Alaska Department of Fish and Game
Division of Wildlife Conservation

Federal Aid in Wildlife Restoration
Management Report Supplement

Brown Bear

A Brown Bear Density and Population Estimate for a Portion of the Seward Peninsula, Alaska

by

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Projects W-23-4 and W-23-5
Study 4.0
December 1993

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SUMMARY

We used capture-mark-resight (CMR) techniques to estimate brown bear density in a 2,067 km^2 (798 mi^2) study area on Alaska's Seward Peninsula north of Nome during early June 1991. The study area contained abundant herds of domestic reindeer that are used by bears; the area also supports small runs of salmon that bears use very little. We used five replicate CMR searches to obtain population estimates of 60.2 bears of all ages, 37.0 bears ≥2.0, and 30.1 independent bears. Corresponding density estimates were 29.1 bears of all ages/1,000 km^2 (95% CI = 26.1-33.4) or 75.4/1,000 mi^2 (95% CI = 67.6-86.5). We estimated density as 17.9 bears ≥2.0/1,000 km^2 (95% CI = 15.0-22.7) or 46.4/1,000 mi^2 (95% CI = 38.9-58.8). For "independent" bears (excludes accompanied offspring of all ages), density was 14.6 bears/1,000 km^2 (95% CI = 12.1-18.4) or 37.8/1,000 mi^2 (95% CI = 31.3-47.7). The estimate for all bears was thought to have an overestimation bias associated with an artificially inflated crop of newborn cubs during spring 1991. This bias did not exist for the units of bears ≥2.0 and for "independent" bears. Results obtained using 3 different estimators ("bear days", mean Lincoln-Petersen, and a maximum likelihood estimator) on the CMR data varied little.

This estimate placed the study area density between that estimated using similar techniques for the Su-hydro study area in northern Unit 13, and for the Noatak study area in Unit 23. Before making the density estimate, 7 of 8 persons who ranked themselves as highly knowledgeable about bear populations in the study area correctly guessed that bear density in this area was between densities observed in Unit 13 and Unit 23 study areas. This suggests that persons with extensive first-hand experience of local bear populations can make reasonable guesses of bear density when provided with comparison data from other areas. Observers in search aircraft demonstrated a tendency to overestimate ages of yearling bears accompanying radio-marked females. This bias would tend to inflate estimates in units of bears ≥2.0. There were differences between teams in number of bears spotted per hour of search effort: the highest team observed 1.9 bears for every bear observed by the lowest team. Observation frequency was 1 independent bear per 2.35 search hours. No significant differences occurred in sightability of bears by class (females with newborn cubs, females with older offspring, single females, and males). As in other studies females with newborn cubs had relatively low sightabilities.

We extrapolated density estimates obtained in the study area to a 32,408 km^2 (12,509 m^2) area, and compared them to available harvest data. The extrapolated population of brown bears ≥2 was 458 bears (14.1 bears/1,000 km^2), ranging from a low of 420 bears (13.0 bears/1,000 km^2) to a high of 495 bears (15.4 bears/1000 km^2). The bear population in the western portion of the unit is being harvested at a rate close to the sustainable level.

<u>Key Words</u>: Aerial survey, brown bear, Capture-mark-resight, brown bear, density estimation, Lincoln index, population estimation, Petersen index, sightability, sustainable harvest, *Ursus arctos*.

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BACKGROUND AND OBJECTIVES

Effective bear management depends on good information on bear population status, trends, and harvests. Accurate information on population size and trend is seldom available because of the expense and technical difficulties in obtaining it. Techniques have recently been developed that permit managers to estimate bear density in a study area using replicated aerial searches and counts of marked and unmarked bears observed (Miller et al. 1987). If the study area selected is representative of the Game Management Unit (GMU) or subunit in which it is conducted, this density estimate can be extrapolated directly, or with subjective stratification, to obtain a bear population estimate in that unit.

With information on sustainable harvest rates derived from field studies and simulation modeling, sustainable harvest quotas for the unit can be derived from this population estimate. Although there are a number of potential sources of error in this process, these techniques provide managers with an objective and defendable method for establishing bear harvest quotas. Because of these sources of error and because brown bear populations are exceedingly slow to recover from excessive harvests, in most cases it will be desirable to set harvest quotas on the conservative side of estimates obtained in this way (Miller 1990).

The primary objective of the portion of the study reported here was to estimate the density of brown bears in a 2,067 km^2 (798 mi^2) study area in Unit 22 on the Seward Peninsula just north of Nome, Alaska. A secondary objective was to use this density estimate to obtain a bear population estimate for each subunit of Unit 22. Another objective was to evaluate the ability of biologists to guess the density in this area before conducting the density estimate and compare the accuracy of the guesses made with the guessers' level of familiarity with bear populations in the area.

METHODS

We captured and marked bears during spring in 1989 and 1990. Records of captured bears are in Table 1. Captured bears were spotted from fixed-wing aircraft, and then immobilized from a helicopter and marked. Bears were marked in the order observed; we captured all bears spotted. We placed collar-mounted VHF radio-transmitters on all bears of suitable size. Bears were captured from a 6,338 km^2 (2,447 mi^2) area (Figure 1) including and surrounding the density estimation study area (Figure 2).

Density estimates were accomplished using procedures described by Miller et al. (1987) and Ballard et al. (1990). We identified a study area where natural features restricting bear movements formed the borders wherever possible (Figure 2). We chose this area to include the spring home ranges of as many previously marked bears as possible, and to include typical proportions of upland and lowland habitat as in the rest of Unit 22. We subdivided this area into 10 quadrats using landscape features that were readily recognizable from the air (Figure 2). We further subdivided five of these quadrats yielding a total of 15 quadrats in the area (Figure 2). The quadrats functioned primarily to allocate and document search effort by search aircraft. We used five aircraft (PA-18) to search for bears in the quadrats assigned, each aircraft with a pilot and observer. Professional hunting guides/air taxi operators (J. Rood and J. Lee) piloted two of the aircraft, ADF&G biologists (J. Schoen, S. Machida) piloted two others, and biologist T. Smith piloted a fifth aircraft under contract to the University of Alaska (UAF). When bears were spotted, the observer would activate a radiotelemetry receiver and determine whether the bear had a radio-transmitter (classified as "marked") or not (classified as "unmarked"). We provided observers with a list of frequencies of marked bears in the area, but this list did not include data on age of offspring. We estimated ages of offspring accompanying adult females and, for marked bears, compared these estimates with known ages of these offspring. We plotted locations of bears observed on maps (USGS 1:63,360 scale). In addition to the search aircraft, a Cessna 185 piloted by biologist J. Coady, flew around the periphery of the study area to document the number of radio-marked bears present for each replicate search. To permit separate population estimates for northern and southern portions of the study area, this airplane also flew the boundary between northern and southern portions to document which portion contained the radio-marked bears. The A portions of quadrats 6, 7, and 8 were in the northern area along with quadrats 9 and 10 while the B portions of these 3 quadrats were in the southern area along with quadrats 1-5 (Figure 2). On some days, the aircraft flying periphery flights helped in search efforts after the periphery flight was finished. We did six replicate searches between 31 May and 7 June. Each replicate was completed on a single day except for the last replicate which required 2 days (6-7 June). The results from the first replicate flight were not used to calculate CMR results because we observed too few marked bears.

STUDY AREAS

A 797-mi^2 (2,447 km^2) area north of Nome was selected as the initial study area (Figure 1). Portions of the study area were accessible by road during summer.

The study area contains the largest herd of reindeer in North America (Cooperative Extension Service unpubl. data, June 1989). This herd has been extensively studied by researchers from the University of Alaska, Fairbanks, and includes a number of radio-collared animals (R. Dietrich, L. Renneker pers comm.). The area supports an expanding herd of muskoxen (*Ovibos moschatus*), including some radio-collared animals (Smith 1987). Many moose (*Alces alces*) also occupy the area (ADF&G files).

Ten river systems within the area support summer runs of anadromous fish: pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*O. keta*) arctic char, (*Salvelinus alpinus*), red salmon (*O. nerka*), silver salmon (*O. kisutch*), and a few king salmon (*O. tshawytscha*). Preliminary analysis of radio-telemetry data suggests little movement of study area bears to these streams during the sparse salmon runs.

Topography varies from coastal lowlands to rugged mountain ranges; the maximum elevation is 1,438 m (4,714 ft). Temperature, rainfall, snow, and ice conditions are typical of maritime areas in northwestern Alaska. The climate of the peninsula's interior is more continental, with greater temperature extremes and lower precipitation. Mean annual precipitation is approximately 36 cm (14 in). Snowcover normally persists from November through May, and it becomes hard-packed with numerous ice layers, particularly near the coast.

The vegetation is dominated by Arctic tundra communities, although treeline transects the northeastern portion of the study area where isolated spruce (*Picea mariana*) are present.

Dense stands of willow (*Salix spp.*) and alder (*Alnus spp.*) are widespread. Cottonwood (*Populus balsamifera*) stands are present but are uncommon.

RESULTS

Previous Captures

Ninety seven bears were captured and marked within a 6,338 km^2 (2,446 mi^2) study area north of Nome during spring 1989 and 1990 (Table 1). During spring 1991, when we estimated density, 36 of these bears had functioning radio-transmitters, and 16 of the collared bears were present at least once in the study area during the 31 May-7 June density estimation (Table 2). The composition of radio-marked bears present at least once in the density estimation study area was 5 females (IDs = 212, 220, 211, 123, and 200) with a total of 11 newborn cubs, 4 females (IDs = 204, 151, 144, and 145) with a total of 7 yearling offspring, 1 female (239) with 2 two-year-old offspring, 1 female (139) with 1 three- year-old offspring, 3 adult females without offspring (236, 127, and 171), and 2 males (Table 2). One female without offspring (236) lost her newborn cubs just before the first replication of the density estimation effort.

The high proportion of females with newborn cubs was, in part, because of capture-related losses of offspring the preceding year. Two females with newborn cub litters in spring 1991 (IDs = 212 and 236) suffered capture-related losses of their yearling litters during capture operations in spring 1990. Without these losses, the study area would have included 4 females with newborn cubs, 4 females with yearlings, 3 females with 2-year-old offspring, and 1 female with 3-year-old offspring during spring 1991. The 1990 accidents which led to a disproportionate number of females with litters of newborn cubs in the study area during spring 1991 may have resulted in an overestimation bias in the population estimate in the unit of bears of all ages.

We did not capture unmarked bears spotted during the density estimation flights.

Population Size and Density

We estimated population size and density in 4 different ways and in 3 different units. We calculated minimum density based on the number of unmarked bears seen plus the number of radio-marked bears known to be in the study area. We also measured bear population size and density using 3 different capture-mark-resight (CMR) estimators: "bear-days" (Miller et al. 1987), mean of daily Petersen estimates (Eberhardt 1990), and a maximum-likelihood estimator (MLE) (White, 1993). We measured bear population size and density in groups of: 1) all bears regardless of age, 2) bears older than 2.0, and 3) "independent" bears. For the estimate of all bears, offspring of whatever age that were still with their mothers were considered marked or unmarked depending on whether their mother was marked or unmarked. Sightings of bears in these family groups were not independent. For the category of bears ≥2, it was necessary to estimate whether unmarked bears were yearlings or older than yearlings based on size. Assuming correct aging, this category eliminated dependent sightings of newborn cubs and yearling offspring, but retained dependent sightings of offspring ≥2 still with their mothers. Categories of all bears and bears ≥2 are useful for comparing with bear densities in other study areas. The category of independent bears excluded observations of dependent offspring of whatever age. This category avoids use of dependent sightings caused by family groups. However, because age at separation may vary in different areas, this category is less useful for comparisons with other areas.

Minimum Population Size and Density

We estimated the minimum population size for each replication as the number of marked bears known to be present on the search area plus number of unmarked bears seen. The average of these values over the 5 replications was the average minimum population (AMP) (Figure 3). For all bears the average minimum population density was 22.1 bears/1,000 km^2; for bears ≥2 it was 12.2/1,000 km^2; and for independent bears it was 10.3 bears/1,000 km^2.

In some cases the lower limit of the confidence interval (CI) for the CMR estimates discussed below was less than the AMP. In these cases the lower limit of the CI was truncated at the AMP value.

Capture-Mark-Resight Estimates

We flew six replicate flights. We saw only 1 marked bear on the first replicate (31 May) so this replicate was not included in CMR estimates. This procedure was also followed when no marked bears were seen on the first flight during the Noatak density estimate in 1989 (Ballard et al. 1991). Inclusion of a flight where no marked bears was observed made little difference in results from the bear-days or MLE estimators but resulted in significant increases in the density estimate using the mean Petersen estimator (Miller, unpublished data).

Bear-days Estimator

Miller et al. (1987) described an estimator for use with replicated CMR data corrected for lack of population closure. This estimator summed over all replicates the number of marks seen, the number of marks present, and the total number of bears seen and substituted these cumulative values into the standard Chapman CMR formula. The result was an estimate for total number of bear-days the study area was occupied during the capture period. This value divided by the number of replicates yielded an estimate of the average number of bears in the study area during the density estimation period. Confidence interval was based on the binomial approximation to the hypergeometric distribution as described by Miller et al. (1987).

Density estimates using the bear-days estimator for the last 5 days of the study period were 28.7 bears/1,000 km^2 for bears of all ages (95% CI = 25.2-34.1), 17.7 bears/1,000 km^2 for bears ≥2.0 (95% CI = 14.2-23.7), and 14.5 bears/1,000 km^2 for independent bears (95% CI = 11.5-19.8) (Figure 3). Values for 80% CIs are in Table 4. It was not necessary to truncate lower limits of CIs at the average minimum number of bears present (AMP).

The point estimate for all bears in the study area increased during the course of the study (Figure 4) but there was little change in the estimate for independent bears (Figure 5). Confidence interval size declined during replications 1 through 3, but remained relatively constant subsequently (Figures 4 and 5). The increase in the point estimate was atypical for CMR bear density estimates in Alaska. The same pattern was observed in one study on Kodiak Island (R. Smith, unpublished data).

Mean Lincoln-Petersen Estimator

We calculated a Chapman estimate for each replication and averaged these for the last 5 replications (Table 5). Confidence intervals were based on the sampling distribution of the individual estimates (Eberhardt 1990). A correction factor for low sample sizes was calculated as recommended by Eberhardt (1990). Density estimates using this estimator for the last 5 days of the capture period were 28.7 bears/1,000 km^2 for bears of all ages (95% CI = 23.1-34.3), 17.9 bears/1,000 km^2 for bears ≥2 (95% CI = 12.5-23.3), and 14.3 bears/1,000 km^2 for independent bears (95% CI = 11.2-17.4) (Figure 3, Table 5). Lower limits of CIs were not truncated by the average minimum number of bears present (AMP). The bias correction factor developed by Eberhardt (1990) did not alter estimates (Table 5).

Maximum Likelihood Estimate (MLE)

The maximum likelihood estimator for CMR data was described by White (1993) for use with data where population closure does not exist but movements of marked animals into and out of the study area are known (Miller et al. in prep.). This expansion involved adding a binomial term to represent the probability that a marked animal was in the study area. Confidence intervals for this estimator are based on the likelihood function (White and Garrott 1990, White 1993). This estimator was termed the "immigration-emigration" model in software developed by G. White for calculating population estimates and confidence intervals. An additional term, T_i, was defined for use with the immigration-emigration model as the total number of marked bears present in the search area at least once during the search period. For the all bear unit, T_i was 37, for bears ≥2.0 T_i was 19, and for independent bears T_i was 16.

Density estimates using this estimator for the last 5 days of the capture period were 29.1 bears/1,000 km^2 for bears of all ages (95% CI = 26.1-33.4), 17.9 bears/1,000 km^2 for bears ≥2 (95% CI = 15.0-22.7), and 14.6 bears/1,000 km^2 for independent bears (95% CI = 12.1-18.4) (Figure 3, Table 6).

Comparison of Estimators

Figure 3 shows estimates and CIs obtained with each of the 4 different estimators. All 3 CMR estimators produced equivalent point estimates. The mean Petersen estimator produced the largest and the MLE estimator produced the smallest confidence interval. The MLE estimator has the soundest theoretical basis (G. White, pers. comm.) and this estimate will be treated as the preferred value.

Density Estimation Units

The estimate for bears of all ages was probably inflated by a disproportionate number of newborn cubs during summer 1991. This resulted from inadvertent losses of 2 litters of yearling offspring during marking operations the previous spring (bear IDs = 212 and 236). As a result, bear 212 had a litter of 2 newborn cubs during the density estimation phase and bear 236 had 1 newborn cub in May but lost this cub before the density estimation phase (Table 2). Radio-marked bears had 2 newborn cubs more than would have been the case without the capture-related loss of a litter the preceding year. For the estimate in category of bears of all ages, cubs and yearlings are treated as marked or unmarked depending on whether their mother is radio-marked or not. This means that for the "all bears" estimation unit, the class of bears with newborn cub litters had a disproportionately larger number of marks. Because this class of bears is suspected to have the lowest sightability (Miller et al. 1987), this would artificially inflate the estimate for bears of all ages.

Another indicator that the all bears category was inflated was provided by the large difference in the estimation category for all bears (29.1 bears/1,000 km^2) and that for bears ≥2 (17.9/1,000 km^2). These data suggest that 38% of the all bear estimate in the Nome area were newborn cubs and yearlings. This is higher than in most other areas studied. Equivalent calculations yielded values of 13% cubs and yearlings in Katmai and Noatak studies, 14% at Black Lake, 17% at Terror Lake, 20% at Karluk Lake, 25% and 35% at Admiralty Island in years 1 and 2, respectively, 31% at the middle Susitna study, and 40% in the upper Susitna study (Miller et al. in prep.). In the central Alaska Range study, the estimate for all bears (10.3/1,000 km^2) was slightly smaller than that for bears ≥2 (11.4/1,000 km^2), a peculiar result caused by small sample sizes.

Because of this potential source of bias for the Nome density estimation results, we prefer using estimation units that exclude newborn cubs. For the Nome results, we recommend using the measurement/units of bears ≥2 or independent bears.

Comparisons With Other Study Areas

Brown bear density has been estimated in 10 different areas in Alaska using CMR techniques like those employed in this study (MIDSU, UPSU, AKR, NOA, KAR, TER, AD, BLA, KAT, NOME), and in 4 additional areas (WBRK, EBKR, ANWR, DENALI) using home range or other techniques (Miller et al. 1987, Dean 1987, Miller 1990, Reynolds and Garner 1987, Ballard et al. 1990, Miller et al. in prep.). Figure 6 shows locations of these studies along with 3 black bear study areas (MIDSUBK, KEN-47 and KEN-69) (Miller et al. 1987, Schwartz and Franzmann 1991, Miller et al. in prep.). The Nome density estimate was between the Denali Park estimate and the MIDSU estimate for the estimate of all bears (which possibly has an overestimation bias as discussed above) and between the MIDSU and Noatak estimate for bears ≥2 (Figures 7 and 8).

Test of Ability to Guess Bear Density

Before calculating the Nome density estimate, we conducted an exercise to evaluate individuals' ability to extrapolate from areas of known bear density to areas of unknown bear density. We did this by distributing a questionnaire (Appendix A) to selected biologists, guides, members of the public, and others around Alaska. This provided bear density data in comparison areas and asked respondents to guess what the bear density would be in the Nome study area. The questionnaire also asked individuals to rank themselves from 1 to 5 for each of 3 criteria: level of familiarity with bear populations in the area, level of familiarity with the area, and level of familiarity with brown bear biology. We also asked respondents to put 80% confidence limits around their guesses.

Interpretation of these results was complicated by asking respondents to make their guesses in categories of bears of all ages. As discussed above, the density estimate in this category was probably inflated by a disproportionately large number of marks on females with newborn cubs, a group suspected of having relatively low sightability. This bias would have been avoided if we had asked respondents to guess in units of bears ≥ 2. The correct relative position for the Nome study area was between the MIDSU and NOATAK study areas for bears ≥ 2. In the following analysis a "correct" response was counted in cases where the respondent guessed the Nome density to be between MIDSU and NOATAK study areas.

Of the 51 respondents, 43% correctly placed the density of the Nome population between the MIDSU and NOATAK study areas. Of the 7 respondents who classified themselves in the highest class for knowledge of bears in the study area, 86% made correct relative placements compared to 71% of the 7 respondents with the highest knowledge of the area, and 30% of the 10 respondents who classified themselves in the highest class with regard to general knowledge about bears in Alaska (Table 7, Figures 9-11).

Since participants did well in estimating bear density, it is not inappropriate to break the promise of confidentiality given prior to making the guesses (Appendix A). These specifics are useful in interpreting the results. The 6 individuals ranking themselves with the highest knowledge of bear populations in the area who "correctly" guessed bear density in this area were W. Ballard (#4), T. Smith (#8 on Figs. 9-11), S. Machida (#9), B. Nelson (#12), J. Coady (#20), and R. Delong (#23). The person in this category who incorrectly guessed that the Nome density was slightly lower than in the Noatak study area was J. Rood (#27). S. D. Miller was guesser #15 in Figs. 9-11. Based on the actual results for the probably inflated unit of all bears, the person who came closest was Nome sport fish biologist Fred DeCicco followed by Anchorage non-game biologist Nancy Tankersley (#1 and #2 respectively in Figs. 9-11).

These results suggest that persons with intensive first-hand experience with bear populations in an area are often able to accurately guess bear density in that area when provided with data from other areas as points of reference. Persons with such knowledge should then be able to extrapolate from an area where density has been estimated to a larger area, such as a unit or subunit, to obtain a population estimate in this larger area. This population estimate can then be the basis for estimating sustainable harvest quotas (Miller 1991). These survey results suggest that general knowledge of bear biology and ecology is not a substitute for first-hand knowledge of an area when it comes to making accurate guesses about density in that area.

We recommend that biologists conduct similar exercises before making future density estimates. We further recommend providing guessers with reference densities based on bears ≥ 2 and asking guessers to estimate density in this same unit to avoid potential biases based on pulses in cub production that may distort estimates in units that include newborn cub cohorts. It would be wise to provide guessers with additional information in future exercises of this sort. Many guessers complained that we provided inadequate information upon which to make a reasonable guess. On his questionnaire, ADF&G bear research biologist Harry Reynolds summarized these concerns:

> I object to the lack of information you've given us. I would like to know: 1) How much of the population probably has access to salmon streams and what the quality of the runs are, 2) If the area biologist feels this area is high, moderate, or low population density compared to the rest of the unit, 3) The average annual harvest for the past 10 years and whether the biologist thinks that is high, moderate, or low and his basis for that estimate, 4) The number of defense of life and property kills and unreported harvest in the area, 5) The number of guides using the area and how much of the harvest they take, and 6) If there are reindeer herders using this or adjacent areas? I guessed for each of these and feel uncomfortable with my estimates because of it. Basically, I extrapolated using my Brooks Range population, downgraded it because of Warren's [NOATAK] estimate (which has high harvest and some salmon), then upgraded it because of availability of salmon and other food resources. From your map, I'd also say that extrapolations to wider areas of the Seward Peninsula should not (or only carefully) include lowlands such as are present to the SE of your study area. Such areas are also prevalent in the NW portion of the Seward Peninsula and I suspect densities would be much lower, especially where there are reindeer herders.

In spite of these concerns, Reynolds' guess (22 bears/1,000 km^2) was "correctly" placed between the MIDSU and NOATAK densities even though he ranked himself in the lowest category relative to familiarity with bears in the Nome study area, in the second lowest category with respect to familiarity with the study area, and, of course, in the highest category with respect to knowledge of bear populations in general. Reynolds' concerns about extrapolation are correct. However, the extrapolations to a wider area do not have to be direct extrapolations. In cases where the habitat or harvest histories are different from that in the reference area, it would be appropriate to delineate a homogeneous area in which the extrapolated density is estimated as a percentage of that of the reference area (a "stratified extrapolation"). This is the process that was followed in extrapolating to obtain population estimates in Unit 22 subunits (see below).

Accuracy of Aerial Identification of Subadults

Observer teams during the spring 1991 density estimate in the Nome study area were provided with lists of frequencies of radio-marked bears and the identification numbers of these bears. However, these lists did not include information on the number or age of offspring with radio-marked females. Observers were asked to estimate the age of offspring with marked females. These estimates provide information on errors in estimating the age of offspring with unmarked females. Accuracy of age estimation ranged from 0% for the 3 family groups observed by team 5 to 89% for the 9 groups observed by team 1 (Table 8). Team 0 had 100% accuracy (2 groups) but these data were discounted because this team included the individuals (Coady and Nelson) that had been radio-tracking these bears and had more knowledge of them than the other teams. Newborn offspring are easy to identify and there were no errors in 10 observations of groups of newborns (Table 9). In 10 observations of yearling groups, observers correctly identified offspring as yearlings 3 times (30%) and mis-identified them as a year older 7 times (Table 9). There were 2 observations of a 2 year-old group; once it was identified correctly by the pilot and once underestimated by a year by the biologist (Table 9) (there was only 1 sighting of this group, counted as 2 because of the disagreement between pilot and observer). There were 2 observations of a group of 3 year-old offspring; they were correctly classified once and once incorrectly classified as a year younger (Table 9).

This analysis indicates there is a tendency to overestimate the age of yearlings. Mis-identification of unmarked yearlings as a year older would cause an overestimation bias in the estimate of bears older than 2.0.

Differences in Ability to Spot Bears by Different Observer Teams

A primary assumption of the CMR approach used to estimate density is that all bears have equal probabilities of being sighted. This assumption was probably violated because some observer teams are more skilled at finding bears than others. This potential source of bias is the primary reason why observer teams rotated between quadrats on successive replications of search effort (Table 3). During the 1991 density estimate the team that observed the most bears saw a bear every 1.68 hours of search effort and the team that saw the least bears saw a bear every 3.13 hours (Table 10). The best team observed 60 independent bears/100 hours of search compared to 32 bears/100 hours for the least efficient team (Table 10). Another way of expressing this is that the best team observed 1.86 bears for every bear observed by the lowest team. Overall, 42.5 independent bears were spotted per 100 hours of search effort (1/2.35 hours) (Table 10).

Sightability by Bear Class

The assumption most likely to be violated in CMR work is that all animals have equal probability of being sighted. This assumption may be violated because of observer bias, as discussed above, or because of behavioral differences. Behavioral differences may be a function of bear class (male, female with newborn cubs, female with older offspring, etc.) or of individual experience or learning (White et al. 1982, Miller et al. 1987). Little can be done with capture heterogeneity based on learning with our CMR design unless marks could be applied using a technique different from that used to obtain sightings. If individual bears are especially shy of our capture techniques then they have a lower probability of having marks and a lower probability of being seen. Both would result in an underestimate of population size.

Capture heterogeneity based on animal class can be investigated. Low capture probabilities for females with newborn cubs was suspected in previous brown bear studies (Miller et al. 1987, Miller 1990). This class of bears tends to remain at high elevations near den sites longer and may move around less. This tends to make them less sightable than other classes of bears (Miller 1987, 1990). Females with yearling and older offspring may be the most sightable because they are highly active and because such a group presents a larger visual image. Sightability by class was defined as the percentage of times radio-marked bears present in the area were seen. In the Nome study, the highest sightability was for 3 single females (50%) followed by 5 females with yearling or older offspring (40%), 5 females with newborn cubs (30%) and 2 males (22%) (Table 2). These differences were not significant between females with newborn cubs and other bears (Chi square = 0.20, 1 d.f., $\underline{P} = 0.60$) or between females with newborn cubs and other females (Chi square = 0.40, 1 d.f., $\underline{P} = 0.53$). Regardless of these non-significant results, in this study as in most other studies (Miller et al. in prep.), females with newborn cubs had relatively low sightability compared with most other classes of bears. Given this trend we recommend premarking of bears during at least 1 season before the density estimation to assure that some marks are placed on estrus females. If this is done, the class that will have newborn cubs, and potentially low sightability, during the density estimation procedure will contain marks in proportion to its occurrence in the population. This minimizes bias caused by capture heterogeneity based on class.

Costs of Density Estimation Project

Bear density is a highly useful statistic for bear managers. Techniques available to obtain density data are very expensive. The density estimation costs for the work accomplished during spring 1991 totaled approximately $35,900 (Table 11). Most costs were associated with 3 charter aircraft since 3 planes used were agency aircraft piloted by agency staff. If we would have had to charter those 3 aircraft at commercial rates, total costs incurred would have been in excess of $46,000. The 2 years of premarking before the density estimation phase were not included as part of these costs because the marked bears were and still are being used to accomplish other objectives.

Estimated Unit 22 Population

To assess the potential impacts of human harvest, it was necessary to extrapolate the bear density estimate from the study area to a much larger area (Figure 12) and compare this estimate with harvest data. Using methods discussed by Ballard *et al.* (1990) and Miller (1990), we identified six areas composed of somewhat similar habitat and suspected hunting history. As was previously indicated, we felt the estimate for all bears had an over estimation bias based on an artificially inflated crop of newborn cubs in spring 1991. Because of this perceived bias and because we were, at this time, only interested in comparing minimum known overall harvest with the density of bears available for harvest, we used the calculated density estimates for bears ≥2.

Density estimates for each of the areas were derived through subjective extrapolation by 4 biologists knowledgeable with the areas (J. Coady, J. Dau, S. Machida, and B. Nelson). All extrapolations were made by consensus of opinion and were comprised of a range from which a medium was derived.

The extrapolated population of brown bears ≥2 for the 32,408 km^2 (12,509 mi^2) area was 458 bears (14.1 bears/1,000 km^2) ranging from a low of 420 bears (13.0 bears/1,000 km^2) to a high of 495 bears (15.4 bears/1,000 km^2). Tables 12 and 13 present the estimated number of brown bears ≥2 for the western portion of Unit 22. Densities ranged from a high in the western portion of Subunit 22B of 18.9 bears/1,000 km^2 to a low in the southern portion of Subunit 22E of 9.8 bears/1,000 km^2.

A Comparison of Actual and Sustainable Harvest

Unit 22 brown bear harvest records have been kept since 1961 (Figure 13). Reported harvest in Unit 22 from 1961 through 1978 was low. The dramatic increase the following year was a direct result of heavy exploitation of bears by non-residents on guided hunts. Concern about overharvest led to the implementation of a non-resident drawing hunt. This action reduced overall harvest from 1980 through 1983. The overall harvest again rose dramatically in 1984 due in part to the following: 1) a lengthening of the spring season by 10 days, 2) the elimination of the $25 resident tag fee, and 3) increased guiding effort in Subunit 22A. Heavy harvest, primarily by residents of Nome, prompted an emergency order which shortened the spring 1987 season in Subunit 22C. The Alaska Board of Game made this a regulation the following year (1988). Increased interest in hunting bears in Unit 22 and ideal spring hunting conditions in spring 1989 produced a current record high known harvest of 56 bears. Although the harvest dropped off the following year (1990), it was within 2 bears of the previous 10-year average harvest of 43 bears annually.

Harvest figures for bears taken from Unit 22 are obtained primarily through sealing records, and do not reflect actual harvest. Authors of Unit 22 brown bear survey-inventory reports written during the past 10 years frequently estimated an additional 10-30 bears were taken and/or destroyed annually. Data to confirm the accuracy of these figures are non-existent. However, because we know unreported harvest occurs we are obligated to provide an estimate of some kind and decided to use 20 bears as the overall annual unreported harvest. As with the known harvest, it is certain the unreported harvest is not evenly distributed throughout the unit. However, data on the exact distribution are unavailable so our calculations were made with the assumption that the distribution was homogenous.

Literature suggests a wide range of sustainable harvest rates for brown bear populations (Lortie unpubl., Reynolds 1976, Sidorowicz and Gilbert 1981). Ballard *et al.* (1990) using the deterministic model developed by Miller and Miller (1988), suggested an annual harvest rate for bears ≥ 2 of 8 may be sustainable in the Noatak study area. Conclusive data on sex composition, natural mortality, and productivity of Seward Peninsula brown bears are unavailable. Although we would have liked to use the model, we felt inaccurate results would therefore be derived. Sustainable harvest densities provided in Table 13 were calculated at 7% of the density estimates of all bears older than 2 years.

We illustrated sustainable harvest density as a single horizontal line. The absence of slope in this line would correctly illustrate sustainable harvest density only when populations were stable (Miller 1990). If populations declined, then the line would have a negative slope; if they increased, then they would have a positive slope. Because in this case the slope was unknown, we mention that when harvest density exceeds sustainable harvest density, sustainable harvest density would decline, rather than remain constant as illustrated. The opposite would also be true if harvest density was less than sustainable, and populations were increasing (to carrying capacity).

When we compared sustainable harvest with the overall known harvest for the western portion of the unit (Figure 14), we noted that with the exception of 1986 and 1989, the known harvest was below the calculated sustainable harvest density. However, when we added estimated unreported harvest, the overall harvest was found to be at or above sustainable harvest during years 1982, 1984, 1985, 1986, and 1989.

A similar comparison for the western portion of Subunit 22B showed both known and estimated harvest to be above sustainable harvest since 1985 (Figure 15).

In Subunit 22C, with the exception of 1983 and 1987, harvest has been at, or in some cases, well above the sustainable harvest level since 1980 (Figure 16). Harvest, both known and estimated, in Subunits 22D and 22E since 1980 have been below the calculated sustainable harvest figure (Figures 17 and 18). We concluded that the brown bear population in western Unit 22 was being harvested at a rate which is now at or close to sustainable harvest limits and if changes in regulation which might increase harvest are adopted, they should only occur in Subunits 22D and 22E.

ACKNOWLEDGMENTS

We wish to thank the following individuals for taking part in the density estimate study: C. Chetkiewicz, J. Coady, J. Dau, R. DeLong, R. Jandt, J. Lee, S. Machida, N. Messenger, L. Renecker, J. Rood, J. Schoen, and T. Smith. W. Ballard assisted in the early stages of this study. Thanks are also extended to I. Parkhurst and S. Machida for clerical and editorial support in preparing this manuscript. Additional funding for the density estimate study was provided by the Bureau of Land Management and the University of Alaska Reindeer Project.

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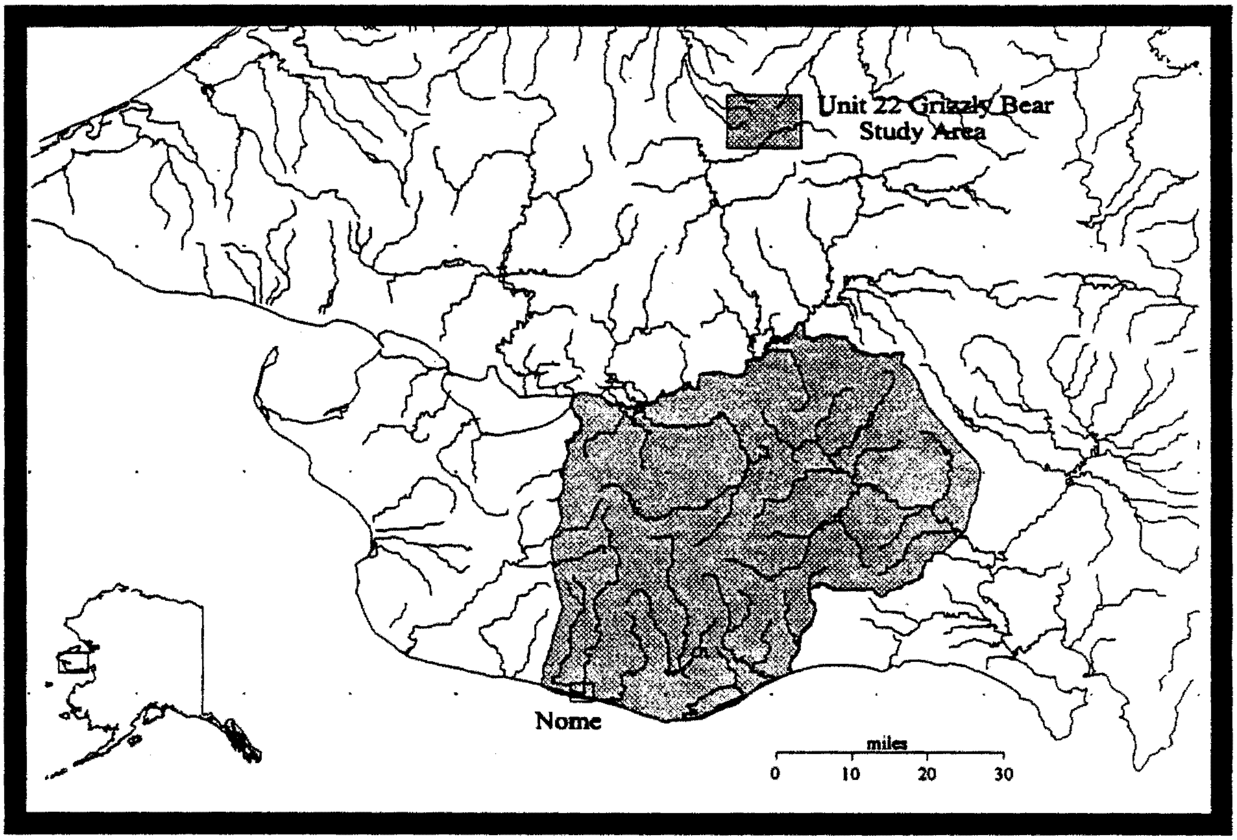


Figure 1. Study area north of Nome, Alaska where brown bears were marked during spring 1989 and 1990.

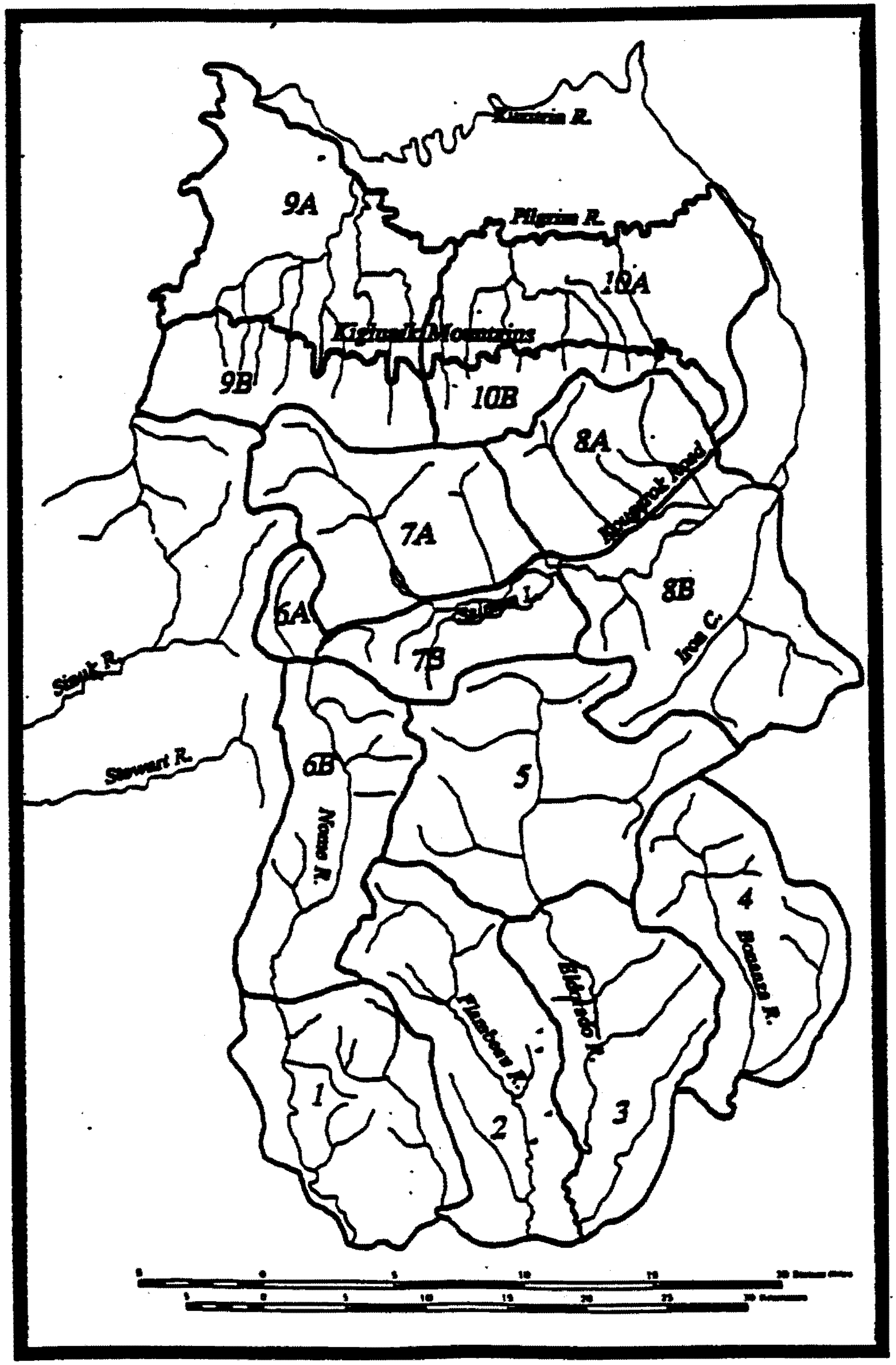


Figure 2. Study are north of Nome, Alaska where brown bear density was estimated during spring 1991. Quadrats illustrated were used to allocate and document search effort.

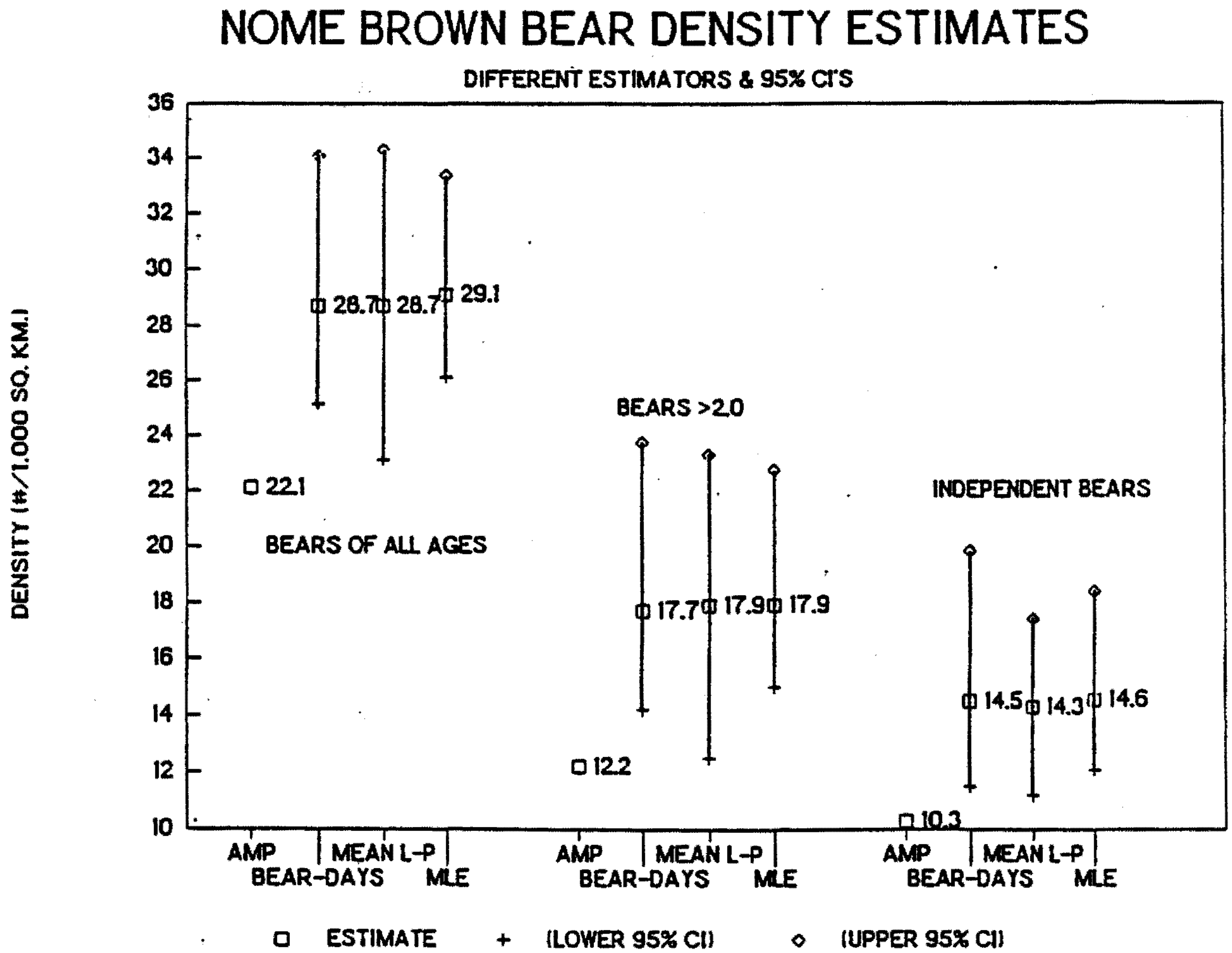


Figure 3. Comparison of density estimates and 95% CIs obtained during average minimum number present (AMP), and CMR estimates based on bear-days, mean Petersen estimates (mean L-P), and maximum likelihood estimators (MLE).

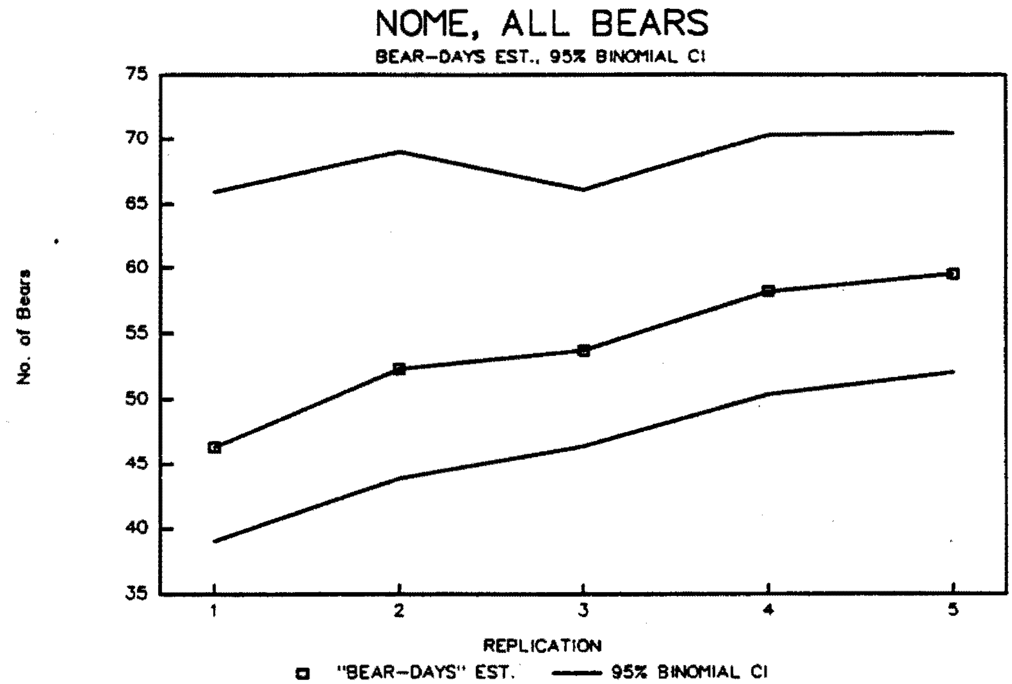


Figure 4. Point estimates and 95% CIs obtained for all bears observed.during replications.

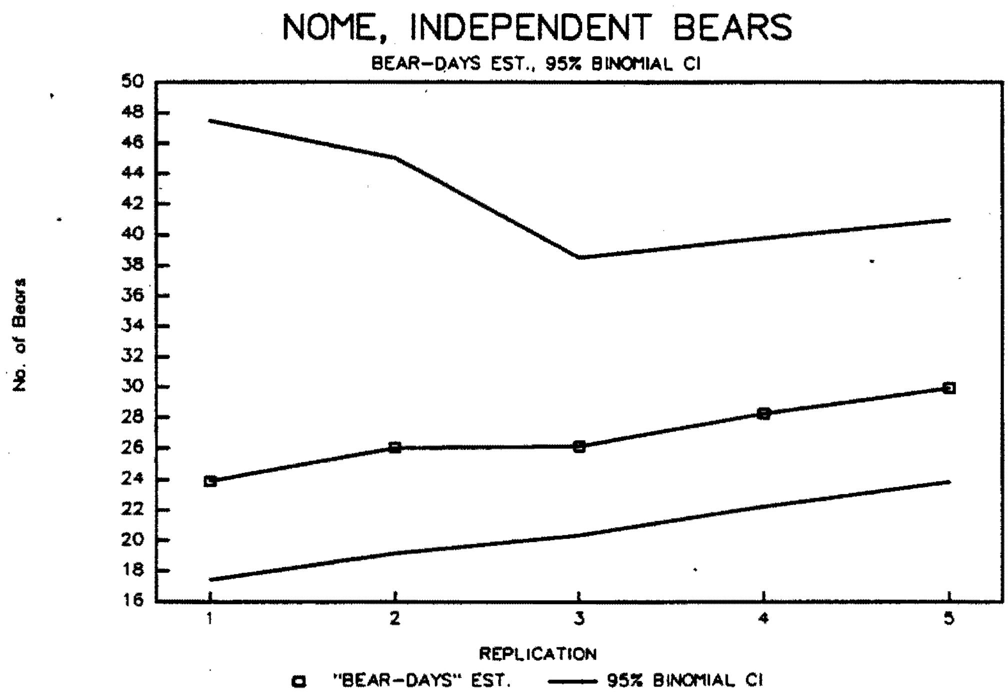


Figure 5. Point estimates and 95% CIs obtained for independent bears observed during replications.

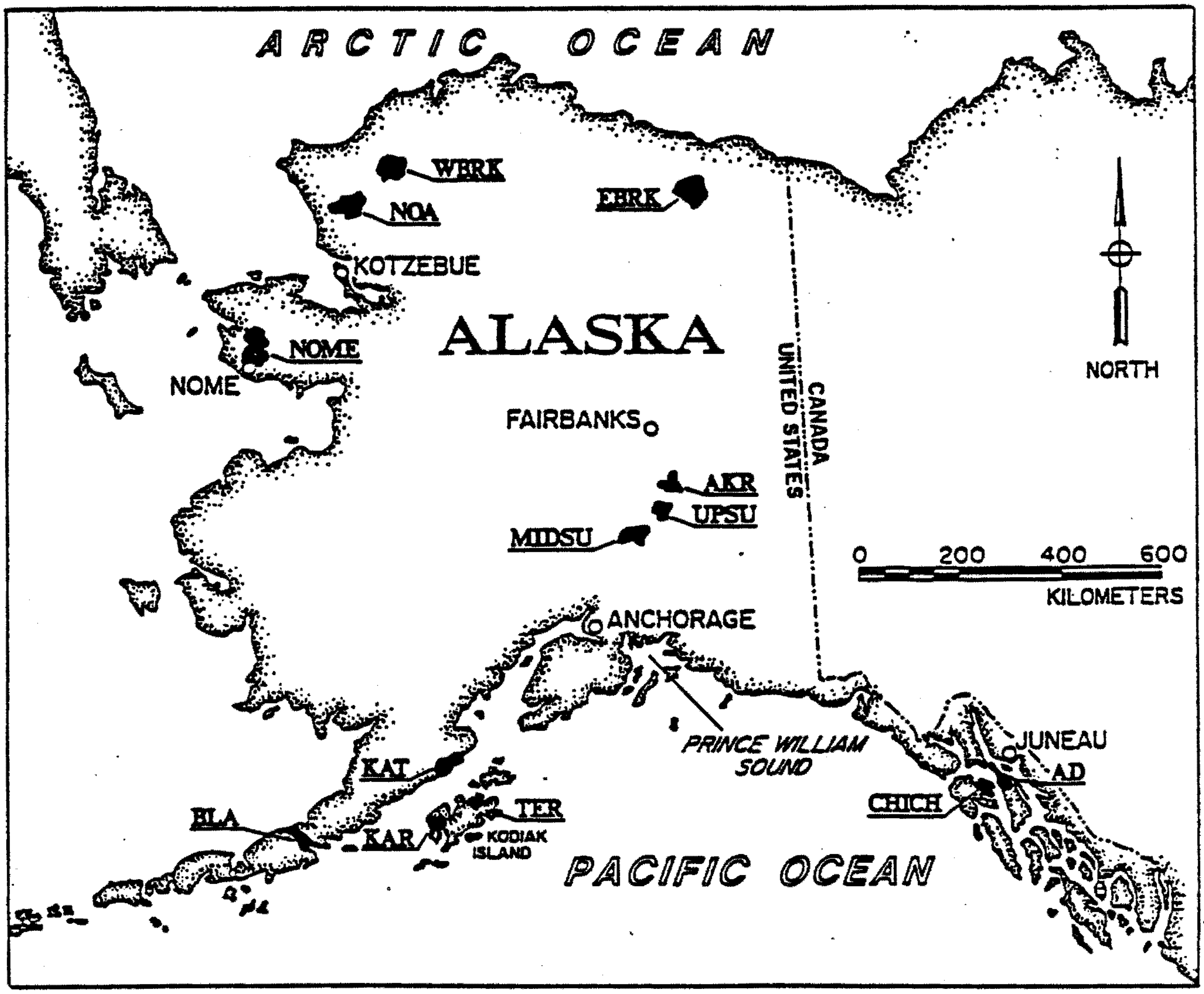


Figure 6. Locations of grizzly and black bear density estimates obtained in different portions of Alaska.

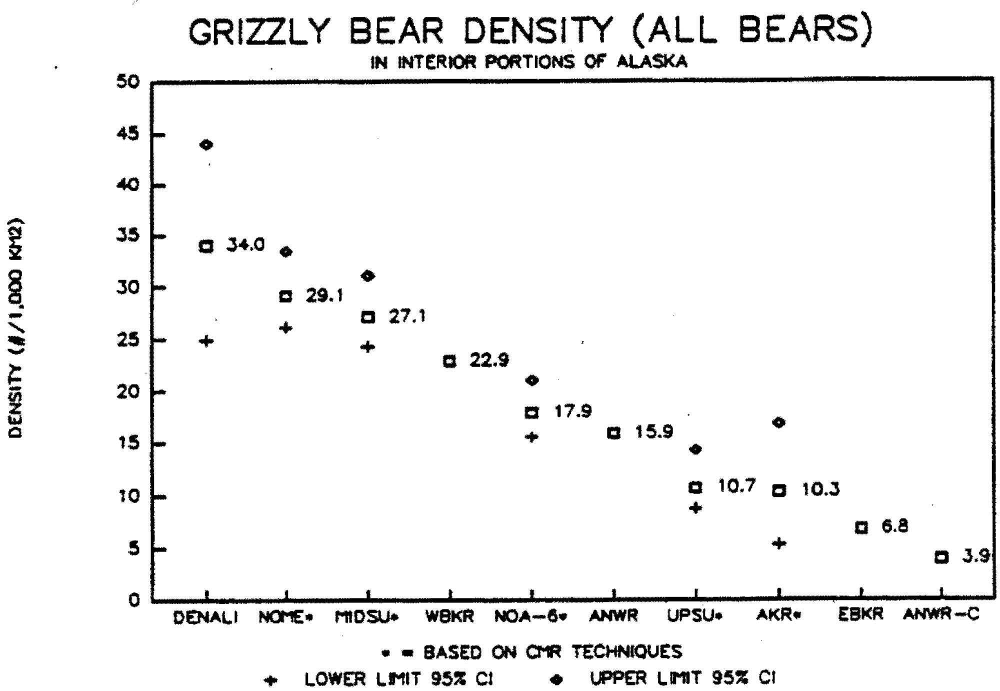


Figure 7. A comparison of Nome grizzly bear density estimate for the all bear unit with estimates in other portions of interior Alaska.

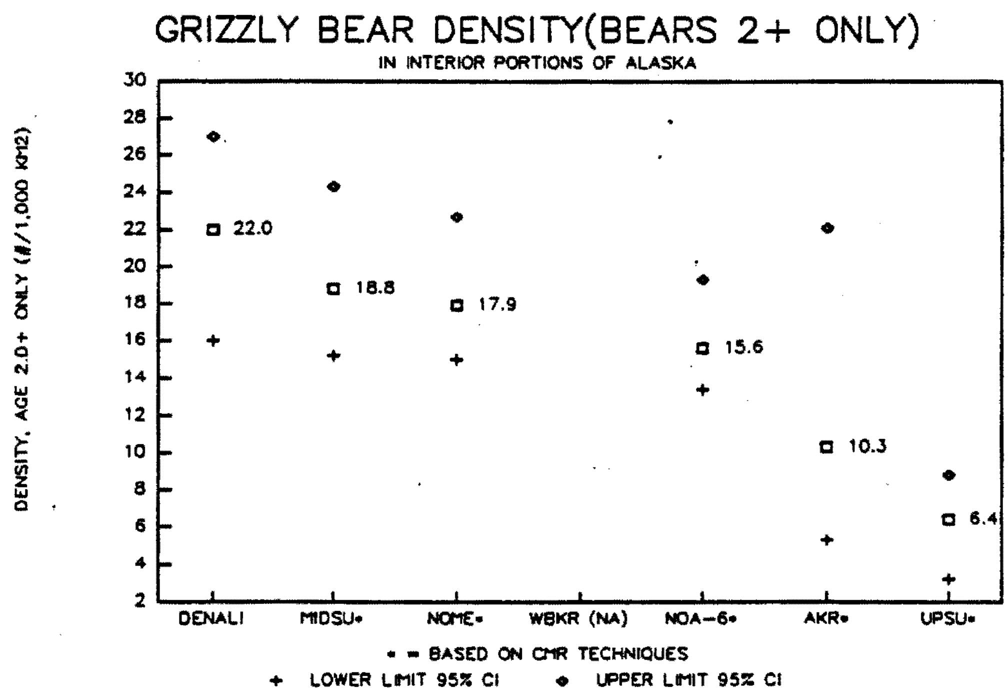


Figure 8. A comparison of Nome density estimate for bears >2.0 with estimates in other portions of interior Alaska (see Fig. 4).

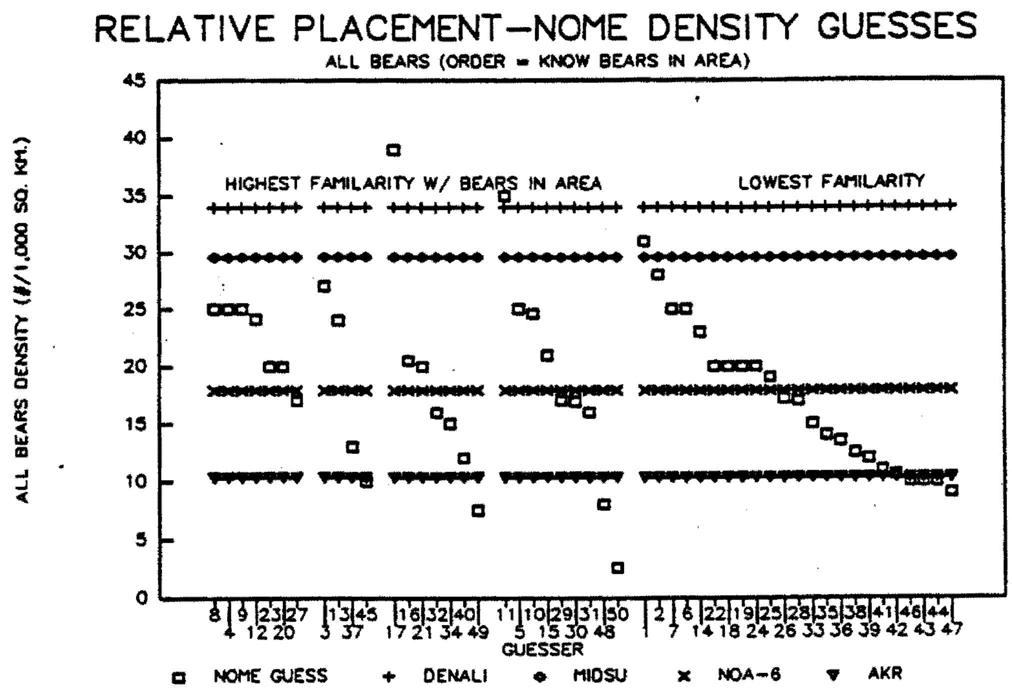


Figure 9. The relative position of pre-study Nome study area grizzly bear density guesses ordered based on knowledge of bears in the study area.

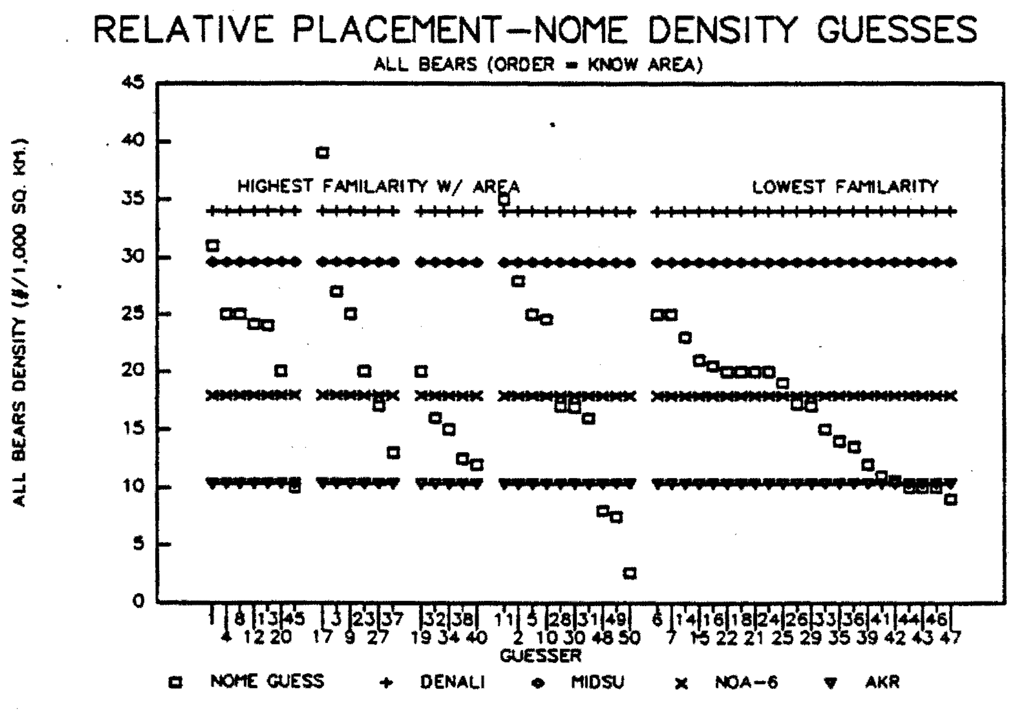


Figure 10. The relative position of pre-study Nome study area grizzly bear density guesses ordered based on knowledge of the study area.

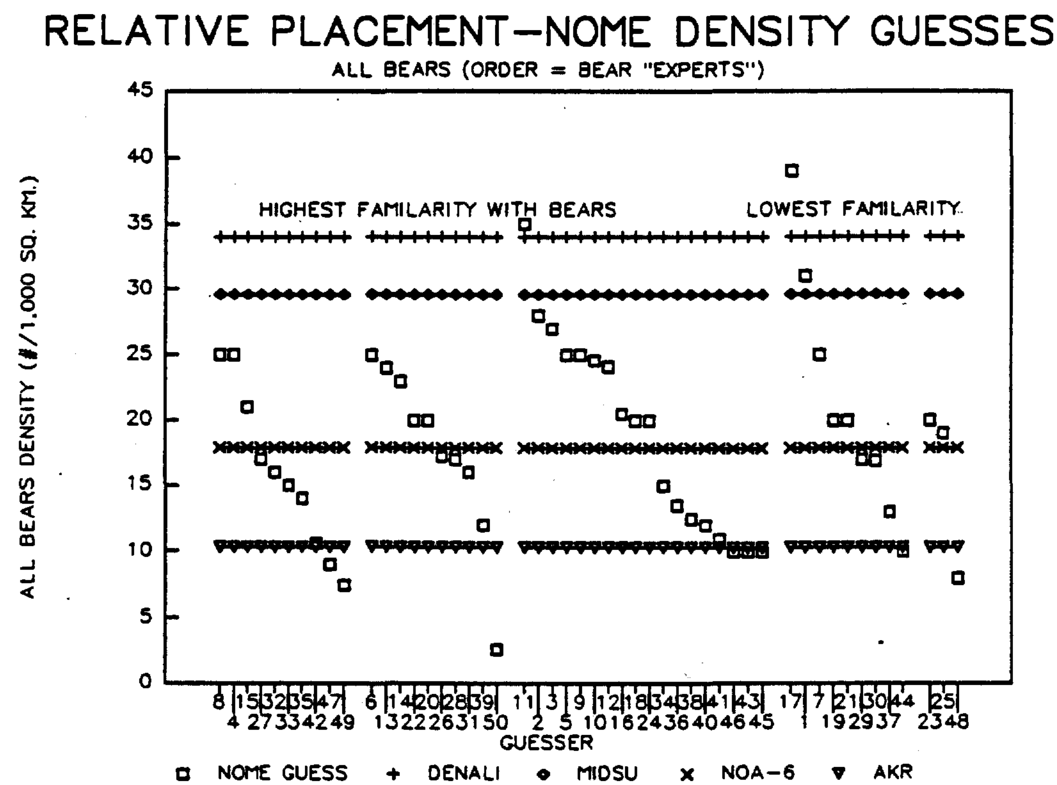


Figure 11. Relative position of pre-study Nome study area grizzly bear density guesses ordered based on knowledge of bears in general.

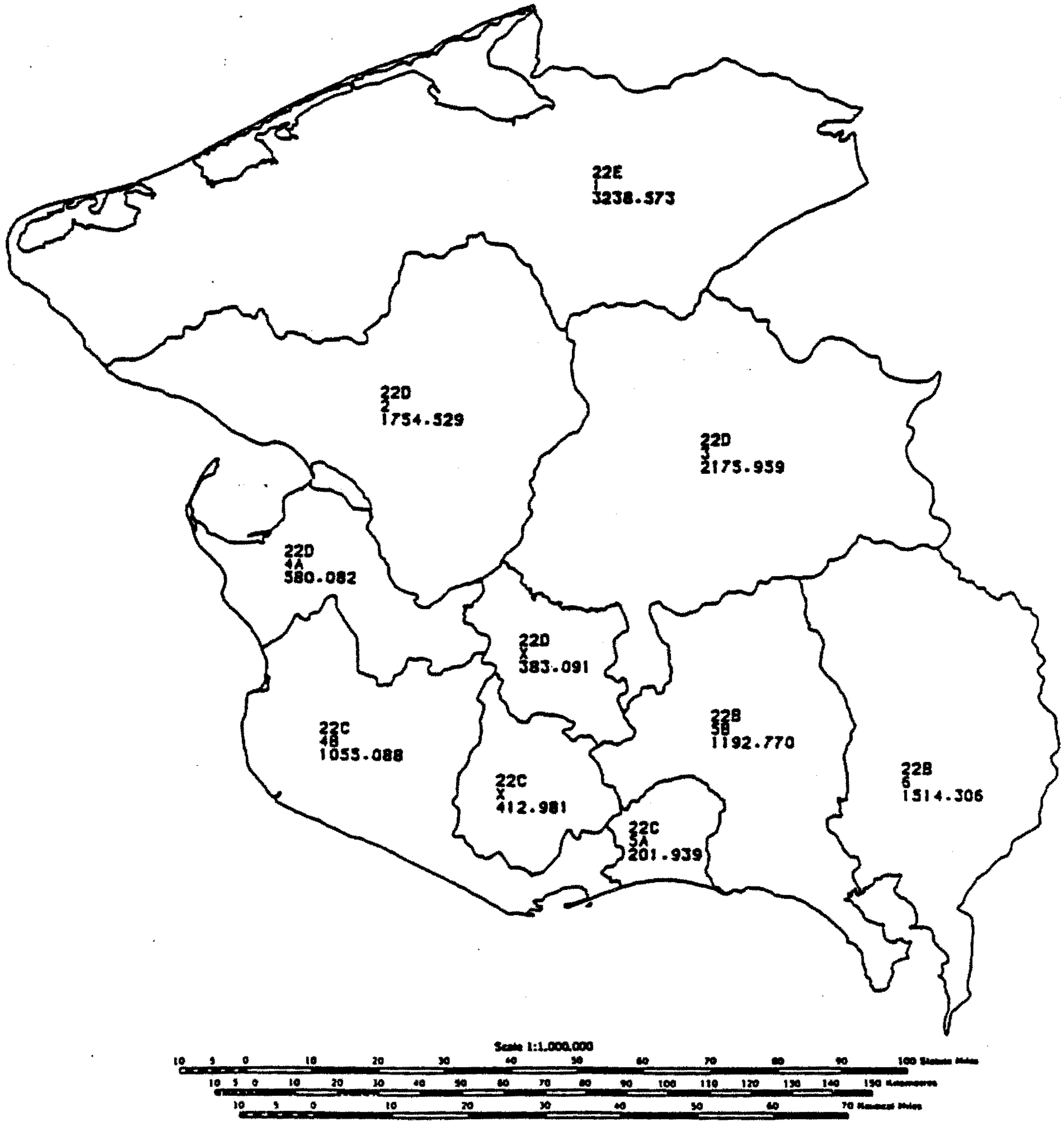


Figure 12. Six areas in the western portion of Unit 22 where grizzly bear density estimates were calculated.

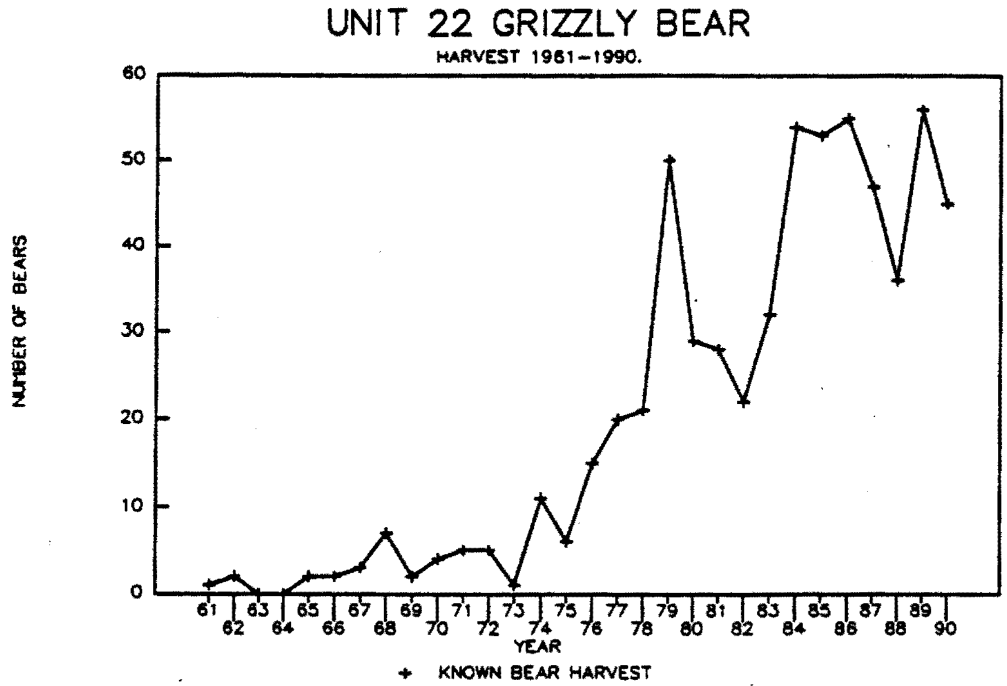


Figure 13. Historical harvest of grizzly bears in Unit 22 for years 1961-1990.

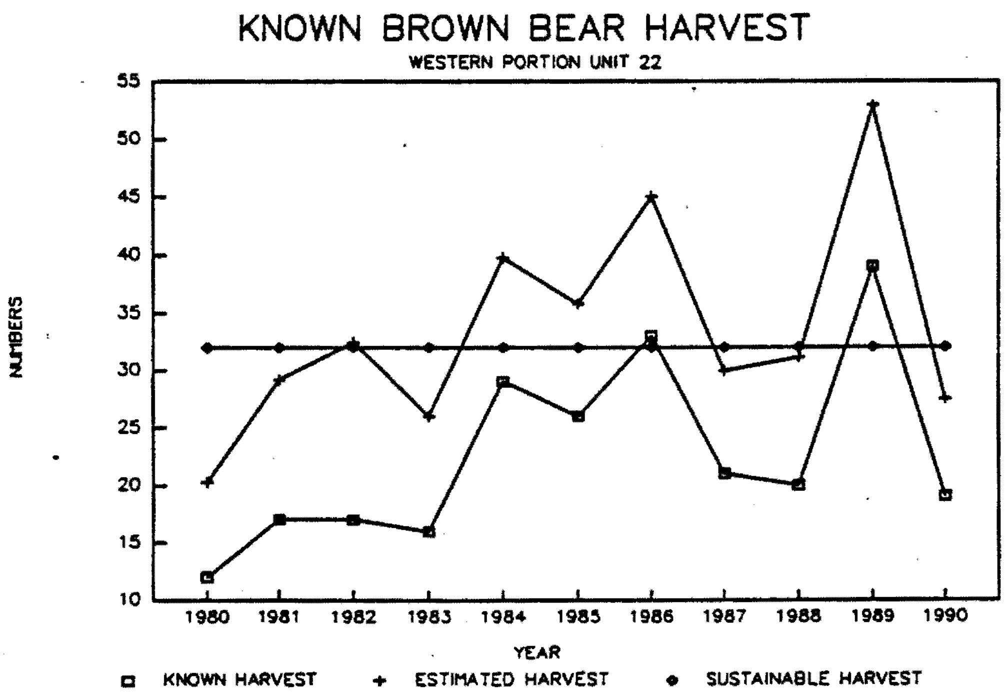


Figure 14. Comparison of known and estimated grizzly bear harvest from western portion of Unit 22 with the estimated sustainable harvest from the same area.

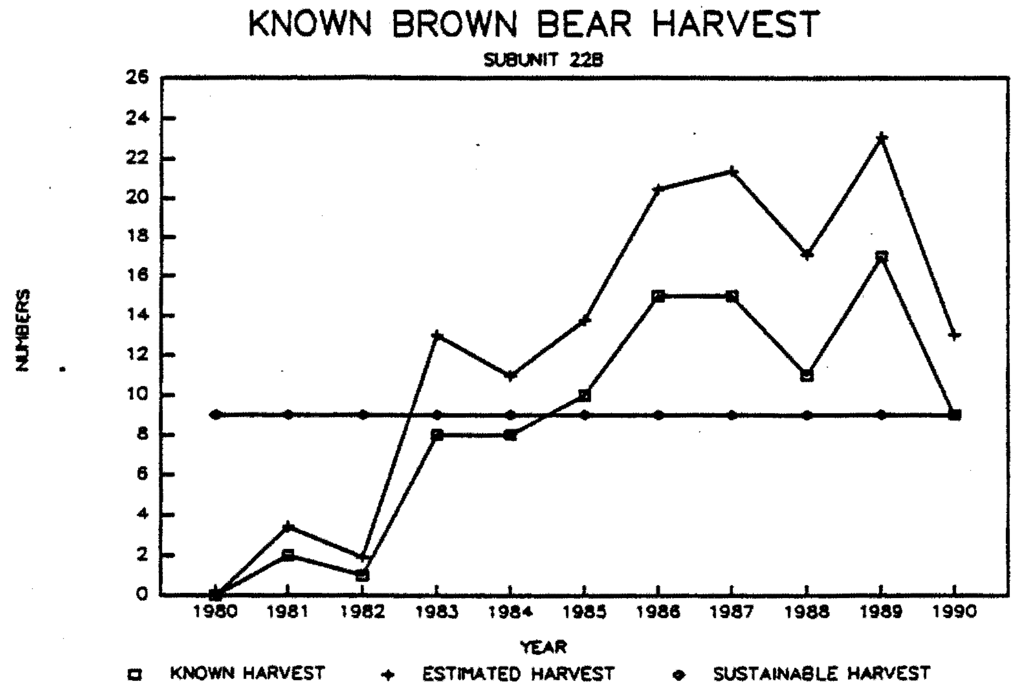


Figure 15. Comparison of known estimated grizzly bear harvest from western portion of Subunit 22B with the estimated sustainable harvest from the same area.

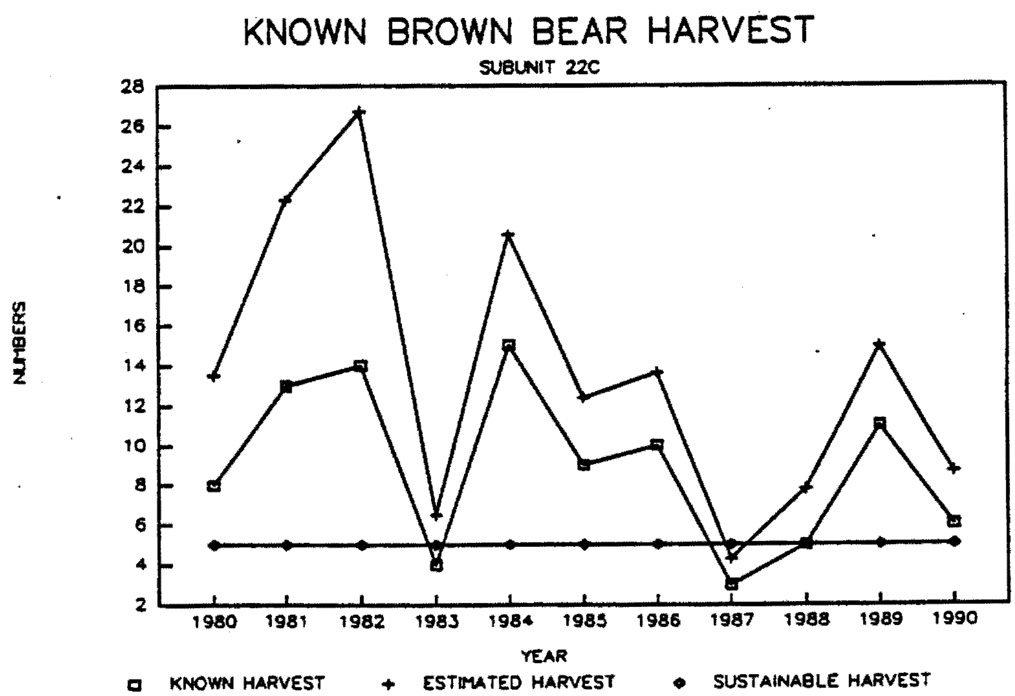


Figure 16. Comparison of known estimated grizzly bear harvest from Subunit 22C with the estimated sustainable harvest from the same area.

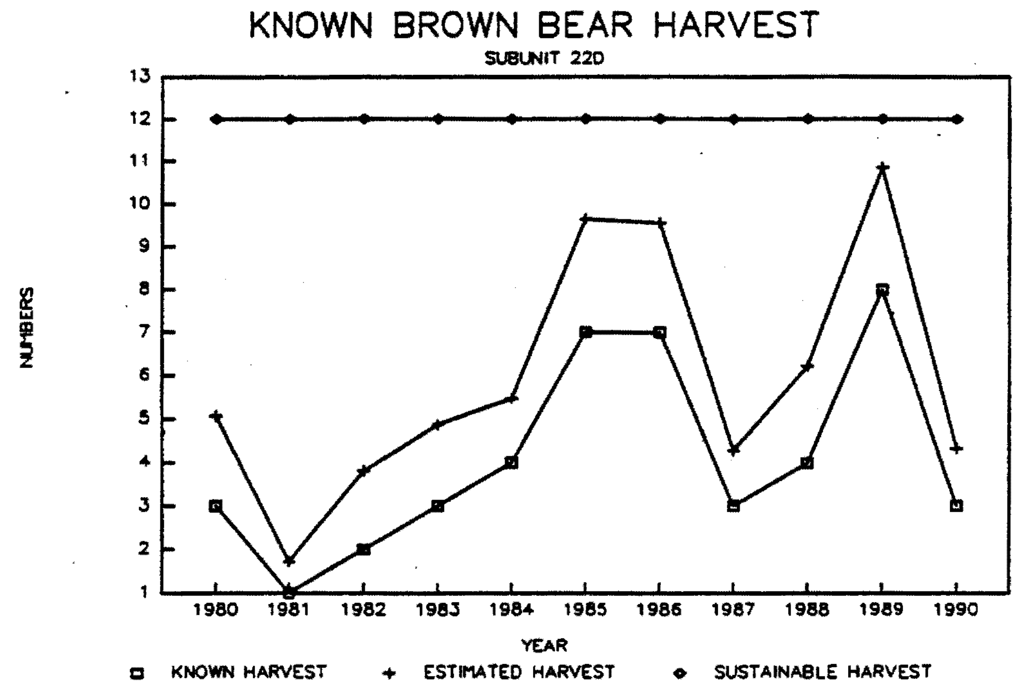


Figure 17. Comparison of known and estimated grizzly bear harvest from Subunit 22D with the estimated sustainable harvest for the same area.

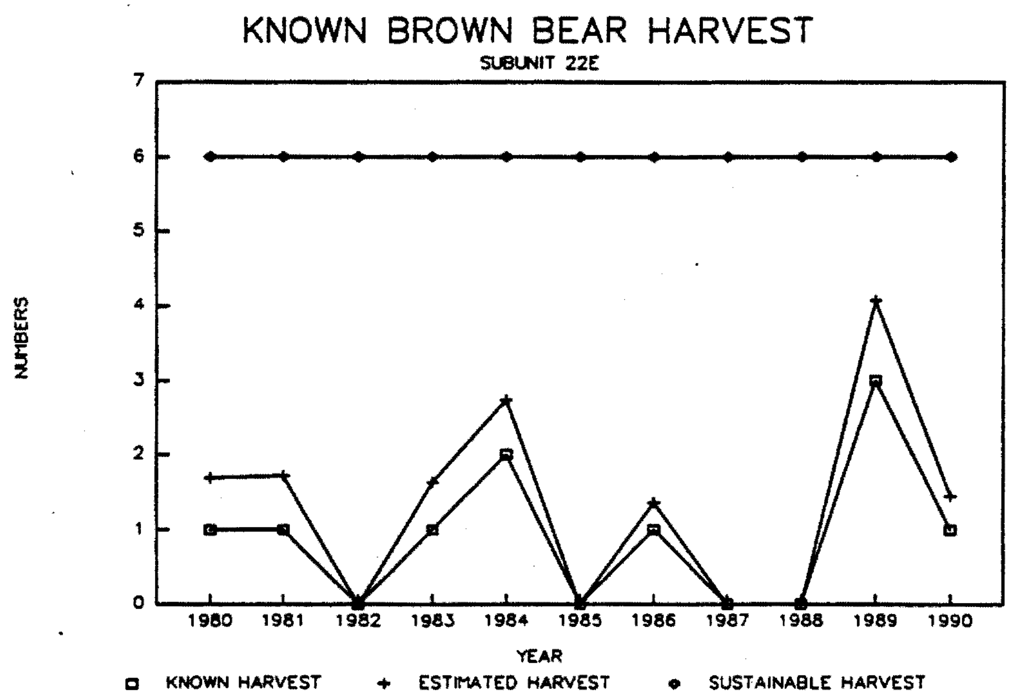


Figure 18. Comparison of known estimated grizzly bear harvest from the western portion of Subunit 22E with the estimated sustainable harvest for the same area.

Table 1. Brown bear capture records from the Seward Peninsula during 1989 and 1990. Cementum ages were determined by G. Matson.

Bear ID	Sex	Adult	Radio S.No.	Capture Date	Capture Location Lat.	Capture Location Long.	Age Est.	Age Cem.	Offspring No.	Offspring Age	Ear Tags Left	Ear Tags Right	Association
123	F	Y[a]	27931-01	3-Jun-89	64.9270	165.1732	15.0	9.5	1	0.5	25RR	48RR	124
124	M	N		3-Jun-89	64.9270	165.1732	0.5	0.5			44RR	46RR	Alone
125	M	Y[a]	27933-01	3-Jun-89	65.0940	165.1092	10.0	6.5			6RR	5RR	126
126	F	Y[a]	27925-01	3-Jun-89	64.6660	163.8870		12.5	0		179RR	181RR	125
127	F	Y[a]	27932-01	3-Jun-89	64.6804	165.2481	11.0	6.5	2	1.5	192RR	191RR	128,129
128	M	N		3-Jun-89	64.6804	165.2481	1.5	1.5			170RR	172RR	127,129
129	F	N		3-Jun-89	64.6804	165.2481	1.5	1.5			174RR	175RR	127,128
130	M	Y[a]	27942-01	3-Jun-89	64.8184	168.8582	13.5	10.5			151RR	154RR	Alone
131	F	Y[a]	27927-01	3-Jun-89	64.9391	165.0050	13.5	12.5	2	0.5	9RR	10RR	132,133
132	F	N		3-Jun-89	64.9391	165.0050	0.5	0.5			177RR	176RR	132,134
133	M	N		3-Jun-89	64.9391	165.0050	0.5	0.5			178RR	188RR	132,133
134	F	Y[a]	27923-01	3-Jun-89	64.9986	165.4094	14.0	8.5	3	2.5	159RR	160RR	135,136,137
135	M	N		3-Jun-89	64.9986	165.4094	2.5	2.5			156RR	155RR	134,136,137
136	M	N		3-Jun-89	64.9986	165.4094	2.5	2.5			158RR	157RR	134,135,137
137	M	N		3-Jun-89	64.9986	165.4094	2.5	2.5			162RR	161RR	134,135,136
138	F	Y[a]	27949-01	4-Jun-89	64.8539	165.3376	4.0	5.5	0		127RR	74RR	Alone
139	F	Y[a]	27951-01	4-Jun-89	64.7058	164.7226		8.5	2	1.5	190RR	189RR	140,141
140	M	N		4-Jun-89	64.7058	164.7226	1.5	1.5			62RR	61RR	139,141
141	F	N		4-Jun-89	64.7058	164.7226	1.5	1.5			72RR	73RR	139,140
142	M	Y[a]	12411-02	4-Jun-89	64.5734	165.0057	8.0	4.5			68RR	67RR	143
143	F	Y[a]	12417-02	4-Jun-89	64.5734	165.0057	6.0	4.5	0		64RR	63RR	142
144	F	Y[a]	12432-02	6-Jun-89	64.8972	164.8268	4.0	5.5	0		75RR	60RR	145
145	F	Y[a]	27926-01	6-Jun-89	64.8978	164.8271	9.0	12.5	0		7RR	8RR	144
146	F	Y[a]	12414-02	6-Jun-89	64.9280	163.9870	10.0	10.5	0		59RR	58RR	147
147	M	Y[a]	12431-02	6-Jun-89	64.9277	163.9884	7.5	7.5			98RR	100RR	146
148	M	Y[a]	12420-02	6-Jun-89	64.8761	164.6314	11.5	8.5			160RR	167RR	149,125
149	F	Y[a]	12418-02	6-Jun-89	64.8760	164.6304			0		86RR	87RR	125,148
150	M	Y		7-Jun-89			6.5	5.5			84RR	85RR	Alone
151	F	Y[a]	12427-02	7-Jun-89	64.7914	164.9664	7.5	8.5	0		83RR	82RR	Alone
152	F	Y[a]	12435-02	7-Jun-89	64.7856	165.1290	4.5	4.5	0		80RR	81RR	142

Table 1. Cont'd.

Bear ID	Sex	Adult	Radio S.No.	Capture Date	Capture Location Lat.	Capture Location Long.	Age Est.	Age Cem.	Offspring No.	Offspring Age	Ear Tags Left	Ear Tags Right	Association
153	F	Y[a]	12422-02	7-Jun-89	65.1494	164.7386		10.5	3	3.5	97RR	96RR	154,155,156
154	F	N		7-Jun-89	65.1494	164.7386	1.5	3.5			78RR	79RR	153,155,156
155	M	N		7-Jun-89	65.1494	164.7386	3.5	3.5			166RR	165RR	153,154,156
156	M	N		7-Jun-89	65.1494	164.7386	3.5	3.5			51RR	52RR	153,154,155
157	F	N		8-Jun-89			3.5	2.5	0		163RR	53RR	Alone
158	F	Y[a]	12424-02	8-Jun-89	65.1471	163.9522	12.5	9.5	0		65RR	66RR	Alone
159	M	N		8-Jun-89	65.2019	163.9216	1.5	1.5			88RR	89RR	160,161
160	F	Y[a]	17811-02	8-Jun-89	65.2019	163.9216	12.5	11.5	2	1.5	95RR	94RR	159,161
161	M	N		8-Jun-89	65.2019	163.9216	1.5	1.5			91RR	90RR	159,160
162	F	N		8-Jun-89			3.5	2.5			93RR	92RR	Alone
163	F	Y[a]	9542-02	8-Jun-89	65.0679	163.8155	12.5	11.5	2	2.5	76RR	77RR	164,165
164	M	N		8-Jun-89	65.0679	163.8155	3.5	2.5			164RR	54RR	163,165
165	M	N		8-Jun-89	65.0679	163.8155	3.5	2.5			56RR	57RR	163,164
166	M	Y[a]	27929	10-Jun-89	64.8578	164.8091	18.5	19.5	0		351WD	352WD	144
167	F	Y[a]	12437-02	8-Jun-89	64.9753	164.2292	10.5	15.5	3	0.5			168,169,170
168	F	N		8-Jun-89	64.9753	164.2292	0.5	0.5					167,169,170
169	M	N		8-Jun-89	64.9753	164.2292	0.5	0.5					167,168,170
170	F	N		8-Jun-89	64.9753	164.2292	0.5	0.5					167,168,169
171	F	Y[a]	12429-02	8-Jun-89	64.7864	164.4869	8.5	6.5	0				172
172	M	Y		8-Jun-89	64.7864	164.4869	7.5						171
173	F	Y[a]	27935-01	8-Jun-89	64.9124	163.8577	16.5	16.5	2	0.5			174,175
174	M	N		8-Jun-89	64.9124	163.8577	0.5	0.5					173,175
175	F	N		8-Jun-89	64.9124	163.8577	0.5	0.5					173,174
147	M	Y[a]	36552	6-Jun-90	64.9750	164.2295	8.5	8.5			98RR	100RR	
149	F	Y[a]	36551	8-Jun-90			14.5	12.5	0		87RR	86RR	
200	F	Y[a]	35929	4-Jun-90	64.7698	164.7643	8.5	16.5	0		1042BR	1037BR	201,142
201	F	Y[a]	35925	4-Jun-90	64.7706	164.7637	0.0	24.5	0		3015RR	3003RR	Alone
202	M	Y		4-Jun-90	64.7784	164.2556	2.5	4.5			1017BR	1003BR	203,171
203	M	N		4-Jun-90	64.7784	164.2556	3.5	3.5			1043BR	1040BR	202,171
204	F	Y[a]	36550	6-Jun-90	64.6371	165.2112		5.5	1	0.5	1044BR	1046BR	205
205	F	N		6-Jun-90	64.6371	165.2112	0.5	0.5			63YR	64YR	204
206	F	Y		6-Jun-90			2.5	5.5	0		1041BR	1045BR	Alone

Table 1. Cont'd.

Bear ID	Sex	Adult	Radio S.No.	Capture Date	Capture Location Lat.	Capture Location Long.	Age Est.	Age Cem.	Offspring No.	Offspring Age	Ear Tags Left	Ear Tags Right	Association
207	F	Y[a]	36553	7-Jun-90	64.6601	164.3639	14.5	12.5	3	1.5	3045RR	3032RR	208,209,210
208	F	N		6-Jun-90	64.6601	164.3639	1.5				51YR	75YR	207,209,210
209	M	N		7-Jun-90	64.6601	164.3639	1.5				376GR	377GR	207,208,210
210	M	N		7-Jun-90	64.6601	164.3639	1.5				380GR	379GR	207,208,209
211	F	Y[a]	36549	7-Jun-90	64.9930	165.1682	12.5	20.5	0		3052RR	3051RR	125
212	F	Y[a]	36554	7-Jun-90	65.0562	165.1320	9.5	9.5	2	2.5	3074RR	3075RR	213,214
213	F	N		7-Jun-90	65.0562	165.1320	1.5	2.5			66YR	65YR	212,214
214	F	N		7-Jun-90	65.0562	165.1320	1.5	2.5			67YR	68YR	212,213
215	M	Y[a]	36556	7-Jun-90	65.1669	164.6412	7.5	6.5			1051BR	1052BR	153
216	F	Y[a]	35928	7-Jun-90	64.8439	163.8065	5.5	5.5	0		3055RR	3054RR	217,218
217	M	Y[a]	36557	7-Jun-90	64.8430	163.8078		5.5			1008BR	1009BR	216,218
218	F	Y[a]	36555	7-Jun-90	64.8436	163.8082	8.5	8.5	0		3073RR	3053RR	216,217
219	M	Y[a]	36558	8-Jun-90	64.6418	164.8002	5.5	4.5			1075BR	1072BR	220
220	F	Y[a]	36560	8-Jun-90	64.6415	164.8006		7.5	0		3018RR	3008RR	219
221	F	Y[a]	36562	8-Jun-90	64.8968	164.1158	14.5	16.5	0		3038RR	3047RR	Alone
222	F	Y[a]	27940	8-Jun-90	64.7375	164.1876	16.5	18.5	0		3009RR	3005RR	223
223	M	Y[a]	35927	8-Jun-90	64.7375	164.1869	6.5				1070BR	1071BR	222
224	F	N		9-Jun-90			2.5	2.5	0		3021RR	3016RR	225,226
225	M	N		9-Jun-90			2.5	2.5			1063BR	1062BR	224,226
226	M	N		9-Jun-90			2.5	2.5			1065BR	1064BR	224,225
227	F	Y[a]	36565	9-Jun-90	64.1406	163.8334	10.5	13.5	3	2.5	3072RR	3071RR	228,229,230
228	F	N		9-Jun-90	65.1400	163.8334	1.5	2.5			3104RR	3103RR	227,229,230
229	M	N		9-Jun-90	65.1406	163.8334	1.5	2.5			1006BR	1007BR	227,228,230
230	F	N		9-Jun-90	65.1406	163.8334	1.5	2.5			3102RR	3101RR	227,228,229
231	F	Y[a]	36563	9-Jun-90	64.8001	165.4120	14.5	23.5	0		3091RR	3006RR	130
232	F	Y[a]	36564	10-Jun-90	65.2131	164.2894	18.5	20.5	0		3105RR	3106RR	215
233	M	Y[a]	27944	10-Jun-90	65.1986	164.4068	15.5				1020BR	1022BR	Alone
234	M	Y[a]	35930	10-Jun-90	64.9925	164.5371	6.5	4.5			1059BR	1060BR	Alone
235	M	N		10-Jun-90	64.8981	164.6795	1.5	1.5			381GR	382GR	236

Table 1. (Cont'd).

Bear ID	Sex	Adult	Radio S.No.	Capture Date	Capture Location		Age		Offspring		Ear Tags		Association
					Lat.	Long.	Est.	Cem.	No.	Age	Left	Right	
236	F	Y[a]	27947	10-Jun-90	64.8981	164.6795	12.5	18.5	1	1.5	3070RR	3069RR	235
237	F	Y[a]	36566	10-Jun-90	64.8405	164.5189	15.5	18.5	1	1.5	3125RR	3124RR	238
238	M	N		10-Jun-90	64.8405	164.5189	1.5	1.5			386GR	384GR	237
239	F	Y[a]	36569	11-Jun-90	64.8108	165.3574	18.5	21.5	2	1.5	3122RR	3123RR	240,241
240	F	N		11-Jun-90	64.8108	165.3574	1.5	1.5			70YR	69YR	239,241
241	M	N		11-Jun-90	64.8108	165.3574	1.5	1.5			394GR	393GR	239,240
242	F	Y[a]	36568	11-Jun-90	64.7789	165.7648		13.5	2	1.5	3121RR	3120RR	243
243	M	N		11-Jun-90	64.7789	165.7648	1.5	1.5			362GR	361GR	242.1.

[a] Collared bears

Blank spaces found throughout table indicate data to either be absent or inappropriate.

Table 2. Status of marked brown bears during spring 1991 Seward Peninsula density estimation study. Ages of adult bears were determined from pre-molar samples analyzed by G. Matson and reflect the calculated ages of bears at the time of the census. Under the heading AREA, the symbol N indicates those bears found in the northern area and the symbol S indicates those bears found in the southern area.

			Young		Repetition No 1				Repetition No 2				Repetition No 3			
					In/		Group		In/		Group		In/		Group	
No	Sex	Age	No	Age	Out	Area	No	Seen	Out	Area	No	Seen	Out	Area	No	Seen
125	M	8.5			In	N	1		In	N	1		In	N	1	
130	M	12.5			In	S	1		In	S	1	Yes	In	S	1	
123	F	11.5	3	0.5	In	N	4		In	N	4		In	N	4	Yes
127	F	8.5			In	S	1		In	S	1	Yes	In	S	1	
139	F	10.5	1	3.5	In	S	2		In	S	2	Yes	In	S	2	Yes
144	F	7.5	2	1.5	In	S	3		In	N	3	Yes	In	N	3	
145	F	14.5	2	1.5	In	S	3		In	S	3		In	S	3	
151	F	10.5	2	1.5	In	S	3		In	S	3	Yes	In	S	3	Yes
171	F	8.5			Out		1		Out		1		Out		1	
200	F	17.5	2	0.5	In	S	3		In	S	3		In	S	3	
204	F	6.5	1	1.5	In	S	2		In	S	2		In	S	2	
211	F	21.5	1	0.5	In	N	2		In	N	2		In	N	2	
212	F	10.5	2	0.5	In	N	3		In	N	3	Yes	In	N	3	Yes
220	F	8.5	3	0.5	In	S	4	Yes	In	S	4		In	S	4	
236	F	19.6	1	0.5	In	N	2		In	S	1	Yes	Out		1	
239	F	22.5	2	2.5	Out		3		In	S	3	Yes	In	S	3	
147	M	9.5			Out		1		Out		1		Out		1	
217	M	6.5			Out		1		Out		1		Out		1	
219	M	5.5			Out		1		Out		1		Out		1	
234	M	5.5			Out		1		Out		1		Out		1	
134	F	10.5			Out		1		Out		1		Out		1	
138	F	7.5	2	1.5	Out		3		Out		3		Out		3	
146	F	12.5	3	1.5	Out		4		Out		4		Out		4	
153	F	12.5	1	0.5	Out		2		Out		2		Out		2	
158	F	11.5			Out		1		Out		1		Out		1	
160	F	13.5	1	3.5	Out		2		Out		2		Out		2	
163	F	13.5	1	3.5	Out		2		Out		2		Out		2	
167	F	17.5			Out		1		Out		1		Out		1	
173	F	18.5			Out		1		Out		1		Out		1	
207	F	13.5			Out		1		Out		1		Out		1	
218	F	9.5	3	0.5	Out		4		Out		4		Out		4	
221	F	17.5			Out		1		Out		1		Out		1	
222	F	19.5	2	0.5	Out		3		Out		3		Out		3	
227	F	14.5	3	2.5	Out		4		Out		4		Out		4	
232	F	21.5			Out		1		Out		1		Out		1	
242	F	14.5			Out		1		Out		1		Out		1	

Table 2. (continued).

				Repetition No 4				Repetition No 5				Repetition No 6			
		Young		In/		Group		In/		Group		In/		Group	
No Sex	Age	No	Age	Out	Area	No	Seen	Out	Area	No	Seen	Out	Area	No	Seen
125M	8.5			In	N	1		Out		1		Out		1	
130M	12.5			In	S	1	Yes	Out		1		In	S	1	
123 F	11.5	3	0.5	In	N	4		In	N	4		In	N	4	Yes
127 F	8.5			In	S	1	Yes	Out		1		In	S	1	
139 F	10.5	1	3.5	In	S	2		In	S	2		In	S	1	Yes
144 F	7.5	2	1.5	In	N	3		In	N	3		In	N	3	
145 F	14.5	2	1.5	In	S	3	Yes	In	S	3	Yes	In	S	3	Yes
151 F	10.5	2	1.5	In	S	3	Yes	In	S	3		In	S	3	Yes
171 F	8.5			Out		1		In	S	1	Yes	In	S	1	
200 F	17.5	2	0.5	In	S	3	Yes	In	S	3	Yes	In	S	3	
204 F	6.5	1	1.5	In	S	2	Yes	In	S	2	Yes	In	S	2	
211 F	21.5	1	0.5	In	N	2		In	N	2		In	N	2	
212 F	10.5	2	0.5	In	N	3		In	N	3		In	N	3	Yes
220 F	8.5	3	0.5	In	S	4	Yes	In	S	4	Yes	In	S	4	
236 F	19.6	1	0.5	In	S	1	Yes	In	S	1	Yes	In	S	1	
239 F	22.5	2	2.5	In	S	3		In	S	3		In	S	3	
147M	9.5			Out		1		Out		1		Out		1	
217M	6.5			Out		1		Out		1		Out		1	
219M	5.5			Out		1		Out		1		Out		1	
234M	5.5			Out		1		Out		1		Out		1	
134 F	10.5			Out		1		Out		1		Out		1	
138 F	7.5	2	1.5	Out		3		Out		3		Out		3	
146 F	12.5	3	1.5	Out		4		Out		4		Out		4	
153 F	12.5	1	0.5	Out		2		Out		2		Out		2	
158 F	11.5			Out		1		Out		1		Out		1	
160 F	13.5	1	3.5	Out		2		Out		2		Out		2	
163 F	13.5	1	3.5	Out		2		Out		2		Out		2	
167 F	17.5			Out		1		Out		1		Out		1	
173 F	18.5			Out		1		Out		1		Out		1	
207 F	13.5			Out		1		Out		1		Out		1	
218 F	9.5	3	0.5	Out		4		Out		4		Out		4	
221 F	17.5			Out		1		Out		1		Out		1	
222 F	19.5	2	0.5	Out		3		Out		3		Out		3	
227 F	14.5	3	2.5	Out		4		Out		4		Out		4	
232 F	21.5			Out		1		Out		1		Out		1	
242 F	14.5			Out		1		Out		1		Out		1	

Table 2. (cont'd).

No.	Sex	Age	Young		No. of Bears			Percent	
			No	Age	In	Out	Seen	In	Seen
125	M	8.5			4	2	0	66.7	0.0
130	M	12.5			5	1	2	83.3	40.0
123	F	11.5	3	0.5	6	0	2	100.0	33.3
127	F	8.5			5	1	2	83.3	40.0
139	F	10.5	1	3.5	6	0	3	100.0	50.0
144	F	7.5	2	1.5	6	0	1	100.0	16.7
145	F	14.5	2	1.5	6	0	3	100.0	50.0
151	F	10.5	2	1.5	6	0	4	100.0	66.7
171	F	8.5			2	4	1	33.3	50.0
200	F	17.5	2	0.5	6	0	2	100.0	33.3
204	F	6.5	1	1.5	6	0	2	100.0	33.3
211	F	21.5	1	0.5	6	0	0	100.0	0.0
212	F	10.5	2	0.5	6	0	3	100.0	50.0
220	F	8.5	3	0.5	6	0	3	100.0	50.0
236	F	19.6	1	0.5	5	1	3	83.3	60.0
239	F	22.5	2	2.5	5	1	1	83.3	20.0
147	M	9.5			0	6	0	0.0	0.0
217	M	6.5			0	6	0	0.0	0.0
219	M	5.5			0	6	0	0.0	0.0
234	M	5.5			0	6	0	0.0	0.0
134	F	10.5			0	6	0	0.0	0.0
138	F	7.5	2	1.5	0	6	0	0.0	0.0
146	F	12.5	3	1.5	0	6	0	0.0	0.0
153	F	12.5	1	0.5	0	6	0	0.0	0.0
158	F	11.5			0	6	0	0.0	0.0
160	F	13.5	1	3.5	0	6	0	0.0	0.0
163	F	13.5	1	3.5	0	6	0	0.0	0.0
167	F	17.5			0	6	0	0.0	0.0
173	F	18.5			0	6	0	0.0	0.0
207	F	13.5			0	6	0	0.0	0.0
218	F	9.5	3	0.5	0	6	0	0.0	0.0
221	F	17.5			0	6	0	0.0	0.0
222	F	19.5	2	0.5	0	6	0	0.0	0.0
227	F	14.5	3	2.5	0	6	0	0.0	0.0
232	F	21.5			0	6	0	0.0	0.0
242	F	14.5			0	6	0	0.0	0.0

Table 3. Distribution of search effort during spring 1991 Seward Peninsula brown bear density estimation study.

Quad	Area	Search Effort (Minutes)						Mean			Search Team				
No	(Mi^2)	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Total	Search Time	Min/mi^2	Min/km^2	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6
1	60.7	119	176	133	126	128	821	136.8	2.25	0.87	3	1	5	3	1
2	74.5	157	174	159	97	189	906	151.0	2.03	0.78	3	5	1	4	3
3	65.3	138	155	98	154	146	817	136.2	2.09	0.81	2	3	1	4	5
4	61.4	152	101	157	189	101	817	136.2	2.22	0.86	2	3	0	5	4
5	82.2	200	163	147	300	191	1,178	196.3	2.39	0.92	1	2	2	5	1
6A	8.0	30	22	36	32	33	175	29.2	3.65	1.41	5	4	3	2	1
6B	56.1	168	104	151	101	148	824	137.3	2.45	0.95	3	2	1	2	4
7A	56.9	98	95	139	117	156	668	111.3	1.96	0.76	5	4	3	2	5
7B	36.3	60	48	56	97	80	409	68.2	1.88	0.73	4	2	4	1	3
8A	42.7	80	80	91	87	110	557	92.8	2.17	0.84	5	4	3	2	5
8B	76.2	141	127	154	178	187	953	158.8	2.08	0.81	2	3	4	1	5
9A	68.6	127	120	110	114	115	696	116.0	1.69	0.65	1	5	2	0	4
9B	26.8	121	88	52	47	56	415	69.2	2.58	1.00	1	5	2	4	4
10A	62.2	97	103	126	104	113	652	108.7	1.75	0.68	4	1	5	3	1
10B	20.0	48	62	75	91	102	423	70.5	3.53	1.36	4	1	5	3	1
	797.9	1,736	1,618	1,684	1,834	1,855	10,311	1,718	2.15	0.83					

Team 0 : Coady/Nelson
Team 1 : Lee/Miller
Team 2 : Schoen/Dau
Team 3 : Machida/Delong (Chetkiewicz on 6/7)
Team 4 : Smith/Chetkiewicz (Renecker on 6/7)
Team 5 : Rood/Jandt (Messenger On 6/7)

Table 4. Estimate of brown bear density and population size near Nome, Alaska based on the bear days estimator.

Bears of All Ages

Day	Date	nl(marks present)	m^2(marks seen)	n^2(total seen)	Min. no. present	Daily L-P	Sight-ability	N^*= Est. avg. No. bears	95% CI For N^* N^*=+/-	Study area Km^2	Density: No./1000 Km^2	Mi^2
1	6/2	36	17	22	41	46.3	0.47	46.28	7.10	2067	22.4	58.0
2	6/3	35	12	21	44	59.9	0.34	52.30	8.01	2067	25.3	65.5
3	6/4	36	18	28	46	55.5	0.50	53.67	6.51	2067	26.0	67.2
4	6/5	34	14	30	50	71.3	0.41	58.15	6.78	2067	28.1	72.9
5	6/6-7	35	14	26	47	63.8	0.40	59.42	6.41	2067	28.7	74.5
		MEAN =		45.6								
		Mean Daily L-P =				59.36	42.61			2067	28.7	74.4

95% CI based on binomial approx. to hypergeometric						80% CI based on binomial approx. to hypergeometric					
For No. bears:		For density (#/1000km^2)		(/1000mi^2)		For No. bears:		For density (#/1000km^2)		(/1000mi^2)	
Lower cl	Upper cl	Lower cl	Upper cl	Lower cl	Upper cl	Lower cl	Upper cl	Lower cl	Upper cl	Lower cl	Upper cl
39.05	65.90	18.89	31.88	48.936	82.572	40.67	58.18	19.68	28.15	50.965	72.897
43.87	68.99	21.22	33.37	54.971	86.441	46.13	62.68	22.32	30.32	57.807	78.535
46.32	66.06	22.41	31.96	58.041	82.777	48.42	61.47	23.43	29.74	60.672	77.027
50.36	70.26	24.37	33.99	63.108	88.039	52.67	65.83	25.48	31.85	66.003	82.482
51.99	70.43	25.15	34.07	65.150	88.248	54.24	66.43	26.24	32.14	67.961	83.235

Table 4 (Continued)

Independent Bears Only												
Day	Date	nl(marks present)	m^2(marks seen)	n^2(total seen)	Min. no. present	Daily L-P	Sight-ability	N^*= Est. avg. No. bears	95% CI For N^* N^*=+/-	Study area Km^2	Density: No./1000 Km^2	Density: No./1000 Mi^2
1	6/2	15	8	13	20	23.9	0.53	23.89	6.10	2067	11.6	29.9
2	6/3	14	4	9	19	29.0	0.29	26.04	6.90	2067	12.6	32.6
3	6/4	15	8	14	21	25.7	0.53	26.10	5.30	2067	12.6	32.7
4	6/5	13	6	16	23	33.0	0.46	28.21	5.40	2067	13.6	35.4
5	6/6-7	15	5	13	23	36.3	0.33	29.91	5.53	2067	14.5	37.5
		MEAN =		21.2								
		Mean Daily L-P =				29.58	43.06			2067	14.3	37.1

95% CI based on binomial approx. to hypergeometric						80% CI based on binomial approx. to hypergeometric					
For No. bears:		For density (#/1000km²)		For density (/1000mi²)		For No. bears:		For density (#/1000km²)		For density (/1000mi²)	
Lower cl	Upper cl	Lower cl	Upper cl	Lower cl	Upper cl	Lower cl	Upper cl	Lower cl	Upper cl	Lower cl	Upper cl
17.41	47.50	8.42	22.98	21.820	59.517	18.76	37.33	9.08	18.06	23.509	46.778
19.18	45.02	9.28	21.78	24.030	56.408	20.85	37.29	10.09	18.04	26.127	46.731
20.35	38.50	9.85	18.62	25.503	48.235	21.87	33.68	10.58	16.29	27.405	42.199
22.20	39.79	10.74	19.25	27.817	49.862	23.87	35.37	11.55	17.11	29.904	44.318
23.82	40.97	11.52	19.82	29.844	51.333	25.55	36.79	12.36	17.80	32.015	46.100

Table 4 (Continued)

Bears > 2.0 Only

Day	Date	nl(marks present)	m^2(marks seen)	n^2(total seen)	Min. no. present	Daily L-P	Sight-ability	N^*= Est. avg. No. bears	95% CI For N^* N^*=+/-	Study area Km^2	Density: No./1000 Km^2	Mi^2
1	6/2	18	11	16	23	25.9	0.61	25.92	4.82	2067	12.62.5	
2	6/3	17	5	10	22	32.0	0.29	28.09	5.84	2067	13.65.2	
3	6/4	18	8	16	26	34.9	0.44	30.63	5.64	2067	14.88.4	
4	6/5	16	6	18	28	45.1	0.38	34.19	6.25	2067	16.52.8	
5	6/6-7	17	5	15	27	47.0	0.29	36.53	6.57	206717.7		45.8
			MEAN =	25.2								
			Mean Daily L-P =			36.99	40.70			2067	17.9	46.3
			SE= 8.06									

95% CI based on binomial approx. to hypergeometric						80% CI based on binomial approx. to hypergeometric					
For No. bears:		For density (#/1000km²)		For density (/1000mi²)		For No. bears:		For density (#/1000km²)		For density (/1000mi²)	
Lower cl	Upper cl	Lower cl	Upper cl	Lower cl	Upper cl	Lower cl	Upper cl	Lower cl	Upper cl	Lower cl	Upper cl
20.23	43.54	9.79	21.07	25.348	54.558	21.44	36.25	10.37	17.54	26.780	45.427
21.94	43.14	10.61	20.87	27.489	54.050	23.47	37.18	11.36	17.99	29.410	46.586
24.44	43.34	11.82	20.97	30.626	54.310	26.11	38.33	12.63	18.54	32.718	48.029
27.30	46.86	13.21	22.67	34.206	58.720	29.24	42.06	14.15	20.35	36.641	52.706
29.38	49.07	14.21	23.74	36.810	61.489	31.44	44.38	15.21	21.47	39.393	55.604

Table 5. Estimate of brown bear density and population size near Nome Alaska based on mean Lincoln Petersen estimate and bias correction factor of Eberhardt (1990).

All Bears:

Day	n^1(marks present)	m^2(marks seen)	n^2(total seen)	Min. No present	Daily L-P	Mean of k L-Ps	Bias corrected estimate	Sample Variance (eq. 2)	(EQ. 13) t w/ (k-1) d.f.	95%CI= +/-	95% CI as % of estimate	Lower 95% CI	Upper 95% CI
1	36	17	22	41	46.3	46.28							
2	35	12	21	44	59.9	53.10	53.10	93.10	12.706	86.69	326.5	-33.6	139.8
3	36	18	28	46	55.5	53.89	53.89	48.43	4.303	17.29	64.2	36.6	71.2
4	34	14	30	50	71.3	58.25	58.25	108.34	3.182	16.56	56.9	41.7	74.8
5	35	14	26	47	63.8	59.36	59.36	87.41	2.776	11.61	39.1	47.8	71.0
			Mean =	45.60	59.36						Truncated =	45.6	
			SE =	10.47									

Day	Area (km^2)	Density #/1000km^2	Density #/1000mi^2	Density (#/1000 km^2) Lower 95% CI	Density (#/1000 km^2) Upper 95% CI	Density (#/1000 mi^2) Lower 95% CI	Density (#/1000 mi^2) Upper 95% CI
2	2067	25.7	66.5	-16.2	67.6	-42.1	175.2
3	2067	26.1	67.5	17.7	34.4	45.9	89.2
4	2067	28.2	73.0	20.2	36.2	52.2	93.7
5	2067	28.7	74.4	23.1	34.3	59.8	88.9

Truncated = 20.3

Table 5. (Continued).

Independent Bears

Day	n^1(marks present)	m^2(marks seen)	n^2(total seen)	Min. No present	Daily L-P	Mean of k L-Ps	Bias corrected estimate	Sample Variance (eq. 2)	(EQ. 13) t w/ (k-1) d.f.	95%CI= +/-	95% CI as % of estimate	Lower 95% CI	Upper 95% CI
1	15	8	13	20	23.9	23.89							
2	14	4	9	19	29.0	26.44	26.47	13.06	12.706	32.47	245.4	-6.0	58.9
3	15	8	14	21	25.7	26.19	26.20	6.73	4.303	6.45	49.2	19.8	32.6
4	13	6	16	23	33.0	27.89	27.90	16.10	3.182	6.38	45.8	21.5	34.3
5	15	5	13	23	36.3	29.58	29.60	26.34	2.776	6.37	43.0	23.2	36.0
			Mean =	21.20	29.58						Truncated =	21.2	
			SE =		5.27								

Day	Area (km^2)	Density #/1000km^2	Density #/1000mi^2	Density (#/1000 km^2) Lower 95% CI	Density (#/1000 km^2) Upper 95% CI	Density (#/1000 mi^2) Lower 95% CI	Density (#/1000 mi^2) Upper 95% CI
2	2067	12.8	33.2	-2.9	28.5	-7.5	73.9
3	2067	12.7	32.8	9.6	15.8	24.7	40.9
4	2067	13.5	35.0	10.4	16.6	27.0	43.0
5	2067	14.3	37.1	11.2	17.4	29.1	45.1
			Truncated =	9.2			

Table 5. (Continued).

Bears > 2.0

Day	n^1(marks present)	m^2(marks seen)	n^2(total seen)	Min. No present	Daily L-P	Mean of k L-Ps	Bias corrected estimate	Sample Variance (eq. 2)	(EQ. 13) t w/ (k-1) d.f.	95%CI= +/-	95% CI as % of estimate	Lower 95% CI	Upper 95% CI
1	18	11	16	23	25.9	25.92							
2	17	5	10	22	32.0	28.96	28.96	18.50	12.706	38.65	266.9	-9.7	67.6
3	18	8	16	26	34.9	30.94	30.94	20.98	4.303	11.38	73.6	19.6	42.3
4	16	6	18	28	45.1	34.49	34.49	64.45	3.182	12.77	74.1	21.7	47.3
5	17	5	15	27	47.0	36.99	37.00	79.65	2.776	11.08	59.9	25.9	48.1
		Mean =		25.20	36.99					Truncated =	25.2		
		SE =		6.97									

Day	Area (km^2)	Density #/1000km^2	Density #/1000mi^2	Density (#/1000 km^2) Lower 95% CI	Upper 95% CI	Density (#/1000 mi^2) Lower 95% CI	Upper 95% CI
2	20470	36.3	-4.32.7	-12.1	84.7		
3	20670	38.8	9.50.5	24.5	53.0		
4	20677	43.2	10.52.9	27.2	59.2		
5	20679	46.4	12.53.3	32.5	60.2		

Truncated = 10.6

Table 6. Brown bear density estimate (number/1,000 km^2) near Nome, Alaska using the maximum likelihood estimator of G. White and last 5 days of effort. Ti = number of marked individuals present in the study area during at least 1 replication.

	Estimated # of bears	Density	95% CI Limits Lower	Upper	T^i
All Bears	60.2	29.12	26.12	33.38	37
Bears >2.0 only	37.0	17.9	15	22.7	19
Independent bears	30.1	14.56	12.09	18.38	16

Table 7. Number of correct guesses on the brown bear density in the Nome study area made before the spring 1991 density estimate ordered by knowledge of bears in the area, by knowledge of the area, and by knowledge of bears in general. A "correct" guess put the Nome density between the middle Susitna River study area and the Noatak study area.

Based on knowledge of bears in study area:	Number Correct	Incorrect	Percent "correct"
1 (Highest)	6	1	85
2	2	2	50
3	2	6	25
4	3	6	33
5 (Lowest)	9	4	39
General knowledge of area:			
1 (Highest)	5	2	71
2	3	3	50
3	1	4	20
4	3	8	27
5 (Lowest)	10	12	45
General knowledge of bears:			
1 (Highest)	3	7	30
2	5	5	50
3	9	9	50
4	3	6	33
5 (Lowest)	2	2	50

Table 8. Family groups observed and number/percent of offspring age estimations by search team during spring 1991 Seward Peninsula bear density estimate.

Team number	Number of family groups observed	Number and percent of correct age estimations of offspring
0	2	2 (100%)
1	9	8 (88%)
2	4	2 (50%)
3	2	0 (0%)
4	3	2 (66%)
5	3	0 (0%)

Table 9. Number of correct and incorrect age determinations of offspring found within the study area during spring 1991 Seward Peninsula bear density estimate.

Bear	Offspring		Number of	Number of correct	Incorrect	
No.	No.	Age	times observed	age determinations	over	under
123	3	0.5	2	2	0	0
200	2	0.5	2	2	0	0
211	1	0.5	0	0		
212	2	0.5	3	3	0	0
220	3	0.5	3	3	0	0
236	1	0.5	0	0		
Total			10	10	0	0
144	2	1.5	1	0	1	0
145	2	1.5	3	0	3	0
151	2	1.5	4	2	2	0
204	1	1.5	2	1	1	0
Total			10	3	7	0
239	2	2.5	1	0	0	1
139	1	3.5	2	1	0	1

Table 10. Summary of effort and observations of search teams involved in Seward Peninsula brown bear density estimate during spring 1991.

Team #	Search Time (Minutes)	Bears Observed: Total	Bears Observed: Independent	≥2	Independent Bears/ 100 Hrs Search Time	Search Time/Sighting: Minutes	Search Time/Sighting: Hours
0	423	9	4	4	57	106	1.76
1	2417	53	24	30	60	101	1.68
2	1885	16	11	12	35	171	1.86
3	1875	15	10	10	32	188	3.13
4	1628	23	12	13	44	136	2.26
5	2083	28	12	14	35	175	2.89
Totals	10,311	144	73	83	43	142	2.35

Table 11. A summary of costs incurred during 1991 Seward Peninsula brown bear density estimate.

Travel/per diem	$ 4,079
Contractual Services	$25,671
Commodities	$ 6,146
Total	$35,896

Table 12. Estimated number of brown bears ≥2 in western portion of Unit 22 based on stratified extrapolation from 1991 density estimate.

Subunit	Total Area (km²)	Area No.	Polygon Area (km²)	Percent of Total Area	Stratification Factor	Estimated number of bears ≥2/1000 km²
22E	4,138	1	8,390	78	0.55	9.8
22D		2	4,545		0.75	13.4
		3	5,637		0.75	13.5
		4a	1,503		80	14.6
		X	993		1.00	18.1
Totals	6,739		12,678	73		14.0
22C		4b	2,733		0.80	14.3
		5a	523		1.10	19.1
		X	1,070		1.00	17.8
Totals	1,674		4,327	100		15.7
22B		5b	3,090		1.10	19.7
		6	3,923		1.00	17.9
Totals	6,840		7,013	40		18.9

Table 13. Density estimations of brown bears ≥2 for the western portion of the Seward Peninsula.

Total area as illustrated in Fig 12.

Area	Area size mi²	km²	Estimated Number of Bears >2 Low	Medium	High
1	3238.6	8390.1	75	82	90
2	1754.5	4545.4	56	61	65
3	2176.0	5637.2	70	75	80
4	1635.2	4236.2	53	60	68
5	1394.7	3613.3	64	71	77
6	1514.3	3923.1	63	70	77
X	796.1	2062.4	36	36	36
Totals	12509.4	32407.7	420	458	495
At a sustainable harvest level of 7%			29	32	34

The Western portion of Subunit 22B

Area	Area size mi²	km²	Estimated Number of Bears >2 Low	Medium	High
5b	1192.8	3090.1	55	61	66
6	1514.3	3923.1	63	70	77
Totals	2707.1	7013.2	118	131	143
At a sustainable harvest level of 7%			8	9	10

Subunit 22C

Area	Area size mi²	km²	Estimated Number of Bears >2 Low	Medium	High
4b	1055.1	2733.4	34	39	44
5a	201.9	523.2	9	10	11
X	413.0	1069.9	19	19	19
Totals	1670.0	4326.5	62	68	74
At a sustainable harvest level of 7%			4	5	5

Table 13. Continued.

Area	Area size		Subunit 22D Estimated Number of Bears >2		
	mi^2	km^2	Low	Medium	High
2	1754.5	4545.4	56	61	65
3	2176.0	5637.2	70	75	80
4a	580.1	1502.8	19	21	24
X	383.1	992.5	17	17	17
Totals	4893.7	12677.9	165	175	187
At a sustainable harvest level of 7%			12	12	13

Area	Area size		Subunit 22E Estimated Number of Bears >2		
	mi^2	km^2	Low	Medium	High
1	3238.6	8390.1	75	82	90
Totals	3238.6	8390.1	75	82	90
At a sustainable harvest level of 7%			5	6	6

Appendix A. Sample questionnaire designed to evaluate ability to guess brown bear density in the Nome area relative to other areas where density was known.

Brown bear density guess in study area north of Nome, Alaska. Made prior to conducting CMR density estimate in this area during Spring 1991.

Your Name________________________________ DATE ________________

Agency & Address____

Level of Familiarity with Nome Study Area: (1 = very familiar, have done a lot of work there; 2 = quite familiar; 3 or 4 = moderate - low; 5 = never been there.)

Level of Familiarity with Brown Bear Populations in General: (1 = brown bear researcher; 2 = manager of grizzlies and other species with considerable field knowledge; 3 = manager with limited amount of field experience; 4 = knowledge of species based primarily on literature, 5 = don't know much about the species)

Comparison Area(s) with which I am familiar that I used as the primary basis for my estimate (circle one): Katmai Coast, Northern Admiralty Island, Kodiak Island (Ter or Kar), Black Lake, Denali Natl. Park, Su-Hydro Area in remote portion of 13E, Western Brooks Range, Noatak Study Area, GMU 13E along the Denali Highway ("UPSU"), Alaska Range-GMU 20A, Eastern Brooks Range, or Other (specify).

My Estimate of Density (Number of bears of all ages per 1,000 km^2):

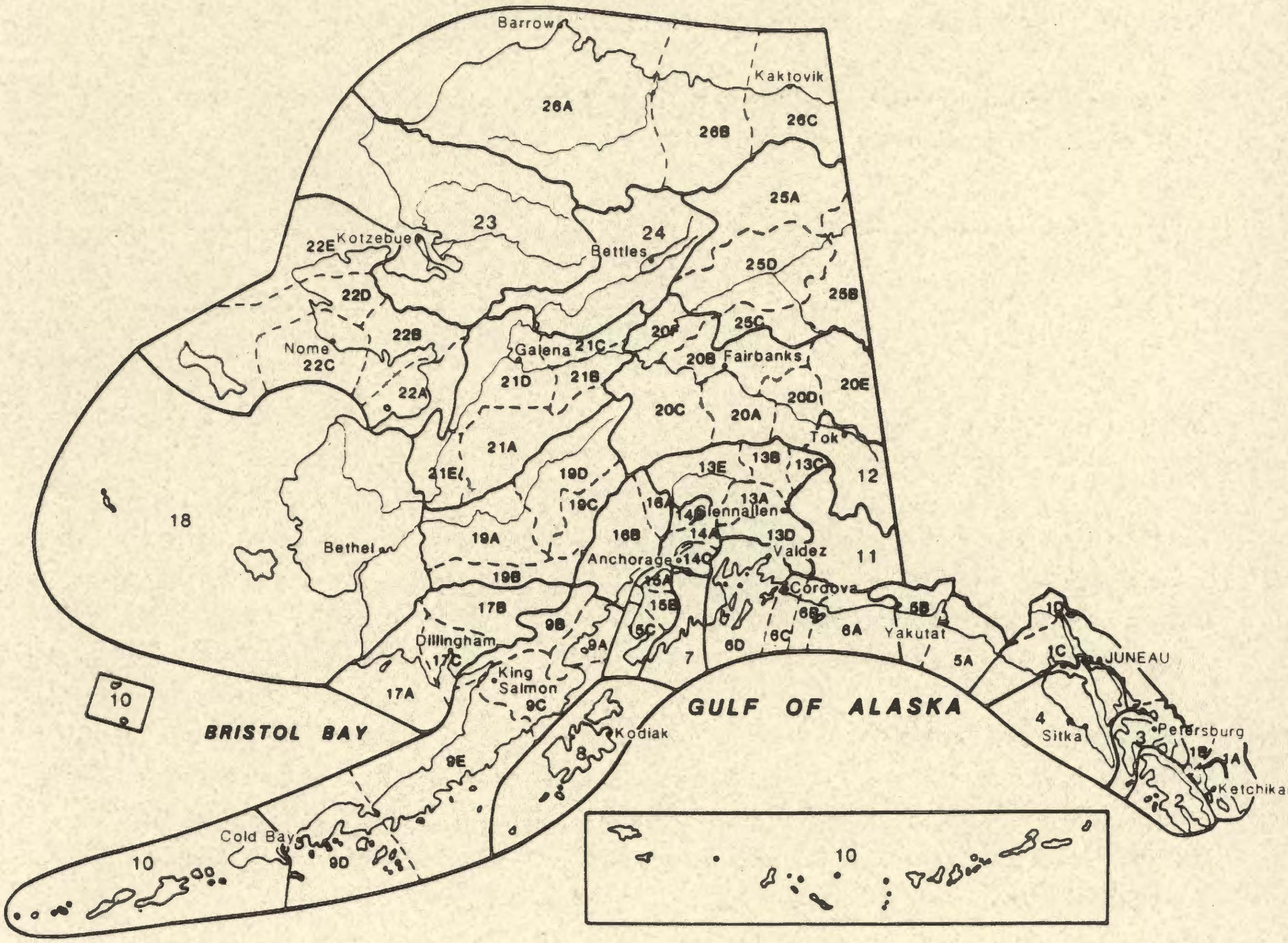
Level of Certainty:

I'm 80% sure that the density for all bears will be higher than
/ 1,000 sq. km.

I'm 80% sure that the density for all bears will be less than
/ 1,000 sq. km.

If you don't wish to be identified by name in the report, provide your initials or other code__________________.

Alaska's Game Management Units



Federal Aid in Wildlife Restoration

The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sales of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program then allots the funds back to states through a formula based on each state's geographic area and the number of paid hunting license holders in the state. Alaska receives 5% of the revenues collected each year, the maximum allowed. The Alaska Department of Fish and Game uses the funds to help restore, conserve, manage, and enhance wild birds and mammals for the public benefit. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes necessary to be reponsible hunters. Seventy-five percent of the funds for this project are from Federal Aid.