BROWN BEAR DENSITY ON THE ALASKA PENINSULA AT BLACK LAKE, ALASKA.

A final report on completion of the density estimation objective and progress report on other objectives of cooperative interagency brown bear studies on the Alaska Peninsula supported by:

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Abstract: Brown bear (<u>Ursus</u> <u>arctos</u>) density was estimated in a 469.31 mi^2 portion of the Alaska Peninsula near Chignik. The study area was a representative cross section of all habitats available to bears in an area considered to be receiving moderate hunting pressure. Six replicate searches were accomplished during 28 May-6 June, 1989. Using a bear days estimator described by Miller et al. (1987), estimated density for all bears was 2.03 mi^2/bear with a 95% CI of 1.77-2.30 mi^2/bear. Estimated density for independent bears (excluding offspring with their mothers) was 3.21 mi^2/bear (95% CI=2.68-3.75). Estimated density for bears older than 2.0 years in estimated age was 2.72 mi^2/bear (95% CI = 2.32-3.14). For data of this type, Eberhardt (in press) recommended using the mean of Lincoln-Petersen estimates obtained during each replicate and confidence intervals based on the variance of this mean. With this approach, the density estimate for all bears was 2.08 mi^2/bear (95% CI = 1.61-2.51), for independent bears the estimate was 3.33 mi^2/bear (95% CI = 2.64-3.90), and for bears older than 2.0 years in age the estimate was 2.85 mi^2/bear (95% CI = 2.21-3.45). Estimated density based on mean number of groups multiplied by mean group size was 2.25 mi^2/bear (95% CI = 1.90-2.74).

In this study the sample sizes were large (estimated total population was 239 bears and estimated number of independent bears was 149), sightability was high (43.2% for independent bears), and proportion of the estimated population of independent bears marked averaged 28%. Because of the large sample, the bias correction factor proposed by Eberhardt (in press) resulted in no change from the original estimates.

As speculated elsewhere (Miller et al. 1987, Miller and Ballard 1982), at Black Lake females accompanied by newborn cubs were thought to have lower sightability than other segments of the population. Under the circumstances existing during this study, this bias would most likely result in an underestimation of bear density. We estimated, based on number of females with litters of yearlings, that this bias might have caused an underestimation of approximately 4% in number of independent bears. Evidence from stream surveys suggests that the actual bias might be smaller than this so no effort was made to correct the density estimate for potential bias based on low sightability of females with newborn cubs.

Bear density varied markedly between different quadrats in the search area. An estimate of the density of bears in each quadrat during spring was independently obtained using the estimated total number bears present and data for each quadrat on search effort expended per bear seen. Based on this we estimated that a quarter of the search area had an overall density of 1 mi^2/bear and a quarter of the area had a density less than 5 mi^2/bear.

Preliminary estimates of population composition were made using bears captured during 1988 and 1989. We compared

this composition with that estimated from captures in this area during the early 1970's. At that time the population was thought to be declining because of heavy hunting. For both sexes, the current population is older. Also, the current adult population has a higher proportion of males (39 males:100 females).

Marked bears had high mortality rates in both 1988 and 1989. Using modified Kaplan-Meier procedures, survivorship for newborn cubs with radio-marked females was 0.60 (95% CI = 0.30-0.90). Survivorship from natural mortality for bears $\geq$ 3 was 0.90 for females (95% CI = 0.83-0.98); radio marked males had no natural mortalities. Overall survivorship from all hunting and natural mortality causes for both sexes $\geq$ 3 was 0.86 (95% CI = 0.77-0.94). These survivorship rates are preliminary and will be refined with additional data.

Proportion of marked bears removed by hunters was estimated. This "exploitation rate" was estimated at 7.7% for the whole population in 1989. Based on a population estimate obtained by extrapolation from the density estimate, the exploitation rate in the harvest counting areas that include the Black Lake study area was estimated as 6.4-7.1% in 1989. Current exploitation rate for bears $\geq$ 2 was estimated as 11.4%. This is in the middle of the range reported for different years in the 1970's (8.5-17.1% for bears $\geq$ 2).

Stream surveys conducted in 1989 indicated the population remains at high density with high productivity of cubs. A comparison of historical stream survey results with harvests and suspected population trends suggests that appropriately conducted stream surveys may reflect population trend. Information on salmon escapement was compiled and indicated that escapement approximately doubled between 1954-62 and 1963-70. A relationship was noted between years of high and low salmon escapement and percent of the population composed of newborns the following year. No relationship between escapement and litter size was observed.

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BACKGROUND AND OBJECTIVES

Effective bear management depends on good information on bear population status, trends, and harvests. On the Alaska Peninsula, as elsewhere, accurate information on population size and trend is seldom available because of the expense and technical difficulties in obtaining it. The Alaska Peninsula supports important brown bear population which are subject to intensive harvest pressure (Sellers and McNay 1984). During the late 1980's, there have been increasing pressures to liberalize bear seasons in this area (Game Management Unit 9). It is desirable to determine population size, sustainable harvest levels, and the effects of past and current harvest levels on the numbers and composition of the Alaska Peninsula bear population in order to evaluate existing management strategies and to formulate new strategies.

Development on the Alaska Peninsula is increasing with proposals for oil and gas development, increased commercial fishing, recreational facility development, and increased settlement and human presence in formerly remote areas. Similar developments have contributed to the reduction of grizzly bears to remnant levels in the lower 48 states (Servheen 1989). This study is designed to provide baseline information on population status that is essential to document population trends resulting from adverse impacts of development.

The importance of such baseline information was demonstrated by the oil spill from the Exxon Valdez in March 1989. The absence of baseline information on population density, movements, and reproductive rates will make it difficult to fully evaluate the impacts of this oil spill. However, the information obtained in this study can be used as surrogate baseline information by which to measure probable changes in the bear populations in areas affected by the spill. Such comparisons are ongoing in companion studies in Katmai National Park.

Because data on bear populations are expensive to obtain, pooling of resources from several agencies will be more effective than several simultaneous, poorly funded studies. The Black Lake study area is the first of several potential study areas on the Alaska Peninsula where cooperative interagency brown bear studies, similar to this study, would be worthwhile and may be conducted.

Objectives established for brown bear research at Black Lake established in the research proposal dated Feb. 19, 1988 included:

1. Estimate spring density of brown bears in a 500 square mile study area in the Black Lake vicinity (Job 1 and 2.1);
2. Estimate sex and age composition of brown bear inhabiting the study area;

3. Estimate productivity of Black Lake bears including: litter size, age at first reproduction, breeding interval, and offspring mortality rates;
4. Estimate mortality rates with special emphasis on mortality resulting from exploitation by hunters. When possible, determine causes of natural mortalities of post-weaning age classes;
5. Compare and evaluate changes in density, population composition, reproductive rates, recruitment rates, and mortality rates that have occurred in the study area since the early 1970s;
6. Document the timing and intensity of use by bears of habitats of special importance such as denning areas, salmon fishing areas, berry and vegetation foraging areas, ungulate calving areas, and others that may become evident through monitoring. Determine if different subpopulations of bears use these areas;
7. Evaluate the efficacy of aerial stream surveys in estimating trends in bear population numbers and composition; and
8. Estimate bear numbers (with probable upper and lower bounds) for GMU subunits 9E and 9D, by extrapolating from the study density estimate.

These objectives will be accomplished in 6 jobs identified as follows:

Job 1. Density estimate,
Job 2. Monitoring for density estimates, reproductive status and movements,
Job 3. Stream surveys and evaluation,
Job 4. Monitor and analyze harvests,
Job 5. Recompilation of data from past studies, and
Job 6. Data analysis and report writing.

STUDY AREA AND METHODS

Bears were captured and marked during 21-24 May 1989 following procedures outlined by Miller and Sellers (1988). Bears were captured in the order they were spotted by a fixed-wing aircraft. During the first days of the capture operation, 4 previously radio-marked bears were still in dens, 2 of these were subsequently determined to have litters of newborn cubs. All bears captured in 1989 were in the density estimation area, herein termed the "census" area (Fig. 1). During spring 1988, all bears were also within the census area except for bear nos. 49-52 that were on the West Fork of the Chignik River.

The census area represented a cross section of habitat across the Alaska Peninsula from the Pacific coast to the Bristol Bay coast (Fig.1). This area was wedge-shaped and the borders were drawn to benefit from natural barriers to movement. The total circumference of the study area was approximately 165.3 km. Of this circumference, large bodies of water represented 32% (Chignik Lagoon [20.5 km], Bristol Bay [9.8 km], Black Lake [10.6 km] and Chignik Lake [11.6 km]). The Chignik River (18.8 km) represented 11%, and high mountain ridges represented 14% (23.3 km). Except for the relatively minor barrier represented by the Chignik River these were very effective barriers to movement. The remaining 43% of the periphery (70.7 km) represented no barrier to bear movements but almost all of this was on the Bristol Bay flatlands where there were few bears to challenge our boundaries. The study area encompassed a 2-dimensional area of 469.31 mi^2. This area was broken up into 11 quadrats (Fig. 2). Following procedures described by Miller et al. (1987), each quadrat was searched during each replicate by 1 of 4 search planes. We determined which radio-marked bears were present within the total search area during each survey. No effort was made to determine in which quadrat marked bears occurred. Six replicate searches were accomplished during the period 28 May-4 June. Replicates 3 and 4 were both accomplished on 31 May. The western portion of replicate 5 was accomplished on 1 June and the eastern portion on 3 June because of weather conditions. All other replicates were accomplished on 1 day. Weather conditions precluded complete searches of portions of some quadrats on some days; areas missed were the higher elevations where clouds were sometimes present or where wind conditions precluded safe flying. Radio-marked bears seen during these searches were classified as "recaptures" of marked animals, bears seen that were not radio-marked were classified as captures of unmarked animals. Following procedures utilized by investigators applying this technique in other areas of high bear density (Barnes et al. 1988, Schoen 1988), unmarked bears seen during searches were not captured and marked.

Search planes were instructed to search at an intensity of approximately 2 minutes/mi^2 on the Bristol Bay flats where bears are highly visible (quadrats 1-3) and at approximately 3 minutes/mi^2 in the more mountainous terrain (quadrats 4-11). We estimated that these different search intensities would make the probability of seeing any individual bear more nearly equal between these different habitats and, considering the 3-dimensional nature of the mountainous terrain, made actual search intensity more nearly equal between quadrats.

In calculating estimates of total population size, offspring accompanying their mothers were classified as marked or unmarked depending on whether their mother was marked or unmarked. This procedure violates the basic assumption that observations are independent. Simulation studies have indicated that violation of this assumption results in a slight tendency to overestimate population size and in an underestimation of variance associated with the estimate (Miller in press). The degree to which the variance is underestimated is directly related to the degree to which the independence assumption is violated. In order to avoid this bias, an additional estimate was calculated for "independent" bears (Barnes et al. 1988). This estimate excluded dependent offspring of whatever age. In order to provide a comparison with densities in other areas where bears may separate from their mothers at different ages, a third density estimate was calculated for that segment of the population 2 years old or older. This eliminates the dependence problem with cubs and yearlings but has more dependence problems than the estimate of independent bears since some 2- and 3-year olds are still with their mothers.

These data were analyzed using the bear-days estimator described by Miller et al. (1987) and using the mean of Lincoln-Petersen estimates from each replicate as recommended by Eberhardt (in press). The sample estimate of variance for this estimate described by Eberhardt(in press) was:

$$s^2 = \frac{\text{summation}(N_i - \text{Nbar})^2}{(k-1)}$$

where k is the number of replicate estimates available, and Nbar is the mean of the estimates from each replication. The confidence interval for this estimate described by Eberhardt (in press) is:

$$+/- \frac{(s)*(t)}{(k)^{1/2}}$$

where (t) has (k-1) degrees of freedom and is read from a table of t statistics for the alpha level desired (95% and 80% CIs are reported here).

Eberhardt (in press, equation 13) also proposed a bias correction factor designed to correct for bias that results from low sample size and low number of resighted marks. This correction factor was applied to the data collected in this study.

Sightability was calculated as the proportion of bears present that were seen. Proportion of the population marked was calculated as mean of the daily values based on the number of marks present divided by the Lincoln-Petersen estimate for that day.

In addition to these estimates, we estimated the number of groups of bears present and multiplied this estimate by mean group size to obtain population estimates. These procedures are more thoroughly described in the text.

Survivorship for radio-marked bears was estimated for 1988 and 1989 using modified Kaplan-Meier procedures (Pollock et al. 1989). Time of death was assigned as the midpoint between the last radio-location flight when the animal was verified alive and the first flight when it was verified as dead. In a few cases this period was more than several months, and in these cases the animal probably died or should have been censored earlier than calculated. For estimating the impacts of one source of mortality, such as hunting, mortalities from other causes were treated as censored observations following the procedures recommended by Pollock et al. (1989). For COY and yearling offspring (none of which were radio-marked), mortality was assumed when they disappeared from litters of radio-marked females unless subsequently they were verified to have survived, in which case they were censored. For unmarked offspring aged 2 years or older, disappearance from litters was assumed to represent weaning rather than mortality, and these animals were censored at the time of separation. Capture related mortalities were not included. Observations were made up until the time of den entrance in 1989.

For survivorship estimation, the year was broken up into 48 "weeks", 4 per month. The first day of each week was on the 1st, 8th, 16th and 24th of each month. This resulted in the last "week" of the month having a variable number of days.

The slight differences between density results reported here and in a preliminary report on this work resulted from 1 bear (#43) that was originally classified as present but never seen. This bear was later determined to have shed it collar near it den site so it was reclassified was unavailable to be recaptured as a marked bear. Differences in ages reported here and in this earlier report represent differences between ages estimated in the field and cementum ages subsequently estimated by G. Mattson.

RESULTS AND DISCUSSION

Captures

Fifty-nine bears were captured in 1988 (38 females and 21 males). Prior to the density estimate in 1989, 40 bears were captured (19 females and 21 males); 4 males and 3 females were recaptures of bears first captured in 1988. An additional 6 radio-marked bears (Nos. 11, 23, 37, 40, 46, and 48) were seen during the 1989 capture operation but not recaptured. One female (no. 90, age 19) captured in 1989 was originally marked in 1970 and recaptured in 1974. Records of all bears captured during this study are presented in Table 1. One capture mortality occurred in 1989 when a partially drugged 2.5 year old male (No. 62) fell off a cliff. This bear was in bear 51's litter along with 2 siblings. In 1989, transmitters were placed on 39 animals: 12 standard collars, 7 collars with canvas spacers designed to rot through within 2 years, 4 collars with surgical rubber spacers designed to drop off within 1 year, and 14 small glue-on transmitters designed to drop off during summer molt (Table 1). Unfortunately only one of the glue-on transmitters remained on a bear more than 2 weeks, many were scraped off within 1 or 2 days.

At the time the density estimation began there were 38 radio-collared females in the Black Lake area; 33 of these were present at least once in the density estimation area during the density estimation phase. These were bear nos. 1, 11, 12, 13, 16, 17, 18, 23, 26, 30, 34, 37, 38, 40, 46, 51, 53, 55, 57, 58, 59, 60, 65, 67, 69, 70, 76, 77, 82, 87, 88, 90, and 92 (Table 2). These 33 females had 15 litters with a total of 30 offspring: 2 litters and 4 offspring were COY, 12 offspring in 5 litters were yearlings, and 14 offspring in 8 litters were aged 2 or greater. The 5 radio-marked females that never entered the census area during the census period (nos. 8, 50, 52, 75, and 80) had no offspring (Table 2). There were 11 radio-marked males in the Black Lake area in spring 1989 (nos. 31, 48, 49, 66, 71, 78, 81, 83, 88, 86, and 91), all were present at least once in the density estimation area (Table 2). Based on these, the total number of marked bears available for capture based on presence at least once in the density estimation area was 44 plus 30 offspring in litters with radio-marked females.

Population and Density Estimation

The results for each replicate flight are presented in Table 2. A high level of natural closure (88.7%) occurred in this study area because of natural barriers to movements (Table 2). Sightability of bears was high, marked bears were seen on 43% of the occasions they were present. Sightability of marked bears varied from 29% during replication 1 to 58% during replication 2 (Table 3). The proportion of the daily estimated population marked averaged 28%. Data on observations of marked and unmarked bears seen during each replicate are summarized in Table 3.

Minimum Population 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 averaged 137.2 bears (range = 123-161) (Table 3). A density estimate based on the largest value for the minimum number of bears known to be present (161) was 2.9 mi^2/bear. This was the number of bears known to be present during replication 4 (Table 3).

Capture-Recapture Estimates

Capture-recapture estimates were calculated in three ways. The first way was the "bear-days" estimator described by Miller et al. (1987). The second was the mean of the daily Lincoln-Petersen estimates and confidence intervals based on the sampling variance of this mean as described by Eberhardt (in press). The third estimate used Lincoln-Petersen procedures to estimate number of groups and this was multiplied by mean group size to derive the total population estimate. This last estimator was based on suggestions made to V. Barnes (USFWS-Kodiak) by T. Drummer (Michigan Technological Univ., Houghton, Michigan).

Bear-Days Estimates, All Bears. Using the bear-days estimator the mean number of bears present on the study area during the search period was 231.1. The calculated 95% CI around this estimate based on the normal approximation to the binomial was 203.9 to 265.6 bears or -11.8% to +14.9% of the estimate. The corresponding density estimate was 2.0 mi^2/bear (95% CI = 1.77-2.30). Because of violation of the independent observation assumption, the true 95% CI would be larger than this calculated interval (Miller in press). The number of independent bears was estimated to be 146.4 (95% CI = 125.2-175.1) (Table 4). Estimates for all bears and for independent bears based on the bear-days estimator are provided in Table 4 and illustrated in Figs. 3 and 4. The bear-days estimator is equivalent to using the means of each of the 3 Lincoln-Petersen parameters (number of marks present, number of marks seen, and total number of bears seen) and this estimator was well-behaved in simulation studies (Eberhardt in press).

Mean Lincoln-Petersen Estimates, All Bears. The population estimate for all bears based on the mean of Lincoln-Petersen estimates obtained for each replicate was 239.0, 3.3% higher than the bear-days estimate. The 95% CI for the mean Lincoln-Petersen estimate based on the sampling variance was +/- 51.7 bears or +/-21.6% of the point estimate (Table 5). The lower limit for this estimate was 190.7 bears; this value is larger than the minimum number of bears known to have been present on one day during the search period (161 bears), so the lower limit was not truncated at this minimum value. The range of this CI encompassed 103 bears compared to 61.7 bears encompassed by the range of the 95% CI based on the bear-days estimate and the binomial approximation to the normal. The population estimate for independent bears based on the mean of Lincoln-Petersen estimates was 149 bears with a 95% CI of +/-28.6 bears (Table 5). Changes in the estimates based on the mean of Lincoln-Petersen estimates that occurred during the course of the study period are presented in Table 5 and illustrated in Figs. 5 and 6. The confidence interval for this estimate was very broad until replication 4 (Figs. 5 and 6). This supports the suggestion by Eberhardt (in press) that at least 3 replications are necessary.

Estimates for Bears > 2.0. Population estimates for the population of bears aged 2.0 and older are presented in Table 4 using the bear-days estimator and in Table 5 using Eberhardt's approach. As expected, this estimate (174 bears) was intermediate between that for the whole population (239) and that for the population of independent bears (149) for the bear-days estimate (Table 4).

Each of these 3 estimates for differing portions of the population has a distinct utility. The estimate of the number of independent bears (excluding dependent young) is the most valid in a statistical sense since the problem of dependent observations is reduced. For comparisons of trend within an area, this estimate has fewer problems. For many management purposes, however, the other estimates-even with their larger statistical flaws-may be more useful. Estimates of total population or population older than 2.0 may be more useful in comparisons of density between areas when age at independence is different in each area. Extrapolation of the estimate of bears older than 2.0 to obtain a population estimate of bears that can legally be hunted is desirable in some cases. The total population estimate may be most useful in cases where exploitation rate is expressed as a function of total population.

Estimates Based on Mean Group Size. One potentially useful way to limit bias from non-independent observations of animals in groups is to estimate number of groups and multiply this by mean group size.

Number of groups and mean group size for bears in the Black Lake study area are presented in Table 6. For analyses based on mean group size, we defined a group as a female with dependent offspring, a breeding aggregation of 2 or more bears, or a group of 2 or more recently separated siblings. A group was "marked" if any individual in the group was radio-marked. Following Drummer (pers. comun.), we defined the following terms:

n_{1i} = number of marked groups present in the area at the start of the *i*th survey ($i = 1, 2, \ldots 6$).

n_{2i} = total number of groups captured in the *i*th survey.

m_i = total number of marked groups captured in the *i*th survey.

T_i = total number of individuals captured in the *i*th survey.

$\bar{G}_i$ = average group size in the *i*th survey: = T_i/n_{2i}.

$\hat{N}_{Gi}$ = estimated number of groups present in the study area for the ith survey, as calculated with the usual Lincoln-Petersen estimator:

$$NG_i = \frac{(n_{1i}+1)(n_{2i}+1)}{(m_i+1)} - 1$$

$\hat{N}_{1i}$ = estimated total number of individual present in the study area at the time of the *i*th survey:

$$(\hat{N}_{Gi})(\bar{G}_i).$$

The final estimate was the mean of all $\hat{N}_{1i}$. The variance was calculated as the sampling variance of this mean (Eberhardt in press.).

In addition to the above procedures suggested by Drummer, we also estimated the number of groups present but not seen. For groups of females with offspring we assumed that group size was unchanged regardless of whether that group was seen. This is not so reasonable an assumption for other bears, termed potential "single" bears. During one replication a marked "single" bear could be seen in a breeding pair with another bear and treated as a capture of a marked group of 2. If this bear was not seen during the next replicate flight, its group size would be unknown. Treating such unseen marked bears as groups of 1 would inflate estimates of number of groups present. For "single" bears we calculated the number of marked groups present, but not seen, as:

$$x_i/b \quad \text{where}$$

x_i = number of marked individuals present but not seen on the *i*th survey, and

b = mean group size for marked "singles" (excludes females with offspring) that were seen during all replications (1.45 for this study).

As a result of these calculations, the value for (n_{1i}) was not an integer. This value included an estimated group size, but the variance associated with this estimate was not incorporated into the variance of $\hat{N}_{Gi}$. As a result the calculated variance underrepresents the true variance.

The estimated total number of groups was 110.24 (Table 7). For each replicate, the estimated number of groups multiplied by the mean group size observed for each replicate (Table 7), resulted in daily population estimates presented in Table 7. The mean of the 6 daily population estimates obtained in this way was 209.2 bears with a 95% CI based on the sampling variance of ± 38 bears (Table 7). We obtained a slightly higher estimate (222.3 bears) by adding an estimate based on mean group size for groups of females with dependent offspring (134.6 bears) and the estimate for all other bears (87.7 bears) (Table 7).

Our estimates based on mean group size are 1-13% lower than the estimates based on the mean of daily Lincoln-Petersen estimates (239 bears) or the bear-days estimator (231 bears) (Tables 4 and 5).

Sources of Bias and Potential Corrections

It appears likely that the application of capture-recapture techniques to estimate bear density at Black Lake resulted in a more accurate and more precise estimate than has occurred in other applications of these procedures in Alaska. The Black Lake study benefited from high sample sizes compared to density estimates obtained in low-density populations in Game Management Units (GMUs) 13 and 23 (Miller 1988, Ballard et al. 1988). Compared to density estimates obtained in areas with high bear densities (GMUs 4 and 8) (Schoen in prep., Barnes et al. 1987), this study had more replicates and included a larger search area with more bears, and somewhat higher sightability. An application in GMU 20 (Reynolds et al. 1987) suffered from relatively small sample size, few replications, and low sightability.

Capture heterogenity. Unequal probability of capture of individual bears is a likely source of bias in all capture-recapture estimates. For bears, females accompanied by newborn cubs may have lower capture probability and lower sightability than other bears (Miller et al. 1987, Miller and Ballard 1982). Low sightability of this group results from late emergence from dens, a tendency to remain in high elevation habitats where spotting bears is more difficult because of weather and other hazards to flying, an increased tendency to hide from spotting planes, and more sedentary behavior. These biases would result in an underestimate of population density unless females with newborn cubs had a disproportionately high number of the marks distributed in the population. This was not the case; only 2 females with newborn cubs were marked in the Black Lake study area, both had been marked in 1988 during the premarking phase of this study. During the marking phase of work conducted in spring 1989, no females with newborn cubs were observed and the 2 previously-marked females that had newborn cubs in spring 1989 were still in dens.

Females with newborn cubs may also have been underrepresented in the sample of bears seen during the density estimation phase. At this time, we spotted 22 groups with newborn cubs but 45 and 44 groups composed of a female with yearling or offspring older than yearling, respectively (Table 8). Of 29 adult, radio-marked females (age >5.0) that were present in the search area at least once during the density estimation phase (Table 2), 14 were without offspring. Of the remaining females, only 2 (13.3%) had newborn cubs compared to 5 (33.3%) with yearlings, and 8 (53.3%) with offspring classified as "older than yearling." For 38 observations of unmarked bears accompanied by offspring, 34.2% were of groups with newborn cubs compared to 52.6% with "yearlings" and 13.2% with offspring "older" than yearlings (Table 3). These observations doubtless include numerous repeated sightings of the same group and the quotation marks indicate that the ages of the offspring were estimated by the observer. These observations support the hypothesis that females with newborn cubs were underrepresented both in the sample of marked bears and in the sample of unmarked bears observed.

<u>Ad hoc evaluation of effects of capture heterogeneity based on reproductive status.</u> Bias will be introduced if females with newborn cubs have lower capture and resighting probabilities. This bias can be evaluated with separate estimates of the population size for bears except females with newborn cubs and their cubs as proposed by Miller et al. (1987). Using the bear-days estimator, the population composed of independent bears excluding females with newborn cubs was estimated as 136.1 bears (95% CI = 116.2-163.1); the mean Lincoln-Petersen for this estimate was 137.8 bears. These estimates are only 13 bears less than the estimate for total independent bears (149) (Table 4).

However, there may have been more than 13 females with newborn cubs (COY) in the study area. Sample sizes were too small to directly estimate number of females with COY. However, samples are adequate to estimate the number of females with yearling offspring. Absent environmental effects influencing cub production, it would be reasonable to assume that there were at least as many females with COY as there were females with yearling offspring (assuming no offspring older than yearlings were incorrectly aged as yearlings).

An estimate of 17.1 females accompanied by yearlings was derived using the bear-days estimator and the capture recapture records listed in Table 2 (95% CI= 11.3-32.3); an estimate of 18.9 females with yearlings was derived using the mean of the Lincoln-Petersen estimates. An estimate of the number of independent bears in the search area "corrected" for capture bias against females with newborn offspring would be 137.8 (all bears excluding females with newborn cubs) plus 17.1 females with newborn cubs based on the estimated number of females with yearlings for a total of 155 bears. This "adjusted" estimate is only 4% higher than the original estimate for number of independent bears (149 bears) (Table 4).

We made similar calculations to estimate total number of bears of all ages. Excluding females with COY and COY, the estimated population size was 204.4 bears based on the mean of daily Lincoln-Petersens (95% CI based on sampling variance = 159-249). Adding 17.1 females with COY and 34.2 COY to this estimate yielded a total population estimate of 255.7. This is 7% higher than the direct population estimate for all bears (239) (Table 5).

These <u>ad</u> <u>hoc</u> efforts to evaluate the possible effect of underestimating the population because of capture bias against females with newborn cubs have obvious problems. Taken at face value, however, they suggest that it might have caused an underestimate of about 4% in number of independent bears and 7% in total population size. If fewer cubs were actually produced in 1989 than in 1988, however, the assumption that there were at least as many females with

COY as with yearlings would be wrong. Based on stream surveys discussed later in this report (see Table 23), it appears that 1989 was a lower than typical year for cub production. If this is correct, the above ad hoc corrections would overestimate the population. Overestimates from these corrections would also result from misclassifying offspring older than yearlings as yearlings. Because of these problems, we do not recommend adjusting the directly calculated population and density estimates to correct for this source of potential bias. These calculations are presented as an example of how such corrections could be made when available evidence suggests they are necessary.

Independent Observations. During the density estimation phase of this study we obtained 607 observations of bears in groups of from 1 to 4 individuals (Table 8). More bears occurred in groups (465) than alone (142) and, including groups of 1, the mean group size was 1.94 bears (Table 8). Of 102 observations of "groups" defined as "adults", single bears, and sibling groups, 53 (26.2%) were groups of "adults" (Table 8), as would be expected during the breeding season when this study occurred. Treating bears in groups as independent sightings when, in fact, they were dependent sightings to some degree, is a source of bias. Simulation studies indicate this bias results in underestimation of variance and causes only slight overestimation bias (Miller in prep.).

Density Characteristics of Study Area

The above-described density estimates pertain to a study area where spring brown bear densities ranged from very high in some portions to very low in others. At this time of year, bears are concentrated in the mountains and foothills and on southerly exposures. There were relatively few bears on the flatlands between the mountains and Bristol Bay (quadrats 1-3) or on northerly aspects of the mountains (quadrat 5). Search effort in each quadrat during each replicate is provided in Table 10 and averaged 2.38 minutes/mi^2 (0.92 minutes/km^2).

In different quadrats the average search effort per independent bear seen (excluding dependent offspring) varied from 9 to 60 minutes (Table 10). A ranking of the different quadrats by this criterion resulted in almost the same ranking as would have been obtained using the number of bears seen per mi^2 (Table 10). There was also little difference in this ranking and a ranking based on total number of bears seen, including dependent young (Table 10). Therefore, search effort per independent bear seen was used to obtain an approximation of the density of bears in each quadrat. This was done by calculating the number of bears seen/minute (the reciprocal of the mean number of minutes searched per bear seen in each quadrat) (x_i). These reciprocals were summed over all quadrats and the proportion of this sum for each quadrat was calculated as the value

(P). Then (P)(239) was the estimated total number of bears in each quadrat where 239 is the estimated number of bears in the whole search area derived from the mean of the Lincoln-Petersen estimates (Table 4). This was converted to a density figure using the area of each quadrat (Table 11). On this basis it was calculated that the highest density was in quadrat 10 (0.86 mi^2/bear) and the lowest density was in quadrat 2 (7.28 mi^2/bear) (Table 11). The 2 lowest density quadrats based on these calculations represented 24.4% of the search area and together had a density of 5.47 mi^2/bear (Table 11).

Population Composition

Sex ratio and reproductive status of bears captured in 1988 was not representative of population composition. We were biased against females accompanied by cubs of the year (COY) because these frequently occurred at high-elevations where capture operations were difficult or dangerous. Bears were very numerous, and with two spotter planes the tagging crews could not keep up with all the bears located. At one point a spotter plane had located 9 separate family groups or individuals. This made it necessary to choose which bears to target and this, in turn, likely made the captures nonrepresentative of the population. We corrected for this possible source of bias in 1989 by using only one spotter plane and immobilizing bears in the order found.

The bias against capturing families with COY (Glenn and Miller 1980) was minimized by estimating the population composition over a two year period. The sample captured during the second year was adjusted to reflect the age and status of these bears during the first year. For example, a 10 year old female captured in 1989 with 2 yearlings was tallied as a 9 yr-old female with 2 COY during the 1988 sample. This made it possible to compare the sex and age composition of bears captured during tagging operations in the 1970's and in this study.

Compared to the early 1970's, the current population has older adults of both sexes and more males. Following a period of increasing harvests, the adult sex ratio was 25 males:100 females in 1970 and 17.4:100 in 1971. Harvests were curtailed in 1974-75 by emergency closure of spring seasons and the population's sex ratio increased to 20.0:100. The population grew during the next 10 years and exploitation rates were lower than during the early 1970's. Currently, the adult sex ratio is estimated at 39.4 males :100 females.

Comparisons with 1970-1975 Studies

In the Black Lake area, Alaska Dep. Fish and Game workers conducted an intensive tagging program during 1970-75, excluding 1973. This study occurred in a 2,800 square mile area surrounding our 1989 Black Lake census area (Fig. 1) (Glenn 1980, Glenn and Miller 1980, Modafferi 1984). During Glenn's study, 344 bears were handled 489 times (including capture mortalities), and 136 of these bears were shot by hunters. In addition, 376 unmarked bears harvested from 1970-89 were old enough to have been alive during at least one year between 1970-75. These data will be used to estimate the population size, density, and exploitation rates during the early 1970's. Because the study area boundaries and harvest reporting units do not align with our study area (Fig. 1), some subjective extrapolations will be necessary. These analyses are in progress and will be reported in subsequent reports.

Status of Marked Bears

In December 1989, 32 bears had functioning transmitters. At least 3 bears had failed transmitters or made long distance dispersals during 1989. During 1989, 10 marked bears were killed by hunters, and 3 bears died of natural causes as described below.

Bear 69 was captured on 22 May 1989 and had 3 yearlings that were not captured. The family reunited after capture and was seen together 5 times through 22 June. On 9 August she was dead and the condition of the carcass suggested she had been dead for at least two weeks. Cause of death could not be determined, but she had been fed upon by another bear. There was no trace of her 3 yearlings.

Bear 75 was captured on 23 May and was seen alive on 24 and 27 May (12 km west of the capture site). On 3 June she was found dead and partially consumed by another bear 9.6 km further west.

Bear 88, a 19 year-old female, was captured on 24 May with an adult male (#89) in attendance. She was seen six days later, also with a large male, 4 km southeast of where she had been captured. On 9 August her collar was retrieved in the midst of a pile of hair, about 5.6 km from where she had been seen previously. A carcass of a female, later determined to be 5 years old, was found nearby with an inverted hide and broken zygomatic arches, suggesting predation by another bear. This younger bear was at first thought to be #88 so no thorough search was made for 88's carcass. Bear 88's collar could have been shed and this bear may still be alive, but it was treated as a mortality in mortality rate calculations. This classification may change when the site is reinspected next year.

The carcass of another bear was seen along Fan Creek during August stream surveys. No no radio signal was heard from this bear and no additional information was obtained on whether it was marked or unmarked.

Unlike 1988 when capture operations caused the separation of several family groups (Miller and Sellers 1989), the capture of maternal females in 1989 did not cause any separations.

Twelve adult females were captured in 1988 that did not have litters of COYs or yearlings. These bears were at least 4 years old and could have bred and had cubs in 1989. Two of these bear had litters of COY in 1989 (Nos. 12 and

38). Two others could have also had litters but their 1989 status was undetermined (Nos. 4 and 43).

Movements of Marked Bears

During 1989, 67 bears were located a total of 530 times including capture locations and general locations of bears killed by hunters (4 of which did not have transmitters). Current status of all marked bears is provided in Table 13. Analysis of movements and habitat use awaits digitizing of locations and mapping of cover types.

Estimated Survivorship Rates

Survivorship results presented in this report are preliminary as they are based on data obtained only in 1988 and 1989. Improved estimates of survivorship will be obtained with additional years of study. Cub survivorship was 0.60, lower than in south-central Alaska (0.69) (Miller in prep. 1987). Survivorship for females 3 or more years old was 0.83, lower than in southcentral Alaska (Miller, unpublished data). Survivorship from hunting (0.95) was slightly higher than from natural mortality (0.91). Because relatively few males were radio-marked, and most collared males quickly shed their radios, little confidence can be placed on estimates of male survivorship (0.83 for males 3 or more years old; 1 mortality from hunting). Calculated survivorship rates are provided in Table 14.

It is too early to draw conclusions from the survivorship estimates obtained so far. However, the relatively high mortality from natural causes suggests the possibility that this population may have relatively high levels of intra-specific stress and mortality. This hypothesis will be further tested with data obtained in additional years. Useful comparisons will also be made with data from bears radio-marked in Katmai National Park where population density and proportion of adult males appears to be higher.

Exploitation Rates

In addition to estimating survivorship, we calculated the proportion of marked bears that were removed by hunters in order to compare exploitation rates with earlier studies. A maximum of 83 marked bears 2.5 years or older were alive at the start of the October 1989 hunting season. During the 3 week hunting season, 10 marked bears (6 males and 4 females) were killed, for a 12.3% exploitation rate for bears older than 2 years. According to stream surveys, COY and yearling bears comprised 37% of the population (assuming 20% of the "older offspring" are 2.5 years old). If the number of marked bears is adjusted upwards by this percentage to account for young bears, the harvest rate for the whole population was 7.7%. This exploitation rate doubtless underestimates actual harvest rate as it was based marked bears, assumed no unknown mortality, and assumed complete detection of marks by sealers.

Exploitation rate was also estimated by extrapolating the density estimate to Uniform Coding Units (harvest areas) 1201 and 2001 and expressing harvest in these areas as a percentage of this population (Miller 1988 and in press). During 1989, 31 bears were killed by hunters in harvest areas 1201 and 2001 (Fig. 1), a 1,537 square mile area which includes the census area. Extrapolation from the census area density resulted in an estimated population of 450-500 bears in these harvest areas. The harvest from this estimated population yielded an estimated exploitation rate for the entire population of 6.4 to 7.1%. This is only slightly lower than the estimate of 7.7% based on harvests of marked bears. It is possible that the population estimate for these harvest areas is inflated because overall bear density could be lower than in the census area.

One of the most important comparisons for management purposes is to contrast exploitation rates during the early 1970's with current rates. Radio collars were not a significant part of the marking efforts during this earlier study. Therefore, we cannot derive estimates of survival rates that are directly comparable. Instead, we will have to assume that during this earlier study survivorship rates from natural mortality causes was similar to those that will be obtained in the current study. Until adequate data are available from this study, calculations of exploitation rates must be based on the maximum number of marked bears that could have been alive during the harvest period (i.e. a minimum exploitation rate for bears 2 or more years old). These calculations are shown in Tables 15-21. In addition, we calculated exploitation rates for the 1970/71 and 1971/72 regulatory years based on only those marked bears that were verified to be alive at these times (i.e. a maximum exploitation rate for bears 2 or more years older) (Tables 15 and 16).

Comparisons were also made with minimum exploitation rates during 1970-75. These estimates used only bears marked within 2 years of the harvest period (Table 22). Comparison data for 1989 exploitation rates were obtained by including 5 natural mortalities, detected with the use of radio telemetry, as bears still available for harvest. This made calculations comparable with data from the early 1970's when natural mortalities of marked bears were undetectable. The minimum exploitation rates for bears 2 or more years old ranged from 8.5% in regulatory year 1970/71 to 17.1% in 1972/73. The 1973/74 and 1974/75 harvests were curtailed by emergency orders which eliminated the spring portion of the hunting season. By 1975, hunting was allowed in alternate regulatory years. Exploitation rates for bears $\geq$ 2 during fall 1975 and spring 1976 harvests were 9.5% and 8.8%, respectively (Table 22). This was followed by closed seasons until fall 1977. The adjusted 1989 exploitation rate was 11.4% for bears $\geq$2 (Table 22). This is midway in the range of exploitation rates calculated for the early 1970's. If accurate, the 1989 estimated exploitation rate is probably higher than is sustainable without causing a change in the population structure and, ultimately, a decline in population size. The effects of these harvest rates, once they are more precisely estimated based on additional data, will be further evaluated in subsequent reports.

STREAM SURVEYS

1989 Survey Results

Five replicate surveys (2.6-2.9 hrs each) were flown during 9-12 August 1989 (Table 23). The third survey (10 August) was aborted because of turbulence when approximately 71% complete in terms of flight time and 84% complete based on the number of bears seen on the other four surveys. Only the West Fork of the Chignik River was not surveyed. Not counting the West Fork, the total count for the other 4 surveys were 164, 172, 149 and 164. On the incomplete third survey, 154 bears had been counted when the fight was ended. In order to include this flight, this value was increased by the average number of bears seen during the other 4 counts of the West Fork (20 bears, range 17-26). This artificially reduced the 1989 variance, but is preferable to throwing out that entire survey or to dropping the West Fork from the other 4 surveys.

Total survey counts in 1989 ranged from 175 to 192 (mean = 181, SD = 6.3) (Table 23). Population composition observed during surveys relatively low production of COY, but a very high proportion of yearlings and older cubs. This indicates good cub production during the previous two years. The percent single bears was within the range of the previous 7 years.

Visual collar flags were use to estimate overall sightability during 1988 stream counts. Lack of adequate sample sizes for males and families with COY hindered efforts to determine sightability bias by sex or age cohort. In 1988 and 1989, the high number of radio-marked bears congregated on several short stretches of streams precluded use of radio telemetry techniques (Barnes 1986). In addition to this problem, the condition of collar flags affixed to bears in 1988 was not known for every bear in 1989. Consequently, no additional analysis of the accuracy of streams surveys could be made. The discussion that follows addresses the usefulness of this technique to detect major changes in population size and composition.

Stream Surveys as a Reflection of Population Size

In an effort to find a practical way to monitor brown bear populations, various types of aerial surveys have been attempted with mixed results. Erickson and Siniff (1963) identified a number of variables that had significant effects on the results of aerial surveys of brown bears congregated along salmon spawning streams. These included observer experience, time of day, time relative to peak salmon spawning, and wind speed. Simultaneous air and ground counts were made 10 times. On average, aerial counts only tallied 47% of the bears known to be present from ground observations. Also, several distinctly notable bears were not seen on replicate counts. These results lead Erickson and Siniff (1963) to conclude that aerial stream counts were incomplete. This conclusion is supported by the results of our study where overall sightability was 30-40%. Even when the exact location of a bear was known from radio signals and several passes were made to spot the bear, only 68% (n=443) of the bears were seen.

Despite the number of factors that can influence the results of stream surveys, Erickson and Siniff (1963) did not rule out this technique: "The findings do not negate the use of aerial surveys, but show that with attention to standardization of controllable variables and with awareness of the limitations in the use of aircraft, aerial observations provide perhaps the only feasible means for extensive population assessments." Since the resumption of aerial surveys in 1982, we have used experienced observers (n=3, with D. Sellers as observer on 22 of 27 surveys), have flown surveys only during the first 12 days of August, and have conducted approximately even numbers of morning (13) and evening (14) surveys. This latter point is important since slightly fewer bears are seen in the morning (mean = 135.7) than in the evening (mean = 144.3) during 23 morning and 23 evening flights made since 1962.

Aerial surveys of alpine habitat have been conducted in Southeast Alaska (Schoen and Beier, 1988) and on Kodiak Island (Atwell et al. 1980). Troyer and Hensel (1969) and Troyer (NPS files) also conducted aerial surveys of bears on salmon spawning streams in southern Kodiak Island and within Katmai National Park, respectively. Barnes (1986) explored whether visibility biases exist towards particular cohorts of bears, and how interdrainage movements of bears between salmon spawning streams and differences in vegetative cover on individual streams affects the proportion of bears spotted on aerial surveys.

Despite the amount of effort applied to aerial surveys of brown bears, there has not been an evaluation of this technique to monitor trends in population size when survey methodology is standardized to minimize the variables described above. From 1962-1989, 46 surveys have been conducted at the peak of sockeye salmon (Oncorhynchus nerka) spawning within the Chignik River/Black Lake area. All surveys were flown in the early morning or evening hours with acceptable weather conditions. Although a number of biologists (n=5) and pilots ($n \geq 8$) have been involved over the years, all are judged to have been experienced. For 1962, this analysis included those early morning and evening surveys made by experienced observers ("A" and "B") prior to 13 August (when bears appeared to disperse). One survey was excluded because of an unrealistically low count of 34 bears (Erickson and Siniff 1963). During one survey in 1974, 1984, and 1989, the drainage of the West Fork of the Chignik

River was not counted because of severe winds. In 1974, the drainage was completed the following morning and 9 bears were added to the August 7 number. On 8 August 1984, the morning flight was ended after 99 bears had been seen. The portion not covered contributed an average of 17 bears (range 14-21) or 12% (range 8-14%) to the total counts for the other 3 flights made that year. Thus 17 bears were added to this survey. The nearly completed 10 August 1989 survey was "completed" by adding 20 bears (the average count for this drainage during the other 4 1989 surveys) (Table 24).

Results of these surveys have been grouped into 6 time periods for comparisons (Tables 24 and 25). Surveys from 1962 reflect a population under very light hunting pressure (Unit 9 harvests reportedly averaged less than 100 prior to 1961 and 120 were killed in 1961). During 7 surveys in 1962, an average of 91.6 (range 81-113; SD =10.2) bears was seen.

During 1965-70, 9 comparable replicate surveys tallied an average of 111.3 bears (range 92-123, SD= 8.8). Within this period there was no detectable trend in number of bears seen per survey. However, significantly more bears were seen compared to the 1962 surveys (Mann-Whitney U test, $\underline{P} < 0.001$) despite greatly increased harvests (1963-70 Unit 9 harvests averaged 172 bears). Within harvest areas 1201 and 2001 (Fig. 1), the average number of bears killed increased from 14 (1961-1962) to 22 (1963-70).

Trends in salmon escapement during this period may be pertinent to this trend. Average sockeye salmon escapements into the Black Lake system increased from 179,800 (1954-62) to 341,700 (1963-70). This near doubling of an important food source could have increased productivity and survival and may have attracted more bears to the survey streams. However, during this period the escapements into adjacent streams remained relatively stable (Fig. 7), and it is unlikely that bears accustomed to fishing at other streams would have switched to the Black Lake system.

During the early 1970's, harvests again increased dramatically and it was believed that the structure of the population, and possibly population size, changed. Unfortunately only a few stream surveys were completed during the 1970's. Two counts (77 and 104 bears) were made in 1974, a key year based on high harvests previously and the emergency closure of the spring 1974 hunting season. Because of the small number of replicates, the 1974 totals are not statistically different than the average counts made during the 1960s. Nevertheless, these data suggest that fewer bears may have been present following the record harvests of 1972 and 1973. Unfavorable weather in 1975 prevented any surveys from being completed. By 1976, following two years with restrictive hunting seasons, 115 bears were counted on the one survey completed.

Ten surveys from 1982-84 showed an average of 149.7 (range 110-173, SD=18.9), while 17 surveys from 1985-89 averaged 178.8 (range 147-217, SD =46.9). These surveys suggest a finite rate of increase from 1974 through 1985 of 1.066.

Stream Surveys and Population Composition

The evaluation of population composition recorded by different observers is somewhat clouded by an unclear definition of "yearlings". It appears Erickson and Siniff (1963) classified as "yearlings", all offspring older than COY. Mid summer observations of 94 known-age families consisting of young older than COY has demonstrated that 20% of them were litters of 2 or 3 year olds (this study and ADF&G unpublished data from McNeil River). In our opinion it is not always possible to accurately classify these older litters during aerial surveys. We have made distinctions only between COY and "older offspring".

It is clear that protected bear populations such as within Katmai National Park and McNeil River State Game Sanctuary have a higher proportion of "single" bears than do heavily hunted populations (NPS and ADF&G unpublished data). In subsequent reports we will examine the proportion of single bears seen during aerial stream surveys at Black Lake in relation to exploitation rates to see if a relationship exists that may provide a rough index to the intensity of harvests.

Effects of Salmon Escapements on COY Production

Bear productivity is influenced by abundance of staple food items such as berries (Rogers 1976, Reynolds et al. 1987, Smith and VanDaele 1988) or garbage (Craighead et al. 1974). Changes in nutritional condition could influence many parameters including age at first litter, conception rate, COY survival, litter size, and interval between litters. Some of these parameters may also be influenced by other factors such as spring weather and availability of alternate foods.

If the number of salmon available to bears affects productivity, high productivity would be expected following years of high escapement and low productivity following years of low escapement. Bear population composition data for Black Lake since 1982 indicate that COY production was high in 1983 (27%) and low in 1986 (13%) and 1989 (12%). During all other years, COY constituted 18-22% of the population (Table 26). The large 1983 COY crop followed a year with very high escapement of 616,117 salmon. The two low COY production years followed the two lowest escapements (377,516 in 1985 and 420,577 in 1988) during this period. Another possible measure of the effect of salmon abundance on productivity would be COY litter size. However, a regression of COY litter size on salmon escapements the previous year from 1982-89 indicated no relationship.

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Table 1. Brown bear capture records at Black Lake, Alaska during 1988 and 1989. Cementum ages represent readings by G. Mattson. C:\BK89\Capture.wkl

ID	SEX	AGE	WT. (LBS)	CAPTURE DATE	EARTAG L.	EARTAG R.	RADIO S.N.	COLLAR TYPE	COLLAR FLAGS	SKULL SIZE(mm) LGTH	SKULL SIZE(mm) WIDTH	COND.	%HB	%PCV	COMMENTS
1	F	11	415	6/1/88	23	24	29739		Y CF	392	227	2	14.5	42.0	W/2@1, captured
2	F	1	125	6/1/88	60	59	NA			271	147	NA	17.0	45.0	W/ #1 & sibling #3
3	M	1	136	6/1/88	59	60	NA			282	151	NA	18.0	45.0	W/ #1 & sibling #2
4	F	12	425	6/1/88	86	85	29740		W CF	370	222	4	16.0	45.0	W/ male #5 and dead ylg.
5	M	14	850	* 6/1/88	80	79	29743			444	259	4	17.0	44.5	W/female #4 & dead ylg.
6	F	4	340	6/1/88	58	57	29719	C.S.	W CF	375	206	3	16.0	45.5	W/male #7
7	M	4	385	6/1/88	31	32	--			371	197	3	15.0	43.5	W/female #6
8	F	4	300	* 6/1/88	1	2	29732		Y CF	351	186	4	17.5	49.0	Alone
9	M	3	475	* 6/2/88	21	22	29730	C.S.	R CF	384	209	3	14.6	42.0	W?/male #10
10	M	3	290	6/2/88	69	70	17??	G	R RtE	374	201	NA	14.0	38.5	w?/male #9
11	F	25	580	6/2/88	92	91	29737		Y CF	406	242	4	14.3	41.0	Alone
12	F	9	370	6/2/88	74	73	29736		W CF	371	208	NA	15.5	47.0	W/ 1@2 (#13)
13	F	2	150	6/2/88	83	84	NA			299	166	NA	15.0	39.0	W/ mom #12
14	M	8	485	6/2/88	17	18	NA			436	240	4	14.5	43.0	W/ male #15
15	M	16	1100	* 6/2/88	75	76	27852	G	R Bk	419	300	5	NA	NA	W/ male #14
16	F	4	275	* 6/2/88	20	19	29734	C.S.		350	196	NA	14.8	44.0	Alone
17	F	18	500	* 6/2/88	13	14	29745		W CF	373	246	5	14.4	47.0	W/ big male, not captured
18	F	11	400	* 6/2/88	82	81	29733		Y CF	394	238	2	16.3	45.0	W/ 2@1 (#19 &20)
19	F	1	110	* 6/2/88	89	90	NA			249	148	3	14.2	43.0	W/ mom #18
20	F	1	90	* 6/2/88	65	66	NA			261	154	2	13.5	41.0	W/ mom #18 & sib (#19)
21	F	3	175	* 6/2/88	51	52	1022	G	W RtE	300	170	4	14.5	40.0	Alone
22	F	9	375	* 6/2/88	NA	NA	NA			379	239	NA	NA	NA	Capture mortality, drowned
A	?	1	100	* 6/2/88	NA	NA	NA					NA	NA	NA	Darted but not handled, recovered
B	?	1	100	* 6/2/88	NA	NA	NA					NA	NA	NA	Darted but not handled, recovered
25	M	16	1000	* 6/2/88	7	NA	NA			446	296	4	NA	NA	Alone, Rt. ear missing
26	F	11	380	6/2/88	5	6	29746		Y CF	386	231	3	14.4	38.0	W/ 3@2 (#27-29)
27	F	2	170	6/2/88	67	68	27829	G	W LfE	300	167	NA	15.0	40.0	W/ #26 & sibs
28	M	2	160	6/2/88	16	15	NA			307	170	NA	13.8	43.0	W/ #26 & sibs
29	M	2	155	6/2/88	97	98	NA		R LfE	295	165	NA	13.9	41.0	W/ #26 & sibs
30	F	9	385	6/3/88	9	10	29724		W CF	377	226	3	16.0	43.0	W/ 1 @ 2* (#31)
31	M	2	140	6/3/88	***	99	NA			289	157	3	19.0	45.0	W/ mom #30
23	F	18	380	6/3/88	76	75	29754			375	228	4	16.0	44.0	W/ 3@1 (only #24 captured)
24	M	1	40	* 6/3/88	86	85	NA			239	128	2	13.0	39.5	W/ mom #23 & 2 siblings
32	F	14	400	* 6/3/88	61	62	29729			377	239	3	NA	NA	Capture mort., w/2@3*(#33 captured)
33	M	2	230	6/3/88	35	36	NA			330	180	3	14.0	42.0	W/ mom #32 & 2 siblings

(continued on next page)

Table 1 Continued.

ID	SEX	AGE	WT. (LBS)	CAPTURE DATE	EARTAG L. R.	RADIO S.N.	COLLAR TYPE	FLAGS	SKULL SIZE(mm) LGTH	SKULL SIZE(mm) WIDTH	COND.	%HB	%PCV	COMMENTS
34	F	12	475 *	6/3/88	95 96	29728		W CF	405	245	4	20.0	47.0	W/ 3@0, not captured
36	F	10	285	6/3/88	45 46	29721		W CF	360	235	2	17.0	45.6	W/ 2@0, captured
A	F	0	24	6/3/88	B20B21	NA			NA	NA	NA	NA	NA	Rototags, w/mom #36, drugged by hand
B	F	0	22.5	6/3/88	B19B21	NA			NA	NA	NA	NA	NA	Rototags, w/mom #36, drugged by hand
37	F	5	340	6/3/88	98 18	29718		W CF	363	200	4	16.0	44.0	W/1@1*(~75lbs), not captured
38	F	16	450 *	6/3/88	22 50	29738		W CF	373	234	3	13.0	40.0	W/1@2*(#39)
39	M	3	215	6/3/88	43 44	1702	G		350	192	3	16.0	40.5	W/ mom #38
40	F	4	340	6/3/88	71 72	29757		W CF	364	189	1	15.0	42.5	Weighed wet, w/ male #41
41	M	13	850 *	6/3/88	34 33	29751		R RtE	410	269	NA	16.5	44.5	W/ female #40
42	M	4	425 *	6/3/88	25 26	29742	C.S.	O CF	387	209	3	18.5	45.5	W/ female #43
43	F	5	275 *	6/3/88	79 80	29750	C.S.	Y CF	352	199	2	13.5	37.0	W/ male #42
44	F	20	425 *	6/3/88	97 70	29735		W CF	411	231	3	17.5	41.0	W/1@2 (#45)
45	F	2	225 *	6/3/88	77 78	29756	C.S.		340	181	3	14.0	42.0	W/ #44(mom)
46	F	10	320 *	6/4/88	7 8	29722		W CF	384	225	2	16.3	44.0	W/ 3@0, not captured
47	M	4	250 *	6/4/88	96 5	29749	SURG.		364	195	5	16.0	45.0	Alone
48	M	3	340	6/4/88	23 24	29720	C.S.	R CF	359	192	3	15.5	43.0	Alone
49	M	6	800 *	6/4/88	11 12	NA			475	260	3	NA	NA	W/ female #50
50	F	4	270 *	6/4/88	29 30	29731	C.S.		371	212	1	17.3	46.0	W/ male #49
51	F	12	400	6/4/88	56 55	29741		W CF	381	242	3	14.6	41.0	W/ 3@1 (not captured, age certain)
52	F	3	345	6/4/88	35 36	29753			360	189	3	15.0	43.0	Alone
53	F	3	250 *	6/5/88	63 64	29727	C.S.	W CF	336	175	2	13.0	37.5	Alone
54	M	3	265	6/5/88	37 38	29752	SURG.	R CF	334	193	2	15.0	48.0	Alone
55	F	9	450 *	6/5/88	26 99	29747		W CF	372	211	3	15.5	42.0	W/ adult male(?)
56	M	2	187	6/5/88	88 87	NA			312	163	2	13.5	38.5	W/ larger adult (mom?)
57	F	8	365	6/5/88	27 28	29748		Y CF	377	217	3	14.0	43.0	W/ large male(?)
58	F	18	450 *	6/5/88	92 93	29755		W CF	378	241	3	14.5	41.0	W/ 2@1, not captured
59	F	6	450 *	5/21/89	304303	29723		W CF	377	207		15	42	
5	M	15	800 *	5/21/89		32235	G	O HUMP	437	268	4			
58	F	19	400 *	5/21/89	093094			W CF						W/2@2,OLD COLLAR
51	F	13	375 *	5/21/89	056055			W CF			3	13	41	OLD COLLAR
60	F	9	450 *	5/21/89	306309	34069		W CF	388	220	4	16.5	46	
61	F	4	200 *	5/21/89	302308	32234	G		306	175	3	8	26	
62	M	2*	170 *	5/21/89										CAPTURE MORTALITY
49	M	7	850 *	5/21/89	011012	32236	G	G BACK	401	269				
64	M	10	1200 *	5/22/89	264262	34071	G		433	270		16.5	44	

(continued on next page)

Table 1 Continued.

ID	SEX	AGE	WT. (LBS)		CAPTURE DATE	EARTAG L. R.	RADIO S.N.	COLLAR TYPE	FLAGS	SKULL SIZE(mm) LGTH	WIDTH	COND.	%HB	%PCV	COMMENTS
65	F	10	450	*	5/22/89	307308	34065		W CF	391	236	3	13	33	W/1@2 (#66)
66	M	2	195		5/22/89	266264	34073	G							W/#65
67	F	3	175	*	5/22/89	300306	34060		W CF	357	189	2	17.5	43	
68	M	6	450	*	5/22/89	250267	29751		R CF	389	221		15	42	
42	M	5	450		5/22/89	025026	34070	G	Blk BA	417	234		15.5	44	
71	M	5	720		5/22/89	89 14	29744	C.S.	R CF	435	269	4	14	43	
69	F	19	390		5/22/89	329329	29725		W CF	362	237	2	14.5	27	W/3@1
70	F	7	375	*	5/22/89	305309	34068		W CF	384	225	3	15	47	W/2@1
72	M	8	775	*	5/23/89	052092	34075	G		392	229	4	15	46	
31	M	3			5/23/89	100099	6306	SURG.	G CF	235	171		16.1	45.5	LAST YR'S MARKS
73	M	2	250	*	5/23/89	263265	32237	G		347	191		14.5	45	
74	M	3	275	*	5/23/89	045064			Y BACK	336	192	2	11.5	35	NO RADIO
75	F	4	300	*	5/23/89	306305	34061		W CF	348	196	3	13.9	39.5	
76	F	14	560		5/23/89	309301	34064		W CF	403	249	3	14.2	41.5	W/1@3 (#77)
77	F	3	310		5/23/89	301301	32233	G		373	208	3	13.2	38	W/mom #76
78	M	4	450	*	5/23/89	266268	15276	C.S.	R CF	385	205		14.1	44	
79	M	10	1050		5/23/89	078009	34074	G		472	299	4	16	48	
80	F	13	566		5/23/89	320321	34066		Y CF	420	250	4	14.1	41	
81	M	4	340		5/23/89	251250	14885	C.S.	O CF	356	188	3	13.9	42	s/n maybe 14985
82	F	14	450		5/23/89	308307	34062		W CF	387	250	3	14.4	38.5	W/2@2 and #83
83	M	6	496		5/23/89	263251	29726	C.S.	R CF	407	235		15.1	43.5	W/#082
84	M	3	310		5/24/89	65 62	32238	G		353	207	2	13.5	39	
85	M	12	1000	*	5/24/89	265269	34072	G		445	284				
86	M	5	460		5/24/89	74 73	29729	SURG.	R CF	393	220	3	14	38	
87	F	12	450	*	5/24/89	003004	34063		W CF	382	236	3	14.5	47	W/3@1
13	F	3	185		5/24/89	83 84	29751	SURG.	W CF	320	170	1	15.5	44	
88	F	19	600	*	5/24/89	037087	6315		W CF	391	243	4	18	51	W/ male #89
89	M	11	900	*	5/24/89	090013	34071	G		444	272	4	18.5	50	W/female #88
90	F	19	500	*	5/24/89	320300	34067		W CF	395	241	3			W/1@1
91	M	4	350	*	5/24/89	077010	29721	C.S.	R CF	366	207	4	18.5	51	
92	F	3	150	*	5/24/89	307310	29756	C.S.	W CF	308	163	3	18.5	53	

*Estimated
COLLAR TYPES: C.S. - w/ canvas spacer, G - glue-on, SURG.= surgical rubber spacer.

Table 2. Status of marked brown bears during density estimation study at Black Lake during spring 1989. Table updated 2/8/90. Bear #66, a collared 2 year-old with #65, is treated as an independent bear when not with #65 (replication 2). Data on group size refers to females with dependent young, other types of groups are not indicated.

			YOUNG		REP.1(5/28)			REP.2(5/30)			REP.3(5/31 am)			REP.4(5/31 pm)			REP.5(6/1-3)			REP.6(6/4)							
			INT.	EST.		GROUP			GROUP			GROUP			GROUP			GROUP			GROUP		No.	No.	No.	%	%
ID	SEX	AGE	NO.	AGE	STAT.	SIZE	SEEN?	STAT.	SIZE	SEEN?	STAT.	SIZE	SEEN?	STAT.	SIZE	SEEN?	STAT.	SIZE	SEEN?	STAT.	SIZE	SEEN?	out	in	seen	in	seen
1	F	12	1	2	in	2	yes	in	2	yes	in	2	yes	in	2	yes	in	2		in	2		0	6	4	100	66.7
8	F	5			out	1		out			out			out			out			out			6	0	-	0	ERR
11	F	26			in	1		in	1		in	1		in	1	yes	in	1	yes	in	1	yes	0	6	3	100	50.0
12	F	10	2	0	in	3		in	3	yes	in	3	yes	in	3	yes	in	3		in	3		0	6	3	100	50.0
13	F	3			in	1		in	1		in	1		in	1	yes	in	1	yes	in	1		0	6	2	100	33.3
16	F	5			in	1		in	1	yes	in	1	yes	in	1		in	1		in	1		0	6	2	100	33.3
17	F	19			in	1	yes	in	1		in	1		in	1	yes	in	1		in	1	yes	0	6	3	100	50.0
18	F	12			in	1		in	1		in	1		in	1		in	1		in	1	yes	0	6	1	100	16.7
23	F	19	2	2	in	3		in	3	yes	in	3		in	3	yes	in	3		in	3		0	6	2	100	33.3
26	F	12			in	1		in	1		in	1		in	1		in	1		in	1		0	6	0	100	0.0
30	F	10			in	1		in	1	yes	in	1	yes	in	1	yes	in	1	yes	in	1	yes	0	6	5	100	83.3
34	F	13	3	1	in	4		in	4		in	4		in	4	yes	in	4		in	4	yes 3	0	6	2	100	33.3
37	F	6	1	2	in	2		in	2	yes	in	1	yes	in	1	yes	in	1	yes	in	1		0	6	5	100	83.3
38	F	17	2	0	in	3		in	3		in	3		in	3		in	3		in	3		0	6	0	100	0.0
40	F	5			in	1		in	1		in	1		in	1		in	1		out	1		1	5	0	83.3	0.0
43	F	6			shed																		-	-	-	-	ERR
46	F	11			in	1		in	1		in	1		in	1		in	1	yes	in	1		0	6	1	100	16.7
50	F	5			out	1		out			out			out			out			out			6	0	-	0	ERR
51	F	13	3	2	in	3	yes	in	3		in	2		in	2		in	4	yes	in	4		0	6	2	100	33.3
52	F	4			out			out			out			out			out			out			6	0	-	0	ERR
53	F	4			in	1	yes	in	1	yes	in	1	yes	in	1	yes	in	1		in	1		0	6	4	100	66.7
55	F	10			in	1		in	1	yes	in	1		in	1		in	1		in	1		0	6	1	100	16.7
57	F	9			in	1		in	1		in	1		in	1		in	1	yes	in	1		0	6	1	100	16.7
58	F	19	2	2	in	3	yes	in	3	yes	in	3	yes	in	3		in	1	yes	in	1		0	6	4	100	66.7
59	F	A 6			in	1		in	1	yes	in	1	yes	in	1	yes	in	1		in	1	yes	0	6	4	100	66.7
60	F	9			in	1	yes	in	1	yes	in	1	yes	in	1	yes	out	1		out	1		2	4	4	66.6	100.0
61	F	4			shed																		-	-	-	ERR	ERR
65	F	10	1	2	in	2	yes	in	1	yes	in	2	yes	out	2		out	2		out	2		3	3	3	50	100.0

Continued......

Table 2. continued.

ID	SEX	YOUNG AGE	INT. NO.	EST. AGE	REP.1(5/28) STAT.	GROUP SIZE	SEEN?	REP.2(5/30) STAT.	GROUP SIZE	SEEN?	REP.3(5/31 am) STAT.	GROUP SIZE	SEEN?	REP.4(5/31 pm) STAT.	GROUP SIZE	SEEN?	REP.5(6/1-3) STAT.	GROUP SIZE	SEEN?	REP.6(6/4) STAT.	GROUP SIZE	SEEN?	No. out	No. in	No. seen	% in	% seen
67	F	3			in	1	yes	in	1	yes	in	1		in	1	yes	in	1	yes	in	1		0	6	4	100	66.7
69	F	19	3	1	in	4		in	4	yes	in	4	yes	in	4		in	4		in	4	yes 3	0	6	3	100	50.0
70	F	7	2	1	in	3		in	3	yes	in	3	yes	in	3	yes	in	3		in	3	yes 2	0	6	4	100	66.7
75	F	4			out			out			out			out			out			out			0	0	_	ERR	ERR
76	F	14	2	3	in	3	yes	in	1	yes	in	1	yes	in	1		in	1	yes	in	1	yes	0	6	5	100	83.3
77	F	3			in	1	yes	in	1	yes	in	1	yes	in	1		in	1		in	1		0	6	3	100	50.0
80	F	13			out			out			out			out			out			out			6	0	-	0	ERR
82	F	14	2	2	in	1		in	1		in	1		in	1	yes	in	1	yes	in	1	yes	0	6	1	100	16.7
87	F	12	3	1	in	4		in	4	yes	in	4		in	4	yes	in	4	yes	in	4		0	6	3	100	50.0
88	F	19			in	1		in	1	yes	in	1		in	1		in	1		in	1		0	6	1	100	16.7
90	F	19	1	1	in	2		in	2		in	2		in	2		in	2		in	2		0	6	0	100	0.0
92	F	3			in	1		in	1		in	1		in	1		in	1		in	1		0	6	0	100	0.0
5	M	15			shed																		-	-	-	ERR	ERR
31	M	3			in	1		in	1		in	1	yes	in	1	yes	in	1	yes	in	1		0	6	3	100	50.0
48	M	4			in	1		in	1	yes	in	1		in	1	yes	in	1		in	1	yes	0	6	3	100	50.0
49	M	7			shed																		-	-	-	ERR	ERR
66	M	2			w/65			in	1	yes	w/65			w/65			w/65			w/65			-	1	1		100.0
71	M	5			in	1	yes	in	1		in	1		in	1		in	1	yes	in	1	yes	0	6	3	100	50.0
73	M	2			shed																		-	-	-	ERR	ERR
78	M	4			in	1	yes	in	1	yes	in	1	yes	in	1		in	1		in	1		0	6	3	100	50.0
79	M	10			shed																		-	-	-	-	-
81	M	4			in	1		in	1	yes	in	1	yes	in	1	yes	in	1		in	1	yes	0	6	4	100	66.7
83	M	6			in	1		in	1		in	1		in	1	yes	in	1		in	1	yes	0	6	2	100	33.3
84	M	3			in	1		in	1	yes	in	1	yes	in	1		fail?	1		fail?	1		0	4	2	100	50.0
85	M	12			shed																		-	-	-	-	-
86	M	5			in	1		in	1	yes	in	1	yes	in	1	yes	in	1		out	1		1	5	3	83.3	60.0
89	M	11			shed																		-	-	-	-	-
91	M	4			in	1		in	1		in	1		in	1		in	1	yes	in	1		0	6	1	100	16.7
																						TOTALS	31	244	105	88.7	

Table 3. Summary of observations of brown bears during spring 1989 brown bear density estimate at Black Lake, Alaska. "Independent bears excludes offspring, of whatever age, still with their mothers.

	REPLICATION: 1	2	3	4	5	6	MEAN	MIN.	MAX.
Marked bears present, all ages =	69	67	65	63	61	59	64.0	59	69
Marked bears seen, all ages =	20	41	30	34	21	22	28.0	20	41
Unmarked bears seen, all ages =	64	56	68	98	79	74	73.2	56	98
No. cubs-of-year =	4	4	13	10	1	3	5.8	1	13
No. "yearlings" =	10	2	3	13	20	19	11.2	2	20
No. "older" than ylgs.=	8	10	13	13	12	5	10.2	5	13
Tot. marked present + unmarked seen =	133	123	133	161	140	133	137.2	123	161
Marked present, independent =	42	43	42	41	39	37	40.7	37	43
Marked bears seen, independent =	12	25	19	21	15	14	17.7	12	25
Unmarked bears seen, independent =	42	40	39	62	46	47	46.0	39	62
Indep. marked present + unmarked seen =	84	83	81	103	85	84	86.7	81	103
Sightability, independent									
No. in	42	43	42	41	39	37	40.7	37	43
No. seen	12	25	19	20	15	14	17.5	12	25
% seen	28.6	58.1	45.2	48.8	38.5	37.8	42.8	28.5	58.1

Table 4. Bear population and density estimates in a 469.31 square mile study area at Black Lake, Alaska based on bear-days estimator of Miller et al. (1987). "L-P" is the Lincoln-Petersen estimate.

BEARS OF ALL AGES, DEPENDENT YOUNG TREATED AS INDEPENDENT SIGHTINGS:

REP.DATE	n1 (marks present)	m2 (marks seen)	n2 (total seen)	Daily L-P	SIGHT-ABILITY	N*(BEAR-DAYS EST.)	EST. DENSIT sq.mi/bear	95% BINOMIAL CI FOR NO. BEARS: lower	upper	95% BINOMIAL CI FOR MI2/BEAR: lower	upper	80% BINOMIAL CI FOR NO. BEARS: lower	upper	80% BINOMIAL CI FOR MI2/BEAR: lower	upper
1 5/28	68	19	83	288.8	0.279	288.80	1.63	203.47	472.88	0.99	2.31	227.65	401.42	1.17	2.06
2 5/30	67	41	97	157.7	0.612	201.27	2.33	165.73	254.72	1.84	2.83	176.52	235.11	2.00	2.66
3 5/31	65	30	98	209.8	0.462	205.08	2.29	174.43	247.74	1.89	2.69	183.96	232.29	2.02	2.55
4 5/31	63	34	132	242.2	0.540	216.76	2.17	188.18	254.55	1.84	2.49	197.21	240.93	1.95	2.38
5 6/1-3	61	21	100	283.6	0.344	227.30	2.06	199.02	263.95	1.78	2.36	208.03	250.77	1.87	2.26
6 6/4	59	22	96	252.0	0.373	231.07	2.03	203.94	265.64	1.77	2.30	212.64	253.21	1.85	2.21
cumulative % =					43.603										
mean daily L-P=				239.02			1.96								
SE=				18.35											

INDEPENDENT BEARS ONLY, DEPENDENT YOUNG NOT INCLUDED IN ESTIMATE:

REP.DATE	n1 (marks present)	m2 (marks seen)	n2 (total seen)	Daily L-P	SIGHT-ABILITY	N*(BEAR-DAYS EST.)	EST. DENSIT sq.mi/bear	95% BINOMIAL CI FOR NO. BEARS: lower	upper	95% BINOMIAL CI FOR MI2/BEAR: lower	upper	80% BINOMIAL CI FOR NO. BEARS: lower	upper	80% BINOMIAL CI FOR MI2/BEAR: lower	upper
1 5/28	41	11	53	188.0	0.268	188.00	2.50	120.20	378.23	1.24	3.90	138.33	300.37	1.56	3.39
2 5/30	43	25	65	110.7	0.581	136.19	3.45	105.90	187.75	2.50	4.43	114.79	168.40	2.79	4.09
3 5/31	42	19	58	125.9	0.452	133.47	3.52	108.64	171.50	2.74	4.32	116.15	157.48	2.98	4.04
4 5/31	41	21	83	159.4	0.512	141.57	3.32	118.27	174.91	2.68	3.97	125.49	162.77	2.88	3.74
5 6/1-3	39	15	61	154.0	0.385	144.25	3.25	122.18	174.87	2.68	3.84	129.07	163.75	2.87	3.64
6 6/4	37	14	61	156.1	0.378	146.39	3.21	125.23	175.10	2.68	3.75	131.88	164.70	2.85	3.56
cumulative % =					43.210										
mean daily L-P=				149.00			3.15								
SE=				10.15											

BEARS OLDER THAN 2.0 ONLY:

REP.DATE	n1 (marks present)	m2 (marks seen)	n2 (total seen)	Daily L-P	SIGHT-ABILITY	N*(BEAR-DAYS EST.)	EST. DENSIT sq.mi/bear	95% BINOMIAL CI FOR NO. BEARS: lower	upper	95% BINOMIAL CI FOR MI2/BEAR: lower	upper	80% BINOMIAL CI FOR NO. BEARS: lower	upper	80% BINOMIAL CI FOR MI2/BEAR: lower	upper
1 5/28	52	19	69	184.5	0.365	184.50	2.54	131.25	297.82	1.58	3.58	146.07	253.53	1.85	3.21
2 5/30	51	31	81	132.3	0.608	153.46	3.06	124.16	199.15	2.36	3.78	132.90	182.24	2.58	3.53
3 5/31	49	23	75	157.3	0.469	155.42	3.02	129.95	192.14	2.44	3.61	137.79	178.72	2.63	3.41
4 5/31	47	24	99	191.0	0.511	165.57	2.83	141.13	199.00	2.36	3.33	148.77	186.89	2.51	3.15
5 6/1-3	45	18	76	185.4	0.400	169.19	2.77	145.85	200.33	2.34	3.22	153.22	189.07	2.48	3.06
6 6/4	43	14	66	195.5	0.326	172.26	2.72	149.53	202.08	2.32	3.14	156.78	191.41	2.45	2.99
cumulative % =					44.948										
mean daily L-P=				174.34			2.69								
SE=				9.15											

Table 5. Brown bear population, density and bias correction estimates at Black Lake, Alaska using estimator and 95% CI proposed by Eberhardt (in press). Data used in making estimates presented in Table 4.

ESTIMATE FOR BEARS OF ALL AGES, DEPENDENT YOUNG TREATED AS INDEPENDENT SIGHTINGS:

(k) REP.	MEAN L-P FOR (k) REPS.	DENSITY mi2/bear	CUM. MEAN NO. MARKS SEEN	DENOMINATOR FOR BIAS CORRECTION FACTOR (eq. 13)	SAMPLE VARIANCE (eq. 2)	FOR 95% t w/ (k-1)d.f.	95% CI FOR NO. OF BEARS: upper	95% CI FOR NO. OF BEARS: lower	95% CI FOR MI2/BEAR: upper	95% CI FOR MI2/BEAR: lower	FOR 80% t w/ (k-1)d.f.	80% CI FOR NO. OF BEARS upper	80% CI FOR NO. OF BEARS lower	80% CI FOR MI2/BEAR: upper	80% CI FOR MI2/BEAR: lower
1	288.8	1.718524	19.00	1.00											
2	223.2	2.223279	30.00	1.00	8597.98	12.706	1056.3	-609.9	0.44	-0.77	3.078	425.0	21.4	1.10	21.91
3	218.7	2.268877	30.00	1.00	4359.37	4.303	382.8	54.7	1.23	8.58	1.886	290.6	146.9	1.61	3.20
4	224.6	2.209650	31.00	1.00	3043.76	3.182	312.4	136.8	1.50	3.43	1.638	269.8	179.4	1.74	2.62
5	236.4	2.099312	29.00	1.00	2979.64	2.776	304.2	168.6	1.54	2.78	1.533	273.8	199.0	1.71	2.36
6	239.0	2.076436	27.83	1.00	2424.41	2.571	290.7	187.3	1.61	2.51	1.440	268.0	210.1	1.75	2.23

ESTIMATE FOR INDEPENDENT BEARS ONLY, DEPENDENT OFFSPRING ARE NOT INCLUDED:

(k) REP.	MEAN L-P FOR (k) REPS.	DENSITY mi2/bear	CUM. MEAN NO. MARKS SEEN	DENOMINATOR FOR BIAS CORRECTION FACTOR (eq. 13)	SAMPLE VARIANCE (eq. 2)	FOR 95% t w/ (k-1)d.f.	95% CI FOR NO. OF BEARS: upper	95% CI FOR NO. OF BEARS: lower	95% CI FOR MI2/BEAR: upper	95% CI FOR MI2/BEAR: lower	FOR 80% t w/ (k-1)d.f.	80% CI FOR NO. OF BEARS upper	80% CI FOR NO. OF BEARS lower	80% CI FOR MI2/BEAR: upper	80% CI FOR MI2/BEAR: lower
1	188.0	2.639946	11.00	1.00											
2	149.3	3.323219	18.00	1.00	2988.24	12.706	640.5	-341.8	0.73	-1.37	3.078	268.3	30.4	1.75	15.45
3	141.5	3.507141	18.33	1.00	1678.14	4.303	243.3	39.7	1.93	11.81	1.886	186.1	96.9	2.52	4.84
4	146.0	3.399931	19.00	1.00	1198.41	3.182	201.1	90.9	2.33	5.16	1.638	174.3	117.6	2.69	3.99
5	147.6	3.362962	18.20	1.00	911.69	2.776	185.1	110.1	2.54	4.26	1.533	168.3	126.9	2.79	3.70
6	149.0	3.331041	17.50	1.00	741.35	2.571	177.6	120.4	2.64	3.90	1.440	165.0	133.0	2.84	3.53

ESTIMATE FOR BEARS OLDER THAN 2.0 ONLY, INCLUDES SOME DEPENDENT OBSERVATIONS OF 2- AND 3-YEAR-OLDS:

(k) REP.	MEAN L-P FOR (k) REPS.	DENSITY mi2/bear	CUM. MEAN NO. MARKS SEEN	DENOMINATOR FOR BIAS CORRECTION FACTOR (eq. 13)	SAMPLE VARIANCE (eq. 2)	FOR 95% t w/ (k-1)d.f.	95% CI FOR NO. OF BEARS: upper	95% CI FOR NO. OF BEARS: lower	95% CI FOR MI2/BEAR: upper	95% CI FOR MI2/BEAR: lower	FOR 80% t w/ (k-1)d.f.	80% CI FOR NO. OF BEARS upper	80% CI FOR NO. OF BEARS lower	80% CI FOR MI2/BEAR: upper	80% CI FOR MI2/BEAR: lower
1	184.5	2.690027	19.00	1.00											
2	158.4	3.133764	25.00	1.00	1365.03	12.706	490.3	-173.6	0.96	-2.70	3.078	238.8	78.0	1.97	6.02
3	158.0	3.140650	24.33	1.00	682.88	4.303	222.9	93.1	2.11	5.04	1.886	186.5	129.6	2.52	3.62
4	166.3	2.984949	24.25	1.00	727.04	3.182	209.2	123.4	2.24	3.80	1.638	188.4	144.2	2.49	3.25
5	170.1	2.917739	23.00	1.00	618.63	2.776	201.0	139.2	2.34	3.37	1.533	187.2	153.0	2.51	3.07
6	174.3	2.846799	21.50	1.00	602.70	2.571	200.1	148.6	2.35	3.10	1.440	188.8	159.9	2.49	2.93

Table 6. Raw data for estimating number of groups of brown bears at Black Lake Alaska during spring 1989. Note a group is considered "marked" if any individual in that group is radio-marked.

GROUP	NUMBER OF MARKED GROUPS SEEN: REPLICATION						NUMBER OF MARKED GROUPS PRESENT BUT NOT SEEN: REPLICATION						NUMBER OF UNMARKED GROUPS SEEN: REPLICATION						TOTAL NUMBER OF GROUPS SEEN: REPLICATION						NO. GROUPS SEEN ON ALL REPLICATIONS
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
Female w/ 1 coy													1	1	1	3	1	1	1	1	1	3	1	1	8
Female w/ 2 coy		1	1	1			2	1	1	1	2	2			3	2		1	0	1	4	3	0	1	9
Female w/ 3 coy													1	1	2	1			1	1	2	1	0	0	5
Female w/ 1 ylg							1	1	1	1	1	1				1	2	1	0	0	0	1	2	1	4
Female w/ 2 ylg		1	1	1		1	1				1		5	1		3	6	6	5	2	1	4	6	7	25
Female w/ 3 ylg		2	1	2	1	2	3	1	2	1	2	1			1	2	2	2	0	2	2	4	3	4	15
Female w/ 1@ 2+	2	2	1	1			1		1	1	1	1	1	1	1	2	3	1	3	3	2	3	3	1	15
Female w/ 2@ 2+	3	2	1	1			1	1	1	1	1	1	2	3	3	4	3	2	5	5	4	5	3	2	24
Female w/ 3@ 2+			1		1							1	1	1	2	1	1		1	1	3	1	2	0	8
Breeding group w/																									
2 bears	2	5	4	6	5	6							2	1	2	3	2	3	4	6	6	9	7	9	41
3 bears					1											1			0	0	0	1	1	0	2
4 bears				1									1					1	1	0	0	1	0	1	3
Sibling group*																									
w/ 2 bears																3	1	2	0	0	0	3	1	2	6
No. seen singles																									
or unseen marked	4	12	9	6	7	5	21	14	17	15	16	16	21	25	17	22	15	13	25	37	26	28	22	18	156
No. Groups**							14.48	9.66	11.72	10.34	11.03	11.03													

Continued on next page

Table 6. continued.

GROUP	NUMBER OF MARKED GROUPS SEEN: REPLICATION 1	2	3	4	5	6	NUMBER OF MARKED GROUPS PRESENT BUT NOT SEEN: REPLICATION 1	2	3	4	5	6	NUMBER OF UNMARKED GROUPS SEEN REPLICATION 1	2	3	4	5	6	TOTAL NUMBER OF GROUPS SEEN REPLICATION 1	2	3	4	5	6	NO. GROUPS SEEN ON ALL REPLICATIONS
MEAN GROUP SIZE																									
Total No. bears	21	46	36	41	28	28	49	26	35	29	40	37	62	51	63	92	72	68	83	97	99	133	100	96	608
Total No. groups**	11	25	19	19	15	14	23.48	13.65	17.72	15.34	19.03	18.03	35	34	32	48	36	33	46	59	51	67	51	47	321
Mean group size	1.9	1.8	1.9	2.2	1.9	2.0	2.1	1.9	2.0	1.9	2.1	2.1	1.8	1.5	2.0	1.9	2.0	2.1	1.8	1.6	1.9	2.0	2.0	2.0	1.9
Family Groups																									
No. bears	13	24	19	19	8	11	28	12	18	14	24	21	33	24	42	55	51	41	46	48	61	74	59	52	340
No. groups	5	8	6	6	2	3	9	4	6	5	8	7	11	8	13	19	18	14	16	16	19	25	20	17	113
Mean group size	2.6	3.0	3.2	3.2	4.0	3.7	3.1	3.0	3.0	2.8	3.0	3.0	3.0	3.0	3.2	2.9	2.8	2.9	2.9	3.0	3.2	3.0	3.0	3.1	3.0
"Breeding" & Sibling Groups:																									
No. bears	4	10	8	16	13	12							8	2	4	15	6	14	12	12	12	31	19	26	112
No. groups	2	5	4	7	6	6							3	1	2	7	3	6	5	6	6	14	9	12	52
Mean group size	2.0	2.0	2.0	2.3	2.2	2.0							2.7	2.0	2.0	2.1	2.0	2.3	2.4	2.0	2.0	2.2	2.1	2.2	2.2
"Breeding", Sibling, and Groups of 1:																									
No. bears	8	22	17	22	20	17	21	14	17	15	16	16	29	27	21	37	21	27	37	49	38	59	41	44	268
No. groups**	6	17	13	13	13	11	14.48	9.66	11.72	10.34	11.03	11.03	24	26	19	29	18	19	30	43	32	42	31	30	208
Mean group size	1.3	1.3	1.3	1.7	1.5	1.5	1.45	1.45	1.45	1.45	1.45	1.45	1.2	1.0	1.1	1.3	1.2	1.4	1.2	1.1	1.2	1.4	1.3	1.5	1.3

* Some sibling groups were doubtless included along with breeding groups

**For marked but unseen bears, number of groups was calculated as (No.bears/1.45) where 1.45 is mean group size of marked bears seen during over all replications (106/73).

Table 7. Estimate of population size based on mean group size at Black Lake Alaska during spring 1989. Any marked bear in a group makes that group "marked". For breeding adults, siblings and single bears, the number of unseen marked groups was calculated based on the group size of marked bears that were seen. C:\BK89\GROUPEST.wk1

FOR ALL GROUPS:

Rep.	GROUP n1(marks present)	GROUP m2(marks seen)	GROUP n2(total seen)	EST. NO. OF GROUPS	OBSERVED MEAN GROUP SIZE (ALL BEARS SEEN)	DAILY EST. NO. BEARS	CUM.MEAN EST. NO. BEARS	SAMPLE VARIANCE	t w/ (k-1) d.f	95% CI= +/-	95% CI FOR NO.OF BEARS LOWER	UPPER	95% CI FOR DENSITY (MI2/BEAR) LOWER	UPPER	95% CI FOR DENSITY(BEARS/1000KM2) LOWER	UPPER
1	34.40	11	46	137.7	1.8	247.77	247.77									
2	38.60	25	59	90.4	1.64	148.23	198.00	4954.03	12.706	632.4	-434.37	830.37	-1.08	0.57	-357.63	683.67
3	36.70	19	51	97.0	1.94	188.22	194.74	2508.91	4.303	124.4	70.30	319.18	6.68	1.47	57.88	262.79
4	34.30	19	67	119.0	1.99	236.85	205.27	2115.92	3.182	73.2	132.08	278.45	3.55	1.69	108.75	229.26
5	34.00	15	51	112.8	1.96	220.99	208.41	1636.38	2.776	50.2	158.19	258.63	2.97	1.81	130.24	212.94
6	32.00	14	47	104.6	2.04	213.38	209.24	1313.22	2.571	38.0	171.20	247.28	2.74	1.90	140.96	203.59
		Avg. no. groups =		110.24		209.24										
			SE=	6.31		13.51										

FOR MATERNAL GROUPS ONLY:

Rep.	GROUP n1(marks present)	GROUP m2(marks seen)	GROUP n2(total seen)	EST. NO. OF GROUPS	OBSERVED MEAN GROUP SIZE (ALL BEARS SEEN)	DAILY EST. NO. BEARS	CUM.MEAN EST. NO. BEARS	SAMPLE VARIANCE	t w/ (k-1) d.f	95% CI= +/-	95% CI FOR NO.OF BEARS LOWER	UPPER	95% CI FOR DENSITY (MI2/BEAR) LOWER	UPPER	95% CI FOR DENSITY(BEARS/1000KM2) LOWER	UPPER
1	14	5	16	41.5	2.88	119.52	119.52									
2	12	8	16	23.6	3	70.67	95.09	1193.32	12.706	310.4	-215.27	405.46	-2.18	1.16	-177.24	333.83
3	12	6	19	36.1	3.21	116.02	102.07	742.62	4.303	67.7	34.37	169.77	13.66	2.76	28.30	139.78
4	11	6	25	43.6	2.96	128.97	108.79	676.02	3.182	41.4	67.43	150.16	6.96	3.13	55.52	123.63
5	10	2	20	76.0	2.95	224.20	131.88	3170.72	2.776	69.9	61.97	201.78	7.57	2.33	51.02	166.13
6	10	3	17	48.5	3.06	148.41	134.63	2582.14	2.571	53.3	81.30	187.97	5.77	2.50	66.93	154.76
		Avg. no. groups =		44.88		134.63										
			SE=	6.51		18.94										

FOR GROUPS OF BREEDING ADULTS, SIBLINGS, AND SINGLE BEARS:

Rep.	GROUP n1(marks present)	GROUP m2(marks seen)	GROUP n2(total seen)	EST. NO. OF GROUPS	OBSERVED MEAN GROUP SIZE (ALL BEARS SEEN)	DAILY EST. NO. BEARS	CUM.MEAN EST. NO. BEARS	SAMPLE VARIANCE	t w/ (k-1) d.f	95% CI= +/-	95% CI FOR NO.OF BEARS LOWER	UPPER	95% CI FOR DENSITY (MI2/BEAR) LOWER	UPPER	95% CI FOR DENSITY(BEARS/1000KM2) LOWER	UPPER
1	20.48	6	30	94.1	1.23	115.77	115.77									
2	26.65	17	43	66.6	1.14	75.91	95.84	794.54	12.706	253.3	-157.41	349.09	-2.98	1.34	-129.60	287.42
3	24.72	13	32	59.6	1.19	70.95	87.55	603.75	4.303	61.0	26.50	148.59	17.71	3.16	21.82	122.34
4	23.34	13	42	73.8	1.4	103.26	91.48	464.24	3.182	34.3	57.20	125.76	8.21	3.73	47.09	103.54
5	24.03	13	31	56.2	1.32	74.20	88.02	407.88	2.776	25.1	62.95	113.09	7.46	4.15	51.83	93.11
6	22.03	11	30	58.5	1.47	85.99	87.68	326.99	2.571	19.0	68.70	106.66	6.83	4.40	56.56	87.82
		Avg. no. groups =		68.13		87.68										
			SE=	5.32		6.74										

Table 8. Number of groups of brown bears seen during density estimation at Black Lake, Alaska during spring 1989. Note that many sightings are resightings of the same group(s).

CLASSIFICATION	GROUP SIZE 1	2	3	4	NO. OF GROUPS	MEAN SIZE
Females with COY	0	8	9	5	22	2.86
Females with "ylgs"	0	4	26	15	45	3.24
Females with ">ylgs"	0	12	24	8	44	2.91
Groups of "adults"*	0	47	4	2	53	2.15
Single bears	142	0	0	0	142	1.00
Groups of "siblings"**	0	7	0	0	7	2.00
TOTALS	142	78	63	30	313	1.94
PERCENT OF GROUPS	45.3	24.9	20.1	9.58	100	

* Includes groups of adults (mostly breeding pairs, some with offspring hanging around), and some sibling groups.

** A consistent effort was not made to identify sibling groups, most are included along with groups of "adults".

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Table 9. Search effort during 1989 brown bear density estimate at Black Lake, Alaska.

Quad.	AREA (mi2)	SEARCH EFFORT (MINUTES) Rep. 1	Rep. 2	Rep. 3	Rep. 4	Rep. 5	Rep. 6	MEAN SEARCH TIME	MEAN MIN./MI2	TARGET MIN./MI2	SEARCH TEAM* Rep. 1	Rep. 2	Rep. 3	Rep. 4	Rep. 5	Rep. 6
1	42.65	64	87	70	53	80	75	71.5	1.68	2	1	2	1	5	4	1
2	78.25	100	147	90	134	106	143	120.0	1.53	2	1	2	1	5	4	2
3	20.59	32	47	49	45	37	29	39.8	1.93	2	1	2	4	5	1	1
4	49.03	106	125	108	77	96	90	100.3	2.05	3	4	5	4	1	5	5
5	36.38	75	75	60	78	70	63	70.2	1.93	3	4	5	4	1	1	2
6	35.75	154	127	147	103	112	93	122.7	3.43	3	4	3	5	2	2	5
7	47.98	89	149	148	164	221	136	151.2	3.15	3	5	3	2	4	5	4
8	51.35	112	116	180	119	173	119	136.5	2.66	3	5	3	2	4	2	4
9	39.96	85	103	99	78	82	107	92.3	2.31	3	5	1	5	1	4	1
10	27.82	103	90	73	85	92	61	84.0	3.02	3	2	5	2	4	1	4
11	39.55	136	116	130	100	103	177	127.0	3.21	3	2	1	5	2	4	5
TOT.	469.31	1056	1182	1154	1036	1172	1093	1115.5	2.38							
MIN/MI2		2.25	2.51	2.45	2.20	2.49	2.33	2.38								

*1=DM/JC, 2=SM/JL, 3=KT/HM, 4=LV/HM, 5=BT/CM.

Table 10. Number of bears seen during brown bear density estimate at Black Lake, Alaska sorted in order of increasing number of independent bears seen/minute of search effort.

Quad.	* MEAN MIN./MI2	NUMBER INDEPENDENT BEARS SEEN: Rep. 1	Rep. 2	Rep. 3	Rep. 4	Rep. 5	Rep. 6	MEAN NO.	** MEAN MIN./BEAR	*** MI2/ MEAN NO.	TOTAL NO.BEARS SEEN, ALL AGES: Rep. 1	Rep. 2	Rep. 3	Rep. 4	Rep. 5	Rep. 6	MEAN NO.	MEAN MIN./BEAR	*** MI2/ MEAN NO.
7	3.15	11	15	11	26	21	18	17.0	8.89	2.82	21	28	26	46	40	31	32.0	4.72	1.50
10	3.02	7	8	5	10	6	2	6.3	13.26	4.39	11	14	11	14	8	6	10.7	7.88	2.61
11	3.21	8	4	9	10	6	11	8.0	15.88	4.94	14	4	12	10	11	12	10.5	12.10	3.77
8	2.66	4	9	10	9	7	10	8.2	16.71	6.29	10	14	16	19	14	17	15.0	9.10	3.42
6	3.43	12	9	5	6	5	3	6.7	18.40	5.36	14	13	7	11	9	11	10.8	11.32	3.30
4	2.05	2	7	5	8	5	3	5.0	20.07	9.81	3	9	8	9	5	4	6.3	15.84	7.74
1	1.68	1	2	4	3	2	5	2.8	25.24	15.05	1	2	5	4	3	5	3.3	21.45	12.79
9	2.31	0	4	3	5	3	5	3.3	27.70	11.99	0	4	8	10	3	7	5.3	17.31	7.49
2	1.53	0	4	5	4	3	2	3.0	40.00	26.08	0	5	6	6	3	5	4.2	28.80	18.78
5	1.93	5	1	0	1	3	0	1.7	42.10	21.83	7	1	0	1	4	0	2.2	32.38	16.79
3	1.93	1	1	0	0	1	1	0.7	59.75	30.89	2	2	0	0	1	1	1.0	39.83	20.59
TOTAL	2.38	51	64	57	82	62	60	62.7	17.80	7.49	83	96	99	130	101	99	101.3	11.01	4.63
MIN/MI2		0.11	0.14	0.12	0.17	0.13	0.13				0.18	0.20	0.21	0.28	0.22	0.21			

* From Table 9.

** Data are sorted from lowest to highest value of search minutes/bear seen

*** Area of quadrat/mean number of bears seen

Table 11. Estimated density in each quadrat of search area based on total estimated population size using the mean of the daily Lincoln-Petersen estimates (239 bears) and a constant calculated from mean number of

Quad.	AREA (mi2)	MEAN MIN./BEAR (xi)	BEARS/ MIN. 1/(xi)	(P) = PROPORTION OF 0.56	IN EACH QUADRAT: ESTIMATED NO. BEARS (239*P)	ESTIMATED DENSITY (mi2/bear)	CUMULATIVE DENSITY (down)	CUMULATIVE AREA (%) (down)	CUMULATIVE DENSITY (up)	CUMULATIVE AREA (%) (up)
10	27.82	13.26	0.08	0.136	32.41	0.86	0.86	5.9	1.96	100.0
7	47.98	8.89	0.11	0.202	48.33	0.99	0.94	16.2	2.14	94.1
11	39.55	15.88	0.06	0.113	27.07	1.46	1.07	24.6	2.49	83.8
6	35.75	18.40	0.05	0.098	23.36	1.53	1.15	32.2	2.70	75.4
8	51.35	16.71	0.06	0.108	25.71	2.00	1.29	43.1	2.95	67.8
4	49.03	20.07	0.05	0.090	21.42	2.29	1.41	53.6	3.25	56.9
1	42.65	25.24	0.04	0.071	17.03	2.50	1.51	62.7	3.59	46.4
9	39.96	27.70	0.04	0.065	15.52	2.58	1.58	71.2	4.01	37.3
3	20.59	59.75	0.02	0.030	7.19	2.86	1.63	75.6	4.80	28.8
5	36.38	42.10	0.02	0.043	10.21	3.56	1.71	83.3	5.47	24.4
2	78.25	40.00	0.03	0.045	10.74	7.28	1.96	100.0	7.28	16.7
SUM =	469.31		0.56	1.000	239.0	1.96				

Table 12. **Sex and age composition of brown bears captured near Black Lake, Alaska, using capture samples from consecutive years with status adjusted for the first year listed.**

	1970-71		1971-72		1974-75		1988-89	
Category	Number	(%)	Number	(%)	Number	(%)	Number	(%)
Adult Females								
Single	15	9	12	6	14	8	9	7
With coy	5	3	17	9	7	4	7	5
With 1-yr-olds	18	11	6	3	11	7	10	8
With 2-yr-olds	2	1	9	4	8	5	7	5
Total	40	24	44	23	40	25	33	27
Offspring with females								
Cubs	13	7	34	18	14	8	17	14
Yearlings	34	20	14	7	24	15	19	15
2-yr-olds	7	4	15	8	19	12	11	9
Subadult Females	33	20	38	20	18	11	12	9
Subadult Males	26	15	33	17	33	21	16	13
Adult Males	10	6	8	4	8	5	13	10
Total Bears	163		186		156		121	
Ad Males:100 Ad Females	25.0		17.4		20.0		39.4	
Mean age of adult males	6.6		7.9		7.2		9.9	
Mean age of adult females	9.0		9.0		10.6		12.2	

Table 13. Current status of brown bears marked near Black Lake 1988-89.

Bear No.	Sex	Age at last contact	Date last location	Current status
001	F	12	12/18/89	Alive, lost 1 of 2 yearlings from 1988 capture Still with #2 on 11/06/89
002	F	2	11/06/89	Still with mother (#1)
003	M	2	10/20/89	Separated from mother at 1.5, hunter kill at 2.8
004	F	13	06/22/89	Collar shed after den emergence
005	M	15	05/25/89	Unk, recapt. in 1989 but glue-on radio shed
006	F	5	05/12/89	Unk, collar shed in den
007	M	4	06/01/88	Unk, no radio
008	F	5	10/15/89	Hunter kill
009	M	3	12/31/88	Unk, collar shed before den enterance
010	M	3	09/08/88	Glue-on radio shed as of 9/8/88
011	F	26	12/18/89	Alive, denned
012	F	10	12/18/89	Alive, denned presummed w/2 COY
013	F	3	12/18/89	Alive, denned
014	M	8	06/02/88	Unk, no radio
015	M	16	06/06/88	Glue-on radio shed
016	F	5	10/05/89	Radio shed
017	F	19	12/18/89	Alive, denned
018	F	12	12/18/89	Alive, denned
019	F	1	06/02/88	Separated from mother (#18) at capture, presummed dead
020	F	1	06/02/88	Separated from mother (#18) at capture, presummed dead
021	F	3	09/22/88	Unk, glue-on shed before den enterance
022	F	10	06/02/88	Capture mortality
023	F	19	12/18/89	Alive, denned
024	M	2	05/31/89	Unk, separated from mother, no radio
025	M	16	06/02/88	Unk, no radio
026	F	12	12/18/89	Alive, denned
027	F	2	06/06/88	Unk, glue-on radio nonfunctional
028	M	2	06/02/88	Unk, no radio
029	M	2	06/02/88	Unk, no radio
030	F	10	12/18/89	Alive, denned
031	M	3	10/25/89	Unk, collar shed
032	F	14	06/03/88	Capture mortality
033	M	3	10/16/89	Hunter kill
034	F	13	12/18/89	Alive, denned w/3 yrlg
036	F	10	06/26/88	Natural mortality
A	F	0		Mother (#36) dead, presummed dead
B	F	0		Mother (#36) dead, presummed dead
037	F	6	12/18/89	Alive, denned
038	F	17	12/18/89	Alive,denned
039	M	3	10/05/89	Hunter kill
040	F	5	12/18/89	Alive, denned
041	M	14	10/06/89	Hunter kill
042	M	5	05/22/89	Unk, glue-on shed
043	F	6	05/12/89	Unk, collar shed after den emergence

Continued...

Table 13. Continued.

Bear No.	Sex	Age at last contact	Date last location	Current status
044	F	20	10/20/88	Natural mortality
045	F	3	05/24/89	Unk, collar shed
046	F	11	12/18/89	Alive, denned
047	M	4	12/05/88	Unk, collar shed before den enterance
048	M	4	12/18/89	Alive, denned
049	M	7	05/25/89	Unk, glue-on shed
050	F	5	12/18/89	Alive, denned
051	F	13	12/18/89	Alive, denned w/2 2.8 possibly
052	F	4	12/18/89	Alive, denned
053	F	4	10/12/89	Hunter kill
054	M	3	09/08/88	Unk, radio failure
055	F	10	12/18/89	Alive, denned
056	M	2	06/05/88	Unk, no radio
057	F	9	12/18/89	Alive, denned
058	F	19	12/18/89	Alive, denned
059	F	6	11/06/89	Alive, denned
060	F	9	12/18/89	Alive, denned
061	F	4	05/24/89	Unk, glue-on shed
062	M	2	05/21/89	Capture mortality
064	M	10	05/23/89	Unk, glue-on shed
065	F	10	12/18/89	Alive, denned
066	M	2	06/22/89	Unk, glue-on shed
067	F	3	10/18/89	Hunter kill
068	M	6	10/08/89	Hunter kill
069	F	19	08/09/89	Natural mortality, presummed 3 yrlgs lost
070	F	7	12/18/89	Alive, denned w/2 yrlg
071	M	5	05/24/89	Unk, glue-on shed
072	M	8	05/23/89	Unk, glue-on shed
073	M	2	06/04/89	Unk, glue-on shed
074	M	3	05/23/89	Unk, glue-on shed
075	F	4	06/03/89	Natural mortality
076	F	14	12/18/89	Alive, denned
077	F	3	10/08/89	Hunter kill
078	M	4	06/22/89	Unk, Radio failure
079	M	10	05/24/89	Unk, glue-on shed
080	F	13	05/30/89	Unk, collar shed
081	M	4	08/30/89	Unk, radio failure or dispersal
082	F	14	12/18/89	Alive, denned
083	M	6	10/25/89	Alive
084	M	3	10/05/89	Hunter Kill
085	M	12	06/04/89	Unk, glue-on shed
086	M	5	06/04/89	Unk, glue-on shed
087	F	12	12/18/89	Alive, denned w/3 yrlgs
088	F	19	08/08/89	Natural mortality
089	M	11	05/24/89	Unk, glue-on shed
090	F	19	12/18/89	Alive, denned w/1 yrlg
091	M	4	12/18/89	Alive, denned
092	F	3	12/18/89	Alive

Table 14. Survivorship of radio-marked brown bears at Black Lake, Alaska during 1988 and 1989 calculated using modified Kaplan-Meier procedures (Pollock et al. 1989).

CUBS WITH RADIOED MOTHERS. In period 4, 3 deaths were from same litter, not independent.

DATES	NO.@ RISK	NO. DEATHS	SURVIVAL RATE	NO. CENSORED	NO. ADDED	LOWER CL	UPPER CL
5/1-5/15	4	0	1.00	0	0	1.00	1.00
5/16-5/23	4	0	1.00	0	0	1.00	1.00
5/24-5/31	4	0	1.00	0	0	1.00	1.00
6/1-6/7	4	0	1.00	0	6	1.00	1.00
6/8-6/15	10	3	0.70	0	0	0.46	0.94
6/16-6/23	7	0	0.70	0	0	0.42	0.98
6/24-6/30	7	0	0.70	0	0	0.42	0.98
7/1-7/31	7	1	0.60	0	0	0.32	0.88
8/1-8/31	6	0	0.60	0	0	0.30	0.90
9/1-9/30	6	0	0.60	0	0	0.30	0.90
10/1-10/3	6	0	0.60	0	0	0.30	0.90
11/1-4/30	6		0.60	3			

FEMALES >=3 ALL TYPES OF MORTALITY

DATES	NO.@ RISK	NO. DEATHS	SURVIVAL RATE	NO. CENSORED	NO. ADDED	LOWER CL	UPPER CL
5/1-5/15	25	0	1.00	0	0	1.00	1.00
5/16-5/23	25	0	1.00	2	9	1.00	1.00
5/24-5/31	25	1	0.96		3	0.88	1.04
6/1-6/7	27		0.96		27	0.89	1.03
6/8-6/15	54	1	0.94			0.88	1.00
6/16-6/23	53		0.94			0.88	1.00
6/24-6/30	53		0.94			0.88	1.00
7/1-7/31	53	2	0.91			0.83	0.98
8/1-8/31	51		0.91			0.83	0.98
9/1-9/30	51		0.91	2		0.83	0.98
10/1-10/3	49	4	0.83			0.74	0.93
11/1-4/30	45		0.83	2		0.73	0.93

continued

Table 14, continued.

FEMALES >=3, HUNTING MORTALITY ONLY

DATES	NO.@ RISK	NO. DEATHS	SURVIVAL RATE	NO. CENSORED	NO. ADDED	LOWER CL	UPPER CL
5/1-5/15	25	0	1.00	0	0	1.00	1.00
5/16-5/23	25	0	1.00	2	9	1.00	1.00
5/24-5/31	32	0	1.00	1	3	1.00	1.00
6/1-6/7	34	0	1.00	0	27	1.00	1.00
6/8-6/15	61	0	1.00	1		1.00	1.00
6/16-6/23	60	0	1.00	0		1.00	1.00
6/24-6/30	60	0	1.00	0		1.00	1.00
7/1-7/31	60	0	1.00	2		1.00	1.00
8/1-8/31	58	0	1.00	0		1.00	1.00
9/1-9/30	58	0	1.00	2		1.00	1.00
10/1-10/3	56	3	0.95	1		0.89	1.00
11/1-4/30	52		0.95	2		0.89	1.01

FEMALES >=3, NATURAL MORTALITY ONLY

DATES	NO.@ RISK	NO. DEATHS	SURVIVAL RATE	NO. CENSORED	NO. ADDED	LOWER CL	UPPER CL
5/1-5/15	25	0	1.00	0	0	1.00	1.00
5/16-5/23	25	0	1.00	2	9	1.00	1.00
5/24-5/31	32	1	0.97	0	3	0.91	1.03
6/1-6/7	34	0	0.97	0	27	0.91	1.03
6/8-6/15	61	1	0.95	0		0.90	1.00
6/16-6/23	60	0	0.95	0		0.90	1.01
6/24-6/30	60	0	0.95	0		0.90	1.01
7/1-7/31	60	2	0.92	0		0.86	0.99
8/1-8/31	58	0	0.92	0		0.85	0.99
9/1-9/30	58	0	0.92	2		0.85	0.99
10/1-10/3	56	1	0.90	3		0.83	0.98
11/1-4/30	52		0.90	2		0.83	0.98

MALES >=3, ALL MORTALITIES. Same result for hunting mo
as there was no natural mortality.

DATES	NO.@ RISK	NO. DEATHS	SURVIVAL RATE	NO. CENSORED	NO. ADDED	LOWER CL	UPPER CL
5/1-5/15	1		1.00		0	1.00	1.00
5/16-5/23	1		1.00		4	1.00	1.00
5/24-5/31	5		1.00	1	3	1.00	1.00
6/1-6/7	7		1.00		3	1.00	1.00
6/8-6/15	10		1.00	1		1.00	1.00
6/16-6/23	9		1.00			1.00	1.00
6/24-6/30	9		1.00	1		1.00	1.00
7/1-7/31	8		1.00			1.00	1.00
8/1-8/31	8		1.00	1		1.00	1.00
9/1-9/30	7		1.00	1		1.00	1.00
10/1-10/3	6	1	0.83	2		0.56	1.11
11/1-4/30	3		0.83	4		0.45	1.22

continued

Table 14, continued.

BOTH SEXES >=3, ALL MORTALITIES

DATES	NO.@ RISK	NO. DEATHS	SURVIVAL RATE	NO. CENSORED	NO. ADDED	LOWER CL	UPPER CL
5/1-5/15	26	0	1.00	0	0	1.00	1.00
5/16-5/23	26	0	1.00	2	13	1.00	1.00
5/24-5/31	37	1	0.97	1	6	0.92	1.02
6/1-6/7	41	0	0.97	0	30	0.92	1.02
6/8-6/15	71	1	0.96	1	0	0.91	1.00
6/16-6/23	69	0	0.96	0	0	0.91	1.00
6/24-6/30	69	0	0.96	1	0	0.91	1.00
7/1-7/31	68	2	0.93	0	0	0.87	0.99
8/1-8/31	66	0	0.93	1	0	0.87	0.99
9/1-9/30	65	0	0.93	3	0	0.87	0.99
10/1-10/3	62	5	0.86	2	0	0.78	0.94
11/1-4/30	55	0	0.86	6	0	0.77	0.94

ALL YEARLINGS, ALL MORTALITIES (Includes 3 assumed mortalities.

DATES	NO.@ RISK	NO. DEATHS	SURVIVAL RATE	NO. CENSORED	NO. ADDED	LOWER CL	UPPER CL
5/1-5/15	3		1.00			1.00	1.00
5/16-5/23	3		1.00		3	1.00	1.00
5/24-5/31	6		1.00		3	1.00	1.00
6/1-6/7	9		1.00		9	1.00	1.00
6/8-6/15	18		1.00			1.00	1.00
6/16-6/23	18		1.00			1.00	1.00
6/24-6/30	18		1.00			1.00	1.00
7/1-7/31	18	3	0.83			0.68	0.99
8/1-8/31	15		0.83	3		0.66	1.01
9/1-9/30	12		0.83			0.64	1.03
10/1-10/3	12		0.83	3		0.64	1.03
11/1-4/30	9		0.83			0.61	1.06

ALL 2-YEAR OLDS, ALL MORTALITIES,

DATES	NO.@ RISK	NO. DEATHS	SURVIVAL RATE	NO. CENSORED	NO. ADDED	LOWER CL	UPPER CL
5/1-5/15	8		1.00	0	0	1.00	1.00
5/16-5/23	8		1.00	0	2	1.00	1.00
5/24-5/31	10		1.00	0	1	1.00	1.00
6/1-6/7	11		1.00	1	6	1.00	1.00
6/8-6/15	16		1.00	0	0	1.00	1.00
6/16-6/23	16		1.00	2	0	1.00	1.00
6/24-6/30	14		1.00	0	0	1.00	1.00
7/1-7/31	14		1.00	4	0	1.00	1.00
8/1-8/31	10		1.00	2	0	1.00	1.00
9/1-9/30	8		1.00	1	0	1.00	1.00
10/1-10/3	7		1.00	1	0	1.00	1.00
11/1-4/30	6	0	1.00	3	0	1.00	1.00

continued

Table 14, continued.

ALL BEARS EXCEPT CUBS, ALL MORTALITIES,

DATES	NO.@ RISK	NO. DEATHS	SURVIVAL RATE	NO. CENSORED	NO. ADDED	LOWER CL	UPPER CL
5/1-5/15	37	0	1.00	0	0	1.00	1.00
5/16-5/23	37	0	1.00	2	18	1.00	1.00
5/24-5/31	53	1	0.98	1	10	0.94	1.02
6/1-6/7	61	0	0.98	1	45	0.95	1.01
6/8-6/15	105	1	0.97	1	0	0.94	1.00
6/16-6/23	103	0	0.97	2	0	0.94	1.00
6/24-6/30	101	0	0.97	1	0	0.94	1.00
7/1-7/31	100	5	0.92	4	0	0.87	0.97
8/1-8/31	91	0	0.92	6	0	0.87	0.98
9/1-9/30	85	0	0.92	4	0	0.87	0.98
10/1-10/3	81	5	0.87	6	0	0.80	0.94
11/1-4/30	70	0	0.87	9	0	0.79	0.94

Table 15. Minimum and maximum exploitation rates for brown bears 2 or more years old marked near Black Lake, Alaska, 1970.

Sex/age category in 1970	Maximum no. alive	Minimum no. alive	1970 fall harvest	1971 spring harvest
Ad Male	7	6	0	1
Ad Female	28	22	0	0
Imm Male	17	12	2	1
Imm Female	19	15	1	0
Total	71	55	4	2
Exploitation	8.5%*	10.9%**		

* Assumes no natural mortality to marked bears.
** Includes only those marked bears that were verified to be alive during the harvest period.

Table 16. Minimum and maximum exploitation rates for brown bears 2 or more years old marked near Black Lake, Alaska, 1971-72. EXPLOIT.WK1

Sex/age category in 1971	Maximum no. alive	Minimum no. alive	1971 fall harvest	1972 spring harvest
Ad Male	8	6	1	1
Ad Female	43	31	2	2
Imm Male	42	29	6	1
Imm Female	45	26	4	0
Total	138	92	13	4
Exploitation	12.3%*	18.5%**		

* Assumes no natural mortality to marked bears.
** Includes only those marked bears that were verified to be alive during the harvest period.

Table 17. Minimum exploitation rates for brown bears 2 or more years old marked near Black Lake, Alaska, 1972-73.

Sex/age category in 1972	Maximum no. alive	1972 fall harvest	1973 spring harvest
Ad Male	17	2	2
Ad Female	67	4	0
Imm Male	45	10	6
Imm Female	46	7	0
Total	175	23	8
Exploitation	17.7%*		

* Assumes no natural mortality to marked bears.

Table 18. Minimum exploitation rates for brown bears 2 or more years old marked near Black Lake, Alaska, 1973-74.

Sex/age category in 1973	Maximum no. alive	1973 fall harvest	1974 spring harvest**
Ad Male	24	3	1
Ad Female	74	2	
Imm Male	44	3	
Imm Female	43	4	
Total	185	12	1
Exploitation	7.0%*		

* Assumes no natural mortality to marked bears.
** The spring 1974 season was closed by emergency order; one bear was killed illegally.

Table 19. Minimum exploitation rates for brown bears 2 or more years old marked near Black Lake, Alaska, 1974-75.

Sex/age category in 1974	Maximum no. alive	1974 fall harvest	1975 spring harvest**
Ad Male	37	1	
Ad Female	100	3	
Imm Male	50	5	
Imm Female	37	3	
Unk. sex/age		2	
Total	224	14	
Exploitation	6.2%*		

* Assumes no natural mortality to marked bears.
** The spring 1975 season was closed by emergency order.

Table 20. Minimum exploitation rates for brown bears 2 or more years old marked near Black Lake, Alaska, 1975-76.

Sex/age category in 1975	Maximum no. alive	1975 fall harvest	1976 spring harvest
Ad Male	48	1	4
Ad Female	106	4	2
Imm Male	60	4	5
Imm Female	38	4	2
Total	252	13	13
Exploitation	10.3%*		

* Assumes no natural mortality to marked bears.

Table 21. Minimum exploitation rates for brown bears 2 or more years old marked near Black Lake, Alaska, 1988-89.

Sex/age category in 1989	Maximum no. alive*	1989 fall harvest	1990 spring harvest
Ad Male	17	2	--
Ad Female	36	1	--
Imm Male	21	4	--
Imm Female	14	3	--
Total	88	10	--
Exploitation	11.4%		

* Confirmed natural mortalities were included to make data comparable to 1970-75 samples.

Table 22. Exploitation rates for marked brown bears 2 years or older captured 1 or 2 years prior to being harvested.

Sex/age category	Maximum no. alive	Fall harvest	Spring harvest
1970			
Ad Male	7	0	1
Ad Female	28	0	0
Imm Male	17	3	1
Imm Female	19	1	0
Total	71	4	2
Exploitation	8.5%		
1971			
Ad Male	8	1	1
Ad Female	43	2	2
Imm Male	42	6	1
Imm Female	45	4	0
Total	138	13	4
Exploitation	12.3%		
1972			
Ad Male	10	1	1
Ad Female	42	3	0
Imm Male	36	9	3
Imm Female	35	4	0
Total	123	17	4
Exploitation	17.1%		
1973			
Ad Male	8	3	The Spring 1974 season
Ad Female	34	2	was closed by Emergency order.
Imm Male	30	2	
Imm Female	24	2	
Total	96	9	
Exploitation	9.4%*		
* This exploitation rate is biased low because bears were not marked in 1973, thus all marked bears were subject to 15 months of natural mortality.			
1975			
Ad Male	14	0	2
Ad Female	41	4	1
Imm Male	44	4	5
Imm Female	27	4	2
Total	126	12	10
Exploitation		9.5%	8.8%
1989			
Ad Male	17	2	
Ad Female	36	1	
Imm Male	21	4	
Imm Female	14	3	
Total	88	10	
Exploitation		11.4%	

Table 23. Black Lake stream survey results. 1982-89.

Date	Females w/young no.	Females w/young %	COY no.	COY %	>COY no.	>COY %	Single bears no.	Single bears %	Total sample	Bears per hour	Comments
1982											
8/8 am	26	19	25	19	25	19	58	43	134	40.20	
8/8 pm	27	18	37	25	29	20	55	37	148	50.74	
Mean	27	19	31	22	27	19	57	40	141	45.47	
1983											
8/9 pm	34	24	33	24	35	25	38	27	140	48.00	USFWS
8/10am	41	25	49	29	34	20	43	26	167	51.12	USFWS
8/10pm	29	19	42	28	24	16	56	37	151	61.22	USFWS
8/12am	35	20	47	27	29	17	62	36	173	55.81	USFWS
Mean	35	22	43	27	31	20	50	32	158	54.04	
1984											
8/7 am	28	25	32	29	22	20	28	25	110	33.85	
8/7 pm	37	22	32	19	47	27	55	32	171	64.04	
8/8 am*	31	27	20	17	36	31	29	25	116	61.88	
8/8 pm	37	24	26	17	44	29	46	30	153	61.20	
Mean	33	24	28	21	37	27	40	29	138	55.24	
1985											
8/5 pm	47	23	35	17	60	29	64	31	206	68.70	
8/6 am	35	20	36	20	45	25	62	35	178	59.30	
8/8 am	47	22	37	17	65	30	66	31	215	67.90	
Mean	43	21	36	18	57	28	64	32	200	65.30	
1986											
8/6 pm	38	22	27	16	46	27	62	36	173	49.40	
8/7 am	25	15	17	10	36	22	85	52	163	51.40	
8/7 pm	41	20	29	14	44	22	88	44	202	61.60	
8/8 pm	34	20	21	13	40	24	71	43	166	47.40	
Mean	35	20	24	13	42	24	77	43	176	52.45	

* Includes the mean number of bears seen 3 other 1984 surveys for the portion not covered.

Continued...

Table 23. Continued.

Date	Females w/young no.	Females w/young %	COY no.	COY %	>COY no.	>COY %	Single bears no.	Single bears %	Total sample	Bears per hour	Comments
1987											
8/7 pm	3	11	2	7	5	18	18	64	28		aborted,
8/12 pm	27	18	34	23	28	19	58	39	147	51.88	turbulence
1988											late in run
8/8 pm	40	25	34	22	47	30	37	23	158	45.14	
8/9 am	51	24	49	23	65	30	50	23	217	62.00	
8/10 am	31	20	23	15	43	28	57	37	154	48.13	
8/10 pm	38	24	31	20	50	32	38	24	157	49.58	
Mean	40	23	34	20	51	30	46	27	172	51.21	
1989											
8/9 am	37	20	26	14	53	29	65	36	181	62.06	
8/9 pm	40	21	25	13	55	29	72	38	192	66.59	
8/10 am*	32	18	20	11	54	31	70	40	175	62.32	
8/12 am	34	19	20	11	56	32	65	37	175	66.88	
8/12 pm	39	22	19	10	64	35	59	33	181	65.03	
Mean	36	20	22	12	56	31	66	37	181	64.58	

** This survey includes the mean number of bears seen in the West Fork drainage on the other 1989 surveys.

Table 24. Number of brown bears counted on each stream survey, at Black Lake, Alaska, 1962-89.

1962		1965-70		1974		1975		1982-84		1985-89	
Date	No. bears	Date	No. bears	Date	No. bears	Date	No. bears	Date	No. bears	Date	No. bears
31 Jul a.m.	94	6 Aug 1965 p.m.	123	5 Aug a.m.	77	5 Aug p.m.	115	8 Aug 1982 a.m.	134	5 Aug 1985 p.m.	206
3 Aug a.m.	81	7 Aug 1965 a.m.	113	6 Aug a.m.	104			8 Aug 1982 p.m.	148	6 Aug 1985 a.m.	178
4 Aug p.m.	91	23 Jul 1969 p.m.	110					9 Aug 1983 p.m.	140	8 Aug 1985 a.m.	215
5 Aug a.m.	81	26 Jul 1969 a.m.	122					10 Aug 1983 a.m.	167	6 Aug 1986 p.m.	173
5 Aug p.m.	95	26 Jul 1969 p.m.	107					10 Aug 1983 p.m.	151	7 Aug 1986 a.m.	163
6 Aug p.m.	113	27 Jul 1969 a.m.	114					12 Aug 1983 a.m.	173	7 Aug 1986 p.m.	202
7 Aug a.m.	86	3 Aug 1969 a.m.	92					7 Aug 1984 a.m.	110	8 Aug 1986 p.m.	166
		3 Aug 1969 p.m.	115					7 Aug 1984 p.m.	171	12 Aug 1987 p.m.	147
		27 Jul 1970 p.m.	106					8 Aug 1984 a.m.	116*	8 Aug 1988 p.m.	158
								8 Aug 1984 p.m.	153	9 Aug 1988 a.m.	217
										10 Aug 1988 a.m.	154
										10 Aug 1988 p.m.	157
										9 Aug 1989 a.m.	181
										9 Aug 1989 p.m.	192
										10 Aug 1989 a.m.	175*
										12 Aug 1989 a.m.	175
										12 Aug 1989 p.m.	181

* Totals adjusted to correct for incomplete survey.

Table 25. Mean number of brown bears per survey for 6 time periods, 1962-89.

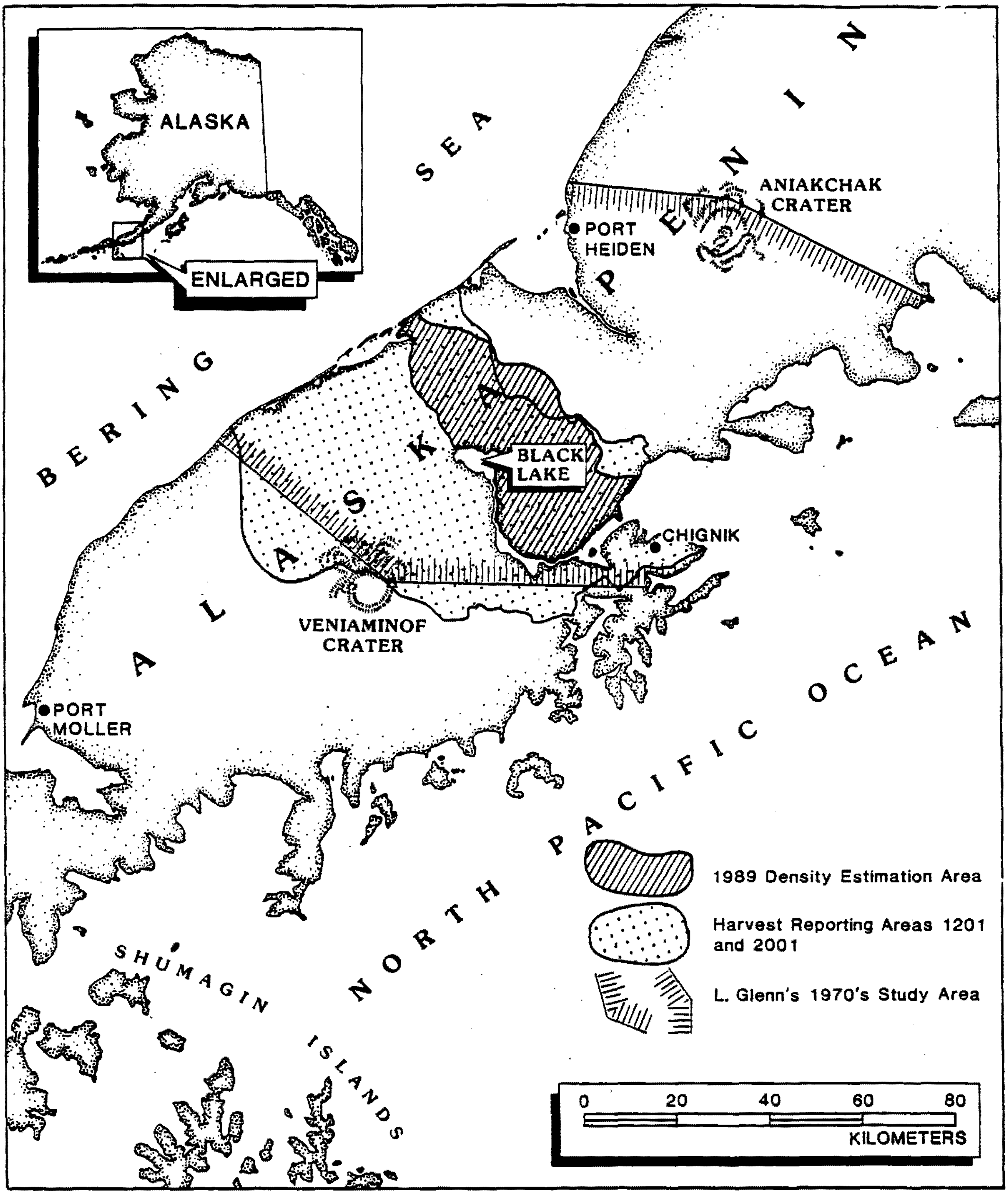
Time period	No. surveys	Mean no. bears	SD	95% CI
1962	7	91.6	10.2	84-99
1965-70	9	111.3a	8.8	106-117
1974	2	90.5	13.5	72-109
1976	1	115	N/A	
1982-84	10	146.3a	20.6	133-159
1985-89	17	178.8a	20.6	169-189

a Means greater ($P<.001$) than previous surveys.

Table 26. Relationship between cub-of-the-year (COY) production and sockeye salmon escapement the previous year into Black Lake, 1982-89.

Salmon escapement	% COY in population	COY litter size	Year
377500	13.3	2.20	1986
420600	12.2	2.05	1989
426200	20.5	2.10	1984
438500	21.8	2.10	1982
566100	20.6	2.25	1987
589300	19.7	2.14	1988
597700	18.1	2.20	1985
616100	27	2.30	1983

Figure 1. Location of the Black Lake density estimation study area, Glenn's 1970's study area and harvest reporting units 1201 and 2001.



ALASKA
ENLARGED
BERING SEA
ALASKA PENINSULA
ANIAKCHAK CRATER
PORT HEIDEN
BLACK LAKE
CHIGNIK
VENIAMINOF CRATER
PORT MOLLER
NORTH PACIFIC OCEAN
SHUMAGIN ISLANDS
1989 Density Estimation Area
Harvest Reporting Areas 1201 and 2001
L. Glenn's 1970's Study Area
0
20
40
60
80
KILOMETERS

Figure 2. Location of quadrats used to estimate brown bear density in the Black Lake study area during spring 1989.

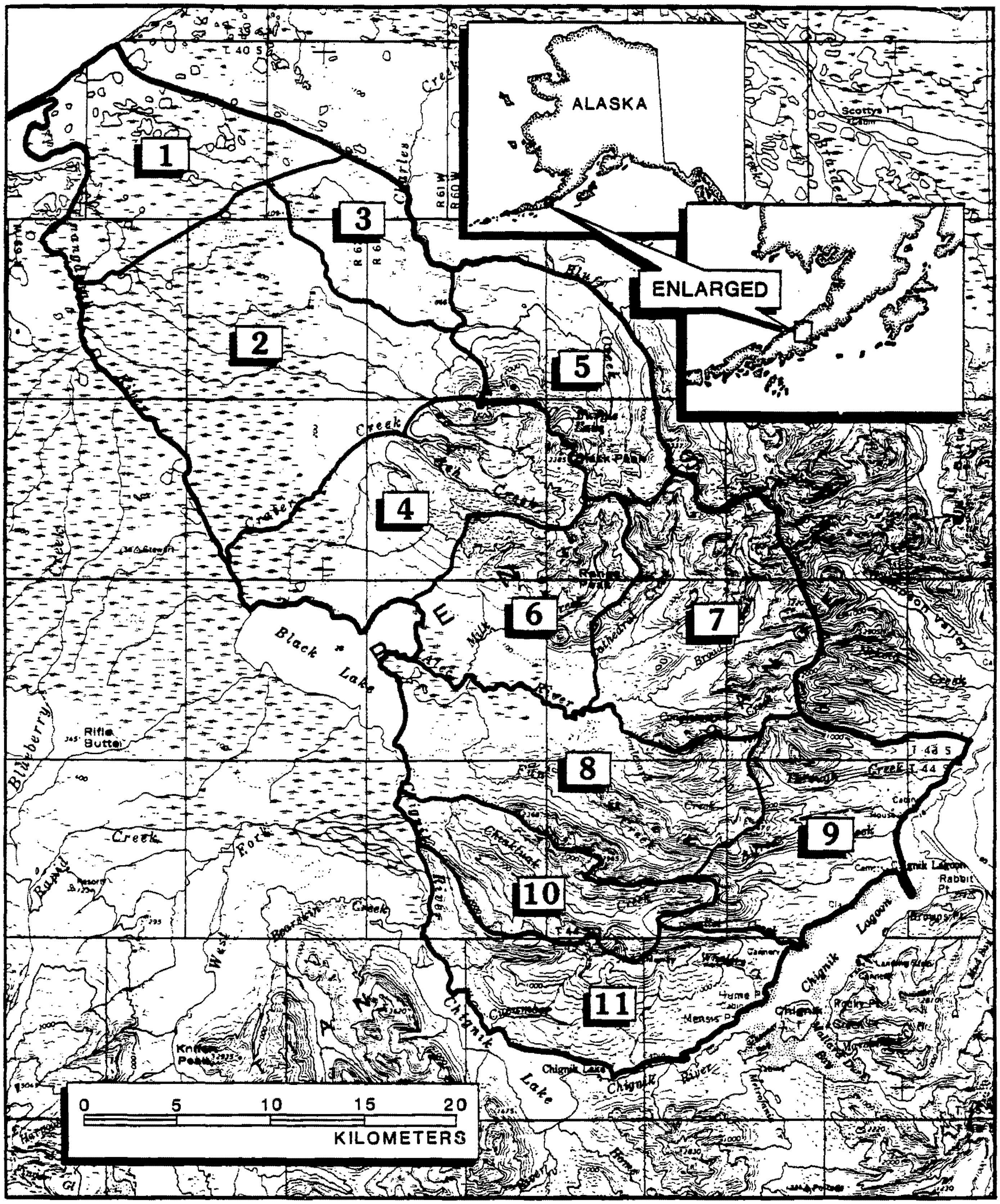
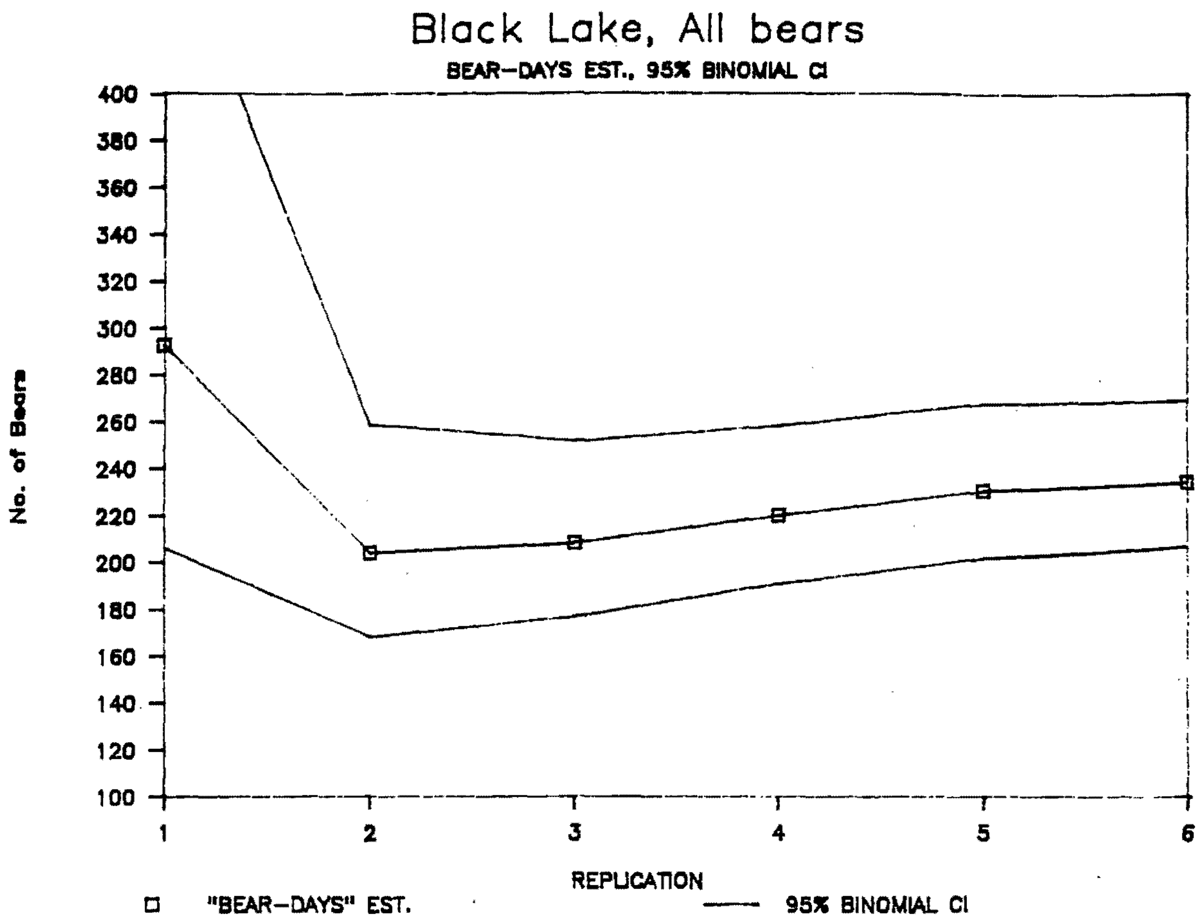

ALASKA
ENLARGED
1
2
3
4
5
6
7
8
9
10
11
Black Lake
Chignik Lake
Chignik Lagoon
Chignik River
Rifle Butte
Knife Peak
Rabbit Pt
Blueberry Creek
West Fork
Bearskin Creek
0
5
10
15
20
KILOMETERS

Figure 3. Trend in bear density estimate and 95% binomial CI using the bear-days estimator of Miller et al. (1987). Estimate includes dependent offspring assumed to have been sighted independently of their mothers.

Figure 4. Trend in bear density estimate and 95% binomial CI using the bear-days estimator of Miller et al. (1987). Estimate is for number of independent bears, excluding dependent offspring.


Black Lake, All bears
BEAR-DAYS EST., 95% BINOMIAL CI
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
No. of Bears
1
2
3
4
5
6
REPLICATION
"BEAR-DAYS" EST.
95% BINOMIAL CI

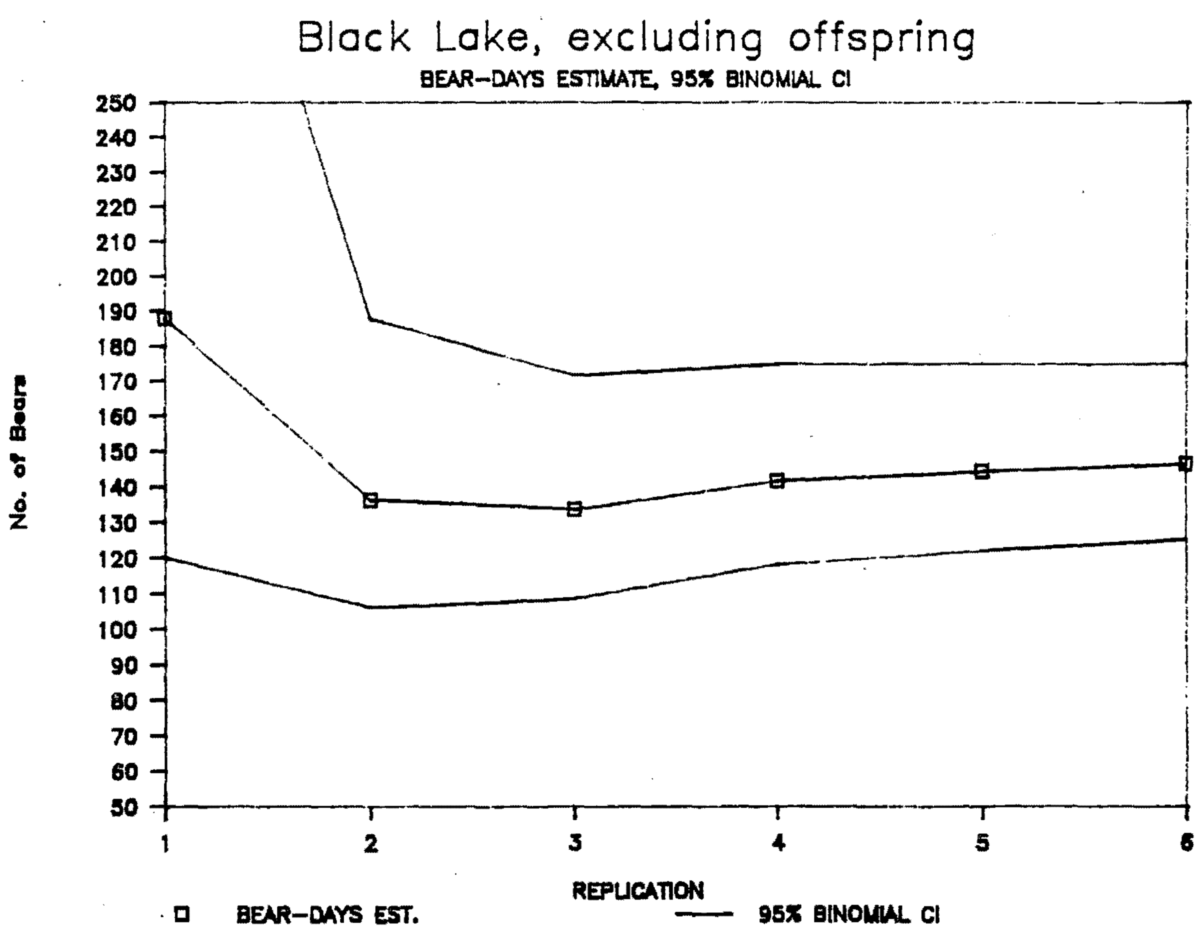
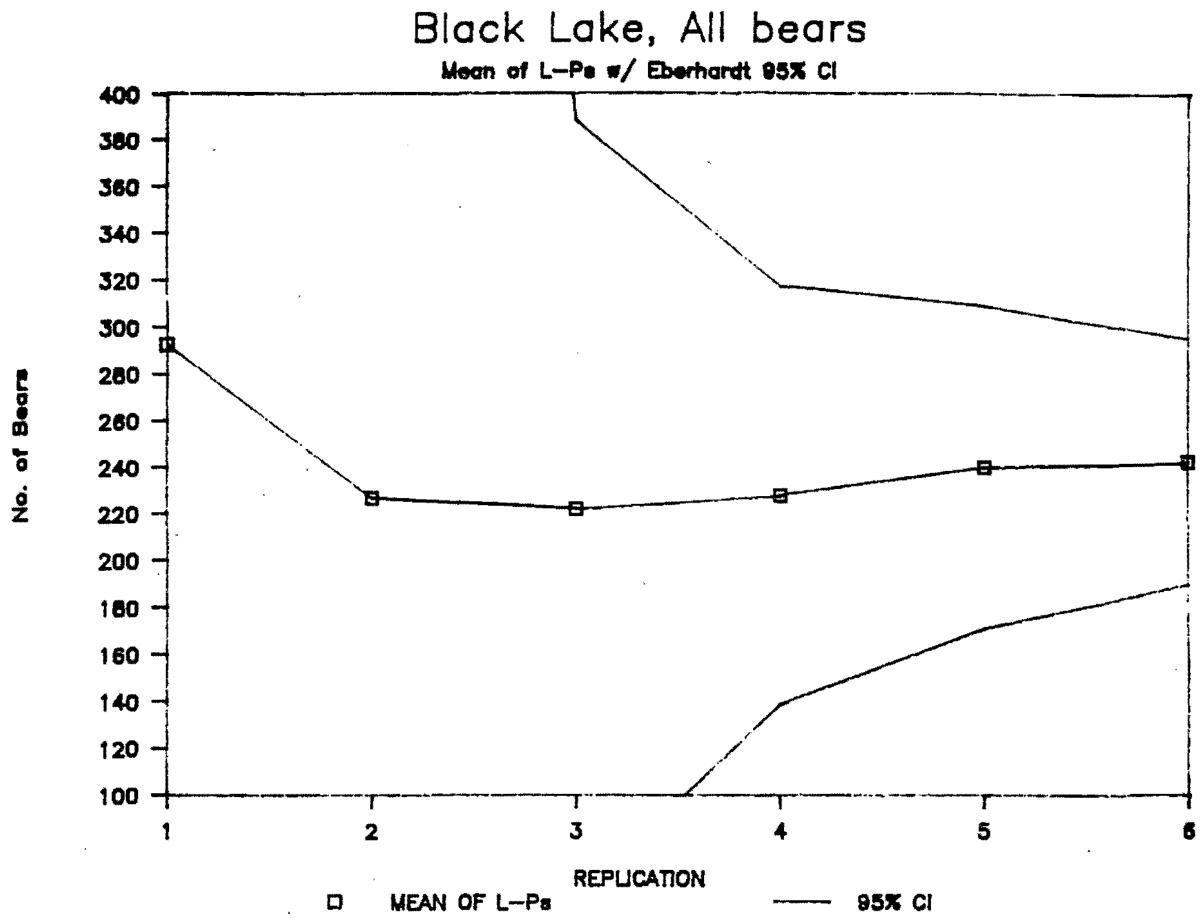

Black Lake, excluding offspring
BEAR-DAYS ESTIMATE, 95% BINOMIAL CI
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
No. of Bears
1
2
3
4
5
6
REPLICATION
BEAR-DAYS EST.
95% BINOMIAL CI

Figure 5. Trend in bear density estimate using the mean of Lincoln Petersen estimates and confidence interval based on sample variance of this mean (Eberhardt in press). Estimate includes dependent offspring who were assumed to have been sighted independently of their mothers.

Figure 6. Trend in bear density estimate using the mean of Lincoln Petersen estimates and confidence interval based on the sampling variance of this mean (Eberhardt in press). Estimate excludes dependent offspring still associated with their mothers.


Black Lake, All bears
Mean of L-Ps w/ Eberhardt 95% CI
No. of Bears
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
1
2
3
4
5
6
REPLICATION
MEAN OF L-Ps
95% CI

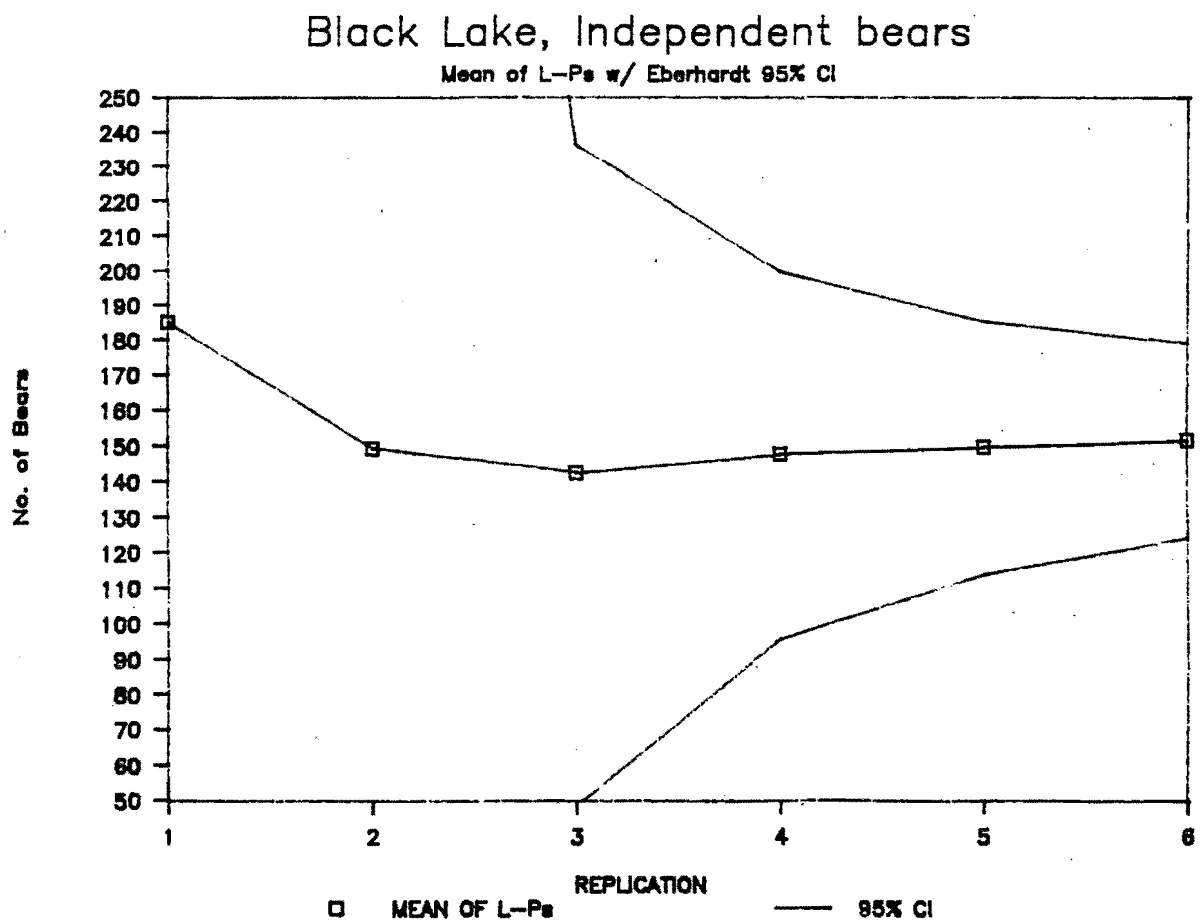
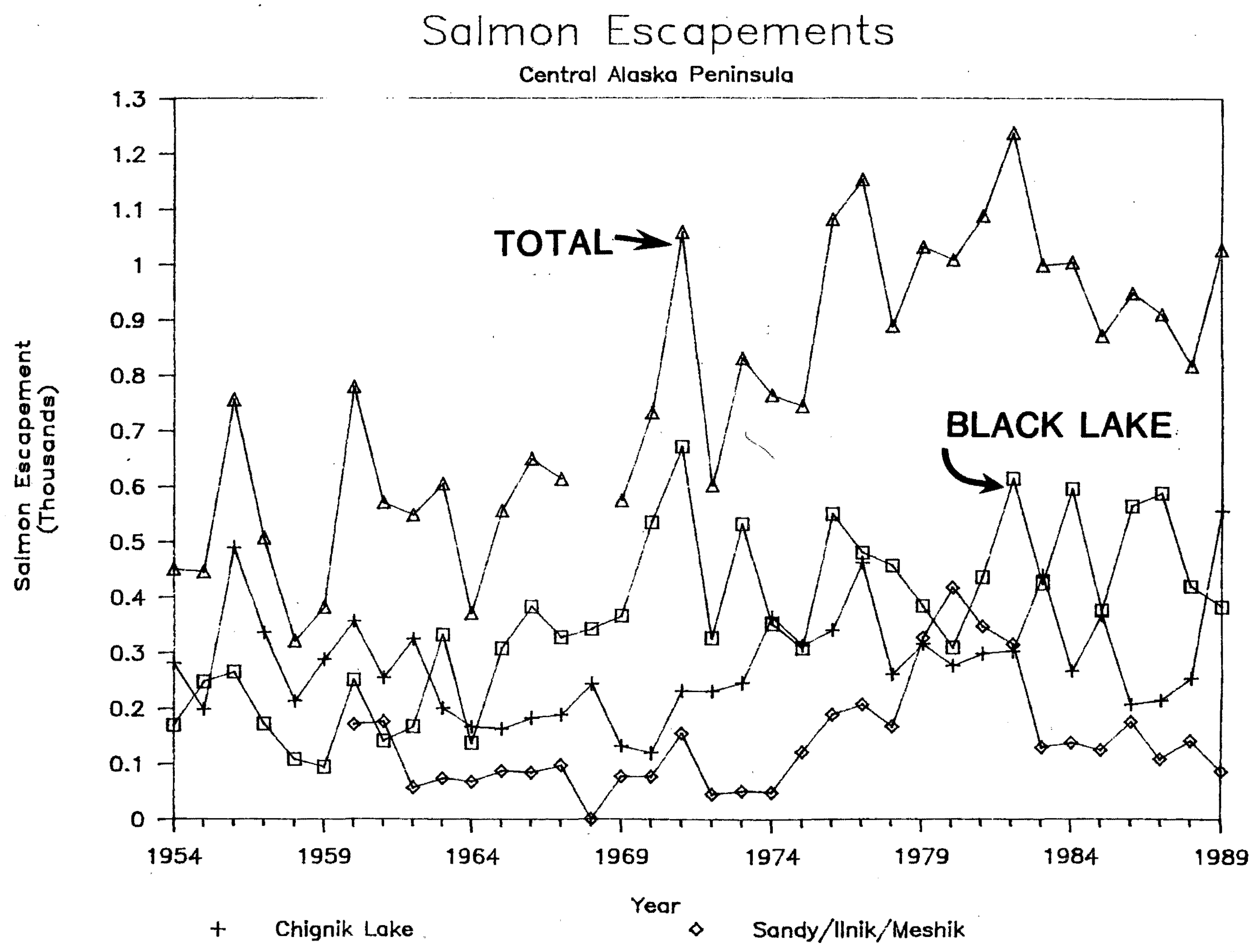

Black Lake, Independent bears
Mean of L-Ps w/ Eberhardt 95% CI
No. of Bears
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
1
2
3
4
5
6
REPLICATION
MEAN OF L-Ps
95% CI

Figure 7. Salmon escapement trends in the Black Lake system, 1954-1989.


Salmon Escapements
Central Alaska Peninsula
Salmon Escapement (Thousands)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
TOTAL
BLACK LAKE
1954
1959
1964
1969
1974
1979
1984
1989
Year
+ Chignik Lake
◇ Sandy/Ilnik/Meshik