ALASKA DEPARTMENT OF FISH AND GAME

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GAME MANAGEMENT UNIT 13 BROWN BEAR STUDIES

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FINAL REPORT (RESEARCH)

State: Alaska

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Project Nos.: W-17-10, W-17-11 and W-21-1

Project Title: Big Game Investigations

Job No: 4.13R

Job Title: Feeding Behavior of Interior Brown Bears

Period Covered: January 1, 1978 to June 30, 1980

SUMMARY

Thirty-eight brown bears were captured and marked by the Alaska Department of Fish and Game in Game Management Unit 13 from 9 April to 23 June, 1978. Twenty-three of these bears were radio-collared. Phencyclidine hydrochloride was used to immobilize bears from a Bell 206 Jet Ranger B helicopter. Eighty-one percent of the bears were immobilized with a single drug injection. Drug dosages were: 1.4 mg/lb for yearlings, 1.0 mg/lb for females and young males and 0.75 mg/lb for adult males. Cubs-of-the-year were captured by hand. Induction time averaged 8.8 minutes and ranged from 4 to 16 minutes.

Sex ratios (1961-1979) and mean age (1969-1979) of bears reported in the sport harvest from GMU 13 were compared to those of captured bears. Males comprised 53 percent of the captured bears and 57 percent of the bears harvested. The mean age of 304 harvested males was 6.4 years compared to 6.6 years for 18 captured males. The mean age of 219 harvested females was 6.8 years of age compared to 7.7 years for 16 captured females. Only bears over 2.0 years of age were included in calculations of mean age of captured animals.

Morphological measurements are presented and briefly discussed. The largest skull measured (male) was 69.2 cm (27⅛ inches) (length + width).

Baseline blood values for spring captured bears are presented.

Three manuscripts were prepared and submitted for publication: "Causes of neonatal moose calf mortality in

southcentral Alaska" (accepted by J. Wildl. Mgmt.), "Home range, daily movements and denning activity of brown bears in southcentral Alaska" (submitted to Can. Field Nat., see Appendix I), and "Homing of transplanted Alaskan brown bears" (submitted to J. Wildl. Mgmt., see Appendix II).

During spring and fall 1978, 23 radio-collared bears were observed on 78 kills. Moose of all age classes comprised 87 percent of the kills. Calf moose comprised 57 percent of the moose kills and 47 percent of the total kill.

Radio-collared bears preyed upon moose calves until mid-July. This confirmed results of moose calf mortality studies which indicated that bear predation was a significant cause of calf moose mortality. After mid-July bears were observed preying upon adult moose and caribou. Overall, radio-collared bears made one ungulate kill every 6.1 days. There were no apparent differences in rates of predation between bears of various ages or family status.

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BACKGROUND

Brown bear (*Ursus arctos*) ecology has been investigated on the Alaska Peninsula (Glenn 1971, 1972, 1973, 1975, 1976), the Brooks Range (Reynolds 1974,1980), and in Southeastern Alaska (Wood 1973, 1974, 1976). All of these bear studies have focused on coastal or arctic populations. Interior Alaska populations, which in recent years have been subjected to increasing levels of sport harvest (Alaska Department of Fish and Game [ADF&G] files) have not been studied and basic knowledge of brown bear biology in these areas is currently insufficient for management. One area where more information is needed is Game Management Unit (GMU) 13, commonly referred to as the Nelchina Basin.

Within recent years increasing numbers of brown bears are being seen and sport harvests have increased (Eide 1978). Limited information indicates that the bear population in the Nelchina Basin may be increasing. From 1948 to 1953 intensive poisoning and aerial shooting by the Federal government reduced predator populations to low levels (Rausch 1967). Although wolves (*Canis lupus*) were the target of this program, bears doubtless were killed as well. Since the early 1950's wolf populations in this area have increased, bear populations appear to have increased also.

Rausch (1969), Bishop and Rausch (1974) and McIlroy (1974) have speculated on the apparent inverse relationships between numbers of predators and moose (*Alces alces*). In light of the importance of GMU 13 to the statewide moose harvest and because of its depressed moose population (Ballard et al. 1980a), a series of studies were initiated to investigate predator-prey relationships in Unit 13. Initially, these studies focused on moose and wolves (Stephenson 1978, Ballard and Taylor 1978a,b, Ballard and Spraker 1979, Ballard et al. 1980a,b, and Ballard et al. In Press). First-year results of a moose calf mortality study identified brown bear predation as a major cause of neonatal moose calf mortality (Ballard and Taylor 1978b). However,

it was not known whether bears of specific ages or family status were responsible for this predation. If such were the case, bear hunting regulations could potentially be manipulated to provide partial relief for the depressed Nelchina Basin moose population. Requests from the public for more liberal bear hunting seasons in order to augment calf moose survival, prompted initiation of this study.

This report presents the findings of the brown bear feeding behavior study (Job 4.13R) supplemented with data from a bear transplant experiment conducted using State funds.

OBJECTIVES

To determine the rates and patterns of predation on moose calves by brown bears, by sex and age class and reproductive conditions.

To determine distribution, seasonal movements and home ranges of brown bears in GMU 13.

STUDY AREA

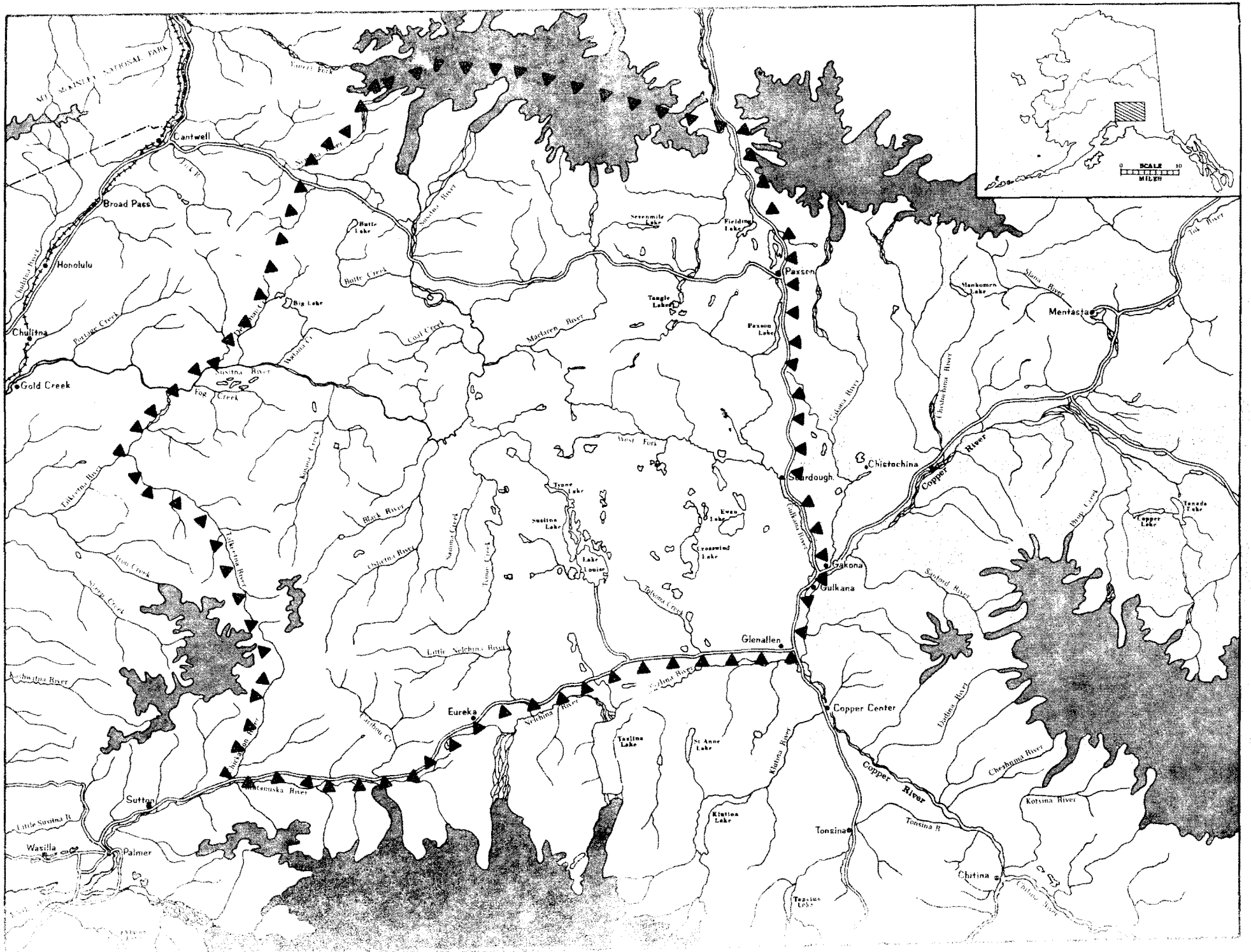
Brown bears were studied in that portion of GMU 13 lying within the following boundaries: The Richardson Highway on the east, the Glenn Highway to the south, the center of the Talkeetna Mountain Range on the west, and the Alaskan Range to the north (Fig. 1). This area corresponded closely to the study area where other radio-telemetry research was in progress (Ballard and Taylor 1978a,b, Ballard and Spraker 1979, Ballard et al. 1980a, Ballard In Press).

PROCEDURES

Initially, bears were located by searching from fixed-wing aircraft (Piper Super Cub PA-18-150) during early morning and late evening hours. After several bears were captured and radio-collared, flights to locate bears were discontinued, since bears were located incidental to monitoring radio-collared moose calves. Bears were captured between 9 April and 23 June 1978.

When a bear was found, its location was relayed by radio to a nearby helicopter (Bell 206B). The helicopter approached to within approximately 25 meters of the bear in order to estimate weight for calculating proper drug dosage.

Fig. 1. Game Management Unit 13 brown bear study area, spring 1978.



Etorphine hydrochloride (M-99, D-M Pharmaceuticals, Inc., Rockfield, MD) and its antidote diprenorphine (M-50-50) were used on one bear; the remainder were immobilized with phencyclidine hydrochloride (Sernylan, BioCeutic Laboratories, St. Joseph, MO). Drug dosages of phencyclidine hydrochloride were: 1.0 mg per pound for females and young adult males and 0.75 mg per pound for adult males (Glenn 1971). For bears located in heavy timber, the helicopter was used to haze the animal towards an open area for easier darting. Drugs were administered with a dart fired from a Cap-Chur Gun (Palmer Chemical and Equipment Co., Douglasville, GA). Experience proved that even older, more wary, bears could be moved into open areas if herded slowly.

When a bear was darted the helicopter retreated, but efforts were made to keep the bear in sight (especially in dense vegetation). If there was no risk of losing a darted bear, the helicopter was landed and the bear was monitored from fixed-wing aircraft. Once immobilized, the helicopter transported a two-man tagging crew to the site. The dart was removed and checked for percent injection.

Adult bears were fitted with radio collars (Model KM-IV, Telonics Company, 1300 West University, Mesa, AZ 85203) which emitted a pulsed signal on frequencies ranging from 150.000 through 151.000 Mhz. These hermetically transmitters sealed had a theoretical life span of 44 months. Each transmitter contained an inverse "mortality sensor" which lowered the pulse rate when the unit remained motionless for a 4-hour period. Theoretically, this extended the life of the radio by utilizing less battery power when bears were denning.

Each bear was ear-tagged with a numbered roto-tag (Oberach Patent, Ltd., London, England). To aid in identifying bears from fixed-wing aircraft each ear tag was accompanied by a colored polyvinyl flag measuring 7 cm by 10 cm. Flags were color coded according to sex, international orange for males and fluorescent green for females.

Captured bears were marked by a 3-digit tattoo number in the upper and lower lips using standard tattoo pliers with 3/8-inch digits and green paste tattoo ink (Stone Manufacturing and Supply Co., 1212 Kansas Avenue, Kansas City, KS 66105).

When practical, both lower first premolars were extracted for age determination. Teeth were sectioned and aged according to methods described by Stoneburg and Jonkel (1966) and Johnson and Lucier (1975). A micrometer was used to measure length of the upper and lower left canines, and gum line widths from both anterior to posterior and from labial to lingual sides.

Blood samples were taken from the femoral artery using 10 ml evacuated vials and 150 ml evacuated bottles. A blood sample was taken in a 10-ml vial containing heparin for determination of percent hemoglobin with a Hb-meter (American Optical Corporation, Buffalo, NY) and packed cell volume (PVC) with a microhematocrit centrifuge (Readocrit-Clay-Adams Company, Parsippany, NJ). Upon returning from the field, the whole blood was centrifuged and sera were separated and placed into 5-ml plastic vials which were immediately frozen. Three-ml samples of these sera were sent to Pathologists Central Laboratory (1100 East Union, Seattle, WA 98122) for blood chemistry analysis and protein electrophoresis (Franzmann and Arneson 1973). Remaining sera have been frozen and stored for possible future analyses.

Hair samples were taken to aid in assessing the animal's condition using techniques presented by Franzmann et al. (1975). Samples were taken on the hump between the bear's shoulders. All hair samples (35) were sent to Dr. Arthur Flynn (Case Western Reserve University, Cleveland, OH) for analyses.

Morphological measurements were taken and recorded on the field data sheet (Fig. 2) provided by Glenn (1972). Measurements included: total length, shoulder height, length of hind foot, neck circumference, heart girth, body length, head width, and head length. Bears were weighed with either a hand-held spring scale with a capacity of 200 pounds (Hanson Model 8920, Northbrook, IL), or a Senator Scale with a capacity of 1500 pounds (Martin-Decker Corp., Santa Ana, CA). The Senator Scale was attached to the helicopter's cargo hook and the bear was weighed in a cargo net fastened to the scale. Weight was read by a biologist on the ground. The weight of the cargo net (40 pounds) was subtracted to yield the bear's live weight. When conditions did not permit weighing the bear its weight was estimated by biologists on the ground.

Radio-collared bears were located from fixed-wing aircraft (Piper Super Cub or Stol Cessna 180) using twin 3-element antennae mounted on each of the aircraft's wing struts and methods similar to those described by Mech (1974). Activity and location were recorded on standard forms and U.S. Geological Survey topographic maps (scale 1:250,000).

Radio-collared bears were located and observed generally twice per day for the first 2 weeks of study. Subsequently, monitoring was reduced to once per day until the end of June then twice monthly. Bears were monitored on the same flights made to locate radio-collared moose calves (Ballard et al. 1980b) and wolves (Ballard and Spraker 1979).

Fig. 2 Nelchina Basin Brown Bear Tagging Data Sheet 1/

Bear No. ____ Date_____ Sex____ Est'd Age____ Cem. Age_____

Collector_____ Recorder_____ Recapture_____ New_____

	Temp.	Pulse Rate	Resp. Rate	Convulsion	Tremor	Other
Time						
Time						

Were all darts checked for complete drug injection? Yes_____ No_____

MEASUREMENTS: Measured Wt._____ T.L._____ Ht. Sh._____ H.F._____ Neck_____

Girth_____ B.L._____ Head: Width_____ Length_____

Length of Upper Left Canine_____ Lower Left Canine_____

PHOTOGRAPHS: Dentition ( ), Collar ( ), Mammae ( ), Whole Bear ( ) Vulva ( )

SPECIMENS COLLECTED: Tooth (Be specific)_____ Blood: Vol._____

Blood Smear: Yes_____ No_____ Vag Smear: Yes_____ No_____ Feces: Yes_____ No_____

Urine: Yes_____ No_____ Milk: (no less than 10 ml prefer 100-200ml) Vol._____

PRODUCTIVITY: Female: No. of .5 yr. olds _____ 1.5 yr._____ 2.5 yr._____

Mamme: Length_____ Color_____ Vulva:_____ Male: Testes Descended: Yes___ No___

Other Bears Present (Describe) _____

RECAPTURE DATA: Tatto: No. ____ Condition _____ Ear Tags (Number, Type, Condition):

Left _____ Right_____

Collar (Number, Type, Condition) _____

NEW TAG DATA: Left Ear: Large Roto No._____ Color_____ Small Roto No._____

Color_____ Right Ear: Large Roto No._____ Color_____ Small Roto No._____

Color_____ Collor: Type_____ Collar Color Code:_____

_____ Collar Plate Ident.: Figure_____

Temporary Markings:_____

Time Departed_____ Completeness of Recovery_____

Comments:_____

_____

Fig. 2 (cont'd)

Nelchina Basin Brown Bear Tagging Data Sheet

Punch Tattoo No. Here

Time Bear First Observed _____

Specific Location _____

Grid No. _____ Map Coordinates _____

DRUG DATA: Est'd Wt. _____ Circle Each Used: 1. Sernalyn 2. Sparine

3. M-99 4. 50-50 5. Other

	Dosage	Time Darted	Time Down	Dart Location
1st Hit				
2nd Hit				
3rd Hit				
Total				

Cont. Comments:

RESIGHTINGS:

1/ Form provided by Glenn (1972)

Prey taken by brown beara was identified on the basis of combinations of coloration, pelage, size, and antlers (Ballard et al. 1979, Ballard In Press). When kills were observed we checked for the presence of other radio-collared bears and wolves. All wolf packs in the bear study areas were radio-collared.

No attempt was made to examine all of the kills attributed to bear predation on the ground. When practical, however, kills were visited by helicopter or fixed-wing aircraft to confirm the cause of mortality according to methods described by Ballard et al. (1979).

RESULTS AND DISCUSSION

Thirty-eight brown bears were captured and marked in GMU 13 from 9 April to 23 June 1978 (Table 1). Eighty-one percent of the study animals were immobilized with a single injection of phencyclidine hydrochloride (Table 2). Seventeen percent required two drug injections and 3 percent required three. Multiple injections were necessary when the bear's weight was underestimated or when the dart failed to fully inject the initial dosage. Mean induction time for bears immobolized with a single injection was 9 minutes (S.D.=3.3) and ranged from 4 to 16 minutes.

Two tagging mortalities occurred. Bear number 226 was captured on an exceptionally warm day in a dry area and never recovered from the effects of the drug, death may have resulted from elevated body temperature. Bear number 233 drowned in a shallow pond during the last few minutes of drug induction. Attempts to haze or lure this bear from the pond with the helicopter were unsuccessful. This bear was the oldest male captured (14+ years). Bear number 206, the oldest female (13 years), also entered a pond during the final mintues of drug induction. However, she was successfully roped and pulled from the pond using the helicopter.

Morphological measurements in relation to age and sex are presented in Tables 3 and 4. Nine adult males (5.5 years and older) averaged 254 kg (559 lbs) (S.D.=24 kg) and ranged from 226 kg (497 lbs) to 289 kg (636 lbs). Ten adult females (5.5 years and older) averaged 124 kg (273 lbs) (S.D.=28 kg) and ranged from 91 kg (200 lbs) to 170 kg (375 lbs), 49 percent of the average weight for adult males. Both measured and estimated weights (Table 3) were included in the above calculations.

The sex ratio of captured bears (older than 2.0 years) was 53 percent males. In comparison, unpublished ADF&G data indicate a sex ratio of 57 percent males to 43 percent

Table 1. Tagging statistics of brown bear captured in Game Management Unit 13 from April 9 to June 23, 1978.

Bear ID Number (Tattoo)	Ear Tag No. L	R	Capture date	Sex	Age (Yrs)	Weight Kg(lbs)	Capture Location
200	990 &	992	4/09/78	M	7.5	289(635)**	Upper West Fork-Gulkana R.
201	801 &	802	5/24/78	M	10.5	227(500)**	Oldman Lake
202	803 &	804	5/24/78	F	8.5	105(230)**	Oldman Lake
203	805 &	806	5/24/78	F	2.5	52(115)**	Upper Tyone Creek
204	807 &	808	5/25/78	F	7.5	141(310)	Curtis Lake
205	809 &	810	5/27/78	M	4.5	205(450)**	Victory Creek
206	811 &	812	5/27/78	F	13.5	170(375)**	Victory Creek
207	813 &	814	5/27/78	F	11.5	98(215)**	Fish Lake
None	815		5/27/78	M	.5	5(12)	Fish Lake
None	816		5/27/78	F	.5	5(12)	Fish Lake
208	819 &	820	5/27/78	F	12.5	91(200)**	Second Hill Lake
209	817 &	818	5/28/78	F	4.5	101(222)	West Fork-Susitna River
210	821 &	822	5/28/78	M	2.5	61(134)	West Fork-Susitna River
211	823 &	824	5/29/78	M	4.5	136(300)**	West Fork-Susitna River
212	825 &	826	5/29/78	F	10.5	105(230)**	West Fork-Susitna River
213	827 &	828	5/29/78	F	10.5	102*225)**	Boulder Creek
214	829 &	830	5/29/78	M	3.5	102(225)**	Valdez Creek
215	831 &	832	5/29/78	F	2.5	75(164)	East Fork-Susitna River
216	833 &	834	5/29/78	M	10.5	255(560)	East Fork-Susitna River
217	835 &	836	5/30/78	M	3.5	139(305)	Middle Fork-Susitna River
218	837 &	838	5/30/78	M	4.5	100(220)	Middle Fork-Susitna River
219	839 &	840	5/30/78	F	4.5	95(210)	West Fork-Susitna River
220	841 &	842	5/31/78	F	5.5	125(275)**	Y Lake
221	843 &	844	5/31/78	F	8.5	136(300)**	Trappers Den
222	851 &	852	6/05/78	M	11.5	289(635)	Twin Lakes
223	845 &	846	6/03/78	M	2.5	92(202)	Trappers Den
224	847 &	848	6/03/78	M	2.5	85(186)	Trappers Den
225	849 &	850	6/04/78	M	4.5	159(350)**	Nelchina River
226*	853 &	854	6/06/78	M	5.5	236(520)	Loon Lake
227	855 &	856	6/07/78	M	9.5	268(590)	Twin Lake
228	857 &	858	6/10/78	M	7.5	226(497)	Upper Tyone Creek
229	859 &	960	6/10/78	F	2.5	95(210)	Upper Tyone Creek
230	861 &	862	6/10/78	M	9.5	250(550)	Monahan Flats
231	863 &	864	6/11/78	F	12.5	154(338)**	Marie Lake
232	865 &	866	6/23/78	F	1.5	45(100)**	Mile 175-Richardson Hwy.
233*	No tags		6/11/78	M	14.5+	250(550)**	Tyone Creek
234	869 &	870	6/23/78	F	5.5	148(325)**	Mile 175-Richardson Hwy.
235	867 &	868	6/23/78	F	1.5	45(100)**	Mile 175-Richardson Hwy.

* Tagging mortality.
** Estimated weight.

Table 2. Dosages of phencyclidine hydrochloride (conc. 100 mg/ml) utilized to immobilize brown bears in Game Management Unit 13 from April 9 to June 23, 1978.

Bear ID Number (Tattoo)	Sex	Age (Yrs)	Weight (kg)	Drug Dosage (ml)	Induction Time (min)	Hit Location	Comments
200	M	7.5	289**	7.0	No reaction	Ctr. back	1st dosage - no effect
				7.0	8	Rt. shoulder	
201	M	10.5	227**	5.0	-	Ctr. back	2nd dosage - 2 ml
202*	F	8.5	105**	4.0	8	L. side behind shld.	Complete injection (M-99)
203	F	2.5	52**	2.0	7	L. shoulder	Complete injection
204	F	7.5	141	4.5	10	Ctr. back	Up & running @ 11 min. 2nd dosage required
				3.0	4	Left rump	
205	M	4.5	205**	4.0	7	Ctr. back	Complete injection
206	F	13.5	170	4.0	-	Ctr. back	2nd & 3rd dosages required wouldn't stay down
				2.0	-	Ctr. back	
				4.0	53	Ctr. back	
207	F	11.5	98**	4.0	8	Ctr. back	Complete injection, down hard
208	F	12.5	91**	3.5	16	Ctr. back	Up & running-required 2nd dosage
				3.0	4	Back of front leg	
209	F	4.5	101	3.0	11	Ctr. back	Complete injection
210	M	2.5	61	3.0	8	Ctr. ribs/left side	Complete injection
211	M	4.5	136**	4.0	13	Mid-back	Complete injection
212	F	10.5	105**	3.0	10	Top left rump	Complete injection
213	F	10.5	102**	3.5	4	Left ribs	Down hard, may have hit vein, convulsed one time only for approximately 30 seconds
214	M	3.5	102**	2.5	10	(?)	Complete injection
215	F	2.5	75	2.5	6.5	Head above left ear	Complete injection
216	M	10.5	255	5.0	10	Ctr. back	Couldn't handle, 2nd dosage I.V.
				1.0	4	Femoral artery	6 convulsions @ 30 seconds each
217	M	3.5	139	3.5	-	Ctr. back	2nd dosage necessary as 1st dart bounced out
				3.0	4.5	Ribs-left side	
218	M	4.5	100	3.0	-	Left rump	No reaction to 1st dart after 16 minutes

Table 2 (cont.). Dosages of phencyclidine hydrochloride (conc. 100 mg/ml) utilized to immobilize brown bears in Game Management Unit 13 from April 9 to June 23, 1978.

Bear ID Number (Tattoo)	Sex	Age (Yrs)	Weight (kg)	Drug Dosage (ml)	Induction Time (min)	Hit Location	Comments
219	F	4.5	95	3.0	12	Rump	Complete injection
220	F	5.5	125**	3.0	9	Base of neck	Complete injection
221	F	8.5	--	1.8	16	Top of head	Given additional 1 ml inter-musc.
				1.0	10	Inner-muscular	(after 1st 16 min. head still up, required 2nd dosage) animal workable at 10 minutes
222	M	11.5	289	6.0	9	Ctr. back	Complete injection
223	M	2.5	92	3.5	4.5	Ctr. back	Complete injection
224	M	2.5	85	3.0	-	Ctr. back	Incomplete injection rec. 2.2 ml
225	M	4.5	159**	0.5		Left ribs	1st dart didn't inject total of 3.5 ml
					2.5	Ctr. back	2nd dart required
226	M	5.5	236	6.0	-	Ctr. back	Could not handle, 2nd dosage required
				1.0	10	Inner-muscular	
227	M	9.5	268	5.0	9	Ctr. back	Complete injection
228	M	7.5	226	4.0	-	-	Could not handle, 2nd dosage required
				1.0	-	Inner-muscular	
229	F	2.5	95	2.0	-	-	0.5 ml sparine, 3rd dosage, 1 ml sernylan
230	M	9.5	250	5.0	9	-	2nd dosage required (I.M.)
				1.0	-		
231	F	12.5	154**	3.0	9	Left rump	Complete injection
232	F	1.5	45**	1.2	9	Left flank	Given additional 0.6 ml sparine
233	M	14.5+	250**	5.0	-	Ctr. back	Complete injection, drowned
234	F	5.5	148**	3.0	7	Ribs (lower left)	Complete injection
235	F	1.5	45**	1.2	4	Low right rump	Given additional 0.6 ml sparine

* Bear immobilized with M-99.
** Weight estimated.

Table 3. Morphological measurements in relation to age of male brown bears captured in Game Management Unit 13 from April 9 through June 23, 1978.

Age (Yrs)	Bear Tattoo Number	Weight (kg)	Total Length (cm)	Shoulder Height (cm)	Length of Hind Foot (cm)	Neck Circum-ference (cm)	Girth (cm)	Body Length (cm)	Head Width (cm)	Head Length (cm)	Head Width and Length (cm)	Length Upper Left canine (mm)	Width Upper Left canine (mm)	Length Lower Left canine (mm)	Width Lower Left canine (mm)
0.5	815*	5													
2.5	210	61	152.4	95.3	29.8	45.4	83.8	84.5	16.8	28.9	45.7	17.0	13.7	16.3	12.4
2.5	223	92	179.7	89.9	31.4	51.1	101.9	96.2	17.8	31.4	49.2	17.6	14.8	20.0	15.8
2.5	224	85	170.1	96.5	30.5	48.3	94.6	99.4	16.8	30.5	47.3	15.1	13.6	18.0	15.0
3.5	214	102**		101.6	31.1	57.2	97.2	100.3	18.4	31.4	49.8	19.0	15.0	20.8	15.1
3.5	217	139	183.5	104.8	32.1	60.3	110.2	110.8							
4.5	218	100	165.1	97.2	28.9	53.7	96.2	95.3	18.1	31.1	49.2	18.6	14.7	20.8	14.6
4.5	205	205**	229.2	128.6	36.8	77.2	124.1	111.8	21.6	38.7	60.3	22.0	16.0	23.0	16.0
4.5	211	136**	182.9	111.4	31.8	73.0	118.7	114.3	21.6	36.8	58.4	22.0	16.3	22.1	16.3
4.5	225	159**	188.3	109.5	34.3	60.6	102.2	102.9	19.4	32.4	51.8	22.0	15.3	22.3	15.2
5.5	226	236	197.5	120.0	35.6	79.4	136.8	104.1	22.9	37.5	60.4	22.8	16.8	22.9	12.8
7.5	200	289**	223.5	132.4	26.0	87.6	148.0		25.4	42.5	67.9				
7.5	228	226	200.0	122.6	36.3	76.8	135.9	126.4	23.3	36.7	60.0	20.0	15.0	20.0	15.5
9.5	227	268	219.7	121.9	35.2	91.4	144.1	128.6	25.1	38.7	63.8	22.3	15.8	21.0	14.8
9.5	230	250	199.7	123.2	34.9	84.5	147.3	130.8				25.0	19.0	21.8	15.6
10.5	201	227**	192.7	121.0	38.9	91.0	151.0	130.0	25.5	38.4	63.9	20.0		21.5	
10.5	216	255	216.5	125.7	34.6	85.1	138.4	130.8	25.1	38.7	63.8	24.3	17.4	22.2	16.0
11.5	222	289	224.2	144.8	40.0	93.3	144.8	137.2	27.3	41.9	69.2	24.2	19.3	27.3	18.0
14.5	233	250**	230.5	131.8	34.9	97.2	140.3	124.5	26.0	39.4	65.4	23.2	22.0	21.5	15.7

* Ear tag number.
** Estimated weight.

Table 4. Morphological measurements in relation to age of female brown bears captured in Game Management Unit 13 from April 9 through June 23, 1978.

Age (yrs)	Bear Tattoo Number	Weight (kg)	Total length (cm)	Shoulder height (cm)	Length of hind foot (cm)	Neck circum-frence (cm)	Girth (cm)	Body length (cm)	Head width (cm)	Head length (cm)	Head width and length (cm)	Length upper left canine (mm)	Width upper left canine (mm)	Length lower left canine (mm)	Width lower left canine (mm)
0.5	816*	5													
1.5	232	45**	142.2	78.7	28.6	44.1	84.5	86.7	15.9	27.3	43.2				
1.5	235	45**	144.8	81.6	25.7	48.3	89.5	81.6	15.9	26.7	42.6	11.1	9.8	9.7	9.4
2.5	203	52**	157.4	93.5	31.0	48.0	86.8	88.5	16.6	29.6	46.1				
2.5	229	95	148.9	91.1	30.5	51.4	86.7	91.1	17.0	27.3	44.3	17.0	11.0	18.2	14.0
2.5	215	75	157.5	89.9	27.0	48.3	89.2	81.3	16.8	28.3	45.1	16.1	13.1	17.0	12.1
4.5	219	95		103.2	30.2	53.7		102.6	17.8	31.8	49.6	17.3	13.1	18.5	13.6
4.5	209	101	184.2	97.2	29.8	57.5	104.8	97.2	18.7	32.4	51.1	17.7	13.6	17.6	13.7
5.5	220	125**	193.7	101.6	31.1	59.1	106.7	109.2	20.3	34.0	54.3	17.1	13.1	18.7	12.8
5.5	234	148**	180.3	102.6	31.8	66.0	119.1	114.3	21.3	33.0	54.3	19.4	15.0	20.2	14.0
7.5	204	141	189.9	101.0	29.5	63.5	111.8	101.7	20.5	35.2	55.7		14.0		15.2
8.5	202	105**	182.0	104.0	32.5	61.0	98.8	104.0	21.1	35.2	56.3				
8.5	221	-	188.6	104.1	30.8	56.5	101.6	106.7	20.0	33.3	53.3	17.9	12.9	18.0	13.0
10.5	212	105**	184.1	96.2	29.2	57.8	96.2	97.2	19.1	31.4	50.5	17.8	12.2	16.4	11.8
10.5	213	102**	185.4	107.6	32.1	53.0	104.8	83.8	22.2	33.0	55.2	18.2	14.2	19.0	13.8
11.5	207	98**	181.0	108.3	32.1	59.1	102.2	93.3	21.6	34.0	55.6	18.2	12.5	18.0	12.5
12.5	208	91**	180.3	107.6	30.8	59.1	106.0	104.1	22.2	35.2	57.4	21.0	15.2	20.8	14.0
12.5	231	154**	205.7	97.8	29.2	66.0	117.5	119.4	21.0	37.1	58.1				
13.5	206	170	198.1		34.6	72.4	135.3	108.0	22.5	36.8	59.3	22.6	15.0	20.6	14.7

* Ear tag number.
** Estimated weight.

females for 888 bears of known sex harvested in GMU 13 from 1961 to 1979. As females accompanied by young are protected by hunting regulations, a higher proportion of males in the harvest relative to their occurrence in the population would be expected. Males, which typically have larger home ranges and are more mobile, may also be more vulnerable to hunters than females.

Teeth of harvested bears have been collected and aged since 1969. The mean age of 304 males in the 1969-1979 sport harvest was 6.4 years compared to 6.6 years for 18 captured males that were harvestable (over 2.0 years of age in 1977). For 219 females harvested during the same period, the mean age was 6.8 years compared to 7.7 years old for 16 females (over 2.0 years of age) that were captured. These data suggest that the age composition of the harvest in GMU 13 is similar to that of the population, especially for the male segment. Harvested females may average younger than females in the population because of a lower probability of younger females being accompanied by young.

Comparisons between sex and age composition of harvested and captured bears suggest that Unit 13 hunters are relatively non-selective and that harvest data may accurately reflect population composition in this unit. Recent initiation of a spring hunting season may alter this situation.

Breeding Status, Productivity and Movements

Breeding status and productivity of captured females over 2 years of age are shown in Table 5. Two 5.5-year-old females in 1978 plus one in 1979 (not shown in Table 5) were accompanied by yearling cubs indicating that they had successfully bred at 3.5 years of age. Females breeding successfully at 3.5 years of age have also been reported on the Alaska Peninsula (Glenn et al. 1972) and on Kodiak Island (Hensel et al. 1969). These results differ, however, from those of Reynolds (1976) for Northern Alaska, Pearson (1972) for the Yukon Territory and Craighead et al. (1969) for Wyoming where minimum breeding ages were determined to be 6.5, 6.5 and 4.5 years old, respectively.

Of the 13 captured females over the age of 3.0 years, (average age = 8.2 years), 6 were accompanied by young and 7 were in estrus (average age = 9.5) (Table 5). Only one female (#207) with cubs was captured in 1978 (Table 5). Three of the females captured in 1978 had cubs in 1979 (#'s 206, 213, 231) (Table 5). Additional data pertaining to productivity, breeding status, home range size, and denning activity are presented as a manuscript (Appendix I).

Table 5. Breeding status and known productivity of female brown bears over 3 years of age, captured in Game Management Unit 13 from April 9 through June 23, 1978.

Bear I.D. number	1978 Age (yrs)	Age first bred (yrs)	Offspring No. -age (yrs)	Remarks
202	8.5	Unk.	None	Lactating, in estrus, and with 10 year old male #201 when captured in 1978, not seen 1979.
204	7.5	4	2 - 2.5	Abandoned young (#229, other unmarked) and was observed with 7 year old male #228 on 6/10/78. Not seen in 1979.
206	13.5	Unk.	None	Lactating and in estrus, with 4 year old male #205 when captured in 1978. Had 3 cubs in 1979.
207	11.5	Unk.	3 - 0.5	Two cubs captured, ear tagged only in 1978: Male #815 and female #816. Had one yearling in 1979.
208	12.5	Unk.	None	Lactating and in estrus, not with a male when captured in 1978. No contact in 1979.
209	4.5	Unk.	None	Not lactating, in estrus and with 2 year old male #210 when captured in 1978. No cubs in 1979.
212	10.5	Unk.	None	Lactating and in estrus, with 4 year old male #211 when captured in 1978. No contact in 1979.
213	10.5	Unk.	1 - 1.5	Lactating - yearling never observed with sow after capture date in 1978. Had two cubs in 1979.
215	2.5	Unk.	None	Not lactating - mammae small (0.8 cm) and pink colored. No radio collar applied.

Table 5 (cont.)

Bear I.D. number	1978 Age (yrs)	Age first bred (yrs)	Offspring No. -age (yrs)	Remarks
219	4.5	Unk.	None	Not lactating, in estrus, mammae small (1.0 cm) and pink in color in 1978. No contact in 1979.
220	5.5	3	1 - 1.5	Lactating in 1978. With one 2 year old young in 1979.
221	8.5	Unk.	2 - 1.5	Lactating in 1978. With two 2 year old cubs in 1979.
231	12.5	Unk.	None	Lactating, in estrus and with 10 year old male #201 in 1978, had three cubs in 1979.
234	5.5	3	2 - 1.5	Lactating, yearlings not with sow in early August 1978. No contact in 1979.

Physiological Status

Table 6 lists the values (ppm) for 35 bear hair samples analyzed for 10 elements by atomic absorption spectroscopy; Zinc ($\bar{x}$ = 239, S.D.=57.5, range 137 to 373), Copper ($\bar{x}$=25.3, S.D.=7.3, range 13-47), Calcium ($\bar{x}$=1016, S.D.=287.1, range 465 to 1710), Magnesium ($\bar{x}$=93, S.D.=18.5, range 65 to 130), Potassium ($\bar{x}$=2088, S.D.=906.3, range 800 to 4280), Sodium ($\bar{x}$=5592, S.D.=638.4, range 3270 to 6780), Cobalt ($\bar{x}$=1.6, S.D.=0.4, range 0.9 to 2.8), Iron ($\bar{x}$=94, S.D.=17.1, range 62 to 126), Manganese ($\bar{x}$=1.1, S.D.=0.3, range 0.5 to 2.0), and Chromium ($\bar{x}$=0.3, S.D.=0.1, range 0.1 to 0.6). Table 7 lists the physiologic values of blood samples collected during this study. The physiological status of this bear population can not be assessed from these blood and hair data because of the absence of comparable data from other regions and seasons. Both sets of data will be placed on a computer and analyzed in other study reports when adequate data for comparison are available.

Food Habits

Observations of kills made by radio-collared brown bears were combined with results of the moose calf mortality study (Ballard et al. In Press). Characteristics of moose calves killed by brown bears have also been published (Ballard et al. 1979) and will not be discussed further.

During summer and fall 1978 radio-collared brown bears were observed on 78 kills (Table 8). Moose calves were the most numerous prey item taken by brown bears, comprising 47 percent of all kills and 51 percent of the ungulate kills. The timing of bear predation on moose calves was identical to that identified during the moose calf mortality study (Ballard et al. In Press); all calves which died from bear predation were killed prior to mid-July. Thereafter, adult moose and adult caribou (*Rangifer tarandus*) were the primary prey items.

We calculated predation rates for individual radio-collared bears by dividing the number of kills into the number of observation days (Table 8). The resulting figures should only be considered approximate rates, however, and may in some cases be inflated. Fuller and Keith (1980) determined that for wolves, predation rates based on observation days inflated kill rate figures because the probability of observing wolves on an old kill was greater than observing them the day upon which the kill was made. This is probably true for this study as well. Brown bears were observed on calf moose carcasses for as long as 2 days, but averaged 1.1 days (Ballard et al. In Press). On adult moose, however, they stayed with a carcass from 1-6 days, averaging 1.8 days. Some adult moose carcasses were

Table 6. Brown bear hair element values by sex and age for bears captured in Nelchina Basin from April 9 through June 23, 1978 (ppm).

Bear I.D. number	Sex	Age (years)	Zinc	Copper	Calcium	Magnesium	Potassium	Sodium	Cobalt	Iron	Manganese	Chromium
200	M	7.5	267	26	825	85	1830	5350	1.3	73	0.8	0.2
201	M	10.5	193	35	650	90	1690	5720	1.9	118	0.6	0.4
202	F	8.5	204	17	930	115	2730	5890	2.0	62	0.7	0.1
203	F	2.5	216	36	1120	95	800	5450	1.3	87	1.0	0.3
204	F	7.5	137	22	1350	130	1350	6030	1.6	65	1.3	0.5
205	M	4.5	293	25	890	65	2380	5580	2.1	108	1.1	0.3
206	F	13.5	304	20	765	95	1770	5820	1.5	104	0.7	0.3
207	F	11.5	185	28	1040	65	1820	6140	1.6	85	1.2	0.4
208	F	12.5	217	19	990	85	3000	5730	1.3	99	0.9	0.4
209	F	4.5	302	17	1080	75	1780	5840	1.5	83	0.6	0.3
210	M	2.5	170	16	1315	70	1160	5370	1.8	86	1.3	0.1
211	M	4.5	206	26	870	80	1930	5410	1.3	111	1.3	0.3
212	F	10.5	261	22	930	115	2160	5590	2.8	93	1.3	0.3
213	F	10.5	255	28	1530	100	2380	6140	1.9	78	1.0	0.3
214	M	3.5	287	30	845	90	2310	5720	1.5	80	1.1	0.4
215	F	2.5	242	27	965	70	4280	6680	1.7	74	1.2	0.4
216	M	10.5	209	31	1005	80	3870	5270	1.3	108	1.6	0.1
217	M	3.5	263	22	1710	130	3120	5630	0.9	82	1.3	0.3
218	M	4.5	184	19	885	110	3210	4550	1.4	105	0.5	0.2
219	F	4.5	348	23	960	100	900	5700	2.4	78	0.9	0.3
220	F	5.5	197	13	930	120	1490	5390	1.2	119	1.0	0.4
221	F	8.5	268	26	1160	90	1090	5110	1.8	97	2.0	0.3
222	M	11.5	317	29	465	85	1150	6030	1.6	83	1.2	0.2
223	M	2.5	261	37	820	100	2670	5010	2.0	122	1.2	0.3
224	M	2.5	373	20	655	115	2120	6580	1.3	101	0.6	0.4
225	M	4.5	217	17	985	85	2070	6430	0.9	83	0.8	0.4
226	M	5.5	226	47	1250	70	1490	3270	1.7	78	1.2	0.4
227	M	9.5	281	19	685	85	4210	6780	1.0	120	1.3	0.3
228	M	7.5	172	38	930	95	1580	5140	1.6	80	1.0	0.2
229	F	2.5	193	27	1630	125	2760	5630	1.6	112	1.1	0.5
230	M	9.5	148	21	565	90	1340	5730	1.6	126	1.3	0.6
231	F	12.5	304	30	935	70	2510	5220	1.5	99	1.4	0.4

Table 7. Blood values as determined by protein electrophoresis by sex and age for brown bear captured in Nelchina Basin from April 9 through June 23, 1978.

Bear ID number	Sex	Age (years)	Total protein GM/100ml	% of total	Albumin GM/100ml	% of total	Alpha 1 Globulin GM/100ml	% of total	Alpha 2 Globulin GM/100ml	% of total	Beta Globulin GM/100ml	% of total	Gamma Globulin GM/100ml	% of total	Albumin/ Globulin	% Hemoglobin	Packed cell volume
200	NO	DATA															
201	M	10.5	6.5	100	3.8	58	0.3	5	0.9	13	0.8	13	0.7	11	1.4		35
202	F	8.5	6.1	100	3.5	58	0.4	6	0.7	11	0.9	14	0.7	11	1.4		52
203	F	2.5	3.8	100	2.2	57	0.4	10	0.5	12	0.5	13	0.3	8	1.3		
204	F	7.5	4.8	100	3.0	62	0.4	8	0.4	8	0.6	13	0.4	8	1.6		45
205	M	4.5	5.9	100	3.7	62	0.3	5	0.7	12	0.6	9	0.7	11	1.7		
206	F	13.5	5.6	100	3.4	61	0.3	6	0.6	11	0.6	10	0.7	12	1.6		
207	F	11.5	5.6	100	3.3	61	0.4	7	0.5	8	0.4	7	0.9	16	1.4		
208	F	12.5	5.5	100	2.7	49	0.4	7	0.9	17	0.7	12	0.8	15	1.0		
209	F	4.5	7.3	100	4.7	64	0.4	5	0.8	11	1.2	16	0.3	4	1.8		49
210	M	2.5	7.7	100	4.6	60	0.6	8	0.6	7	1.3	17	0.6	8	1.5		51
211																	50
212	F	10.5	7.4	100	4.6	61	1.0	13	0.3	4	1.1	15	0.5	6	1.6	20+	46
213	F	10.5	7.0	100	4.7	68	0.4	6	0.6	9	0.7	9	0.6	9	2.1	20+	48
214	M	3.5	6.7	100	3.8	57	0.5	7	0.9	14	0.7	10	0.9	13	1.3		48
215	F	2.5	6.5	100	4.7	73	0.4	6	0.6	9	0.5	8	0.3	4	2.7		47
216	M	10.5	8.0	100	5.0	62	0.6	7	0.9	12	0.8	10	0.8	10	1.6		46
217	M	3.5	7.8	100	4.9	62	0.6	8	0.8	10	0.9	11	0.7	9	1.7		
218																	
219																	
220	F	5.5	7.0	100	4.3	61	0.5	7	1.1	15	0.7	10	0.5	7	1.6		
221	F	8.5	7.0	100	5.1	73	0.3	4	0.5	5	0.7	10	0.5	7	2.7		
222	M	11.5	8.2	100	5.3	65	0.5	6	1.1	13	0.9	11	0.5	6	1.8	18	53
223	M	2.5	6.6	100	4.1	61	0.5	7	0.7	10	1.1	16	0.3	5	1.6	17.6	47
224	M	2.5	6.6	100	4.3	65	0.5	8	0.7	11	0.8	12	0.3	5	1.8	18.9	48
225	M	4.5	7.2	100	4.8	67	0.5	7	0.6	8	0.7	10	0.7	10	2.0	19	50
226	M	5.5	8.1	100	4.9	60	0.3	4	1.3	16	1.0	12	0.7	8	1.5	17	31
227	M	9.5	8.0	100	5.1	63	0.4	5	0.7	9	1.2	15	0.6	8	1.7	19	48
228	M	7.5	7.8	100	4.7	60	0.4	5	1.0	13	0.9	11	0.9	11	1.5		41
229	F	2.5	7.2	100	4.7	66	0.6	8	0.7	9	0.9	12	0.4	5	1.9		49
230	M	9.5	7.1	100	4.8	67	0.4	6	0.6	8	0.7	9	0.7	9	2.0		49
231	F	12.5	8.3	100	5.0	60	0.6	8	0.8	10	0.9	10	1.0	12	1.5		40
232	F	1.5	6.7	100	3.6	54	0.5	7	0.9	14	0.6	9	1.0	15	1.5		43
233	NO	DATA															50
234	F	5.5	7.0	100	4.6	65	0.4	6	0.7	9	0.7	9	0.7	10	1.9		48
235	F	1.5	5.6	100	3.6	64	0.5	9	0.5	10	0.5	9	0.5	9	1.8		48

Table 8. Summary of radio-collared brown bear predation observations in the Nelchina and upper Susitna River Basins from 26 May to 1 November 1978.

Bear number	Sex-age(yr)	Family status	No. of observation days	Prey							Obs. days/kill
				Moose calves	Adult moose	Unidentified moose	Adult caribou	Beaver	Misc.[a]	Total	
200	M- 7.5	single	5							0	0
201	M-10.5	single	20	2	1					3	6.7
202	F- 8.5	single	25	5	1					6	4.2
204	F- 8.5	w/2(1.5 yrs)	25	2	1					3	8.3
205	M- 4.5	single	29	3	6					9	3.2
206	F-13.5	single	31	2	2					4	7.8
207	F-11.5	w/3(0.5 yrs)	23	1					1	2	11.5
208	F-12.5	single	33	9	4		1		1	15	2.2
209	F- 4.5	single	22			2				2	11.0
211	M- 4.5	single	16		1					1	16.0
212	F-10.5	single	17							0	0
213	F-10.5	single	16	1	1					2	8.0
216	M-10.5	single	10	1						1	10.0
217	M- 3.5	single	17	3	1					4	4.3
219	F- 4.5	single	12		1		1			2	6.0
220	F- 5.5	w/1(1.5 yrs)	29	1		1		2		4	7.3
221	F- 8.5	w/2(1.5 yrs)	28	5	1					6	4.7
222	M-11.5	single	11	1	2	1				4	2.8
225	M- 4.5	single	25	1	2				2	5	5.0
227	M- 9.5	single	8		1					1	8.0
228	M- 7.5	single	11		1					1	11.0
231	F-12.5	single	19		1		1			2	9.5
234	F- 5.5	w/2(1.5 yrs)	5		1					1	5.0
		Total	437	37	28	4	3	2	4	78	5.6

[a] Includes small mammals and unidentified species.

revisited, but no revisiting was observed on moose calf carcasses. In addition, we probably failed to observe some kills and observations of some individual bears were too infrequent to evaluate their summer food habits.

Based upon observation days, adult brown bears made a kill every 5.6 days (Table 8). They were observed on ungulate prey once every 6.1 days. Kill rates by individual bears were variable, ranging from no kills to a kill every 2.2 days. We compared ratios of observation days to number of kills for each bear by family class (single boars and sows, sows with 1.5 to 2.5-year-olds, and sows with 0.5-year-olds) to determine if any particular group was disproportionately represented. Single adult sows had the highest kill rate (1 kill/5.0 days) while sows with young had the lowest rate (1 kill/8.5 days). However, no statistical differences in kill rates by family classes were detected ($P>0.05$), indicating that adult bears were preying upon ungulates in the same proportions regardless of family status. Also, we could detect no differences ($P>0.05$) for mean number of kills/bear between older ($\geq$6 years old) and younger bears.

During the first half of summer 1978, moose were the most numerous ungulate in the study area. As summer progressed, however, and the Nelchina Caribou Herd began leaving the Kosina Creek calving grounds, caribou may have become the most abundant ungulate. Bears were not observed on caribou kills until late summer. Caribou might have been a more important prey item than our data indicate as observations were relatively infrequent in late summer.

Identification of brown bears as significant predators of moose will create problems for game managers attempting to manage moose (Ballard et al. 1980). If bears of all age and family classes are preying upon moose to the extent indicated in this study, then simple manipulation of bear sport hunting regulations will not likely reduce the impact of bear predation on moose.

RECOMMENDATIONS

Long-term brown bear studies should be initiated in GMU 13 to monitor and determine productivity, mortality, year-round food habits, census methods, and desirable harvest levels. This is particularily important as results of moose calf mortality studies (Ballard et al. 1980, In Press) have resulted in public requests for liberalized bear hunting seasons. The public perception is that reduced bear densities will increase moose populations. As pointed out by Reynolds (1980), the population statistics necessary to adequately manage bears can be acquired only through long-term studies.

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Appendix I.

Home Range, Daily Movements, Breeding and Denning Activity of Brown Bears in Southcentral Alaska

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Ballard, W. B., S. D. Miller, and T. H. Spraker. Home range, daily movements, breeding, and denning activity of Brown Bears in southcentral Alaska. Canadian Field - Naturalist 95( ):

Abstract: Twenty-three radio-collared adult Brown/Grizzly Bears (Ursus arctos) were studied in the Nelchina Basin of southcentral Alaska during 1978 and 1979. Radio-collared bears were seen on 85.4% of 644 radio locations. Home ranges of adult females averaged 408 km^2 while those of adult males averaged 769 km^2. Daily movements of males averaged 7.7 km/d while those of females averaged 7.0 km/d. Three females successfully bred at 3.5 years of age, two at 4.5 years and one at 5.5 years. Breeding occurred during May and June. The average litter size was 1.9 young including both 0.5-and 1.5-year-old young. It was hypothesized that first year cub mortality was high and that sows with cubs were underrepresented in the sample. Most bears entered dens in late October and emerged between 9 April and 12 May. Results from this study were compared with other studies in North America.

Key Words: *Brown Bear, Ursus arctos, home range, daily movements, denning, breeding, litter size*

Alaskan Brown Bear ecology has been investigated on the Alaska Peninsula (Glenn 1972, 1976), Kodiak Island (Hensel et al. 1969), the Brooks Range (Reynolds 1974, 1976, 1980) and on Admiralty Island in southeastern Alaska (Klein 1958, Wood 1976). All of these studies have focused on coastal or arctic populations. Studies have not been conducted on interior Alaskan Brown Bear populations which in recent years have been subjected to increasing levels of sport harvest (Alaska Department of Fish and Game [ADF&G] files). This study reports on some aspects of Brown Bear biology basic to management of populations in Alaska's Game Management Unit (GMU) 13, commonly referred to as the Nelchina Basin.

Predation by Brown Bears was intensively studied during 1978 and 1979 in response to results of Moose (Alces alces gigas) studies implicating Bear predation as a significant cause of Moose calf mortality (Ballard et al. 1980). Results of the Bear predation study were presented elsewhere (Ballard et al. 1981, Spraker et al. 1980). Sex-age

structure, productivity, home range size and denning activity of this previously unstudied population were assessed incidental to the predation study.

Study Area

The study was conducted in the Nelchina and upper Susitna River Basins of southcentral Alaska. Much of the area is contained in GMU 13, an area of 61,595 km^2 of which 18,798 km^2 is above 1200 m in elevation. Topography, geology, vegetation and climate of the area have been thoroughly described (Skoog 1968, Rausch 1969, Bishop and Rausch 1974, Ballard 1981). In this report the area is called the Nelchina Basin.

Studies in 1978, including home range determinations, were concentrated in GMU 13 Subunits 13A, 13B and eastern half of 13E described by Spraker et al. 1980. Followup studies in 1979, which involved capturing and transplanting Bears from a 3,436 km^2 portion of the Nelchina Basin, were done near the headwaters of the Susitna River, an area where Brown Bear density was estimated to be 1 Bear/41 km^2 (Ballard et al. 1980).

Procedures

From 8 April-23 June 1978, 36 Brown Bears were immobilized with phencyclidine hydrochloride (Glenn 1971) utilizing helicopter darting techniques (Spraker et al. 1980). Data on an additional 48 Bears captured and transplanted between 22 May and 22 June 1979, including eight recaptures of 1978 Bears (Miller and Ballard 1980), are included in calculations of age of sexual maturity, average litter size, productivity, and survival of young. Four cubs were captured by hand. Each adult Bear captured in 1978 (n = 23, generally 4 yr old) was equipped with a radio collar (Telonics, Mesa, AZ), ear-tagged with red plastic roto-tags (Oberach pat., Ltd., London, England), weighed, measured (Glenn 1972), and had both lower premolars extracted for age determination by methods similar to those described by Stoneburg and Jonkel (1966).

Radio-collared Bears were observed twice daily for the first 2 weeks of study, once daily through the remainder of June 1978, and once per week subsequently. These bears were radio-located from fixed-wing aircraft according to methods described by Mech (1974), and radio locations were plotted on 1:250,000 scale maps. This portion of the study was terminated in summer 1979.

Minimum home ranges of individual Bears were estimated by connecting outermost radio locations (Mohr 1947). Area of the resulting polygon was determined with a Numonics Model 1224 electronic digitizer. Daily movements were determined

by measuring straight-line distances moved between observations on consecutive days. Measurements of these distances were accurate to ±0.8 km.

Results and Discussion

Apparently female Nelchina Basin Brown Bears attain sexual maturaty at a slightly younger age than that determined for other areas of North America. Age of sexual maturity in other areas of Alaska ranged from 3.5 to 6.5 years on the Alaska Peninsula (Glenn et al. 1976) and Kodiak Island (Hensel et al. 1969), and from 6.5 to 12.5 years of age in the Brooks Range (Reynolds 1976 and 1980). In the Yukon Territory, Pearson (1975) reported that Grizzlies reach sexual maturity between 5 and 7 years of age. In Yellowstone National Park, Craighead et al. (1969) reported that although some females bred at 3.5 years of age they did not produce cubs; sexual maturity was reached between 4.5 and 8.5 years of age. In this study three 5.5-year-old females (2 in 1978 Table 1, and 1 in 1979) were accompanied by yearling young indicating that these females had successfully bred at 3.5 years of age. Of 13 females unaccompanied by young at the time of initial capture, 5 were lactating and in estrus (ages 8.5, 10.5, 12.5, 12.5, and 13.5), 7 were not lactating but were in estrus (ages 3.5, 4.5, 4.5, 4.5, 4.5, 4.5, and 5.5) and 1 was neither lactating nor in estrus (age 2.5). Only one of the females that was in estrus but not lactating in 1978 (#209, age 4.5) was seen again in 1979; in 1979 this female had no cubs but was again in estrus. Two females 6.5 years of age had yearling young indicating successful breeding at 4.5 years of age and one additional female had successfully bred at 5.5 years of age. Eight other captured females (ages 8-16) were accompanied by cubs or yearlings but these may have had previous litters as well. Although sexual maturity in the Nelchina population may be reached at 3.5 years, most females probably mature at 4.5 years.

Two females accompanied by 2.5-year-old young when originally captured in 1978, were subsequently observed with other adult Bears indicating breeding activity after a 3 year interval. One of these sows was not observed the following spring, but the other was observed the following spring without cubs. One 10-year-old sow, captured in the spring of 1978 with a single yearling, never was observed again with this yearling, a probable capture-induced separation. This sow was subsequently observed in the company of other adult Bears and in the spring of the following year she had two newborn cubs. Therefore, she successfully bred the same spring she lost her yearling cub, a reproductive interval of 2 years.

Bears observed in this study had an average of 1.9 young per litter (includes both cub and yearling litters); falling

Table 1. Summary of sex, age and radio location data for 23 Brown Bear studied in the Nelchina Basin study area during 1978 and 1979.

Bear No.	Sex-age	Reproductive status	Radiolocation 1978	Radiolocation 1979	Range km^2	Daily movements - 1978 Period	Daily movements - 1978 $\bar{x}$(km)	Daily movements - 1978 Range(km)	Denning dates Entrance 1978	Denning dates Emergence 1979
209	♀ - 4	alone	25	1	241.4	5/28-6/22	8.5	2.4-18.4		
219	♀ - 4	breeding	20		305.1	5/30-6/9	6.1	0.8-20.8	10/27	
220	♀ - 5	w/1-1.5 yr	39	7	580.7	6/2-6/24	9.0	0.0-25.6	10/19	
202	♀ - 8	breeding, w/male 201	37		439.0	5/29-6/21	12.3	0.0-34.4		
204	♀ - 7	w/2-2.5 yr	28		523.4	5/29-6/20	11.0	3.2-30.4		
221	♀ - 8	w/2 1.5 yr	34	2	859.9	6/4-6/21	4.6	0.0-9.6	10/25	
212	♀ - 10	breeding	21		222.2	5/29-6/21	7.5	3.2-16.0		
213	♀ - 10	w/1-1.5 yr	23	1	193.5	5/29-6/22	3.7	0.0-16.8	10/27	
207	♀ - 11	w/3-0.5 yr	43	7	307.4	5/28-6/24	2.9	0.0-8.8		5/19-31
208	♀ - 12	alone	46	1	733.5	5/28-6.20	7.2	1.6-16.0	10/25+	
231	♀ - 12	breeding, w/male 228	20	16	262.9	6/11-6/21	7.4	2.4-12.0	10/25	
206	♀ - 13	breeding, w/male 205	45	4	223.3	5/28-6/23	4.3	0.0-14.4	10/19	5/9-19
234	♀ - 5	w/2-1.5 yr	6		*					

Table 1 (cont.)

Bear No.	Sex-age	Reproductive status	Radiolocation 1978	Radiolocation 1979	Range km^2	Daily movements - 1978 Period	Daily movements - 1978 $\bar{x}$(km)	Daily movements - 1978 Range(km)	Denning dates Entrance 1978	Denning dates Emergence 1979
217	♂ - 3	alone	19		281.5	6/5-6/25	5.6	0.0-12.8		
205	♂ - 4	w/sow 206	41		798.0	5/27-6/28	7.4	0.0-18.4		
211	♂ - 4	w/sow 212	19	1	472.2	5/29-6/21	4.5	0.0-12.0		
225	♂ - 4	alone	28	5	1038.1	6/4-6/21	3.2	0.0-9.6	10/25+	
200	♂ - 7	alone	6	4	312.9				10/19+	4/9
228	♂ - 7	w/sow 231	14		1252.0	6/15-6/20	27.2	17.6-37.6		
227	♂ - 9	w/sow	13		495.5	6/13-6/17	3.7	0.0-8.8		
201	♂ - 10	w/sow 202	24	2	1381.5	5/29-6/19	15.8	1.6-43.2	10/27	4/16-22
216	♂ - 10	alone	14	1	586.1	5/29-6/3	3.2	0.0-8.0	10/23	
222	♂ - 11	alone	25	2	1069.7	6/5-6/21	6.2	0.0-16.0		

1/ Does not include Bear captured and transplanted in 1979.
* Home range size not determined.

within the range of litter sizes reported elsewhere in North America (Table 2). On the basis of our limited sample, Nelchina Basin Bears appear to have smaller litters than those recorded for coastal Brown Bear populations but comparable in size with those from other interior populations. Due to our small sample (n=4) of litters with newborn cubs and high cub mortality we suspect that litter sizes for Nelchina Bears may be larger than available data indicate. The small sample of sows with newborn cubs in 1978 (1 compared with 4 yearling litters and 1 litter of 2-year-olds) probably resulted from capture biases against these particular family groups. Sows with newborn cubs are suspected to be more secretive and less likely to be seen from fixed-wing aircraft than other Bears (Miller and Ballard 1980). Similar observations have been made by Glenn and Miller (1980) for the Alaska Peninsula. This hypothesis was strengthened by the results of 1979 capture efforts in a portion of the 1978 study area when, as in 1978, only one sow with newborn cubs was captured although seven sows with yearlings were captured. These seven sows must have been present in 1978 with newborn cubs, but were not found by the fixed-wing aircraft search techniques utilized.

Our hypothesis of high cub mortality in the Nelchina Bear population is supported by the relatively small size of yearling litters (Table 2) and by observations of cub losses. Of eight newborn cubs in three litters, only one individual is known to have survived to 1.5 years of age. In 1979, two of the lost cubs were transplanted along with their sow to another location and their loss may be related to this disturbance, two others were lost subsequent to entering their 1978/79 den but prior to our first sighting of the sow in late May 1979 and two cubs (in an original litter of 3) were lost between 8 June and 11 June 1979. Causes of cub mortality are unknown but predation by adult males may be significant as suggested by Reynolds (1980). For example, on 1 July a sow and the single cub, survivor of a litter of three, were observed running from a single adult Bear.

Radio-collared Bears were observed on 85.4% of the occasions they were radio-located (n=644). Observability of individual Bears varied from 59.3% to 97.2%. Absence of observation was often associated with den site observations or hazardous terrain which precluded more thorough searches. For Bears observed on relatively flat terrain, where thorough searches were possible, sow 207 with three 0.4-year-old cubs was the least frequently observed (84.0%). Relative to other adult Bears, sows with newborn cubs appeared more secretive in behavior, frequently hiding in dense bushes.

Home ranges of radio-collared female Bears were significantly smaller ($P<0.05$, $\bar{x}$ = 407.7 km^2, range 193.5 to

Table 2. Brown Bear litter sizes reported in various North American studies.

Source	Area	Average litter size (No. of litters observed) Age of young		
		0.5	1.5	0.5-1.5
Pearson 1975	Southwestern Yukon Territory	1.7(11)	1.5(11)	1.6(22)
Martinka 1974	Glacier Natl. Park, Montana	1.7(35)	1.8(30)	1.7(65)
This study	Nelchina Basin, Alaska	2.8(4)	1.6(11)	1.9(15)
Reynolds 1976	Eastern Brooks Range, Alaska	1.8(13)	2.0(7)	1.9(20)
Reynolds 1980 & pers. comm.	Western Brooks Range, Alaska	2.0(24)	2.3(8)	2.1(32)
Mundy 1963	Glacier National Park, B.C.	1.9(81)	1.8(45)	1.9(126)
Klein 1958	Southeastern Alaska	2.2(25)	1.9(35)	2.0(60)
Glenn et al. 1976 & updated	McNeil River, Alaska	2.2(27)	1.8(20)	2.0(47)
Glenn et al. 1976 & updated	Black Lake, Alaska Peninsula	2.1(19)	2.1(51)	2.1(70)
Hensel et al. 1969	Kodiak Island, Alaska	2.2(98)	2.0(103)	2.1(201)
Craighead et al. 1976	Yellowstone National Park	2.2(68)	-	-

733.5 km^2) than male home ranges which averaged 768.7 km^2 (range 281.5 to 1381.5 km^2). Combining sexes yielded an average home range of 571.9 km^2. Home ranges of females accompanied by young ($\leq$2.5 yrs, $\bar{x}$ = 451.2 km^2) did not differ significantly (P>0.05) from home ranges of single females (364.4 km^2). Generally, older Bears ($\geq$6 yrs) appeared to have larger home ranges than younger Bears, but differences were not significant (P>0.05). These trends were similar to those reported by Pearson (1975) in SW Yukon Territory except that Yukon sows with cubs had smaller home ranges than sows accompanied by older young (1.5 and 2.5 years old). This may be the case for Nelchina Bears as well, but it could not be shown with available data. In the western Brooks Range, Reynolds (1980) determined that home range size declined successively as follows: breeding males, breeding females, sub-adult females, and females with offspring. As has been reported elsewhere in North America (Craighead and Craighead 1967; Mundy and Flook 1973; Pearson 1975; Reynolds 1980), the home ranges of Nelchina Basin Bears were not exclusive and considerable, to complete, overlap existed in the home ranges of all sex and age groups.

Average home range sizes of Nelchina Basin Bears were compared with those reported elsewhere in North America (Table 3). Except for northwest Alaskan male Bears, Nelchina Bears had larger home ranges than those reported elsewhere in North America. Geographic differences in home range sizes probably reflect food availability.

Average daily movements of the 23 radio-collared Brown Bears ranged from 2.9 to 27.2 km/d during late May and June 1978 (Table 1). Males averaged 7.7 km/d while females averaged 7.0 km/d, a difference which was not significant, (P>0.05). Individual Bear movements ranged from 0.0 to 8.0 km/d for Bear 216 to 17.6 to 37.6 km/d for male 228. Pearson (1975) stated that daily activities and movements of Bears were associated with food gathering throughout the year except, possibly, during the breeding season when male movements were influenced by movements of females. Movements presented here reflect both activities. We were unable to detect significant (P>0.05) differences in daily movements based on either sex, age, family status, or predation rates (Spraker et al. 1980) of individual Bears.

Reynolds (1980) pointed out that calculations of daily movement were correlated, to some degree, with the length of time between sightings. For Bears where observations were separated by less than 2 d, western Brooks Range males moved 6.0 km and females moved 4.0 km, both of which were shorter distances than those reported in this study when consecutive observation days were used.

Table 3. Comparison of reported home range sizes of Brown/Grizzly Bears in North America (adapted from Reynolds 1980).

Area	Sex	Sample size	Average home range km^2	Source
Yellowstone National Park	♂	6	161	Craighead 1976
	♀	14	73	
Southwestern Yukon	♂	5	287	Pearson 1975
	♀	8	86	
Northern Yukon	♂	9	414	Pearson 1976
	♀	12	73	
Western Montana	♂	3	513	Rockwell et al. 1978
	♀	1	104	
Nelchina Basin	♂	10	769	This study
	♀	12	408	
Northwestern Alaska	♂	8	1350	Reynolds 1980
	♀	18	344	

Breeding activity was in progress in late May when the capture phase of the study was initiated and continued through the third week of June . These dates corresponded with observations in Mt. McKinley National Park (Murie 1944). We observed copulations on 7 and 12 June 1978. Of 112 visual observations of radio-collared Bears accompanied by other adult Bears in 1978, 96% occurred during May and June. Only 80% of all observations were in this period, a significant difference from expected values ($X^2 = 18.3$, $P<0.001$). Fifteen of the 17 radio-collared Bears (excluding 6 bears accompanied by cubs and yearlings) were observed with other adult Bears during this time period. The two exceptions included: Female 209, originally accompanied by a 2.5-yr-old which was subsequently lost, and male (217) which was probably sexually immature (3.5 yr). Sows accompanied by cubs or yearlings were not observed in association with other Bears.

Bears began visiting den sites in early October. Of eight Bears for which data were available, seven entered dens between 17 and 27 October 1978. One female (208) was near, but not yet in the den on 25 October when she was last observed. Bear emergence in spring 1979 ranged from 9 April to 12 May. Sows accompanied by young generally remained at den sites longer than single adults, one Bear remained as late as 31 May. These observations were similar to those reported elsewhere in North America (Murie 1944, Craighead and Craighead 1972, Pearson 1975 and others).

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Appendix II.

Homing of Transplanted Alaskan Brown Bears

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Abstract: Forty-seven brown bears (*Ursus arctos*) were captured and transplanted in Alaska in 1979. Post-release data from radio telemetry or hunter kills are adequate to evaluate the survival and homing movements for 20 adults and 9 young. Twelve adults are known to have returned to their capture sites in an average of 58 days (13 to 113 days); these were transplanted an average distance of 198 km (145-255 km). Eight adults, transplanted an average distance of 233 km (168-268 km), were classified as non-homing. Two yearlings successfully homed with their mother, 1 yearling survived with a non-homing mother, and 2 cubs and 4 yearlings were lost or died. Neither sex nor reproductive status was correlated with observed incidence of return, but age (for males) and distance transplanted (sexes lumped) was significantly correlated ($P<.05$). No threshold distance, beyond which transplanted bears would not return, could be determined. Initial post-release movements of non-homing as well as homing bears suggest that most bears were aware of the correct homing direction. Although apparent breeding behavior was observed, none of the transplanted females are known to have had cubs in the year after their transplant. Transplantation of nuisance brown bears was concluded to be an unreliable management procedure.

Keywords: brown bear, grizzly bear, *Ursus arctos*, transplant, homing, Alaska.

Wildlife managers are frequently requested to provide non-lethal resolution of conflicts between bears and man. Often the proposed solution is to move the bear away from the area of conflict. Biologists generally recognize this approach is inadequate, both because the bear, accustomed to association with man, frequently becomes a problem elsewhere or because the bear returns to the site of capture. This general recognition is, however, supported by relatively little published data.

As part of a 5-year study on the impacts of predation on moose (*Alces alces*) populations in southcentral Alaska (Ballard et al. in prep.), the Alaska Department of Fish and Game (ADF&G) artificially reduced brown bear populations in a portion of Alaska's Game Management Unit 13. This reduction was accomplished by capturing bears within an experimental area on the headwaters of the Susitna River and

transporting them far enough away that bear predation on moose calves in this area would be lessened for at least 6 weeks following moose parturition. Data were collected on rates and frequency of return of the transplanted brown bears.

Homing in black bears (*Ursus americanus*) has been reviewed by Beeman and Pelton (1976). In their study in the Great Smoky Mountains National Park, the greatest distance a homing black bear had been transplanted was 64 km. Erickson (1964) reported the return of a Michigan black bear moved 152 km, and Alt (1980) reported a case in which an adult male black bear in Michigan homed after being transplanted by air a distance of 251 km.

Data on homing brown bears are less extensive. At Wakeman Sound, British Columbia, 8 bears were moved distances of 32 to 84 km from the capture site and all but one (a sow and cub moved 38 km) returned (Draft Manuscript, "Wakeman Grizzly Relocation" provided by D. M. Hebert). It was noted that the rugged terrain on the British Columbia coast was of little deterrent to returning bears. In Yellowstone National Park, 7 of 14 grizzly bears returned after having been moved distances of between 80 and 95 km in 1971 (Border Grizzly Technical Committee, Working Paper #3, Draft #4, April 1, 1977). Homing of transplanted nuisance brown bears has also been discussed by Craighead (1976), Craighead and Craighead (1972), Cole (1972) and, Pearson (1972). Typically, these bears were transplanted distances of less than 100 km and high frequencies of homing were observed.

Cowan (1972:363) recommended trapping and transplanting as a management procedure for "intractable" bears. He suggested that the transplant location be "far removed from the ranges of [the bear's] experience" and that it was "particularly important that the release plan acknowledge normal return distances." Cowan recommended careful documentation and publication of transplant records to increase our knowledge of normal return distances.

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Materials and Methods

Bears were captured in May and June 1979. They were spotted from fixed-wing aircraft, immobilized by a dart (Palmer Chemical and Equipment Co., Douglasville, GA) fired from a helicopter (Bell 206B), slung by helicopter to a nearby base of operations where they were weighed, measured, had specimens collected (teeth, hair, and blood), and had identifying marks applied. Radio collars (Telonics, Mesa, AZ) were applied only on adult bears. Ear flags, ear tags and lip tattoos were applied to all bears. Reproductive status of females was determined by examination of coloration and size of the vulva. Immobilized bears were loaded in the bed of an open pickup truck and driven either directly to their release sites or to an airport where they were loaded into a Cessna 206 and flown to remote airstrips for release.

Initial immobilization for all but 9 bears was obtained with Phencyclidine hydrochloride (Sernylan, BioCeutic Laboratories, St. Joseph, MO) at doses of 1 mg./lb. of estimated body weight. Sernylan was also used for immobilization maintenance doses (0.5-1.0 mg/lb.) during transport for all but 6 bears. Bears not treated with Sernylan were given a mixture of Ketamine hydrochloride (Vetalar, Parke-Davis and Co.) and Xylazine (Rompun, Bayer) (Hebert and McFetridge, 1979) at doses of 5 mg/lb. of estimated body weight for initial immobilization and 2.5-5.0 mg./lb. for immobilization maintenance. Newborn cubs were captured by hand and transported in a cage without drugs, two yearlings were also transported in a cage without drugs. Ketamine hydrochloride/xylazine mixtures were discontinued for immobilization maintenance because the mixture's effects proved to be unpredictable and, therefore, unsafe for the bears' handlers.

Biologists remained with bears transported by truck to their release sites until these bears recovered from the drug and regained mobility. For 24 bears, mobility was regained in an average of 14.4 hours (6.4-26.2 hours) from the time of initial immobilization. Recovery was not observed for bears transported by aircraft to their release sites, but all sites were subsequently checked to verify that the bears had recovered and left. No more than 2 adult bears were released simultaneously at the same place.

Twelve efforts were made to relocate transplanted bears in 1979 (1 in May, 4 in June, 3 in July, 2 in August, 1 in September and 1 in October). In addition to these flights, numerous relocations were obtained incidental to other studies ongoing in the region in 1979 and 1980. Radio-collared animals were ultimately distributed over an area of approximately 31,000 km^2; this large area made regular relocations of all animals impossible. Locations of bears were plotted on U.S. Geological Survey maps at a scale of 1:250,000. From these maps, the distance transplanted was measured in a straight line from point of capture to point of release without regard to topographic or hydrographic features. The same procedure was followed in measuring distances between relocations.

Rates of movement were calculated by dividing the distance between consecutive sightings by the number of days between sightings. These results are obviously represent an underestimate of actual movement rates.

The criteria utilized in making a determination on when a particular bear had returned was subjective in some cases. Previous studies in this area (Ballard et al. in prep.) indicated an average home range size of 572 km^2 using minimum home range polygons (Mohr 1947). A home range of this area, if circular, would have an "average home range diameter" (AHRD) of 27 km. All bears classified as returned were within 1.2 AHRD from their capture sites except for 2: 244 and 273 were, respectively, 3.8 and 2.3 AHRD from their capture sites when classified as having returned on the basis of more random movements than previously shown. We felt that whatever clues these bears had utilized to get this close to their capture site would have permitted them to finish the journey if they had any desire to do so. A third bear (209) was 4.4 "AHRD" from its capture site when last spotted, and was not classified as having returned.

The statistical test utilized was the student's t test for difference between means and indicated values of (P) are 2-tailed probability levels.

The Study Area

Bears were captured in the headwaters of the Susitna River in southcentral Alaska. The area is bordered on the north by the Alaska Range and on the east by the Clearwater Mountains. Although brown bears are abundant in this area, bear density here is considered roughly equivalent to the areas of southcentral Alaska where captured bears were released. (Sterling Eide, ADF&G, pers. comm.).

Bears were transplanted to the east to several places in the vicinity of Mentasta Pass where the Glenn Highway crosses the Mentasta Mountains, into the Wrangell Mountains and

along the Copper River in the foothills of the Chugach Mountains, and to the southwest along the lower Susitna River.

Results

Forty-eight brown bears were captured in a 3,436 km^2 experimental area. All were successfully transplanted except for 1 male that accidentally drowned during capture and a female that died within a day after an apparently successful recovery at the release site. One male (237) quickly returned to the study area and was retransplanted, bringing the total number of successful releases to 47.

Some homing data are available 34 of these releases; relocations of radio-collared adults in 20 cases, from young accompanying radio-collared females in 11 cases, and from hunter kills of marked but not radio-collared bears in 3 cases. In 1979 and 1980, a total of 127 relocations were obtained for the transplanted bears (excluding cubs and yearlings) (Tables 1 and 2).

For 13 of the transplanted bears, including 3 yearlings, no homing data are available. These animals were too small for the non-expanding types of radio collars utilized and they have not yet appeared in the hunter harvest.

In 12 cases transplanted adults are known to have returned to the study area, 5 males and 7 females (Table 1). The returning males were transplanted an average of 211 km (145-255 km) and returned in an average of 24 days (13-39 days) (Tables 1 and 3). Returning females were transplanted an average of 189 km (145-211 km) and were identified as having returned in an average of 72 days (33-113 days) (Tables 1 and 2). There is no significant difference in the transplant distance between returning males and returning females ($t=1.7$, 10 d.f., $P>.10$).

Because of the delays in verification of the date of return, these bears actually returned more quickly than the above data indicate. The number of days from the previous sightings prior to return until the bear was verified as having returned averaged 33 days (Table 3). Two uncollared bears which were shot by hunters in the fall of the year following their transplant are not included in these calculations.

In 8 cases (excluding offspring), bears are thought, or known, not to have returned (Table 3). These bears were transplanted an average of 233 km (168-268 km) and remained an average of 180 km (105-303 km) from their original capture site when last observed.

Table 1. Movement data for bears known to have returned.

Bear #	Sex/ (Reproductive Status)/Age	Direct Distance Transplanted From Capture Site (km)	AHRD*	Direct Distance Returned (km)	Distance From Capture Site When Classified (km)	Returned AHRD*	No. Of Relocations Pre-Return	Post-Return	No. Of Young Returned	Dates Monitore
2371	M/10.5	145	5.4	145	18	0.7	1	4	-	6/3/79-6/23/79
2372		215	8.0	215	33	1.2	0	5	-	6/23/79-10/7/7
272	M/9.5	209	7.7	209	13	0.5	2	3	-	6/6/79-7/27/79
218**	M/5.5	230	8.5	215	23	0.9	0	1	-	5/26/79-9/6/80
268**	M/4.5	255	9.4	258	14	0.6	0	1	-	6/5/79-5/10/80
♂ Avg. =	7.5	211	7.8	208	20	0.7				
213	F/(w/2@0.5)/11.5	173	6.4	173	14	0.5	7	2	0	5/22/79-10/19/
236	F/(Turgid)/5.5	145	5.4	145	6	0.2	5	7	-	5/23/79-4/25/8
240	F/(w/2@1.5)/5.5	207	7.7	208	-	-	3	3	?	5/23/79-8/4/80
251	F/(w/2@1.5)/10.5	211	7.8	211	13	0.5	3	14	0	5/30/79-8/14/8
269	F/(w/2@1.5/16.5	199	7.4	199	12	0.4	3	4	2	6/6/79-9/29/80
244	F/(w/1@1.5)/6.5	201	7.4	106	103	3.8	3	4	0	5/25/79-8/4/80
273	F/((Turgid))/3.5	188	7.0	135	61	2.6	3	3	-	6/7/79-8/22/80
♀ Avg. =	8.5	189	7.0	168	35	1.3				
♂ and ♀ Avg. =	8.2	198	7.3	173	28	1.0				

* "Average Home Range Diameter" = 27 km.
** No radio collar, bear shot by hunter.

Table 2. Movement data for bear not known to have returned (includes individuals known not to have returned, and those which probably did not return).

Bear #	Sex/ (Reproductive Status)/Age	Direct Distance Transplanted (km)	AHRD****	Dates Under Observation	No. Of Locations After Release	Direct Distance From Capture Site To Last Location (km)	AHRD****
211	M/5.5	268	9.9	5/31/79-9/12/79	5	185	6.9
265	M/4.5	268	9.9	6/4/79-5/10/80 (shot)	6	303	11.2
246	M/4.5 (no radio)	211	7.8	5/25/79-9/23/79 (shot)	1	218	8.1
230*	M/10.5	256	9.5	6/1/79-5/24/80 (shot)	2	105	3.9
♂ Avg.	6.2	251	9.3		3.5	202	7.5
209**	F(turgid)/5.5	260	9.6	6/4/79-8/15/80	8	118	4.4
215	F(anestrus)/3.5	168	6.2	5/24/79-8/15/80	8	113	4.2
248	F(turgid)/4.5	249	9.2	5/26/79-9/30/79	6	190	7.0
261***	F(w/2@1.5)/7.5	184	6.8	6/1/79-6/6/80	4	210	7.8
♀ Avg.	5.3	215	8.0		6.5	158	5.9
Both Sex Avg.	5.8	233	8.6		5.0	180	6.7
INSUFFICIENT DATA							
216	M/11.5	178	6.6	5/22/79-6/15/79	4	166	6.2
247	M/8.5	240	8.9	5/26/79-5/31/79	1	201	7.4
258	M/21.5	286	10.7	5/30/79-7/27/79	1	305	11.3

* Bear 230 may have been returning when shot, its collar was shed by 6/15/79 at a distance of 249 km (159 mi.) from its capture site. It was much closer to home when it was shot in 1980.

** Bear 209 appeared to be returning in 1980. In May 1980 it was 198 km from its 1979 capture site, 77 days later it was only 118 km from its capture site.

*** One yearling lost by 6/8/79, other survived until final 1979 sighting on 9/30/79.

**** "Average Home Range Diameter" = 27 km.

Table 8. Number of days and distance moved between last sighting prior to return and date verified back.

Bear #	Number Days From Release Until Known To Be Back	Number Days From Last Sighting Prior To Return And Date Verified Back	Direct Distance Moved From Last Sighting Prior To Return And Place Where Verified Back (km)
MALES			
237_1	19	15	136
237_2	13	11	180
272	39	31	195
Male average	24	17	170
FEMALES			
213	74	11	63
236	43	21	91
240	92	84	195
251	33	16	62
269	69	55	188
244	82	44	55
273	113	43	30
Female average	72	39	98
All bear average	58	33	85

The distance returning bears were transplanted was significantly different ($P<.05$) than nonreturning bears when both sexes were lumped together. Treating sexes separately yields no significant differences for homing versus non-homing males ($P>.10$) or females ($P>.20$).

The average age for all nonreturning bears was 5.8 years compared to 8.1 years for all returning bears (Tables 1 and 3), but this difference was not significant ($P>.10$). Returning bears averaged older than nonreturning bears for each sex (Tables 1 and 3), but the differences were not significant for either sex ($P>.10$).

The age data are more revealing if hunter-killed bears are excluded (Tables 1 and 3). Information on homing obtained from bears killed by hunters may be biased by hunter selectivity. On this basis, 2 males returned (average age 10.0 years) and 3 males did not return (average age 4.8 years), a significant difference in age ($P<.005$). Seven radio-collared females returned (average age of 8.5) and 3 did not (average age 4.5), a nonsignificant difference ($P>.10$). With sexes lumped the age difference between returning and nonreturning bears was significant ($P<.05$).

Two of the nonreturning females were in estrus when captured, one had a single yearling and one was nonparous. Females in estrus, and with cubs, therefore, were present in both the returning and nonreturning bears (Tables 1 and 3).

Relocation data for 3 of the radio-collared bears are inadequate to determine whether they returned or not (Table 3). Male 258 initially moved 38 km in a non-homing direction and shed his collar. Male 247 initially moved 46 km in an approximate homing direction, but his signal was lost within 6 days following release. Male 216 also initially moved in a homing direction, but his signal was lost within 24 days following release. Therefore, of the 3 bears with insufficient data, 2 were last located closer to their capture site than their point of release (Table 3).

The minimum distance moved while returning was calculated by summing the direct distances moved between sightings. For 10 radio-collared bears known to have returned, the sum of the distances between sightings until return averaged 107 % of the direct distance back (61-130%). This suggests that returning bears moved back with a minimum of nondirected movements.

Female 244 had covered only 61% of the direct distance back when she was classified as having returned, 103 km from her capture site. We suspect she was captured on the northern limit of her range and was on the southern limit when she was classified as having returned. Beyond any question she was back the following year when she was seen only 10 km from her capture site.

The rates of movement while homing and subsequent to return were calculated by dividing the direct distance moved between sightings by the number of days between sightings. Prior to return, homing bears moved an average of 3.6 km/day compared to 0.6 km/day subsequent to return (Table 4) a significant difference ($t=3.2$, 16 d.f., $P<.01$). This differential was greater for males than for females (Table 4). For each returned bear the rate of movement was greater prior to return than subsequent to return (Table 4).

The data on movement rates do not accurately reflect actual movement rates because of varying, and long, sighting intervals. Previous, more intensive, studies of 21 undisturbed brown bears in the experimental area indicated daily movement rates averaging 7.7 km/day (0-43.2 km/day) (Ballard, et al. in prep.). Although this is not significantly different ($P>.20$) from the movement rates of homing bears prior to return in this study (3.6 km/day, Table 4), the difference is in the opposite direction from what would be expected. This is probably because of biases introduced by sighting intervals of different lengths. One bear (213) included in both studies illustrates this point. In earlier studies this bear was observed 23 times in 24 days and had an average movement rate of 3.7 km/day (0-16.8 km/day) (Ballard, et al. in prep.). The following year she was observed 7 times in a period of 74 days from the time of release until her return was verified (Tables 1 and 2) and had an average movement rate in this period of 2.8 km/day (Table 4).

The rate of movement for bears known not to have returned averaged 1.4 km/day (Table 4). This is significantly different from the rate for homing bears prior to return ($t=2.4$, 15 d.f., $P<.10$), and held for each sex (for males $t=2.8$, 4 d.f., $P<.05$; for females $t=2.05$, 9 d.f., $P<.10$). Non-homing bears had significantly different (more rapid) movement rates than did homing bears subsequent to return ($t=2.4$, 14 d.f., $P<.05$). This differential was significant for females ($t=2.17$, 9 d.f., $P<.10$), but not for males ($t=0.8$, 4 d.f., $P>.4$).

The direction of movement was defined as "homing" if the direction taken from the previous sightings was within 35 degrees of the direction required to return to the capture site. Homing bears moved in a homing direction for 87% of the distance between sightings and for 89% of the days between sightings (Table 5). Nonreturning bears moved in a homing direction for only 39% of the distances between sightings and for only 27% of the days between sightings (Table 5).

The rates of movement in homing and non-homing directions were roughly equivalent for homing bears ($t=1.0$, 16 d.f., $P>.2$) as well as non-homing bears ($t=2.0$, 12 d.f., $P>.05$) (Table 5).

Table 4. Total documented distances moved between sightings and movement rates of radio-collared brown bears. Does not include locations subsequent to den emergence in 1980.

	No. Days In Intervals		Distance Moved In Intervals (km)		Movement Rate (km/day)	
	Prior To Return	Post-Return	Prior To Return	Post-Return	Prior To Return	Post-Return
RETURNING BEARS						
MALES						
237[1]	19	13	162	18	8.5	1.4
237[2]	11	66	180	75	16.4	1.1
272	39	19	232	15	5.9	0.8
$\bar{x}$ (returning males):	23	33	191	36	8.3**	1.1**
FEMALES						
213	74	43	209	6	2.8	0.1
236	43	105	182	63	4.2	0.6
240*	92	no data	239	no data	2.6	no data
251	33	106	241	36	7.3	0.3
269	69	65	259	23	3.8	0.4
244	82	22	122	22	1.5	1.0
273	113	11	175	12	1.6	1.1
$\bar{x}$ (returning females):	69	59	198	27	2.9**	0.5**
$\bar{x}$ (returning bears of both sexes):	54	50	196	30	3.6**	0.6**
NON-RETURNING BEARS						
MALES						
211	103		226		2.2	
265	43		47		1.1	
216***	23		28		1.0	
$\bar{x}$ (non-returning males):	56		100		1.8**	
FEMALES						
209	111		165		1.9	
215	153		199		1.3	
248	96		147		1.3	
261	110		66		0.6	
$\bar{x}$ (non-returning females):	118		144		1.2**	
$\bar{x}$ (non-returning bears of both sexes):	91		125		1.4**	

[redacted] 240 not included in calculation of averages.

** Calculated by dividing summation of distances for all bears by summation of days for all bears.

*** Bear 216 included with non-returning bears in this table although contact was lost with this bear after 23 days (4 relocations) of release.

Table 5. Distances moved and frequency of movements in homing and non-homing directions by transplanted brown bears (1979 data only).

	In Homing Direction				In Non-Homing Direction			
Bear #	No. Observations	No. Days	Distance (km)	Rate (km/day)	No. Observations	No. Days	Distance (km)	Rate (km/day)
RETURNING BEARS								
MALES								
237_1	1	15	136	9.1	1	4	26	6.5
237_2	1	11	180	16.4	0	0	0	--
272	1	31	195	6.3	2	8	37	4.6
$\bar{x}$ (returning males):	1.0	19	170	9.0*	1	4.0	21	5.3*
FEMALES								
213	6	66	175	2.7	2	8	34	4.3
236	4	36	143	4.0	2	7	39	5.6
240	3	91	216	2.4	1	1	23	23.0
251	3	32	210	6.6	1	2	31	15.5
269	2	62	224	3.6	2	7	35	5.0
244	2	58	95	1.6	2	25	27	1.1
273	3	112	175	1.6	1	1	0	0.0
$\bar{x}$ (returning females):	3.3	65.3	176.9	2.7*	1.6	7.3	27.0	3.7*
$\bar{x}$ (returning bears of both sexes):	2.6	51.4	174.9	3.4*	1.4	6.3	25.2	4.0*
NON-RETURNING BEARS								
MALES								
211	2	38	79	2.1	3	65	147	2.3
265	3	25	35	1.4	2	18	12	0.7
216	1	8	9	1.1	2	7	6	0.9
$\bar{x}$ (non-returning males):	2.0	23.7	41.0	1.7	2.3	30	55	1.8*
FEMALES								
209	3	52	75	1.4	3	59	90	1.5
215	3	32	95	3.0	4	121	104	0.9
248	1	12	33	2.8	5	84	114	1.4
261	1	6	9	1.5	2	104	57	0.6
$\bar{x}$ (non-returning females):	2.0	25.5	53.0	2.1*	3.5	92	91.3	1.0*
$\bar{x}$ (non-returning bears of both sexes):	2.0	24.7	47.9	1.9*	3.0	65.4	75.7	1.2*
$\bar{x}$ (all bears):	2.8	40.4	122.6	3.0*	2.1	30.7	46.0	1.5*

* Σ distance/Σ days

Initial post release movements were in a homing direction for 5 of the 10 radio-collared bears which returned and for 5 of the 7 radio-collared bears which did not. This suggests that many of the bears not returning "knew" where home was, but chose not to return.

It is probable that some of the bears classified as nonreturning in Table 3, actually returned but have not been discovered because of radio failures. At last contact with these bears, all but 4 (265, 246, 261 and 258) were closer to their capture sites when last seen than they were at the point of their release; on the average, these 7 bears were 32% (7-59%) closer to their captures sites when last seen than they were at the point of release (Table 3). The 4 bears which were farther from their capture sites when last seen than when released, averaged 9% farther (3-14%) (Table 3).

Two of the bears classified as nonreturning (209 and 230) may have been returning in 1980 rather than in the year of their release. Female 209 was seen in May 1980, 198 km south of her capture site, but was next seen in August 1980 only 118 km southeast of her capture site and on a reasonably direct route back. Relative to the transplant distance (206 km), in May she was 24% of the way back and in August she was 55% back. Male 230 shed his collar 2 weeks following release at a point 249 km southeast of his capture site. This bear was shot almost a year later (May 1980) only 150 km southeast of his capture site. Relative to the transplant distance (256 km) bear 230 shed his collar when he was 3% of the way back but was shot when he was 59% of the way back.

The routes followed by some of the transplanted bears suggest influences by natural or man-made barriers. Five bears (209, 211, 265, 261 and 269) initially headed back to their capture sites but reversed direction prior to crossing the Copper River, a large river with a braided flood plain. Only one of these bears (269) is known to have eventually returned to its capture site. Bear (209) is known to have eventually crossed the Copper River (by September 1979), but there is no evidence that 211, 265 or 261 ever successfully crossed the Copper River. Five other radio-collared bears released east of the Copper River (258, 230, 273, 272 and 2372) showed no evidence of any hesitation or deflection prior to crossing the Copper River, 3 of these bears returned directly to capture sites, one quickly shed its collar (258) and the last (230) also shed its collar but appeared to be returning when it was shot in 1980.

The movements of 3 bears appeared to be influenced by highways. Female 213 (with 2 cubs) moved on a direct homing, heading northwest, following release until she encountered the Glenn Highway, 8 days and 21 km north of her

release site. Nine days following release she lost her cubs. She remained south but within 1-8 km of the Glenn Highway for at least 2 more weeks until she crossed the highway on a direct route back. Some of her dilatory behavior may have been related to the loss of her cubs, but she was deflected for at least 1 day and 16 km prior to loosing her cubs. She paralleled the highway for at least 34 km before crossing. Female 244 (with 1 yearling) headed directly back until she encountered the Glenn Highway within 13 days following release and crossed the highway within 21 days following release, a less obvious deflection. The yearling with 244 remained with her after she crossed the Glenn Highway, but was lost shortly afterwards. Female 240 (with 2 yearlings) was released between the Copper River (on the east) and the north-south Richardson Highway (on the west). Moving north in a homing direction from the release point these bears remained between the highway and the river within 6 km of the town of Copper Center (where the highway and river are adjacent), then crossed the highway and moved in a nonhoming direction (southeast) for at least 23 km. This bear eventually crossed the Glenn Highway and returned to her capture site.

It would be a mistake to conclude from these instances of apparent deflections of homing bears by the Copper River that rivers, highways or bodies of water serve as barriers to homing. Julius Reynolds (ADF&G) captured a 3.8-year-old male brown bear near Cordova on 17 September 1973 and transplanted it by boat to Montague Island in Prince William Sound, a direct distance of 93 km. This bear was killed 28 days later within 100 m of its capture site (ADF&G files). A direct route back would have required swimming 11.3 km to Hinchinbrook Island and additional swims of 1 km and 2.8 km to Hawkins Island and the mainland, respectively. The only alternative route off Montague Island would have required initial movements in a non-homing direction, a swim of 8.5 km to LaTouche Island, four additional swims of about 2 km to the mainland, and a complete circle around western Prince William Sound, crossing numerous glaciers and fiords, to return to Cordova; this route would have required moving a minimum of 290 km across exceptionally rough terrain and the initial third of this distance would have been in a non-homing direction. Therefore, this bear must have swam a minimum of 8.5 km, most probably 11.3 km, at right angles to the tides and in the frigid waters of Prince William Sound in order to return.

Of the 9 young transplanted with radio-collared females only 3 were still with their mothers when last sighted in 1979. Four returning females lost 5 of 7 young while 1 nonreturning female lost 1 of 2 young. One additional female (240) was not observed after her return to the capture site in 1979 so the status of her 2 yearlings could not be verified; the yearlings are known to have survived

for at least 9 days following release at which time they were 8% closer to their capture site than they were at the release point. Only 1 female (203) with cubs-of-the-year was captured and she lost both (10-17 days after release) prior to her return.

The 4 yearlings lost averaged 46 kg in weight and included the largest (63 kg) and the smallest (21 kg) yearlings. The three surviving yearlings (with 269 and 261) averaged 43 kg (41-45 kg). The surviving yearling cubs included 1 male and 2 females, the lost yearlings included 3 males and 1 female. Both lost cubs-of-the-year were males.

Survival times of the lost offspring varied from a minimum of 0 to a maximum of 36 days (Table 6). Interestingly, the smallest yearling captured (with sow 244) is known to have survived longer than the other lost yearlings (Table 6). Female 261 with her 1 surviving yearling was seen 7 days after release and 9 km from the release point with a partially buried, and unidentifiable, dead animal which may have been her missing yearling. These data suggest that cub losses were not related to capture, transportation or drugs. The female which died following recovery (254) was exceptionally aggressive when she recovered from the drug, chasing the pickup truck in which she had been transported, attacking the Trans-Alaska oil pipeline, and abusing both her yearlings. This abuse did not, however, result in the death or evident serious injury of either yearling.

It is unknown whether the lost young died, but it is probable. Cases where lone cubs have survived have been reported (Johnson and LeRoux 1973). However, it is a reasonable speculation that the lost offspring released into terrain which was unfamiliar to their mothers, would have been particularly vulnerable to predation by resident boars and many probably died. The only offspring with an evident preexisting injury was a yearling (with female 240) which had an injured right front paw with no claws remaining. However, both of 240's yearlings are known to have survived for at least 9 days and 44 km following release; whether they survived until 240 returned to her capture site was not verified.

Seven of the 11 transplanted and radio-collared adult females were observed in 1980, but none of them were accompanied by offspring in 1980. Two of these 6 (273 and 209) were in estrus when captured but were not subsequently observed with another bear; there is no evidence, therefore, that they bred. Female 244, which had a yearling in 1979 that she lost by 2 July 1979, was observed with an adult bear on 15 September 1979, but had no offspring when seen in July 1980. Female 251 had 2 yearlings that she lost by 19 June 1979, was not seen subsequently in 1979, and had no offspring when spotted on 18 July 1980. Female 215 was not

Table 6. History of offspring which were lost subsequent to release.

Mother	Offspring ages	Offspring weights (mg)	Days from release until last seen	Days from release until first missed	Direct distance moved from release until last seem (km)	Direct distance moved from release until first missed (km)
213*	0.5, 0.5	5, 5	10	17	37	55
251*	1.5, 1.5	61, 63	8	19	90	179
244*	1.5	21	20	36	51	67
261**	1.5***	41 or 40***	0	7	0	9

* Bear eventually returned.
** Bear did not return.
*** Sibling (41 or 40 kg) survived at least until October 1979.

turgid when transplanted, was seen with an adult bear on 3 July 1979, and had no offspring when spotted on 15 August 1980. Bear 269 successfully homed with both of her yearlings in 1979 and had no young with her in September 1980. The productivity of 5 transplanted females could not be verified as they were not resighted in 1980; two of these (236 and 248) were in estrus when captured but only 236 was later seen with another bear. The other 3 radio-collared females not resighted in 1980 had cubs or yearlings when captured and none of these was sighted with another adult bear subsequent to release.

Three transplanted males were seen with smaller, presumably female, bears subsequent to release. Male 237 was seen with 2 different females between 10 and 23 June, he was breeding with female 236 when initially captured on 22 May. Male 265 was seen with another adult on 8 June and male 216 was seen with another adult from 31 May to 8 June.

The drugs utilized for immobilization during transport had no apparent affect on probability of return. Homing bears included individuals immobilized and maintained with Ketamine/Rompun mixtures (213), immobilized with Sernylan but maintain with Ketamine/Rompun (236 and 237), immobilized with Ketamine/Rompun and maintained with Sernylan (251), and both immobilized and maintained with Sernylan (2372, 272, 218, 268, 240, 269, 244, 273). The Ketamine/Rompun mixture for immobilization maintenance was used on only 6 bears because it was discovered that they often would recover unexpectedly fast from the effects of this drug combination, thereby creating serious hazards for the handlers.

There was no apparent difference in incidence of homing between bears transported by truck to their release site and those transported by truck to an airport and flown to their release site. Returning bears included 7 transported by truck an average distance of 187 km (145-230 km) and 5 transported by truck and plane an average distance of 213 km (188-255 km). Bears not known to have returned included 4 transported by truck an average distance of 229 km (168-268 km) and 4 transported by truck and aircraft an average distance of 242 km (184-268 km).

Discussion

Average home range diameters for bears in the experimental area were known from previous work. Homing bears were transplanted an average of 7.3 (5.4-9.4) average home range diameters from their point of capture. Although it is possible that a few bears were released within an area with which they had previous experience, at these distances it is probable that most bears were completely unacquainted with their release sites. The direction of movement following release, for both returning and nonreturning bears, suggests

that most transplanted bears knew the correct homing direction and that successful homing was not dependent on random movements until familiar terrain was encountered.

Therefore, it is likely that previous knowledge of the release location is not necessary for a bear to successfully home; other clues to the correct homing direction must be perceived and utilized. Lentfer (1972, 1973) has suggested that polar bears inhabiting drifting pack ice seem to be able to navigate, without physical reference points, in order to maintain their position or to find seasonally reoccurring areas of food abundance. Homing brown bears may be able to navigate in similar fashion. The clues utilized in making these directed movements remain an interesting, and difficult, topic for future study.

Although homing bears were moved significantly farther than non-homing bears, no threshold distance, beyond which bears could or would not home, was demonstrated in this study. We suggest that whether a transplanted bear returns or not appears more related to an individual bear's motivation to return, than to its ability to do so. This motivation, in turn, is affected most by the bear's age and second by its sex, with older bears and males being more likely to return. Doubtless a very important factor in this motivation is the acceptability of the habitat into which a bear is transplanted. A bear accustomed to feeding in garbage dumps may find excellent natural habitats inadequate, however, even wild bears with no history of using garbage dumps can be highly motivated to return as shown in this study. We conclude that transplanting problem bears, even long distances, is a solution with a high probability of failure.

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