Alaska Department of Fish and Game
Division of Game
Federal Aid in Wildlife Restoration
Research Final Report

IMPACTS OF INCREASED HUNTING PRESSURE ON THE DENSITY, STRUCTURE, AND DYNAMICS OF BROWN BEAR POPULATIONS IN ALASKA'S MANAGEMENT UNIT 13

by
Sterling D. Miller

Project W-22-6
Job 4.21
December 1988

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SUMMARY

In an attempt to reduce brown bear numbers and increase survivorship of moose calves in Alaska's Game Management Unit (GMU) 13, brown bear (Ursus arctos) hunting regulations were liberalized during the years 1980 through 1986. Reported brown bear harvests from this area increased. An average of 132 bears/year were taken during the years 1983 through 1986 (i.e., when bag limits were 1/year and combined winter, spring, and fall seasons totaled 273 days), compared with an average of 59 bears/year during the years 1976 through 1979 (i.e., when bag limits were 1 every 4 years and there was only a fall season totaling 40 days).

During this project (spring of 1987), a density estimate of 6.7 bears >2.0 years old/1000 km^2 (95% CI = 5.2-10.1 bears/1000 km^2) was obtained in spring 1987 in an experimental area where hunting pressure was thought to have been relatively heavy. This represented a decline from an earlier-reported density estimate obtained (using a similar technique) in this same area during 1979 of 12.9 bears/1000 km^2 (95% CI = 7.3-31.5 bears/1000 km^2). The density estimate obtained in 1987 is also lower than one obtained using the same technique in 1985 in a nearby area where hunting pressure was thought to be moderate (19.1 bears/1000 km^2; 95% CI = 16.7-23.2 bears/1000 km^2). Densities in 1985 and 1987 were measured using recently developed modifications of capture-recapture techniques (Miller et al. 1987). These estimates may represent the first time differences in bear densities have been documented using statistically valid and replicable techniques.

The major factor contributing to the lower density in the 1987 study area was increased hunting pressure; although other factors, including mining development and translocation of bears from the area in 1979, may have contributed to the documented differences. The impact of hunting was also evident in the sex ratio of captured bears in the 3 studies conducted in GMU 13. The male:female ratios for bears >5.0 years old were 113:100, 77:100, 38:100 in 1979, 1985, and 1987, respectively. These data indicate depletion of adult male bears. In the 1987 study, both median and mean ages of captured male bears (>2.0 years old) were younger than those in the 1979 study but about the same as those in the 1985 study. Corresponding differences in mean or median ages of captured females were not observed.

Harvest data from different geographic regions in GMU 13 were examined to determine if increases in harvest were widely distributed or localized. Except for remote portions of Subunit 13C, harvests increased throughout the unit following liberalization of regulations.

Data on sex composition of harvests from GMU 13 were examined to determine if the altered population status indicated by the documented changes in density and population composition could be discerned in harvest data. Increasing proportions of females in fall harvests of adult bears (>50% since 1980) appeared to parallel the population decline better than other indicators. High vulnerability of males during spring seasons tended to mask the decline in the sex ratio when spring and fall seasons are lumped.

Data on age composition of harvests were more ambiguous in reflecting the decline of bear populations in GMU 13. I developed a number of hypotheses regarding the age of harvested bears in a declining population and correlated the percentage of males harvested in the fall (1980-1987) with all of the age classes that were harvested. This correlation yielded an estimated exploitation rate for bears >2.0 years old of 20%, but the technique (Fraser et al. 1982) failed to indicate whether this rate was higher than those prior to the liberalized seasons (1970-1979). Mean and median age of males (i.e., all males and males >5.0 years) in fall harvests have been declining in recent years, but no trend in the data on mean age of females was observed. Mean and median ages of harvested males were younger than those of harvested females.

The distribution of ages in harvest data were examined for perspectives on population trend that were not evident in mean or median age data. The number of 2-year-old bears in hunter harvests increased markedly following the liberalization of the seasons; in more recent years, the number of 2-year-olds

harvested declined, possibly reflecting a decline in the number of adult females left in the population. Data from harvests of middle-aged bears (i.e., 5-10 years old) were more difficult to interpret, but it appeared that numbers of (1) middle-aged males have been low since prior to the liberalized regulation and (2) middle-aged females have started to become depleted. Number of old (i.e., >10 years old) bears harvested annually is still increasing; however, a decline in availability of these animals, caused by heavy exploitation of middle-aged bears, is likely to occur.

A deterministic model was developed and used to estimate the sustainable exploitation rates of bears having the reproductive characteristics documented for those in GMU 13. The population estimate used in this model was based on an extrapolation from available density estimates. Using conservative estimates of natural mortality rates, I determined that the GMU 13 population could sustain harvests of 66 male bears >2 (8% of population >2), 43 bears >5 (7.7 % of population >5), 29 females >2 (5.8% of females >2), and 21 females >5 (5.8% of females >5). If stabilizing bear populations at existing levels becomes the management objective for GMU 13, harvests should probably be maintained at less than these calculated values. These estimates of sustainable harvest levels are only slightly higher than those made by Taylor et al. (1987) for a polar bear population that had similar reproductive parameters.

Because of the decreased abundance of adult males caused by heavy hunting pressure, data on survivorship of newborn and yearling offspring of radio-collared adult females during 1978-1987 were examined for indications that survivorship was increasing. No such trend was found; during this period the mortality rates for 61 cubs and 40 yearlings were 36% and 23%, respectively. Seasonal mortality rates for cubs, calculated using the MICROMORT program (Heisey and Fuller 1985), were lower in fall and winter (7%) than in spring (35%).

Data on reproductive parameters of radio-marked brown bears and black bears are presented.

Key words: Alaska, brown bear, Ursus arctos, density estimate, capture-recapture, Lincoln index, harvest rate, sustainable harvest, population trend, population modeling, population composition, brown bear reproductive rates, black bear reproductive rates.

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OBJECTIVES

To document changes in density and in the sex and age composition in a brown bear population subjected to heavy rates of harvest by hunters;

To monitor changes in individual bear reproductive performance and survivorship in a population subjected to heavy harvest rates; and

To investigate the hypothesis that brown bear cub survivorship is inversely related to the proportion of adult males in the population.

This report is a final report on the 1st objective, although additional information on changes in population density or composition may need to be collected as a follow-up to the results reported here (i.e., depending on the bear management strategy adopted and followed in GMU 13). Progress on the 2nd and 3rd objectives is reported here; these objectives represent the continuation of bear studies begun in 1980 (Miller 1987).

STUDY AREA AND METHODS

Density estimation procedures generally followed those described by Miller et al. (1987); unlike this 5-year study, which concluded in 1985, the 1987 density estimate was conducted in an area where there had been only 1 year of telemetry studies immediately preceding it. Earlier telemetry studies on bears in this area had been conducted in 1977-1979 (Spraker et al. 1981, Ballard et al. 1982). This preceding year of telemetry study (i.e., premarking phase) was designed to identify and minimize potential sources of bias in the density estimation procedures (Miller et al. 1987).

Twenty-one bears, including 6 cubs and 1 yearling, were captured and marked during the premarking phase of this study (3-5 June 1986). The sexes and ages of these bears are presented in Table 1. Radio transmitters were placed on ten of these bears (Table 1). Bears were captured in a larger area than the one used to estimate density (Fig. 1); we expected them to be in the density estimation area at some time during the following year. During the premarking phase, special effort was made to deploy transmitters on estrous adult females; most of them would be accompanied by newborn cubs the following year, and this class of females was thought to have low sightability (Miller and Ballard 1982, Miller et al. 1987). This objective was incompletely achieved because the only 2 bears that could have potentially given birth the following year were captured in the premarking phase: No. 458 (a 17-year-old female) and No. 454 (a 4-year-old female). Both of these bears had cubs in the spring of 1987. Four females with newborn cubs were captured during the premarking phase: 1 female with yearling offspring, 2 adult males, and 5 subadults (2 males and 3 females) (Table 1).

One or 2 relocations of bears marked during the premarking phase were obtained during that phase; additional relocations were obtained during flights conducted on 6 June, 9 July, 5 August, 5 September, and 24 September 1986 and during May 1987. This reduced monitoring schedule was mandated by budgetary constraints.

Density estimation efforts were timed to begin on the last day of the spring hunting season. Initiation of density estimation efforts could reasonably have begun earlier; however, in an effort to minimize disturbance to bear hunters, they were not begun until 31 May 1988. Previous studies have established that radio-marked bears are out of dens by this time. Monitoring of radio-marked bears revealed that they were all out of dens when the 1987 density estimation phase started.

Density estimation efforts terminated on 8 June 1987; at this time, leaves were beginning to emerge on willows at lower elevations in the study area. Leaf emergence would have reduced sightability of bears in these areas within 1-2 days following termination of the study. When the study terminated, snow and ice still predominated at moderate-to-high elevations in the mountains. Leaf emergence coincided with study termination on 8 June because I felt that additional effort would not significantly improve the estimate.

A search area of approximately 1309 km^2 (505.3 mi^2) was identified; this area represented a portion of the 3436-km^2 (1327 mi^2) area from which 48 brown bears were removed in 1979 (Miller and Ballard 1982). This search area contained approximately 51.7 km^2 above 5,000 feet in elevation that were not considered to be bear habitat (Miller 1987). Consequently, density estimates were based on an area of 1257 km^2 (485.3 mi^2).

The search area was bordered on the south by the Denali Highway, the south fork of the Nenana River, and the height of land between Valdez and Windy Creeks. On the east it was bordered by the crest of the Clearwater Mountains and on the north by the foothills of the Alaska Range. The search area extended westward to nearly the end of Monihan Flat. It was subdivided into 7 quadrats; all but three of these were further divided in half (Fig. 1). Quadrats were established to allocate and document search effort, and they were drawn along readily identifiable landmarks.

Independent density estimates were made for 2 portions of the search area. Quadrats Nos. 1-3 (520.6 km^2) were bordered on the west by the middle fork of the Susitna River and on the east by the crest of the Clearwater Mountains. These quadrats are in the Clearwater Controlled Use Area where hunting using motorized vehicles is not allowed. This area also contains a large open-pit gold mine at Valdez Creek. It is probable that extensive human activity in the vicinity of this mine has caused a displacement of bears in at least a 52-km^2 (20 mi^2) area of bear habitat. During this study no bears were seen in the vicinity of mining operations. No effort was made to reduce the size of the search area and thus make the density estimates based only on undisturbed habitats, because the exact boundaries of the affected area was unknown. It is also likely that mining activity in this area resulted in increased and unreported shooting of bears by miners (R. Tobey, pers. commun.). The second portion of the search area, the Monihan area (736.3 km^2), was somewhat larger than the Clearwater area and included quadrat Nos. 4-7; it was centered on flat lowlands at an elevation of about 2,700 feet.

Vegetation types in the study area are predominantly shrubs dominated by dwarf birch (*Betula nana*) and willow (*Salix* spp.); local areas of spruce (*Picea glauca* and *P. marianna*) occur along river courses and in areas of poor drainage. Spruce and birch trees (*B. papyrifera*) are less common in this area than in the area studied in 1985 (Miller 1987). Correspondingly, bears inhabiting lowland areas below about 3,000 feet in elevation had higher sightability than those in the 1985 study area. Above an elevation of 3,000 feet, sightability was roughly equivalent in both areas.

As described by Miller et al. (1987), the density estimation procedure involved searching for bears from fixed-wing aircraft (Piper Supercub PA-18). When a bear was spotted, telemetry equipment was used to ascertain whether it was radio-marked and, if so, its identity. Spotting a bear with a radio-collar was considered a recapture, while spotting a bear without a radio-collar was considered a capture. With the aid of a helicopter, unmarked bears were captured and marked. On each day of the density estimation procedure, the periphery of the search area was flown and telemetry equipment utilized to determine whether radio-marked bears were inside the search area. This procedure is designed to correct for lack of geographic closure and to monitor movements of bears across search area boundaries (Miller 1987). It was further determined whether marked bears were in the Monihan or Clearwater portions of the search area. Bears radio-located near the boundary of the search area were precisely located to determine whether they were in or out of it and in which direction they were traveling.

Each aircraft contained a pilot and a biologist. Typically, closure determination flights were made in the morning; personnel in the aircraft assisted in spotting efforts. Three aircraft were used during the early portion of the study, and an additional aircraft was added on 4 June to reduce pilot fatigue and to permit an increase in spotting effort. Average daily spotting effort varied from 2.1-3.1 min/mi² (Table 2). Some of this variation in effort was caused by changes in both weather and spotting conditions (e.g., in thick cover more intense searches were necessary than in more open habitats). Effort varied from a low of 1.4 min/mi² to a high of 3.9 min/mi² (Table 2). Complete searches were conducted on 7 days (Table 2). On 6 June weather conditions did not permit searching the Clearwater area, and data were collected only for the Monihan area; bad weather precluded work in either area on 3 June.

An effort was made to avoid biases resulting from sightings of bears occurring in groups. For groups consisting of a female with offspring, independence of observation was obtained by making population and density calculations only for bears older than yearlings (Miller et al. 1987). Additional aggregations of bears occurred during spring for breeding purposes. Following procedures developed for Kodiak Island (Roger Smith unpubl. data; Earl Becker, pers. commun.), an attempt was made to minimize the bias that results if the 2nd bear of a mating pair is not independently observed. This can happen if the 2nd bear is observed during the intensive searches (i.e., circling) undertaken to determine if the 1st bear has been radio-marked. Therefore, when a bear is sighted, the surrounding area is searched at the standard intensity to determine if another bear is present before the intensive search is begun on the initially sighted bear. In this study, no additional bears were spotted using this procedure.

Calculations followed Miller et al. (1987); however, confidence intervals based on the binomial distribution were calculated using a program developed by Dan Reed and Jesse Venable (ADF&G files). This program permitted greater precision, and it also permitted varying alpha levels in calculation of confidence intervals. Confidence intervals for the 1985 results were recalculated using this program, and slight differences from previously reported values resulted.

Following termination of studies in spring 1987, radio-collars on many bears were removed (Table 1) because funds were not available to monitor these bears. Collars equipped with drop-off features or collars on bears that could be monitored as part of other studies were left on.

An experiment was conducted to test the practicality of an alternative method of attaching transmitters to bears for only a short period of time (density estimation procedures). This experiment was based on procedures previously tested for marine mammals (Fedak et al. 1983); using pop rivets, we attached Telonics transmitters (model Nos. 200 and 300) to a 3.5 x 3.5 in^2 of hardware cloth. A patch of hair on the bear's back was clipped with scissors until the hairs were 1.0-1.5 inches long. The transmitter was placed on this patch in such a manner that the hairs stuck through the hardware cloth holes. Devcon epoxy glue was then smeared over the hardware cloth and protruding hairs to attach the transmitter to the bear's fur. Transmitters attached in this manner are termed "glue-ons" (Table 1A).

This attachment mechanism worked well; no bears dislodged the transmitters during the study period. Care must be taken to avoid clipping the hairs so short that the glue contacts the bear's skin and causes irritation. Most of these transmitters were removed on the final day of study (9 June), so the actual time that molt occurred and the transmitters fell off was not determined. The transmitters had antennas that were only 8 inches long; this was to avoid problems resulting from bears or their companions pulling the transmitter antenna out. This antenna length, however, is too short to provide adequate range for tracking purposes (i.e., transmitters could not be heard from a distance of >2 miles). According to information provided by Telonics, antennas should be at least 10 inches long to provide adequate range.

Bears captured during the premarking phase in 1986 were immobilized with M99 (etorphine hydrochloride, Lemmon Co., Sellersville, PA). In 1987 bears were immobilized with Telazol (tiletamine hydrochloride and zolazepam hydrochloride, A.H. Robins, Richmond, VA) using dosages of 5-22 mg/kg (Appendix E). Cubs were captured by hand. No drug-related mortalities occurred in this study, but one cub died, apparently of suffocation in the capture bag where it was being held (Table 1A).

Budget

Density estimates of the type conducted in FYs 1986 and 1987 are expensive. For documentary purposes, approximate operational expenses for FY 1986 (premarking phase) and FY 1987 (density estimation phase) are provided in Table 1B. These costs are only approximate because it was difficult to separate costs from our project and an associated one that was conducted simultaneously. Fixed-wing and helicopter charter costs were about $110/hour and $410/hour, respectively. Aviation fuel costs were $1.60/gallon and $1.11/gallon for 100 Octane and Jet B, respectively. Manpower costs are not included in these calculations. Ferry costs from sites where aircraft were based are included in these costs. Ferry costs for helicopter in each year were about $1,300, and ferry costs for fixed-wing aircraft were about $500 in 1986 and about $750 in 1987.

RESULTS AND DISCUSSION

Density Estimation

Premarking Phase:

One of the 10 bears radio-marked during the premarking phase in 1986 was shot by a hunter prior to initiation of the density estimate in spring 1987. Five of the remaining radio-marked bears (Nos. 453, 454, 461, 462, and 465) were not present in the search area during the density estimation phase. One bear marked in the premarking phase but not radio-collared (No. 459) was recaptured in the search area in the spring of 1987. Correspondingly, the premarking effort contributed 5 bears (Nos. 455, 457, 458, 459, and 460) to the density estimate; only No. 458 had cubs in 1987. Several of the premarked bears that did not enter the search area during 1988 had been very near the periphery and/or captured in the search area in 1986.

Previous studies suggested that females with newborn cubs may have lower sightability than other bears (Miller and Ballard 1982, Miller et al. 1987). During the premarking phase, we selectively deployed marks on breeding females because these bears would have cubs the following year and therefore lower sightabilities. However, a large number of the females caught during the premarking phase had newborn cubs (i.e., four of the 7 females >4.0), and only two were alone (Table 1).

The value of the premarking effort in this study was apparent; the first day of the density estimation phase was useful in deriving the final estimate because marked bears were already present in the study area. Also, documented movements of bears marked during the premarking phase were helpful in establishing search area boundaries in 1987.

Density Estimation Phase:

Raw data on the bears that were observed or known to be present on each day of the density estimation phase, as well as their reproductive status and location (i.e., Monihan or Clearwater areas), are presented in Table 3. Sexes and ages of these bears can be determined by referring to Table 1.

Whole Study Area. Density estimates, as well as 80% and 90% binomial confidence intervals, obtained using the bear days estimator (Miller et al. 1987) are presented in Table 4, Part A. The most appropriate estimate is for bears 2 years of age or older (i.e., >2.0), because it avoids problems of nonindependence of observations that result from groups composed of females with their offspring (Miller et al. 1987).

The bear days estimate of number of bears (≥2.0 years old) present in the search area (N*) was only 8.37; the 95% confidence interval (CI) for this estimate was 6.4-12.9 bears, and the 80% CI was 6.55-12.67 bears (Table 4, Part A). This yielded a density estimate in the search area (habitat <5,000 feet elevation) of 6.67 bears/1000 km² (95% CI = 5.21-10.08 bears/1000 km², 80% CI = 5.58-8.74 bears/1000 km²) (Table 4, Part A). Similar density estimates were calculated for all bears using the data in Table 3. My estimate assumed that offspring (cubs and yearlings) with their mothers were independently sighted or present in the search area; because this assumption is obviously wrong, the estimate should be viewed skeptically. The bear days estimate for all bears was 13.21 (95% CI = 10.6-18.5; 80% CI = 11.3-16.5). This yielded a density estimate of 10.51 bears/1000 km² (95% CI = 8.41-14.68; 80% CI = 9.0-13.1). The difference between this estimate and the estimate for bears >2.0 years old would suggest that 37% of the population was composed of cub and yearling bears; a similar result (32%) was noted by Miller et al. (1987).

In GMU 13 most adult females separate from their offspring when they are age 2.5. In areas where females keep their offspring longer, biologists (e.g., Ballard et al. 1988) prefer to calculate density estimates for bears >3.0 years old. In order to make our estimates directly comparable, our 2-year-olds were deleted from our data and density estimates for bears >3.0 years old were calculated. Data for the 1985 and 1987 studies are presented in Table 4 (Parts C and D).

Confidence intervals based on the binomial approximation were used as the criteria presented for use of the normal approximation (Seber 1982:64) were not met. Using cumulative values over the whole study period (bears >2.0), estimated p (m_2/n_2 or proportion of sample that is marked) was 16/27 or 0.59. For p of this size, n_2 must be approximately 50 to use the normal distribution; in this study it was 27.

Because of possible violations of capture-recapture assumptions, the CI's calculated for these estimates should be viewed with some skepticism; they may be wider than specified for the given alpha level. Errors in point estimation and in CI calculation will result from assumption violations and are likely to be especially damaging when sample sizes are small (White et al. 1982, Otis et al. 1978).

A graphic representation of how density estimates and CI's changed during the estimation procedure is provided in Fig. 2. As in the 1985 application of this procedure (Miller et al. 1987), point estimates changed little with successive days of effort, but CI's around the estimate became smaller (Fig. 2).

A Lincoln-Petersen estimate can be calculated for each day of the capture period. The mean of these daily estimates (i.e., 8.6 bears >2) was very close to the bear days population estimator (i.e., 8.4 bears >2). Similar results were found for the 1985 study (Miller et al. 1987).

Given the small number of bears (i.e., 8.3) estimated to be in the 1987 search area on an average day over the 7-day search period, it is noteworthy that a density estimate was possible. Only 28 sightings of bears (>2.0 years old) in the search area were made to obtain this estimate (no more than 1 sighting per bear per day was counted). In contrast, sample sizes were much larger in the 1985 study area, which was only 4.8% larger (Table 4, Part B). In 1985, 42 sightings of bears were made during a 7-day search period, and the estimated number of bears (>2.0 years old) present on a average day was 25.1. Comparisons between 1985 and 1987 studies are presented in Table 4 and Fig. 2. Sightability (i.e., number of times a bear known to be present was spotted) was higher in the 1987 area (47%) than in the 1985 area (24%) (Table 4).

Clearwater and Monihan Areas. The 1987 search area was divided into 2 portions: the mountainous Clearwater area and the adjacent and somewhat larger Monihan area that is characterized by flat lowlands and rolling foothills. Our purpose was to determine if the Clearwater area (where hunting with motorized vehicles is not allowed) had a different bear density than the Monihan area; moreover, we wanted to analyze the effectiveness of the density estimation procedure on small populations. Using the bear days estimator, the average number of bears (>2.0 years old) present over a 6-day period in the Clearwater area was 2.3 (80% CI = 1.8-4.9) (Table 5, Part A), compared with 6.1 over a 8-day period in the Monihan area (80% CI = 5.0-8.4) (Table 5, Part B). Density (bears >2.0 years old) was also estimated to be lower in the Clearwater area (4.4 bears/1000 km^2, 80% CI = 3.5-9.5) than in the Monihan area (8.32 bears/1000 km^2, 80% CI = 6.8-11.4).

Trend in these estimates followed the same general pattern as for the whole area (Fig. 3), but CI's, as a percentage of the estimate, were much larger than we had expected because of the small sample size. Although the CI's for the estimates from each area overlapped, the CI for the Monihan estimate did not overlap the Clearwater estimate (Fig. 3, Table 5).

Bias and Direction of Error:

It is necessary to make every effort to eliminate sources of systematic bias in estimates. In using the result of these estimates in making management decisions, it is important to recognize the direction and likely magnitude of systematic error that might have been introduced by violation of underlying assumptions of capture-recapture techniques.

Lack of Population Closure. For each day's effort, geographic closure was approximated with the periphery flights, which were designed to determine whether marked animals were present in the search area. This procedure requires that closure be assumed on any particular day, even when the status of an animal may change during that day (e.g., from "in" to "out" or vice versa). This occurred when one bear moved into the search area after the periphery flight; its status was changed to "in." In another case a bear was observed during the periphery flight moving out of the search area. As the quadrat containing this bear had yet to be searched, this bear was classified as "out." In general, these problems do not represent systematic bias.

Another closure problem may have resulted from disturbances caused by the operation of fixed-wing aircraft and helicopters. Aircraft search effort was intensive during the study period. These disturbances may have caused bears to leave the study area. I suspected this effect might exist based on the high frequency with which radio-marked bears were located just outside of the periphery of the search area. I did not suspect this problem in the 1985 study (Miller et al. 1987) because bears may have become used to fixed-wing aircraft and helicopter noise as a result of many different studies ongoing in this area that used aircraft. Clearly a disturbance effect, if it had occurred, would have resulted in underestimation of the density.

Unequal Catchability. Unequal catchability can result either from differential sightability by class of animal (e.g., females with newborn cubs, subadults, etc.) or from differential sightability of individuals based on individual behavioral and morphological (e.g., coat color) characteristics or habitat. If there is differential catchability, it probably would result in more marks being placed on the individuals with highest sightability. These same individuals would be recaptured more often than individuals with lower sightability and this, in turn, would result in an underestimation of population size; the degree of error potentially would be large, especially when sample sizes are small. In previous studies of brown bears in this and nearby areas, the class of females accompanied by newborn cubs was thought to have lower sightability than other bears (Miller and Ballard 1982a, Miller et al. 1987). Evidence supporting this conclusion was not found in this 1987 study or in similar studies elsewhere in Alaska (ADF&G, unpubl. data). Correspondingly, the null hypothesis that different classes of bears are equally sightable was not rejected. This does not mean that bears had equal catchability.

Independence of observations. Problems that derive from nonindependence in sighting members of family groups were avoided by calculating estimates only for bears >2.0 years of age. No bears accompanied by 2-year-old offspring were in the study area. One breeding pair was captured on day 2 (Nos. 471 and 472), and the female of this pair apparently was in the process of weaning a yearling cub (No. 475). Unlike most bears, this trio remained in the same small valley throughout the study period, and by the last few days of the study, pilots had learned where they were and seldom missed seeing them (thereby also violating the equal catchability assumption). This bias would also cause an underestimation, but its impact on the point estimate appeared small because population estimates changed little during the final days of study (Table 4).

Management Implications

Background:

Starting in 1980 the Alaska Board of Game adopted increasingly liberal brown bear hunting regulations in GMU 13; this was in response to research results demonstrating that (1) brown bear predation was a significant cause of spring moose calf mortality in this area (Ballard et al. 1981) and (2) greatly reduced brown bear densities could, in some circumstances at least, result in increased survivorship of moose calves (Ballard and Larson 1985, Ballard and Miller in press). These liberalizations included adding a spring season, lengthening the spring and fall seasons, and increasing bag limits to 1 bear/year (Table 6).

The sustainable harvest levels for bears in GMU 13 has not been clearly established. During the period of harvest expansion in the early 1980's, this uncertainty led to conflicting interpretations of the population trend. The argument was advanced by some that the increasing number of young animals in the harvest probably indicated the population was in a phase of rapid growth. Miller and Ballard (1980:121) hypothesized that brown bear harvests in GMU 13 could not be greatly increased without the risk of exceeding sustainable levels of harvest. The evidence available at that time was inadequate to support or reject either interpretation.

Changes in Harvest:

Reported brown bear harvests increased dramatically following the liberalization of regulations, reaching a maximum annual harvest of 146 bears in 1984 (Table 6). During the 4 years prior to the liberalizations (1975-1979), harvests averaged 59/year (range = 41-73). From 1985 to 1986 (i.e., 1 bear/year bag limit fully in effect) an average of 132 bears/year were reported harvested (range = 117-146). In the fall of 1987 the bag limit returned to 1 bear/4 years, and the fall harvests declined from an average of 86 in the preceding 4 years to 58 (Table 6). The increase in the reported harvest for 1985 to 1986 may be exaggerated. An unknown proportion of the bears reported killed in GMU 13 were actually killed elsewhere and falsely reported as GMU 13 bears; this premise is based on (1) information received from informants, (2) cases made or suspected by Fish and Wildlife Protection officers, and (3) observations by biologists (i.e., of alleged GMU 13 bears that had morphological characteristics atypical for bears from that area). From 3% to 10% of the reported harvest in GMU 13 during this period was taken elsewhere. This "bootlegging" of kills, along with other considerations, led to reinstitution of 1 bear/4 year bag limits in fall 1987.

Changes in Bear Density:

Regardless of the possible errors in harvest data, there was a significant increase in the GMU 13 harvest starting in 1980. A primary objective of this study was to estimate the degree of changes in bear density and population composition resulting from these increased harvests. These changes were compared with a density estimate that had been made for the same area in 1979 (Miller and Ballard 1982a) and one for a nearby area in 1985 (Miller et al. 1987, Miller). Brown bear hunting in the nearby area (Su-hydro) was more difficult because of access constraints (i.e., aircraft, the Denali Highway, and off-road vehicles (ORV).

Miller and Ballard's (1987a) density estimate was obtained using capture-recapture techniques that differed from those employed in this study; bears marked in 1978 were assumed to be present throughout specified periods (May 22-June 7 and June 22) when 48 marked and unmarked bears were captured and transported out of the area (Miller and Ballard 1982b) as part of a predation study (Ballard and Larson in press, Ballard and Miller in press). Two bear density estimates for this study area were presented by Miller and Ballard (1982b): one for bears of all ages (41 bears/km²) and another for bears >3.0 (1 bear/60 km²). These estimates must be recalculated to permit direct comparison with the 1987 estimate, which is based on bears age >2.0 years old. The comparison between the 1979 and 1985 estimates presented by Miller et al. (1987) was based on the estimates for bears of all ages. However, as discussed above, this estimate violates the assumption of independent sightability for family groups of a female and her offspring. Moreover, estimates are least biased by violation of this assumption if offspring with their mothers are excluded from the calculations. In GMU 13, most females separate from their offspring when offspring are 2 years old (Miller 1987), so the 1979 estimate was converted to this same base. This still requires assuming that females accompanied by 2-year-old offspring are sighted independently from their mothers when some are still not separated and are sighted together.

The original data for the 1979 study are presented in Appendix 5 of Ballard et al. (1980). Of the 11 bears >2.0 years old that were previously marked (7 males and 4 females), seven were recaptured (5 males and 2 females) out of a total of 32 captures (18 males and 14 females). This provides a population estimate of 48.5 bears >2.0 years old, instead of the 41 bears >3.0 reported by Miller and Ballard (1982a). The 95% binomial confidence interval around this estimate is 27.5-118.5 bears. This estimate is based on a total area of 3437 km² (1327 mi²), including the area above 5,000 feet elevation (i.e., nonbear habitat). The 1987 estimate was based on the area below 5,000 feet elevation, representing about 5% of the area examined in 1979.

The 1979 density estimate was almost certainly exaggerated because of the assumption that the population was closed; as discussed by Miller et al. (1987), the 1985 data was based on this assumption, and compared with the bear days estimator, it resulted in a 12.2% overestimation of the population numbers. This overestimate resulted from lack of population closure; the population estimate was derived from an area larger than the search area. If we had assumed the population was not closed, the 1979 population estimate for bears >2.0 years of age would have been 42.6 bears (95% CI = 24.2-104.0). This converts to a density estimate (habitat <5,000 feet) of 12.9 bears ≥2.0 years old/1000 km² (95% CI = 7.3-31.3), or 33.4 bears ≥2.0 years old/1000 mi² (95% CI = 19.0-81.6).

The corresponding density estimate, which was based on data collected in 1987, was 6.7 bears/1000 km², and the 95% CI was 5.2-10.1 (Table 4, Part A). This estimate appears significantly lower than that for 1979; i.e., the respective 95% CI's did not overlap (Fig. 4). If an ad hoc correction factor is added to compensate for the suspected low relative catchability of females with newborn cubs (e.g., Miller and Ballard [1982a]), then the disparity between 1979 and 1987 would become even larger.

Similarly, the 1987 estimate is lower than the 1985 estimate from the Su-hydro area; the 95% CI's for density estimates in these 2 areas do not overlap (Fig. 4). Using the point estimates to compare densities in these areas, the 1987 upper Susitna brown bear density is about half of what it was in 1979 and 35% of the 1985 density in the Su-hydro area.

In terms of brown bear habitat quality, I consider the upper Susitna and Su-hydro areas to be approximately equivalent. The upper Susitna area may be more typical, but in the Su-hydro area, at least some bears have access to an interior run of salmon at Prairie Creek; this factor probably contributed to a higher relative density there (Miller 1987). On the other hand, brown bears in the Su-hydro area compete with black bears; while in the upper Susitna area, black bears are rarely observed. Taking all these factors into account, the Su-hydro area may have a higher carrying capacity for brown bear than the upper Susitna area.

Currently, the primary difference affecting bear densities in these 2 areas is hunter accessibility. The Denali Highway runs through the upper Susitna study area, while the Su-hydro area is accessible only by airplane or long ORV trails. For purposes of harvest analysis, the Denali Highway area was defined as a strip on both sides of the highway along its entire length from Paxton to Cantwell. Brown bear sealing records for sport harvests from 1980-1986 indicate that 35 of 161 brown bears killed by sport hunters in the Denali Highway area were taken with the use of aircraft (21.7%), compared with 131 of 173 (75.7%) in a central Unit 13 area, which includes the Su-hydro study area (Appendix A). In the Denali Highway area most bears were shot by hunters using highway vehicles (N=58, 36%), followed by ORV's (N=41, 25.5%) and boats (N=17, 10.6%). In central Unit 13, highway vehicles accounted for 5.2% of hunter access (N=9), followed by ORV's (11%, N=19) and boats (5.8%, N=10). Hunters using horses accounted for only 4 bears each in the Denali Highway (2.5%) and central Unit 13 (2.3%) areas.

The Clearwater area, where hunting by motorized vehicles is not permitted, had a lower estimated density than the Monihan area (Fig. 3). These results are the opposite of what would have been expected if hunting had been the primary factor influencing density in these areas. The most probable interpretation of these results is that the Clearwater area is composed of largely mountainous terrain that is used by bears during denning periods; many bears, except females with newborn cubs, leave this area following den emergence in the spring and forage for vegetation and moose calves at lower elevations in the Monihan area (Miller and Ballard 1982a, Spraker et al. 1981, Miller and Ballard 1980).

Other Factors Potentially Affecting Bear Densities in the 1987 Study Area:

As mentioned previously, the 1987 study was conducted in an area where a large mining company had begun operations after the 1979 density estimate; moreover, that estimate was made after 48 bears had been removed from an area that included the 1987 study area. These factors, as well as increased hunting pressure, may have contributed to a density that was lower than those estimated for the 1979 and 1985 studies. On the other hand, approximately half of the study area was in a controlled-use area where hunting using motorized vehicles was not allowed; therefore, the hunting impacts were less marked than those in open hunting areas. These factors may complicate interpretation of the differences in densities noted above.

Residual impacts of the transplant, if any, are undocumented; however, this factor must be considered along with increased hunting pressure when interpreting the reduction in density documented above. When this study was conducted in 1987, I suspected that brown bear densities in the study area were not significantly different than those in surrounding areas where bears had not been transplanted for the following reasons:

1. Sixty percent of the radio-marked, transplanted bears returned (Miller and Ballard 1982b).

2. An estimated 40% of the population in the removal area were not captured and transplanted (Miller and Ballard 1982b).

3. The area from which bears had been removed was relatively small (3436 km²), compared with movements made by bears throughout the entire area (Ballard et al. 1982, Miller 1987). Immigration from surrounding areas, especially by subadults, into those habitats vacated by transplanted bears probably occurred.

4. Fall moose calf:cow ratios, which increased dramatically in the fall following the transplant, returned to and have remained at approximate pretranslocation levels by the following year (Ballard and Miller, in press).

5. Reported hunter harvests along the Denali Highway (including the transplant area) generally increased from 1980 to 1983 (Fig. 5).

In the bear removal area, the number of bears killed during fall seasons from 1974 to 1978 were 6, 12, 8, 4, and 10, respectively (average = 8.0); during the fall seasons from 1979 to 1987, the number of bears killed in this area were 8, 6, 11, 7, 8, 7, 8, 9, and 5, respectively (average = 7.7) (ADF&G, unpubl. data). These data do not indicate a reduction in harvest following the transplant operation; such a reduction might be expected if the transplant operation had had a significant long-term effect on bear densities. Fall seasons were longer between 1980 and 1987 than they had been previously (Table 6), and hunters had probably put in more effort for each bear killed.

The open-pit gold mining operation at Valdez Creek undoubtedly has caused some reduction in bear density in the study area. There have been reports of miners killing bears without reporting them (Tobey, pers. commun.); however, I have no means of estimating the number of such deaths. So far, none of the bears radio-marked in this area during 1986 or 1987 have disappeared in a manner that would suggest poaching.

The mine at Valdez Creek is a large operation that employs as many as 140 individuals; 85-90 people are at the site during the working season. Test drilling occurs throughout the Valdez Creek drainage, and it will begin in the Windy Creek drainage soon. Unquestionably, the mining activity has reduced the amount of habitat available to bears. The area from which bears have been displaced through disturbance is unknown; however, the area from which they have been displaced because of a destruction of habitat is about 52 km^2 (20 mi^2), representing 4.1% of the amount of bear habitat in the search area (1257 km^2). Subtracting this impact area from search area would result in only a small increase in the density estimate (from 6.67 to 6.95 bears/1000 km^2). This is not a significant difference.

Changes in Population Composition:

Hunters take more male than female bears because they tend to be larger trophies, have larger home ranges, and are more likely to come in contact with hunters (Bunnell and Tait 1980). During spring seasons, males are also more vulnerable because they come out of their dens earlier (Miller 1987). These differences result in a relatively larger proportion of females (i.e., older age classes) in heavily hunted populations than in lightly hunted populations. This characteristic has been used in models of bear exploitation rates (Paloheimo and Fraser 1981, Tait 1983).

Bears older than 5.0 years present in the search area at least once during the search period were used to estimate the percentage of females in the adult population: 17 in the bears transplanted in 1979 (47% females), 23 in the 1985 density estimate (57% females), and 10 in the 1987 estimate (73% females) (Table 7). The male:female ratios for bears >5 years old were 113:100, 77:100, and 38:100 in 1979, 1985, 1987, respectively. Changes in sex ratio for bears >2.0 years old are less marked (Table 7) because of the relatively large movement by subadult males. In 1987 there were 5 subadult males in the search area (ages 2-4 years old) compared with only 2 subadult females. This composition is consistent with the following hypothesis: the 1987 estimate was conducted on a population that had been subjected to relatively heavy hunting pressure, causing a reduction in the proportion of males in the adult population. It should be noted that this population composition estimate is based on captures in a given search area and would tend to overestimate the actual proportion of males because males from a larger area, compared with females, would overlap the search area at some time during the search period because their movements are more extensive (Miller 1987, Ballard et al. 1982.). Increased harvests of females by hunters in fall seasons also suggests a reduction in proportion of males in the population (Tobey 1987).

There is another theory implicit in bear management: heavily exploited populations tend to be younger than lightly exploited populations. This theory must be applied with caution because a young, rapidly growing population might have a similar age structure (Caughley 1974, Tait 1983, Beecham 1983). In the following analysis of age structure, only bears >2.0 years old were used because of possible year-to-year variation in cub production and survival.

Both median and mean ages of males were lower in the 1987 study than in the 1979 or 1985 studies (Table 7). Mean and median ages of females in the 1987 study were older than those in the 1979 study but about the same as those in the 1985 study (Table 7). These results probably reflect a situation where the number of older males available to hunters had been reduced to the point that few males were being harvested, and most of those had been young recruits. These data do not yet reflect a similar trend for females. Females in the adult age classes are legally protected from hunting when accompanied by cub or yearling offspring; therefore, adult females are depleted less rapidly than adult males, which are always vulnerable. This analysis, by itself, reveals little about whether the base of adult females is being depleted. It is possible, however, that the increasing age of adult females being harvested may indicate an undermining of the base population of females that are producing recruits. In this instance, many females would be harvested before reaching the periodically protected adult age classes. The remnant base of adult females are becoming increasingly old, and they are being harvested at a high rate during years when they are not legally protected (i.e., when accompanied by litters of cubs or yearlings). Therefore, the base of adult females is declining as a result of senility and harvest. This decline will, at some point, become clear when few recruits are being harvested and a higher proportion of the female harvest is composed of younger animals, as is currently the case for males.

Harvest Data Analysis

The increased brown bear harvests in GMU 13 have resulted in a decline in bear density and changes in population structure in the readily accessible northern portion of that unit. Managers of exploited bear populations in Alaska use the sex and age composition of harvests to assist in their interpretation of bear population trends. Correspondingly, in a area where changes in bear numbers are occurring, it may be instructive to see if indicators of these changes are present in the harvest data.

For purposes of this analysis, the harvest data were examined from different portions of the unit. These portions were selected on the basis of their ease of hunting accessibility; Mark Chihuly (ADF&G, Anchorage) agreed with these designations. All bear kills in Alaska are allocated to a specific Uniform Coding Area, and these areas were grouped as indicated in Appendix A.

Location of Harvests:

Compared with the mid-1970's, an approximate doubling of the reported brown bear harvest occurred in the unit during the 1980's (Figs. 1 and 2). Along the Denali Highway, where the 1987 density estimate was conducted, harvests reached a peak in 1984, declining in the following 2 years (Fig. 1). This decline reflected a growing scarcity of bears. In less easily accessible portions of the unit, little increase in the harvest was observed (e.g., Subunit 13C); however, a major increases in the harvest occurred in remote portions of

Subunits 13A, 13B, and 13E (i.e., central 13) (Fig. 2). Since few bears were taken in Subunit 13C, subsequent analyses were based on the data from all of GMU 13.

Sex Ratios:

Males tend to be more vulnerable to hunters than females; therefore, an increase in the proportion of females in the harvest may be an indicator of an increasing harvest rate (Bunnell and Tait 1981, Fraser et al. 1982, Tait 1983, Harris 1984). The proportion of females in the fall hunter harvest has increased, exceeding 50% since 1980 (Figs. 7 and 8). The proportion of females in the harvest is higher for older bears (>5.0 years old) than it is for all bears. In contrast, females constituted 34% of the harvest of bears >3 years old in an Alaska Range population considered to be heavily hunted (Reynolds et al. 1987). In a very lightly exploited north slope population, females (all ages) constituted 58% of the population (Reynolds and Hechtel 1984).

Age Ratios:

Biologists have long recognized the difficulties in interpreting age ratios in harvest data (Caughley 1974). Changes in harvest age may reflect the trend when selectivity by age class occurs. However, age ratio data may be slow to reflect changes in population status, and trends in these ratios may have contradictory interpretations. In order to understand the harvest age data, it is necessary to establish the likely circumstances that have existed in GMU 13 and to determine how these circumstances have changed and how these changes might influence data on harvest ages.

In GMU 13 it is likely that predator control activities in the 1950's caused a marked reduction in bear populations (Ballard and Larson, in press). Following this, the seasons were conservative; consequently, the bear population increased until harvests became more intensive in the 1970's. Following significant liberalizations of seasons and bag limits, including initiation of a spring season in 1980, harvests increased markedly (Table 6).

Bears in GMU 13 are classified as "brown" bears by the Boone and Crockett Club, yet they are typically smaller trophies than more coastal brown bears and, therefore, are little hunted by those who desire a large record-book bear. During fall seasons brown bear hunting in this area is typically opportunistic; bears are incidentally harvested during moose or caribou hunts. Spring hunts for bear occur when other big game seasons are closed. These hunts are more selective for males and older bears than fall hunts because of 2 factors:

(1) spring den emergence and (2) the presence of unweaned offspring with some females.

Changes are to be expected in the harvest age data when a population is being exploited beyond sustainable levels. The following hypotheses address these changes.

1. The number of young bears in the harvest would increase. This increase would be especially notable in the fall harvest, since older animals are being selectively removed in spring harvests. The proportion of young animals in the harvest would also increase as a result of increasing unavailability of older animals. Ultimately, lack of adult females would result in an abrupt decline in recruitment and availability of young animals.

2. The number of middle-age animals in the fall harvest would at first increase and then decline because of lack of recruitment from younger age classes. This decline should occur earlier for males than for females because of the higher vulnerability of males.

3. The number of old animals in the fall harvest would follow the same pattern as that for middle-age animals, but the effect would occur later because lack of recruitment to old age-classes would take longer to work its way through the middle age-classes. It is possible that decline in older age-classes might occur before the decline in middle age-classes under conditions where high rates of removal of older animals were occurring during the spring season.

4. An increase in the proportion of adult females in the harvest would precede a decline in recruitment of younger individuals.

5. Depletion of older age-classes would result in a decline in the mean age of harvested animals. This would be apparent for males before it became apparent for females.

6. Regardless of population trend, selective harvests of males over females would yield a younger mean age for males in the harvest than for females. An expanding disparity between the mean ages of the sexes would be an indicator of increasingly heavy harvests and selectivity.

7. Sex ratios should favor females over males, especially in heavily exploited age-classes.

8. During periods of heavy exploitation, a higher percentage of males in the harvest would be younger bears. This

model is based on the method described by Fraser et al. (1982).

For annual harvests, no trend in mean age of harvested bears has been evident since 1980 for either males (Fig. 9) or females (Fig. 10). Hunting has been limited to spring seasons since 1980, so previous historical data are not presented in Figs. 9 or 10.

Since fall harvests have been held for decades, they provide a longer period of time for comparisons. There is no apparent trend in the mean age of females (Fig. 12), but the mean age of males appears to be declining for all males and for males >5 years old (Fig. 11).

For harvest age data for areas characteristically having small samples sizes and occasionally very old individual bears, median age is sometimes used instead of mean. Trends in median ages for annual harvests in GMU 13 (Table 13) and for fall harvests (Fig. 14) suggest the same trends as mean data. For both mean and median ages, male bears in the harvest were younger than females (Figs. 11-14); this trend reflects the higher relative vulnerability of males to hunters that have yielded the differences in sex ratios discussed above. Although the trends are not clear, the data illustrated in Figs. 11-14 suggest that the disparity between the mean ages of males and females is becoming greater.

When males are more vulnerable in the harvest than females, the proportion of males is high in younger age-classes but lower in older age-classes, because comparatively fewer males survive (Fraser et al. 1982). This hypothesis has many problems, which have been pointed out by its authors as well as by Harris and Metzgar (1987); regardless, we used it to determine if the proportion of younger-age bears has increased in recent years. Only fall data were used in this analysis. Interestingly, data from 1970 to 1979 did not reveal the predicted pattern; during this period the percentage of males in the harvest remained high or increased in the older age-classes, compared with the younger age-classes (Fig. 15). Data from 1980-1987 fit the predicted pattern better (Fig. 16); however, no comparisons with the earlier period were possible. Fraser et al. (1982) suggested that this hypothesis could be used to roughly estimate exploitation rate (i.e., reciprocal of the x value at the point where y = 50% males). For the 1980-1987 data illustrated in Fig. 16, the estimated exploitation rate is 20% for brown bears aged 2-17 years in GMU 13.

More insights into population trends can be obtained by examination of the distribution of ages in the harvest than by examination of means or medians. Three age-classes were used for this analysis. Two-year-olds were classified as "young" bears, bears aged 5-10 years as as "middle-aged", and bears older than 10 years as "old."

Young Bears. Special attention was paid to 2-year-old bears that were facing the first season in which they could have been legally shot. Offspring typically separate from their mothers at age 2 in GMU 13 (Miller 1987). In both annual and fall data, number of 2-year-old bears increased during the period from 1970 to 1984 (Figs. 17 and 18). This increasing trend may have changed to a declining trend in the last 2 years (Figs. 17 and 18). A decline of this nature, if substantiated with additional year's data, may indicate the decline in recruitment into subadult age classes suggested in hypothesis No. 1 (see p. 19). The proportion of the fall harvest that is composed of 2-year-olds has also increased in the last decade (Fig. 18).

Middle-Aged Bears. Harvest data on middle-aged bears is presented in Figs. 19-24. The number of males harvested annually increased dramatically with initiation of the spring seasons (Fig. 19); during fall seasons the number of males harvested has remained constantly low since 1970 (Fig. 20). There is no clear pattern to the proportion of the harvest composed of middle-aged males, but during fall seasons from 1970 to 1981, the proportion appeared to be in a general decline followed by an increase.

The number of middle-aged females in fall harvests was relatively stable between 1970 and 1981; that number increased slightly for a few years, but it may be declining (Fig. 22). The same pattern is evident in the annual data (Fig. 21) and in the proportion of middle-aged females in the harvest (Figs. 21 and 22). Throughout much of the period for which data are available, there have been more middle-aged females harvested than middle-aged males (Figs. 19-22), but there is no clear trend for these data.

The number of middle-aged bears (both sexes) in the harvest also increased during the early 1980's (Figs. 23 and 24), although it may have declined in more recent years. Considering only the data from bears harvested during fall seasons, this pattern is more apparent in the data for females (Figs. 21 and 22) than it is for males (Figs. 19 and 20). The male harvest may still be increasing annually (Fig. 19) because of the high vulnerability of adult males during spring seasons. During the years 1970 through 1987, there is no apparent trend in the sex ratio of middle-aged bears killed by hunters (Fig. 25); however, for older bears the proportion of females in the harvest has increased (Fig. 26). This suggests that older bears are more heavily exploited than younger ones; however, according to harvest data obtained during the 1970's, there is no apparent sex ratio pattern for this age-class (Fig. 15).

Old Bears. Harvests are still increasing for older bears in Unit 13 (Figs. 27-32). The clearest upward trend is in the number of old females harvested annually (Fig. 29). Trends in males are less apparent, perhaps because so few old males are harvested (Figs. 31 and 32), compared with the number of old females taken (Figs. 29 and 30).

It appears that a number of hypotheses (see pp. 19 & 20, Nos. 1-8) are supported by the GMU 13 harvest data. Without independent verification of population status based on density estimates of the type reported earlier in this report, the observed patterns could be misinterpreted. However, a parsimonious interpretation based solely on the sex and age composition of the harvest data in GMU 13 would lead most managers to conclude the population was being exploited in excess of sustainable levels.

Estimation of Sustainable Harvest Rates

Density estimates from this and the 1985 studies (Miller et al. 1987) were extrapolated to all of GMU 13 to provide a population estimate of 823 bears (>2.0 years old). To make this estimate, Warren Ballard, Robert Tobey, and I classified GMU 13 into density strata based on our consensus guess of the densities in different areas relative to either the 1985 or 1987 density estimation areas (Memo from S. Miller to R. Tobey, dated 16 July 1987). This was a preliminary effort, but there has not been an opportunity to make a more refined estimate. In my opinion, this estimate is more likely to be too high than too low.

Reproductive data from GMU 13 is available from 6 years of study (1980-1986) in the Susitna Hydroelectric Project study area (Miller 1987). The northern limit of this area is within 10 miles of the southern border of the 1987 study area.

Various methods can be used to estimate a sustainable mortality rate for a population of animals for which estimates are available for both reproductive parameters and population size. Using the reproductive rates for GMU 13, I developed a simple, deterministic model based on LOTUS 1-2-3 (Lotus Development Corporation) to estimate numbers of bears that could be theoretically taken from a brown bear population of 823 individuals (>2.0). This model deals with a population of brown bears whose ages range from 2 to 30 years old. Input parameters for this model are (1) initial population structure (number in each age-sex class for ages 2-30), (2) sex- and age-specific survivorship from type-1 ("hunting") and type-2 mortalities ("natural"), (3) mean interval in years between successive successful production of litters that reach age 2 years, (4) mean litter size when litters reach age 2 years, (5) proportion of females that are adult in each age-class (giving birth at that age or younger), and (6) sex ratio of 2-year-olds.

A similar exercise using a different model resulted in the following estimate: polar bear (Ursus maritimus) populations could sustain annual hunter harvests of adult (>3 years) females of no more than 1.6% of the total population and a total mortality of no more than 2.6% from all sources (Taylor et al. 1987a). Since reproductive parameters in this study were similar to those for GMU 13 brown bears, it is possible to compare their estimate with mine.

An iterative process was used with the LOTUS model to obtain a stable number approximating the population estimate for GMU 13 (i.e., 823 bears), including a stable age distribution and the reproductive parameters (Miller 1987). The input values (i.e., vulnerability to hunting) were adjusted until a stable population with a stable age distribution was obtained. In making these adjustments, a twofold differential between male and female vulnerability to hunting was maintained.

Two different simulations were made. In the first one, natural mortality was set to zero until age 20; hunting mortality was the total sustainable mortality from all sources. In the second simulation, conservative guesses of natural mortality were entered and hunting mortality represented the remaining mortality the population could sustain.

The assumptions and parameters used provided an estimate of sustainable annual mortality (from all sources) of 100 bears (age >2.0 years). Of these, 34 can be females (age >5.0 years) and 47 can be females (age >2.0 years) (Table 8).

Comparisons of modeled sustainable mortality levels with actual reported harvests from GMU 13 suggest that the current reported harvest, by itself, represents more than the sustainable level of mortality (from all causes) for the GMU 13 population for most sex-age classes of bears (Table 8). The estimates presented in Table 8 are exaggerations of sustainable levels of hunting mortality of the GMU 13 population (older than 2.0 years) for the following reasons:

1. Natural mortality occurs in age-classes 2 to 19; not all mortality is attributable to hunting.

2. As a result of using mean annual recruitment rate/adult female, the recruitment rate is actually less than that estimated by the model. This parameter overestimates actual recruitment rate in species with reproductive intervals >1 year (Taylor et al. 1987b).

3. The actual age composition in GMU 13 doubtless contains fewer adult females than the modeled population; this results in an overestimate of productivity because younger bears (ages 2-5 years) are more vulnerable to hunters than older ones and older females are legally protected when they are with cub or yearling offspring. Also, since harvests have been increasing, the assumption of a stable age distribution is certainly wrong; the population pyramid is certainly broader based (more young individuals) than would occur with a stable age distribution of an unhunted population.

It should also be noted that harvesting at sustainable levels calculated for the whole unit will result in overharvesting in accessible areas and underharvesting in remote, less-accessible areas.

The total sustainable mortality model included no natural mortality, except for very old bears. Natural mortality exists, although it is difficult to quantify. Addition of conservative estimates of natural mortality to the model provides a more realistic maximum estimate of sustainable levels of hunting mortality. When this is done, current harvests markedly exceed estimated sustainable levels in all categories (Table 9). The sustainable harvest of 21 adult (>5 years old) females (Table 9) is 2.5% of the total population (age >2 years).

In order to compare this figure with the sustainable mortality of <1.6% for adult (>3 years old) polar bears (Taylor 1987a), the number of yearling and cub bears needed to be added to the GMU 13 population estimate and the numerator for percentage harvested needed to be converted to bears >3 years old. Numbers of cubs and yearlings were back-calculated from the number of 2-year-olds using cub and yearling mortality estimates obtained in GMU 13. The estimated cub mortality was 36%, and the estimated yearling mortality was 24% (Miller 1987). The model stabilized at production of 52 2-year-olds/year; a back-calculation using yearling and cub mortality rates provided an estimated annual population of 107 cubs and 68 yearlings for each sex. Adding these to the population of 830 provided a total spring population estimate of 1180 bears. In the stabilized harvest of bears aged 3 and 4 years, there were 9 males and 5 females. Adding the 5 females to the harvest of 21 females >5 years old (Table 2) provided a stabilized harvest of females >3 years old of 26 bears, or 2.2% of the total population. This number is close to the 1.6% estimate obtained for polar bears with similar reproductive parameters (Taylor et al. 1987a).

In an Alaska Range population thought to be exploited in excess of sustainable levels, the mean mortality rate was estimated to be 12.5-13.4% (Reynolds et al. 1987). The calculated sustainable mortality rate generated by my model for bears >2.0 years old was 8% (Table 9). If my estimation of sustainable harvest rates is correct and applicable to Reynolds' study area, it suggests that his population is being overexploited by approximately 4-6%/year.

Management Recommendations

Game Division staff intend to recommend to the Alaska Board of Game that brown bear populations be stabilized at 1987 levels. Since 1980, it has been the Board's intent to increase and maintain high numbers and harvests of moose and caribou and low (i.e., below maximum) numbers of predators in GMU 13. Wolf populations have remained relatively low during 1975 to the present (Ballard et al. 1987, Bergerud and Ballard 1988). The desire to increase moose numbers is the reason bear regulations were liberalized starting in 1980. Currently, moose in much of GMU 13 are thought to be at or near estimated carrying capacity for average winter conditions in some areas (W. Ballard, pers. commun.). It is unclear whether the healthy status of these ungulate populations is related more to a long series of mild winters during the last decade or to reduced numbers of predators; probably both factors have played roles (Ballard et al. 1987, Ballard and Whitman 1987). Regardless, it seems clear that moose in GMU 13 are not currently suppressed by predators to the degree that bear reduction programs are necessary to allow moose populations to grow; it appears that the situation in GMU 13 is different than the one north of the Alaska Range in Unit 20 (Gasaway et al. 1983).

In some areas brown bears move to caribou calving grounds and prey extensively on caribou calves (Reynolds and Garner 1987). In Unit 13 some movements to caribou calving areas by brown bears were observed, but these were infrequent (Miller 1987). Brown bear predation on caribou in GMU 13 is unlikely to be a limiting factor on caribou population in this area or to the Nelchina herd, which has increased to about 30,000 animals (ADF&G files).

The rate of increase of both moose and caribou populations in GMU 13 is currently thought to be restrained primarily by human harvests (R. Tobey, pers. commun.). There is little evidence to suggest that it is desirable to increase population growth rates for either species in this area. Under these circumstances, there is little logic for further reductions of bear populations in GMU 13.

The rate of decline in GMU 13 brown bear numbers will undoubtedly be slowed by the decrease in bag limit adopted for the 1987-88 regulatory year (Table 6). It is probable, however, that season changes will also have to be adopted to prevent further declines. According to my preliminary estimation of sustainable harvest levels, the annual harvest in GMU 13 should not exceed 20 females >5.0 years old or 30 females >2.0 years old (Table 9). Also, the population will probably continue to decline as long as the sex ratio in fall harvest continues to exceed 50% female (Figs. 7 and 8); female harvests should be reduced. This may be difficult to achieve if, as discussed above, the male segment of the population has already been significantly reduced.

Season adjustments should be made to obtain harvests of adult females that do not exceed sustainable levels. There are clear trends in chronology of kill by sex and age classes for spring seasons (Figs. 33 and 34). Males tend to emerge from dens before females (Miller 1987). Reflecting this, a higher proportion of females in the kill occurred progressively throughout the spring season, with a much higher proportion occurring during the last week of May (Fig. 34); this week also has the oldest mean age of females (Fig. 33). If not the entire May season, then certainly, the last 2 weeks of it should be eliminated.

For fall seasons, less can be done with opening and closing dates to concentrate hunting effort away from adult females (Figs. 33 and 34). Although relatively few bears were killed in October (i.e., the period of den entrance), the late-October season could be eliminated because it was not added until 1980 (Table 6). If further reductions in harvest are needed to meet management guidelines, the whole of the October season could be eliminated.

Trends in Cub Survivorship

Brown bears are known to be intraspecific predators, especially on young bears (Dean et al. 1986, Miller 1987). In an Alberta black bear study, reduction in number of adult males in a population appeared to increase survivorship of cubs as well as immigration (Young and Ruff 1982). However, predation on brown bear offspring is not caused just by males. In 3 instances observed at McNeil River, Alaska, an adult female killed another female's offspring (Hessing and Aumiller, unpubl. data).

In Alaska it has been hypothesized that increased survivorship of cubs may be the result of heavy hunting conditions where males are selectively removed. This might result in increased recruitment when harvests increase. As documented above, hunting pressure and harvests have increased in GMU 13, resulting in a reduction of the proportion of adult males in the population. Given this, it is appropriate to examine the offspring survivorship data that have been collected since 1978 to see if there is support for this hypothesis. Much of the data on cub survivorship was collected in the Su-hydro study area where bear densities have been less reduced than in the current study area.

Data on offspring survivorship are derived from observations of radio-marked females and changes in the number of offspring accompanying them. Absence from a litter of formerly present offspring does not necessarily prove that the offspring have died; however, telemetry studies indicate that this is usually the case (Miller 1987). For purposes of this analysis, bears were classified as cubs from time of initial den emergence to time of emergence from their 2nd den as yearlings. Bears were classified as "yearlings" from the time of their 2nd den emergence to time of their 3rd emergence as 2-year-olds.

Misinterpretation of early weaning as mortality occurs more often for yearlings than for cubs. In the spring of 1987 I documented 1 case where an actively breeding female (No. 472) was also apparently in the process of weaning a yearling offspring (No. 475). This yearling stayed near the breeding pair (No. 472 and No. 471) for a week. No prior or subsequent information is available for these bears because they were not captured until the spring of 1987 and their transmitters were removed at termination of the density estimation portion of this study. This is the only case of yearling weaning I have observed in GMU 13, and I suspect that it is rare.

I have seen only 2 cases where a female went into a den with 2-year-old offspring and weaned them as 3-year-olds (e.g., one of these was for No. 283 in the spring of 1988 and is not included in Table 14). In all other cases, offspring have been weaned as 2-year-olds (Miller 1987).

Raw data on offspring survivorship are presented in Tables 10-13 and are summarized in Table 14. Comparing proportion of cubs of radio-marked females that were lost annually during 1980-1987 suggests these data are not related to year ($r = 0.07$; Fig. 35). A better relationship was found showing decreasing mortality of yearlings during 1981-1987 ($r = 0.87$; Fig. 35); combining yearling and cubs during this period resulted in a poor fit ($r = 0.23$; Fig. 36).

The analyses based on proportion of cubs lost (Figs. 35 and 36) can be misleading because they do not take into account the time of death (Heisey and Fuller 1985). Correspondingly, these analyses were repeated using radio-days; i.e., cubs with radio-marked mothers were also treated as radio-marked. The MICROMORT program was used to calculate these mortality rates (Heisey and Fuller 1985). Sample sizes (number of mortalities) were smaller for these analyses because mortalities that could not be timed accurately (± 15 days and within one of the 3 seasons) were not included in the analyses of mortality by season.

Based on radio-days, fall and winter cub mortality rates (0.07) were comparable to the spring cub mortality rates (0.35) (Table 10, Fig. 37). Spring mortality rates of newborn cubs had a weak positive relationship during 1981-1987 (Fig. 38, Table 10). This analysis, like that based on the proportion of cubs lost, provides no support for the hypothesis that cub mortality is declining in GMU 13 as a consequence of increased hunting pressure concentrated on males. Possible explanations for this lack of relationship include the following:

1. There is no relationship because cub survivorship is independent of the proportion of adult males in the population over the range that has existed during this period. If this is true, the variation in cub survivorship between years would be related to some other factor (i.e., most likely year-to-year variations in food supply).

2. The relationship exists but not under the conditions that existed during this study. Perhaps no effect was observed because males were not yet sufficiently reduced in the area from which most of the cub mortality data derived. Most (i.e., 71 of the 81 cubs during 1981-1987) of the cub survivorship data were collected in the Su-hydro area where the increase in hunting pressure has been less marked.

3. The relationship exists, but it may be overwhelmed by other factors (e.g., food) in some years and, thereby, complicate interpretation.

Annual mortality rates for cubs and yearlings were estimated using MICROMORT. Mortality rates were not constant throughout the year (Fig. 37, Table 10), so these data should be cautiously interpreted. The average annual cub mortality was estimated as 0.442 (Table 10, Fig. 37). Annual mortality for yearlings was 0.193 (Table 10). For yearlings, lumping years 1978-1987 provided an annual spring mortality estimate of

0.164 (Table 10). For the period 1978 to 1983 spring mortality was higher (0.322) than during 1984 to 1987 (0.074) (Table 10).

I suspect the data indicating a downward trend in yearling mortality is misleading. I think this "trend" actually reflects differences in survivorship related to annual differences in food supply as observed for black bears by Rogers (1976). Miller (1987) suspected a berry crop failure in this area during summer of 1981. Four of the 7 yearling mortalities that occurred during the spring occurred in 1982, following this suspected failure.

Brown Bear Reproductive Rates

Studies of reproductive biology have been conducted on radio-marked brown bears in GMU 13 as part of studies conducted during 1978 through the present one. These studies are designed to estimate reproductive rates of female bears in this area. Summaries of these results were presented by Miller (1987). These data are combined with additional data obtained during this study and from infrequent monitoring (i.e., 4 flights/year) of bears captured during Su-hydro studies (Tables 10-16).

Mean litter size for 50 litters of newborn cubs was 2.1 (range 1-4), and 40.5% of cubs did not survive their first year (Table 10). Mean litter size for 45 yearling litters was 1.8 (range 1-3), and 18.2% of yearlings were lost prior to emergence from dens at age 2.3 (Table 11). Litters of 2-year-old offspring averaged 1.7 bears (range 1-3) (Table 12). Reproductive histories of individual females are presented in Table 13. Losses of cubs and yearlings during 1978 to 1987 are presented in Table 14. Morphometrics of cubs and yearling bears handled in these studies are presented in Tables 16 and 17. Similar reproductive data for black bears are presented in Appendix D.

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Table 1A. Brown bears captured in upper Susitna River studies, 1986 & 1987.

	Capture						
Tattoo	Sex	Age	Wt.(lbs.)	Date	Serial #	Ear Tags	Comments
453	F	4	250[a]	6/3/86	6345	2443/2363	w/2@0, lost 1c but successfully reintroduced next day
468	F	0.5	15	6/3/86	--	562/561	w/G453
--	F	0.5	17	6/3/86	--	558/559	w/G453
454	F	4	175[a]	6/3/86	6278	2358/2353	alone, no tattoo
455	M	8	525	6/3/86	(6351)	(2058/1700)	alone, drop-off collar, removed all tags 6/87
456	F	6	250[a]	6/4/86	(15290)	(2441/2352)	w/2@0, one captured, shot 5/87
--	M	0.5	33	6/4/86	--	551/552	w/uncaptured sibling & 456
457	M	7	525	6/4/86	15291	(2129/2066)	w/458, drop-off collar, removed all tags 6/87
458	F	17	200[a]	6/4/86	6443	2421/2446	w/457, drop-off collar
459	F	3	100[a]	6/4/86	--	2435/2407	alone, recaptured 6/87
460	F	7	300[a]	6/4/86	6349	560/564	w/2@0, no ear flags, roto tags
--	M	0.5	30	6/4/86	--	--	capture mortality
--	F	0.5	30	6/4/86	--	553/554	w/460 & sibling
461	F	5	275[a]	6/5/86	15284	1529/2427	w/1@0
--	M	0.5	26	6/5/86	--	567/555	w/461
462	F	7	275[a]	6/5/86	6298	2412/2487	w/1@1 (463), magnet left on? in '86, okay in '87
463	M	1.5	90[a]	6/5/86	--	2193/2198	w/G462
464	M	2	150[a]	6/5/86	--	2185/2177	alone
465	F	3	250[a]	6/5/86	(6309)	1525/2442	alone, collar removed 6/87
466	F	2	150[a]	6/5/86	--	2097/2056	offspring w/G335 (Su-Hydro)
467	M	3	190	6/5/86	--	2144/2138	alone
468	F	1	70	5/30/87	27826	558/559	w/mom 453 & sibling, glue-on transmitter
459#2	F	4	198	5/30/87	6344	(same)	alone, rot-away collar
					27827		glue-on radio (mod. 300)
469	F	6	275[a]	5/30/87	19053	2364/2424	w/2@1, '85 radio
					1023		glue-on transmitter (mod, 200), 19-50ppm
470	M	2	185	5/30/87	(3.930[b])	2176/2179	alone, glue-on transmitter
470#2	M	2	--	6/8/87	--	--	removed transmitters, shot 9/87
471	M	5	450[a]	5/30/87	--	2099/1699	w/girlfriend 472
471#2	M	5	--	6/8/87	--	--	removed radio
472	F	12	375[a]	5/30/87	--	3076/3045	estrus, w/boyfriend (471) and 1@1 (475)
472#2	F	12	--	6/8/87	--	--	removed radio
473	F	6	295	5/30/87	--	3075/3096	alone

Table 1A. Continued.

Tattoo	Capture						
	Sex	Age	Wt.(lbs.)	Date	Serial #	Ear Tags	Comments
473#2	F	6	--	6/8/87	--	--	removed radio
474	M	3	335	5/31/87	6302	2512/2658	alone, '85 radio
					27828	--	glue-on radio (mod 300)
475	M	1	70[a]	5/31/87	1022	2637/2504	w/472 and stepdad, glue-on radio
475#2	M	1	--	6/8/87	--	--	removed transmitter, checked teeth
476	M	2	150[a]	5/31/87	19048	2067/2065	w/477 (sibling?)
					27852	--	
476#2	M	2	--	6/8/87	--	--	removed transmitters
477	F	2	125[a]	5/31/87	--	2654/2699	w/476 (sibling?)
477#2	F	2	--	6/8/87	--	--	removed radio, shot 9/87
478	F	9	340[a]	6/1/87	X988	3026/3046	w/2@1
					1700	--	glue-on radio (mod. 300)
479	M	2	224[a]	6/4/85	--	2503/2681	alone
479#2	M	2	--	6/8/85	--	--	removed collar
480	M	2	205	6/4/85	--	2649/2635	alone
480#2	M	2	--	6/8/87	--	--	removed collar
481	F	14	282	6/5/87	6287	3016/3064	w/3@1, old '85 radio
482	F	7	300[a]	6/6/87	--	3093/3080	w/3@1
482#2	F	7	--	6/8/87	--	--	removed radio
457#2	M	8	600[a]	6/7/87	--	--	removed collar & ear tags, both badly infected
455#2	M	9	550[a]	6/8/87	--	--	removed collar & ear tags, both badly infected
465	F	4	310[a]	6/8/87	--	(same)	removed collar

[a] estimated.
[b] glue-on transmitter.

Table 1B. Operational expenses for the density estimation project (2 phases) conducted in GMU 13 during 1986 and 1987.

Supplies and Transportation		Cost (thousands of dollars)
FY 1986 (premarking phase)		
Fuel, supplies, and misc.		7.7
Telemetry equipment		7.0
Helicopter charter		8.6
Fixed-wing charter		8.0
	Subtotal	31.3
FY 1987 (density estimation phase)		
Fuel, supplies, and misc.		14.7
Telemetry equipment		3.6
Helicopter charter		13.6
Fixed-wing charter		24.8
Monitoring premarked bears		4.1
	Subtotal	60.8
	Total	92.1

Table 2. Size of quadrats (sq. mi.) and search effort (minutes) during each day of spring 1987 bear density estimation effort in upper Susitna River Study area.[a]

Quad-	Size	DAY 1		DAY 2		DAY 3		DAY 4		DAY 5		DAY 6		DAY 7		TOTAL	TOTAL	Avg.	PART DAY
rat	(mi^2)	5/30	min/mi^2	5/31	min/mi^2	6/1	min/mi^2	6/2	min/mi^2	6/4	min/mi^2	6/5	min/mi^2	6/7	min/mi^2	minutes	min/mi^2	min/mi^2	6/6
1	82.0	185	2.3	172	2.1	206	2.5	188	2.3	241	2.9	295	3.6	281	3.4	1568	19.1	2.7	0
2	83.0	210	2.5	183	2.2	233	2.8	199	2.4	248	3.0	284	3.4	224	2.7	1581	19.0	2.7	0
3	36.0	140	3.9	96	2.7	129	3.6	135	3.8	113	3.1	125	3.5	126	3.5	864	24.0	3.4	0
4	48.7	113	2.3	70	1.4	111	2.3	106	2.2	119	2.4	147	3.0	173	3.6	839	17.2	2.5	117
5	53.1	113	2.1	120	2.3	154	2.9	143	2.7	120	2.3	133	2.5	182	3.4	965	18.2	2.6	142
6	110.6	192	1.7	218	2.0	282	2.5	285	2.6	272	2.5	322	2.9	264	2.4	1835	16.6	2.4	245
7	72.0	144	2.0	178	2.5	180	2.5	277	3.8	180	2.5	206	2.9	169	2.3	1334	18.5	2.6	162
Total:	485.3	1097	2.3	1037	2.1	1295	2.7	1333	2.7	1293	2.7	1512	3.1	1419	2.9	8986	18.5	2.6	666

[a] Area above 5,000 feet elevation (19.96 sq. mi.) is not included in area calculations but area around Valdez Ck. mine (20.71 sq. mi.) is included.

Table 3. Raw capture/recapture data for 1987 upper Susitna brown bear density estimate.[a]

DAY	DATE	New bears captured	Marked bears seen	Marked bears present
1	30 May	469 w/2@1(M) 473 alone(M) 470 alone(M) 459 alone(M)	460 w/1@1(CL)	458 w/1@0(CL) 460 w/1@1(CL)
2	31 May	474 (CL) 475 ylg(M) 476 w/477(M) 477 w/476(M)	470(M)	458 w/1@0(CL) 469 w/2@1(M) 471 (M) 470 (M)
3	1 June	478 w/2@1(CL)	474(CL) 476(M) 455(M)	458 w/1@0(CL) 474(CL) 455(M) 470(M) 476(M) 475 ylg.(M) 477(M) 472(M) 471(M)
4	2 June		471(M) 472(M) 476(M)	478(CL) 477 w/2@1(M) 476(M) 455(M) 472(M) 475 ylg.(M) 471(M)
5	4 June	479(M) 480(M)	458 w/1@0(CL) 475 ylg(M)	458 w/1@1(CL) 459(CL) 476(M) 475 ylg(M) 455(M) 471(M) 472(M)
6	5 June	481w3@1(M)	457(CL) 459(CL) 471(M) 472(M) 475 ylg(M) 480(M)	457(CL) 459(CL) 475 ylg(M) 476(M) 471(M) 472(M) 480(M)

Table 3. Continued.

DAY	DATE	New bears captured	Marked bears seen	Marked bears present
7 (Monihan area only)*	6 June	482 w/3@1(M)	475 ylg(M) 471(M) 472(M)	480(M) 471(M) 472(M) 475 ylg(M)
7(CL) 8(M)	7 June		471(M) 472(M) 475 ylg(M) 482 w/3@1(M)	480(M) 471(M) 472(M) 475 ylg(M) 482 w/3@1(M)

[a] M= Monihan area, CL= Clearwater area.

[b] Only the Monihan area was worked on this day; no data for Clearwater.

Table 4. Capture data and corresponding density estimates made using the bear-days estimator.

Part A. Upper Susitna brown bear data from 1987, includes bears older than 2.0, whole study area.

DATE	n_1[a]	m_2[b]	n_2[c]	Daily L-P[d]	Sight-ability	N*	AREA (sq.km)	Est. density #/1000km²	Est. density sq.km/bear	95% confidence intervals: No. bears lower cl	upper cl	(#/1000km²) lower cl	upper cl	80% confidence intervals: No. bears lower cl	upper cl	(#/1000km²) lower cl	upper
5/30	2	1	5	8.0	0.50	8.0	1257	6.364	157.13	2.79	392.16	2.221	311.978	3.43	95.69	2.725	76.1
5/31	4	1	4	11.5	0.25	11.2	1257	8.884	112.57	5.00	106.76	3.977	84.934	6.12	49.34	4.870	39.2
6/1	8	3	4	10.3	0.38	11.3	1257	9.016	110.91	6.82	33.67	5.426	26.786	7.80	23.28	6.206	18.5
6/2	6	3	3	6.0	0.50	9.7	1257	7.690	130.03	6.64	20.28	5.279	16.137	7.33	15.73	5.831	12.5
6/4	6	1	3	13.0	0.17	10.6	1257	8.443	118.58	7.31	21.27	5.815	16.920	8.10	16.83	6.443	13.3
6/5	6	5	6	7.2	0.83	9.4	1257	7.452	134.20	7.05	15.27	5.612	12.147	7.63	12.90	6.071	10.26
6/8	4	3	3	4.0	0.75	8.4	1257	6.661	150.13	6.55	12.67	5.212	10.082	7.01	10.98	5.578	8.7

cumulative sightability - 0.47
mean daily L-P = 8.56

Part B. Su-hydro brown bear data from 1985, includes bears older than 2.0, whole study area.

DATE	n_1[a]	m_2[b]	n_2[c]	Daily L-P[d]	Sight-ability	N*	AREA (sq.km)	Est. density #/1000km²	Est. density sq.km/bear	95% confidence intervals: No. bears lower cl	upper cl	(#/1000km²) lower cl	upper cl	80% confidence intervals: No. bears lower cl	upper cl	(#/1000km²) lower cl	upper
6/1	10	2	5	21.0	0.20	21.0	1317	15.945	62.71	11.72	189.75	8.897	144.080	13.27	89.13	10.078	67.6
6/2	13	1	1	13.0	0.08	20.5	1317	15.566	64.24	13.04	97.38	9.901	73.937	14.39	57.24	10.927	43.4
6/3	14	4	7	23.0	0.29	21.8	1317	16.578	60.32	15.27	49.08	11.593	37.265	16.75	37.27	12.719	28.3
6/4	17	5	9	29.0	0.29	24.1	1317	18.282	54.70	17.85	41.91	13.557	31.824	19.41	34.72	14.741	26.3
6/9	19	5	9	32.3	0.26	26.1	1317	19.826	50.44	20.09	40.52	15.253	30.768	21.68	34.89	16.462	26.4
6/10	22	6	6	22.0	0.27	25.2	1317	19.109	52.33	20.42	35.37	15.505	26.859	21.70	31.48	16.473	23.9
6/11	19	4	5	23.0	0.21	25.1	1317	19.048	52.50	20.76	33.91	15.763	25.746	21.94	30.58	16.659	23.2

cumulative sightability - 0.24
mean daily L-P = 23.33

Table 4. Continued.

Part C. Upper Susitna brown bear data from 1987, includes bears >3.0, whole study area.

DATE	n_1[a]	m_2[b]	n_2[c]	Daily L-P[d]	Sight-ability	N*	AREA (sq.km)	Est. density #/1000km²	Est. density sq.km/bear	95% confidence intervals: No. bears lower cl	95% No. bears upper cl	95% (#/1000km²) lower cl	95% (#/1000km²) upper cl	80% confidence intervals: No. bears lower cl	80% No. bears upper cl	80% (#/1000km²) lower cl	80% (#/1000km²) upper cl
5/30	2	1	4	6.5	0.50	6.50	1257	193.38	5.17	2.48	317.46	1.97	252.55	2.94	76.92	2.34	61.20
5/31	3		2	11.0	0.00	10.00	1257	125.70	7.96	3.90	595.24	3.10	473.54	4.90	143.68	3.90	114.30
6/1	5	2	3	7.0	0.40	8.83	1257	142.30	7.03	4.76	44.50	3.78	35.40	5.56	25.74	4.42	20.48
6/2	4	2	2	4.0	0.50	7.25	1257	173.38	5.77	4.57	20.90	3.63	16.62	5.13	14.55	4.08	11.58
6/4	5	1	1	5.0	0.20	7.23	1257	173.89	5.75	4.82	18.02	3.83	14.33	5.34	13.19	4.25	10.49
6/5	4	4	5	5.0	1.00	6.38	1257	197.06	5.07	4.70	11.64	3.74	9.26	5.08	9.45	4.05	7.52
6/8	3	3	3	3.0	1.00	5.64	1257	222.76	4.49	4.39	9.11	3.49	7.25	4.68	7.71	3.72	6.13

cumulative sightability - 0.50
mean daily L-P = 5.93

Part D. Su-hydro brown bear data from 1985, includes bears >3.0, whole study area.

DATE	n1[a]	m2[b]	n2[c]	Daily L-P[d]	Sight-ability	N*	AREA (sq.km)	Est. density #/1000km²	Est. density sq.km/bear	95% confidence intervals: No. bears lower cl	95% No. bears upper cl	95% (#/1000km² lower cl	95% (#/1000km² upper cl	80% confidence intervals: No. bears lower cl	80% No. bears upper cl	80% (#/1000km²): lower cl	80% (#/1000km²): upper cl
6/1	10	2	5	21.0	0.20	21.00	1317	62.71	15.95	11.72	189.75	8.90	144.08	13.27	89.13	10.08	67.67
6/2	11	1	1	11.0	0.09	18.75	1317	70.24	14.24	11.91	88.91	9.04	67.51	13.14	52.26	9.98	39.68
6/3	13	3	5	20.0	0.23	19.67	1317	66.97	14.93	13.61	48.47	10.34	36.81	14.92	35.67	11.33	27.09
6/4	15	5	9	25.7	0.33	21.63	1317	60.90	16.42	15.92	38.85	12.09	29.50	17.32	31.83	13.15	24.17
6/9	18	5	9	30.7	0.28	23.80	1317	55.34	18.07	18.22	37.55	13.83	28.51	19.68	32.15	14.94	24.41
6/10	20	6	6	20.0	0.30	22.79	1317	57.79	17.30	18.46	32.28	14.02	24.51	19.62	28.64	14.90	21.75
6/11	17	4	5	20.6	0.24	22.63	1317	58.18	17.19	18.72	30.75	14.21	23.35	19.78	27.68	15.02	21.02

cumulative sightability - 0.25
mean daily L-P = 21.28

[a] n_1 = No. of marked bears present
[b] m_2 = No. of marked bears seen
[c] n_2 = Total no. of bears seen
[d] L-P = Lincoln-Peterson Estimate

Table 5. Comparison of density estimates in Clearwater and Monihan protions of 1987 study area.

Part A. Clearwater area brown bear data from 1987, includes bears older than 2.0

											80% confidence intervals			
											No. bears		Density(No./1000km²)	
Day	DATE	n_1[a]	m_2[b]	n_2[c]	Daily L-P[d]	Sight-ability	N*	AREA (sq.km)	Est.density No./1000km²	Est.density sq.km/bear	lower cl	upper cl	lower cl	upper cl
1	5/30	2	1	1	2.0	0.50	2.0	520.6	3.842	260.30	2.00	20.00	3.842	38.417
2	5/31	1	0	1	3.0	0.00	2.5	520.6	4.802	208.24	1.58	29.24	3.037	56.166
3	6/1	2	1	2	3.0	0.50	3.0	520.6	5.763	173.53	1.94	11.69	3.734	22.450
4	6/2	1	0	0	1.0	0.00	2.7	520.6	5.122	195.23	1.75	10.52	3.360	20.205
5	6/4	2	1	1	2.0	0.50	2.5	520.6	4.802	208.24	1.80	6.49	3.462	12.463
6	6/5	2	2	2	2.0	1.00	2.3	520.6	4.375	228.56	1.84	4.94	3.528	9.489

cumulative sightability = 0.55; mean daily L-P = 2.25

Part B. Monihan area brown bear data from 1987, includes bears older than 2.0

											80% confidence intervals			
											No. bears		Density (No./1000km²)	
Day	DATE	n_1[a]	m_2[b]	n_2[c]	Daily L-P[d]	Sight-ability	N*	AREA (sq.km)	Est.density No./1000km²	Est.density sq.km/bear	lower cl	upper cl	lower cl	upper cl
1	5/30	0	0	4	4.0	ERR	4.0	736.34	5.432	184.09				
2	5/31	3	1	3	7.0	0.33	7.5	736.34	10.186	98.18	2.87	100.67	3.898	136.718
3	6/1	6	2	2	6.0	0.33	8.0	736.34	10.865	92.04	5.01	23.17	6.797	31.461
4	6/2	5	3	3	5.0	0.60	6.7	736.34	9.118	109.67	4.92	12.14	6.678	16.493
5	6/4	4	0	2	14.0	0.00	7.9	736.34	10.787	92.70	5.71	14.80	7.749	20.103
6	6/5	4	3	4	5.3	0.75	7.1	736.34	9.665	103.47	5.46	11.15	7.419	15.145
7	6/6	3	2	3	4.3	0.67	6.7	736.34	9.054	110.45	5.26	9.80	7.138	13.310
8	6/7	4	3	3	4.0	0.75	6.1	736.34	8.318	120.22	5.02	8.38	6.811	11.380

cumulative sightability = 0.48; mean daily L-P = 6.20

[a] n_1 = No. of marked bears present
[b] m_2 = No. of marked bears seen
[c] n_2 = Total no. of bears seen
[d] L-P = Lincoln-Peterson Estimate

Table 6. Summary of brown bears regulations and harvests in Alaska's GMU 13, 1961-1988.

Calendar year	Bag limit	Spring season	Fall season	Total No. days	Spring kill	Fall kill	Total kill
1961	1/year	none	9/1-9/30	30	0	42	42
1962	1/year	none	9/1-9/30	30	0	32	32
1963	1/year	none	9/1-9/30	30	0	43	43
1964	1/year	none	9/1-9/30	30	0	38	38
1965	1/year	none	9/1-10/15	30	1	47	48
1966	1/year	none	9/1-9/30	30	0	63	63
1967	1/year	none	9/1-9/30	30	0	32	32
1968	1/4years[a]	none	9/15-10/15	21	0	39	39
1969	1/4years	none	9/20-10/20	31	0	17	17
1970	1/4years	none	9/15-10/5	21	0	26	26
1971	1/4years	none	9/1-10/5	35	0	70	70
1972	1/4years	none	9/10-10/10	31	0	48	48
1973	1/4years	none	9/10-10/10	31	0	45	45
1974	1/4years	none	9/1-10/10	40	0	72	72
1975	1/4years	none	9/1-10/10	40	0	80	80
1976	1/4years	none	9/1-10/10	40	0	59	59
1977	1/4years	none	9/1-10/10	40	1	40	41
1978	1/4years	none	9/1-10/10	40	2	62	64
1979	1/4years	none	9/1-10/10	40	0	73	73
1980	1/4years	5/10-5/25	9/1-10/31	56	15	69	84
1981	1/4years	5/10-5/25	9/1-10/31	77	24	58	82
1982	1/year*	4/25-5/25	9/1-12/31	153	23	59	82
1983	1/year	1/1-5/31	9/1-12/31	273	36	81	117
1984	1/year	1/1-5/31	9/1-12/31	273	47	77	124
1985	1/year	1/1-5/31	9/1-12/31	273	55	91	146
1986	1/year	1/1-5/31	9/1-12/31	273	45	95	140
1987	1/4years[a]	1/1-5/31	9/1-12/31	273	45	58	103
1988	1/4years	1/1-5/31	9/1-12/31	273	ND	ND	ND

[a] Starting July 1 of year

Table 7. Comparison of population composition in 1979, 1985, and 1987 studies.

	1979			1985			1987		
	Males	Females	Both	Males	Females	Both	Males	Females	Both
Number >2.0	19	15	34	14	17	31	8	10	19
Number >5.0	9	8	17	10	13	23	3	8	12
Mean age (>2.0)	6.4	7	6.6	9.9	10.2	10	4.1	10.0	6.6
Median age (>2.0)	4	5	5	9	7	9	2	7	6
Bears >2.0									
% females			44			55			56
Males/100 females			127			82			80
Bears >5.0									
% females			47			57			73
Males/100 females			113			77			38

[a] Composition is based on bears present in study area at least once during search period.

Table 8. Estimated maximum sustainable brown bear mortality levels (all types of mortality to bears age 2 or older) in GMU 13. Estimates obtained using parameters and assumptions outlined below.

	Modeled % Annual Mortality[a]	Modeled Total No. Dying	ACTUAL GMU 13 1984-1986 mean annual harvests[b]
All bears >2	12.2	100	137
All bears >5	11.7	63	66
Males >2	18	53	73
Females >2	9	47	60
Males >5	18	29	33
Females >5	9	34	33

[a] Mortality of the population in that category, i.e. % of bears older than 2 that are killed each year.

[b] Based on aged and sexed bears only

Input values and assumptions behind estimated GMU 13 maximum sustainable mortality rate.

INPUT VALUES

1. Only one type of mortality ("hunting") occurs in age classes 2-19. A second type of mortality for both males and females ("natural") begins in ages 20-22 (10%), and continues in ages 23 (20%) and >23 (5%). This second mortality is to prevent some bears from living forever.

2. For each sex "hunting" mortality is independent of age and males are twice as vulnerable (18%/year) as females (9%).

3. Reproductive rates are those estimated in GMU 13 Su-Hydro studies (Miller 1987).

4. Sex ratios of 2 year-olds is 50:50 (actual observed sex ratio for yearlings in GMU 13 was 16 males:8 females; for 2-year-olds it was approximately 10 males:8 females) (Miller et al. 1987:121,83)

ASSUMPTIONS

1. Above conditions have existed for long enough to have resulted in a stable age distribution (this exercise was accomplished by adjusting inputted survivorship rates until a stable population [N=821 of age 2+] was achieved and this population composition was used as the inputted initial population).

Table 8. Continued.

2. Harvests are equally distributed throughout the unit (in fact some areas are more heavily hunted than others).

3. Recruitment can be expressed on an annual basis/adult female (this is implicit in the model and will yield a systematic overestimate of recruitment rate in bears and other species with reproductive cycles >1 year [Taylor et al. 1987b]).

Table 9. Estimated sustainable brown bear mortality levels given minimum levels of natural mortality for brown bears in GMU 13.[a]

	Modeled % annual mortality[b]	Modeled total No. shot	ACTUAL GMU 13 1984-1986 mean annual harvests[c]
All bears (N = 180)	5.6	66	137
All bears >2.0 (N = 183)	8.0	66	137
All bears >5.0	7.7	43	66
Males >2.0	11.2	37	73
Females >2.0	5.8	29	60
Males >5.0	11	22	33
Females >5.0	5.8	21	33

[a] Estimates obtained using parameters and assumptions outlined below.
[b] Mortality of the population in that category, i.e. % of bears older than 2 that are killed each year.
[c] Based on aged and sexed bears only.

INPUT VALUES

1. Hunting mortality rates for males (12%) is twice that for females (6%) but is constant for all age classes within a sex.

2. Annual natural mortality rates are constant between sexes but varys by age as follows: Age 2 (6%), 3(5%), 4(4%), 5-16(3%), 17-20(6%), 21-22(10%), 23-24(20%), >24(50%).

3. Reproductive rates are those estimated in GMU 13 Su-Hydro studies (Miller 1987).

4. Sex ratios of 2 year-olds is 50:50.

5. Other assumptions are same as listed under Table 1 but this run stabilized at a population of 830 bears.

Table 10. Mortality rates for cub and yearling brown bears calculated using MICROMORT (Heisey and Fuller 1985).

Category	Mortality rate	95% CI	No. Radio-days survived	No. deaths
Cubs, 1978-1987				
Spring	0.351	0.226-0.457	4875	23
Fall	0.075	0.002-0.143	4706	4
Winter	0.070	0-0.144	7436	3
Annual	0.442	0.312-0.548	17017	30
Cubs in spring				
1978	0.000	---	195	0
1979	0.714	0-0.950	146	2
1980	---	---	---	---
1981	0.227	0-0.459	714	2
1982	0.215	0-0.513	379	1
1983	0.499	0.016-0.747	529	4
1984	0.320	0.008-0.534	952	4
1985	0.369	0-0.626	598	3
1986	0.253	0-0.512	630	2
1987	0.465	0.076-0.691	732	5
Yearlings, 1978-1987				
Spring	0.164	0.460-0.269	3582	7
Fall	0.000	---	3172	0
Winter	0.000	0-0.099	5141	1
Annual	0.193	0.063-0.306	11895	8
Yearlings in spring				
1978-1983	0.322	0.048-0.519	1179	5
1984-1987	0.074	0-0.167	2403	2

Table 11. Summary of Nelchina Basin brown bear litter size data for cubs-of-the-year (based on spring observations of radio-collared bears), 1978-87.

Bear ID (year-age)	Litter Size (Coy) (year)	Comments	Usable summary
207 (1978, 11)	3 (1978)	When last seen on 10/7/78 had all 3 cubs on 5/31/79, had only 1 yearling which stayed with her until last observation on 9/12/79	2 of 3 lost
213 (1978, 10)	2 (1979)	Lost apparent yearling due to 1978 capture, had newborns when transplanted in 1979, lost these 8-16 days after release, bear apparently died in study area after return	none-transplant bias
231 (1979, 13)	3 (1979)	Turgid in 1978, bred, lost 2 of 3 cubs by 6/11/79, survivor lived at least until last observation on 8/3/79 (no exit data in 1980)	2 of 3 lost
206 (1978, 13)	3 (1979)	Lactating female with male in 1978, during last observation prior to shedding collar the cubs were not seen but undergrowth was thick (6/17/79)	none
313 (1981, 10)	1 (1981)	Bear had a 2-year-old offspring in 1980, lost cub (possible capture-related)	1 of 1 lost (capture related?)
313 (1982, 11)	2 (1982)	Both survived	0 of 2 lost
312 (1981, 11)	2 (1981)	Had a 2-year-old in 1980, lost 1 cub by 6/18, other weaned in 1983	1 of 2 lost
312 (1984, 14)	3 (1984)	Capture-related losses (collared)	none
283 (1981, 13)	2 (1981)	Weaned 2@2 in 1980, lost 1 cub by 9/1 other lost as yearling	1 of 2 lost

Table 11. Continued.

Bear ID (year-age)	Litter Size (Coy) (year)	Comments	Usable summary
283 (1983, 15)	1 (1983)	Killed by brown bear by 5/17/83, cub was collared	1 of 1 lost
283 (1985, 17)	2 (1985)	Both survived to den exit	0 of 2 lost
337 (1981, 13)	3 (1981)	Cubs and female reunited, 1 cub lost in 81/82 den, other 2 survived to exit (1 weaned in 1983, other lost as yearling)	1 of 3 lost
337 (1984,16)	2 (1984)	Both survived to den exit, collared cubs	0 of 2 lost
344 (1981, 5)	2 (1981)	Both lost in '82 as yearlings	0 of 2 lost
344 (1983, 7)	2 (1983)	Lost 1 in early July - other survived to den exit	1 of 2 lost
379 (1982, 5)	2 (1982)	Both survived	0 of 2 lost
341 (1982, 7)	2 (1982)	Survived until 7/15/82 when bear was lost	none
341 (1986, 11)	1 (1986)	Survived	0 of 1 lost
299 (1982, 15)	1 (1982)	Bear weaned 2@2 in 1981, cub lost by 6/9/62	1 of 1 lost
299 (1983, 16)	3 (1983)	All cubs collared, alive to den exit	0 of 3 lost
281 (1983, 6)	2 (1983)	Both killed by brown bear by 6/1/83, cubs collared	2 of 2 lost
281 (1984, 7)	2 (1984)	Lost both in May, 1 suspected killed by brown bear, other unknown (accidental drowning?), collared cubs	2 of 2 lost

Table 11. Continued.

Bear ID (year-age)	Litter Size (Coy) (year)	Comments	Usable summary
281 (1985, 8)	2 (1985)	Lost 1 in June, other survived	1 of 2 lost
394 (1983, 6)	1 (1983)	Lost (capture related?) by 5/16, bred	1 of 1 lost (capture related?)
403 (1983, 6)	2 (1983)	Lost 1 in Sept., other ok to den exit	1 of 2 lost
403 (1986, 9)	3 (1986)	2 survived to exit	1 of 3 lost
384 (1984, 13)	2 (1984)	Survived to September at least	0 of 2 lost
396 (1984, 14)	1 (1984)	Lost in May	1 of 1 lost
335 (1984, 6)	2 (1984)	Both survived to den exit	0 of 2 lost
340 (1984, 6)	2 (1984)	Both survived to den exit, collared cubs	0 of 2 lost
340 (1987, 9)	3 (1987)	Lost all in early summer	3 of 3 lost
388 (1984, 15)	2 (1984)	Capture-related losses (collared)	none
388 (1985, 16)	2 (1985)	Survived to den exit	0 of 2 lost
423 (1984, 21)	4 (1984)	One died in July (collared), others ok to den exit	1 of 4 lost
423 (1987, 24)	1 (1987)	Lost in early summer	1 of 1 lost
381 (1985, 6)	2 (1985)	Survived to exit	0 of 2 lost
396 (1985, 16)	2 (1985)	Lost in June	2 of 2 lost
425 (1985, A)	2 (1985)	Survived	0 of 2 lost

Table 11. Continued.

Bear ID (year-age)	Litter Size (Coy) (year)	Comments	Usable summary
447 (1986, 8)	2 (1986)	Lost contact (shed collar)	none
420 (1986, 21)	2 (1986)	Both lost in mid-summer	2 of 2 lost
273 (1987, 11)	3 (1987)	Survived to September at least	0 of 3 lost so far
314 (1987, 9)	3 (1987)	Lost 1 in late summer	1 of 3 lost, at least
453 (1986, 4)	2 (1986)	Both survived to exit	0 of 2 lost
454 (1987, 5)	2 (1987)	Unknown survival (shed collar)	none
456 (1986, 6)	2 (1986)	Cubs lost in den?	2 of 2 lost
458 (1987, 18)	1 (1987)	Lost in mid-summer	1 of 1 lost
460 (1986, 7)	2 (1986)	1 lost due to capture	none
461 (1986, 5)	1 (1986)	Lost due to capture	none
461 (1987, 6)	2 (1987)	1 lost in mid-summer	1 of 2 lost, at least
462 (1987, 8)	2 (1987)	Survived to September at least	0 of 2 lost so far

Summary

No. of cubs	No. of litters	mean litter size (range)	
103	50	2.1 (1-4)	34 of 84 cubs lost in first year of life = 40.5% (2 of these possibly capture-related)

Table 12. Summary of Nelchina Basin brown bear litter size data for litters of yearlings (based on spring observation of radio-collared bears), 1978-1987.

BEAR ID (year-age)	Litter size (yearlings) (year)	Comments	Summary
220 (1978, 5)	1 (1978)	Yearling entered den and was weaned in 1979, bred	0 of 1 lost
221 (1978, 8)	2 (1978)	Survived, weaned in 1979	0 of 2 lost
234 (1978, 5)	2(1978)	Paxson dump bear, lost apparent yearlings between 6/23/78 and 8/4/78, reportedly had cubs in August 1979, radio failed	none
240 (1979, 5)	2 (1979)	Bear transplanted with yearlings, not known if yearlings, survived to return to study area, bear was alone on 7/18/80	none
244 (1979, 6)	1 (1979)	Thin female transplanted with yearling, yearling survived at least 21 days, female bred, but alone in July and August 1980	none-transplant bias
251 (1979, 10)	2 (1979)	Very large yearlings lost 10-17 days after transplant, bear had no cubs in 1980 (August)	none-transplant bias
254 (1979, 9)	2 (1979)	Female died after transplant (yearlings??)	none
261 (1979, 7)	2 (1979)	Lost 1 yearling between 1 and 7 days after transplant, other survived at least until Sept., didn't return to study area	none-transplant bias
269 (1979, 16)	2 (1979)	Transplanted, returned to study area with female, no cubs on 9/29/80, shot in fall 1981 reportedly without cubs	none, transplant bias

Table 12. Continued.

BEAR ID (year-age)	Litter size (yearlings) (year)	Comments	Summary
274 (1979, 11)	1 (1979)	Transplanted, no radio	none
207 (1978, 11)	1 (1979)	Survived until 9/12/79	0 of 1 lost
231 (1978,12)	1 (1979)	Survived until 8/79	none
213 (1978, 10)	1 (1978)	Apparent yearling was not captured, had cubs following year	1 of 1 lost (capture related?)
277 (1980, 10)	2 (1980)	Yearlings visually aged, not captured, survived to enter den, no exit data as bear shed collar in den	0 of 2 lost
299 (1980, 13)	2 (1980)	Both survived, weaned next year	0 of 2 lost
299 (1984, 17)	3 (1984)	Survived with internals to exit from den	0 of 3 lost
312 (1982, 12)	1 (1982)	Survived, weaned next year	0 of 1 lost
281 (1986, 9)	1 (1986)	Survived, weaned next year	0 of 1 lost
283 (1982, 14)	1 (1982)	Lost by 5/18/82	1 of 1 lost
283 (1986, 18)	2 (1986)	Survived, weaned next year	0 of 2 lost
337 (1982, 14)	2 (1982)	Lost 1 by 6/17/82, other survived	1 of 2 lost
337 (1985, 17)	2 (1985)	Survived to den exit	0 of 2 lost
380 (1982, 15)	2 (1982)	Both survived to den entrance, at least 1 exited den and was weaned	0 of 2 lost

Table 12. Continued.

Bear ID (year-age)	Litter size (yearlings) (year)	Comments	Summary
344 (1982, 6)	2 (1982)	Lost 1 by 6/17, other by 7/26/82	2 of 2 lost
344 (1984, 8)	1 (1984)	Lost 1 in May, sibling lost year before	1 of 1 lost
313 (1983, 12)	2 (1983)	Lost 1 (surgery related?) by 6/2/83, other survived thru October	0 of 1 lost
379 (1983, 6)	2 (1983)	Lost 1 in June-September period	1 of 2 lost
420 (1984, 19)	2 (1984)	Survived to den exit	0 of 2 lost
314 (1985, 7)	1 (1985)	Survived to den exit	0 of 1 lost
335 (1985, 7)	2 (1985)	1 lost in June, other survived to exit	1 of 2 lost
340 (1985, 7)	2 (1985)	Survived to October at least	0 of 2 lost (?)
381 (1986, 7)	2 (1986)	Survived, weaned next year	0 of 2 lost
388 (1986, 17)	2 (1986)	Survived, weaned next year	0 of 2 lost
403 (1984, 7)	1 (1984)	Survived thru November at least	0 of 1 lost
403 (1984, 10)	2 (1987)	--	--
423 (1985, 22)	3 (1985)	All survived to den exit	0 of 3 lost
425 (1986, A)	2 (1986)	Both lost in mid-summer - possibly capture related. Not seen until 6 weeks following capture.	none

Table 12. Continued.

Bear ID (year-age)	Litter size (yearlings) (year)	Comments	Summary
341 (1987, 12)	1 (1987)	--	--
453 (1987, 5)	2 (1987)	Survived until September at least	--
460 (1987, 8)	1 (1987)	Survived until September at least	--
469 (1987, A)	2 (1987)	Survived until mid-summer at least	--
472 (1987, A)	1 (1987)	Collar removed, lost contact	none
478 (1987, A)	2 (1987)	--	--
481 (1987, A)	3 (1987)	--	--
482 (1987, A)	3 (1987)	Collar removed, lost contact	none

Summary

No. of yearlings	No. litters	Mean litter size (range)	
79	45	1.8 (1-3)	8 of 44 lost = 18.2% (1 loss possibly capture-related)

Table 13. Summary of Nelchina Basin brown bear litter size data for litters of 2-year-olds (based on observations of radio-collared bears).

Bear ID (year-age)	2-year-old litter size (year)	Comments
204 (1978, 7)	2 (1978)	weaned by 6/19/78, bred
281 (1987, 10)	1 (1987)	weaned by 6/5
283 (1980, 12)	2 (1980)	weaned in mid-June, bred, new litter next year
283 (1987), 19)	2 (1987)	still with mother on 9/24/87
312 (1980, 10)	1 (1980)	weaned right after capture in May, new litter in 1981
312 (1983, 13)	1 (1983)	weaned by 6/13, bred
313 (1980, 9)	1 (1980)	weaned by May, bred, new litter in 1981
313 (1984, 13)	1 (1984)	weaned in May, bred
220 (1978, 5)	1 (1979)	weaned by 6/17, bred
221 (1978, 8)	2 (1979)	--
269 (1979, 16)	2? (1980)	--
299 (1980, 13)	2 (1981)	weaned in 5/81, new litter in 1982
337 (1983, 15)	1 (1983)	weaned by 5/15, bred
337 (1986, 18)	2 (1986)	still with mother in 86/87 den
381 (1987,8)	2 (1987)	exited den with mother @ age 3
384 (1983, 12)	3 (1983)	weaned by 6/13, one of these 3 may not have been part of this litter, bred
388 (1983, 14)	2 (1983)	weaned by 6/13, bred
388 (1987, 18)	2 (1987)	weaned by 6/23
396 (1983, 13)	2 (1983)	weaned by 6/1, bred
331 (1981, 6)	2 (1981)	weaned by 6/15, bred, no cubs in 1982, died in 1982 (reason?)

Table 13. Continued.

Bear ID (year-age)	2-year-old litter size (year)	Comments
379 (1984, 7)	1 (1984)	apparently weaned cub (time?), bred
314 (1986, 8)	1 (1986)	bear lost in May '86
420 (1985, 20)	2 (1985)	weaned in May
423 (1985, 23)	3 (1986)	3 @ 2 in June 1986

Summary

No. of 2-year-olds	No. of litters	Mean litter size (range)
41	24	1.7 (1-3)

Table 14A. Brown bear offspring survivorship and weaning, GMU 13 studies (excludes bears transplanted in 1979).

Year	Mother's ID (age in year when first captured) G207 (11 in 1978)	G220 (5 in 1978)	G221 (8 in 1978)	G204 (7 in 1978)	G321 (12 in 1978)
1978	3 cubs, April-Oct.	1 yearling, May-Oct.	2 yearlings, May-Oct.	2 @ 2 in May, weaned in June and bred	bred
1979	1 yearling, May-Sept. 2 yearlings, lost in 78/79 den?	1 @ 2, weaned in June	2 @ 2 weaned	no data in May, radio failure	2 of 3 cubs lost in June, 1 survived April-Sept.
1980	no data	no data	no data	no data	no data

Year	G331 (6 in 1981)	G334 (10 in 1981)	G341 (6 in 1981)	G337 (13 in 1981)	G344 (5 in 1981)	G335 (3 in 1981)	G340 (3 in 1981)
1981	2 @ 2 weaned in May, bred	weaned 1 @ 2 in May, bred, bear missing since Sept.	alone, bred in May	lost 1 @ 0 in winter den, 2 survived	2 @ 0 survived	weaned from mother	alone
1982	no cubs, bred, died in July (reason?)	no data	had 2 @ 0 thru July, bear missing subsequently	lost 1 @ 1 in June, other survived	lost 1 @ 1 in May, lost other in early July	alone, bred	alone
1983	--	no data	no data	weaned 1 @ 2 in May, bred	2 @ 0, lost 1 by late June, other survived	alone, bred	alone
1984	--	no data	no data	w/2 @ 0, collared, both survived	1 @ 1 lost in May, bear lost in July	w/2 @ 0 thru Oct.	w/2 @ 0, survived
1985	--	no data	alone	w/2 @ 1, survived	--	2 @ 1, lost in June	2 @ 1, survived to den entrance

Table 14A. Continued.

Year	Mother's ID (age in year when first captured)						
	G331 (6 in 1981)	G334 (10 in 1981)	G341 (6 in 1981)	G337 (13 in 1981)	G344 (5 in 1981)	G335 (3 in 1981)	G340 (3 in 1981)
1986	--	no data	w/1 @ 0	w/2 @ 2	--	1 @ 2 weaned	alone, assume weaned young
1987 (to Sept.)			w/1 @ 1	2 @ 3, weaned		alone, bred	3 @ 0, all lost early in summer, bred

Year	G380 (15 in 1982)	G394 (6 in 1983)	G384 (12 in 1983)	G379 (5 in 1982)	G388 (14 in 1983)	G381 (3 in 1982)
1982	2 @ 1 survived until denning, one may have died in den	no data	no data	2 @ 0 survived	no data	alone
1983	at least 1 @ 2 weaned in May, possibly both shot in Sept.	lost 1 @ 0 in May (?capture-related possible?), bred	weaned 2 or 3 @ 2 in June, bred	1 of 2 survived, lost 2 (June-Sept.)	weaned 2 @ 2	alone, bred
1984	--	alone, shot	w/2 @ 0 thru Sept., missing	probably weaned 1 @ 2 after May 23	w/2 @ 0, capture-related cub loss, bred	alone, bred
1985	--	--	--	alone, shot	w/2 @ 0, survived	w/2 c, survived
1986	--	--	--	--	w/2 @ 1, survived	w/2 @ 1, survived
1987 (to Sept.)					w/2 @ 2, weaned	w/2 @ 2, weaned

Table 14A. Continued.

Year	G396 (13 in 1985)	G403 (6 in 1983)	G407 (4 in 1983)	G420 (19 in 1984)	G423 (20 in 1984)	G425 (14 in 1984)	273 (3 in 1979)	314 (7 in 1985)
	Mother's ID (age in year when first captured							
1983	weaned 2 @ 2 in May, bred	2 @ 0 thru Aug., lost 1 in Sept.	alone	no data	no data	no data	--	--
1984	lost litter of 1 @ 0 in May, breeding?	w/1 @ 1, lost after April	alone	w/2 @ 1, survived	4 @ 0, one lost in July, others survived to Oct.	alone, bred	--	--
1985	2 @ 0 lost in	?	alone	weaned 2 in June	3 @ 1 survived	w/2 cubs, survived	alone	1 @ 1 survived
1986	alone, bred	w/3 @ 0	alone	w/2 @ 0, both lost in June	3 @ 2 weaned in May	w/2 @ 1, lost in June-July	alone	1 @ 2 weaned in May-June
1987	alone, bred	w/2 @ 1	alone, bred	no data	w/1 @ 0, lost in early summer	alone, bred	w/3 @ 0	3 @ 0, 1 lost in mid-summer

Year	447 (7 in 1985)	453 (A in 1986)	454 (A in 1986)	456 (A in 1986)	458 (A in 1986)	460 (A in 1986)
1985	alone, bred	--	--	--	--	--
1986	w/2 @ 0, shot	w/2 @ 0	alone, bred	w/2 @ 0	alone, bred	w/2 @ 0, 1 lost
1987 (to Sept.)	--	w/2 @ 1	w/2 @ 0	alone, shot 5/23	w/1 @ 0, lost in mid-summer	w/1 @ 1

Table 14A. Continued.

Year	Mother's ID (age in year when first captured)					
	461 (7 in 1985)	462 (A in 1986)	469 (A in 1986)	472 (A in 1986)	478 (A in 1986)	481 (A in 1986)
1986	w/1 @ 0, lost, capture-related?	w/1 @ 1, weaned	--	--	--	--
1987 (to Sept.)	w/2 @ 0, 1 lost in mid-summer	w/2 @ 0	w/2 @ 1	w/1 @ 1, weaned	w/2 @ 1	w/3 @ 1

Year	482 (A in 1987)
1987 (to Sept.)	w/3 @ 1

Table 14B. Age at first reproduction for GMU 13 (Su-hydro area) brown bears.

	Age						
ID No.	3	4	5	6	7	8	9
202	?	?	?	?	?	adult	adult
204	?	?	cubs	adult	adult	adult	adult
209	?	open	open[c]	open	?	?	?
215	open	open	?	?	?	?	?
219	?	open	?	?	?	?	?
220	?	cubs	adult	adult	adult	adult	adult
221	?	?	?	?	adult	adult	adult
234	?	cubs	adult	adult	adult	adult	adult
240	?	cubs	adult	adult	adult	adult	adult
244	?	?	cubs	adult	adult	adult	adult
248	?	open	?	?	?	?	?
261	?	?	?	adult	adult	adult	adult
264	?	open	?	?	?	?	?
267	?	open	?	?	?	?	?
273	open	?	?	?	?	?	?
277	?	?	?	?	?	?	adult
281	open	open	open	adult	adult	adult	adult
306	open	?	?	?	?	?	?
312	?	?	?	?	?	adult	adult
313	?	?	?	?	adult	adult	adult
314	?	?	?	adult	adult	adult	adult
315	open	?	open	open	?	?	?
331	?	cubs	adult	adult	adult	adult	adult
334	?	?	?	?	?	adult	adult
335	open	open	open	cubs	adult	adult	adult
340	open	open	open	cubs	adult	adult	adult
341	?	?	?	open[c]	adult	adult	adult
344	?	?	cubs	adult	adult	adult	adult
379	?	?	cubs	adult	adult	adult	adult
381	open	open	open	adult	adult	adult	adult
385	open	open	?	?	?	?	?
394	?	?	?	adult	adult	adult	adult
395	open	?	?	?	?	?	?
397	?	open	?	?	?	?	?
398	?	open	open	?	?	?	?
403	?	?	?	adult	adult	adult	adult
407	?	open	open	open	open	open	cubs?
447	?	?	?	?	open[c]	adult	adult
453	?	cubs	adult	adult	adult	adult	adult
454	?	?	cubs	adult	adult	adult	adult
456	?	?	?	cubs	adult	adult	adult
460	?	?	?	?	cubs	adult	adult

Table 14B. Continued.

ID No.	Age 3	4	5	6	7	8	9
461	?	?	cubs	adult	adult	adult	adult
462	?	?	?	cubs	adult	adult	adult
465	open	open	?	?	?	?	?
469	?	?	cubs	adult	adult	adult	adult
478	?	?	?	?	?	adult	adult
482	?	?	?	cubs	adult	adult	adult

[a] The following calculations exclude all question marks.

AGE	3	4	5	6	7	8	9
# sub-adults	11	15	8	3	1	1	0
# 1st litters	0	5	7	6	1	0	1
# ^{2}1st litters	0	0	5	17	26	32	33
% "adult"	0.0	25.0	60.0	88.5	96.4	97.0	100.0

Mean age of first litter = 5.35 years

The following calculations correct for missing data by assuming litters were produced the following year for bears that died prematurely (when ^{2}5.4).

AGE	3	4	5	6	7	8	9
# sub-adults	11	15	8	3	1	1	0
# 1st litters	0	5	7	7	3	0	1
# ^{2}1st litters	0	0	5	17	26	32	33
% "adult"	0.0	25.0	60.0	88.9	96.7	97.0	100.0

Mean age of first litter = 5.35 years

[b] adult means first litter was at indicated age or younger.

[c] open means had no litter but not considered a subadult as could have had a previous, unobserved litter.

Table 15. Summary of known losses from brown bear litters of cubs and yearlings.

Year of emergence	Losses of cubs	Losses of yearlings
1978	2 of 3 lost (G207)[b]	0 of 3 lost (G221, G220)
1979	2 of 3 lost (231)[c]	0 of 1 lost (G207)[d]
1980	no data	0 of 4 lost (G299, G277)[e]
1981	4[f] of 10 lost (G312, G313, G283, G337, G344)	no data
1982	1[g] of 5 lost (G299, G313, G379)	4 of 8 lost (G312, G283, G337, G344, G380)[h]
1983	6[i] of 11 lost (G283, G344, G299, G281, G394, G403)	2 of 4 lost (G379, G313)[j]
1984	4 of 15 lost (281, 337, 335, 340, 384[k], 396, 423)	1 of 7 lost (299, 344, 403[l], and 420)
1985	3 of 12 lost (283, 281, 381, 396 425, 388)	1 of 10 lost (314, 335, 340[l], 423, 337)
1986	4 of 13 lost (341, 447[l], 420, 403, 453, 456, 460)	2 of 10 lost (281, 381, 388, 283, 425, 462)
1987 (incomplete data)	7 of 15 lost (273, 314, 340, 423, 458, 461, 462)	0 of 14 lost (341, 403, 453, 460, 469, 478, 481)
Totals	33 of 87 lost = 38%	10 of 61 lost = 16%
Excluding possible capture-related deaths and incomplete data:	22 of 61 lost = 36%	9 of 40 lost = 23%

[a] Losses dated from emergence in year indicated to emergence the following year.

[b] IDs of females included are indicated in parentheses.

[c] Last observation on 8/3/79.

[d] Last observation on 9/12/79.

Table 15. Continued.

[e] G277 shed collar in den so family status in spring 1981 was not determined, assumed 2 off-spring were alive at emergence in 1981.

[f] One lost cub may have been capture-related (from litter of 1 with G313).

[g] From litter of one with G299 (bears not handled).

[h] G380 had 2 yearlings thru den entrance in 1982, only one was verified with her in spring 1983, but both were counted as surviving.

[i] One lost cub may have been capture-related (from litter of 1 with G394).

[j] One of G313's yearlings died within 1 month of surgery to install internal transmitter (other survived); assumed this death was not surgery-related.

[k] Last observation on 9/6/84.

[l] Last observation in Sept.-October.

Table 16. Morphometrics of brown bear cubs-of-the-year handled in GMU 13, 1978-1986.

Cub ID	Mother's ID	Date handled	Sex	Wt(lbs)	Comments
001	G213	22 May 1979	M	10.0	transplanted, see Spraker
002	G213	22 May 1979	M	10.0	et al. (1981)
--	G207	27 May 1978	M	12.0	see Spraker, et al. (1981)
--	G207	27 May 1978	F	12.0	
G338	G283	6 May 1981	M	12.0	ear tagged
G339	G283	6 May 1981	F	13.0	ear tagged
G336	G313	6 May 1981	F	--	cub abandoned?, ear tagged
003	G283	14 May 1983	F	--	collared
004	G394	15 May 1983	F	10.0	neck=230mm, ear tagged
005	G281	15 May 1983	M	8.5	collared
006	G281	15 May 1983	F	8.3	collared
418	G299	18 May 1983 (den)	M	over 10.0	neck=225mm, collared
419	G299	18 May 1983 (den)	M	over 10.0	neck=245mm, collared
417	G299	18 May 1983 (den)	M	over 10.0	neck=225mm, collared
016	G388	16 May 1984	M	13.5	collared, 13.5 lbs (5/29/84)
017	G388	16 May 1984	F	-	collared
021	G281	17 May 1984	M	14.0	collared, neck = 250mm
022	G281	17 May 1984	M	13.5	collared
008	G337	17 May 1984	F	12.3	collared, neck = 220
009	G337	17 May 1984	F	11.5	collared, neck = 230
023	G340	17 May 1984	?	16.5	collared
024	G340	17 May 1984	?	14.0	collared
025	G423	18 May 1984	M	7.0	collared, smallest of 4 in litter
---	G423	18 May 1984	F	-	not collared
018	G312	16 May 1984	F	17.0	collared
019	G312	16 May 1984	M	16.0	collared
020	G312	16 May 1984	M	17.0	collared

Table 16. Continued.

Cub ID	Mother's ID	Date handled	Sex	Wt(lbs)	Comments
---	G453	3 June 1986	F	15.0	ear tagged
---	G453	3 June 1986	F	17.0	ear tagged
---	G456	4 June 1986	M	33.0	ear tagged
---	G460	4 June 1986	M	30.0	capture mortality
---	G460	4 June 1986	F	30.0	ear tagged
---	G461	5 June 1986	M	26.0	ear tagged
---	G273	5 June 1987	F	16.0	ear tagged
---	G273	5 June 1987	M	18.0	ear tagged

Totals: 18 males and 15 females

Table 17. Morphometrics of brown bear yearlings handled in GMU 13, 1978-1986.

Yrlg ID	Mother's ID	Date handled	Sex	Wt(lbs)	Comments
G232	G234	23 June 1978	F	100(est.)	Spraker, et al. (1981)
G235	G234	23 June 1978	F	100(est.)	
G238	G240	23 May 1979	M	95	transplanted, see
G239	G240	23 May 1979	F	65	Ballard et al. 1980
G245	G244	24 May 1979	F	46	transplanted, op cit.
G252	G251	27 May 1979	M	134	transplanted, op cit.
G253	G251	27 May 1979	M	139	
G256	G254	27 May 1979	M	47	transplanted, op cit.
G257	G254	27 May 1979	M	47	
G262	G261	2 June 1979	M	90	transplanted, op cit.
G263	G261	2 June 1979	M	87	
G270	G269	6 June 1979	F	100	transplanted, op cit.
G271	G269	6 June 1979	F	95	
G275	G274	7 June 1979	M	68	transplanted, op cit.
G297	G399	4 May 1980	M	65	tagged
G298	G399	4 May 1980	M	65	tagged
G382	G313	14 May 1983	M	66	implant transmitter
G383	G313	14 May 1983	F	53	implant transmitter, died
G417	G299	15 May 1984	M	94	implant transmitter (small)
G418	G299	15 May 1984	M	86	implant transmitter (large)
G419	G299	15 May 1984	M	84	implant transmitter (small)
G421	G420	17 May 1984	M	78	sibling not captured, large implant and breakaway.
G429	G314	1 June 1985	F	104	breakaway collar, shot Sep. 86
G463	G462	5 June 1986	M	90(est.)	ear tagged
G468	G453	30 May 1987	F	70(est.)	glue on radio
G475	G472	31 May 1987	M	75(est.)	glue on radio

Totals: 17 males and 9 females

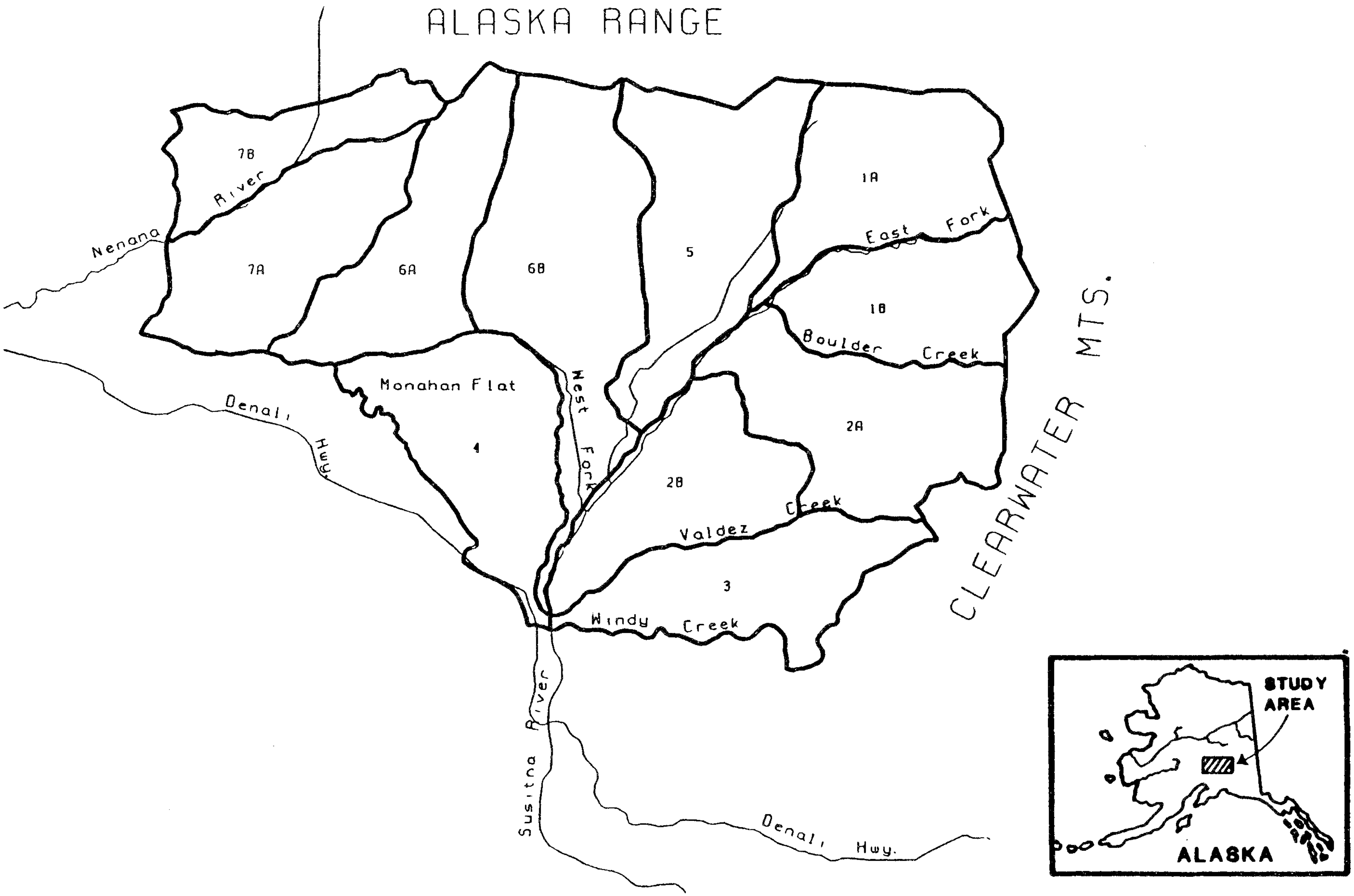
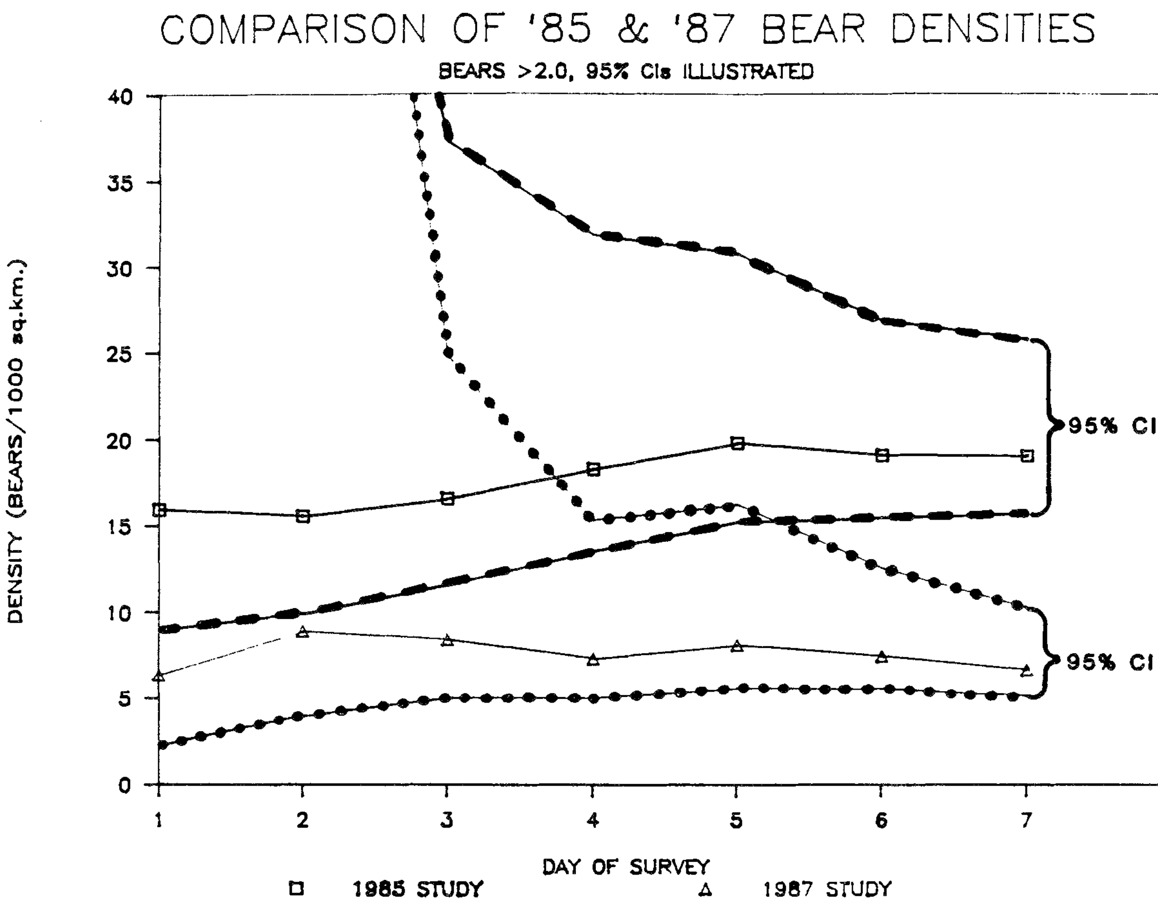


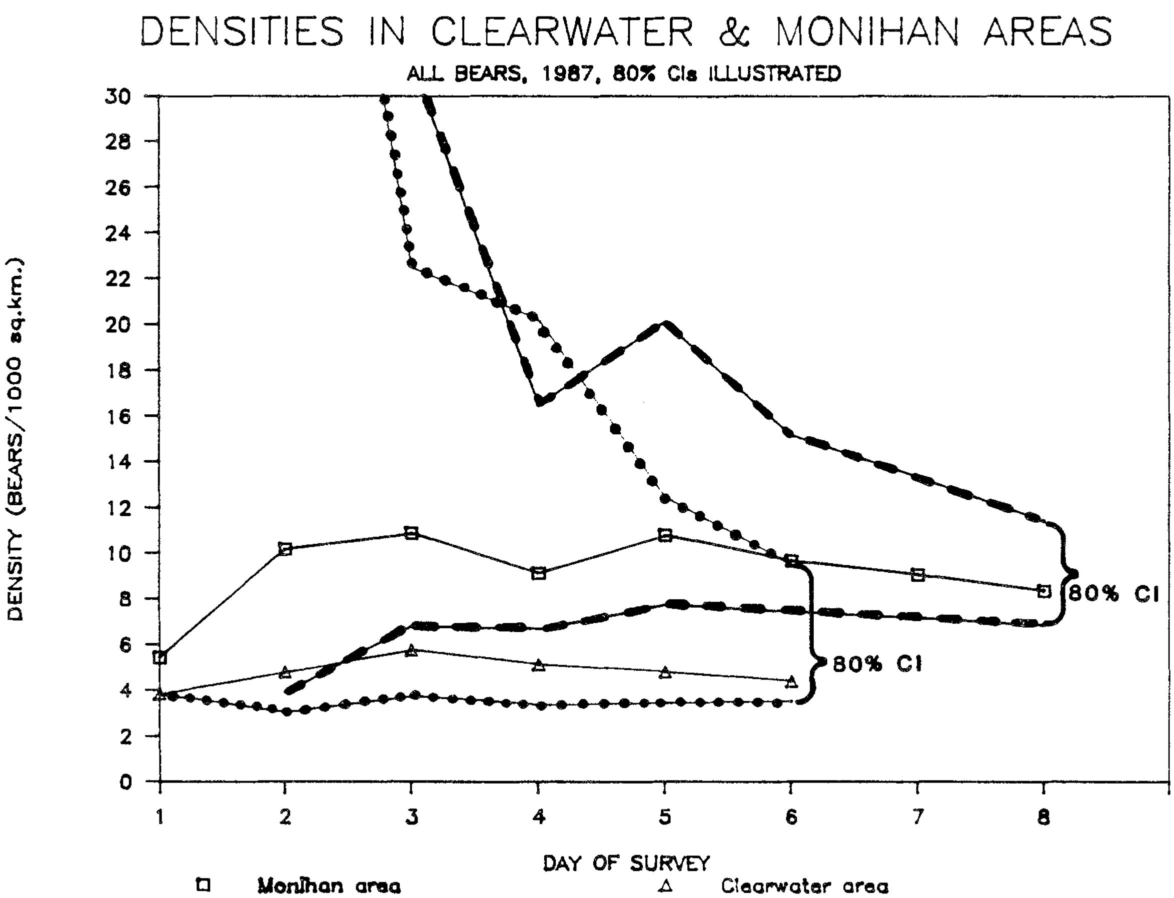
Figure 1. Search area and quadrats used in 1987 to estimate brown bear density in the upper Susitna River study area. Map Scale 1: 339011

Figure 2. Comparison of density estimates obtained in 1985 (Susitna Hydroelectric Project) and 1987 (Upper Susitna River) study areas. Based on bears older than 2.0 years, 95% CI illustrated. [Compare.wk1, comp95.pic].

Figure 3. Comparison of density estimates obtained separately for the Clearwater and Monihan portions of the 1987 upper Susitna River study area. Bears of all ages are included, 80% CI illustrated. [2areaold.wk1, 2areaold.pic].



COMPARISON OF '85 & '87 BEAR DENSITIES
BEARS >2.0, 95% CIs ILLUSTRATED
DENSITY (BEARS/1000 sq.km.)
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
95% CI
95% CI
DAY OF SURVEY
1985 STUDY
1987 STUDY



DENSITIES IN CLEARWATER & MONIHAN AREAS
ALL BEARS, 1987, 80% CIs ILLUSTRATED
DENSITY (BEARS/1000 sq.km.)
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
80% CI
80% CI
DAY OF SURVEY
Monihan area
Clearwater area

Figure 4. Comparison of density estimates obtained in the upper Susitna area prior to the initiation of season liberalizations in 1979 adjusted to same units as other estimates), in the same area in 1987, and in the more lightly hunted Susitna hydroelectric project area in 1985. Only bears older than 2.0 years are included, 95% CI is illustrated. The 1985 and 1987 estimates were obtained using the technique of Miller et al. 1987. The 1979 estimate was obtained using less precise capture-recapture procedures (Miller and Ballard 1982). [Compare.wk1, 3areas2.pic)].

COMPARISON OF GMU 13 BR. BEAR DENSITIES

INCLUDES BEAR >2.0, 95% CIs ILLUSTRATED

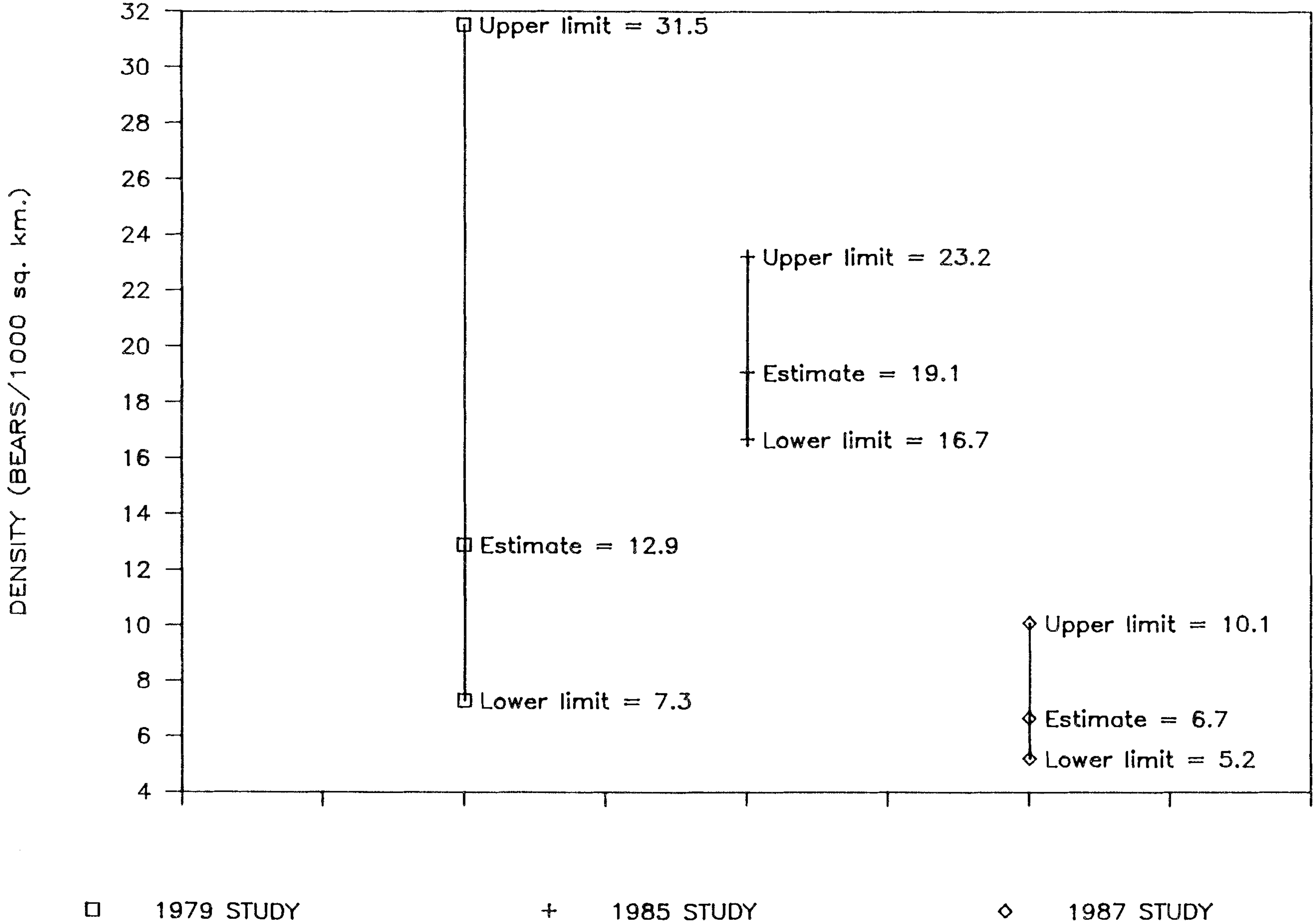
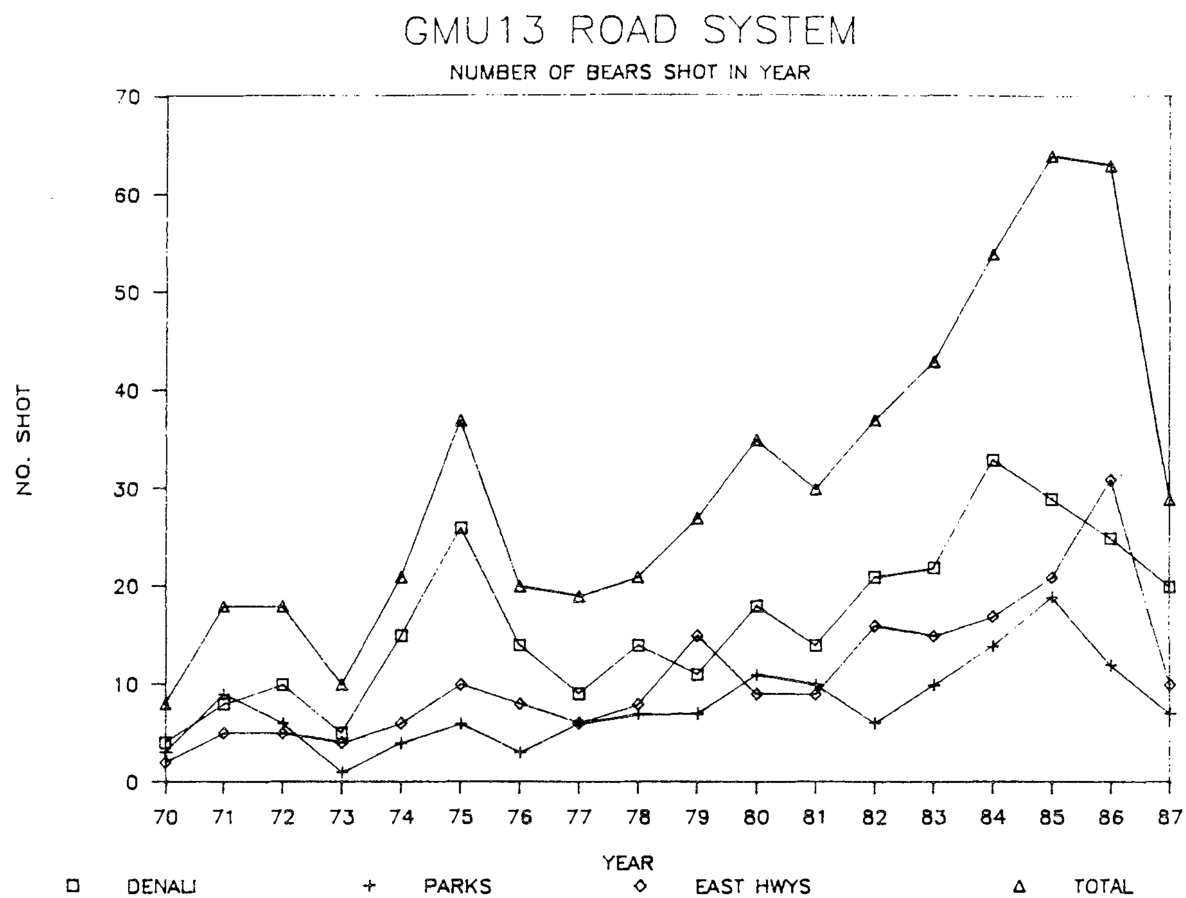


Figure 5. Trends in brown bear harvests in different portions of the road system in Game Management Unit 13. 1970-1987. [Where1.pic].

Figure 6. Trends in brown bear harvests in different portions of Game Management Unit 13 not accessible by roads, 1970-1987. [Where2.pic].


GMU13 ROAD SYSTEM
NUMBER OF BEARS SHOT IN YEAR
NO. SHOT
0
10
20
30
40
50
60
70
70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87
YEAR
DENALI
PARKS
EAST HWYS
TOTAL

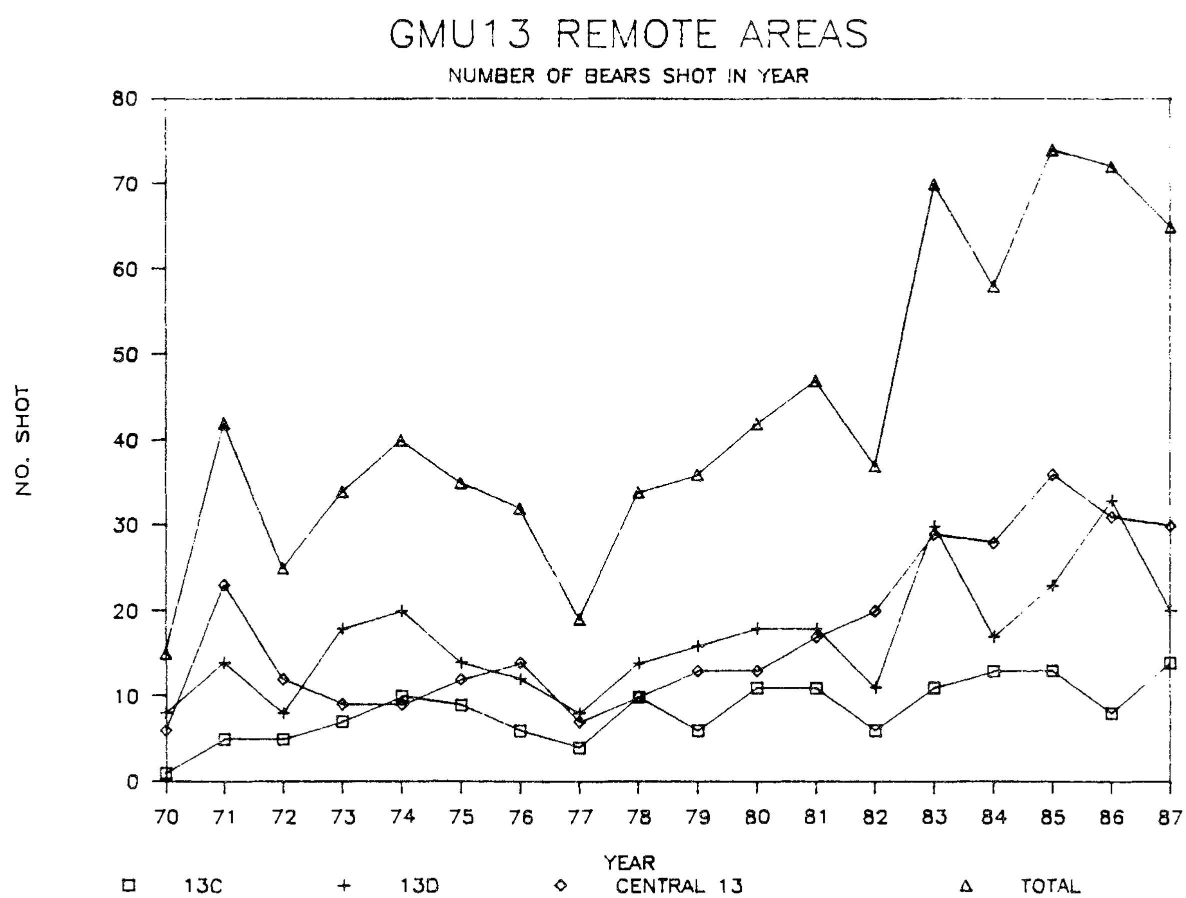
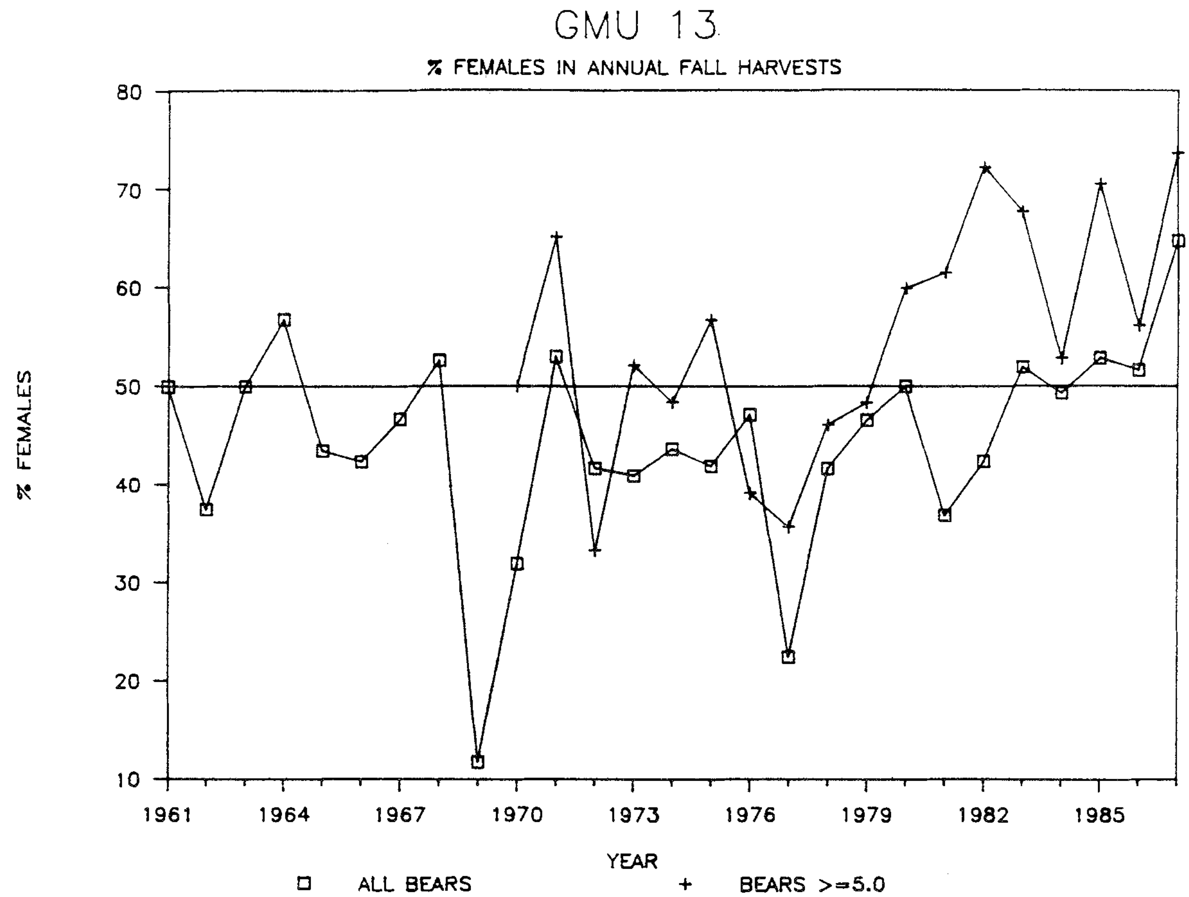

GMU13 REMOTE AREAS
NUMBER OF BEARS SHOT IN YEAR
NO. SHOT
0
10
20
30
40
50
60
70
80
70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87
YEAR
13C
13D
CENTRAL 13
TOTAL

Figure 7. Trends in percent females in fall harvests of brown bears in GMU 13. All bears and just bears older than 5.0 years are both illustrated.

Figure 8. Trends in percent females (3 most recent years data lumped together) in fall harvests of brown bears in GMU 13. All bears and just bears older than 5.0 years are both illustrated. [%S_A.pic].


GMU 13
% FEMALES IN ANNUAL FALL HARVESTS
% FEMALES
YEAR
ALL BEARS
BEARS >=5.0
80
70
60
50
40
30
20
10
1961
1964
1967
1970
1973
1976
1979
1982
1985

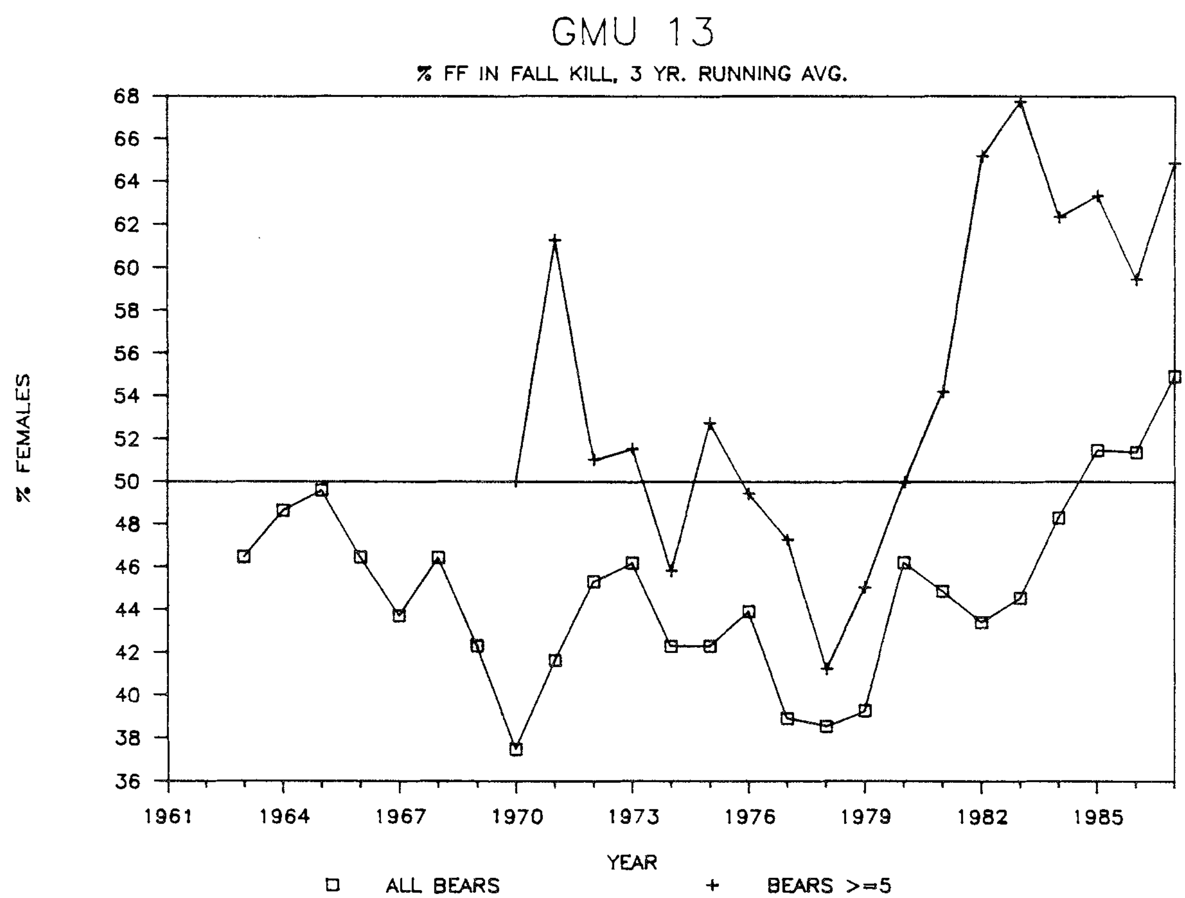

GMU 13
% FF IN FALL KILL, 3 YR. RUNNING AVG.
% FEMALES
YEAR
ALL BEARS
BEARS >=5
68
66
64
62
60
58
56
54
52
50
48
46
44
42
40
38
36
1961
1964
1967
1970
1973
1976
1979
1982
1985

Figure 9. Trends in mean age of male brown bears killed in GMU 13 during 1980-1987. Regressions are fitted to values for bears of all ages (r-0.77) and for bears older than 5.0 years (r= 0.07). [Yrmales.pic].

Figure 10. Trends in mean age of female brown bears killed in GMU 13 during 1980-1987. Regressions are fitted to values for bears of all ages (r-0.23) and for bears older than 5.0 years (r= 0.09). [Yrff.pic].


MEAN AGE IN BROWN BEAR KILL, GMU 13
MALES IN YEAR, r=0.77(ALL), 0.07(>5)
MEAN AGE
12
11
10
9
8
7
6
5
4
80
81
82
83
84
85
86
87
YEAR
ALL AGES
BEARS > 5.0

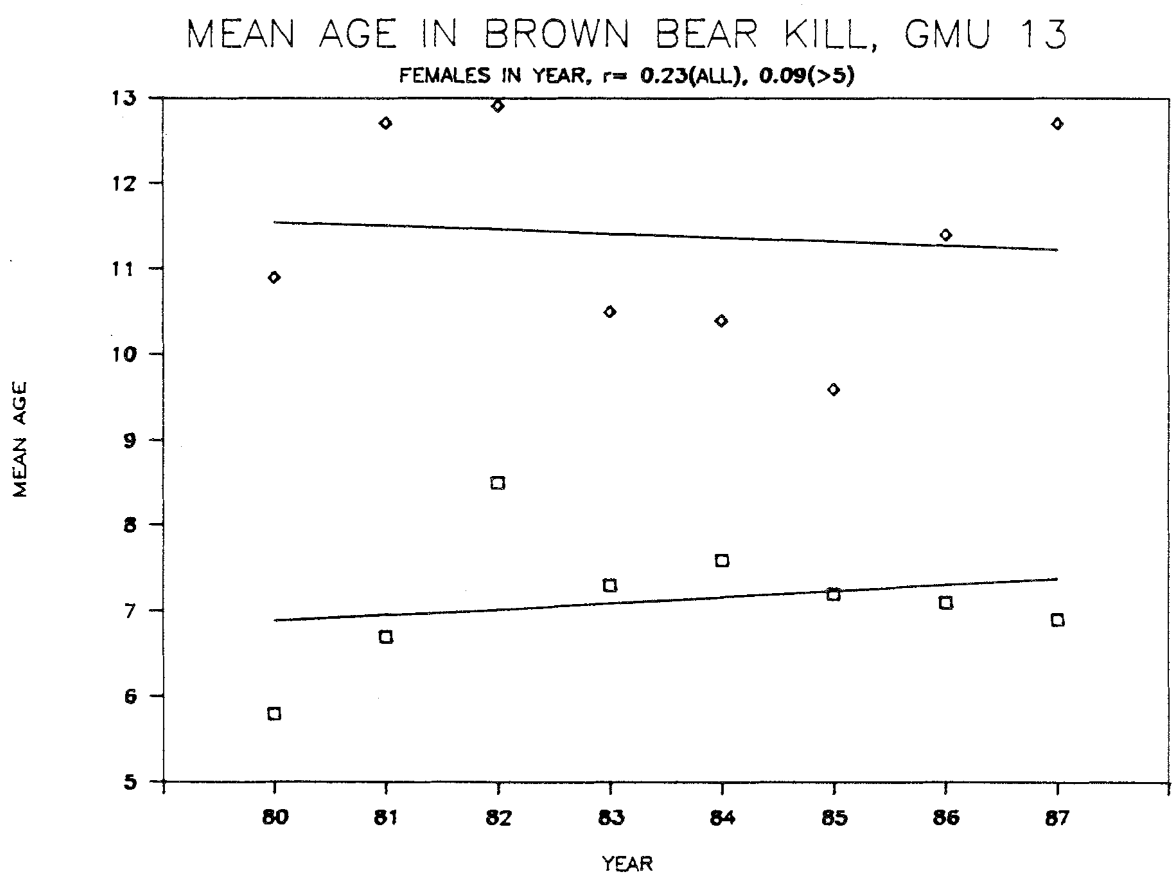
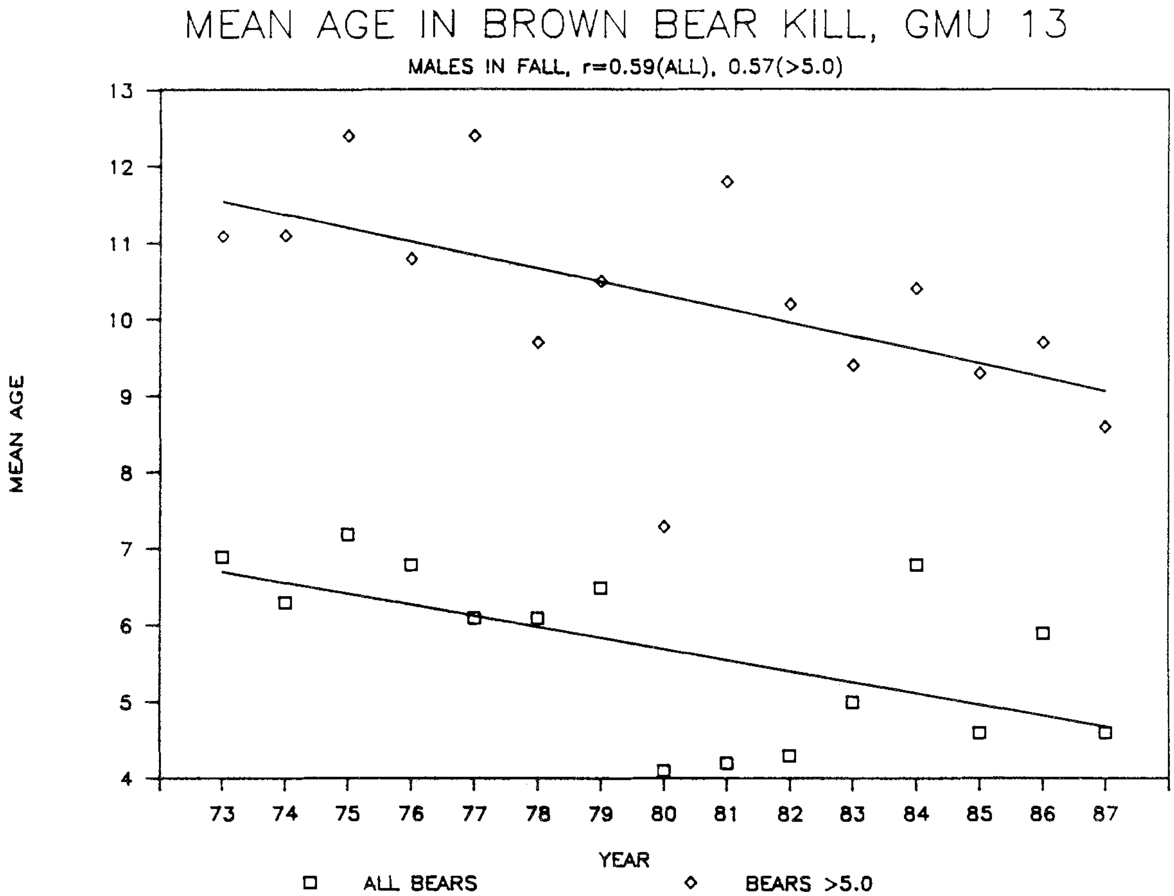

MEAN AGE IN BROWN BEAR KILL, GMU 13
FEMALES IN YEAR, r= 0.23(ALL), 0.09(>5)
MEAN AGE
13
12
11
10
9
8
7
6
5
80
81
82
83
84
85
86
87
YEAR

Figure 11. Trends in mean age of male brown bears killed in GMU 13 during fall seasons, 1980-1987. Regressions are fitted to values for bears of all ages (r-0.59) and for bears older than 5.0 years (r= 0.57). [Fallmales.pic].

Figure 12. Trends in mean age of female brown bears killed in GMU 13 during fall seasons, 1980-1987. Regressions are fitted to values for bears of all ages (r-0.21) and for bears older than 5.0 years (r= 0.56). [Fallff.pic].


MEAN AGE IN BROWN BEAR KILL, GMU 13
MALES IN FALL, r=0.59(ALL), 0.57(>5.0)
MEAN AGE
YEAR
ALL BEARS
BEARS >5.0

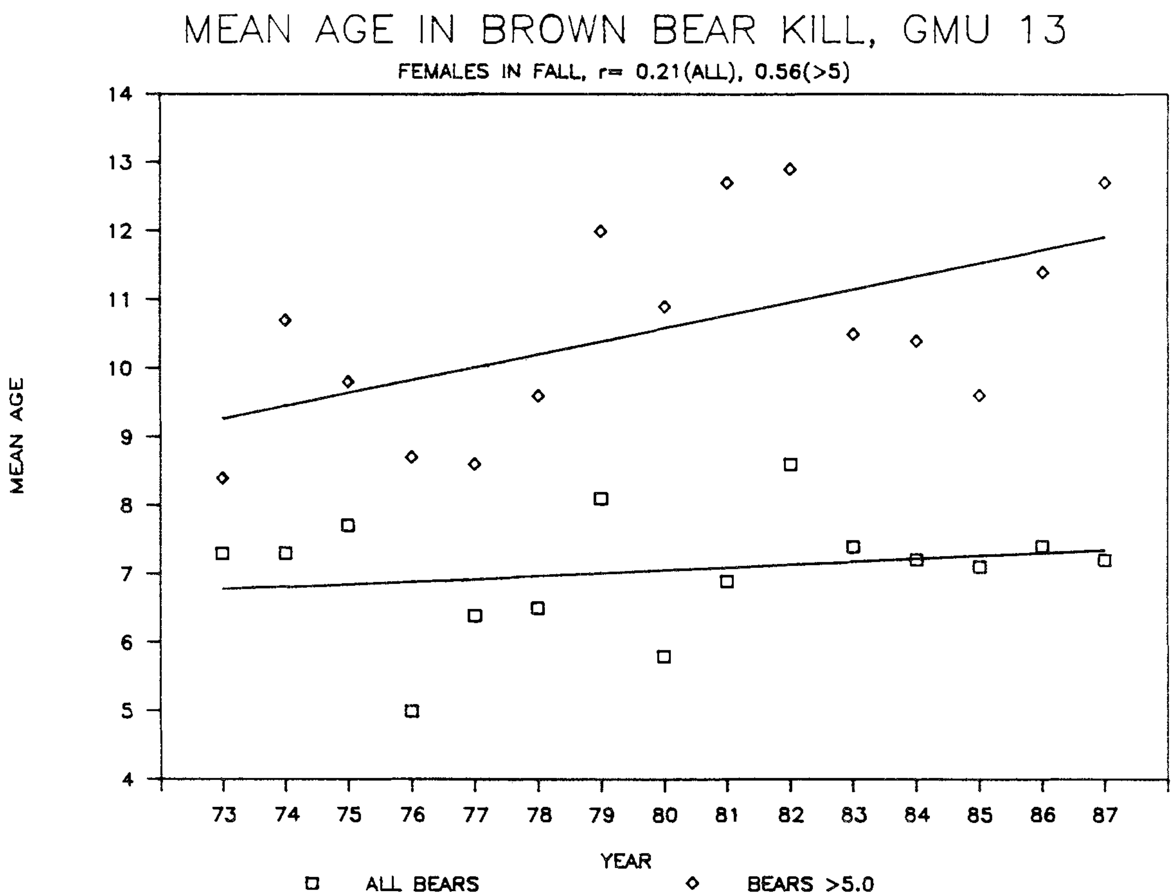
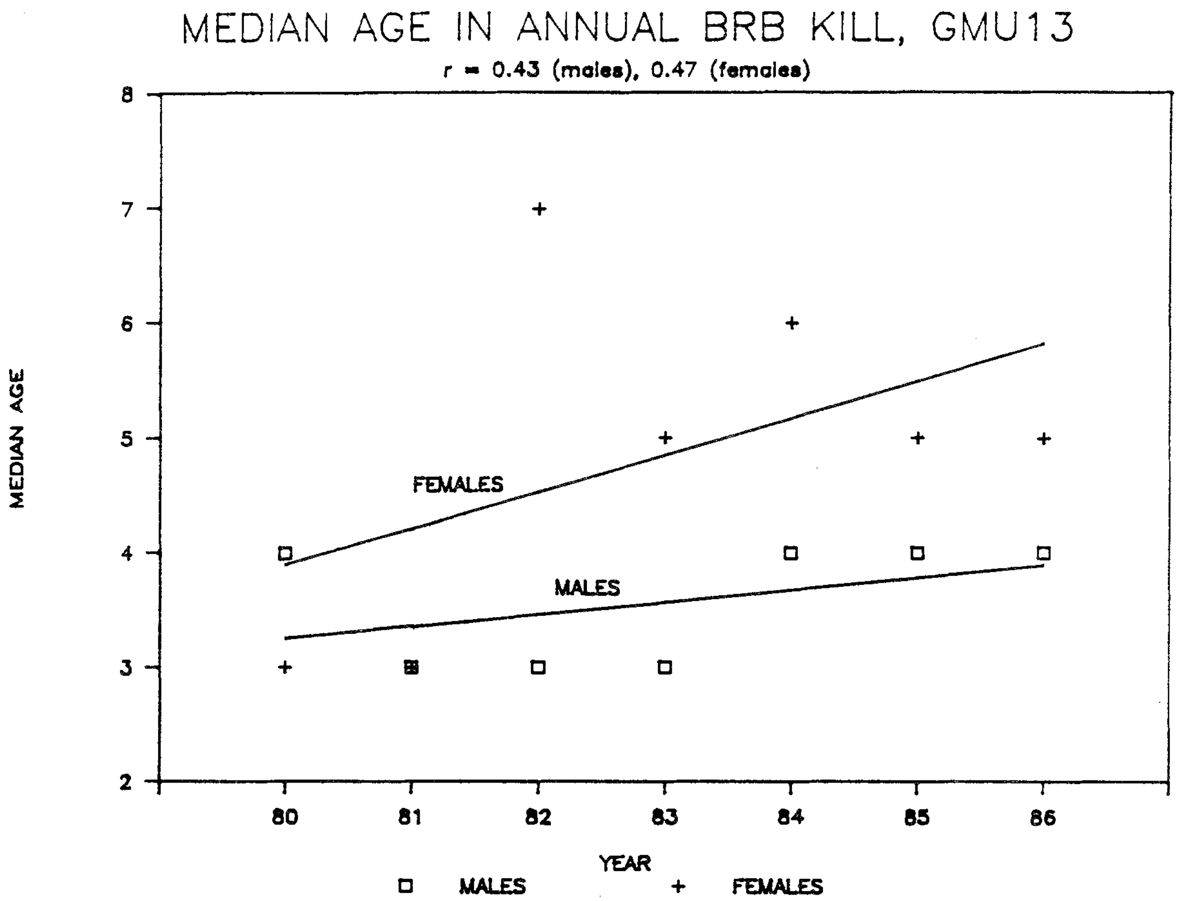
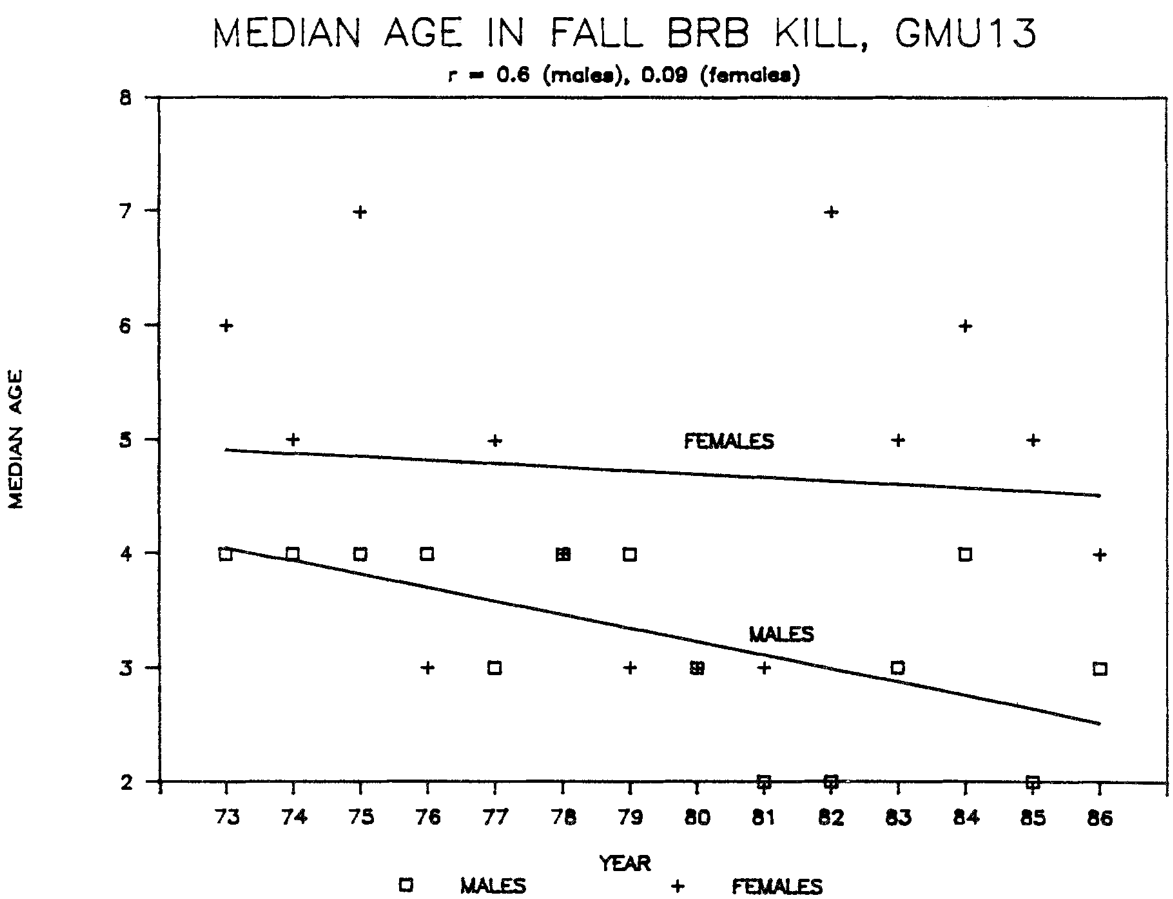

MEAN AGE IN BROWN BEAR KILL, GMU 13
FEMALES IN FALL, r= 0.21(ALL), 0.56(>5)
MEAN AGE
YEAR
ALL BEARS
BEARS >5.0

Figure 13. Trends in median age of male and female brown bears killed annually in GMU 13 during 1980-1987. Regressions are fitted to values for females (r-0.47) and for males (r= 0.43). [Medians.wk1, medyear.pic].

Figure 14. Trends in median age of male and female brown bears killed during fall seasons in GMU 13 during 1980-1987. Regressions are fitted to values for females (r-0.09) and for males (r= 0.6). [Medians.wk1, medfall.pic].



MEDIAN AGE IN ANNUAL BRB KILL, GMU13
r = 0.43 (males), 0.47 (females)
MEDIAN AGE
FEMALES
MALES
YEAR
MALES
FEMALES



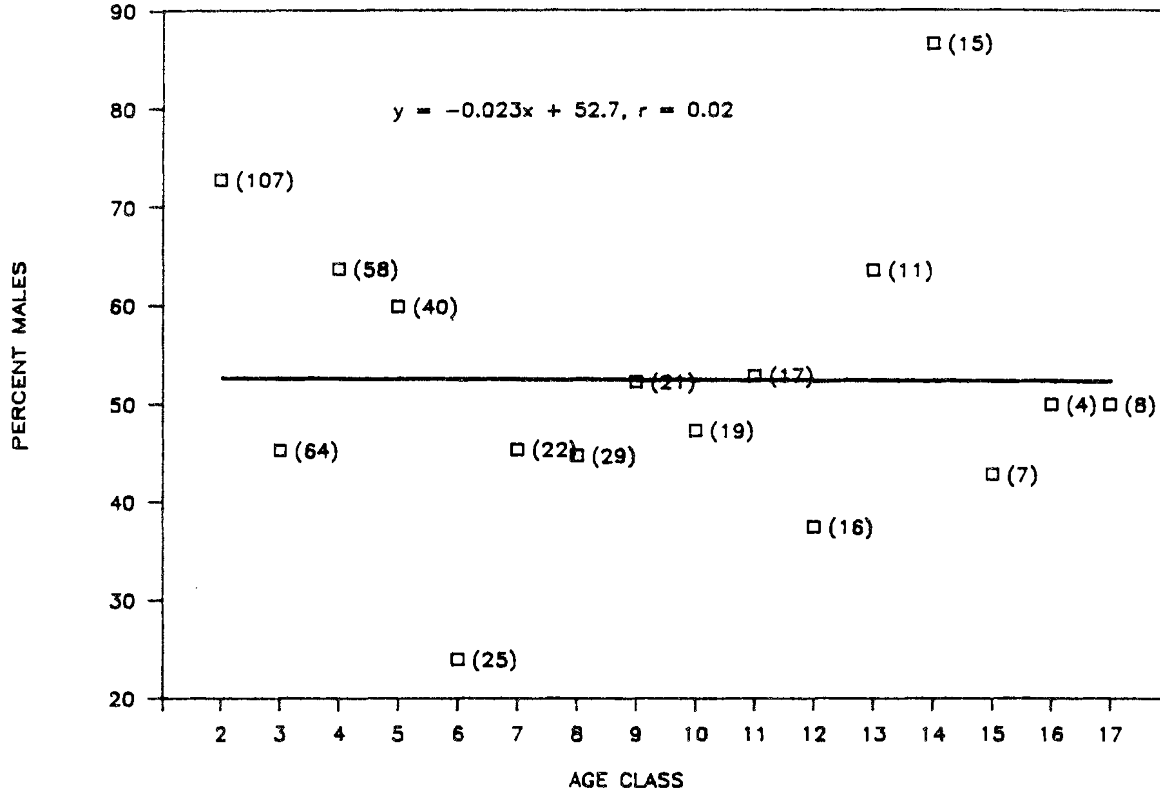
MEDIAN AGE IN FALL BRB KILL, GMU13
r = 0.6 (males), 0.09 (females)
MEDIAN AGE
FEMALES
MALES
YEAR
MALES
FEMALES

Figure 15. Regression of percent males on age class of bears in GMU 13 harvest during period 1970-1979. Only bears harvested during fall seasons included, number of bears harvested indicated in parentheses. [Fraser.wk1, early.pic].

Figure 16. Regression of percent males on age class of bears in GMU 13 harvest during period 1980-1987. Only bears harvested during fall seasons included, number of bears harvested indicated in parentheses. [Fraser.wk1, late.pic].

% MALES BY AGE CLASS IN GMU 13 HARVEST

BROWN BEARS FOR PERIOD 1970–1979, (N)



% MALES BY AGE CLASS IN GMU 13 HARVEST

BROWN BEARS FOR PERIOD 1980–1987, (N)

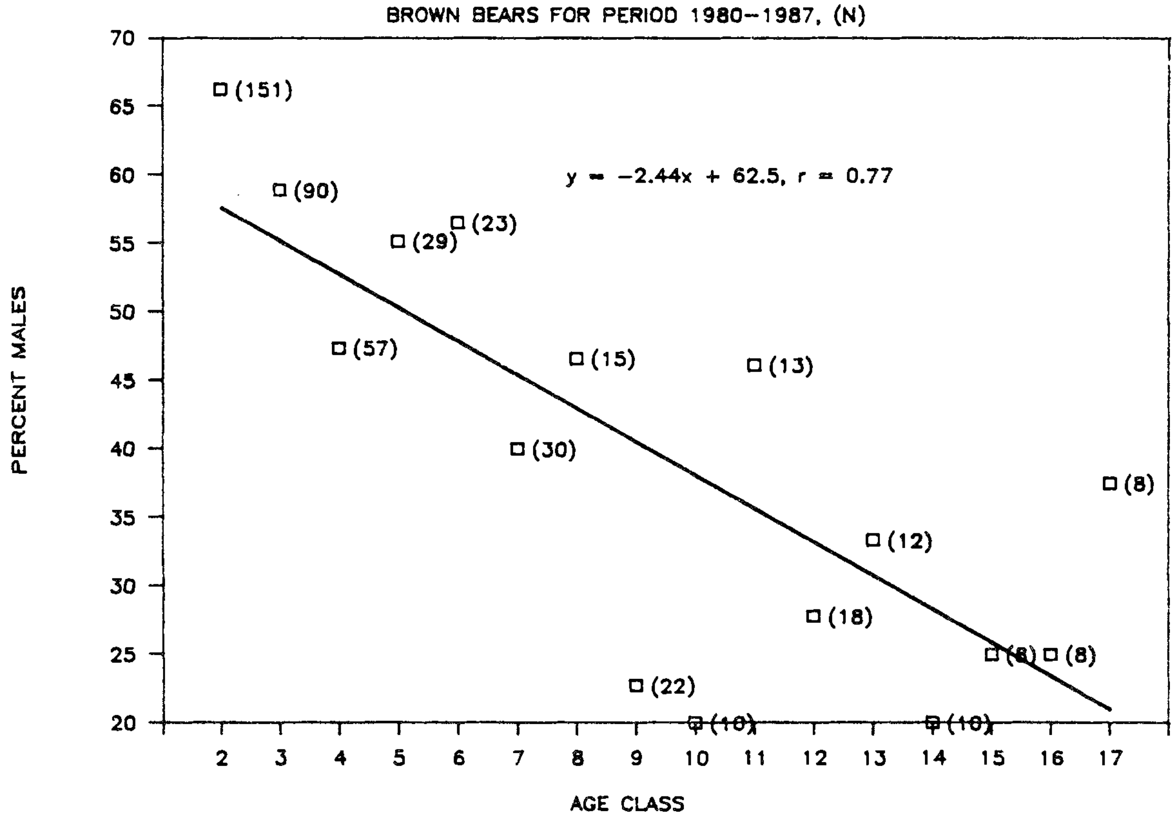
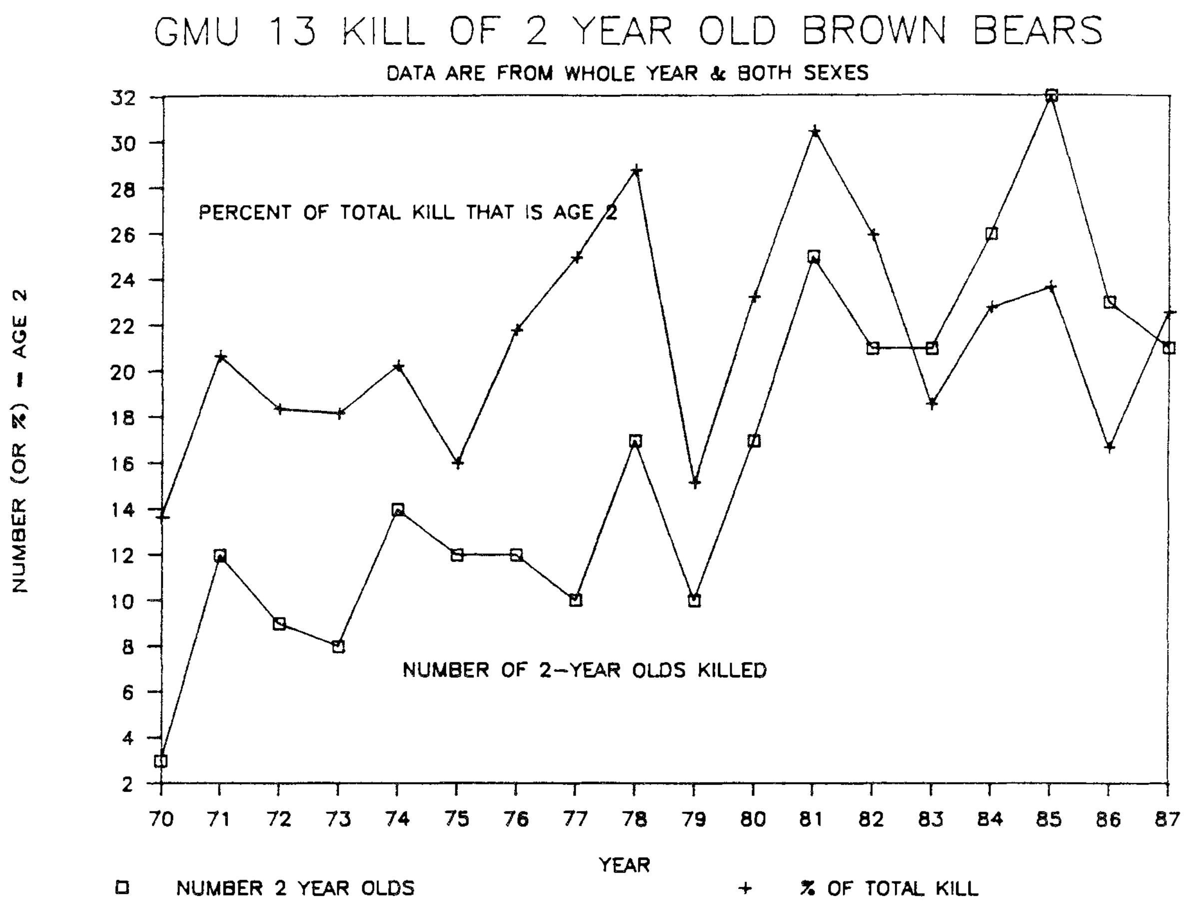


Figure 17. Trends in hunter kill of 2 year old brown bear in Alaska's GMU 13, 1970-1987. Both sexes lumped and data are lumped for spring and fall seasons. [Young.wk1, age2.pic].

Figure 18. Trends in hunter kill of 2 year old brown bear in Alaska's GMU 13, 1970-1987. Both sexes lumped and data are lumped for fall season only. [Young.wk1, age2fall.pic].


GMU 13 KILL OF 2 YEAR OLD BROWN BEARS
DATA ARE FROM WHOLE YEAR & BOTH SEXES
NUMBER (OR %) - AGE 2
PERCENT OF TOTAL KILL THAT IS AGE 2
NUMBER OF 2-YEAR OLDS KILLED
YEAR
NUMBER 2 YEAR OLDS
% OF TOTAL KILL

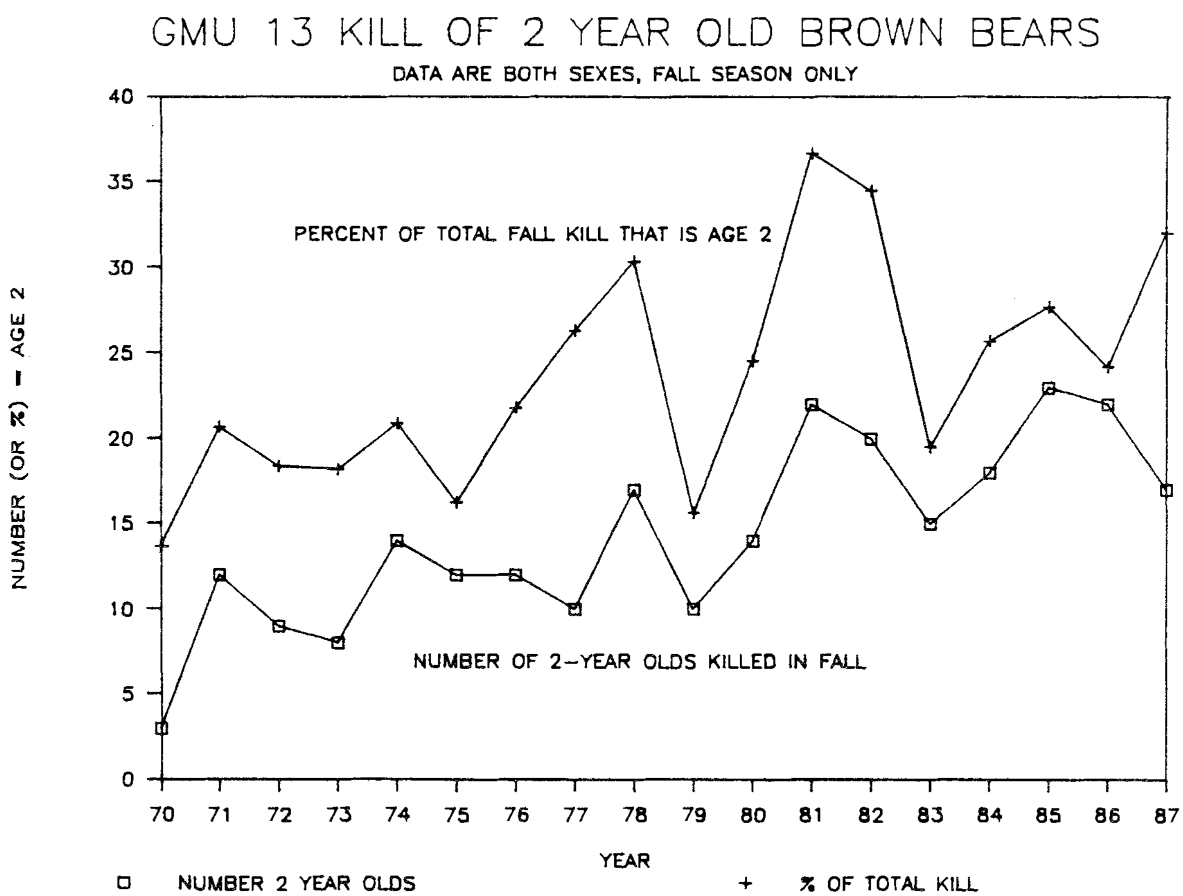
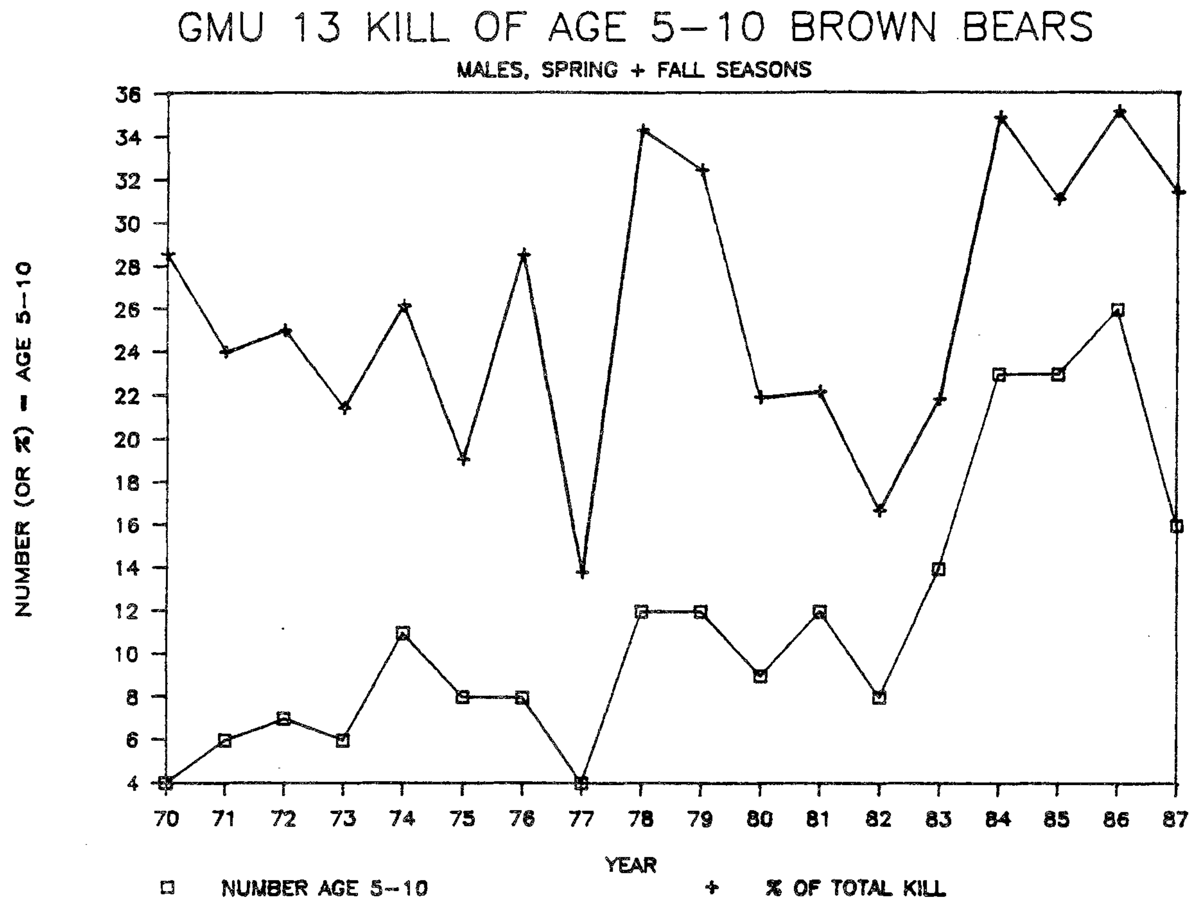

GMU 13 KILL OF 2 YEAR OLD BROWN BEARS
DATA ARE BOTH SEXES, FALL SEASON ONLY
NUMBER (OR %) - AGE 2
PERCENT OF TOTAL FALL KILL THAT IS AGE 2
NUMBER OF 2-YEAR OLDS KILLED IN FALL
YEAR
NUMBER 2 YEAR OLDS
% OF TOTAL KILL

Figure 19. Trends in hunter kill of age 5-10 year old brown bear males in Alaska's GMU 13, 1970-1987. Data are for fall seasons only. [old.wk1, midff.pic].

Figure 20. Trends in hunter kill of age 5-10 year old brown bear males in Alaska's GMU 13, 1970-1987. Data are for fall season only. [old.wk1, midffa.pic].


GMU 13 KILL OF AGE 5–10 BROWN BEARS
MALES, SPRING + FALL SEASONS
NUMBER (OR %) – AGE 5–10
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
YEAR
NUMBER AGE 5–10
% OF TOTAL KILL

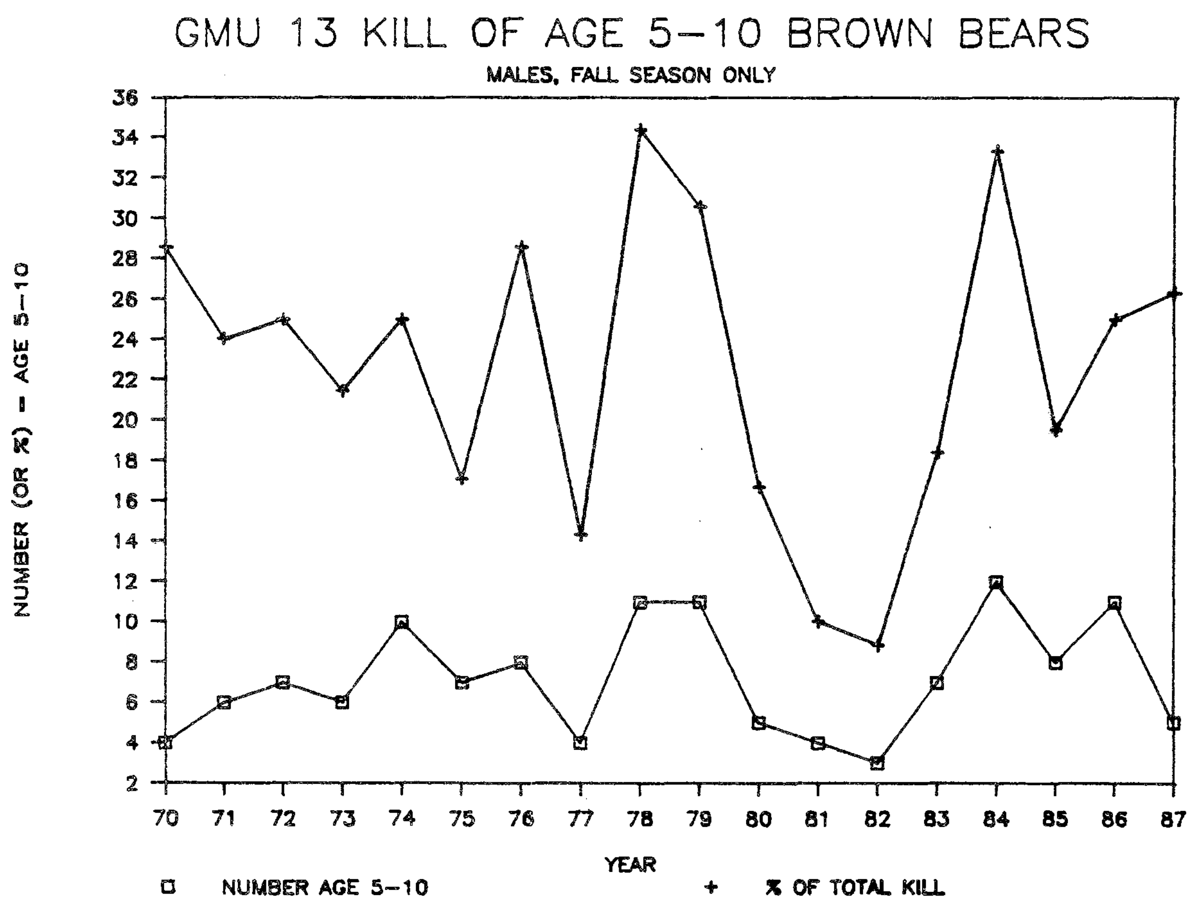
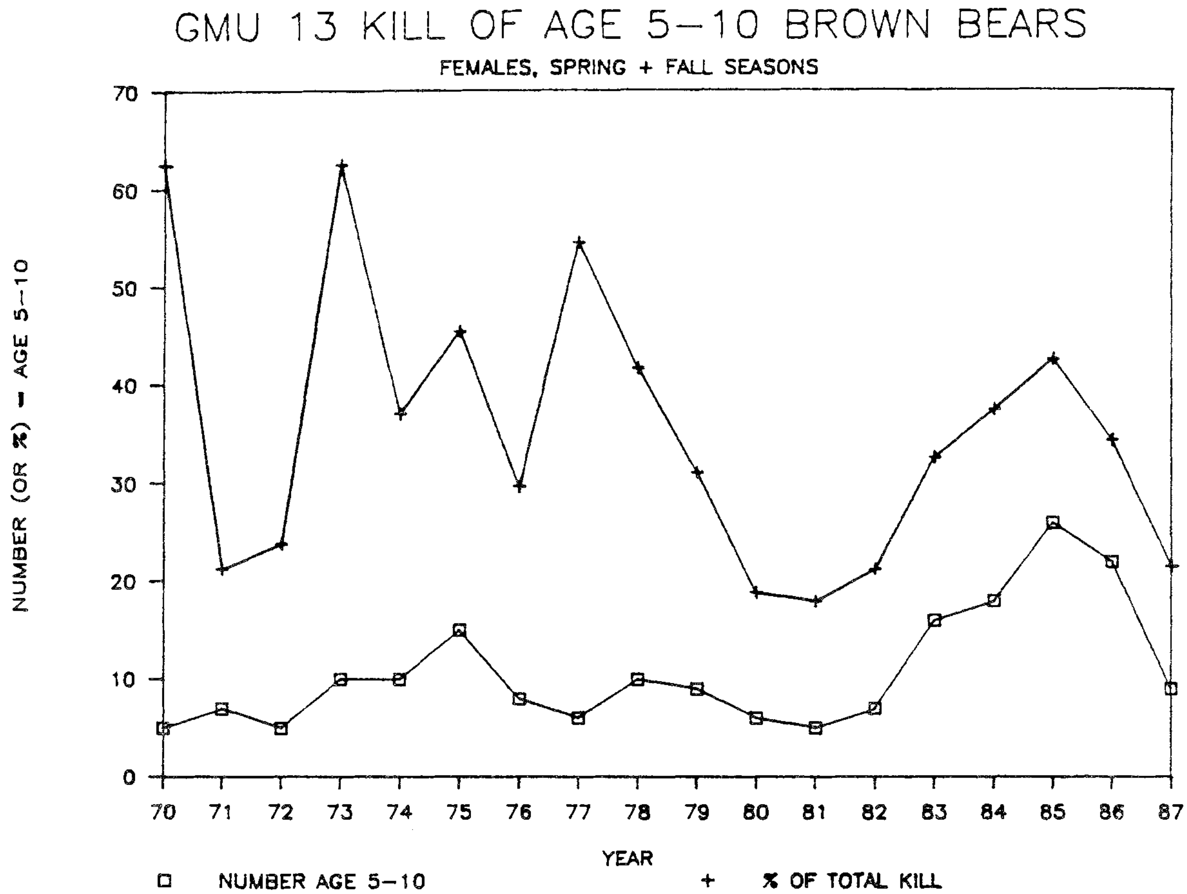

GMU 13 KILL OF AGE 5–10 BROWN BEARS
MALES, FALL SEASON ONLY
NUMBER (OR %) – AGE 5–10
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
YEAR
NUMBER AGE 5–10
% OF TOTAL KILL

Figure 21. Trends in hunter kill of age 5-10 year old brown bear females in Alaska's GMU 13, 1970-1987. Data are lumped for spring and fall seasons. [old.wk1, midff.pic].

Figure 22. Trends in hunter kill of age 5-10 year old brown bear females in Alaska's GMU 13, 1970-1987. Data are for fall seasons only. [old.wk1, midffa.pic].


GMU 13 KILL OF AGE 5-10 BROWN BEARS
FEMALES, SPRING + FALL SEASONS
NUMBER (OR %) - AGE 5-10
0
10
20
30
40
50
60
70
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
YEAR
NUMBER AGE 5-10
% OF TOTAL KILL

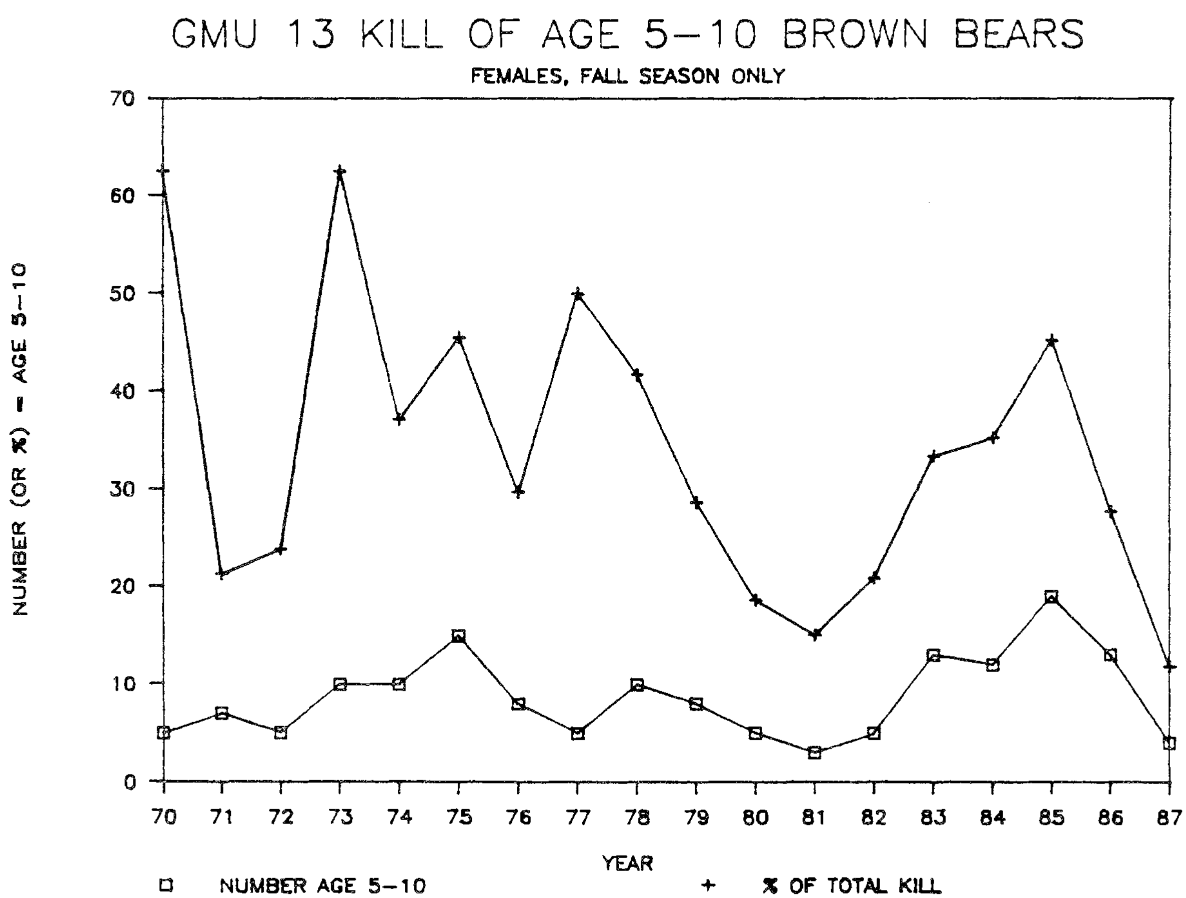
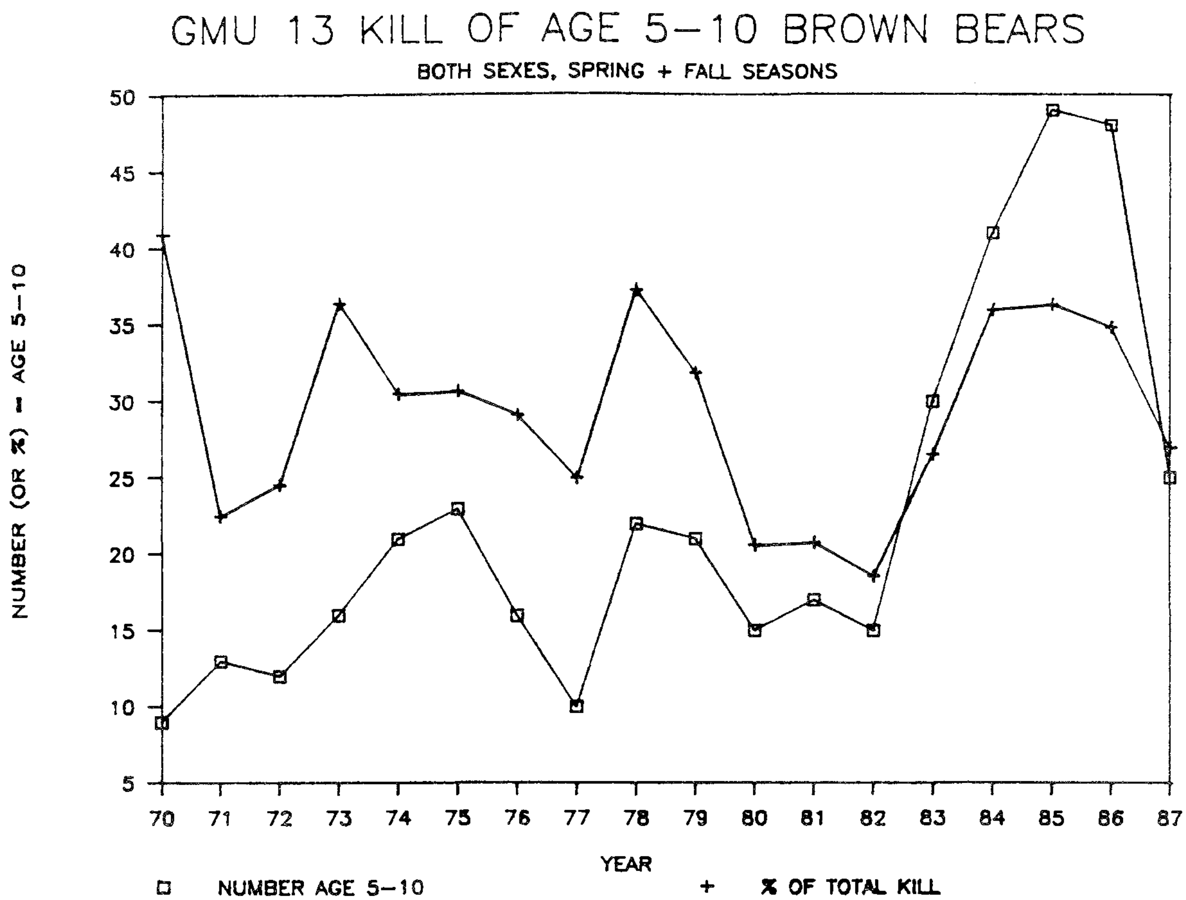

GMU 13 KILL OF AGE 5-10 BROWN BEARS
FEMALES, FALL SEASON ONLY
NUMBER (OR %) - AGE 5-10
0
10
20
30
40
50
60
70
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
YEAR
NUMBER AGE 5-10
% OF TOTAL KILL

Figure 23. Trends in hunter kill of age 5-10 year old brown bear in Alaska's GMU 13, 1970-1987. Both sexes lumped and data are lumped for spring and fall seasons. [old.wk1, midall.pic].

Figure 24. Trends in hunter kill of age 5-10 year old brown bear in Alaska's GMU 13, 1970-1987. Both sexes lumped and data are lumped for fall season only. [old.wk1, midalla.pic].


GMU 13 KILL OF AGE 5-10 BROWN BEARS
BOTH SEXES, SPRING + FALL SEASONS
NUMBER (OR %) - AGE 5-10
50
45
40
35
30
25
20
15
10
5
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
YEAR
NUMBER AGE 5-10
% OF TOTAL KILL

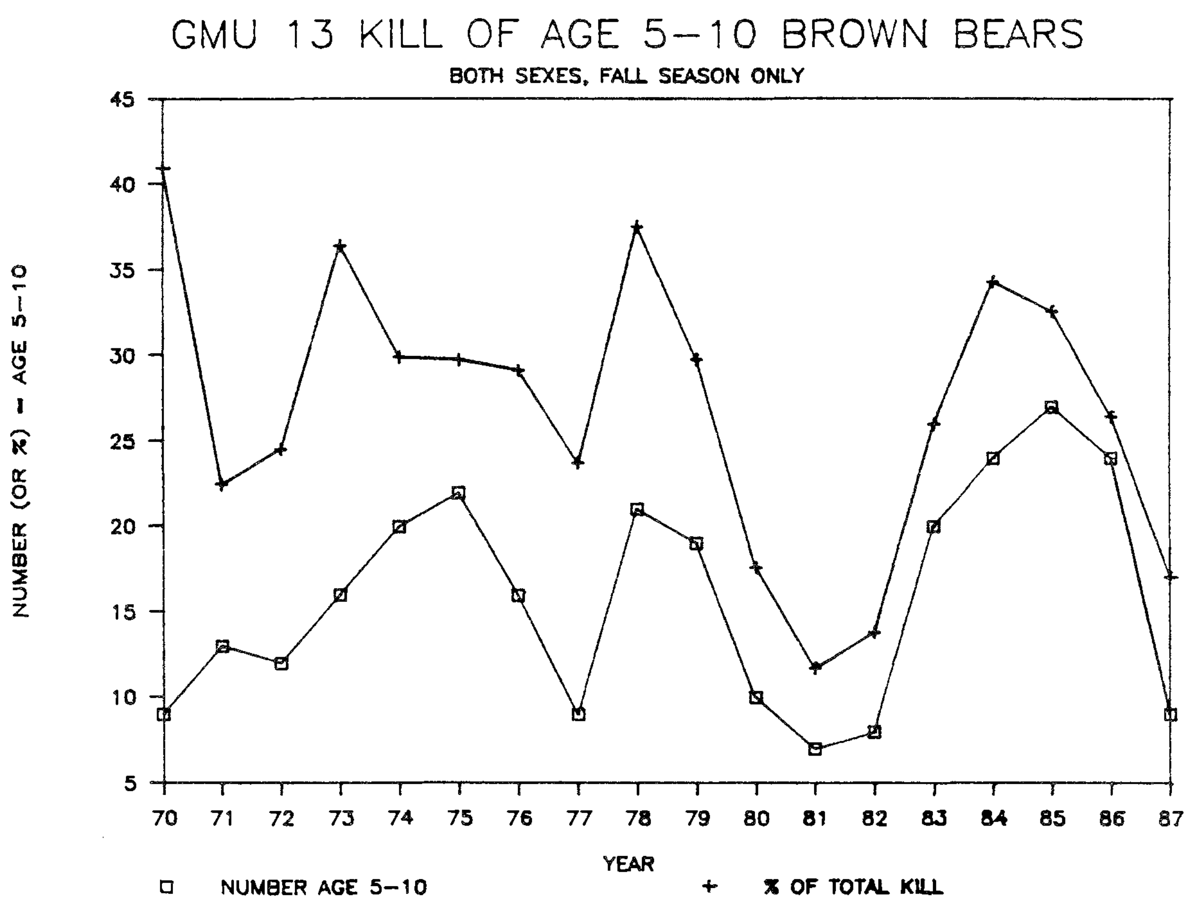
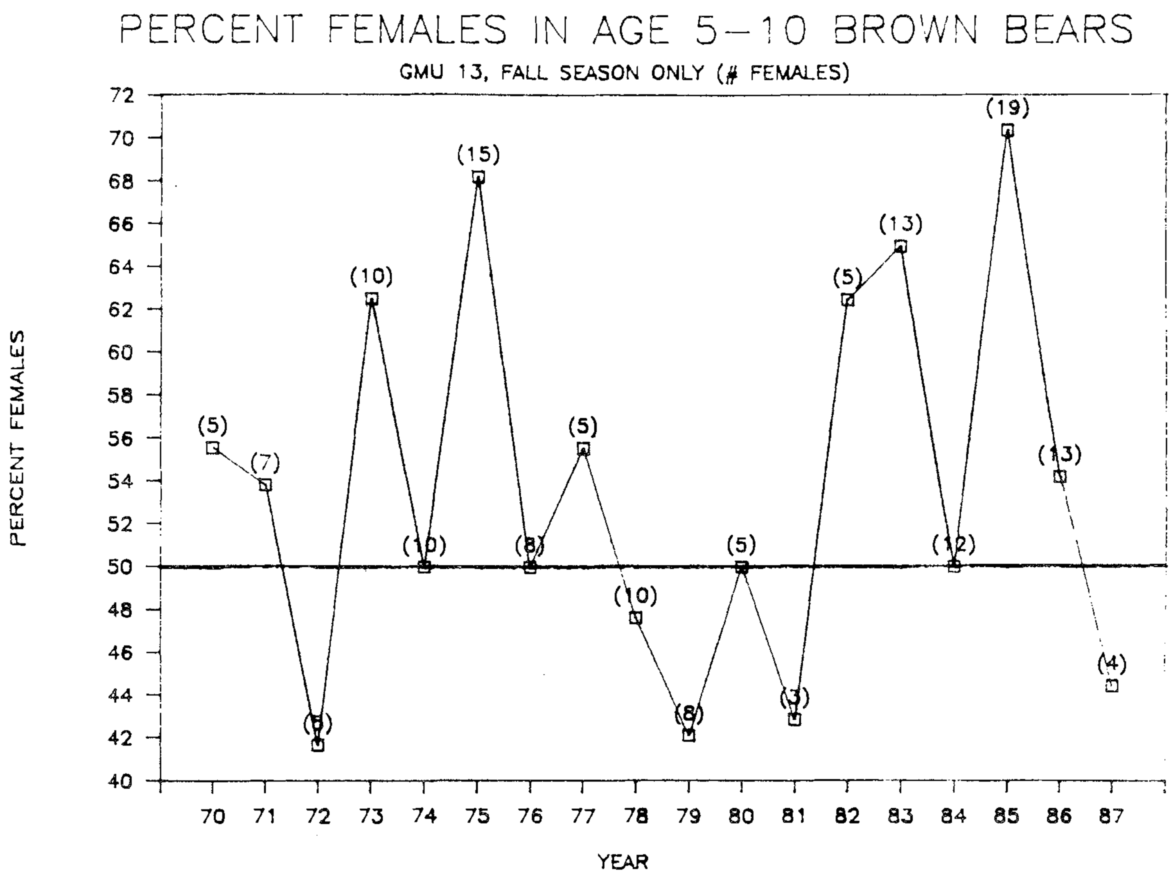
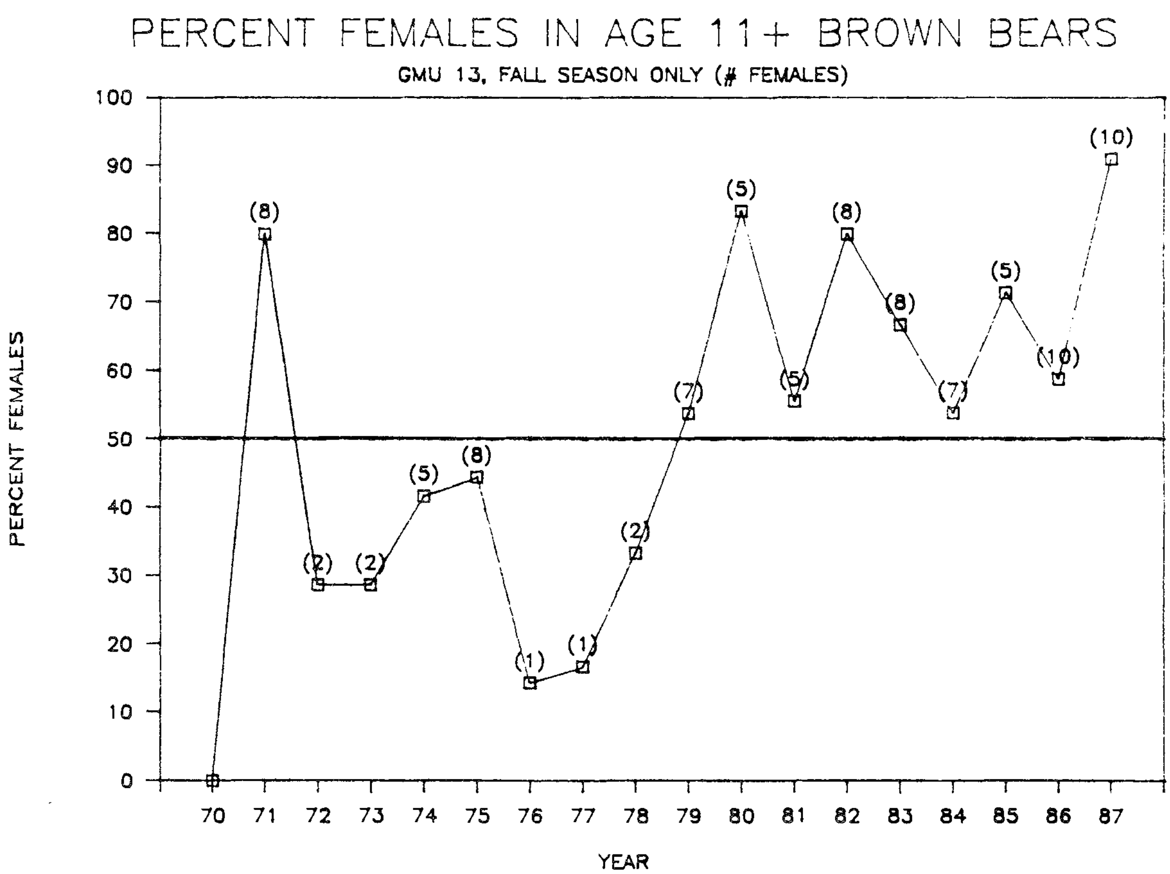

GMU 13 KILL OF AGE 5-10 BROWN BEARS
BOTH SEXES, FALL SEASON ONLY
NUMBER (OR %) - AGE 5-10
45
40
35
30
25
20
15
10
5
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
YEAR
NUMBER AGE 5-10
% OF TOTAL KILL

Figure 25. Trends in percent females in harvest of brown bears aged 5-10 years old during fall seasons in GMU 13. Number of females harvested indicated in parentheses. [Old.wk1, %ffmid.pic].

Figure 26. Trends in percent females in harvest of brown bears aged 11+ years old during fall seasons in GMU 13. Number of females harvested indicated in parentheses. [Old.wk1, %ffmid.pic].



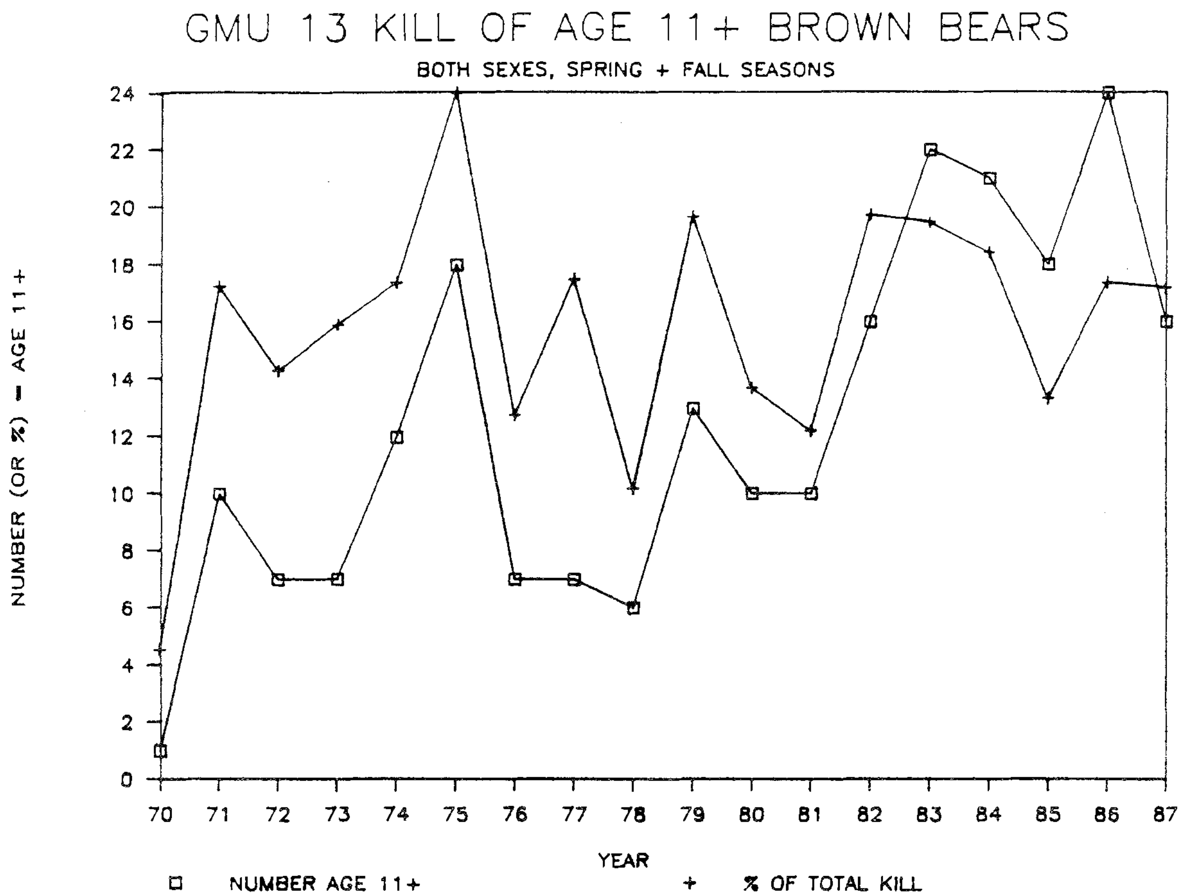
PERCENT FEMALES IN AGE 5–10 BROWN BEARS
GMU 13, FALL SEASON ONLY (# FEMALES)
PERCENT FEMALES
YEAR



PERCENT FEMALES IN AGE 11+ BROWN BEARS
GMU 13, FALL SEASON ONLY (# FEMALES)
PERCENT FEMALES
YEAR

Figure 27. Trends in hunter kill of age 11+ year old brown bears in Alaska's GMU 13, 1970-1987. Data are lumped for both sexes and for spring and fall seasons. [old.wk1, oldall.pic].

Figure 28. Trends in hunter kill of age 11+ year old brown bears in Alaska's GMU 13, 1970-1987. Both sexes lumped and data are lumped for fall season only. [old.wk1, oldalla.pic].


GMU 13 KILL OF AGE 11+ BROWN BEARS
BOTH SEXES, SPRING + FALL SEASONS
NUMBER (OR %) - AGE 11+
0
2
4
6
8
10
12
14
16
18
20
22
24
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
YEAR
NUMBER AGE 11+
% OF TOTAL KILL

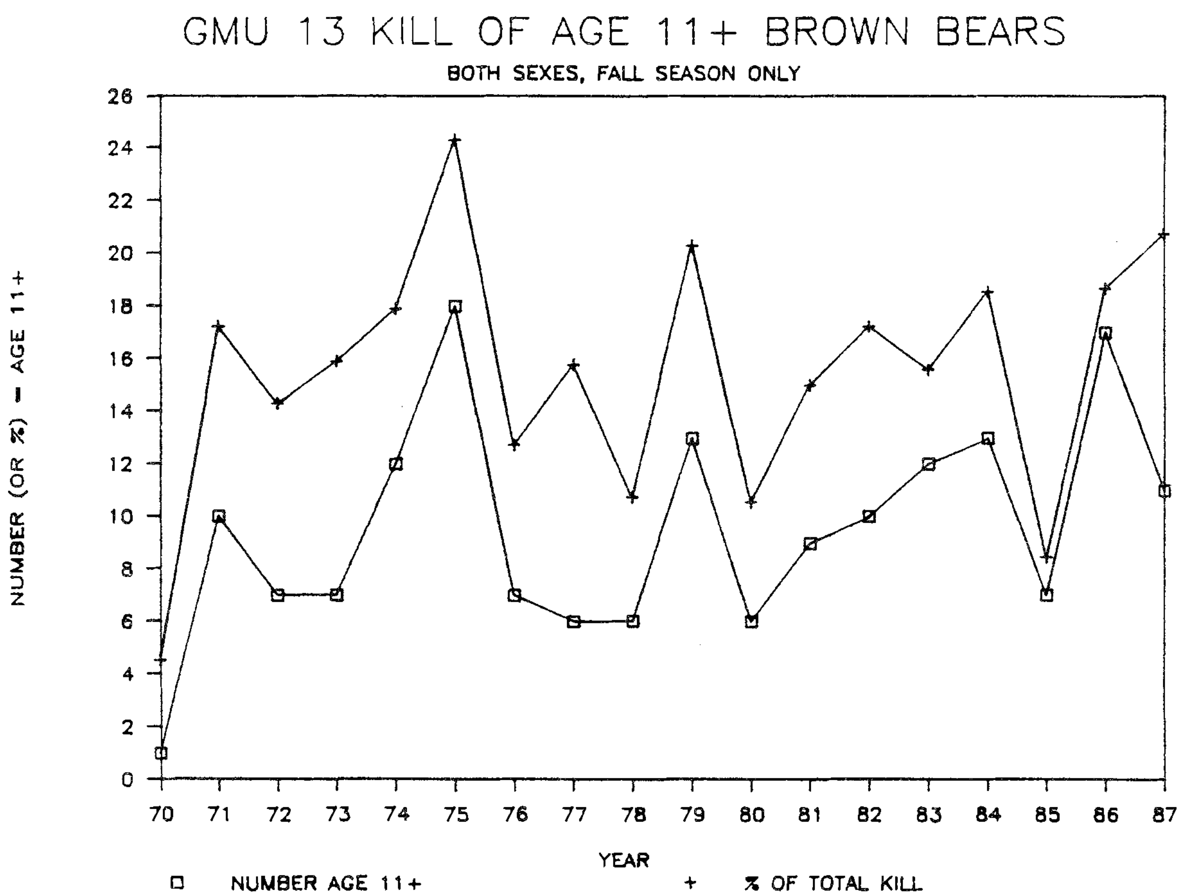
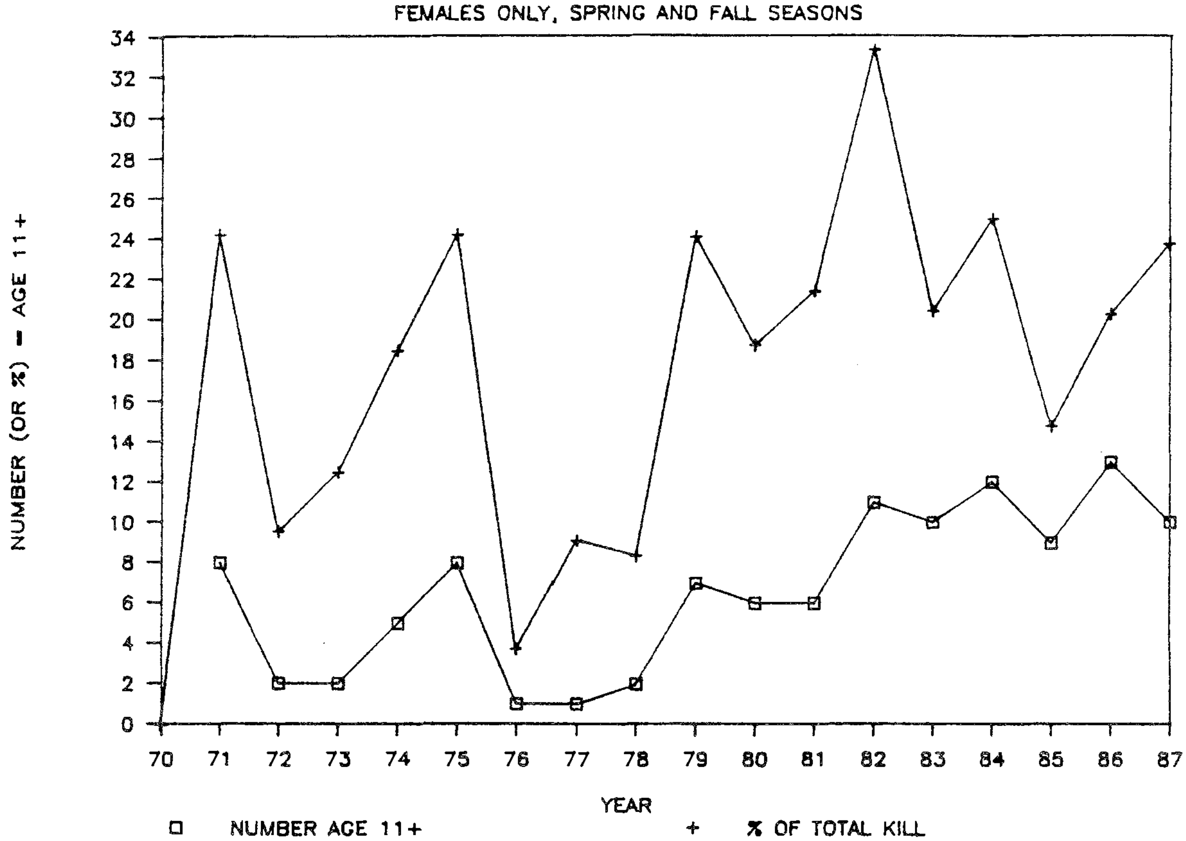

GMU 13 KILL OF AGE 11+ BROWN BEARS
BOTH SEXES, FALL SEASON ONLY
NUMBER (OR %) - AGE 11+
0
2
4
6
8
10
12
14
16
18
20
22
24
26
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
YEAR
NUMBER AGE 11+
% OF TOTAL KILL

Figure 29. Trends in hunter kill of age 11+ year old brown bear females in Alaska's GMU 13, 1970-1987. Data are lumped for spring and fall seasons. [old.wk1, oldff.pic].

Figure 30. Trends in hunter kill of age 11+ year old brown bear females in Alaska's GMU 13, 1970-1987. Both sexes lumped and data are lumped for fall season only. [old.wk1, oldffa.pic].

GMU 13 KILL OF AGE 11+ BROWN BEARS

FEMALES ONLY, SPRING AND FALL SEASONS



GMU 13 KILL OF AGE 11+ BROWN BEARS

FEMALES ONLY, FALL SEASON ONLY

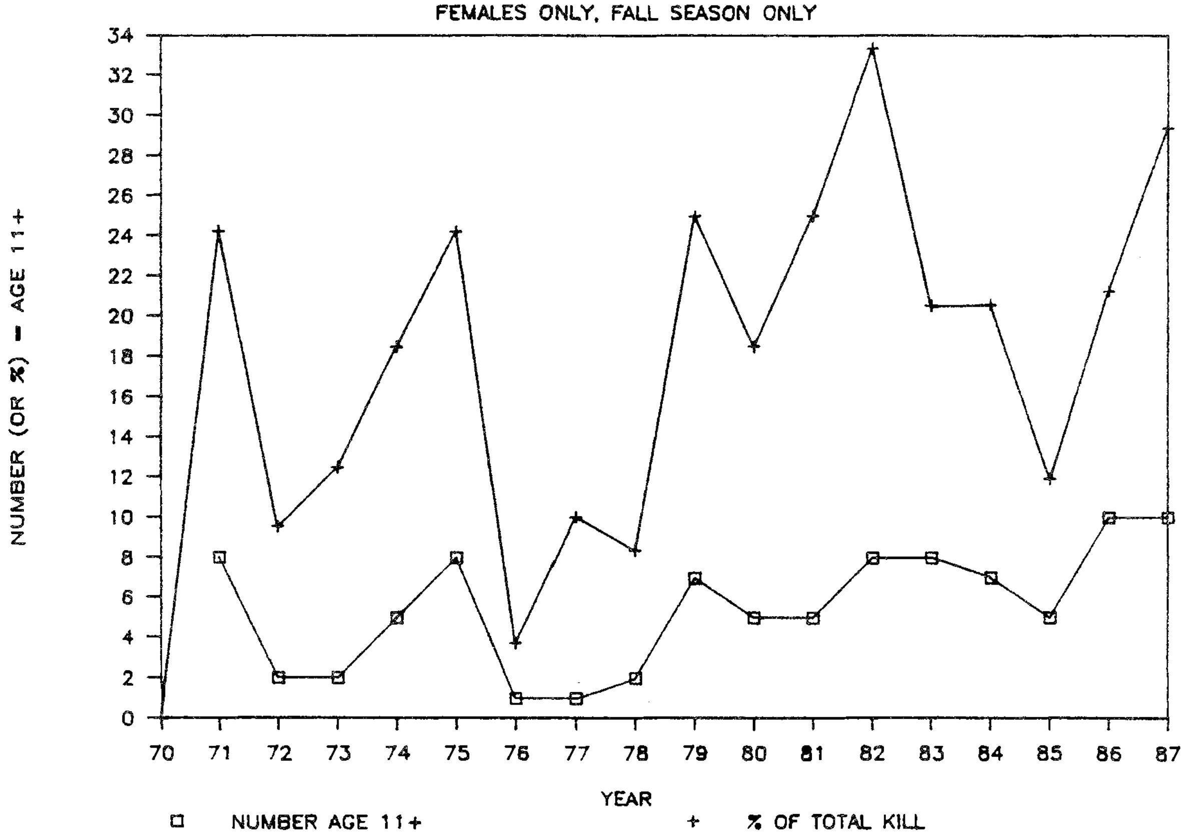
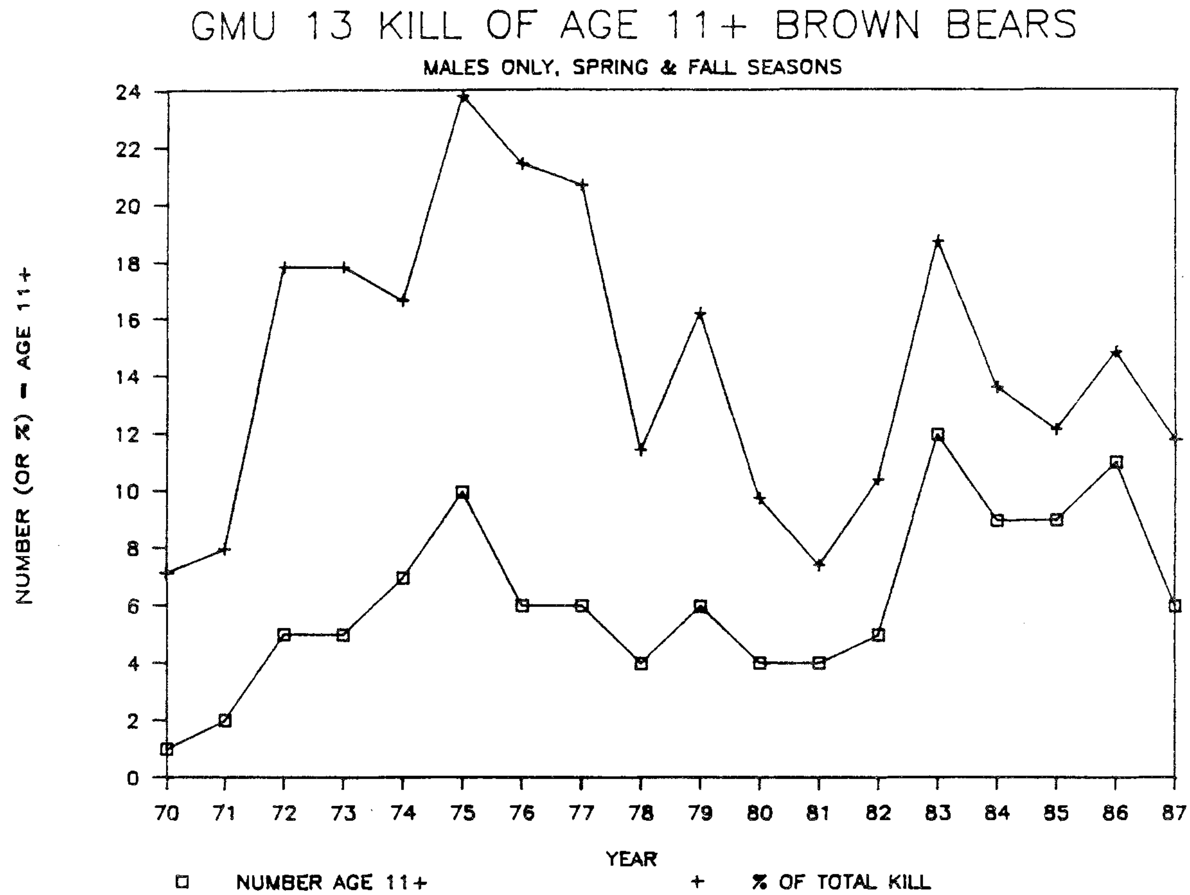


Figure 31. Trends in hunter kill of age 11+ year old brown bear males in Alaska's GMU 13, 1970-1987. Data are lumped for spring and fall seasons. [old.wk1, oldmm.pic].

Figure 32. Trends in hunter kill of age 11+ year old brown bear females in Alaska's GMU 13, 1970-1987. Both sexes lumped and data are lumped for fall season only. [old.wk1, oldmma.pic].


GMU 13 KILL OF AGE 11+ BROWN BEARS
MALES ONLY, SPRING & FALL SEASONS
NUMBER (OR %) - AGE 11+
24
22
20
18
16
14
12
10
8
6
4
2
0
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
YEAR
NUMBER AGE 11+
% OF TOTAL KILL

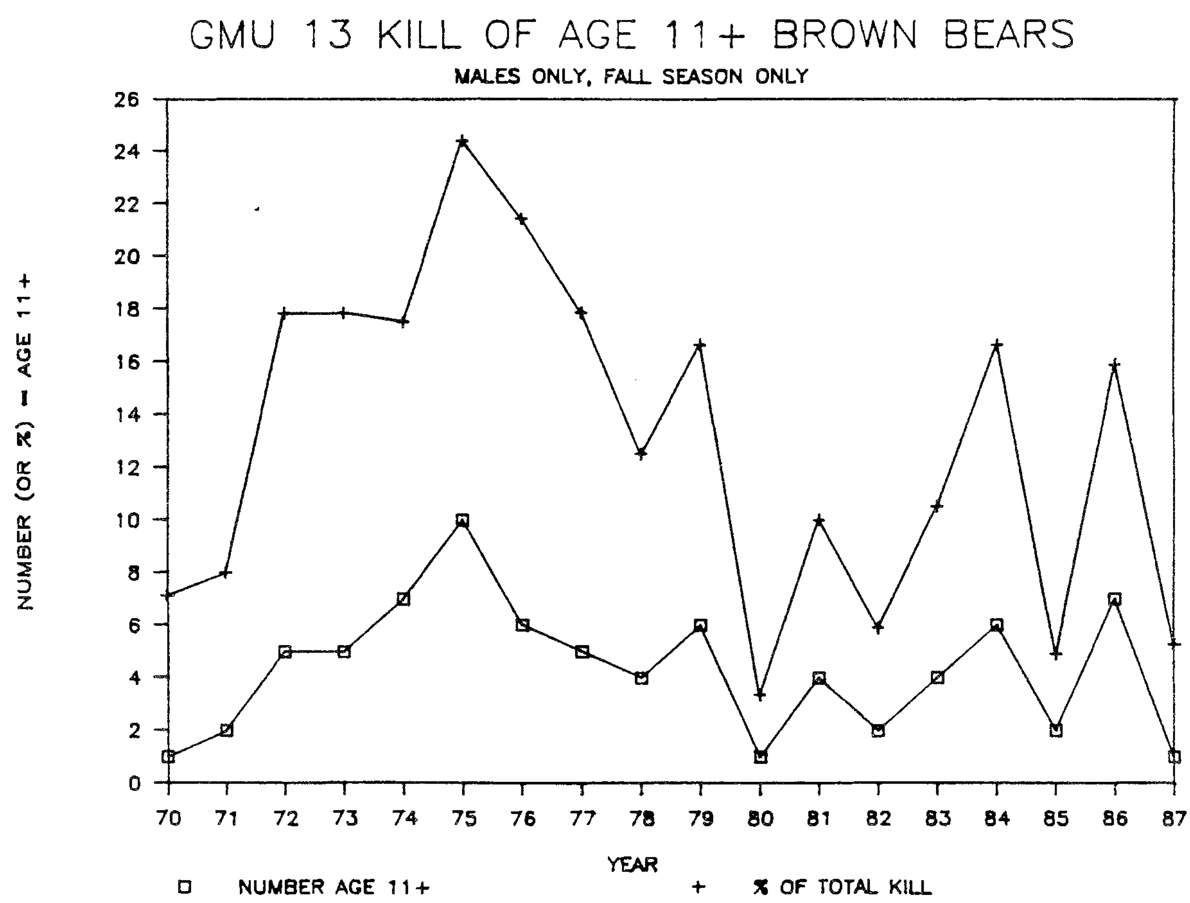
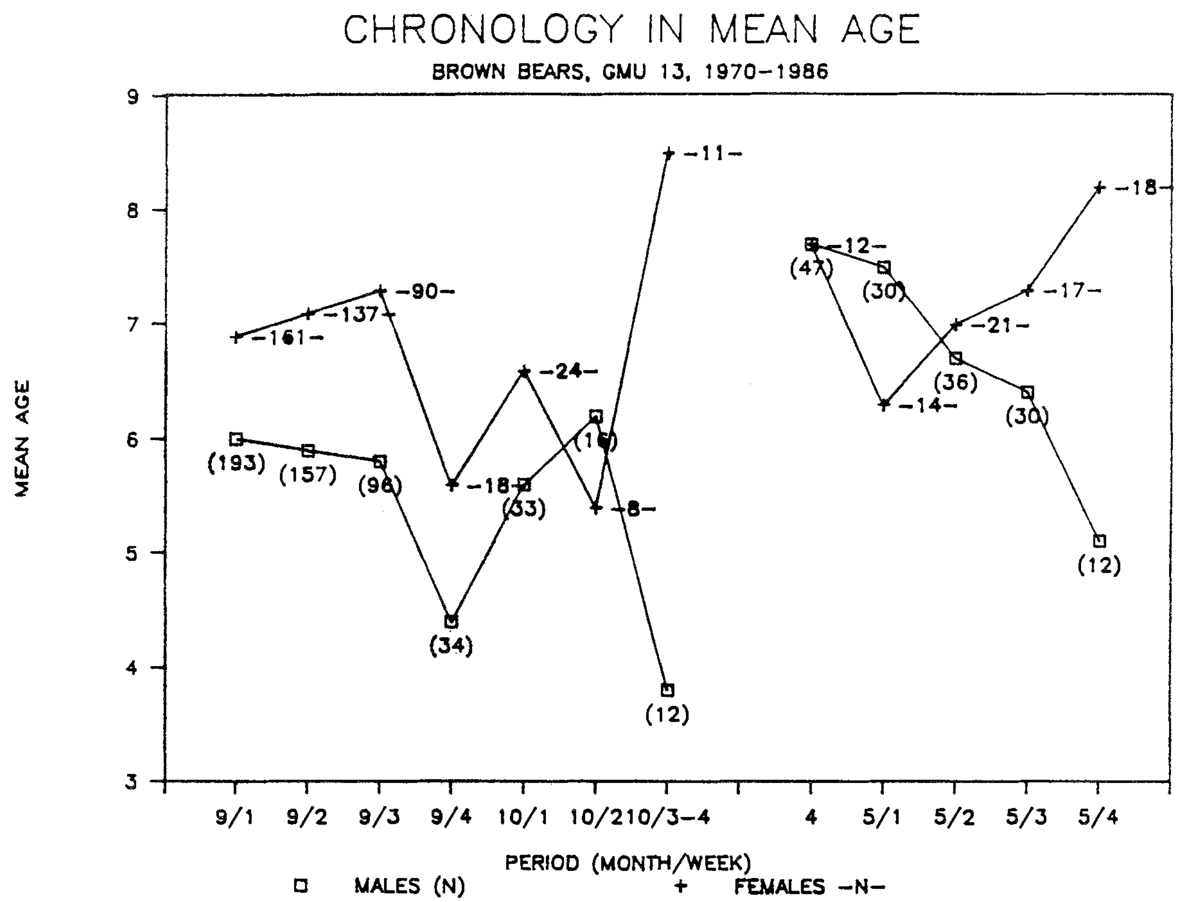

GMU 13 KILL OF AGE 11+ BROWN BEARS
MALES ONLY, FALL SEASON ONLY
NUMBER (OR %) - AGE 11+
26
24
22
20
18
16
14
12
10
8
6
4
2
0
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
YEAR
NUMBER AGE 11+
% OF TOTAL KILL

Figure 33. Chronology in mean age of brown bears killed in Alaska's GMU 13 during the period 1970-1986. Number of bears killed, and aged, in each period is indicated. Relatively small sample sizes for spring season reflect the absence of spring seasons prior to 1980. [Chronage.wk1, age1.pic].

Figure 34. Chronology in sex ratio of brown bears killed in Alaska's GMU 13 during the period 1970-1986. Number of bears killed, and sexed, in each period is indicated. Relatively small sample sizes for spring season reflect the absence of spring seasons prior to 1980. [Chronage.wk1, chronsex.pic].


CHRONOLOGY IN MEAN AGE
BROWN BEARS, GMU 13, 1970-1986
MEAN AGE
PERIOD (MONTH/WEEK)
MALES (N)
FEMALES -N-

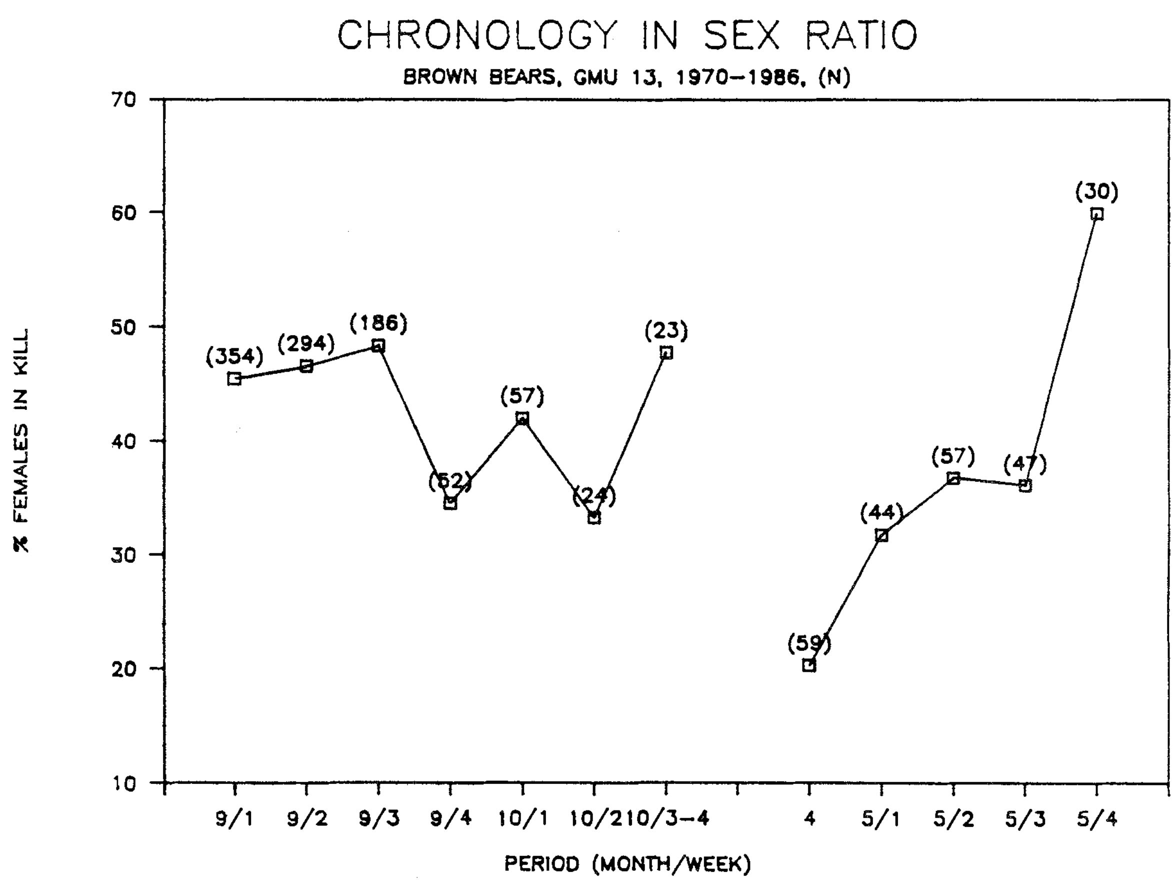
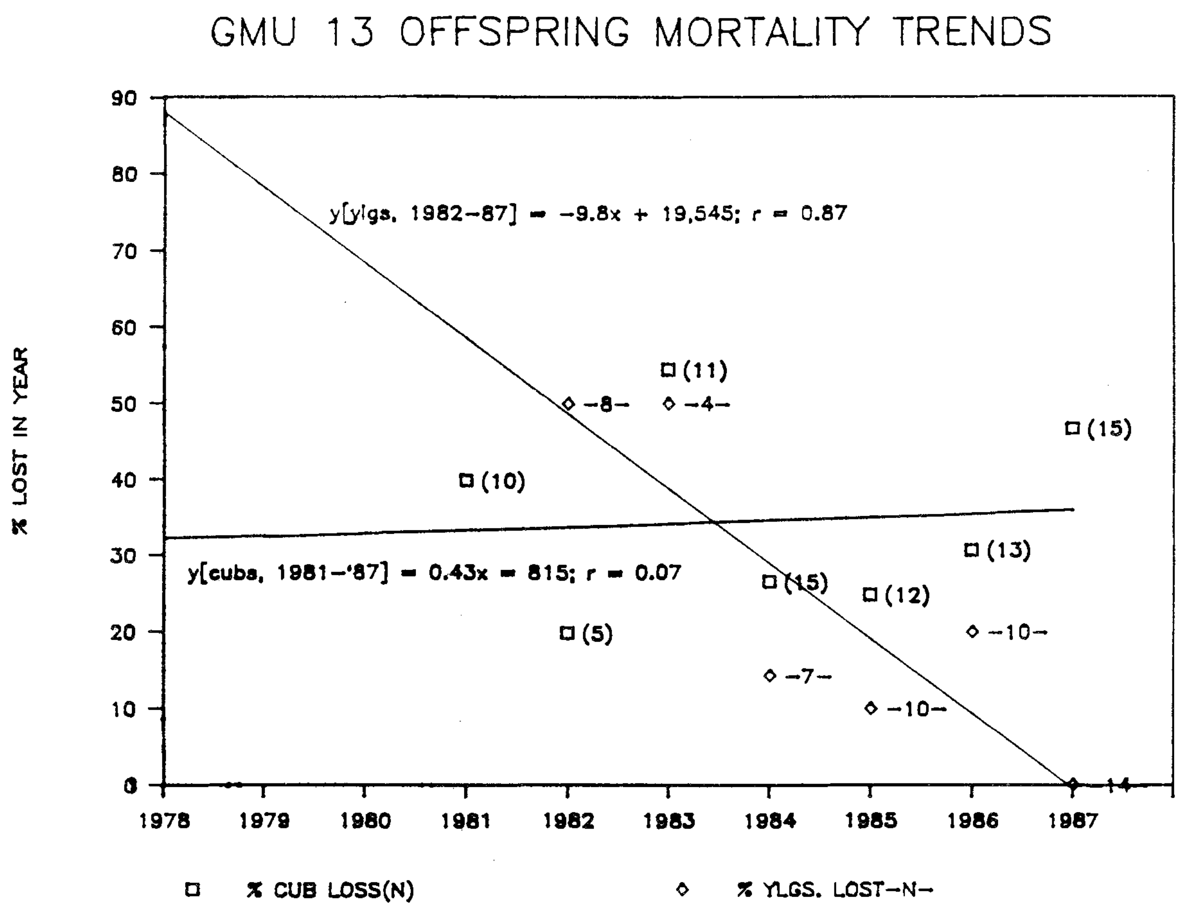

CHRONOLOGY IN SEX RATIO
BROWN BEARS, GMU 13, 1970-1986, (N)
% FEMALES IN KILL
PERIOD (MONTH/WEEK)

Figure 35. Trends in mortality rates of cub and yearling offspring of radio-marked female brown bears in Alaska's GMU 13, 1978-1987. [Loss.wk1, loss.pic].

Figure 36. Trends in mortality rates of cub and yearling (combined) offspring of radio-marked female brown bears in Alaska's GMU 13, 1978-1987. [Loss2.wk1, loss.pic].


GMU 13 OFFSPRING MORTALITY TRENDS
% LOST IN YEAR
y[ylgs, 1982–87] = –9.8x + 19,545; r = 0.87
y[cubs, 1981–'87] = 0.43x = 815; r = 0.07
(11)
-8-
-4-
(15)
(10)
(13)
(15)
(12)
(5)
-10-
-7-
-10-
-14-
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987
% CUB LOSS(N)
% YLGS. LOST–N–

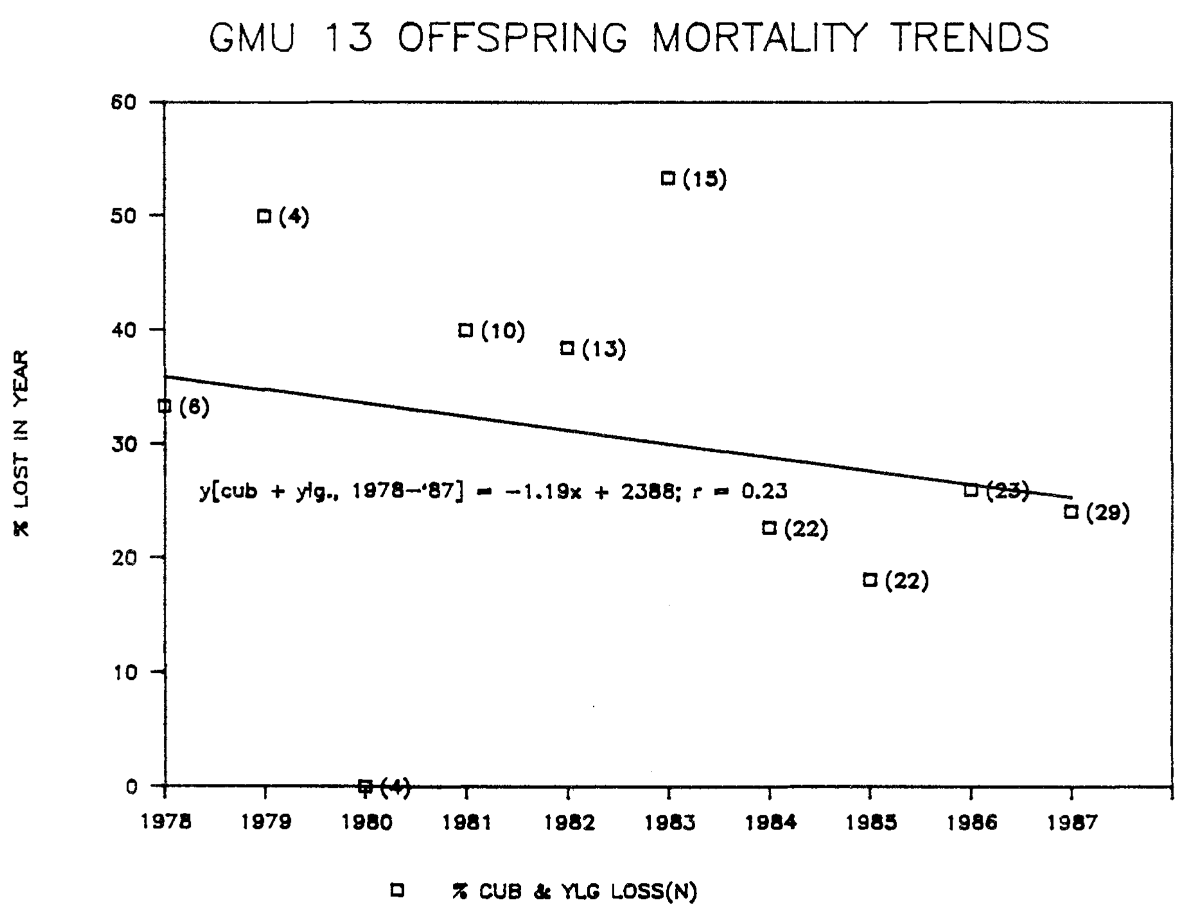
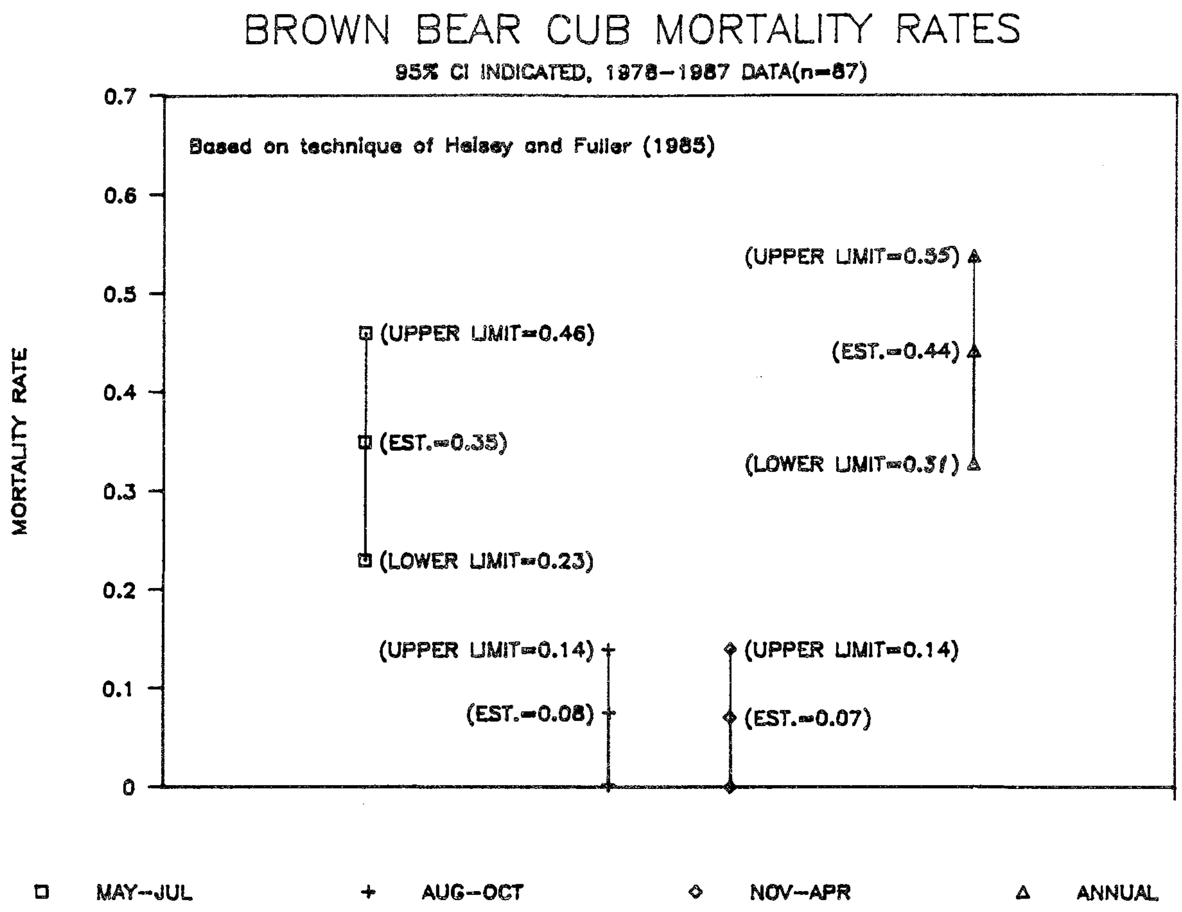
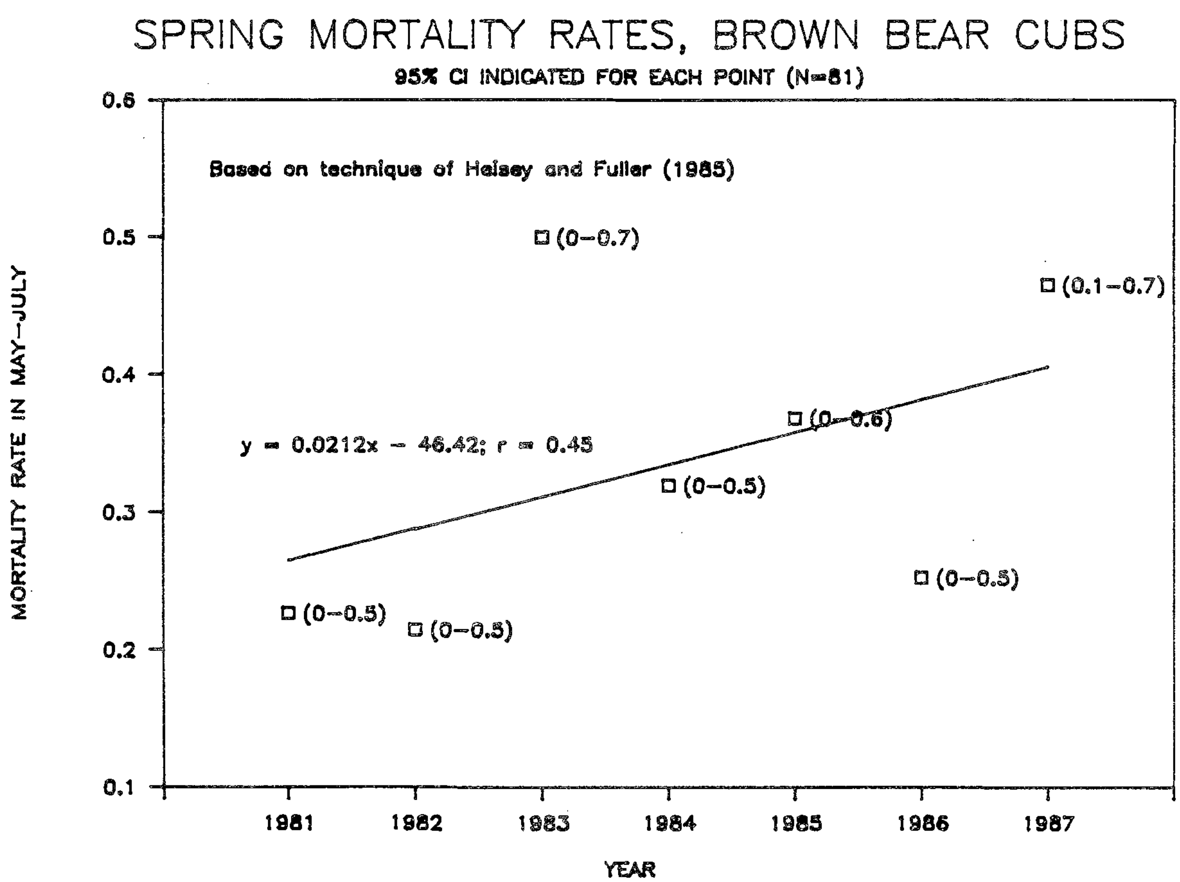

GMU 13 OFFSPRING MORTALITY TRENDS
% LOST IN YEAR
(15)
(4)
(10)
(13)
(6)
y[cub + ylg., 1978–'87] = –1.19x + 2388; r = 0.23
(23)
(29)
(22)
(22)
(4)
1978 1979 1980 1981 1982 1983 1984 1985 1986 1987
% CUB & YLG LOSS(N)

Figure 37. Seasonal mortality rates of brown bear cubs of radio-marked females calculated using MICROMORT. [Brbsp.wk1, brbsp.pic].

Figure 38. Trends in spring mortality rates of brown bear cubs of radio-marked females during 1981-1987 calculated using MICROMORT. [Brbsp.wk1, brbsp.pic].


BROWN BEAR CUB MORTALITY RATES
95% CI INDICATED, 1978-1987 DATA(n=87)
Based on technique of Halsey and Fuller (1985)
MORTALITY RATE
(UPPER LIMIT=0.46)
(EST.=0.35)
(LOWER LIMIT=0.23)
(UPPER LIMIT=0.14)
(EST.=0.08)
(UPPER LIMIT=0.14)
(EST.=0.07)
(UPPER LIMIT=0.55)
(EST.=0.44)
(LOWER LIMIT=0.31)
MAY-JUL
AUG-OCT
NOV-APR
ANNUAL


SPRING MORTALITY RATES, BROWN BEAR CUBS
95% CI INDICATED FOR EACH POINT (N=81)
Based on technique of Halsey and Fuller (1985)
MORTALITY RATE IN MAY-JULY
y = 0.0212x - 46.42; r = 0.45
(0-0.5)
(0-0.5)
(0-0.7)
(0-0.5)
(0-0.6)
(0-0.5)
(0.1-0.7)
YEAR

Appendix A. Groupings of Uniform Coding Areas used in analysis of GMU 13 brown bear harvest data.

1. Run 1. ("bear removal area plus dump codes"):

13E 2500 thru 13E 2900	
13E 3100 thru 13E 3200	
13E T01-blank	Nenana River 13E unk.
13E Z00-blank	Denali Hwy., Unknown 13E
13E S01-blank	Susitna River, 13E unk.
13E S00-blank	
13E S05-blank	
13E S06-blank	
13E T01-blank	
13B 0500 thru 13B 0800	
13B S00-blank	Susitna River 13B unk.
13B S05-blank	
13B S06-blank	Susitna River (N. of Forks)
13Z S05-blank	Susitna River (Butte Ck. to the forks 13)
13Z S06-blank	Susitna River (N. of forks, 13)
13Z S07-blank	Tyone River, 13 unk.

2. Run 2 ("Denali Hwy. plus dump codes"):

All of run 1 plus:

13E Z00-blank	Unit 13E unk.
13E Z00 076, 082, & 085	
13B 0300 thru 13B 0400	
13B 0900 thru 13B 1300	Eastern Denali Hwy.
13B 1600 thru 13B 1700	Paxton Lk.
13B Z00-76	Denali Hwy Unk. 13B
13Z Z00-76	Denali Hwy. Unk. 13

3. Run 3. ("Western 13E remote")

13E 0300 thru 13E 0700	W. of Parks Hwy., 13E

4. Run 4. ("13C remote")

13C 0100 thru 0500	E. of Gakona River, 13C
13C C00-blank	Copper River, 13C unk.
13C C01-blank	Slana River
13C C02-blank	Gakona River, E. bank

5. Run 5. ("13D remote")

13D 0100 thru 13D 0600	
13D 1000	Klutina Lk.
13D 1200	Tazlina Lk.
13D 0800	
13D 1600 thru 13D 1700	
13D 1900 thru 13D 2200	
13D 1300 thru 13D 1400	
13D Z00-blank	Chugach Mts.

Appendix A. (cont'd)

6. Run 6 ("Central 13 remote")

13E 1200 thru 13E 1400	Su Hydro
13E 1600 thru 13E 2400	Su Hydro
13E S00-blank	Susitna River 13E unk.
13E S02-blank	Talkeetna River 13E, unk.
13E S03-blank	Kosina Ck., 13E unk.
13A 1400 thru 13A 1900	Su Hydro (1900 not on map)
13A 2100	
13A 0800 thru 13A 0900	
13A S00-blank	Susitna River 13A unk.
13A S02-blank	Talkeetna River
13A S03-blank	Kosina River
13A S04-blank	Susitna River, Jay Ck-Butte Ck., 13A
13A S07-blank	Tyone River/Ck. 13A unk.
13B 0100 thru 13B 0200	Su Hydro
13B 1500	
13B S04-blank	Susitna River, Tyone-McLaren
13B S07-blank	Tyone River
13Z S03-blank	Kosina Ck. 13 unk.
13Z S04-blank	Susitna River (Jay Ck-Butte Ck., 13)
13Z S02-blank	Talkeetna River 13 unk.

7. Run 7 ("All of remote Unit 13"):
Areas in runs 3, 4, 5, and 6 lumped.

8. Run 8 ("Western 13E roads")

13E 0100 thru 13E 0200	
13E 0800 thru 13E 1100	
13E 3000	
13E 1500	
13E S01-blank	Chulitna River, unk.

9. Run 9 ("Glenn & Richardson Hwys, Lk. Louise")

13B 1400	
13B 1800	
13B C03-blank	Gulkana River 13B
13B T02-blank	Delta River 13B unk.
13B Z00-076 & 084	
13B C93 1784	Richardson Hwy
13B C02-blank	Gakona River, W. bank
13A 0100	Copper River, 13A unk.
13A 0300 thru 13A 0700	
13A 1000 thru 13A 1300	
13A 2000	Lk. Louise
13A C03-blank	Gulkana River 13A unk.
13A C04-blank	Tazlina River 13A unk.
13A M00-blank	Matanuska River 13A unk.
13A M02-blank	
13A Z00-072, 073 & 084	Lk. Louise Rd., unk., Glenn & Richardson Hwy unk. 13A

Appendix A. (cont'd)

13D 1800	
13D 2300	
13D 0900	
13D 1100	Copper Center
13D 1500	
13D 0700	
13D C00-blank	Copper River, 13D unk.
13D C00 070 & 084	
13D C04-blank	Tazlina River, 13D unk.
13D M00-blank	Matanuska River, 13D unk.
13C C00 073	Glenn Hwy, unk. 13C Tok cutoff
13Z C00-blank	Copper River 13 unk.
13Z C02-blank	Gakona River 13 unk.
13Z C03-blank	Gulkana River, 13 unk.
13Z C04-blank	Tazlina River 13 unk.
13Z M00-blank	Matanuska River, 13 unk.
13Z-Z00 073, 076 & 084	Unk. Hwy, Unit 13.

10. Run 10 ("All of Unit 13 Road system")
All of the areas in runs 2, 8, and 9 lumped.

Appendix B. Sightability of brown bears in five different parts of Alaska.

By S. Miller, W. Ballard, R. Smith, V. Barnes, and H. Reynolds.

Table B1. Summary of sightability data for brown bear studies in different portions of Alaska. Individual data are presented in Table 2.

	ALL MALES				ALONE FEMALES			
AREA	No. times "seen"	No. times "in"	TOTAL % seen	No. Indiv.	No. times "seen"	No. times "in"	TOTAL % seen	No. Indiv.
GMU 13	19	65	29.2	17	12	32	37.5	10
GMU 8	12	29	41.4	11	34	93	36.6	28
GMU 23	12	37	32.4	10	16	47	34.0	14
GMU 4	10	32	31.3	8	2	15	13.3	3
GMU 20	0	3	0.0	2	5	17	29.4	7
TOTAL	53	166	31.9	48	69	204	33.8	62

	ALL FEMALES				ALL FEMALES EXCEPT W/COY			
AREA	No. times "seen"	No. times "in"	TOTAL % seen	No. Indiv.	No. times "seen"	No. times "in"	TOTAL % seen	No. Indiv.
GMU 13	31	86	36.0	24	22	53	41.5	18
GMU 8	57	160	35.6	48	47	136	34.6	41
GMU 23	22	72	30.6	19	20	61	32.8	17
GMU 4	24	70	34.3	14	18	55	32.7	11
GMU 20	6	18	33.3	8	6	18	33.3	8
TOTAL	140	406	34.5	113	113	323	35.0	95

	FEMALES W/2 1-3				FEMALES W/COY			
AREA	No. times "seen"	No. times "in"	TOTAL % seen	No. Indiv.	No. times "seen"	No. times "in"	TOTAL % seen	No. Indiv.
GMU 13	10	21	47.6	8	9	33	27.3	6
GMU 8	13	43	30.2	13	10	24	41.7	7
GMU 23	4	14	28.6	3	2	11	18.2	2
GMU 4	16	40	40.0	8	6	15	40.0	3
GMU 20	1	1	100.0	1				
TOTAL	44	119	37.0	33	27	83	32.5	18

	ALL BEARS			
AREA	No. times "seen"	No. times "in"	TOTAL % seen	No. Indiv.
GMU 13	50	151	33.1	41
GMU 8	69	189	36.5	59
GMU 23	34	109	31.2	29
GMU 4	34	102	33.3	22
GMU 20	6	21	28.6	10
TOTAL	193	572	33.7	161

Table B2. Raw sightability data obtained during bear density estimation studies in Alaska.

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Area Codes: 1 = GMU 1 3(85), 2 = GMU 13 (87), 3 = GMU 23, 4 = GMU 4 (87), 5 = GMU 8 (TERROR LK.), 6 = GMU 8 (KARLUK), 7 = GMU 20.

Sex codes: 1 = male, 2 = female

Status codes: 1 = alone (includes breeding pairs), 2 = with COY, 3 = with ylg(s), 4 = with @ 2, 5 = with @3.

Age codes: 99 = age unknown ¶3, some ages estimated.

MALES 1985 Su-hydro estimate

AREA	Bear ID	sex	age	status	No. times "seen"	No. times " in"	TOTAL % seen
1	421	1	2	1	1	5	20.0
1	382	1	3	1	2	5	40.0
1	427	1	3	1	1	6	16.7
1	422	1	7	1	1	4	25.0
1	282	1	9	1	1	7	14.3
1	214	1	9	1	0	3	0.0
1	280	1	10	1	1	2	50.0
1	399	1	11	1	2	6	33.3
1	309	1	17	1	0	2	0.0
1	400	1	22	1	0	6	0.0
	TOTAL	10			9	46	19.6

MALES 1987 Upper Susitna estimate

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
2	476	1	2	1	2	4	50.0
2	480	1	2	1	1	2	50.0
2	474	1	3	1	1	1	100.0
2	470	1	2	1	1	2	50.0
2	457	1	8	1	1	1	100.0
2	455	1	9	1	1	3	33.3
2	471	1	5	1	3	6	50.0
	TOTAL	7			10	19	52.6

Table B2. (cont'd)

MALES Summary, GMU 13

	sex	status	No. times "seen"	No. times "in"	TOTAL % seen
	1	1	19	65	29.2
N =	17				

MALES 1987 Noatak study

AREA	Bear ID	sex	age	status	No. times seen"	No. times "in"	TOTAL % seen
3	31	1	4	1	1	1	100.0
3	34	1	6	1	3	7	42.9
3	24	1	9	1	0	1	0.0
3	45	1	9	1	1	6	16.7
3	46	1	9	1	2	5	40.0
3	56	1	99	1	0	2	0.0
3	57	1	99	1	1	6	16.7
3	64	1	99	1	2	5	40.0
3	68	1	99	1	1	2	50.0
3	72	1	99	1	1	2	50.0
	TOTAL	10			12	37	32.4

MALES 1987 Kodiak (Terror Lake) study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times " in"	TOTAL % seen
5	147	1	2	1	0	2	0.0
5	150	1	4	1	0	2	0.0
5	151	1	4	1	2	3	66.7
5	102	1	8	1	1	3	33.3
5	4	1	9	1	0	3	0.0
5	137	1	9	1	3	3	100.0
	TOTAL	6			6	16	37.5

MALES 1987 Kodiak (Karluk Lake) study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
6	802	1	3	1	0	3	0.0
6	796	1	11	1	1	2	50.0
6	801	1	8	1	3	4	75.0
6	807	1	21	1	2	3	66.7
6	809	1	9	1	0	1	0.0
	TOTAL	5			6	13	46.2

Table B2. (cont'd)

MALES Summary GMU 8 data from Kodiak

	sex	status	No. times "seen"	No. times "in"	TOTAL % seen
	1	1	12	29	41.4
N =	11				

MALES 1987 Admirality study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times " in"	TOTAL % seen
4	97	1	12	1	0	1	0.0
4	13	1	20	1	2	2	100.0
4	61	1	10	1	0	5	0.0
4	52	1	5	1	0	4	0.0
4	46	1	6	1	2	5	40.0
4	98	1	15	1	3	5	60.0
4	76	1	4	1	1	5	20.0
4	27	1	4	1	2	5	40.0
	TOTAL	8			10	32	31.3

MALES 1986 NW Alaska Range

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
7	1371	1	2	1	0	2	0.0
7	1310	1	17	1	0	3	0.0
	TOTAL	2			0	5	0.0

FEMALES-ALONE 1985 Su-hydro estimate

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
1	437	2	2	1	1	4	25.0
1	398	2	4	1	0	6	0.0
1	397	2	4	1	0	3	0.0
1	447	2	7	1	0	2	0.0
1	273	2	9	1	1	2	50.0
1	341	2	10	1	1	4	25.0
1	420	2	20	1	0	1	0.0
	TOTAL	7			3	22	13.6

Table B2. (cont'd)

FEMALES-ALONE 1987 Upper Susitna estimate

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
2	477	2	2	1	0	3	0.0
2	459	2	4	1	1	2	50.0
2	472	2	5	1	3	5	60.0
	TOTAL	3			9	10	90.0

Summary, GMU 13

	sex	status	No. times "seen"	No. times "in"	TOTAL % seen
	2	1	12	32	37.5
N =	10				

FEMALES-ALONE 1987 Noatak study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
3	8	2	5	1	2	5	40.0
3	32	2	4	1	2	3	66.7
3	20	2	6	1	1	3	33.3
3	2	2	6	1	1	2	50.0
3	41	2	7	1	1	3	33.3
3	22	2	9	1	4	7	57.1
3	9	2	14	1	0	4	0.0
3	43	2	18	1	3	6	50.0
3	65	2	99	1	1	3	33.3
3	66	2	99	1	0	1	0.0
3	67	2	99	1	1	4	25.0
3	69	2	99	1	0	2	0.0
3	70	2	99	1	0	2	0.0
3	71	2	99	1	0	2	0.0
	TOTAL	14		16	47		34.0

Table B2. (cont'd)

FEMALES-ALONE 1987 Kodiak (Terror Lake) study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
5	125	2	5	1	1	3	33.3
5	19	2	11	1	0	3	0.0
5	44	2	8	1	1	3	33.3
5	51	2	13	1	1	3	33.3
5	55	2	18	1	1	3	33.3
5	85	2	8	1	1	2	50.0
5	88	2	13	1	1	3	33.3
5	99	2	13	1	1	3	33.3
5	140	2	99	1	0	3	0.0
5	141	2	99	1	1	3	33.3
5	143	2	99	1	0	3	0.0
5	145	2	99	1	1	2	50.0
5	148	2	99	1	0	3	0.0
	TOTAL	13			9	37	24.3

FEMALES-ALONE 1987 Kodiak (Karluk Lake) study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times in"	TOTAL % seen
6	791	2	2	1	1	4	25.0
6	810	2	3	1	1	4	25.0
6	783	2	4	1	2	4	50.0
6	800	2	4	1	1	4	25.0
6	803	2	5	1	0	4	0.0
6	806	2	5	1	2	4	50.0
6	808	2	4	1	3	4	75.0
6	755	2	24	1	2	4	50.0
6	742	2	19	1	3	4	75.0
6	765	2	10	1	3	4	75.0
6	792	2	13	1	2	4	50.0
6	794	2	13	1	1	4	25.0
6	798	2	11	1	1	3	33.3
6	811	2	5	1	2	4	50.0
6	776	2	12	1	1	1	100.0
	TOTAL	15			25	56	44.6

Table B2. (cont'd)

FEMALES-ALONE Summary GMU 8 data from Kodiak

	sex	status	No. times "seen"	No. times "in"	TOTAL % seen
	2	1	34	93	36.6
N =	28				

FEMALES-ALONE 1987 Admirality study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
4	79	2	5	1	0	5	0.0
4	71	2	6	1	1	5	20.0
4	16	2	7	1	1	5	20.0
	TOTAL	3			2	15	13.3

FEMALES-ALONE 1986 NW Alaska Range

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
7	1370	2	2	1	1	3	33.3
7	1361	2	4	1	1	3	33.3
7	1341	2	13	1	1	3	33.3
7	1320	2	21	1	1	2	50.0
7	1318	2	17	1	0	2	0.0
7	1311	2	16	1	0	1	0.0
7	1308	2	10	1	1	3	33.3
	TOTAL	7			5	17	29.4

FEMALES WITH OFFSPRING AGED 1-3 1985 Su-hydro estimate

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
1	340	2	7	3	2	4	50.0
1	314	2	7	3	2	6	33.3
1	337	2	17	3	0	3	0.0
1	423	2	21	3	4	4	100.0
	TOTAL	4			8	17	47.1

Table B2. (cont'd)

FEMALES WITH OFFSPRING AGED 1-3 1987 Upper Susitna estimate

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
2	460	2	8	3	1	1	100.0
2	469	2	6	3	0	1	0.0
2	478	2	9	3	0	1	0.0
2	482	2	7	3	1	1	100.0
	TOTAL	4			2	4	50.0

Summary, GMU 13

	sex	status	No. times "seen"	No. times "in"	TOTAL % seen
	1	1	10	21	47.6
N =	8				

FEMALES WITH OFFSPRING AGED 1-3 1987 Noatak study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
3	53	2	99	3	0	4	0.0
3	63	2	99	3	3	5	60.0
3	58	2	99	3	1	5	20.0
	TOTAL	3			4	14	28.6

FEMALES WITH OFFSPRING AGED 1-3 1987 Kodiak (Terror Lake) study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
5	20	2	11	4	1	3	33.3
5	22	2	12	4	3	3	100.0
5	119	2	9	4	1	3	33.3
5	131	2	14	4	0	3	0.0
5	132	2	18	4	1	3	33.3
5	133	2	13	5	0	3	0.0
5	136	2	17	4	0	3	0.0
	TOTAL	7			6	21	28.6

Table B2. (cont'd)

FEMALES WITH OFFSPRING AGED 1-3 1987 Kodiak (Karluk Lake) study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
6	713	2	10	3	1	4	25.0
6	741	2	14	3	1	4	25.0
6	760	2	11	3	2	3	66.7
6	793	2	10	3	2	4	50.0
6	776	2	12	4	0	3	0.0
6	707	2	18	4	1	4	25.0
	TOTAL	6			7	22	31.8

Summary GMU 8 data from Kodiak

	sex	status	No. times "seen"	No. times "in"	TOTAL % seen
	2		13	43	30.2
N =	13				

FEMALES WITH OFFSPRING AGED 1-3 1987 Admirality study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
4	39	2	15	3	0	5	0.0
4	84	2	11	3	1	5	20.0
4	85	2	8	3	3	5	60.0
4	89	2	11	3	3	5	60.0
4	96	2	8	3	1	5	20.0
4	55	2	11	4	2	5	40.0
4	64	2	18	4	2	5	40.0
4	60	2	26	4	4	5	80.0
	TOTAL	8			16	40	40.0

FEMALES WITH NEWBORN CUBS 1986 NW Alaska Range

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
7	1321	2	20	3	1	1	100.0
	TOTAL	1			1	1	100.0

Table B2. (cont'd)

FEMALES WITH NEWBORN CUBS 1985 Su-hydro estimate

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
1	381	2	6	2	0	1	0.0
1	281	2	8	2	2	7	28.6
1	396	2	15	2	3	7	42.9
1	388	2	16	2	2	7	28.6
1	425	2	99	2	1	7	14.3
	TOTAL	5			8	29	27.6

FEMALES WITH NEWBORN CUBS 1987 Upper Susitna estimate

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
2	458	2	18	2	1	4	25.0
	TOTAL	1			1	4	25.0

FEMALES WITH NEWBORN CUBS Summary, GMU 13

	sex	status	No. times "seen"	No. times "in"	TOTAL % seen
	1	2	9	33	27.3
N =	6				

FEMALES WITH NEWBORN CUBS 1987 Noatak study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
3	28	2	10	2	0	7	0.0
3	59	2	99	2	2	4	50.0
	TOTAL	2		2	2	11	18.2

FEMALES WITH NEWBORN CUBS 1987 Kodiak (Terror Lake),
2 FF w/coy in dens not included

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
5	11	2	11	2	0	4	0.0
5	46	2	11	2	3	3	100.0
5	64	2	25	2	2	3	66.7
5	86	2	12	2	3	3	100.0
	TOTAL	4			8	13	61.5

Table B2. (cont'd)

FEMALES WITH NEWBORN CUBS 1987 Kodiak (Karluk Lake) study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
6	730	2	20	2	0	4	0.0
6	762	2	13	2	1	4	25.0
6	784	2	11	2	1	3	33.3
	TOTAL	3			2	11	18.2

Summary GMU 8 data from Kodiak

	sex	status	No. times "seen"	No. times "in"	TOTAL % seen
	2	2	10	24	41.7
N =	7				

FEMALES WITH NEWBORN CUBS 1987 Admiralty study

AREA	Bear ID	sex	age	status	No. times "seen"	No. times "in"	TOTAL % seen
4	43	2	21	2	1	5	20.0
4	14	2	13	2	3	5	60.0
4	56	2	18	2	2	5	40.0
	TOTAL	3		2	6	15	40.0

Table B3. Sightability data obtained during bear density estimation studies.

Weighted by individual, not by No. times present as in Table 1. Updated 3/24/88.

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Area Codes: 1 = GMU13(85), 2 = GMU 13 (87), 3 = GMU 23, 4 = GMU 4 (87), 5 = GMU 8 (TERROR LK.), 6 = GMU 8 (KARLUK), 7 = GMU 20.

Sex/status codes: 1 = subadult (2-4) male, 2 = subadult (2-4) female, 3 = adult male, 4 = adult females alone, 5 = female with coy, and 6 = females with @ 1-3.

Season codes: 1 = breeding, 2 = nonbreeding

Area	season	class	'Pseen	Pnotseen	Total N
1	1	1	0.7668	2.2330	3
1	1	3	1.2259	5.7738	7
2	1	1	2.5000	1.5000	4
2	1	3	1.8333	1.1667	3
3	1	1	1.0000	0.0000	1
3	1	3	2.5619	6.4381	9
5	1	1	0.6667	2.3333	3
5	1	3	1.3333	1.6667	3
6	1	1	0.0000	1.0000	1
6	1	3	1.9167	2.0833	4
4	2	1	0.6000	1.4000	2
4	2	3	2.0000	4.0000	6
7	1	1	0.0000	1.0000	1
7	1	3	0.0000	1.0000	1
1	1	2	0.2500	2.7500	3
1	1	4	0.7500	3.2500	4
2	1	2	0.5000	1.5000	2
2	1	4	0.6000	0.4000	1
3	1	2	0.6667	0.3333	1
3	1	4	3.2213	9.7787	13
5	1	2	0.0000	0.0000	0
5	1	4	3.3331	9.6669	13
6	1	2	2.5000	4.5000	7
6	1	4	4.5833	3.4167	8
4	2	2	0.0000	0.0000	0
4	2	4	0.4000	2.6000	3
7	1	2	0.6667	1.3333	2
7	1	4	1.1667	3.8333	5
1	1	6	1.8333	2.1667	4

Table B3. (cont'd)

Area	season	class	'Pseen	Pnotseen	Total N
2	1	6	2.0000	2.0000	4
3	1	6	0.8000	2.2000	3
5	1	6	1.9999	5.0001	7
6	1	6	1.9200	4.0800	6
4	2	6	3.2000	4.8000	8
7	1	6	1.0000	0.0000	1
1	1	5	1.1429	3.8571	5
2	1	5	0.2500	0.7500	1
3	1	5	0.5000	1.5000	2
5	1	5	2.6667	1.3333	4
6	1	5	0.5833	2.4167	3
4	2	5	1.2000	1.8000	3
7	1	5	0.0000	0.0000	0

Appendix C. Analysis of brown bear sightability data

by

Earl Becker

Memorandum dated 4 April 1988

Last month I wrote a memo on the results of my analysis of brown bear sightability, unfortunately, some of the data I was given to use in the analysis was incorrect. Since then, I've been given the correct data, reanalyzed the data, and will report the results in this memo.

In my initial analysis I was trying to develop a mathematical model to test if study area and/or bear class was statistically significant in explaining bear sightability on a statewide basis. The appropriate model to use is the logit model, which is a loglinear model in which the response variable is specified. I specified bear sightability as the response variable, and used bear class and study area as possible explanatory variables. Logit models 'adjust' the analysis for differences in the number of bears in each bear class and each study area, and then determines if the sightability differences by bear class or study area are statistically significant. In this analysis each bear had a weight of one, so for example, if a bear was in the study area four times but seen only once, 0.25 of an observation would be recorded as seen and 0.75 of an observation as not-seen.

A logit, loglinear model was fit to the brown bear sightability data from the following areas:

1) GMU 13 (1985) + GMU 13 (1987)
2) GMU 23
3) GMU 8 (Terror Lake)
4) GMU 8 (Karluk Lake)

with the following classes of bears:

1) subadults
2) breeders
3) female with coy
4) female with yearlings

Due to small sample size, lone male and females were classified as breeders, male and female subadults were classified as subadults, and data from GMU 20 and GMU 4 were not used in the analysis. There was no problem with zero cells in this data set, so one-half was not added to each cell. The 1987 GMU 13 data was not large enough to be analyzed alone and, as a result, was combined with the 1985 GMU 13 data.

Data:

		No. of bears	
Area	Bear-class	seen	not seen
	1	4.0168	7.9830
	2	4.4092	10.5905
1	3	1.3929	4.6071
	4	3.8333	4.1667
	1	1.6667	0.3333
	2	5.7832	16.2168
2	3	0.5000	1.5000
	4	0.8000	2.2000
	1	0.6667	2.3333
	2	4.6664	11.3336
3	3	2.6667	1.3333
	4	1.9999	5.0001
	1	2.5000	5.0000
	2	6.5000	5.0000
4	3	0.5833	2.4167
	4	1.9200	4.0800

The best model was one with no area or bear class term, and said that bear sightability was constant over all areas and bear classes. The model predicted the odds of seeing a bear versus not seeing a bear, on any given day, is 0.516 to 1, which translates to a predicted sightability of 0.340 (S.E. 0.042). Predicted sightability is obtained by solving the following formula for p: $p/(1-p) = R$; where R is the odds ratio, and solving for p. The standard errors were obtained using binomial distribution results.

By examining the parameter estimates from force fitting the bear class effects into the model, it can easily be seen that bear class is not significant. The results are listed below:

Bear Class	Seen vs. Not	Sightability	S.E.
Subadult	0.548:1	0.354	0.096
Breeders	0.489:1	0.329	0.058
F w/coy	0.522:1	0.343	0.123
F w/yrlg+	0.554:1	0.357	0.098
Best Model	0.516:1	0.340	0.042

By examining the parameter estimates from force fitting the area effects into the model, it can easily be seen that area is not significant. The results are listed below:

Bear Class	Seen Vs. Not	Sightability	S.E.
GMU 13*	0.499:1	0.333	0.074
GMU 23	0.42:1	0.302	0.085
Terror L.	0.500:1	0.333	0.086
Karluk L.	0.657:	0.397	0.091
Best Model	0.516:1	0.340	0.042

* - 1985 + 1987 data sets combined.

One thing to note from the above two tables is that the range in sightability estimates is much greater for the study area effect versus the bear-class effect.

In the second part of my analysis, I constructed a goodness of fit statistic to test for departures from the assumption of constant capture probability, by both day and individual, among marked bears where the capture probability used in the calculations of this statistic was the average sightability of all bears. This statistic consisted of a treating each bear as a binomial random variable, using the number of days the bear stayed in the study area as n, and determining the expected distribution of the number of times this bear should have been sighted, using the average sightability of that study area as that bears capture probability. These random variables were then added up to generate the expected number of bears which should have been seen 'X' times under the null hypothesis (capture homogeneity). Since the data consisted of only marked bears, we are only making inferences about differences in capture probabilities among marked bears. The following areas were tested, GMU 13, GMU 23, Terror Lake, and Karluk Lake, these four study areas pooled, and GMU 4.

Data Summary:

GMU 13	Times Seen	Observed	Expected
	0	12	12.54
	1	18	14.36
	2	7	8.46
	3	3	3.96
	4	1	1.34
	5	0	0.30
	6	0	0.04
	7	0	0.002

GMU 23	Times Seen	Observed	Expected
	0	9	9.23
	1	11	10.69
	2	5	5.95
	3	3	2.34
	4	1	0.66
	5	0	0.12
	6	0	0.01
	7	0	0.001

Terror Lake	Times Seen	Observed	Expected
	0	11	9.49
	1	13	13.33
	2	2	6.21
	3	4	0.96

Karluk Lake	Times Seen	Observed	Expected
	0	5	5.53
	1	12	10.83
	2	8	8.75
	3	4	3.39
	4	0	0.50

Above four areas	Times Seen	Observed	Expected
	0	37	36.71
	1	54	49.74
	2	22	29.00
	3	14	10.32
	4	2	2.63
	5	0	0.53
	6	0	0.07
	7	0	0.004

GMU 4	Times Seen	Observed	Expected
	0	5	3.75
	1	6	7.38
	2	6	6.69
	3	4	3.28
	4	1	0.82
	5	0	0.08

The summary statistics listed below have pooled the cells with low expected values to obtain an expected cell value close to one (Cochran's rule).

Summary Statistics:

Area	P-value
GMU 13	0.789
GMU 23	0.982
Terror L.	0.005
Karluk L.	0.932
Above four areas	0.409
GMU 4	0.922

Based on the results above, there was strong evidence that the constant capture probability assumption was not met for the Terror Lake data set. Based on contribution to the Chi-square statistic ((Obs. - Exp.) 2/Exp.), it is easily seen that the four bears observed on all three days of the study, when only one was expected, was the main contributor to the rejection of the hypothesis of capture homogeneity. It is interesting to note this study had the smallest number of trials (three); this study also had the smallest 'day' effect, since the trails were 'pieced together' from several different days. I suspect that increasing the number of trials would've reduced the capture heterogeneity problem. It is much harder to get abnormal results over a five-trial period versus a three-trail period, therefore, for all of the mark and recapture studies, I recommend five trials as a minimum number. Except for the data set from Terror Lake, we did not reject the null hypothesis, however, this does NOT mean that we proved that we have capture homogeneity.

Appendix D. Black bear reproductive data updated from that presented by Miller (1987a).

Table D1. Summary of black bear litter size data based on observations of bea with litters of newborn cubs.

MOTHER'S ID (age-year)	LITTER SIZE	COMMENTS
B289 (10 in spring '81)	3	lost 1 in August, 2 survived
B289 (12 in spring '83)	2	lost 1 cub in September, other survived to den exit
B289 (14 in spring '85)	2 (in den) [2 at exit]	both survived to yearling age
B289 (16 in spring '87)	1	survived to Aug., at least
B301 (8 in spring '81)	2	both survived to yearling age
B301 (10 in spring '83)	2 (in den) [2 at exit]	survivorship undetermined, female shed collar
B317 (7 in summer '80)	2 (summer)	initial capture in summer, both survived to fall, cubs not seen with bear at initial capture
B317 (10 in '83)	2 (in den) [2 at exit]	lost 1 in June, other survived to den exit
B317 (12 in spring '85)	2 (in den) [2 at exit]	1 survived to den entrance, 1 lost in July
B317 (13 in spring '87)	2	survived to Aug., at least
B318 (5 in summer '80)	1 (summer)	survived
B318 (8 in '83)	2 (den) [2 at exit]	both lost by 6/6/83 apparently, shed collar
B328 (7 in summer '81)	2 (summer)	bred in 1980. Lost 1 by 7/29/81, shed collar in den (not sure if survived until exit)
B328 (11 in spring '85)	3 (in den) [3 at exit]	lost 6/6 - 7/24
B328 (13 in spring '87)	3	survived to den entrance
B326 (5 in summer '80)	2 (summer)	bear shot in 1980, cubs may have been adopted by B317
B321 (11 in spring '81)	2	no cubs in summer 1980, both cubs lost by 8/24/81, no litter in '82, no litter verified in 1983 but may have lost a litter early in 1983, bred in 1983

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Table D1. (cont'd)

MOTHER'S ID (age-year)	LITTER SIZE	COMMENTS
B321 (14 in '84)	2	lost 1 of 2 by 6/29, other survived to den entrance
B327 (5 in summer '80)	2 (summer)	both survived to yearling age
B327 (8 in '83)	2 (den)	cubs survived into June, female
B349 (6 in spring '83)	2 (den) [0 at exit?]	first litter, no cubs in summer '81 or spring '82, cubs apparently lost in May '83, collar shed in July -- no ylgs on 5/84
B349 (8 in spring '85)	2 (in den) [2 at exit]	one survived to den entrance, 1 lost in August
B349 (9 in '87)	2	survived to den entrance
B354 (5 in '82)	2	both survived to den entrance, at least 1 ylg at exit in '83
B354 (7 in '84)	2	may have lost 1 by den entrance date
B354 (9 in '86)	2	1 lost in Sept., other ok to exit
B361 (8 in '83)	4 (in den) [3 at exit]	lost 1 in den prior to exit, others survived to den exit in '84
B361 (12 in '87)	2	survived to den entrance
B370 (8 in '83)	2 (in den) [2 at exit]	bear missing after 5/23/83, cubs alive at that time
B363 (6 in '84)	2 (in den) [2 at exit]	None lost to den entrance
B363 (8 in '87)	2	survived to den entrance
B364 (10 in '86)	2	both survived to den exit
B369* (6 in '84)	2 (in den) [2 at exit]	none lost to den entrance
B369* (9 in '87)	2	survived
B372* (10 in '83)	3(in den) [3 at exit]	lost 1 in early July, others survived to 7/20, female lost in September '83

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Table D1. (cont'd)

MOTHER'S ID (age-year)	LITTER SIZE	COMMENTS
B374* (7 in '83)	3	think lost 2 in July, bear shot in September '83
B375* (6 in '83)	2	both survived to exit in '84
B376* (5 in '83)	3 (in den) [3 at exit]	all survived to exit in '84
B377* (5 in '83)	[1-2??] NOT COUNTED	cubs may have been lost prior to or during capture, cubs not seen during capture but saw at least 1 cub 9 days earlier on 5/10/83
B377 (6 in '84)	some (in den) [0 at exit]	heard at least 1 cub in den, none seen at exit
B377 (7 in '85)	2 (in den) [2 at exit]	lost 1 in June, other in August-September
B377 (9 in '87)	3	at least 2 survived
B378* (7 in '83)	2(den) [2 at exit]	both survived to '84 den exit
B378* (9 in '85)	1	survived to den entrance
B378* (11 in '87)	2	survived to den entrance
B379 (9 in '83)	3(den) [2 at exit]	lost all cubs by 5/23/83, bred again, died in July
B402* (12 in '85)	2 (in den) [2 at exit]	both survived to den entrance
B404* (11 in '83)	1	survived thru 7/20/83 at least, not seen in '84
B405* (17 in'83)	2	both survived to den exit in '84
B406* (11 in '83)	2	both survived to den exit in '84
B409* (?)(6 in '84)	?	not observed in '84
B409* (7 in '85)	2	probable age = cub, survived
B409* (9 in '87)	2	survivorship?
B410* (7 in '83)	2	both survived thru June, bear shot in July

Table D1. (cont'd)

MOTHER'S ID (age-year)	LITTER SIZE	COMMENTS
B411* (9 in '84)	2	status at entrance into '84 den unknown
B438 (9 in '86)	3	B438 probably shot by 9/5/86, cub status unknown
B441 (11 in '87)	2	survived
B329 (7 in '87)	2	1 lost in June-Aug., other ok
B448 (8 in '87)	2	assumed lost when mother died

Total number of cubs	Number of litters	Mean litter size (range)	Comments (includes)
119	56	2.13(1-4)	all cub litters counted at earliest observation
104	49	2.12(1-3)	spring observations only (w/o den data or summer litters)
110	50	2.20(1-4)	earliest observation excluding summer litters
44	19	2.3(2-4)	observations in dens only

* Downstream study area

Table D2. Summary of black bear litter size data based on observations of bears with litters of yearlings (age at exit from den).

MOTHER'S ID (age-year)	LITTER SIZE	COMMENTS
B288 (10 in 1980)	3	bred in 1980, ylgs with female into August, shed collar in 1980
B290 (8 in 1980)	2	weaned by 6/23/80, bred in 1981, collar removed on 8/5/81 (neck scarred)
B289 (9 in 1980)	2	weaned by 5/22/80, bred, 3 cubs in '81
B289 (13 in 1984)	1	with mom to September bred in June
B289 (11 in 1982)	2 (in den)	weaned by 6/9/82, bred, had 2 cubs in 1983
B289 (15 in 1986)	2	weaned by 7/9/86
B301 (7 in 1980)	1	weaned by 6/12/80, bred, had 2 cubs in 1981
B301 (9 in 1982)	2	weaned by 6/17/82, bred, had 3 cubs in 1983
B317 (8 in 1981)	2	weaned by 6/18/81, bred, 1 ylg returned and was with female until 9/9/81, no cubs in 1982
B317 (11 in 1984)	1	weaned in June, bred
B318 (6 in 1981)	1 (den)	ylg (B330) weaned by 5/29/81, bred, ylg died by 8/24/81, no (reason?) cubs in 1982, bred again, 2 cubs in 1983
B318 (10 in 1985)	2	B318 not located after 6/11/85
B327 (5 in 1981)	2 (den)	ylg B329 and sibling, sibling weaned by 6/5/81, B329 by 6/21, bred, no cubs in 1982, bred again, cubs in 1983
B349 (9 in 1986)	1	
B354 (6 in 1983)	1 (?)	at least 1 ylg exited den (perhaps both?), weaned by 6/2/83
B354 (10 in '87)	1	weaned after 6/7

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Table D2. (cont'd)

MOTHER'S ID (age-year)	LITTER SIZE	COMMENTS
B363 (8 in 1985)	2	weaned by 9/4/85
B364 (8 in 1984)	3	2 weaned early, bred, still with one in September
B364 (11 in '87)	2	2 weaned in June
B369* (7 in 1985)	2 (in den) [2 at exit]	
B402* (10 in 1983)	3	weaned in early July
B402* (13 in 1986)	2	weaned by September
B409* (8 in '86)	2	probable age = 1
B411* (8 in 1983)	2	weaned after 6/13
B321 (15 in 1986)	1	weaned by 6/27/85
B361 (9 in 1984)	3	entered den w/mom, weaned at age 2
B375* (11 in 1984)	2	weaned in June
B376* (8 in 1984)	3	weaned 2 in June, 1 with mom in October
B378* (8 in 1984)	2	Not seen after June
B404* (12 in 1984)	[?]	'84 status not verified
B405* (18 in 1984)	2	with mom into August
B406* (12 in 1984)	2	weaned by September
B432 (6 in 1985)	1	weaned by 6/3/85

Total number of ylgs. observed	number of litters	mean litter size (range)	comments
59	31	1.90(1-3)	all litters with ylgs. counted

* Downstream study area

Table D3. Reproductive histories of radio-marked female black bears. ("Shed" refers to removal by bear of radio collar.) Bears were in upstream study area unless otherwise indicated.

Year	289 (9 in '80)	290 (8 in '80)	301 (7 in '80)	317 (7 in '80)
1980	w/2@1 weaned in May-bred	w/2@1 weaned in June	w/1@1 weaned in June	w/2@0 in Aug.
1981	w/3@0, 1 lost in Aug.	alone, bred collar removed	w/2@0,	w/2@1, weaned in June, bred, reunitd w/1@1 thru Sept.
1982	weaned 2@1, May-June, bred	--	w/2@1, weaned in June, bred	no newborns, possibly w/1@2 into June,
1983	w/2@0, 1 lost in Sept.,	--	w/2@0, shot in Sept.	w/2@0, 1 lost in June
1984	weaned 1@1 in May, bred, reunited June-Sept. weaned in Sept.	--	--	w/1@1, weaned, June, bred, reunited predenning
1985	w/2@0, survived	--	--	w/2@0, 1 lost in July, other okay thru Sept. at least
1986	w/2@1, weaned (date?)	--	--	alone in June
1987	w/1@0, survived	--	--	w/2@0, survived

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Table D3. (cont'd)

Year	318 5 in '80	321 10 in '80	325 11 in '80	327 5 in '80	328 6 in '80	329 1 in '81	349 4 in '81	354 5 in '82	361 7 in '82	363 4 in '82
1980	w/1@0 in Aug.	alone in Aug.	alone in Aug.	w/2@0 in in Aug.	alone in Aug.	with mother 327	--	--	--	--
1981	w/1@1, weaned in May, bred	w/2@0, lost both in Aug.	alone, shed in next den	w/2@1 in den, 1 weaned in May, other in June, bred	w/2@0, 1 lost in July, other okay thru Sept., collar shed	weaned from 327 in June	alone	--	--	--
1982	alone	alone	--	alone, bred	?	alone	alone	w/2@0 to den entrance	alone	alone, bred?
1983	w/2@0, suspect lost both June, shed	think lost litter very early, bred	--	w/2@0, mother died in July	?	alone, bred?	w/2@0, both lost in den	w/1@1 weaned in May, bred	w/4@0 in den, 1 lost in den	alone, bred
1984	[must have had at least 2@0 based on 1985]	w/1@0 (in July)	--	--	alone, bred	alone, bred?	alone	w/2@0, 1 lost in Sept.	w/3@1 not weaned--seen in den	w/2@0 survived
1985	w/2@1 in June when reported	w/1@1 weaned in June	--	--	w/3@0, all lost in June-July	alone, bred?	w/2@0 in den, 1 lost in Aug.	alone (June)	w/3@2, weaned in June	w/2@1 weaned, date?
1986	?	alone	--	--	alone	alone	w/1@1, weaned (date?)	w/2@0 (Sept.), 1 lost in Sept. 2	alone in June	alone, bred
1987	--	alone, died	--	--	w/36, survived	w/2c, 1 lost in June-Aug.	w/2c, survived	w/1@1, weaned	w/2c, survived	w/2c, survived

(continued on next page)

Table D3. (cont'd)

Year	364 6 in '82	Downstream 367 4 in '82	Downstream 369 4 in '82	Downstream 370 7 in '82	Downstream 372 9 in '82	Downstream 374 7 in '82	Downstream 375 9 in '82	Downstream 376 6 in '82	Downstream 377 4 in '82	Downstream 378 6 in '82	Downstream 402 10 in '83
1982	alone, bred, collar failed	alone	alone	alone	alone, bred	alone?	w/3@1?	alone?	alone	alone	--
1983	[must have had cubs based on 1984]	alone-shot	alone	w/2@0, failed collar	w/2@0, failed collar	w/3@0, 2 died in July, shot in fall	w/2@0, survived	w/3@0	alone?	w/2@0, survived	w/3@1, weaned in June
1984	w/3@1, weaned in June-July, bred, reunited w/1 in Sept.	--	2@0 in den lost 1 in Sept.	--	--	--	w/2@1 weaned in July	w/3@1, weaned in May, reunited in July and Sept.	alone	w/2@1, weaned	alone
1985	w/1@2 in June	--	w/1@1 weaned in June-July	--	--	--	shot in spring	alone?	w/2@0, 1 lost in June, other in July-Aug.	w/1@0, survived	w/2@0
1986	w/2@0, survived thru Sept.	--	alone?	--	--	--	--	alone	alone	alone	w/2@1, survived
1987	w/2@1 weaned	--	w/2c, survived	--	--	--	--	alone, bred	w/3c, 2+ survived	w/2c, survived	alone

(continued on next page)

Table D3. (cont'd)

Year	Downstream 404 11 in '83	Downstream 405 17 in '83	Downstream 406 11 in '83	Downstream 409 5 in '83	Downstream 410 7 in '83	Downstream 411 8 in '83	431 11 in '85	432 6 in '85	438 8 in '85	441 9 in '85	448 6 in '85
1982	--	--	--	--	--	--	--	--	--	--	
1983	w/1@0 thru July, then ??	w/2@0, survived	w/2@0, survived	alone?	w/2@0 shot	w/2@1, weaned June-Aug.	--	--	--	--	
1984	alone in Aug.	w/2@1, not weaned	w/2@1, weaned in June-Aug., collar failed	alone?	--	w/2 c, survived	--	--	--	--	
1985	3@0 in den, shot in spring	w/2@2, weaned in June, shot	--	w/20 probable age	--	w/2@1	alone, bred	w/1@1, weaned in June, bred	w/2@2?, age??	alone, bred	alone, bred
1986	--	--	--	w/2@1 probable age	--	alone	alone in June	alone in June	w/3@0, shot	alone bred	alone
1987	--	--	--	w/2c, survivorship?	--	ND	ND	alone, shot	--	w/2c, survived	w/2c, died in summer

Table D4. Summary of known losses of black bear cubs-of-the-year. Losses calculated during first season out of den (in dens or at emergence from dens as cubs to entrance into dens as cubs).

Year	Upstream study area	Downstream study area	Both areas
1980	no data	no data	--
1981	4 of 9 lost (289, 301, 321, 328)	no data	4 of 9 lost
1982	0 of 2 lost (354)	no data	0 of 2 lost
1983 complete data	8 of 13 lost (289, 317, 361, 349)	1 of 12 lost (375, 376, 377**, 378, 405, 406)	9 of 25 lost
1983 incomplete data*	[2 of 2 lost (318]	[3 of 6 lost (372, 374)]	[5 of 8 lost]
1984 complete data	1 of 4 lost (321, 363)	0 of 2 lost (369)	1 of 6 lost
1984 incomplete data*	[1 of 2 lost (354)]	[1 of ? lost (377)]	[1 of 2 lost]
1985 complete data	7 of 11 lost (289, 317, 328, 349, 377)	0 of 3 lost (378, 402)	7 of 14 lost
1986 complete data***	0 of 4 lost (354, 364)	0 of 0 lost	0 of 4 lost
1987 complete data****	2 of 18 lost (289, 317, 328, 349, 354, 361, 363, 441, 329)	0 of 4 lost (369, 378)	2 of 22 lost
TOTALS (all years)	22 of 61 = 36% lost	1 of 21 = 5% lost	23 of 82 = 28% lost

* incomplete data resulted from not observing the family status of the bear before it entered its winter den, shed collars, collar failures, or early hunter kills. Tabulated losses occurred prior to loss of the female to these causes.

** B377 may have lost 2 of 2 rather than the 1 of 1 tabulated in 1983, the initial litter size was not known with certainty.

*** B438 and B409 had inadequate data.

**** Not included are B377 (at least 2 of 3 survived), B409 (? of 2 survived), and B448 (2 of 2 assumed lost when mom died or was killed)

Table D5. Age at first reproduction for GMU 13 (Su-hydro area) black bear females. "Adult" means first litter was at indicated age or younger, "open*" means had no litter but not considered a subadult as could have had a previous, unobserved, litter.

		AGE					
ID	area	3	4	5	6	7	8
289	u	?	?	?	?	?	adult
290	u	?	?	?	?	adult	adult
301	u	?	?	?	cubs	adult	adult
317	u	?	?	?	?	adult	adult
318	u	?	?	cubs	adult	adult	adult
326	u	?	?	cubs	adult	adult	adult
327	u	?	?	cubs	adult	adult	adult
328	u	?	?	?	open*	cubs	adult
329	u	open	open	open	open	cubs	adult
349	u	?	open	open	cubs	adult	adult
354	u	?	?	cubs	adult	adult	adult
361	u	?	?	?	open*	adult	adult
363	u	?	open	open	cubs	adult	adult
364	u	?	?	?	open*	cubs	adult
367	d	?	open	open	?	adult	adult
368	d	open	?	?	?	?	?
369	d	?	open	open	cubs	adult	adult
370	d	?	?	?	?	open*	adult
374	d	?	?	?	?	open*	adult
375	d	?	?	?	?	?	adult
376	d	?	?	?	open*	cubs	adult
377	d	?	open	open	open	cubs	adult
378	d	?	?	?	open*	cubs	adult
409	d	?	?	open	open	cubs	adult
410	d	?	?	?	?	adult	adult
411	d	?	?	?	?	cubs	adult
432	u	?	?	cubs	adult	adult	adult
438	u	?	?	?	?	adult	adult
446	u	?	?	open	?	?	?
448	u	?	?	?	open*	open*	adult
# subadults		2	6	8	3	0	0
# 1st.litters		0	0	5	4	7	0
$\#^2$1st.litter		0	0	0	5	15	28
% "adult"		0.0	0.0	38.5	75.0	100.0	100.0

Mean age of first reproduction = 6.13 years

Appendix E. Brown bear immunization and physical data from those captured in the Susitna and Nenana River drainages in Unit 13 in 1987.

Date	Bear #	Sex	Age	Weight (kg)[a]	Telazol (mg)[b]	Telazol (mg/kg)	Induction time[c] (min)
5/30	459	F	4	90	1000	11.1	1.9
5/30	468	F	1	27E	600	22.2	0.6
5/30	469	F	6	125E	1000	8.0	5.4
5/30	470	M	2	84	1000	11.9	4.7
5/30	471	M	5	205E	1400	6.8	5.0
5/30	472	F	12	148E	600	4.0	11.0
5/30	473	F	6	134	1000	7.5	2.8
5/31	474	M	3	152	1000	6.6	3.6
5/31	475	M	1	32E	600	18.8	1.1
5/31	476	M	2	68E	600	8.8	1.6
5/31	477	F	2	57E	500	8.8	1.7
6/1	478	F	9	155E	1000	6.5	3.1
6/4	479	M	2	102	1000	9.8	2.5
6/4	480	M	2	93	1000	10.8	1.8
6/5	481	F	14	128	1000	7.8	3.1
6/5	341	F	12	142	1000	7.0	9.4
6/5	281	F	10	136E	1000	7.4	4.4
6/5	337	F	19	131	1000	7.6	3.8
6/5	340	F	9	155	1000	6.5	5.2
6/5	273	F	11	136E	1000	7.4	2.1
6/5	314	F	9	145E	1000	6.9	2.2
6/6	482	F	7	136E	1000	7.4	3.9
6/7	457	M	8	273E	1400	5.1	3.5
6/8	455	M	9	250E	1600	6.4	4.6
6/8	465	F	4	130E	1000	7.7	11.0
6/8	482	F	7	136E	1000	7.4	5.0
6/8	480	M	2	93	1000	10.8	3.1
6/8	479	M	2	102	1000	9.8	1.9
6/8	477	F	2	57E	1000	17.5	2.4
6/8	476	M	2	68E	1000	14.7	1.2
6/8	475	M	1	32E	600	18.8	1.4
6/8	473	F	6	134	1000	7.5	4.6
6/8	472	F	12	148E	1000	6.8	2.6
6/8	471	M	5	205E	1400	6.8	4.0
6/8	470	M	2	84	1000	11.9	4.6
Mean (Standard deviation)						9.5(±4.4)	3.7(±2.6)

[a] "E" means estimated, otherwise actual measured weight.

[b] Telazol is the A.H. Robins product name for the drug mixture of tiletamine hydrochloride and zolezepam hydrochloride, which is supplied in powdered form with equal mg concentrations of each drug. It was reconstituted to provide 200 mg/ml (100mg tiletamine and 100 mg zolazepam) solution. Recommended dose for brown bear is 7-9 mg/kg.

[c] Induction time is defined here as the time from initial injection until the bear was in sternal or lateral recumbency and no longer able to support itself on any of its legs. It may still have the ability to move its head and neck.

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