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Alaska Department of Fish and Game
Division of Wildlife Conservation

Population Dynamics and Habitat Partitioning of a Naturally Regulated Brown Bear Population on the Coast of Katmai National Park

1993 Annual Progress Report

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A cooperative interagency study
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SUMMARY

This report presents results obtained during 1989-93 from a study that evaluated the effects of the *Exxon Valdez* oil spill on coastal brown bears *Ursus arctos*. Funding through the first 3 years was provided by the Alaska Department of Fish and Game's (ADF&G) damage assessment program; in 1992 funding was provided by the National Park Service (NPS). Beginning in 1993, a Natural Resource Preservation Project (NRPP) grant provided funding to further document the dynamics of a high density, protected brown bear population regulated by natural conditions. Consequently, this study has evolved into Phase II of the interagency Black Lake study to allow comparisons of population parameters between an unhunted population (Katmai) and a population (Black Lake) subjected to different harvest levels over time (Sellers 1994).

The research hypothesis addressed by the study of comparative population dynamics of 3 brown bear populations (Black Lake -1970s; Black Lake - current; and Katmai) is that different rates of harvest will result in different population structure, density, survival rates, and recruitment. We hypothesize that higher rates of harvest will result in: (1) lower proportion of adult males, (2) higher proportion of family groups, (3) younger age structure, (4) overall lower survival rates for independent bears, but proportionally less natural mortality, (5) lower population density, (6) higher recruitment rates as a result of larger litters, higher survival rates of offspring, and shorter reproductive interval. Ancillary hypotheses include: (1) higher population density and higher proportion of adult males (which are expected to result from lower harvests) will increase competition for food and will result in smaller body size (particularly for subdominate sex/age cohorts), lower reproductive rates, larger home ranges, higher rates of subadult dispersal, and more conspecific predation.

With Tom Smith as coprincipal investigator, habitat partitioning will be emphasized throughout the remainder of this study.

Progress meeting each of the study objectives is described below.

<u>Objective 1</u>. Compared to the hunted population at Black Lake, the unhunted Katmai population had a higher ratio of adult males to adult females, more adult males in the population, and a lower proportion of the population in family groups. Counting only independent bears (excluding offspring in family groups), the mean age of both males and females was older in Katmai than at Black Lake.

Objective 2. The survival rate (excluding hunting mortality) for adult females in Katmai (0.927) was similar ($P > 0.60$) to that found at Black Lake (0.913). The survival rate for cubs was lower ($P < 0.01$) in Katmai (0.35) than at Black Lake (0.61), but there was no difference in yearling survival in Katmai (0.768) and at Black Lake (0.797) ($P > 0.50$).

Objective 3. Since 1989, only 2 bears (adult males) marked in Katmai have been killed by a hunter (outside the park). The harvest rates for adult males and the entire Katmai population are estimated at 1.7% and 0.34% per year, respectively.

Objective 4. Over 30 hours of aerial survey time were logged in Katmai National Preserve between 22-30 May 1993, and 103 bears were classified. Early leaf emergence hampered survey efforts and limited the number of replicate counts. During 2 complete surveys, 39 and 46 bears were seen. Based on subjective evaluation, sightability was judged to be intermediate between the CMR density estimate on the Katmai coast and at Black Lake, yielding a density estimate of 120-168 bears/1,000 km^2. The sex and age composition of bears seen in the preserve was similar to that found on the Katmai coast (64% single bears and 20% adult males).

Objective 5. The results of the composition surveys covered under Objective 4 suggest the population during late May in the preserve is approximately 131-184 bears. The very crude population estimate for the Park of 1,500-2,000 bears, made after the 1990 CMR density estimate in the coastal study area, has not been refined pending progress on GIS vegetation mapping and habitat evaluation.

Objective 6. Test the hypothesis that productivity of Katmai coastal bears is lower than at Black Lake and other hunted coastal bear populations. Litter sizes of both cubs and yearlings are smaller in Katmai than at Black Lake (cubs, $P = 0.030$; yearlings, $P = 0.064$). Of 15 litters weaned in Katmai, 7 were 2-year-olds, 6 were 3-year-olds, and 2 were 4-year-olds. Reproductive interval in Katmai is 6.2 years between successfully weaned litters. Overall recruitment is 0.28 2.5-year-olds/adult female/year versus 0.36 at Black Lake.

Objective 7. Identify locations and document the timing and intensity of use by bears of habitats of special importance such as sedge flats, clam beds, and salmon streams both inside and outside the park. Since 1989, 2,764 locations of marked bears have been recorded. Further analysis of these locations will be undertaken once the GIS is operational and vegetative mapping is complete.

Objective 8. Calculate adult female home range size and compare with home range size at Black Lake. During 1989-93, 28 adult females have been relocated at least 30 times, and 12 have over 70 locations. As of December 1993, 30 adult females were alive with functioning radiocollars. Similar sample sizes are available for Black Lake.

Objective 9. Document subadult male and female dispersal patterns, survival rates, and habitat selections. During May 1993, 18 subadults (2-4 years old) still accompanying their mothers were captured and fitted with expandable collars. By October 1993, only 7 of these collars were still on. One subadult was killed by another bear, and the other 10 collars fell off because of failure of the PVC tubing material.

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BACKGROUND

Katmai National Park supports the most dense and largest protected population of brown bears in the world. As such, it offers unmatched opportunities to learn about natural processes of population regulation and habitat selection, which have important implications for managing brown bears in unhunted and hunted environments. Both exploited and unexploited brown bear populations are difficult to manage because there are few techniques to document population trends directly and because the species is highly sensitive to disturbances from human development and activity. Also, brown bears have one of the lowest reproductive rates of North American mammals and can only endure low rates of human-caused mortality. As a result, bear populations are slow to recover from excessive reductions.

An interagency (NPS, USFWS and ADF&G) brown bear research project began in 1988 at Black Lake on the Alaska Peninsula. The central focus of this study is to measure the effects of hunting on the population dynamics of brown bears in prime habitat. This project involves assessing current status of the bear population (density, composition, exploitation rates, survival rates, movements, etc.) and making comparisons with population parameters collected from the same area in the early 1970s when the population was subjected to much higher harvests. Field work on the Black Lake study will be completed in 1995, and progress through December 1993 has been summarized (Sellers 1994).

A second phase of the Black Lake project was envisioned to be a comparison study of an unhunted population within the core of Katmai National Park. Prior to approval of a final study proposal for the Katmai phase of the interagency study, the *Exxon Valdez* oil spill (EVOS) occurred in Prince William Sound in March 1989, spilling 11 million gallons of crude oil. Within a few weeks it became apparent that ocean currents would deposit oil on the beaches of the Alaska Peninsula. The coast of Katmai National Park was the first to be fouled. Brown bears, as top level omnivore, were vulnerable to ingesting crude oil from carcasses of oiled birds and marine mammals, from consuming contaminated marine invertebrates (particularly clams and mussels), or from ingesting oil directly (grooming or even eating oil mousse). ADF&G was appointed lead agency for assessing the effects of the oil spill on brown bears. The Katmai coast was chosen as the study area because of early exposure to oil, the high density of brown bears, and observations that bears rely on intertidal resources. The timing and location of the EVOS allowed the Black Lake brown bear project to serve as a control area against which to compare data from oil-fouled areas.

Objectives of the EVOS brown bear study on the Katmai coast are listed.

1. Test the hypothesis that brown bears in an oil contaminated area of the Alaska Peninsula ingested hydrocarbons (as measured from fecal and blood samples) at higher concentrations than did bears captured in an uncontaminated area (Black Lake).

2. Test the hypothesis that natural mortality rates of female brown bears near oiled areas of the Katmai coast were higher than for females in other coastal populations that were not oiled.

3. Test the hypotheses that some of the natural mortality of brown bears near the Katmai coast could be attributed to physiological effects of ingested hydrocarbons.

4. Estimate the brown bear population density within a representative study area along the Katmai coast using a modified capture-mark-resight (CMR) technique.

5. Identify potential alternative methods and strategies for restoration of lost use, populations, or habitat if injury is identified.

A report on this project was written (Lewis and Sellers 1991) but has not been widely distributed because of incomplete analyses of data and pending litigation. Funding for field work from the State of Alaska was terminated on 30 June, 1991 with the exception of money to remove radiocollars from any bears not involved in further research.

Because preliminary analysis of data collected during 1989-91 showed little effect on a population level from the EVOS, this study area was deemed suitable for documenting population dynamics of an unhunted population. Consequently, the EVOS brown bear study evolved into Phase II of the interagency study, and a proposal was submitted in 1991 for NRPP funding. This proposal just missed the national cutoff, so funding for the 1992 field season was provided by the NPS Alaska Regional Office. The project was approved for NRPP funding for 1993-95.

INTERAGENCY STUDY OBJECTIVES

The major goal is to test the hypothesis that the brown bear population on the central coast of Katmai National Park has different population attributes and is regulated by different mechanisms than exist at Black Lake or other hunted populations in Alaska. Specific objectives to meet this goal are listed.

1. Test the hypothesis that the population sex and age structure of the Katmai Coastal population has a higher ratio of males:females, an older age structure including a smaller proportion of subadult bears, and a lower percentage of family groups than exist at Black Lake and other hunted populations.

2. Test the hypothesis that natural mortality rates of adult females, cubs, and yearlings is higher within Katmai National Park than in hunted populations of brown bears at Black Lake and other hunted coastal populations.

3. Test the hypothesis that the exploitation rate for Katmai coastal bears, based on marked bears being sealed in the legal harvest, is lower than at Black Lake.

4. Evaluate the usefulness of aerial composition surveys to provide trend information between and within areas.

5. Using the 1990 population estimate and stratification data from composition surveys, estimate the total bear population within Katmai National Park and Preserve.

6. Test the hypothesis that productivity of Katmai bears (including such parameters as litter size, age at first successful weaning, reproductive interval and average recruitment) are lower in Katmai than at Black Lake and other hunted populations in coastal areas.

7. Identify locations and document the timing and intensity of use by bears of habitats of special importance (e.g., sedge flats, clam beds, salmon streams, etc.) both inside and outside the park.

8. Calculate adult female home range size and compare with home range size at Black Lake as a measure of habitat quality.

9. Analyze habitat components of subadult selected ranges and document male and female subadult dispersal patterns and subadult survival rates.

STUDY AREA

Bears were captured from Swikshak River to Amalik Bay (Fig. 1). The primary study area was bordered by Shelikof Strait on the east and the crest of the Aleutian Mountains (to 2,318 m) on the west. Within this area the CMR density estimate was conducted in a 900 km^2 area extending from Hallo Bay to Amalik Bay.

Dense shrubs, primarily alder (*Alnus crispa sinuata*), dominate the slopes of the mountains; alder and willows (*Salix* spp.) dominate lower elevations. Grass/forb meadows predominated by blue stem (*Calamagrostis canadensis*) are interspersed with shrub communities on most slopes. Trees are sparse, but occasional stands of "cottonwood" (*Populus balsamifera*), paper birch (*Betula Papyrifera kenaica*), and Sitka spruce (*Picea sitchensis*) are at low elevation. Bears forage on coastal sedge flats at Swikshak, Chiniak, Hallo Bay, and Kukak Bay. Numerous salmon (primarily pink [*Oncorhynchus gorbuscha*], chum [*O. keta*], and coho [*O. kisutch*]) streams are distributed throughout the study area. Snow and ice fields dominated above 1,000 m elevation.

Although the Katmai study area has many physical and biological similarities to the Black Lake study area, several notable differences contribute to the difference in bear densities. The Black Lake area has proportionally much less marine coastline and none of the heavily used salt marsh community. Approximately 30% of the Black Lake area is Bering Sea coastal plain dominated by fresh water sedge marsh and ericaceous shrub tundra which did not attract much bear use until after the density estimate period.

The Black Lake area received moderate to heavy bear harvests for the last 25 years while the Katmai study area has been closed to hunting since 1931.

METHODS

Bears were radiomarked during the spring of 1989, 1990, 1992 and 1993. Bears were captured by darting from a helicopter. Standard radiocollars were attached to adult females. Due to rapid growth, standard collars of fixed circumference may become too tight on subadults and males and were not used. On such bears a nonpermanent transmitter was attached by inserting a canvas spacer (Hellegren et al. 1988), designed to rot through within 18 months, into a regular collar or by glueing a small transmitter to the fur on the bear's back. In 1993 an experimental design of an expandable collar was used on subadults. This collar consisted of tubular PVC material in 2 diameters. The smaller tube fit inside the larger one and was attached with elastic belting. A canvas spacer held the collar in a fixed circumference until the canvas rotted, at which time the two PVC tubes were free to pull apart to the extent allowed by the elastic.

Density was estimated using the general procedure described by Miller et al. 1987. This procedure involved replicated searches of the area in fixed-wing aircraft (PA-18). When bears were seen, telemetry equipment was activated to determine whether the bear was marked (with a functioning radiotransmitter) or unmarked. If a bear was marked, its identity, association and location were recorded. Unmarked bears were not captured, but estimated sex/age (adult male, medium-sized adult, family group, and subadult) and location were recorded. The estimated age of offspring was also recorded. The number of radiomarked bears present in the area searched was determined using radiotracking gear in a manner that did not influence normal search patterns. Radiomarked bears were not located, but their presence in each bay was verified by telemetry signals during the searches.

Following the period of marking, 5 fixed-wing aircraft, each with a biologist and pilot, were available to conduct the searches. Unfortunately, bad weather prevented any searches during the period 23-31 May 1990. It was important to accomplish these searches before leaf emergence restricted sightability of bears. By 31 May leaves were well developed, especially on lower, south facing slopes, so the density estimate was canceled. Weather improved on June 3 and one replicate was accomplished using a single airplane. Based on this flight, it seemed other efforts would be successful even with the high level of leaf emergence and lower than ideal sightability. Consequently, 3 more replicates were flown during 5-7 June, each with 2 aircraft. Density was estimated based on these 4 replicate searches. Total time spent looking for bears during these 4 searches was 459, 547, 665, and 593 minutes, respectively.

Surveys in May 1993 within Katmai Preserve were conducted with the same procedure and intensity as the CMR density estimate flights, except there were no marked bears present. The Preserve was divided into 4 blocks to distribute search effort.

Three independent sources of data on population composition are available for making comparisons: (1) capture samples, (2) observations made during routine telemetry flights, and (3) observations during the 1990 density estimate. Each of these methods has associated biases and/or practical limitations. For instance, samples collected in the spring have a bias against capturing and observing females with cubs (i.e., bears < 1 year old) because these families tend to remain at higher elevations (Miller et al. 1987) where terrain and weather combine to hamper search efforts (Glenn and Miller 1980). Additionally, some of these families remain in dens until as late as the second week of June.

To minimize this spring capture bias against females with cubs, sex and age composition was determined over a 2-year period, with adjustment of the second year's sample to reflect the age and status of the bears in the previous year (Miller and Sellers 1992). For example, a 10-year-old female captured in 1990 with 2 yearlings was tallied as a 9-year-old female with two cubs for the 1989-90 sample.

Despite biases associated with specific methods of measuring population composition, collectively these samples provide insights into population composition and, considered jointly, permit evaluation of changes in population composition over time and comparisons with other populations assessed with similar techniques.

Survival rates of radiocollared bears and dependent offspring were determined by Kaplan-Meier procedures (Pollock et al. 1989). We investigated bear mortalites to determine cause of death.

Differences among means, ranks and survival rates were determined by *t*-tests, one-way ANOVA, Kruskal-Wallis, or Mann-Whitney tests. Chi-squared tests were used on proportional data sets.

RESULTS AND DISCUSSION

Captures

From 1989 through 1993, 122 bears were captured 145 times (Table 1). In 1989, 36 bears were captured and 30 radiotransmitters (including 20 regular collars and 10 collars with canvas spacers) were deployed. In 1990, 43 bears were captured (including 2 recaptures) and 42 transmitters (14 regular collars, 14 with canvas spacers, and 14 glue-on radios) were deployed. In October 1991, 4 bears were recaptured to remove breakaway collars that had not yet dropped off. In 1992, 31 bears were captured (including 15 recaptures) and 28 regular collars were fitted. In 1993, 31 bears were captured (including 2 recaptures) and 10 regular collars and 19 expandable collars (including 1 modified for an adult female) were deployed.

A total of 5 bears (2 subadult males and 3 adult females) died as a result of being captured – 1 during each capture operation. Although this rate of capture mortality (3.4%) is not exceptionally high, it is troublesome. One capture mortality occurred in October 1991 when a misplaced dart fitted with a 6 cm needle (used to penetrate accumulated subcutaneous fat deposits) hit the chest area. The other 4 were killed by other bears before they fully recovered from being tranquilized. In 2 of these (an adult female and a juvenile male), the killer was known to be an adult male, and in the other 2 cases the identity of the attacker was unknown. These deaths occurred despite attempts to periodically monitor recovery (which typically takes 2 to 3 hours with Telazol), and a policy of airlifting estrus females to safe recovery sites so their scent trails could not be followed by courting males. At Black Lake (Sellers 1994) and on Kodiak Island (R. Smith, ADF&G, Kodiak, pers. commun.), no tranquilized bear has ever been killed by another bear prior to full recovery. Two possible factors in these deaths are the exceptionally high bear density and high proportion of adult males in Katmai. Another possible factor may be that Black Lake and Kodiak bears, because they are hunted (particularly adult males), may have more fear of human scent lingering on marked bears and avoid them.

Population Size and Density Estimates

At the time density estimation began, there were 44 radiomarked bears in the study area (33 females and 11 males). Eighteen of these females were accompanied by a total of 28 offspring (ages 0-3). Four other bears radiomarked in 1989 did not enter the study area during the density estimate in 1990. During the density estimate, the population of marked bears was naturally closed because all radiomarked bears present at least once were present during all 4 replicate searches and no radiomarked bears moved onto the search area during the search period. This means that the value for T_i (total number of individual marked bears present at some time during the density estimation phase) was the same as M_i (number of marked bears in the search area during each replicate search). These values were 62, 44, and 52, respectively, for the estimates of all bears, independent bears, and bears > 2 years old. One glue-on radio was shed between replicate 2 and 3, reducing the number of radiomarked bears from 44 to 43.

For each replication, information on the association with other bears, presence in the search area, and sightings is provided in Table 2. For each replication, summary information on presence and sightings of both marked and unmarked bears is presented in Table 3. The group size of marked females with 2- or 3-year-old offspring is not precisely known if these bears were not seen during or shortly after the search period because these offspring may have separated from their mothers. To bracket the feasible range caused by this uncertainty, the maximum and minimum number of marks present were calculated. This uncertainty does not affect estimates of number of "independent" bears (excluding offspring still with their mothers) but does affect estimates of all bears and bears >2 years old.

Minimum Population and Density Estimate

A minimum number of bears known to be present was calculated as the sum of marked bears present and unmarked bears seen. For bears of all ages this minimum number was 142, 162, 182, and 159 for replications 1-4, respectively (Table 3). Based on at least 182 bears present in the study area the minimum density would be 202 bears/1,000 km^2 (523/1,000 mi^2, 1.9 mi^2/bear). The minimum number of independent bears was largest during replication 3; 131 bears were seen or known present.

In both cases, the minimum number of bears estimated in this way was significantly less than the lower limit of the 95% CI calculated below. This means that it would not be helpful to truncate the confidence interval at this minimum value.

Capture-Recapture Estimates

Capture-recapture estimates were calculated in 3 ways. The first way utilized the bear-days estimator described by Miller et al. (1987). The second method utilized the mean of the Lincoln-Petersen estimates calculated for each of the 4 replications. The third method utilized the maximum likelihood estimator described by White (1993). Results from all 3 of these estimators are presented here.

In comparison with the Katmai estimate, the density estimate from Black Lake the year before was more precise because of more replications (6 instead of 4), higher visibility of bears (43% of independent bears instead of 21%), more intensive search effort (0.9 min/km^2 instead of 0.6), and higher percentage of marked bears in the population (28% of independent bears instead of 12%). These problems with the Katmai estimate would not have existed if weather had permitted the estimate to be conducted as originally planned, before leaves emerged and before temporary, glue-on transmitters were shed (n = 12).

Bear-days Estimates in Katmai and Black Lake. Using the bear-days estimator, the number of bears (all ages) present on the Katmai study area during the search period was 493. The calculated 95% CI around this estimate based on the binomial approximation to the hypergeometric distribution was 394-651. The corresponding density estimate was 547 bears/1,000 km^2 (95% CI = 437-722 bears/1,000 km^2) (Table 4). For independent bears, the estimated density was 407 bears/1,000 km^2 (95% CI = 311-571 independent bears/1,000 km^2) (Table 4). For bears >2 years old, the estimated density was 474 bears/1,000 km^2 (95% CI = 368-647 bears >2/1,000 km^2). To accommodate the uncertainty of weaning dates for families of marked bears, calculations were made for the maximum and minimum number of offspring still with their mothers (Table 5).

Density estimates were lower for the Black Lake study during which search conditions were better and a more precise estimate was obtained (Miller and Sellers 1992). At Black Lake, the estimate for bears of all ages was 190 bears/1,000 km^2 (95% CI = 168-219), about 35% of that estimated in Katmai. As a percentage of the 95% CI for the Katmai density estimate, the Black Lake density was 26% to 43% of that estimated for the Katmai coast. For independent bears, the Black Lake density was estimated at 121 bears/1,000 km^2 ((95% CI = 103-104 bears/1,000 km^2). This density is 30% of that estimated for independent bears on the Katmai coast (21% to 39% based on the Katmai CI). For bears >2 years old, the Black Lake density was estimated at 142 bears/1,000 km^2 ((95% CI = 123-166 bears >2.0/1,000 km^2). This density is 30% of that estimated for bears >2 years old on the Katmai coast (22% to 39% based on the Katmai CI).

Mean Lincoln-Petersen Estimates in Katmai. Estimates and confidence intervals based on the mean Lincoln-Petersen estimator (Eberhardt 1990) are presented in Table 6. The mean Lincoln-Petersen density estimate for all bears was 537 bears/1,000 km^2 (95% CI = 454-621 bears/1,000 km^2), just 2% less than the bear-days estimate of density. For independent bears the mean Lincoln-Petersen estimate was 396 bears/1,000 km^2 (95% CI = 314-479 bears/1,000 km^2), just 3% less than the bear-days estimate.

The entire range of the 95% CI can be expressed as a percentage of the estimate to compare the relative size of the CIs associated with different estimators. For the estimate of all bears, the CI of the mean Lincoln-Petersen was 31% of the estimate, compared to 52% for the bear-days estimator. For the estimate of independent bears, the CI of the mean Lincoln-Petersen was 42% of the estimate, compared to 50% with the bear-days estimator. Even though the bear-days CI was asymmetric (larger above than below the estimate) and the mean Lincoln-Petersen estimate was symmetric, the entire range of the mean Lincoln-Petersen CI was contained within the bear-days CI. These results suggest that for the Katmai data, the bear-days CI was more conservative than that calculated using the mean Lincoln-Petersen.

Maximum Likelihood Estimates in Katmai. Estimates using the maximum likelihood estimator and CI described by White and Garrott (1990) are presented in Table 7. These density estimates were similar to the other estimators used but the CI was smaller.

Potential Errors Due to Time of Weaning. Because leaves were out during the density estimate period, it was difficult to verify whether 2- and 3-year old offspring were still with their radio-marked mothers. This influences the number of "marked" bears available to be resighted in the estimates for bears of all ages and bears >2 years old. An attempt was made to verify the family status of radiomarked females immediately following the density estimate, but not all bears were seen at this time. Some bears were not seen until midsummer. The range of error introduced by uncertainty over family status was estimated by (1) assuming that all families were still together (the "maximum" estimate) and (2) assuming that all family groups had separated (the "minimum" estimate) (Table 6). A subjective estimate or "best" estimate was also made of whether they were together or not. The "best" estimate was based both on the estimated age of the young (large or probable 3-year-old offspring were assumed more likely to have separated and smaller or 2-year-old offspring less likely to have separated at the time the density estimate was conducted) and on the elapsed time between the last observation of the intact family and the density estimate period. The range of result is reported in Table 8. For the bear-days estimator, the minimum estimate was <4% smaller than the best estimate for both all bears and bears >2 years old; the maximum estimate was about 15% higher. Similar results were found for the mean Lincoln-Petersen estimate except the maximum estimate was 38% higher than the best estimate for bears >2 years old (Table 9).

Extrapolated Population Estimate

The very crude population estimate for Katmai Park of 1,500-2,000 bears made after the 1990 CMR density estimate of the coastal study area has not been refined pending progress on GIS mapping and habitat evaluation. Surveys during late May 1993 (see below) estimated an additional 131-184 bears in the preserve. Results of these surveys were similar to previous subjective density estimates (Sellers and Miller 1991).

Population Composition

Adult Sex Ratios

During 1989-90 26 adult (≥5 years old) males and 34 adult females were captured on the Katmai coast, yielding a sex ratio of 76 males:100 females. This ratio was higher ($X^2 = 10.75$, df = 1, $P = 0.001$) than the ratio of 21 males:100 females at Black Lake during the early 1970s (26 males and 124 females, Sellers 1994). The Katmai sex ratio was also higher than at Black Lake in 1988-89 (39 males:100 females, $n = 13$ males and 33 females, Sellers 1994), but the low level of significant ($X^2 = 2.58$, df = 1, $P = 0.108$) was attributed to relatively small sample sizes. During CMR density estimate flights in Katmai in 1990, adult males made up a higher proportion (20%) of bears seen ($n = 456$) than during the 1989 Black Lake density estimate (10.9%, $n = 607$), ($X^2 = 16.9$, df = 1, $P < 0.001$).

Bears in family groups accounted for a lower percentage of bears observed during the Katmai CMR density estimate (39.7%) than during the Black Lake density estimate (55.5%), ($X^2 = 26.2$, df = 1, $P < 0.001$).

Subadult Sex Ratios

The Katmai sex ratio of subadults (2-4 years old) captured during 1989-90 in Katmai was nearly equal (8 females and 9 males). The subadult sex ratio at Black Lake in 1988-89 was 133 males:100 females (n = 16 males and 12 females).

Age Structure

The average age of adults captured was not different between Katmai and Black Lake, (males = 10.5 and 9.9, respectively; females = 10.8 and 12.2, respectively).

However, the overall population of independent bears (excluding offspring in family groups) of both sexes in Katmai was older than at Black Lake due to a lower proportion of subadults in Katmai (22%) than at Black Lake in 1988-89 (37%) or the early 1970s (54%), ($P < 0.03$). Consequently, the average age of all independent males was higher in Katmai ($\bar{x} = 9.2$, $n = 35$) than at Black Lake either during 1988-89 ($\bar{x} = 6.9$, $n = 32$; $t = 1.96$, df = 64, $P = 0.05$) or during 1970-75 ($\bar{x} = 3.9$, $n = 122$; $t = 3.76$, df = 37, $P = 0.001$). The average age of all independent females captured in Katmai ($\bar{x} = 9.8$, $n = 44$) was higher than for Black Lake in the 1970s ($\bar{x} = 7.1$, $n = 218$; $t = 3.54$, df = 60, $P = 0.001$) but was not different from the 1988-89 Black Lake sample ($\bar{x} = 10.3$, $n = 48$; $t = 0.44$, df = 88, $P = 0.66$).

The low number of subadults in Katmai, compared to Black Lake, may result from one or more of the following factors: lower recruitment, lower survival of subadults, higher rates of dispersal of subadults, or higher rates of survival of adults (especially males). These potential differences will be further tested when additional data are available on subadult movements and survival rates.

Composition/Trend Surveys

Brown bear surveys were conducted in Katmai National Preserve during 22-30 May 1993. The original study design called for up to 5 replicate surveys, but given the advanced stage of leaf phenology and the single survey team, only 2 surveys were completed. During over 30 hours of actual survey time a total (including duplication) of 103 brown bears were counted, an average of 3.41 bears/hr. The number of bears seen per hour was lower than at Black Lake (5.45 bears/hr) and the Katmai Coast (12.3 bears/hr). Survey intensity in the preserve averaged 1.74 minutes/mi^2. This intensity was lower than during the Black Lake density estimate (2.38 minutes/mi^2) and was similar to the search effort during the Katmai coastal density estimate (1.63 minutes/mi^2).

The preserve was divided into 4 count areas (Moraine Creek, Nanuktuk Creek, Nonvianuk River and Kukaklek), based on the need to break up the area into manageable-sized quadrants and to examine theories about bear densities. Two complete surveys were made on each area and partial surveys were done on Nanuktuk Creek on 22 May and Moraine Creek on 24 May; these were aborted due to poor conditions (low clouds and turbulence) (Table 9). The 2 completed surveys of the preserve yielded counts of 39 and 46 bears. Because no radiocollared bears were present, we could not directly calculate a sightability correction factor to estimate the total bear population of the preserve. During the 1989 CMR density estimate at Black Lake, we saw an average of 43% of marked bears. This work had ideal timing regarding phenological development and had among the highest sightability of all spring density estimates in Alaska (Miller et. al, in press). In contrast, the 1990 Katmai coastal CMR density estimate was done after leaf emergence (similar phenology to the preserve's) and only 21% of marked bears were seen. We are confident that the sightability during the surveys in the preserve fell within these values. Habitat within the preserve included more area of open tundra and flat barren snow/rock than in the Katmai coastal area, so we believe we had a higher sightability than the 21% recorded there. On the other hand, bears seem to prefer slopes with thicker brush, which indicates the sightability was lower than the 43% achieved under near perfect conditions at Black Lake. The rate of repeat sightings of the same family groups or very distinctive individuals was low, further suggesting sightability was relatively low. Using the best single count of 46 bears and sightability rates of 25%, 30% and 35%, we estimated total population for the preserve was 184, 153, and 131 bears, respectively.

Unfortunately, a tremendous amount of work and expense would be required to narrow this range of estimated population size. However, for the purposes of bear management, these estimates are useful. For example, when a harvest rate of 5% (the rate currently used for Unit 9) is applied to the extremes of the population estimates, the allowable sport harvest for the preserve is 7-9 bears per season. Harvests within the preserve from 1990-92 averaged 8 bears, and keeping harvests to this narrow a range without imposing a limited permit system is a formidable challenge.

Converting the range of population estimates to density figures, the preserve has between 120 and 168 bears:1,000 km^2 (i.e., 1 bear:2.3-3.2 mi^2). The two western count areas had a lower density (1 bear:6.6-9.1 mi^2) than did the Nanuktuk area (1 bear:1.4-2.0 mi^2). If the density estimate for the western areas is extrapolated to the remainder of the Alagnak drainage (a reasonable procedure based on similarity of habitat types and early summer bear distribution), there would be roughly 50 additional bears downstream of the preserve. Thus, the population estimate of 195 bears for the entire drainage made in 1990 by extrapolation (Sellers and Miller 1991) seems reasonable.

The second major objective of these surveys was to estimate composition of the brown bear population to determine if current harvest levels are affecting sex and age structure. Based on the number of breeding pairs and single bears of obviously large size, 21 (20%) of the 103 bears seen were adult males. This is virtually identical with the findings of the Katmai coastal density estimate. Of all bears seen, 64% were not in family groups, another indication the population is under relatively light harvest pressure. Two points require emphasis: (1) the composition data are based on a relatively small sample size (probably less than 80 different individuals) and (2) reported harvests during 1980-1988 averaged 3 per year and were considerably below the calculated sustainable harvest level.

Harvest Rates

Only 2 bears marked in Katmai National Park have been killed by hunters during the period 1989-93. Both adult males (#150, killed in Oct. 1991; and #318, killed in Oct. 1993) were killed outside the park boundary near Becharof Lake, at least 85 km south from their capture locations. During this period a maximum of 36 adult males were marked for a maximum of 135 bear-years. If the calculated annual survival rate of 0.958 for adult males (see below) is applied to each of the 36 bears, a corrected and more realistic sample of 118 adult male bear-years can be used. Thus, the harvest rate for adult males is estimated at 1.7% per year, with a minimum rate of 1.5% per year if no marked bears died of natural causes. Obviously, the calculated harvest rate for all other marked cohorts is 0%. If adult males compose 20% of the population (see above), the estimated harvest rate for the entire population is 0.34% per year.

Reproductive Biology

Age at First Production of Young

The minimum mean age at first birth is 7.2 years (2 at 6, 7 at 7, 2 at 8 and 1 at 9). The minimum age at which females produced first litters of cubs that survived to weaning (2.5 years old) was 8.0 (n = 9). These 9 bears lost at least 4 litters prior to weaning their first cubs. The minimum mean age for first production of a litter that survived at Black Lake was 6.7 (n = 12) (Sellers 1994).

Litter Size

Mean litter size for cubs of radiocollared females first seen during capture or at den emergence (May or early June) was 2.12 (n = 25 litters). This was significantly smaller (t = 2.22, P = 0.03) than at Black Lake ($\bar{x}$ = 2.54, n = 28, Sellers 1994). For comparisons with other study area (e.g., McNeil River), we also determined the mean cub litter size at midsummer to be 2.11 (n = 19). By fall, the mean cub litter size was 2.18, but this does not count 10 litters that had no survivors by 10 months of age. It is quite evident that using the change in average litter size to reflect cub mortality grossly underestimates mortality because the loss of entire litters is not reflected.

The mean litter size for yearlings at den emergence or capture was 1.75 (n = 24 litters), and was smaller (t = 1.83, P = 0.07) than at Black Lake ($\bar{x}$ = 2.13, n = 23 [Sellers 1994]). The mean yearling litter size in midsummer was 1.71 (n = 19), and by fall was 1.61 (n = 18 litters). Three entire yearling litters were known to be lost between spring and fall.

Mean spring litter size for 2-year-olds was 1.74 (n = 27). Average size of litters $\geq$1-year-old seen during midsummer tracking flights (which may include some duplicate sightings) was 1.70 (n = 174).

Age at Family Separation

Radiocollared females weaned 7 litters at 2.5 years of age, 6 litters at 3.5 years, and 2 at 4.5 years. There was no difference in the mean age of females weaning litters at 2 years of age (14.6 years old, range 9-22) versus females weaning litters at 3- or 4-years of age (12.6 years old, range 9-20).

Reproductive Interval and Recruitment

During 1989-1993, only 2 radiocollared bears successfully weaned two litters. These were weaned at 3-year intervals, but by virtue of their success in the 5 years of this study, these bears form a highly biased sample. We used the most optimistic scenarios for all adult females observed for at least 4 years (n = 19) to calculate a minimum weaning interval of 5.6 years.

Because of different methodology between various studies on the Alaska Peninsula, we used the cumulative summary of production based on the number of 2-year-old litters produced for all adult female bear-years. For the current comparisons, only adult females captured in 1989 and 1990 are used because capture samples after 1990 were biased toward females with litters composed of offspring 1 year old or older. We will only include bears captured after 1990 when they have been under observation for at least 4 years. A total of 34 adult females have produced a total of 17 litters of cubs ≥ 2 years old (total of 30 cubs) in 106 bear years, yielding 6.2 years per successful litter and production of 0.28 2.5 year-old cubs/adult female per year.

At McNeil the average recruitment was 0.34 yearlings/adult female per year (Sellers and Aumiller 1994). If this rate is adjusted to account for yearling mortality from summer through the next spring, as estimated in Katmai (see below) and Black Lake (Sellers 1994), the average recruitment at McNeil would be approximately 0.31 2.5-year-olds/adult female per year.

Estimated Survival Rates

Survival estimates have been updated through 1993 (Table 10), but are still considered preliminary. Annual survival for females ≥ 3 is 0.927. During 1989-93, 10 adult females with functional radiocollars died of natural causes. One (#136) was believed to have been caught in an early spring avalanche. We have not been able to get to the remains of bear #113, which are in a ravine, to determine the cause of her death. Bear #317 apparently was killed by another bear in the late fall of 1993. She was the only confirmed victim of conspecific predation that was not accompanied by offspring. Seven other females died while accompanied by offspring (3 with cubs, 1 with a yearling, and 3 with ≥ 2-year-olds). One of these (#160) died during May, but the cause of death could not be determined. Three bears (#117, 123 and 159) were killed by other bears (as evidenced by severe wounds to the head) in July. The other 3 maternal females (#143, 182 and 192) died after mid July, but the cause of death could not be determined.

The natural mortality rate for maternal females seems higher than for single females; statistical comparisons will be made in the final report.

Survival rates for cub and yearlings were 0.349 and 0.768, respectively. When maternal females died of natural causes, their cubs or yearlings were included as natural deaths. The survival rate for males ≥ 3 years old was 0.958. Subadult survival rates will be calculated after 1994 when the fate is determined for several bears collared in 1993.

Status and Movements of Marked Bears

During 1989-93, 28 adult females were relocated at least 30 times each, and 12 have over 70 locations (Table 11). In total, approximately 2,760 locations of marked bears have been recorded. As of December 1993, 30 adult females were alive with functioning radiocollars. Because of the difficulty of keeping radiocollars on males without risking neck injury, only temporary radio attachment designs have been used. Consequently, only 9 males have been relocated >20 times. The current status of radiocollared bears is listed in Table 11.

During May 1993, 18 subadults (2-4 year old) still accompanying their mothers were captured and fitted with expandable collars. By October 1993, only 7 of these collars were still on. One subadult was killed by another bear, and the other 10 collars fell off prematurely because of failure of the PVC tubing material.

Further analysis of movements, home range and habitat use awaits digitizing of these locations and mapping of cover types.

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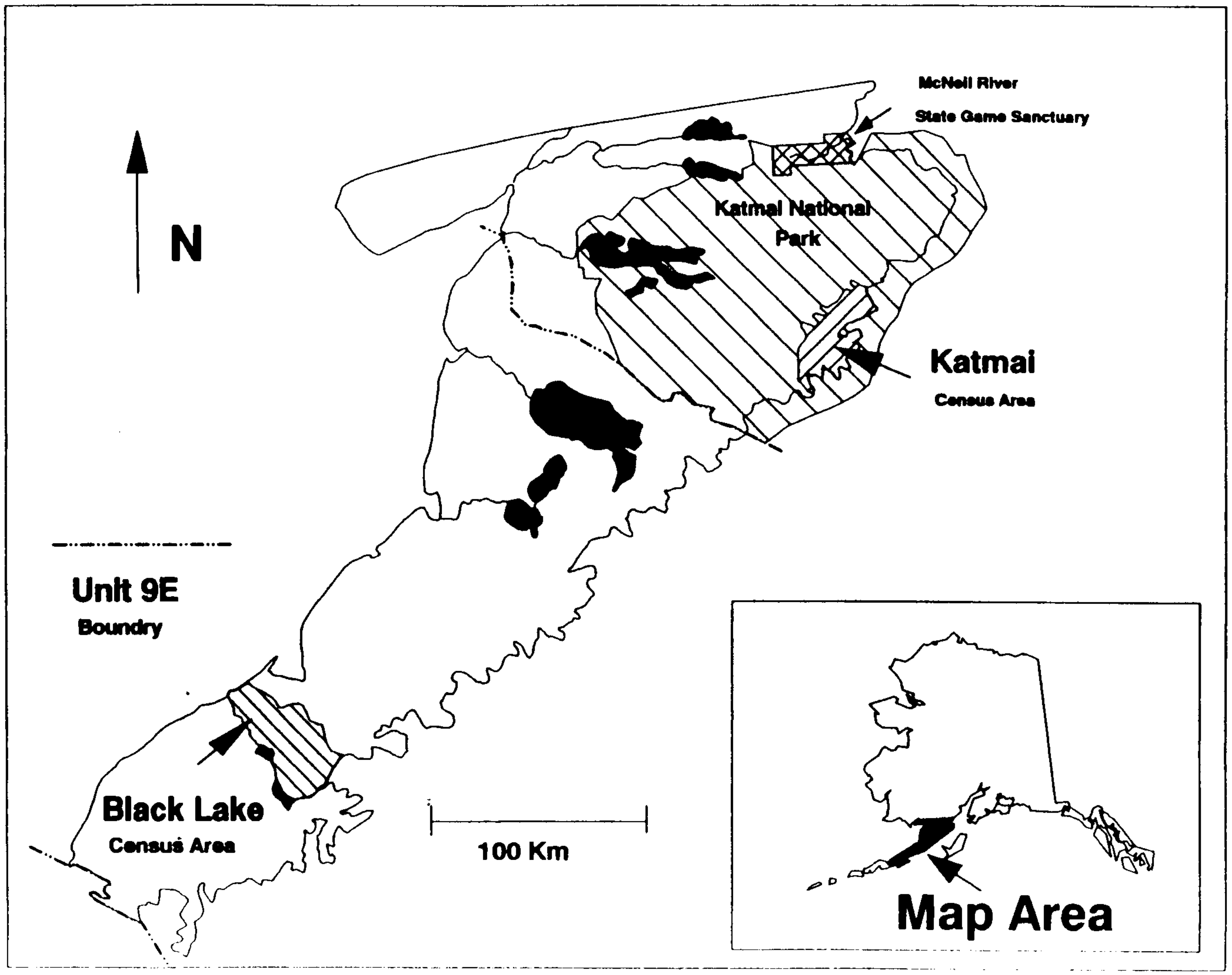


Figure 1. Brown bear study area on the coast of Katmai National Park

Table 1. Brown bear capture data, Katmai Coast, 1989-93.

ID	Sex	Age	Weight	Capture Date	Ear tags Left	Ear tags Right	Ear tags Color	Radio Collar Type	Hb (%)	PVC (%)	Comments
101	M	5	~400	5/31/89	42	41	R	CANVAS	14.2	41.0	Alone
102	M	8	~800	5/31/89	2509	2651	R	NONE	16.5	45.0	With uncaptured female
103	M	4	~275	5/31/89	51	55	R	CANVAS	13.9	41.0	Alone
104	F	14	425	5/31/89	53	54	W	REG	15.0	43.0	With #105
105	M	20	~900	5/31/89	2641	95	R	NONE	17.0	45.0	With #104
106	F	6	~400	6/4/89	99	95	Y	REG	16.2	48.0	With #107
107	M	13	~800	6/4/89	39	40	R	NONE	16.5	48.5	With #106
108	F	5	~250	6/4/89	3088	3086	Y	REG	16.7	48.5	With uncaptured ad. male
109	M	7	~430	6/4/89	2634	2628	R	CANVAS	16.0	46.5	Alone
110	M	7	~375	6/4/89	47	48	R	CANVAS	14.6	42.0	Alone
111	F	10	~300	6/5/89	3066	3208	Y	REG	15.9	46.5	W/2@2
112	F	12	~350	6/5/89	3098	86	Y	REG	14.3	41.0	W/2@1
113	F	19	~375	6/5/89	NONE	300	Y	REG			W/2@2, Becharof #05-02
114	F	9	~375	6/5/89	262	253	Y	REG	13.8	37.5	W/2@0
115	F	4	~325	6/5/89	3001	3097	Y	REG	15.0	42.0	With uncaptured adult male
116	M	4	~350	6/5/89	83	72	R	CANVAS	16.2	48.0	Alone
117	F	6	~325	6/5/89	3298	3031	Y	REG	13.8	41.0	Alone
118	F	12	~300	6/5/89	265	266	Y	REG	17.6	48.5	With #119
119	M	10	~800	6/5/89	46	93	R	NONE	17.7	50.0	With #118
120	F	8	~400	6/5/89	256	260	Y	REG	14.5	41.5	W/1@2
121	M	3	~350	6/5/89	2638	2685	R	CANVAS	13.6	39.0	Alone
122	M	3	~200	6/5/89	61	2640	R	CANVAS	15.5	43.0	Alone
123	F	11	~350	6/5/89	3039	3050	Y	REG	15.0	40.0	W/1@0
124	F	8	~400	6/5/89	3051	3029	Y				With uncaptured adult male
125	M	8	~500	6/6/89	2644	2669	R	NONE	16.5	49.0	Alone
126	F	5	~300	6/6/89	257	259	Y	REG	15.6	44.5	With uncaptured adult male
127	F	4	~225	6/6/89	3003	3030	Y	CANVAS	18.7	49.5	Alone
128	F	16	~350	6/6/89	3285	3028	Y	REG	14.5	39.5	W/1@1
129	F	15	430	6/6/89	267	272	Y	REG	12.5	35.5	W/2@2
130	F	11	~300	6/6/89	3210	3041	Y	REG	16.5	47.5	W/1@1
131	F	16	~350	6/6/89	3057	3096	Y	CANVAS	10.2	29.0	Alone
132	F	10	~375	6/6/89	3038	3021	Y	REG	15.9	44.0	With uncaptured adult male
133	F	8	~430	6/6/89	271	251	Y	BLACK	16.7	45.5	Alone
134	F	4	~200	6/6/89	3280	3069	Y	CANVAS	13.9	39.0	Alone

Table 1. Cont.

ID	Sex	Age	Weight	Capture Date	Ear tags Left	Right	Color	Radio Collar Type	Hb (%)	PVC (%)	Comments
135	F	8	~325	6/6/89	100	3014	Y	CANVAS	16.3	47.0	W/2@1
136	F	8	~400	6/13/89	3073	3035	Y	NONE	14.6	45.0	W/2@1
127	F	5	~375	5/21/90				REG	17.0	50.0	Alone
135	F	9	~325	5/19/90				REG	13.8	36.4	Alone
137	M	16	~950	5/19/90	345	346	R	GLUE			Alone
138	M	12		5/19/90	303	205	R	GLUE	15.5	45.7	Alone
139	M	6	~250	5/19/90	211	306	R	GLUE	15.0	44.2	Alone
140	M	8		5/19/90	207	222	R	CANVAS	15.3	42.0	Alone
141	M	15	~850	5/19/90	327		R	GLUE	16.0	47.5	Alone
142	M	14		5/19/90	181	197	Y	GLUE	15.0	41.5	Alone
143	F	16	~300	5/19/90	185	177	Y	REG	14.8	44.1	W/2@2
144	M	3		5/19/90	307	309	R	CANVAS	15.0	43.6	Alone
145	F	11	~325	5/19/90	183	396	Y	REG	16.7	48.3	With #146
146	M	16	~950	5/19/90	201	202	R	GLUE	11.0	29.1	With #145
147	M	10	~750	5/20/90	394	388	R	CANVAS	13.3		Alone
148	F	6	~275	5/20/90	156	151	Y	HEAVY CAN	13.0	36.0	Alone
149	M	12	~750	5/20/90	341	333	R	GLUE	10.5	26.0	Alone
150	M	10	~950	5/20/90	304	311		GLUE	18.0	45.0	Alone
151	F	4	~250	5/20/90	393	383	Y	CANVAS	14.5	45.8	Alone
152	M	19	~1000	5/20/90	221	301	R	GLUE			Alone
153	M	10	~550	5/20/90	219	220	R	GLUE	14.0	41.7	Alone
154	F	11	~325	5/20/90	400	176	Y	REG			W/1@2 or 3
155	M	3	~225	5/20/90	334	332	R	CANVAS	13.3	37.4	Alone
156	M	23	~850	5/20/90	225	215	R	GLUE	14.5	35.3	With uncaptured female
157	M	7	~450	5/20/90	314	313	R	CANVAS	14.0	47.8	With uncaptured female
158	M	5	~250	5/20/90	316	319	R	CANVAS	13.5		Alone
159	F	8	~275	5/20/90	397	180	Y	REG	14.8	45.1	W/1@1
160	F	15		5/20/90	31	29	Y	REG	14.3	28.4	W/1@2
161	F	8	~300	5/21/90	46	36	Y	REG	15.5	50.0	W/2@2 or 3
162	M	5	~400	5/21/90	370	365	R	CANVAS	17.0	51.7	With #163
163	F	5		5/21/90	420	409	Y	HEAVY CAN	15.0	41.4	With #162
164	F	4	290	5/21/90	392	394	W	HEAVY CAN	16.5	50.9	With uncaptured subadult

Table 1. Cont.

ID	Sex	Age	Weight	Capture Date	Ear tags Left	Ear tags Right	Ear tags Color	Radio Collar Type	Hb (%)	PVC (%)	Comments
165	M	8		5/21/90	213	214	R	GLUE	14.5	43.1	Alone
167	M	2	~175	5/21/90	340	343	R	GLUE	14.0	46.6	Alone, killed by another be
168	F	5		5/21/90	26	27	Y	CANVAS	12.5	34.5	With uncaptured subadult
169	F	14	~375	5/21/90	176	416	Y	REG	17.3	51.7	W/1@2
170	M	7		5/21/90	355	351	R	GLUE	15.5	44.8	Alone
171	F	22	~500	5/21/90	042	33	Y	REG	16.4	49.1	Alone
172	F	12		5/21/90	049	45	Y	REG	15.0	44.8	W/2@1
173	F	10	~400	5/21/90	158	174	Y	REG	14.5	44.0	W/2@2
174	F	14		5/21/90	408	407	Y	REG	16.0	49.1	With #175, Becharof #84-09
175	M	9	~750	5/21/90	391	376	R	GLUE			With #174
176	M	10	~575	5/22/90	352	359	R	HEAVY CAN	18.5	47.0	Alone
177	F	5	325	5/22/90	187	190	Y	GLUE/CAN	15.8	44.8	Alone
178	F	17	~450	6/12/90	270	268	Y	REG			W/2@1
140	M	9	~700	10/23/91				Remove collar			With another large male
144	M	4	~550	10/23/91				Remove collar			W/3@0, Capture mortality
148	F	7	~375	10/23/91				Remove collar			Alone
158	M	6		10/23/91				Remove collar			Alone
104	F	17		6/6/92	053	054	Y	REG		41.0	Alone
106	F	9		6/5/92	099	095	Y				With uncaptured bear
108	F	8	~350	6/6/92	3088	3086	Y			49.0	W/3@0
111	F	13		6/5/92	3066	3208	Y				With uncaptured adult male
113	F	22		6/5/92	036 Y	217	W				W/2@2
117	F	9	~350	6/4/92	3298	3031	Y			49.0	W/3@0
120	F	11		6/6/92	256	260	Y			49.0	W/1@0
126	F	8		7/16/92							W/3@0
128	F	19		7/16/92							W/3@0
130	F	13		6/5/92	3210	3041	Y			48.0	With uncaptured adult male
136	F	11		7/16/92							W/2@0
145	F	13	~375	6/6/92	183	396	Y			45.0	W/2@1
163	F	7	~375	6/6/92	420	409	Y			45.0	With uncaptured adult male
172	F	14		6/6/92	049	045	Y			40.0	Alone
174	F	16		6/7/92	408	407	Y			49.0	Alone
179	F	10	~400	6/4/92	205	206	W			43.0	W/2@2

Table 1. Cont.

ID	Sex	Age	Weight	Capture Date	Ear tags Left	Ear tags Right	Ear tags Color	Radio Collar Type	Hb (%)	PVC (%)	Comments
180	M	4	~450	6/4/92							Alone
181	F	8	~400	6/4/92	319	315	W			46.0	W/1@1
182	F	21	~450	6/4/92	309	305	W			41.0	W/1@2
183	F	13	~375	6/4/92	423	178	Y			49.0	With #184
184	M	9	~800	6/4/92							With #183
185	F	13		6/5/92	403	413	Y			48.0	W/2@2
186	F	11	~400	6/6/92	157 Y	256	W				W/2@1
187	F	10	~450	6/6/92	252	255	Y			45.0	W/2@2
188	F	19	~450	6/6/92	204	201	W			44.0	W/3@2
189	M	~10	~450	6/6/92	195	387	Y			43.0	Alone
190	F	14	~450	6/6/92	192	415	Y			41.0	W/2@1
191	F	15	~450	6/6/92	164	163	Y			39.0	W/3@0
192	F	17	~300	6/7/92	389	199	Y			43.0	W/1@1
193A	F	17	~450	6/7/92	040	050	Y			46.0	W/1@1
193B	F	8		7/17/92	3053	121	Y			48.0	W/1@2
135	F	12	295	5/17/93	121R	121	Y	REG	13.0	43.0	W/4@2
154	F	14	~380	7/15/93	400Y	176	Y	REG			W/1@1
301	F	6	370	5/17/93	125Y	NONE		REG	12.7	46.5	With young male
302	M	2	210	5/17/93	108Y	108	R	EXPAND	14.3	42.0	With mother #193
303	M	2	~140	5/17/93					14.0	49.5	With mother #186, Killed by
304	M	2	~70	5/17/93	104Y	104	R	EXPAND	14.0	46.0	With mother #135 & siblings
305	F	2	~70	5/17/93	127R	127	Y	EXPAND	13.5	45.0	With mother #135 & siblings
306	M	2	~90	5/17/93	117Y	117	R	EXPAND	12.5	41.0	With mother #135 & siblings
307	F	2		5/17/93	126R	126	Y	EXPAND	10.9	39.5	With mother #185
308	M	2		5/17/93	105Y	105	R	EXPAND	13.2	43.5	With mother #145
309	F	2	~70	5/17/93	101R	101	Y	EXPAND	12.0	35.5	With mother #145
310	F	19	315	5/17/93	123Y	123	R	REG	14.5	45.5	W/3@1
311	F	3	~135	5/17/93	103R	103	Y	EXPAND	13.5	56.0	With mother #187
312	M	3	~140	5/17/93	124Y	124	R	EXPAND	13.8	44.0	With mother #187
313	F	5	350	5/18/93	114R	114	Y	REG	14.7	37.4	With uncaptured adult male
314	F	4	265	5/18/93	111R	111	Y	EXPAND	16.6	49.5	With mother #179

Table 1. Cont.

ID	Sex	Age	Weight	Capture Date	Ear tags Left	Ear tags Right	Ear tags Color	Radio Collar Type	Hb (%)	PVC (%)	Comments
315	M	4		5/18/93	102Y	102	R	EXPAND	15.2	43.4	With mother #188
316	F	4	~110	5/18/93	106R	106	Y	EXPAND	16.5	47.0	With mother #188
317	F	12	525	5/18/93	122Y	122	R	REG	14.0	52.5	With uncaptured adult male
318	M	5	415	5/18/93	116Y	116	R	NONE	14.7	44.5	With uncaptured adult male
319	F	10	330	5/18/93	109R	109	R	REG	16.2	49.5	W/2@1
320	F	18	385	5/19/93				REG	13.1	42.5	W/2@1
321	F	4	345	5/19/93	110R	110	Y	REG	13.2	41.5	With uncaptured adult male
322	F	21	260	5/19/93				REG	12.7	37.5	W/2@2
323	M	2	~60	5/19/93	112Y	112	R	EXPAND	10.9	38.0	With mother #322
324	M	2	~80	5/19/93	129R	129	Y	EXPAND	10.7	37.5	With mother #322
325	F	23	340	5/19/93	128Y	128	R	REG	12.8	42.0	W/2@2
326	M	2	~120	5/19/93	132Y	132	R	EXPAND			With mother #325
327	F	2	~75	5/19/93	107R	107	Y	EXPAND	10.8	36.0	With mother #325
328	F	2	~140	5/19/93	120R	120+I16	Y	EXPAND	12.8	41.0	With mother #190
329	M	2	195	5/19/93	131Y	131	R	EXPAND	15.0	42.0	With mother #190

Table 2. Status of marked brown bears during density estimation on Katmai coast, 1990. Data on group size refer to females with dependent young; other types of groups are indicated as (P) for pairs or (S) for siblings

		Young		Rep.1 (6/3)			Rep.2 (6/5)			Rep.3 (6/6)			Rep.4 (6/7)								
ID	Sex	Int no.	Est. age	In?	Group size	Seen?	In?	Group size	Seen?	In?	Group size	Seen?	In?	Group size	Seen?	No. out	No. in	No. seen	% in	% seen	Final family status
104	F			IN			IN			IN			IN			0	4		100	0	
106	F	1	0	IN	1?		IN	1?		IN	1?		IN	1?		0	4		100	0	W/AD MALE ON 6/8
108	F			IN	(P)	YES	IN			IN			IN			0	4	1	100	25	
111	F	2	3	IN	1?		IN	1?		IN	1?		IN	1?		0	4		100	0	W/AD MALE ON 6/8
113	F	3	0	IN	4		IN	4		IN	4		IN	4		0	4		100	0	W/3 COY ON 6/8
114	F	2	1	IN	3	YES	IN	3		IN	3		IN	3		0	4	1	100	25	W/2 @ 1 ON 6/8
117	F	1	0	IN	2		IN	2		IN	2	YES	IN	2	YES	0	4	2	100	50	W/1 COY ON 6/7
118	F			IN			IN			IN			IN			0	4		100	0	
120	F	1	3	IN	2		IN	2	YES	IN	2	YES	IN	(P)	YES	0	4	3	100	75	W/AD MALE ON 6/7
121	M			OUT			OUT			OUT			OUT			4	0		0		
123	F	3	0	OUT			OUT			OUT			OUT			4	0		0		
126	F			IN			IN	(P)	YES	IN			IN			0	4	1	100	25	
127	F			IN			IN			IN			IN			0	4		100	0	
128	F			IN	(P)	YES	IN			IN			IN			0	4	1	100	25	
129	F	2	3	IN	1?		IN	1?		IN	1?		IN	1?		0	4		100	0	ALONE ON 7/11
130	F	1	2	IN	2		IN	2		IN	2		IN	2		0	4		100	0	W/1 @ 1 ON 6/8
132	F	1	0	IN	2		IN	2		IN	2		IN	2		0	4		100	0	W/1 COY ON 6/12
133	F			IN	1	YES	IN	(P)	YES	IN			IN			0	4	2	100	50	ALONE BY 6/3
134	F			IN			IN			IN			IN			0	4		100	0	
135	F	2	2	IN	1?		IN	(P)	YES	IN	(P)	YES	IN			0	4	2	100	50	W/AD MALE ON 6/5
136	F			OUT			OUT			OUT			OUT			4	0		0		
139	M			IN			IN		YES	IN		YES	IN		YES	0	4	3	100	75	
140	M			IN			IN			IN			IN		YES	0	4	1	100	25	
143	F	2	2	IN	1?		IN	(P)	YES	IN			IN			0	4	1	100	25	W/AD MALE ON 6/5
144	M			IN			IN			IN			IN			0	4		100	0	
145	F			IN			IN			IN			IN			0	4		100	0	
146	M			IN			IN	(P)	YES	IN	(P)	YES	IN	(P)	YES	0	4	3	100	75	
147	M			OUT			OUT			OUT			OUT			4	0		0		
148	F			IN			IN			IN			IN			0	4		100	0	
151	F			IN			IN			IN			IN			0	4		100	0	
153	M			IN			IN			DROPPED			DROPPED			0	2		100	0	
154	F	1	2	IN	2		IN	2		IN	2	YES	IN	2		0	4	1	100	25	TOGETHER 6/6
155	M			IN			IN			IN			IN			0	4		100	0	
157	M			IN			IN	(P)	YES	IN			IN			0	4	1	100	25	
158	M			IN			IN			IN	(P)	YES	IN			0	4	1	100	25	
159	F	1	1	IN	2	YES	IN	2	YES	IN	2		IN	2		0	4	2	100	50	
161	F	2	2	IN	1?		IN	1?		IN	1?		IN	1?		0	4		100	0	SHED BY 6/27
162	M			IN			IN		YES	IN			IN			0	4	1	100	25	
163	F			IN			IN			IN			IN			0	4		100	0	
164	F	1	3	IN	1?		IN	1?		IN	1	YES	IN			0	4	1	100	25	ALONE ON 6/6
165	M			IN			IN			IN			IN	(P)	YES	0	4	1	100	25	
168	F			IN	(S)	YES	IN	(P)	YES	IN	(P)	YES	IN	(P)	YES	0	4	4	100	100	
169	F	1	2	IN	2	YES	IN	2?		IN	2?		IN	2?		0	4	1	100	25	UNKNOWN
171	F			IN			IN			IN			IN	(P)	YES	0	4	1	100	25	
172	F	2	1	IN	3		IN	3		IN	3	YES	IN	3	YES	0	4	2	100	50	W/2 @1 ON 6/27
173	F	2	2	IN	3		IN	3		IN	3	YES	IN	3		0	4	1	100	25	W/2 @ 2 ON 6/27
174	F			IN			IN			IN	(P)	YES	IN			0	4	1	100	25	
177	M			IN			IN			IN		YES	IN			0	4	1	100	25	
															TOTAL	16	174	40	92	23	

Table 3. Summary of observations of brown bears during brown bear density estimate on Katmai "Independant bears" excludes offspring, of what ever age, still with their mothers.

	REPLICATION 1	2	3	4	MEAN	MIN.	MAX.
Marked bears present, all ages (most likely number)	62	62	61	60	61.3	60	62
Independent marked bears present	44	44	43	43	43.5	43	44
Marked bears seen							
All ages	11	13	20	12	14.0		
Independent	7	11	13	9	10.0	7	13
Unmarked bears seen, all ages	80	100	121	99	100.0	80	121
No. cubs-of-year	0	4	4	7	3.8	0	7
No. "yearlings	12	19	10	1	10.5	1	19
No. older than "ylgs."	68	77	107	91	85.8	107	68
No. independent	64	72	88	79	75.8	64	88
Total marked and unmarked bears se							
No. all ages	91	113	138	111	113.3	91	138
No. independent	71	83	101	88	85.8	71	101
Sightability, independent marked bears							
No. inside area	44	44	43	43	43.5	43	44
No. seen	7	11	13	9	10.0	7	13
% seen	15.9	25.0	30.2	20.9	23.0	16.3	29.5

Table 4. Population and density estimates for brown bears in Katmai Natl. Park coastal study area using the bear-days estimator

Estimates for bears of all ages

								95% CI			
						Cumulative	Density	Number of bears		Bears/1000 km2	
Date	Marks resen	Marks seen	Total seen	Daily L-P	% seen	estimate no. bears	No. bears/ 1000km2	Lower	Upper	Lower	Upper
6/3/90	62	11	91	482	18	482	535	301	1002	334	1111
6/5/90	62	13	113	512	21	512	568	365	806	405	895
6/6/90	61	20	141	418	33	476	529	368	655	409	726
6/7/90	60	12	111	525	20	493	547	394	651	437	722
cumulative % =					23						
mean daily L-P=				484			537				
SE=				20.5							

Estimate of population size based on independent bears only (excluded offspring with their mothers)

								95% CI			
						Cumulative	Density	Number of bears		Bears/1000 km2	
Date	Marks resen	Marks seen	Total seen	Daily L-P	% seen	estimate no. bears	No. bears/ 1000km2	Lower	Upper	Lower	Upper
6/3/90	44	7	71	404	16	404	448	228	1084	254	1203
6/5/90	44	11	83	314	25	363	402	247	621	274	690
6/6/90	43	13	101	320	30	352	390	260	519	288	576
6/7/90	43	9	88	391	21	367	407	280	514	311	571
cumulative % =					23						
mean daily L-P=				357			396.2				
SE=				20.3							

Estimate for bears × 2 years old

								95% CI			
						Cumulative	Density	Number of bears		Bears/1000 km2	
Date	Marks resen	Marks seen	Total seen	Daily L-P	% seen	estimate no. bears	No. bears/ 1000km2	Lower	Upper	Lower	Upper
6/3/90	52	8	76	452	15	452	502	264	1116	293	1238
6/5/90	52	12	89	366	23	415	460	287	688	319	763
6/6/90	51	17	126	366	33	399	443	302	567	335	629
6/7/90	50	9	98	504	18	427	474	332	583	368	647
cumulative % =					22.4						
mean daily L-P=				422			468.3				
				SE=	29.5						

Table 5. Estimate of brown bear density using the bear-days estimator and maximum and minimum numbers of offspring still with their mothers.

Estimate for all bears with maximum number of offspring still with their mothers

Date	Marks present	Marks seen	Total seen	Daily L-P	Sightabty	Estimate no. of bears	No. of bears /1000km2	95% CI For No. bears est. lower	95% CI For No. bears est. upper	95% CI no./1000km2 lower	95% CI no./1000km2 upper
6/3/90	73	11	91	566	0.15	566	628	354	1179	393	1309
6/5/90	71	13	113	585	0.18	594	659	424	936	470	1039
6/6/90	69	20	141	472	0.29	548	608	424	754	471	836
6/7/90	68	12	111	593	0.18	565	627	452	747	502	828
		cumulative % sightability			0.20						
		mean daily L-P=		554			615				
			SE=	24							

Estimate for all bears with minimum number of offs with their mothers

Date	Marks present	Marks seen	Total seen	Daily L-P	Sightabty	Estimate no. of bears	No. of bears /1000km2	95% CI For No. bears est. lower	95% CI For No. bears est. upper	95% CI no./1000km2 lower	95% CI no./1000km2 upper
6/3/90	60	11	91	467	0.18	467	518	291	969	323	1076
6/5/90	60	13	113	496	0.22	496	550	353	780	392	866
6/6/90	59	20	141	405	0.34	461	512	356	633	396	703
6/7/90	58	12	111	507	0.21	477	529	381	630	423	699
		cumulative % sightability			0.21						
		mean daily L-P=		469			520				
			SE=	20							

Table 5. Cont.

Estimate for bears >2.0 with maximum number of offspring still with their mothers

Date	Marks present	Marks seen	Total seen	Daily L-P	Sightabty	Estimate no. of bears	No. of bears /1000km2	95% CI For No. bears est. lower	95% CI For No. bears est. upper	95% CI no./1000km2 lower	95% CI no./1000km2 upper
6/3/90	62	8	76	538	0.13	538	597	315	1330	349	1476
6/5/90	60	12	89	421	0.20	486	539	337	807	374	895
6/6/90	58	17	126	415	0.29	463	514	351	659	389	731
6/7/90	57	9	98	573	0.16	493	548	383	674	425	748
					cum.=						
	mean daily L-P=			487	0.16		540				
			SE=	35							

Estimate for bears >2.0 with minimum number of offspring still with their mothers

Date	Marks present	Marks seen	Total seen	Daily L-P	Sightabty	Estimate no. of bears	No. of bears /1000km2	95% CI For No. bears est. lower	95% CI For No. bears est. upper	95% CI no./1000km2 lower	95% CI no./1000km2 upper
6/3/90	50	8	76	435	0.16	435	483	254	1073	282	1191
6/5/90	50	12	89	352	0.24	399	442	276	661	307	734
6/6/90	49	17	126	352	0.35	384	426	290	545	322	605
6/7/90	48	9	98	484	0.19	410	456	319	560	353	622
					cum.=						
	mean daily L-P=			406	0.19		450				
			SE=	28							

Table 6. Brown bear density estimate in the Katmai Natl. Park study area using the mean of Lincoln Petersen estimates and confidence interval based on sampling mean (Eberhardt 1990). Additional estimates made using maximum and minimum numbers of offspring still with their mothers.

Bears of all ages, most likely number of marks present

								95% CI FOR			
								No. of bears		No./1000km2	
Date	Marks present	Marks seen	Total seen	Daily L-P	Mean of L-Ps	Sample Variance	Density #/1000km2	lower	upper	lower	upper
6/3/90	62	11	91	482	482		535				
6/5/90	62	13	113	512	497	450	551	306	688	340	763
6/6/90	61	20	141	418	471	2293	522	352	590	390	654
6/7/90	60	12	111	525	484	2252	537	409	560	454	621

Independent bears only, most likely number of marks present

								95% CI FOR			
								No. of bears		No./1000km2	
Date	Marks present	Marks seen	Total seen	Daily L-P	Mean of L-Ps	Sample Variance	Density #/1000km2	lower	upper	lower	upper
6/3/90	44	7	71	404	404		448				
6/5/90	44	11	83	314	359	4050	398	-213	931	-236	1033
6/6/90	43	13	101	320	346	2543	384	221	471	245	523
6/7/90	43	9	88	391	357	2196	396	282	432	313	479

Bears > 2 only, most likely number of marks present

								95% CI FOR			
								No. of bears		No./1000km2	
Date	Marks present	Marks seen	Total seen	Daily L-P	Mean of L-Ps	Sample Variance	Density #/1000km2	lower	upper	lower	upper
6/3/90	52	8	76	452	452		502				
6/5/90	52	12	89	366	409	3743	454	-140	959	-156	1064
6/6/90	51	17	126	366	395	2496	438	271	519	300	576
6/7/90	50	9	98	504	422	4643	468	314	530	348	589

Table 6. Cont.

Bears of all ages, maximum number of marks present

Date	Marks present	Marks seen	Total seen	Daily L-P	Mean of L-Ps	Sample Variance	Density #/1000km2	95% CI FOR No. of bears lower	95% CI FOR No. of bears upper	95% CI FOR No./1000km2 lower	95% CI FOR No./1000km2 upper
6/3/90	73	11	91	566	566		628				
6/5/90	71	13	113	585	576	180	639	455	696	505	773
6/6/90	69	20	141	472	541	3659	601	391	692	434	767
6/7/90	68	12	111	593	554	3119	615	465	643	517	714

Bears > 2.0 only, maximum number of marks present

Date	Marks present	Marks seen	Total seen	Daily L-P	Mean of L-Ps	Sample Variance	Density #/1000km2	95% CI FOR No. of bears lower	95% CI FOR No. of bears upper	95% CI FOR No./1000km2 lower	95% CI FOR No./1000km2 upper
6/3/90	62	8	76	538	538		597				
6/5/90	60	12	89	421	480	6809	532	-262	1221	-290	1355
6/6/90	58	17	126	415	458	4786	508	286	630	318	699
6/7/90	57	9	98	573	487	6497	540	359	615	398	683

Bears of all ages, minimum number of marks present

Date	Marks present	Marks seen	Total seen	Daily L-P	Mean of L-Ps	Sample Variance	Density #/1000km2	95% CI FOR No. of bears lower	95% CI FOR No. of bears upper	95% CI FOR No./1000km2 lower	95% CI FOR No./1000km2 upper
6/3/90	60	11	91	467	467		518				
6/5/90	60	13	113	496	481	422	534	297	666	329	739
6/6/90	59	20	141	405	456	2160	506	340	571	378	634
6/7/90	58	12	111	507	469	2106	520	396	542	439	601

Bears >2.0 only, minimum number of marks present

Date	Marks present	Marks seen	Total seen	Daily L-P	Mean of L-Ps	Sample Variance	Density #/1000km2	95% CI FOR No. of bears lower	95% CI FOR No. of bears upper	95% CI FOR No./1000km2 lower	95% CI FOR No./1000km2 upper
6/3/90	50	8	76	435	435		483				
6/5/90	50	12	89	352	394	3466	437	-135	923	-150	1024
6/6/90	49	17	126	352	380	2319	421	260	499	289	554
6/7/90	48	9	98	484	406	4269	450	302	510	335	566

Table 7. Brown bear population and density estimates in Katmai Natl. Park using the maximum liklihood estimator of White and Garrott (1990). Data on most likely number of marks present when date of weaning was uncertain.

	Ti	Population estimate	95% CI Lower	95% CI Upper	Density (#/1000km2)	95% CI Lower	95% CI Upper
Bears of all ages	62	514	405	627	570	449	696
Independent bears	44	388	292	493	431	324	547
Bears >2.0	52	473	341	568	525	378	630

Table 8. Katmai estimates with variable number of offspring still with marked mothers when date of weaning was uncertain.

	Number of bears			Density (no./1000 km2)			
		95% CI			95% CI		% difference from bes estimate
	Estimate	Lower	Upper	Estimate	Lower	Upper	
Bear-days estimator							
All bears							
Minimum	477	381	630	529	423	699	-3.2
Best	493	394	651	547	437	722	
Maximum	565	452	747	627	502	829	14.6
Bears > 1							
Minimum	411	319	560	456	354	621	-3.7
Best	427	332	583	474	368	647	
Maximum	494	383	674	548	425	748	15.7
Mean Lincoln-Petersen estimator							
All bears							
Minimum	468	395	541	519	438	600	-3.3
Best	484	409	560	537	453	621	
Maximum	554	465	643	615	516	713	14.5
Bears > 1							
Minimum	406	302	510	451	335	566	-3.8
Best	422	314	530	468	348	589	
Maximum	584	456	712	648	506	790	38.4

Table 9. Brown bear composition surveys of Katmai National Preserve, 22-30 May, 1993.

Area	Date	Number minute	Number w/ cu Litter siz 2	3	Number w/ yearli Litter size 2	3	Number w/ 2-yr. olds Litter size 1	2	Number breeding pairs	Number single bea smal	mediu	large	Total bears	Bears/ hour	
Nanuktuk Cr.															
~ 140 mi2	5/22/93	221	0	0	0	0	0	1	3	4	2	0	15	4.1	
	5/27/93	251	0	1	0	0	1	0	4	2	5	2	23	5.5	
	5/29/93	268	0	1	1	0	0	1	5	1	6	0	27	6	
Moraine Cr.															
~150 mi2	5/24/93	107	0	0	0	0	0	0	1	0	1	0	3	1.7	Aborted
	5/27/93	286	0	0	1	1	0	0	0	2	1	1	11	2.3	
	5/30/93	307	2	0	0	1	0	0	0	0	2	2	14	2.7	
Branch															
~56 mi2	5/22/93	101	0	0	0	0	0	0	0	0	0	1	1	0.6	
	5/29/93	78	0	0	0	0	0	0	1	0	1	0	3	2.3	
N of Kukaklek															
~76 mi2	5/24/93	102	0	0	0	1	0	0	0	0	0	0	4	2.4	
	5/30/93	93	0	0	0	0	0	0	1	0	0	0	2	1.3	
Total		1,812	2	2	2	3	1	2	15	9	18	6	103	3.4	

Table 10. Survival rates of radio-marked brown bears at Katmai Alaska , 1989-94 calculated using modified Kaplan-Meir procedures.

Females >2 Natural mortality only, 1989-94

DATES	NO. @ RISK	NO. @ DEATHS	SURVIVAL RATE	NO. CENSORED	NO. ADDED	LOWER CI	UPPER CI	VAR(SURV)
5/1-5/15	123	2	0.984	0	0	0.96	1.01	0.0001
5/16-5/23	121	0	0.984	0	30	0.96	1.01	0.0001
5/24-5/31	151	2	0.971	1	22	0.94	1.00	0.0002
6/1-6/7	170	0	0.971	2	13	0.95	1.00	0.0002
6/8-6/15	181	1	0.965	1	1	0.94	0.99	0.0002
6/16-6/23	180	0	0.965	1	0	0.94	0.99	0.0002
6/24-6/30	179	1	0.960	1	0	0.93	0.99	0.0002
7/1-7/31	177	3	0.944	4	1	0.91	0.98	0.0003
8/1-8/31	171	2	0.933	5	0	0.90	0.97	0.0003
9/1-9/30	164	0	0.933	9	0	0.90	0.97	0.0004
10/1-10/31	155	0	0.933	5	0	0.89	0.97	0.0004
11/1-4/30	150	2	0.920	0	0	0.88	0.96	0.0005
Total		10						

Cumulative cub survival at Katmai, Alaska, 1989-94.

DATES	NO. @ RISK	NO. @ DEATHS	SURVIVAL RATE	NO. CENSORED	NO. ADDED	LOWER CI	UPPER CI	VAR(SURV)
5/1-5/15	37	7	0.811	0	4	0.70	0.92	0.0034
5/16-5/23	34	1	0.787	0	11	0.66	0.91	0.0039
5/24-5/31	44	3	0.733	0	17	0.62	0.85	0.0033
6/1-6/7	58	1	0.721	0	1	0.62	0.82	0.0025
6/8-6/15	58	4	0.671	0	1	0.57	0.77	0.0026
6/16-6/23	55	0	0.671	1	2	0.57	0.77	0.0027
6/24-6/30	56	2	0.647	2	0	0.55	0.75	0.0026
7/1-7/31	52	7	0.560	0	0	0.46	0.66	0.0027
8/1-8/31	45	7	0.473	0	0	0.37	0.57	0.0026
9/1-9/30	38	5	0.411	0	0	0.31	0.51	0.0026
10/1-10/31	33	2	0.386	3	1	0.28	0.49	0.0028
11/1-4/30	29	6	0.306	0	0	0.21	0.40	0.0022

Cumulative yearling survival at Katmai, Alaska, 1989-94.

DATES	NO. @ RISK	NO. @ DEATHS	SURVIVAL RATE	NO. CENSORED	NO. ADDED	LOWER CI	UPPER CI	VAR(SURV)
5/1-5/15	15	0	1.000	0	0	1.00	1.00	0.0000
5/16-5/23	15	0	1.000	0	10	1.00	1.00	0.0000
5/24-5/31	25	0	1.000	0	0	1.00	1.00	0.0000
6/1-6/7	25	0	1.000	0	12	1.00	1.00	0.0000
6/8-6/15	37	0	1.000	0	2	1.00	1.00	0.0000
6/16-6/23	39	1	0.974	0	0	0.93	1.02	0.0006
6/24-6/30	38	0	0.974	0	0	0.92	1.02	0.0006
7/1-7/31	38	1	0.949	0	0	0.88	1.02	0.0012
8/1-8/31	37	4	0.846	1	0	0.74	0.95	0.0030
9/1-9/30	32	1	0.820	1	0	0.70	0.94	0.0038
10/1-10/	30	1	0.792	0	0	0.66	0.92	0.0043
11/1-4/30	29	0	0.792	0	0	0.66	0.92	0.0045

Table 10. Con't.

Cumulative adult male (>2) survival at Katmai, Alaska, 1989-94.

DATES	NO. @ RISK	NO. @ DEATHS	SURVIVAL RATE	NO. CENSORED	NO. ADDED	LOWER CI	UPPER CI	VAR(SURV)
5/1-5/15	9	0	1.000	0	0	1.00	1.00	0.0000
5/16-5/23	9	0	1.000	1	22	1.00	1.00	0.0000
5/24-5/31	30	0	1.000	6	2	1.00	1.00	0.0000
6/1-6/7	26	1	0.962	3	3	0.89	1.03	0.0014
6/8-6/15	25	0	0.962	2	0	0.89	1.04	0.0014
6/16-6/23	23	0	0.962	0	0	0.88	1.04	0.0015
6/24-6/30	23	0	0.962	1	0	0.88	1.04	0.0015
7/1-7/31	22	0	0.962	2	0	0.88	1.04	0.0016
8/1-8/31	20	0	0.962	0	0	0.88	1.04	0.0018
9/1-9/30	19	0	0.962	5	0	0.88	1.05	0.0019
10/1-10/	14	0	0.962	5	0	0.86	1.06	0.0025
11/1-4/30	9	0	0.962	0	0	0.84	1.08	0.0040

Table 11. Number of radiolocations and status of brown bears marked on the Katmai coast, Alaska, 1989-93.

ID	Sex	Year of birth	Initial capture date	Radio type**	Year 1989	1990	1991	1992	1993	Total	Status
101	M	1984	5/31/89	CS	29					29	Collar dropped off
102	M	1981	5/31/89	NONE	1					1	Unknown. no radio
103	M	1985	5/31/89	CS	1					1	Collar shed immediately
104	F	1975	5/31/89	REG	30	21	13	18	16	98	Alive
105	M	1969	5/31/89	NONE	3					3	Unknown, no radio
106	F	1983	6/04/89	REG	17	16	9	16	15	73	Alive
107	M	1976	6/04/89	NONE	1					1	Unknown, no radio
108	F	1984	6/04/89	REG	16	17	10	6		49	Dead, possible capture related
109	M	1982	6/04/89	CS	1					1	Radio malfunction
110	M	1982	6/04/89	CS	26					26	Collar dropped off
111	F	1979	6/05/89	REG	31	20	10	10	15	86	Alive
112	F	1977	6/05/89	REG	3					3	Collar shed
113	F	1970	6/05/89	REG	17	21	12	18	6	74	Dead, natural mortality
114	F	1980	6/05/89	REG	32	20	9			61	Radio malfunction
115	F	1985	6/05/89	REG	10					10	Collar shed
116	M	1985	6/05/89	CS	23					23	Collar dropped off
117	F	1983	6/05/89	REG	31	23	12	11		77	Dead, natural mortality
118	F	1977	6/05/89	REG	30	21	8			59	Collar shed
119	M	1979	6/05/89	NONE	1					1	Unknown, no radio
120	F	1981	6/05/89	REG	28	22	11	17	14	92	Alive
121	M	1986*	6/05/89	CS	31	14				45	Collar dropped off
122	M	1986	6/05/89	CS	15					15	Radio malfunction
123	F	1978	6/05/89	REG	28	10				38	Natural mortality
124	F	1981*	6/05/89		1					1	Killed by bear at capture site
125	M	1970	6/06/89	NONE	1					1	Unknown, no radio
126	F	1984	6/06/89	REG	27	19	11	18	13	88	Alive
127	F	1985	6/06/89	REG	14	15	12	15	17	73	Alive
128	F	1973	6/06/89	REG	26	20	12	17	14	89	Alive
129	F	1974	6/06/89	REG	28	12				40	Radio malfunction
130	F	1978	6/06/89	REG	26	18	4	12	15	75	Alive
131	F	1973	6/06/89	CS	10					10	Collar dropped off
132	F	1979	6/06/89	REG	25	18				43	Collar shed
133	F	1981	6/06/89	REG	26	13				39	Radio malfunction
134	F	1985	6/06/89	CS	29	15				44	Collar dropped off
135	F	1981	6/06/89	CS	15	17	14	17	18	81	Alive
136	F	1981	6/13/89	REG	27	19	13	16	3	78	Dead, natural mortality
137	M	1974	5/19/90	GO		1				1	Unknown, radio shed immediately
138	M	1978	5/19/90	GO		2				2	Unknown, radio shed within a week
139	M	1984	5/19/90	GO		7				7	Radio dropped
140	M	1982	5/19/90	CS		10	12			22	Collar removed
141	M	1975	5/19/90	GO		1				1	Unknown, radio shed within a week
142	M	1976	5/19/90	GO		1				1	Unknown, radio shed within a week
143	F	1974	5/19/90	REG		16	13			29	Natural mortality

Table 11. Cont.

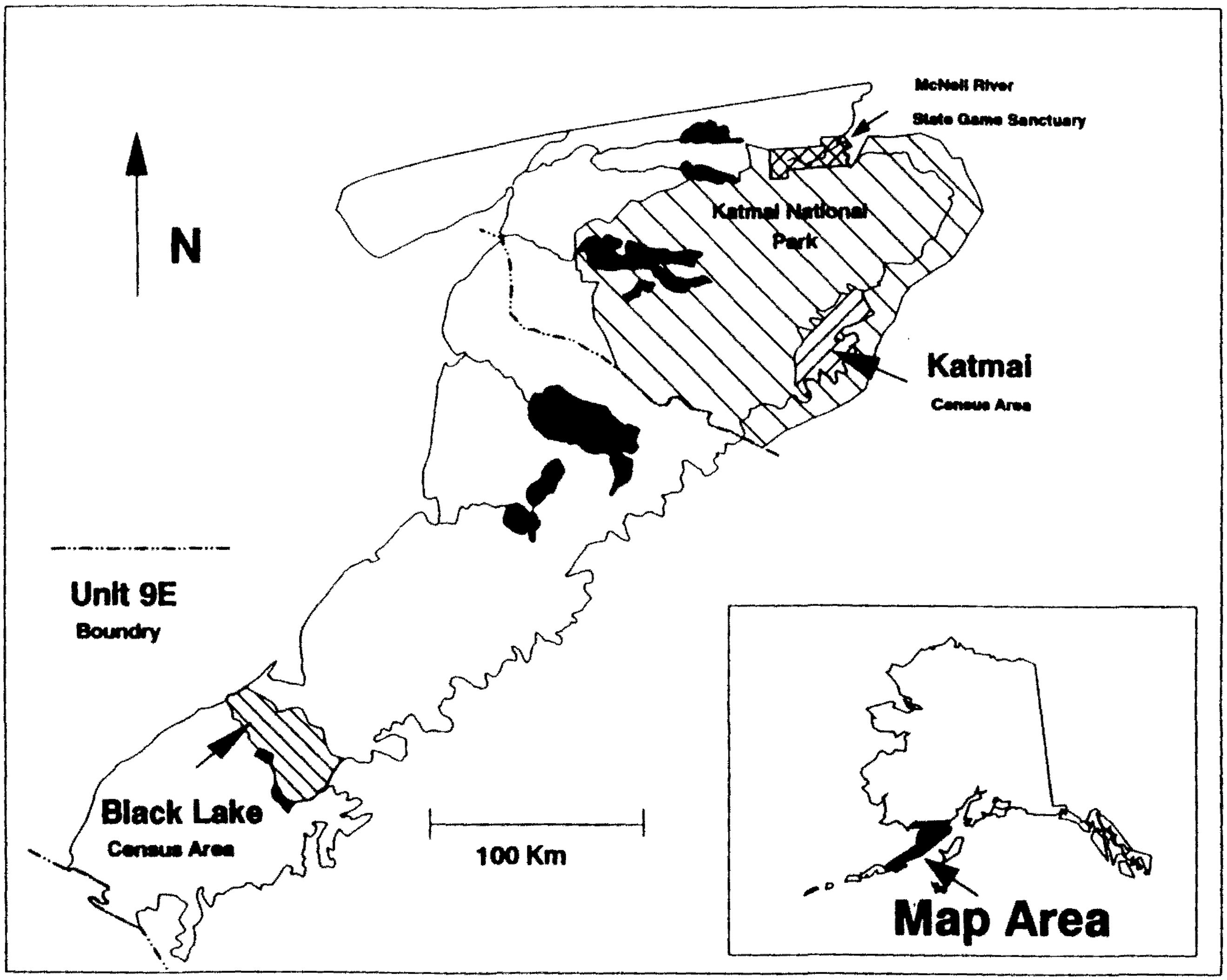
ID	Sex	Year of birth	Initial capture date	Radio type**	Year 1989	1990	1991	1992	1993	Total	Status
144	M	1987	5/19/90	CS		14	12			26	Collar removed
145	F	1979	5/19/90	REG		16	10	13	17	56	Alive
146	M	1974	5/19/90	GO		5				5	Radio dropped
147	M	1980	5/20/90	CS		9				9	Collar dropped
148	F	1984	5/20/90	CS		13	17			30	Capture mortality
149	M	1978	5/20/90	GO		1				1	Unknown, radio shed within a week
150	M	1980	5/20/90	GO		1	1			2	Radio shed within a week, hunter-kill
151	F	1986	5/20/90	GO		14	7			21	Collar dropped
152	M	1971	5/20/90	GO		2				2	Natural mortality
153	M	1980	5/20/90	GO		1				1	Unknown, radio shed within a week
154	F	1979	5/20/90	REG		13	12	16	13	54	Alive
155	M	1987	5/20/90	CS		15	5			20	Collar dropped
156	M	1967	5/20/90	GO		1				1	Unknown, radio shed within a week
157	M	1983	5/20/90	CS		8				8	Collar dropped
158	M	1985	5/20/90	CS		16	10			26	Collar dropped
159	F	1982	5/20/90	REG		14	7			21	Natural mortality
160	F	1975	5/20/90	REG		3				3	Natural mortality
161	F	1982	5/21/90	REG		4				4	Collar shed
162	M	1985	5/21/90	CS		17	10			27	Collar dropped
163	F	1998	5/21/90	CS		13	13	17	14	57	Alive
164	F	1986	5/21/90	CS		4				4	Radio malfunction
165	M	1982	5/21/90	GO		3				3	Unknown, radio shed within a week
167	M	1988	5/21/90	GO		1				1	Killed by bear at capture site
168	F	1985	5/21/90	CS		18	13			31	Collar dropped
169	F	1976	5/21/90	REG		12	9			21	Unknown, radio malfunction
170	M	1983	5/21/90	GO		1				1	Unknown, radio shed within a week
171	F	1968	5/21/90	REG		6				6	Collar shed
172	F	1978	5/21/90	REG		14	10	18	14	56	Alive
173	F	1980	5/21/90	REG		16	10			26	Unknown, radio malfunction
174	F	1976	5/21/90	REG		10	10	11	10	41	Alive
175	M	1981	5/21/90	GO		1				1	Unknown, radio shed within a week
176	M	1980	5/22/90	CS		3				3	Unknown, radio shed within a week
177	F	1985	5/22/90	CS		8				8	Radio malfunction
178	F	1973	6/12/90	REG		13	9			22	Radio malfunction
179	F	1982	6/4/92	Reg				11	18	29	Natural mortality, 6/2/94
180	M	1988	6/4/92					1		1	No radio
181	F	1984	6/4/92	Reg				6		6	Collar shed
182	F	1971	6/4/92	Reg				6		6	Natural mortality
183	F	1979	6/4/92	Reg				12	15	27	Alive
184	M	1983	6/4/92					1		1	No radio
185	F	1979	6/5/92	Reg				11	15	26	Alive
186	F	1981	6/6/92	Reg				12	16	28	Collar shed

Table 11. Cont.

ID	Sex	Year of birth	Initial capture date	Radio type**	1989	1990	1991	1992	1993	Total	Status
187	F	1982	6/6/92	Reg				12	16	28	Killed by another bear 5/1/94
188	F	1973	6/6/92	Reg				12	18	30	Alive
189	M		6/6/92	Reg				2		2	Collar shed
190	F	1978	6/6/92	Reg				7	13	20	Alive
191	F	1977	6/6/92	Reg				11	13	24	Alive
192	F	1975	6/6/92	Reg				6		6	Natural mortality
193A	F	1975	6/6/92	Reg				13	16	29	Alive
193B	F	1984	6/6/92	Reg				4		4	Collar shed
301	F	1987	5/17/93	Reg					17	17	Alive
302	M	1991	5/17/93	Expand					11	11	Collar shed
303	M	1991	5/17/93						1	1	Killed by bear at capture
304	M	1991	5/17/93	Expand					10	10	Collar shed
305	F	1991	5/17/93	Expand					10	10	Collar shed
306	M	1991	5/17/93	Expand					14	14	Alive, still with mom
307	F	1991	5/17/93	Expand					14	14	Alive, alone
308	M	1991	5/17/93	Expand					9	9	Collar shed
309	F	1991	5/17/93	Expand					9	9	Collar shed
310	F	1974	5/17/93	Reg					13	13	Alive
311	F	1990	5/17/93	Expand					13	13	Alive, alone
312	M	1990	5/17/93	Expand					13	13	Alive, alone
313	F	1988	5/18/93	Reg					12	12	Alive
314	F	1989	5/18/93	Expand					11	11	Collar shed
315	M	1989	5/18/93	Expand					14	14	Alive, alone
316	F	1989	5/18/93	Expand					10	10	Collar shed
317	F	1981	5/18/93	Reg					14	14	Natural mortality
318	M	1988	5/18/93						1	1	No radio
319	F	1983	5/18/93	Reg					13	13	Alive
320	F	1975	5/19/93	Reg					12	12	Alive
321	F	1989	5/19/93	Reg					11	11	Alive
322	F	1972	5/19/93	Reg					12	12	Alive
323	M	1991	5/19/93	Expand					9	9	Collar shed
324	M	1991	5/19/93	Expand					8	8	Collar shed
325	F	1968	5/19/93	Reg					13	13	Alive
326	M	1991	5/19/93	Expand					9	9	Collar shed
327	F	1991	5/19/93	Expand					12	12	Alive, still with mom
328	F	1991	5/19/93	Expand					11	11	Alive, alone
329	M	1991	5/19/93	Expand					2	2	Natural mortality
Totals					660	699	350	393	662	1055	

* Age estimated
** REG = regular, CS = canvas spacer, GO = glue on

Brown bear study area on the coast of Katmai National Park



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Alaska Department of Fish and Game
National Park Service