

# PATTERNS OF GRIZZLY BEAR PREDATION ON CARIBOU IN NORTHERN ALASKA

HARRY V. REYNOLDS, III, Alaska Department of Fish and Game, 1300 College Road, Fairbanks, AK 99701

GERALD W. GARNER, U.S. Fish and Wildlife Service, Arctic National Wildlife Refuge, 101 12th Avenue, Fairbanks, AK 99701

**Abstract:** We investigated grizzly bear (*Ursus arctos*) use of caribou (*Rangifer tarandus*) as carrion and prey in 3 areas: 2 areas were in or adjacent to the traditional calving grounds of large caribou herds, and 1 area that did not include caribou calving grounds. The western Brooks Range study area was located in the mountains and foothills near the calving grounds of the Western Arctic Caribou Herd (est. 200,000 in 1985); the Arctic National Wildlife Refuge study area was in the coastal plain and foothills of the eastern Brooks Range in the calving grounds of the Porcupine Caribou Herd (est. 150,000 in 1985); and the Canning River study area was in the mountains and foothills of the eastern Brooks Range, 80 km southwest of the calving grounds of the Porcupine Herd. Predation or scavenging was determined from direct observation, locating radio-collared bears feeding on caribou, and from blood on the muzzles of captured bears. The Canning River bear population was distant from calving grounds, showed little use of caribou, and was characterized by low population density and productivity. Caribou were used as carrion and prey by the 2 grizzly bear populations for which calving caribou were available. Bear population density and productivity were higher when caribou were available, even though patterns of caribou use by bears differed between the 2 areas. Near the calving grounds of the Western Arctic Herd, western Brooks Range grizzly bears stayed within their established seasonal home ranges and used caribou as the caribou migrated through their home ranges. In contrast, on the Porcupine Herd calving grounds, some Arctic Refuge bears left seasonal home ranges in the mountains to take advantage of the caribou on the coastal plain, staying only as long as the calving caribou were available. In addition, some bears that preyed on Porcupine Herd animals apparently traveled long distances following the path of migrating caribou to the calving grounds. No bears from the Canning River study area were observed to leave their home ranges to reach the calving grounds. The proportion of caribou that were killed by bears vs. those that were scavenged was not determined. Although most caribou killed by bears were calves, adults were also preyed upon. Grizzly bears of all sex and age classes fed on caribou.

*Int. Conf. Bear Res. and Manage.* 7:59-67

In the past, even though it was generally acknowledged that grizzly bears could cause serious loss of domestic livestock (Knight and Judd 1983, Brown 1985), the effects of grizzly bear predation on wild animals, including moose (*Alces alces*) and caribou populations in Alaska, were believed to be negligible (Lent 1964, Skoog 1968, Franzmann et al. 1980). Recently, however, there has been growing evidence that predation by black bears (*U. americanus*) and grizzly bears was responsible for depressing survival rates of moose calves in some areas of Alaska (Franzmann et al. 1980, Ballard et al. 1981). Grizzly bears have been observed killing caribou (Lent 1964, Skoog 1968, Murie 1981), but the effects of grizzly bear predation on caribou populations have not been investigated.

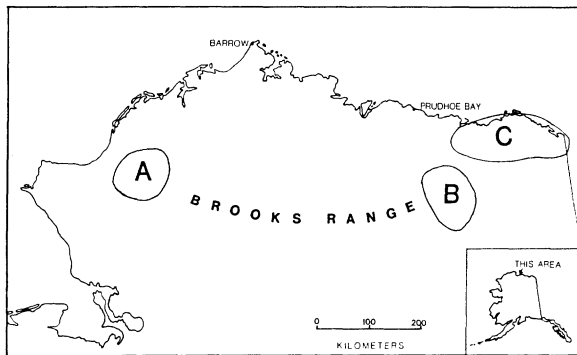
We addressed questions of grizzly bear-caribou interrelationships as well as grizzly bear population biology, food habits, and habitat use in 3 separate areas of extreme northern Alaska. In 1973-75, we studied grizzly bears (the Canning River population) in the Canning River drainage of the eastern North Slope of the Brooks Range. Beginning in 1977, ongoing long-term research (the western Brooks Range population) has taken place in the upper Utukok and Kokolik river drainages in the western North Slope of the Brooks Range. Research emphasis on bear-caribou interactions was greatest during 1977-80. Furthermore, as part of an effort to determine the potential impacts of oil exploration, research was con-

ducted during 1982-85 in the Arctic National Wildlife Refuge in extreme northeastern Alaska (the Refuge population).

We thank the following biologists for assistance with field data collection and bear capture: the late R. Ball, R. Brannon, D. Craighead, L. Craighead, J. Curatolo, J. Elliott, C. George, J. Hechtel, C. Hyatt, L. Martin, P. Martin, M. Mastellar, R. Quimby, P. Reynolds, M. Phillips, J. Want, and G. Weiler. Research in all 3 areas was supported by the Alaska Dep. of Fish and Game; additional funding was provided during 1973-75 in the Canning River study area by Alaskan Arctic Gas through Renew. Resour. Consult. Serv., Ltd.; during 1977-85 in the Western Brooks Range by the U.S. Dep. Int., Fish and Wildl. Serv., Bur. of Land Manage. Arctic Resource Area, Nat. Park Serv., Office of Naval Res., and the Naval Arctic Res. Lab.; and during 1982-85 in the Arctic Nat. Wildl. Ref. primary support was provided by the U.S. Fish and Wildl. Serv.

## STUDY AREAS

The study areas for the 3 grizzly bear populations were on the north slope of Alaska's Brooks Range at approximately 69° North latitude (Fig. 1). The arctic climate in this region is characterized by short, cool summers and long, cold winters; mean annual precipitation is 15-35 cm and falls mostly as snow (National Petroleum Reserve in Alaska Task Force 1978). The growing season for the treeless tundra of



1. Location of 3 grizzly bear study areas in northern Alaska: the western Brooks Range study area (A), the Canning River study area (B), and the Arctic National Wildlife Refuge study area (C).

the region usually lasts from mid-June to mid-August. The low-lying vegetation provides little cover for grizzly bears, except for willows (*Salix* spp.) along streams and river courses. Spetzman (1959) provides a detailed description of vegetation of the North Slope. We delineated the region into 3 physiographic categories: the coastal plain, generally flat with elevations less than 300 m; the foothills, characterized by buttes and ridges, with elevations between 300–900 m; and mountains, ranging in elevation between 900–2,000 m with river valleys of 500–1,000 m.

The western Brooks Range study area includes 5,200 km<sup>2</sup> of the upper reaches of the Utukok and Kokolik river drainages and is in the southern portion of the traditional calving grounds of the Western Arctic Caribou Herd. Most of the area is characterized by foothills.

The 3,900 km<sup>2</sup> Canning River study area includes primarily mountainous topography of the Canning, Ivishak, and upper East Fork of the Chandalar rivers. Caribou of the Central Arctic Caribou Herd sometimes winter in the area but few inhabit the area during summer.

The 9,800 km<sup>2</sup> Arctic National Wildlife Refuge study area (the Arctic Refuge) reaches to the Arctic Ocean and is primarily coastal plain, but includes a 3–20 km wide band of foothills to the south. The Porcupine Caribou Herd uses most of the study area as calving grounds, although intensity of use of specific localities varies from year to year.

## METHODS

Bears were captured from helicopters using immobilizing drugs sernylan (phencyclidine hydrochloride) or M-99 (etorphine hydrochloride) administered by dart guns. Acepromazine maleate was used as a tranquilizer in conjunction with sernylan injections.

All bears captured were marked with individually coded ear flags visible from the air and selected bears were fitted with radiocollars (Telonics, Inc., Mesa, Ariz.). One hundred twenty-three bears were captured in the western Brooks Range, 80 in the Canning River area, and 145 in the Arctic Refuge. Most relocations of bears were obtained via aircraft by radio-tracking bears fitted with transmitters or locating bears visually. Density estimates for the western Brooks Range and Canning River study areas were based on the number of bears seen in the study areas, including captured and unmarked but identifiable individuals (mostly offspring of marked bears). To account for those bears that did not stay in the study area throughout the year, the proportion of the home range of each bear outside the study area was estimated, and the sum of these fractional home ranges was subtracted from the study area population (Reynolds 1976, 1980). Because data analyses are not complete for the Refuge study (Garner et al. 1984, 1985), density was based on estimated values of proportional home ranges and incidences of dispersal.

Age structure, age at 1st production of cubs, mean litter size, and reproductive interval were used as indicators of population productivity potential. Ages were determined by examining cementum annuli of premolar teeth (Mundy and Fuller 1964, Stoneberg and Jonkel 1966, Craighead et al. 1970). Reproductive status was determined from (1) size, coloration, and lactating condition of mammae; (2) observations of male-female pairing; and (3) number and age of offspring observed in family groups (Reynolds 1984). To determine the exact age at which females 1st produce offspring, young females must be observed for 2–5 successive years. Such samples are very small in low density populations. To calculate this reproductive measure, we augmented sample sizes by assuming that young, previously unproductive females that were observed breeding produced their 1st litters the next year. This assumption results in a bias toward minimum age. In addition, we assumed that those females observed with offspring at the time of capture that would have been 6–8 years old when the cubs were produced, had their 1st litters at that age. (Based on direct observations and the minimum ages observed above, they would have been too young to produce and wean a litter before the litter they were observed with at capture. However, these females

may have lost a litter and bred again, biasing this indicator.)

Predation and scavenging behavior were observed by locating radio-collared bears, by other biologists locating radio-collared caribou cows and calves (Whitten et al. 1984, 1985), and during aerial surveys for bears and caribou on calving grounds and migratory routes. In addition, some observations were made from the ground by field crews using binoculars and spotting scopes. Where practical, carcass remains were examined after bears left the area.

Another indication of bear use of caribou was the presence of blood on the muzzles of captured bears. It is unlikely that such blood came from species other than caribou. Moose rarely occur in the western Brooks Range or the Refuge study areas and, although muskoxen (*Ovibos moschatus*) are present on the Refuge area, predation or scavenging by bears was observed only 3 times in 4 years. It is also unlikely that the blood resulted from fights between bears or cannibalism because no fresh wounds or other similar evidence of aggression were present on any bloodied-muzzle bears. Although we used the presence of blood as an indicator of caribou use, we did not determine how long blood remained on grizzly bear hair, though most blood appeared fresh. Absence of blood on a bear was not necessarily an indication that the bear did not feed on caribou, because several bears were initially located feeding on caribou but did not have bloody muzzles when captured shortly afterward.

## RESULTS AND DISCUSSION

### Seasonal Availability of Caribou

Caribou migration patterns differ among study areas. Annual patterns of movement and the portions of the core calving grounds used varies from year to year, but general use patterns are traditional (Hemming 1971). During spring migration in the western Brooks Range area caribou generally move through the area from the south in mid-May to reach the calving grounds in the northern half of the study area by 25 May-10 June. Beginning 15-25 June, caribou start their postcalving migration moving southwesterly through the study area, usually in widely scattered groups of 20-1,000. Often, though not every year, caribou move back through the area in groups of 1,000-30,000 during the postcalving shift on 1-20 July (Lent 1964).

The Porcupine Herd, which uses the Refuge, moves through the area from the east to reach calving

grounds on the coastal plain by 25 May-3 June. Once there, herd movement varies from year to year but generally revolves around the center of the study area. Caribou remain on the coastal plain until 1-10 July, when they begin postcalving migration to the east (Whitten et al. 1985).

A few caribou, usually bulls and nonbreeding yearlings, occur in the Canning River study area during summer. This area is 80 km southwest of the calving grounds of the Porcupine Herd and 110 km southeast from those of the Central Arctic Caribou Herd.

### Methods of Obtaining Caribou

Grizzly bears used several methods to kill caribou. They were observed "charging" groups of caribou in the western Brooks Range and the Refuge study areas. The initial response by most groups was to flee. However, in the resulting confusion some cows and calves became separated and, as they searched for each other, grizzly bears sometimes caught calves. A variation of this technique was to chase moving bands of caribou. This method was the most often observed hunting method in the Refuge (Phillips 1984). Unsuccessful chases were normally ended after an approximately 100 m chase. Successful chases were normally < 100 m; however, some successful chases were 400-800 m (Reynolds 1980, Phillips 1984).

Grizzly bears killed adult caribou and calves by charging groups; however, adult caribou usually easily outran grizzly bears. Adult caribou that were killed may have been debilitated by disease or injury; it is also reasonable to assume that vulnerability of cows increases as a result of calving and birth-related complications. In addition, caribou may be more vulnerable in areas where visibility is reduced by vegetation. For example, a radio-collared female caribou and her calf were killed by grizzly bears in an area where visibility was obscured by 2 m tall willows.

Grizzly bears were observed exploiting caribou at traditionally used river crossings in the western Brooks Range but not in the Refuge. Twelve bears were attracted to 1 crossing area west of the Kokolik River. One adult male was observed killing 2 calves and 1 adult, and feeding on carcasses of at least 3 other calves and 1 adult between 15-21 June 1979. Calves were commonly separated from cows at river crossings, increasing their vulnerability to predation. The physical stress of swimming a river may further weaken injured and debilitated animals. In the Refuge

area, caribou apparently crossed rivers where they were encountered; therefore, there are no specific crossing sites where increased availability of caribou attracted bears.

Grizzly bears were observed apparently locating calves by scent in both calving grounds. On 3 occasions, grizzly bears located and fed on calves after searching areas used by calving and postcalving caribou. We did not determine whether calves located by scent were dead, alive, healthy, injured, or newborn. These bears may have killed the calves earlier and were returning to feed on the carcass or the carcasses may have been scavenged.

Grizzly bears also killed caribou during incidental encounters between bears and large groups of caribou. For example, in July 1983, an adult male grizzly bear was foraging along a river bench in the Refuge when a postcalving aggregation of approximately 10,000 caribou approached the bear's position from upstream. The bear was in a small depression when a group of 80–100 caribou came over the ridge within 30 m of the bear. The bear made several 30–40 m charges into the milling group, then abandoned the chase and stood watching as the group moved downstream. Meanwhile, another group of 50–100 caribou came over the upstream ridge behind the bear. When they were within 20 m, the bear charged, chasing the group in several 30 m circles. In the confusion of the milling caribou, a calf stumbled, fell, and was killed by the bear.

#### Use of Caribou

Grizzly bears were observed feeding on 82 caribou carcasses in the Refuge and 26 caribou carcasses in

the western Brooks Range (Table 1). For those observations where age of the dead caribou could be determined, western Brooks Range bears fed on 57.7% calves, while the Refuge bears fed on 52.3% calves. Actual killing of caribou by bears was observed in 15 cases in the western Brooks Range and 13 cases in the Refuge; most (96.4%) of these observed kills were calves.

The chronology of these predatory activities in the western Brooks Range coincided with the pulsing availability of caribou as they moved through the study area during calving, postcalving migration, and postcalving shift. Observed caribou predation by bears occurred late May through mid-July (Table 1). In 1978, 8.8% ( $N = 102$ ) of all grizzly bear sightings between 6 June and 3 July were of bears at caribou carcasses.

In the Refuge study area caribou are usually available from late May through early July. Most calf predation by bears was confined to late May through June (Table 1), but bears were observed feeding on adult carcasses through mid-October. During 1982–85, 1,694 observations were made of 113 radio-collared grizzly bears between 25 May and 30 June and 20.1% (341) of these were of bears in the immediate vicinity of caribou. Of the 341 occasions in which bears were near caribou, 7.9% (27) involved grizzly bears chasing caribou, and only 11% (3) chases were successful. Phillips (1984) observed 11 predatory attempts in late June 1983 on the Refuge, with 18.2% (2) being successful.

These data indicate that grizzly bears readily use caribou in the western Brooks Range and the Refuge as prey and carrion when caribou are available. As

Table 1. Grizzly bears observed feeding on caribou carcasses, making kills, and chasing caribou in the Porcupine and Western Arctic caribou herds.

Activity of bears	Porcupine Herd (Refuge study area) (1982–85)		Western Arctic Herd (Western Brooks Range study area) (1977–79)	
	<i>N</i>	Time of year	<i>N</i>	Time of year
Feeding on caribou carcasses				
adult caribou	31	mid-May–mid-Oct	11	late Jun–mid-Jul
caribou calves	34	late May–late Jun	15	late Jun
unidentified caribou	10	late May–mid-Oct	—	—
probable caribou	7	late May–early Aug	—	—
Making kills				
adult caribou	—	—	1	late June
caribou calves	13	Jun–late Jul	14	late May–late Jun
Chasing caribou	27	23 in Jun 1 in Jul 3 in Aug	—	—

Table 2. Characteristics of grizzly bears observed feeding on caribou carcasses in the Porcupine and Western Arctic caribou herds.

Category	Porcupine Herd (1982–85)		Western Arctic Herd (1977–79)	
	Number of caribou carcasses	%	Number of caribou carcasses	%
Known sex and age composition of bears at carcasses				
Adult males	15	29.4	16	43.2
Adult females	19	37.3	17	45.9
Subadult males	15	29.4	2	5.4
Subadult females	2	3.9	2	5.4
Total carcasses where age and sex of bears known	51		37	
Bear associations at caribou carcasses				
Breeding pairs	9	12.3	—	—
Females with young	6	8.2	10	25.6
Cubs of year	3	4.1	—	—
Yearlings	1	1.4	4	10.3
2-year-olds	2	2.7	—	—
Single bears	58	79.5	29	74.4
Total caribou carcasses	73		39	

calves become older and more mobile (late June), bears are apparently unable to kill calves as readily.

Grizzly bears of all age and sex classes prey on or scavenge caribou. During 1978 and 1979 in the western Brooks Range, 37 of 39 bears observed feeding on caribou carcasses were of known age and sex (Table 2). Adult bears accounted for 89.1% of these sightings with nearly equal representation for each sex. One breeding pair was observed feeding on caribou carcasses in 1980. Females with young accounted for one-quarter of these sightings, but the majority were single bears. During 1982–85 in the Refuge study area, 73 observations of bears feeding on caribou carcasses were recorded. Adult females were seen on carcasses more frequently than any other age and sex class (Table 2). Of bears seen at carcasses, breeding pairs on the Refuge accounted for 12.3% of all sightings, whereas females with young were rarely seen at carcasses. Again, the majority of observations of bears feeding on caribou carcasses were of single animals.

Of 27 different predatory attempts observed on the Refuge, adult females were observed chasing caribou more frequently than other sex and age classes (Table 3). Adult males were rarely observed chasing caribou, and breeding pairs were observed chasing caribou on 5 occasions. Most bears observed chasing caribou were single animals and the proportion observed chasing caribou (Table 3) was similar (74%) to that

observed feeding on caribou carcasses (Table 2). Males were observed at 58.5% of all carcasses, but were involved in only 17.7% of the chases. Adult females were involved in 64.7% of the chases but were observed feeding on only 37.3% of the carcasses. These data may indicate that adult and subadult males were successful gaining possession of carcasses that other bears had killed or scavenged. This is a reasonable assumption because adult and some subadult males are the larger and more aggressive members of the bear population (Hornocker 1962, Egbert and Stokes 1976).

The occurrence of blood on the muzzle of bears is another indication that bears use caribou. In spring 1985, 31.8% ( $N = 22$ ) of all bears captured in the western Brooks Range study area had blood on their muzzle or were feeding on a caribou carcass at the time of capture. In the Refuge, 15 (7.8%) of 192 bears captured from 1982 through 1985 had blood on the muzzle.

#### Availability of Caribou Calves

Most caribou calf mortality occurs within the 1st 8 weeks after birth. Causes of neonatal mortality in a Canadian caribou population, listed in decreasing order of importance, were: predation (by wolves, *Canis lupus*), abandonment by maternal cows, stillbirths, physiological or pathological disorders (non-specific), pneumonia, malnutrition, and injuries

Table 3. Characteristics of grizzly bears observed chasing caribou in the Porcupine Caribou Herd, 1982–85.

Category	Number of chases	Percentage
<b>Known sex and age composition of bears chasing caribou</b>		
Adult males	1	5.9
Adult females	11	64.7
Subadult males	2	11.8
Subadult females	3	17.7
Total chases (sex known)	17	
<b>Bear associations chasing caribou</b>		
Breeding pairs	5	18.5
Females with young	2	7.4
Cubs of year	1	3.7
2-year-olds	1	3.7
Single bears	20	74.1
Total chases (all bears)	27	

(Miller and Broughton 1974). These causes of mortality are likely similar to those responsible for calf losses in Western Arctic and Porcupine caribou herds except that because wolf density is low, wolves are responsible for few caribou deaths. Instead, calving caribou in northern Alaska are available to grizzly bears and small predators including golden eagles (*Aquila chrysaetos*), red foxes (*Vulpes fulva*), arctic foxes (*Alopex lagopus*), and wolverines (*Gulo gulo*).

During a concurrent study of neonatal caribou calf mortality in the Refuge, a mortality rate of 15.9%, 6.7%, and 14.5% of the marked sample occurred during June 1983, 1984, and 1985, respectively (Whitten et al. 1984, 1985; Whitten, pers. commun.). Grizzly bear predation was responsible for 10.0% of this mortality in 1983, none in 1984, and 22.2% in 1985. Although grizzly bears use caribou calves as a food source in the Refuge, the overall impact of this predation is not believed to be a major factor in regulating the Porcupine Herd (Whitten, pers. commun.).

Calf mortality from all causes in the 1st 3 weeks of life provides a measure of the availability of calves to the bear population, but does not differentiate proportions attributable to bear predation. In 1979, the Western Arctic Herd was estimated to contain 113,000 animals. If one assumes that 45% of the herd was yearling cows or older and that 70% of these cows had calves (Davis et al. 1980), then a total of approximately 36,000 calves was present on the Western Arctic Herd calving grounds in 1979. In 1979 the apparent mortality rate of Western Arctic Herd calves during the 1st 3 weeks in June was estimated

at 23% (Davis et al. 1980) or approximately 8,300 calves. If calves weigh an average of 5.9 kg at birth and gain 450 g per day (Skoog 1968), a minimum total biomass of 49,000 kg, including hide, bones, and waste, was available for predators and scavengers in the western Brooks Range.

In 1985, the Porcupine Herd was estimated to contain 150,000 animals with approximately similar sex and age composition as that described above (Whitten, pers. commun.). Applying similar calculations to the herd results in an estimate of 67,500 yearling and older cows, and 47,250 calves. The average mortality rate detected in the 3-year calf study was 12.4% during June (Whitten et al. 1984, 1985; Whitten, pers. commun.). Using the same weight assumptions as above, a minimum total biomass of 35,000 kg, including hide, bones, and waste, was available for predators and scavengers in the Refuge.

#### Patterns of Use

Grizzly bears in the study areas displayed different patterns of movement in apparent response to the availability of caribou as carrion or prey. In the Canning River study area, bears stayed within their home ranges in the mountainous terrain. Maximum distance between sightings of 13 bears ranged between 16–65 km but none traveled to caribou herds 80–110 km distant (Reynolds 1976).

In the western Brooks Range area, the availability of caribou to grizzly bears appears to depend more on caribou calving in or moving through a bear's home range than on bears extending home ranges

used during the rest of the year to reach caribou concentrations. Of 34 bears for which home ranges were determined by radiotelemetry, only 2 expanded their home ranges to reach caribou concentrations, and these expansions were small. Generally, grizzly bears did not move from their established seasonal ranges to reach calving or migrating caribou, but moved to those portions of their ranges where caribou were available. As a result, when caribou calve in areas of low grizzly bear density, bear predation and scavenging is minimized. In years when caribou calve in the southern portions of the calving grounds or when snow conditions result in caribou calving before they reach the calving grounds, the potential for contact with higher densities of grizzly bears increases and their vulnerability to predation increases.

After caribou leave the calving grounds in large aggregations, they contact higher densities of grizzly bears as they cross the foothills during postcalving migration. It is during this time that Western Arctic Herd caribou appear to be the most vulnerable to bear predation. In this early stage of the postcalving migration, a few calves are still being born and cows that were debilitated by calving are still traveling with the aggregations. Cows and calves separated from and searching for each other probably have increased vulnerability to predation. Furthermore, it seems reasonable that the majority of cow-calf separations that occur after leaving the calving grounds would occur in the 1st week of postcalving migration. At this time, calves are still young and unfamiliar with their environment, they often lag behind their mothers when the migrating aggregations run, and may balk at following their mothers as the groups cross swollen rivers.

Bears associated with the Porcupine Herd showed a different movement pattern. When caribou were not on the coastal calving grounds, most bears used portions of their home ranges that occurred in the mountains and foothills. When caribou were on calving grounds, most bears moved there, remaining until the caribou migrated back into Canada. Exceptions to this pattern included those bears, usually young males, that appear to have followed the caribou herd as it migrated to the calving grounds from Canada. Most of these bears later dispersed. Other young bears of both sexes whose maternal home ranges were in the mountains and foothills also used the coastal plain after the herd left the area. This was especially true during 1985 when more bears than usual, including solitary adults and family groups, were observed on

the coastal plain, apparently taking advantage of a high lemming (*Lemmus trimucronatus*) population.

Physiographic differences between the western Brooks Range and the Arctic Refuge may contribute to the differences in bear movements to take advantage of caribou availability. The 5,800 km<sup>2</sup> study area in the western Brooks Range is composed primarily of foothills; no coastal plain is present. This provides a wide variety of habitat types and phenological stages that supply the vegetation and ground squirrel (*Spermophilus parryii*) populations that are the mainstay of grizzly bear food habits (Hechtel 1985). In contrast, the Refuge study area is primarily coastal plain and only 25% contains a narrow band of foothill topography. Also, on the eastern end of the Refuge area, the coastal plain is reduced in width from 96 km on the western side to 19 km, greatly concentrating caribou movements there. The fact that the coastal plain and the calving ground is more accessible to bears of the foothills and mountains in the Refuge may result in the observed bear movement pattern.

#### Population Characteristics

The 2 grizzly bear populations that had access to concentrations of calving caribou had higher population density than the population that did not (Table 4). In addition, measures of productivity appear to be higher in the 2 populations that had access to caribou, but these measures could not be tested statistically because of sample collection problems. Age structure of captured bears in the western Brooks Range and Refuge indicate productive populations, despite the loss of the 1983 Refuge cub cohort presumably due to severe winter and spring weather (Garner et al. 1984). Similarly, ages at 1st production of young appear to be lower where caribou were available, probably a reflection of the earlier attainment of sufficient body weight and fat resources necessary to produce young (Rogers 1976). The major differences among litters of the 3 areas was that no 3-cub litters were observed during the Canning River study while 3-cub litters were relatively common in the other 2 areas.

To accurately assess the contribution to increased productivity that caribou make to grizzly bear populations in northern Alaska, the survival of young bears through subadult to adult age classes needs to be determined. The apparent close link between caribou calving areas and associated grizzly bear pop-

Table 4. Relationships of availability of calving caribou to measures of grizzly bear population productivity.

Population measure estimates	Location of grizzly bear population <sup>a</sup>		
	Western Brooks Range	Canning River	Arctic National Wildlife Refuge
Caribou			
Herd size	113,000 <sup>b</sup>	None	150,000
Initial calf production	36,000	None	47,000
Period of calf availability to grizzly bears	25 May–25 Jun	None	25 May–10 Jul
Grizzly bears			
Density (bears/100 km <sup>2</sup> )	2.28	0.68	1.59
Age classes (%)			
Cub-2 years	45	27	32
3–5 years	14	9	18
≥ 6 years	41	67	50
Measures of productivity			
Mean age at 1st reproduction (sample size)	7.4 (16)	9.7 (19)	7.3 (16)
Reproductive interval (yrs)	4.1 (16)	—	4.1 (20)
$\bar{x}$ litter size (no. litters)	1.95(44)	1.85(20)	2.05(40)

<sup>a</sup> Data for study areas in western Brooks Range from Reynolds (1980, in press); in Canning River from Reynolds (1976, in press); and in Arctic National Wildlife Refuge from Garner et al. (1985), but also including unpublished data from 1985.

<sup>b</sup> Population for 1979 (Davis et al. 1980); population in 1985 was estimated at 200,000 (Alaska Dep. of Fish and Game files, 1985).

ulations should be taken into account by resource managers.

## LITERATURE CITED

- BALLARD, W. B., T. H. SPRAKER, AND K. P. TAYLOR. 1981. Causes of neonatal moose calf mortality in south-central Alaska. *J. Wildl. Manage.* 45:335–342.
- BROWN, D. E. 1985. The grizzly in the Southwest: documentary of an extinction. Univ. Oklahoma Press, Norman. 274pp.
- CRAIGHEAD, J. J., F. C. CRAIGHEAD, JR., AND H. E. MCCUTCHEN. 1970. Age determination of grizzly bears from fourth premolar tooth sections. *J. Wildl. Manage.* 34:353–363.
- DAVIS, J. L., P. VALKENBURG, AND H. V. REYNOLDS. 1980. Population dynamics of Alaska's Western Arctic Caribou Herd. *Proc. Int. Reindeer/Caribou Symp.* 2:595–604.
- EGBERT, A., AND A. STOKES. 1976. The social behavior of brown bears on an Alaskan salmon stream. *Int. Conf. Bear Res. and Manage.* 3:41–56.
- FRANZMANN, A. W., C. C. SCHWARTZ, AND R. O. PETERSON. 1980. Moose calf mortality in summer on the Kenai Peninsula, Alaska. *J. Wildl. Manage.* 44:764–768.
- GARNER, G. W., H. V. REYNOLDS, L. D. MARTIN, T. J. WILMERS, AND T. J. DOYLE. 1984. Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge. Pages 330–358 in G. W. Garner and P. E. Reynolds, eds. 1983 update report baseline study of the fish, wildlife, and their habitats. U.S. Dep. Int., Fish and Wildl. Serv., Anchorage, Alaska. 614pp.
- \_\_\_\_\_, G. J. WEILER, J. M. MORTON, AND J. M. NOLL. 1985. Ecology of brown bears inhabiting the coastal plain and adjacent foothills and mountains of the northeastern portion of the Arctic National Wildlife Refuge. Pages 268–296 in G. W. Garner and P. E. Reynolds, eds. 1984 update report baseline study of the fish, wildlife, and their habitats. U.S. Dep. Int., Fish and Wildl. Serv., Anchorage, Alaska. 777pp.
- HECHTEL, J. L. 1985. Activity and food habits of barren-ground grizzly bears in Arctic Alaska. M.S. Thesis, Univ. Mont., Missoula. 73pp.
- HEMMING, J. 1971. The distribution and movement patterns of caribou in Alaska. Alaska Dep. Fish and Game, Tech. Bull. 1. 60pp.
- HORNOCKER, M. 1962. Population characteristics and social and reproductive behavior of grizzly bears in Yellowstone National Park. M.S. Thesis, Univ. Mont., Missoula. 94pp.
- KNIGHT, R. R., AND S. L. JUDD. 1983. Grizzly bears that kill livestock. *Int. Conf. Bear Res. and Manage.* 5:186–190.
- LENT, P. C. 1964. Calving and related social behavior in the barren-ground caribou. Ph.D. Thesis, Univ. Alberta, Edmonton. 220pp.
- MILLER, F., AND E. BROUGHTON. 1974. Calf mortality on the calving ground of the Kaminuriak caribou during 1970. *Can. Wildl. Serv. Rep. Ser. No. 26.* 26pp.
- MUNDY, K. R. D., AND W. A. FULLER. 1964. Age determination in the grizzly bear. *J. Wildl. Manage.* 28:863–866.
- MURIE, A. 1981. The grizzlies of Mt. McKinley. *Sci. Monogr. Ser. No. 14.* U.S. Dep. Int., Nat. Park Serv., Wash., D.C. 251pp.
- NATIONAL PETROLEUM RESERVE IN ALASKA TASK FORCE. 1978. Physical profile. NPR-A 105(c) Study Rep. 1. U.S. Dep. Int., Bur. Land Manage., Anchorage, Alaska. 124pp.
- PHILLIPS, M. K. 1984. Habitat use and behavior of grizzly bears in the Arctic National Wildlife Refuge. Pages 45–73 in G. W. Garner and P. E. Reynolds, eds. 1983 update report baseline study of fish, wildlife, and their



- habitats. U.S. Dep. Int., Fish and Wildl. Serv., Anchorage, Alaska. 614pp.
- REYNOLDS, H. V. 1976. North Slope grizzly bear studies. Alaska Dep. Fish and Game, Fed. Aid in Wildl. Rest., Final Rep. Proj. W-17-6 and W-17-7. Job 4.8R-4.11R. Juneau. 20pp.
- . 1980. North Slope grizzly bear studies. Alaska Dep. Fish and Game, Fed. Aid in Wildl. Rest., Prog. Rep. Proj. W-17-11. Jobs 4.14-4.15R. Juneau. 75pp.
- . 1984. Structure, status, reproductive biology, movement, distribution, and habitat utilization of a grizzly bear population. Alaska Dep. Fish and Game, Fed. Aid in Wildl. Rest., Final Rep. Proj. W-21-2, W-22-1, and W-22-2. Job 4.14R. Juneau. 29pp.
- ROGERS, L. L. 1976. Effects of mast and berry crop failures on survival, growth, and reproductive success of black bears. Trans. North Am. Wildl. Nat. Resour. Conf. 41:431-438.
- SKOOG, R. O. 1968. Ecology of the caribou (*Rangifer tarandus granti*) in Alaska. Ph.D. Thesis, Univ. Calif., Berkeley. 699pp.
- SPETZMAN, J. 1959. Vegetation of the Arctic Slope of Alaska. U.S. Geol. Surv. Prof. Pap. No. 302-B. 58pp.
- STONEBERG, R. P., AND C. J. JONKEL. 1966. Age determination of black bears by cementum layers. J. Wildl. Manage. 30:411-414.
- WHITTEN, K. R., G. W. GARNER, AND F. J. MAUER. 1984. Calving distribution, initial productivity, and neonatal mortality of the Porcupine Caribou Herd, 1983. Pages 359-420 in G. W. Garner and P. E. Reynolds, eds. 1983 update report baseline study of the fish, wildlife, and their habitats. U.S. Dep. Int., Fish and Wildl. Serv., Anchorage, Alaska. 614pp.
- , F. J. MAUER, AND G. W. GARNER. 1985. Calving distribution, initial productivity and neonatal mortality of the Porcupine Caribou Herd, 1984. Pages 527-621 in G. W. Garner and P. E. Reynolds, eds. 1984 update report baseline study of the fish, wildlife, and their habitats. U.S. Dep. Int., Fish and Wildl. Serv., Anchorage, Alaska. 777pp.