 caribou. The majority of successful hunters (75%) took only 1 caribou, while

20% took 2 each, and only 12% reached the bag limit of 3. In addition, 1 person harvested 5 CAH caribou from Subunit 26C, where a higher bag limit was in effect.

As in previous years, about half of those hunting CAH caribou flew into the area, while most others used the haul road (Dalton Highway) for access. Fly-in hunters had a higher success rate (87% vs. 52%) but killed fewer caribou per person than did successful road hunters. The higher average take among road hunters is attributable to a few, more successful, individuals using snow machines or off-road vehicles.

Only 1 Nuiqsuit resident and 2 Kaktovik residents reported hunting the CAH. In addition, Kaktovik residents reportedly took 25-40 CAH caribou from the Canning River delta in late July 1981 and an unknown number (probably 25 or fewer) from the Sadlerochit Mountains in May 1982. Both areas are in Subunit 26C, where the season was open July 1-March 31. The harvest by Nuiqsuit residents was probably less than 50 caribou, some of which were taken during the closed season.

Management Summary and Recommendations

The CAH has been increasing by approximately 13% per year since 1978 and currently numbers about 9,000 (6,660 adults). The long-term welfare of the herd may be compromised on its calving grounds and summer range by rapidly expanding petroleum development. The Department should continue to conduct studies as necessary, to advise industry and other agencies of possible conflicts, and to contribute toward the development and implementation of mitigative policies.

Sport harvest of the CAH is low relative to herd size and productivity. However, harvest is increasing with greater use of the haul road and as more fly-in hunters discover the area. There is currently a surplus of bulls, however, and limiting harvest to bulls should accommodate sport hunters without affecting herd productivity.

Harvest of CAH caribou by Kaktovik residents occurs in Subunit 26C, where longer seasons and larger bag limits apply, but that take is presently inconsequential to overall population status. Although the current harvest by Nuiqsuit residents is low, a few cows are probably taken, and some hunting apparently occurs after the legal season. The open season should remain "bulls only," and harvest of CAH cows should be discouraged through strict enforcement of the regulations. Nuiqsuit residents will have ample opportunity to fill additional needs for caribou in Subunit 26A, where very liberal seasons will be in effect next year.

The current closed season from October 16-February 14 was implemented to prevent the taking of rutting bulls in poor condition. This restriction probably has little effect on total harvest and could be eliminated or reduced to October 16-November 15. The bag limit of 3 bulls, however, should remain in effect.

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APPENDIX A. Sex and age composition counts of the Central Arctic Herd, 1981-82.

Season	Cows		Calves			Yearlings			Bulls			Total
	No.	%	No.	%	/100C	No.	%	/100C	No.	%	/100C	
Calving (June)	1,535	46	1,335	40	85	334	10	22	133	4	9	3,337
Postcalving (July)	1,625	39	1,042	25	65	333	8	20	1,167	28	70	4,167
Rut (October)	699	41	448	26	64	--[a]	--	--	565	33	81	1,712
Spring (April/May)	747	35	451	21	60	--	--	--	926	44	124	2,124

[a] Yearlings classified as adult cows or bulls.

Appendix D. Survey observations on the calving grounds of the Central Arctic Herd, 11-14 June 1981.

Obs. No.	Total No.	B	C	Ca	Y	Obs. No.	Total No.	B	C	Ca	Y
1	4	1	2	1		37	6		3	3	
2	4	2			2	38	9		4	4	1
3	10	7			3	39	2		1	1	
4	5	3			2	40	4		1	1	2
5	6	6				41	8		2	2	4
6	8	2			6	42	2		1	1	
7	11	8			3	43	3		2		1
8	3				3	44	2				2
9	4	1			3	45	8		4	3	1
10	16	10	1	1	4	46	2				2
11	3				3	47	1				1
12	3		1	1	1	48	7		2	2	3
13	18		6	2	10	49	1				1
14	77		32	31	14	50	3	1			2
15	9	1	3	1	4	51	20		11		9
16	4		1		3	52	1		1		
17	6		3	2	1	53	13		7	6	
18	9		3	3	3	54	5		2		3
19	17		8	6	3	55	5		2	3	
20	17		6	6	5	56	2				2
21	2		1	1		57	5		2	2	1
22	1				1	58	2		1	1	
23	3		1		2	59	98		56	39	3
24	6	2			4	60	4		2	2	
25	6		3		3	61	10		5	5	
26	4				4	62	10		5	5	
27	12		5	4	3	63	20		10	10	
28	6		3	2	1	64	9		4	3	2
29	6	1	2	2	1	65	6		3	3	
30	23		10	6	7	66	2		1	1	
31	10		4	4	2	67	4		2	2	
32	21		11	10		68	6		3	3	
33	6		3	3		69	31		15	15	1
34	54		28	21	5	70	11		6	5	
35	17		8	7	2	71	9		4	4	1
36	5		3	2		72	1				1

Appendix D. Survey observations on the calving grounds of the Central Arctic Herd, 11-14 June 1981. (Continued)

Obs. No.	Total No.	B	C	Ca	Y	Obs. No.	Total No.	B	C	Ca	Y
73	9		5	4		109	26		14	11	1
74	3	1			2	110	34		17	17	
75	29		15	14		111	13		7	5	1
76	8		3	2	3	112	1		1		
77	5		3	2		113	9		2	1	6
78	22		10	9	3	114	13	3	3	2	5
79	36		18	18		115	30		15	15	
80	116		57	56	3	116	33		17	15	1
81	13		6	6	1	117	9		5	4	
82	20		10	9	1	118	2		1	1	
83	2				2	119	5		2	2	1
84	2				2	120	43		21	21	1
85	2		1		1	121	4		2	2	
86	14		7	7		122	13		6	5	2
87	4				4	123	2		1	1	
88	2		1		1	124	4		2	1	1
89	3		1		2	125	1		1		
90	4		2	2		126	4		2	2	
91	2		1	1		127	11		4	4	3
92	2		1	1		128	4		2	2	
93	4		2	2		129	1				1
94	2				2	130	19		9	7	3
95	1				1	131	14		8	6	
96	4		2		2	132	17		9	7	1
97	2		2			133	9		4	3	2
98	17		8	6	3	134	2				2
99	50		25	25		135	31		15	13	3
100	32		16	16		136	25		13	12	
101	36		18	17	1	137	37		19	18	
102	9		4	4	1	138	19		10	9	
103	22		11	11		139	11		6	4	1
104	10		5	5		140	2		1		1
105	42		22	20		141	5	1	2	2	
106	22		11	11		142	8		3	2	3
107	20		10	10		143	2		1	1	
108	14		7	7		144	20		8	8	4

Appendix D. Survey observations on the calving grounds of the Central Arctic Herd, 11-14 June 1981. (Continued)

Obs. No.	Total No.	B	C	Ca	Y	Obs. No.	Total No.	B	C	Ca	Y
145	3		1	1	1	206	2		1		1
146	3	1			2	207	2		1	1	
147	3		2		1	208	1		1		
148	1	1				209	11		4	4	3
149	3				3	210	21		9	8	4
150	5		2	2	1	211	20		9	7	4
151	7		3	3	1	212	2	2			
152	7		3	3	1	213	2		1		1
153	4		2	2		214	2		1	1	
154	4		2	2		215	28		13	13	2
155	1				1	216	85		42	40	3
156	4		2	2		217	152		78	70	4
157	3	1	1		1	218	50		26	24	
158	11	9			2	219	3		2	1	
159	1	1				220	2		1		1
160	4		2		2	221	5		3	2	
161	4	2	1		1	222	6	4			2
162	4	4				223	6	5			1
163	1	1				224	2		1	1	
164	10		5	5		225	43		25	17	1
165	2		1	1		226	32		16	14	2
166	2		1	1		227	22		11	11	
167	5		3	2		228	66		35	31	
168	6		3	3		229	3		2		1
169	20		10	10		230	104		56	47	1
170	11		5	5	1	231	60		30	30	
171	14		7	7		232	50		26	24	
172	21		11	9		233	8		5	3	
173	6		3	3		234	5		3	2	
174	2		1	1		235	13		5	4	4
200	2		1	1		236	2		1	1	
201	20		13	5	2	237	14		8	6	
202	3	2			1	238	55		29	26	
203	3		2	1		239	10		5	5	
204	3	1	2			240	26	2	13	11	
205	8	6			2	241	54		28	26	

Appendix D. Survey observations on the calving grounds of the Central Arctic Herd, 11-14 June 1981. (Continued)

Obs. No.	Total No.	B	C	Ca	Y
242	7	1	5	1	
243	18		9	9	
244	4		2	2	
245	2		1	1	
246	2		1	1	
247	4		2	2	
248	2		2		
249	9		5	4	
250	7	3	2		2
251	1	1			
252	27		15	12	
253	8		4	4	
254	2		1	1	
255	28		11	8	9
256	4				4
257	17		8	5	4
258	34		19	13	2
259	6		3		3
260	1		1		
261	1		1		
262	5	2	2		1
263	14	2	3	2	7
264	4		2		2
265	4		2		2
266	3		1		2
267	2		1	1	
268	2		1		1
269	4		1		3
270	4		2	2	
271	2		1	1	
272	2		1	1	
273	15	9	3		3
274	3		1		2
275	2	1			1
276	2	2			
277	2		1	1	
278	1	1			
279	2		1		1
281	3		2	1	
282	3	3			
283	2		1	1	
284	3	3			
285	2	2			
286	2		1		1
287	1	1			
288	4	4			
289	2		1	1	
290	23		12	11	
291	8		3	2	3
292	17	8	2		7
293	5		4	1	
294	13	4	8	1	
295	1		1		
296	2		1		1
297	5		2		3
298	12		6	6	
299	9		5		4
300	7		5		2
301	41		21	14	6
302	40		21	17	2
303	4	2	1	1	
304	5		3		2
305	2	2			
Totals	3468	143	1662	1336	367

B = bulls, C = cows, Ca = calves, Y = yearlings

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

APPENDIX E

A Draft Issue Paper on
CARIBOU AND PETROLEUM DEVELOPMENT
Alaska Department of Fish and Game

November 1982

ISSUE PAPER NO.   : CARIBOU AND PETROLEUM DEVELOPMENT

I. ISSUE

Intensive petroleum-related development on Alaska's Arctic Slope is not compatible with barren-ground caribou (*Rangifer tarandus granti*). Surface alteration has resulted in displacement of Central Arctic caribou from previously occupied components of range. Although, to date, losses of habitat have been localized, apparently with no adverse effects on herd productivity, uncontrolled or improperly planned future development on State and Federal lands could remove large areas of caribou habitat, with potentially serious consequences to all of the Arctic herds. Caribou represent a valuable recreational and subsistence resource. State and Federal land management agencies should fully acknowledge the conflicts associated with industrial activity and adopt more conservative policies of subsurface leasing and surface development.

II. BACKGROUND:

Virtually the entire Arctic Slope may be considered caribou habitat. The Western Arctic, Teshekpuk, Central Arctic, and Porcupine herds (totaling nearly 300,000 caribou) all occupy this region during 2 or more phases of their annual cycle (Hemming 1971, Davis 1980). Currently, only the Central Arctic Herd is in contact with intensive industrial activity. However, considering the potential for rapid development, it is conceivable that all 4 herds will be affected simultaneously on various portions of their respective ranges. Primary concerns are based on studies in the Central Arctic region, other reports on caribou behavior, nutritional requirements, and theoretical considerations regarding the value of various habitats.

Parturient and postpartum caribou appear to be generally intolerant of stressful surroundings and seek areas of little or no disturbance. In fact, intensive oilfield development may result in virtual abandonment of areas previously occupied during calving. Such displacement apparently has occurred in response to industrial growth near Prudhoe Bay (Cameron et al. 1979; Cameron and Whitten 1980; Smith and Cameron 1983). Numerous other reports cite the heightened sensitivity of female caribou immediately before, during, and following parturition (de Vos 1960; Lent 1964, 1966a; Kelsall 1968; Bergerud 1974; Roby 1978).

The possible consequences of displacing female caribou from preferred calving areas have been the subject of considerable debate and speculation. Although there is no precedent involving industrial inundation of calving grounds, various concerns regarding increased neonatal mortality have a firm basis in evolutionary theory. From a natural selection point of view, it is illogical that female caribou in relatively poor condition would undertake early spring migration to such areas if no net advantage was to be realized. Early snow melt, advanced emergence of new vegetation, scarcity of predators, and/or proximity to insect relief habitat have been cited as advantages related to the selection and repeated use of specific calving areas (Lent 1964, 1966b;

Kelsall 1968; Skoog 1968). The calving grounds of all 4 Arctic herds are each characterized by at least 2 of these attributes.

Under some circumstances, the calving environment may be crucial to calf production and/or subsequent survival. Thus, if caribou attain maximum fat stores by fall and encounter ideal winter conditions, use of suboptimal calving habitat may be little more than an inconvenience. However, given nutrient deficiencies in summer or during a winter of heavy snowfall, surviving female *Rangifer* enter the spring season in poor condition (Cameron and Luick 1972; Dauphiné 1976), yet are faced with the stresses of late pregnancy, parturition, and lactation. Loss of access to favorable calving areas might then be catastrophic to calving caribou, their offspring (Miller 1974a), and, ultimately, to the herd itself. Displacement to an area of abundant predators would have more direct, and potentially more severe, consequences. Considering the fundamental importance of the calving process itself and the distinctive physical characteristics of traditional calving grounds, free access of parturient caribou to these areas should be maintained to the greatest extent possible.

Avoidance of intensively developed areas by cows and calves also extends through the summer months. Calf percentages observed from road systems within the Prudhoe Bay Complex and the Trans-Alaska Pipeline (TAP) Corridor have been substantially lower than comparable regional values determined by aerial survey (Cameron et al. 1979; Cameron and Whitten 1980, 1982). Again, such displacement may be of a matter for concern, depending on the size and character of the area in question. Postpartum female caribou, in particular, must consume adequate amounts of high-quality forage to replenish body reserves and to meet the increased metabolic demands of lactation (White and Luick 1976; Luick et al. 1980; Kuropat and Bryant 1980). Similarly, calves must maximize forage intake during this period; adequate summer growth is critical to subsequent survival (Haukioja and Salovaara 1978).

Insects are a strong force in the summer ecology of caribou. Daily movements are closely related to the emergence and activity of mosquitos and Oestrid flies (Curatolo 1975; Roby 1978). Insect activity varies directly with temperature and inversely with wind velocity (White et al. 1975). On warm, calm days Central Arctic caribou move rapidly to coastal sand dunes, river deltas, and offshore islands; typically, such areas are sparsely vegetated and exposed to cool breezes. With an abatement of insect attack, caribou drift inland. Thus, oscillatory movements occur between coastal habitat and inland feeding sites (White et al. 1975; Cameron and Whitten 1982). The Teshekpuk Herd responds similarly to insect harassment, occupying areas near the barren beaches of Harrison Bay (P. Reynolds, unpubl. observ.). The Western Arctic Herd, however, utilizes primarily altitudinal relief areas in the western foothills of the Brooks Range (Skoog 1968; J. Davis, unpubl. observ.). Porcupine Herd caribou combine coastal-inland oscillations with altitudinal movements during postcalving migrations between Alaska and the Yukon Territory (Whitten and Cameron, unpubl. observ.).

Despite topographic differences in insect relief habitat, use of such areas is consistently beneficial. The ecological strategy is maximum intake of the highest quality forage available and minimum expenditure of energy. Apparently the energy cost of moving to insect relief habitat, where forage may be less abundant, is more than offset by the energy savings associated with reduced insect harassment (White et al. 1981); a decline in insect activity is accompanied by a prompt return to grazing areas (Cameron and Whitten 1982).

Considered collectively, caribou summer movements and the related changes in habitat use (Roby 1978) are closely linked to forage preference (Skogland 1980; White et al. 1981) and, ultimately, to the success of summer growth and fattening (Reimers 1972; Dauphine 1976). The nutritional status of caribou entering the fall season may, under some circumstances, be an important determinant of overwinter survival (White et al. 1981). In addition, females in poor condition tend to be characterized by low reproductive performance (Dauphine 1976; Parker 1981; E. Reimers, unpubl.). Therefore, preserving free movements of caribou between the various components of summer range is highly desirable. As insect relief sites, coastal deltas warrant special attention because of their limited size and occurrence.

Displacement of cows and calves by industrial activity also occurs in fall (Cameron and Whitten 1980, unpubl.), and similar problems during winter and early spring are possible. However, these conflicts are ostensibly less important than those on calving and summer habitats, principally because options for suitable winter ranges are generally numerous; indeed, caribou winter distribution itself is extremely variable. Nevertheless, petroleum development of sufficient overall magnitude could reduce the usable amount of any seasonal habitat below the minimum required to support a given caribou herd.

Regardless of seasonal differences in the nature or level of conflict with industrial activity, concerns for the future status of caribou on the Arctic Slope are based on one fundamental assumption: access to various habitats has survival value to caribou. Traditional movements and overall patterns of range occupancy are consistent with forage phenology and availability (Klein 1970; Chapin et al. 1975; White et al. 1981; Whitten and Cameron 1980), and are sustained further by dominant individuals and social facilitation (Espmark 1970; Miller et al. 1972; Klein 1980). The phases of the caribou annual cycle, and the specific concerns applicable to each, cannot be viewed in isolation, but rather as an interdependent sequence of events. Substantial perturbation of one phase will likely result in reduced success of another.

Numerous reports have dealt with the responses of caribou to man-made linear structures (Child 1974, 1975; Miller et al. 1972; Banfield 1974; Hanson 1981; Johnson and Todd 1977), sensory disturbances (de Vos 1960; Lent 1964, 1966a; Bergerud 1974; Calef et al. 1976; Miller and Gunn 1979; Horejsi 1981), and various combinations of stimuli that typify petroleum-related development (Klein 1971, 1980; Miller 1974b; Cameron et al. 1979; Kelsall and Klein 1979; Cameron and Whitten 1980; Whitten and Cameron 1982). Despite these and a plethora of unpublished studies, analyses and literature reviews, our understanding of caribou disturbance behavior remains largely incomplete. However, some general criteria for pipeline design, special crossing structures, and seasonal disturbance limitations have been developed and are routinely recommended for incorporation into various permit stipulations. Several additional studies are now in progress, and the results should enable a refinement of the current guidelines.

Although site-specific conflicts can be mitigated to a certain degree, concerns involving the cumulative effects of large-scale surface development have not been addressed. Unfortunately, combinations of physical and sensory disturbance are extremely difficult to quantify, and, consequently, there is no rational basis for specifying the precise nature and level of regional development permissible within caribou range.

Major oilfields are among the principal threats to caribou habitat. Within these complexes the proximity of processing centers, camps, and support facilities may be extremely important in terms of disturbance effect; that is, whether caribou perceive various oilfield components as separate entities or as related structures which together constitute a single larger stimulus. Certainly, connecting roads, pipelines, and associated traffic would further intensify the disturbance effect. On a regional level, proximate complexes with connecting transportation networks may preclude or reduce caribou occupancy of, or movements through, large areas of otherwise usable habitat. In the extreme case, special use areas (e.g., calving grounds, insect relief habitat) might be lost, effectively reducing carrying capacity of the range.

Retaining adequate size and diversity of caribou habitat is the most important goal. Acceptable productivity of the Central Arctic Herd (Whitten and Cameron 1983), despite local displacement, suggests that suitable alternate habitats remain. Preserving such options, both locally and regionally, is essential to the continued well-being of this as well as the other Arctic herds.

III. CURRENT SITUATION:

At present, only State lands in the mid-Beaufort region are affected by petroleum development. Virtually all subsurface rights between the Colville and Canning Rivers, south to about 69°40'N latitude, have been leased or are scheduled to be leased within the next 4 years. This constitutes a band of the Arctic Coastal Plain approximately 150 km long and 80-100 km in width. Until recently, major development has occurred only between the Kuparuk and Sagavanirktok Rivers, from the coast line inland to Deadhorse airport. This Prudhoe Bay Industrial Complex (PBC) lies within the Prudhoe Bay Production Unit (PBU). The complex is the site of intensive activity and consists of a maze of roads, several support/processing facilities, a complex of above-ground pipelines, 2 major airports, and numerous private businesses. West of the Kuparuk River, widespread construction is underway in ARCO's 3-phase Kuparuk Development Area (KDA); Phase I production commenced in early 1982.

There are a number of imminent development scenarios on the central Arctic Slope. Within the PBU, ARCO's oilfield network has expanded across the west channel of the Sagavanirktok River, and SOHIO's production facilities now extend west of the Kuparuk River. In addition, SOHIO/EXXON's man-made islands off the Sagavanirktok Delta are rapidly approaching the production phase. Farther to the east, ARCO, SOHIO, EXXON, Chevron, Mobil, and Shell are actively engaged in exploration. Development of EXXON's Point Thomson field appears probable.

Impending development west of the Kuparuk River includes massive expansion of KDA production facilities, smaller SOHIO and Mobil projects, and a separate CONOCO unit at Milne Point. As a further complication, KDA expansion will include construction of a large airport, a new dock at Oliktok Point, and a North Slope Borough "industrial park." Eventual development of offshore reserves will contribute further to the expanding infrastructure onshore, with a corresponding increase in the level of associated activity. In summary, it appears likely that regional petroleum development will continue to expand and intensify, encompassing the majority of existing and proposed State lease tracts, some 1.4 million ha.

Considerable petroleum development on adjacent Federal lands also appears probable. National Petroleum Reserve-Alaska (NPR-A) lease sales in 1982 consisted of 400,000 ha of subsurface rights. An additional 800,000 ha will be offered for sale annually. Within the Central Arctic Management Area (CAMA) 1 million ha or more will be available for leasing in the near future. The Federal mandate to explore the coastal portion of the Arctic National Wildlife Refuge (ANWR) may ultimately open an additional 650,000 ha to development.

If all lands identified as having oil and gas potential are eventually developed, approximately 12.5 million ha, nearly 60% of the Arctic Slope, would be involved. Although simultaneous exploitation of such a vast area is improbable, it is unrealistic to presume that the distribution, intensity, and timing of future surface development will be fortuitously in harmony with caribou.

To some extent, lack of development foresight is a reflection of limited geotechnical data and economic unknowns. Preliminary exploratory data are neither entirely conclusive nor adequate for meaningful projections; detailed seismic testing and confirmation drilling are required to delineate and characterize each reservoir. Ultimately, crude oil prices, which are notoriously variable, dictate the feasibility of developing a given reserve.

Because of these uncertainties, exploration and production often occur simultaneously in adjacent areas, each proceeding independently in a piecemeal fashion. Hence, the oilfield complex near Prudhoe Bay has emerged as a seemingly haphazard matrix of roads, pipelines, and facilities. Access is frequently redundant, production lines pose physical impediments to caribou movement, and little attempt has been made to consolidate and centralize support and production activities. Widespread disturbance within the PBC has resulted in losses of caribou habitat (Smith and Cameron 1983). Future planning and coordination must deal more effectively with all aspects of development, from leasing to termination.

Many of the undesirable effects of industrial activity can be successfully mitigated; others clearly cannot, given the present development philosophy. Direct harassment (e.g., helicopter overflights, ATV activity) can presumably be minimized through appropriate regulations, stipulations, and company operating policies. Similarly, improved pipeline design will hopefully minimize physical impediments to caribou movement. In contrast, there is little control over the character of an emerging oilfield complex in terms of access/transport routes, construction activity, traffic, and the design/placement of various facilities. Most importantly, past experience suggests that strategic planning at the regional level will be extremely difficult, as little or no coordination exists between State, Federal, and private landowners. In reality, site-specific restrictions are of limited value if regional development is effectively out of control. Nevertheless, until a comprehensive land use plan is established and implemented through the leasing process, the conduct of individual developments should continue to be modified, as necessary, to minimize local conflicts with caribou. Through continued studies of the disturbance behavior and habitat requirements of caribou, as well as improved planning efforts, caribou can hopefully be protected in a manner that is consistent with orderly--and economically sound--development of Alaska's petroleum resources.

IV. RECOMMENDATIONS

The Department of Fish and Game should:

A. Finalize management plans for the various Arctic caribou herds; establish minimum population sizes and use priorities.

B. Initiate programs of habitat assessment and comprehensive surface use planning for the Arctic Slope; establish broad development criteria for various important, sensitive, and critical habitats.

C. Establish a Memorandum of Understanding with the Alaska Department of Natural Resources, and seek Cooperative Agreements with the U.S. Fish and Wildlife Service, the Bureau of Land Management, the U.S. Geological Survey, and the North Slope Borough. Such interagency agreements should:

   1. acknowledge the necessity for a cooperative approach to land use that will maintain an adequate caribou population and yet permit orderly development of petroleum resources.

   2. provide for the best possible definition of the location, size, and characteristics of petroleum reservoirs prior to leasing.

   3. provide for a multi-agency review process for tract nomination, considering:

      a. the relative value of each area as caribou habitat and the availability of suitable alternate habitats;
      b. projections of the size and intensity of related surface development, probable transportation routes,

and estimated requirements for extraction/processing facilities; and

c. the proximity to existing proposed industrial/urban development, and the probable scope of regional development.

4. establish and implement a strategic leasing plan that will ensure the continued availability of adequate critical, alternate, and total caribou habitat on State, Federal, and private lands.

5. require industry to formulate a surface unit plan that is coincident with, and approved as part of, the subsurface production unit; development standards would be specified for each surface unit.

6. establish a mechanism to expedite decisions, technical input, revision of development standards, and conflict resolution.

7. provide for long-term support of relevant research on the disturbance behavior and habitat requirements of caribou.

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APPENDIX F

Excerpts from
NORTH SLOPE STATE LANDS
GUIDELINE DOCUMENT

Alaska Department of Fish and Game

January 9, 1981

NORTH SLOPE STATE LANDS GUIDELINE DOCUMENT
Alaska Department of Fish and Game

The oil and gas industry in the Beaufort Sea region has complained that the resource agencies lack consistency during project review and permitting. Conversely, the resource agencies have complained that the projects proposed by industry often lack long-term planning, sufficient concern for the environment, and awareness of established procedures and policies. The purpose of this guideline document is to serve as a vehicle for meaningful communication between industry and this agency.

This document is a succinct compilation of concerns which are often expressed as stipulations or recommendations by the Alaska Department of Fish and Game (ADF&G). The document is currently and always open to refinement; we are hopeful that this document will serve to alleviate most of the expressed problems and will serve to establish an informed working relationship between industry and this agency.

Roadways

The oscillatory movements of Central Arctic caribou in response to varying insect densities follow a north-south pattern to and from the Beaufort Sea coast. To avoid conflict with these midsummer movements, it is highly desirable that roadways and pipelines be aligned north-south wherever possible.

Any future transportation corridor from the Sagavanirktok River to the Point Thomson area or beyond should be routed to avoid major conflicts with caribou. This Department must be involved in the timely review of any such proposal (authority: 1979 Beaufort Sea Lease Stipulations; Alaska Coastal Management Program Standards; 6 AAC 80.070; AS 16.05.020-2).

Pipelines

Elevated pipelines shall be offset from the gravel roadway or construction pad the maximum distance possible to dilute the visual stimulus of a road/pipeline complex, thereby encouraging caribou passage. Elevated pipelines shall be constructed such that ground surface-to-pipe clearances are at least five (5) feet at the pile bents, but subject to the following exceptions:

1. In areas where the proposed route is in close proximity to existing pipelines of inadequate clearance or near other structures/activities that are in serious conflict with caribou movements, a waiver of this requirement may be granted.

2. In areas identified as important caribou movement zones, greater clearances may be required; appropriate design recommendations will be made on a case-by-case basis, and

3. Buried sections of pipelines, particularly through major drainages, may be required to assure the unrestricted movement of caribou.

PETROLEUM FACILITIES

Minimize and Consolidate

The goal of resource management agencies is to minimize environmental impacts. One method of achieving this goal is to encourage petroleum operators to minimize the construction of facilities. Unnecessary duplication of roads, construction of roads between facilities where access to the facilities from main roads has already been provided, and the use of pipeline construction pads where existing roads could be used are examples of activities that should be avoided.

Another means of achieving minimal adverse impact is to consolidate facilities so that the area of disturbance is reduced. Consolidation can occur if there is cooperation among operators to avoid the duplication of facilities and if there is long-range planning for the future development of areas, including the establishment of corridors for future roads and pipelines.

Production unit agreements mandate the lessees within the unit to coordinate their activities to maximize hydrocarbon recovery, prevent waste, provide for efficient production, and conserve renewable resources. To facilitate the latter, it is imperative that renewable resource agency input be incorporated into unit development plans and agreements.

SPECIAL STIPULATIONS

Caribou

The areas west of the Kuparuk River and east of the west channel of the Sagavanirktok River are vital to the continued integrity of the Central Arctic Caribou Herd. Within areas designated on the attached maps it is imperative that structures be designed and constructed to assure the free passage of caribou and that caribou not be disturbed, nor movements impeded during critical periods (authority: 1979 Beaufort Sea Lease Stipulations; AS 16.05.020-2; AS 16.05.050-1; Airborne Hunting Act):

1. a. May 15 through June 20 (May 15 through May 30--staging of parturient females; June 1 through June 20--calving)

   Exploratory activities should be scheduled during the winter months and be terminated by May 15. Within areas identified as caribou calving areas, industry shall be limited to those essential maintenance and operational activities associated with production. The major areas are located between the Colville and Kuparuk Rivers and between the East Channel of the Sagavanirktok River and the Canning River, from the Beaufort Sea coastline to thirty (30) miles inland.

b. July 7 through August 5 (movements to and from insect relief/feeding habitat)

Within those areas identified as insect relief/feeding habitat, industry is encouraged to conduct only those essential maintenance and operational activities associated with production. However, the Department can approve construction activities which are limited spatially or are in close proximity to areas of intensive development. Proposals for major construction over an extensive area and those for any construction which might be substantially incremental to ongoing activities will not be approved by this Department. Primary insect relief/feeding habitat lies between the Colville and Kuparuk Rivers (including the river floodplains/deltas) and between the West Channel of the Sagavanirktok River and the Canning River (including the river floodplains/deltas), from the Beaufort Sea coastline to thirty (30) miles inland.

To facilitate an informed response by this Department, it is essential that industry provide this Department a comprehensive outline of all activities planned during this period.

2. The area between the Kuparuk and Sagavanirktok Rivers has some value as insect relief/feeding habitat. Within this area structures, such as roadways and pipelines, must be designed to assure free passage of caribou.

3. At no time during the spring and summer months (May 15 through September 15) should road or air traffic west of the Kuparuk River or east of the west channel of the Sagavanirktok River exceed the minimum required. Road traffic should be screened carefully to avoid unauthorized and unnecessary use, and authorized trips should be scheduled as infrequently as practicable, using vehicle convoys if appropriate. In general, transport activities from midday through late afternoon are less likely to conflict with caribou during the insect season.