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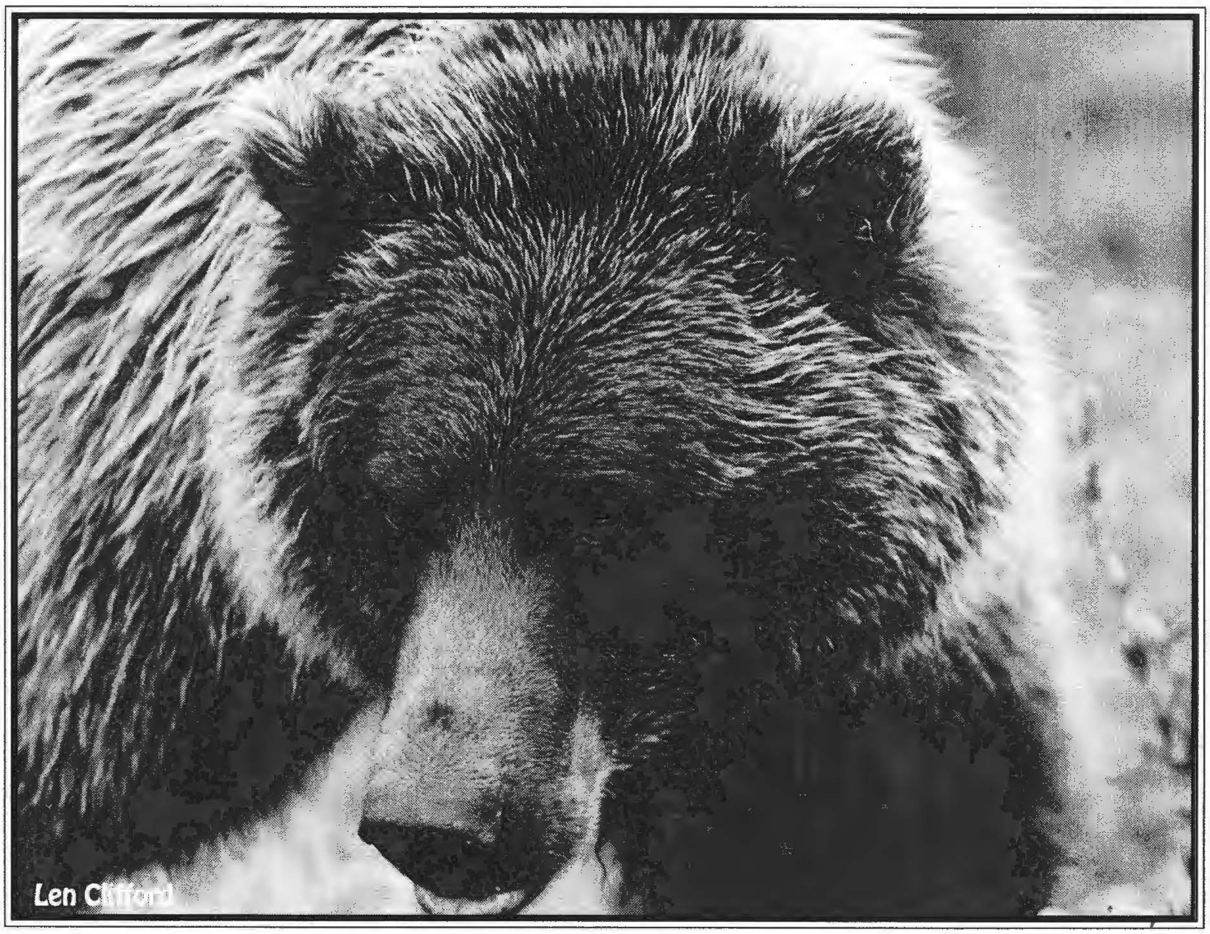
Alaska Department of Fish and Game
Division of Wildlife Conservation

Dynamics of a Hunted Brown Bear Population at Black Lake, Alaska

1993 Annual Progress Report

Richard A. Sellers



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SUMMARY

This report presents results through the sixth year of an interagency study of the dynamics of a hunted brown bear (*Ursus arctos*) population and makes comparisons with work conducted in the early 1970s near Black Lake on the Alaska Peninsula. During the current study, 114 bears were captured 147 times. During 1970-75, 344 different bears were captured 502 times. Progress meeting each of the study objectives is described below.

Objective 1. Estimate spring density of brown bears in a 500 mi^2 study area near Black Lake.

This job was completed in 1989 and results reported in Miller and Sellers (1992). Density was calculated to be 191 bears/1,000 km^2 (1 bear/2.02 mi^2) for all bears and 164 bears/1,000 km^2 for bear ≥2 years old.

Objective 2. Estimate the sex and age composition of the brown bear population inhabiting the study area.

Population structure was examined using 3 types of samples: capture samples, aerial surveys, and harvest data. Capture data provided an estimated adult sex ratio of 39 males:100 females. Adult males made up 10.7% of the 1988 and 1989 capture samples. Similarly, adult males composed 10.9% of all bears (n = 607) seen during the 1989 census. Family groups accounted for 55.5% of bears seen during the census flights. Mean ages for adult males and females were 9.9 and 12.2 years, respectively. Subadults made up 22% of the population.

Objective 3. Estimate productivity and reproductive parameters.

Mean cub (defined as a bear < 1 year old) litter size was 2.54 (n = 35) in the spring and 2.04 (n = 26) in the fall. Mean yearling litter size was 2.14 (n = 29) in the spring and 2.04 (n = 25) in the fall. Mean spring litter size for 2-year-old bears was 1.96 (n = 28). Mean age for females producing their first successfully reared litter was 6.3 years. Radiocollared females weaned 16 litters at 2.5 years of age and 4 litters at 3.5 years of age. Recruitment was estimated at 0.36 2-year-olds/adult female/year. Reproductive interval is estimated at 5.0 years.

Objective 4. Estimate survival rates for various sex/age cohorts.

Current annual survival rates are estimated at 0.60 for cubs, 0.80 for yearlings, 0.96 for 2-year-olds, and 0.87 for females ≥3 years old. For females ≥3 years old, hunting accounted for 32% of the deaths.

Objective 5. Compare and evaluate changes in density, population composition, reproductive rates, recruitment rates, and mortality rates in the study area since the early 1970s.

Harvest rates during the early 1970s were approximately twice as high for adult males, adult females and subadult males as during the current study. Harvest rates during the early 1970s were estimated at 8.4% for all bears and 10.5% for bears ≥2 years old. Estimates for the current study are 4.8% and 6.2%-6.6% for all bears and bears ≥2 years old, respectively. The ratio of adult males:100 adult females in 1970-72 and 1974-75 was about half the current estimate. Mean age of adult males and adult females in 1988-89 were higher than those found in the 1970s capture samples. Harvest statistics show a higher proportion of males and higher mean age for males in

recent years compared to the early 1970s. During the early 1970s, subadults made up 32%-37% of the population, versus about 22% currently. Recent aerial survey data show a higher proportion of the population is not in family groups compared to the period of the late 1960s and early 1970s.

Objective 6. Document habitat use and movement patterns.

Since 1988, over 2,600 locations have been recorded for marked bears. Thirty-six bears have been relocated at least 30 times, and 15 have been relocated between 70 and 90 times. Twenty-three adult females still have active radiocollars. Analysis of home ranges, seasonal distribution, dispersal, and other aspects of habitat use will be completed for the final report.

Objective 7. Evaluate the effectiveness of aerial stream surveys.

From 1982 through 1992, over 6,800 bears have been classified during 39 replicate surveys. Comparisons of current survey results with those of the late 1960s and early 1970s show the population has increased (both in terms of total counts and number of bears seen per flight hour) and is now comprised of more single bears. These findings parallel other results documented independently. With careful control of survey procedure, this technique provides an efficient, relatively inexpensive, way to detect major changes in the bear population.

Objective 8. Estimate the total number of bears in Subunits 9D and 9E.

Based on census results at Black Lake (1989) and on the Katmai coast (1990), we extrapolated densities for the remainder of Unit 9. The estimate for areas open to hunting was 5,680 brown bears. When areas closed to hunting (i.e., National Parks and McNeil River/Douglas River area) are included, the total brown bear population estimate for Unit 9 is 7,900.

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BACKGROUND

Both exploited and unexploited brown bear populations are difficult to manage. There are few techniques available to document population trends directly and the species is highly sensitive to disturbances related to human development and activity. Also, brown bears have reproductive rates among the lowest of North American mammals, and populations, as a result, can sustain only low rates of harvest and are slow to recover from inadvertent overharvests.

The need for baseline data on population parameters of brown bears on the Alaska Peninsula was a primary motive for this study. The importance of good baseline data was demonstrated by the March 1989 *Exxon Valdez* oil spill. The lack of baseline information on population density, reproductive rates, survival rates, movements, and habitat use have hindered attempts to assess the effects of this oil spill on brown bears. Results of this study can serve as surrogate baseline information to measure probable changes in bear populations exposed to oil from the *Exxon Valdez*. Such assessment work is proceeding along the coast of Katmai National Park. In addition, the Katmai project can function as a companion to this study, providing comparisons of population dynamics between an unhunted population and a moderately harvested population at Black Lake.

Effective management of brown bear populations exploited by hunters depends on good information on population status, trends, and harvest rates. On the Alaska Peninsula, as elsewhere, information on population size and trend is seldom available in reliable form because of the expense and technical difficulties of obtaining accurate estimates. The Alaska Peninsula supports important brown bear populations subject to intensive harvest pressure (Sellers and McNay 1984). During the early 1970s an extensive tagging study (Glenn 1980, Glenn and Miller 1980) coincided with a period of excessive harvests. Hunting seasons in 1974 and 1975 were curtailed by emergency orders which closed the spring seasons. During the next 10 years of restrictive alternating seasons, the bear population grew. Since 1980, there has been increased hunting pressure on the growing population and harvests have increased. In 1985, the fall season was extended by including the first 6 days of October. Fall harvests have increased dramatically, yet there has been intensive pressure, both from the guide industry and local residents, to further liberalize regulations and harvest more bears. It is desirable to determine population size, sustainable harvest levels, and the effects of past and current harvest levels on the number and composition of the Alaska Peninsula bear population in order to evaluate existing management strategies and, if necessary, to formulate new strategies.

The earlier study in this area provides an opportunity to compare characteristics of a heavily overexploited population with those of the current population. Tagging occurred during 1970-1975, excluding 1973: 344 bears were handled 505 times; 136 of these bears were shot by hunters. The current and former study areas are illustrated in Figure 1.

OBJECTIVES

1. To estimate spring density of brown bears in a 500 mi^2 study area near Black Lake;

2. To estimate sex and age composition of the brown bear population inhabiting the study area;

3. To estimate productivity of Black Lake bears, including age at first reproduction, litter size, reproductive interval, and recruitment;

4. To estimate survival rates for several sex/age groups and for natural versus hunting mortality;

5. To compare and evaluate changes in density, population composition, reproductive rates, recruitment rates, and mortality rates in the study area since the early 1970s;

6. To document the timing and intensity of use by bears of habitats of special importance such as denning areas, salmon streams, berry and vegetation foraging areas, ungulate calving areas, and others that may become evident through monitoring. Determine if different subpopulations of bears use these areas;

7. To evaluate the efficacy of aerial stream surveys in estimating trends in bear population size and composition; and

8. To estimate bear numbers for Game Management Units 9E and 9D by extrapolation from the study density estimate.

STUDY AREA AND METHODS

Description of the study area and field methods were reported earlier (Miller and Sellers 1992). Additional discription of the Black Lake area was provided by Glenn and Miller (1980). Figure 1 shows the various areas on the Alaska Peninsula discussed below.

During the current reporting period, we monitored radiocollared bears, retrieved collars that dropped off or were associated with dead bears, and analyzed data. The procedures used in the mark-recapture density estimate were discussed in Miller and Sellers (1992).

Three independent sources of data on population composition are available for making comparisons: 1) capture samples; 2) aerial surveys, including both stream surveys and observations made during the 1989 density estimate; and 3) harvest statistics. Each of these methods has associated biases and/or practical limitations which are discussed under the respective results. Regardless, each provides insights into the population composition and, considered jointly, permits evaluation of changes in population composition over time.

Harvest statistics were based on mandatory sealing that requires the hide and skull of each bear be examined by a department representative. A premolar tooth was extracted for cementum age determination (Mundy and Fuller 1964, Craighead et al. 1970), skull measurements were taken, and the hide examined to determine the sex and the presence of any ear tags or lip tattoos.

Annual harvest rates were calculated for various sex/age cohorts ≥ 2 years of age based on the maximum number of marked bears at risk each year. This was necessary because, except for adult females, other cohorts were not monitored intensively with radiocollars during 1988-93 and because telemetry was not a significant part of the study during the early 1970s. Consequently, survival rates were not judged to be accurate enough to estimate the actual number of marked bears available to be harvested. This method yielded a minimum harvest rate; but unless natural survival rates differed between the 2 study periods, comparisons should reflect differences in actual harvest rates.

Because of the importance of harvest rates for adult females, we also calculated a harvest rate based on the number of adult females, with active radiocollars, alive from 1988 to 1993. We assumed that natural mortality of adult females during the early 1970s was similar or lower than estimated from the current study (an assumption based on lower population density, lower proportion of adult males, and high salmon escapements into the Chignik/Black Lake system during the early 1970s), and applied the natural survival rate from this study to correct the number of adult females available to be harvested during the early 1970s.

We also calculated an average annual harvest rate during 1988-92 for Uniform Code Units (UCU) 09E-1201 and 09E-2001 (hereafter called the Black Lake Harvest Area [BLHA]), a 3,970 km^2 area which encompasses the 1989 Black Lake census area (Figure 1). A population estimate was made by extrapolating results from the 1,214 km^2 (469 mi^2) census area to the entire BLHA. Annual harvest rates were derived by dividing the annual sport kill by the estimated bear population, which was assumed to be stable during 1988-92.

Stream surveys of the Black Lake area were standardized following recommendations of Erickson and Siniff (1963). Since resuming aerial surveys in 1982, we used the following procedures to ensure standardization:

1. Sellers received training in the technique and survey route in 1982 from the same pilot (J. Swiss) and observer (L. Miller) who did most of the surveys during the 1960s and early 1970s.

2. All surveys used a supercub (PA-18) aircraft.

3. All surveys were during peak sockeye salmon (*Oncorhynchus nerka*) availability (3-12 August).

4. All surveys were either in the early morning or evening.

   No difference in total bears counted has been detected between morning ($\bar{x}$ = 168, n = 15) and evening ($\bar{x}$ = 179, n = 24) surveys (t = 1.11, 25 df, P = 0.28), especially if two unaccountably low morning surveys in 1984 are excluded (t = 0.238, P = 0.812). Similarly, during the period 1965-76, no difference was found between morning and evening surveys (t = 1.42, 6 df, P = 0.20). If the 2 surveys done in 1974 (both morning surveys), when the bear population was at its lowest level, are excluded, the difference is even less apparent (113 in the evening vs. 110 in the morning; t = 0.35, 4 df, P = 0.74).

5. The same observer (Sellers) did all surveys except in 1983.

6. The number of different pilots used (n = 6) was minimized.

7. Weather was a constant concern, and several surveys were aborted because of turbulence. If the survey was aborted when less than 85% complete, based on the average number of bears seen, the results were not used. Three incomplete surveys that were terminated when more than 85% complete were "finished" by applying the average number of bears seen during other surveys in the same year to the portion of the route not surveyed. In these three cases, portions of the West Fork drainage were not surveyed. Of all completed surveys since 1986, the West Fork drainage accounted for an averaged 12.7% of the total bear count (n = 4,327). Put another way, we saw an average of 22.8 bears in the West Fork drainage (range = 12-41, SD = 7.6).

Sockeye salmon escapements into the Chignik and Black Lake systems were counted by the ADF&G Div. of Commercial Fisheries staff as fish passed through a weir located below Chignik Lake. Differentiation between the early Black Lake run and the later Chignik Lake run was accomplished by scale analysis (A. Quimby, ADF&G, Kodiak, pers. commun.).

Survival rates of radiocollared bears and dependent offspring were determined by Kaplan-Meier procedures (Pollock et al. 1989). We investigated carcasses and sites of bears that died of natural causes to try to determine the circumstances. Differences among means, ranks, and survival rates were determined by t-tests, one-way ANOVA, Kruskal-Wallis, or Mann-Whitney tests. Chi-squared tests were used on proportional data sets.

RESULTS AND DISCUSSION

Population Size and Density Estimate

The Capture-Mark-Resight (CMR) estimate of population density (Objective 1) was completed in 1989 and was previously reported (Miller and Sellers 1992). The 1,214 km^2 (469 mi^2) count area contained an estimated 231 bears (95% C.I. = 204-266). On one of the 5 replicate surveys, a minimum of 161 different bears were seen. The calculated density of 191 bears/1,000 km^2 (1 bear/2.02 mi^2) ranks this population the 5th highest among the 12 areas in Alaska where CMR density estimates have been made (Miller et al. submitted). The bear density at Black Lake was over 7 times greater than in any studies in Interior Alaska, but was lower than in all other coastal areas (Miller et al. submitted). The relatively low density for a coastal area was partially attributed to the large study area which included a portion of the Bristol Bay coastal plain which had an estimated density of only 55 bears/1,000 km^2 (Miller and Sellers 1992). The mountainous portion of the study area had estimated densities of 300 to 400/1,000 km^2 (Miller and Sellers 1992), similar to Kodiak Island (Barnes et al. 1988).

Population Composition

Objectives 2 and 5 involve determining the composition of the current Black Lake bear population and making comparisons with the composition of the population in the early 1970s. The emphasis of the following discussion is to evaluate effects of different levels of harvest on the composition of the bear population. A secondary goal is to examine biases in different methods of collecting population composition data.

Capture Samples

Maternal females. There is a bias against capturing and observing females with cubs (i.e., bears <1 year old) during May and June because these families tend to remain at higher elevations (Miller et al. 1987) where terrain and weather combine to hamper search efforts (Glenn and Miller 1980). To minimize this spring capture bias against females with cubs and to compensate for a slight difference in the timing of capture work between the early 1970s (when 90% of the captures were made between 10 June and 8 July) and 1988-89 (when all captures were from 21 May-5 June), sex and age composition was determined over 2-year periods, with adjustment of the second year's sample to reflect the age and status of the bears in the previous year (Miller and Sellers 1992). For example, a 10-year-old female captured in 1989 with 2 yearlings was tallied as a 9-year-old female with 2 cubs for the 1988-89 sample. These adjustments also help correct for possible sources of bias based on failure to capture bears in the order in which they were observed in 1988 (Miller and Sellers 1992). These same adjustments were made for the sample of bears captured during the early 1970s so that comparisons could be made. The years for which these adjustments are made are indicated as hyphenated years (e.g., 1970-71 includes as cubs in 1970 bears captured as yearlings in 1971; the period 1971-72 includes these same bears as yearlings). Adjusted composition data from capture samples are presented in Table 1.

Despite the slight difference in timing of capture work in the two Black Lake studies, the adjusted composition data (described above) indicated about the same proportion of adult females had cubs (23% versus 21%) and older young (44% versus 51%) during the early 1970s and 1988-89.

Adult Sex Ratios. There were no significant differences in sex ratios of captured adults during the 1970s ($X^2 = 0.40$, df = 2, $P = 0.82$) (Table 1), so these data were treated as a single sample (1970-74). The adult sex ratio increased from a mean of 21 adult males:100 adult females during 1970-74 to 39 adult males:100 adult females during 1988-89, ($X^2 = 2.64$, df = 1, $P = 0.104$).

Subadult Sex Ratios. Sex ratios were not different for subadults captured during 1970-72, (95, 89 and 96 males:100 females, respectively $P = 0.76$), so these were combined to yield a sex ratio of 93:100 ($n = 67$ males and 72 females). During 1974-1975, the subadult sex ratio increased to 142 males:100 females ($n = 61$ males and 43 females).

There is a potential capture bias in favor of subadult males which tend to have more extensive movements than females (Miller 1990). In theory, the longer a capture period lasts, the more problems this bias could cause; i.e., the subadult sex ratio for a sample captured over 1 week would theoretically have a lower male:female ratio than would a larger sample collected over a month from the same population (Miller 1990*a*). The possibility that this influenced the change in sex ratio between 1970-72 and 1974-75 was examined. The 1970-72 sex ratio was based on captures over an annual average of 27 days (22 days in 1970, 28 days in 1971, and 32 days in 1972); the 1974-75 sex ratio was derived from captures over an average of 26 days per year (31 days in 1974 and 20 days in 1975). There is no evidence the length of the capture period had an influence on the sex ratio.

Although the change in subadult sex ratios between 1970-72 and 1974-75 was not statistically different ($X^2 = 2.61$, 1 df, $P = 0.106$), the apparent increase in subadult males was also reflected in harvest statistics. This suspected influx of subadult males parallels the change noted in a black bear population at Cold Lake, Alberta (Kemp 1977, Young and Ruff 1982) after a reduction in adult males, and several possible explanations are examined in more detail in the section "Growth in number of immature males" (page 14). The subadult sex ratio in 1988-89 was 133 males:100 females ($n = 28$).

Age Structure. There were no significant differences in mean ages of adults of either sex between years during the early 1970s (females, $KW = 3.275$, df = 2, $P = 0.19$; males $KW =$

2.772, df = 2, P = 0.25). Consequently, these data were pooled for comparison with the 1988-89 capture sample. Adult females captured during the early 1970s were significantly younger ($\bar{x}$ = 9.6 years, n = 122) than during 1988 ($\bar{x}$ = 12.21, n = 33) (Mann-Whitney U = 1345, P = 0.003). Adult males captured during the early 1970s were also younger ($\bar{x}$ = 7.2 years, n = 26) than in the 1988 sample ($\bar{x}$ = 9.9, n = 13) (Mann-Whitney U = 95, P = 0.026). Overall, subadults made up a significantly higher proportion of all independent bears in the 1970s sample (54%) than in the 1988-89 sample (37%), (X^2 = 6.6, df = 1, P = 0.01).

Population composition comparisons between capture sample, census observations (1989), and stream surveys

During the early 1970s, only 4.7% of adult females (≥5.0 years old; n = 107) captured in June had cub litters, compared to 35% captured in July (n = 23). In 1988 and 1989, only 8% of the capture sample consisted of family groups that included cubs, and 10.4% of 607 bears seen during the 1989 early June census were females with cubs. Of 1,590 bears seen during August stream surveys in 1988 and 1989, 22% were in families with cubs. The bias against seeing families with cubs during the spring is further emphasized because both high natural mortality rates of cubs (Bunnell and Tait 1985, Miller 1990*b*) and reduced sightability due to thicker vegetation theoretically should reduce the proportion of cubs counted between spring and late summer surveys.

There was less bias against capturing females with young ≥1 year old. During the early 1970s, 33% of the capture sample was of females with older offspring while 38% of 2,644 bears seen on late summer aerial surveys during 1965-76 were such families. Females with young ≥1 year old made up 39% of the 1988-89 capture sample, 48% of the 1989 census observations, and 46% of the 1988-89 aerial survey observations.

Adult males made up 10.7% of the 1988-89 capture sample (Table 1). Based on very large size for single bears or association as a breeding pair, 10.9% of 607 bears seen during the 1989 census flights were classified as adult males. The proportion of bears in family groups was also similar between captures in 1988-89 (56%) and the 1989 census observations (55.5%). This similarity suggests we were successful in capturing a representative sample of the bears visible during late May and early June.

As compared to spring capture and census observation samples, August stream surveys suffered from a bias against seeing adult males. During 1989 stream surveys <1% of 883 bears were classified as adult males, compared to 10.7% in the capture sample and 10.9% during census flights. This may result from adult males in August being more nocturnal and/or more adept at hiding from aircraft than they are in spring during the peak of breeding season and prior to leaf emergence.

Harvest Rates

Black Lake:

Harvest of marked bears. Harvest rates during 1971-73 were over twice as high as during 1988-92 for all cohorts except immature females (Table 2). Applying these cohort-specific minimum harvest rates to the population of bears ≥2 years old, as reconstructed from capture samples, harvest rates were 11.1% during 1971-73 and 6.2% during 1988-92. For the entire population, the harvest rates were 8.8% in the early 1970s and 4.8% currently.

Because the harvest of adult females is so critical to brown bear population dynamics, and because a large sample of radiocollared adult females was available during 1988-93, we also calculated a harvest rate based on the number of radiocollared adult females known to be alive. During 1988-93, 5 radiocollared females were harvested during a total of 176 bear-years, for an average annual harvest rate of 2.8%.

Extrapolated harvest rates. The current population estimate, as extrapolated from the 1989 Black Lake density estimate, for the BLHA is 460 bears of all ages or 335 bears ≥2 years old. An annual average of 22 (range 18-31) bears were killed within this area during 1988-92. The average annual harvest for 1988-92 was 4.8% for all bears and 6.6% for bears ≥2 years old. These rates compare favorably with corresponding rates of 4.8% and 6.2% calculated above for marked bears.

Several independent data (e.g., results of bear aerial surveys along salmon streams, L. Glenn's estimate in Miller and Ballard 1982, and preliminary Jolly-Seber calculations) suggest the bear population density was lower (perhaps by ≥50%) during the early 1970s than currently estimated. Even if the population was only 30% lower during the early 1970s (i.e., 322 bears in the BLHA), the harvest rate, based on an average kill of 31.3 bears/year during 1971-73 (range 27-35), would have been about 9.7%, or twice as high as calculated for 1988-92.

Historical Harvests. Bear harvests began increasing in 1966, and from 1966 to 1968 averaged 29 bears (range 25-33) per year for the BLHA. The reported harvests in 1969 and 1970 dropped significantly (17 and 11, respectively), but this was attributed to illegal bootlegging (Faro 1970) rather than actual harvest reductions. During 1971-73, an average of 31.3 bears (range 27-35) was harvested within this area. Beginning in 1974 there was only 1 season per calendar year, and the average harvest during 1974-87 dropped to 18 bears (range 14-23). From 1988 to 1992 the average harvest increased to 22 bears/year (range 18-31).

Analysis of Historic Harvest Data from Subunit 9E

Management biologists, for lack of other feasible methods, have traditionally relied on harvest statistics to analyze the status of brown bear populations. Most recent work on interpretation of harvest data has focused on computer models, and a number of potentially serious problems have been raised (Miller and Miller 1990, Harris 1984, Tait 1983). The work at Black Lake offers a rare opportunity to compare independent measurements of population density and composition between 2 time periods having different harvest rates. As discussed above, capture data collected in similar fashion at Black Lake have shown increases in the proportion of adult males and adult ages between the early 1970s and 1988-89. I believe these changes in population composition are a direct result of reduced hunting pressure and they are reflected in harvest statistics. The analysis presented below uses data from Subunit 9E, a 30,770 km^2 area which includes the Black Lake study area (Figure 1), to provide large enough sample sizes for statistical testing. Trends in harvest pressure were similar between the Black Lake area and the larger Subunit 9E.

Interpretation of harvest data. An explanation of some of the inherent difficulties of analyzing harvest statistics is required to avoid erroneous interpretations. Many variables in addition to size and composition of the brown bear population affect harvest parameters. To interpret the historic effects of brown bear harvests on the Subunit 9E population, a thorough understanding of regulations and hunting conditions is essential.

Several regulations implemented during the late 1960s (e.g., 1967 - prohibition on hunting same day as airborne, 1968 - change of bag limit from 1 bear per year to 1 bear every 4 years, 1969 - limit of 2 clients for guides in Unit 9 and the requirement that guides personally present bear hides and skulls for sealing rather than using temporary sealing forms) promoted the bootlegging of bears taken by guided hunters. A survey of 4 taxidermy shops in the lower 48 states showed that 37% of the brown bears received from Alaska during 1968-69 had not been sealed (Faro 1970). Consequently, official records underestimate the total reported harvest at least for 1968-70. These changes, plus the lack of age data from harvested bears, limit analysis of harvest data prior to 1971.

Differences in sex and age vulnerability based on season also influence interpretation of harvest data. Adult males are more vulnerable during spring hunts for a number of reasons, including scarcer foods, less vegetative cover, and more activity associated with the breeding season. A higher percentage of females are either in dens or are accompanied by young during spring seasons. Although only females with cubs or yearlings are legally protected, guides and hunters report that families with 2.5-year-old or older offspring receive a level of de facto protection during the May hunting season. To avoid the problems associated with differential vulnerability, I analyzed fall and spring harvests separately. Despite the above considerations, I believe hunting regulations, hunting patterns, and data collection were stable enough after 1970 for interpretation of harvest statistics.

Historic harvest levels - Subunit 9E. Brown bear sealing requirements were implemented in 1961 and no formal record of prior harvests are available. Federal enforcement personnel working on the Alaska Peninsula estimated hunting pressure was very light during the 1950s and harvests from all of Unit 9 were estimated to be less than 100 per year (J. W. Lentfer, Alas. Dep. Fish and Game, unpubl.). Illegal killing of brown bears along certain stretches of coast by commercial fishermen was rumored to be common, but the magnitude cannot be assessed. The reported regulatory year (i.e., from 1 July-30 June) harvest from Subunit 9E during 1961/62-63/64 averaged 95 bears (range 90-101). During 1964/65-67/68, the Unit 9E harvests averaged 141 (range 120-160). During 1968/69 and 69/70 the reported harvests dropped to 94 and 60, but regulatory changes mentioned above lead to illegal bootlegging and nonreporting of bears harvested. Obviously this underreporting of harvest hampers interpretation of the effects of hunting. By 1971/72 regulations were changed to reduce the benefits to guides from bootlegging bears, and the reported harvest increased to 121. The 1972/73 harvest jumped to 203 bears. Biologists were concerned by the sharp rise in harvests and the high exploitation rate of bears marked at Black Lake and imposed emergency closures of spring seasons in 1974 and 1975 that caused annual harvest during 1973/74-1976/77 to decline to an average of 87 bears (range 82-93). During the next 10 years, under a regime that closed the season every other regulatory year, the average annual harvest was 122 bears (range 111-133). Harvests increased in the late 1980's, and during 1988-92 averaged 159 (range 141-183) per year. Harvest patterns were parallel between Subunit 9E and Black Lake (see above).

Change in ratio analysis. One of the simpler models used in the past to evaluate harvest data has been the "age-related change in sex ratio" method first explored by Fraser (1976) and Paloheimo and Fraser (1981). This technique relies on differential vulnerability of one sex (males being more vulnerable to hunting in the case of bears [Bunnell and Tait 1980]) to skew the sex ratio in the harvest toward females as a cohort ages. This is because fewer males have survived to reach the older age classes. More recent reviews of this model (Fraser et al. 1982, Harris and Metzgar 1987, and McLellan and Shackleton 1988) have spelled out the assumptions and limitations of this technique. Because of these limitations, I do not advance this analysis as a way to estimate actual harvest rates, but rather use it as a reality check on the analysis presented elsewhere in this report. The relationship between age and sex ratio in the Unit 9E total harvests for 1971-73 and 1987-92 were weak (r = 0.54 and 0.56, respectively), and the change in ratio for the recent period was opposite of that expected (Figure 2). The positive slope of the regression line for the period 1987-92 could be explained only if the natural mortality rate of adult females was much higher than for adult males and/or if hunter selectivity was extremely successful in harvesting older males. Another problem with using total annual harvests is that a higher proportion of harvest occurred during spring hunts (when males are more vulnerable) from 1987 to 1992 (48%) than during 1971-73 (29%).

The relationship for just the fall harvests in Subunit 9E during the same time period was closer to the predicted pattern (Figure 3). The predicted harvest rates from fall kills were about 17% for 1971-73 and 7% for 1987-92. Although these rates are close to those determined from the harvest of marked bears, the usefullness of the "change in ratio" method to estimate actual harvest rate is compromised because the vulnerability of females decreases once they reach maturity and are legally protected when accompanied by cubs or yearlings.

The most significant use of this model is that the regression lines from total harvest and fall-only harvests from 1971-73 versus 1987-92 were significantly different, substantiating different harvest rates for the 2 time periods. Similar analysis and conclusions were reached for a brown bear population south of the Alaska Range that was subjected to increased harvest rates (Miller 1988).

Hypothesized changes in harvest statistics. If harvests during the late 1960s and early 1970s were excessive, especially on males, theoretically the sex ratio and mean age of males in the harvest during the period of overharvest and perhaps for several years thereafter would be lower than either before the overharvest or after the population recovered. Differences in regulations affecting hunter selectivity and the collection of data (see above) preclude analysis of age or sex ratio data before the period of overharvest.

Sex ratios in the fall harvests in Subunit 9E. Sex ratios were compared for 2 time periods: "Overharvest" (1972-75) and "Current" (1989-91). The sex ratios in the harvest during 1972-75 were similar ($\bar{x}$ = 50.8% males, range 49.5%-52.3%, SE = 0.58, n = 404, P = 0.98). The sex ratios in 1989 and 1991 were 59.5% and 62% males, respectively, and did not differ (P = 0.64) so they were pooled for an average of 60.8% males (n = 339), which was significantly higher (X^2 = 7.49, 1 df, P = 0.006) than during 1972-75 .

Sex ratios in the spring harvests in Subunit 9E. Spring harvests consistently have a higher percentage of males than do fall harvests. Analysis of spring harvest sex and age statistics is weakened in Subunit 9E because the 2 seasons (1974 and 1975) most likely to show the effects of previous overharvest were closed by emergency order. The previous 2 spring seasons (1972 and 1973) both had 73.3% males (n = 91), which was not different than the 76.4% (n = 301) during 1990-92 (X^2 = 0.36, 1 df, P = 0.55).

Age structure in the fall harvests in Subunit 9E. Kruskal-Wallis test of male ages for 3 periods (1972-75 - overharvest; 1977-81 - early recovery; and 1989-91 - current) showed no between year differences (P = 0.93; 0.26; and 0.39, respectively) so data were pooled within each time period. The average age of males during both the overharvest period ($\bar{x}$ = 5.12 years, SE = 0.24, n = 204) and early recovery ($\bar{x}$ = 4.68 years, SE = 0.18, n = 206) periods were lower (X^2 = 12.2 and 20.2, respectively, P < 0.001) than during the current period ($\bar{x}$ = 6.71 years, SE = 0.36, n = 199). The difference between the overharvest and early recovery periods was not different (X^2 = 1.17, P = 0.28); and is suggestive that, following overharvest of males, the population age structure will probably be skewed toward younger animals and the mean age of males during the early recovery period may remain low or even decline further for several years even after harvest rates are reduced. A similar delayed drop in mean age of harvested males under conditions of overexploitation has been mimicked in some computer models (Harris 1984, Miller and Miller 1990). Miller (1988) also demonstrated a decline in mean age of harvested males during a period when harvests increased and the population declined. That population has not recovered to the point where age structure in the harvest approaches the pattern evident before harvests grew (Miller 1993).

No pattern of changes between the 3 time periods in female ages in the harvest were detected. This is not surprising because approximately two-thirds of the adult females are protected each year because they are accompanied by offspring. Additionally, the harvest rate for subadult females during the early 1970s (unlike all other segments of the population) was not different than current rates.

Age structure in the spring harvest in Subunit 9E. Analysis of the age structure from spring harvests is hindered by the closure of the spring 1974 and 1975 seasons. I would have expected these 2 years to show the greatest effects of overharvest during the previous 3 years. Because of the lack of data from these 2 key years, I only tested 2 time periods, Overharvest-Early Recovery (1972-1980) versus Current (1988-1992). No differences in male ages between years were found within these 2 periods ($P = 0.58$ and 0.56, respectively) so data were pooled within each period. The average age of males was lower ($X^2 = 27.0$, $P < 0.001$) during the Overharvest-Early Recovery period ($\bar{x} = 6.97$ years, SE = 0.23, $n = 282$) than during the Current period ($\bar{x} = 8.77$ years, SE = 0.26, $n = 325$). As with fall ages, no pattern was evident for female ages in the spring harvests.

Percentage of "older" males in the harvest. Another way to analyze the effects of excessive harvest of males during the early 1970s and the subsequent recovery is to compare the percentage of the harvest composed of older males (≥8 years of age). During regulatory years 1972/73 through 1974/75, an average of 6.8% (range 6.5%-7.0%, $n = 323$) of the total fall harvest was composed of older males. During the early recovery period (1975/76-1981/82), the percentage of older males declined to 5.1% (range 4.3%-7.2%, $n = 445$). During the 2 most recent fall seasons (1989 and 1991) the percentage of older males was 13.5% ($n = 199$).

Interpretation of spring harvest data is hindered by the closure of the 2 key seasons (1974 and 1975). In 1973 only 11.7% of the spring harvest ($n = 60$) was older males. During 1975/76-1981/82, an average of 22.9% (range 16.9%-31.1%, $n = 437$) of the spring harvest was older males. In the 2 most recent spring seasons, an average of 36.1% of the harvest ($n = 305$) was older males.

Miller (1988) detected a drop in the proportion of old males in the Unit 13 fall harvest with increased harvest pressure, but the pattern was not apparent in spring harvests or for females in either season.

Growth in number of immature males. Capture samples at Black Lake discussed above indicated the proportion of subadult males in the population increased in 1974 and 1975. This apparent change in population composition was also reflected in the fall harvests for Subunit 9E during the early recovery period. During 1977 and 1979, an average of 63.4% of the fall harvest was males, significantly higher than during 1972-75 ($X^2 = 37.58$, 1 df, $P < 0.001$). During the spring 1976 and 1978 an average of 77.4% were males, compared to an average of 73.3% during 1972-73. While the change in the proportion of males in the spring harvest was not significant ($P = 0.44$), this might have been because spring 1974 and 1975 seasons were canceled.

High harvests of adult males in the years preceding 1974 could have created a situation favoring immigration or higher survival of subadult males. Capture samples from 1971 and 1972 showed that adult males made up only 4.3% of the total population. If the total population in the BLHA was about 320 bears (i.e., about 30% below current estimates), then there would have been roughly 14 adult males alive in 1972. The reported harvest of 7 and 10 adult males during the 1971/72 and 1972/73 seasons from the BLHA represents annual harvests of 50%-71% of adult males. During 1972, the minimum harvest rate for marked adult males was 27%. The actual harvest rate probably lies between these estimates, indicating the adult male cohort was under extremely heavy hunting pressure.

An appealing, though far unsubstantiated, theory is that juvenile and subadult survival (especially for males) improves after overharvest because of lower conspecific predation resulting from depletion of adult males. Although Miller (1990*c*) argued against any evidence for this density dependent mechanism, no studies have been conducted where the adult male segment was reduced as low as documented at Black Lake in the early 1970s.

It is intriguing that the cohort produced in 1971 seemed to show a shift in sex ratio from even (6 male and 6 females captured in 1971 as cubs) to skewed towards males (15 male and 7 female yearlings captured in 1972), suggesting differential survival favoring males. Too few cub were captured in 1972 (n = 3) and 1973 (0) to permit additional examination, and the above data could be an aberration due to small sample sizes.

At Cold Lake, Alberta, the experimental removal of adult male black bears increased population and subadult sex ratio caused by an influx of subadult males and, possibly, higher survival of young bears (Kemp 1976, Young and Ruff 1982). Ruff (1982) estimated that nearly 80% of the increase in population size was the result of immigration from the surrounding unhunted population. Recent reevaluation of the Cold Lake study (Gershalis 1994) questions whether early conclusions of a density dependent effect are justified.

To further examine the possibility of immigration, I compared the sex ratio of subadults originally captured while still with their mothers ("resident" bears) against subadults initially caught as independent bears ("unknown residents"). Although some "unknown residents" undoubtedly were raised in the study area, some were potential immigrants. During 1970-72, the subadult sex ratios were 79 males:100 females (n = 43) for "residents" and 102 males:100 females for "unknown residents" (n = 117). During 1974-75, the sex ratio of "resident" subadults was 113 males:100 females (n = 64), while the sex ratio of subadults of unknown residency was 208 males:100 females (n = 40). The increase in proportion of "resident" subadults indicates improved survival while the increased proportion of "unknown resident" males suggests higher survival and/or immigration could have been involved.

Examination of subadult male movements, especially for males whose mothers had known home ranges, would answer many of the questions about the origins of young males that appear after adult males have been removed. Unfortunately, this type of data is difficult to collect and is scarce in the literature. At Black Lake, a substantial number of subadult males were marked with tattoos and ear tags, but radiotelemetry was not used. To examine whether the apparent increase in subadult males noted during the mid 1970s was the result of immigration, I compared how many marked males known to be "residents" (i.e., originally captured with their mothers inside the study area) were later (≥1 season after initial capture) killed by hunters either inside or outside the study area. I could not compare actual distance between initial capture location and kill site because the reported locations of many kills were not specific enough. I also did the same for young males (≤5 years old) first captured alone, and consequently of "unknown residency." There was no difference in the percentage of young resident males killed outside the study area (42%, n = 19) compared to "unknown residents" (35%, n = 34) (X^2 = 0.241, df = 1, P = 0.624). The high percentage of young resident males killed outside the study area demonstrates that dispersal of young males is prevalent even in populations with a very reduced number of resident adult males. Reynolds (1993) found in a population subjected to high harvests that all subadult males dispersed from their mother's home range.

Unlike the Cold Lake situation, a reservoir of unhunted brown bears did not exist near Black Lake. Harvest rates were high throughout the Alaska Peninsula during the early 1970s; routes of immigration were limited because of topography, and the closest refugia for bears (Katmai National Monument) was approximately 300 km away. Harvest rates for subadult males at Black Lake during the overharvest period were nearly as high as for adult males and were much higher than for either adult or subadult females (Table 2). Consequently, I believe that an increased proportion of subadult males in capture and harvest samples must have resulted from growth of this segment of the population over a large area (i.e., at least all of Subunit 9E-30,770 km^2), rather than by immigration or a reduction in other segments of the population.

The increase in the proportion of immature males that occurred after the reduction of adult males did not prevent the population from recovering. Some bear researchers (e.g., LeCount 1987, black bears; Wielgus 1993, brown bears) have hypothesized that high harvests of adult males lead to an increase in the number of subadult males (presumed to be immigrants), reducing the productivity of adult females either through displacing them from better habitats or by conspecific predation (primarily on offspring). This theory is predicated on immigrant males having no genetic investment until they begin siring cubs. Because resident subadult males also have little genetic investment except in their own families, and have been shown to disperse from maternal home ranges even in heavily hunted populations (Reynolds 1993), it seems a moot question whether the subadult males are immigrants or residents. Furthermore, it seems highly unlikely that subadult males could displace adult females from preferred habitats or kill their offspring. By the time these males reach the age and size where they could have any detrimental influence on adult females, they probably have already begun to make their genetic contribution (i.e., if few older males are present, it follows that more young adults will breed available females). In a protected population such as Katmai, with a high density of resident adult males, every female's home range overlaps with several adult males (Sellers, unpubl. data); each maternal female is bound to encounter males that did not sire her offspring and which theoretically could benefit (genetically) by killing her offspring and gaining an opportunity to sire her next litter. As the density of adult males and the ratio of adult males to adult females increase, so does the risk of infanticide from nonsire males. This is true whether the adult males originated in the area or were immigrants. Consequently, maternal females, especially those with cubs, seem to avoid all adult males by remaining in dens longer, by using higher elevation habitats until cubs gain better mobility, and in some cases by reducing their home ranges.

Summary and Conclusions of Harvest Analysis

I believe that sustainable harvests, especially for adult males, were exceeded beginning as early as 1965, but the problem of unreported kill during 1968-70 and lack of age data cloud this interpretation. Annual harvests at Black Lake during the early 1970s were estimated at 19.7% of adult males, 11.1% of all bears ≥2 years of age, and 8.8% of the total population. For Subunit 9E, the peak harvest of 203 bears in 1972/73 represents a 9.1% harvest rate if the bear population then was 30% lower than currently estimated.

High harvests during the early 1970s first reduced the number of adult males. This is demonstrated by the low ratio of adult males:adult females (21:100 in the Black Lake capture sample) and the low proportion of adult males in the harvest. I believe that at least through 1973 even the number of subadult males was reduced, and that if hunting had not been curtained in 1974, the sex ratio would have been imbalanced even further. The effects of this level of hunting pressure on the female cohort are less easily discerned from harvest statistics. During the early 1970s, the harvest rate for adult females marked at Black Lake was estimated conservatively at 5.1%. Had hunting restrictions not been imposed in 1974, the effects on females would have escalated.

As measured against brown bear management objectives, I believe the Subunit 9E population recovered during the period 1975-1988 as defined by the following parameters:

1. The ratio of adult males: adult females in the 1988-89 capture sample at Black Lake was almost double the ratio found during the early 1970s.

2. Based on stream surveys and other estimates, the population density has increased, probably by at least 30%.

3. While the degree of recovery could be debated, the bear population demonstratively is sustaining a higher harvest with a greater proportion of older males than was evident during the late 1960s and early 1970s.

4. This level of population growth occurred during a 13-year period when harvests in Subunit 9E totaled 1,564 bears ($\bar{x}$ = 120 per year). Based on current population estimates, this would have been an annual harvest rate of at least 3.8%.

5. The recovery would have been prolonged had females been more severely affected during the early 1970s. The recovery was also aided, to an undetermined degree, by mild weather and improved salmon escapements since the early 1970s in Bristol Bay systems, generally pristine habitat conditions.

6. The bear population has grown despite a large proportion of subadult males in the population during the early recovery phase.

I believe that harvest statistics, in this case primarily from fall hunting season, indicated excessive harvests and were correctly interpreted by managers at the time to make prudent management decisions. Reliance only on harvest statistics is risky, and I advise employing every direct or indirect index to population status. Nevertheless, I cautiously offer the following conclusions about interpreting harvest statistics.

1. Harvest statistics are best interpreted under relatively stable regulations and hunting patterns.

2. Sample sizes must be fairly large for specific fall or spring seasons, in this case ranging from 60-183 per season for Subunit 9E. Only if the proportion of the total annual kill during fall and spring seasons remains constant can these statistics be combined to increase sample sizes.

3. Overharvest typically first affects the male cohort and will be evident in a decline in the proportion of males and the average age of males. These changes are likely to be most evident in fall harvests. The sex ratio in the fall harvest approached 1:1 during 1972-75. Although a decline in the mean age of males was supported by this study and in Unit 13

(Miller 1988, 1993), a similar pattern could result from a rapidly expanding population with an age structure weighted toward young bears. However, in the case of a highly productive, growing population, the proportion of total males in the harvest would probably not decline.

4. Even after harvest rates were reduced, the mean age of males in the fall harvest remained low for several years. However, the percentage of males (primarily subadults) increased in both the fall and spring harvest shortly after reduction of harvest rate. The origin of this "bloom" of subadult males remains speculative and could have resulted from one or more of the following: increased production of male cubs, increased survival of juvenile and subadults males, and increased immigration of subadult males.

5. During the period of recovery, harvest data were very noisy. Because of this, managers are cautioned against making drastic changes in harvest regulations based on data from 1 year. If a manager is in doubt about the level of harvest, it may be necessary to "weather out" one year of low sex ratio or reduced mean age of males by retaining existing regulations to ensure that a 2- or 3-year trend is developing.

Reproductive Biology

Reproductive histories of females marked during 1970-75 and 1988-93 are presented in Tables 3 and 4, respectively.

Age at First Production of Young. At least 3 different definitions of age at first production have been reported in various brown bear literature. The most common is age at which cubs are first produced, regardless of their fate. This parameter has been reported both as the minimum age at which a female gives birth and as the mean age at which a sample of females has produced cubs. The other measure, which is more pertinent for population modeling, is the age at which a sample of females first produce litters that are successfully weaned. To further complicate interpretation of this parameter, some authors have used only those females verified to have produced a litter while others have reported a minimum age at production so that the sample can include bears that are known not to have produced cubs at a given age. Often when studies are of relatively short duration, a potential bias is introduced that underestimates the age of first production. This happens when a female is followed for several years but does not produce her first litter before the study ends or she is "censored." For instance, a bear captured at age 5 and followed until age 8 without producing a litter would have an age at first production of ≥9. But in some studies this bear is excluded from the calculation of age at first production, while in other studies a "minimum" age of first production would use the age of 9 for that bear.

Three females produced cubs at 4 years of age during the early 1970s. However, this was not common, as only 7% of all 4-year-olds (n = 42) were known to have produced cubs. During 1988-92, 1 of 10 females produced cubs at age 4. Combining both study periods, only 7.8% (n = 52) of bears produced a litter at age 4. Two of these 4 litters were raised successfully. By age 5, 39% (n = 33) had produced cubs for both study periods.

The mean age at first successful production of cubs was 6.3 years (range 4-7, n = 8) for the current study. However, several females were killed (n = 2), or had radiocollar malfunctions (n = 2) before producing their first litter. When these are included, the age at first successful production was at least 6.7 years (range 4-9+).

Because L. Glenn's work in the early 1970s did not benefit from the use of radiocollars, age at first production of a successful litter was defined as a litter that was observed at 2.5 years of age or by having a marked cub confirmed (e.g., recaptured or killed by a hunter) to have survived past age 2. During the early 1970s, the minimum mean age for successful production of a litter was 5.7 years (n = 19) which was not different than the current study (Mann-Whitney U = 49.5, P = 0.142).

Litter Size. Mean litter size for cubs of radiocollared females first seen during capture or at den emergence (May or early June) was 2.54 (n = 28 litters). For comparisons with other study areas (e.g., McNeil River), the mean cub litter size at midsummer was 2.30 (n = 23). By fall, the mean cub litter size was reduced to 2.11, not counting 6 litters that had no survivors by 10 months of age. No mortality over the first winter has yet been detected. The mean litter size for yearlings at den emergence or capture was 2.13 (n = 23 litters). The mean yearling litter size in midsummer was 2.00 (n = 23), and by fall was 1.95 (n = 22 litters). Mean litter size for 2-year-olds was 1.88 (n = 25) in spring and 1.89 (n = 9) in fall.

Modafferi (1984) summarized Black Lake mean litter sizes from early summer capture period (June and early July) during the early 1970s as follows: cub = 2.21 (n = 19); yearlings = 2.10 (n = 51); and 2-year-olds = 2.22 (n = 18).

Mean litter size for cubs seen during aerial surveys at Black Lake during 1982-92 did not differ by individual survey ($P > 0.15$) or between years (P = 0.60), so these data were pooled for an average of 2.20 cubs (range of annual means 2.06-2.36, n = 606 litters). The size of litters ≥1 year old showed more variation within and between years, and overall averaged 1.99 (range of annual means 1.72-2.37, n = 874 litters). Older litters were smaller than average in 1986 (1.73, n = 96) and 1991 (1.72, n = 83) and larger than average in 1982 (2.37, n = 19) and 1987 (2.36, n = 14).

Age at Family Separation. Radiocollared females have weaned 11 litters at 2.5 years of age and 7 litters at 3.5 years. No females keep offspring past 3.5 years of age. There was no difference between the mean age of females weaning litters at 2 years of age (13.9 years old, range 6-23) and females weaning litters at 3 years (13.4 years old, range 9-16).

Productivity versus Salmon Availability. Bear productivity can be influenced by abundance of staple foods such as berries (Rogers 1976, Reynolds et al. 1987, Miller 1988, Smith and VanDaele 1988), ungulate prey (Schwartz and Franzmann 1991), and garbage (Craighead et al. 1974). Changes in nutritional condition of females could influence many reproductive parameters including age at first reproduction, conception rate, litter size, cub survival rates, and interval between litters. The link between abundance of a staple food item and reproductive parameters is obscured by other factors such as availability of alternative foods, weather, and intraspecfic social interactions.

At Black Lake, salmon is the primary staple of the bears' diet; above all other available salmon runs, sockeye salmon spawning in Black Lake tributaries is the focus of attention for bears in the core study area from mid July through September. To examine the relationship between the availability of salmon on productivity, I tested the correlation between the number of cubs in the population seen during aerial stream surveys and the Black Lake sockeye salmon escapement the previous year during 1982-92 (Table 5). There was a positive relationship between the average number of cubs seen during all surveys within a year and the previous year's salmon escapement (Bartlett X^2 = 10.96, df = 1, P = 0.001). There was also a positive correlation between the proportion of cubs and the previous year's escapement (X^2 = 4.61, df = 1, P = 0.03). There was no relationship between cub litter size and escapement the previous year (X^2= 0.022, df = 1, P = 0.882).

Reproductive Interval and Recruitment. Through 1993 only 4 radiocollared bears have successfully weaned two litters. Two of these were weaned at 3-year intervals and 2 at 4-year intervals. By virtue of their success in the 6 years of this study, these bears form a highly biased sample. I used the most optimistic scenarios for other females (n = 35) to calculate a minimum mean weaning interval of 4.6 years. The number of females with weaning invervals longer than 4 years include 7 with a minimum of 5 years; 8 with at least a 6-year interval; 4 with at least a 7-year interval; and 1 each with at least an 8- and 9-year interval.

Because of different methodology between various studies on the Alaska Peninsula, I have explored the use of a cumulative summary of production based on the number of 2-year-old litters produced for all adult female bear-years. For the current study, a total of 45 adult females produced a total of 29 litters of cubs ≥2 years old (total of 52 cubs) in 145 bear-years, for an average of 5.0 years per successful litter and an average of 0.36 cubs weaned/adult female/year. During the early 1970s, 66 adult females produced 41 litters (total of 88 cubs) in 168 bear years, for an average of 4.1 years per litter and an average of 0.52 cubs weaned/adult female/year.

Estimated Survival Rates

Survival estimates have been updated through 1993 (Table 6) but are still considered preliminary. Annual survival for females ≥3 is 0.87 for all causes of mortality; survival from natural mortality was 0.92 and was not significantly different from the survival rate of 0.95 for females in the Katmai study area (X^2 = 0.98, 1 df, P > 0.30). The survival rates for cubs and yearlings were 0.56 and 0.83, respectively.

Aerial Surveys of Bears on Salmon Streams

1992 results. During 7-11 August 1992, 3 replicates of the Black Lake stream surveys were completed (Table 7). Poor weather prevented additional replications. The average of 213 bears (range 182-239) seen per survey is the highest ever; however, the average of 61.5 bears seen per hour is similar to the past few years. Production of cubs was the highest since 1983, and the increased number of cubs and yearlings, rather than more independent bears, accounted for the higher average count in 1992.

Analysis of historic stream surveys. Although aerial surveys were initiated at Black Lake in 1958, the first evaluation of this technique as a potential means for assessing trends in bear populations was in 1962 (Erickson and Siniff 1963). They analyzed several variables and found that observer experience, time of day, timing relative to peak of salmon spawning, and excessive wind speed could affect survey results. Since this early evaluation of aerial surveys of brown bears, this technique has continued to be applied. Alpine habitats have been surveyed in Southeast Alaska (Schoen and Beier 1988) and on Kodiak Island (Atwell et al.

1980). Troyer and Hensel (1969) and Troyer (NPS files) conducted surveys of brown bears on salmon spawning streams on Kodiak Island and Katmai National Park, respectively. Barnes (1986) evaluated whether visibility biases existed toward particular cohorts of bears and how interdrainage movements of bears between salmon spawning streams and differences in vegetative cover on individual streams affected the proportion of bears spotted on aerial surveys.

Erickson and Siniff (1963) identified a number of factors that influenced counts of brown bears concentrated on stream survey in the Black Lake area; however, they did not rule out this technique: "The findings do not negate the use of aerial surveys, but show that with attention to standardization of controllable variables and with awareness of the limitations in the use of aircraft, aerial observations provide perhaps the only feasible means for extensive population assessments."

Despite the amount of effort applied to brown bear aerial surveys, there has not been an evaluation of this technique to monitor trends in population size or composition when survey methodology was standardized and repetitive surveys were conducted over many years. The work at Black Lake allows this type of evaluation because of independent data on changes in population size and structure.

Simultaneous air and ground counts were made 10 times in 1962 and on average aerial counts tallied 47% of the bears present from ground counts (Erickson and Siniff 1962). Sightability of brown bears has now been evaluated in several habitat types in Alaska during spring CMR censuses and has ranged from 21%-47% for independent bears (Miller et al. submitted). During 1989 census flights in the Black Lake study area, overall sightability averaged 43% (Miller and Sellers 1992). The ability of brown bears to escape detection from aerial surveys is amply demonstrated by the results of telemetry surveys. During this study, when the exact location of a bear was known from radio signals and several passes with the aircraft were made to spot the bear, only in 59.3% (n = 1,596) of the cases was the bear seen.

From 1962-1992, 58 surveys were conducted during peak sockeye salmon spawning in the Chignik River/Black Lake area. Statistical analysis of stream survey data focused on 3 parameters: total counts, number of bears seen per hour, and percentage of bears not in family groups (i.e., "single" bears).

I only included 7 1962 surveys done in the early morning or evening by experienced observers ("A" and "B" in Erickson and Siniff 1963) prior to 13 August (when bears appeared to disperse). One survey meeting these criteria was excluded as an outlier because the count of 34 bears was unrealistically low. During 7 comparable surveys in 1962, the average was 91.6 (range 81-113, SD = 10.2) bears. Specific flight times for this study were not provided, but surveys were about 2.5 hours in length (Erickson and Siniff 1963). Based on the average count of 91.6 bears/survey and an average of 2.5 hours/survey, approximately 37 bears were seen per survey hour. These results indicate a brown bear population under light hunting pressure but during a prolonged period of relatively low salmon escapements (i.e., mean sockeye salmon escapement into Black Lake was 179,800, range 94,000-266,000 during 1954-62).

During 1965-70, 9 comparable surveys tallied an average of 111.3 bears (range 92-123, SD = 8.8). Within this period there was no detectable trend in the number of bears seen per survey; however, more bears were seen than during the 1962 surveys (Mann-Whitney U test = 6.50, $P < 0.008$). This increase took place during a period of higher salmon escapements (1963-70 average escapement was 341,700, range 137,000-536,300) but also while bear harvests were increasing. The near doubling of an important food source could have increased bear productivity and survival, or affected bear distribution. A change in bear distribution during the peak of the salmon run would probably occur if other traditional fishing areas became less productive. Sockeye salmon escapements into the Ilnik system did decrease from an average of 95,000 in 1960 and 1961 to an average of 14,000 during 1962-64. This decrease in salmon may have caused some bears to move into the Black Lake tributaries during 1965-70. The trend of increased harvests during the late 1960s, heavily targeted toward males, probably did not reduce the size of the bear population but may have influenced the composition of the population.

During the early 1970s harvests increased dramatically (see above) while salmon runs into Black Lake remained strong (1971-74 $\bar{x}$ = 471,000, range 326,300-671,700). As described above, evidence suggested that sustainable yield was exceeded and the bear population structure and density was affected. Unfortunately, only a few aerial surveys were completed in the early 1970s. The 2 surveys in 1974 tallied 77 and 104 bears and were not significantly different than the counts during the 1960s. Nevertheless, the 1974 surveys are consistent with the hypothesis of overharvests during the late 1960s and early 1970s. This overharvest reduced the proportion of single bears (especially males) in the population, and by 1974 the total population size was probably reduced. Unfavorable weather in 1975 prevented surveys from being completed. By 1976, after 2 years of restricted hunting, 115 bears were counted on the 1 survey. Ten surveys during 1982-84 showed an average of 149.7 (range 110-173, SD = 18.9), and 29 surveys during 1985-92 averaged 184 bears (range 147-239, SD = 21.5).

Kruskal-Wallis tests for the total number of bears observed per survey within each period were not significantly different (1965-76, K-W = 11.1, 7 df, $P = 0.13$; 1982-84, K-W = 1.72, 2 df, $P = 0.42$; and 1985-92, K-W = 11.1, 7 df, $P = 0.13$), so survey results were pooled within each period. Mann-Whitney U tests showed that more bears were seen on surveys during 1982-84 than during the earlier period ($X^2 = 14.2$, 1 df, $P < 0.001$), and that more bears were seen during 1985-92 surveys than during the earlier 2 periods ($X^2 = 30.3$ and 14.7, 1 df, $P < 0.001$).

A comparison of the number of bears seen per survey hour indicated recent surveys (1985-92) averaged more bears/hour (58.6 bears/hr., SD = 7.4) than surveys during 1965-76 (39.0 bears/hr, SD = 9.0) ($t = 8.09$, 35 df, $P < 0.001$). There is a practical upper limit to the number of bears that can be counted per hour of survey time. As more bears are seen, proportionally more time is spent unproductively (in terms of seeing additional bears) circling to get accurate classification. Other portions of the survey route consistently have low bear use but must be covered at normal search intensity.

<u>Stream surveys and population composition</u>. Bears observed during stream surveys were classified into the following groups: females w/cubs; females w/cubs ≥1 year old; or single bears. It is often impossible during aerial surveys to be certain of the age of juveniles after their first year. I made distinctions only between families of cubs and "≥1 year olds." During 1988-92 in late summer, 22% of 37 radiocollared females with offspring ≥1 actually had 2-year-olds.

I hypothesize that as harvest rates increase, the proportion of a bear population not in family groups (i.e., "single" bears) decreases. This results from several factors, including: male bears are more vulnerable to hunters (because of more extensive movements), males are more highly prized by hunters, and maternal females and their cubs and yearlings are legally protected. Also, females with older offspring receive a level of de facto protection either because hunters are unsure of the age of the cubs or because, even though legal quarry, some hunters would avoid shooting a recognized mother bear. As harvest rate increases, the males and chronically unproductive females are removed, leaving a higher proportion of adult females with dependent offspring.

Although I can not directly test this hypothesis, I examined the composition of brown bear populations under different levels of harvest to see if the proportion of single bears is compatible with the above theory. Bears along the coast of Katmai National Park represent one of the most protected population in North America. Of 75 brown bears tagged there during 1989-92 and potentially available for 258 bear-years, only 1 has been legally harvested (Sellers, unpubl. data). During 1989-91, single bears made up 63.2% of all bears (n = 1,426) observed during summer telemetry flights along the Katmai coast (Sellers, unpubl. data). McNeil River State Game Sanctuary, situated just north of Katmai National Park, is also a very lightly hunted population and has a high percentage of single bears in the population. Of all bears cataloged at McNeil during 1976-91, 61% (range 52-73% , SD = 6.5) have been single (Sellers and Aumiller, 1994). An average of 71% of bears (n = 449) seen on 9 repetitive aerial surveys of McNeil Reiver during 15-19 July 1991 were single (S. Miller, unpubl. data). During 1958-60, when legal harvests on the Alaska Peninsula were estimated at less than 100 per year and hunting pressure was considered light, single bears averaged 50.2% (range = 45.3-52.3%, n = 825) of bears seen during aerial surveys of the southern Alaska Peninsula (ADF&G, unpubl. data).

The proportion of single bears seen during stream surveys increased from an average of 23.3% (range 15-31%, SD = 6.4, n = 14 surveys) during 1965-76 to an average of 36.0% (range 23-53%, SD = 7.7, n = 39 surveys) during 1982-92 (t = 5.5, 51 df, $P < 0.001$).

Aerial counts of brown bears concentrated on salmon streams on the Alaska Peninsula have documented differences in composition of the population ranging from 15% to over 70% single bears. Because of fairly high variation within replicate counts in one year and between successive years, I caution against over interpretation of results from aerial surveys. However, a general pattern is evident which reflects the effects of harvest rate on the composition of bear populations. It seems safe to conclude a coastal brown bear population with over 60% single bears is under light harvest pressure. Conversely, a population that contains less than 25% single bears may be overharvested. Populations with 30%-50% single bears, as detected through aerial surveys, are probably being harvested at moderate rates and should be monitored closely.

Status and Movements of Marked Bears

Marking Summary. The number of bears captured in this study was 59, 40 (including 7 recaptures), 5, and 43 (including 26 recaptures) during 1988, 1989, 1990, and 1991, respectively. In total, 103 radiocollars, including 22 with breakaway features (either canvas [Hellgren 1988] or surgical rubber spacers), and 19 glue-on radios were put on bears. The glue-on radios were designed to be put on young bears or on adult males whose necks were larger than their heads, thus precluding the use of collars. The primary purpose was to have an unbiased sample of radiomarked bears for the census. For such use it was necessary for the glue-on radios to stay attached for at least the density estimate period (i.e., about 14 days from the time of capture). Two glue-on radios remained attached from 173 to 219 days, 2 lasted between 30-70 days, 6 remained on for 4-14 days, and 9 fell off in less than 4 days.

Sixteen of the 22 breakaway collars had a canvas spacer and 6 were attached with surgical rubber tubing. Of the 16 collars with canvas spacers, one transmitter malfunctioned within several days of deployment; 2 transmitters quit after being on for 100-180 days. One bear carried its transmitter for at least 120 days before the bear died of natural causes. One bear had its collar on for 499 days when it was killed by a hunter who reported that the neck was cut by the collar and was infected. Another bear was captured in October 1990 to remove its collar which had been on for 505 days. This collar caused no ill effects and was badly frayed, indicating it probably would have dropped off before doing any damage to the bear. The other 10 fell off because the canvas rotted. Approximate life expectancy for the canvas spacers was calculated using midpoints between the last date the collar was known to have been on the bear and the first date it was confirmed to have been shed. Sometimes this period spanned several months, as in cases when the collar was shed in a den. On average, the canvas spacers lasted approximately 1 year. Five of the 16 were on longer than a year, and one could have remained on for as long as 670 days. The surgical tubing lasted a shorter time, with only 1 of 6 staying on for more than a year. Of the 81 regular collars put on bears, 5 were pulled off. Two of these were cast off almost immediately after capture, and the others were shed after being on between 6 months and slightly over 1 year.

Movements. During 1992, 35 bears were relocated an average of 14 times each (range 3-17) for a total of 475 locations. In 1993, 28 bears were located 328 times (range 3-15). Nine females first captured in 1988 and monitored continuously have now been relocated an average of 79 times each (range 73-90). Thirty-six bears have been relocated ≥30 times and 15 females have ≥70 locations. Over 2600 locations (Table 8) have been recorded for all bears marked during this study. Twenty-three adult females with active radiocollars entered dens in 1993.

Mortalities. During 1992, 7 marked bears (# 7, 13, 15, 49, 72, 82, and 204) were killed during the spring hunting season. Two of these (#82 and 204) had active radiocollars. Five adult females with active radiocollars died of natural causes.

On 4 May 1992 a very large adult male was feeding on the carcass of bear #211A. Tracks at the scene and a field necropsy suggested the attack initiated at the den site and culminated about 100 meters down hill of the den. The bear apparently had been dead for 2-3 days. I could not access the den, but there were no tracks of cubs visible and no milk could be expressed from the teats, indicating she did not have cubs.

On 18 May 1992 a hunter killed a 10-year-old male that was feeding on the carcass of bear #1. The hunter did not examine the carcass and did not know the carcass was a marked bear. I did not reach the carcass until 1 June, by which time decomposition of the carcass and lack of snow prevented reconstruction of the scene. I examined the den and immediate vicinity and found no sign of cubs.

On 18 October 1992 I examined the remains of bear #55, which was seen 5 October with 3 cubs on the same salmon stream. The carcass was fresh (estimated at < 2 days old) but was approximately 90% consumed. I also found the remains of 1 cub nearby. Blood in the trachea of #55 and the crushed skull of the cub suggest that another bear may have killed them.

Sometime between 24 August and 6 September 1992, bear #95 died near a salmon stream. I recovered the radiocollar on 17 October, but the combination of decomposition and flooding, which scattered bones and prevented us from even finding the skull, preclude any speculation on how she died.

Bear #212 died between 5 and 17 October 1992. On 5 October she was seen near the site of her death with 2 yearlings. The condition of her skull (broken zygomatic arch) and drag marks at the site suggest another bear had killed her. We found no sign of the yearlings.

In 1993, no marked bears were reported killed by humans. Three cases of natural mortality to radiocollared adult females were investigated. Bear #38 was found dead on 11 May 1993 with an adult male bedded down next to the carcass. The carcass was located in a snow shoot directly below the den site, and survey of the snow patch revealed only her tracks and those of an adult male. She had numerous severe bite marks on the top of her head and was dead less than 4 days. She had weaned a 3-year-old the previous May and was seen with an adult male on 17 June 1992. Milk was expressed from her mammary glands, but no sign of cubs was found. Some meat from the thigh and shoulder had been eaten. From this evidence, I surmise that she was killed by the adult male, possibly while defending cubs.

Bear #97 was found dead on 11 May 1993 with an adult male feeding on the carcass. She was estimated to have been dead less than 4 days. A portion of the left shoulder and rib cage had been eaten. The carcass was in a precarious location and further examination was not possible. This bear was last seen the previous October in nearly the same location with 2 cubs.

Bear #96 died during early October 1993. She had cubs when last seen on 27 August. The kill site was examined on 22 October, but little was left of her carcass and no cub remains were found. The carcass had been buried by another bear, and both zygomatic arches were broken, suggesting she had been killed by another bear. This bear had a broken rear leg when first captured in 1990. The leg was still broken in 1991 when she was recaptured and probably never fully repaired itself.

During 1988-1993, a total of 21 cases of natural mortalities were investigated, including 4 of unmarked bears. The victims included 16 adult females, 2 subadult females, 2 yearlings (1 male and 1 unknown), 1 cub, and 1 adult male. This last case involved a 5-year-old male (#78) that moved 62 km from its capture site and was not discovered until several months after its death, so no further information is available. The timing of death for the other 20 incidents was know within at most 2 weeks. Ten incidents occurred in the spring, 5 during the peak salmon fishing season of late July and August, and 5 in the fall. No information of the cause of death was available for 9 incidents, but in 3 of these cases the carcasses were apparently fed upon by other bears. In one case an adult female (#36) was involved in a snow slide that swept her off a cliff. Although I have not witnessed any deaths in progress, in 8 cases I suspected intraspecific predation, because of severe damage to the skull and/or the presence of a bear feeding on a fresh carcass. Besides the cases in 1992 and 1993 described above, in 1988 the male yearling of bear #4 was probably killed by bear #5, a 14-year-old male. Although these observations are not definitive of patterns of natural mortality, I include them because of the scarcity of other data on causes of natural mortality. The current status of radiocollared bears is listed in Table 3. Analysis of movements, home range, and habitat use awaits digitizing of these locations and mapping of cover types.

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Figure 1. Map of Subunit 9E and the Black Lake study area.

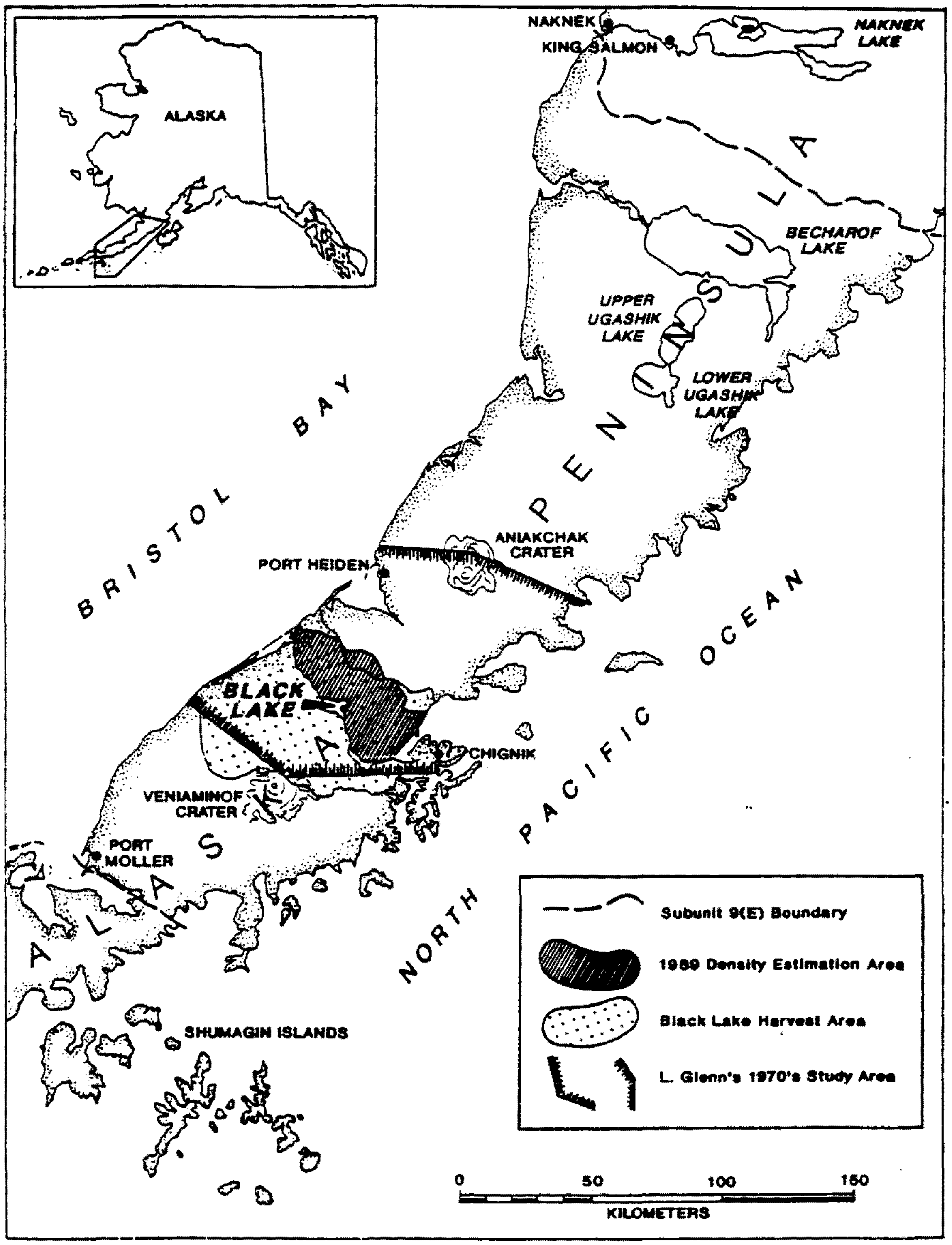


Figure 2. Percent males by age class for both spring and fall hunts in Subunit 9E, 1971-73 and 1987-92.

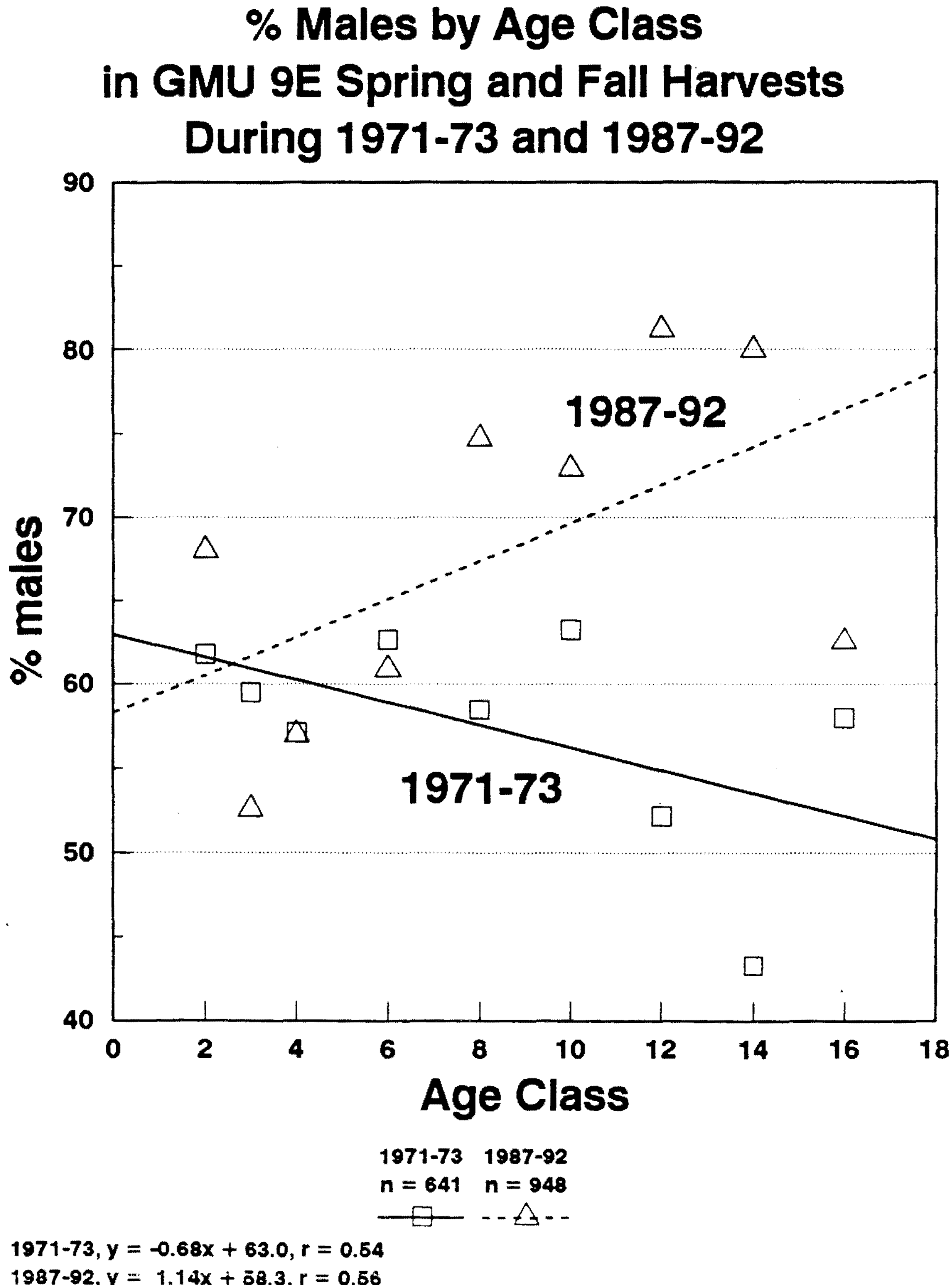


Figure 3. Percent males by age class for fall hunts in Subunit 9E, 1971-73 and 1987-92.

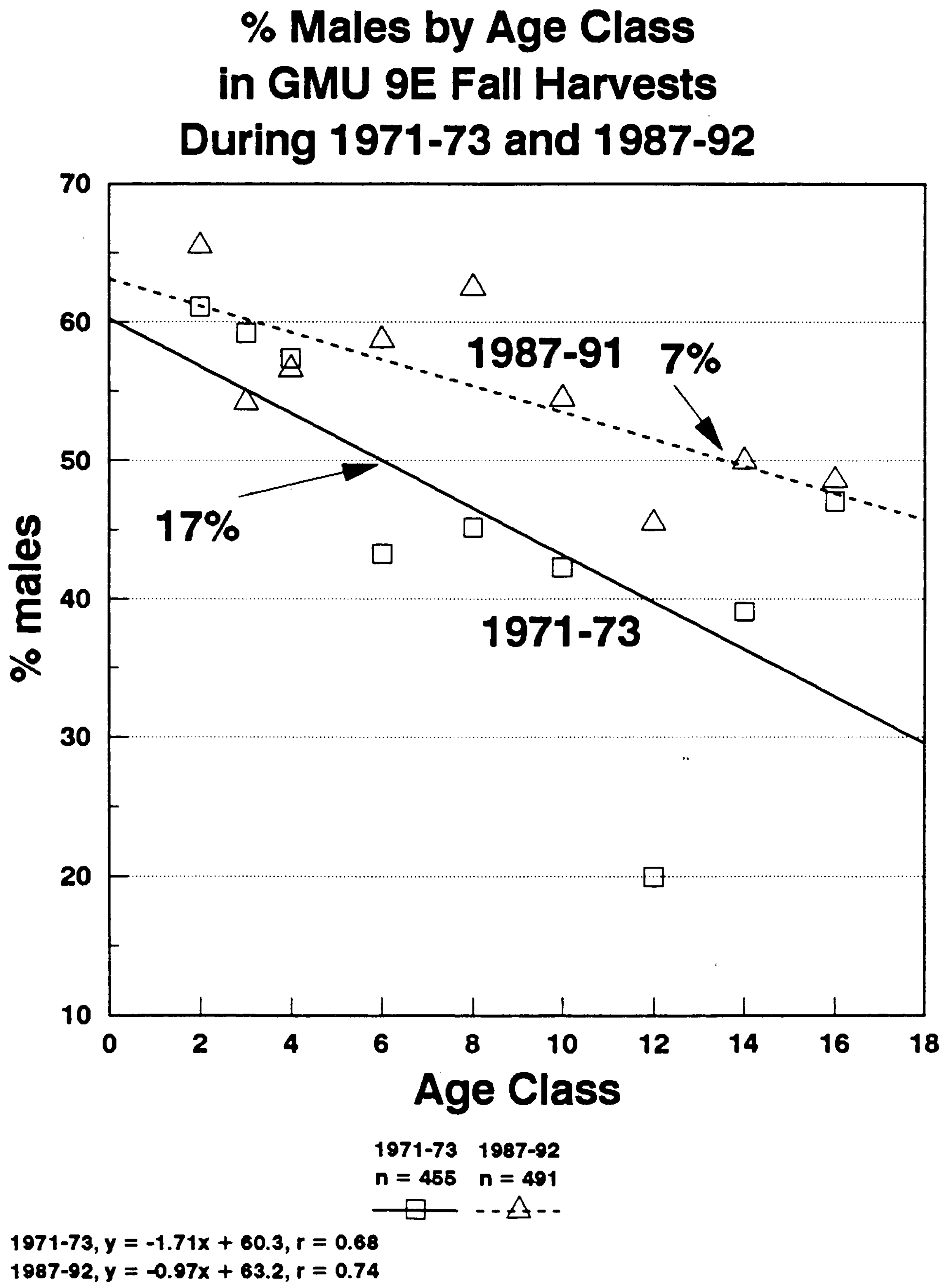


Table 1. Sex and age composition of brown bears captured near Black Lake, Alaska, using capture samples from consecutive years with status adjusted to the first year listed.

Category	1970-71 Number	(%)	1971-72 Number	(%)	1974-75 Number	(%)	1988-89 Number	(%)
Cubs								
Males	1		22		7		0	
Females	9		12		7		2	
Unk sex	3		0		0		15	
Total	13	8	34	18	14	9	17	14
Yearlings								
Male	20		5		13		6	
Females	19		10		11		3	
Unk sex	1		4		0		11	
Total	40[a]	25	19[b]	10	24	15	20[c]	17
Age 2-4								
Male	23	14	38	20	42	27	20	17
Female	34	21	43	23	27	17	16	13
Unk sex	3		0		1		2	
Total	60	37	81	44	70	45	38	31
Adult females								
Single	15	9	12	6	14	8	9	7
With cubs	5	3	17	9	7	4	7	5
With yearlings	18	11	6	3	11	7	10	8
With ≥2-yr-olds	2	1	9	4	8	5	7	5
Total	40	24	44	23	40	25	33	27
Adult males	10	6	8	4	8	5	13	10
Total bears	163		186		156		121	
Ad males:100 ad females	25.0		17.4		20.0		39.4	
Mean age of ad males	6.6		7.9		7.2		9.9	
Mean age of ad females	9.0		9.0		10.6		12.2	
Subad males:100 subad females	67.6		88.4		155.6		125.0	
Mean age of males =>2	3.6		3.5		3.4		5.6	
Mean age of females => 2	6.1		6.0		7.4		9.2	

[a] Includes 6 bears captured as lone 2.5-year-olds in 1971
[b] Includes 5 bears captured as lone 2.5-year-olds in 1972
[c] Includes 1 bear captured as a lone 2.5-year-old in 1989

Table 2. Minimum annual harvest rates (percent) of brown bears marked at Black Lake, Alaska 1971-73 and 1988-92.

	Adult males				Adult females				Immature males				Immature females			
Year	Maximum no. at risk	no. killed	Minimum harvest rate	95% CI	Maximum no. at risk	no. killed	Minimum harvest rate	95% CI	Maximum no. at risk	no. killed	Minimum harvest rate	95% CI	Maximum no. at risk	no. killed	Minimum harvest rate	95% CI
1971	11	2	18.2	6.8-29.6	47	2	4.3	1.4 -7.1	42	7	16.7	6.1-27.2	46	3	6.5	2.2-10.9
1972	20	2	10.0	3.4-16.6	72	6	8.3	2.8-13.9	45	9	20.0	7.6-32.4	47	6	12.8	4.5-21.0
1973	30	8	26.7	10.8-42.5	78	2	2.6	0.8 -4.3	42	6	14.3	5.1-23.5	43	4	9.3	3.2-15.4
1971-73	61	12	19.7	7.5-31.9	197	10	5.1	1.6 -8.5	129	22	17.1	6.3-27.8	136	13	9.6	3.3-19.0
1988	6	0	0.0	0.0 -0.0	20	0	0.0	0.0 -0.0	13	0	0.0	0.0 -0.0	11	0	0.0	0.0 -0.0
1989	18	2	11.1	3.9-18.4	36	1	2.8	0.9 -4.7	19	4	21.1	8.1-34.0	12	3	25.0	10.0-40.0
1990	22	0	0.0	0.0 -0.0	43	1	2.3	0.7 -3.9	8	0	0.0	0.0 -0.0	5	0	0.0	0.0 -0.0
1991	28	3	10.7	3.7-17.7	56	1	1.8	0.6 -3.0	5	0	0.0	0.0 -0.0	4	0	0.0	0.0 -0.0
1992	28	4	14.3	5.1-23.5	56	2	3.6	1.1 -6.0	2	0	0.0	0.0 -0.0	3	1	33.3	14.5-52.2
1988-92	102	9	8.8	3.0-14.7	211	5	2.4	0.7 -4.0	47	4	8.5	2.9-14.2	35	4	11.4	4.0-18.9

Table 3. Reproductive status of adult female brown bears at Black Lake, Alaska, 1988-93.

				Cubs		Yearlings		2.5 yr. olds		3.5 yr. olds		
Bear ID	Year	Age	Barren	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Comments
1	1988	11				2	1					One cub separated at capture
	1989	12						1	1			
	1990	13	X									
	1991	14	X									
	1992	15	X									Killed by another bear at den site
4	1988	12	X									Collar shed at den
6	1988	4	X									Collar shed in den
	1991	7		3	2							Recaptured
	1992	8				2	2					
	1993	9						2	0			Weaned 2 in May
8	1988	4	X									
	1989	5	X									Hunter kill, 10/89
11	1988	25	X									
	1989	26	X									
	1990	27	X									
	1991	28	X									Shed collar
12	1988	9						1	0			
	1989	10		2	2							
	1990	11				2	2					Radio malfunction
13	1988	2	X									
	1989	3	X									
	1990	4	X									Collar shed
	1992	6	X									Hunter kill in May, teats medium size, suggesting she may have had and lost cubs in 1991

Table 3. Continued.

Bear ID	Year	Age	Barren	Cubs Spring	Cubs Fall	Yearlings Spring	Yearlings Fall	2.5 yr. olds Spring	2.5 yr. olds Fall	3.5 yr. olds Spring	3.5 yr. olds Fall	Comments
17	1988	18	X									
	1989	19	X									
	1990	20	X									
	1991	21		3	2							
	1992	22				2	2					
	1993	23						2	0			Weaned 2 In June
18	1988	11				2	0					Family separated after capture
	1989	12	X									
	1990	13	X									
	1991	14		3	0							
	1992	15		3	1							2 cubs may have been separated at capture
	1993	16				1	1					
23	1988	18				2	2					
	1989	19						2				Weaned
	1990	20	?									Natural mortality,
26	1988	11						3				Weaned
	1989	12	X									
	1990	13		3	2							Some confusion over age of cubs in fall
	1991	14				2	2					
	1992	15						2				Weaned prior to May 23
	1993	16		3	3							
30	1988	9						1				Weaned
	1989	10	X									
	1990	11	X									
	1991	12		3	2							
	1992	13				2	2					
	1993	14						2	0			Weaned 2 in June

Table 3. Continued.

Bear ID	Year	Age	Barren	Cubs Spring	Cubs Fall	Yearlings Spring	Yearlings Fall	2.5 yr. olds Spring	2.5 yr. olds Fall	3.5 yr. olds Spring	3.5 yr. olds Fall	Comments
34	1988	12		3	3							
	1989	13				3	3					
	1990	14						3	0			Weaned
	1991	15	X									
	1992	16	X									
	1993	17	X									
36	1988	10		2								Natural mortality
37	1988	5				1	1					
	1989	6						1	0			Weaned
	1990	7	X									
	1991	8	X									
	1992	9		1	3-1 = 2							Adopted 2 COY between 6/17-6/22, but ended w/only 2
	1993	10				2	0					Lost 2 yearlings in Aug.
38	1988	16						1	0			Weaned
	1989	17		2	1							
	1990	18				1	1					
	1991	19						1	1			
	1992	20								1		Weaned by June 17
	1993	21		?								Killed by Ad. male in May
40	1988	4	X									
	1989	5	X									
	1990	6		3	2							
	1991	7				2	2					Radio off air after Nov. 1991

Table 3. Continued.

Bear ID	Year	Age	Barren	Cubs		Yearlings		2.5 yr. olds		3.5 yr. olds		Comments
				Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	
43	1988	5	X									Shed collar
44	1988	20						1	1			Mother died, cub survived
46	1988	10		3	0							
	1989	11	X									
	1990	12	X									Natural mortality
50	1988	4	X									
	1989	5	X									
	1990	6	X									Collar shed
51	1988	12				3	3					
	1989	13						3	2			
	1990	14	X									
	1991	15		3	3							
	1992	16				3	3					
	1993	17						3	?			Radio failure in June
52	1988	3	X									
	1989	4	X									
	1990	5	X									
	1991	6	X									
	1992	7		2	2							
	1993	8				2	2					
55	1988	9	X									
	1989	10	X									
	1990	11	X									
	1991	12	X									
	1992	13		3	0							Killed by another bear, 1 COY carcass found

Table 3. Continued.

Bear ID	Year	Age	Barren	Cubs Spring	Cubs Fall	Yearlings Spring	Yearlings Fall	2.5 yr. olds Spring	2.5 yr. olds Fall	3.5 yr. olds Spring	3.5 yr. olds Fall	Comments
57	1988	8	X									
	1989	9	X									
	1990	10	X									
	1991	11	X									
	1992	12	X									
	1993	13	X									
58	1988	19				2	2					
	1989	20						2	0			Weaned
	1990	21		2	2							
	1991	22				2	2					
	1992	23						2				Weaned by June 23
	1993	24	X									
59	1989	6	X									
	1990	7	X									Hunter kill, 5/90
60	1989	9	X									
	1990	10		3	1							Last COY lost
	1991	11	X									
	1992	12		1	0							Cubs lost by June 1, seen with adult male following
	1993	13		2	2							
65	1989	10						1	0			Weaned
	1990	11		3	0							
	1991	12	X									
	1992	13		4	2							Two cubs lost between May 31 and June 17
	1993	14				2	2					
69	1989	19				3						Natural mortality

Table 3. Continued.

Bear ID	Year	Age	Barren	Cubs Spring	Cubs Fall	Yearlings Spring	Yearlings Fall	2.5 yr. olds Spring	2.5 yr. olds Fall	3.5 yr. olds Spring	3.5 yr. olds Fall	Comments
70	1989	7				2	2					
	1990	8						2	2			
	1991	9								2	0	Weaned
	1992	10		2	2							
	1993	11				2	0					Lost 2 in mid August
76	1989	14								2	0	Weaned
	1990	15	X									
	1991	16		3	3					Radio off air after Oct. 15		
80	1989	13	X									Shed collar
	1990	14		Unknown								
	1991	15				2	2					
	1992	16						2				Weaned by June 23
	1993	17	X									
82	1989	14						2	0		Weaned	
	1990	15		3	1							
	1991	16				1	1					
	1992	17						1				Both #82 and cub were killed by hunters in May
87	1989	12				3	3					
	1990	13						3	3			
	1991	14								3	?	
87	1992	15		3	3							
	1993	16				3	3					
88	1989	19	X									Natural mortality

Table 3. Continued.

Bear ID	Year	Age	Barren	Cubs		Yearlings		2.5 yr. olds		3.5 yr. olds		Comments
				Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	
90	1989	19				1	1					Radio malfunction
95	1990	20	X									Radio Malfunction
	1991	21	X									
	1992	22	X									Natural Mort., cause unkn.
96	1990	14	X									Broken back leg
	1991	15	X									Broken back leg
	1992	16	X									
	1993	17		3	0							Female killed by another bear in Oct.
97	1990	11				2	1					
	1991	12						1	0			Weaned
	1992	13		2	2							
	1993	14				2						Killed by another bear in May
98	1990	11				2	2					
	1991	12						2	2			
	1992	13								2		Weaned by June 22
	1993	14	X									
202	1991	11						2	2			
	1992	12								2		Weaned by June 22
	1993	13		3	1							Lost 2 about Aug. 1
203	1991	21				3	3					
	1992	22						3				Weaned by June 29
	1993	23		2	1							Lost 1 in late August
204	1991	3	X									
	1992	4	X									Hunter kill in May

Table 3. Continued.

Bear ID	Year	Age	Barren	Cubs Spring	Cubs Fall	Yearlings Spring	Yearlings Fall	2.5 yr. olds Spring	2.5 yr. olds Fall	3.5 yr. olds Spring	3.5 yr. olds Fall	Comments
205	1991	5	X									Hunter kill 10/91
206	1991	17	X									
	1992	18	X									
	1993	19	X									
207	1991	12	X									
	1992	13		1	0							Cub lost by June 22
	1993	14		2	2							
208	1991	16						2	2			
	1992	17								2		Weaned by 6/23
	1993	18	?									Collar shed at den emergence
210	1991	17				3	1					
	1992	18						1				Collar shed by 6/22
211A	1991	19	X									
	1992	20	X									Killed by adult male about May 4
211B	1991	3	X									
	1992	4	X									
	1993	5	X									
212	1991	6		2	2							
	1992	7				2	0					Killed by another bear between Oct. 5 and Oct. 18
213	1991	8	X									
	1992	9	X									
	1993	10		3	3							
215	1991	7	X									
	1992	8	X									
	1993	9		3	1							Lost 2 in Oct. ?

Table 4. Reproductive status of adult female brown bears captured at Black Lake, Alaska, 1970-75.

Bear ID	Year	Age	Barren	Cubs		Yearlings		2.5 yr. olds		3.5 yr. olds		Comments
				Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	
2	1971	4	X									
3	1971	6				2						Yearlings ID #4 and 5
	1972	7	X									Litter survived, #4 captured in 1975
4	1971	1										
	1975	4	X									
9	1971	5		1								COY ID #10
	1972	6	X									#10 killed in Fall 1972
11	1971	10		1								COY ID #12, survived at least thru 10/71
16	1971	7				1						Yearling #17
19	1971	5		2								COY ID # 20 and 21
	1972	6	X									Lactating
	1974	8		3	2							COY ID #60, 61 and 62; #60 was killed in 1976
	1976	10	X									Killed by hunter in 5/76
23	1971	13		3								COY ID #24, 25, 26
	1972	14				3						
41	1974	6				2						Yearling ID #42 and 43
51	1974	16						2				
53	1974	4	X									
58	1975	2										
	1977	4	X									Hunter kill in 10/77
66	1974	21						1				

Table 4. Continued.

Bear ID	Year	Age	Barren	Cubs		Yearlings		2.5 yr. olds		3.5 yr. olds		Comments
				Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	
67	1974	6	X									
85	1974	6		2								COY ID #86, 87
	1981	13	?									Hunter kill 10/81
90	1974	4	X									
91	1974	4	X									
	1975	5	X									Hunter kill 10/75
94	1974	10						3	3			ID #95, 96, 97; 95 killed by hunter 10/75
101	1974	16				2						Yearling ID #102, 103; #102 killed by hunter 10/75
109	1974	12				1						Yearling ID #110
113	1974	9		2	2							COY ID #114, 115
	1975	10				2						
116	1970	10						2				
	1974	14	X									
117	1974	8				2	2					
118	1975	13				2						
129	1975	6	X									
400	1972	11				2 (#401 and 402)						Both yearlings recaptured in 1974
	1973	12	X									Hunter kill 10/73
405	1972	17						3 (#406, 407 and 1 other)				#406 killed in 1974, #407 killed in 1977
408	1972	4	X									

Table 4. Continued.

Bear ID	Year	Age	Barren	Cubs		Yearlings		2.5 yr. olds		3.5 yr. olds		Comments
				Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	
409	1972	14				1 (#410)						With consorting male, yearling some distance away
	1974	16				4 (# 80, 81, 82, 83)						#80 killed 10/77, #82 killed 5/80
414	1972	3										
	1973	4	X									Hunter kill 10/73
414	1972	8				2 (#416 and 417)						#416 killed 10/74
	1974	10	X									
	1977	13					2					Killed DLP 10/77
425	1972	7	X									Lactating
427	1972	12				3 (#428, 429, 430)						#428 recaptured in 1974, #429 killed 10/73
431	1972	4	X									
	1974	6				2 (#47 and 48)						#48 recaptured in 1975
	1975	7	X									
433	1972	17				2 (#434 and 435)						
	1974	19				1 (#434)	0					#435 found dead 6/15/74, #434 killed by hunter 10/74
	1975	20	X									Hunter kill 10/75
436	1972	5	X									
437	1972	8				2 (#438 & 439)						
440	1972	7				1 (#441)						
443	1972	2										
	1974	4	X									
445	1972	14				1 (#446)						

Table 4. Continued.

Bear ID	Year	Age	Barren	Cubs Spring	Cubs Fall	Yearlings Spring	Yearlings Fall	2.5 yr. olds Spring	2.5 yr. olds Fall	3.5 yr. olds Spring	3.5 yr. olds Fall	Comments
447	1972	8				3 (#448, 449, 450)						
452	1972	6	X									
454	1972	8				3 (#455, 456, 457)						#455 killed 10/75
455	1975	4	X									Killed by hunter 10/75
458	1972	12								3 (#459, 460, 461)		
463	1972	7				2 (#464 & 465)						
	1974	9	X									
	1975	10		2								
468	1972	8									1 (#469)	
	1975	11				3	1					Yearling #127 killed 5/78
701	1970	3										
	1971	4	X									
	1972	5	X									Hunter kill 5/72
703	1970	9				2	2					Yearlings #704 killed 5/78, #705 recaptured 1972
	1971	10	X									
	1972	11										Hunter kill 10/72
706	1970	3	X									
	1971	4	X									
707	1970	7				1	1					Yearling #708
	1971	8	X									#708 recaptured alone

Table 4. Continued.

Bear ID	Year	Age	Barren	Cubs Spring	Cubs Fall	Yearlings Spring	Yearlings Fall	2.5 yr. olds Spring	2.5 yr. olds Fall	3.5 yr. olds Spring	3.5 yr. olds Fall	Comments
708	1971	2										
	1972	3	X									
	1974	5	X									
712	1972	3	X									
	1974	5				3	0					2 yearlings died at capture, other lost by Sept.
	1975	6		2								
717	1970	6	X									Mammae large
	1974	10	X									
719	1970	8	X									
	1972	10						2 (#420 & 421)				
	1974	12						2	2 (#420 &421)			
722	1970	18				2	2					Yearlings 723 and 724
	1971	19						1				#723 missing
	1972	20										Hunter kill 10/72, #724 also killed 10/72
725	1970	3	X									
	1971	4	X									
	1974	7						3	3			Cubs #69, 70, 71
	1977	10						2				
	1978	11	X									
725[b]	1970	9		2 (#726 &727)								

Table 4. Continued.

Bear ID	Year	Age	Barren	Cubs		Yearlings		2.5 yr. olds		3.5 yr. olds		Comments
				Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	
728	1970	10				2	2 (#729 & 730)					#730 killed by hunter 10/72
	1974	14						3	3			#33, 34, 35; #33 & 34 recaptured alone in 1975
731	1970	7				2	2 (#732 &733)					
	1971	8						2	2			
	1972	9								2		#732 killed 10/72; #733 killed 5/76
	1974	11				2 (#92 & 93)						#93 killed in 10/77
733	1970	1										
	1971	2										
	1972	3	X									
	1974	5	X									
	1975	6	X									Hunter kill 10/75
734	1970	6				1 (#735)						#735 recaptured in 1971 alone
	1974	10		2								
736	1970	3	X									
	1971	4	X									
738	1970	13						4	4			Young included #739 (killed in 1972) and #740 (recaptured in 1972)
742	1970	3	X									
	1971	4	X									
745	1970	15	X									

Table 4. Continued.

Bear ID	Year	Age	Barren	Cubs		Yearlings		2.5 yr. olds		3.5 yr. olds		Comments
				Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	
747	1970	5				1 (#748)						
	1971	6						1				
	1972	7	X									
	1974	9				2 (#98 & 99)						#98 killed 10/77; #99 killed 10/75
	1975	10	X									
749	1970	3	X									
	1972	5	X									Hunter kill 10/72
750	1970	9				2 (#751 & 1 unmarked)						#751 killed 1973
753	1970	14				2 (754 &755)						#754 killed 10/71
	1971	15	X									
	1974	18	X									
756	1970	5	X									
757	1970	13				3 (#758, 759 &760)						
	1971	14	X									
761	1970	9	X									
	1971	10	X									
764	1970	6				2	2 (#765 & 766)					#765 killed 5/74
	1972			1 (#462)								
769	1970	5	X									Lactating
	1971	6	X									
	1975	10	X									Lactating
	1976	11		2	2							
	1977	12				2						

Table 4. Continued.

Bear ID	Year	Age	Barren	Cubs Spring	Cubs Fall	Yearlings Spring	Yearlings Fall	2.5 yr. olds Spring	2.5 yr. olds Fall	3.5 yr. olds Spring	3.5 yr. olds Fall	Comments
770	1970	11				2 (#771 &772)						
	1974	15	X									
773	1970	7	X									
	1974	11				3 (#57, 58, 59)						
	1975	12						3				#57 killed 5/76; #58 killed 10/77
776	1970	3	X									
	1971	4	X									
778	1970	2										
	1971	3	X									
	1972	4	X									
779	1970	5	X									
	1971	6		3	1							COY #13, 14, 15
	1974	9		3								
	1975	10				2						
781	1970	3	X									
	1971	4			3							Hunter kill 10/71, reported to have had 3 COY, large mammae
782	1970	5	X									
785	1970	6				2	2 (#786 & 788)					#786 recaptured through 1975; #788 killed 10/77
	1972	8	X									
790	1970	4	X									
794	1970	12					3 (#795, 796 and 1 unmarked)					#796 killed in 10/71

Table 4. Continued.

Bear ID	Year	Age	Barren	Cubs Spring	Cubs Fall	Yearlings Spring	Yearlings Fall	2.5 yr. olds Spring	2.5 yr. olds Fall	3.5 yr. olds Spring	3.5 yr. olds Fall	Comments
798	1970	2										
	1972	4	X									
802	1968	7		3								
806	1968	4		X								
809	1968	13		2								
811	1986	15		3								
818	1971	7				2 (#819 &820)						#819 killed 10/72
822	1971	4	X									
	1972	5	X									Hunter kill 5/72
823	1971	4	X									
	1972	5	X									
825	1970	10				1	1 (#710)					
	1971	11							1			
	1974	14							3 (#72, 73 and 1 unmarked)			#72 killed 10/77
	1975	15	X									
828	1971	3	X									
	1972	4	X									
	1974	6	X									
	1975	7	X									Lactating
	1976	8		2								
	1980			3								
829	1971	16				3						
	1975	20				1 (#138)						

Table 4. Continued.

Bear ID	Year	Age	Barren	Cubs Spring	Cubs Fall	Yearlings Spring	Yearlings Fall	2.5 yr. olds Spring	2.5 yr. olds Fall	3.5 yr. olds Spring	3.5 yr. olds Fall	Comments
831	1971	4	X									
836	1971	5	X									
	1974	8						3	3 (#30, 31, 32)			#30 killed 10/77; #32 killed 10/75
	1975	9	X									
838	1971	13	X									
839	1971	10				3	4 (#840, 841, 842)					All 3 young recaptured in 1972
	1974	13				2 (#104 and 105)						#104 killed 10/75
843	1971	4	X									
	1972	5	X									
	1973	6	X									Killed by hunter 10/73
851	1968	6	X									
	1970	8				2 (#712 and 713)						#712 recaptured in 1974
	1971	9	X									
	1972	10	X									
	1974	12				3 (#68 and 2 unmarked)						#68 captured in 1975
	1978	16							2			
854	1971	8						2 (#855 and 856)				#855 killed 10/72
	1972	9	X									
861	1971	5	X									
864	1971	8						2 (#865 and 966)				#865 killed 10/73 and #866 killed 10/75

Table 4. Continued.

Bear ID	Year	Age	Barren	Cubs		Yearlings		2.5 yr. olds		3.5 yr. olds		Comments
				Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	
867	1971	16						3 (#833, 868 and 869)				#833 killed 10/73; 868 killed 10/71; 869 recaptured in 1974
	1972	17	X									Hunter kill 10/72
869	1971	2										
	1972	3	X									
	1974	5	X									
872	1971	3	X									
	1972	4	X									
	1975	7	X									
	1976	8	X									

Table 5. Relationship between cub production and sockeye salmon escapement into Black Lake the previous year, 1982-92.

Salmon escapement	Number of cubs	% cubs in population	Cub litter size	Year
377,516	24	13.6	2.24	1986
384,004	34	18.4	2.21	1990
420,577	22	12.2	2.06	1989
426,177	28	20.3	2.14	1984
434,543	27	14.6	2.36	1991
438,540	31	22.0	2.09	1982
566,088	34	23.1	2.25	1987
589,291	34	19.8	2.14	1988
597,712	36	18.0	2.16	1985
616,117	43	27.2	2.31	1983
722,138	47	22.1	2.19	1992

Table 6. Cumulative survival rates of radio-marked brown bears at Black Lake, Alaska, 1988-93 calculated using modified Kaplan-Meir procedures.

Dates	No. @ Risk	No. @ Deaths	Rate	Survival Censored	No. Added	No. CI	Lower CI	Upper Var(Surv)
Cubs-of-the-year with radioed mothers								
5/1-5/15	82	0	1.00	0	0	1.00	1.00	0.0000
5/16-5/23	81	1	0.99	0	0	0.96	1.01	0.0001
5/24-5/31	81	0	0.99	2	10	0.96	1.01	0.0001
6/1-6/7	89	0	0.99	3	0	0.96	1.01	0.0001
6/8-6/15	86	7	0.91	0	0	0.85	0.97	0.0009
6/16-6/23	79	1	0.90	0	2	0.83	0.96	0.0011
6/24-6/30	80	4	0.85	0	0	0.78	0.92	0.0013
7/1-7/31	76	1	0.84	0	0	0.76	0.92	0.0015
8/1-8/31	75	9	0.74	0	0	0.65	0.82	0.0019
9/1-9/30	66	2	0.72	0	0	0.62	0.81	0.0022
10/1-10/31	64	6	0.65	0	0	0.56	0.74	0.0023
11/1-4/30	58	4	0.60	0	0	0.51	0.70	0.0025
Yearlings, all mortalities, including 3 assumed mortalities								
5/1-5/15	38	2	0.95	0	0	0.88	1.02	0.0012
5/16-5/23	36	0	0.95	0	5	0.88	1.02	0.0013
5/24-5/31	41	0	0.95	0	3	0.88	1.01	0.0012
6/1-6/7	44	0	0.95	0	15	0.88	1.01	0.0011
6/8-6/15	59	0	0.95	0	4	0.89	1.00	0.0008
6/16-6/23	63	0	0.95	0	0	0.89	1.00	0.0007
6/24-6/30	63	1	0.93	0	0	0.87	0.99	0.0009
7/1-7/31	62	3	0.89	0	0	0.81	0.96	0.0014
8/1-8/31	59	4	0.83	0	0	0.74	0.91	0.0020
9/1-9/30	55	0	0.83	0	0	0.74	0.92	0.0022
10/1-10/31	55	2	0.80	2	0	0.70	0.89	0.0023
11/1-4/30	53	0	0.80	0	0	0.70	0.89	0.0024
All 2-year-olds, all mortalities,								
5/1-5/15	24	1	0.96	0	0	0.88	1.04	0.0016
5/16-5/23	23	0	0.96	0	0	0.88	1.04	0.0017
5/24-5/31	23	0	0.96	0	0	0.88	1.04	0.0017
6/1-6/7	23	0	0.96	0	1	0.88	1.04	0.0017
6/8-6/15	24	0	0.96	0	0	0.88	1.04	0.0016
6/16-6/23	24	0	0.96	3	0	0.88	1.04	0.0016
6/24-6/30	21	0	0.96	1	0	0.87	1.04	0.0018
7/1-7/31	20	0	0.96	2	0	0.87	1.04	0.0019
8/1-8/31	18	0	0.96	2	0	0.87	1.05	0.0021
9/1-9/30	16	0	0.96	0	0	0.86	1.05	0.0024
10/1-10/31	16	0	0.96	0	0	0.86	1.05	0.0024
11/1-4/30	16	0	0.96	0	0	0.86	1.05	0.0024

Table 6. Continued.

Females ≥3, all types of mortality								
5/1-5/15	140	4	0.97	1	2	0.94	1.00	0.0002
5/16-5/23	137	3	0.95	3	15	0.91	0.99	0.0003
5/24-5/31	146	1	0.94	2	28	0.91	0.98	0.0003
6/1-6/7	171	0	0.94	0	13	0.91	0.98	0.0003
6/8-6/15	184	1	0.94	1	6	0.90	0.97	0.0003
6/16-6/23	188	1	0.93	1	0	0.90	0.97	0.0003
6/24-6/30	186	0	0.93	1	0	0.90	0.97	0.0003
7/1-7/31	185	3	0.92	0	0	0.88	0.96	0.0004
8/1-8/31	182	1	0.91	0	0	0.87	0.95	0.0004
9/1-9/30	181	0	0.91	2	0	0.87	0.95	0.0004
10/1-10/31	179	8	0.87	1	0	0.83	0.92	0.0005
11/1-4/30	170	0	0.87	7	0	0.83	0.92	0.0006
Females ≥3, hunting mortality only								
5/1-5/15	140	0	1.00	4	2	1.00	1.00	0.0000
5/16-5/23	138	3	0.98	4	15	0.95	1.00	0.0002
5/24-5/31	146	0	0.98	3	28	0.95	1.00	0.0001
6/1-6/7	171	0	0.98	0	13	0.96	1.00	0.0001
6/8-6/15	184	0	0.98	2	6	0.96	1.00	0.0001
6/16-6/23	188	0	0.98	2	0	0.96	1.00	0.0001
6/24-6/30	186	0	0.98	1	0	0.96	1.00	0.0001
7/1-7/31	185	0	0.98	3	0	0.96	1.00	0.0001
8/1-8/31	182	0	0.98	1	0	0.96	1.00	0.0001
9/1-9/30	181	0	0.98	2	0	0.96	1.00	0.0001
10/1-10/31	179	4	0.96	5	0	0.93	0.99	0.0002
11/1-4/30	170	0	0.96	7	0	0.93	0.99	0.0002
Females ≥3, natural mortality only								
5/1-5/15	140	3	0.98	2	2	0.95	1.00	0.0001
5/16-5/23	137	1	0.97	4	15	0.94	1.00	0.0002
5/24-5/31	147	1	0.96	2	28	0.94	0.99	0.0002
6/1-6/7	172	0	0.96	0	13	0.94	0.99	0.0002
6/8-6/15	185	1	0.96	1	6	0.93	0.99	0.0002
6/16-6/23	189	1	0.95	1	0	0.93	0.98	0.0002
6/24-6/30	187	0	0.95	1	0	0.93	0.98	0.0002
7/1-7/31	186	3	0.94	0	0	0.91	0.97	0.0003
8/1-8/31	183	1	0.93	0	0	0.90	0.97	0.0003
9/1-9/30	182	0	0.93	2	0	0.90	0.97	0.0003
10/1-10/31	180	4	0.91	5	0	0.87	0.95	0.0004
11/1-4/30	171	0	0.91	8	0	0.87	0.95	0.0004

Table 6. Continued.

Dates	No. @ Risk	No. @ Deaths	Survival Rate	No. Censored	No. Added	Lower CI	Upper CI	Var(Surv)
Males ≥3, all mortalities (one natural and two hunting)								
5/1-5/15	3	0	1.00	0	0	1.00	1.00	0.0000
5/16-5/23	3	0	1.00	0	10	1.00	1.00	0.0000
5/24-5/31	13	0	1.00	1	7	1.00	1.00	0.0000
6/1-6/7	19	0	1.00	0	0	1.00	1.00	0.0000
6/8-6/15	19	0	1.00	0	1	1.00	1.00	0.0000
6/16-6/23	20	0	1.00	0	0	1.00	1.00	0.0000
6/24-6/30	20	0	1.00	1	0	1.00	1.00	0.0000
7/1-7/31	19	0	1.00	3	0	1.00	1.00	0.0000
8/1-8/31	16	0	1.00	1	0	1.00	1.00	0.0000
9/1-9/30	15	0	1.00	1	0	1.00	1.00	0.0000
10/1-10/31	14	3	0.79	3	0	0.60	0.98	0.0094
11/1-4/30	8	0	0.79	5	0	0.53	1.04	0.0165

Table 7. Black Lake stream survey results. 1982-92.

Date	Females w/young no.	Females w/young %	COY no.	COY %	>COY no.	>COY %	Single bears no.	Single bears %	Total sample	Total adults	Bears per hour	Comments
1982												
8/8 am	26	19	25	19	25	19	58	43	134	84	40.20	
8/8 pm	27	18	37	25	29	20	55	37	148	82	50.74	
Mean	27	19	31	22	27	19	57	40	141	83	45.47	
1983												
8/9 pm	34	24	33	24	35	25	38	27	140	72	48.00	USFWS
8/10am	41	25	49	29	34	20	43	26	167	84	51.12	USFWS
8/10pm	29	19	42	28	24	16	56	37	151	85	61.22	USFWS
8/12am	35	20	47	27	29	17	62	36	173	97	55.81	USFWS
Mean	35	22	43	27	31	20	50	32	158	85	54.04	
1984												
8/7 am	28	25	32	29	22	20	28	25	110	56	33.85	
8/7 pm	37	22	32	19	47	27	55	32	171	92	64.04	
8/8 am*	31	27	20	17	36	31	29	25	116	52	61.88	
8/8 pm	37	24	26	17	44	29	46	30	153	83	61.20	
Mean	33	24	28	21	37	27	40	29	138	71	55.24	
1985												
8/5 pm	47	23	35	17	60	29	64	31	206	111	68.70	
8/6 am	35	20	36	20	45	25	62	35	178	97	59.30	
8/8 am	47	22	37	17	65	30	66	31	215	113	67.90	
Mean	43	21	36	18	57	28	64	32	200	107	65.30	
1986												
8/6 pm	38	22	27	16	46	27	62	36	173	100	49.40	
8/7 am	25	15	17	10	36	22	85	52	163	110	51.40	
8/7 pm	41	20	29	14	44	22	88	44	202	129	61.60	
8/8 pm	34	20	21	13	40	24	71	43	166	95	47.40	
Mean	35	20	24	13	42	24	77	43	176	109	52.45	
1987												
8/7 pm	3	11	2	7	5	18	18	64	28			aborted
8/12pm	27	18	34	23	28	19	58	39	147	85	51.88	late survey
1988												
8/8 pm	40	25	34	22	47	30	37	23	158	77	45.14	
8/9 am	51	24	49	23	65	30	50	23	217	101	62.00	
8/10am	31	20	23	15	43	28	57	37	154	88	48.13	
8/10pm	38	24	31	20	50	32	38	24	157	76	49.58	
Mean	40	23	34	20	51	30	46	27	172	86	51.21	

Table 7. Continued.

Date	Females w/young no.	Females w/young %	COY no.	COY %	>COY no.	>COY %	Single bears no.	Single bears %	Total sample	Total adults	Bears per hour	Comments
1989												
8/9am	37	20	26	14	53	29	65	36	181	102	62.06	
8/9pm	40	21	25	13	55	29	72	38	192	112	66.59	
8/10am*	32	18	20	11	54	31	70	40	175	101	62.32	
8/12am	34	19	20	11	56	32	65	37	175	99	66.88	
8/12pm	39	22	19	10	64	35	59	33	181	98	65.03	
Mean	36	20	22	12	56	31	66	37	181	102	64.58	
1990												
8/3 pm	36	21	25	15	41	24	67	40	169	103	54.17	
8/4 pm	43	23	31	16	56	29	61	32	191	104	67.49	
8/5 pm	41	21	37	19	48	24	74	37	200	115	66.67	
8/6 pm	36	20	36	20	44	24	68	37	184	104	62.80	
8/7 am	38	21	41	22	43	23	61	33	183	99	61.00	
Mean	39	21	34	18	46	25	66	36	185	105	62.42	
1991												
8/5 pm	27	16	24	14	30	17	91	53	172	118	48.68	New Pilot
8/6 pm	29	17	26	15	32	18	88	50	175	117	51.47	New Pilot
8/7 pm	33	17	26	13	40	20	97	49	196	130	58.51	New Pilot
8/9 pm	39	20	30	15	41	21	86	44	196	125	57.65	New Pilot
Mean	32	17	27	14	36	19	91	49	185	123	54.08	
1992												
8/9 pm	43	20	55	25	39	18	82	37	219	125	61.12	
8/10am	38	21	34	19	46	25	64	35	182	102	55.15	
8/10pm*	50	21	52	22	53	22	86	36	239	135	68.29	
Mean	44	21	47	22	46	22	77	36	213	121	61.52	

* These surveys include the mean number of bears seen in the West Fork drainage on the other surveys conducted the same year.

Table 8. Summary of number of locations and status of brown bears at Black Lake, Alaska, 1988-93.

Bear Tattoo	Sex	Initial capture date	Year born	Age at capture	No. of Locations 1988	1989	1990	1991	1992	1993	Total	Current status
1	F	6/1/88	1977	11	13	13	14	15	4		59	Natural mortality
2	F	6/1/88	1987	1	1						1	Unknown, never radioed
3	M	6/1/88	1987	1	1	1					2	Hunter kill 10/89
4	F	6/1/88	1976	12	12						12	Collar shucked
5	M	6/1/88	1974	14	5						5	Recaptured 1 time, radio shed
6	F	6/1/88	1984	4	10			13	15	13	51	Alive w/active collar
7	M	6/1/88	1984	4	1				1		2	Hunter kill 5/92
8	F	6/1/88	1984	4	12	8					20	Hunter kill 10/89
9	M	6/2/88	1985	3	9	1					10	Unknown, collar shed
10	M	6/2/88	1985	3	10			1			11	Glue-on shed in 1988, Hunter kill 10/91
11	F	6/2/88	1963	25	9	12	14	14			49	Shed collar
12	F	6/2/88	1979	9	10	12	14				36	Unknown, radio malfunction
13	F	6/2/88	1986	2	1	9	6				16	Collar shed in 1990, hunter kill 5/92
14	M	6/2/88	1980	8	1						1	Unknown, never radioed
15	M	6/2/88	1972	16	2			1			3	Hunter kill, 5/92
16	F	6/2/88	1984	4	10	9					19	Unknown, collar shed
17	F	6/2/88	1970	18	10	12	14	16	16	13	81	Alive w/active collar
18	F	6/2/88	1977	11	10	11	14	15	16	14	80	Alive w/active collar
19	F	6/2/88	1987	1	1						1	Presumed dead, separated from mom at capture
20	F	6/2/88	1987	1	1						1	Presumed dead, separated from mom at capture
21	F	6/2/88	1985	3	8	1					9	Unknown, glue-on shed
22	F	6/2/88	1979	9	1						1	Capture mortality
23	F	6/3/88	1970	18	11	10	4				25	Natural mortality
24	M	6/3/88	1987	1	1						1	Unknown, never radioed
25	M	6/2/88	1972	16	1						1	Unknown, never radioed

Table 8. Continued.

Table 8. Continued.

Bear Tattoo	Sex	Initial capture date	Year born	Age at capture	No. of Locations 1988	1989	1990	1991	1992	1993	Total	Current status
26	F	6/2/88	1977	11	9	10	15	14	14	11	73	Alive w/active collar
27	F	6/2/88	1986	2	2						2	Unknown, glue-on radio shed
28	M	6/2/88	1986	2	1						1	Unknown, never radioed
29	M	6/2/88	1986	2	1						1	Unknown, never radioed
30	F	6/3/88	1979	9	10	12	16	16	13	14	81	Alive w/active collar
31	M	6/3/88	1986	2	1	12					13	Unknown, collar shed
32	F	6/3/88	1974	14	1						1	Capture mortality
33	M	6/3/88	1986	2	1	1					2	Hunter kill 10/89
34	F	6/3/88	1976	12	13	12	16	15	15	12	83	Alive w/active collar
36	F	6/3/88	1978	10	4						4	Natural mortality
37	F	6/3/88	1983	5	11	17	16	15	17	14	90	Alive w/active collar
38	F	6/3/88	1972	16	10	14	17	13	14	3	71	Natural mortality
39	M	6/3/88	1985	3	3	1					4	Hunter kill 10/89
40	F	6/3/88	1984	4	9	11	15	15			50	Unknown, radio malfunction
41	M	6/3/88	1975	13	2	1					3	Collar shed, hunter kill 10/89
42	M	6/3/88	1984	4	7	1					8	Unknown, glue-on shed
43	F	6/3/88	1983	5	9	3					12	Unknown, collar shed
44	F	6/3/88	1968	20	10						10	Natural mortality
45	F	6/3/88	1986	2	11	3					14	Unknown, collar shed
46	F	6/4/88	1978	10	9	11	6				26	Natural mortality
47	M	6/4/88	1984	4	11	1					12	Unknown, collar shed
48	M	6/4/88	1985	3	10	12	1				23	Unknown, collar shed
49	M	6/4/88	1982	6	1	2			1		4	Glue-on radio shed in 1989, hunter kill 5/92
50	F	6/4/88	1984	4	9	10	13				32	Unknown, collar shed
51	F	6/4/88	1976	12	11	14	14	15	17	7	78	Radio failure
52	F	6/4/88	1985	3	12	8	12	12	18	13	75	Alive w/active collar

Table 8. Continued.

Bear Tattoo	Sex	Initial capture date	Year born	Age at capture	No. of Locations 1988	1989	1990	1991	1992	1993	Total	Current status
53	F	6/5/88	1985	3	9	12					21	Hunter kill 10/89
54	M	6/5/88	1985	3	6						6	Unknown, radio malfunction
55	F	6/5/88	1979	9	9	9	13	13	14		58	Natural mortality
56	M	6/5/88	1986	2	1						1	Unknown, never radioed
57	F	6/5/88	1980	8	11	8	14	14	13	13	73	Alive w/active collar
58	F	6/5/88	1970	18	10	12	14	15	12	12	75	Alive w/active collar
59	F	5/21/89	1983	6		11	4				15	Hunter kill 5/90
60	F	5/21/89	1980	9		13	15	14	15	14	71	Alive w/active collar
61	F	5/21/89	1985	4		2					2	Unknown, glue-on radio shed
62	M	5/21/89	1987	2		1					1	Capture mortality
64	M	5/22/89	1979	10		2					2	Unknown, glue-on radio shed
65	F	5/22/89	1979	10		12	15	14	17	14	72	Alive w/active collar
66	M	5/22/89	1987	2		6					6	Unknown, glue-on radio shed
67	F	5/22/89	1986	3		12					12	Hunter kill 10/89
68	M	5/22/89	1983	6		2					2	Hunter kill 10/89
69	F	5/22/89	1967	22		6					6	Natural mortality
70	F	5/22/89	1982	7		13	16	12	17	15	73	Alive w/active collar
71	M	5/22/89	1984	5		1	1				2	Unknown, collar shed
72	M	5/23/89	1981	8		1			1		2	Hunter kill, 5/92
73	M	5/23/89	1987	2		2					2	Unknown, glue-on radio shed
74	M	5/23/89	1986	3		1					1	Never radioed
75	F	5/23/89	1985	4		3					3	Natural mortality
76	F	5/23/89	1975	14		12	14	15			41	Unknown, radio malfunction
77	F	5/23/89	1986	3		7					7	Hunter kill 10/89
78	M	5/23/89	1985	4		5	1				6	Natural mortality
79	M	5/23/89	1979	10		2					2	Unknown, glue-on radio shed
80	F	5/23/89	1976	13		2		11	14	13	40	Alive w/active collar

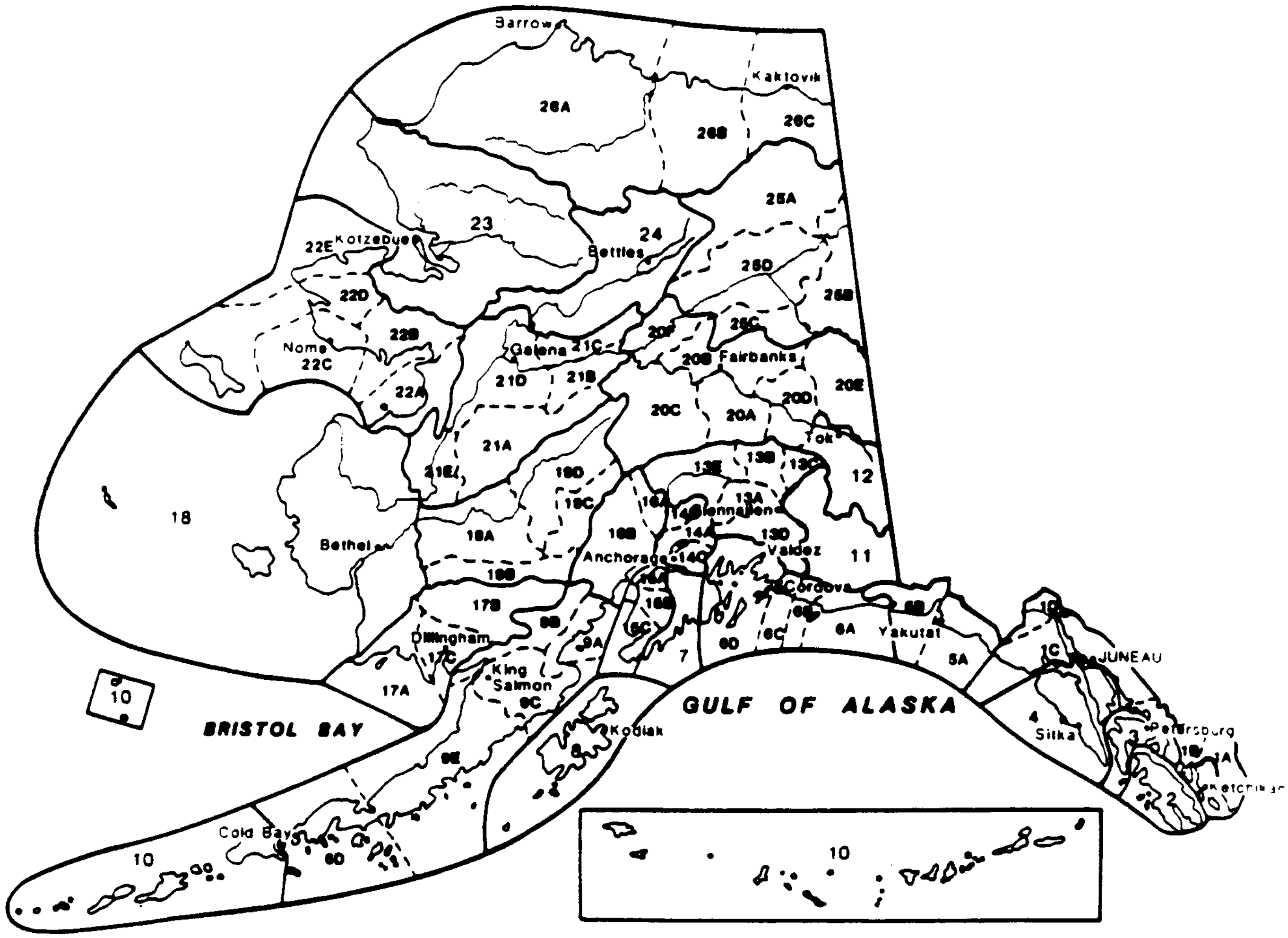
Table 8. Continued.

Bear Tattoo	Sex	Initial capture date	Year born	Age at capture	No. of Locations 1988	1989	1990	1991	1992	1993	Total	Current status
81	M	5/23/89	1985	4		5					5	Radio malfunction, hunter kill 10/91
82	F	5/23/89	1975	14		11	15	12	4		42	Hunter kill, 5/92
83	M	5/23/89	1983	6		7	1				8	Unknown, collar shed
84	M	5/24/89	1986	3		5					5	Hunter kill 10/89
85	M	5/24/89	1977	12		2					2	Unknown, glue-on radio shed
86	M	5/24/89	1984	5		6					6	Unknown, collar shed
87	F	5/24/89	1977	12		14	13	16	17	11	71	Alive w/active collar
88	F	5/24/89	1970	19		3					3	Natural mortality
89	M	5/24/89	1978	11		2					2	Unknown, glue-on radio shed
90	F	5/24/89	1970	19		9					9	Unknown, radio malfunction
91	M	5/24/89	1985	4		7	11				18	Unknown, radio removed
92	F	5/24/89	1986	3		8	3				11	Suspect unreported hunter kill 5/90
95	F	6/14/90	1970	20			11	14	10		35	Natural mortality
96	F	6/14/90	1976	14			9	12	16	13	50	Natural mortality
97	F	6/14/90	1979	11			12	15	16	3	46	Natural mortality
98	F	6/14/90	1979	11			10	14	13	12	49	Alive w/active collar
178	M	6/14/90	1984	6			6	3			9	Hunter kill 10/91
201	M	6/4/91	1988	3				1			1	Unknown, never radioed
202	F	6/3/91	1980	11				11	14	14	39	Alive w/active collar
203	F	6/4/91	1970	21				11	15	11	37	Alive w/active collar
204	F	6/4/91	1988	3				10	4		14	Hunter kill, 5/92
205	F	6/4/91	1986	5				11			11	Hunter kill 10/91
206	F	6/6/91	1974	17				9	16	14	39	Alive w/active collar
207	F	6/6/91	1979	12				10	12	11	33	Alive w/active collar
208	F	6/5/91	1975	16				12	14	3	29	Collar shed
209	M	6/6/91	1988	3				1			1	Unknown, never radioed
210	F	6/6/91	1974	17				8	3		11	Collar shed

Table 8. Continued.

Bear Tattoo	Sex	Initial capture date	Year born	Age at capture	No. of Locations 1988	1989	1990	1991	1992	1993	Total	Current status
211A	F	6/6/91	1972	19				10			10	Killed by ad. male 5/4/92
211B	F	6/6/91	1988	3				10	15	14	39	Alive w/active collar
212	F	6/6/91	1985	6				11	15		26	Natural mortality
213	F	6/14/91	1983	8				9	17	13	39	Alive w/active collar
214	F	6/14/91	1989	2				1			1	Unknown, never radioed
215	F	6/14/91	1984	7				9	13	14	36	Alive w/active collar
Total locations					359	478	419	513	485	328	2,609	

Alaska's Game Management Units



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