TERROR LAKE HYDROELECTRIC PROJECT
KODIAK ISLAND, ALASKA

FINAL REPORT ON BROWN BEAR STUDIES
(1982-1986)

by

Roger B. Smith

and

Lawrence J. Van Daele

Submitted to the
Alaska Power Authority
June 1988

Alaska Department of Fish and Game
Division of Wildlife Conservation
211 Mission Road
Kodiak, Alaska 99615
1991

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EXECUTIVE SUMMARY

This report summarizes studies conducted by the Alaska Department of Fish and Game to monitor the impacts of construction and operation of the Terror Lake Hydroelectric Project on brown bears in northern Kodiak Island, Alaska from 1982 through 1986. The Terror Lake project includes a dam on Terror Lake, in the Kodiak National Wildlife Refuge, and a 10 km (6 mi) tunnel through a mountain ridge to a penstock and powerhouse in the Kizhuyak River drainage. The powerhouse is connected to the city of Kodiak by a 27 km (17 mi) powerline and to the village of Port Lions by a 21 km (13 mi) powerline. Construction began in 1982 and the facility was generating power by 1985. Up to 480 construction personnel were active in remote field camps at the peak of construction in 1983.

Brown bears were investigated by direct observation and by radio-telemetry. One-hundred forty individual bears were captured a total of 197 times. We placed radio collars on 84 bears, including 32 males and 52 females. The radio-collared bears were relocated 4,792 times during the 5 year study. To facilitate analysis of project impacts on brown bears, this study was divided into 2 phases: construction (1982-1984), and post-construction (1985-1986). That analysis was hampered, however, by the lack of comparable pre-project data.

An extrapolation of a census conducted in 1987 indicated that the project study area contained 367 bears (including cubs), and had a density of 0.278 bear/km^2 (0.72 bear/mi^2).

Radio-collared female bears produced their first litters as early as age 4 years and continued to produce cubs as late as age 26 years. The mean minimum reproductive interval was 4.6 years and the overall cub production rate by eligible females was 46%. Newborn litter sizes averaged 2.5 cubs and 33% of the cubs first observed as newborns survived to age 2. Cannibalism by adult male bears was the only documented source of natural cub mortality. Fifty-three percent of the cubs were weaned at age 2 and 47% were weaned at age 3. Breeding activity was observed as early as mid-May and as late as early August, with the peak in mid-June. Breeding associations including single males and multiple females were not uncommon. No correlation between construction activity and reproductive success was established in this study.

Thirty-seven marked bears were known to have died during this investigation. Sport hunting was the leading cause of death (43%), accounting for 71% of the known marked male deaths and 20% of the marked female deaths. Natural causes were the leading reasons of death for marked females (30%). Seven bears died during capture operations, a 3.6% capture mortality rate. No bears were reported killed by project personnel during the construction or operation of the project, although 1 bear was killed in 1981 by a prospective contractor.

Radio-collared bears made substantial use of all major habitat categories in the study area at various times of the year. Bears favored alpine areas for dens, but moved to lowland and midslope areas in early spring to feed on emerging vegetation. Rapidly developing vegetation on midslopes to alpine areas remained important into July. In August, most bears moved to lowland areas as salmon and salmonberries became available. Salmon remained an important item into October, and Kizhuyak and Terror Rivers had large seasonal concentrations of bears. In late September ripening berries in midslope areas attracted bears away from salmon streams and by October most bears were located in berry-producing midslope shrub fields. Movement to alpine denning areas was evident by early November. We found significant seasonal differences between the habitat categories used by bears in various reproductive categories.

Sixty-four radio-collared bears were located in 184 dens during this study. Seventy-one percent of these dens were in alpine areas and the mean den elevation was 665 m (2,182 ft). Ninety-three percent of the dens were associated with steep slopes, large rock outcrops or cliffs. Aspects varied, but 42% were

northerly or northeasterly. Most dens appeared to be excavated, but natural cavities and snow dens were also observed. Significant den concentration areas were identified at Den Mountain and Baumann Creek. These 2 areas combined composed only 1% of the core study area, but they contained 36% of the dens of radio-collared bears. Females occupied 96% of the dens of radio-collared bears in these 2 concentration areas. Individual bears throughout the study area exhibited a high degree of fidelity to den sites from 1 year to the next; 51% of the dens were less than 1 km (0.6 mi) apart in successive years and the mean distance was 1.7 km (1.1 mi). We noted differences in den entrance/emergence chronology attributed to both bear reproductive status and weather. Den entrance began in October and continued into January. Generally, pregnant females were the first to enter dens and males were the last to den. Den emergence dates ranged from February to July, with males the first to emerge and females with newborn cubs the last to leave dens. There was apparent delayed denning by bears in all reproductive categories during years with warm, wet autumns. Sixteen radio-collared females used 2 dens in a single season on at least 1 occasion. Timing of movement to second dens appeared weather-related as 62% of the movements occurred during the unseasonably warm, wet late autumn/early winter months of 1985. Seven males in 11 instances did not den during at least 1 of the winters they were monitored. This represented 27% of the radio-collared males and 32% of the denning periods recorded for radio-collared males during this study. These instances of non-denning did not appear to be either project- or weather-related.

Annual home range sizes for females with at least 10 radio-tracking location points ranged from 1.2 to 197.7 km^2 (0.5-76.3 mi^2) and for males ranged from 30.0 to 465.0 km^2 (11.6-179.5 mi^2). Attempts to correlate individual bears' home range sizes with construction activity were confounded by annual variations in food availability, and changing age and reproductive status. Approximately half the bears in the study area were considered to have been affected by the hydroelectric project based on the proximity of their home ranges to project features. There was no significant difference in the mean home range sizes of "project" and "non-project" bears during the construction and post-construction phases of this investigation. Individual bears exhibited a wide range of reactions to project activities.

Analysis of the movements of individual radio-collared bears with home ranges most closely associated with project sites indicated that bears exhibited relatively high tolerance to construction activities. Some individual bears appeared to have been displaced from preferred feeding areas with little cover on the Kizhuyak River, primarily during construction of the powerlines in 1983. Feeding activities in that area resumed to some extent during the post-construction period. Some bears appeared to move nearer to construction sites at the peak of activity, possibly because they were habituated to disturbances or they were attracted to the relatively small amounts of discarded food near worksites.

The Terror Lake reservoir was found to be relatively lightly used bear habitat, although bears were occasionally observed there during construction. No bears were captured in the Terror Lake basin until 1985 and 1986, after construction of the dam was completed. Bears were frequently seen by construction and operation personnel throughout the study. Workers reported observing 262 bears from 1982 to 1984, mostly in the Kizhuyak River drainage. Aggressive bear behavior was only noted in 2 cases.

Studies conducted before construction of the Terror Lake Hydroelectric Project predicted that the project would have several effects on bears, including: 1) reduction of denning near project features; 2) disruption of bear movements; 3) declines in the number of bears feeding near construction activities; and, 4) reduced use of alpine areas. Displacement of bears away from the project was predicted to result in excessive competition for food and den sites. The project related bear displacement was also predicted to result in direct conflicts between bears. We attributed no direct bear mortality to construction and operation of the hydroelectric project, although improved access via the construction road and powerline right-of-way indirectly contributed to the deaths of 2 bears. Bears continued to use traditional feeding areas and travel routes in lowland and midslope areas near project features throughout construction. Dense vegetation apparently provided adequate security in most areas, and it was suspected that some individual bears adopted a more nocturnal feeding pattern near construction activities. Bears used the open areas at the mouth of the Kizhuyak River and alpine areas near construction activities less frequently during the construction phase than during the post-construction phase. Helicopter activity over open areas was suspected to have caused the most disturbance to bears. Residents of Port Lions village attributed nuisance bear problems in 1985 to bears being displaced by the Terror Lake Hydroelectric Project; however, radio-tracking data did not support that perception.

Bear dens were found over a broader elevational range than had been predicted in pre-project impact assessments. Major project features were built at elevations well below the mean elevation of dens located in this study. Most den concentration areas were not affected by the project. The repeated use of approximately the same locations for denning by individual bears in successive years suggests that disturbance from project construction was less than had been predicted. The few natural mortalities that occurred at den sites were apparently not caused by project activities. Although permanent loss of potential den sites may have occurred near the powerhouse, penstock and access road, where permanent human activity resulted from the project, the overall impact on the bear population was probably not of major significance.

Improper disposal and storage of garbage at the Kizhuyak construction camp and at other work sites attracted bears and resulted in several confrontations between bears and workers. One radio-collared female bear tailored her activities to nearly exclusive occupancy of the Kizhuyak camp environs in 1984. The contractor failed to correct these garbage problems after repeated warnings and was cited by State of Alaska authorities. An out-of-court settlement resulted in a fine and agreement to implement specific stipulations on the storage and handling of garbage.

Delineating long-term and permanent impacts of the Terror Lake Hydroelectric Project was only partially within the scope of this investigation. Electric power generated by the project will provide additional incentive for land development and progressive declines in bear habitat quality associated with those developments will have long-term, cumulative effects on the brown bear population. The estimated loss of vegetative production from project construction was 508 HA (1,255 acres). The presence of a small work force at the powerhouse will be a minor disturbance to bears in the area and occasional confrontations between workers and bears will occur, some of which are expected to result in bears being killed in defense of life or property. Continued use of helicopters to service project facilities will disturb of some bears in open areas. Increased recreational use of the project area by deer hunters and improved access via powerline rights-of-way and access roads is expected to result in increased instances of bears killed in defense of life or property. The availability of electricity to private lands along the west shore of Kizhuyak Bay will make those lands more attractive for year-round occupancy and will result in diminished quality of bear habitat, displacement of bears, and direct killing of bears.

The excellent record of neither human injuries nor bears killed by project personnel during this project was owed to several factors. The extensive negotiations which preceded authorization of construction on the Kodiak National Wildlife Refuge gave the brown bear a high public profile, demanding the attention of the contractors and agencies involved. The presence of a U.S. Fish and Wildlife Service environmental monitor, educational programs on bear safety presented by agency personnel, a strict firearms policy imposed by the contractors, and the relatively tolerant nature of brown bears were responsible for the lack of serious conflicts.

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INTRODUCTION

Construction of a hydroelectric facility on northern Kodiak Island, Alaska was first proposed by the Kodiak Electric Association (KEA) in 1965. The facility was to consist of a dam on Terror Lake in the Kodiak National Wildlife Refuge, a 10 km tunnel through a mountain ridge to a penstock and powerhouse in the Kizhuyak River drainage. A 27 km powerline was to connect the powerhouse with the city of Kodiak. Serious consideration of the project began in 1977. In 1979 and 1980, KEA and the Alaska Power Authority (APA) contracted the Arctic Environmental Information and Data Center (AEIDC) to provide information on brown bears (*Ursus arctos middendorfi*) in the proposed project area and estimate the potential impacts of the project on this population (Hickock and Wilson 1979, Spencer and Hensel 1980).

Spencer and Hensel (1980) predicted that construction and operation of the project would effect brown bears in several ways including: 1) eliminate bear denning near the powerhouse and reduce denning in Kizhuyak River, Watchout Creek, and Terror River drainages during construction; 2) disrupt bear movements in the Kizhuyak River and Watchout Creek drainages as well as interdrainage travel between major drainages on northern Kodiak Island; 3) sharp declines in the numbers of bears feeding in all habitat types of the Kizhuyak River, Watchout Creek and Eagle Creek drainages; and, 4) reduce use of alpine feeding areas and travel routes. Displacement of bears into adjacent areas with already high bear densities was predicted to result in excessive competition for food and den sites as well as direct conflicts between bears. Projected long-term effects of the project included permanent loss of den sites near the powerhouse, reduced use of feeding areas in the Kizhuyak River drainage feeding areas, and permanent loss of feeding areas inundated by the Terror Lake reservoir.

Studies to monitor the impacts of construction and operation of the Terror Lake Hydroelectric Project on wildlife were required by the Federal Energy Regulatory Commission as a condition for licensing. The requirement was intended to partially mitigate for habitat loss because of project construction. The Alaska Department of Fish and Game (ADF&G) was contracted by APA to conduct the study on brown bears. It was recognized that definitive answers about the effects of the hydroelectric project would be difficult to provide because pre-construction studies were not sufficiently detailed to serve as a basis for comparison. Actual construction of the project began in March 1982, shortly before ADF&G began the brown bear study, thereby eliminating the opportunity to acquire additional pre-construction data. The study objectives were to:

1. Delineate and characterize the impacts of the Terror Lake Hydroelectric Project on brown bears;
2. Monitor changes in specific habitats such as major denning and feeding areas and travel routes;
3. Monitor changes in the number and sex and age composition of bears inhabiting the impact area; and,
4. Determine changes in movement patterns and activities of bears in response to construction activities.

The study was conducted for 5 years, 3 years during active construction (1982-1984) and 2 years during the post-construction phase (1985-1986). This report summarizes the results of that investigation.

Acknowledgments

The authors are indebted to numerous individuals who contributed their time and talents to this project. Vic Barnes, U.S. Fish and Wildlife Service, was a valued partner throughout all phases of the project. Susan Malutin, ADF&G, typed innumerable drafts and reports, but more importantly, she "covered the office" and provided moral support. Leon Metz, ADF&G, collected field data for 2 years of the project and assisted in analyzing those data. Butch Patterson, provided safe and enthusiastic flying, and he regularly made extraordinary efforts to be available to fly.

Expert helicopter flying skills were provided by C. Lofstedt, V. Lofstedt, B. Lofstedt and M. Houke. Skillful performances by fixed-winged pilots R. Wright, H. Terry and J. Miller resulted in safe and efficient radio-tracking flights. Personnel from the U.S. Coast Guard Air Station in Kodiak are thanked for allowing occasional use of their helicopters and expertise. Several helicopter pilots employed by the contractor also provided assistance.

Capture and tagging operations were done with field assistance from W. Ballard, B. Ballenger, B. Cassell, T. Chatto, G. DeBella, S. Gibbens, H. Heffernan, N. Hunter, S.D. Miller, D. McAllister, S. Peterson, H. Reynolds, R. Sellers and D. Zwiefelhofer. Tooth aging was accomplished by M. Chihuly and E. Goodwin.

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Special thanks are extended to the ADF&G staff who provided support during this project. Karl Schneider's editorial skills and his persistence in securing approval and funding for this project were especially valuable. Dan Timm, S. Eide, J. Faro, G. Bos and J. Trent provided their supervisory skills and assisted in scheduling additional staff support. Carolyn Crouch was invaluable in providing administrative support. Beth Abdelo, S. Lawler and P. Miles are thanked for their assistance with typing.

STUDY AREA

The Terror Lake Hydroelectric Project brown bear study area is located in the northern portion of Kodiak Island, Alaska, and includes portions of the Terror, Kizhuyak, Sharatin, Viekoda, Ugak, and Uganik Bay drainages (Figure 1). The area encompasses 1,461 km^2 and elevations range from sea level to 1,340 m. Much of the coastline is rugged, with bedrock outcrops, boulder-strewn beaches, and headlands exposed to severe wave action. Broad deltas and extensive tidal flats occur at the mouths of Terror and Kizhuyak rivers. The inland topography varies from rolling hills and gentle valleys northwest of Kizhuyak Bay, to steeply ascending ridges and peaks along tributaries into the Kizhuyak and Terror drainages (Figure 2). Vegetation varies from marine aquatics in the bays to dense shrub thickets along hillsides to alpine heath on glaciated ridges. Detailed descriptions of the vegetative characteristics of the study area are contained in Hickock and Wilson (1979) and in the "Results (Habitat use)" section of this report. The area's maritime climate is influenced by the Japanese current and is characterized by frequent fog, rain, and wind. Temperatures are mild throughout the year, maximum temperatures generally range from 13-18^{oc} and winter temperatures below -6^{oc} are infrequent. Annual precipitation usually exceeds 180 cm.

Indigenous mammals occurring within the study area include the brown bear, red fox (*Vulpes vulpes*), river otter (*Lutra canadensis*), short-tailed weasel (*Mustela erminea*), northern vole (*Microtus oeconomus*) and little brown bat (*Myotis lucifugus*). Sitka black-tailed deer (*Odocoileus hemionius sitkensis*) were introduced to Kodiak Island in the 1920s and are abundant in the study area. Mountain goats (*Oreamnos americanus*), introduced in the 1950s, frequent suitable habitat throughout the study area. Beaver (*Castor canadensis*) and snowshoe hares (*Lepus americanus*), species introduced in the 1930s, are also common. Four species of Pacific salmon (*Oncorhynchus* spp.) occur with pink (*O. gorbuscha*) and chum salmon (*O. keta*) being the most common. Coho salmon (*O. kisutch*) are present in smaller numbers and sockeye (*O. nerka*) inhabit Barabara, Uganik and Saltery Lake systems. Hickock and Wilson (1979) reported observations of 59 different bird species in the study area.

The village of Port Lions is the only permanent human settlement in the study area. A 1986 census by the Kodiak Island Borough reported 291 people in the village. There are 3 seasonally occupied residences along Kizhuyak Bay, 2 near Hidden Basin, 1 on Saltery Lake and 1 on Terror Bay. Hunters camp throughout the area, with most use occurring near the bays. The U.S. Fish and Wildlife Service administers a public use cabin on the west shore of Viekoda Bay. All bays are frequented by commercial fishermen throughout the year.

DESCRIPTION OF TERROR LAKE HYDROELECTRIC PROJECT

Project Features

The Terror Lake Hydroelectric Project was designed to provide a 20 MW conventional hydroelectric power source for the city of Kodiak. Terror Lake, a natural lake approximately 40 km southwest of Kodiak city, was impounded with a 747 m long by 59 m high concrete-faced zoned rockfill dam. The dam raised the elevation of the lake from 381 m to 433 m. The basic project catchment area includes the upper Terror River drainage (6138 HA) and the resultant reservoir has an estimated capacity of 138,170,000 m^3. Reservoir overflow is self-regulated by a mostly unlined graywacke spillway that originates on the north side of the dam at the 433 m level. Water is directed through a man-made channel which terminates in the natural bed of Terror River approximately 300 m downstream from the dam.

Water from the reservoir is transported to the Kizhuyak River drainage via an 8.2 km long by 3 m diameter underground tunnel. The tunnel originates at the 381 m level of the Terror Lake reservoir and ends at the 340 m level near Rolling Rock Creek. Supplemental water is added via side tunnels from diversions of Shotgun, Falls, and Rolling Rock Creeks. The Shotgun Creek diversion includes a 12 m high by 6 m wide rockfill dam and an associated 351,581 m^3 reservoir. The Falls Creek diversion includes a 6 m high by 4 m wide dam and an associated 6,785 m^3 reservoir. The diversion at Rolling Rock Creek is 6 m high and 4 m wide, has no pondage, and also serves for surge protection.

Water from the main tunnel enters a 945 m long steel penstock and drops 308 m into a powerhouse (elevation 32 m) near the Kizhuyak River. The penstock is 2.4 m in diameter at its junction with the tunnel and tapers to a diameter of 1.3 m at the powerhouse. For most of its length the penstock is buried in soil with some concrete caps. The powerhouse includes two 10 MW turbines with accommodations for a third in the future. Water from the powerhouse drains through a gravel channel approximately 520 m into the Kizhuyak River.

A 27 km long 138 KV transmission line transfers electricity from the powerhouse to the Kodiak city distribution system. The line spans a low esker between Kizhuyak River and Watchout Creek and traverses the north side of the Watchout Creek drainage through a pass into Elbow Creek (Figure 2). It extends along a plateau north of Elbow Creek until it crosses where the creek makes a 90° bend to the north. The transmission line then continues west into the Buskin Lake drainage, along the south side of the lake, terminating at a switching station near the Kodiak airport. A 21 km long distribution line originates at the powerhouse, and follows the access road along the Kizhuyak River and continues along the western shore of Kizhuyak Bay, approximately 500 m inland, until it connects with the electric distribution system at Port Lions village.

A gravel access road extends approximately 6.5 km from a rock-fill jetty in Kizhuyak Bay along the west side of Kizhuyak River to the powerhouse. The road continues west about 12.9 km from near the powerhouse, traverses Falls Creek pass, and branch roads descend to Terror Lake spillway and the tunnel entrance. A construction road which circled the west side of Terror Lake was inundated when the reservoir was filled.

Construction camps were established at the head of Kizhuyak Bay, at the powerhouse location, and on the west side of Terror Lake. The Kizhuyak Bay camp was ultimately dismantled and revegetated, and the Terror Lake camp site was inundated when the reservoir filled. The powerhouse camp was dismantled after construction activities ceased, but the site remained as a storage pad. Quarry sites were located in several locations near the project with the main sites near the spillway north of Terror Lake and immediately south of the lake along upper Terror River. A rock-crusher and concrete manufacturing facility was established near the dam at Terror Lake in an area that was ultimately inundated.

Housing for a small permanent staff was constructed near the powerhouse. The road from Kizhuyak Bay to the powerhouse is maintained year-round but deep snow makes the road to Terror Lake impassable most of the year. Access to the dams and powerlines is primarily via helicopter. Most daily operating commands to the dam are via radio transmissions from staff in either Kodiak or the powerhouse. These transmissions are relayed via repeating antennas which were placed atop a ridge on Elbow Mountain, on a ridge west of Upper Kizhuyak River, in the pass near Falls Creek and on the dam at Terror Lake.

Project Activities

Construction of the Terror Lake Hydroelectric Project began in March 1982 with the establishment of a temporary camp and a jetty at the head of Kizhuyak Bay to support access road construction. By mid-July that camp had been expanded to accommodate 90 people and the access road had been pushed to Terror Lake. In August the jetty camp was closed and approximately 200 personnel began occupying the newly constructed powerhouse camp. The jetty camp area was thereafter used as a staging area for equipment and for fuel storage. Construction of the power tunnel began in early September and earthmoving at the Terror Lake dam site had begun by that time.

A second camp west of Terror Lake was completed and occupied by October 1982. During November continuous blasting and drilling operations were underway on the Rolling Rock Creek dam access road and the Falls Creek tunnel. By mid-December the placement of fill began at the Terror Lake dam site and work on the power tunnel outlet was well underway. Two-hundred eighty personnel, including 170 at the Terror Lake camp and 110 at the powerhouse camp, were employed at the end of 1982.

Construction activity reached its peak in 1983, with work in progress on all major project features employing up to 480 people. Excavation and construction of the embankment at the Terror Lake dam site began in early February and was completed by July. Concrete facing work on the dam began in early August and the dam was completed by late October. An access road along the northwest side of Terror Lake dam began in May and completed by late August. The Terror Lake construction camp was removed and the reservoir was being filled by November. Construction of the main power tunnel continued through 1983. Diversion works on Falls Creek and Shotgun Creek were completed by November. Construction of the Rolling Rock Creek diversion continued intermittently throughout the year. Construction of the penstock began in February and was finished by October. The powerhouse construction commenced in April and continued though 1983.

Right-of-way clearing for the Kodiak transmission line started in February 1983 and line construction continued through October. Tracked equipment was used for access along the right-of-way in lower Watchout Creek and Kizhuyak River. Helicopters were used extensively during all phases of the transmission line construction. Peak helicopter use occurred from June through October 1983, when up to 7 helicopters were often operating simultaneously in the Elbow Creek to Kizhuyak River corridor between 0700 and 1800 hours. Helicopters were used extensively for slingloading wet concrete from near Kodiak city to transmission towers. They were also used to transport personnel and portable excavation equipment to remote transmission tower sites. Work on the Port Lions distribution line began with right-of-way clearing in May 1983. Construction occurred between late July and August. Tracked vehicles and helicopters were used for access, but the much simpler single pole design required relatively little helicopter support and manpower compared with the more complex Kodiak line.

The intensity of construction activity in 1984 was much reduced from that of the previous 2 years. Installation of equipment at the powerhouse and switchyard was the major activity. The access road to Terror Lake was closed by snow until April. Installation and testing of the valve gate facility at the Terror Lake dam were completed by June and the reservoir continued to be filled. Work was completed on the Falls Creek and Rolling Rock Creek diversion works and the main power tunnel and penstock were finished. Maintenance of the powerhouse access road, including culvert installations and roadbed improvements, continued intermittently throughout the year. Restoration and seeding of most disturbed areas was accomplished by September. Most construction equipment and camp facilities were removed by November when the work force had declined to less than 50 people. The access road to Terror Lake was closed by snow in mid-November. Only 2 helicopters were working in the project,area during most of 1984.

The first year of the operational phase of the Terror Lake Hydroelectric Project began in 1985 with electrical power generated throughout most of the year. A maintenance crew was permanently stationed at the powerhouse to oversee operations. A helicopter was used periodically for maintenance activities throughout the year, including a generator failure in July. Water flow from Terror Lake was reduced until the reservoir was filled in August, but flows from tributary streams appeared sufficient for salmon spawning in the lower river.

Severe weather caused damage to the transmission line near the head of Elbow Creek in mid-December and increased helicopter activity occurred while repairs were made. Overall, however, both road and aerial traffic were much reduced in 1985.

Operation continued through 1986 with no construction activity. The road to Terror Lake was closed by snow drifts into August. Helicopter traffic was restricted to periodic flights to sling propane bottles to the repeater sites and to provide access to the dam and to a gauging station on lower Terror River. A permanent crew of approximately 5 individuals occupied housing near the powerhouse throughout the year.

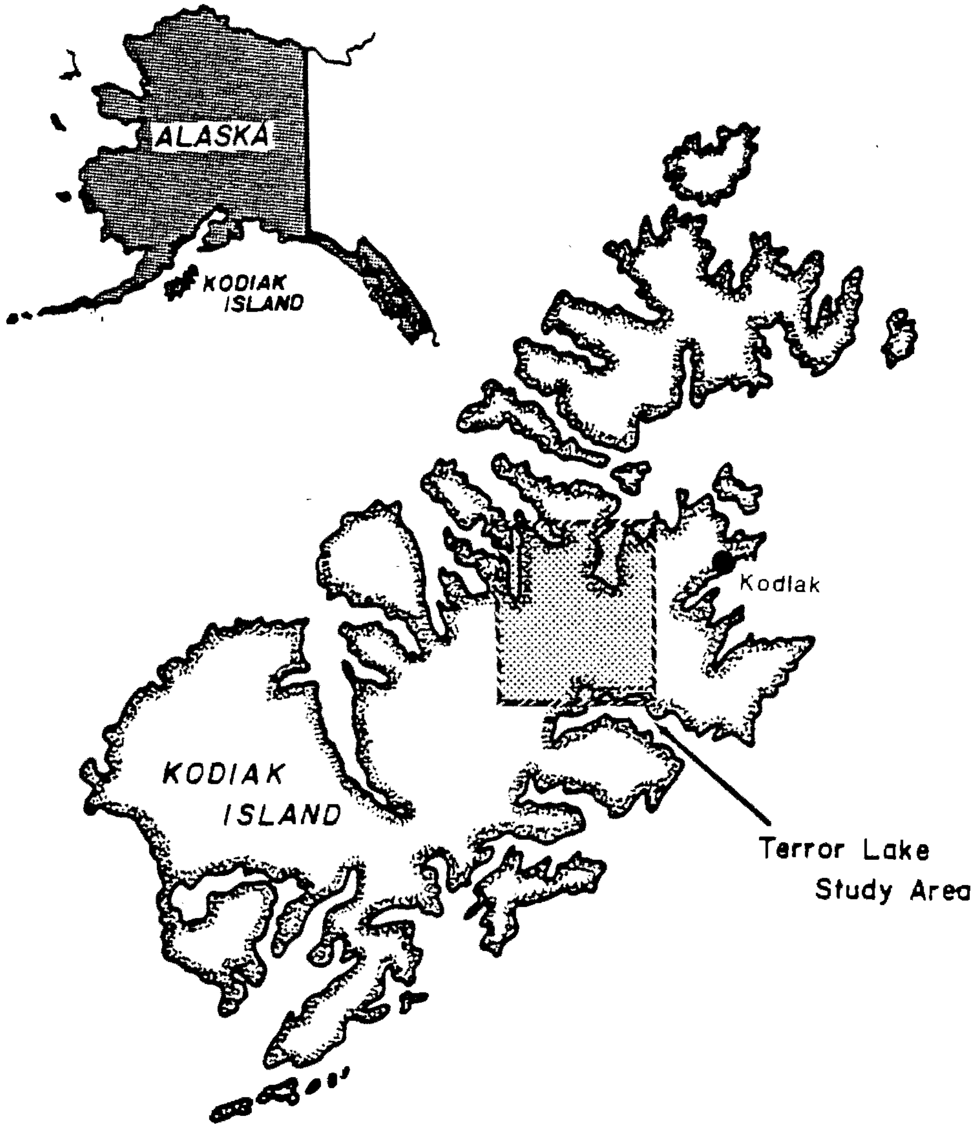


Figure 1. Location of the Terror Lake Hydroelectric Project brown bear study area, Alaska.

METHODS AND RESULTS

Capture and Radio-collaring Methods

Brown bears were located with a PA-18 Super Cub fixed-wing aircraft. They were captured by pursuit with a Bell 206B Jet Ranger helicopter and then shot with immobilizing darts. Most bears were immobilized with etorphine (M-99; Lemmon Co., Sellersville, PA), and its antagonist, diprenorphine (M50-50), was administered after handling was completed. One bear was captured from the ground using Phencyclidine hydrochloride (Sernylan). Cubs < 1 yr old were captured by hand and immobilized with etorphine.

In 1982, the first year of the study, bears were captured in April, May and July. Capturing in the following 4 years was done in June and July. We attempted to capture bears throughout the study area, but the most intensive search effort was made near project features.

All captured bears were permanently marked with tattoos (lip and/or groin) and numbered ear-tags were attached to most bears. A premolar tooth was extracted for age determination, reproductive condition was assessed, blood was drawn, and standard morphological measurements were taken. Bears estimated at 3 years or older were fitted with radio collars equipped with mortality sensors (Telonics Inc., Mesa, AZ). Two 2 year old bears were radio-collared. Ear-radios (Telonics Inc., Mesa, AZ) were attached to 4 bears, including 1 male which also had a radio collar, but the ear-radios failed or were shed so quickly that their use was discontinued.

Capturing and Radio-collaring Results

During 1982-1986, 140 individual brown bears were captured (Tables 1 and 2). Including re-captured bears, 197 captures were made. The captured bears included 87 adults and 53 cubs which accompanied captured females. The 87 adults included 33 males (37.9%) and 54 females (62.1%). Radio collars were placed on 84 bears: 9 on males 2-4 years old; 23 on males >5 years old; 5 on females 2-4 years old; and 47 on females >5 years old. By December 1986, 32 bears retained functional radio collars, including 4 males and 28 females.

Figure 2. Terror Lake Hydroelectric Project brown bear study area, Kodiak Island, Alaska.

Table 1. Brown bears captured in Terror Lake hydroelectric study area, 1982-1986.

Bear number	Sex	Age	Capture date	Ear tags (Right/Left)	Radio-collared	Current status	Date last located	Comments
001	F	3.5	4/22/82	1799/1784	yes	Dead	8/20/83	Radio failed by 8/29/87; hunter kill 10/25/86
002	M	15.5	4/22/82	1833/1844	yes	Unknown	6/06/84	Collar removed 6/06/84; captured mortality 5/22/87
		17.5	6/06/84	1833/---	no			
003	M	5.5	4/22/82	1839/1842	yes	Unknown	6/09/83	Collar shed by 6/02/83
004	M	6.5	4/22/82	1836/1834	yes	Alive; functional	1/12/87	Collar shed by 10/20/83
		9.5	6/21/85	1967/1972	yes	radio		
005	F	13.5	4/23/82	1744/1740	yes	Alive; functional	12/26/86	
		15.5	7/11//84	2059/1740	yes	radio		
		17.5	6/23/86	2059/1740	yes			
006	M	2.5	4/23/82	1825/1823	yes	Dead	5/21/82	Cub of 055; hunter kill 5/30/82
007	M	2.5	4/23/82	1819/1824	yes	Dead	4/30/83	Cub of 005; hunter kill 5/18/83
008	F	11.5	4/23/82	1739/1749	yes	Alive; functional	12/26/86	Radio failed by 10/20/83
		14.5	6/21/85	2004/2048	yes	radio		
009	M	2.5	4/23/82	1820/1829	no	Dead	4/23/82	Cub of 008; hunter kill 4/29/85
010	F	2.5	4/23/82	1726/1735	no	Unknown		Cub of 008
011	F	6.5	4/23/82	1728/1733	yes	Alive; functional	12/26/86	
		8.5	6/05/84	1728/---	yes	radio		
		10.5	6/23/86	---/---	yes			

Table 1. Continued.

Bear number	Sex	Age	Capture date	Ear tags (Right/Left)	Radio-collared	Current status	Date last located	Comments
012	F	1.5	4/23/82	1781/1732	no	Unknown	4/23/82	Cub of 011; suspect dead by 7/06/82
013	M	1.5	4/23/82	1814/1816	no	Unknown	4/23/82	Cub of 012; suspect dead by 7/07/82
014	M	6.5	4/23/82	1818/1847	yes	Unknown	8/30/83	Probable radio failure by 9/08/83
015	F	7.5	4/25/82	1741/1743	yes	Dead	3/04/86	Natural mortality 1-3/86
		9.5	6/06/84	1741/1743	yes			
016	M	11.5	4/25/82	1809/1808	yes	Unknown	10/21/83	Collar shed by 10/20/83
017	F	21.5	4/23/82	1789/1731	yes	Unknown	11/12/83	Probable radio failure 11/12/83-3/19/84
018	F	5.5	4/25/82	1747/1750	yes	Dead	5/13/86	Died unknown cause 5/13-5/21/86
		7.5	6/08/84	1747/1750	yes			
019	F	6.5	4/25/82	1736/1782	yes	Alive; functional	1/12/87	
		8.5	7/12/84	1736/1782	yes	radio		
		10.5	6/23/86	---/---	yes			
020	F	6.5	4/25/82	1746/1738	yes	Alive; functional	12/26/86	
		8.5	7/10/84	1746/2049	yes	radio		
		10.5	7/02/86	---/2049	yes			
021	M	5.5	4/25/82	---/---	no	Dead	---	Capture mortality

Table 1. Continued.

Bear number	Sex	Age	Capture date	Ear tags (Right/Left)	Radio-collared	Current status	Date last located	Comments
022	F	7.5	4/25/82	1730/1729	yes	Alive; functional radio	12/05/86	
		9.5	6/08/84	1730/1729				
		11.5	6/24/86	---/---	yes			
023	M	3.5	4/26/82	1805/1802	yes	Dead	---	Radio failed by 9/25/84; capture mortality 6/23/85
		4.5	6/02/83	1950/1802	yes			
		6.5	6/23/85	---/---	no			
024	M	7.5	4/26/82	1803/1810	yes	Unknown	4/30/84	Shed collar by 5/20/84
025	M	13.5	4/26/82	1840/1827	yes	Unknown	7/12/82	Shed collar by 7/05/82
026	M	5.5	4/26/82	1816/1813	yes	Dead	---	DLP[a] kill at cannery 8/15/82
027	M	13.5	4/27/82	1812-1822	yes	Dead	9/26/83	Collar shed by 5/21/82; hunter kill 10/12/83
		14.5	6/02/83	1812-1822	yes			
028	M	3.5	4/27/82	1837/1817	yes	Dead	4/30/83	Hunter kill 5/03/83
029	F	17.5	4/29/82	---/---	yes	Dead	9/30/82	Suspect hunter kill by 10/07/82
030	M	2.5	4/29/82	1804/1807 1801	yes	Unknown	5/10/82	Cubs of 029; ear-radio failed by 5/10/82
031	M	2.5	4/29/82	1843/1821	no	Unknown	4/29/82	Cub of 029
032	M	2.5	4/29/82	1850-1806	no	Unknown	4/29/82	Cub of 029

Table 1. Continued.

Bear number	Sex	Age	Capture date	Ear tags (Right/Left)	Radio-collared	Current status	Date last located	Comments
033	M	3.5	5/01/82	1852/1853	yes	Unknown	4/30/83	Suspected radio failure by 5/20/83
034	F	13.5	5/02/82	1757/1755	yes	Unknown	9/08/82	Radio failure by 9/15/82
035	F	2.5	5/02/82	---/1763	yes	Unknown	5/02/82	Cub of 034; ear-radio failed
036	F	2.5	5/02/82	1765/1768	no	Unknown	5/02/82	Cub of 034
037	F	4.5	5/02/82	1748/1788	yes	Dead	11/06/84	Natural mortality by 5/85; died near den
		6.5	6/05/84	1748/1788	yes			
038	F	3.5	5/02/82	1777/1797	yes	Dead	6/23/86	Capture mortality 6/23/86
		5.5	7/09/84	1777/1797	yes			
		7.5	6/23/86	---/---	no			
039	M	2.5	5/02/82	---/1858	yes	Unknown	5/21/82	Ear-radio failed by 6/01/82
040	M	2.5	5/02/82	1854/1862	no	Dead	5/08/85	Radio failed by 9/25/84; hunter kill 5/10/86
		3.5	6/02/83	1854/1862	yes			
		5.5	6/21/85	1854/1955	yes			
041	M	2.5	5/02/82	1864/1841	no	Unknown	5/02/82	
043	F	4.5	7/22/82	---/---	no	Dead	---	Capture mortality
044	F	3.5	7/22/82	1796/1795	yes	Alive; functional radio	12/05/86	
		5.5	7/09/84	1796/1795	yes			
		7.5	6/24/86	---/---	yes			

Table 1. Continued.

Bear number	Sex	Age	Capture date	Ear tags (Right/Left)	Radio-collared	Current status	Date last located	Comments
045	M	5.5	7/22/82	1875/1863	yes	Unknown	8/03/83	Collar shed by 8/11/83
046	F	6.5	7/23/82	1769/1762	yes	Alive; functional	12/05/86	
		8.5	7/09/84	1769/1762	yes	radio		
		10.5	6/23/86	---/---	yes			
047	F	1.5	7/23/82	1764/1773	no	Unknown	7/23/82	Cub of 046
048	F	23.5	7/24/82	1794/1792	yes	Dead	11/21/84	Natural mortality near den by 5/85
		25.5	6/05/84	1794/2034	yes			Natural mortality by 5/85; died near den
049	M	1.5	7/24/82	1874/1830	no	Unknown	7/24/82	Cub of 048
050	F	1.5	7/24/82	1780/1771	no	Unknown	7/24/82	Cub of 048
051	F	8.5	7/24/82	1742/1791	yes	Alive; functional	1/12/87	
		10.5	7/12/84	1742/1791	yes	radio		
		12.5	6/24/86	---/---	yes			
052	F	1.5	7/24/82	1759/1761	no	Unknown	7/24/82	Cub of 051; suspect dead by 9/8/87
053	F	8.5	7/24/82	---/---	no	Dead	---	Capture mortality
054	M	1.5	7/24/82	1871/1860	no	Unknown	7/24/82	Cub of 053; orphaned at capture
055	F	13.5	7/24/82	1787/1766	yes	Alive; functional	12/05/86	
		15.5	6/08/84	---/---	yes	radio		
		17.5	6/24/86	---/---	yes			

Table 1. Continued.

Bear number	Sex	Age	Capture date	Ear tags (Right/Left)	Radio-collared	Current status	Date last located	Comments
056	F	0.5	7/24/82	1772/1753	no	Unknown	7/24/82	Cub of 055
057	M	0.5	7/24/82	1872/1867	no	Unknown	7/24/82	Cub of 055
058	M	0.5	7/24/82	1861/1856	no	Unknown	7/24/82	Cub of 055
059	M	3.5	7/25/82	1882/1887	yes	Dead	4/24/84	Hunter kill 5/13/85
		5.5	7/11/84	1882/1920	yes			
060	F	14.5	7/25/82	1718/1767	yes	Alive; functional	12/26/86	Radio failed by 3/19/84
		17.5	7/05/85	2094/2050	yes	radio		
061	F	0.5	7/25/82	1725/1723	no	Unknown	7/25/82	Cub of 060
062	F	0.5	7/25/82	1714/1716	no	Unknown	7/25/82	Cub of 060
063	F	0.5	7/25/82	1722/1715	no	Unknown	7/25/82	Cub of 060
064	F	20.5	7/25/82	1724/1719	yes	Alive; functional	12/26/86	
		22.5	6/04/84	1724/1719	yes	radio		
		24.5	6/23/86	---/---	yes			
065	F	1.5	7/25/82	1798/1751	no	Unknown	7/25/82	Cub of 064
066	F	1.5	7/25/82	1754/1758	no	Unknown	7/25/82	Cub of 064
067	F	20.5	7/25/82	1785/1783	yes	Unknown	10/14/85	Shed collar by 12/85
		22.5	7/09/84	2017/2219	yes			

Table 1. Continued.

Bear number	Sex	Age	Capture date	Ear tags (Right/Left)	Radio-collared	Current status	Date last located	Comments
068	F	1.5	7/25/82	1737/1775	no	Unknown	7/25/83	Cub of 067
069	F	1.5	7/25/82	1760/1720	no	Unknown	7/25/82	Cub of 067
070	F	4.5	7/26/82	1711/1706	yes	Alive; functional	11/20/86	
		6.5	7/10/84	2224/1706	yes	radio		
		8.5	6/23/86	2224/---	yes			
071	F	8.5	7/26/82	1707/1702	yes	Alive; functional	01/12/87	
		10.5	7/10/84	1707/2045	yes	radio		
		12.5	6/24/86	---/2045	yes			
072	F	18.5	7/26/82	1786/1756	yes	Dead	10/04/85	Killed by another bear 10/04-10/14/85
		20.5	6/08/84					
073	M	0.5	7/26/82	1870/1892	no	Unknown	7/26/82	Cub of 072; suspect dead by 10/29/82
074	F	17.5	7/26/82	1727/1752	yes	Dead	10/26/84	DLP kill by deer hunter 10/28/84
		19.5	7/09/84	1727/1752	yes			
075	F	1.5	7/26/82	1717/1703	no	Unknown	7/26/82	Cub of 074
076	M	1.5	7/26/82	1873/1845	no	Unknown	7/26/82	Cub of 074
077	F	20.5	7/26/82	1779/1705	yes	Dead	8/20/83	Radio failed by 8/31/83; DLP kill by deer hunter 10/28/84

Table 1. Continued.

Bear number	Sex	Age	Capture date	Ear tags (Right/Left)	Radio-collared	Current status	Date last located	Comments
078	F	8.5	6/02/83	2025/2001	yes	Dead	10/24/86	Hunter kill 10/29/86
		10.5	6/21/85	2025/2026	yes			
		11.5	6/23/86	---/2026	yes			
079	M	14.5	6/02/83	1928/1933	yes	Unknown	6/09/84	Collar removed 6/09/84
		15.5	6/09/84	1928/---	no			
080	F	25.5	6/02/83	2065/2066	yes	Unknown	7/11/83	Shed collar by 7/21/83
081	F	10.5	6/03/83	2067/2064	yes	Dead	10/30/86	Hunter kill 11/09/86
		12.5	6/21/85	2067/2237	yes			
082	F	2.5	6/03/83	2012/2015	no	Unknown	6/03/83	Cub of 081
083	M	2.5	6/03/83	1930/1929	no	Dead	6/03/83	Cub of 081; hunter kill 5/07/84
084	M	12.5	6/03/83	1927/1926	yes	Unknown	9/26/83	Collar shed by 10/2/83
085	F	4.5	6/03/83	2055/2054	yes	Alive; functional radio	7/21/86	Collar shed by 7/21/86
		6.5	6/20/85	2228/2054	yes			
086	F	8.5	6/03/83	1776/1712	yes	Alive; functional radio	1/12/87	
		10.5	6/23/85	1776/2249	yes			
087	F	1.5	6/03/83	2073/2058	no	Unknown	6/03/83	Cub of 086
088	F	9.5	6/04/83	2071/2072	yes	Alive; functional radio	1/12/87	Radio failed by 9/04/84
		12.5	7/03/86	---/---	yes			

Table 1. Continued.

Bear number	Sex	Age	Capture date	Ear tags (Right/Left)	Radio-collared	Current status	Date last located	Comments
089	F	2.5	6/04/83	2016/2007	no	Unknown	6/04/83	Cub of 088
090	F	2.5	6/04/83	2024/2005	no	Unknown	6/04/83	Cub of 088
091	F	8.5	6/04/83	2056/2075	yes	Dead	4/24/85	Natural mortality by 5/85
092	F	5.5	6/05/83	2052/2074	yes	Alive; functional	11/20/86	Radio failed by 10/09/84
		8.5	7/01/86	---/---	yes	radio		
093	F	1.5	6/05/83	2006/2020	no	Unknown	6/05/83	Cub of 092; abandoned after capture
094	F	1.5	6/05/83	2003/2023	no	Unknown	6/05/83	Cub of 092; abandoned after capture
095	M	4.5	6/05/83	1907/1921	yes	Dead	5/09/83	Natural mortality by 5/20/84; killed by bear
096	F	7.5	6/05/83	2062/2069	yes	Dead	12/05/83	Natural mortality near den by 5/86
		9.5	6/23/85	2062/2021	yes			
098	M	7.5	6/04/84	1865/1910	yes	Dead	4/24/85	Hunter kill 4/27/85
099	F	10.5	6/05/84	2030/2035	yes	Alive; functional	12/26/86	
		12.4	6/23/86	---/2035	yes	radio		
100	M	5.5	6/05/84	2949/1877	yes	Unknown	10/30/86	Suspect radio failed by 11/05/86
101	M	9.5	6/05/84	1831/1883	yes	Dead	6/21/85	Capture mortality 6/21/85
		10.5	6/21/85	---/---	---			

Table 1. Continued.

Bear number	Sex	Age	Capture date	Ear tags (Right/Left)	Radio-collared	Current status	Date last located	Comments
102	M	5.5	6/05/84	1890/1915	yes	Alive; functional radio	1/12/87	
		7.5	7/02/86	1890/1915	yes			
103	M	6.5	6/06/84	1880/1938	yes	Unknown	10/20/84	Radio failed by 1/01/86
104	M	4.5	6/08/84	1889/1924	yes	Unknown	1/12/85	Radio failed by 3/85
105	M	5.5	6/08/84	1935/1939	yes	Dead	6/22/84	Hunter kill by 11/04/84
106	F	0.5	7/09/84	2044/2032	no	Unknown	7/09/84	Cub of 046; suspect dead by 11/21/84
107	M	0.5	7/09/84	1916/1898	no	Unknown	7/09/84	Cub of 046; suspect dead by 11/2/84
108	M	0.5	7/09/84	1914/1932	no	Unknown	7/09/84	Cub of 074; orphaned by 10/28/84
109	M	0.5	7/09/84	1918/1832	no	Unknown	7/09/84	Cub of 074; orphaned by 10/28/84
110	F	0.5	7/09/84	2031/2042	no	Unknown	7/09/84	Cub of 074; orphaned by 10/28/84
111	F	0.5	7/10/84	2018/2215	no	Unknown	7/10/84	Cub of 071
112	F	0.5	7/10/84	2219/2213	no	Unknown	7/10/84	Cub of 071
113	F	0.5	7/10/84	2019/2022	no	Unknown	7/10/84	Cub of 071
114	F	6.5	7/10/84	1925/1922	yes	Unknown	8/13/84	Shed collar by 8/28/84
115	M	0.5	7/12/84	1917/1911	no	Unknown	7/12/84	Cub of 019

Table 1. Continued.

Bear number	Sex	Age	Capture date	Ear tags (Right/Left)	Radio-collared	Current status	Date last located	Comments
116	M	0.5	7/12/84	1866/1923	no	Unknown	7/12/84	Cub of 019
117	F	0.5	7/12/84	2039/2029	no	Unknown	7/12/84	Cub of 051
118	F	0.5	7/12/84	2043/2041	no	Unknown	7/12/84	Cub of 051
119	F	6.5	7/13/84	2205/2208	yes	Alive; functional radio	12/5/86	
120	M	12.5	7/13/84	1946/1945	yes	Alive; functional radio	1/12/87	
121	F	13.5 15.5	7/13/84 7/01/86	2203/2202 ---/---	yes no	Dead	7/01/86	Capture mortality 7/01/86
122	F	1.5	7/13/84	2014/2002	no	Unknown	7/13/84	Cub of 121
123	F	13.5	7/13/84 6/23/86	2009/2037 2009/2037	yes	Dead	8/06/86	Illegal kill by 8/17/86
124	F	2.5	7/13/84	2027/2201	no	Unknown	7/13/84	Cub of 123
125	F	2.5	7/13/84	2223/2036	no	Unknown	7/13/84	Cub of 123
126	F	2.5	7/23/84	2033/2046	no	Dead	7/13/84	Cub of 123; DLP kill by deer hunter 11/10/86
127	F	8.5	7/13/84	2217/2038	yes	Dead	10/26/84	Hunter kill 11/03/84

Table 1. Continued.

Bear number	Sex	Age	Capture date	Ear tags (Right/Left)	Radio-collared	Current status	Date last located	Comments
128	F	8.5	7/04/85	2216/2078	yes	Alive; functional radio	1/12/87	
129	F	11.5	7/04/85	2233/2234	yes	Alive; functional radio	1/12/87	
130	M	3.5	7/04/85	1952/1953	yes	Unknown	5/28/86	Suspect radio failed or emigrated by 6/15/86
131	F	12.5	7/04/85	2204/2245	yes	Alive; functional radio	1/12/87	
132	F	16.5	7/05/85	2229/2227	yes	Alive; functional radio	12/5/86	
133	F	11.5	7/05/85	2019/2240	yes	Alive; functional radio	12/5/86	
134	F	1.5	7/05/85	2222/2226	no	Unknown	12/05/86	Cub of 133
135	F	16.5	12/05/85	2060/2085	yes	Alive; functional radio	1/12/87	Captured at Port Lions dump
136	F	16.5	6/24/86	---/---	yes	Alive; functional radio	12/5/86	
137	M	8.5	6/25/86	---/---	yes	Alive; functional radio	1/12/87	

Table 1. Continued.

Bear number	Sex	Age	Capture date	Ear tags (Right/Left)	Radio-collared	Current status	Date last located	Comments
138	F	11.5	6/25/86	---/10974	yes	Alive; functional radio	12/5/86	
139	M	6.5	6/25/86	---/---	yes	Alive; functional radio	1/12/87	
140	F	10.5	7/03/86	---/---	yes	Alive; functional radio	1/12/87	
141	F	9.5	7/03/86	---/---	yes	Alive; functional radio	12/5/86	
142	M	12.5	7/03/86	---/---	yes	Unknown	7/03/86	Shed collar by 7/12/86

a - Defense of life or property.

Table 2. Summary of brown bear captures in Terror Lake hydroelectric study area by year, 1982-1986.

Year	No. bears captured			Captured bear identification no.		No. bears radio-collared			No. capture mortalities (bear id. no.)
	New	Recaptures	Total captures	New	Recaptured	Initial	Replacement	Total	
1982	76	0	76	001-041 043-077	---	43	---	43	3 (021, 043, 053)
1983	19	3	22	078-096	023, 027, 040	13	2	15	0
1984	30	23	53	098-127	022[a], 005, 011, 015 018, 019, 020, 022 037, 038, 044, 046 048, 051, 055, 059 064, 067, 070, 071 072, 074, 079[a]	14	21	35	0
1985	8	11	19	128-135	004, 008, 023, 040 060, 078, 081, 085 086, 096, 101	7	9	16	2 (023, 101)
1986	7	20	27	136-142	005, 011, 019, 020 022, 038, 044, 046 051, 055, 064, 070 071, 078, 088, 092 099, 102, 121, 123	7	18	25	2 (038, 121)
TOTALS	140	57	197			84	50	134	7

a - radio-collar removed

Population Density

Methods

Brown bear densities were estimated in 2 separate areas on Kodiak Island in 1987 (Barnes et al. 1988) using techniques developed by Miller et al. (1986). The 2 bear density estimates were done in a 350 km^2 area within the Terror Lake study area and in a 630 km^2 area on southwestern Kodiak Island. Barnes et al. (1988) extrapolated to estimate the brown bear population for the entire Kodiak archipelago by subdividing the area into 31 smaller units (Figure 3) and estimating bear densities in each of these units based on their similarity to the 2 areas for which density estimates were done in 1987. We estimated brown bear numbers in the Terror Lake Hydroelectric Project study area by using a planimeter and 1:63,360 USGS topographic maps to calculate the area of the bear density subunits developed by Barnes et al. (1988) located within the study area boundaries and multiplying these areas by appropriate density estimates.

Results

The Terror Lake Hydroelectric Project study area included portions of 8 separate units with densities of independent bears ranging from 0.039 bears/km^2 to 0.227 bears/km^2 (Figure 3; Table 3). A density of 0.220-0.227 bears/km^2 occurred in 60% (800 km^2) of the Terror Lake study area. The estimated population was 247 independent bears (excluding dependent cubs). The calculated mean density overall in the study area was 0.189 independent bears/km^2.

An estimate of the total population in the study area, including dependent cubs, was made by using a multiplier based on the ratio of radio-collared bears to dependent cubs of radio-collared bears present in the 1987 census area. The resulting population estimate was 367 bears (1.487 X 247 bears) for a mean density of 0.275 bears/km^2.

This method of estimating the total population is subject to considerable bias, but it has a better basis than previous estimates by Smith and Van Daele (1984) and Spencer and Hensel (1980). Using data from captured bears, sightings of unique unmarked family groups, and sightings of unmarked single bears, Smith and Van Daele (1984) estimated the total population in the study area at 324 bears in 1982. Spencer and Hensel (1980) estimated the population of the Kizhuyak and Terror drainages at 200 bears by using the ratio of single bears to bears in unique family groups observed in the 2 drainages during field work in 1980. They did not estimate the population in the Ugak Bay drainages included in the study area. For the approximate area of the Kizhuyak and Terror drainages described by Spencer and Hensel (1980), we estimated 190 bears (including dependent cubs) based on the extrapolation from the 1987 census. A mean density of 0.323 bears/km^2 was calculated for the 582 km^2 area.

The population estimation made by Spencer and Hensel (1980) before project construction is not strictly comparable to the estimate based on the 1987 census. However, the similarity of the 2 estimates (190 vs. 200) suggests that there was no net loss of brown bears attributable to the impacts of construction.

Figure 3. Location of the Terror Lake Hydroelectric Project brown bear study area in relation to the geographic subunits used to extrapolate brown bear densities on the Kodiak archipelago, Alaska (Barnes et al. 1988).

Table 3. Estimated population of brown bears in the Terror Lake hydroelectric project study area based on the 1987 density estimation procedure (Barnes et al. 1988).

Geographic unit	Density estimate (bears/km²)	Area (km²)	Estimated no. independent bears	Estimated no. all bears (including dependent young)
15 Zachar-Uganik Bay	.227	223	51	76
16 Terror River-Kizhuyak Bay	.220[a]	582	129	192
12 Sheratin Bay	.176	112	17	25
11 Kupreanof Peninsula	.176	42	6	9
17 NW Ugak Bay	.129	287	37	54
10 Uganik Island	.121	8	1	2
18 NE Ugak Bay	.086	70	6	9
19 Chiniak Bay	.039	10	<1	<1
		1,334	247	367

Mean density independent bears = 0.189 bears/km²

Mean density all bears = 0.275 bears/km²

a - Density in area actually surveyed in 1987.

Reproduction

Methods

Reproduction data were collected by examining captured bears and by observing radio-collared bears and their offspring. Reproductive status of captured females was determined by examining the condition of their mammae and vulva. Ages of captured cubs were determined from size, tooth eruption, and by sectioning pre-molars of yearling and older cubs. Ages of cubs not captured were estimated by their size and behavior. The reproductive status of radio-collared females was determined by their association with other adults and the number and ages of offspring accompanying them. Data on age of first reproduction were based on cementum line counts, usually from a single premolar tooth.

Results

Reproductive Age

Reproductive data were collected for 54 captured females >3 yrs old (Table 4). At least 2 years of data were collected for 42 (78%) radio-collared females and 5 years of data were available for 15 (28%) females.

The earliest age at which a radio-collared bear produced cubs was 4 years (Table 5). Female 092 was captured with 2 yearlings when she was 5.5 yrs old, indicating that she successfully bred at 3.5 yrs old. Three females produced young at a 5.5 yrs old (011, 046, 114). Among 4 females which were 3.5 or 4.5 years old at capture, and showed no evidence of previous reproduction, only 1 produced cubs by age 6.5 (070). One of the 4 females (037) died near her den at age 6.5. Another (038) had not produced cubs when she died during a capture attempt at 7.5 years old. The 4th female (044) had not produced cubs by the end of this study at age 7.5 yrs. Three single females <7 yrs old were lactating when captured, indicating they had recently lost or weaned cubs.

The maximum age at which radio-collared females produced cubs was 23 years (Table 4). One 23 year old female (067) produced a litter of 3 cubs and a 22 year old female (048) produced a litter of at least 2 cubs. Among 7 females aged 20 years or older, 4 (57%) were accompanied by cubs during at least 1 year of the study. The oldest captured female (080) was 26 years old and she was in estrus.

Reproductive Interval

A reproductive interval was defined as the period between successive weanings of cubs by a female. Because few complete intervals were actually observed during the 5 year duration of this study, reproductive intervals were back-dated based on ages of cubs when first observed and projected by assuming weaning would occur at 2 years old. Forty-one complete reproductive intervals were projected for 34 females (Table 6). The projected reproductive interval for 34 litters was 4.39 years (range = 3-9 years). Only 8 of 15 litters (53%) for which weaning ages were determined were weaned at 2 years old, so this reproductive interval should be considered a conservative minimum. If it were assumed that the ratio of observed weanings at 2 and 3 years old will occur in the litters projected to occur at 2 years, an adjusted mean minimum reproductive interval of 4.60 years resulted.

Among the 41 intervals projected, interruptions due to loss of offspring occurred in 9 (22%) cases. One female (092) abandoned her yearling litter immediately after the family group was captured. Predation by males was suspected to have been the most common source of cub loss, although only 1 incident of predation on cubs was documented.

Annual Productivity

Annual productivity by eligible adult females >5 years old varied from 11.1% to 63.6% during the study (Table 7). Because this study and previous work by Hensel et al. (1969) indicate that relatively few females produce cubs until they are at least 5 years old, only females >5 years old were included in this analysis. Only 11.1% productivity was recorded in 1983 and 1986. The overall cub production rate was 46.2%.

Fluctuations in annual productivity by adult females did not appear to be correlated with project construction activity. High and low years in productivity occurred during both the construction (1983, 1984) and post-construction (1985, 1986) periods. The 2 years which had the lowest productivity followed years with poor berry production (1982, 1985). Extremely late green-up of vegetation occurred in 1985 further suggesting that nutritional deficiencies may have factored into low productivity.

Litter Size

The mean litter size observed for 29 newborn cub litters produced by radio-collared females was 2.48 cubs (Table 8). Only 1 (4%) single cub litter was recorded although unmarked females with single cubs were commonly seen. No radio-collared females were seen with litters larger than 3 cubs. Litters of 2 (45%) and 3 (52%) were most common.

Mean litter size for older cubs was: yearling--2.00 (n=36); 2 years--2.04 (n=25); 3 years--2.00 (n=6). Litters of 2 cubs were most frequently recorded: yearling--56%; 2 year--56%; 3 year--67%. No litters larger than 3 were recorded for older cubs.

Sex Ratio of Captured Cubs

The sex ratio of captured cubs favored females by nearly a 2:1 ratio. The 53 cubs of radio-collared females included 34 (64.1%) females and 19 (35.8%) males (Table 9). Females were more frequently captured in all age classes: cubs-of-the-year--8 males, 11 females; yearling--4 males, 14 females; 2 year--7 males, 9 females. Captures were probably biased toward females because larger, more elusive litter members were often not captured. Hensel et al. (1969) found that the sex ratio of 81 cubs-of-the-year and yearling cubs captured on Kodiak Island was nearly equal (41F:40M).

Survivorship of Cubs

Survivorship to yearling status was determined for 23 litters first observed as cubs-of-the-year (Tables 10 and 11). Thirty-five of 56 cubs (62.5%) survived, with a mean litter size of 2.43. Seven (30.4%) entire litters were lost, 6 (26.1%) females lost a single member of a 2 or 3 cub litter, and 10 (43.5%) entire litters survived. Four females died while accompanied by cub-of-the-year litters and those litters were not included in this analysis. Although independent cubs in their first year are known to survive (Johnson and LeRoux 1973), it is suspected that such survival is rare on Kodiak.

One case of adoption of a cub-of-the-year was recorded. A female (071) was seen on 10 separate occasions over a 5 1/2 week period with 2 cubs. She was last seen with 2 cubs at 1442 hr on 10 July 1984. Less than 1 hr later at 1538 hr when she was captured, she was accompanied by 3 cubs. The 3 cubs were females with weights ranging from 8.6-10.9 kg. This female retained all 3 cubs until they reached at least 2.8 years, when 1 cub disappeared from the litter. The circumstances leading up to this adoption were not observed but the adopted cub may have strayed from a nearby family group which was disturbed by the presence of the helicopter in the area.

Survivorship from yearling to 2 year old status was determined for 10 litters first observed as cubs-of-the-year (Tables 10 and 11). At least 1 member survived to age 2 in 6 of the 10 litters (60%). Four females lost entire yearling litters and 1 female lost 1 of 2 yearlings in her litter. Thirteen of 20 yearlings (65.0%) survived to age 2.

Combining the results for litters first observed as cubs-of-the-year with those for litters first observed as yearlings resulted in survivorship of 67.4% (31 of 46) from yearling to 2 year old status. In 66.7% of the litters (16 of 24) at least 1 member survived. Entire litters were lost in 33.3% of the cases and in 8.3% of the cases a single member of a 2-cub litter was lost. Complete litters survived in 13 cases (54.1%).

Overall survivorship to age 2 years was determined for 17 litters which were first observed as cubs-of-the-year (Table 11). Only 4 (23.5%) entire litters survived. Eleven (64.7%) entire litters were lost before reaching 2 years of age. At least 1 member of 6 (35.3%) litters survived. Thirteen of 39 (33.3%) cubs survived to age 2 years.

Survivorship from 2 years to 3 years old was determined for 7 litters, including 2 litters which were first seen as cubs-of-the-year. All 19 of the litter members survived.

Cannibalism by adult males was suspected to be the most frequent source of mortality in cubs. A litter of 2 cubs-of-the-year was killed and eaten by a bear near the natal den in 1983 (Smith et al. 1985). A large adult was observed in close proximity to the site, apparently following the cubs' mother (096). An 8 year old single female (020) captured in July 1984, who had been predicted to have cubs, was lactating and had several wounds on her forelegs indicating she had been fighting with another bear. Two incidents in which yearling or older cubs were attacked by adult bears were observed by hunting guides in May 1985.

Characteristics of Family Break-up

Weaning ages for 15 litters of known-age cubs (cementum age or first seen as cubs-of-the-year) were determined (Table 13). Eight (53.3%) litters were weaned at 2.3 years and 7 (46.7%) litters were weaned at age 3.3 years. Mean litter size at weaning was 1.93 (n=15). Mean litter size for 2 year old offspring was 1.88 (n=8) and mean litter size for 3 year old offspring was 2.00 (n=7). Family break-up occurred from mid-May to early July.

Females that weaned offspring at 3 years old were significantly older ($p< 0.1$) than females which weaned cubs at 2 years old. The mean age of females weaning offspring at 2 years old was 14.3 years (range = 11-17 years) and the mean age of females weaning 3 year old offspring was 18.1 years (range = 10-25 years).

Breeding Activity

Breeding activity was observed as early as mid-May and as late as the first week of August. Peak breeding activity appeared to be in mid-June. Associations of 3-4 breeding age adults were occasionally seen during the breeding season (Smith and Van Daele 1986a). Although the sexes of all individuals could not be determined in most cases, relative sizes and behavior indicated that single males were associated with multiple females in these groups. Seventeen percent (8 of 46) of the apparent breeding associations involving radio-collared bears from 15 May-31 July 1984 were judged to be of 1 male and multiple females.

Capturing and handling bears during the breeding season had little apparent effect on subsequent breeding activities (Smith et al. 1985). One male was still accompanied 3 days after capture by the same female he had been associated with when captured. Another male was associated with a radio-collared female when he was captured, and was seen copulating with an unmarked female 3 days later.

Table 4. Reproductive history of radio-collared female brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

Bear No.	Age in 1986 or last observation	Reproductive Status 1982	1983	1984	1985	1986	Comments
001	3	Single	Single	Unk	Unk	Unk	Radio failed by 8/20/83; hunter kill 10/25/86
005	17	2-2 yr	2 coy[a]	2-1 yr	2-2 yr	2-3 yr	Weaned 2-2 yrs by 5/30/82; weaned 2-2 yr olds by 7/21/86
008	15	2-2 yr	Single	1+ coy	1-1 yr	1-2 yr	Weaned 2-2 yrs by 6/15/82; radio failed by 10/20/83; weaned 1-2 yrs by 6/24//86
011	10	2-1 yr	Single	2 coy	1-1 yr	Single	Lost 1 cub by 5/30/82, 1 cub by 7/31/82; lost 1 cub by 5/29/85, 1 cub by 11/17/85.
015	10	1-2 yr?	Single	2 coy	Dead	---	Lactating 4/25/82; w/1 probable 2 yr 5/4/82; cub lost or weaned by 5/12/82; lactating 6/06/84; lost 1 cub by 7/20/85, 1 cub by 10/14/85; natural mortality 1-3/86.
017	22	Single	Single	Unk	Unk	Unk	Radio failed by 3/19/84.
018	9	Single	Single	Single	2 coy	Dead	Lactating 6/08/84; lost both cubs by 11/01/85; died unknown cause by 5/11/86.
019	10	Single	Single	2 coy	2-1 yr	Single	Lactating 4/25/82; lost 1 cub by 10/4/85, 2nd cub by 12/23/85.
020	10	Single	Single	2 coy	3 coy	2-1 yr	Lactating 4/25/82; lost both cubs 6/15-7/04/84; lost 1 cub 5/29-6/27/85; lost 1 cub 5/25-7/02/86.

Table 4. Continued.

Bear No.	Age in 1986 or last observation	Reproductive Status 1982	1983	1984	1985	1986	Comments
022	12	Single	Single	Single	3 coy	2-1 yr	Lactating 4/25/82; lost 1 cub 9/12/85-5/25/86.
029	17	3-2 yr	Dead	---	---	---	Weaned 3 cubs by 5/20/82; died unknown cause by 10/?/82.
034	13	2-2 yr	Unk	Unk	Unk	Unk	Weaned 2-2 yr cubs by 6/15/82; radio failed by 9/08/82.
037	7	Single	Single	Single	Dead	---	Natural mortality by 5/85.
038	7	Single	Single	Single	Single	Single	Capture mortality 6/23/86.
043	4	Single	---	---	---	---	Capture mortality 7/22/82.
044	7	Single	Single	Single	Single	Single	
046	10	2-1 yr	Single	3-coy	Single	Single	Lost 1 cub by 10/7/82; lost 2nd cub 10/07/82-5/08/83; lost 1 cub by 10/02/84, 2 more cubs lost by 11/21/84.
048	26	2-1 yr	2-2 yr	2-3 yr	Dead	---	Weaned 2-3 yr cubs by 6/5/84; natural mortality by 5/24/85.
051	12	1-1 yr	Single	2 coy	1-1 yr	Single	Lost cub by 9/8/82; lost 1 cub between 10/26/84 and 5/29/85, 2nd cub by 6/15/85.
053	8	1-1 yr	---	---	---	---	Capture mortality 7/24/82

Table 4. Continued.

Bear No.	Age in 1986 or last observation	Reproductive Status 1982	1983	1984	1985	1986	Comments
055	17	3 coy	2-1 yr	1-2 yr	3 coy	Single	Lost 1 cub by 5/19/82, 2nd cub by 5/30/83; weaned 1-2 yr cub by 5/29/84; lost 1 cub by 10/14/85, 2 more cubs lost by 5/13/85.
060	18	3 coy	2-1 yr	2-2 yr	2-3yr	Single	Lost 1 cub by 10/10/82; weaned 2-3 yr cubs by 7/05/85.
064	24	2-1 yr	1-2 yr	1-3 yr	Single	Single	Lost 1 cub 8/25/82-6/15/83; weaned 1-3 yr cub by 5/29/84.
067	23	2-1 yr	2-2 yr	2-3 yr	3 coy	unk	Weaned 2-3 yr cubs by 6/04/84; shed radio-collar by 9/25/85.
070	8	Single	Single	2 coy	2-1 yr	2-2 yr	
071	12	1 coy	Single	3 coy	3-1 yr	3-2 yr	Lost cub by 9/30/82; seen w/2 cubs for 1st 5 weeks in 1984, possibly adopted 3rd cub; lost 1 cub by 9/05/86.
072	21	2 coy	Single	Single	Single	Dead	Lost both cubs by 10/29/82; killed by bear 10/85.
074	19	2-1 yr	2-2 yr	3 coy	Dead	---	Weaned 2-2 yr cubs by 7/01/83; DLP[b] kill 10/28/84.
077	22	3-1 yr	3-2 yr	2 coy	Dead	---	Weaned 3-2 yr cubs by 5/28/83; radio failed 8/83; DLP kill 10/28/84.

Table 4. Continued.

Bear No.	Age in 1986 or last observation	Reproductive Status 1982	1983	1984	1985	1986	Comments
078	11	---	Single	2 coy	2-1 y	Single	Lost both cubs by 9/25/85; hunter kill 10/29/86.
080	26	---	Single	unk	unk	unk	Oldest female captured; shed collar by 7/21/83.
081	13	---	2-2 yr	3 coy	3-1 yr	3-2 yr	Weaned 2-2 yrs by 7/11/83; with cubs on 8/28/86; hunter kill 11/09/86.
085	7	---	Single	Single	Single	Single	
086	11	---	1-1 yr	Single	Single	Single	Lost cub by 10/29/83; lactating 6/23/85.
088	12	---	2-2 yr	2-3 yr	unk	Single	Weaned 2-3 yr cubs by 10/12/83; radio failed by 9/84.
091	8	---	Single	3 coy	1?-1 yr	Dead	Died in den 4/24-6/27/85; 1-1 yr cub seen at den 4/24/85.
092	8	---	2-1 yr	Single	3 coy	3-1 yr	Abandoned cubs at capture 6/05/83.
096	9	---	Single	2 coy	2 coy	Dead	Cubs killed near den by 5/20/84; died near den between 12/05/85-5/20/86.
099	12	---	---	Single	Single	Single	
114	6	---	---	2-1 yr	unk	unk	Shed collar by 8/13/84.

Table 4. Continued.

Bear No.	Age in 1986 or last observation	Reproductive Status 1982	1983	1984	1985	1986	Comments
119	8	---	---	Single	2 coy	2-1 yr	Lost 1 cub by 11/20/86.
121	15	---	---	2-1 yr	2-2 yr	3 coy	Weaned 2-2 yr cubs by 7/25/85; capture mortality 7/01/86.
123	15	---	---	3-2 yr	3-3 yr	Single	Weaned 3-3 yr cubs by 6/27/85; illegal kill 8/86
127	8	---	---	Single	Dead	---	Hunter kill 10/26/84.
128	9	---	---	---	3-1 yr	2-2 yr	Lost 1 cub by 7/20/85, possibly capture-related; weaned 2-2 yr cubs by 6/24/86.
129	12	---	---	---	3 coy	2-1 yr	Lost 1 cub 12/29/85-6/24/86.
131	13	---	---	---	2-1 yr	2-2 yr	Cubs not weaned by 11/10/86.
132	17	---	---	---	3-1 yr	3-2 yr	Cubs not weaned by 11/10/86.
133	12	---	---	---	1-1 yr	1-2 yr	Cubs not weaned by 11/20/86.
135	17	---	---	---	3 coy	3-1 yr	Lost 1 cub by 10/11/86.
136	16	---	---	---	---	3-1 yr	
138	11	---	---	---	---	Single	

Table 4. Continued.

Bear No.	Age in 1986 or last observation	Reproductive Status 1982	1983	1984	1985	1986	Comments
140	10	---	---	---	---	Single	
141	9	---	---	---	---	1-1 or 2 yr	

[a] - Coy-cub-of-the-year

[b] - DLP-killed in defense of life or property

Table 5. Minimum ages of production of first litter by radio-collared female brown bears >5 yrs old when captured in Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

Bear number	Age at 1st capture	Date of 1st capture	Age at which 1st litter observed was produced	Reproductive status at 1st capture
001	3	4/22/82	None by age 4	Single, pre-estrus
011	6	4/23/82	5	w/2-1 yr old
018	5	4/25/82	8	Single, lactating
019	6	4/25/82	8	Single, lactating
020	6	4/25/82	8	Single, lactating
037	4	5/02/82	None by age 6	Single
038	3	5/02/82	None by age 7	Single
043	4	7/22/82	-	Single; capture mortality
044	3	7/22/82	None by age 7	Single
046	6	7/23/82	5	w/2-1 yr old
070	4	7/26/82	6	Single
085	4	6/03/83	None by age 7	Single
092	5	6/05/83	4	w/2-1 yr old
114	6	7/10/84	5	w/2-1 yr old (age estimated)

Table 6. Observed and projected reproductive intervals for radio-collared adult female brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

			Annual reproduction status[b]									
Bear No.	Maximum age at beginning of interval	Minimum cycle length[a]	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
005	10	3	B	C	Y	2/B						
005	13	4	2/B	C	Y	2	3/B					
008	8	3	B	C	Y	2/B						
008	11	4	2/B	B	C	Y	2/B					
011	4	9	B	C	Y/B	B	C	Y/N	B	C	Y	2/B
015	7	-	W/B	B	B	C	Dead					
018	5	-	B	B	B	C	Dead					
019	6	7	B	B	C	Y/N	B	C	Y	2/B		
020	6	5	B	B	C/B	C	Y	2/B				
022	7	5	B	B	B	C	Y	2/B				
029	14	3	B	C	Y	2/B	Dead					
034	10	3	B	C	Y	2/B						
046	4	8	B	C	Y/B	C/N	B	B	C	Y	2/B	

Table 6. Continued.

Bear No.	Maximum age at beginning of interval	Minimum cycle length[a]	Annual reproduction status[b] Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
048	21	4	B	C	Y	2	3/B	Dead				
051	6	9	B	C	Y/N	B	C	Y/B	B	C	Y	2/B
055	12	3	B	C	Y	2/B						
055	15	5	W/B	C/B	B	C	Y	2/B				
060	13	4	W/B	C	Y	2	3/B					
060	17	4	W/B	B	C	Y	2/B					
064	18	4	B	C	Y	2	3/B					
064	22	4	W/B	B	C	Y	2/B					
067	18	4	W/B	C	Y	2	3/B					
067	22	3	W/B	C	Y	2/B						
070	5	4	B	C	Y	2	3/B					
071	7	6	B	C/N	B	C	Y	2	3/B			
072	17	-	B	C/N	B	B/Dead						
074	15	3	B	C	Y	2/B						

Table 6. Continued.

Bear No.	Maximum age at beginning of interval	Minimum[a] cycle length	Annual reproduction status[b] Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
074	18	-	W/B	C/DEAD								
077	18	3	B	C	Y	2/B						
077	21	-	W/B	C/DEAD								
078	8	-	B	C	Y/N	B/DEAD						
081	7	3	W/B	C	Y	2/B						
081	10	-	W/B	C	Y	2/DEAD						
086	6	8	B	C	Y/N	B	B	B	C	Y	2/B	
088	6	4	B	C	Y	2	3/B					
088	10	5	W/B	B	B	C	Y	2/B				
092	3	6	B	C	Y/B?	B	C	Y	2/B			
099	10	5	B	B	B	C	Y	2/B				
119	6	3	B	C	Y	2/B						
121	11	3	B	C	Y	2/B						
123	10	4	B	C	Y	2	3/B					

Table 6. Continued.

Bear No.	Maximum age at beginning of interval	Minimum cycle length[a]	Annual reproduction status[b] Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
128	6	3	B	C	Y	2/B						
129	10	3	B	C	Y	2/B						
131	10	4	B	C	Y	2	3/B					
132	14	4	B	C	Y	2	3/B					
133	9	4	B	C	Y	2	3/B					
135	15	3	B	C	Y	2/B						
136	14	3	B	C	Y	2/B						

a - Length of reproductive cycle represents minimum values based on projections before and after actual observations; weaning at 2 yrs old assumed in projections.

b - Underlining indicates reproductive status was not actually observed but was projected.
Code is: C/B-lost cubs-of-year, bred; Y/B-lost yearlings, bred; C or Y/N-lost cubs-of-year or yearlings after breeding season; C-with cubs-of-year; Y-with yearlings; 2-with 2-year old cubs; 3-with 3 year old cubs; W/B-weaned offspring, bred.

Table 7. Predicted vs. actual cub production by radio-collared adult (>5 yrs) female brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1983-86.

		No. females predicted w/coy[a]	No. females w/coy	Percent reproductive success	Mean age females w/coy	Mean age females w/o coy
Project	1983	9	1	11.1	14.0	9.3 (range=5-22)
Construction	1984	22	14	63.6	10.6 (range=8-22)	8.4 (range=5-20)
Post-	1985	15	8	53.3	11.7 (range=7-23)	11.5 (6-23)
Construction	1986	9	1	11.1	15.0	12.7 (7-24)

a - coy = cubs-of-the-year

Table 8. Litter size and number of offspring, by age class, observed for radio-collared female brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

Age class and litter size	No. litters observed 1982	1983	1984	1985	1986	Total litters	Total offspring	Mean litter size
coy[a]								
1	1	0	0	0	0	1	1	
2	1	1	8	3	0	13	26	
3	2	0	5[b]	7	1	15	45	
Total	4	1	13	10	1	29	72	2.48
1 yr								
1	2	1	0	4	1[c]	8	8	
2	6	3	3	4	4	20	40	
3	1	0	0	4	3	8	24	
Total	9	4	3	12	8	36	72	2.00
2 yr								
1	1	1	1	0	2	5	5	
2	3	5	1	2	3	14	28	
3	1	1	1	0	3	6	18	
Total	5	7	3	2	8	25	51	2.04
3 yr								
1	0	0	1	0	0	1	1	
2	0	0	3	1	1	5	10	
3	0	0	0	1	0	1	3	
Total	0	0	4	2	1	7	14	2.00

a - cubs-of-year
b - includes 1 litter with 1 adopted cub
c - litter possibly 2 yrs old; classified at 1 yr for mean litter size calculation

Table 9. Sex and age composition of cubs captured with radio-collared females in Terror Lake hydroelectric project study area, Kodiak, Island, Alaska 1982-1986.

Age class	Males	(N=19)	Females	(N=34)
COY[a]	057,058,073,107 108,109,115,116	(N=8)	056,061,062,063 106,110,111,112 113, 117, 118	(N=11)
1 yr	013,049,054,076	(N=4)	012,047,050,052 065,066,068,069 075,087,093,094 122,134	(N=14)
2 yr	006,007,009,030 031,032,083	(N=7)	010,035,036,082 089,090,124,125 126	(N=9)

a - cubs-of-the-year

Table 10. Survivorship of litters first observed as cubs-of-the-year of radio-collared female brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

Bear no.	Mortality of coy[a]	No. coy surviving to age 1	Mortality of yearlings	No. yearlings surviving to age 2	Cumulative Survival to age 2	
					Litter 1	Litter 2
005	None	2 of 2	None	2 of 2	2 of 2	---
011	1 lost Nov-May	1 of 2	1 lost Nov-May	0 of 1	0 of 2	---
015	2 lost by fall	0 of 2	---	---	0 of 2	---
018	2 lost by fall	0 of 2	---	---	0 of 2	---
019	None	2 of 2	2 lost Oct-Dec	0 of 2	0 of 2	---
020	2 lost by July; 1 lost Dec-May	0 of 2; 2 of 3	1 of 2 lost by late fall	?[b]	0 of 2	?
022	1 lost Sept-May	2 of 3	None	?	---	?
046	1 lost by Oct, 2 lost by Dec	0 of 3	---	---	0 of 3	---
051	1 lost Oct-May	1 of 2	1 lost by June	0 of 1	0 of 2	---
055	1 lost by May; 1 lost by Oct, 2 lost Dec-May	2 of 3; 0 of 3	1 lost May-June	1 of 2; ---	1 of 3	0 of 3
060	1 lost by Oct	2 of 3	None	2 of 2	2 of 3	---
067	3 of 3 alive in Sept when shed collar	---	---	---	---	---
070	None	2 of 2	None	2 of 2	2 of 2	---

Table 10. Continued.

Bear no.	Mortality of coy[a]	No. coy surviving to age 1	Mortality of yearlings	No. yearlings surviving to age 2	Cumulative Survival to age 2 Litter 1	Litter 2
071	1 lost by Sept; none, suspect adopted 1 of 3	0 of 1; 3 of 3	None	3 of 3	0 of 1	3 of 3
072	1 lost by Aug, 1 lost by Oct	0 of 2	---	---	0 of 2	---
074	3 of 3 alive when female killed in Oct	---	---	---	---	---
077	2 of 2 alive when female killed in Oct	---	---	---	---	---
078	None	2 of 2	2 lost by Sept	0 of 2	0 of 2	---
081	None	3 of 3	None	3 of 3	3 of 3	---
091	3 of 3 entered den where female died	---	1 yearling seen at den in April	---	---	---
092	None	3 of 3	3 of 3 alive by fall	?	?	---
096	2 of 2 entered den where female died	---	---	---	---	---
119	None	2 of 2	1 lost by Nov	?	?	---

Table 10. Continued.

Bear no.	Mortality of coy[a]	No. coy surviving to age 1	Mortality of yearlings	No. yearlings surviving to age 2	Cumulative Survival to age 2	
					Litter 1	Litter 2
129	1 lost Dec-June	2 of 3	2 of 2 alive by fall	?	?	---
135	None	3 of 3	1 lost by Oct	?	?	---

a - cubs-of-the-year

b - indicates litter will be 2 yrs old in 1987.

Table 11. Summary of survivorship of litters of radio-collared female brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

	Total litters	Complete litters surviving	Litters with 1 or more surviving members	Total cubs	Cubs surviving	% survivorship
Survivorship to yearlings for litters first seen as cubs-of-year	23	10	16	56	35	62.5
Survivorship of yearlings to 2 yrs old for litters first seen as cubs-of-year	10	5	6	20	13	65.0
Survivorship of yearlings to 2 yrs old for litters first seen as yearlings	14	8	10	26	18	69.2
Combined survivorship of yearlings to 2 yrs old	24	13	16	46	31	67.4
Survivorship to 2 yrs old for litters first seen as cubs-of-year	17	4	6	39	13	33.3

Table 12. Survivorship of litters of radio-collared female brown bears first observed as yearlings in the Terror Lake Hydroelectric Project study area, Kodiak Island, Alaska, 1982-1986.

Bear no.	Mortality of yearlings	No. yearlings surviving to age 2
008	0	1 of 1
011	2 lost by Aug	0 of 2
046	1 lost by Oct, 1 lost by den emergence	0 of 2
048	0	2 of 2
051	1 lost by Sept	0 of 1
053	?	? of 1 orphaned at capture
064	1 lost Sept-June	1 of 2
067	0	2 of 2
074	0	2 of 2
077	0	3 of 3
086	1 lost by Oct	0 of 1
092	?	? of 2 abandoned at capture
121	0	2 of 2
128	1 lost by July; possibly separated at capture	2 of 3
131	0	2 of 2
133	0	1 of 1

Table 13. Characteristics of family break-up in known age litters of radio-collared female brown bears in Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

Bear no.	Age of mother at weaning	Age cubs when 1st observed	Original litter size	Weaned litter size	Date female 1st seen alone
005	13	2 yr	2	2	5/30
008	11, 15	2 yr, 1 yr	2, 1	2, 1	6/15, 6/24
029	17	2 yr	3	3	5/20
034	13	2 yr	2	2	6/15
055	15	coy	3	1	5/29
074	17	2 yr	2	2	7/01
121	14	1 yr	2	2	7/25

Bear no.	Age of mother at weaning	Age cubs when 1st observed	Original litter size	Weaned litter size	Date female 1st seen alone
005	17	coy	2	2	7/21
048	25	1 yr	2	2	6/25
060	17	coy	3	2	7/05
064	22	1 yr	2	1	5/29
067	22	1 yr	2	2	6/04
088	10	2 yr	2	2	5/29
123	14	2 yr	3	3	6/27

Adult Mortality

Methods

Mortality data were collected by investigating deaths of radio-collared bears as soon as possible after they died and by interviewing hunters who killed marked bears. Mortality sensors in the radio-collars decreased the pulse rate of the transmitted signal when bears did not move for 2 or more hours. Bears were suspected to be dead when a mortality signal was received for 2 or more consecutive radio-tracking flights (except during denning periods). Helicopters were used for transportation to inspect carcasses in most cases. Areas around the radio-collars were searched to find portions of carcasses and possible clues to the cause of death. Gross necropsies were performed in the field.

Hides and skulls of all bears killed by hunters on Kodiak and adjacent islands must be sealed by Alaska Department of Fish & Game representatives before they can be transported to other locations. Bears killed in defense of life or property (DLP) were also inspected and sealed by biologists. Hides were examined for ear-tags and tattoos. When marked bears were discovered, hunters were interviewed to determine location, activity and association of the bear when it was killed. Hunters were given a short description of the study and the opportunity to view data on the individual bear they killed.

Survivorship rates were calculated by analyzing data from radio-collared females that were continuously monitored and whose fates were known from the time of capture through the end of the study (31 December 1986)(Trent and Rongstad 1974). Bears that died because of capture activities were excluded from the analysis. Males were also excluded from analysis because most retained functional radio-collars for only short periods of time. Confidence intervals about the survivorship rate were calculated by using the MICROMORT microcomputer program (Heisey and Fuller 1985).

Results

Mortality of Marked Bears

Thirty-seven marked brown bears, including 17 males (46%) and 20 females (54%), were known to have died during this investigation (Table 14). Twenty-two (59%) died in Kizhuyak Bay drainages, 10 (27%) in Terror Bay drainages, 1 (3%) in Viekoda Bay drainages, 1 (3%) in Ugak Bay drainages and 3 (8%) died outside of the study area, including 2 near Uganik Bay and 1 near Barling Bay. The mean age of all marked bears known to have died was 9.9 years (Table 15). Mortality from sport hunting was the leading cause of death (43%; n=16), followed by natural causes (19%; n=7), capture-related causes (19%; n=7), and DLP incidents (11%; n=4) (Table 16). In 3 cases (8%) the cause of death could not be determined.

Sport Hunting Mortalities

Sport hunting seasons for brown bears were 1 April to 15 May and 25 October to 30 November during each year of the study. Hunting was regulated by permit, with an unlimited number of permits available for the portion of the study area east of Kizhuyak Bay/River and Hidden Basin Creek (Hunt Area 250). Permits were limited to 39 per year in the rest of the study area (Hunt Areas 201, 202, 225, and 226). Hunters were allowed to harvest 1 bear every 4 years. Cubs less than 2 years old, and females accompanied by cubs less than 2 years old, could not legally be killed.

Hunters reported killing 87 brown bears in the study area from 1982-1986, including 63 (72%) males and 24 (28%) females. Fourteen (16%) of those were bears that had been marked during this investigation, including 10 (71%) males and 4 (29%) females. The mean age of bears harvested from the study area was 6.2 years old (Table 15). The mean age of marked bears harvested in the study area was 7.3 years old. No statistically significant differences between marked and unmarked bears harvested within the study area were noted in either the sex ratio ($p>0.1$) or the age classes by sex ($p>0.1$). Two marked males were killed by hunters outside the study area, 1 near Uganik Lake and the other near Barling Bay.

Marked bear mortalities by sport hunters ranged from 1 bear killed in 1982 to 5 bears killed in 1985. Marked males were disproportionately vulnerable to sport harvest compared to marked females. Sport harvest was responsible for 71% of the known mortalities of marked males whereas only 20% of the known marked female mortalities were caused by hunters.

Natural Mortalities

Seven marked bears (1 male and 6 females) were known to have died of natural causes. The mean age of these bears was 13.3 years (Table 15). The mean age of females that died of natural causes was not significantly different from the mean age of females killed by hunters ($p>0.1$).

Four female bears (015, 037, 091, and 096) died at or near their den sites. Direct causes of mortality could not be determined in any of these cases. Two bears (Male 095 and Female 072) apparently were been victims of intraspecific predation or fighting. Both carcasses had wounds characteristic of bear inflicted injuries and both were partially consumed by bears. One female (048) was found in an avalanche path. Whether she was killed by an avalanche or died previously could not be determined.

Natural mortality was more common in marked females than in marked males. Thirty percent of marked female deaths were attributed to natural causes while only 6% of marked male deaths were attributed to natural causes.

Capture Mortalities

Seven bears, including 3 (43%) males and 4 (57%) females, died during capture operations. The mean age of these bears was 8.9 years (Table 15). Males and females appeared equally vulnerable to capture mortality as 18% of marked male and 21% of the marked female deaths were capture-related. Capture mortality rates were inflated because, unlike other causes of death, all capture-related mortality was known and reported. One-hundred-and-forty individual bears were captured a total of 197 times for a capture mortality frequency of 3.6% (7/197).

Six of the deaths (Males 021,023,101 and Females 038,043,053) were apparently caused by adverse reactions to the immobilizing drug (etorphine) and stress associated with capture activities. One capture-related death (Female 121) occurred when the immobilized animal fell into a stream and drowned.

Defense of Life or Property Mortalities

Nine bears, including 3 (33%) males and 6 (67%) females, were reported as killed under DLP provisions within the study area from 1982-1986 (Alaska Administrative Code 5 AAC 92.410 provides for the "taking of game in defense of life or property" by individuals). Mean age of these DLP mortalities was 10.1 years (Table 15). Three of the DLP bears, all females, had been marked during this project. One marked male was killed under DLP provisions outside the study area.

The 3 marked females (074,077,126) were killed in DLP incidents by deer hunters near Kizhuyak Bay. Females 074 and 077, both with cubs-of-the-year litters, were killed in separate incidents near Kizhuyak Bay on 28 October 1984. Female 126 was killed near the access road at the head of the bay on 10 November 1986. The single male (026) was killed by residents of an abandoned cannery on the

Northeast Arm of Uganik Bay. DLP mortalities accounted for 6% of the known mortality of marked males and 11% of the known mortality of marked females.

Other Mortality

Three marked females died of unknown causes. During fall 1982 Female 029 was suspected to have denned near Sharatin Bay. Further investigation during the following spring revealed that she had not denned, but had died, probably in October 1982. The cause of her death could not be determined, but her carcass was found close to an area where both deer and bear hunting had occurred.

Female 018 lost a litter of cubs-of-the-year within her traditional home range near Baumann Creek in October 1985. She then moved to the vicinity of Port Lions and was observed on several occasions by local residents while she was feeding in the village landfill. In May 1986 she was found dead near the Port Lions airport, within 1 km of the landfill. Because of advanced decomposition when her body was found, the cause of death could not be determined.

Female 123 died in Hilary Creek within 300 m of an off-road vehicle trail along the Port Lions transmission line on about 15 August 1986. She had been shot at least twice with a large caliber rifle. Her death was apparently a malicious killing because the wounds indicated that she was fleeing when she was shot.

Numerous unconfirmed reports were received that 10-15 bears were killed illegally in the vicinity of Port Lions at the northern edge of the study area in 1985. Several carcasses were recovered in the vicinity but no marked bears were found.

Survivorship Rate

Data from 38 adult females that were monitored for a total of 1238 monitor months were used to calculate the survivorship rate. Thirteen of these bears died during the study period. Seven died of natural causes, 3 were killed by hunters, 1 was killed under DLP provisions, and 2 died of other causes. Mean annual survivorship of these bears was 0.87 (95% confidence interval=0.81-0.94), when all sources of mortality (except capture mortality) were considered.

Table 14. Mortality of tagged brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

Bear	Age	Sex	Date of Kill	Cause	Location
001	7.8	Female	10/25/86	Hunter	Kizhuyak Bay
006	2.4	Male	5/30/82	Hunter	Kizhuyak Bay
007	3.4	Male	5/18/83	Hunter	Kizhuyak Bay
009	5.3	Male	4/29/85	Hunter	Watchout Creek
015	11.3	Female	Spring 85	Natural	Baumann Creek
018	9.5	Female	5/00/86	Other	Port Lions
021	5.3	Male	4/25/82	Capture	Terror Bay
023	10.5	Male	6/22/85	Capture	Baumann Creek
026	5.7	Male	8/16/82	DLP[a]	NE Arm Uganik
027	14.8	Male	10/14/83	Hunter	Saltery Lake
028	4.4	Male	5/03/83	Hunter	Kizhuyak Bay
029	17.8	Female	Fall 82	Other	Sharatin Bay
030	5.4	Male	5/06/85	Hunter	Watchout Creek
037	7.3	Female	Spring 85	Natural	Den Mountain
038	7.5	Female	6/23/86	Capture	Terror Bay
040	7.4	Male	5/10/86	Hunter	Kizhuyak Bay
043	4.6	Female	7/22/82	Capture	Barabara Flats
048	26.3	Female	Spring 85	Natural	Terror River
049	4.4	Male	5/12/85	Hunter	Terror Bay
053	8.6	Female	7/24/82	Capture	Terror Bay
059	6.4	Male	5/13/85	Hunter	NE Arm Uganik
072	21.9	Female	10/14/85	Natural	Terror Bay
074	19.8	Female	10/28/84	DLP	Kizhuyak Bay
077	22.8	Female	10/28/84	DLP	Kizhuyak Bay
078	11.8	Female	10/29/86	Hunter	Kizhuyak Bay
081	13.9	Female	11/09/86	Hunter	Watchout Creek
083	3.4	Male	5/07/84	Hunter	Kizhuyak Bay
091	10.5	Female	6/00/85	Natural	Kizhuyak River
095	5.4	Male	5/00/84	Natural	Sharatin Bay
096	10.3	Female	Spring 86	Natural	Viekoda Creek
098	8.3	Male	4/27/85	Hunter	Kizhuyak Bay
101	10.5	Male	6/21/85	Capture	Baumann Creek
105	5.9	Male	11/04/84	Hunter	Barling Bay
121	15.6	Female	7/01/86	Capture	Kizhuyak Bay
123	15.7	Female	8/15/86	Other	Hilary Creek
126	4.9	Female	11/10/86	DLP	Kizhuyak River
127	8.9	Female	11/03/84	Hunter	Kizhuyak Bay

[a] - bear killed under defense of life or property provisions (5 AAC 92.410)

Table 15. Age data for brown bears that were known to have died within the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

	Males			Females			Total		
Cause of Death	Mean age	Sample size	Range	Mean age	Sample size	Range	Mean age	Sample size	Range
ALL CAUSES[a]									
(marked bears only)	6.4	17	2.4-14.8	12.8	20	4.9-26.3	9.9	37	2.4-26.3
SPORT HUNTING									
All bears in area	5.7	63	2.4-20.8	7.4	23	1.8-15.8	6.2	86	1.8-20.8
Marked bears in area	5.9	10	2.4-14.8	10.6	4	7.8-13.9	7.3	14	2.4-14.8
DEFENSE OF LIFE[b]									
All bears in area	7.1	3	3.8-9.8	11.8	5	4.8-22.8	10.1	8	3.8-22.8
Marked bears in area	---	0	---	15.8	3	4.9-22.8	15.8	3	4.9-22.8
CAPTURE MORTALITY									
(marked bears only)	8.8	3	5.3-10.5	9.1	4	4.6-15.6	8.9	7	8.9-15.6
NATURAL MORTALITY									
(radio-collared bears)	5.4	1	--5.4--	14.6	6	7.3-26.3	13.3	7	5.4-26.3

a - includes all marked bears known to have died during this study, including those listed elsewhere on this table, those killed outside the study area, and those that died of undetermined causes. Does not include marked cubs that were still dependent on their mother when they died.

b - bears killed under State of Alaska defense of life or property provisions (5AAC 92.410).

Table 16. Causes of mortality of marked brown bears known to have died during the Terror Lake Hydroelectric Project, Kodiak Island, Alaska, 1982-1986.

Cause	Males	Females	Total
Hunter	12 (71%)	4 (20%)	16 (43%)
Natural	1 (6%)	6 (30%)	7 (19%)
Capture	3 (18%)	4 (21%)	7 (19%)
DLP[a]	1 (6%)	3 (16%)	4 (11%)
Other	0 (0%)	3 (15%)	3 (8%)
TOTAL	17 (46%)	20 (54%)	37

a - bears killed under Defense of Life or Property provisions (5AAC 92.410).

Habitat Use

Methods

Data on elevation and overstory vegetation were recorded for all brown bear observations. Overstory composition within 1 ha of the bears' locations was noted and classified into 1 of 19 categories (Appendix I). The most common plants found in each of the 19 categories were identified during on-site visits, using Hulten (1968) and Hickock and Wilson (1979). Each of the 19 categories was assigned to 1 of 3 major habitat categories identified by elevational range. Although overlap occurred between adjacent elevational ranges, 3 distinct categories could be discerned: alpine (>450 m), midslope (150-450 m), and lowland (<150 m).

The area within each habitat category (elevation range) was measured with a planimeter from 1:63,360 topographic maps. Chi-square and Bonferoni-Z statistics were employed to analyze the bear use of each of these categories by month and bear reproductive status, relative to the availability of each habitat category. Statistical significance was calculated at the 90% level. Data for the entire 5 year study period were analyzed together to bolster sample sizes and dampen effects of individual variation and variations between years. To eliminate observability bias, only data from radio-collared bears of known sex were used. Data for January, February, and March were consolidated into 1 category (winter) for purposes of this analysis because radio-tracking flights were only flown once a month during these months.

Information on foods used by bears was obtained by observations of bears' feeding activities during radio-tracking flights, occasional on-ground observations of bears, inspection of feeding sites, and field examinations of scats. These data were used to develop a subjective analysis of feeding habits and no systematic effort was made to quantify them.

Results

Description of Habitat Categories

Few radio-collared bear observations were made outside the terrestrial and freshwater areas in Kizhuyak, Viekoda, and eastern Terror Bay drainages. These drainages encompassed 774.3 km^2, made up the core of the 1,461.4 km^2 study area which was used in habitat use analysis. Within the core study area, 40.3% (312.2 km^2) was classified as alpine, 33.1% (256.3 km^2) was midslope, and 26.6% (205.7 km^2) was in the lowland category.

Alpine areas were defined as all lands above 450 m elevation. The study area shows signs of recent glaciation with numerous horns, cirques, moraines, and a few active alpine glaciers which persist in the vicinity of the highest peak, Mount Glottof (1,343 m). Steepsided peaks are often rock covered with scattered volcanic ash deposits, and little soil development. Lichens and small pioneering herbaceous plants are the main vegetation occurring on these sites. On moderate slopes (30-45%) where soil has developed, dense sedge/forb complexes occur. Gentle slopes and benches are often covered with mat-forming ericaceous shrubs and dwarf willow (*Salix* spp.)/birch (*Betula nana exilis*) thickets. Lower portions of the alpine, particularly on south-facing slopes, are frequently populated by a vegetative complex characteristic of the alder (*Alnus crispa sinuata*) communities found in midslope and lowland areas. Individual shrub species growing at this interface are generally shorter than specimens growing in lower elevations. Krummholz Sitka spruce (*Picea sitchensis*) are also found in sparsely scattered groves at the lower limit of the alpine areas.

Midslope areas are defined as all lands between 150 m and 450 m in elevation. These areas are typified by dense shrub thickets interspersed with tall grass/forb meadows. Shrub thickets are dominated by alder, with abundant elderberry (*Sambucus racemosa*) and devil's club (*Echinopanax horridum*) present. The understory is generally moist and dominated by various species of fern. Grass meadows are predominantly bluestem (*Calamagrostis canadensis*)/salmonberry (*Rubus spectabilis*)/fireweed (*Epilobium angustifolium*) complexes. Scattered groves of cottonwood (*Populus balsamifera*) occur along some stream courses and near seeps. Spruce occurs mainly in the northern part of the study area. Extensive cliffs and numerous large rock outcrops are found in midslope areas, usually adjacent to major drainages. Salmon (*Oncorhynchus* spp.) are not found in midslope streams.

Lowland areas are defined as areas below 150 m in elevation. These areas are varied, ranging from intertidal mudflats to dense shrub thickets. Shrub/grass complexes comparable to those in midslope areas cover gentle to moderately sloping hillside. Extensive areas of flat to rolling tall grass meadows are common in the northern portion of the study area. These flats are dominated by bluestem grass, salmonberry, fireweed, and other herbaceous species. Dense spruce groves are common in the Viekoda Bay, Sharatin Bay, and northern Kizhuyak Bay areas. Cottonwoods and willows grow along major stream courses throughout the lowlands, with dense cottonwood groves along the lower reaches of Terror and Kizhuyak Rivers. These major drainages also support sedge (*Carex* spp.) meadows in the upper intertidal areas at river mouths. Intertidal mudflats with aquatic vegetation and mussel (*Mytilus edulis*) beds extend 1 km from the mouth of Kizhuyak River and 3 km from the mouth of Terror River at low tide. Less extensive mudflats are also present at the ends of other large streams. Salmon are abundant from July through early October in most streams in lowland areas.

Intra-annual Use of Habitat

All habitat categories were used by bears during the year (Figure 4). Bears favored alpine areas for dens, but moved to lowland and midslope areas early in spring. Observations of bears feeding during spring suggested that they were taking advantage of emerging vegetation. Newly developing vegetation from midslopes to alpine remained important into July. In August, most bears moved into lowland areas, as salmon became available in many study area streams. Lower Terror River was the salmon spawning stream most heavily used by bears in the study area. Concentrations of up to 40 bears were not uncommon during peak use periods. Lower reaches of Kizhuyak River and Watchout Creek also received intensive use by fishing bears from the eastern portion of the study area. Salmon remained an important food item into October. Feeding on berries occurred concurrently with the movement to salmon streams. By mid-September bears were increasingly frequenting midslope areas where elderberries and devil's club berries appeared to be a major feeding attraction. By October and early November, most bears were located in dense brushlands in midslope habitat. Movement to alpine denning areas was evident by late October and continued into December.

Habitat Use by Radio-collared Bears by Reproductive Category

Intra-annual habitat use differed significantly for each of the major bear reproductive categories: male, lone female, female with cubs-of-the-year, and female with yearling and older cubs. Individual females' use of habitats often changed between years, depending on their reproductive status.

Habitat Use by Males:

Thirty-four radio-collared males were re-located or observed 1,079 times. During the winter period, there was no significant selection for any of the habitat categories (Figure 4, Table 17), but mean elevations were higher than at any other time of the year (Figure 5, Table 18). In April, lowland areas were occupied more frequently than during the winter, as males used emerging sedges and grasses along the coast; but there was no significant selection for any category. During May and June, males occupied the midslope habitat category at significantly greater levels than expected. Within this category, shrub and grass/shrub mixes accounted for 86% and 84%, respectively, of the observations. Emerging forbs and ferns provided readily available sources of food. Alders begin to leaf-out in May, affording cover for bears.

Lowland areas became significantly more important during July, August, and September, as salmon and salmonberries became available in the study area. A noticeable movement away from midslopes began in July. In August, males were at their lowest mean elevations of the year and lowland areas were used 185% greater than expected. In September, midslope areas were used more frequently than expected. Salmon were abundant during September; however, ripening elderberries and devil's club berries in midslope cover types offered alternate food sources away from salmon streams. Both midslopes and lowlands continued to be important into October, although there was no significant selection for either habitat category.

Most salmon runs were completed by November. Although a few live coho salmon were still available, male bears continued to move away from the lowland habitat category into midslope habitat. The highest degree of midslope use occurred in November (96% greater than expected). Persistent elderberry and devil's club fruits were frequently used foods. Some predation on deer and scavenging of hunter-killed deer occurred. A similar use pattern was observed during December with less selection for any habitat category, as males were apparently using all available food sources.

Alpine cover types were used less than expected throughout the year, including the winter denning period. The reduced use of alpine was statistically significant from May through November.

Habitat Use by Lone Females:

Forty-five females were radio-located or observed 2,051 times while they were without dependent offspring. These bears made significant use of alpine areas during winter months (Figure 4, Table 18) with a mean elevation virtually identical to that recorded for females with new cubs and for females with yearlings (Figure 5, Table 18). During April, alpine areas were still used significantly more often than expected, but increasing use of midslope areas was also noted.

Alpine became noticeably less important in May as midslopes became significantly more important. Significant use of midslope habitat continued into June and lone females' use of habitat categories closely resembled that of males'. The availability of emerging vegetation and the onset of breeding season probably precipitated movements into midslope areas by both males and lone females. Like the males, lone females were most frequently found in midslope shrub or grass/shrub mix areas in May (75% of the observations) and June (81% of the observations). Midslope areas became less important in July as lone females used the different habitat categories in proportion to their availability, possibly the result of individual variation.

Salmon were an important source of food for lone females during August, as lowlands were used significantly more often than expected (101%). Salmonberries also became available in lower elevations during July and August of most years. Substantial movement out of lowland areas occurred in September as lone females made significant use of midslope areas, probably attracted by ripening elderberries and devil's club berries. This pattern continued into October.

During November, alpine habitats were used significantly more than expected as many lone females moved into denning habitat. Movements into the alpine continued into December, as lone females exhibited use patterns similar to those observed for females with yearling and older cubs. These early movements into alpine habitats may have been pregnancy-related, as single females, presumed to be pregnant, moved into alpine denning areas sooner than other bears.

Habitat Use by Females with Cubs-of-the-Year:

Twenty-four radio-collared females were observed or radio-tracked on 574 occasions while with cubs-of-the-year. Significant use of alpine areas occurred from winter through July (Figure 4, Table 17). These family groups commonly emerged from alpine dens late in the spring and remained near den sites for some time after emergence. Alpine sedges began growing as soon as snow patches receded and the sedges provided a substantial source of high quality food into July.

In August, females and their new cubs moved to lowlands and used these habitats at levels approaching significance. Use of lowlands was statistically significant in September, undoubtedly related to use of salmon and salmonberries. September also brought a movement into midslope areas as berries ripened. This movement continued into October as midslopes were occupied at significant levels -- 119% greater than expected.

Females with new cubs moved into denning habitat in November, but did not select for any particular habitat category. December data also show no significant selection of any cover types; however, a decline in the mean elevation (Figure 5, Table 18) and increased use of midslope areas are evident. These anomalies are a factor of individual variation as sample sizes were small because of inclement weather, and the few individuals that were radio-located were denned in midslope areas while they had cubs-of-the-year.

Habitat Use by Females with Yearling or Older Cubs:

Forty radio-collared females were radio-located or observed on 1,088 occasions while with yearling or older cubs. Alpine areas were used more often than expected into May as these family groups commonly occupied alpine dens (Figure 4, Table 17). Soon after emergence, females with older cubs followed use patterns similar to those of lone females and males, making significant use of midslope areas in June. Emerging herbaceous vegetation apparently provided an abundant nutritious food source in the midslope habitat.

In July, many females with older cubs left midslopes and joined the females with new cubs to make significant use of alpine areas. Although alpine sedges and forbs varied in abundance each year, their presence seemed to attract females with older cubs back into the alpine.

Females and their older cubs used lowland areas with greater intensity than any of the other 3 classes of bears in August and September, 202% and 147% greater than expected, respectively. Easily accessible salmon and berries provided important sources of food during this period.

Midslope areas gained importance in October, but no habitat category was preferred by females with older cubs at a statistically significant level. Movements into alpine denning areas began in November and by December the alpine was used significantly more often than expected.

Habitat Categories in Proximity to the Project

Land considered to be close (<500 m) and mid-distance (500-1,500 m) to project features made up 18.2% (140.8 km^2) of the core study area.

Alpine habitat categories comprised 39.7% (55.9 km^2) of the area, midslope comprised 27.8% (39.1 km^2) and lowlands comprised 32.5% (45.8 km^2). The alpine proportion is comparable to the amount present in the entire study area (40.3%), the midslope proportion is lower (33.1% for the entire study area) and the lowland proportion is greater (26.6% for the entire study area).

Twelve percent (n=568) of the total radio-collared bear observations were within 1500 m of project features. Seventy-two (12.7%) of these observations were of males, 233 (41.0%) were lone females, 64 (11.3%) were females with new cubs, and 199 (35.0%) were females with older cubs. These proportions were comparable to those recorded for the entire study area for lone females (42.8%) and females with new cubs (12.0%), but were lower for males (22.5% in the entire study area) and higher for females with older cubs (22.7% in the entire study area). Fifty-eight percent of the observations were during construction years (1982-84) and 42% were during the post-construction years (1985-86).

Within the 1,500 m proximity of project features, radio-collared bears appeared to use alpine areas 68.5% less often than expected during the entire year, compared to 24% less than expected in the entire study area. Midslope areas were used 45.0% greater than expected near the project compared to 33.5% greater than expected in the entire study area. Lowlands were used 45.2% more often than expected near project features compared to 5.3% less often than expected for the entire study area.

Sample sizes are not sufficient to analyze the data by month and reproductive status without undue bias from individual variation. Differing percentages of each reproductive status between the entire study area and the area near project features prohibits a statistical comparison of habitat use by the 2 sample populations.

There appeared to be higher use of lowlands and lower use of the alpine in areas near the project. Coincidentally, most salmon streams on the west side of Kizhuyak Bay and all salmon producing areas of Kizhuyak River and Watchout Creek are within 1,500 m of project features. These streams provide salmon for most bears ranging in the eastern portion of the study area. The paucity of observations in alpine areas may have been project related since 90.1% (64) of them were made after construction (1985-86) and only 9.9% (7) were during construction (1982-84).

Inter-annual Variation in Habitat Use

Bears in all reproductive categories exhibited some degree of inter-annual variation in their habitat use patterns (Figure 6). Although no empirical measurements of food resources other than salmon were available (Table 19), vegetative development apparently influenced many of these variations.

Lone females and females with older cubs had the greatest inter-annual variability in spring/summer alpine use. During 1985, a year when alpine vegetation was relatively late in emerging, females with older cubs had their lowest June use and highest July use of alpine areas during the study period. Lone females exhibited a similar but less pronounced use pattern. In 1984, a year of relatively early alpine phenology, a reverse pattern was noted. Lone females made their highest June use and lowest July use of alpine areas. No data were collected for females with older cubs in June 1984, but the lowest alpine use in July by this reproductive category occurred that year. Males and females with cubs-of-the-year did not exhibit obvious inter-annual variations in alpine use.

Salmon in lowland areas were important to bears in all reproductive categories during August of every year. In 1985, a year of delayed alpine development and poor berry crops in the study area, bears remained in lowland areas longer than during other years of the study, suggesting that salmon were particularly important that year.

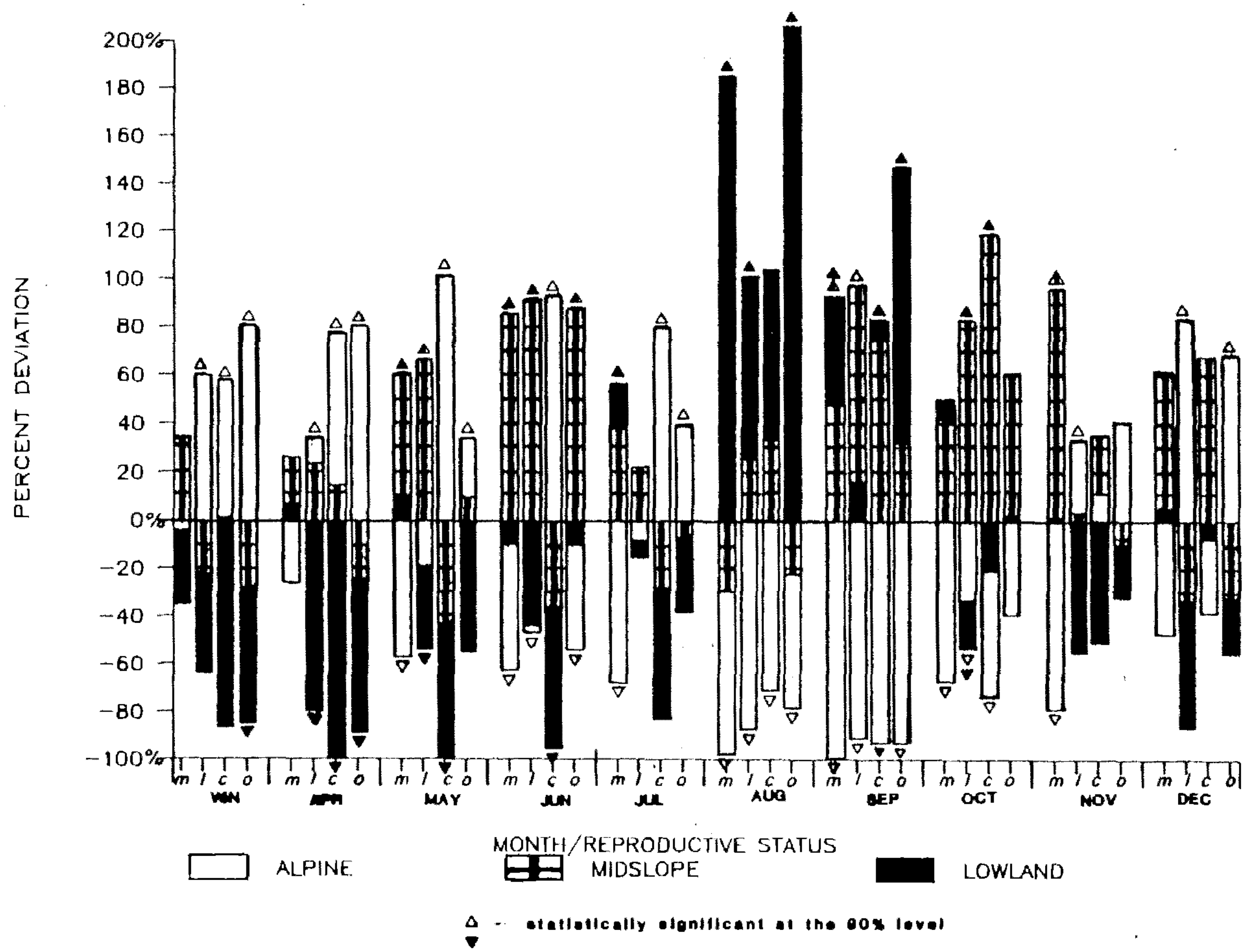


Figure 4. Intra-annual cover type use by radio-collared brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, as measured by the percent deviation from expected in 3 elevation categories, 1982-1986 (m=males; l=lone females; c=females with cubs-of-the-year; o=females with older cubs).

Table 17. Cover type use by radio-collared brown bears in the Terror Lake hydroelectric project area, Kodiak Island, Alaska, 1982-1986. (Percent deviation from expected).

	ALPINE				MIDSLOPES				LOWLAND			
Month	Males	Lone females	Females w/coy	Females w/old cubs	Males	Lone females	Females w/coy	Females w/old cubs	Males	Lone females	Females w/coy	Females w/ old cubs
Winter	-40%	+60*	+58%*	+81%*	+34%	-22%	+1%	-28%	-35%	-64%	-86%	-85%*
April	-26%	+34*	+77%*	+80%*	+26%	+23%	+14%	-24%	+7%	-80%*	-100%*	-89%*
May	-57*	-19%	+101%*	+34%*	+61%*	+66%*	-43%	+9%	+10%	-54%*	-100%	-56%
June	-63*	-46%*	+93%*	+54%*	+38%*	+91%*	-36%	+87%*	-10%	-44%	-95%*%	-10%
July	-68*	-8%	+80%*	+39%*	+38%	+22%	-28%	-7%	+56%*	-15%	-83%	-38%
August	-98*	-78%*	-71%	-78%*	-29%	+25%	+33%	-22%	+185%	+101%	+104%	+202%*
September	-100*	-91%*	-93%*	-93%*	+47*	+97%*	+74%*	+32%	+93%*	+16%	+83%	+147%*
October	-67%*	-33%*	-73%*	-39%	+42%	+83%*	+119%*	+61%*	+50%	-53%*	-21%	+2%
November	-79%*	-33%*	+11%	+40%	+96%	+3%	+35%	-12%	+1%	-55%	-51%	-33%
December	-47%	+83%*	-38%	+68%*	+61%	-33%	+67%	-32%	+5%	-86%	-7%	-55%

* statistically significant at $p < 0.1$

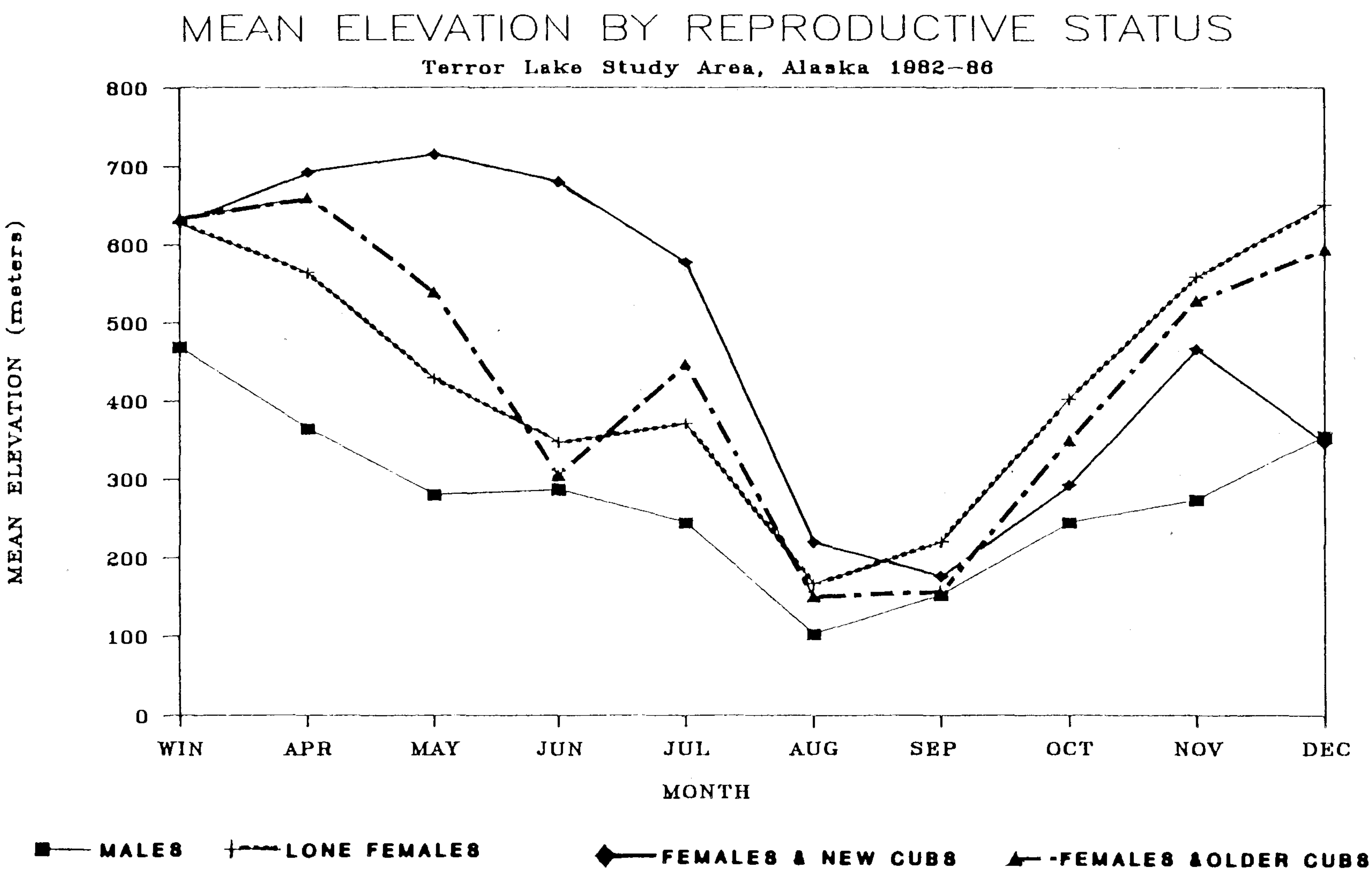


Figure 5. Mean elevations of radio-collared brown bears, by month, in the Terrror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986 (WIN=January, February and March)

Table 18. Mean elevations of radio-collared brown bear observations in the Teror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986 (sample sizes in parentheses).

Month	MEAN ELEVATION (meters)			
	Males	Lone Females	Females with new cubs	Females with older cubs
Winter	469 (70)	628 (93)	630 (33)	635 (92)
April	365 (134)	565 (192)	694 (56)	661 (132)
May	281 (109)	430 (196)	717 (53)	540 (122)
June	287 (121)	348 (213)	682 (90)	305 (97)
July	245 (147)	372 (293)	579 (80)	448 (150)
August	102 (153)	167 (307)	220 (68)	151 (144)
September	153 (131)	221 (263)	177 (71)	158 (133)
October	245 (115)	403 (282)	293 (65)	350 (118)
November	274 (81)	559 (158)	467 (38)	529 (69)
December	356 (28)	653 (54)	347 (20)	595 (31)

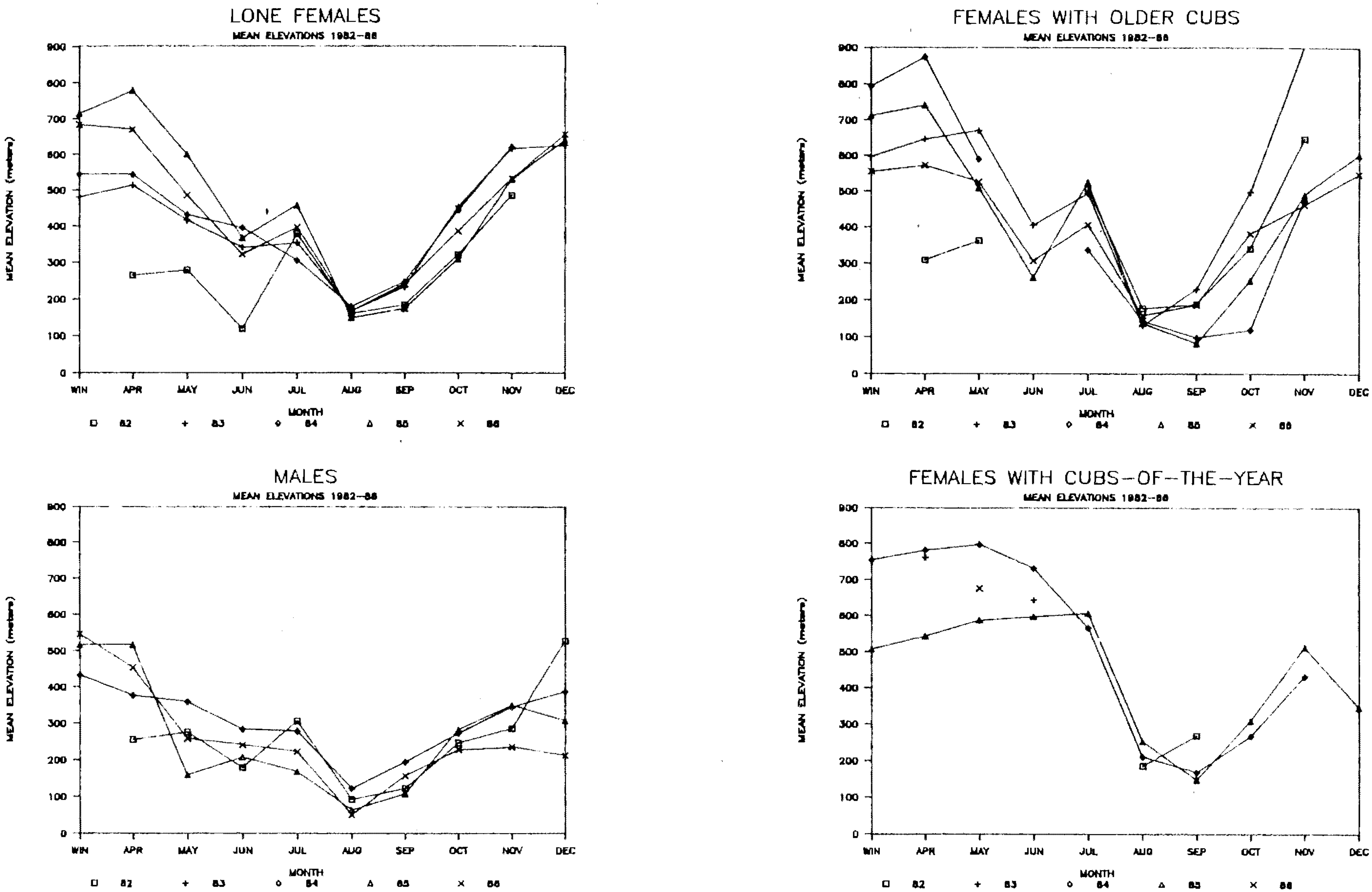


Figure 6. Inter-annual variation in mean elevations of observations of radio-collared brown bears in select reproductive categories in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986 (analyzed for sample sizes of at least 5 observations per month).

Table 19. Peak salmon escapement counts observed during aerial surveys of major streams in the Terror Lake hydroelectric project brown bear study area, Kodiak Island, Alaska, 1982-1986.

	Reported escapement by year and species[a] (thousands)														
	1982			1983			1984			1985			1986		
Location	Pink	Chum	Red	Pink	Chum	Red	Pink	Chum	Red	Pink	Chum	Red	Pink	Chum	Red
Terror River	33.5	12.9	---	38.3	10.1	---	68.0	10.0	---	80.0	3.0	---	196.0	10.0	---
Kizhuyak River	23.6	6.8	---	17.8	3.2	---	34.0	9.0	---	35.0	28.5	---	25.2	57.0	---
Elbow Creek	13.0	4.0	---	16.0	5.0	---	24.5	11.5	---	37.9	5.5	---	51.0	22.0	---
Baumann Creek	4.0	---	---	8.1	---	---	21.0	---	---	21.0	---	---	3.3	---	---
Hilary Creek	2.7[b]	---	---	0.4	---	---	2.5[b]	---	---	2.5	---	---	2.5	---	---
Barabara Creek	0.3	---	1.2	0.2	---	3.3	0.2	---	1.6	0.0	---	0.9	0.0	---	0.9
Pestchani Creek	0.4	---	---	0.6	---	---	2.7	---	---	1.6	---	---	4.0	---	---
Clara's Creek	ND[c]	---	---	1.2	---	---	3.2	---	---	4.1	---	---	ND[c]	---	---
Saltery Creek	25.0	8.0	28.0	28.0	5.0	46.4	28.0	10.0	120.0	28.0	6.0	26.0	23.0	0.2	38.3[d]

[a] - data from unpublished files of the Alaska Department of Fish and Game, Division of Commercial Fisheries; pink (humpback) salmon - Oncorhynchus gorbuscha, chum (dog) salmon - O. keta, red (sockeye) salmon - O. nerka

[b] - fish were observed in bay immediately adjacent to the mouth of the creek.

[c] - no data (no surveys conducted).

[d] - weir counts.

Denning

Methods

Data on denning chronology, den locations and bear reproductive status were collected during radio-tracking flights scheduled at weekly intervals. Den entrance dates were estimated to be between the last date a bear was known to be out of a den and the first date a bear was known to be in a den. Emergence dates were estimated to be between the last date a bear was closely associated with a den and the first date a bear was no longer associated with a den. Close association was considered to be daily use of the den itself, although some short forays from the den may have occurred. Denning periods were calculated as the maximum number of days in the den (MAXDAYS), the minimum number of days in the den (MINDAYS), and the average number of days in the den ((MINDAYS + MAXDAYS)/2). Estimated slope categories (flat, gentle - <30%, moderate - 30-45%, steep - >45%), aspects (8 categories based on true bearing), cover types and den locations were recorded in the field. Elevation and distance data were derived from USGS 1:63,360 topographic maps. Data on den construction were collected during annual visits to selected accessible dens during the summer.

Results

Denning Chronology

Bears began gradually to move into denning habitat in mid-October. Activities of bears observed during radio-tracking flights suggested that typical denning behavior consisted of periods of excavation activity interspersed with extended rest periods. Bears often made excavations in several adjacent locations before completing an acceptable den. In most cases, females entered dens earlier than did males, and pregnant females entered dens earlier than other lone females or females with cubs (Figure 7, Tables 20 and 21).

Den entrance dates of radio-collared females varied annually (Figure 8, Tables 22 and 23). Analysis of these variations was complicated by imprecise weather and food availability data, interannual variability in the number, timing, and coverage of radio-tracking flights, and unequal proportions of radio-collared bears in each reproductive category during each year of the study.

Radio-collared females had the latest den entrance dates in 1986 (Figure 8), the year with the highest autumn precipitation (October, November and December = 70.6 cm; 12.4 cm above average) and the second highest autumn temperatures (3.78^{oC}; 2.00^{oC} above average) noted during the study (Tables 24 and 25). Delayed denning during late November and December of 1982 and 1985 coincided with above average precipitation in those months (1982 - 53.6 cm, 20.6 cm above average; 1985 - 61.5 cm, 28.4 cm above average). Although these data suggest a correlation between warm, wet autumns and late den entrance, they are not sufficient to derive a consistent, direct relationship between den entrance chronology and weather patterns observed in Kodiak city each year.

Although a few individuals left their dens as early as February, den emergence generally began in early April. Typical emergence behavior consisted of opening the den entrance, long lethargic periods at the mouth of the den, short forays in the immediate den vicinity, and, finally, abandonment of the den site (emergence). Chronology of emergence was the inverse of entrance, with males emerging soonest, followed by lone females and females with yearling and older cubs. Females with newborn cubs were usually the last group to emerge. Consequently, males had the shortest mean denning period (mean = 132 days) and females with new cubs had the longest (mean = 202 days)(Figure 9).

Den emergence dates varied annually (Figure 9), but as with den entrance chronology, these variations could not be directly linked to weather phenomena. In den years 1983-84 and 1984-85 there appeared to be an inverse correlation between the chronology of entrance and emergence. In 1983-84 radio-collared females seemed to enter dens later and emerge from dens earlier than during other years. Conversely, during den year 1984-85 radio-collared females appeared to enter dens earlier and emerge from dens later than during other years.

Den Locations and Site Characteristics

Sixty-four bears (47 females and 17 males) were located at 184 den sites during this study (Figure 10, Appendix II). There were 108 dens (59%) in the Terror drainage, 59 (32%) in the Kizhuyak drainage, 9 (5%) in the Viekoda drainage, 4 (2%) in the Sharatin drainage, and 4 (2%) in the Uganik drainage.

Seventy-one percent of the dens (n=131) were located in alpine habitat (>450 m), 27% (n=50) in midslope areas (150-450 m), and 2% (n=3) in lowland areas (<150 m)(Table 26). There was no significant difference (p>0.1) between the habitat categories used for dens by radio-collared males and females; however, males occupied dens in midslope areas more frequently than did females (Table 27).

Den elevations ranged from 91 to 1,189 m, with a mean of 665 m (Table 28). Mean elevations of dens varied between years for both sexes, but no consistent trends were evident.

Sixty-five percent of the dens (n=120) were located on steep slopes (>45%; >41°), 30% (n=55) were on moderate slopes (30-45%; 27-41°), 5% (n=9) were on gentle slopes (<30%; <27°), and no dens were dug into flat areas (Table 29). Of the dens located on moderate or gentle slopes, 80% (51/64) were associated with cliffs or rock outcrops. Consequently, 93% (171/184) of the dens were in microhabitats with steep slopes. Males occupied dens on moderate slopes more often than did females; however, differences were not significant (p>0.1) (Table 30).

Thirty radio-collared individuals (26 females and 4 males) denned within areas described as "usable denning habitat" by Spencer and Hensel (1980). Thirty-eight percent (70/184) of the dens of radio-collared bears observed from 1982-1986 were within this zone. Ninety-one dens (49%) were at elevations above this zone, 4 (2%) were below it, and 19 (10%) were outside Spencer and Hensel's (1980) study area. Den concentrations near Baumann Creek and Leanne Mountain were included in this "usable habitat" zone, but den concentrations at Den Mountain were not.

Aspects of den sites were variable, with north and northeasterly aspects most frequent (42%; n=78) (Figure 11, Tables 31 and 32). South and southwesterly aspects were also common (28%; n=51).

Construction characteristics of dens could not always be accurately determined and some dens located by radio-tracking were not seen because of snow cover and rugged terrain. Most dens were apparently excavated into hillsides or under rock outcrops. Excavated snow dens and natural cavities in rock formations were also used, but not as commonly. Twenty-five dens were inspected on-site, including 15 excavated dens, 5 snow dens, 3 natural rock cavities, and 2 snow dens in rock cavities (Table 33).

Den characteristics varied annually (Tables 26, 28, 29 and 31). These variations were not consistent nor did they appear to correlate with weather patterns, sex of the bear, nor project activities.

Den Concentrations

Den Mountain and Baumann Creek were identified as significant den concentration areas (Figure 10). The 2 areas combined comprised only 1% (780 ha) of the core study area, but they contained 36% (67/184) of the dens of radio-collared bears, including 40% (64/161) of the dens of females and 13% (3/23) of the dens of males (Table 34).

Den Mountain is a 1,119 m glaciated peak about 2 km north of Terror River (T29S, R24W, Section 1, and, T29S, R23W, Sections 6 and 7). Most dens were located on steep tundra slopes and barren rock escarpments in north- and west-oriented cirques on Den Mountain. Natural cavities and excavated dens were used, but most dens appeared to be excavated.

Thirty-seven dens of 10 radio-collared bears were located on Den Mountain during this study, 95% (n=35) of which were occupied by females. Twenty-two percent (35/161) of the dens used by females and 9% (2/23) of those used by males in the study area were in this region. Unmarked bears exhibiting denning behavior were also observed in the area every year.

Radio-collared bears occupying Den Mountain exhibited a high degree of fidelity to den sites. Seventy-four percent (20/27) of the dens in this area were within 1 km of the den used during the previous year. The mean distance between dens of individual females in successive years was 1.0 km (n=25; range= 0.0-9.2 km). Both males (059, 095) that denned in the area were less than 5 years old and immediately vacated the area soon after emergence. Most of the females had home ranges that were restricted to the area between Terror River and Baumann Creek (Figure 12). A few ventured as far north as Viekoda Creek, but only 1 (064) was radio-located within 1,500 m of project features.

The middle reaches of Baumann Creek (T28S, R24W, Sections 2, 10, 11, and 12) flow through a narrow valley approximately 150-180 m in elevation, bordered by steep sides to 610 m. The south-facing slope is vegetated with dense alder thickets interspersed with rock outcrops. The valley floor is predominantly a grass/forb meadow with patches of willow and alder. The north-facing slope is predominantly a fractured rock cliff. Thirty dens of 9 radio-collared bears were located in this area during this study, 97% of which were occupied by females. Eighteen percent (29/161) of the dens of females and 4% (1/23) of the dens of males in the study area were in this area. Mean elevations of dens in Baumann Creek was 410 m, somewhat lower than the overall mean elevation of 665 m.

Although the dense vegetation and the fractured rocky terrain often precluded close observation of actual den sites, the use of natural rock cavities for dens appeared greater here than in other den concentration areas. Spencer and Hensel (1980) reported the use of natural rock cavities near Baumann Creek, the first record of natural cavity use by bears on Kodiak. Numerous unmarked bears were also observed in dens, further supporting the importance of this drainage for denning.

Throughout the study period, individual female bears denning near Baumann Creek exhibited a high degree of fidelity to previously used den sites (mean =1.58 km; n=18; range= 0.0-2.7 km). The only male bear (137) occupying a Baumann Creek den was an adult that had a main activity area adjacent to his den. Home ranges of females were generally restricted to areas between Terror River and Clara's Creek, but movements to Kizhuyak and Uganik Bay drainages were not uncommon (Figure 13). Only 1 female (015) was radio-located within 1,500 m of project activities or features.

Denning concentrations were also located in the Kizhuyak Bay drainage. Pestchani Mountain, a 948 m peak located east of the head of Kizhuyak Bay, contained 19 dens (18 occupied by females, 1 occupied by a male) of 6 individual bears (5 females, 1 subadult male). Leanne Mountain, a 1,116 m peak west of the head of Kizhuyak Bay, contained 11 dens of 5 bears (all females). Dens in both areas were mainly excavated near rock outcrops or cliffs.

<u>Fidelity to Den Sites</u>

Individual brown bears exhibited a high degree of fidelity to specific den sites throughout the study period. Data on successive den use were collected for 107 dens used by 42 radio-collared bears (Table 35). Fifty-one percent (55/107) of the bears occupied successive dens that were less than 1 km apart. Included were 8 instances in which females occupied the same den site during 2 successive seasons (019, 046-twice, 070, 078, 096, 099, and 121). Thirty-three percent (35/107) of the dens were 1 to 3 km apart and 16% (17/107) were more than 3 km apart in successive years. The mean distance between individual dens in successive years was 1.67 km (n = 107; range = 0.0 - 20.0 km). Males exhibited less fidelity to den sites (mean = 8.92 km; n = 4; range = 1.3 - 20.0 km) than did females (mean = 1.39 km; n = 103; range = 0.0 - 9.2 km), but sample sizes for males were too small to statistically confirm this difference.

Eight females (005, 011, 018, 022, 046, 051, 055 and 071) were radio-located in dens during each of the 5 denning periods covered by this study. Maximum distances between dens used by these individuals ranged from 0.7 to 9.2 km. Mean maximum distance was 4.1 km.

The relative proximity of several dens to project features during construction and operational phases of the project suggests that displacement of bears from traditional denning areas was not as serious a problem as had been predicted. Eleven dens of 6 individuals (Females 008, 011, 119, 131, 135 and Male 028) were located within 1500 m of project activities or features. Five of these dens were near powerlines, 3 were near the road, and 3 were near the dam. Two dens (008, 028) were occupied during the peak construction periods in the 1982-83 and 1983-84 denning seasons (1 near the road and 1 near a powerline). Pre-project den distribution surveys conducted by aerial reconnaissance in 1980 (Spencer and Hensel 1980) and in 1982 yielded 3 dens and 4 dens, respectively, at locations within 1,500 m of areas that were later occupied by project features.

Thirty-five dens of 17 radio-collared bears (15 females and 2 males) were located in the "primary impact area" described by Spencer and Hensel (1980). Thirteen of these dens were occupied during the 1982-83 and 1983-84 denning seasons, when construction activity was at its peak. Overall movements and interannual movements of den locations by individual radio-collared bears did not indicate that any project-related displacement of bear denning occurred within the "primary impact area."

Denning Anomalies

Twenty-four radio-collared bears did not conform to the conventional denning pattern of entering a single winter den and remaining in that den throughout the denning period. Sixteen individual females used 2 separate dens in 21 instances. In 12 cases, involving 7 males and 1 female, bears did not occupy winter dens.

Sixteen radio-collared females (005, 008, 015, 019, 020, 022, 046, 051, 055, 060, 070, 071, 078, 081, 086 and 129) used 2 dens in a single season on at least 1 occasion during the study period (Table 36). No radio-collared males exhibited this behavior. Females that used only 1 den during a season occupied dens that were at significantly higher elevations ($P<0.1$) (694 m) than the initial dens of females that moved dens within a season (579 m).

Characteristics of first and second den sites were not noticeably different. Mean elevations of second den sites (631 m) were higher than mean elevations of first den sites (579 m), but this difference was not statistically significant ($p>0.1$). Aspects and slopes of first and second den sites were similar. Mean distance between den sites was 1.5 km and distances ranged from 0.3 km to 8.9 km. None of the movements to second dens appeared related to disturbance from the project.

Ten of the 21 instances of second dens involved single (possibly pregnant) females or females that emerged with newborn cubs and 11 involved females with yearling or older cubs. No dens were moved in 1982-83, 1 was moved in 1983-84, 3 were moved in 1984-85, 13 were moved in 1985-86 and 4 were moved in 1986-87.

The high number of movements in 1985-86 coincided with a record December rainfall in Kodiak city (50.3 cm; 34.3 cm greater than the 30 year average).

Den entrance and emergence dates could not be ascertained accurately for bears using second dens, so timing of den movements and denning periods could not be specified. Using the average of the total known number of days in dens by all bears that used second dens provided an estimate of denning periods. The average number of days in first dens (mean = 52; n = 15) was significantly shorter ($p<0.5$) than the average number of days in second dens (mean = 84; n = 15).

Seven males (002, 003, 023, 079, 101, 120 and 139) in 11 instances apparently did not den during at least 1 of the winters that they were monitored. These represent 27% (7/26) of the individual males and 32% (11/34) of the denning periods for males during the study period. Non-denning did not appear to vary between years. Three cases occurred in 1982-83, 3 in 1983-84, 2 in 1984-85, 2 in 1986-87, and 1 in 1985-86. One bear (120) did not den for the 3 consecutive years he was monitored, 2 (002,023) did not den for 2 consecutive years, and 4 were monitored during only 1 denning season. Typical winter behavior of these bears apparently involved extended periods of lethargy in alder or spruce habitats, interspersed with movements over short distances.

Deciding whether or not an individual male was denned was not always a clearcut decision. One male (002) was originally reported as being denned within less than 1 km of the access road near the Kizhuyak tunnel portal in 1982-83. Although a den for this bear was never seen, he was radio-located 5 times from mid-November to early February at approximately the same location. By mid-March he had moved 300-400 m closer to project activities and was observed bedded under a large boulder for 3 consecutive days. During the following winter, this bear moved extensively and was observed in every month except January. We suspect that he made similar, albeit shorter, movements during the winter of 1982-83. In the final analysis, this bear was assigned to the nondenning category for both 1982-83 and 1983-84.

The only female that did not den (018) lost her cubs-of-the-year in October 1985 within her traditional home range near Baumann Creek. She spent the winter near the village of Port Lions, several kilometers from her previous home range. Village residents reportedly observed her foraging in the village landfill. She was found dead in May 1986 within 1 km of the landfill. Cause of death could be determined, but she appeared emaciated and had little subcutaneous fat.

Another female (019), which was believed to have entered her 1985-86 den with at least 1 yearling, left her den by mid-February and was alone when she was first observed on 4 March. She did not enter another den during that denning season.

Figure 7. Chronology of den entrance and emergence of radio-collared brown bears in each reproductive category, Terror Lake Hydroelectric Project study area, Kodiak Island, Alaska, 1982-1986.

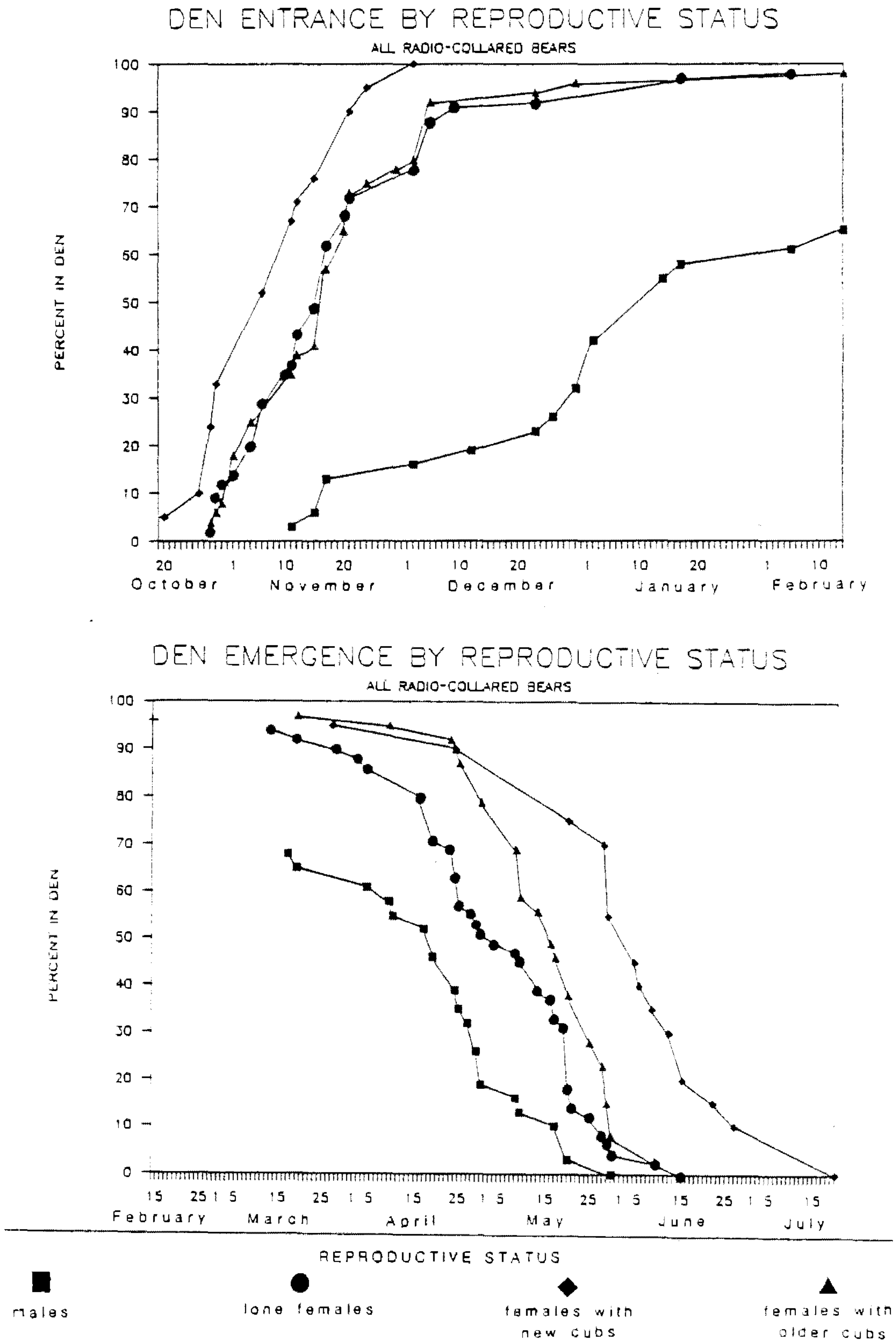


Table 20. Chronology of den entrance dates for radio-collared bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

	Males		Lone females[b]		Females with older cubs[b]		Females with new cubs[b]	
Date[a]	Cum.[c]	%[d]	Cum.	%	Cum.	%	Cum.	%
20 OCT	0	0	0	0	0	0	1	5
26 OCT	0	0	0	0	0	0	2	10
28 OCT	0	0	1	2	2	4	5	24
29 OCT	0	0	6	9	3	6	7	33
30 OCT	0	0	8	12	4	8	7	33
01 NOV	0	0	9	14	9	18	7	33
04 NOV	0	0	13	20	13	25	7	33
06 NOV	0	0	19	29	15	29	11	52
10 NOV	0	0	23	35	15	29	11	52
11 NOV	1	3	24	37	18	35	14	67
12 NOV	1	3	28	43	20	39	15	71
15 NOV	2	6	32	49	21	41	16	76
17 NOV	4	13	40	62	29	57	16	76
20 NOV	4	13	44	68	33	65	16	76
21 NOV	4	13	47	72	37	73	19	90
24 NOV	4	13	47	72	38	75	20	95
29 NOV	4	13	47	72	40	78	20	95
02 DEC	5	16	51	78	41	80	21	100
05 DEC	5	16	57	88	47	92	-	-
09 DEC	5	16	59	91	47	92	-	-
12 DEC	6	19	59	91	47	92	-	-
23 DEC	7	23	60	92	48	94	-	-
26 DEC	8	26	60	92	48	94	-	-
30 DEC	10	32	60	92	49	96	-	-
02 JAN	13	42	60	92	49	96	-	-
14 JAN	15	55	60	92	49	96	-	-
17 JAN	18	58	63	97	49	96	-	-
05 FEB	19	61	64	98	49	96	-	-
14 FEB	20	65	64	98	50	98	-	-
28 MAR	21	68	64	98	50	98	-	-
10 APR	21	68	64	98	51	100	-	-
(did not den)	(10)	(32%)	(1)	(2%)	(0)	-	(0)	-
TOTAL	31		65		51		21	

a - date of the first radio-tracking flight that an individual bear was in its den.

b - female reproductive status as determined at time of emergence; e.g. an adult female that entered a den alone and emerged with cubs-of-the-year is listed here as a female with new cubs, and a female that entered with cubs-of-the-year and emerged with yearlings is listed as a female with older cubs.

c - cumulative number of bears in dens; all denning instances by radio-collared bears, including those that did not den; in cases where bears used more than 1 den in a particular season, only data on entrance into the first den are used in this table.

d - percent of all bears in each reproductive category denned by a given date.

Table 21. Chronology of den emergence dates for radio-collared bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

	Males[b]		Lone females[b]		Females with older cubs		Females with new cubs	
Date[a]	Cum.[c]	%[d]	Cum.	%	Cum.	%	Cum.	%
(did not den)	10	32	1	2	0	0	0	0
14 FEB	10	32	2	4	0	0	0	0
13 MAR	10	32	3	6	0	0	2	2
17 MAR	10	32	3	6	0	0	2	4
19 MAR	11	35	4	8	1	3	2	4
27 MAR	11	35	4	8	1	3	1	5
28 MAR	11	35	5	10	1	3	1	5
02 APR	11	35	6	12	1	3	1	5
04 APR	12	39	7	14	1	3	1	5
09 APR	13	42	7	14	2	5	1	5
10 APR	14	45	7	14	2	5	1	5
16 APR	14	45	10	20	2	5	1	5
17 APR	15	48	10	20	2	5	1	5
19 APR	17	54	14	29	2	5	1	5
23 APR	17	54	15	31	3	8	1	5
24 APR	19	61	18	37	4	10	2	10
25 APR	20	65	21	43	5	13	2	10
27 APR	21	68	21	43	5	13	2	10
28 APR	21	68	22	45	5	13	2	10
29 APR	23	74	23	47	5	13	2	10
30 APR	25	81	24	49	8	21	2	10
03 MAY	25	81	25	51	8	21	2	10
08 MAY	26	84	26	53	12	31	2	10
09 MAY	27	87	27	55	16	41	2	10
13 MAY	27	87	30	61	17	44	2	10
16 MAY	27	87	31	63	20	51	2	10
17 MAY	28	90	33	67	21	54	2	10
19 MAY	28	90	34	69	21	54	2	10
20 MAY	30	97	40	82	24	62	5	25
21 MAY	30	97	42	86	24	62	5	25
25 MAY	30	97	43	88	28	72	5	25
28 MAY	30	97	45	92	30	77	6	30
29 MAY	30	97	46	94	33	85	9	45
30 MAY	31	100	47	96	36	92	9	45
04 JUN	-	-	47	96	36	92	11	55
05 JUN	-	-	47	96	36	92	12	60
08 JUN	-	-	47	96	36	92	13	65
09 JUN	-	-	48	98	38	97	13	65
12 JUN	-	-	48	98	38	97	14	70
15 JUN	-	-	49	100	39	100	16	80
22 JUN	-	-	-	-	-	-	17	85
27 JUN	-	-	-	-	-	-	18	90
20 JUL	-	-	-	-	-	-	20	100
TOTAL	31		49		39		20	

Table 21. Continued.

a - date of the first radio-tracking flight that an individual bear was no longer associated with its den.

b - all denning instances by radio-collared bears, including instances in which bears did not den; in cases where bears used more than one den in a particular denning period, only data on emergence from the second den are used in this table.

c - cumulative number of bears out of dens.

d - percent of all bears in each reproductive category out of their dens by a given date.

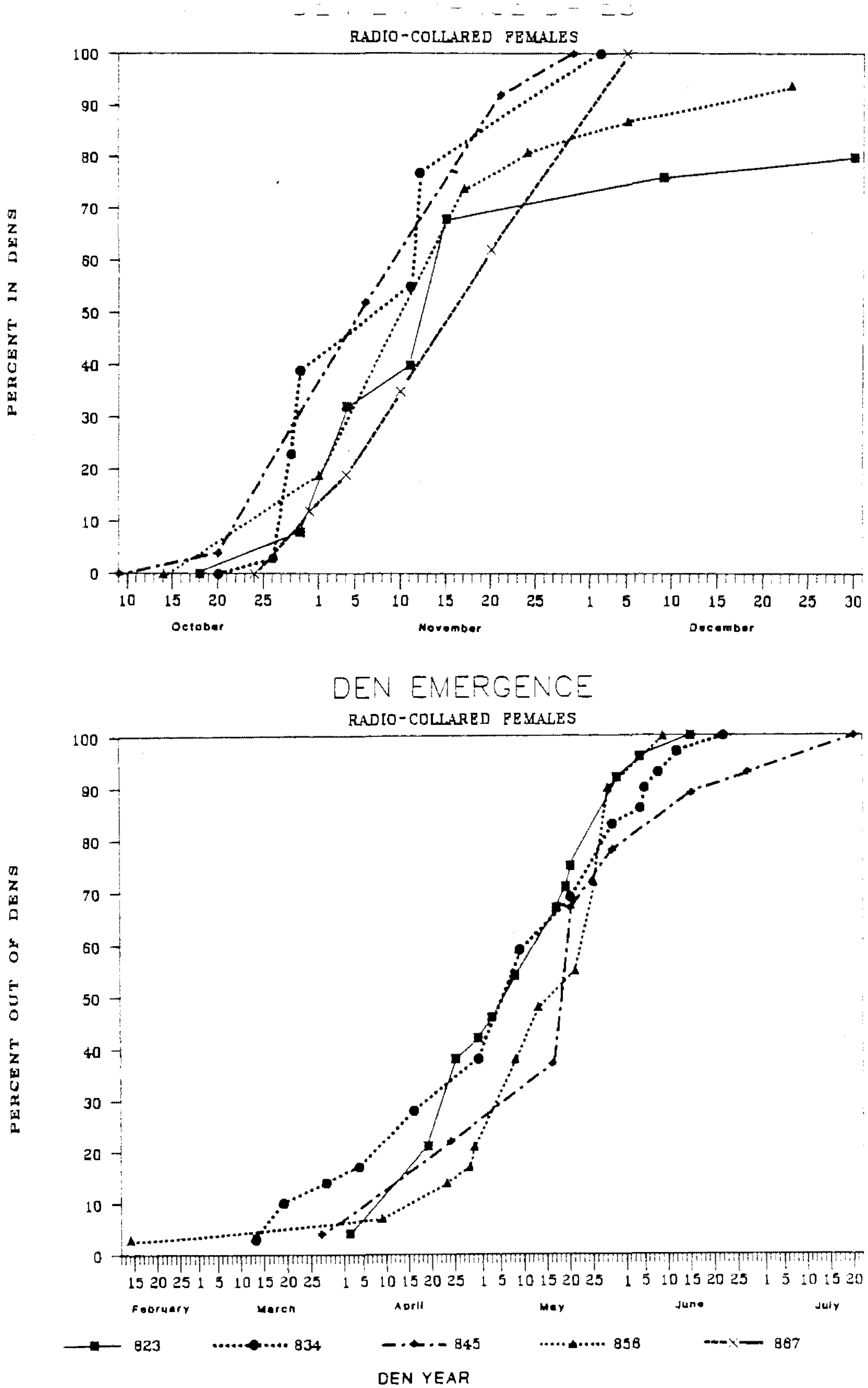


Figure 8. Chronology of den entrance and emergence of radio-collared female brown bears during each denning season, Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986 (Note: see Tables 22 and 23 for sample sizes and explanations).

Table 22. Interannual den entrance chronology of radio-collared females in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

	DEN YEAR									
	1982-83		1983-84		1984-85		1985-86		1986-87	
Date[a]	Cum.[b]	%[c]	Cum.	%	Cum.	%	Cum.	%	Cum.	%
20 OCT	0	0	0	0	1	4	0	0	0	0
26 OCT	0	0	1	3	1	4	0	0	0	0
28 OCT	0	0	7	23	1	4	0	0	0	0
29 OCT	2	8	5	40	1	4	0	0	0	0
30 OCT	2	8	5	40	1	4	0	0	3	11
01 NOV	2	8	5	40	1	4	6	21	3	11
04 NOV	8	33	5	40	1	4	6	21	5	19
06 NOV	8	33	5	40	13	52	6	21	5	19
10 NOV	8	33	5	40	13	52	6	21	9	33
11 NOV	10	42	17	57	13	52	6	21	9	33
12 NOV	10	42	24	80	13	52	6	21	9	33
15 NOV	16	67	24	80	13	52	6	21	9	33
17 NOV	17	71	24	80	13	52	22	76	9	33
20 NOV	17	71	24	80	13	52	22	76	17	63
21 NOV	17	71	24	80	23	92	22	76	17	63
24 NOV	17	71	24	80	23	92	24	83	17	63
29 NOV	17	71	24	80	26	100	24	83	17	63
02 DEC	17	71	30	100	-	-	24	83	17	63
05 DEC	17	71	-	-	-	-	26	90	27	100
09 DEC	19	79	-	-	-	-	26	90	-	-
23 DEC	19	79	-	-	-	-	28	97	-	-
30 DEC	20	83	-	-	-	-	28	97	-	-
17 JAN	22	92	-	-	-	-	28	97	-	-
05 FEB	23	96	-	-	-	-	28	97	-	-
14 FEB	23	96	-	-	-	-	29	100	-	-
10 APR	24	100	-	-	-	-	-	-	-	-
(did not den)	(0)		(0)		(0)		(0)		(0)	
TOTAL	24		30		26		30		27	

a - date of the first radio-tracking flight that an individual bear was in its den. (Note: Interannual variation in specific den entrance dates are influenced by the timing of radio-tracking flights).

b - cumulative number of bears in dens.

c - percent of all radio-collared female bears in each den year that were denned by a given date.

Table 23. Interannual den emergence chronology of radio-collared females in the Terror Lake Hydroelectric Project study area, Kodiak Island, Alaska, 1982-1986.

	DEN YEAR							
	1982-83		1983-84		1984-85		1985-86	
Date[a]	Cum.[b]	%[c]	Cum.	%	Cum.	%	Cum.	%
14 FEB	0	0	0	0	0	0	1	4
13 MAR	0	0	1	3	0	0	1	4
17 MAR	0	0	1	3	0	0	1	4
19 MAR	0	0	4	14	0	0	1	4
27 MAR	0	0	4	14	1	4	1	4
28 MAR	0	0	5	17	1	4	1	4
02 APR	0	0	5	17	1	4	1	4
04 APR	0	0	6	21	1	4	1	4
09 APR	0	0	6	21	1	4	2	7
10 APR	0	0	6	21	1	4	2	7
16 APR	0	0	9	31	1	4	2	7
17 APR	0	0	9	31	1	4	2	7
19 APR	4	17	9	31	1	4	2	7
23 APR	4	17	9	31	1	4	4	14
24 APR	4	17	9	31	6	22	4	14
25 APR	8	35	9	31	6	22	4	14
27 APR	8	35	9	31	6	22	4	14
28 APR	8	35	9	31	6	22	5	18
29 APR	8	35	9	31	6	22	6	21
30 APR	9	39	12	41	6	22	6	21
03 MAY	10	43	12	41	6	22	6	21
08 MAY	12	52	12	41	6	22	10	36
09 MAY	12	52	17	59	6	22	10	36
13 MAY	12	52	17	59	6	22	13	46
16 MAY	12	52	17	59	10	37	13	46
17 MAY	15	65	17	59	10	37	13	46
19 MAY	16	70	17	59	10	37	13	46
20 MAY	17	74	20	69	18	67	13	46
21 MAY	17	74	20	69	18	67	15	54
25 MAY	17	74	20	69	18	67	20	71
28 MAY	17	74	20	69	18	67	25	89
29 MAY	17	74	24	83	21	78	25	89
30 MAY	21	91	24	83	21	78	25	89
04 JUN	22	96	25	86	21	78	25	89
05 JUN	22	96	26	90	21	78	25	89
08 JUN	22	96	27	93	21	78	25	89
09 JUN	22	96	27	93	21	78	28	100
12 JUN	22	96	28	97	21	78	-	-
15 JUN	23	100	28	97	24	89	-	-
22 JUN	-	-	29	100	24	89	-	-
27 JUN	-	-	-	-	25	93	-	-
20 JUL	-	-	-	-	27	100	-	-
TOTAL	23		29		27		28	

Table 23. (continued).

a - date of the first radio-tracking flight that an individual bear was no longer associated with its den. (Note: Interannual variation in specific den emergence dates are influenced by the timing of radio-tracking flights).

b - cumulative number of bears out of dens.

c - percent of all radio-collared female bears in each den year that were denned by a given date.

Table 24. Average monthly temperatures (degrees Celcius) recorded by the National Weather Service at the Coast Guard Air Station, Kodiak Island, Alaska, 1982-1986.

Month	1982	1983	1984	1985	1986
January	0.4 (+0.5)[a]	-0.7 (-0.6)	0.4 (+0.5)	4.0 (+4.1)	-0.2 (-0.1)
February	-2.2 (-0.8)	2.8 (+4.2)	-3.6 (-2.2)	-1.8 (-0.4)	-0.9 (+0.5)
March	2.1 (+1.7)	4.7 (+4.3)	3.6 (+3.2)	-4.0 (-4.4)	0.2 (-0.2)
April	2.2 (-1.1)	5.4 (+2.1)	2.6 (-0.7)	-0.1 (-3.4)	1.3 (-2.0)
May	6.4 (+0.2)	8.1 (+1.9)	6.5 (+0.3)	5.3 (-0.9)	6.4 (+0.2)
June	9.6 (-0.2)	11.1 (+1.3)	10.7 (+0.9)	7.9 (-1.9)	8.6 (-1.2)
July	12.8 (+0.7)	13.9 (+1.8)	13.2 (+1.1)	11.3 (-0.8)	12.4 (+0.3)
August	12.8 (+0.1)	14.4 (+1.7)	14.2 (+1.5)	12.3 (-0.4)	11.7 (-1.0)
September	9.9 (0.0)	10.8 (+0.9)	10.7 (+0.8)	10.6 (+0.7)	10.3 (+0.4)
October	3.9 (-1.2)	6.0 (+0.9)	5.3 (+0.2)	2.5 (-2.6)	6.8 (+1.7)
November	2.5 (+1.0)	3.4 (+1.9)	1.1 (-0.4)	0.4 (-1.1)	2.4 (+0.9)
December	2.9 (+4.2)	3.4 (+4.7)	3.1 (+4.4)	2.4 (+3.7)	2.1 (+3.4)

a - deviation from 30-year average (1951-1980)

Table 25. Average monthly precipitation (centimeters) recorded by the National Weather Service at the Coast Guard Air Station, Kodiak Island, Alaska, 1982-1986.

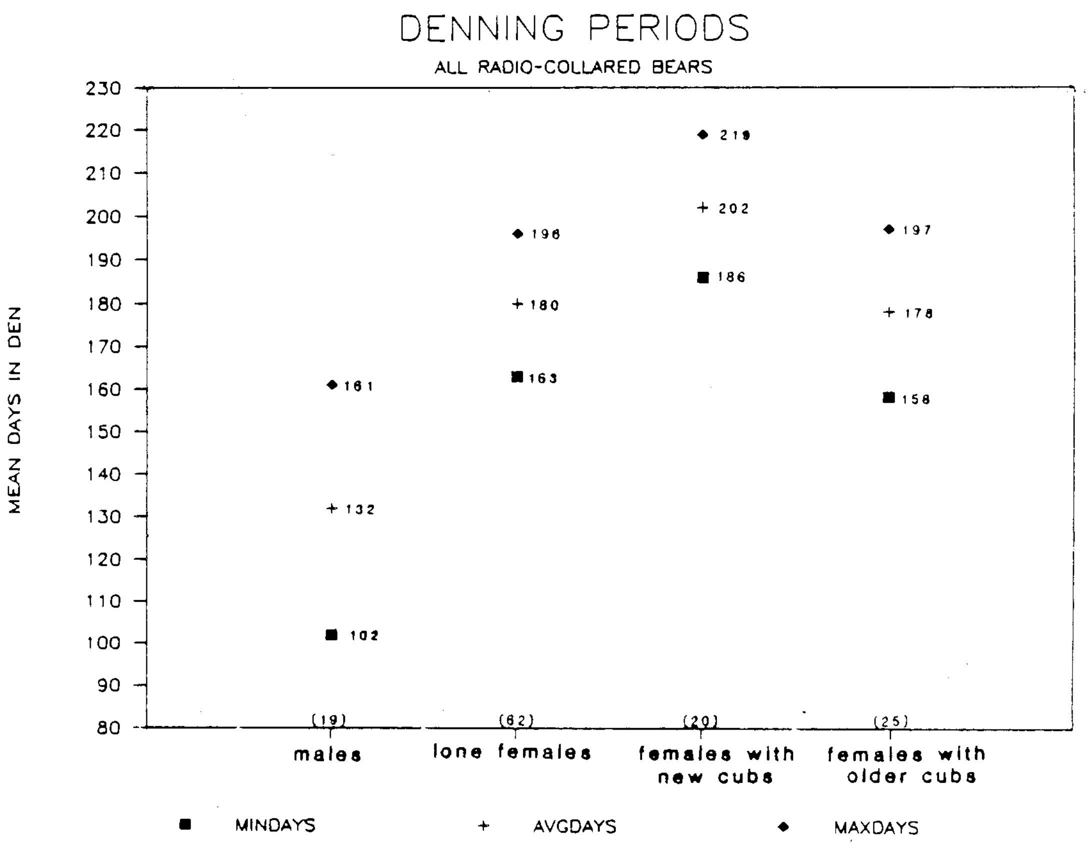
Month	1982	1983	1984	1985	1986
January	18.3 (-2.8)[a]	23.4 (+2.3)	25.7 (+4.6)	36.6 (+15.5)	29.5 (+8.4)
February	5.3 (-10.7)	19.3 (+3.3)	14.7 (-1.3)	4.8 (-11.2)	16.0 (+0.8)
March	5.1 (-5.3)	21.1 (+10.7)	25.1 (+14.7)[b]	14.5 (+4.1)	11.7 (+1.3)
April	9.1 (-3.1)	5.8 (-6.4)	16.0 (+3.8)	14.7 (+2.5)	6.9 (-5.3)
May	14.2 (-5.3)	32.3 (+12.7)[b]	12.4 (-7.1)	3.8 (-15.7)	5.6 (-14.0)
June	18.5 (+9.9)	20.1 (+11.4)	13.2 (+4.6)	16.8 (+8.1)	33.5 (+24.9)
July	9.7 (-0.3)	5.6 (-4.3)	7.6 (-2.3)	25.9 (+16.0)[b]	6.9 (-3.0)
August	5.6 (-7.6)	1.8 (-11.4)[c]	3.6 (-9.7)	7.6 (-5.7)	16.0 (+2.8)
September	25.7 (+6.4)	7.4 (-11.9)	21.3 (+2.0)	20.6 (+1.3)	5.6 (-13.7)
October	8.9 (-16.5)	13.7 (-11.7)	8.1 (-17.3)	8.4 (-17.0)	27.4 (+2.0)
November	19.3 (+2.3)	39.1 (+22.1)	12.7 (-4.3)	11.1 (-5.8)	13.7 (-3.3)
December	34.3 (+18.3)	6.1 (-9.9)	14.0 (-2.0)	50.3 (+34.3)[b]	29.5 (+13.7)

a - deviation from 30-year average (1951-1980).

b - record high rainfall for that month.

c - record low rainfall for that month.

Figure 9. Average denning periods of radio-collared brown bears in each reproductive category, Terror Lake Hydroelectric Project study area, Kodiak Island, Alaska, 1982-1986.



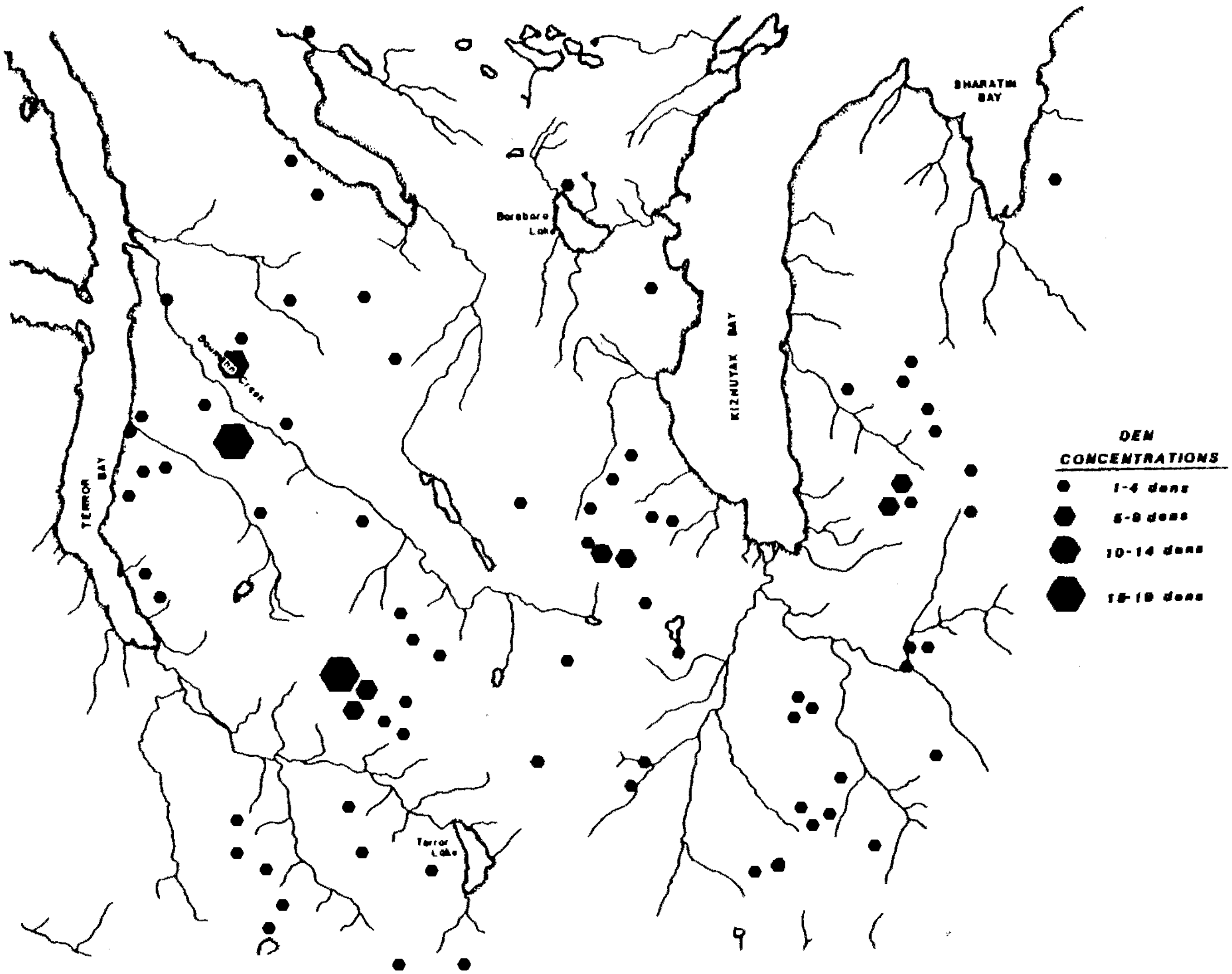


Figure 10. Den locations of radio-collared brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

Table 26. Annual distribution of den locations by cover type/elevation for radio-collared brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

	Cover Type			
Den Year	Lowland (<150m)	Midslope (150-450 m)	Alpine (>450 m)	TOTAL
1982-83	0 (0%)	14 (41%)	19 (59%)	33
1983-84	0 (0%)	10 (31%)	25 (69%)	35
1984-85	2 (5%)	8 (22%)	27 (73%)	37
1985-86	1 (2%)	12 (26%)	34 (72%)	47
1986-87	0 (0%)	6 (19%)	26 (81%)	32
TOTAL	3 (2%)	50 (27%)	131 (71%)	184

Table 27. Distribution of den locations by cover type/elevation for radio-collared male and female brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

	Cover Type			
Sex	Lowland (<150 m)	Midslope (150-450 m)	Alpine (>450 m)	TOTAL
Male	0 (0%)	9 (39%)	14 (61%)	23
Female	3 (2%)	41 (25%)	117 (73%)	161
TOTAL	3 (2%)	50 (27%)	131 (71%)	184

Table 28. Mean elevations of dens used by radio-collared brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

Den Year	Mean den elevation in meters (range; sample size) Males	Females	All Bears
1982-83	562 (305-1006; 9)	632 (152-1036; 24)	613 (152-1036; 33)
1983-84	621 (274-1006; 4)	738 (335-1189; 31)	725 (274-1189; 35)
1984-85	786 (427-1097; 5)	686 (91-1128; 32)	699 (91-1128; 37)
1985-86	671 (366-1128; 4)	634 (244-1097; 43)	637 (244-1128; 47)
1986-87	305 (305; 1)	669 (198-1097; 31)	657 (198-1097; 32)
TOTAL	629 (274-1128;23)	671 (91-1189;161)	665 (91-1189;184)

Table 29. Slope of den sites, by year, used by radio-collared brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

Den Year	Flat (0%[a])	Gentle (<30%)	Moderate (30-45%)	Steep (>45%)	TOTAL
1982-83	0 (0%[b])	0 (0%)	10 (28%)	23 (72%)	33
1983-84	0 (0%)	3 (8%)	5 (17%)	27 (75%)	35
1984-85	0 (0%)	1 (3%)	10 (27%)	26 (70%)	37
1985-86	0 (0%)	4 (9%)	19 (40%)	24 (51%)	47
1986-87	0 (0%)	1 (3%)	11 (34%)	20 (63%)	32
TOTAL	0 (0%)	9 (5%)	55 (30%)	120 (65%)	184

a - percent slope; slopes were estimated visually and some error and/or overlap probably occurred because of variability between observers and mis-judgments.

b - percent of total.

Table 30. Slope of den sites used by radio-collared male and female brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

Sex	Flat (0%[a])	Gentle (<30%)	Moderate (30-45%)	Steep (>45%)	TOTAL
Male	0 (0%[b])	0 (0%)	13 (57%)	10 (43%)	23
Female	0 (0%)	9 (6%)	42 (26%)	110 (68%)	161
TOTAL	0 (0%)	9 (5%)	55 (30%)	120 (65%)	184

a - percent slope; slopes were estimated visually and some error and/or overlap probably occurred because of variability between observers and mis-judgments.

b - percent of total.

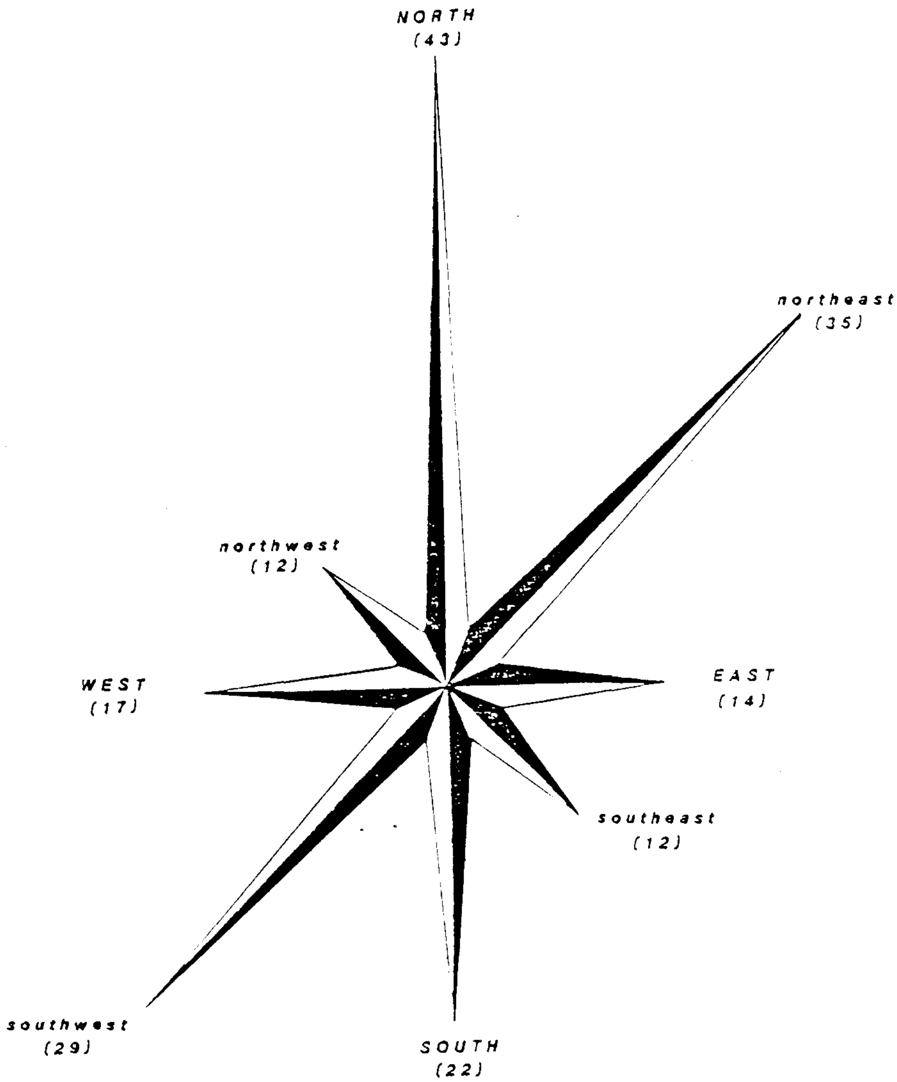


Figure 11 . Aspects of den sites used by radio-collared brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986 (sample sizes in parentheses).

Table 31. Aspects of dens, by year, used by radio-collared brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986 (percent in parentheses).

Den Year	DEN SITE ASPECT North	Northeast	East	Southeast	South	Southwest	West	Northwest	TOTAL
82-83	6 (19)	8 (25)	4 (13)	2 (6)	1 (3)	7 (22)	2 (6)	3 (9)	33
83-84	11 (31)	5 (14)	1 (3)	2 (6)	6 (19)	7 (19)	2 (6)	1 (3)	35
84-85	7 (19)	7 (1)	2 (5)	4 (11)	5 (14)	8 (22)	4 (11)	0 (0)	37
85-86	11 (23)	10 (21)	4 (9)	3 (6)	6 (13)	6 (13)	3 (6)	4 (9)	47
86-87	8 (25)	5 (16)	3 (9)	1 (3)	4 (13)	1 (3)	6 (19)	4 (13)	32
TOTAL	43 (23)	35 (19)	14 (8)	12 (7)	22 (12)	29 (16)	17 (9)	12 (7)	184

Table 32. Aspects of dens used by radio-collared male and female brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986 (percent inparentheses).

Den Year	North	Northeast	East	Southeast	South	Southwest	West	Northwest	TOTAL
	DEN SITE ASPECT								
Male	4 (17)	5 (22)	2 (9)	2 (9)	4 (17)	3 (13)	1 (4)	2 (9)	23
Female	39 (25)	30 (19)	12 (7)	10 (6)	18 (11)	26 (16)	16 (10)	10 (6)	161
TOTAL	43 (23)	35 (19)	14 (8)	12 (7)	22 (12)	29 (16)	17 (9)	12 (7)	184

Table 33. Construction characteristics of inspected dens used by radio-collared brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-86.

Bear Number	Den year used	Status[a]	Date visited	Structure type[b]	Entrance size (m)	Chamber size (m)	Comments
004	82-83	M	08/15/83	dug	1.4*1.6	1.2*1.3*1.4	
005	82-83	FNC	07/14/83	dug	0.4*0.6	0.6*0.6*0.9	
005	83-84	FCY	08/29/84	snow	-------	-----------	first of two dens
005	83-84	FCY	08/29/84	dug	no data	no data	helicopter visit
007	82-83	M	07/14/83	dug	0.9*0.5	1.1*1.3*1.2	
014	82-83	M	08/16/83	snow	-------	-----------	
037	82-83	FN	09/16/83	dug	-------	0.8*1.1*1.4	part collapsed
037	83-84	FN	08/29/84	dug	1.0*0.8	1.0*1.5*3.0	
040	83-84	M	08/29/84	dug	no data	no data	helicopter visit
044	82-83	FN	07/15/83	snow/dug	-------	-----------	collapsed
044	84-85	FN	08/28/85	snow	-------	-----------	
046	82-83	FYN	09/15/83	snow	-------	-----------	
059	82-83	M	09/15/83	snow/rock	-------	-----------	
070	82-83	FN	08/15/83	snow	-------	-----------	
070	83-84	FNC	08/29/84	dug	no data	no data	helicopter visit
071	82-83	FN	08/15/83	dug	-------	-----------	collapsed
072	83-84	FN	08/29/84	rock	2.0*0.8	4.0*4.0*1.5	
074A	82-83	FY2	07/15/83	rock	2.8*0.9	1.2*2.7*0.9	1 of 2 chambers
074B	82-83	FY2	07/15/83	rock	0.5*0.8	0.9*0.9*1.9	2 of 2 chambers
074	83-84	FNC	08/29/84	dug	no data	no data	helicopter visit
091	84-85	FCN	06/27/85	dug	-------	-----------	collapsed
092	83-84	FN	08/29/84	dug	no data	no data	helicopter visit

Table 33. Continued.

Bear Number	Den year used	Status[a]	Date visited	Structure type[b]	Entrance size (m)	Chamber size (m)	Comments
096	83-84	FN	08/29/84	rock	2.0*0.5	0.9*0.9*1.7	two entrances
096	84-85	FNC	08/28/85	dug	0.5*0.7	0.6*0.6*1.5	part collapsed
096	85-86	FCN	06/25/86	dug	-------	-----------	same den as 84/5
099	84-85	FN	08/25/85	snow/rock	-------	-----------	

a - Reproductive status of the bear when it occupied the den: M = male; FN = lone female; FNC = female entered alone, emerged with cubs-of-the-year (coy); FCY = female entered with coy, emerged with yearlings; FCN = female entered with coy, emerged alone; FY2 = female entered with yearlings, emerged with 2-year-olds; FYN = female entered with yearlings, emerged alone.

b - Den construction type: dug = den was excavated in ground; snow = den was excavated entirely in snow; rock = den was in a natural rock cavity.

Table 34. Characteristics of denning concentration areas in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

Concentration Area	Number of Individual Bears		Number of Dens Used		Mean Den Elevation (meters)	Elevation Range (meters)	Drainage
	Male	Female	Male	Female			
Den Mountain	2	8	2	35	945	640-1067	Terror
Baumann Creek	1	8	1	29	410	122- 625	Terror
Pestchani Mtn	1	5	1	18	697	213- 853	Kizhuyak
Leanne Mtn	0	5	0	11	945	838-1036	Kizhuyak

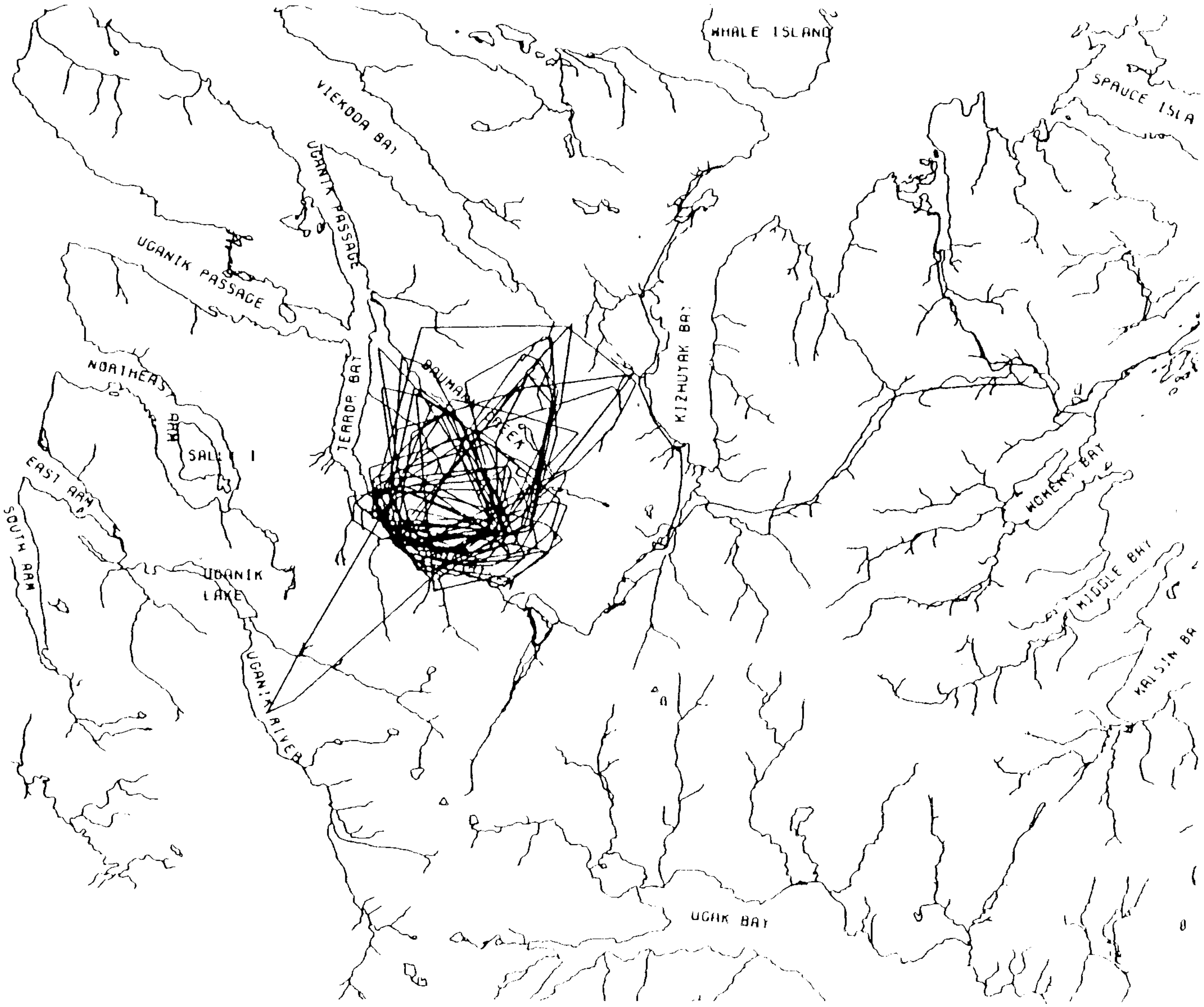


Figure 12. Annual home range polygons of radio-collared brown bears that denned in the Den Mountain area, Kodiak Island, Alaska, 1982-1986.

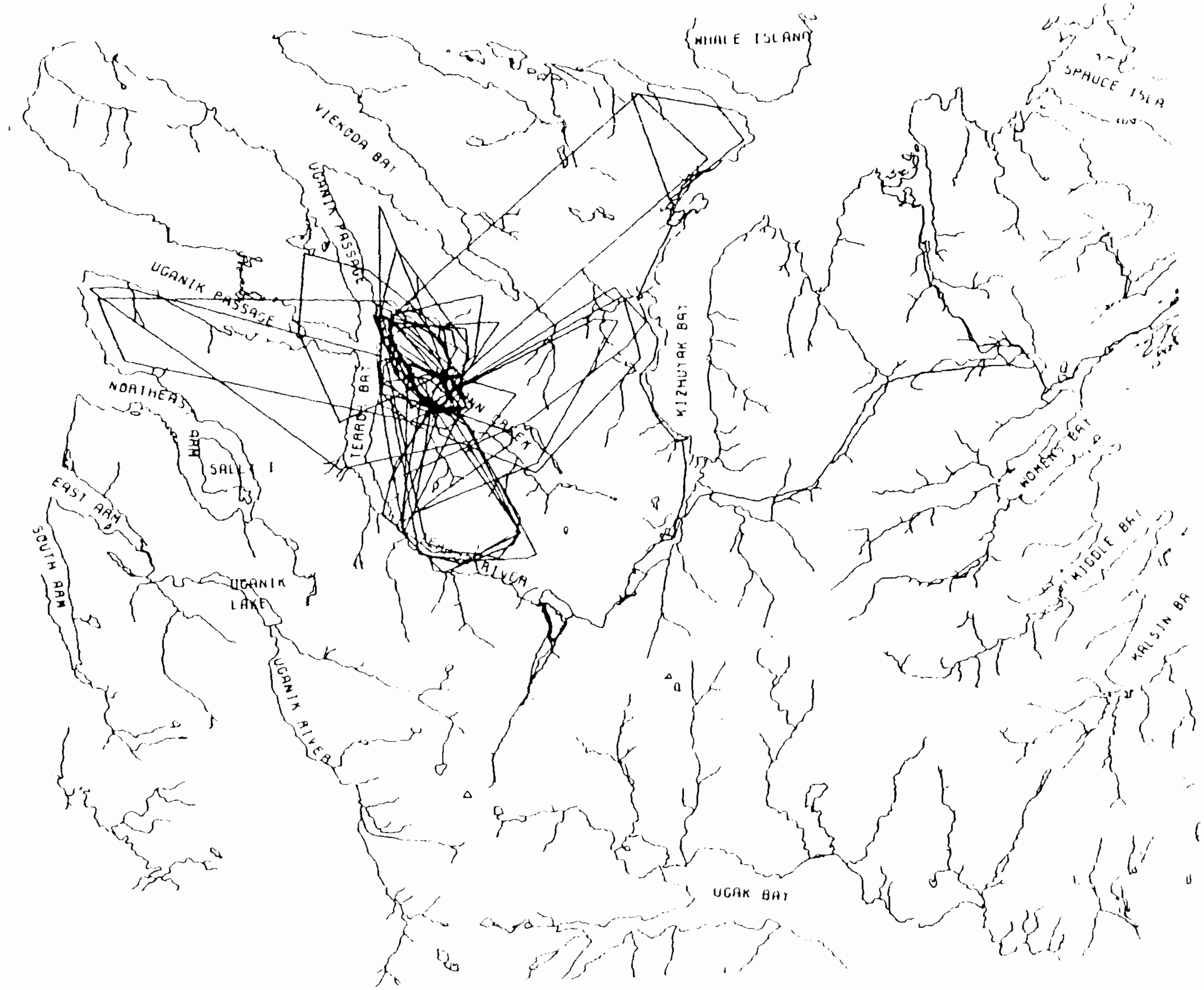


Figure 13. Annual home range polygons of radio-collared brown bears that denned in the Baumann Creek area, Kodiak Island, Alaska, 1982-1986.

Table 35. Distance between dens of individual radio-collared brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986. (Second den site distances in parentheses).

Bear Number	Distance between dens in successive years (kilometers) 82/83-83/84	83/84-84/85	84/85-85/86	85/86-86/87	Maximum distance 1982-87
FEMALES					
005	1.2 (1.1)	1.8 (0.6)	0.8 (0.6)	1.1	2.3
008	-	-	-	0.4	-
011	0.5	4.1	5.5	7.8	7.8
015	0.5	0.4	0.3 (1.5)	-	-
017	0.5	-	-	-	-
018	1.1	1.9	-	-	-
019	2.0	3.4	3.4	0.0 (0.8)	4.5
020	-	0.8	1.4	1.9 (2.3)	-
022	0.2	3.4	1.0	0.5	3.4
037	4.0	3.7	-	-	-
038	0.4	0.6	0.1	-	-
044	1.7	0.9	0.5	0.7	-
046	1.2	0.0	0.0	1.7 (0.3)	1.7
048	0.1	0.1	-	-	-
051	0.2	0.8	9.2 (0.9)	0.2 (0.5)	9.2
055	0.2	0.3	0.3 (0.3)	0.2	0.7
060	3.6	-	-	0.1	-
064	0.1	0.1	-	2.1 (1.5)	-
067	2.5	2.3	-	-	-
070	0.1	0.0	3.7 (0.2)	-	-
071	2.2	1.8	2.9 (1.1)	0.7	3.2
072	2.3	0.2	-	-	-
074	2.5	-	-	-	-
078	-	0.0	3.2 (2.3)	-	-
081	-	0.4	3.3 (3.5)	-	-
085	-	0.4	-	-	-
086	-	1.0	0.8	1.8	-
091	-	0.1	-	-	-
096	-	1.8	0.0	-	-
099	-	-	0.0	0.3	-
119	-	-	0.8	-	-
121	-	-	0.0	-	-
123	-	-	1.3	-	-
128	-	-	-	0.8	-
129	-	-	-	1.2	-
131	-	-	-	3.0	-
132	-	-	-	1.2	-
133	-	-	-	0.2	-
135	-	-	-	4.0	-

Table 35. Continued.

Bear Number	Distance between dens in successive years (kilometers) 82/83-83/84	83/84-84/85	84/85-85/86	85/86-86/87	Maximum distance 1982-87
MALES					
024	12.4	-	-	-	-
059	20.0	2.0	-	-	-
100	-	-	1.3	-	-

Table 36. Characteristics of den sites used by radio-collared female brown bears that occupied more than 1 den in a given denning season in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

Bear[a]	Age	ASN	Habitat	ELV	SLP	ASP	EARLY IN	LATE IN	EARLY OUT	LATE OUT	MIN	MAX	RNG	AVG	DNYR	Location	Dist.
005	15	CY	ALPSNW	701	S	N	831020	831111	840313	840319	123	151	28	137	834	PESTCHANI MTN	0.5
005	15	CY	ALPSNW	732	S	N	840313	840319	-	-	-	-	-	-	834	PESTCHANI MTN	0.5
005	16	Y2	ALPSNW	671	S	E	841106	841121	850102	850313	42	127	85	84	845	PESTCHANI MTN	0.8
005	16	Y2	ALPSNW	853	M	NE	850102	850313	850424	850520	42	138	96	90	845	PESTCHANI MTN	0.8
005	17	23	ALPSNW	762	S	NE	851014	851101	851124	851223	23	70	47	96	856	PESTCHANI MTN	1.3
005	17	23	ALPSNW	853	M	E	851124	851223	860429	860508	127	165	38	146	856	PESTCHANI MTN	1.3
008	15	Y2	LOWCLF	122	S	N	851014	851101	851223	860214	52	123	71	88	856	WATCHOUT CR	1.0
008	15	Y2	MIDSNW	305	M	SW	851223	860214	860429	860508	74	136	62	105	856	WATCHOUT CR	1.0
015	11	N	MIDCLF	366	S	NE	851101	851117	851229	860214	47	105	58	76	856	BAUMANN CR	1.4
015	11	N	MIDSNW	366	M	NE	851229	860214	-	-	-	-	-	-	856	BAUMANN CR	1.4
019	10	N	ALPCLF	564	S	W	861024	861104	-	-	-	-	-	-	867	BAUMANN CR	0.8
019	10	N	ALPCLF	579	S	NE	861110	861120	-	-	-	-	-	-	867	CLARA'S CR	0.8
020	9	NC	MIDMIX	213	M	S	841026	841106	841121	850313	15	138	123	76	845	BAUMANN CR	0.8
020	9	NC	MIDMIX	396	S	SW	841121	850313	850313	850327	0	126	126	63	845	BAUMANN CR	0.8
020	10	CY	MIDSHB	381	M	SW	851124	851205	860214	860304	71	100	29	86	856	BAUMANN CR	1.4
020	10	CY	ALPCLF	518	S	NE	860214	860304	860513	860525	70	100	30	85	856	BAUMANN CR	1.4
020	10	Y2	ALPCLF	579	S	W	861110	861120	-	-	-	-	-	-	856	BAUMANN CR	0.7
020	10	Y2	ALPSHB	488	M	NW	861120	861205	-	-	-	-	-	-	856	BAUMANN CR	0.7
022	10	NC	ALPSHB	518	M	N	841026	841106	850328	850415	142	171	29	156	845	FALLS CR/TERROR	1.3
022	10	NC	MIDSNW	366	S	W	850328	850415	850529	850615	44	79	35	62	845	TERROR BAY	1.3
046	10	NC	ALPCLF	762	M	N	861110	861120	-	-	-	-	-	-	867	DEN MTN	1.7
046	10	NC	ALPSNW	884	S	N	861120	861205	-	-	-	-	-	-	867	DEN MTN	1.7
051	12	N	MIDCLF	396	S	N	851014	851117	851205	851223	18	70	52	44	856	BAUMANN CR	8.9
051	12	N	ALPCLF	914	S	N	851229	860106	860429	860513	113	135	22	124	856	DEN MTN	8.9
051	12	N	ALPCLF	975	S	NW	861030	861110	-	-	-	-	-	-	867	DEN MTN	0.3
051	12	N	ALPSNW	1036	S	S	861120	861205	-	-	-	-	-	-	867	DEN MTN	0.3
055	17	CN	ALPCLF	945	M	N	851014	851101	851101	851117	0	34	34	17	856	DEN MTN	0.8
055	17	CN	ALPCLF	945	S	NE	851101	851117	860429	860513	163	193	30	178	856	DEN MTN	0.8
060	18	N	ALPSNW	716	M	NW	851101	851117	851124	851223	7	52	45	30	856	HILARY CR	0.5
060	18	N	ALPCLF	610	S	N	851124	851223	860521	860525	149	182	33	166	856	HILARY CR	0.5

Table 36. Continued.

Bear[a]	Age	ASN	Habitat	ELV	SLP	ASP	EARLY IN	LATE IN	EARLY OUT	LATE OUT	MIN	MAX	RNG	AVG	DNYR	Location	Dist.
070	8	Y2	ALPCLF	579	S	NE	851101	851117	851117	851217	0	46	46	23	856	ELBOW MTN	3.8
070	8	Y2	ALPSNW	732	S	S	851217	851223	860521	860525	149	159	10	154	856	PESTCHANI MTN	3.8
071	12	Y2	ALPCLF	579	M	E	851101	851117	851117	851223	0	52	52	26	856	WATCHOUT CR	1.9
071	12	Y2	ALPSNW	686	M	E	851117	851223	860429	860513	127	177	50	152	856	WATCHOUT CR	1.9
078	11	N	ALPSNW	732	G	S	851205	851223	851223	851229	0	24	24	12	856	ELBOW MTN	1.8
078	11	N	ALPSNW	686	G	SW	851223	851229	860423	860428	115	126	11	120	856	PESTCHANI MTN	1.8
081	13	Y2	ALPSNW	732	M	NE	851101	851117	851117	851223	0	52	52	26	856	WATCHOUT CR	0.4
081	13	Y2	ALPTND	716	M	E	851117	851223	860521	860525	149	189	40	169	856	WATCHOUT CR	0.4
086	11	N	MIDMIX	335	M	SW	851101	851117	860214	860304	89	123	34	106	856	BAUMANN CR	0.8
086	11	N	MIDCLF	335	S	NE	860304	860321	860409	860423	19	50	31	34	856	BAUMANN CR	0.8
129	12	CY	ALPCLF	518	S	N	851014	851101	851205	851223	34	70	36	52	856	VIEKODA BAY	1.0
129	12	CY	MIDMIX	244	M	N	851229	860106	860429	860508	113	130	17	122	856	VIEKODA BAY	1.0

a - Bear: bear number

Age: cementum age from analysis of lower premolar tooth

ASN: association: N=alone, NC-entered den alone and emerged with new cubs, CN=entered with new cubs and emerged alone; CY=entered with new cubs and emerged with yearlings; YN=entered with yearlings and emerged alone; Y2=entered with yearlings and emerged with 2-year-olds; 2N=entered with 2-year-olds and emerged alone; 23=entered with 2-year-olds and emerged with 3-year olds.

Habitat: a 2-part description of the vegetative cover 1 HA around the den site. The first 3 characters refer to the elevation category: ALP=alpine (>450 m); MID=midslope (150-450 m); LOW=lowland (<150 m). The second characters refer to the vegetative category as described in Appendix, e.g. SNW=snow, CLF=cliff, MIX=mixed shrub/grass complex, SHB=shrub complex, TND=tundra, GRS=grass.

ELV: elevation above sea level in meters.

SLP: S=steep (>45%), M=moderate (30-45%), G=gentle (<30%).

ASP: N=north, NE=northeast, E=east, SE=southeast, SW=southwest, W=west, NW-northwest; all aspects are based on true north.

EARLY IN: date of the last radio-tracking flight that a bear was deemed out of the den. Note: all dates are in decending order (year, month, day), e.g. 831020=20 OCT 83.

LATE IN: date of the first radio-tracking flight that a bear was deemed in the den.

Table 36. Continued.

EARLY OUT: date of the last radio-tracking flight that a bear was deemed in the den.
LATE OUT: date of the first radio-tracking flight that a bear was deemed out of the den.
MIN: minimum number of days in the den (LATE IN through EARLY OUT).
MAX: maximum number of days in the den (EARLY IN through LATE OUT).
RNG: range of days between MIN and MAX.
AVG: average number of days in the den (MIN+MAX/2).
DNYR: den year, e.g. 834 is den year 1983/1984.
Location: drainage in which den was located.
Distance: linear distance in kilometers between successive den sites in a given year.

Movements and Habitat Use by Radio-collared Bears

Methods

Radio-collared bears were re-located by fixed-wing aircraft from April through December at scheduled 1 week intervals. Radio-tracking flights were made at least once a month during January, February and March to verify den locations and to assess mid-winter movements. Unsuitable flying weather resulted in less frequent re-location of bears than had been planned. Bear locations were plotted on 1:63,360 scale topographic maps. Standardized forms were used to record data on habitat for each re-location including; estimated slope; vegetation; aspect; estimated snow depth and percent cover; distance from project features/activities. When bears were actually seen, their activities and associations with other bears were noted.

Maps and relocation points were digitized on a computer. Home range polygons were calculated using minimum convex polygons generated by connecting outermost re-location points. Areas of home range polygons were computed, excluding marine waters.

Results

A total of 4,792 point locations of 87 radio-collared bears was recorded from April 1982-December 1986 (Table 37). For males (n=34) 1,079 point locations were recorded. For females (n=53) 3,713 point locations were recorded. The number of re-locations for individual bears ranged from 2-138 during the 5 year study. Because of higher mortality rates and a greater rate of transmitter failure and loss, individual males were generally observed for shorter periods than were females. Fourteen individual females and no males were radio-collared for the entire 5 years of the study.

Home Range

Annual home range size for females with at least 10 radio-tracking locations points ranged from 1.2 to 197.7 km^2 (Table 38). Annual home range size for males ranged from 30.0-465.0 km^2. The mean annual home range size of females ranged from 24.1 km^2 in 1984 to 31.4 km^2 in 1986 (Table 38). The mean annual home range size of males ranged from 108.6 km^2 in 1986 to 170.2 km^2 in 1982.

Attempts to correlate home range size with construction activity were confounded by annual variations in the food availability, and age and reproductive status of individual bears. Considerable difference in the abundance and seasonal availability of foods including salmon, berries and herbaceous vegetation during each year of this investigation were documented in previous reports (Table 39) (Smith and Van Daele 1984, 1986a, 1986b, and Smith et al. 1985). The annual home range size for 14 female brown bears which were closely associated with project features were compared during construction and post-construction years of the study (Table 40). For bears with home ranges most closely associated with project features, 64.3% (n=9) had the largest annual home ranges in 1985 and 1986, the 2 post-construction years of the study (Table 41). Only 21.4% (n=3) had their smallest home ranges in either 1985 or 1986. Eleven of 14 females (78.6%) had their smallest home ranges in 1982-1984, the years of project construction. A bias was present in 1982 because some bears were not captured until July that year. Disturbance from construction activities may have resulted in some individual bears using smaller areas during 1982-84, but the data are not conclusive.

Annual home range sizes of 5 bears which were closely associated with project features were compared with annual home range sites of 8 bears which were not closely associated with the project, using only bears for which there were 5 years of relocation data (Tables 42 and 43). There was no significant difference

($p>0.1$) in the mean home range sizes of "project" and "non-project" bears during the construction and post-construction phases of this investigation.

Home Range and Movements of Individual Radio-collared Bears Affected by the Project

Annual movement patterns and home ranges of individual radio-collared bears were discussed in considerable detail in previous progress reports (Smith and Van Daele 1984, 1986a, 1986b, Smith et al. 1985). Bear movements were correlated with seasonal habitat preferences related to food availability, den site selection, human activity, including construction activities, breeding, and other intraspecific interactions. Male bears were found to have home ranges approximately 4 times larger than those of females. Females were most often found to inhabit relatively specific areas, usually confined to 1 or 2 closely adjacent drainages. Relatively little interchange occurred between females inhabiting the Kizhuyak Bay and Terror Bay drainages, respectively, although some overlap occurred in alpine feeding areas west of Kizhuyak River and in the upper Baumann Creek drainage. Few radio-collared bears of either sex were regularly found in the Terror Lake impoundment area.

Comparing movements of radio-collared bears which were most closely associated with project features during the construction (1982-84) and post-construction (1985-86) period provided some insight into the impacts of construction and operation of the Terror Lake Hydroelectric Project on the brown bear population. This analysis was confounded by the lack of comparable pre-project movements data, however. Construction activities (access road construction) began nearly simultaneously with the first capture operation in April 1982 and some disturbance from helicopters and other pre-project reconnaissance by construction personnel had already occurred. Initial captures were purposely biased toward bears which were located near major project features in the Kizhuyak Bay and Terror Lake drainages to maximize the opportunity for observing the effects of the project construction activities on subsequent movements of radio-collared bears. Because no major shifts in habitat use by individual radio-collared bears were seen during the study, the changes in annual movements believed to be related to construction activities were often subtle and unquantifiable.

Radio-collared bears varied in their association with features and activities of the hydroelectric project's features and activities, ranging from those with home ranges remote from project features to those with project features central in their home ranges. The relative closeness of each bear's association with the project features was rated as objectively as possible to assess which bears potentially were affected by the project (Table 44). Factors used to assign these ratings included: 1) the proximity of each bear's point locations to project features; 2) relative levels of construction activity associated with project features; 3) proximity to helicopter travel routes; 4) shifts in home range polygons between years; and, 5) movement patterns indicated by sequential radio-locations. Among 48 females with ratings, 16 (33.3%) were rated high, 9 (18.8%) were rated medium and 23 (47.9%) were rated as having low associations with the project. For 28 males, 17 (60.7%) were rated high, 6 (21.4%) were rated medium and 5 (17.9%) were considered to have had little association with the project. A total of 28 (36.8%) bears of both sexes were assigned low ratings. It is our opinion that those bears were not directly affected by construction or operation of the Terror Lake Hydroelectric Project. Bears assigned medium and low association ratings were 56.6% (43/76) of the radio-collared bears. A crude extrapolation indicated that more than half the bears in the study area were relatively unaffected by the project. Considering the deliberate bias toward capturing bears closest to the project features, probably a much smaller percent of the bear population in the study area was subject to direct impacts from the project.

Movements of Females in Kizhuyak Bay Drainages

Females with home ranges in Kizhuyak Bay drainages were most often found to be closely associated with the construction project. Several females had home ranges which included the access road, powerhouse, Kodiak transmission line, or the construction camp (001, 008, 011, 044, 060, 067, 071, 078, 081, 091, 119, 123, 136). Others were found near the Port Lions transmission line, but had little association with other project features (015, 064, 077, 127, 135). Several females with home ranges in the Sharatin Bay and northeastern drainages into Kizhuyak Bay, had little association with project features (070, 074, 092, 121).

Female 001 consistently frequented the access road corridor in lower Kizhuyak River in 1982 and was located near salmon spawning streams in lower Kizhuyak River from August to October. Before its transmitter failed in August 1983, it continued to use the slopes west of Kizhuyak River. This female bear was killed by a bear hunter on 25 October 1986 approximately 1 km north of its Rolling Rock Creek capture site. Although no additional data were available after its transmitter failed, we can conclude that this bear was not permanently displaced by construction activities.

Female 005 appeared to have avoided traditionally used habitat, particularly salmon feeding areas near Kizhuyak Bay, in 1983 during construction of the Kodiak transmission line. This particular bear returned in 1984 after completion of the line (Figure 14). The intensive helicopter use and presence of ground crews working on the line in Watchout Creek apparently resulted in displacement of this bear's activity area northward approximately 5-7 km in 1983 (Smith et al. 1985). Female 005 had a litter of 2 newborn cubs in 1983 and possibly required greater security from disturbance. Its activity areas in 1984 and 1985 were similar to those observed in 1982, before construction of the line. The bear's periodic movements to the Pestchani Creek drainage again in 1986 confounded this analysis, but during that year it also frequented the lower slopes east of Kizhuyak Bay near salmon feeding areas where it was not observed in 1983. Its 1983 home range was the smallest and the farthest removed from salmon feeding streams, supporting the conclusion that transmission line construction activities caused a shift in its habitat use pattern. The fact that its litter born in 1983 survived to weaning age, suggests that the displacement was not deleterious to cub survival, however.

Female 008 was not located near salmon streams in lower Watchout Creek in 1982 and 1983 during project construction, but was closely associated with the salmon streams in 1985 and 1986 (Figure 15). This bear was located 3 times in September 1985, and 3 times in August 1986 within 0.5 km of salmon spawning areas in Kizhuyak River. Intensive helicopter activity near these streams in 1982 and 1983 was suspected to have caused it to avoid feeding on salmon (Smith and Van Daele 1984; Smith et al. 1985). Its movement to salmon feeding areas during the 2 post-construction years of the study indicates that disturbance from construction activities resulted in a marked change in its habitat use patterns.

Female 011 occupied approximately the same area west of Kizhuyak Bay during all 5 years of the study. This bear approached closest to project features in November 1984, denning near Lake Leanne, after most construction work was completed. It was not found closely associated with salmon streams during the study. This bear was apparently little-affected by project activities.

Female 044 frequented the access road and jetty area in the lower Kizhuyak River drainage regularly every year except 1982, when it favored alpine habitat west of Kizhuyak River (Figure 16). This bear was located near salmon spawning areas in lower Kizhuyak River in late summer during 1983-86. Although construction activity in 1982 may have been a deterrent to its use of lower Kizhuyak River, even more intensive activity in 1983 apparently had little deterrent affect.

Female 060 occupied approximately the same activity area in the Hilary Creek drainage west of Kizhuyak Bay during each of the 5 years of the study (Figure 17). It was active near the Port Lions transmission line while the line was under construction in August 1983. As the result of confrontations between bears and transmission line construction crews during that period, unauthorized harassment of bears seen near the line was done by helicopter pilots transporting crews. Apparently bears immediately began using the cleared transmission right-of-way as a trail in 1983. Food scraps that were routinely discarded near construction sites by workers may have additionally attracted bears. The timing of the construction in late summer also coincided with peak berry use at low elevations and with feeding on salmon in Hilary Creek. Although disturbance and active harassment of bears could have resulted in some temporary displacement of bear 060, it was not known if the bear was actually harassed or if it was involved in any confrontations with workers. Vegetative cover was particularly dense near the transmission line, providing excellent security for bears.

Female 067 used the area west of Kizhuyak Bay from 1982-1984 (Figure 18). From late August through September 1982, she ranged between the Eagle Creek drainage near the jetty and lower Kizhuyak River when salmon were available. This bear was observed feeding on salmon with its 2 yearling cubs during daylight hours, less than 0.5 km east of the access road, on 22 and 23 September 1982. In 1983 and 1984 it was most often found northwest of the Kizhuyak Bay jetty and was not observed frequenting Kizhuyak River and Eagle Creek salmon streams as it did in 1982. The increased helicopter traffic associated with transmission line construction in 1983 may have caused it to avoid the relatively exposed salmon streams in favor of the dense cover west of Kizhuyak Bay. The relatively greater abundance of berries in 1983 and 1984 compared with 1982 might have been a factor in its movements also. This bear was found feeding on salmon in Eagle Creek with her 3 cubs-of-the-year on 12 September 1985, the first year of post-construction study. Between 14 October and 29 December 1985, it made an unusual move approximately 30 km west of its former home range to the Uganik Bay drainage, where it shed its radio-collar. This bear's movements indicate that although it may have avoided disturbance, it continued to use favored feeding areas to at least a limited extent during project construction.

Female 071 occupied the lower Kizhuyak River and Watchout Creek throughout the study (Figure 19). This bear was located farther from salmon spawning areas in lower Watchout Creek in 1982 than in subsequent years. It exhibited high tolerance of the intensive activity during construction of the Kodiak transmission line in 1983, having been located within 500 m of the line on 7 of 15 locations. It was more often found in 1985 and 1986 (post-construction) along tributaries in the lower Kizhuyak River flats where vegetative cover was relatively scant compared to areas upstream. Although this post-construction shift to more open habitat was relatively subtle, it was believed to be a response to reduced disturbance.

Female 078 exhibited a preference for mid-elevations east of Kizhuyak Bay (Figure 20). In 1983, the year it was first captured, this bear was not located closer than 1.5 km to salmon streams and we suspected that construction activity on the Kodiak transmission line might have deterred it from using the Lower Watchout Creek drainage. That suspicion appeared to have been confirmed in September 1984 when it was found twice within 500 m of salmon streams in lower Kizhuyak River and again in September 1985 it was located twice near salmon streams. However, in 1986 it was not located below 150 m elevation and was not located closer than 1.3 km to a salmon spawning area. Construction activity was not a major influence on the movements of this bear which appeared to have an individual preference for mid-upper elevations in Watchout Creek.

Female 081 used the Kizhuyak River drainage adjacent to the construction camp and access road from 1983 through 1986. This bear was apparently rarely inhibited by construction activities in 1983, having frequently been located near the Kodiak transmission line, construction access road, and the construction camp during peak construction activity. We saw it crossing the road from west to east near mile 1 at 1700 hr on 16 August 1983. During a momentary lag in traffic it crossed the road and proceeded directly to the nearest salmon spawning area east of the road. This bear exhibited little change in its movement patterns in 1984, 1985 and 1986, further confirming that construction activities were not a significant disturbance. Female 081 was killed in the lower Kizhuyak River by a hunter on 9 November 1986. Deer hunting activity along the access road and in the lower Kizhuyak River valley was fairly intensive then and it may have been attracted by the availability of deer scraps left by hunters.

Female 091 was usually located south of the Kodiak transmission line while it was under construction in 1983, although it crossed the right-of-way several times between successive locations. This bear exhibited similar movements in 1984 but was found more often in the lower Kizhuyak River salmon spawning areas after completion of the line. It died in its den about 4 km southeast of the construction camp of unknown causes early in 1985.

Female 119 centered her activities around the construction camp and powerhouse site in the Kizhuyak River drainage in 1984 and its 4.2 km^2 home range was the smallest recorded for a female that year (Figure 21). Smith and Van Daele (1986a) detailed this bear's frequent visits to the camp where it was attracted by garbage. In 1985, when accompanied by a litter of 2 newborn cubs, this bear was located only once within 1 km of the camp, apparently preferring the higher slopes west of Kizhuyak River. A similar pattern was noted in 1986. The absence of significant amounts of garbage and possibly a greater need for security while it was with cubs resulted in apparent avoidance of the camp area during the 2 post-construction years of the study.

Female 119 was only 4 years old when the project began in 1982 and we suspected it quickly learned to forage on food scraps left at work sites. When captured in 1984 at 6 years old, this bear had already adopted a consistent pattern of foraging at the camp and had become a serious nuisance. It was a fortunate coincidence that construction activities were completed before this bear had cubs and could have become much more dangerous. This bear exemplified the typical pattern of habituation to human food sources which so frequently leads to the demise of bears near settlements.

Female 123, first captured in July 1984, ranged from Eagle Creek and lower Kizhuyak River north and west to the Hilary Creek drainage (Figure 22). Except for an unusual movement north of Barabara Lake in July 1986, its movement patterns were similar from 1984 through 1986. This bear was shot and killed approximately 200 m west of the intersection of the Port Lions distribution line and Hilary Creek between 6 and 17 August 1986. Fresh "3-wheeler" tracks were present on the distribution line right-of-way above the creek and it was suspected that whoever shot this bear gained access via the line. The distribution line was used by residents of Port Lions for off-road vehicular access almost immediately after it was cleared in 1983. Although it could not be confirmed that this bear was killed by someone using this trail, the roads and trails constructed for this hydroelectric project facilitated access into high density bear habitat, and increased confrontations with bears are predicted.

Movements of Females in Terror Lake Area

The immediate environs of Terror Lake was not found to be heavily used by bears during this study. Although attempts were made to capture bears as close to project features as possible, none of the captured bears regularly used the Terror Lake impoundment area in 1982, 1983, or 1984. The Terror Lake impoundment and dam site vicinities were intensively searched by spotter aircraft during every capture operation, but bears were rarely seen and none were captured there until 1985 and 1986, after construction had been completed. Intensive construction activity in the Terror Lake basin in 1982 and 1983 undoubtedly was a deterrent to bears, although occasional sightings of bears were reported by construction workers. Spencer and Hensel (1980) reported several sightings of bears in the Terror Lake basin before construction. Four unmarked adult bears were seen feeding on vegetation on 15 June 1982 on the slope northeast of Terror Lake at about 500 m elevation during a radio-tracking flight (Smith and Van Daele 1984).

Three females with young (131, 132, 133) were captured in Goat Creek drainage, a tributary of Terror River approximately 3 km west of Terror Lake, in early July 1985 (Figures 23, 24 and 25). Female 131, a 12-year-old with 2 yearlings captured on 4 July, was observed bedded on 20 July in alpine habitat approximately 400 m west of Terror Lake. On 25 July this bear was seen walking with its litter about 2 km north of the Terror Lake dam site. It was located in the lower Terror River through mid-October and by 17 November it had denned at 732 m, approximately 2 km west of the Terror Lake dam. In 1986, 12 of 19 (63%) locations after this bear emerged from its den were in a 10 km^2 area on the slope west of Terror Lake, where it was frequently seen feeding on alpine vegetation. After intermittent movements between Terror Lake and lower Terror River, this bear denned at 550 m, 0.6 km east of the upper Terror Lake impoundment. Females 132 and 133 used the lower Terror River and Goat Creek drainages in 1985 and 1986, but were not found near the impoundment.

Two females captured in 1986 also used the Terror Lake impoundment area. Female 140, a 10-year-old single bear, was captured on 3 July near the west shore of upper Terror Lake. This bear was found again on 12 July near the west shore of Terror Lake at 460 m. It ranged from lower Terror River to the brushy hills below the dam site through early October. By 20 November it had denned at 730 m, 0.8 km east of the lake. Bear 141, a 9-year-old female with a 1- or 2-year-old cub, was captured on 3 July approximately 0.5 km west of the Terror Lake impoundment. It ranged throughout the Terror River drainage and denned 3.2 km west of Terror Lake at 1100 m.

Female 085 was notable for its pattern of abrupt movements between its main activity area in the upper south Viekoda and Barabara Lake drainages and its denning area on the prominent ridge west of upper Terror Lake (Figure 26). The 2 areas are about 10-15 km apart. Although its 1983-84 and 1984-85 den sites were among the closest of any radio-collared bears to Terror Lake, there was no evidence that this bear spent more time in the Terror Lake vicinity than was necessary to move to and from its den site. Female 085 denned twice relatively close to Terror Lake and it is unlikely that construction activities influenced its movements. Its 1985-86 den location was not found, but its abrupt disappearance after 1 November 1985 and sudden re-appearance by 13 May 1986 suggest that it probably denned in the same area for 3 consecutive years.

Female 088 was captured on 4 June 1983, 2 km northwest of the Terror Lake dam site. This bear used alpine habitat northwest of the dam site in 1983 and 1984. It denned on Den Mountain in 1983-84 and its transmitter failed by late August 1984. It was re-captured in July 1986 and it continued to favor the Terror River and upper Baumann Creek drainage and was found no closer to Terror Lake dam than it had been during active construction in 1983 and 1984. Although this bear was more regularly located near Terror Lake than other radio-collared females, its post-construction movements indicated that the Terror Lake impoundment was not part of its normal home range.

Movements of Males

Correlating movements of males with impacts of construction was especially difficult. Fewer males than females were radio-collared and males suffered higher mortality rates and a higher frequency of transmitter failure and loss. No radio-collared male was under observation for the entire 5 years of the study, but several males were radio-collared long enough to gain insight into their movements during active construction.

Males generally made much longer and more abrupt movements than did females. Wide ranging movements observed from May though July were probably directed toward breeding activity. Movements between major drainages in the study area were common. Mean home range size was 3 to 5 times greater for males than for females (Table 38). Smith and Van Daele (1984) detailed the movements of several radio-collared males in 1982, the first year of construction.

Male 002, 16 years old when captured near Rolling Rock Creek in April 1982, was apparently highly tolerant of construction activities in 1982 and 1983. This bear ranged widely throughout the study area into the Terror and Viekoda Bay drainages before returning to the lower Kizhuyak River in mid-August 1982 (Figure 27). After spending the remainder of the summer and fall near Kizhuyak Bay, it moved to less than 1 km north of the construction access road near Rolling Rock Creek, where it was initially believed to be denned. Between 5 February and 17 March 1983 it moved about 0.5 km from the north side of Rolling Rock Creek to the south side of Rolling Rock Creek. Blasting had been done intermittently near the penstock site for several days before March 17 when the bear was observed from a nearby vantage point bedded under a prominent boulder in upper Rolling Rock Creek. Explosives were used for avalanche control above Rolling Rock Creek on 19 March and the bear was observed by the U.S. Fish and Wildlife Service environmental monitor still bedded under the boulder later that day. When next located on 2 April this bear had moved several kilometers north of Rolling Rock Creek. Disturbance from blasting and other activities was not sufficient to cause it to abandon the area immediately, however. After moving west to upper Baumann Creek in mid-summer, the this bear again returned to lower Kizhuyak River where it was located near salmon streams in September and October during construction of the Kodiak transmission line. This bear continued to frequent the project area in 1984, remaining active into at least mid-January. On 13 March it was located at approximately the same location it occupied during the previous winter. On 19 March it was seen bedded 1 km north of the Kizhuyak tunnel portal. On 24 and 30 April it was located in dense brush within 100 m of the access road near Kizhuyak River. This bear was bedded and apparently undisturbed by nearby vehicular traffic when seen on 24 April. It was recaptured on 6 June near Hilary Creek, when its radio collar was removed and an ear flag was attached. Construction workers subsequently reported seeing a large ear-flagged bear near the tunnel portal on several occasions. This bear was the most frequently found radio-collared male near the construction area.

Male 027 was found several times in lower Watchout Creek in June-September 1983 during peak construction activity on the Kodiak transmission line (Figure 28). It was usually located in dense brush north of the transmission line near well-used bear trails leading to salmon spawning areas in Watchout Creek. Although it was not seen, the bear was probably feeding on salmon during periods when construction activities were shut down. This bear was killed by a hunter near Saltery Creek (Ugak Bay) on 12 October 1983.

A 3-year-old male (028) was found within 2.5 km of the construction access road near Kizhuyak River on 6 of 20 locations in 1982, remaining in the active construction area from late August to early October (Figure 29). Although it was radio-located within 300 m of the access road several times, this bear was seldom seen. Ground radio-tracking on 21-23 September 1982 confirmed that this bear regularly crossed the access road at night, presumably to feed on salmon in the lower Kizhuyak River. In 1983, it ranged into the Viekoda Bay drainage where it was killed by a hunter on 3 May.

Male 040, a 4-year-old when captured in 1983, ranged east of Kizhuyak Bay and north of the Kodiak transmission line in 1983 (Figure 30). During the following 3 years it also frequented the Watchout Creek drainage south of the line, which indicated that construction activity in 1983 may have restricted its movements. However, a probably alternate explanation is that this bear ranged farther each year with increasing maturity. The latter conclusion is supported by the fact that this bear's annual home range size increased progressively each year until early 1986 when it was killed by a hunter south of Watchout Creek.

A 5-year-old male (045) exhibited a nocturnal activity pattern in the lower Kizhuyak River during ground tracking on 21-23 September 1982. This bear was a frequent occupant of the construction area in Kizhuyak River from mid-August through late September. Before it shed its transmitter in late August 1983, it occupied a much smaller activity area near Barabara Lake, several kilometers from the Kizhuyak River construction sites (Figure 31).

Male 084, a 12.5-year-old captured east of the powerhouse site and construction camp on 3 June 1983, moved intermittently between Kizhuyak River, Ugak Bay, and Terror Bay until it shed its radio collar in early October (Figure 32). This bear was located within 100 m of the access road on 30 August 1983, near the penstock, while construction workers were on-site. Its close location to active construction and frequent movements through the Kizhuyak River drainage indicate it was relatively tolerant of construction activities.

Four males (003, 004, 016, 145) moved from Kizhuyak River south into the Ugak Bay drainage in 1982. No radio-collared females were located in the Ugak Bay drainage during the study. The 4 males all were located near Saltery Creek, which supports excellent runs of 4 species of salmon and was a previously known area of high bear density. Although these movements could be interpreted as reactions to disturbance from construction, it is more probable that these bears made normal movements to traditional feeding grounds unrelated to project activities, because 3 of the bears (004, 016, 045) returned to the project area later in 1982.

No radio-collared males were found to frequent the Terror Lake area, although home range polygons of 3 males included Terror Lake (002, 004, 084). Because males ranged over much larger areas than did females, it is probable that other radio-collared males may have visited the Terror Lake basin without having been found there during radio-tracking flights. However, since females were not found near the lake until the post-construction period, and males throughout the study area made significantly less use of alpine areas during time they were not in dens, there was probably little to attract males to Terror Lake during construction.

A sub-adult male (007), the 2-year-old weaned offspring of female 005, occupied an activity area similar to that of its mother in 1982, although it ranged closer to the Kizhuyak Bay jetty than the mother did. This male bear was killed by a hunter in early 1983. Its male sibling (006) was killed by a hunter near the head of Kizhuyak Bay less than a month after its capture in April 1982. Other subadults of both sexes which were weaned by radio-collared females continued to frequent the Kizhuyak River project sites, based on subsequent kill locations (009, 030, 083, 126).

A 5-year-old male (105) moved 61 km from its capture site north of Den Mountain to the location where it was killed near Barling Bay (southeastern Kodiak Island) between late June and 4 November 1984 (Figure 33). That was the longest movement recorded during this study. It is improbable that the movement was related to trauma associated with capture nor with other disturbance, because this bear remained in the immediate area of its capture for at least 2 weeks before disappearing. Dispersal by young males during the breeding season is probably not an unusual occurrence.

Table 37. Relocation histories of brown bears radio-collared in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986.

Bear	Sex	Calculated birth year[a]	Number of observations 82	83	84	85	86	Total
001	female	1979	23	13	--	--	--	36
002	male	1967	23	23	14	--	--	63
003	male	1977	13	8	--	--	--	21
004	male	1976	13	17	--	17	21	68
005	female	1969	18	27	22	23	32	122
006	male	1980	5	--	--	--	--	5
007	male	1980	20	7	--	--	--	27
008	female	1971	20	19	--	17	29	85
011	female	1976	22	22	35	27	32	138
014	male	1976	20	16	--	--	--	36
015	female	1975	20	21	28	24	2	95
016	male	1971	19	22	--	--	--	41
017	female	1961	20	18	--	--	--	38
018	female	1977	20	21	29	22	13	105
019	female	1976	22	24	20	24	33	123
020	female	1976	22	21	31	23	29	126
022	female	1975	20	22	28	21	29	120
023	male	1975	24	24	26	1	--	75
024	male	1975	20	21	6	--	--	47
025	male	1969	7	--	--	--	--	7
026	male	1977	5	--	--	--	--	5
027	male	1969	5	15	--	--	--	20
028	male	1979	21	9	--	--	--	30
029	female	1965	18	--	--	--	--	18
030	male	1980	3	--	--	--	--	3
033	male	1979	20	6	--	--	--	26
034	female	1969	14	--	--	--	--	14
035	female	1980	2	--	--	--	--	2
037	female	1978	20	22	29	7	--	78
038	female	1979	19	21	29	19	10	98
039	male	1979	3	--	--	--	--	3
040	male	1979	1	16	24	15	9	65
044	female	1979	13	27	34	25	30	129
045	male	1977	13	21	--	--	--	34
046	female	1976	11	23	30	26	31	121
048	female	1959	12	23	26	10	--	71
051	female	1974	14	24	36	20	32	126
055	female	1969	12	22	26	20	29	109
059	male	1979	13	22	29	5	--	69
060	female	1968	17	24	6	15	32	94
064	female	1962	12	24	28	21	27	112
067	female	1962	13	24	39	25	--	101
070	female	1978	13	21	20	25	31	110

Table 37. Continued.

Bear	Sex	Calculated birth year[a]	Number of observations 82	83	84	85	86	Total
071	female	1974	12	21	32	25	31	121
072	female	1964	13	22	29	17	--	81
074	female	1965	13	23	31	--	--	67
077	female	1962	14	18	1	--	--	33
078	female	1975	--	16	31	32	29	108
079	male	1969	--	16	20	--	--	36
080	female	1958	--	7	--	--	--	7
081	female	1973	--	17	28	27	28	100
084	male	1970	--	14	--	--	--	14
085	female	1979	--	15	26	23	11	75
086	female	1975	--	16	26	26	27	95
088	female	1974	--	15	15	--	17	47
091	female	1975	--	14	30	11	--	55
092	female	1978	--	17	23	--	20	60
095	male	1979	--	15	7	--	--	22
096	female	1976	--	16	29	27	3	75
098	male	1977	--	--	22	7	--	29
099	female	1974	--	--	19	26	33	78
100	male	1979	--	--	17	21	24	62
101	male	1975	--	--	20	10	--	30
102	male	1979	--	--	19	17	18	54
103	male	1978	--	--	22	1	--	23
104	male	1980	--	--	17	1	--	18
105	male	1979	--	--	4	--	--	4
114	female	1978	--	--	8	--	--	8
119	female	1978	--	--	19	23	31	73
120	male	1972	--	--	16	30	35	81
121	female	1971	--	--	16	23	15	54
123	female	1971	--	--	16	25	20	61
127	female	1976	--	--	13	--	--	13
128	female	1977	--	--	--	17	27	44
129	female	1974	--	--	--	15	29	44
130	male	1982	--	--	--	15	9	24
131	female	1973	--	--	--	14	31	45
132	female	1969	--	--	--	13	28	41
133	female	1974	--	--	--	14	29	43
135	female	1969	--	--	--	6	35	41
136	female	1970	--	--	--	--	18	18
137	male	1978	--	--	--	--	17	17
138	female	1975	--	--	--	--	18	18
139	male	1980	--	--	--	--	19	19
140	female	1976	--	--	--	--	18	18
141	female	1977	--	--	--	--	18	18
142	male	1974	--	--	--	--	2	2

a - birth year was calculated by subtracting cementum ages (derived from analyzing premolar tooth sections) from capture dates.

Table 38. Annual home range sizes of radio-collared brown bears in the Terror Lake Hydroelectric Project study area, Kodiak Island, Alaska, 1982-1986.

		Mean area of home range polygons (km^2)		Range in areas of home range polygons (km^2)	
Year	(Sample sizes)	Males	Females	Males	Females
1982	(N=12 males, 27 females)	170.2	29.8	30.0-465.0	5.8-131.9
1983	(N=13 males, 33 females)	114.5	30.8	32.4-208.5	7.0-159.3
1984	(N=12 males, 33 females)	127.4	24.1	44.0-279.0	4.6- 67.2
1985	(N=7 males, 33 females)	135.8	24.8	12.5-130.0	3.4-126.4
1986	(N=7 males, 36 females)	108.6	31.4	16.4-202.2	1.2-197.7

Table 39. Relative abundance of brown bear food resources in the Terror Lake Hydroelectric Project study area, Kodiak Island, Alaska, 1982-1986.

	SUBJECTIVE ABUNDANCE RATINGS				
Year	Alpine vegetation	Low elevation herbaceous vegetation	Berries	Salmon	Overall
1982	excellent	good	poor	fair	GOOD
1983	fair	excellent	excellent	fair	GOOD
1984	good	excellent	good	good	GOOD
1985	poor	poor	poor	fair	POOR
1986	fair	good	fair	excellent	GOOD

Table 40. Comparative annual home range sizes of radio-collared female brown bears closely associated with Terror Lake hydroelectric project features during construction (1982-84) and post-construction (1985-86) periods.

Bear	Year with largest home range	(Area home range in km^2)	Year with 2nd largest home range	(Area home range in km^2)	Year with smallest home range	(Area home range in km^2)	Years with $\geq$5 re-locations
005	1986	(15.8)	1984	(15.4)	1983	(8.5)	1982-1986
008	1985	(17.1)	1986	(16.6)	1982	(5.8)	1982,1983, 1985,1986
011	1986	(64.3)	1985	(58.5)	1983	(24.9)	1982-1986
044	1983	(25.4)	1984	(16.2)	1985	(10.9)	1982-1986
060	1983	(36.7)	1984	(15.0)	1985	(6.3)	1982-1986
067	1985	(90.0)	1984	(29.1)	1983	(11.7)	1982-1986
071	1984	(23.4)	1985	(20.3)	1982	(12.7)	1982-1986
078	1985	(19.4)	1986	(14.1)	1984	(7.1)	1983-1986
081	1983	(23.7)	1986	(20.2)	1985	(15.9)	1982-1986
088	1986	(55.8)	1984	(33.2)	1983	(25.5)	1983,1984, 1986
091	1984	(29.0)	1983	(26.5)	1983	(26.5)	1983,1984
099	1985	(111.2)	1986	(72.7)	1984	(52.7)	1984-1986
119	1985	(8.6)	1986	(5.3)	1984	(4.2)	1984-1986
123	1986	(49.6)	1985	(26.9)	1984	(22.9)	1984-1986

Table 41. Synopsis of relative annual home range sizes of radio-collared female brown bears closely associated with Terror Lake hydroelectric project features during construction (1982-84) and post-construction (1985-86) periods.

		No. bears	%
Construction	Largest home range polygon in 1982	0	-
	Largest home range polygon in 1983	3	21.4
	Largest home range polygon in 1984	2	14.3
Post-	Largest home range polygon in 1985	5	35.7
Construction	Largest home range polygon in 1986	4	28.6
	TOTAL	14	100.0

		No. bears	%
Construction	Smallest home range polygon in 1982	2	14.3
	Smallest home range polygon in 1983	5	35.7
	Smallest home range polygon in 1984	4	28.6
Post-	Smallest home range polygon in 1985	3	21.4
Construction	Smallest home range polygon in 1986	0	-
	TOTAL	14	100.0

Table 42. Comparison of annual home range sizes for radio-collared female brown bears closely associated and not closely associated with features of the Terror Lake hydroelectric project, Kodiak Island, Alaska, 1982-1986.

Bear Number	Home Range Size (square kilometers)				
	1982	1983	1984	1985	1986
PROJECT BEARS[a]					
005	17.0	8.5	15.4	8.4	15.0
011	35.0	24.9	32.4	58.5	64.0
044	16.0	25.4	16.2	10.9	15.0
060	14.0	36.7	15.0	6.3	9.0
071	13.0	17.7	23.4	20.3	18.0
Mean	19.0	22.6	20.5	20.9	24.2
NON- PROJECT BEARS[b]					
019	17.0	12.4	11.5	6.5	42.0
020	11.0	29.8	4.6	12.8	28.0
022	13.0	9.1	12.1	10.4	10.0
038	20.0	32.6	34.9	13.0	4.0
046	95.0	47.5	20.5	38.6	30.0
051	50.0	42.9	51.1	41.2	44.0
055	20.0	11.1	16.9	21.5	28.0
070	8.0	7.0	5.9	16.3	20.0
Mean	29.3	24.1	19.7	20.0	25.8

a - radio-collared bears which were monitored throughout the project (1982-1986) and were radio-located within 1500m of project features at least once.

b - radio-collared bears which were monitored throughout the project (1982-1986) and were never radio-located within 1500m of project features.

Table 43. Analysis of annual home range sizes for radio-collared female brown bears closely associated and not closely associated with features of the Terror Lake hydroelectric project, Kodiak Island, Alaska, 1982-1986.

Home Range Proximity	Mean Home Range Size: Construction (1982-1984)	Post-Construction (1985-1986)	Percent Change[a]
PROJECT[b]	20.7 km^2	22.6 km^2	+12.6%
NON-PROJECT[c]	24.4 km^2	22.9 km^2	-6.1%

a - no significant difference between project and non-project bear home ranges ($P>0.01$).

b - includes 5 radio-collared bears which were monitored throughout the project (1982-1986) and were radio-located within 1500m of project features at least once.

c - includes 8 radio-collared bears which were monitored throughout the project (1982-1986) and were never radio-located within 1500m of project features.

Table 44. Listing of radio-collared brown bears by relative levels of association with Terror Lake hydroelectric project activities, 1982-1986.

Females with HIGH association		Females with MEDIUM association		Females with LOW association	
Bear	Major drainage(s) of home range	Bear	Major drainage(s) of home range	Bear	Major drainage(s) of home range
001	Kizhuyak	064	Terror/Viekoda/Kizhuyak	015	Terror
005	Kizhuyak	070	Kizhuyak	017	Terror
008	Kizhuyak	074	Kizhuyak	018	Terror
011	Kizhuyak/Viekoda	077	Kizhuyak	019	Terror
044	Kizhuyak	085	Terror	020	Terror
060	Kizhuyak	088	Terror	022	Terror
067	Kizhuyak	099	Terror/Kizhuyak	029	Sharatin
071	Kizhuyak	120	Kizhuyak	034	Terror
078	Kizhuyak	127	Kizhuyak/Sharatin	037	Terror
081	Kizhuyak			038	Terror
091	Kizhuyak			046	Terror/Viekoda/Uganik
119	Kizhuyak			048	Terror
123	Kizhuyak			051	Terror
131	Terror			055	Terror/Viekoda
136	Kizhuyak			072	Terror
140	Terror			092	Sharatin
				096	Viekoda
(N=16)		(N=9)		128	Viekoda/Kizhuyak
				129	Viekoda/Terror
				132	Terror
				133	Terror
				135	Kizhuyak
				138	Terror
				(N=23)	

Table 44. Continued.

Males with HIGH association		Males with MEDIUM association		Males with LOW association	
Bear	Major drainage(s) of home range	Bear	Major drainage(s) of home range	Bear	Major drainage(s) of home range
002	Kizhuyak/Terror	024	Terror/Kizhuyak	026	Terror
003	Kizhuyak/Ugak	033	Sharatin/Buskin	059	Terror/Uganik
004	Kizhuyak/Terror	095	Kizhuyak/Terror	100	Terror/Uganik
006	Kizhuyak	098	Kizhuyak/Sharatin	102	Terror
007	Kizhuyak	101	Terror/Kizhuyak	137	Terror
014	Kizhuyak/Terror	121	Kizhuyak/Sharatin		
016	Kizhuyak/Terror				
023	Kizhuyak/Terror			(N=5)	
027	Kizhuyak/Ugak	(N=6)			
028	Kizhuyak				
040	Kizhuyak				
045	Kizhuyak				
079	Kizhuyak/Viekoda				
084	Kizhuyak/Terror				
103	Uganik/Kizhuyak				
104	Kizhuyak				
139	Kizhuyak				
(N=17)					

Association code (bears with at least 5 locations):

HIGH - Home range close to or encompassed major project features and/or helicopter travel routes and movements indicated possible response to project activities.

MEDIUM - Home range close to project features but movements did not indicate response to project activities.

LOW - Home range remote from project features.

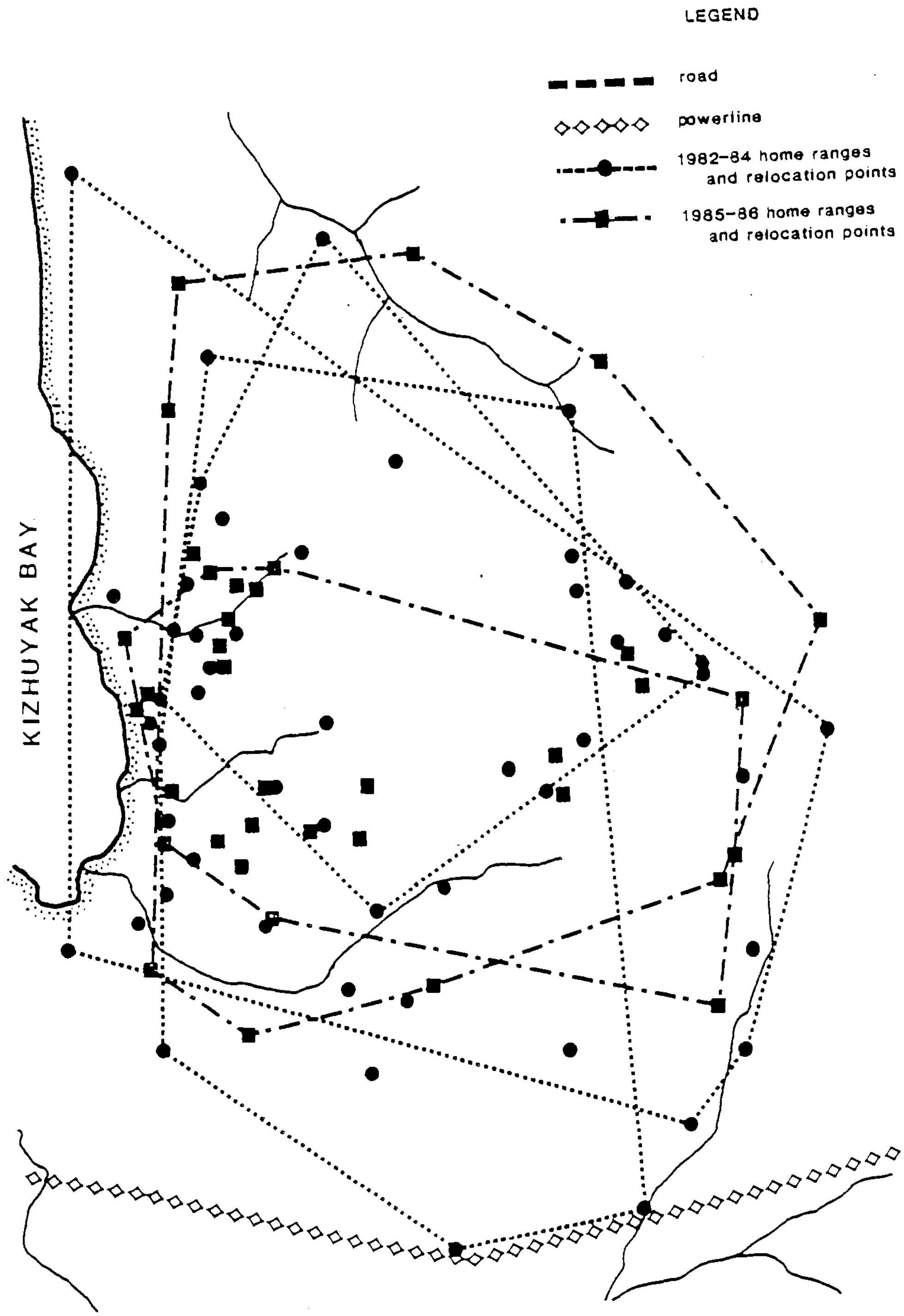


Figure 14. Radio-tracking locations points and annual home range polygons for female brown bear 005, Kodiak Island, Alaska.

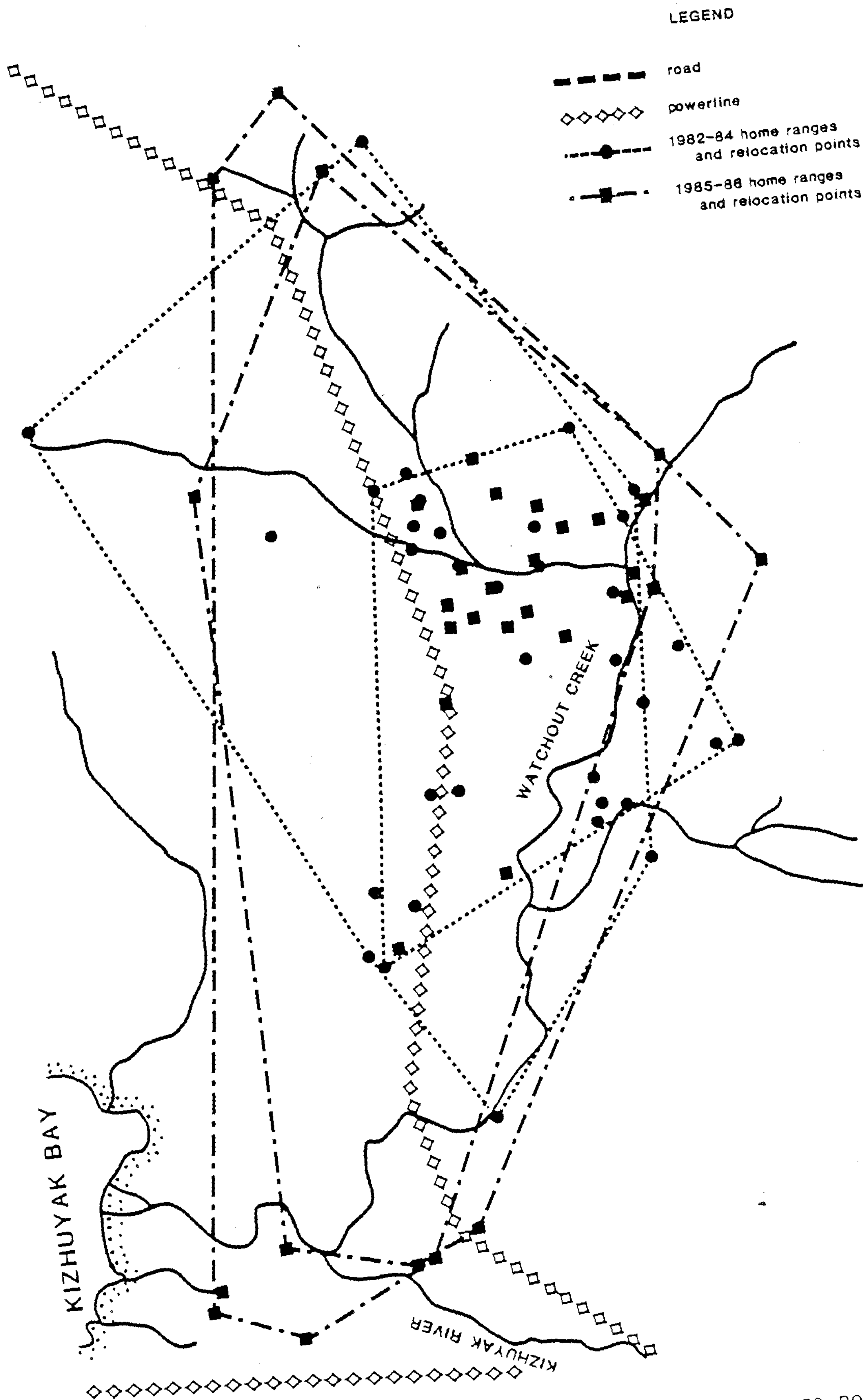


Figure 15. Radio-tracking locations points and annual home range polygons for female brown bear 008, Kodiak Island, Alaska.

Figure 16. Radio-tracking locations points and annual home range polygons for female brown bear 044, Kodiak Island, Alaska.

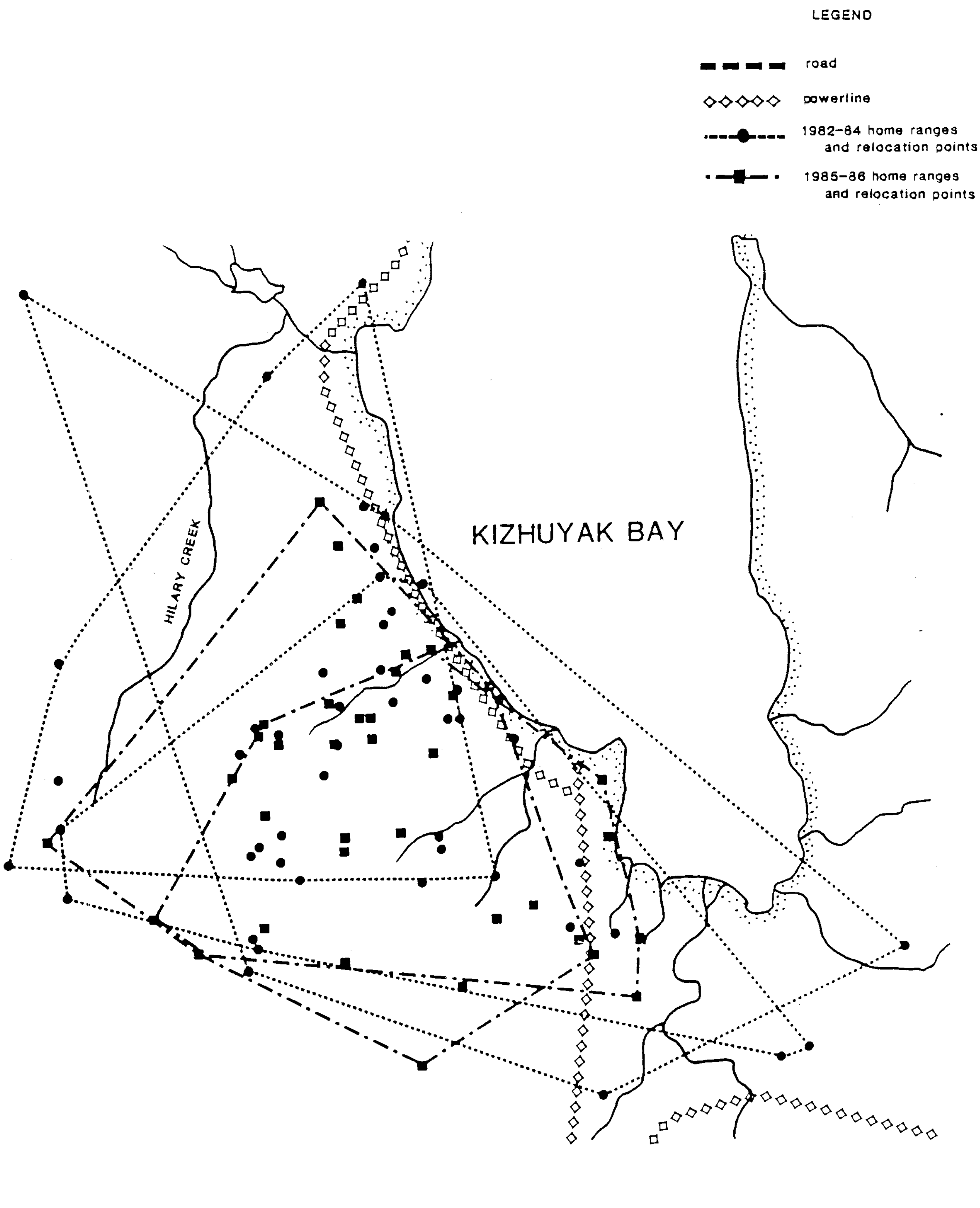
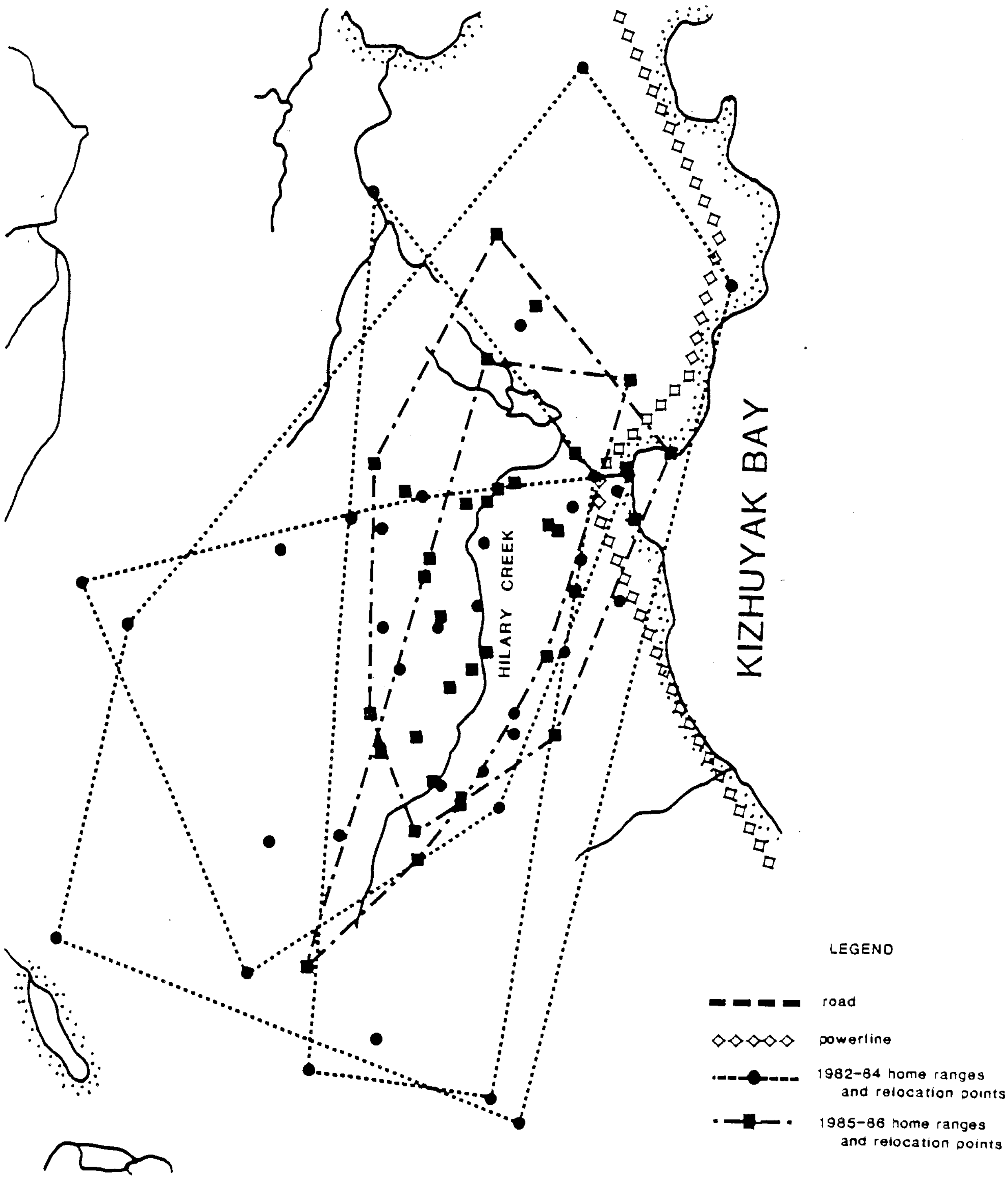


Figure 17. Radio-tracking locations points and annual home range polygons for female brown bear 060, Kodiak Island, Alaska.



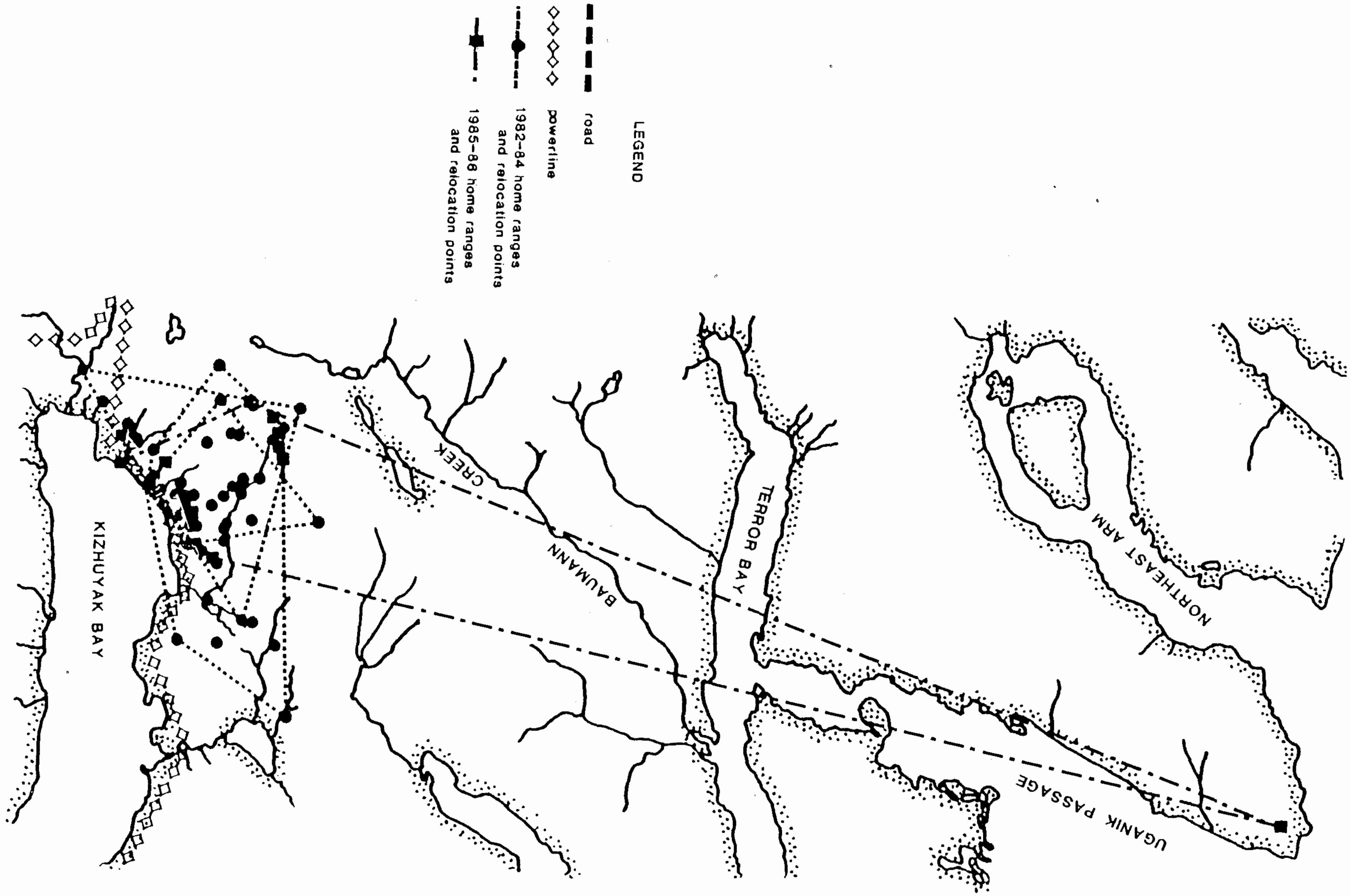


Figure 18. Radio-tracking locations points and annual home range polygons for female brown bear 067, Kodiak Island, Alaska.

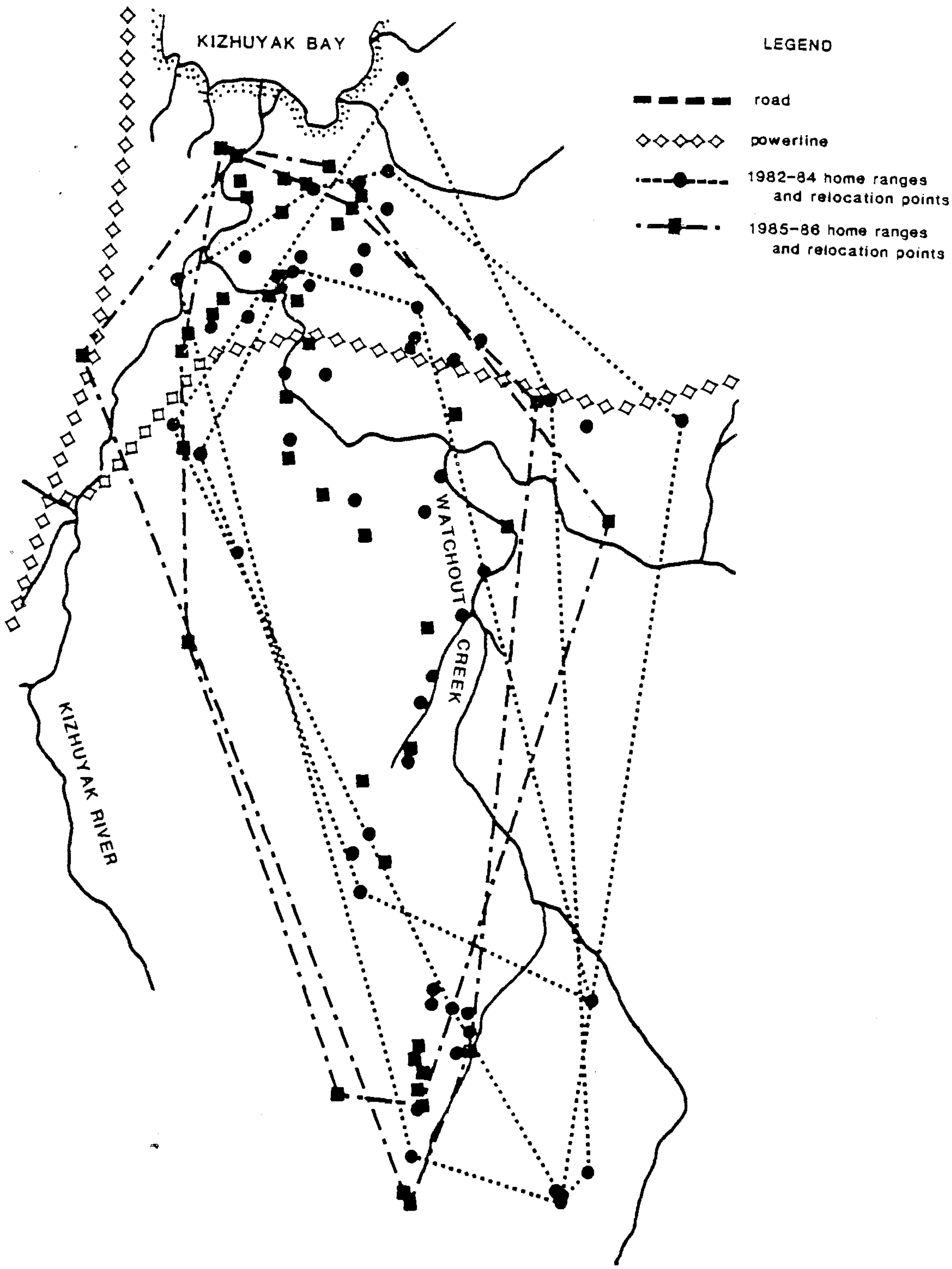


Figure 19. Radio-tracking location points and annual home range polygons for female brown bear 071, Kodiak Island, Alaska.

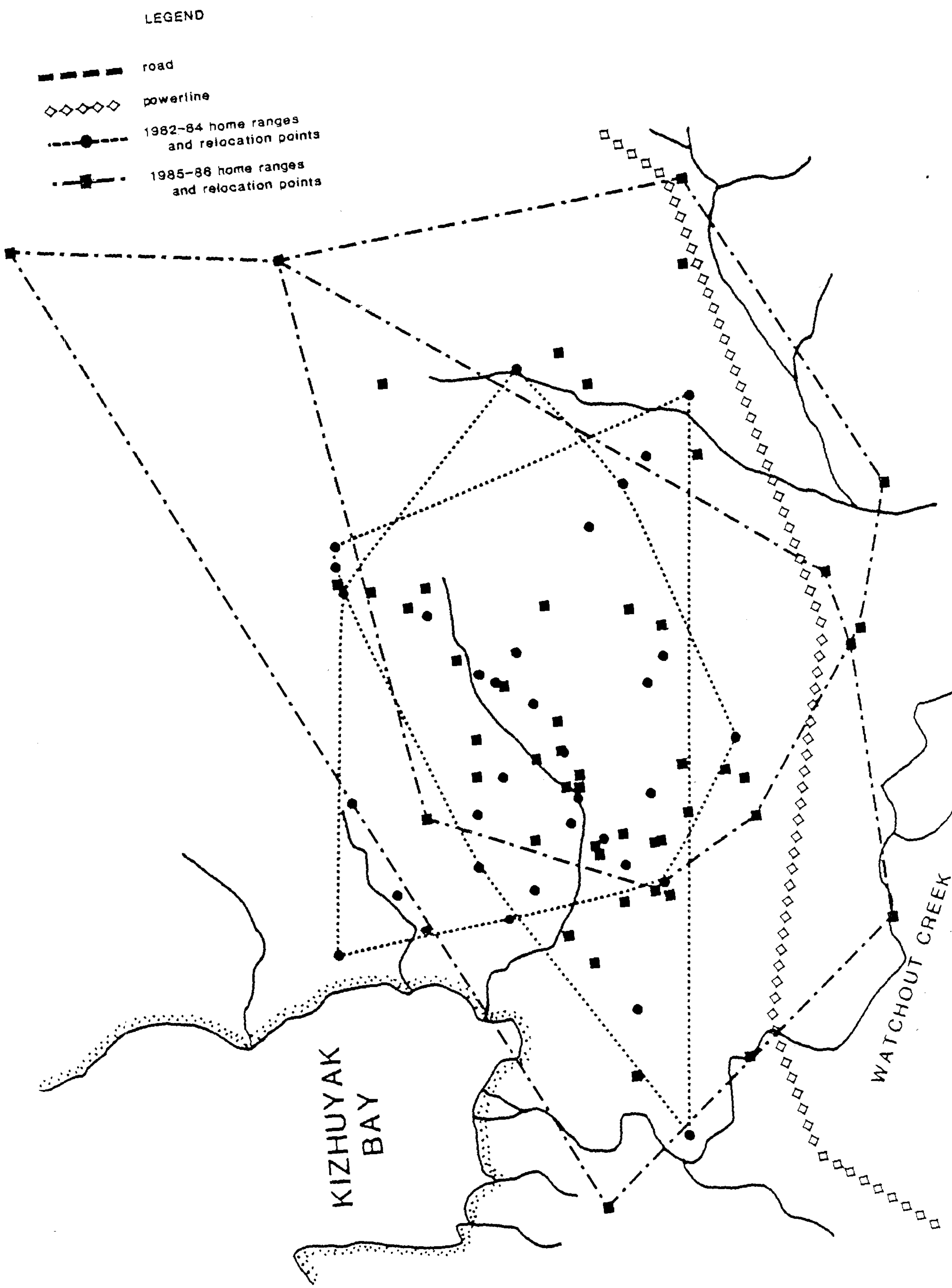


Figure 20. Radio tracking location points and annual home range polygons for female brown bear 078, Kodiak Island, Alaska.

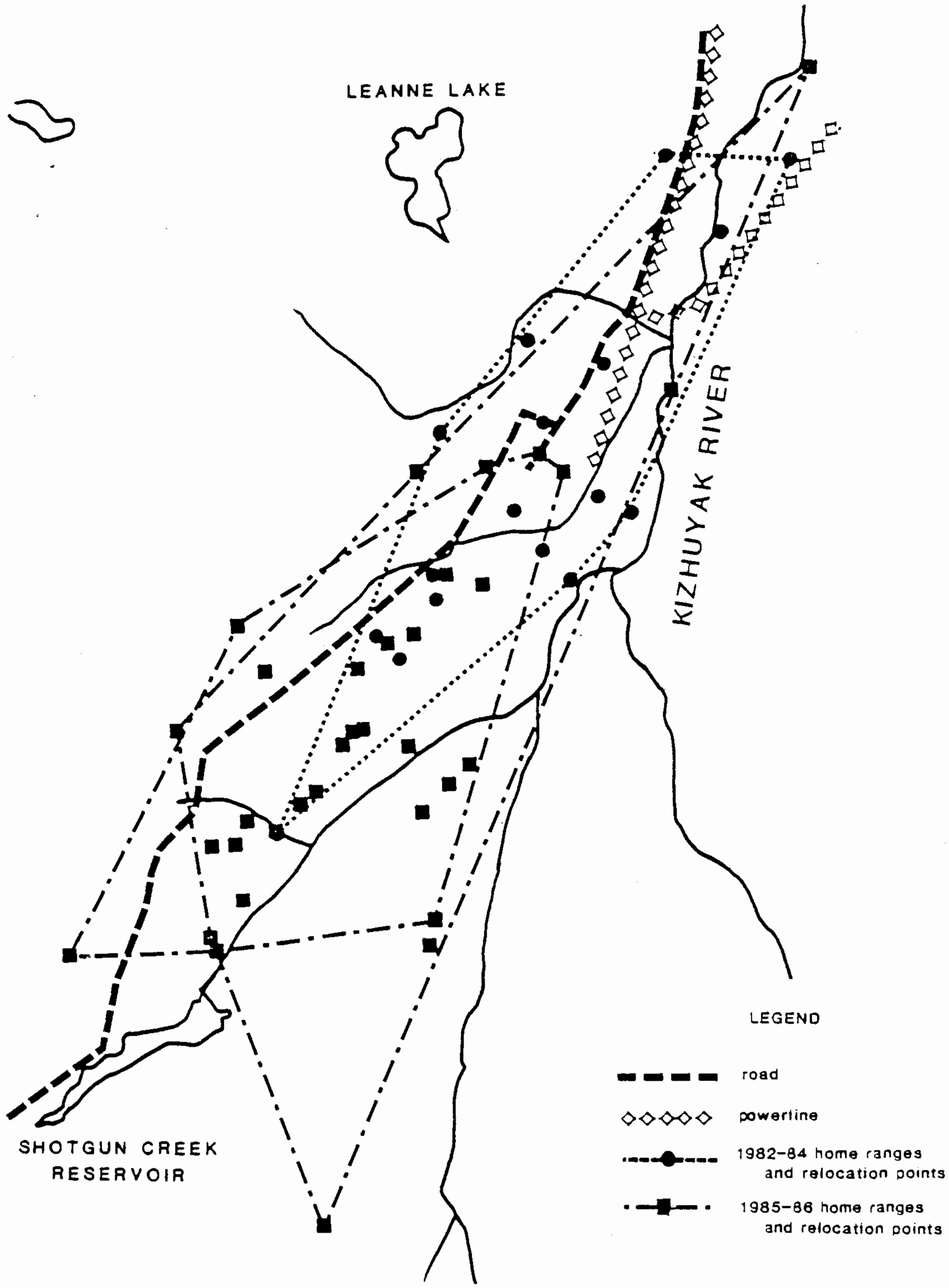


Figure 21. Radio-tracking location points and annual home range polygons for female brown bear 119, Kodiak Island, Alaska.

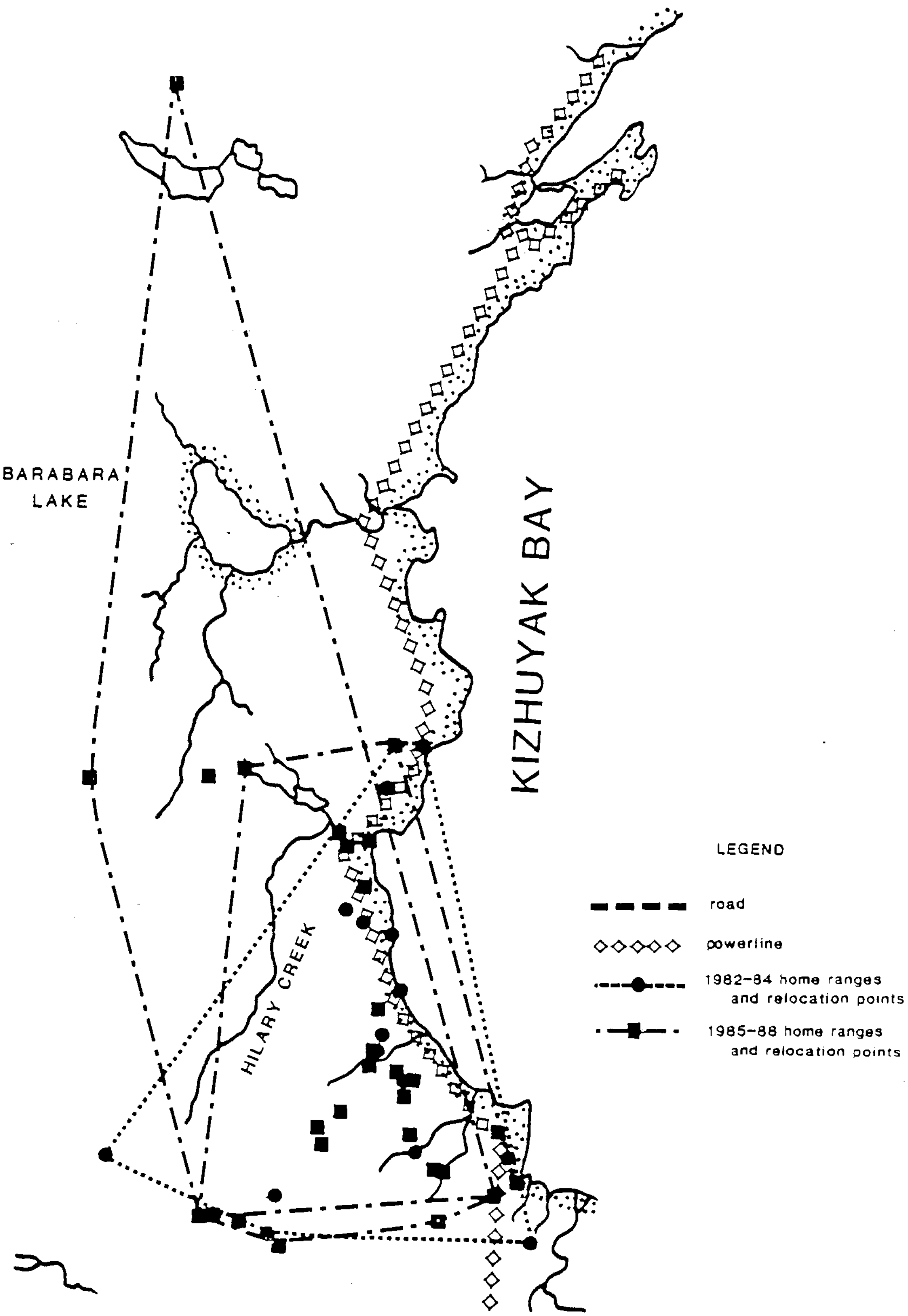


Figure 22. Radio-tracking locations points and annual home range polygons for female brown bear 123, Kodiak Island, Alaska.

Figure 23. Radio-tracking locations points and annual home range polygons for female brown bear 131, Kodiak Island, Alaska.

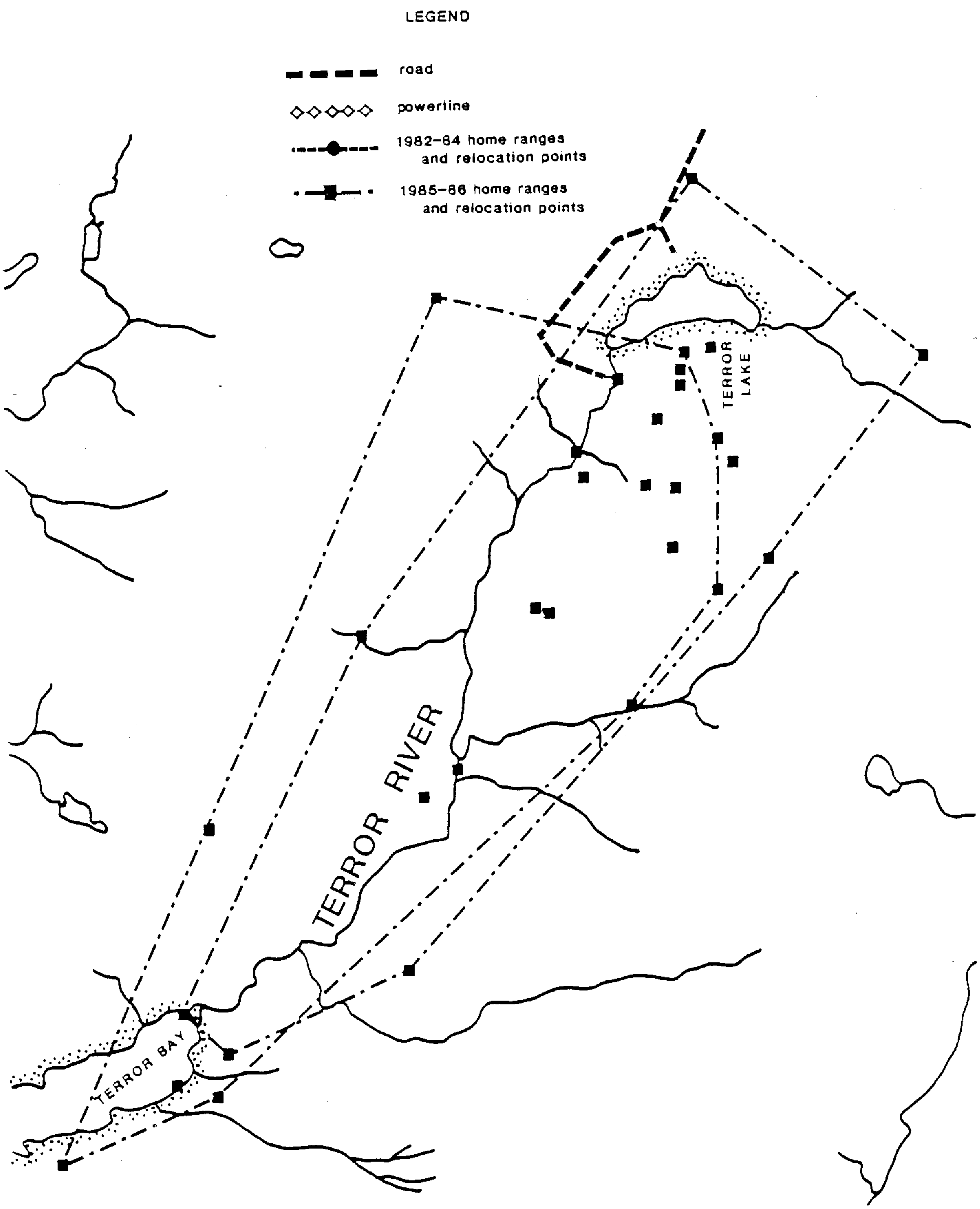


Figure 24. Radio-tracking locations points and annual home range polygons for female brown bear 132, Kodiak Island, Alaska.

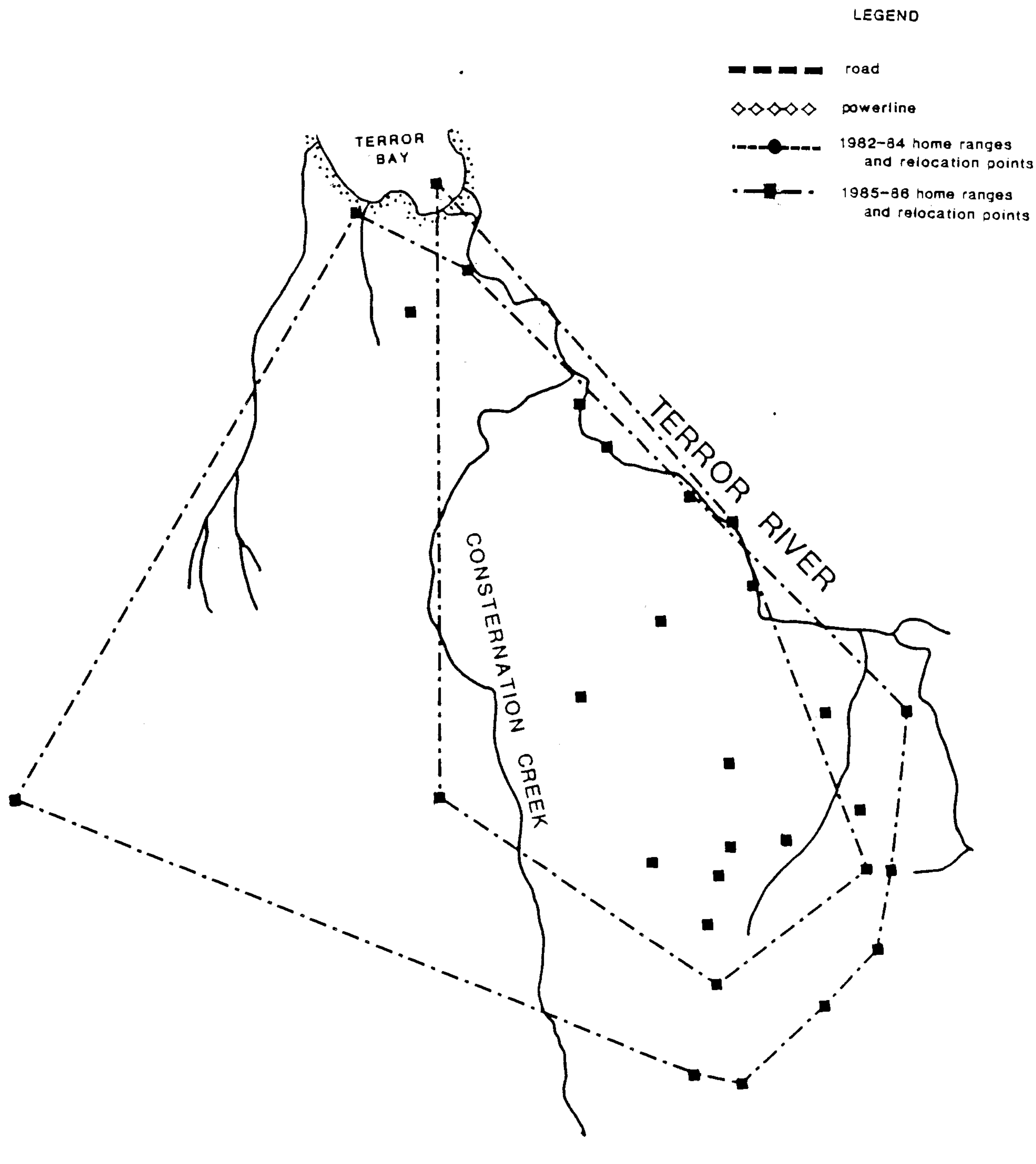


Figure 25. Radio-tracking locations points and annual home range polygons for female brown bear 133, Kodiak Island, Alaska.

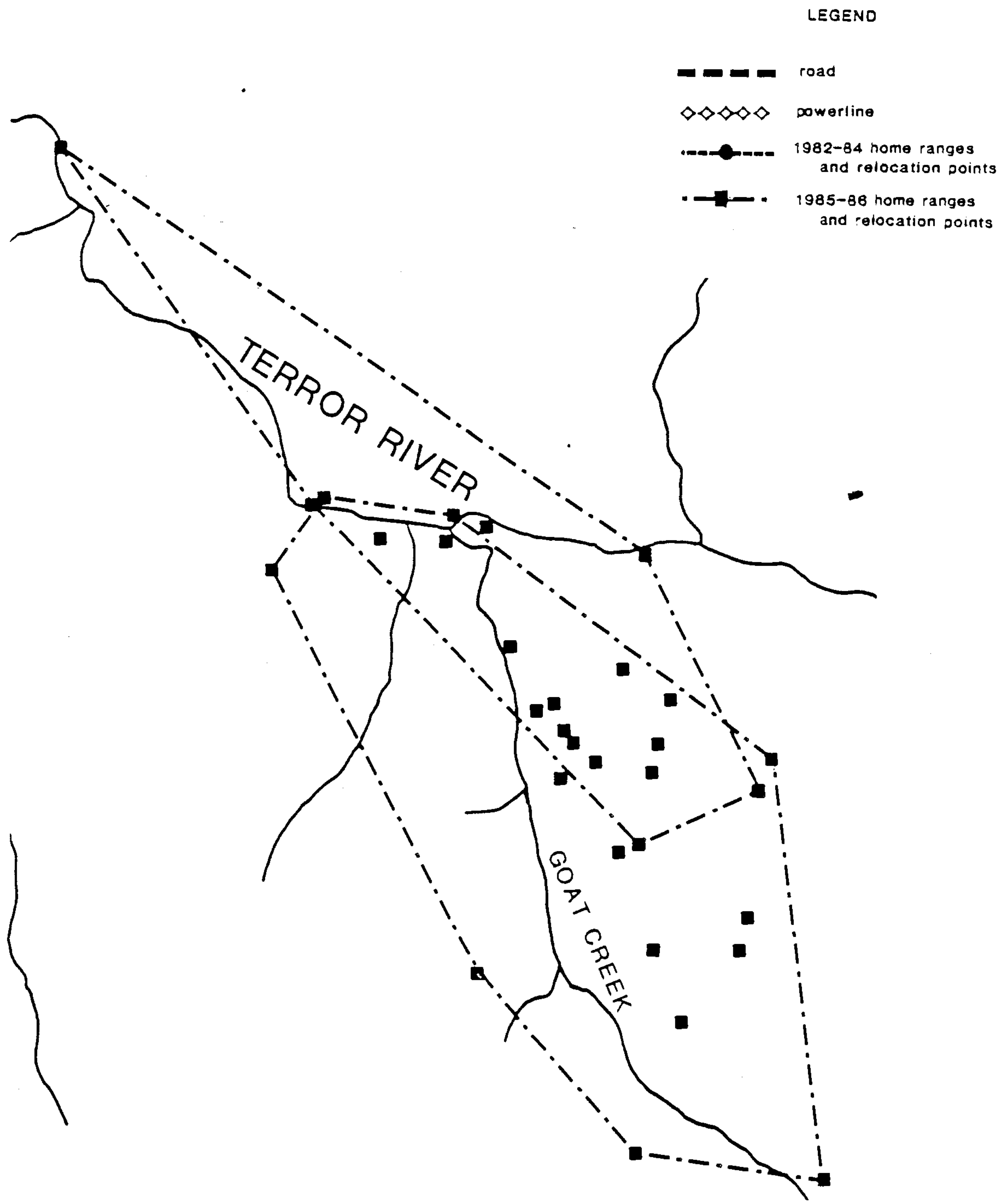


Figure 26. Radio-tracking locations points and annual home range polygons for female brown bear 085, Kodiak Island, Alaska.

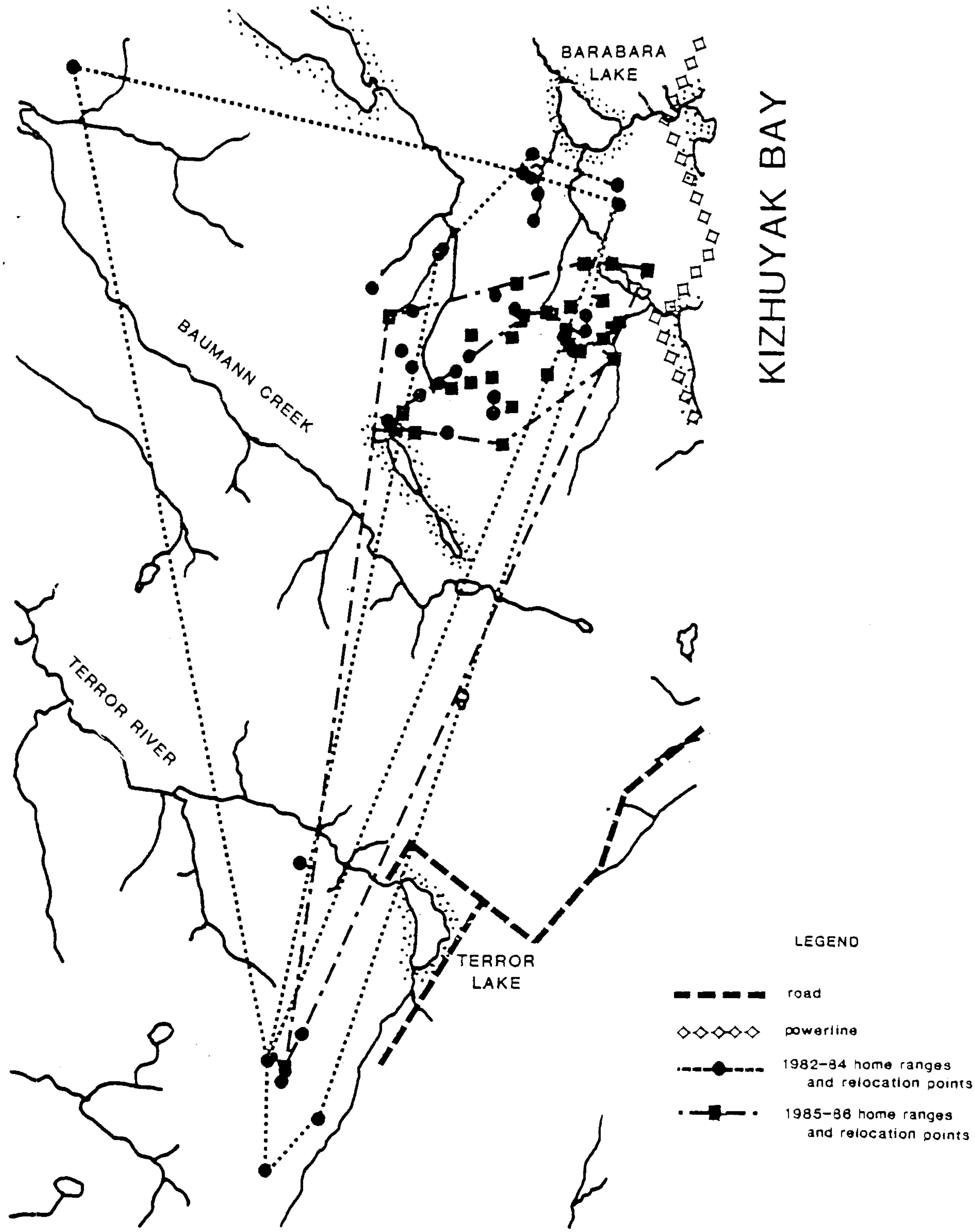


Figure 27. Radio-tracking locations points and annual home range polygons for male brown bear 002, Kodiak Island, Alaska.

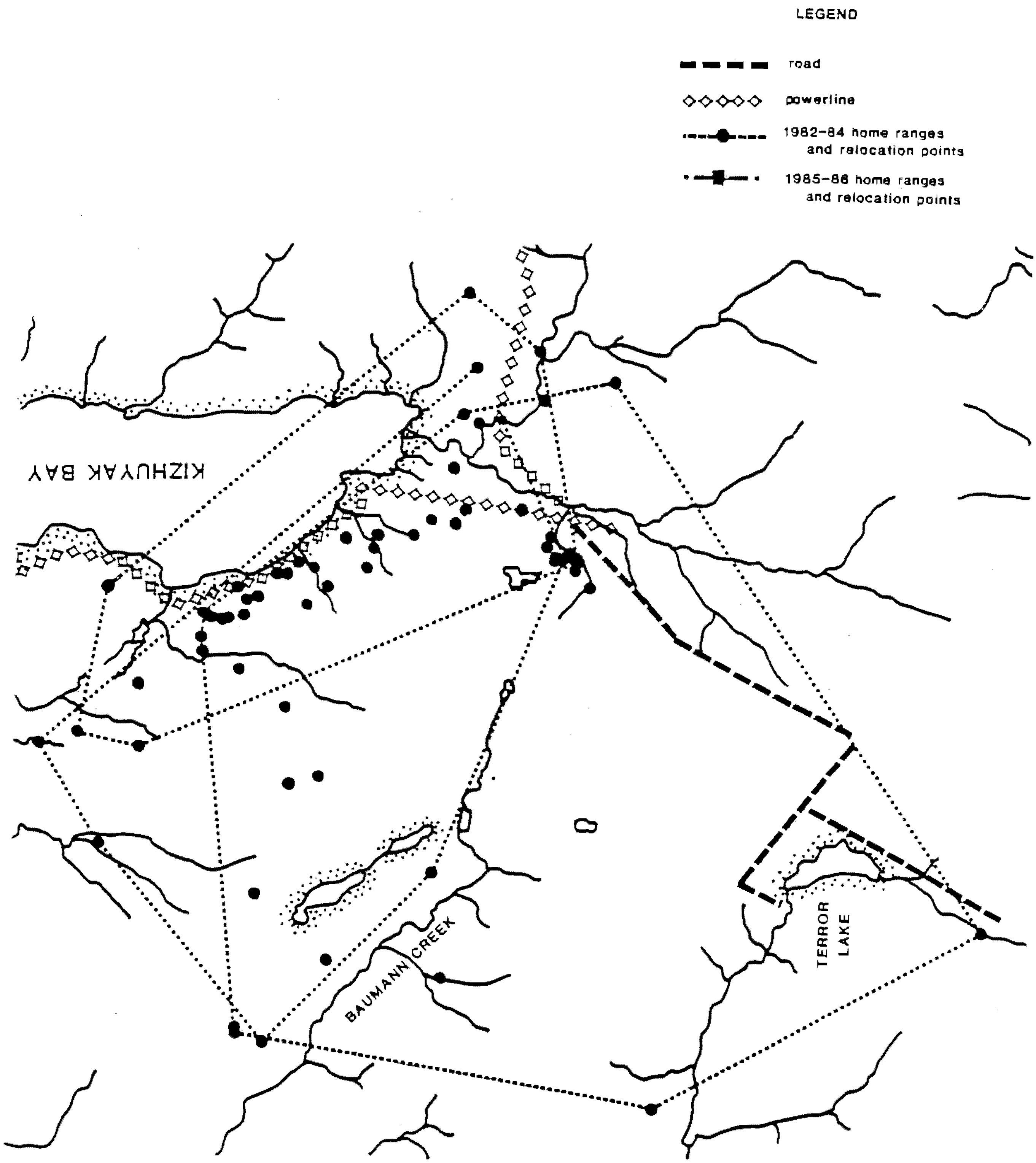


Figure 28. Radio-tracking locations points and annual home range polygons for male brown bear 027, Kodiak Island, Alaska.

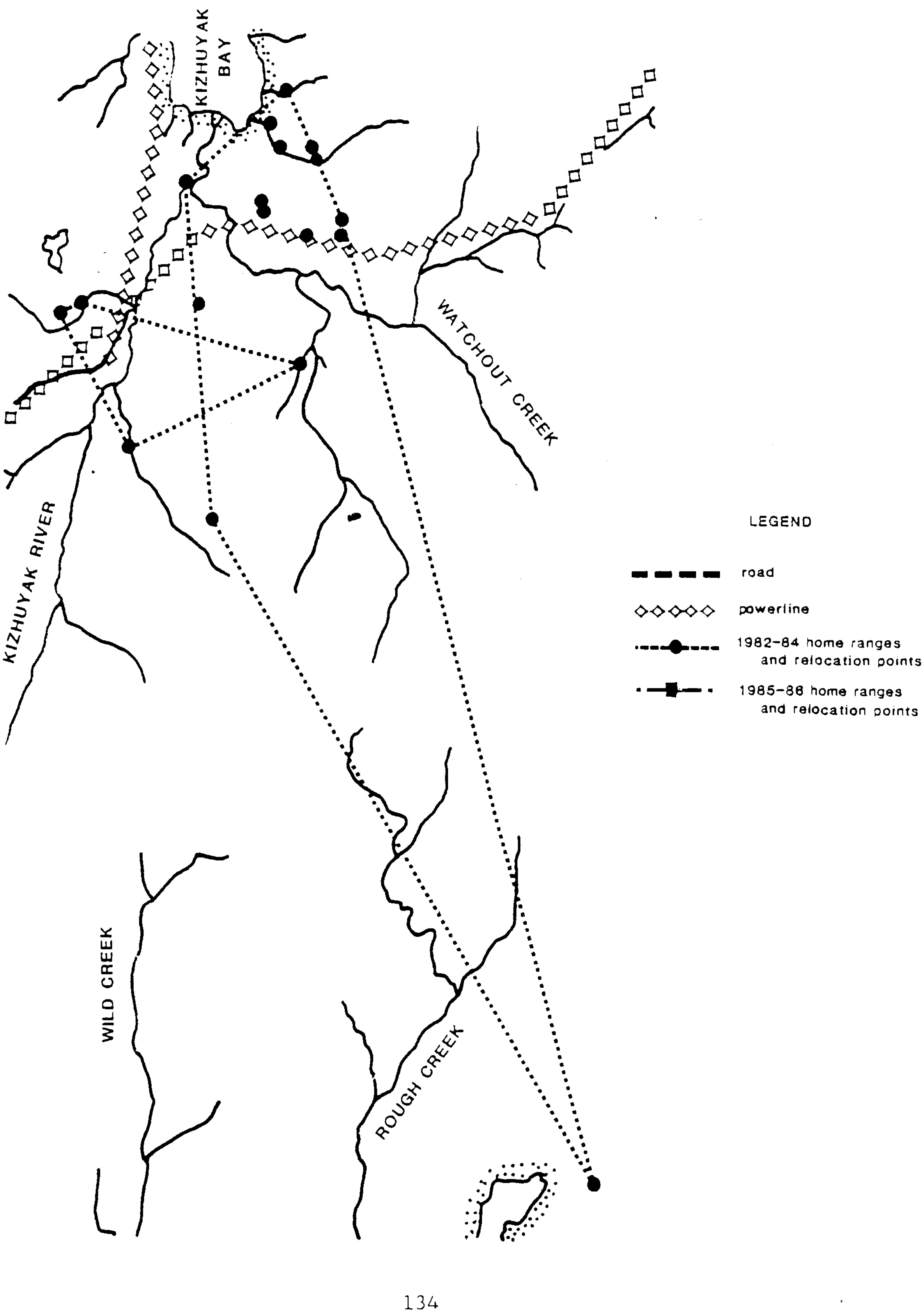


Figure 29. Radio-tracking locations points and annual home range polygons for male brown bear 028, Kodiak Island, Alaska.

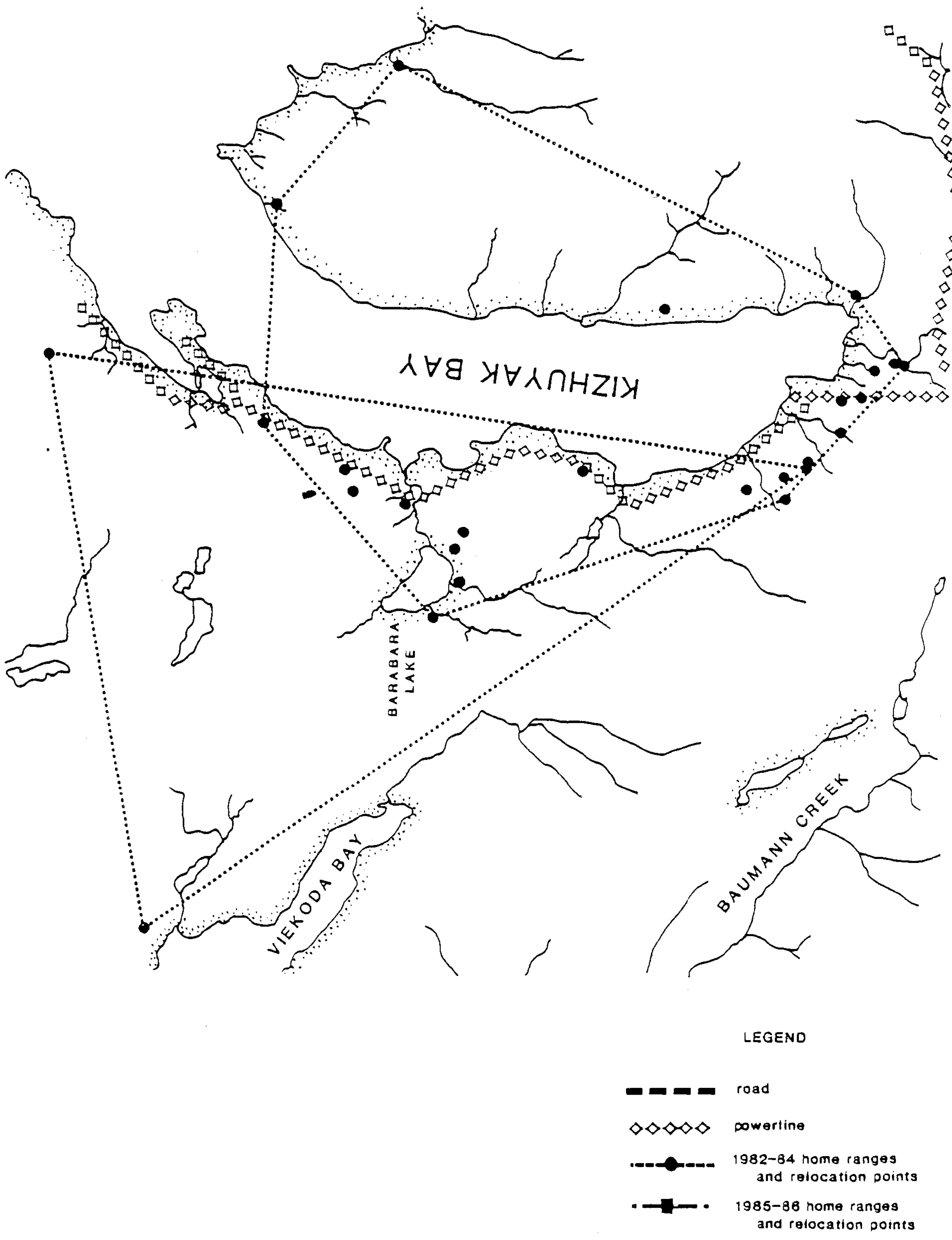


Figure 30. Radio-tracking locations points and annual home range polygons for male brown bear 040, Kodiak Island, Alaska.

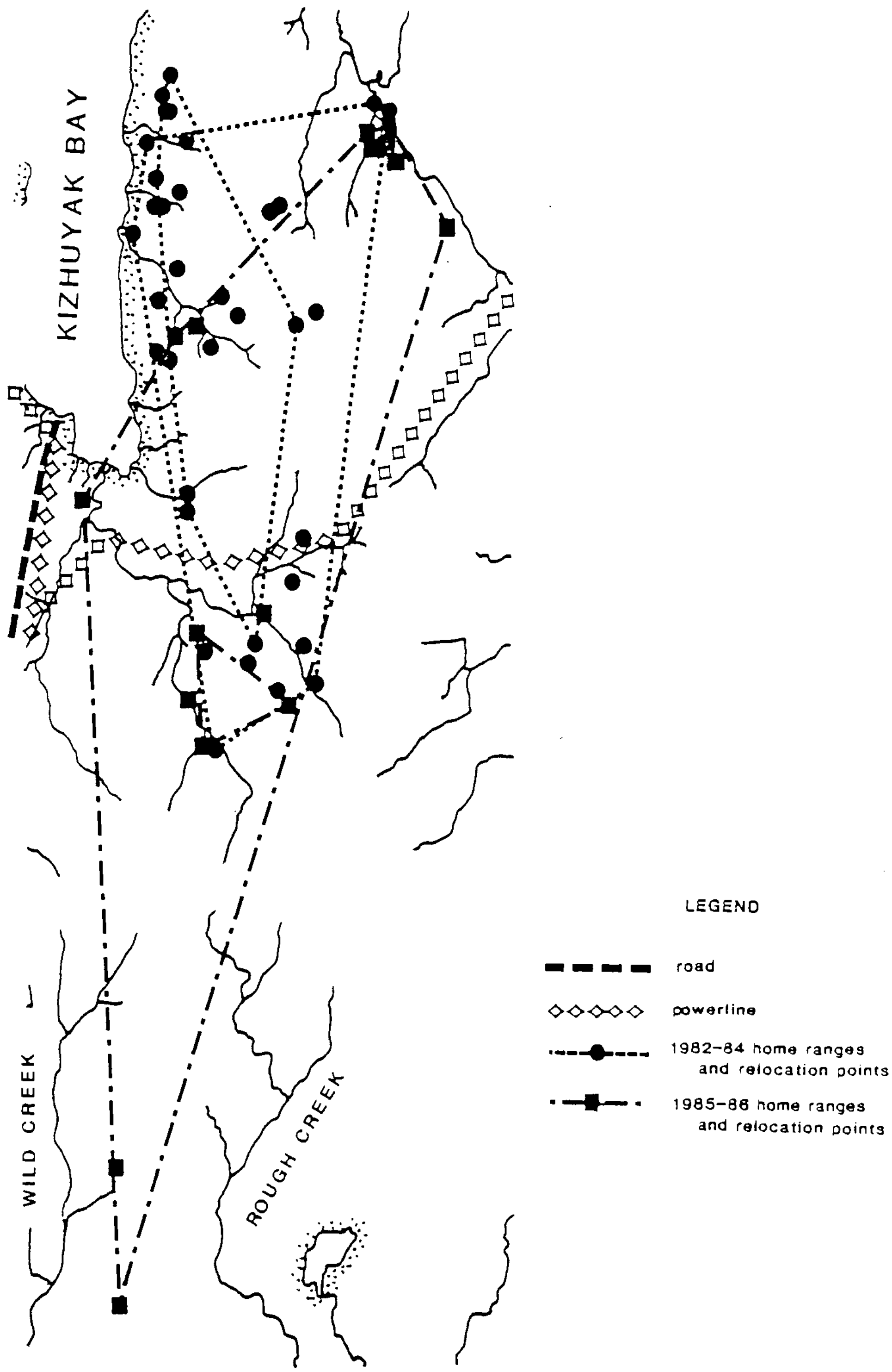


Figure 31. Radio-tracking locations points and annual home range polygons for male brown bear 045, Kodiak Island, Alaska.

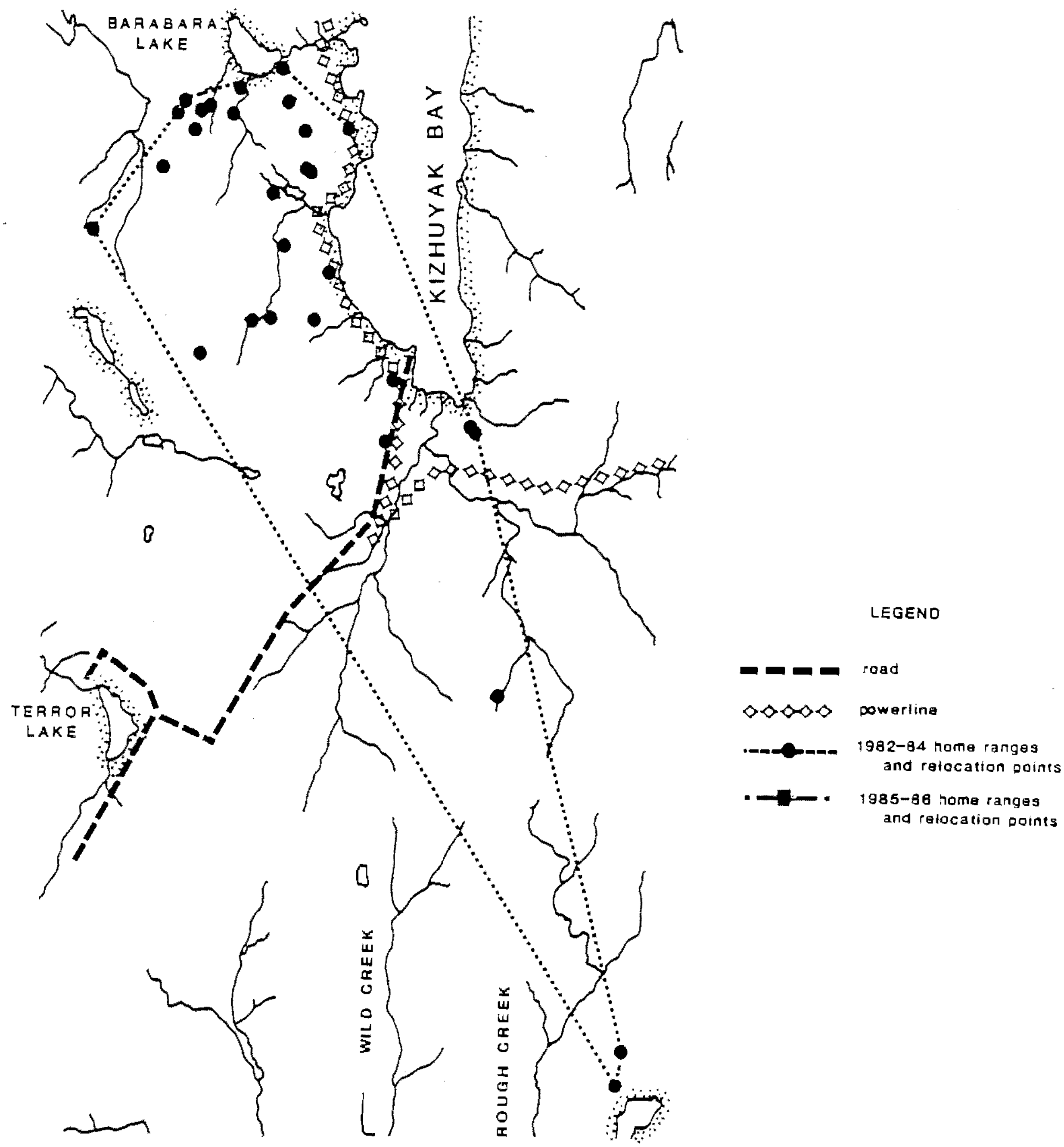


Figure 32. Radio-tracking locations points and annual home range polygons for male brown bear 084, Kodiak Island, Alaska.

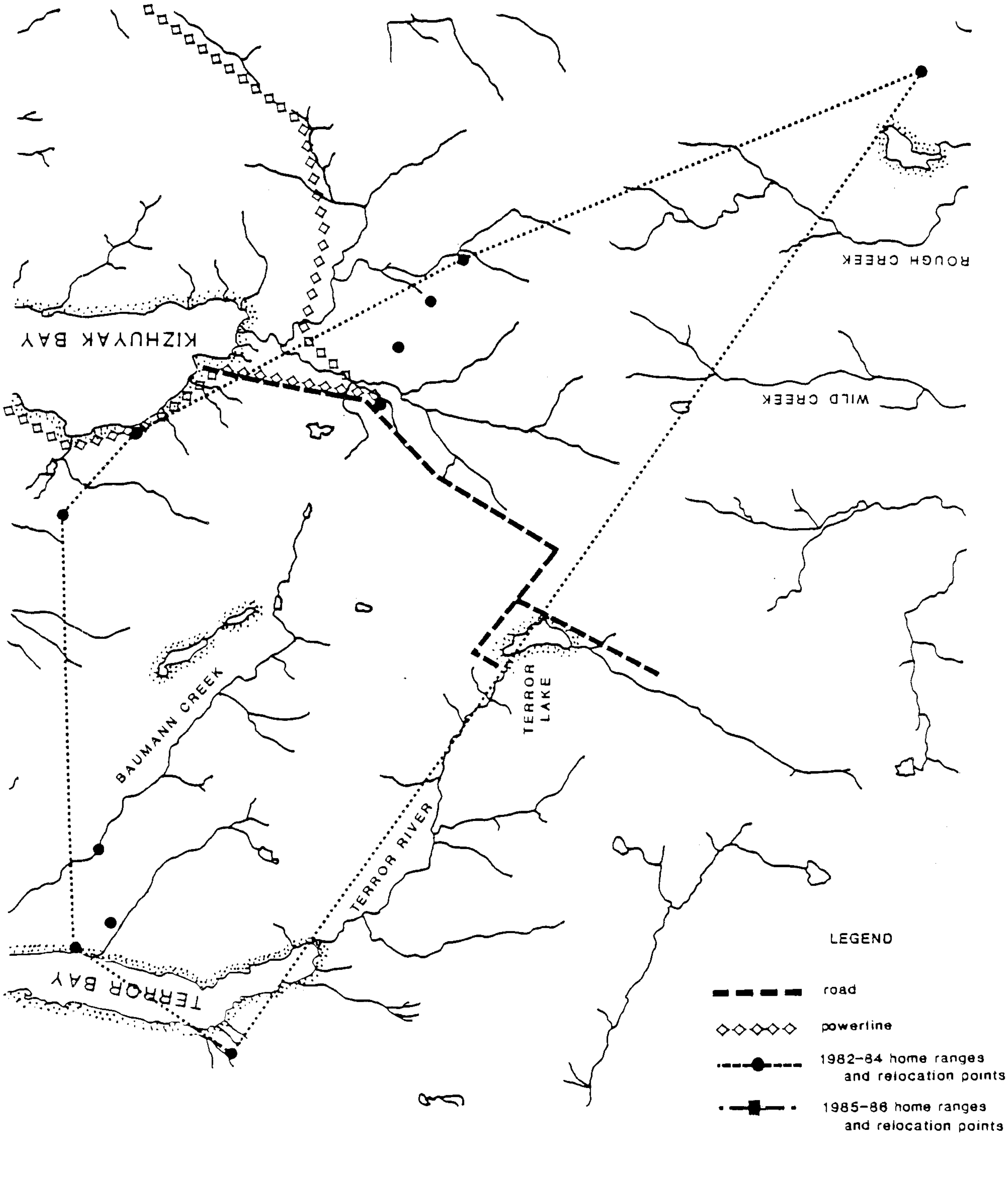
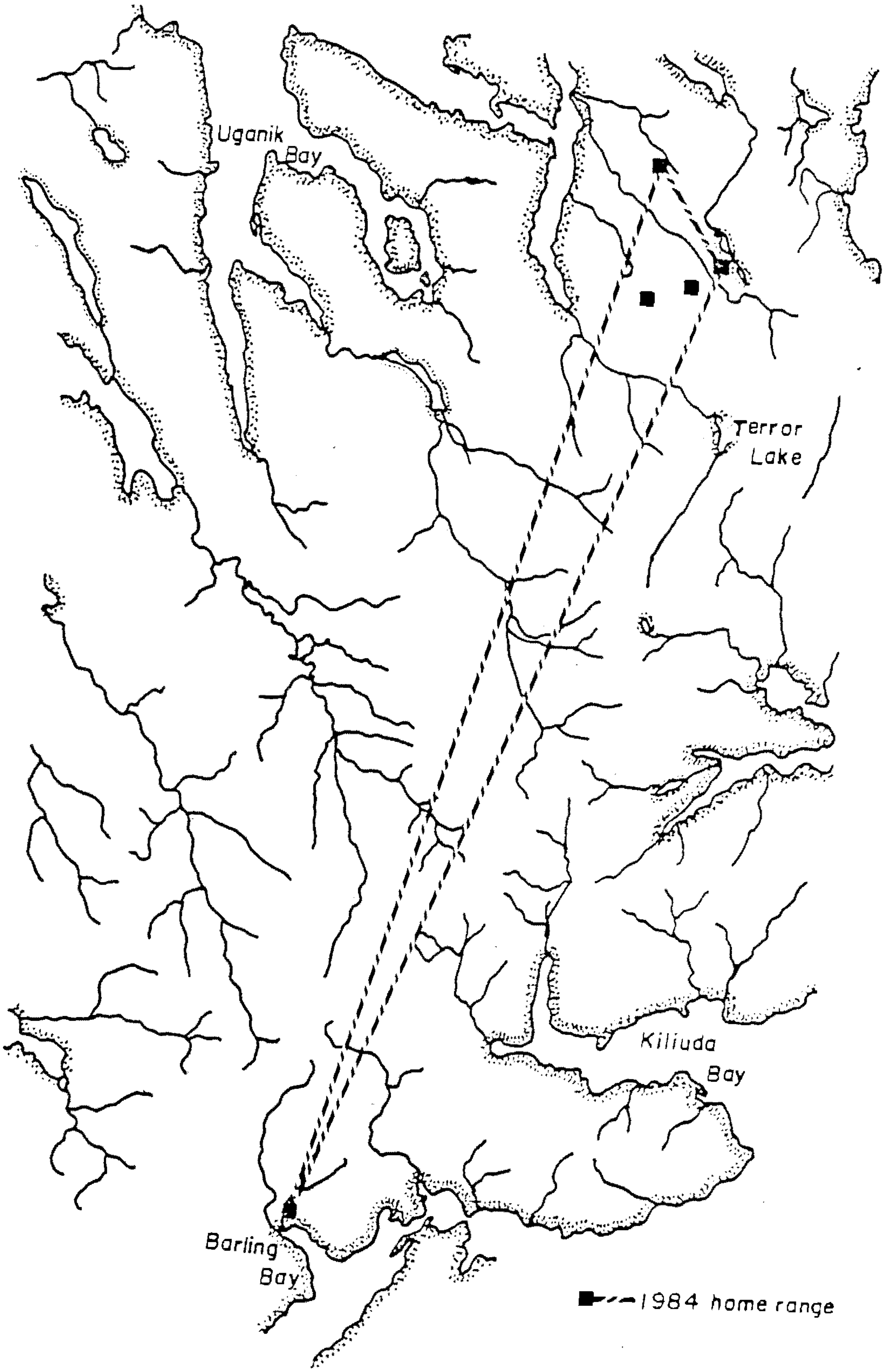


Figure 33. Radio-tracking locations points and annual home range polygons for male brown bear 105, Kodiak Island, Alaska.



Bear Observations by Construction Personnel

Methods

Observations recorded by project personnel provided an indication of the frequency and types of interactions with bears which occurred during construction. Reports were solicited during orientation briefings and standardized forms were available on bulletin boards at the construction camps. The USFWS environmental monitor assisted by collecting and recording many of the reports.

Results

Project personnel reported observing 262 bears between September 1982 and November 1984 (Table 45 and Appendix III). Bears were usually traveling through the project area, but a wide range of other activities including fishing, digging, predation, and feeding were noted. Bears were reported most often crossing the first 3 km of the access road adjacent to the lower Kizhuyak River. Bears were reported on the grounds of the Kizhuyak camp and powerhouse site on 12 occasions in 1983, where they foraged for garbage.

In only 2 of the 183 (1.1%) reports received was aggressive behavior noted. A female with 3 cubs charged to within 50 m of a bus along the road corridor in an alpine area east of Terror Lake on 1 occasion. The other incident involved a female, with 3 cubs, that charged a survey crew near the Port Lions line on 29 July 1983, prompting the crew to climb a tree.

Radio collars were seen on 9 bears. One ear-flagged bear was also reported.

The reported observations undoubtedly represented a small percentage of the actual number of bears seen by construction personnel. Collectively, the reported observations indicate that bears continued to pursue a wide range of activities in close proximity to construction activities. They also illustrate the relatively amicable relations that existed between workers and bears throughout the project.

Table 45. Summary of brown bear observations by construction personnel in the Terror Lake Hydroelectric Project study area, Kodiak Island, Alaska, 1982-1984.

	Bears observed (by reproductive status)			
Year	No. single/ unclassified	No. maternal females	No. cubs with females	Total Reported
1982	27	11	20	58
1983	136	12	27	175
1984	21	3	5	29
TOTAL	184	26	52	262

DISCUSSION

Population Parameters

Reproduction

One female first produced cubs at age 4 in this study, confirming the results of Hensel et al. (1969) for Kodiak Island and Modaferri (1984) for the Alaska Peninsula, on the age of first successful reproduction in brown bears. Only 1 of 4 females aged 3 or 4 at capture was seen with cubs by age 6 years, suggesting that many females are not successful in producing a first litter until at least age 7. Hensel et al. (1969) documented an increasing frequency of placental scars to age 7 years when all females were determined to be sexually mature. Three single females < 6-years-old when captured were lactating, indicating that the females had produced cubs, but the cubs were lost before capture. Modaferri (1984) suggested that a female's first breeding may be less successful than subsequent ones.

Females as old as 23 years produced cubs in this study and 1-26 year old female was in estrus. These data support the conclusion of Modaferri (1984) and Reynolds and Hechtel (1986) that brown bears continue to breed and produce cubs throughout their lives.

The mean minimum interval between successive weanings by females was calculated at 4.60 years. We agree with Reynolds and Hechtel (1986) and Miller (1987) that because litters are often lost before weaning, the interval between weanings best approximates the potential productivity by females. Interruptions because of loss of offspring occurred in 22% of the 41 intervals projected in this study.

Litter sizes recorded in this study were within the range of sizes previously reported in Alaska (Hensel et al. 1969, Modaferri 1984, Reynolds and Hechtel 1986, Miller 1984). Mean size of cub-of-the-year litters was 2.46 (n=28), higher than the 2.23 cubs (n=98) recorded by Hensel et al. (1969). Only 4% single cub litters were recorded in this study compared to 22% single cub litters reported by Hensel et al. (1969). The higher mean litter size and lower frequency of single cub litters seen in this study probably reflects the earlier first observation of litters, which telemetry facilitated. Hensel et al. (1969) were at a disadvantage because they often did not observe litters until mid-summer, after some mortality had already occurred.

Estimating survivorship of cubs to the age at which they become independent is difficult and relatively few studies have documented the fate of individual litters (Bunnell and Tait 1985). Survivorship to 2 years of age of known-age offspring first observed as cubs-of-the-year was 33.3% (13 of 39) in this study. Eleven (64.7%) entire litters were lost before reaching age 2 years.

Mortality was highest for cubs-of-the-year (37.5%), but yearling mortality (including litters seen first as yearlings) was also relatively high (31.7%). Comparable mortality rates were reported in studies in other areas of Alaska. Miller (1984) reported 41-47% loss of cubs-of-the-year and 30-33% mortality of yearlings in the Susitna Basin. Modaferri (1984) reported 31% mortality and 43% mortality in cubs-of-the-year from McNeil River and Black Lake, respectively, on the Alaska Peninsula. Reynolds and Hechtel (1986) reported 44% mortality in cubs-of-the-year and 12% for yearlings in the northcentral Alaska Range. Schoen and Beier (1986) reported 40% loss of cubs-of-the-year in Southeastern Alaska. Barnes (1986) observed 33% mortality of cubs-of-the-year on Southwestern Kodiak Island and 22% mortality overall in cubs to age 3 years.

Cannibalism by adult males was the only source of natural cub mortality documented during this study, supporting previous reports from other areas in Alaska (Troyer and Hensel 1969, Miller 1984, Reynolds and Hechtel 1986, Schoen and Beier 1986). It is suspected that cannibalism may be a particularly significant mortality source in high density populations such as Kodiak's where the frequency of chance encounters between bears is great.

One case in which a female with 2 cubs adopted another cub-of-the-year was observed in this study. A similar incident was observed by Erickson and Miller (1963) at McNeil River on the Alaska Peninsula, but Hensel et al. (1969) observed no cases of adoption on Kodiak Island in observations of 201 litters.

Female brown bears on Kodiak Island more often retain their offspring until the cubs reach 3-years-old than was previously believed. Hensel et al. (1969) did not observe females accompanied by 3-year-old cubs and they reported that cubs become self-sufficient at 2-years-old on Kodiak Island. Modaferri (1984) reported that only 7% of maternal females at Black Lake on the Alaska Peninsula had 3-year-old offspring. Barnes (1986) recently reported that 70% (7 of 10 litters) of the weanings of known-age litters occurred at about 3.3-years-old on Southwestern Kodiak Island. In this study for litters of known age, 46.7% were weaned at 3.3 years and 53.2% were weaned at 2.3 years. Reasons for the discrepancy between the data of Hensel et al. (1969) and data derived from recent investigations on Kodiak are not known, but it is suspected that using radio-telemetry provided more accurate information on weaning dates and age of litters than did techniques available to Hensel et al.

Adult bears were observed paired from mid-May to early August, generally consistent with Hensel et al. (1969) who reported a May 1-July 15 breeding season. Breeding associations of 1 male with 2-3 females were seen on several occasions, although conventional pairings were most common. Modaferri (1984) previously reported seeing similar associations on the Alaska Peninsula and suggested that such associations would be advantageous in a hunted population skewed toward females.

Adult Mortality

Mortality data collected during this investigation provide some insight into mortality factors throughout the study area. The data are, however, biased. Natural mortality is the most underrated mortality factor since data on natural mortality were only obtained when bears with functioning radio collars died. Bears killed illegally and bears killed in DLP incidents were undoubtedly subject to underreporting bias, as well.

Sport harvested bears were reported with a reliable degree of accuracy. No evidence suggests that any sport killed bears were unreported from the study area from 1982-1986. Identifying marks such as tattoos and ear tags could have possibly been overlooked, but it is improbable because all sport killed bears were inspected carefully by biologists in Kodiak. The percentage of mortality attributed to sport harvest was probably inflated relative to other mortality factors.

Male bears were much more vulnerable to sport harvest than females. Sport hunters were responsible for 71% of the deaths of marked males and only 20% of the deaths of marked females. The mean age of marked males killed by hunters was 5.9 years whereas the mean age of marked females killed by hunters was 10.6 years. Under current regulations independent male bears are eligible for harvest during 2 hunting seasons each year. Females are much less vulnerable since they cannot be legally harvested when accompanied by cubs. Habitat use patterns of males also predispose them to increased hunter pressure. Males are the first to emerge from their dens in the spring and the last to enter dens in the fall. The 25 October fall hunting season opening date approximates the date when females begin entering dens. Relatively few females have emerged from dens by the 1 April opening date of the spring hunting season. Therefore, numerous females are not available to hunters because they are denned during portions of the hunting seasons. Males also tend to use lower elevation habitats than females during the hunting seasons so hunters are more likely to see males.

Habitat Use

Habitat Category Use

Radio-collared brown bears made substantial use of all major habitat categories (alpine, midslope, lowland) in the Terror Lake study area at various times of the year. Although all bears exhibited characteristic individual movement patterns, the sample size was large enough to detect significant interannual use patterns as well as unique use patterns by reproductive category. Collectively, bears in the study area followed a pattern similar to that described by Kistchinski (1972) for brown bears in coastal northeast Siberia. Bears favored alpine areas for dens, but moved to lowland and midslope areas in early spring to take advantage of emerging vegetation. Rapidly emerging vegetation from midslopes to alpine remained important into July. In August, most bears moved to lowland areas as salmon became abundant in many streams. Salmon remained an important food item into October. In late September, ripening berries in midslope areas attracted bears away from streams and by October and early November, most bears were located in berry-producing midslope shrub fields. Movement to alpine areas was evident by early November and continued into December.

Males made little use of alpine areas and occupied the lowest mean elevations throughout the year. They were the first group of bears to emerge from their dens and used developing vegetation in lowland and midslope areas in early spring. Clark (1957) noted similar feeding habits in the Karluk Lake area of southwestern Kodiak Island. Single females commonly denned in alpine areas, but by May they were in areas similar to those occupied by males. Feeding on emerging vegetation and the onset of breeding seasons were reasons for the coincident use of habitats by males and single females through June. In May, females with older cubs began moving from alpine denning areas. By June, they had joined the single bears in midslope areas.

Females with newborn cubs had habitat use patterns markedly different from bears in other reproductive categories during spring and early summer. They remained spatially separated from other bears by staying in or near their alpine dens through June. Since little food is available in the alpine during this time period, significant use of remote alpine areas may be a means to protect infant cubs from predatory males during a period of relatively low food availability. This hypothesis is further supported by several observations of females with newborn cubs that moved their families from midslope or relatively low alpine den sites into remote alpine areas soon after emergence.

Herbaceous vegetation developed in alpine areas as the snow receded, offering females and cubs-of-the-year their first readily available forage. Many females with older cubs moved back into alpine areas in July. Atwell et al. (1980) described similar summer alpine feeding in the Uganik highlands, approximately 20 km southwest of the study area. He noted that *Carex macrocheata* was the most important plant species to area bears. Lone females used all habitat categories in July with little apparent selection. Males began using lowland habitats significantly in July as the first salmon and salmonberries became available. Male use of alpine areas was significantly lower than expected from May through November.

During August, bears in all reproductive categories moved to the lowlands as salmon became abundant. Although research methods were not directed at detecting diurnal use patterns, there was no apparent spatial or temporal separation of reproductive categories during this time period. Terror and Kizhuyak Rivers and Watchout and Hilary Creeks were especially important fishing streams. Salmonberries also became available in late July to early August in lowland areas during most years. Most bears continued to use salmon into September, but midslope shrub fields supporting abundant berry crops, became increasingly important for lone females and females with cubs-of-the-year.

Lowland use by all females decreased in October, while use of midslopes continued. Males persisted in their use of lowlands, but also showed increasing midslope use in October. Troyer and Hensel (1964) augmented Clark's (1957) work in the Karluk Lake areas, also noting the substantial use of berries in the fall. They stated that elderberry was the most important fruit, followed by highbush cranberry (*Viburnum edule*), bearberry (*Arctostaphylos uva-ursi*), and salmonberry. In the Terror Lake study area, it appeared that elderberry was the most important fruit, followed by devil's club berries, a species rarely found in southwestern Kodiak, and salmonberries.

Sitka black-tailed deer, which have become abundant throughout Kodiak Island since Troyer and Hensel's (1969) study, are available to bears throughout the study area. In spring and fall both bears and deer frequent midslope areas. October and November are preferred by deer hunters because the brush loses its leaves and the deer go into rut. Bears are rapidly learning to associate deer hunting activities with easily accessible food (Smith et al. 1988). Within the study area, the frequency of scavenging hunter killed deer is unknown, but suspected to be common by some individual bears based on hunter reports. Predation on deer by bears was also documented, but it appeared to be relatively uncommon.

Movements into alpine denning areas began in late October and early November. Pregnant females were the first to move into denning areas followed by females with offspring. Males remained in midslope areas from September through December. The degree of use of midslope areas declined in December as males apparently made use of all available food sources.

Bear use of habitat categories was also influenced by interannual variations in vegetative phenology. Alpine areas were used earlier and for shorter periods of time during years of relatively early alpine phenology. This was probably because sedges mature more rapidly during years of early snowmelt; hence they are nutritious and palatable to bears for relatively shorter periods of time (Atwell et al. 1980). Lone females and females with older cubs exhibited the greatest variation in annual use of alpine areas in summer. Males never made extensive use of the alpine and females with new cubs remained in alpine areas regardless of vegetative phenology.

Interannual variation in the availability of other food sources, including grasses and sedges, various berries, and salmon also occurred during each year of the study. Bears apparently adjusted to shortages in particular food types by using alternate foods. Methods employed during this study were not sensitive enough to objectively analyze either the relative availability of each food type or the degree of use of each type by the bears.

Radio-collared bears were observed near project activities and features throughout the study period. Lowland areas near the project were used much more frequently than were lowlands in the entire study area. Midslope areas were used about equally and alpine areas near the project were used less often than they were used throughout the entire study area. High use of lowlands is probably a coincidence of the powerline corridors which crossed all major salmon producing streams in the Kizhuyak Bay drainage. These streams provided an important food source for bears in the eastern half of the study area and the streams were surrounded by dense brush which provided bears with security from project activities. Dense brush in both lowland and midslope areas provided good cover to secure bears from project activities. Alpine areas, however, furnished inadequate cover for security. Bears apparently avoided project activities in alpine areas during construction (1982-1984) but they returned to the project alpine area afterwards (1985-86).

Denning

Brown bears in the study area displayed a marked variation in denning chronology based on their reproductive status. Females entered dens earlier than did males, and pregnant females were the earliest to den. Denning began in late October and by mid-November over 50% of the radio-collared females were in dens. By the beginning of December, over 90% of the females were denned. In contrast, males did not begin entering dens until mid-November and it was not until the beginning of January that 50% were in dens. Twenty-seven percent of the radio-collared males never denned during this study.

Chronology of den emergence followed a reverse pattern as males were the first to emerge, followed by lone females, females with yearling and older cubs and, females with cubs-of-the-year. Fifty percent of the males had emerged by mid-April, 75% by the end of April and all were out of dens by the end of May. In contrast, 50% of the females with cubs-of-the-year had emerged by 1 June, 75% by mid-June and the latest emergence was in mid-July. Males had the shortest denning periods and females that emerged with new cubs had the longest.

Similar denning chronology patterns have been reported by Schoen et al. (1987) in southeastern Alaska, Judd et al. (1986) in the Yellowstone area, Serveen and Klaver (1983) in Montana, and Kistchinski (1972) in Siberia. Onset of den entrance was gradual and not related to the first heavy snowfall, as was reported in the Yellowstone area (Craighead and Craighead 1972). Interannual variations in den entrance and emergence were not consistently correlated to temperature or precipitation data recorded at Kodiak city. However, there appeared to be delayed denning by bears in all reproductive categories during some years that had warm, wet autumns. There was a possible inverse correlation between the chronology of entrance and emergence in a given den year by females. This may have been caused by the availability of food resources during the preceding autumn. During years when food was relatively more abundant, female bears tended to enter dens earlier and stay in their dens longer. Increased cub production during these years also lengthened the average denning period of females since more females were accompanied by new cubs and stayed at their den sites longer.

Bears in the Terror Lake study area preferred steep slopes in alpine habitat for den sites. Over 90% of the dens of radio-collared bears were associated with cliffs or steep hillsides (>45% slope). These slopes provided suitable topography for excavation as well as occasional natural cavities which could be adapted for denning. A variety of substrates were apparently used but no selection for certain soil types was evident. In most cases, bears made several diggings before excavating their final den. These exploratory diggings may have been abandoned because of inadequate soil depths or unsuitable conditions. Soil depth and stability were usually a critical factor; however, some bears used partial or complete snow dens in areas which offered only scant soil over bedrock or unstable talus. Aspects of den sites varied. Northerly and northeasterly aspects were most common, but these aspects may have been incidental to other site characteristics.

Snow retention characteristics of a site were cited by several authors as critical factors in grizzly bear denning habitat in the Rocky Mountains (Craighead and Craighead 1972, Vroom et al. 1980, Serveen and Klaver 1983). Although most dens in northern Kodiak Island were snow covered throughout the denning season, bears apparently did not seek out sites with notably greater snow depths. Schoen et al. (1987) reported den site characteristics on Admiralty Island in southeastern Alaska similar to those observed in the northern Kodiak area. They speculated that snow is probably less important for insulation in south-coastal Alaska, where winter temperatures rarely fall below -20°C, than in colder interior areas. Instead, they suggested that bears need dry cold sites where temperatures generally remain below freezing and surface water is rare. This hypothesis may explain the preponderance of dens in alpine areas (70%) and on steep, well-drained slopes in the Terror Lake study area.

Less than 40% of the dens of radio-collared bears were within the "usable denning habitat" zone described by Spencer and Hensel (1980). This zone included most of the mid-elevation (150m to about 600m) shrub habitat in the study area and did not encompass most of the alpine areas. Criteria for Spencer and Hensel's (1980) suitable denning habitat were based on research conducted primarily in southern Kodiak Island (Troyer and Hensel 1969, Lentfer et al. 1972). Extrapolation from southern Kodiak to northern Kodiak has proven inappropriate since the 2 areas differ somewhat in climate, vegetative characteristics, geologic history and topography.

Two conspicuous den concentration areas were found in the study area. The Den Mountain and Baumann Creek areas combined comprised less than 1% of the core study area yet they contained 37% of the dens of radio-collared bears, including 40% of the dens of females and 13% of the dens of males. The sites are remarkably different from each other. Den Mountain is a high glaciated peak, whereas the middle reaches of Baumann Creek are in midslope habitats and include a narrow, flat valley surrounded by steep hillsides interspersed with numerous cliffs. Females occupied 96% of the dens used by radio-collared bears in these 2 concentration areas. Two of the 3 males that inhabited dens within these den concentration areas were less than 5-years-old and they abandoned the area soon after emergence. Therefore, only 1% of the dens were occupied by adult males that had activity areas which included the sites. All females using these concentration areas had activity ranges near their dens, most venturing less than 10 km from their dens sites throughout the year. Two other den concentration areas were noted in the Kizhuyak Bay drainage: Leanne Mountain and Pestchani Mountain. These sites were similar to Den Mountain in topography. Neither were used by radio-collared adult males during the study period.

Schoen et al. (1987) reported little overlap between male and female denning areas on Admiralty Island. However, neither they nor other authors have noted denning concentrations comparable to those seen during this study. High bear densities and a local environment rich in food resources may be responsible for this occurrence. Since females are able to satisfy all of their needs in small areas in northern Kodiak, they usually occupy relatively small annual home ranges. Sites such as Den Mountain and Baumann Creek may offer the best den site characteristics within the home ranges of several bears and thus have disproportionately heavy use. Tradition may also play a part in the development of den concentration areas. Cubs apparently occupied home ranges similar to those occupied by their mothers after family breakup. Female cubs in interior Alaska often remain in the vicinity of their mothers' home range into adulthood while males frequently disperse soon after they become sexually mature (Reynolds et al. 1987). A combination of similar home ranges and learned denning behavior may result in a large number of females in the same denning area.

Individual brown bears exhibited a high degree of fidelity to specific den sites throughout the study area. Over half the dens occupied by individual radio-collared bears were less than 1 km apart in successive years. The highest degree of fidelity was by bears on Den Mountain where 74% of the successive dens were within 1 km of each other. Females apparently had a greater degree of fidelity than did males. Mean distances between dens of individual females in successive years was considerably less in the Terror Lake study area (2.2 km) than was observed in southeastern Alaska (3.5 km)(Schoen et al. 1987). Dens of males were at similar mean distances in the 2 study areas.

Based on the distribution of dens found during pre-project denning surveys, and results of this study, areas with large concentrations of dens were apparently little affected by the Terror Lake Hydroelectric Project. Some radio-collared bears continued to use the "primary impact area" (Spencer and Hensel 1980) during the peak construction periods and 2 bears denned within 1,500 m of project construction activities. Bears continued to den in areas near project features after construction. Although short term displacement of some bears may have occurred, no evidence of project-related denning displacement of radio-collared bears was detected during this study.

Two notable anomalies in denning behavior were observed in this study; use of multiple dens by 16 bears and failure to enter dens by 8 bears. Sixteen females used 2 separate dens in 21 instances. There was no apparent correlation between maternal status or cub age and the frequency of den movements. Second dens were usually a little higher than first dens, but site characteristics and locations were similar. Timing of movements to second dens apparently was related to weather. Sixty-two percent of the movements occurred during the unseasonably warm and wet late autumn/early winter months of 1985. Similar, albeit fewer, movements occurred during the previous denning season, in early 1985, when there was another unseasonably warm, wet period. These weather phenomena probably caused some den flooding which led bears to abandon these dens.

Aberrant denning behavior by females may have been food-related as well as weather-related. The warm, wet weather in late 1985 culminated a year of relatively poor food availability for bears in the study area. As noted earlier, bears entered dens late that year and emerged early from them the following spring. Several bears that moved to different dens sites during that year were observed foraging before entering their second dens. Two females that lost litters of cubs during and before denning travelled extensively outside their traditional home range during the 1985-86 winter.

The occurrence of males not denning was not apparently related to interannual variations in weather or food availability. Males were observed active throughout winter every year of the study. More than 25% of the radio-collared males did not den during at least 1 year of the study. It is not uncommon to see bear tracks throughout the winter months in most areas of Kodiak archipelago. We found no report of nondenning brown/grizzly bears in the literature. The relatively warm winter climate and long seasonal abundance of foods probably allow some bears to remain active for longer periods on the Kodiak as compared to other brown/grizzly bear range. Nondenning bears apparently spent much of their time bedded in shrub or spruce microhabitats and intermittently traveled relatively short distances within their normal home ranges. Although these bears never entered dens, their behavior appeared similar to the "walking hibernation" described by Nelson et al. (1983) for bears that had recently emerged from hibernation. No data on winter feeding were collected during this study, but it is suspected that nondenning bears reduced their food intake and metabolism during the winter.

Four radio-collared bears died in their dens during this study. All were females between 8 and 10 years old. Two died during the 1984-85 denning season and 2 died during the 1985-86 season. No direct cause of mortality could be determined.

Project Impacts

Impacts of the Terror Lake Hydroelectric Project can be classified into short-term impacts, with little residual effect on the brown bear population, and permanent impacts which negatively affect productivity of the population and the carrying capacity of the habitat. Much of this section will be devoted to analysis of the short-term impacts and a discussion of how the brown bear population responded to the invasive but transitory effects of construction activities. The study was divided into 2 phases, a 3 year construction phase (1982-84) and a 2 year post-construction or operational phase (1985-86), to facilitate a "before and after" analysis. Comparable pre-project data were not available, a limitation which was initially identified in the formation of the study objectives. An analysis of predicted impacts of the project on brown bears by Spencer and Hensel (1980) was based on relatively limited aerial surveys to delineate denning habitat, 268 observations of brown bears and their sign made during field reconnaissance in the project area in 1980, and a review of current literature. Although that analysis was not based on comparable methodology, it provided a useful reference for comparing predicted impacts with impacts documented in this study.

Defining the effects of construction and operations of the Terror Lake Hydroelectric Project on brown bears required somewhat subjective interpretation of results. Because relatively little pre-project data were available, changes in bear movements, habitat use and other activities were interpreted with the consideration that any anomalies were potentially related to construction activities. Other variables such as weather patterns, plant phenology, annual and seasonal variations in food availability, and other environmental factors were carefully considered as well in attempting to analyze project-related impacts.

A necessary assumption was made that the movements and activities of radio-collared bears adequately represented the brown bear population in the study area. Captures were deliberately biased toward bears found closest to project features assuming that those bears would be most affected by project activities. The sample of adult males was somewhat limited because they shed radio collars relatively quickly and because they had higher mortality rates than females. It is important to recognize that many individual bears active in the study area near construction activities were not radio-collared and these bears may have been either more or less affected by project activities than the radio-collared bears.

Short Term Impacts on Habitat Use and Population Biology

Impacts on Reproduction

No relationship between construction activity and reproductive success was established in this study. Annual productivity (percent of eligible females that produced cubs) varied with highs and lows in productivity recorded during both construction and post-construction years. Cub mortality was comparable to that recorded in other Alaskan brown bear populations. Mattson et al. (1986) suggested that lower reproductive success and higher mortality of females was associated with avoidance of human developments in Yellowstone National Park. Active avoidance of construction by 1 female with a cub-of-the-year litter was suspected, but most maternal females did not demonstrate marked avoidance of construction activities. It appeared that bears adapted to disturbances caused by construction activities without major changes in foraging strategies or habitat use patterns. It is improbable that energy levels of individual bears were affected to the extent that reproductive success declined.

Breeding activity was little affected by construction activities. Capture operations disrupted breeding activities temporarily but captured bears of both sexes resumed breeding activities within as little as 3 days after capture.

Impacts on Mortality

No direct mortality of bears was attributed to construction and operation of the Terror Lake Hydroelectric Project from 1982-1986. Natural mortalities, including deaths from intraspecific predation or fighting, and unexplained deaths at den sites occurred. Spencer and Hensel (1980) suggested that displacement of bears by construction activities could result in increased intraspecific aggression and competition, but we had no evidence to either confirm or deny that the natural mortalities verified in this study were related to displacement of bears by construction.

Improved access via the construction road and powerline rights-of-way indirectly contributed to the deaths of at least 2 bears, 1 killed by a deer hunter in DLP incidents (126) and 1 an illegal, unreported kill (123). As increased recreational use occurs along these access routes, so is the incidental killing of brown bears expected to increase.

Construction activities had no known effects on sport hunting mortality. Hunting was closely regulated by a permit system. Development of roads and powerlines provided minor improvements in access for bear hunters, but hunting success was probably unaffected. Several hunters and a guide obtained copies of, or reviewed the annual reports from this brown bear study, attempting to improve their chances of success. There was no evidence that the reports contributed to improved hunter success during this study, but providing seasonal locations on maps for individual bears with small home ranges could potentially enhance a hunter's chances of locating a specific bear.

Project-related mortality during the study included 7 capture-related deaths, an average of 1.4 bears/year for the 5 year study. The 3.6% capture mortality frequency recorded during the study was comparable to that of other brown bear studies in Alaska.

The loss of 4 adult females through capture-related mortality resulted in a loss of productivity in the bear population. Separation and abandonment of cubs occurred in 1 or 2 instances during captures, another minor loss of productivity. Although not a direct result of construction, such losses must be considered as real impacts resulting from development activities because environmental studies have become a nearly universal requirement in the decision-making process regarding developments on public lands.

Impacts on Movements and Seasonal Habitat Use

This section provides a broad overview of how brown bear movements were affected by construction and operation of the Terror Lake Hydroelectric Project. The movements of individual radio-collared bears related to project activities which were discussed in a previous section, provided a background for this more general treatment.

Impacts on Seasonal Use of Major Food Sources

Relative density of vegetative cover was an important factor in determining how bears used habitat near project features: the denser the vegetation, the better the security was for bears to continue using habitat without altering their "normal" activity patterns. Disturbance from construction activities resulted in some loss of feeding opportunities in habitats with little available security cover for bears. Feeding by bears on sedges in intertidal areas is relatively common in late spring and early summer. Although bears were occasionally observed and sign of bears feeding on sedges was found in the Kizhuyak River intertidal flats and near Hilary Creek during active construction, bears were more commonly seen feeding on sedges in the Terror River intertidal area, where relatively little disturbance occurred. The proximity of the access road and the frequent helicopter traffic near the Kizhuyak intertidal area, which was particularly heavy in 1983 during construction of the 2 transmission lines, were major potential sources of disturbance. When bears in open terrain were approached by helicopter during capture operations, they characteristically fled to the nearest brush or rocky area. The disruption of feeding activity in the Kizhuyak intertidal area was perhaps compensated for by bears adopting more nocturnal activity patterns or by adopting alternate feeding strategies, such as concentrating on herbaceous plants simultaneously greening up on lower slopes.

Summer feeding in alpine habitat within sight of project activities diminished during construction. Over 90% of the observations of radio-collared bears in alpine habitat within 1,500 m of project features were made during the 2 post-construction years, 1985 and 1986. Alpine habitat near project features was used less and lowland habitat was used more than expected based on relative availability of the 2 habitat types. Use of alpine habitat on the slopes of Den

Mountain, northwest of Terror Lake, by radio-collared bears was common during construction but no radio-collared bears were observed feeding on alpine vegetation in the Terror Lake basin during construction. Three radio-collared bears (132, 140, 141) captured in 1985 and 1986 were seen in alpine areas near the lake during the post-construction period. Both radio-collared and unmarked bears were commonly found feeding in alpine areas in upper Watchout Creek and upper Kizhuyak River both during and after construction. Those areas were apparently far enough removed from construction activities that disturbance was a minor factor.

Bears congregated near salmon streams throughout the project area during late July through September. The Kizhuyak River and Watchout Creek drainages were subjected to the most disturbance from construction activities of any salmon streams in the study area. Comparing movements of individual radio-collared bears during and after construction indicated that bears more commonly used the lower stretches of Kizhuyak River and Watchout Creek, which had less security cover, in 1985 and 1986. During construction, bears appeared to prefer upstream stretches with dense streamside cover of cottonwoods, willows and alders, despite the intensive activity near these salmon streams during construction of the Kodiak transmission line in 1983. Eagle Creek, a small stream with only a few hundred pink salmon located within a few meters of the western edge of the equipment storage area near Kizhuyak Bay, continued to be used by bears during construction despite the intensive activity nearby.

Bears could regularly be seen feeding on salmon from vantage points along the construction access road and workers frequently reported seeing bears crossing the road near lower Kizhuyak River in August and September throughout this investigation. We suspect that bears may have adopted more nocturnal feeding patterns in this area in response to disturbances.

Salmon are such an attractive food source that bears apparently tolerate high levels of human disturbance if security cover is available. Some individual bears may have been less tolerant and may have shifted their activity areas, as was suspected for female 005 in 1983, but most bears apparently adjusted their feeding strategies to compensate for lost opportunities for feeding on salmon in lower Kizhuyak River. The abundance of berries and other preferred foods in densely brush-covered lower slopes near construction sites may have evoked comparable levels of tolerance to disturbance as well.

High turbidity in lower Terror River in late September 1982 was suspected to have caused bears to leave salmon feeding areas prematurely (Smith and Van Daele 1984). Excavation at the dam site and siltation from a gravel washing operation produced extremely turbid conditions in Terror River which may have interfered with bears' fishing.

Significant impacts on salmon production were not predicted in either the Terror or Kizhuyak River drainages in pre-project impacts analyses (Federal Energy Regulatory Commission 1981). Subsequent monitoring of salmon escapement and survival of pre-emergent pink salmon fry in these streams has not detected any declines attributed to effects of construction (Prokopowich and Brown 1986). Although alterations of water flow regimes in both Kizhuyak Bay and Terror River drainages occurred as a result of the project, there was no apparent decline in the salmon available to bears in the study area.

Although bears may have altered their use of lower slopes somewhat near project features, as was predicted by Spencer and Hensel (1980), results of this study indicate that some bears continued to occupy areas during construction where dense brush provided adequate security cover. In early summer, bears continued to feed on herbaceous vegetation in lowland and mid-land habitat below 450 m. This habitat also contained the major berry-producing species which bears favored from mid-summer to late fall. The frequent location of several radio-collared bears on shrub-covered slopes in the lower Kizhuyak River and Watchout Creek drainages during construction activities indicated that bears continued to pursue traditional seasonal feeding patterns.

Previous investigators have reported that grizzly bears avoid areas of human activity, including roads (Harding and Nagy 1977, Archibald et al. 1986, Mattson el at. 1986). A significant decline in the use of a roadside corridor by 2 radio-collared female grizzly bears in coastal British Columbia was correlated with logging truck traffic (Archibald et al. 1986). In sharp contrast with our results, they reported that bears discontinued use of salmon feeding areas near the road during active logging. Bears resumed feeding on salmon during periods when logging activities ceased. They also found that the relative availability of vegetation forming visual barriers was not a factor in determining activity patterns. Movements of several brown bears away from an area of logging road construction on Chichagof Island in southeastern Alaska were also interpreted as a negative response to disturbance (Schoen and Beier 1986).

Impacts on Travel Routes and Daily Activity Patterns

Delineation of travel routes, particularly those between drainages, could usually only be surmised based on sequential radio-locations of individual animals. Spencer and Hensel (1980) identified several specific passes and travel corridors used by bears in the study area and our results generally confirmed their observations. Although brown bear use of traditional routes is evidenced by well-worn trails in passes, near streams, and along the coastline, trails are by no means a requirement for bear movements. Well established bear trails were prominent along all salmon spawning areas and the access routes between the streams and adjacent slopes used for security cover were visible.

The use of some trails between Kizhuyak River and the slope west of the river was altered by the destruction of short sections of established bear trails during construction of the access road. The frequent observations by workers of bears crossing the road, confirmed by sequential locations of radio-collared bears, indicated the road was not a serious barrier to movements to and from the lower Kizhuyak River. The attractiveness of salmon as a food source was apparently great enough to overcome aversion to vehicular traffic and construction activity.

Post-construction movements of brown bears west of Kizhuyak River may have been somewhat altered, as was suggested by Spencer and Hensel (1980), during the April-May post-denning period. Vegetative cover was least available during that period, and the potential for disturbance was much greater than it was after leaf-out occurred. However, several radio-collared bears continued to use this area in April and May throughout this investigation.

Although Spencer and Hensel (1980) suggested that construction activities might seriously disrupt travel along an access corridor between Kizhuyak Bay, Viekoda Bay and Baumann Creek, we found little evidence to that effect. Sequential locations of several radio-collared bears indicated travel was common along lower slopes between the west side of Kizhuyak Bay and the Viekoda Bay drainages. The extremely dense vegetative cover below 500 m throughout the study area allowed bears to maintain a high level of security.

Use of travel routes in alpine habitat was potentially most sensitive because of the lack of cover. Spencer and Hensel (1980) generally identified the "primary impact zone" as the area within sight of major project features including the dam, access road and construction camp. The frequent passage of helicopters and vehicles along the access road through the alpine area between Kizhuyak River and Terror Lake probably had some deterrent affect on bear movements through that area. The finding that fewer visual observations of radio-collared bears near project features were made during construction than occurred in the post-construction period supports the opinion of Spencer and Hensel (1980) that travel in open, alpine habitat was diminished. Occasional observations of bears by construction workers near Terror Lake and in the access road corridor between

Falls Creek and Terror Lake indicates that a complete cessation of travel through alpine corridors did not occur, however.

Analysis of the frequency of visual observations of radio-collared bears during the construction and post-construction periods of the study also suggests that bears avoided open habitat where they could be easily observed. For radio-collared bears located within 500 m of construction features during construction (1982-84), in only 26.8% of the locations were bears actually seen. In contrast, bears were seen in 45.2% of the bear locations within 500 m of project features during post-construction.

Spencer and Hensel (1980) identified the pass approximately 2.5 km north of the Terror Lake dam site as a travel corridor which would be disrupted by construction. Although the high level of construction activity at the dam site in 1982 and 1983 was probably a deterrent to use of the immediate dam site area, continued use of alpine habitat north and west of the pass was verified by locations of radio-collared bears. Shrub cover is relatively sparse in the pass which rises to about 550 m, but dense vegetation is found below 450 m on both sides of the pass. There was no evidence that construction activities at Terror Lake were a significant barrier to bears moving between the Terror River and Baumann Creek drainages. There was little evidence that a significant barrier to movements between Terror River and Baumann Creek to the north occurred because of construction activities at Terror Lake as predicted by Spencer and Hensel (1980).

Interchange of bears between the Terror River and Baumann Creek drainages occurred via Terror Bay and the 530 m pass west of Den Mountain. These areas appeared to be more important travel routes than the pass closer to Terror Lake. Although the mitigation plan required that helicopter traffic be routed to avoid bear concentration areas, there were numerous "sight-seeing" flights by project personnel in which bears were approached closely by helicopters. Brown bears in the study area were much more sensitive to approach by helicopters than by fixed-wing aircraft.

The significance of helicopter use to overall movements by bears is unknown, but undoubtedly daily movements of certain individual bears were influenced by helicopter traffic. Bears were actively harassed by helicopters to a limited extent during construction of the Port Lions transmission line in 1983 after reported confrontations between bears and construction workers. Because active harassment was not a widespread practice of long duration the overall impact on bear movements was probably minor.

Impacts on Denning

Spencer and Hensel (1980) identified bear denning as 1 of the activities most sensitive to disturbance from construction. However, their predictions were based on incomplete knowledge of habitat requirements for denning in the study area. That data void was filled by using radio-telemetry to locate dens and redefine denning habitat. Because they characterized a much lower elevational zone as prime denning habitat than was found in this study, their original assessment of the potential for disturbance to denning activity was based on the belief that major project features were located within or near important denning areas. In fact, the major project features (powerhouse, construction camp, dam) were at elevations well below the 665 m mean elevation of dens located in this study. The construction access road traversed approximately 8 km of alpine habitat between Terror Lake and Kizhuyak River, but its location was several kilometers from the nearest mountain peaks where concentrated denning was found. Because denning bears were located in sites over a much broader elevational range than Spencer and Hensel found, denning habitat in the study area was probably not as limited as they suspected.

Dens of several radio-collared bears were found west of lower Kizhuyak River during the first 3 years of the study. Spencer and Hensel (1980) stated that denning would be eliminated or greatly reduced during project construction in this area. The favored denning areas were found near the summit of the peaks (Leanne Mountain) and the upper reaches of the southernmost tributary into Hilary Creek, not the slope immediately adjacent to the powerhouse and tunnel.

Although it could be argued that bears denned at higher elevations because of the intensity of disturbance from construction on the lower slopes, the fact that denning concentrations were found near peaks at similar elevations throughout the study area tends to discount that argument. Spencer and Hensel based their assessment of the importance of this area for denning on early spring aerial surveys of habitat below 750 m but they were unable to verify dens in the slopes west of Kizhuyak River. These surveys were made when bears were actively emerging from dens, and the presence of tracks and bears seemed to support the conclusion that bears were denning there. However, actual den sites of these bears may have been in higher elevations which were not searched.

A 16-year-old male (002) was located from mid-November to mid-March within less than 1 km of the Kizhuyak tunnel portal site during the 1982-83 denning period. This bear was originally reported as having denned in this area (Smith and Van Daele 1984), but because no den site was actually seen and because of its relatively early movement we now suspect that this bear may not have entered a conventional den and was semi-active. This bear moved from the north side to the south side of Rolling Rock Creek between 5 February and 17 March 1983 when it was seen from the ground bedded under a prominent boulder. Blasting activity which had been occurring near the penstock site for several days previously, may have been a factor in the bear's movement, but it was observed in exactly the same location on 19 March, shortly after explosives were used for avalanche control in upper Rolling Rock Creek. This suggests that the bear was relatively tolerant of disturbance.

Blasting and other intensive excavation and construction activities which were conducted mainly during 1982 and 1983, could have disturbed unmarked bears in their dens or prevented use of some potential den sites. Monitoring denning locations and movements of radio-collared bears during the first 3 years of the project could not establish any direct relationship, however.

Bears in dens frequently tripped the motion sensors in their radio collars after 1 or more low approaches by the radio-tracking aircraft. The significance of such disturbances once or twice a month was probably of little consequence, as dens were not abandoned. Nevertheless this indicated that bears in dens could be disturbed by noises as minor as those from a low flying aircraft. Garner et al. (1983) reported that some brown bears in northeastern Alaska abandoned recently dug dens when approached by survey aircraft. Reynolds et al. (1986) noted that overflights resulted in increased heart rates of denned bears near the onset of spring emergence, but they did not consider such disturbance significant. Reynolds et al. (1976) reported that bears abandoned 5 den sites in northeastern Alaska after the dens were approached by a helicopter and noted that bears seemed most probably to abandon dens during or shortly after den construction. On 1 occasion during this study, an adult male bedded at the base of a small spruce tree was repeatedly overflown by a survey aircraft without the bear awakening or tripping the motion sensor in its radio collar.

Extensive use of helicopters may have deterred denning activity by bears. Heavily traveled alpine areas such as Elbow Creek pass and along the access road between Kizhuyak River and Terror Lake would have been particularly susceptible to such disturbance. Because radio-collared bears denned successfully each year during construction, it seems improbable that such disturbance had significant impacts. Moreover, it appears that availability of denning habitat was not a limiting factor on the bear population.

Few dens were found in the Terror Lake basin. Our findings generally supported Spencer and Hensel's (1980) predictions that construction activity would cause bears to avoid denning near Terror Lake, but that denning would resume after construction was completed. During the construction period, the closest location of a den of a radio-collared bear to Terror Lake was the 1983-84 den of female 085, located at 1,190 m, 4 km southwest of the lake. Dens of 2 females (131, 140) were located 300-500 m above the eastern side of the Terror Lake basin in 1986-87. Unfortunately, neither of those 2 bears were captured until 1985, so their den locations during the construction phase of the project were unknown.

Although our limited data on denning near Terror Lake tend to support Spencer and Hensel's (1980) predictions, the denning habitat used by radio-collared brown bears in the Terror drainages was considerably different from what they delineated. "Useable" denning habitat described by Spencer and Hensel did not include the area east of Terror Lake where 2 bears denned in 1986-87, nor did it include the upper elevations of Den Mountain, which was found to be a major denning concentration area. They considered the lower slopes west of Terror Lake as the most important denning habitat near the lake, supporting 20% of the dens in the Terror River drainage. They predicted a significant decline in denning within 5 km west of the lake, an area which encompasses most of Den Mountain and the peaks west of the dam site, where numerous dens of radio-collared bears were located both during the construction and post-construction phases of the project.

Impacts on denning were probably much less severe during construction than had been predicted for the Terror Lake drainage. By late October 1983 construction of the dam was complete, so major use of heavy equipment was confined to only the 1982-83 den year. The Terror Lake construction camp, which was built west of upper Terror Lake in late 1982, was removed by November 1983. That camp was a project feature added for the contractor's convenience which was not considered in pre-project studies by Spencer and Hensel (1980). Disturbance to denning from a permanent Terror Lake camp was potentially greater than had been predicted, but the overall impact from a single winter's operation was probably minor.

It is improbable that potential or actual den sites were inundated by the Terror Lake reservoir or any of the smaller impoundments. Denning habitats identified during this study were generally at elevations well above the 433 m final elevation of Terror Lake.

The repeated use of approximately the same locations for denning by individual bears in successive years suggests that disturbance from project construction was less than had been predicted. Only 1 radio-collared bear (female 005) was believed to have shifted her activity area and den site to avoid disturbance from transmission line construction activity in 1983. The actual distance between her 1982-83 and 1983-84 den sites was only about 1.2 km. That bear denned north of Watchout Creek (Pestchani Mountain) for 5 consecutive years and the maximum distance between all of her den sites was 2.3 km. Similar results were found for other bears considered "closely associated" with project features. Female 071 had 5 consecutive dens in upper Watchout Creek with a maximum separation of 3.2 km. Female 119 denned for 3 consecutive years beginning in 1984 in upper Falls Creek, within 1 km of the access road. The high fidelity of individual bears to specific denning areas is considered a good indication that major disruption of denning did not occur during project construction. Den locations for individual bears were unknown before the 1982-83 den year, but captures in April 1982 were concentrated in suspected denning areas near planned project features. During that time only construction of the access road was underway and disturbance was minimal in the study area. It is believed that may bears were captured near their 1981-82 den sites. With rare exceptions, home ranges and den locations subsequently delineated for those bears supported that conclusion.

Radio-collared females changed den sites during the winter in 21 instances. Although the dates of these changes were not precisely determined, they generally occurred early in the denning period and were generally correlated with unusually warm, rainy periods. The movements between first and second den sites were relatively short (mean=1.5 km), suggesting that traumatic disturbances were not involved in the movements. Bears with dens remote from project activities used second den sites as well as bears located relatively close to project activities. Disturbance from construction activities was not a suspected cause of these den site changes.

Snow machine tracks were observed within 75 m of a denned single female (078) on 9 April 1986, north of Watchout Creek. When next located, on 23 April, this bear was still in the den although the entrance was open. Reynolds et al. (1983) reported the abandonment of a brown bear den in northern Alaska which may have resulted from close approach by seismic crews. Recreational snow machine use in denning areas of Watchout Creek, Elbow Creek and northern Ugak Bay drainages became increasingly common during this study and the potential for disturbing denned or recently-emerged bears appeared high.

Several radio-collared males did not den but were somewhat active all winter. One male (002) which was captured in April 1982 near the eventual site of the Kizhuyak tunnel portal returned to within 1 km of the portal by mid-November 1982. That bear was apparently somewhat active all winter, but it remained close to the tunnel portal during active construction and did not vacate the area until late March when male bears normally begin moving extensively after leaving dens. During the following winter the bear did not den, but was located several kilometers north of active construction sites. This bear's normal denning pattern may have been disrupted by construction activities in its favored wintering area. Other males which did not den were much less closely associated with project features. We believe some males commonly do not den irrespective of potential sources of disturbance.

The few natural mortalities which occurred at den sites could be interpreted to support Spencer and Hensel's (1980) hypothesis that bears displaced by construction would den in marginal habitats. However, 3 of 4 bears that died at dens had home ranges well removed from project features and each had at least 1 previous successful den at nearly identical sites.

Although permanent loss of potential denning sites may have occurred near the powerhouse, penstock, and access road, where permanent human activity resulted from the project, the overall impact on the bear population was probably not of major significance. Deer hunting activities along the access road may be a permanent source of disturbance to bear denning in late fall, but the area affected is extremely small.

Impacts of Brown Bear Study

Several studies to determine impacts of large-scale developments, such as logging, mineral extraction, and hydroelectric projects, have been done in Alaska and Canada (Archibald el at. 1986, Miller 1987, Schoen and Beier 1986). These studies relied heavily on information collected from radio-collared bears. The capture and handling of bears require unavoidable risks to the animals. Seven bears died during capture operations in this study from 1982-1986. That loss represented 5% of the individual bears captured. The mortality rate from all 197 captures, including re-captures, was 3.6%, close to the 4.0% mortality rate reported by Miller (1987) for 151 brown bear captures in the Susitna Hydroelectric Project impact study.

One case of capture-related cub abandonment was verified. Female 092 abandoned a litter of 2 1.4-year-old cubs after the family group was captured in June 1983. Two young ear-flagged bears matching the cubs' description were seen in upper Elbow Creek in September, but it is not known if they survived. Another female (129) may have become separated from 1 of her 3 cubs-of-the-year as the result of her capture. When she was next located only 2 cubs remained in her litter.

During radio-tracking flights some unavoidable disturbance of bears occurred during low-level passes. Although bears sometimes fled at the approach of the aircraft, most bears appeared to show little concern unless repeated low passes were made. Frequently bears were never seen and their reactions were unknown. Bears appeared somewhat habituated to fixed-wing aircraft irrespective of the research activity. We believe the radio-tracking had little effect on bears' movements and was not detrimental.

Long Term and Future Impacts

Delineating long-term and permanent impacts of the Terror Lake Hydroelectric Project is only partly within the scope of this study. Direct impacts, such as removal of vegetation and inundation of uplands by the reservoir, are straightforward. Other impacts of the development, such as the increased potential for bears to be killed as the result of improved access, cannot be quantified in a 5 year study.

Development of the Terror Lake Hydroelectric Project was intended to produce electrical power more economically, thereby improving the economic development potential of the city of Kodiak and surrounding lands. Because the Terror Lake project provided additional incentive to land development, future impacts on brown bear habitat not considered in this study can be predicted. Brown bear habitat managers recognize these progressive declines in habitat quality occurring with multiple land use developments and are attempting to predict their effects using a "cumulative effects" model (Weaver et al. 1985). The cumulative effects of the Terror Lake project will be considered in this discussion, but the emphasis will mainly be on observed impacts of construction and predicted impacts of operation and maintenance of the project.

Loss of Vegetative Production

Long-term loss of vegetation through development of the Terror Lake Hydroelectric Project was originally estimated at a maximum of 437 ha (Federal Energy Regulatory Commission 1981). Included in the estimate were 235 ha lost to inundation by the Terror Lake dam and 202 ha lost to other construction sites. The dam at Terror Lake was built higher than original specifications, and the resulting impoundment flooded 306 ha of terrestrial vegetation. Additional impoundments, including the Shotgun Creek and Falls Creek diversions, occupied an estimated additional 10 ha. Access roads, equipment storage yards, rock quarries, spill sites, dams and gravel pads, were estimated at a minimum of 192 ha. We estimate that project construction permanently altered 508 ha of wildlife habitat; approximately 0.4% of the 1,400 km^2 study area.

Re-seeding of roadsides, spoils piles and other sites with non-native grasses was done after construction of the project. Revegetation efforts were only partly effective because of lack of soil and steep, eroded slopes in some disturbed areas. Vegetation comparable to that which was removed will not develop within the 50 year expected life of the Terror Lake Hydroelectric Project on most sites, however. Therefore, such sites were considered permanently lost as productive habitat for purposes of this analysis.

Impacts of Operation and Maintenance

Low intensity disturbance of bears will continue in the access road corridor and powerhouse/tunnel portal complex in the Kizhuyak River valley. Normally 4 workers staff the Kizhuyak facility. Facilities allow for housing up to 4 families, but because of the remoteness of the location, it is improbable that full occupancy by families will occur. The presence of the small permanent work force at the powerhouse will be a minor disturbance factor. Occasional confrontations between workers and bears will occur, some of which are expected to result in bears being killed in DLP incidents.

Continued use of helicopters to service facilities at the Terror Lake dam site, for repairing transmission lines, and other maintenance work will result in occasional low level flights and disturbance of bears in open alpine areas and in the Kizhuyak River delta.

Potential loss of den sites on the western slope of Kizhuyak River was a long-term habitat loss predicted by Spencer and Hensel (1980). They predicted that up to 10 bears or 20% of the bears denning in the Kizhuyak River drainage would be permanently displaced by construction of permanent facilities and continued human occupancy during construction. We believe that operation of the facility will have negligible effects on bear denning because most den sites identified during the study were located at much higher elevations than areas delineated as denning habitat in their study. Most activity by workers occurs at the powerhouse, on the access road between Kizhuyak Bay and the powerhouse, and at the power tunnel/penstock area, well below the elevation of preferred denning habitat. Maintenance activities at the Terror Lake dam site and tunnel using helicopters for transportation could disrupt bear denning within a short radius of those sites.

Increased recreational use of the project area by deer hunters, which has occurred since construction of the project is an additional source of disturbance which could result in decreased use by bears. The project area is popular for residents of Kodiak city and Port Lions, as well as non-local hunters that use the Alaska Marine Highway ferry system for access to either Kodiak or Port Lions. The road along Kizhuyak River and the construction trail along the Port Lions powerline have facilitated access into the project area. Improved knowledge of the area by project personnel and their friends also increased the number of recreational users. This additional recreational activity will result in increased killing of bears in DLP incidents. Increased harvests of bears by bear hunters will probably not result from this improved access, though, because bear hunting is regulated by a restrictive permit system.

Removal of brush and trees along the access road resulted in a long-term loss of security for bears traveling along Kizhuyak River between the powerhouse and the Kizhuyak River delta. Several breaks in the visual barrier screening Kizhuyak River from the access road were created by clearing trees for the transmission line right-of-way, borrow areas and equipment storage yards. Although partial regeneration of woody vegetation will occur within 10-20 years at some sites, the probability of bear/human encounters is increased by the loss of screening vegetation along the road.

A permanent loss of wilderness value and aesthetics resulted from construction and operation of the project. Hunters are the main recreational users of the area. One big game guide operates in the Kizhuyak River drainage, specializing in guiding non-resident brown bear hunters. Compared to other areas on Kodiak Island, the project area will be less desirable to bear hunters and the big game guide operating there can be expected to realize less income than guides operating in less developed areas.

Development of the Terror Lake Hydroelectric Project is expected to result in impacts on brown bears which were not originally considered. Construction of the distribution line to Port Lions was an additional development forced by litigation after the completion of pre-project environmental studies. Nearly all the coastal lands transected by the line have subsequently been transferred from public to private ownership through the Alaska Native Land Claims Settlement Act of 1972. Several cabins have been built on those lands since 1982 and it is expected that electrical power will be made available to the landowners. The availability of electricity and the proximity to Port Lions and the city of Kodiak will make those lands attractive for year-round occupancy. The result will be increased mortality of brown bears through DLP and illegal killings. Increased disturbance will result in displacement of bears and a diminished quality of brown bear habitat.

Availability of surplus electrical power inevitably results in added incentives for land development. A 77 km long distribution line was built in 1986 to provide electrical power to scattered residences along the road system south on northeastern Kodiak Island. Ultimately providing electricity to rural areas will facilitate future growth in Kodiak Island's human population, resulting in more recreational use of brown bear habitat to which Smith el al. (1988) attribute recent increases DLP killings of brown bears.

Expansion of the Terror Lake project, possibly including water diversions from the Uganik Bay and Ugak Bay drainages which were planned but not constructed, will probably be proposed in the near future. A study is being conducted to determine potential impacts on salmon by reducing water flow into Terror River (L. White, ADF&G, personal communication). Construction of a salmon hatchery near the powerhouse is also under consideration. Although increased salmon production would benefit bears by providing additional food, an intensified commercial salmon fishery and associated increases in human activity in the area could result in additional disturbance and bear human-confrontations in the Kizhuyak Bay drainage.

Miscellaneous Direct Impacts on Brown Bears

Evaluating impacts of construction required analyzing the affects of brown bears being attracted to human food sources. Follman et al. (1980) reported that the most frequent nuisance animal problem reported during construction of the Alaskan pipeline project was associated with improper handling of garbage. Although nuisance bear problems during the Terror Lake project were minor compared to those of the Alaska pipeline, their causes were basically similar. Improper disposal and storage of garbage at the Kizhuyak construction camp and at other work sites attracted bears and resulted in several confrontations between bears and workers. The volume of garbage available at work sites was small because an oil-fired incinerator located at the Kizhuyak camp was in regular use after September 1982. The problem was that the contractor failed to collect garbage daily and often allowed garbage to be stored temporarily in open containers that were easily accessible to bears.

A chronic problem area was an unauthorized burn pile and the metals dump, both located at the northeastern edge of the Kizhuyak camp pad. Refuse containers from the shop, powerhouse and other work sites frequently contained food and food containers which were dumped at the burn pile along with lumber, tires and other combustible material. The pile was often allowed to accumulate for several days before being burned, and food stuffs were often only partly burned. Workers reported seeing bears rummaging in the burn pile frequently and we found fresh bear sign there on nearly every inspection. Remains of the burn pile were periodically hauled to the metals dump where they continued to attract bears because they were not adequately buried. Unauthorized burn piles were also used at the tunnel portals and other remote work sites and similar problems with attracting bears occurred. Improper functioning of the incinerator sometimes resulted in partly incinerated food being put in the metals dump.

One radio-collared female (119) tailored her activities to nearly exclusive occupancy of the Kizhuyak camp environs in 1984. Workers reported seeing this bear repeatedly foraging in the burn pile. She was also seen trying to enter the incinerator compound and was found feeding in large plywood totes used temporarily for garbage storage.

The contractor failed to correct these problems after repeated warnings by the USFWS environmental monitor and State of Alaska authorities. The contractor was finally cited in 1984 for violation of Alaska Administrative Code 5 82.218, which prohibits leaving food or garbage in a manner which attracts bears. In the out-of-court settlement, the contractor was fined $1,000 and agreed to implement specific stipulations on storage and handling of garbage (Appendix IV).

Because of the delay in the arrival and assembly of the incinerator, an open burn pit located near milepost 1 of the access road was used for garbage disposal from April to September 1982. Little use of this burn pit by bears was observed, probably because it was located in a cleared gravel pit at the edge of the road with little available security cover.

Although no workers were observed deliberately feeding bears, anonymous reports indicated that it did occur occasionally. Workers frequently discarded lunch sacks along the road and near work sites, a practice which virtually assured that most bears in the project area encountered small amounts of human food from time to time. There was little evidence that garbage availability was an important factor influencing movements of radio-collared bears, with the exception of female 119. Some bears were exposed to human foods during project construction, but the long term effects on bears were not known.

Although a few reports of bears charging workers were received, mainly during construction of the transmission lines, no physical contacts occurred. No bears were reported killed by workers during the 5 year study. The contractor's policy prohibiting all but supervisory personnel from carrying firearms was an important deterrent to unnecessary killings. Surveying parties and transmission line workers in more remote areas were often armed, but fortunately no bears were killed. One bear was killed in 1981 before the project began, when the bear reportedly charged a potential contractor who was inspecting the proposed access road route along Kizhuyak River.

The excellent record of neither human injuries nor bears killed by project personnel during this project was owed to several factors. The extensive negotiations which preceded the authorization of this project and the precedent established by allowing construction of a major hydroelectric project on a National Wildlife Refuge gave the brown bear a high profile, demanding the attention of the contractors and agencies involved in the project. The presence of an environmental monitor employed by USFWS exerted considerable influence on the conduct of construction activities with potential impacts on bears. Although the environmental monitor had little regulatory authority over the contractor, he provided valuable liaison between the contractor and regulatory agencies (Hosking 1984). He identified violations of the mitigation plan and kept the contractor and regulatory agencies informed about them.

Efforts to educate workers on bear safety also were beneficial. Several presentations on bear safety were made to workers during the project by ADF&G and USFWS personnel. Because of the frequent turnover of personnel, some workers did not attend these orientations or did so only after several weeks on the job. More systematic scheduling and standardized format could have improved this effort, but insufficient agency manpower was available.

Although results of this study indicated that neither major immigration nor emigration of bears occurred in response to construction, there was a public perception that nuisance bear problems increased because of bears being displaced by the project. Unusually high numbers of bears were reported at the village of Port Lions, north of the study area, in 1985. An unfenced landfill/garbage pit located at the edge of the village has a long history of attracting bears. At a public meeting in Port Lions in December 1985, villagers stated their belief that the Terror Lake project had caused bears to move into the village. Data were presented by ADF&G showing that radio-collared bears had maintained similar home ranges throughout construction and that the high visitation rate in Port Lions was related to a poor berry crop, late vegetative green-up and failure of the sockeye salmon run in nearby Barabara Lake (Smith and Van Daele 1986a). An unusually high rate of encounters between deer hunters and brown bears throughout Kodiak Island during the autumn 1985 further suggested that low food abundance was a factor in nuisance bear problems in Port Lions. The belief that construction of the Terror Lake project caused bears to move into Port Lions is still widely held by residents of the village.

Study Evaluation and Recommendations

We believe this study fulfilled its major objectives. Using aerial radio-telemetry as the primary method to collect data was the most applicable technique considering the size and remoteness of the study area. Comparative analysis of bear habitat use during the construction and post-construction phases indicated that shifts in habitat use in response to construction were relatively subtle. Had major shifts or significant emigration of bears from the study area occurred as a result of disturbance from construction, the techniques employed in this study would have detected them. Information on brown bear life history, habitat use, movements, and population dynamics collected during the study will be important for making future management decisions.

All objectives were not met with equal success. Delineating the zone of impact of the construction project was an elusive objective, confounded by the lack of pre-construction data. Bears which had well-defined home ranges located farthest from project features were apparently unaffected, whereas bears with home ranges transecting project activities were assumed to have been affected. We believe that certain bears became somewhat habituated to disturbances associated with the project, therefore the "impact zone" for individual bears probably changed as they became accustomed to the disturbances. Consequently, the "impact zone" of the project could not be described strictly by geographic boundaries, because construction sites were continuously changing and levels of disturbance varied.

This study did not investigate daily responses of individual bears to site and time-specific disturbances, but use of localized areas with concentrated food sources, such as salmon streams, should be considered for more intensive investigation in future studies. Although the time of day that individual bears were re-located was purposely varied in this study, aerial telemetry was limited to daylight hours. Remote sensing methods, including remote radio-telemetry or photography, would produce added insight into daily activity patterns of individual bears and their responses to disturbances.

Documenting changes in the sex and age composition, and numbers of bears inhabiting the study area, was a study objective met within broad limits. No major change in numbers or composition was observed, but techniques employed in the study were not sensitive to small changes. Application of the bear density estimation technique in 1987, although not strictly within the objectives and scope of this study, provided useful comparisons with previous population estimates. The density estimation techniques should be applied in future impacts studies to monitor changes in population size and composition.

The pre-project study for the Terror Lake Hydroelectric Project (Spencer and Hensel 1980) provided useful information on general patterns of habitat use, but a more conclusive assessment of the impacts of the project would have been possible if the pre-project study had employed radio-telemetry of bears. Beginning our investigation in the first year of project construction made interpreting bears' responses to construction activities difficult. Collection of 2 years of post-construction data allowed meaningful comparisons of brown bear movements with those found during the 3 years of construction. However, it was difficult to distinguish between the responses of individual bears to construction activities versus normal responses to natural variations in environmental conditions, such as food availability, vegetative phenology, and weather.

We recommend that future studies on the impacts of development projects on brown bears should provide for collecting at least 2 years of data on bear movements and habitat use before beginning a project, as well as 2 years of post-project data. Objective techniques for measuring abundance and seasonal availability of major food sources should be incorporated into future studies. We also stress the importance of monitoring a relatively large sample of bears in all age, sex, and reproductive classes, to dampen the effects of the highly individualized behavior patterns of bears.

The long-term effects of hydroelectric projects on brown bears should be addressed in designing future impacts studies, and additional studies for continued monitoring of the Terror Lake project are recommended. Although long-term negative impacts from construction of the Terror Lake Hydroelectric Project were predicted (Spencer and Hensel 1980, this study), no requirement for future impacts studies was incorporated into the project mitigation plan. We suggest that a study be initiated in the near future to address the predicted long-term effects of the Terror Lake Hydroelectric Project on bears. The effects of enhanced human access into brown bear habitat, via the road and the powerline rights-of-way, should be monitored. Additional water diversions still under consideration, including the Hidden Basin and Mt. Glottof diversions, would require an additional impacts analysis. The influence of increased availability of electrical power on future land development along the Chiniak and the Port Lions distribution lines, neither of which were considered in the original Terror Lake project environmental analysis, should be documented. Changes in the water flow regimes currently under study should be monitored for their effects on distribution and availability of salmon to bears in both the Kizhuyak and Terror River drainages. Without a directed study, the predicted long-term effects, as well as possible unpredicted effects of the Terror Lake Hydroelectric Project on brown bears, will not be adequately documented.

Evaluating the habitat mitigation plan for the Terror Lake Hydroelectric Project was not a study objective, but some aspects of the mitigation procedures are pertinent to assessing impacts on brown bears. Hosking (1984) cited numerous violations of prescribed mitigation procedures regarding garbage disposal during the project. Consequently, bears were attracted to work sites by improper garbage storage and inadequate procedures for preventing access by bears to food and garbage. It is virtually impossible to impress upon workers and supervisors, who are inexperienced with bears, that seemingly insignificant amounts of human foods can attract bears, thus creating a nuisance bear problem. It is incumbent on the licensing agency to incorporate detailed specifications on handling food and garbage into the project license and to vigorously enforce the stipulations during construction (see Appendix I).

The mitigation settlement negotiated by the affected governmental agencies and national conservation organizations is an exceptionally good model for planning future developments in important brown bear habitat. Dedicating 280 km^2 of State and Kodiak Island Borough-owned land in the Kiliuda and Ugak Bay drainages to be managed primarily as brown bear habitat, represents a significant means of mitigating long-term effects of the Terror Lake Hydroelectric Project. The agreement to prohibit livestock grazing on additional lands on the Shearwater Peninsula was a valuable mitigation method, as well. Potentially the most significant long-term mitigative measure was establishing the Kodiak Brown Bear Research and Habitat Maintenance Trust, a $500,000 fund dedicated to perpetuating the brown bear population on Kodiak Island. If managed judiciously, this fund can be expected to support projects beneficial to preserving brown bear habitat indefinitely.

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Appendix I - Vegetative categories used to classify brown bear habitat use in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska.

1. ALPINE - elevation greater than 450 m.

<u>Snow</u> - areas covered by 70% or more snow. Snow densities of this degree were considered to be significant.

<u>Cliff</u> - areas in which cliffs or rock outcrops are the major component.

<u>Tundra</u> - sedge/forb meadows. *Carex macrocheata* is the most common species of sedge. Lupine (*Lupinus nootkatensis*), geranium (*Geranium erianthum*), paintbrush (*Castilleja unalaschensis*), and saxifrages (*Saxifraga* spp.) are the dominant forbs. This vegetative complex is common on steep mountain sides. On flatter sites "tundra" is composed of a low-growing shrub complex composed of crowberry (*Empetrum nigrum*), lowbush cranberry (*Vaccinium vitis-idaea*), dwarf willow (*Salix* spp.) and dwarf birch (*Betula nana exilis*).

<u>Shrub</u> - interface with the MIDSLOPE SHRUB habitat category. Primarily alder (*Alnus crispa sinuata*) overstory.

2. MIDSLOPE - elevation 150-450 m.

<u>Snow</u> - areas covered by 70% or more snow.

<u>Cliff</u> - areas in which cliffs or rock outcrops are the major component.

<u>Grass</u> - areas covered by 70% or more grass. These areas are primarily a grass/salmonberry complex with bluestem grass (*Calamagrostis canadensis*), and salmonberry (*Rubus spectabilis*) intermixed with rose (*Rosa nutkana*), and fireweed (*Epilobium angustifolium*), cow parsnip (*Heracleum lanatum*), false hellebore (*Veratrum viride*), angelica (*Angelica* spp.), lupine and horsetail (*Equisetum arvense*).

<u>Grass/shrub Mix</u> - shrubs and grass are the main components of this habitat category, but neither comprises more than 60% of the area. This may be the interface between GRASS and SHRUB cover types, however, the more common situation is a SHRUB covered hillside interspersed with GRASS meadows. Vegetative composition of this habitat category is a mix of that described for GRASS and SHRUB.

<u>Shrub</u> - alder or birch (*Betula papyrifera kenaica*) comprise 60% or more of the overstory. Alder is by far the most common shrub in the study area. Birch occur only on moist hillsides above the heads of Terror and Kizhuyak Bays. Red elderberry (*Sambucus racemosa*), and devil's club (*Echinopanax horridum*) are also common components of the shrub complex. Understory is typically moist and vegetation is primarily herbaceous including: ferns (Aspidiaceae, Thelpteridacese, and Athyriaceae), false hellebore, nettle (*Urtica lyallii*), and club mosses (*Lycopodium* spp.)

<u>Riparian/Bog</u> - Cottonwood (*Populus balsamifera*) or river beds are the most obvious vegetative feature. River valleys or poorly drained seeps are characterized by this habitat category. Understory is similar to the GRASS/SHRUB MIX habitat category. Salmon do <u>not</u> occur in the MIDSLOPE RIPARIAN/BOG habitat category in this study area.

<u>Spruce</u> - Sitka spruce (*Picae sitchensis*) is the most common overstory feature. Understory is sparse under the spruce and similar to the GRASS/SHRUB MIX adjacent to the spruce.

3. LOWLANDS - elevation less than 150 m.

<u>Snow</u> - area covered by 70% or more snow.

Cliff - areas in which cliffs or rock outcrops are the major component.

Grass - areas covered by 70% or more grass. These areas are primarily a grass/salmonberry complex similar to that found in the MIDSLOPE GRASS habitat category. Associated vegetation is also similar to the MIDSLOPE GRASS type.

Grass/Shrub Mix - shrubs and grass are the most common component of this habitat category, but neither comprises more than 60% of area. Similar to the MIDSLOPE GRASS/SHRUB mix habitat category.

Shrub - alder or birch comprise 60% or more of the area. Similar to MIDSLOPE SHRUB habitat category.

Riparian/Bog - Cottonwood or river bed are the most obvious vegetative feature. This habitat category characterizes the lower reaches of most major drainages and major creeks in the study area. Willow (*Salix* spp.), beach rye (*Elmus arenarius*), sedges (*Carex* spp.), and various forbs are common as are species found in adjacent GRASS AND SHRUB cover types. Salmon are seasonally abundant in most areas included in this habitat category. Sockeye salmon (*Oncorhynchus nerka*) begin entering Barabara Creek and Lake in mid-May and move into tributaries of Barabara Lake in July. Pink salmon (*O. gorbuscha*) occur in virtually all coastal streams from July to September and are the most abundant salmon in the study area. Chum salmon (*O. keta*) are most common in Kizhuyak and Terror Rivers from mid-July to early October. Coho salmon (*O. kisutch*) occur in most coastal streams from August to November.

Spruce - Sitka spruce is the most common overstory feature. Understory is sparse under the spruce themselves and similar to the GRASS/SHRUB mix adjacent to the spruce.

Intertidal - includes beach, tidal mudflats, and intertidal sedge flats. *Carex lyngbyaei*, goosetongue (*Plantago maritima*), and beach rye are common along the coastal fringe. Mudflats at the mouths of Terror and Kizhuyak Rivers contain eelgrass (*Zostera marina*).

Appendix II. Characteristics of den sites used by radio-collared brown bears in the Terror Lake hydroelectric project study area, Kodiak Island, Alaska, 1982-1986. (Explanations of abbreviations are found at the end of this appendix[a].)

BEAR	SEX	AGE	ASSN	HABITAT	ELEV	SLP	ASP	EARLYIN	LATEIN	EARLYOUT	LATEOUT	MIN	MAX	RNG	AVG	DNYR	LOCATION	COMMENTS
1	F	4	N	ALPSNW	838	M	NE	821104	821115	830419	830425	155	172	17	164	823	LEANNE MOUNTAIN	
4	M	7	N	ALPSNW	792	M	SW			830430	830517	0	0	0	0	823	UPPER KIZHUYAK RIVER	
4	M	10	N	ALPSNW	579	S	S	860106	860214	860409	860429	54	113	59	84	856	FALLS CREEK (TERROR)	
5	F	14	NC	ALPSNW	762	S	SE	821018	821115	830602	830604	199	229	30	214	823	PESTCHANI MOUNTAIN	
5	F	15	CY	ALPSNW	701	S	N	831020	831111	840313	840319	123	151	28	137	834	PESTCHANI MOUNTAIN	FIRST OF TWO DENS IN 834
5	F	15	CY	ALPSNW	732	S	N	840313	840319	0	0	0	0	0	0	834	PESTCHANI MOUNTAIN	SECOND DEN IN 834
5	F	16	Y2	ALPSNW	671	S	E	841106	841121	850102	850313	42	127	85	84	845	PESTCHANI MOUNTAIN	FIRST OF TWO DENS IN 845
5	F	16	Y2	ALPSNW	853	M	SE	850102	850313	850424	850520	42	138	96	90	845	PESTCHANI MOUNTAIN	SECOND DEN IN 845
5	F	17	23	ALPSNW	762	S	SE	851014	851101	851124	851223	23	70	47	46	856	PESTCHANI MOUNTAIN	FIRST OF TWO DENS IN 856
5	F	17	23	ALPSNW	853	M	E	851124	851223	860429	860508	127	165	38	146	856	PESTCHANI MOUNTAIN	SECOND DEN IN 856
5	F	17	NC	ALPTND	671	M	E	861024	861030	0	0	0	0	0	0	867	PESTCHANI MOUNTAIN	
7	M	3	N	ALPSNW	579	M	N	821029	821115	830425	830430	161	183	22	172	823	PESTCHANI MOUNTAIN	
8	F	12	N	MIDSNW	244	S	SE	821029	821111	830410	830419	150	172	22	161	823	WATCHOUT CREEK	
8	F	15	Y2	LOWCLF	122	S	N	851014	851101	851223	860214	52	123	71	88	856	WATCHOUT CREEK	FIRST OF TWO DENS IN 856
8	F	15	Y2	MIDSNW	305	M	SW	851223	860214	860429	860508	74	136	62	105	856	WATCHOUT CREEK	SECOND DEN IN 856
8	F	15	NC	MIDSHB	198	M	W	861030	861110	0	0	0	0	0	0	867	WATCHOUT CREEK	
11	F	7	N	ALPSNW	853	S	NW	821104	830117	830430	830503	103	180	77	142	823	LEANNE MOUNTAIN	
11	F	8	NC	ALPSNW	869	S	SW	831020	831028	840520	840529	205	222	17	214	834	LEANNE MOUNTAIN	
11	F	9	CY	ALPCLF	610	S	NE	841106	841121	850520	850529	180	204	24	192	845	KIZHUYAK RIVER	
11	F	10	N	ALPSNW	975	S	NW	851124	851205	860525	860528	171	185	14	178	856	UPPER BAUMANN CREEK	
11	F	10	N	ALPTND	503	M	N	861120	861205	0	0	0	0	0	0	867	VIEKODA CREEK	
14	M	7	N	MIDSHB	427	S	SW	821209	830117	830419	830425	92	137	45	114	823	CLARA'S CREEK	
15	F	8	N	MIDCLF	396	S	NE	821018	821029	0	830402	0	166	166	83	823	BAUMANN CREEK	
15	F	9	N	MIDCLF	396	S	N	831029	831112	840404	840416	144	170	26	157	834	BAUMANN CREEK	
15	F	10	NC	MIDCLF	335	S	N	841106	841121	850415	850424	145	169	24	157	845	BAUMANN CREEK	
15	F	11	N	MIDCLF	366	S	NE	851101	851117	851229	860214	47	105	58	76	856	BAUMANN CREEK	FIRST OF TWO DENS IN 856
15	F	11	N	MIDSNW	366	M	NE	851229	860214	0	0	0	0	0	0	856	BAUMANN CREEK	DIED IN DEN; 2ND 856 DEN
16	M	12	N	ALPSNW	518	S	NE	821115	821230	830410	830419	101	155	54	128	823	HILARY CREEK	
17	F	22	N	MIDCLF	427	S	NW	821007	821029	830410	830425	163	200	37	182	823	BAUMANN CREEK	

Appendix II. Continued.

BEAR	SEX	AGE	ASSN	HABITAT	ELEV	SLP	ASP	EARLYIN	LATEIN	EARLYOUT	LATEOUT	MIN	MAX	RNG	AVG	DNYR	LOCATION	COMMENTS
17	F	23	N	MIDSHB	457	G	NE	831029	831112	0	0	0	0	0	0	834	BAUMANN CREEK	SIGNAL LOST IN DEN
18	F	6	N	MIDSNW	335	S	N	821029	821115	830410	830419	146	172	26	159	823	BAUMANN CREEK	
18	F	7	N	MIDCLF	457	S	N	831020	831029	0	840319	0	151	151	76	834	BAUMANN CREEK	
18	F	8	NC	ALPSNW	625	M	W	841106	841121	850627	850720	218	256	38	237	845	BAUMANN CREEK	
19	F	7	N	MIDSNW	457	S	NE	821115	821209	830410	830419	122	155	33	138	823	BAUMANN CREEK	
19	F	8	NC	ALPCLF	579	S	SW	831112	831202	840424	840608	144	209	65	176	834	BAUMANN CREEK	
19	F	9	CY	LOWCLF	122	S	S	841121	841129	850415	850424	137	154	17	146	845	BAUMANN CREEK	
19	F	10	YN	ALPTND	610	M	SW	851101	851117	851223	860214	36	105	69	70	856	BAUMANN CREEK	
19	F	10	N	ALPCLF	564	S	W	861024	861104	0	0	0	0	0	0	867	BAUMANN CREEK	FIRST OF TWO DENS IN 867
19	F	10	N	ALPCLF	579	S	NE	861110	861120	0	0	0	0	0	0	867	CLARA'S CREEK	SECOND DEN IN 867
20	F	8	N	MIDCLF	335	S	N	831021	831112	840319	840328	128	159	31	144	834	BAUMANN CREEK	
20	F	9	NC	MIDMIX	213	M	S	841026	841106	841121	850313	15	138	123	76	845	BAUMANN CREEK	FIRST OF TWO DENS IN 845
20	F	9	NC	MIDMIX	396	S	SW	841121	850313	850313	850327	0	126	126	63	845	BAUMANN CREEK	SECOND DEN IN 845
20	F	10	CY	MIDSHB	381	M	SW	851124	851205	860214	860304	71	100	29	86	856	BAUMANN CREEK	FIRST OF TWO DENS IN 856
20	F	10	CY	ALPCLF	518	S	NE	860214	860304	860513	860525	70	100	30	85	856	BAUMANN CREEK	SECOND DEN IN 856
20	F	10	Y2	ALPCLF	579	S	W	861110	861120	0	0	0	0	0	0	867	BAUMANN CREEK	FIRST OF TWO DENS IN 867
20	F	10	Y2	ALPSHB	488	M	NW	861120	861205	0	0	0	0	0	0	867	BAUMANN CREEK	SECOND DEN IN 867
22	F	8	N	MIDSNW	305	M	SW	821029	821115	830430	830517	166	200	34	183	823	TERROR BAY	
22	F	9	N	MIDSHB	335	G	SW	831021	831029	840404	840416	158	178	20	168	834	TERROR BAY	
22	F	10	NC	ALPSHB	518	M	N	841026	841106	850328	850415	142	171	29	156	845	FALLS CREEK (TERROR)	FIRST OF TWO DENS IN 845
22	F	10	NC	MIDSNW	366	S	W	850328	850415	850529	850615	44	79	35	62	845	TERROR BAY	SECOND DEN IN 845
22	F	11	CY	ALPSHB	579	M	NW	851014	851124	860513	860525	170	223	53	196	856	FALLS CREEK (TERROR)	
22	F	11	Y2	ALPCLF	610	S	NE	861024	861030	0	0	0	0	0	0	867	FALLS TERROR CREEK	
24	M	8	N	ALPSNW	610	S	E	821104	830205	830425	830430	79	177	98	128	823	GOAT CREEK	
24	M	9	N	MIDSHB	427	M	NE	831202	840328	840328	840404	0	124	124	62	834	FALLS CREEK (TERROR)	
28	M	4	N	MIDSNW	396	M	E	821115	830117	830410	830419	83	155	72	119	823	KIZHUYAK BAY	
33	M	4	N	MIDSNW	305	M	NW	821115	830117	830410	830417	83	153	70	118	823	SHARATIN BAY	
37	F	5	N	ALPSNW	884	S	NE	821007	821104	830410	830419	157	194	37	176	823	DEN MOUNTAIN	
37	F	6	N	MIDSHB	396	M	N	831112	831202	821202	840313	0	122	122	61	834	UPPER BAUMANN CREEK	
37	F	7	N	ALPCLF	823	S	NE	841026	841106	0	0	0	0	0	0	845	DEN MOUNTAIN	DIED IN DEN; AVALANCHE

Appendix II. Continued.

BEAR	SEX	AGE	ASSN	HABITAT	ELEV	SLP	ASP	EARLYIN	LATEIN	EARLYOUT	LATEOUT	MIN	MAX	RNG	AVG	DNYR	LOCATION	COMMENTS
38	F	4	N	ALPSNW	945	S	SW	821007	821104	830430	830508	177	213	36	195	823	DEN MOUNTAIN	
38	F	5	N	ALPSNW	1021	S	S	831028	831112	840424	840430	164	185	21	174	834	DEN MOUNTAIN	
38	F	6	N	ALPCLF	914	S	SW	841106	841121	850424	850520	154	195	41	174	845	DEN MOUNTAIN	
38	F	7	N	ALPSNW	945	S	S	851014	851117	860423	860429	157	197	40	177	856	DEN MOUNTAIN	
40	M	5	N	ALPSNW	777	S	S	831111	831202	840430	840509	150	180	30	165	834	ELBOW MOUNTAIN	
40	M	7	N	ALPSNW	610	M	NW	851101	851117	860429	860508	163	188	25	176	856	WATCHOUT CREEK	
44	F	4	N	ALPSNW	640	S	NE	821029	821115	830519	830530	185	213	28	199	823	KIZHUYAK BAY	
44	F	5	N	ALPSNW	1021	S	NW	831111	831202	840520	840529	170	200	30	185	834	LEANNE MOUNTAIN	
44	F	6	N	ALPSNW	1021	S	S	841107	841121	850529	850615	189	220	31	204	845	LEANNE MOUNTAIN	
44	F	7	N	ALPSNW	853	M	SW	851101	851117	860525	860609	189	220	31	204	856	LEANNE MOUNTAIN	
46	F	7	YN	ALPSNW	853	M	NE	821104	830410	830430	830508	20	185	165	102	823	DEN MOUNTAIN	
46	F	8	NC	ALPCLF	1036	S	N	831026	831028	840604	840612	220	230	10	225	834	DEN MOUNTAIN	
46	F	9	CN	ALPCLF	1006	S	N	841121	841129	850424	850520	146	180	34	163	845	DEN MOUNTAIN	
46	F	10	N	ALPCLF	1006	S	N	851101	851117	860513	860521	177	201	24	189	856	DEN MOUNTAIN	
46	F	10	NC	ALPCLF	762	M	N	861110	861120	0	0	0	0	0	0	867	DEN MOUNTAIN	FIRST OF TWO DENS IN 867
46	F	10	NC	ALPSNW	884	S	N	861120	861205	0	0	0	0	0	0	867	DEN MOUNTAIN	SECOND DEN IN 867
48	F	24	Y2	ALPSNW	975	S	S	821102	821104	830519	830530	196	209	13	202	823	DEN MOUNTAIN	
48	F	25	23	ALPSNW	1021	S	SW	831021	831028	840430	840509	185	201	161	93	834	DEN MOUNTAIN	
48	F	26	N	ALPSNW	975	S	S	841106	841121	850415	850424	145	169	241	57	845	DEN MOUNTAIN	
51	F	9	N	ALPSNW	945	S	N	821104	821209	830517	830519	159	196	371	78	823	DEN MOUNTAIN	
51	F	10	NC	ALPCLF	975	S	N	831021	831026	840615	840622	233	245	122	39	834	DEN MOUNTAIN	
51	F	11	CY	ALPSHB	975	S	SE	841026	841106	850424	850520	169	206	371	88	845	DEN MOUNTAIN	
51	F	12	N	MIDCLF	396	S	N	851014	851117	851205	851223	18	70	52	44	856	BAUMANN CREEK	FIRST OF TWO DENS IN 856
51	F	12	N	ALPCLF	914	S	N	851229	860106	860429	860513	113	135	221	24	856	DEN MOUNTAIN	SECOND DEN IN 856
51	F	12	N	ALPCLF	975	S	NW	861030	861110	0	0	0	0	0	0	867	DEN MOUNTAIN	FIRST OF TWO DENS IN 867
51	F	12	N	ALPSNW	1036	S	S	861120	861205	0	0	0	0	0	0	867	DEN MOUNTAIN	SECOND DEN IN 867
55	F	14	CY	ALPSNW	914	S	NE	821007	821104	830508	830517	185	222	372	04	823	DEN MOUNTAIN	
55	F	15	Y2	ALPCLF	930	S	E	831021	831028	840430	840509	185	201	161	93	834	DEN MOUNTAIN	
55	F	16	NC	ALPCLF	960	S	NE	841026	841106	850623	850627	204	229	252	16	845	DEN MOUNTAIN	
55	F	17	CN	ALPCLF	945	M	N	851014	851101	851101	851117	0	34	34	17	856	DEN MOUNTAIN	FIRST OF TWO DENS IN 856

Appendix II. Continued.

BEAR	SEX	AGE	ASSN	HABITAT	ELEV	SLP	ASP	EARLYIN	LATEIN	EARLYOUT	LATEOUT	MIN	MAX	RNG	AVG	DNYR	LOCATION	COMMENTS
55	F	17	CN	ALPCLF	945	S	NE	851101	851117	860429	860513	163	193	301	78	856	DEN MOUNTAIN	SECOND DEN IN 856
55	F	17	N	ALPTND	914	S	NE	861030	861110	0	0	0	0	0	0	867	DEN MOUNTAIN	
59	M	4	N	ALPSNW	1006	M	N	821104	821230	830519	830530	140	207	671	74	823	DEN MOUNTAIN	
59	M	5	N	MIDSHB	274	M	N	831202	840114	840114	840319	0	108	108	54	834	NE ARM UGANIK BAY	
59	M	6	N	MIDSHB	427	M	NE	0	0	850415	850424	0	0	0	0	845	UGANIK RIVER	
60	F	15	CY	MIDSNW	366	M	W	821104	821115	830519	830530	185	207	22	196	823	HILARY CREEK	
60	F	16	Y2	ALPCLF	1067	S	SW	831029	831112	840424	840430	164	185	21	174	834	HILARY CREEK	
60	F	18	N	ALPSNW	716	M	NW	851101	851117	851124	851223	7	52	45	30	856	HILARY CREEK	FIRST OF TWO DENS IN 856
60	F	18	N	ALPCLF	610	S	N	851124	851223	860521	860525	149	182	33	166	856	HILARY CREEK	SECOND DEN IN 856
60	F	18	NC	ALPCLF	518	S	NW	861110	861120	0	0	0	0	0	0	867	HILARY CREEK	
64	F	21	Y2	ALPSNW	945	S	N	821029	821104	830530	830615	207	229	22	218	823	DEN MOUNTAIN	
64	F	22	23	ALPSNW	975	S	N	831029	831112	840430	840509	170	193	23	182	834	DEN MOUNTAIN	
64	F	23	N	ALPCLF	1067	S	SW	841026	841106	850327	850424	141	180	39	160	845	DEN MOUNTAIN	
64	F	24	N	ALPSNW	1036	S	N	0	0	860525	860528	0	0	0	0	856	DEN MOUNTAIN	
64	F	24	NC	ALPTND	640	M	N	861024	861030	0	0	0	0	0	0	867	DEN MOUNTAIN	
64	F	24	NC	ALPSNW	762	G	NW	861110	861120	0	0	0	0	0	0	867	DEN MOUNTAIN	
67	F	21	Y2	ALPSNW	1036	S	N	821018	821104	830520	830530	197	224	27	210	823	LEANNE MOUNTAIN	
67	F	22	23	ALPCLF	549	S	W	831028	831029	840430	840509	184	194	10	189	834	HILARY CREEK	
67	F	23	NC	ALPSNW	975	S	S	841026	841106	850705	850720	241	267	26	254	845	LEANNE MOUNTAIN	
70	F	5	N	ALPSNW	640	S	SW	821111	830117	830508	830517	111	187	76	149	823	PESTCHANI MOUNTAIN	
70	F	6	NC	ALPCLF	732	S	N	831020	831028	840424	840605	179	229	50	204	834	PESTCHANI MOUNTAIN	
70	F	7	CY	ALPCLF	732	S	N	0	0	850424	850516	0	0	0	0	845	PESTCHANI MOUNTAIN	
70	F	8	Y2	ALPCLF	579	S	NE	851101	851117	851117	851217	0	46	46	23	856	ELBOW MOUNTAIN	FIRST OF TWO DENS IN 856
70	F	8	Y2	ALPSNW	732	S	S	851217	851223	860521	860525	149	159	10	154	856	PESTCHANI MOUNTAIN	SECOND DEN IN 856
71	F	9	N	ALPSNW	732	S	E	821115	830205	830517	830520	101	186	85	144	823	WATCHOUT CREEK	
71	F	10	NC	ALPSNW	762	S	SE	831020	831112	840509	840520	179	213	34	196	834	WATCHOUT CREEK	
71	F	11	CY	ALPSNW	732	S	E	0	0	850520	850529	0	0	0	0	845	WATCHOUT CREEK	
71	F	12	Y2	ALPCLF	579	M	E	851101	851117	851117	851223	0	52	52	26	856	WATCHOUT CREEK	FIRST OF TWO DENS IN 856
71	F	12	Y2	ALPSNW	686	M	E	851117	851223	860429	860513	127	177	50	152	856	WATCHOUT CREEK	SECOND DEN IN 856
71	F	12	23	ALPSNW	762	S	SW	861120	861205	0	0	0	0	0	0	867	UPPER KIZHUYAK RIVER	

Appendix II. Continued.

BEAR	SEX	AGE	ASSN	HABITAT	ELEV	SLP	ASP	EARLYIN	LATEIN	EARLYOUT	LATEOUT	MIN	MAX	RNG	AVG	DNYR	LOCATION	COMMENTS
72	F	19	N	MIDSNW	152	M	SW	821115	830117	830419	830425	92	161	69	126	823	FALLS CREEK (TERROR)	
72	F	20	N	MIDCLF	366	G	SW	831012	831029	840328	840404	151	175	24	163	834	FALLS CREEK (TERROR)	
72	F	21	N	LOWSHB	91	M	SW	841026	841106	850424	850520	169	206	37	188	845	TERROR BAY	
74	F	18	Y2	MIDSHB	213	S	SW	821029	821111	830425	830430	165	183	18	174	823	PESTCHANI CREEK	
74	F	19	NC	ALPCLF	777	S	NE	831028	831029	840520	840529	204	214	10	209	834	ELBOW MOUNTAIN	
77	F	21	Y2	MIDSHB	305	S	E	821115	821230	830419	830425	110	161	51	136	823	BARABARA HILL	
78	F	9	NC	ALPSNW	808	S	S	831028	831111	840529	840604	200	220	20	210	834	PESTCHANI MOUNTAIN	
78	F	10	CY	ALPSNW	792	M	SE	841106	841121	850424	850516	154	191	37	172	845	PESTCHANI MOUNTAIN	
78	F	11	N	ALPSNW	732	G	S	851205	851223	851223	851229	0	24	24	12	856	ELBOW MOUNTAIN	FIRST OF TWO DENS IN 856
78	F	11	N	ALPSNW	686	G	SW	851223	851229	860423	860428	115	126	11	120	856	PESTCHANI MOUNTAIN	SECOND DEN IN 856
81	F	11	NC	ALPSNW	869	S	NE	831029	831111	840520	840529	191	213	22	202	834	UPPER KIZHUYAK RIVER	
81	F	12	CY	ALPCLF	975	S	W	0	0	850520	850529	0	0	0	0	845	UPPER KIZHUYAK RIVER	
81	F	13	Y2	ALPSNW	732	M	NE	851101	851117	851117	851223	0	52	52	26	856	WATCHOUT CREEK	FIRST OF TWO DENS IN 856
81	F	13	Y2	ALPTND	716	M	E	851117	851223	860521	860525	149	189	40	169	856	WATCHOUT CREEK	SECOND DEN IN 856
85	F	5	N	ALPCLF	1189	S	SW	831021	831028	840319	840416	143	178	35	160	834	UPPER TERROR RIVER	
85	F	6	N	ALPCLF	1128	S	NE	841026	841106	850424	850520	169	206	37	188	845	UPPER TERROR RIVER	
86	F	9	YN	MIDMIX	427	M	S	831112	831202	840114	840319	43	128	85	86	834	BAUMANN CREEK	
86	F	10	N	MIDCLF	244	S	N	841026	841106	850415	850424	160	180	20	170	845	BAUMANN CREEK	MAY HAVE HAD A COY
86	F	11	N	MIDMIX	335	M	SW	851101	851117	860214	860304	89	123	34	106	856	BAUMANN CREEK	FIRST OF TWO DENS IN 856
86	F	11	N	MIDCLF	335	S	NE	860304	860321	860409	860423	19	50	31	34	856	BAUMANN CREEK	SECOND DEN IN 856
86	F	11	NC	ALPSHB	549	S	S	861104	861110	0	0	0	0	0	0	867	BAUMANN CREEK	
88	F	10	23	ALPSNW	1036	S	S	831028	831111	840424	840430	165	185	20	175	834	DEN MOUNTAIN	
88	F	12	N	ALPCLF	1006	S	S	861120	861205	0	0	0	0	0	0	867	DEN MOUNTAIN	
91	F	9	NC	ALPCLF	785	S	W	831028	831111	840509	840520	180	205	25	192	834	UPPER KIZHUYAK RIVER	
91	F	10	CY	ALPSNW	747	S	SW	841027	841106	0	0	0	0	0	0	845	UPPER KIZHUYAK RIVER	DIED IN DEN
92	F	6	N	ALPTND	792	S	SE	831028	831202	840430	840509	150	194	44	172	834	ELBOW MOUNTAIN	
95	M	5	N	ALPCLF	1006	S	S	831028	831111	840416	840424	157	179	22	168	834	DEN MOUNTAIN	
96	F	8	N	ALPSHB	488	M	NE	831111	831202	840509	840520	159	191	32	175	834	VIEKODA CREEK	
96	F	9	NC	MIDMIX	320	G	NE	841009	841020	850524	850615	216	249	33	232	845	VIEKODA CREEK	
96	F	10	CN	MIDGRS	320	G	NE	851101	851117	0	0	0	0	0	0	856	VIEKODA CREEK	DIED IN DEN

Appendix II. Continued.

BEAR	SEX	AGE	ASSN	HABITAT	ELEV	SLP	ASP	EARLYIN	LATEIN	EARLYOUT	LATEOUT	MIN	MAX	RNG	AVG	DNYR	LOCATION	COMMENTS
98	M	8	N	ALPSNW	732	M	SW	841129	850102	850424	850427	112	149	37	130	845	ELBOW MOUNTAIN	
99	F	11	N	ALPSNW	671	S	SW	841027	841106	850424	850516	169	201	32	185	845	UPPER BAUMANN CREEK	
99	F	12	N	ALPCLF	671	S	W	851014	851117	860429	860508	163	206	43	184	856	UPPER BAUMANN CREEK	
99	F	12	N	ALPSNW	732	M	W	861120	861205	0	0	0	0	0	0	867	UPPER BAUMANN CREEK	
100	M	6	N	ALPSNW	1036	S	NE	841129	850102	850424	850520	112	172	60	142	845	GOAT CREEK	
100	M	7	N	ALPCLF	1128	S	NE	851205	851223	860423	860429	121	145	24	133	856	GOAT CREEK	
102	M	6	N	ALPTND	1097	S	SE	841020	841212	850424	850520	133	212	79	172	845	UPPER UGANIK RIVER	
103	M	7	N	ALPSNW	640	M	N	841129	850102	0	0	0	0	0	0	845	UGANIK RIVER	LOST SIGNAL IN DEN
119	F	7	NC	MIDCLF	457	S	SW	841106	841121	850424	850520	154	195	41	174	845	KIZHUYAK RIVER	
119	F	8	CY	ALPSHB	503	G	SE	851014	851101	860528	860609	208	238	30	223	856	KIZHUYAK RIVER	
121	F	14	Y2	ALPSNW	655	M	N	0	0	850424	850516	0	0	0	0	845	PESTCHANI MOUNTAIN	
121	F	15	NC	ALPCLF	671	S	NE	851014	851124	860525	860528	182	226	44	204	856	PESTCHANI MOUNTAIN	
123	F	14	23	ALPSNW	975	S	W	841107	841121	850424	850520	154	194	40	174	845	LEANNE MOUNTAIN	
123	F	15	N	ALPCLF	914	M	W	851014	851101	860513	860521	193	219	26	206	856	LEANNE MOUNTAIN	
128	F	9	Y2	MIDCLF	305	S	S	851205	851223	860409	860423	107	139	32	123	856	VIEKODA BAY	
128	F	9	NC	MIDCLF	366	S	SE	861120	861205	0	0	0	0	0	0	867	VIEKODA BAY	
129	F	12	CY	ALPCLF	518	S	N	851014	851101	851205	851223	34	70	36	52	856	VIEKODA BAY	FIRST OF TWO DENS IN 856
129	F	12	CY	MIDMIX	244	M	N	851229	860106	860429	860508	113	130	17	122	856	VIEKODA BAY	SECOND DEN IN 856
129	F	12	Y2	MIDSNW	457	M	N	861110	861205	0	0	0	0	0	0	867	UPPER TERROR RIVER	
130	M	4	N	MIDSHB	366	M	SE	851014	851117	860321	860409	124	177	53	150	856	TERROR RIVER	
131	F	13	Y2	ALPCLF	732	S	W	851014	851117	860528	860609	192	238	46	215	856	TERROR LAKE	
131	F	13	Y2	ALPCLF	549	M	W	861110	861120	0	0	0	0	0	0	867	UPPER TERROR RIVER	
132	F	17	Y2	ALPCLF	1097	S	N	851014	851117	860525	860528	189	226	37	208	856	GOAT CREEK	
132	F	17	23	ALPSNW	914	S	E	861120	861205	0	0	0	0	0	0	867	GOAT CREEK	
133	F	12	Y2	ALPCLF	732	M	N	851014	851117	860513	860528	177	226	49	202	856	TERROR RIVER	
133	F	12	23	ALPSNW	579	M	N	861120	861205	0	0	0	0	0	0	867	TERROR RIVER	
135	F	16	CY	MIDCLF	244	S	S	851229	860214	860321	860409	35	101	66	68	856	BARABARA LAKE	
135	F	17	Y2	MIDCLF	305	S	E	861120	861205	0	0	0	0	0	0	867	BARABARA HILL	
136	F	17	Y2	ALPSNW	640	S	NE	861110	861120	0	0	0	0	0	0	867	KIZHUYAK BAY	
137	M	9	N	MIDSNW	305	M	S	861120	861226	0	0	0	0	0	0	867	BAUMANN CREEK	

Appendix II. Continued.

BEAR	SEX	AGE	ASSN	HABITAT	ELEV	SLP	ASP	EARLYIN	LATEIN	EARLYOUT	LATEOUT	MIN	MAX	RNG	AVG	DNYR	LOCATION	COMMENTS
138	F	12	NC	MIDCLF	320	S	N	861024	861104	0	0	0	0	0	0	867	BAUMANN CREEK	
140	F	11	N	ALPCLF	732	S	W	861110	861120	0	0	0	0	0	0	867	UPPER BAUMANN CREEK	
141	F	10	Y2	ALPCLF	1097	S	N	861110	861120	0	0	0	0	0	0	867	GOAT CREEK	

a - BEAR: bear number
SEX: F=female; M=male
AGE: cementum age from analysis of lower premolar tooth
ASSN: association: N=alone, NC=entered den alone and emerged with new cubs, CN=entered with new cubs and emerged alone; CY=entered with new cubs and emerged with yearlings; YN= entered with yearlings and emerged alone; Y2=entered with yearlings and emerged with 2-year-olds; 2N=entered with 2-year-olds and emerged alone; 23=entered with 2-year-olds and emerged with 3-year-olds
HABITAT: a two-part description of the vegetative cover 1 HA around the den site. The first 3 characters refer to the elevation category: ALP=alpine (>450 m); MID=midslope (150-450 m); LOW=lowland (<150 m). The second 3 characters refer to the vegetative category as described in Appendix I, e.g. SNW=snow, CLF=cliff, MIX=mixed shrub/grass complex, SHB=shrub complex, TND=tundra, GRS=grass
ELEV: elevation above sea level in meters
SLP: S=steep (>45%), M=moderate (30-45%), G=gentle (<30%)
ASP: N=north, NE=northeast, E=east, SE=southeast, S=south, SW=southwest, W=west, NW=northwest; all aspects are based on true north
EARLYIN: date of the last radio-tracking flight that a bear was deemed out of the den. Note: all dates are in decending order (year, month, day), e.g. 831020=20 OCT 83
LATEIN: date of the first radio-tracking flight that a bear was deemed in the den.
EARLYOUT: date of the last radio-tracking flight that a bear was deemed in the den.
LATEOUT: date of the first radiotracking flight that a bear was deemed out of the den.
MIN: minimum number of days in the den (LATEIN through EARLYOUT)
MAX: maximum number of days in the den (EARLYIN through LATEOUT)
RNG: range of days between MIN and MAX
AVG: average number of days in the den (MIN+MAX/2)
DNYR: den year, e.g. 834 is den year 1983/1984
LOCATION: drainage in which den was located
COMMENTS: comments on individual bear or its den

Appendix III. Brown bear observations recorded by construction personnel in the Terror Lake hydroelectric project area, Kodiak Island, Alaska, 1982-1984. (Explanations of abbreviations are found at the end of this appendix[a]).

Date	Time	bears	Association	Location	Drainage	Activity	Habitat	Comments
1982								
9/05	0730	1	single	below tunnel portal	K	W	B	crossing road
9/18	0910	1	adult	1/4 mi N of tunnel portal	K	W	B	moving to east
9/19	1130	1	adult	Kizhuyak R. near MP 2.5	K	SR	W	
9/21	0745	4	sow w/3coy	east of Terror L. tunnel portal	T	R	B	sow charged to within 50 yds of bus
9/21	0900	1	sub-adult	MP 1.5 Kizhuyak road	K	R	B	crossed road from east to west
9/21	0830	4	sow w/3coy	Coho Slough 1/2 mi. east MP 1.5	K	F	W	chasing salmon
9/22	0930	1	adult	Rolling Rock Ck.	K	R	B	moving east to west
9/23	1720	1	adult	near MP 1	K	W	B	crossed road toward Kizhuyak R.; radiocollared w/white collar flag
10/4	1730	3	1 lg adult, 1 sow w/1cub	south of burnpit near near MP 1	K	R	B	crossed road toward Kizhuyak R.
10/6	0750	3	sow w/2coy	upper Falls Ck.	K	W	T	moving to northwest
10/6	0750	1	adult	below lower tunnel portal	K	W	B	moving to west; radiocollared w/red collar flag
10/6	1400	1	adult	1/2 mi above lower portal	K	W	B	moving to Kizhuyak R.
10/7	1620	1	adult	below lower portal	K	W	B	moving to west
10/8	0900	1	adult	below lower portal	K	W	B	moving to east
10/8	1400	1	adult	200 yd north of lower portal	K	W	B	moving across access road headed west
10/9	0800	1	adult	near MP 1	K	W	B	moved across road to west
10/10	0945	1	adult	stream east of MP 1	K	F	E,F	fishing; observed for 15 min.
10/10	1400	1	adult	north Falls Ck. dam site	K	W,R,O	T,B	last seen sitting watching road
10/12	1100	1	adult	200 yds north of lower portal	K	W	G	crossed access road toward Rolling Rock Creek
10/12	1210	1	adult	access road/penstock road	K	W,F	G,B	

Appendix III. Continued.

Date	Time	bears	Association	Location	Drainage	Activity	Habitat	Comments
10/13	1630	1	small adult	Kizhuyak camp	K	W	C,B	walked through edge of camp
10/14	0700	4	sow w/3coy	Kizhuyak flats	K	W	F	
10/15	0712	1	single	east of access road near burnpit	K	-	B	
10/15	1130	1	adult	200 ft below lower portal	K	W	B	
10/15	1300	1	adult	near lower tunnel portal	K	B	B	
10/15	1755	1	single	near MP 6	K	W	T,B	moving west
10/17	1100	1	adult	Kizhuyak camp trees	K	W	C,B	entered edge of camp pad, then into
11/9	0900	2	sow w/1-2 yr old	north of Terror L. intermittently all day	T	W,S	B	moving uphill from Terror L.; seen
11/10	1445	2	sow w/1coy	north side Terror L.	T	W	G,B	
11/11	0900	2	sow w/1coy	north side Terror L.	T	W	G,B	3rd consecutive day bears seen
11/12	1245	2	sow w/1coy	north side Terror L.	T	W,F	G,B	4th day seen; last seen at 1330 west of quarry #1
11/14	1230	1	adult	below outlet portal	K	W	G,B	
11/15	0900	1	lg adult	upper Shotgun Ck.	K	W	T,E	moved east across Shotgun Ck.
11/16	0800	3	sow w/2coy	quarry #1 Terror L. dam	T	W	T,B	moving east toward north side lake
11/17	1030	1	adult	upper Falls Creek	K	W	T,E	
11/20	1400	2	sow w/1coy	quarry #1 Terror Lake	T	W	T	possible denning area?

Appendix III. Continued.

Date	Time	bears	Association	Location	Drainage	Activity	Habitat	Comments
1983								
3/19	0930	1	adult	Elbow Ck. near T-line tower #43	S	B	B	possible den
4/08	1550	1	adult	upper Watchout Ck. near	K	R	B,S	T-line tower #42
4/11	1000	1	adult	upper Watchout Ck. near	K	B	G,B	T-line tower #23
4/11	1500	1	adult	upper Watchout Ck. near T-line tower #23	K	W	G,B	same bear in previous observation
4/24	1530	1	adult	Shotgun Creek	K	W	T,S	moving east to west
4/27	0600	1	adult	North of quarry #1 at Terror Lake	T	W	S	
4/27	1230	1	adult	slope south of Terror Lake dam	T	W	S	
5/03	1600	1	adult	between tunnel and camp near power cable	K	S,P,W	G,B	swatting and biting power cable
5/12	0900	1	adult	beach north of Rolling	K	W	G,B	Rock Creek
5/13	0730	1	adult	on access road to Rolling Rock Creek dam	K	W,B,P	E,S	sliding in snow; wouldn't move for road grader
5/13	1000	2	1 large	above Eagle Ck. Falls	K	B,W,P	G,B	1 small
5/16	1430	1	1 adult	north of Falls Creek	K	R	S	confronted surveyor at 20' and fled
5/16	0800	6	1 sow w/3coy;	Kizhuyak R. flats	K	S,W,F	F	2 singles
5/16	1045	1	adult	upper Rolling Rock Ck.	K	W,F	B	
5/17	1130	3	sow w/2yrls.	Eagle Ck. above jetty	K	W,P	G,B	
5/19	0500	1	adult	east of Kizhuyak camp	K	W,O	G,B	vocalizing
5/21	1500	1	adult	east of Kizhuyak camp	K	W,B	G,B	
5/21	1700	3	sow w/2yrls.	westside Kizhuyak R. flats	K	W	G,B	
5/23	1800	1	adult	south of tunnel portal	K	W	B	
5/24	1100	1	adult	ridge east of Kizhuyak	K	F	G,B	dug up grass patch

Appendix III. Continued.

Date	Time	bears	Association	Location	Drainage	Activity	Habitat	Comments
5/24	1745	2	adults	upper Rolling Rock Ck. near portal	K	F,W	B	
5/25	0600	1	adult	north of Rolling Rock Ck.	K	W	B,G	
5/25	0910	1	adult	above outlet portal	K	W	T,G	
5/25	1900	4	sow w/3yrls.	westside Kizhuyak flats	K	F,R,P,W	G,B,T	
6/05	AM	3	sow w/2- 2 yr old	in quarry and spillway at dam	T	S,W	E	bears previously observed several times
6/07	---	2	sow w/1coy	Terror River above lake	T	W	S	moving up Terror River
6/09	1600	2	adults	above outlet portal	K	S,W	G,B	
6/10	1230	2	adults	west of Terror L. dam	T	P	S	repeatedly sliding in snow
6/11	0630	2	adults	west of Terror L. dam	T	W,P	S	sliding on snow
6/11	0630	1	adult	outlet below Terror L. dam	T	W	B	
6/12	1600	3	adults	above tunnel portal	K	W	G,S	crossed access road east to west
6/14	0700	1	sub-adult	garbage burnpit at outlet portal	K	F	E	feeding on garbage
6/15	0730	1	adult male	access road near tunnel inlet	T	S,W	S	stood on hind legs; sex verified
6/16	0730	1	adult	southwest of outlet portal	K	S,W	B	
6/17	1000	2	adults	1/4 mi above Shotgun Ck. dam	K	W	S	
6/18	1205	1	lg adult	Falls Ck.-Shotgun Creek confluence	K	R,W	G,B	
6/22	1530	1	sub-adult	near penstock	K	W	B	probably same bear next 2 obs.
6/22	1700	1	sub-adult	near penstock	K	W	B	
6/22	2100	1	sub-adult	near penstock	K	W	B	
6/23	0700	1	lg adult	near T-line Kizhuyak R.	K	B	E	bedded on spoils pile at towerbase
6/23	1930	1	sub-adult	Kizhuyak camp near dorms	K	S,W	C	seen several times near pad

Appendix III. Continued.

Date	Time	bears	Association	Location	Drainage	Activity	Habitat	Comments
6/24	0700-1000	3	sow w/2coy	Kizhuyak R. delta	K	S,B,W	G	seen several times
6/26	1930	1	sub-adult	Kizhuyak camp	K	W,R	C	seen several times in camp
6/27	1000	1	sub-adult	Kizhuyak camp	K	W	C	
6/29	1130	3	sub-adults	Port Lions T-line	K	S,W	G,B	
6/30	1000	1	small adult	upper Rolling Rock Ck.	K	W,F	G,B	
6/30	1200	1	adult	west of Terror Lk camp	T	W	S	seen on skyline
7/02	2300	1	adult	west edge of quarry #1 Terror Lake	T	S	B,E	drills and equipment operating within 100 yds.
7/03	1000	2	adults	west of Terror L. camp	T	W	G,B	
7/05	1300	1	lg adult	east of Falls Ck pass	K	S,R	T	
7/08	1600	1	sub-adult	waste disposal site Kizhuyak camp	K	S,W,R,F	E	rummaging in incinerated waste
7/10	0630	1	adult	MP 2 Kizhuyak road	K	R	B	
7/10	1600	1	adult	Falls Creek pass	K	F	T	
7/11	0830	1	sub-adult	Falls Creek diversion	K	W,F	G,B	moving to southeast
7/11	1600	1	sub-adult	Falls Creek pass	K	W	G	
7/11	1700	2	adults	Falls Creek diversion	K	R	E,G,B	ran into worksite, stopped, retreated
7/12	0720	1	adult	Falls Creek pass	K	W,F	G,B	
7/12	1800	1	adult	north of Rolling Rock Creek diversion	K	F	T	
7/13	0830	1	adult	Falls Creek "knob"	K	W,F	G,B	bear seen twice later in day
7/13	1030	1	adult	NW of quarry #1 Terror L.	T	W,F	S	spotter plane circling bear
7/13	1400	1	adult	Falls Ck snow guage	K	W	S	
7/15	0530	1	adult	south of outlet portal	K	W,F	T,G	
7/16	0423	1	adult	Kizhuyak camp	K	W	C	walked around dorms
7/16	0900	1	adult	1/4 mi. north of access road east Terror L.	T	W,F	T,G,R,S	
7/16	1000	2	adults	1/2 mi north of quarry #1 Terror Lake	T	W,F	T,R	
7/19	1145	1	adult	storage pond Rolling Rock Creek mouth	K	W	G,B,E	

Appendix III. Continued.

Date	Time	bears	Association	Location	Drainage	Activity	Habitat	Comments
7/21	0700	1	small adult	access road Rolling Rock Creek mouth	K	R	B,E	
7/21	2000	1	adult	access road near MP 1	K	W,R	B	crossed road from east to west
7/22	0700	1	adult	between outlet portal and Falls Creek	K	R	G,B	
7/22	0800	1	adult	Falls Ck. snow guage	K	F	G	
7/22	0800	2	adults	NW of quarry #1 Terror L.	T	S,W,F,	G,B	seen intermittently from 0800 to 1400.
7/22	0820	1	adult	NW of quarry #1 Terror Lake	T	W	G,B	largest bear seen
7/23	1615	1	adult	Falls Ck. diversion	K	R	G,B	
7/24	0800	1	sub-adult	Kizhuyak camp	K	W	C	likely same bear previously reported
7/25	1600	3	adult and 2 cubs?	Port Lions T-line	K	R	B	bear between pilot and helicopter
7/26	0800	1	adult	Port Lions T-line	K	W	B	
7/26	1300	1	sub-adult	Kizhuyak camp waste site	K	R,O	E	rummaging in debris
7/26	1300	1	sub-adult	Kizhuyak camp waste site	K	R,O	E	rummaging in debris
7/26	1510	1	adult	1/4 mi north of Kizhuyak camp	K	R,F	B	fed on salmonberries near road for 2-3 hrs; crossed road
7/27	0630	2	adults	Port Lions T-line	K	R	B	bears near work party; helicopter hazed bear away; 1 bear radiocollared
7/28	1930	1	sub-adult	entrance of tailrace into Kizhuyak River	K	B	R	bear bedded on gravel bar
7/29	---	4	sow w/3 cubs	Port Lions T-line crew climbed tree	K	R	B	sow "slow-charged" survey crew;
8/08	1430	1	adult	near storage yard on access road	K	S,W	B	radio-collared; walked toward Kizhuyak River delta
8/09	1300	1	small adult	penstock excavation concrete	K	W,R	E	bear appears when helicopters sling
8/09	1330	1	sub-adult	penstock excavation	K	W	E	moving to north

Appendix III. Continued.

Date	Time	bears	Association	Location	Drainage	Activity	Habitat	Comments
8/10	0730	3	sow w/2 lg cubs	Port Lions T-line	K	R	B	work crew retreated and bears left
8/10	0900	1	sub-adult	near Kodiak T-line Kizhuyak River	K	W	G,B	walking from east to west
8/10	1030	1	adult	access road MP 1	K	W	B	crossed access road west to east
8/11	1730	1	adult	Kizhuyak R. near T-line	K	W	R	carrying a deer fawn
8/11	1945	1	adult	Kizhuyak R. near T-line	K	W	B	radio-collared; cream collar flag
8/12	0805	1	small adult	MP 2 access road	K	R	B	crossed road from west to east; radio-collared; cream collar flag; bear seen several times this week
8/12	1330	1	adult	MP 2.5 access road	K	W	G	
8/16	1430	1	small adult	Kizhuyak camp	K	W	B,C	
8/17	0800	3	sow w/2cubs	Port Lions T-line	K	W,R,P	B	sow radio-collared; 1 cub w/green left and red right ear flag, bears traveled in T-line ROW
8/18	1530	2	different size	east of Kizhuyak R	K	W,R	G,B	larger bear radio-collared
8/28	1830	1	adult	MP 1.5 access road	K	R	B	moving to west
8/29	1600	1	small adult	Falls Ck. "knob"	K	W	G	
8/29	1900	2	cubs	MP 1.5 access road	K	R	B	natal rings
8/30	1930	1	adult	MP 1 access road	K	R	B	
8/31	1915	1	medium adult	1/2 mi north Kizhuyak camp	K	R,W,	B	crossed road and ran uphill; disturbed by helicopter hauling concrete
9/01	0800	1	small adult	east of penstock	K	F	G	feeding on deer fawn
9/01	0825	1	---	access road near Rolling Rock crossing	K	R	B	ran across road toward west
9/01	0600	1	adult	Kizhuyak R. east side	K	F	W	catching and eating salmon
9/05	0730	1	adult	access road near Kizhuyak R. flats	K	R	E	scared by vehicle and ran toward east

Appendix III. Continued.

Date	Time	bears	Association	Location	Drainage	Activity	Habitat	Comments
9/11	1715	1	adult sow	Kizhuyak camp	K	W,S	B,C	alternately walked from camp pad to to brush SE of pad
9/12	1000	1	adult	Kizhuyak R.	K	W,R	B,R	frightened sport fisherman
9/13	0700	1	adult	Kizhuyak R. flats	K	F	W	
9/14	0615	2	adults	MP 2 access road	K	R	B	smallest adult w/radiocollar; crossed road from west to east
9/15	1315	1	lg adult	Kizhuyak River	K	F	W	fishing; bear moved into brush by fisherman's shouting
9/15	1900	1	adult	Kizhuyak R/Watchout Creek junction	K	F,W	W	fishing
9/16	0730	1	adult	Kodiak T-line near Kizhuyak River	K	W	G,B	moving to east
9/17	1430	1	small adult	Kizhuyak R. below Rolling Rock Creek	K	W	W	
9/19	0900	4	sow w/3coy	Kizhuyak R., Beaver Dam Creek	K	W,R.F	G,B,W	fishing; crossed flats westward into brush below access road
9/19	1100	1	adult	Kizhuyak R., Beaver Dam Creek	K	F	G	
9/19	1100	1	sub-adult	Kizhuyak camp	K	W	E,C	walked through disposal site and camp pad
9/20	0545	1	---	powerhouse	K	W	E,C	worker and bear equally surprised
9/20	1600	2	adult,sub-adult	Beaver Dam Creek	K	F,W,R	G,B	fishing; helicopter spooked larger bear, but small bear kept fishing
9/21	1800	5	---	Kizhuyak R. delta	K	F,W	W	fishing
10/16	1200	1	adult	penstock road	K	W,F	G,B	
10/19	0700	1	adult	east of Shotgun Ck. dam	K	W	B	
11/15	1345	1	adult	east of Kizhuyak R. near stream guage	K	W	G,B	
11/16	1015	1	adult	east of Kodiak T-line, Watchout Creek	K	O	G,B	sitting

Appendix III. Continued.

Date	Time	bears	Association	Location	Drainage	Activity	Habitat	Comments
11/17	1530	1	adult	base of cliffs north of Rolling Rock Ck.	K	W	B	
11/26	1200	1	adult	300 yds east of Falls Creek dam	K	B	S	

Appendix III. Continued.

Date	Time	bears	Association	Location	Drainage	Activity	Habitat	Comments
1984								
4/12	1930	1	single	within 200 yds. of gravel pit at Kizhuyak camp	K	W	E	
5/01	0530	1	single	400 yds. west of Kizhuyak camp	K	O		chewing on power cable
5/07	1900	1	single	near MP 3 on access road	K	W,B,F	B	grabbing for roots
5/11	1100	1	single	1/2 mi east of MP 3	K	W	G,B,W	moving toward Kizhuyak R.
5/20	1620	3	sow w/2cubs	between access road and Rolling Rock Ck.	K	S,W,	B,R	
5/24	1500	1	adult	on road 1/4 mi below Kizhuyak tunnel portal	K	R	B	crossed road into Rolling Rock Ck
5/25	2000	3	sow w/2cubs	near water tank in Kizhuyak camp	K	W	C	
5/25	1520	1	adult	1/4 mi. N. of access road switchbacks	K	W	G,B	
5/26	2000	1	single	1/4 mi S. of penstock	K	S,W,F	G,B	
6/01	0700	1	adult	upper Falls Creek	K	O	G,R	attempting to prey on goats; chased or knocked one goat kid off 100' cliff
6/11	2100	1	single	east of MP 0.5	K	F	G,W	eating grass
6/17	2045	1	single	at tailrace near power-house	K	W,F	B,E.W	
6/28	1915	1	single	west of Shotgun Ck. dam	K	W,F	B,R	
6/30	1630	1	single	1/4 mi west of access road near Falls Ck.	K	F	T,B	
7/10	1730	1	adult	west of upper Falls Ck	K	W,F	T,G	feeding on alpine blossoms
7/13	0900	1	lg adult	near Falls Creek	K	F	T,G	feeding on grass
7/23	1930	1	single	east side Kizhuyak Bay	K	R	R	scared by motorboat
7/26	0650	1	single	1 mi south of Kizhuyak tunnel portal	K	W	G,B	red flag in one ear

Appendix III. Continued.

Date	Time	bears	Association	Location	Drainage	Activity	Habitat	Comments
7/29	1430	2	2 adults	Dovolno Pt. near cabin	K	W,F	G,O	one bear walking on beach; larger bear feeding on hillsite
7/30	0700	1	3-4yr old	1/2 mi from outlet valve house	T	R	G,B,R	
7/30	0645	1	adult	near Falls Ck dam	K	W	T,R	
9/17	0800	2	sow w/ 1-2 yr old	east of MP 2	K	F	F,W	catching salmon
unk/	2245	1	single	near Kizhuyak tunnel portal	K	W	G,B,R	walking and sliding down slope; crossed access road; radio-collared

Appendix III. Continued.

a - Key to Abbreviations:

Habitat

B - brush
C - camp pad
E - excavation, road, storage pad
F - tide flats
O - other
R - rock, bare soil
S - snow
T - tundra
W - stream, lake

Activity

B - bedded, sleeping
F - feeding
O - other
P - playing
R - running
S - standing
W - walking

Association

coy - cubs-of-year

Drainage and location

K - Kizhuyak Bay, River
S - Sharatin Bay, Elbow Creek
T - Terror Bay, River
MP - milepost on access road

APPENDIX IV. Agreement between the State of Alaska and Kiewit-Groves on garbage disposal practices at the Terror Lake Hydroelectric Project.

1. All garbage and food-contaminated utensils, paper, etc. will be collected and burned in the camp incinerator on at least a daily basis. No burning of food scraps or food containers will be done at work sites anywhere in the project area.

2. The incinerator will be operated at a temperature sufficient to completely burn food and other organic matter to a mineral ash.

3. The incinerator and compound will be maintained in proper working order. Gates and doors will be kept securely closed and kept in good repair.

4. Unlined plywood containers will not be used for temporary storage of garbage. Only metal containers or other suitable containers with waterproof liners will be used. Containers will be cleaned frequently with disinfectant to minimize odors.

5. Trash bags from dwellings, mess halls and job sites will be transferred directly to the truck or other conveyance and no temporary storage of trash bags outside the buildings will be done.

6. Food, lunch containers, and other food-contaminated refuse will not be left in open vehicles, pickup beds or in other conveyances where such items would be easily accessible to bears.

7. Designated containers for lunch sacks, drink cups and utensils will be provided in secure areas at all job sites. Containers shall be lined with clean plastic bags and be kept securely covered.

8. No food or food-contaminated refuse will be disposed of anywhere in the project area except in designated food containers.

9. The kitchen area and any area used for storage of food will be securely fenced to prevent entry by bears.

10. All new employees and current employees will be informed of proper garbage disposal and food handling practices. New employees shall be so informed upon their first arrival at the site. Employees shall be expressly informed that these procedures are required by the State of Alaska, and that failure to comply with these practices could subject the company or its employees to criminal liability for attracting bears to the site.