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ALASKA DEPARTMENT OF FISH AND GAME

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M O R T A L I T Y S T U D Y

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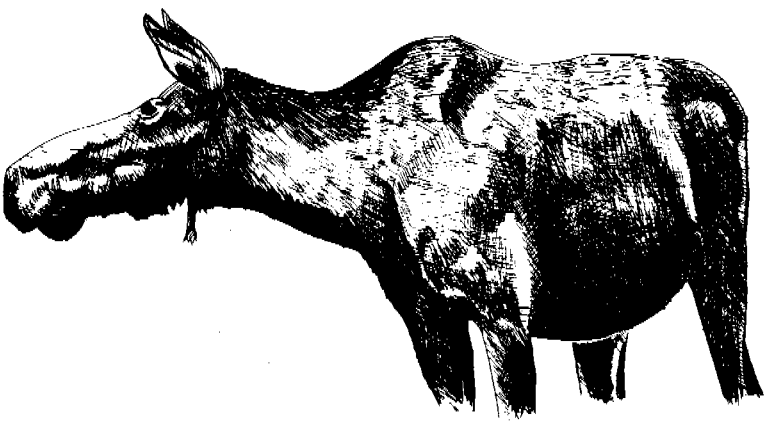

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Final Report
Federal Aid in Wildlife Restoration
Projects W-17-10 and W-17-11, Job No. 1.24R

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FINAL REPORT (RESEARCH)

State: Alaska

Cooperators: Albert W. Franzmann, Charles C. Schwartz and Rolf O. Peterson

Project No.: W-17-10, W-17-11 Project Title: Big Game Investigations

Job No.: 1.24R Job Title: Kenai Peninsula Moose Calf Mortality Study

Period Covered: July 1, 1977 through June 30, 1979

SUMMARY

During spring 1977 and 1978, 67 moose calves were radio-collared with mortality sensor transmitters. The study area was on the Kenai Peninsula, Alaska, in the calving areas within 13 km of the Kenai Moose Research Center (MRC). Forty-seven calves which remained bonded with their cows were monitored by aerial flights and by a fixed tower and monitoring station at the MRC for causes of mortality. Calf mortality was attributed to: black bear predation (16 calves, 34%), brown bear predation (3 calves, 6.4%), wolf predation (3 calves, 6.4%), unknown predation (2 calves, 4.3%), and unknown mortality (2 calves, 4.3%). For both years total predation accounted for 48.9 percent of moose calf mortality and total moose calf mortality was 57.4 percent.

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BACKGROUND

Results of work accomplished under Job 1.24R have been documented in two manuscripts. The first, "Causes of summer moose calf mortality on the Kenai Peninsula, Alaska" by Albert W. Franzmann, Charles C. Schwartz and Rolf O. Peterson, was prepared for publication in the Journal of Wildlife Management. It provides the body of this report. The second manuscript, "Comparison of techniques utilized to determine moose calf mortality in Alaska" by Warren B. Ballard, Albert W. Franzmann, Kenton P. Taylor, Theodore A. Spraker, Charles C. Schwartz and Rolf O. Peterson, was presented by Ballard at the 15th North American Moose Conference and Workshop in March 1979, at Kenai, Alaska. An abstract of that paper appears as Appendix I of this report.

Although neonatal and summer moose (*Alces alces*) calf mortality has long been recognized as an important factor in moose population dynamics, few data are available defining causes. In the Tanana Valley of Central Alaska, Gasaway et al. (1977) recorded a decrease in moose calf numbers from 44 to 14 per 100 cows from June to November 1975. Based on available evidence, they concluded that predation by wolves (*Canis lupus*) was the most probable cause of these losses. Significant predation by wolves on young ungulates has been reported elsewhere (Mech 1966, Mech and Frenzel 1971, Kuyt 1972, Miller and Broughton 1974, and VanBallenberghe et al. 1975).

LeResche (1968) observed a decrease in moose calf numbers from 84.3 to 36.2 per 100 cows from May to October near Palmer, Alaska. He did not consider black bears (*Ursus americanus*) an important predator of moose calves, but observed a brown bear (*Ursus arctos*) killing a cow and two calves. LeResche also reported several accidental calf deaths and desertion of calves by cows in two instances. Wolf predation was not considered a problem. Chatelain (1950) reported a high incidence of black bears eating young moose calves on the Kenai Peninsula.

After an absence of about 50 years, wolves reappeared on the Kenai Peninsula during the 1960's. Present densities seasonally peak at approximately one wolf/80 km^2 on the study area (Peterson, unpub. data). With three major predators on the Kenai Peninsula (wolves, black and brown bears) and four major ungulates (moose, caribou [*Rangifer tarandus*], Dall sheep [*Ovis dalli*] and mountain goats [*Oreamnos americanus*]), it

was desirable that we obtain a better understanding of predator-prey relationships and to what extent they influenced summer moose calf mortality. The technology developed by Schlegel (1976) in Idaho to determine the influences of predators on elk (*Cervus canadensis*) calves was adopted to study moose calves in Alaska.

OBJECTIVES

To determine the extent and causes of moose calf mortality on the Moose River Flats, Kenai Peninsula.

METHODS

The study was conducted from the Moose Research Center (MRC) which is centered approximately 13 km from each boundary of the study area. The MRC is on the Kenai National Moose Range in the northwestern Kenai Peninsula lowlands. Detailed description of the study area appeared in Oldemeyer et al. (1977).

Calves were located by visual search from helicopter (Bell Jet Ranger II) during the peak calving period in late May and early June. Capture of calves was by: (1) immobilizing the cow with darts (Cap-Chur, Palmer Co., Douglasville, GA) fired from a helicopter and subsequently landing to process the calf which in most instances was standing near the immobilized cow, or (2) calves alone were captured by approaching the cow and calf with the helicopter and forcing the cow away from the calf. The helicopter then landed near the calf and the calf was processed and radio-collared, or just radio-collared. Attempts were made to obtain calves as young as possible (1-3 days age); this was best done by an aerial search of the study area daily and capturing each calf we found.

From 29 May through 7 June 1977, 13 cows were immobilized and processed and 16 associated calves (three cows had twin calves) were radio-collared and processed. On 31 May and 7 June 1977, nine calves were radio-collared without immobilizing the cow. During 1977, 25 calves were radio-collared and 13 cows were immobilized. Two calves died when the cow died, one calf's radio failed immediately and one calf was found drowned the day after capture. From 24 May through 13 June 1978, 10 cows were immobilized and processed and 11 associated calves (one cow had twin calves) were radio-collared and processed. From 24 May through 1 June 1978, 31 calves were radio-collared without immobilizing the cow. During 1978, 42 calves were radio-collared and 10 cows were immobilized (Table 1).

Processing the cows and calves included blood-sampling the cows from the jugular vein (Franzmann and LeResche 1978); blood-sampling the calves from the radial vein using a 21 gauge needle on a 10 cc syringe; plucking and collecting at least 1 gr of hair from the hump (Franzmann et al. 1975); measuring total length, chest girth and hind foot length (Franzmann et al. 1978); weighing the calves; extracting the first incisor from the cow for aging (Sergeant and Pimlott 1959); and assessing condition class of the cow (Franzmann and LeResche 1978). Collected samples were processed

as outlined by Franzmann et al. (1976). Roto-tags (Nasco Inc., Modesto, CA) were placed in each calf's ear and cows were visual-collared, ear-tagged and flagged (Franzmann et al. 1974).

During 1977 the cows were immobilized using a combination of 7 mg etorphine (M-99, D-M Pharmaceuticals Inc., Rockville, MD), 300 mg xylazine hydrochloride (Rompun, Haver-Lockhart, Shawnee, KS), and 250 units hyaluronidase (Wydase, Wyeth Laboratories, Inc., Philadelphia, PA). Upon completion of processing both cow and calf, or just calves, the antagonist diprenorphine (M 50-50, D-M Pharmaceuticals, Inc., Rockville, MD) was injected into the cow's jugular vein. In 1978 the dosage of xylazine hydrochloride was reduced from 300 mg per adult cow to 100 mg and the etorphine dosage was increased from 7 to 9 mg per adult cow. Hyalurondiase was not used in the immobilizing mixture in 1978.

In 1977 the radio transmitters (AVM Instrument Co., Champaign, IL) placed on the calves ranged in frequency from 164.025 to 164.919 and while in motion pulsed at approximately 60 beats/minute. When movement ceased for approximately four hours the pulse tripled (188 to 217 beats/min). The radio collar was designed to expand from 33 cm to 66 cm circumference and then fall off. It was fashioned after the design for expanding goose neck bands and was constructed of vinyl plastic (4 cm wide x 2 mm thick). The transmitter was encased in acrylic and fastened to the collar by vinyl plastic rings through which the collar could freely expand. A 25-cm insulated wire antenna protruded from the encased transmitter and extended along the side of the collar. In 1978, the radio transmitters (Telonics Co., Mesa, AZ) ranged in frequency from 165.025 to 165.170 MHz and while in motion pulsed at approximately 60 beats/minute. When movement ceased for approximately one hour the pulse tripled. Ribbon antennas (2 x 42 cm) were between two polyvinyl strips of the expandable collar designed by Schlegel (1976).

From 30 May to 15 June 1977, the calves were monitored and located by daily flights in a fixed-wing aircraft (PA-12) equipped with two four-element yagi antennas clamped to each wing strut and connected to a receiver (AVM Instrument Co., Champaign, IL).

By 15 June 1977, a 30-m tower equipped with two yagi antennas had been erected at the MRC. A Falcon Five receiver (Wildlife Materials Inc., Carbondale, IL) and automatic scanner (W. W. Cochran design) were used to monitor the calves. Standing calves were easily monitored in slow mode but we could not always detect fast mode signals when the collar was on the ground. These circumstances provided another option to monitor the calves, that of regularly (every hour or two) monitoring the calves with the receiver at the MRC. If a calf's signal was not heard for several hours, we were alerted to monitor more intensively, and if no signal was heard for 4 to 6 hours we would check the calf using fixed-wing aircraft. When a fast signal was monitored we would similarly respond. If a calf's fate could not be determined from the fixed-wing aircraft, a helicopter or fixed-wing aircraft on floats (Cessna 185) was employed to go to the area. Ground search was done with the aid of a two-element, hand held antenna (Telonics Co., Mesa, AZ) attached to the portable receiver. A thorough investigation of the calf remains and

Table 1. Capture and spot capture status of moose cows and calves for calf mortality study on the Kenai Peninsula, Alaska.

Date	Cows Immobilized	Calves Processed with cow			Calves Processed without cow[2]		
		Bonded	Unknown[1]	Separated	Bonded	Unknown	Separated
29 May 77	10	7	2	2			
31 May 77	3	3		2	2		1
7 June 77					3	2	1
1977 Total	13[3]	10	2	4	5	2	2
24 May 78	8	3	2	5	1	1	
25 May 78					3		
26 May 78	1	1			8		
29 May 78					12	1	2
30 May 78					2		
1 June 78					1		
13 June 78	1	1					
1978 Total	10[4]	5	2	5	27	2	2
Grand Total	22	15	4	9	32	4	4

1 Unknown category includes calves dead at capture or immediate transmitter failure.
2 Calves processed without cow in 1978 were radio-collared only.
3 Three cows had twin calves.
4 One cow had twin calves.

area was made and, if predation was suspected, the carcass was examined for puncture wounds, claw marks, parts consumed and chewed, subcutaneous hemorrhage and position. Signs around the carcass, such as tracks, scats, hair, and beds were noted. A necropsy was performed on calves which were sufficiently intact. Hair, scat and bone samples were collected and the carcass was photographed.

During the 1978 calf monitoring period we relied primarily upon fixed-wing aircraft, because the MRC monitoring system was not always functioning. However, in 1978 we had 16 black bears and four brown bears radio-collared in the study area which provided additional information on moose calf mortality. These bears were radio-collared for another study, but with benefits of obtaining additional information on moose calf mortality as a secondary objective.

RESULTS

Field techniques were modified while we searched for methods which were most beneficial and productive to the overall study objective; to determine the cause of neonatal and summer moose calf mortality. Sixty-seven moose calves were radio-collared and 22 cows were immobilized during the 2-year study. Cow-calf bonds were retained in 15 calves radio-collared with the cow and 32 calves radio-collared alone, providing 47 radio-collared calves to monitor (Table 1). By definition, a bonded cow and calf or calves were a unit that remained together at least 48 hours subsequent to capture.

Capture Method and Cow-calf Separation

Mean induction time for cow moose during the study was 8.8 minutes (range 3-17 min.). The alterations in dosage of etorphine and xylazine hydrochloride between years and the elimination of hyaluronidase in 1978 had no noticeable affect on response of the cow during the induction or post-induction period. In both years we experienced a higher proportion of cow-calf separation when the cow was handled than when the calf alone was captured (37.9% versus 10.5%).

In 1978 we altered the capture technique for calves alone in that we did not collect physiologic data from the calf (blood, hair, measurements and weight). This was done to minimize cow-calf separation, because in 1977 we had experienced 28.6 percent (2 of 7 calves) separation when when we took the additional time to collect the data. Cow-calf separation in 1978 dropped to 6.9 percent (2 of 29 calves) (Table 1).

Physiologic and Morphometric Measurements

Because of cow-calf separation problems experienced with immobilizing the cow of the calf to be radio-collared and time consumed in taking physiologic data from calf only captures, we were not able to obtain the quantity of physiologic and morphometric data that we anticipated.

Cows' ages ranged from 4 to 14 years with a median of 8.7 (n=23). There was an obvious lack of 4 to 7-year-old moose which would represent

the age cohorts from the early 1970's when high calf mortality was experienced on the Kenai Peninsula (Franzmann and Arneson 1973).

Calf weights, measurements and physiologic data obtained during this study will be combined with similar data from other moose calf studies in Alaska (Ballard and Taylor 1978) and reported as base-line data for moose calves at parturition.

Bonded Calf Mortality

Only calves that had retained the cow-calf bond for at least 48 hours after capture were monitored to establish natural mortality. Fifteen calves in 1977 and 32 calves in 1978 remained bonded with their cows. By 13 July 1977, 60 percent (9 calves) of the bonded calves had been killed by predators. Black bear predation was 40 percent (6 calves); wolf predation was 6.7 percent (1 calf); brown bear predation was 6.7 percent (1 calf); unknown predation was 6.7 percent (1 calf), and unknown mortality was 6.7 percent (1 calf). Total mortality was 66.7 percent (10 calves) (Table 2). By 30 July 1978, 43.8 percent (14 calves) had been killed by predators. Black bear predation was 31.3 percent (10 calves); brown bear predation was 6.3 percent (2 calves); and wolf predation was 6.3 percent (2 calves); accidental death was 6.3 percent (2 calves), and unknown death was 2.1 percent (1 calf) (Table 2). Patterns and proportions of mortality were similar for both years. Predation accounted for 48.9 percent of moose calf mortality (black bear--34.0%, brown bear--6.4%, wolf--6.4%, and unknown predator--2.1%). Total moose calf mortality for both years was 57.4 percent.

In 1978 no black bear predation was recorded after 18 June and in 1977 none after 13 July with all but one occurring in June. Calves were monitored to 5 August 1977; by then the three remaining radio-transmitters either had fallen off or ceased to function. For 1978 six radio-transmitters were still on calves and functioning on 5 April 1979.

Mortality assessments were made on a case by case basis. Each mortality had its own characteristics and circumstances. The following case histories from calves monitored will demonstrate this and provide the basis for judgements made.

Calf #41-145 was monitored on fast mode at 1600 hrs on 2 June 1977 and we arrived at the site at 1900 hrs. No predators were seen in the area. The cow was sighted 100 m from the carcass (#41 collar). Birch (*Betula papyrifera*)--spruce (*Picea mariana*) canopy cover was approximately 10 percent. The uncovered carcass was 90 percent consumed, with only parts of skull, mandible and teeth, broken femurs, other bone pieces and the partially inverted hide remaining. No predator sign was located (scats, hair, or prints). The hide was ripped in several places. The cause of mortality was recorded as unknown predator, but was likely a black or brown bear, as bears will invert the hide.

Calf #43-141 was located by fixed-wing aircraft on 2 June 1977, with a black wolf near the slow mode signal site at 0800. At 1930 we went to the area by helicopter. The black wolf was again sighted in the

Table 2. Causes of moose calf mortality based upon monitoring 47 calves during summers 1977-78 on the Kenai Peninsula, Alaska.

	1977	Percent (n-15)	1978	Percent (n-32)	1977 1978	Percent (n-47)
Black bear	6	40.0	10	31.3	16	34.0
Brown bear	1	6.7	2	6.3	3	6.4
Wolf	1	6.7	2	6.3	3	6.4
Unknown Predator	1	6.7	0	0	1	2.1
Total predator mortality	9	60.0	14	43.8	23	48.9
Accidental	0	0	2	6.3	2	4.3
Unknown	1	6.7	1	3.1	2	4.3
Total mortality	10	66.7	17	53.1	27	57.4

area, and the signal was still on slow mode. The calf's carcass was found buried in the duff layer at the base of a hill in a mature birch stand with 50 percent canopy cover. The calf was approximately 40 percent consumed with the hind legs lying 47 m from the remainder of the buried carcass (hide still intact). The radio collar was on the carcass. The cow was not seen in the area. Wolf predation was considered to be the cause of mortality.

On 3 June 1977, a black bear was sighted at 0745 near the slow mode signal origin of calf #42-143, but neither cow nor calf was observed. On subsequent morning flights (4 and 5 June) neither cow nor calf was sighted, though the signal origin location remained the same. At 1900 on 5 June a fast mode signal was detected 1900 m over Kenai Airport. On 7 June we went to the site via helicopter and found the calf carcass 84 percent consumed (by weight). All that remained were bone fragments and the partially inverted hide, which had 30-40 cm tears. The radio was 20 m from the feeding site. Four bear scats were located within a 30 m radius of the feeding site. Black bear predation was recorded as the cause of mortality.

On 11 June 1977, cow #48 and calf #48-148 had moved 17.6 km up Thurman Creek into the mountains. The signal location was identified but the calf was not seen in the heavy spruce. Two black bears were sighted in the area. On 12 June at 0830 the slow mode signal was located farther up Thurman Creek but neither cow nor calf were seen. A black bear was sighted 1 km from the signal. On the morning of 13 June the signal was on fast mode. We went to the area via helicopter and located the uncovered calf carcass on a hillside near Thurman Creek in a 20 percent spruce canopy cover. The partially inverted hide and partially eaten head (ears, tongue, and nose) were at a site 12 m from the broken radio collar, parts of broken femur, and scapula. No predator sign was found in the area. The cause of mortality was determined to be black bear predation.

On 12 June 1977, at 0930 the carcass of calf #50-126 was sighted in a clump of spruce from a fixed-wing aircraft. A large black bear was feeding on a winter-kill calf 60 m from the calf carcass. Cow #50 was not in the area. The radio signal was on slow mode. On 13 June we went to the site via helicopter. The signal was still on slow mode and the cow was still not in sight. The uncovered carcass was 80 percent consumed (all flesh except one thigh) and was located in a spruce bog area with 30 percent canopy cover. The leg bones were not cracked and the head was eaten. The hide was partially inverted and torn. The cause of mortality was determined as black bear predation.

From 0300 on 14 June 1977 to 1400 on 15 June we were not able to monitor any signal from calf #157 using the tower and receiver at the MRC. A fixed-wing aircraft was flown to the area and two large brown bears were seen feeding on the carcass of calf #157. No flights were made to land at the site because the predator had been positively identified. The remains at the site were negligible. Brown bear predation was recorded as the cause of mortality.

The signal from #44-189 was sporadic or not heard at MRC on 21 and 22 June 1977. The fast mode signal was received via fixed-wing aircraft on 23 June at 0930 and the carcass was sighted. At 1500 we arrived at the site via fixed-wing aircraft on floats. The calf carcass was 300 m south of Buteo Lake in spruce-birch regrowth with 10 percent canopy cover. The carcass was 95 percent utilized with only mandibles and teeth, hooves, hide and bone fragments remaining. The broken radio collar was at the feeding area. Black bear sign was evident (four scats, and tracks). The carcass was not covered, but there were two excavated areas (1 m^2) within 10 m of the carcass. The cow was not in the area. The cause of mortality was recorded as black bear predation.

The signal from calf #191 went off on 29 June (0715 hrs) and was not picked up again until 30 June (2130 hrs) when it was on slow mode. The next morning (1 July, 0645 hrs) it was on fast mode. We inspected the site on the afternoon of 1 July and determined it to be black bear predation. There were 10 black bear scat piles in the area. The carcass was 90 percent utilized under 20 percent canopy cover. The calf had moved nearly 20 km from 27 June to 29 June. The kill site was 20 km from tower, and we received a good signal, perhaps, because the transmitter was lying under a very tall spruce tree.

On 5 July 1977, calf #38-163 was monitored by aircraft on fast mode. Nothing could be sighted in the area which was 25 km east of the tower near the Chickaloon River. The helicopter was used to go to the area and we found only the intact collar. An intensive search of the area provided no clues; however, the collar had small teeth marks in it and we assumed the collar had been carried to the area by a small mammal. No cause of mortality could be determined for this calf.

On 15 July 1977, calf #40-148 was monitored by fixed-wing aircraft on fast mode. An on-ground inspection at the site indicated black bear predation. Black bear scats, tracks and hair were found at the site. The calf had been sighted in the area on 12 July, and we assumed that no significant movement was associated with predation in this case.

On 27 May 1978, twin calves #1872 and #1863 were monitored on fast mode via fixed-wing aircraft flight. When located on the ground, both calves were approximately 75 percent consumed. Radio-collared black bear B-5 was about 1.6 km from the kill site. No predator sign was near the area; however, when autopsied #1872 had four skull puncture wounds, two on each side of the skull with one posterior and one anterior to the eye. The wounds were 6 and 7 cm apart indicating the predator was a black bear. Calf #1863 had puncture wounds over the loin area and the pelvis was crushed. The cow was standing approximately 50 m from the calves. The calves were in the same area as they were the day before. Both were very small calves weighing less than 14 kg.

On 29 May 1978, calf #251 was monitored on fast mode from the MRC tower. We went to the site via helicopter and found both calf #251 and its twin #253 dead. Calf #251 was 85 percent consumed and all that remained was the hide, head, and lower legs. Calf #253 was 65 percent consumed. The hide, head and most of the red meat were not eaten. The

tongue was removed. Four black bear scats and three beds were in the immediate vicinity of the kill. One hour after we found the calves, black bear B-8 was radio-tracked and located 1.6 km from the kill site. Both calves had been observed near the kill site the previous day with the cow. On 27 May the cow and twins were located about 1 km north of the 28 May sighting. This predation was classified as black bear.

Calf #1854 was monitored from the fixed-wing aircraft on 1 June 1978 on fast mode. The calf was located 2 km from its original capture site. It had been 90 percent consumed. All that remained were the hide and lower limbs. The skull had been opened and brains removed. There were six black bear scats near the carcass.

Calf #1865 was monitored from the fixed-wing aircraft on fast mode on 1 June 1978. The 90 percent consumed carcass was found 100 m from capture site; everything had been eaten except the head, hide and lower legs. One black bear scat was located near the carcass. Both calf #1854 and #1865 had been killed within 24 hours of our locating them.

Calf #5-239 was monitored by fixed-wing aircraft on fast mode on 4 June 1978. The calf had been only 30 percent consumed. Radio-collared black bear B-13 was only 100 m from kill site and we believe that the bear was frightened away from the carcass at our approach. Only the viscera, loin and part of the hind legs had been eaten. Black bear hair was found 2 m from the kill site between the kill site and the carcass.

Calf #1870's signal was monitored on fast mode from the MRC on 12 June 1978. It had been 90 percent consumed but instead of having its viscera consumed and red meat partially eaten, the viscera were lying at the site. The hind legs had been dragged away 20 m from kill site. The ends of the bone and joint surfaces had been chewed and the hide was inverted on the limbs. A wolf track was imprinted on the spilled rumen content. About 3 m from the site another wolf track was impressed in the muskeg.

On 14 June 1978, a fast signal was detected from calf #9708 from the MRC tower. The calf had been regularly observed near the old drilling pad on the road to the MRC. We drove to the pad and picked up the signal and walked to the calf. The calf was nearly 100 percent consumed. All that remained were bone fragments, the jaw and teeth. One bear scat was 5 m from the feeding site and another about 10 m away. The scats appeared to be black bear based on size, and consisted primarily of cranberries and vegetation, however, it could have been a brown bear.

On 15 June 1978, calf #255 was tracked to an area adjacent to Rabbit Foot Lake. The signal came from a clump of trees near the lake, but no cow or calf could be seen. After we circled the area, a female brown bear and two 2 1/2-year-old cubs came from the wooded area. The signal continued on the slow mode, but we suspected that the signal would be on fast mode within a short period of time. Attempts to monitor the signal from the MRC failed. The next day we attempted to monitor the signal from the fixed-wing aircraft, but even directly over the area we could not pick up the signal. On 18 July 1978, we took a helicopter to the area and after ground searching found the calf and radio. The calf had been nearly completely consumed and the radio-transmitter was

damaged. The antenna was torn from the radio collar and the transmitter itself was not functioning. We concluded that the brown bears had killed the calf, perhaps just before our initial flight over the area, and had also destroyed the radio transmitter. We were fortunate to have found the calf. This instance supports one of the main reasons for relocating the animals regularly.

On 17 June 1978, calf #1866 was monitored on fast mode from the MRC. At the site we found the calf 90 percent consumed. Only the hide and lower limbs were remaining. There were two black bear scats in the area and black bear hair was discovered at the kill site. This was one calf of a set of twins; the other twin and the cow were about 500 m from the kill unharmed. On 16 June 1978, the cow and both calves had been located about 3 km east of the kill site.

On 17 June 1978, a fast mode signal was heard from calf #1860 via fixed-wing aircraft, but we could not see the calf in the spruce forest near Bear Lake. On 18 June 1978, we landed on Bear Lake, tracked the calf, and found it 95 percent consumed. All that remained were the hide and hooves and bone and teeth fragments; the skull top was removed and brains eaten. Subcutaneous hemorrhage and puncture marks were located on the hide in the rump area. A large scat was found in the area which contained many bone and hair fragments and brown bear hair was found adjacent to the kill on bushes.

On 18 June 1978, black bear B-8 was radio-tracked and located approximately 200 m south of Red Poll Lake. This adult male bear was observed traveling north and feeding on vegetation. Approximately 30 minutes later, calf #1975 was located on the south shore of Red Poll Lake. Initially, only the cow was observed. She appeared to be very agitated and paced back and forth in a small (50 m^2) area with her head down and ears back. After considerable searching, the calf was located 30 m from the cow. Black bear B-8 was lying about 3 m from the carcass. It appeared that B-8 had just killed this calf. We returned to this area in a helicopter within one hour. The calf had been partially eaten (viscera, loin, and ribs) and its carcass was still warm. Black bear B-8 was sighted 100 m from the carcass. There was also one black bear scat 2 m from the kill site, plus an obvious bed.

On 10 July 1978, a fast mode signal was detected from calf #12-1865 via fixed-wing aircraft. The calf was sighted from the air lying along Rifle Lake with the cow (#12 visual collar) nearby. We went to the area on foot and found the intact calf. The cow was still in the area. Examination of the calf revealed a puncture wound medially to the point of the shoulder. Autopsy revealed that the wound progressed posteriorly and penetrated the chest wall between the fourth and fifth ribs fracturing the distal end of the fifth rib. Inflammation was evident throughout the thorax. A fragment of wood was found in the wound indicating a possible puncture with a stick.

Calf #1852 was monitored on fast mode signal on 1 August 1978 by fixed-wing aircraft. Nothing could be seen from the air. A helicopter was taken to the area 6 hours later. The carcass was 90 percent consumed, however, the digestive tract was relatively intact. Rumen content had spilled out. Three wolf scats and eight beds were in the

immediate area. The kill site and feeding site were both identified. The calf's mortality was classified as wolf predation.

On 7 August 1978, a fast mode signal was detected from calf #1863A via fixed-wing aircraft near Nest Lake. We went to the calf on foot and found the calf intact. The calf had wounds on the lower jaw, throat, right hind leg below the hock, and on each side of the loin area. All wounds were suppurating. Autopsy revealed extensive inflammation of the lungs. Death apparently was caused by secondary infection from the puncture wounds. We assumed that the calf survived a predator attack, but died later from the effects of that attack. However, we did classify the death as accidental.

On 20 September 1978 we detected a fast signal from a radio-transmitter that we thought had malfunctioned. We went to the site and discovered that we had not taken the magnet off the transmitter when we originally collared the calf and that it took nearly 4 months before the magnet moved enough to activate the transmitter. The calf had died when only a few days old, but cause of death could not be determined and it was classified unknown.

On 27 January 1979 the radio-transmitter from calf #1872A was turned in at the Fish and Game office at Soldotna. The transmitter and collar were located at a wolf kill site near Ursus Lake. The calf's shoulder was opened and most of the shoulder was eaten. The wolf had also eaten through the rib cage and the heart, lungs, and liver were eaten. The calf's body was still warm. The only tracks at the site were wolf tracks, and the observer thought there were three or four different sets of wolf tracks.

On 16 May 1979, Jim Wollington, Kenai National Moose Range, recovered the radio transmitter and collar from calf #1873 in the Thurman Creek drainage. This had been identified as a wolf-killed calf by aerial observation on 27 January 1979; however, at that time the observer was not aware that the calf had a radio collar.

On 24 February 1979, two calf signals were on fast mode. Calf #9709 was located at Forest Lake and calf #1857A at Vixen Lake, cause of death was not definately determined for either calf, but we believe calf #1857A starved.

The last four mortalities discussed were not evaluated in this report since it was directed toward causes of moose calf mortality during summer. It is clear that black bear predation occurs early in summer and nearly ceases after early July. Wolf predation appears to increase proportionately after this time. Four of the last five mortalities for which we could determine causes were wolf predations.

The calf mortality transmitters were last monitored on 5 April 1979. Six calves were monitored on slow mode (#s 7-241, 10-235, 11-257, 1858, 1871, and 1877). Nine of the original radio transmitter signals were not received (#s 2-233, 3-237, 249, 1967, 1955, 9693, 9696, 9704, and 9907A). Radio signals from calves #2-233 and #3-237 were never received after placing the radio collars on the calves, and the radio on calf #249 did not function because its magnet was not removed. Table 3 summarizes fate of calves and transmitters for 1978.

Table 3. 1978 radio-collared calves and transmitter fate.

Radio collar and calf number	Bonded on (April 79)	Bonded off (calf dead)	Cow/calf separation (not bonded)	Transmitter failure	Comment
1-229			X		Raised at MRC
1-231			X		Raised at MRC
2-233				X	Never received
2-237				X	Never received
4-227			X		
5-239		X			Blk. bear predation
7-241	X				
8-243			X		
10-235	X				
10-245			X		Raised at MRC
249				X	Magnet not removed
255		X			Brn. bear predation
251		X			Blk. bear predation
253		X			Blk. bear predation
1871	X				
1875		X			Blk. bear predation
1866		X			Blk. bear predation
1877	X				
1865		X			Blk. bear predation
1867				X	
11-257	X				
1863		X			Blk. bear predation
1872		X			Blk. bear predation
1873		X			Jan. 79 wolf pred.
1854		X			Blk. bear predation
1852		X			Wolf predation
1855				X	
1858	X				
1860		X			Brn. bear predation
1863A		X			Accidental death
1872A		X			Jan. 79 wolf pred.
9693				X	
9696				X	
9704				X	
9708		X			Blk. bear predation
9709		X			Unknown
1857			X		Raised at MRC
9907			X		
1857A		X			Winter starvation
1870		X			Wolf predation
9907A				X	
12-1865		X			Accidental death
Total	6	20	7	9	

In addition to recording predation with calf mortality transmitters in this study, we were able to witness additional calf predation by monitoring bears radio-collared for another study (Schwartz and Franzmann 1978). On 25 May 1978, radio-collared female black bears B-13 and B-14 were at a recent moose calf kill. On 2 June 1978, we observed radio-collared black bear B-8 resting on a ridge above a calf kill. He had been chased away by an uncollared black bear which went to the kill and fed. On 16 June 1978, radio-collared male black bear B-19 was feeding on a recently killed calf.

Overall, we were able to associate five of the 16 radio-collared black bears with moose calf predation. Radio-collared brown bears A-1 and A-2 were seen feeding on a recently killed adult female moose, and A-2 was seen feeding on a moose calf. An uncollared brown bear female with cubs was seen feeding on dead calf #255. Radio-collared wolves #15026 and #134 were observed killing a moose calf and harassing the cow on 29 May 1978.

The area supports a high density of black bears, and through 30 June 1978, on 15 different flights over the study area we observed 30 uncollared black bears and three uncollared brown bears.

DISCUSSION

During this study, certain procedures proved more useful than others. The one-hour setting for activation of the fast mode was much better than the four-hour setting. We did experience a few false alarms (6) with the one-hour setting, but in general we benefited by getting to the dead animal sooner. Immobilization of the cow or processing the calf to obtain physiological data was not justified due to the higher cow-calf separaton rate experienced. Lessened handling of the calf and speedier application of radio collars improved chances of retaining the cow-calf bond. The automated monitoring system saved aerial monitoring flight expenditure; however, the system alone would not suffice, because a great deal of added information was obtained by regularly flying over the study area. The automated system, however, was a good adjunct to aerial monitoring. Radio-collared bears and wolves on the study area facilitated the evaluation of predation. Studies of this type obviously benefit from integration with related studies of potential predators.

The question arises as to whether or not the calves classified as predation mortalities may have died of other causes prior to predation. With our intensive monitoring, we made 784 aerial sightings of radio-collared moose calves and 4,313 individual radio contacts with calves without visual observations. With this intensive monitoring we were able to examine 85.1 percent of the mortalities within 24 hours and 55 percent within 12 hours; 25.9 percent were observed prior to the signal being activated. Mortalities examined after 48 hours were classified as unknowns or, in one case, accidental. Additionally, non-use of dead calves and cows for extended periods was observed. Separation and starvation of four calves (including one set of twins) and capture-related deaths of two cows occurred during this study. We were not able to check back on all capture-related deaths, but those which we checked were virtually unutilized for days. Cow #47 was necropsied on 31 May

1977, and no sign of disturbance was noted until 12 June 1977. Calf #39-171 died on 6 June 1977 and had not been disturbed as of 14 June 1977. Calf #169 had been dead 36 hours prior to radio recovery, and it was undisturbed at that time. Calf #151 died 8 June 1977, was necropsied the same day, and when visited on 18 June had not been utilized. Similar lack of utilization of dead calves was reported in another moose calf mortality study in Alaska (Ballard and Taylor 1978).

The Kenai Peninsula moose population has declined since the early 1970's, but stabilized at a low point around 1975. Random stratified counts from the Kenai National Moose Range reflect this; in 1971 the moose population estimate was 7904 $\pm$ 1461, in 1973 it was 5692 $\pm$ 1348, in 1974 it was 4850 $\pm$ 1045, in 1975 it was 3375 $\pm$ 986, and in 1976 it was 3782 $\pm$ 605. No counts were made in 1977 due to lack of snow. This population decline was attributed primarily to the decrease in browse quality and quantity (Oldemeyer et al. 1977) and the severity of winter mortality during the early 1970's.

Heavy winter calf mortality and resulting poor recruitment in the early 1970's influenced the age structure of the moose population in such a manner that moose in part of their peak productive years are absent from the present population. Of 23 cow moose for which ages were determined during this study, only four were in the 4 to 7-year age bracket (17.4%) and the mean age was 8.7 years.

Re-establishement of wolves on the Kenai Peninsula coincided with the moose population decline, and heavy moose winter mortality in the early 1970's contributed to their rapid build up to a present density of one wolf/78 km^2. Road kills on the Kenai vary from 100 to 250 moose per year depending on snow conditions. The annual harvest (bull only) since 1974 has ranged from 285 to 368. In addition, poaching, accidental and miscellaneous mortality contribute to the total.

Nevertheless, in recent years certain factors were influencing the Kenai Peninsula moose population in a positive manner. A mechanical browse rehabilitation program using tree crushers (LeTourneau Co., Longview, TX) was initiated by the Kenai National Moose Range in 1975. Approximately 2,805 ha have been rehabilitated through 1978. These areas have attracted large numbers of moose at various times of the year. In 1969, a 33,000 ha burn occurred on the Kenai Peninsula lowland. Moose use of this area has increased in recent years. The past three winters have been relatively mild which improved overwinter survival of moose. The twinning rate for moose in spring 1978 was 22.2 percent (8 of 36) based upon random radio-collaring of calves as we found them on the study area. With this apparently high twinning rate we may speculate that this moose population is presently realizing its reproductive potential.

The problem facing the Kenai Peninsula moose population appears to be--can this low density, old age population maintain itself or expand in spite of the witnessed high rate of black bear predation on calves and the year around wolf and brown bear predation in addition to other forms of mortality? As we more accurately define the forces working on this moose popultion we can make better population assessments. This study detailed predation as an additional negative force working on the population and demonstrated that mortality transmitters on moose calves would provide important post natal life history information.

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APPENDIX I

COMPARISON OF TECHNIQUES UTILIZED TO DETERMINE MOOSE CALF MORTALITY IN ALASKA

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Abstract: Studies to assess neonatal moose (Alces alces gigas) calf survival were conducted in two areas (Nelchina Basin and Kenai Peninsula) of Southcentral Alaska during 1977 and 1978. Equipment, techniques and costs associated with conducting the studies were compared. Calf abandonment was influenced by several factors such as handling method, length of time processed and strength of cow-calf bond. Abandonment rates were lowest when only the calf was captured and no morphometric and physiologic data were obtained, and highest when both cow and calf were captured and all data were obtained.

Radio-transmitters utilized in the studies doubled or tripled their pulse rates whenever they remained motionless for either 4 or 1 hour periods; indicating that a mortality had occurred. Mortality of radio-collared calves was determined by monitoring from both fixed-wing aircraft and ground stations. A total of 2,192 visual observations of radio-collared calves were made during the studies while radio signals alone were monitored on 6,617 occasions.

A total of 110 predator killed moose calves were examined during the studies. Characteristics of calf kills make by brown bear (Ursus arctos), black bear (Ursus americanus) and wolf (Canis lupus) were described. It was concluded that the techniques developed during these studies provided reliable data on causes of mortality which would not have been obtainable otherwise.