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WOLF REPORT

by

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Volume XII
Project Progress Report
Federal Aid in Wildlife Restoration
Project W-17-5, Jobs 14.3R, 14.4R, 14.5R, 14.6R and 14.7R (2nd half) and
Project W-17-6, Jobs 14.3R, 14.4R, 14.5R and 14.6R (1st half)

(Printed June, 1974)

JOB PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Robert O. Stephenson (Arctic) and Jerome J. Sexton (Southcentral)

Project Nos.: Project Title: Big Game Investigations

Job No.: XIVA-14.3R Job Title: Characteristics of Exploited Wolf Populations

Job No.: XIVB-14.4R Job Title: The Spring and Summer Food Habits of Alaska Wolves

Job No.: XIVB-14.5R Job Title: The Condition and Characteristics of Ungulate Prey Taken by Wolves

Job No.: XIVB-14.6R Job Title: Characteristics of Wolf Den Sites

Job No.: XIVA-14.7R Job Title: Radio Telemetry of Wolves in Northern Alaska

Period Covered: January 1, 1973 through December 31, 1973

SUMMARY

Wolf population estimates for the northcentral Brooks Range are discussed. Data collected during late winter and spring 1973, suggest a density of 1 wolf per 76 square miles, which is similar to the fall 1972 estimate of 1 wolf per 65 square miles. Data collected since spring 1971 suggest that the wolf population in the 3600 square-mile area around Anaktuvuk Pass has increased from a low density of 1 wolf per 124 square miles in spring 1971, to roughly 1 wolf per 65 to 75 square miles in spring 1973. Observations made by residents of the area during fall 1973 suggest no further increase in density since spring, indicating that the increase in population may have slowed or stopped. The sex and age composition of wolves harvested in this area is discussed.

The distribution of 11 active dens in the northern Brooks Range is discussed. The average distance between dens (where intervening areas were thoroughly searched) was 20.6 air miles, slightly less than the average distance indicated in 1972 (Stephenson and Johnson 1973). However, four of these dens were located in areas where sheep or caribou populations were higher than average for the region, possibly causing dens to be located nearer each other (16 air miles) than is usual.

In order to test the validity of cementum layers as an age criterion for wolves, canine teeth from 20 wolf skulls, including six of known age, were sectioned using a cryostat and standard histological techniques. Data from known-age skulls indicated that a "non-transparent" cementum layer is formed during each winter of a wolf's life as has been described for several other species of Canidae.

The mean pack size of wolves sighted in Units 11 and 13 in 1972-73 was 3.1. This indicates a possibly significant reduction in wolf numbers since 1970-71.

The winter of 1972-73 was less severe than those of the previous two years in the Nelchina basin. As a result relatively few wolf-killed ungulates were found. This made comparisons with previous year's data impossible.

CONTENTS

BACKGROUND

The background for wolf *(Canis lupus)* studies in Alaska has been discussed extensively in previous reports (cf: Rausch 1966, 1967, 1969; Stephenson and Johnson 1972) and will not be repeated here. The wolf is, by virtue of its intelligence, mobility, and low population density, one of the most difficult large mammals to study using classical methods. Quantitative data reflecting the long-term interrelationships between wolves and their ungulate prey, and the precise mechanisms through which wolf populations adjust to prey availability are only now being gathered, and it likely will be some time before we can understand the natural mechanisms through which wolf populations are controlled, and the effects that hunting by man has on wolf population dynamics.

Indications of a very low population of wolves on the North Slope in 1970 prompted the initiation of population monitoring and other studies of wolves in the area. The population has increased from a level of about 1 wolf per 125 mi.^{2} (1971) to a level of roughly 1 wolf per 70 mi.^{2} (1973). Concurrent with population level studies a good deal of effort has been devoted to recording the knowledge of the wolf possessed by the Nunamiut Eskimo of Anaktuvuk Pass. While both of these efforts in northern Alaska will continue to some degree, more population studies will be done in Southcentral and Interior Alaska since a greater potential for conflict in the use of ungulates by wolves and people exists there.

OBJECTIVES

To assess wolf population levels and determine the characteristics of exploited wolf populations in Arctic and Southcentral Alaska.

To determine the food habits of wolves during the spring and summer in Arctic and Southcentral Alaska.

To determine the physical condition and characteristics of ungulate prey taken by wolves in Arctic and Southcentral Alaska.

To characterize the ecology of wolf den sites in Arctic and Southcentral Alaska.

The specific effort to characterize wolf den sites has been discontinued as an isolated objective due to the large number of dens visited in 1970 (Stephenson and Johnson 1972). These dens, as related in the 1972 report, were located by Nunamiut Eskimos now living in Anaktuvuk Pass. A final report on this aspect of the study is in preparation. Since work in the vicinity of Anaktuvuk was conducted with limited aircraft support only a small number of wolf kills were located and little progress has been made in this aspect of the study.

PROCEDURES

In the course of the work on characteristics of wolf den sites it became apparent that the Nunamiut, due to some special circumstances, had developed a specific and accurate knowledge of the wolf. This prompted a concerted effort to spend time with the Nunamiut, incorporating them as the principal aides in wolf studies in the Brooks Range. This undertaking has been a major objective in both 1972 and 1973, and involved primarily on-the-ground travel to denning areas for summer observation. Following an effort to locate active dens in May 1973, ground-based observations were attempted at a den in the Killik River area. The den found near the Killik River was abandoned shortly after it was found, probably due to interference by aircraft. No observations of wolves at a den were made because of this. Observations of wolves hunting and scavenging near Anaktuvuk were obtained, however, and will be included in a report on the Nunamiut knowledge of wolves.

Seasonal estimates of the wolf population in the vicinity of Anaktuvuk Pass were made using observations of wolves and wolf tracks made by Stephenson and about 15 Nunamiut hunters during travels with snow machines. Reliable wolf sightings made by pilots were also used.

Carcasses of wolves trapped by Nunamiut were collected and autopsied to obtain insight into the sex and age composition of the wolf population, food habits information, measurements for studies of sexual dimorphism, and measurements of nutritional status.

Systematic wolf surveys totaling 60.8 hours were flown in March 1973 in Game Management Unit 13 and the adjacent parts of Units 11 and 12 to assess wolf abundance. A change in personnel, which left the project without an investigator for several months and reduced emphasis on the location of wolf kills, limited the number of wolf sightings made. Observations of wolves made on moose and caribou surveys were recorded, and observations of pack size and coloration were compiled from wolf sealing records.

Little effort was directed at locating wolf killed ungulates. Kills located during surveys for wolves and other species were examined when possible using procedures described by Stephenson and Johnson (1973). Kills from Game Management Units 6, 7 and 15 were examined as well as those found in Units 11 and 13.

FINDINGS (ARCTIC STUDIES)

Estimate of Population Density, Anaktuvuk Pass Area, Spring 1973

In a previous progress report (Stephenson and Johnson 1973) I presented data on wolf numbers in the 3600 square-mile area around Anaktuvuk Pass with estimates of population density (expressed in square miles per wolf). Comparable data from the spring of 1973 are presented below.

Most of the sightings recorded in Table 1 were made by Nunamiut hunters during March and April. In addition to those wolves listed in Table 1, and seen within the 3600 $mi.^2$ area, a pack of four gray wolves, another consisting of three grays and one black, and one of one gray and one white wolf were seen in the Killik River Valley west of the study area. Reports from other areas adjacent to the study area suggest a density of wolves similar to that around Anaktuvuk.

The density of 1 wolf per 76 square miles should be regarded as only a rough estimate since the data were not collected in a strictly systematic fashion. As indicated in Table 2, the estimated density is similar to that estimated in fall, 1972, while average pack size is slightly lower. However, the small sample size does not allow a strict comparison. According to Nunamiut hunters, wolves were relatively scarce in the area during mid-winter as were caribou (*Rangifer tarandus*). The only caribou observed during the mid-winter months was a group of about 100 in the Killik River area.

In March 1973 the Nunamiut noticed that packs of wolves which had not been present during fall and mid-winter began to move through the Anaktuvuk area. It was the opinion of several Nunamiut hunters that these wolves were searching for caribou or other food and had come from the south and east.

Table 1. Summary of nonduplicated sightings of wolves in spring, 1973, northcentral Brooks Range.

Obs. No.	Date	Location	Number	Black	Gray	White	Remarks
1	10 March	Tulugak Lake	8	1	7		
2	13 March	Tulugak Lake	9		9		
3	16 March	Gunsight Pass Chandler River	7	4	3		Remains of 4 moose in area
4	10 April	Anaktuvuk Pass	4		4		
5	11 April	Loon Lake	4		4		
6	12 April	North Fork of Koyukuk	5		5		
7	14 April	Tulugak Lake	3		3		
8	18 April	Hunt Fork	5	-	-	-	Tracks only
9	20 April	Kanayut River	6		6		
		TOTALS	51	5	46	0	

Average Pack Size 5.6
Gray:black ratio 100:11
51 wolves identified in 3600 sq. mi. area
Estimated density = 1 wolf/76 sq. mi.

Table 2. Summary of wolf densities estimated for the northcentral Brooks Range, 1971, 1972 and 1973.

Season and Year	No. Wolves Enumerated*	Area (sq. mi.)	Density in Sq. Mi. per Wolf	Average Pack Size	Gray:Black Ratios
Spring, 1971	29	3600	1 wolf/124 sq. mi.	4.0	100:30
Fall, 1971	45	3600	1 wolf/80 sq. mi.	6.5	100:40
Fall, 1972	315	30,000	1 wolf/95 sq. mi.	estimated from occurrence of active dens	
Fall, 1972	55	3600	1 wolf/65 sq. mi.	6.5	100:30
Spring, 1973	51	3600	1 wolf/76 sq. mi.	5.6	100:11

*Based on direct observations supplemented by the occurrence of tracks except for fall, 1972 estimate for 30,000 $mi.^2$ area which was based on the spatial distribution of active dens.

The fact that few or no caribou overwintered in the vicinity of Anaktuvuk apparently caused wolves to rely to a great extent on moose (*Alces alces*) for food. Wolves were common along the major drainages in the foothills on the North Slope which constitute winter range for moose in that area. Several Nunamiut who hunted along the Chandler, Siksikpuk, Kanayut and Nanushuk Rivers in late winter 1972-73 reported that wolves seemed to be concentrated there. One 55 year-old trapper, Ben Ahgook, said that wolf sign along parts of the Chandler River was more abundant than any he had seen.

The remains of moose killed by wolves were common along the Chandler River during this period.

Estimates of wolf densities in Arctic North America are few. For and area of 480,000 mi.^{2} in the Northwest Territories Kelsall (1957) estimated a density of from 1 wolf per 60 to 120 mi.^{2}. In Mt. McKinley National Park Murie (1944) placed wolf density at 1 wolf per 50 mi.^{2}. Kuyt (1972) found that in a area of 384 mi.^{2} constituting caribou winter range in the Northwest Territories, wolf densities reached 1 per 6.9 mi.^{2}, but he pointed out that this density occurred only at a time of maximum winter concentration of caribou and that there were no wolves more than 20 miles from the center of caribou concentration. This situation contrasts with that in much of Alaska in that caribou are virtually the only ungulate prey for wolves in much of the Northwest Territories and wolves migrate from large areas to concentrate on caribou wintering areas. More recently Parker (1973) arrived at estimates of wolf density similar to Kuyt's from his studies on caribou wintering areas in northwestern Manitoba and northeastern Saskatchewan. Parker's estimates ranged from 1 wolf per 13.8 mi.^{2} in January to a maximum density of 1 wolf per 7.8 mi.^{2} reached during maximum concentration of wintering caribou in February. Caribou densities in the area surveyed ranged from 14 per mi.^{2} in January to 68.5 per mi.^{2} in April in a herd comprised of a total of about 51,000 caribou. Parker also pointed out the transient nature of these high densities of caribou and wolves and stated that wolves occur at much lower densities during most of the year, rarely being seen during summer.

From intensive studies of the food habits and behavior of tundra wolves on Central Baffin Island, Canada, Clark (1971) estimated wolf densities at a maximum of 120 mi.^{2} per wolf from 1966 to 1969.

The work of Rausch (1969), in an area of approximately 16,000 mi.^{2} in the Nelchina Basin in Alaska, showed an increase in wolf density from 1 wolf per 1,300 mi.^{2} in 1953, following cessation of intensive predator control work by U.S.F.W.S. involving poison and aerial gunning, to a maximum of about 1 wolf per 35 mi.^{2} in 1965 followed by a reduction to 1 wolf per 50 mi.^{2} in 1967.

In Southeastern Alaska, Atwell et al. (1963) estimated an average density of about 1 wolf per 40 mi.^{2} for the 7,500 mi.^{2} of wolf range south of Fredrick Sound and cited 1 wolf per 25 mi.^{2} as the maximum density achieved there. In this area black-tailed deer (*Odocoileus hemionus sitkensis*) are the primary food of wolves. On white-tailed deer (*Odocoileus virginianus*) range in Ontario (Pimlott et al. 1969) and Minnesota (Mech 1973) wolf densities are reported at roughly 1 per

10 mi.^{2} on good deer range and lower densities are common over large areas. These densities are roughly double those observed in higher latitudes and very likely reflect the greater basic productivity of the lower latitudes and coastal habitat.

The density figures derived from observations in the northcentral Brooks Range (Table 2) are most similar to those of Rausch (1969) for Southcentral Alaska, and Clark (1971) for Baffin Island.

Moose Population - North Slope

In 1970, 1971, 1973 and 1974 moose counts were conducted on the Chandler River between its confluence with the Ayiyak River and the mouth of the Chandler on the Colville River (Table 3).

The count area is approximately 40 miles long and 1.5 to 2 miles wide. In the first three years the counts were made using very similar methods (C-185 or C-180 aircraft, slow flight, S-turns) and under essentially good conditions (complete snow cover and strong light). In 1973, however, heavy overcast resulted in flat light and probably lowered the percentage of animals seen. Also, the 1973 count was done one and two months later than the 1970 and 1971 counts, respectively, and the effect of this difference in timing is unknown. In 1974 the count was done with a PA-18 aircraft in such a way that each section of willows was covered individually, the flight pattern varying with the habitat. This and the slower speed and better visibility provided by the PA-18 should make the 1974 data the most reliable in terms of approaching total count. Even with the more thorough counting technique used in 1974 the data from this year corroborate the suggestion of a decrease in population seen in the 1973 count data. The data suggest that a decrease in total population of roughly 30 percent took place between 1970 and 1974 in spite of modest calf production and survival. Similarly, data form the Colville River between Umiat and the mouth of the Killik River suggest a decrease in moose numbers of about 26 percent (307 moose counted in 1970 compared to 226 in 1974).

The apparent decrease in population is likely due to a combination of severe winter weather and increased predation by wolves. Many older Nunamiut reported that the winter of 1970-71 was the most severe, in terms of temperature, wind and snow accumulation, in the last 30 years. The number of moose overwintering in the mountains adjacent to Anaktuvuk Pass was correspondingly high (highest in the memory of older Nunamiut) and it is likely that the severe conditions caused an increased winter kill, increased vulnerability to predators, and possibly emigration of some moose to other areas.

My general impression in flying over other river drainages on the North Slope, such as the Colville River between Umiat and the mouth of the Killik River, during 1973, was that numbers were generally lower than in 1970.

Table 3. Moose count data, Chandler River. Census area includes floodplain of Chandler River from mouth of Ayiyak River north to the mouth of the Chandler River.

Date	Flight Time	Number Adults	Number Calves	Total Moose	Percent Calves
April, 1970	-	130	40	170	23.5
March, 1971	1:20	132	26	158	16.5
May, 1973	1:10	61	Calves not distinguished	61	-
April 1974	3:30	100	21	121	17.0

It is possible that the high numbers of moose noted on the North Slope by many people including the Nunamiut during the last decade represented a temporary "superabundance" of moose in view of the fact that the range was successfully colonized by moose only during the 1930's, apparently having been rarely frequented by moose prior to that time (LeResche et al. 1974). Two other factors that may have fostered high numbers of moose are: (1) the lessened impact of Nunamiut hunters brought about by the cessation of annual trips to and from the coast which were made for trading purposes during the late 1800's and early 1900's; and (2) the lower population of Nunamiut that returned to the Brooks Range in the late 1930's. Rasmussen (1928) reports that he counted 500 Nunamiut at the mouth of the Colville River in 1924; according to Gubser (1965) 65 Nunamiut were present in the northern Brooks Range and North Slope in 1949. Since moose are largely confined to habitat along the major drainages (which were also the major Nunamiut travel routes) on the North Slope, and are relatively more visible there than elsewhere, it would seem that the Nunamiut hunting could well have prevented the establishment of a large population.

One other factor that may have been of importance in allowing the moose population to grow to the extent that it apparently did was the extensive predator control programs, involving aerial gunning and poisoning, that the U.S.F.W.S. conducted on the North Slope in the late 1940's and early 1950's. In addition, sustained legal and illegal aerial hunting of wolves by the public occurred until 1970.

The factors discussed above were probably involved in promoting an increase in moose numbers on the North Slope; however, the importance of each is not known. Factors that might account for an apparent (and perhaps not widespread) decrease in recent years include an increased wolf population, the abnormally severe winters of 1970-71 and 1971-72, and possible deterioration of winter range due to a temporary "superabundance" of moose. Acting together, these factors could have been especially effective. More extensive aerial moose counts will be done in April 1974 in order to better characterize the status of the moose population in GMU 26.

The high moose population on the North Slope may have likewise provided favorable conditions for an increase in wolf population following the prohibition of aerial hunting in Unit 26 in 1970. At this time the wolf population was low and an increase would have been expected once the level of hunting pressure lessened. A reduction in the moose population could have been an influence in stabilizing the wolf population in view of the lack of other readily attainable prey species for wolves in the foothills during the winters of 1970-71, 1971-72 and 1972-73. Had caribou wintered in this area during these years it is probable that the wolf population would have increased to a higher density than was observed in 1973. Emigration of wolves also has an unknown but probably significant effect on wolf population levels in this area.

Harvest of Wolves - Anaktuvuk Pass

During the winter of 1972-73 residents of Anaktuvuk Pass trapped 64 wolves. The age and sex breakdown is given in Table 4. Data from winter 1971-72, although incomplete, are included for comparison.

Table 4 shows a preponderance of males, both pups and adults, in the harvest for both years. Mech (1970) reviewed data on sex ratios of wolves killed in various areas and found that in 7 of the 16 reports available sex ratios were within 3 percent of being even. Of 9 reports of ratios differing more than 3 percent from 50:50, 7 are biased toward males. Mech concluded that there is no ready explanation for the excess of males in certain areas, but suggested that disproportionate sex ratios could result from the birth of excess males, or from the possibility that males are more hardy or aggressive and that in populations under such stress as a low food supply or a high density males survive at a greater rate than females. There is as yet no satisfactory explanation for this phenomenon.

The data also suggest that the relative number of pups in the population has decreased slightly from 1971-72, but that pups still comprise more than 50 percent of the population.

Occurrence of Active Dens - 1973

During summer field work in the vicinity of Anaktuvuk Pass I was able to establish the locations of four potential active dens and deduced the general location of another den from observations of adult wolves in June and July and pups in August in the Anaktuvuk River Valley.

Potential active dens were identified by the presence of fresh digging and concentrations of wolf tracks and/or by the presence of adult wolves during late April and May. The general locations of potentially active dens included the North Fork of the Koyukuk, the upper Anaktuvuk River, Gunsight Mountain on the Chandler River, the Okokmilaga River and the Killik River. The air mile distances between adjacent dens were 16, 48, 56, 40 and 26 miles. In one case it is not known whether pups were reared at the den, but in the remaining four cases information obtained later in the summer indicated that natal dens were located in these areas.

During the summer of 1973 Robert Summerfield, a graduate student at the University of Alaska, studied Dall sheep (*Ovis dalli*) population dynamics and movement patterns in the Atigun Canyon, 100 miles east of Anaktuvuk Pass. He reported the locations of two active wolf dens, one near the east end of the canyon and one near the west end. Approximately 16 air miles separated the dens. At one den 15 pups and 3 gray adults were observed while at the other, 5 pups and an unspecified number of adults were seen. The fact that 15 pups were present at one den strongly suggests that two litters were raised together.

Also during the summer of 1973, studies conducted on wildlife in the Canning River area by Harry Reynolds (ADF&G), Audrey Magoun

Table 4. Sex and age composition of wolves harvested by residents of Anaktuvuk Pass, winters 1971-1972, 1972-1973. Animals of unknown sex and age were not included in the calculation of percentages. The adult classification includes wolves over one year of age (juveniles and adults).

Trapping Period	Male Pups		Female Pups		Male Adults		Female Adults		Total Pups		Total Adults		Unk.	Total
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%		
1970-71	-		-		-		-		-		-			20*
1971-72	10	28	7	25	6	21	0	0	19	79	6	21	8	36
1972-73	24	40	11	18	15	25	9	15	35	59	24	40	5	64
Total	34	39	18	21	21	24	9	10	54	62	30	34	13	100

*Approximate total wolves killed, records of age and sex not kept in this year.

(University of Alaska graduate student), Roland Quimby and David Roseneau (Renewable Resources Ltd.), revealed the locations of four active dens. These included one on the upper Ivishak River, two on the Canning River and one on the Kavik River. Distances between each den and the one nearest to it were 16, 34 and 16 air miles, respectively. A total of 25 pups were observed at these 4 dens representing litters of 4, 5, 5 and 11. Four adults were seen with the litter of 11 pups but it could not be determined whether more than one lactating female was present so the possibility exists that the 11 pups comprised a single litter.

The areas between dens in the Atigun Canyon area and in the Canning River area were covered quite thoroughly during extensive studies and there is little chance that there were other active dens between those reported. Near Anaktuvuk the only areas that were covered adequately enough to provide reasonable assurance that other dens were not present were the areas between dens on the North Fork of the Koyukuk, and Anaktuvuk River, and between dens on the Okokmilaga and Killik Rivers, distances of 16 and 26 air miles, respectively. Combining these distances with those from the Atigun and Canning areas, an average distance between active dens of 20.6 air miles is indicated. This figure is slightly lower than that of 25 miles given as an average distance between dens in the Anaktuvuk area during 1973 and before (Stephenson and Johnson 1973). In two of the above cases, the relatively close proximity of dens (16 air miles) may be attributed to greater than average densities of prey species. In the Canning River area, 2 dens 16 miles apart were located precisely in an area where approximately 2,000 caribou overwintered (Reynolds, pers. comm.). Similarly, the Atigun Canyon area supports relatively high densities of sheep during winter and summer, as well as occasional moose, and, during spring, caribou.

Cementum Aging of Wolves

In order to test the validity and practicality of cementum layers as age criteria for wolves, canine teeth from 20 wolf skulls including 6 of known age, were sectioned using a cryostat and standard histological techniques. Sections were stained with Paragon Multiple Stain for frozen sections and rinsed with water. Stained sections were examined under a binocular microscope.

Longitudinal sections of the roots of lower canines were used in all specimens and both upper and lower canines of three specimens were sectioned so that a comparison of cementum layer characteristics could be made. The number and clarity of layers in upper and lower canines were the same in each case and only lower canines will be used in the future. Cementum layers were detectable in most specimens and particularly in older animals, although one section was so thin that cementum lines were not visible. As Klevezal and Kleinenberg (1969) pointed out, primary layers are fainter than subsequent ones, the latter being more definite and consistent over the length of the root.

Data from six known-age wolves are presented in Table 5. The column labeled "No. Cementum Lines" indicates simply the number of dark (non-transparent) bands visible in the section. "Cementum Age" indicates

Table 5. Cementum layer data from known-age wolves reared at NARL, Barrow, Alaska.

Accession Number	Date Died	Sex	Number Cementum Lines	Cementum Age (yrs.)	Known Age	NARL Name	Remarks
61226	7/2/72	M	None visible	None	1 year & 1 mo.	"Black 1971 Male	Sections too thin to show layers.
61222	10/2/72	F	2	2 1/2	2 years & 4 mo.	"Black Red Tag"	
61047	11/16/71	F	2 plus dark border	2 1/2	2 years & 5 mo.		
61224	2/18/71	F	3	3	2 years & 8 mo.	"Princess II"	
61225	10/5/70	M	3	3 1/2	3 years & 4 mo.	"Tim Sr."	
61223	4/8/72	M	4 plus dark border	4 1/2	4 years & 10 mo.	"Baggy Eyes"	

the age estimated from the number of cementum layers assuming that a dark band is formed during each winter of a wolf's life. The "Known Age" is given in years and months as established by records from the Naval Arctic Research Laboratory at Barrow, Alaska, where all of the known-age wolves were reared.

These data suggest that a "non-transparent" cementum layer is formed during each winter of a wolf's life. Thus, each dark cementum band should represent an additional year of life. The dark band formed in the winter prior to the death of the animal may lie at the outer edge of cementum if the animal died in mid-winter or early spring, or it may be bordered by a more transparent band of cementum if the wolf died in summer or fall.

In their review of age determination in mammals based on annual layers in dentine, cementum and the periosteal zone of bone, Klevezal and Kleinenberg (1969) noted that the most extensive cementum age studies of the Canidae have been done on the Arctic fox (*Alopex lagopus*) but stated that layers of cementum have also been discovered in red foxes (*Vulpes fulva*) and wolves. However, this is the only mention made of wolves and no specific data were cited. R. A. Rausch, of the Alaska Department of Fish and Game, has sectioned teeth from several hundred wolves including some from known-age animals but has not yet finished analyzing these data. His findings regarding cementum deposition in wolves do, however, corroborate the general pattern described here (Rausch, pers. comm.). Klevezal and Kleinenberg have shown that in Arctic foxes of known age, regular cementum layers existed in all specimens studied. The number of layers corresponded, as a rule, to the age of the animal. They also noted that cementum is thickest on the lower part of the canine root which indicates that a longitudinal section through the lower part of the root is best for study of annual layers. Klevezal and Kleinenberg also compared the structure of cementum of molars and canines in the upper and lower jaws of one specimen and found that the clarity and number of layers in the various teeth were identical.

From their own work and that of others, Klevezal and Kleinenberg concluded that in northern mammals the narrow (non-transparent) band of an annual layer of cementum forms during the winter period and reflects a retardation of cementum growth rate. They also noted that the legibility of primary annual layers (those formed in the first year or two of an animal's life) is significantly less than subsequent layers, because seasonal oscillations in the growth rate of tissues of teeth are probably expressed less sharply during the initial years.

Cementum layer data from selected wolf specimens are presented in Table 6. A comparison of cementum age estimates with the remarks on tooth wear suggests that the degree of tooth wear coincides at least roughly with the estimated cementum age.

Of interest is the extreme age of a white male wolf (#61094) trapped near Anaktuvuk Pass. This wolf had been observed by residents of Anaktuvuk since 1968 and was distinguished by his large size, pure white pelage and elusive behavior. Several Nunamiut hunters stated that

Table 6. Cementum layer data from selected wolves.

Accession Number	Date Killed	Location	Sex	Color	Number Cementum Lines	Cementum Age	Remarks
61015	12/16/70	Anaktuvuk Pass	M	Black	4	5	Teeth worn
61024	3/21/71	Anaktuvuk Pass	F	Gray	2	3	Teeth showing very little wear
61045	May 1971	Deadwood Cr. Central, AK	F		6	7	Heavy wear on teeth. Canine and carnassial missing - jaw healed.
61060	April 1972	Birch Creek	M		6	6	Heavy wear on teeth
61065	9/21/72	Anaktuvuk Pass	M	Gray	1	1-1/2	Light wear on teeth
61056(A)	4/24/72	Delta River	M	Gray	2	2	Largest male in pack of six
61056(B)	4/24/72	Delta River	M	Gray	5 possibly 6	5 or 6	About 10 lbs. lighter and noticeably smaller than 61056(A)
61056(C)	4/24/72	Delta River	F	Gray	4	4	Pregnant female
61037	9/6/71	Murphy Dome, Fairbanks	F	Gray	4	4-1/2	Light wear on teeth
61067	1968	Anaktuvuk Pass	F		6 possibly 7	6 or 7	Skull found at den near Anaktuvuk, teeth showed heavy wear
61070	10/24/72	Anaktuvuk Pass	F	Gray	Trace of one line	1-1/2	Nonparous adult-dentition and size indicated wolf was older than one year
61077	11/1/72	Okokmilaga River	F	Black	2 plus dark border on cementum	2-1/2	Light wear on teeth
61094	3/14/73	Anaktuvuk Pass	M	White	12	12	Suggestion of an additional 3 lines. Age could be 15, extreme wear on teeth.

it would be almost impossible to trap this wolf without using a special rawhide snare, but the wolf was eventually caught in a conventional steel trap set. Four of this wolf's upper incisors had been lost a considerable time before death as evidenced by the completely healed over tooth sockets. Both upper and lower premolars were worn level with the maxillae and mandibles, respectively, and the adjacent bone was worn flat. Wear on upper and lower molars was quite heavy, the sharp crest on each carnassial being reduced to a flat area 1/4 inch wide. A considerable portion of the wear on canines and premolars was likely due to the wolf chewing on the trap as evidenced by the freshly cracked surfaces of these teeth. Despite the heavy tooth wear and its advanced age, the wolf weighed 95 pounds and had subcutaneous fat deposits of only slightly less than average depth (1/8 inch on rump). The only comparable data from wild canids of which I am aware are those cited by Knowlton (1972) who reported that the oldest wild coyotes (*Canis latrans*) recorded are a 14.5 year-old female from western Colorado and a 13.5 year-old male from Texas. Young (1944) summarized records from known-age captive wolves which indicate that a 10-year-old wolf is very old and that 16 years is the maximum life span.

Radio-telemetry of Wolves

This phase of the study has been completed and its results published in the following paper: Henshaw, R.E. and R.O. Stephenson. 1974. Homing in the gray wolf (*Canis lupus*). Mammal. 55(1):234-237.

FINDINGS (SOUTHCENTRAL STUDIES)

Wolf Abundance

A total of 87 wolves (Table 7) were observed in Units 11 and 13 during 1972-73 (excluding observations 16 and 23 which were possible resightings). Of these animals 34 were seen in Unit 11 and 53 in Unit 13. Poor and irregular snow conditions made it impossible to conduct the survey in a manner that would permit a reliable estimate of total numbers. These data provide some indication of relative abundance when compared to previous years, however.

According to Rausch (1967) mean pack size is a good indication of wolf abundance. During the 1970-71 wolf study in Unit 13, the mean pack size recorded in all types of wolf observations combined (observations primarily by Department of Fish and Game personnel and analysis of aerial wolf hunter reports) was 7.1 (Stephenson and Johnson 1972). The mean pack size for Units 11 and 13 combined during 1972-73 was 3.1, with mean pack sizes of 3.8 in Unit 11 and 2.8 in Unit 13. These figures are based primarily on observations by Alaska Department of Fish and Game personnel.

Using wolf sealing certificates to determine pack size has several shortcomings. Trappers who trap only one wolf may assume it is the only wolf in the pack. The number of wolves in the pack is commonly unknown. Also, trappers who take more than one wolf from a pack do not always indicate that additional wolves were taken from the same pack. These biases must be considered when analyzing wolf pack size data based on sealing records.

Table 7. Summary of Sightings of Wolves from July 1, 1972 through June 30, 1973
Southcental (Nelchina Basin) Alaska

Obs. No.	Date	Location	Black	Gray	White	Brown	Total Number	Remarks
1	7/29/72	Unit 11 Mud Volcano - Mt. Drum	-	2	-	-	2	---
2	9/15/72	Unit 13C Slana River	-	1	-	-	1	---
3	9/20/72	Unit 13B Gakona River	1	4	-	-	5	---
4	9/26/72	Unit 13A Cache Creek	1	-	-	-	1	---
5	10/3/72	Unit 13C Slana - Tok Road	-	3	1	-	4	---
6	10/25/72	Unit 13A Crosswind Lake	3	3	-	1	7	---
7	11/1/72	Unit 13B Dicky Lake	-	2	-	-	2	---
8	11/13/72	Unit 11 Sanford River	3	10	-	-	13	---
9	11/22/72	Unit 11 Klawasi River	-	1	-	-	1	---
10	12/6/72	Unit 11 Long Lake	1	-	-	-	1	---
11	12/10/72	Unit 11 Kotsina River	-	1	-	-	1	---
12	12/20/72	Unit 13C Gakona River	-	1	-	-	1	---

Table 7 (cont). Summary of Sightings of Wolves from July 1, 1972 through June 30, 1973
Southcental (Nelchina Basin) Alaska

Obs. No.	Date	Location	Black	Gray	White	Brown	Total Number	Remarks
13	12/20/72	Unit 11 Dry Lake #1	-	4	-	-	4	---
14	2/27/73	Unit 13B Gakona River	-	2	-	-	2	---
15	2/27/73	Unit 13B Gulkana River	-	1	-	-	1	---
16	3/2/73	Unit 13B Gakona River	-	1	-	-	1	Possibly a resighting of one of the gray wolves from Observation Number 14.
17	3/7/73	Unit 11 Sanford River	3	3	-	-	6	---
18	3/15/73	Unit 13C Gakona River	-	1	-	-	1	---
19	3/17/73	Unit 13E Wells Creek	5	1	-	-	6	---
20	3/17/73	Unit 13A Upper Tolsona Creek	1	3	-	-	4	---
21	3/17/73	Unit 13E Susitna River	-	2	-	-	2	---
22	3/17/73	Unit 13E Honolulu Creek	-	2	-	-	2	One wolf had a limp in his left rear leg.
23	3/17/73	Unit 13E Portage Creek	-	1	-	-	1	Possibly a resighting of one of the gray wolves from Observation Number 21.

Table 7 (cont). Summary of Sightings of Wolves from July 1, 1972 through June 30, 1973
Southcentral (Nelchina Basin) Alaska

Obs. No.	Date	Location	Black	Gray	White	Brown	Total Number	Remarks
24	3/18/73	Unit 13D Tazlina River	-	1	-	-	1	---
25	3/20/73	Unit 13A Little Nelchina River	1	-	-	-	1	---
26	3/31/73	Unit 13A Old Man Lake	2	4	-	-	6	---
27	4/17/73	Unit 13A Moose Creek	-	4	-	-	4	---
28	5/10/73	Unit 13A Talkeetna River	2	-	-	-	2	---
29	6/29/73	Unit 11 Boulder Creek	-	5	-	-	5	---
30	6/30/73	Unit 11 Sanford River	-	1	-	-	-	Wolf was near bands of caribou
Totals for both Units 11 and 13 Mean pack size = 3.1 Black:gray ratio = 37:100 {Excluding observations 16 and 23}			23	64	1	1	89	
Totals for Unit 11 Mean pack size = 3.8 Black:gray ratio = 26:100			7	27	-	-	34	
Totals for Unit 13 Mean pack size = 2.8 Black:gray ratio = 46:100 {Excluding observations 16 and 23}			16	37	1	1	55	

In Unit 11 during the 1972-73 trapping season 48 wolves were taken. On sealing certificates for 8 of these 48 wolves pack sizes were reported as unknown. The mean pack size reported on the sealing records for the remaining 40 wolves was 2.7 with a range of one to nine.

In Unit 13, during the 1972-73 trapping season, 80 wolves were taken. Sealing certificates for 12 of these 80 wolves indicated that pack size was unknown. The mean of reported pack sizes was 3.4 (range 1-25). It is interesting to note that the same mean pack size in 1972-73 of 3.1 for the combined units was calculated from both visual observations and wolf sealing data.

Although the data are limited, reduction of the mean pack size form 7.1 in 1971 to 3.1 in 1973 indicates a possibly significant reduction in wolf numbers in the Nelchina basin. Moose and caribou numbers declined over the previous few years and it is reasonable to expect that wolf numbers would follow a similar trend.

Wolf Coloration

According to Stephenson and Johnson (1972) wolf coloration should be monitored because the ratio of dark to light colored individuals might be an indicator of the wolf population trend.

Of the 87 wolves (Table 7) observed primarily by Alaska Department of Fish and Game personnel in Units 11 and 13 during 1972-73 (excluding observations 16 and 23 which were possible resightings), the black:gray ratio was 37:100 (23 blacks and 63 grays). The breakdown of data from individual units was: Unit 11, 7 blacks and 27 grays = 26:100, Unit 13, 16 blacks and 35 grays = 46:100.

Based on information gathered by wolf sealing during 1972-73 the combined Units 11 and 13 black:gray ratio was 38:100 using data of 36 black and 96 gray wolves. In Unit 11, 10 blacks and 38 grays were reported taken for a black:gray wolf ratio of 26:100. In Unit 13, 16 black and 58 gray wolves were taken for a black:gray ratio of 28:100.

The combined Unit 11 and 13 black:gray ratio, calculated from observations by biologists, was essentially the same as that calculated from sealing data, 37:100 and 38:100, respectively. This is slightly higher than the 25:100 reported for 1971-72 by Stephenson and Johnson (1973) but is substantially lower than reported from previous years when the Nelchina wolf population was increasing (Stephenson and Johnson 1972).

Utilization by Humans

The price of wolf pelts during 1972-73 was slightly higher than previous years due to a shortage of long fur pelts in the European market. Aerial wolf hunting permits were not issued. Recorded harvests for Unit 11 were 23 in 1970-71, 56 in 1971-72 and 48 in 1972-73. Harvests for Unit 13 were 91 in 1970-71, 111 in 1971-72 and 80 in 1972-73. The lack of aerial permits appears to have been largely offset by increased incentive for trapping due to higher prices, however different methods of determining harvest prior to 1971-72 may have biased the results.

Physical Condition of Ungulate Prey

On wolf and other types of surveys an attempt was made to locate any dead ungulates on which wolves had been feeding. To help determine the cause of death and physical condition of the ungulate at death, the lower jaw was collected for age determination and the femur for marrow fat content whenever possible.

U.S. Department of Commerce climatological data indicate that during the winter of 1972-73 snow depths were not as great as in the past two winters in Units 11 and 13. With less frequent snowfalls, old crusted snow made tracking of wolves and finding "wolf kills" extremely difficult.

During the study period 10 moose and two caribou "wolf killed" carcasses were located in Units 11 and 13. There were also three illegal and three road-killed caribou found in the Eureka area of Unit 13.

Unfortunately, specimens from three of the "wolf kills," two of the illegal kills and all three road-killed animals were reported to have never been received by the Alaska Department of Fish and Game, Anchorage Game Laboratory.

Six "wolf killed" moose were found in Units 15A and 15B East. One "wolf killed" moose was located in Unit 6. Two moose that had probably fallen over a cliff and one possible poacher kill were also located in Units 7 and 15B East, respectively.

Table 8 summarizes data from all cervid carcasses examined during the study period. Included for comparative purposes are a number of caribou and moose that died from causes other than wolf predation.

Whenever possible, the sex and age were determined for all ungulate prey known to have been killed by wolves. Excluding one calf, only four "wolf killed" moose from the Nelchina Basin area were aged. Four of the "wolf kill" moose from the Kenai Peninsula were calves and one was a yearling. The one "wolf killed" cow moose from Unit 6 was 15-years old.

Quantative analysis of fat deposits has frequently been used as a criterion of physical condition of animals. Various procedures for determination of bone marrow fat have been reviewed by Neiland (1970). Mech (1970) found that only 15 percent of "wolf killed" adult moose examined on Isle Royal had low marrow fat content. In Alaskan moose, it appears that adult animals with 20 percent or less and calves with less than 10 percent fat in their long bone marrow are approaching death through starvation/malnutrition (Stephenson and Johnson 1973). Marrow samples of five "wolf killed" adult moose from Units 11 and 13 averaged 87.6 percent dry weight (mostly fat). One "wolf killed" calf moose had 23.0 percent dry weight in the marrow whereas two other moose of unknown age from Unit 13 had dry weights of 82.0 and 5.9 percent, respectively.

Table 8
SUMMARY OF OBSERVED "WOLF KILLS" - SOUTHCENTRAL ALASKA
July 1, 1972-June 30, 1973

Accession or Specimen No.	Species	Sex	Cementum Age	Marrow % Dry Weight	Specimens Collected (Bones, Hair, etc.)	Collection Date	Collected By	Location	Remarks
NCS-M-72-24	Moose	Sex Unk	--	--	None	11/21/72	N. Steen	Fox Lk. 1/3 way up Gakona R. on east side, Unit 13C	Totally utilized wolf kill
67232 (NCS-M-72-25)	Moose	F	12-14	95	Jaw, femur	12/30/72	N. Steen	Head of Klawasi Cr., Unit 11	Totally utilized wolf kill
NCS- 72-26	Caribou	F	--	--	Jaw only	1/ 5/73	A. Runyan (guide)	Mi. 137 Glenn Hwy., Unit 13A	Illegal kill. Anchorage game lab. reports that specimens were never received.
NCS- 72-27	Caribou	Sex Unk	--	--	Jaw only	1/ 1/73	N. Steen	Mi. 135 Glenn Hwy., Unit 13A	Illegal kill. Anchorage game lab. reports that specimens were never received.
NCS- 72-28	Caribou	F	--	--	None	1/18/73	N. Steen	Mi. 133 Glenn Hwy., Unit 13A	Illegal kill
67225 (NCS- 73-29)	Moose	F	2	86	Jaw & "long bone"	1/31/73	N. Steen	15 mi. east of confluence of Chistochina R. & Copper R. on north side of Copper R., Unit 13C	Wolf kill, total utilization
67230 (NCS- 73-30)	Moose	F	13	86	Jaw, femur	2/ 5/73	N. Steen	North bank of Susitna R. which would be directly north of Clarence Lk., Unit 13E	Possible wolf kill, 75% utilization

Table 8 (cont)

SUMMARY OF OBSERVED "WOLF KILLS" - SOUTHCENTRAL ALASKA
July 1, 1972-June 30, 1973

Accession or Specimen No.	Species	Sex	Cementum Age	Marrow % Dry Weight	Specimens Collected (Bones, Hair, etc.)	Collection Date	Collected By	Location	Remarks
NCS- 73-31	caribou	M	--	--	Jaw only	2/10/73	T. Jordan (F&W Protection)	Eureka, Unit 13A	Road kill, Anchorage game lab. reports that specimens were never received.
NCS- 73-32	Caribou	F	--	--	Jaw only	2/10/73	T. Jordan (F&W Protection)	Eureka, Unit 13A	Road kill, Anchorage game lab. reports that specimens were never received.
67228 (NCS- 73-33)	Moose	Sex Unk	--	88	"long bones" only	2/ 1/73	N. Steen	Second Hill Lk. Unit 13A	Possible wolf kill 75% utilization. Brown bear on kill 2/1/73
NCS- 73-34	Caribou	Sex Unk	--	--	Jaw, "long bone", front leg, pelvic girdle	2/26/73	N. Steen	Little Nelchina R., Unit 13A	Possible wolf kill, 50% utilization. Anch. game lab. reports that specimens were never received.
67231 (NCS- 73-35)	Moose	F	9	89	Jaw, femur, hair	3/ 2/73	N. Steen	Upper Gakona R. east of Round Top Mt., Unit 13B	Wolf kill 50% utilization
67226 (NCS- 73-36)	Moose	Sex Unk	calf	23	Femur only	3/13/73	C. McMahan (guide)	5 mi. southeast Hogan Hill, Unit 13B	Wolf kill 100% utilization
NCS- 73-37	Moose	Sex Unk	--	--	Jaw only	3/13/73	C. McMahan (guide)	Jay Cr. Headwaters, Unit 13E	50% utiliaztion, possible wolf kill, Anchorage game lab. reports that specimens were never received.

Table 8 (cont)

SUMMARY OF OBSERVED "WOLF KILLS" - SOUTHCENTRAL ALASKA
July 1, 1972-June 30, 1973

Accession or Specimen No.	Species	Sex	Cementum Age	Marrow % Dry Weight	Specimens Collected (Bones, Hair, etc.)	Collection Date	Collected By	Location	Remarks
67229 (NCS- 73-38)	Moose	Sex Unk	--	82	Femur, hair, no jaw	3/23/73	N. Steen	Along west bank of Susitna R. 1 mi. north of confluence of Tyone R., Unit 13E	Wolf kill 50% utilization
67227 (NCS- 73-39)	Moose	Sex Unk	--	5.9	Femur, hair, no jaw	3/23/73	N. Steen	Along the east bank of Susitna R. 1 1/2 mi. north from mouth of Tyone R., Unit 13B	Wolf kill 90% utilization
NCS- 73-40	Caribou	Sex Unk	--	--	Jaw, femur, pelvic girdle	3/23/73	N. Steen	John Lk. 2 mi. north-west of Slide Mt. Unit 13A	Possible wolf kill, Anchorage game lab. reports that specimens were never received.
NCS- 73-41	Caribou	F	--	--	Jaw only	4/ 2/73	N. Steen	Mi. 123 Glenn Hwy., Unit 13D	Car kill, Anchorage game lab. reports that specimens were never received.
67233 (LN-73-1)	Moose	M	--	18	Femur only	3/ 5/73	L. Nichols	Doroshkin Bay, Skilak Lk. Unit 15BE	Killed but not eaten. Tracks of 8 wolves present
67234 (LN-73-2)	Moose	F	calf	8.2	Femur only	2/23/73	L. Nichols	Skilak Lk. Unit 15BE	Wolf kill
67235 (LN-73-3)	Moose	F	--	6.2	Femur only	2/24/73	L. Nichols	Kenai R. Canyon below Sportsman Lodge, Unit 7	May have fallen from cliff

Table 8 (cont)

SUMMARY OF OBSERVED "WOLF KILLS" - SOUTHCENTRAL ALASKA
July 1, 1972-June 30, 1973

Accession or Specimen No.	Species	Sex	Cementum Age	Marrow % Dry Weight	Specimens Collected (Bones, Hair, etc.)	Collection Date	Collected By	Location	Remarks
67236 (LN-73-4)	Moose	Sex Unk	calf	7.6	Femur only	2/24/73	L. Nichols	Kenai R. Canyon below Sportsman Lodge, Unit 7	May have fallen from cliff
67237 (LN-73-3)	Moose	Sex Unk	calf	12	Femur only	2/23/73	L. Nichols	Skilak Lake, Unit 15BE	Possible poacher kill "cleaned" by wolves
67246 (019)	Moose	F	yearling	58	Femur only	12/30/72	J. Davis	South end lower Ohmer Lake, Unit 15A	Wolf kill
67250 (204)	Moose	F	calf	6.6	Femur only	2/ 9/72	J. Davis	1 mi. south of upper landing Skilak Lake. Unit 15BE	7 wolves
67251 (207)	Moose	F	calf	9.3	Femur only	2/18/73	J. Davis	1/4 mi. east of upper Skilak Lake landing pad on Skilak Loop Road. Unit 15A	Thompson saw 2 wolves
67252 (208)	Moose	M	calf	16	Femur only	2/ 1/73	J. Davis	SE corner of Blizzard Lake Unit 15A	7 or 8 wolves
67253	Moose	F	15	--	Jaw, hair, lower leg bones, pelvic girdle	3/17/73	J. Reynolds	Martin River Flats, Unit 6	Wolf kill, 8 wolves

On the Kenai Peninsula six "wolf killed" moose were located. One moose of unknown age had 18.0 percent dry weight in the marrow. A yearling female had 58.0 percent dry weight and four calves averaged 10.0 percent.

Also from the Kenai Peninsula were the following: one moose that may have fallen form a cliff (age unknown)--percent dry weight 6.2; a calf that may have fallen from a cliff (7.6); and one calf that was possibly a poacher kill, but "cleaned" by wolves (12.0). Unfortunately, the 15-year old "wolf killed" cow moose in Unit 6 did not have usable leg bones for marrow analyses when found.

Little can be concluded from the above data except that they generally agree with the conclusion of Stephenson and Johnson (1973). It appears that it will be difficult to locate large samples of "wolf kills" in areas with relatively low ungulate and wolf populations in mild winters.

RECOMMENDATIONS

Arctic

An estimate of wolf population density should be made a least once annually for the 3,600 mi.^{2} area around Anaktuvuk Pass and the collection of wolf carcasses taken by Nunamiut should continue. This will provide continuity in population level and age ratio data for this wolf population.

A concerted attempt should be made to gather scats and food remains from recently used dens in both the Arctic and Interior regions.

The collection of "wolf kill" remains should continue as opportunities arise in the course of work in the Brooks Range and Interior.

Wolf populations should be monitored in Interior Alaska by means of aerial surveys carried out annually on selected areas representative of habitat-faunal associations in the region.

Southcentral

Additional information on the characteristics and condition of ungulate prey of wolves should be collected as it becomes available. The status of the wolf population in the Nelchina Basin should continue to be monitored with emphasis on systematic censusing to provide reliable information on wolf densities. Studies should be directed at determining the effects of wolves on the present reduced moose and caribou populations.

ACKNOWLEDGMENTS

Thanks are again extended to the residents of Anaktuvuk Pass for their cooperation in this study, and especially to Bob Ahgook and Justus Mekiana for sharing their extensive knowledge of wildlife and otherwise assisting in every aspect of this study. Richard Shideler also deserves special thanks for his able assistance during the spring and summer of 1973 and Bill Gasaway of the Fairbanks Laboratory staff deserves thanks for sectioning wolf teeth for cementum aging.

Grateful acknowledgment is also given to the following persons:

Nicholas C. Steen, Game Biologist, ADF&G for his invaluable assistance; Charles V. Lucier and Donald G. Calkins of the Dept. of F&G Laboratory in Anchorage where the specimens were processed; advice from Karl B. Schneider, Region II Research Coordinator; the expert flying of Ken Bunch, Cleo McMahan, and Jack Wilson; and the assistance of Gregory N. Bos, David B. Harkness, Lyman Nichols, Jr., Paul A. LeRoux, James L. Davis, and Julius L. Reynolds, Game Biologists, ADF&G.

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