ALASKA DEPARTMENT OF FISH AND GAME
JUNEAU, ALASKA

STATE OF ALASKA
Jay S. Hammond, Governor

DEPARTMENT OF FISH AND GAME
Ronald O. Skoog, Commissioner

DIVISION OF GAME
Ronald J. Somerville, Director
Donald E. McKnight, Research Chief

NATURAL MORTALITY OF WESTERN ARCTIC CARIBOU

BY
James L. Davis
and
Patrick Valkenburg

Volume II

Project Progress Report
Federal Aid in Wildlife Restoration
Project W-21-1, Job 3.24R

(Printed February 1981)

JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: James L. Davis and Patrick Valkenburg

Project No.: W-21-1 Project Title: Big Game Investigations

Job No.: 3.24R Job Title: Qualitative and Quantitative Aspects of Natural Mortality of the Western Arctic Caribou Herd

Period Covered: July 1, 1979 through June 30, 1980 (limited data through September 1980 included)

SUMMARY

Since April 1979, 44 Western Arctic Herd (WAH) caribou have been equipped with radio collars. Excluding those collared in April 1980, 9 of 19 males lost collars during their first winter after collaring. By 15 September 1980, four male deaths were verified and one female was presumed to have died. Annual mortality rates of the radio-collared caribou were 18.3 percent (n=27.3 animal years) for all animals, 36 percent (n=11.0 animal years) for males, and 6.8 percent (14.7 animal years) for females. Of the 4 males that died, 2 were shot, 1 was probably killed by wolves, and 1 was either killed or died and was scavenged by a grizzly bear. The annual natural mortality rate for males was 18 percent. Cause of death for the one female was not determined so the maximum natural mortality rate for females was 6.8 percent.

Eighteen radio-collared females arrived at or near the Utukok River calving area in late May 1980 and produced 14 calves. Among females without calves, probably only one was over 2 years old and she produced a calf in 1979. In 1979, four females were equipped with radio collars, all of which arrived on the calving ground and produced a calf. Combining the 1979 and 1980 data, 17 of 18 (94%) females older than 2 years produced calves. Of 10 radio-collared females located 3 months after calving in 1980, seven were accompanied by calves (70% calf survival).

The WAH has probably been growing at a minimum annual rate of about 14 percent since 1976. Based on our estimates of population size, recruitment, and hunting mortality from 1976 to 1980, we calculated a mean annual natural mortality rate of about 9 percent.

Wolves were relatively abundant in the range of the WAH from at least 1974 to 1978, but since then numbers have probably been much lower in the Kobuk, Selawik, and lower Noatak drainages (i.e. most of Game Management Unit 23) and portions of Units 24 and 26. Grizzly bears are the single most important predator of neonatal caribou in the WAH, but their overall impact on the herd is unknown. Other natural mortality factors are discussed.

CONTENTS

BACKGROUND

The Western Arctic Herd (WAH) was one of several Alaskan caribou *(Rangifer tarandus granti)* herds that declined during the early 1970's (Davis 1978). Because the WAH was the largest herd in North America, and its decline was numerically most dramatic, its population dynamics and management have been a focus of public and scientific attention since the decline was detected in 1975 (Davis and Valkenburg 1978).

Recent population modeling of the WAH (Davis et al. In Press, Doerr 1979, In Press) and an intensified management program have demonstrated the need for better biological data. Several studies addressing many facets of the WAH were initiated in recent years and are providing some of the required data. However, rates of natural mortality and the causes of this mortality have not been adequately determined. Caribou biologists familiar with population demography acknowledge that such data are essential to understanding the population dynamics of any caribou herd (Klein and White 1978). Davis et al. (In Press) concluded that natural mortality (particularly predation) contributed greatly to the recent decline of the WAH.

Because empirical data were not available for ongoing modeling and planning, information about natural mortality has been extrapolated from the literature. Rates of natural mortality published in the literature are few, and of limited value, consisting primarily of generalities from studies conducted a decade or more ago under different conditions than now exist in the WAH. Skoog (1968) and Kelsall (1968) suggested annual natural mortality rates of 5-6 percent for animals older than yearlings when relatively few wolves *(Canis lupus)* and grizzly bears *(Ursus arctos)* were present.

Bergerud (1971) found that males had a higher mortality rate (9%) than females (4%) in Newfoundland. In a recent review of population dynamics of North American caribou, Bergerud (1978) stated, "The natural mortality rate of adults when there are normal densities of predators has not been determined yet, but it probably will average 7-13 percent, depending upon predator densities." Determining actual mortality rates and the extent to which mortality is compensatory is important for management considerations and is requisite to understanding herd population dynamics.

This study is complementary to a concurrent study (National Park Service (NPS) Proposal No. 9100-78-05) designed to determine the seasonal home range use, social structure, and habitat selection of the WAH. The Alaska Department of Fish and Game is conducting that study through a 3-year contract from NPS. Caribou radio-collared for both jobs will increase the total sample size without detracting from the major objective of either job.

OBJECTIVE

To determine the age, sex, condition, and cause of death of adult caribou dying from natural causes (all factors other than human-induced mortality), and to monitor 50 radio-collared caribou to help quantify mortality factors.

PROCEDURES

Quantitative Assessment of Natural Mortality

From early October 1979 through mid-April 1980 we monitored 30 radio-collared caribou. Using the methods and radio collars described in Davis and Valkenburg (1979a), we captured and collared 21 additional caribou in late April 1980. Attempts to capture caribou with tangle nets (Miller et al. 1971) were unsuccessful, primarily because we could not locate caribou in areas with deep snow and thick cover. Western Arctic caribou generally do not pass through areas of dense cover except at some river crossings, and here the technique was largely unsuitable.

Radio-tracking was done from Cessna 185, Bellanca Scout, and Super Cub aircraft equipped with paired 2, 3, or 4 element yagi antennae. Range of signal reception varied from 10 mi (16km) to 100 mi (160km) and seemed to depend on aircraft type, antenna type, terrain, altitude of the tracking aircraft, and perhaps temperature. We obtained the greatest range with the Cessna 185 equipped with 3 element yagi antennae in relatively warm weather (0°C) from an altitude of 10,000 ft (3,000m) above the ground. We made no systematic attempt to determine the best combination of antennae and aircraft but the Cessna 185 seemed to be better than

fabric-covered aircraft with similar antennae. We radio-tracked for 256 hours in four aircraft from October 1979 through September 1980 (Table 1).

An unbiased estimate of annual natural mortality rates (male, female, both) was calculated using a procedure empirically derived by W. Gasaway (pers. comm.). The procedure entails calculating the mean number of months that all collars were functioning, excluding those animals that died, multiplying this mean times the number of total collars, including those that had died, to determine the number of collared-animal months of monitoring, dividing this product by 12 to convert to collared-animal years monitored, then dividing the number of mortalities by the calculated collared-animal years.

In conjunction with collaring in April 1980, we also conducted composition counts from a helicopter to estimate the survival rate of calves from June 1979.

An aerial photo-census was conducted in July 1980 following previously developed methods (Davis et al. 1979), and composition of the post-calving aggregations was sampled using a helicopter and ground observers. The resulting estimate of population size will be evaluated with our estimates of mortality and productivity and compared with previous models of the dynamics of the herd.

Qualitative Assessment of Natural Mortality

During our flights to relocate collared caribou, we also searched for carcasses and, where practical, tried to determine cause of death, by observing signs around the kill site, and the condition of the carcass. We collected long bones and mandibles to determine condition and age of the animal (Neiland 1970, Goodwin and Ball 1979). As an index to relative abundance, we recorded sightings of predators and evidence of their presence, examined sealing records for harvested wolves, and talked to residents of areas in which caribou wintered.

During our flights we looked for obviously infirm caribou and recorded these observations. During July a number of dead and dying caribou were seen by or reported to us. We made some flights specifically to locate and necropsy these caribou and determine how widespread the mortality was.

RESULTS

Use of Radio-Collared Caribou to Quantify Natural Mortality

All caribou captured and collared during this study and the NPS funded study are listed in Table 2. As of September 1980, 24 male and 20 female caribou have been radio-collared,

Table 1. Summary of flights conducted for radio-tracking, locating carcasses, and collaring caribou in northwest Alaska from 1 October 1979 through 15 September 1980.

Month	Hours Flown				Total # Flights	Total # Hours Flown
	Bellanca Scout	Cessna 185	Super Cub	Bell 206 Helicopter		
October		25			1	25
November						0
December						0
January	5	11	6		5	22
February	2	7			3	9
March	15	2			3	17
April	40	8	35	30	15	113
May			6		2	6
June	5		16		9	21
July	20				4	20
August			8		1	8
September		15			2	15
Totals	87	68	71	30	45	256

Table 2. List of caribou captured in the WAH, April 1979 through April 1980.

Permanent Accession Number	Collar Number	Frequency	Where and When Collared	With Calf June 1980	Age/Sex	Comments
102,262	81	150.005	Tinayguk 4/17/80		Adult M	
102,220	62	150.015	Ambler 10/2/79		Young M	Killed by bear? 9/80 picked up 9/13/80
101,999	69	150.020	Kevuk 4/19/79		Young M	Missing since 7/79
102,264	82	150.022	Tinayguk 4/17/80		Adult M	
101,998	64	150.025	Kevuk 4/19/79		Adult M	Dropped, Atkasook 11/79?
102,203	32	150.030	Ambler 9/28/79		Young M	
102,269	31	150.035	Anaktuvuk 4/18/80	Unk	Adult F	Missing since tagging
102,263	60	150.040	Tinayguk 4/17/80		Adult M	
102,004	34	150.045	Hunt R. 5/2/79	No	Adult F	
102,003	63	150.050	Hunt R. 5/2/79		Young M	Dropped shortly after tagging; picked up 3/15/80
102,206	61	150.055	Ambler 9/29/79	Yes	Adult F	
102,204	78	150.060	Ambler 9/28/79		Young M	Dropped Ambler R. 4/80
102,001	68	150.065	Selawik Hills 5/1/79		Young M	
102,279	39	150.070	Chandler 4/23/80		Old Ad F	
102,202	73	150.085	Ambler 9/28/79		Young M	Missing since tagging
102,205	77	150.090	Ambler 9/28/79		Young M	Dead/drop Kilovilik Cr. 4/80
102,207	74	150.095	Ambler 9/29/79		Young M	Dropped early 4/80, Shaktoolik R.
102,209	37	150.100	Ambler 9/29/79	Yes	Adult F	
102,201	76	150.105	Ambler 9/28/79		Young M	Killed by wolves 12/79
102,218	2	150.115	Ambler 10/1/79		Young M	Shot 10/27/79 Dahl Cr, picked up
102,273	new 2	150.115	Chandler 4/23/80	No	Young F	
102,006	1	150.120	Driftwood 5/9/79	Yes	Adult F	
102,213	66	150.125	Ambler 9/30/79		Adult M	Shot 3/1/80 Shaktoolik R.
102,210	75	150.130	Ambler 9/29/79		Adult M	Dropped Tagagawik R. 4/80
102,208	36	150.135	Ambler 9/29/79	Yes	Adult F	
102,274	3	150.145	Chandler 4/23/80	Yes	Adult F	
102,005	9	150.150	Driftwood 5/9/80	Yes	Adult F	
102,215	71	150.155	Ambler 9/30/79		Adult M	Dropped winter 79/80 Upper Tagagawik; picked up 4/8/80
102,216	6	150.160	Ambler 10/1/79	No	Young F	

Table 2. (Continued).

Permanent Accession Number	Collar Number	Frequency	Where and When Collared	With Calf June 1980	Age/Sex	Comments
102,268	30	150.170	Anakatuvuk 4/18/80	Yes	Adult F	
102,276	10	150.175	Chandler 4/23/80	Yes	Adult F	
102,007	33	150.190	Driftwood 5/9/79	Yes	Adult F	
102,007	67	150.195	Kevuk 4/19/79		Young M	
102,217	0	150.200	Ambler 10/1/79	Yes	Adult F	
102,211	38	150.210	Ambler 8/29/79	No	Adult F	
102,275	5	150.215	Chandler 4/23/80	Yes	Adult F	
102,214	65	150.220	Ambler 9/30/79		Adult M	Missing since tagging
102,221	79	150.225	Ambler 10/2/79		Adult M	Dropped W. Purcell Mtn; picked up 4/3/80
102,260	new 79	150.225	Tinayguk 4/17/80		Adult M	Missing since tagging
102,277	35	150.230	Chandler 4/23/80	Yes	Adult F	
102,266	11	150.235	Anaktuvuk 4/18/80	Yes	Adult F	
102,219	4	150.240	Ambler 10/2/80	Unk	Adult F	Dead unknown causes; Redstone R. 9/11/80
102,212	72	150.245	Ambler 9/30/79		Adult M	Dropped mouth Pah R. 11/80; picked up 4/80
102,278	new 72	150.245	Chandler 4/23/80		Adult M	Missing since 4/80 unknown cause
	Handled but not collared					
102,261	12523, 12524 ear tags				Young M	Ear tags only
	Died during or after immobilization					
102,265	8	150.205	Tinayguk 4/17/80	Unk	Old Ad F	
102,267	7	150.250	Anaktuvuk 4/18/80		Young F	Dead shortly after tagging; unknown cause
102,270			Anaktuvuk 4/18/80			Died next day, collar removed
102,271			Anaktuvuk 4/18/80			Died, collar removed
102,272			Anaktuvuk 4/18/80			Died, collar removed
102,280	new 71	150.155	Chandler 4/23/80	Unk	Adult F	Missing since 4/80
102,002			Tagagawik R. 5/1/79		Adult M	Died, collar removed
	Visual collar only					
102,222	80	-	Ambler 10/2/79		Adult M	

[1] Young refers to caribou between 1 and 3 years old.

1 male was collared with a numbered visual collar, and 1 young male was ear-tagged only.

Attrition of the collars is summarized in Table 3. About one-half of the males lost collars, but no females lost collars. Collars must be fairly loose on males to allow for expansion of the neck during rut and for growth of subadults. Therefore, when males shed their antlers, collars are often slipped off.

Because of variable collar retention time, radio transmitter life, and time of death, it is difficult to determine how to calculate an unbiased estimate of mortality rates from collared animals. Using the procedure developed by Gasaway (pers. comm.), we used the data in Table 2 to determine the number of months each transmitter was functioning up to 15 September 1980. We calculated monitoring periods of 27.3, 11, and 14.7 caribou years, respectively, for both sexes, males, and females, respectively.

During the monitoring period four males died and one female was presumed to have died. Thus, the annual mortality rate was (5/27.3) 18 percent for both sexes, (4/11) 36 percent for males, and (1/14.7) 7 percent for females.

Two of the four males that died were killed by hunters, one during the legal season in March, and one about 2 weeks after the first season closed on 15 October. The two natural mortalities included one that was probably killed by wolves and one that was either killed or died and was scavenged by a grizzly bear. Therefore, half of the total male mortality, 18 percent, was natural mortality. Although our sample is small, it is noteworthy that findings were similar to those from the Delta Caribou Herd in 1979 and 1980 (Davis and Valkenburg In Press) and to those found in the literature (see citations in Davis and Valkenburg In Press).

The only presumed female mortality during the monitoring period was not verified as an actual mortality. A mortality signal was located on the tundra but no carcass or collar was seen. The location was north of Ambler in an area where people often hunt caribou, but we as yet have no evidence to suggest whether the presumed mortality was from natural causes. If we assume it was killed by humans, then we can calculate natural mortality rates of (2/27.3) 7 percent for both sexes, (2/11) 18 percent for males, and (0/14.7) no mortality for females. Likewise, if we presume that the female died of natural causes the figures would be (3/27.3) 11 percent for both sexes, and (1/14.7) 7 percent for females.

Existence of females with radio collars enabled us to estimate productivity and mortality of calves during 1979 and 1980. Of 18 females that arrived on the calving area or

Table 3. Status and attrition of 44 radio collars placed on caribou in the WAH as of 15 September 1980.

Status	Young[1]		Adult		Total
	Male	Female	Male	Female	
Functioning	3	2	4	14	23
Killed by humans	1	0	1	0	2
Probably killed by wolves	0	0	1	0	1
Probably killed by grizzly bears	1	0	0	0	1
Total suspected predator kill	1	0	1	0	2
Dead unknown cause	0	0	0	1	1
Total mortality	2	0	2	1	5
Shed collar	4	0	5	0	9
Missing[2]	2	0	3	2	7
Total	11	2	14	17	44

[1] Young refers to caribou 1 to 3 years old.

[2] Not heard since April 1980.

were found during calving in 1980, 14 had calves (78%). Of the 4 that did not calve, 3 were classified as subadults when tagged (i.e. 2 or 3 years old). Incisors were taken for aging but have not yet been processed. The remaining female of the four nonproducers was definitely an adult, but the absence of hard antlers when seen in spring 1980 indicated she was not pregnant. At least 1 of the 14 females that produced a calf in 1980 was a subadult. All four females collared in 1979 were adults and they all produced calves that year. Ninety-four percent of the adult females from the 2 years produced calves. Of the 14 that produced calves in 1980, 10 were relocated in August or September and 7 (70%) were accompanied by calves. Two of the collared females appeared not to have calves with them in August but were accompanied by calves in September, indicating that the presence or absence of a calf is sometimes difficult to ascertain. Females and calves can be temporarily separated or loosely associated in a group, or adoption is theoretically possible. Herd composition data from fall 1980 are not available to compare overall calf survival to survival of calves whose dams were collared.

Estimating Natural Mortality Through Modeling

Estimated growth of the WAH since 1976 is illustrated in Table 4. Using estimates of annual population size, human harvest, and recruitment, we calculated annual adult natural mortality, and mean annual adult natural mortality for the years 1976 through 1979. This exercise can be instructional but its limitations should be recognized. For instance, underestimated human harvest would overestimate natural mortality and vice versa. Also, the fairly broad confidence interval that brackets the estimated population size must be considered. In fact, although the calculated mean annual mortality rate of 9.2 intuitively seems reasonable, low annual rates in 1976 and 1977 versus large rates in 1978 and 1979 are the opposite of what several indices to natural mortality rates suggest. This whole approach warrants considerable discussion in a future report.

Mortality of calves has been low in the WAH since 1976 with the possible exception of 1977 when total calf mortality may have approached 60 percent (Table 5). In that year, oestrid fly (*Oedemagena tarandi* and *Cephenomyia trompe*) harassment was severe and some animals carried extremely high numbers of larvae in spring 1978. Judging from calf/female ratios, calf mortality was substantially higher on the arctic coastal plain than on other winter ranges, and may have been related to the combination of parasitism by oestrid fly larvae and the severe weather conditions characteristic of that area.

Data in Table 5 are most valuable in a comparative sense. Computation of mortality from ratios assumes that no adult

Table 4. Calculation of adult natural mortality based on estimates of population size, recruitment, and human harvest in the Western Arctic Caribou Herd, 1976-1980.

Year	July Population Estimate	Population Estimate[1] (older than calves)	Recruitment (% short yearlings in April)	Expected Population[2] (older than calves)	Human Harvest[3]	Adult Natural Mortality[4] (%)
1976	75,000[5]	51,750				
1977	90,000[5]	63,450	26	69,932	3,100	3,382(6.5)
1978	102,000[5]	72,114	17	76,446	3,000	1,332(2.1)
1979	113,000[5,6]	77,744	23	93,655	4,000	11,911(16.5)
1980	[138,000][7]	[89,700]	25	103,659	5,000	8,959(11.5)
				Mean Annual Adult Natural Mortality = (9.2)		

[1] No data available for 1979 on calf percent of herd in July, so the mean of 31.2% for all other years was assumed.

[2] Expected population = previous July population (older than calves) plus recruitment.

[3] Calculated from permit returns and estimates of illegal kill.

[4] Adult natural mortality = expected population (older than calves) less July population (older than calves) less human harvest.

[5] From Davis et al. 1979.

[6] This estimate is probably low because calving ground censuses have consistently given lower population estimates than use of the aerial photo-direct count-extrapolation technique.

[7] The actual 1980 population could be 10-20 larger as this estimate is a conservative 14% increase of the minimum 1979 population.

Table 5. Calf mortality in the WAH, 1976 to 1980.

Cohort Year	Peak calf/100 females ratio in June	Survival to 3 weeks calves/100 females (% mortality since June peak)	Survival to 4 months calves/100 females (% mortality since 3 weeks[1])	Survival to April (i.e. 10 months (additional % mortality from 4 months)	Total Annual Mortality
1976[2]	73	54 (26)	48 (5)	55 (0)[2]	31%
1977	69	52 (25)	42 (14)	29 (19)	58%
1978	68	63 (7)	48 (22)	50 (0)[2]	29%
1979	65	N.A.	N.A.	53 (18)[3]	18%
1980	82[4]	66 (20)	53 (20)		

[1] This figure is adjusted to compensate for the addition of female yearlings to the adult female segment of the population.

[2] These figures indicate that mortality was not measurable over winter by standard survey methods.

[3] Counts were done too late in spring to accurately estimate calf/female ratios. This figure was calculated using calf/100 older than calf figures and by assuming 50 bulls/100 females in the population.

[4] Counts were done in the central calving area where calf/female ratios are high.

mortality occurred and that composition counts are representative of the local population. Both assumptions are probably not correct.

Qualitative Aspects of Natural Mortality

During approximately 125 hours of flying over caribou winter range in February, March, and April, we found four carcasses of caribou that had been killed or fed on by wolves and one of a caribou that was killed by a wolverine *(Gulo gulo)*. One of those being fed upon by wolves was a calf that had been killed by humans and left, and the one killed by the wolverine had been previously wounded by hunters. We saw only five wolves and found carcasses of another five that had been skinned. In comparison, during the same period in 1977 we saw 32 wolf-killed caribou and 30 wolves in about 75 hours of flying. In April 1977 wolf density in the Selawik River drainage was estimated at 1 per 30 mi^2 (77 km^2) (ADF&G files). In 1977 about 150 wolves were killed in that portion of the Kobuk and Selawik River drainages utilized by the WAH for winter range. Considerably less than half that number has been taken annually since (Table 6). Some of this decrease may reflect the poorer tracking conditions which hampered aerial hunters in years after 1977.

In the central and western Brooks Range in 1977 wolf densities were estimated to range from 1 wolf per 60 mi^2 (153km^2) in the upper Koyukuk River drainage to 1 wolf per 100 mi^2 (256km^2) in the upper Noatak River drainage (ADF&G files). The central Brooks Range was again surveyed in 1978 and no significant change in numbers was detected (ADF&G files).

Although the Department planned to estimate wolf numbers in GMU 23 and 24 in 1980, no census was accomplished because of poor snow conditions. Based on our aerial surveys and conversations with local hunters and pilots, we believe that wolf numbers south of the Brooks Range are considerably lower than they were prior to 1977. On the calving area wolves are essentially absent; none has been seen there for 2 years although one pack has denned on the southern fringe since at least 1977.

Reported wolf harvest from the three Game Management Units in the range of the WAH is summarized in Table 6. Although not all wolves taken are reported in sealing records, the data are useful for year-to-year comparisons and support our contention that wolves have decreased in GMU 23 but probably not in the Brooks Range portion of GMU 24.

Reasons for the decreased wolf population in GMU 23 could include a higher than normal incidence of rabies since 1977, distemper in 1978 similar to that documented in dogs in the area (unpublished data, Rabies Virology Unit, Arctic Health Research Center, Fairbanks), continued exploitation by

Table 6. Reported take of wolves in the range of the WAH for 1975 through 1980.

Year	GMU 23[1]	GMU 24[2]	GMU 26[3]	Total
1974-75	47	65	6	118
1975-76	144	45	34	223
1976-77	150	55	35	240
1977-78	64	55	38	157
1978-79	48	102	31	181
1979-80	16	49	15	80

[1] Kobuk River, Noatak River, Selawik River areas.

[2] Upper Koyukuk drainage, central Brooks Range. Up to 20% of these animals are from areas outside the caribou range.

[3] Arctic slope. Although this unit includes the entire arctic slope east to the Canadian border, more than 90% of the wolves taken come from the area between the Anaktuvuk and Etivluk Rivers.

humans, and a natural response by wolves to lowered prey abundance (Davis et al. In Press). Rabies was widespread in red foxes *(Vulpes vulpes)* and arctic foxes *(Alopex lagopus)*, and it was also confirmed in one wolf in northwest Alaska (Stephenson 1979) and a pack in northeastern Alaska (Chapman 1978). The distemper was not documented in the wild, but according to D. Ritter (pers. comm., Rabies Virology Unit, Arctic Health Research Center, Fairbanks, 1980) that is not unusual as it is very difficult to find suitable carcasses for diagnoses.

Grizzly bears are probably the second most important predator of caribou in the WAH, but during some years they may take more caribou than do wolves. Most predation by bears is on calves during June, but some adults are also taken. It is difficult to estimate the number of calves killed by bears. Some bears kill far more calves than others, and some have far more opportunities than others. In 1978 observers saw a sow and three yearlings kill four calves in less than 2 hours, but other bears may go for days without taking a calf. The Department is presently studying grizzly bear predation on caribou calves to determine its influence on caribou (Reynolds 1980).

Density of grizzly bears in the southern portion of the calving area is relatively high; 1 bear/35 mi^2 (90km^2) (Reynolds 1980). In the northern part of the calving area (i.e. north of the Utukok River) the density is probably much lower. The caribou generally remain in the southern portion of the calving area for about 10 to 14 days after the onset of calving before moving to the higher foothills and mountains (Davis and Valkenburg 1979b) where the density of bears is again lower (Reynolds 1980).

As caribou calves approach about 1 month of age they become much less vulnerable to bears. Although we have seen bears catch calves after a chase of up to 1 mile (1.6km), they generally rely on surprise followed by a short chase. This technique is highly successful when the calves are less than a week old. After that calves run as fast as older caribou and can usually outrun a bear even on short, high-speed chases. However, a considerable amount of predation occurs in the post-calving aggregations when bears charge large dense groups and cause confusion (Reynolds 1980).

One way that the number of calves taken by bears can be roughly estimated is by knowing the number of bears that caribou are likely to encounter and the average number of calves taken per bear. Another is by calculating the decrease in calves/100 females from composition counts during calving to sometime later. Unfortunately, as yet we have no adequate information on the average number of calves taken per bear. We also do not know how much of the decrease in calf/female ratios is due to the influx of nonparturient

females from the periphery of the calving area or mortality caused other than by bears. After caribou disperse on the arctic coastal plain in August, predation by bears probably decreases drastically.

Other Causes of Natural Mortality

Disease and severe weather during winter and at calving time are other potentially important causes of mortality in caribou herds (Neiland 1972, Miller 1974, Bergerud 1978). Predation, disease, and severe weather are often related in that debilitated animals are easier for predators to catch. Confusion between predation and scavenging activity compounds problems in segregating the different causes of mortality.

Even though highly adapted to the arctic environment, northern caribou populations can be rather drastically influenced by severe weather (Miller 1978). The WAH is not at the northern extreme of caribou range in North America and climatic conditions are more favorable than in the arctic islands and barren lands of the Northwest Territories (Calef, pers. comm.; Miller and Broughton 1974). Nevertheless, winter weather is severe enough to cause mortality, especially to weaker caribou, and icing conditions can cause some mortality. In early 1977, 12 caribou that died from malnutrition were found on the arctic slope. Most carcasses were found in a small area near the Colville River and the overall effect on the population was probably minimal. Overwinter survival of calves was excellent on the arctic slope that year but may have been slightly lower than on the south side of the Brooks Range.

In early 1978 caribou wintering on the arctic coastal plain suffered mortality from the combination of severe weather and very heavy infestation by oestrid fly larvae.

Two freezing rains occurred on the north side of the Brooks Range in 1979-80 and two ice layers were present in the snow after late November, at least in the Driftwood area. Many caribou may have responded to this condition by moving south into the Brooks Range and northern foothills where they have not wintered in large numbers for several years. Those remaining on the coastal plain may have suffered some mortality. We found numbers of "hair piles" on the tundra in July, and there were more dead caribou, fewer calves and fewer caribou wintering near Prudhoe Bay than in any year since 1975 (ADF&G files). Our spring 1980 survival counts indicated that calf mortality was probably higher among animals wintering on the coastal plain than in the northern foothills and areas south of the Brooks Range. On the arctic coastal plain the calf/female ratio was probably about 30-35/100, but in the Brooks Range and Kobuk/Selawik

River drainages it was more like 40-50/100. However, fall composition data were not obtained from the coastal plain area so there may have been fewer calves beginning winter.

In July 1977 a number of caribou died from unknown causes and dead and dying caribou were reported by several individuals in the western Brooks Range. Magnitude of this mortality was not documented. A similar situation took place in late July and August 1980. Department personnel found at least 20 caribou that died. Of these, three were examined in the field and three were brought to Fairbanks and examined. All of the caribou were in poor condition, and one had lesions and other signs implicating the hoofrot bacterium *Bacillus necrophorus* although it was not isolated. Hoofrot is a widely and commonly found disease among caribou and reindeer, and it appears to be more of a problem in years when insect harassment is high (Nikolaevski 1961, Neiland 1972). Presumably the caribou are more active and sustain more cuts from mechanical injury. The bacillus, which occurs naturally in soil, can then invade the caribou. Hot, still weather prevailed in July 1980 and mosquitoes were unusually abundant compared to the two preceding summers. July and August 1977 were also relatively warm and windless. Footrot symptoms may be confused with those of brucellosis, but in any event these two diseases are probably responsible for the so-called summer disease in caribou (Neiland 1972). A previous investigation of the condition led Neiland (1972) to believe that less than 1 percent of the animals were affected, and some unknown portion of these recover.

RECOMMENDATIONS

We have encountered several obstacles in our study of social structure and natural mortality, and a brief discussion of these may be helpful to others contemplating such studies. In an area as large as northwest Alaska it is difficult to locate collared caribou with any regularity and accurately determine cause of death when they die. Weather is so often poor in early winter that a caribou may die and not be located for up to a month. Frequent precipitation and constantly changing snow conditions confound efforts to examine carcasses and differentiate between scavenging and predation. Radio collars should prove useful in determining mortality rates, but they may be of limited value for segregating types of mortality unless relocations can be made every few days.

We have had considerable trouble keeping collars on males. The circumference of the neck of rutting males is very close to that of the head. Even though we realized that collars should be put on as tightly as possible on males in the fall, one-third of all collars were dropped (all but one from subadults). When lying on the ground a collar is much

more difficult to find due to terrain interference and so may be lost. We are currently developing an expandable collar which should also prove useful on calves. Also, collaring only adult males would minimize the loss rate.

During this study and other caribou studies in the past, we used helicopters and immobilizing equipment for capturing the animals (Davis and Valkenburg 1979a). The technique works well on caribou in deep snow where running is impeded, but it can result in unacceptably high mortality or injury. During this study a minimum of 5 of 29 animals were lost due to trauma from capture equipment. Also, when using a helicopter it is difficult to catch several caribou from the same group because the groups tend to split or mix and even animals immobilized together often respond to the antidote differently. The method is rather expensive too, averaging about $500 per caribou. For the study of social structure, it is necessary to capture several animals from the same band. We are investigating other capture techniques including hand-fired rocket nets that can be used from helicopters.

ACKNOWLEDGMENTS

We wish to thank M. Robus and J. Silva of the Bureau of Land Management for assistance with radio-tracking and providing us with useful observations incidental to their work in the Buckland River vicinity. J. Rood, J. Walker, and J. P. Jacobson provided efficient and reliable services with their aircraft and otherwise helped greatly with logistics. R. Pegau, H. Melchior, H. Reynolds, A. Magoun, and D. A. Johnson assisted with some of the field work and made a concerted effort to collect specimens from caribou dying in summer 1980. F. DeCicco, L. Aumiller, and F. Mauer provided free labor during our abortive and sometimes humorous attempts to capture caribou in tangle nets. K. Neiland and R. Zarnke assisted with necropsy of dead caribou. J. Coady and D. McKnight reviewed the manuscript.

LITERATURE CITED

Bergerud, A. T. 1971. The population dymanics of Newfoundland caribou. Wildl. Monogr. No. 25. 55pp.

_____. 1978. Caribou. Pages 83-101 *In* J. L. Schmidt and D. L. Gilbert, eds. Big Game of North America, Ecology and Management. Stackpole Books, Harrisburg, PA.

Chapman, R. 1978. Rabies: decimation of a wolf pack in Arctic Alaska. Science:201:365-367.

Davis, J. L. 1978. History and current status of Alaska caribou herds. Pages 1-8 *In* D. R. Klein and R. G. White, eds. Parameters of caribou populations in Alaska: Proceedings of a symposium and workshop. Biol. Pap. Univ. Alaska, Fairbanks. Spec. Rep. No. 3.

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

_____, and _____. 1979a. Natural mortality of Western Arctic caribou. Alaska Dept. Fish and Game, Fed. Aid Wildl. Rest. Proj. W-17-11, Job 3.24R. Juneau. 8pp.

_____, and _____. 1979b. Caribou distribution, population characteristics, mortality, and responses to disturbance in northwest Alaska. Pages 13-52 *In* P. C. Lent, ed. Vol. I, Studies of selected wildlife and fish and their use of habitats on and adjacent to NPR-A 1977-1978. National Petroleum Reserve in Alaska 105(c). Field Study 3, USDI, Anchorage. 226pp.

_____, _____, and S. J. Harbo. 1979. Refinement of the aerial photo-direct count-extrapolation caribou census technique. Alaska Dept. Fish and Game, Fed. Aid Wildl. Rest., Proj. W-17-11, Job 3.25R. Juneau. 23pp.

_____, _____, and H. V. Reynolds. In press. Population dynamics of Alaska's Western Arctic Caribou Herd. *In* Proceedings of the Second Intl. Reindeer/ Caribou Symposium, Rorøs, Norway.

Doerr, J. 1979. Population analysis and modeling of the Western Arctic Caribou Herd with comparisons to other Alaska *Rangifer* populations. M.S. Thesis, Univ. Alaska, Fairbanks. 341pp.

_____. In press. Modeling the population decline of two Alaskan caribou herds. *In* Proceedings of the Second International Reindeer/Caribou Symposium, Rorøs, Norway.

Goodwin, E. and R. Ball. 1979. Hematoxylin hot bath staining technique for tooth cementum annuli age determination. ADF&G, Anchorage, 11 pp.

Kelsall, J. P. 1968. The migratory barren-ground caribou of Canada. Queen's Printer, Ottawa. 340pp.

Klein, D. R., and R. G. White, eds. 1978. Parameters of caribou population ecology in Alaska: Proceedings of a symposium and workshop. Biol. Pap. Univ. Alaska, Fairbanks. Spec. Rep. No. 3. 49pp.

Miller, F. L. 1978. Numbers and distribution of Peary caribou on the arctic islands of Canada. Pages 16-19 *In* D. R. Klein and R. G. White, eds. Parameters of caribou population ecology in Alaska. Biol. Pap. Univ. Alaska, Fairbanks. Spec. Rep. No. 3.

_____, D. F. Behrend, and G. D. Tessier. 1971. Live capture of barren-ground caribou with tangle nets. Trans. N.E. Sect. Wildl. Soc. 28:83-90.

_____, and E. Broughton. 1974. Calf mortality on the calving ground of Kaminuriak caribou during 1970. Can. Wildl. Serv. Rep. Ser. No. 26. Ottawa. 26pp.

Neiland, K. A. 1970. Weight of dried marrow as indicator of fat in caribou femurs. J. Wildl. Manage. 34(4): 904-907.

_____. 1972. Caribou disease studies. Alaska Dept. Fish and Game, Fed. Aid Wildl. Rest. Proj. W-17-2 and W-17-3, Job 18.1R. Juneau. 42pp.

Nikolaevskii, L. D. 1961. Diseases of reindeer. Pages 230-293 *In* P. S. Zhigonov, ed. *Severnoe Olenevadstvo*. Moskva, Izd. Sel'skokhozyaistvennoi Literatury Zhurn. i Plakatov. Transl. from Russian, Jerusalem 1968.

Reynolds, H. V. 1980. North Slope grizzly bear studies. Alaska Dept. Fish and Game, Fed. Aid Wildl. Rest. Proj. W-17-11, Job 4.14R an 4.15R. Juneau. 85pp.

Skoog, R. O. 1968. Ecology of the caribou (*Rangifer tarandus granti*) in Alaska. Ph.D. Thesis, Univ. California, Berkeley. 699pp.

Stephenson, R. O. 1979. Abundance, movements, and food habits of wolves in and adjacent to NPR-A. Pages 53-88 *In* P. C. Lent, ed. Vol. I, Studies of selected wildlife and fish and their use of habitats on and adjacent to NPR-A, 1977-1978. National Petroleum Reserve in Alaska 105(c). Field Study 3, USDI, Anchorage. 226pp.

PREPARED BY:

Patrick Valkenburg
Game Biologist I
and
James L. Davis
Game Biologist III

APPROVED BY:

Ronald J. Somerville
Director, Division of Game

Donald A. McKnight
Research Chief, Division of Game

SUBMITTED BY:

John W. Coady
Regional Research Coordinator