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

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

by
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Study 4.21
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SUMMARY

In this reporting period I completed final editing on 3 manuscripts, prepared another manuscript that will be printed in 1990, and wrote review drafts of another paper. Brown bears (Ursus arctos) with radio transmitters were monitored in the spring, midsummer, and fall to determine reproductive status. Transmitters applied in 1986 or 1987 were replaced on 11 bears as part of long-term reproductive rate studies. Data were developed and presented illustrating that during much of the 1980's bear harvests in GMU 13 were well above sustainable levels in all subunits except, perhaps, Subunit 13D. Minimum annual harvest rates of marked bears averaged 8.3% during the years 1980 to 1989 (range = 4%-13%). Including suspected unreported harvests, the average was 13% (maximum = 37%). Harvest rates for males (10-yr average = 7.3%) were higher than for those females (4.9%). These harvest rates underestimate the actual rates because of natural, unreported, or unrecognized mortalities. I was unsuccessful in an effort to correct for these sources of error using the number of bears marked in 1978 and 1979 that were never reported in the harvest (29% of males and 68% of females). Using the Kaplan-Meier approach, survivorship of newborn cubs (COY) in litters with radio-marked females was 0.70 (95% CI = 0.61-0.79). In spite of increased bear harvests, no trend in cub survivorship was evident. During the years 1978 to 1990, 33% of 98 cubs with radio-marked females died. During the same period 15% of 67 yearlings were lost from litters. Mean litter size was 2.1 for cubs, 1.8 for yearlings, and 1.8 for 2-year-olds. Sex ratios of cubs and yearlings were not different from 50:50 ($P > 0.10$). Age at first litter production was 5.6 years. Reproductive intervals were 3 years in 59% of 44 intervals that were observed or are pending. Mean reproductive interval was 3.75 years (range = 2-8 yrs). Simulation studies revealed that reduced predation on moose (Alces alces) neonates results in long-term increases in fall calf:cow ratios. These results form the null hypothesis by which to evaluate any results of reducing bear densities in GMU 13 on moose calf survivorship.

Key words: Alaska, brown bear, *Ursus arctos*, density estimate, population trends, reproductive rates, litter size, reproductive interval, age of first reproduction.

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OBJECTIVES

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

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

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

RESULTS AND DISCUSSION

A final report on objective No. 1 was presented by Miller (1988), these results were also published (Miller 1990). Miller (1987) reported progress on objective Nos. 2 and 3. These 2 objectives expand upon work accomplished during the Susitna hydroelectric project (Miller 1987), additional progress is reported here. Reproductive rates for brown bears marked in GMU 13 have been studied since 1978. As part of these studies, transmitters were scheduled to be replaced on marked bears during spring 1989. This was not accomplished because these transmitters were used to investigate the impacts of the Exxon Valdez oil spill on brown bears in Katmai National Park. Instead, transmitters were replaced during spring 1990 on 11 bears that had been originally marked during the period 1980-1987. All recaptured bears were adult females. Radio transmitters were removed from males in spring 1987 or were shed shortly afterwards when specially designed canvass spacers rotted through. Capture histories for brown bears marked in GMU 13 since 1980 are presented in Table 1.

Publications

During this reporting period final editing was accomplished on 3 papers that were published in Vol. 8 of the Intl. Conf. for Bear Res. and Management: "Population management of bears in North America", "Detection of differences in brown bear density and population composition caused by hunting", and "Denning ecology of brown bears in southcentral Alaska and comparisons with a sympatric black bear population". Another manuscript on "Impact of increased bear hunting on survivorship of bear cubs" is in press in the Wildl. Soc. Bulletin. Preliminary drafts of a manuscript describing the impacts of reduced bear densities on survival of moose calves in GMU 13 were prepared, and portions of these analyses are presented in this report. I began preliminary compilation of data from other investigators for a paper describing the results of 9 Alaskan capture-recapture brown bear density estimates.

Status and Trends for Brown Bear Populations in GMU 13

Research conducted in the late 1970's indicated that brown bears were killing many moose (*Alces alces*) calves and that an experimental reduction in bear densities resulted in increased calf survivorship (Ballard and Larsen 1987, Ballard and Miller 1988). This research was done during the early stages of recovery of the moose population from a series of severe winters during the early 1970s (Ballard et al. in press). These results led the Alaska Board of Game to liberalize hunting opportunities for brown bears in GMU 13 as well as in many other portions of southcentral Alaska (Miller 1990a). This resulted in an increased bear harvest (Appendix A:Table 1). Evidence illustrating that the increasing harvests resulted in a declining bear density was presented by Miller (1988, 1990a, 1990b) and is reviewed in Appendix A. Appendix A presents a portion of a manuscript prepared during this reporting period. This manuscript examines available evidence on whether reduced bear densities caused or accelerated moose population growth in GMU 13 through improved moose calf survival. Only the introduction and portion describing changes in bear density of this manuscript is presented in Appendix A. This, as well as other portions, is being reviewed and revised.

Simulated Impacts of Reduced Predation on Moose Cow:calf Ratios:

I conducted simulation studies to evaluate whether a long-term increase in moose calf:cow ratios should be expected under conditions where calf survivorship was increasing as a result of reduced predation. This was part of the analysis discussed above. These studies were designed to evaluate the hypothesis that increases might not occur because increased calf survival resulted in increased numbers of subadult cows. Subadult cows have lower productivity than adult cows, and augmented numbers of subadult cows in a population could mask increases in calf:cow ratios because subadult cows cannot be readily distinguished from adults. Results of these simulation studies are presented in Appendix B in the form of a modified version of a ADF&G memo dated 22 Jan. 1990.

Comparisons of Sustainable and Actual Kill Densities in GMU 13:

Trends in bear populations are difficult and expensive to document (Miller 1990c). Evidence for such trends is also difficult to illustrate in ways that can be readily understood. During this reporting period, materials were prepared to demonstrate to the Alaska Board of Game that bear populations were declining and that hunting opportunities should be restricted. These materials included graphs that compared trends in reported harvest density with estimated sustainable harvest density (Figs. 1-6).

For these graphs, harvest density was calculated as reported harvest/unit area (Miller 1990a). Sustainable harvest density estimates were obtained from population estimates for each subunit in GMU 13 obtained by subjective extrapolation from density estimates obtained in 2 portions of GMU 13 during 1985 and 1987 (Miller 1988, 1990a, 1990b). The extrapolations were made by concensus opinion from 3 biologist knowledgeable with the area (W. B. Ballard, R. Tobey, and myself). Both habitat conditions and suspected history of hunting were considered in making these extrapolations. The resulting population estimates have been previously discussed and used to derive estimates of sustainable harvest numbers (Miller 1988, 1990a). The actual population estimates are presented in Table 1 of Appendix C.

At the time these estimates were made in 1987, they were identified as preliminary efforts. I believe these results overestimated population size. In 1987, however, even an overestimate was useful in demonstrating that existing harvest levels exceeded even generous estimates of sustainable levels. This was not generally acknowledged at the time. Additional and independent efforts at extrapolating from the available density estimates should be made to refine the population estimates for GMU 13.

Sustainable harvest density was illustrated with 3 parallel horizontal lines. The absence of slope in these lines correctly illustrates sustainable harvest density only when populations are stable. When populations are declining, these lines should have a negative slope; when increasing they should have a positive slope. Since this slope is unknown, however, it is enough to point out that when harvest density exceeds sustainable harvest density, sustainable harvest density must be declining, rather than constant as illustrated in Figures 1-6. The opposite is also true--when harvest density is less than sustainable, populations may be increasing at a rate that is influenced by proximity to carrying capacity (Miller 1990c). Sustainable harvest densities illustrated in Figs. 1-6 were calculated as explained below:

1. Sustainable harvest density was calculated as 8% of the density of bears older than 2.0 years old (Miller 1988). This rate is almost certainly higher than can actually be sustained, because it was calculated using conservative estimates of natural mortality (Miller 1988:49). For the whole population, this is equivalent to a harvest rate of about 5.7% (Miller 1988).

2. The sustainable harvest density estimate highlighted with x-marks (Figs. 1-6) is based on the population estimate obtained by extrapolation from the 1985 and 1987 density estimates in Unit 13 as discussed above. This is the best estimate of sustainable harvest density currently available. The other parallel lines represent bounds on this value as discussed below (#3). One advantage to this estimate is that it is expressed in the same unit as the harvest density values illustrated, the whole surface area of the subunit or unit is used rather than just "bear habitat" as defined in #3.

3. Two of the horizontal lines represent 8% of the estimated bear density in 1985 in the Su-hydro area (19.05 bears >2/1,000 km^2) and in 1987 in the upper Susitna area (6.67 bears >2/1,000 km^2). These density estimates are for "bear habitat", loosely defined as the area lower than elevations of 5,000 feet. This is close but not identical to the whole surface area used in calculating harvest density. In 1985 the Su-hydro area probably had a density as high as anywhere in GMU 13. The upper Susitna area has equivalent potential as bear habitat but has been heavily hunted and bear density has been reduced. In most of GMU 13, actual sustainable harvest density would probably be between these lines if the 8% sustainable harvest rate is correct.

4. Harvest density includes only bears of known sex and age. If bears of unknown sex or age were included, harvest density values would be marginally higher.

5. Harvest density figures are likely inflated to some degree by bootlegging into the unit during the period when the bag limit was 1/year in GMU 13 but 1/4 years elsewhere.

Harvest Rate for Brown Bears Marked in GMU 13:

Some impression of harvest intensity can be gained from examination of the rate at which marked bears are removed from the population by hunters. These data were presented by Miller (1987). Data through 1986 on harvest of bears marked in 1978 and 1979 were presented in Tables 25 and 26 of Miller (1987). Since no additional bears marked in 1978 and 1979 have been reported subsequently (1987-spring 1990), these tables are not repeated here. Updated harvest rates for bears marked in 1980-1987 in GMU 13 are presented in Table 2; this updates information in Table 27 of Miller (1987).

Minimum Percent Shot

For both sexes of bears, the annual percentage of marked bears known to be shot ranged from 4% (in 1980-fall season only) to 13% in 1984 (10 year average = 8.3%) (Table 2). These percentages were derived by dividing the number known harvested by the total number of marks potentially still available. Minimum harvest rates were higher for males (10 year average = 7.3%, range = 5-29%) than for females (average = 4.9%, 0-11%) (Table 2).

Reynolds (1990) used a different approach to estimate harvest rates in a heavily-hunted study area just north of the Alaska Range from GMU 13. Instead of looking at just marked bears, harvest rates were calculated as a percentage of total known population as well as of total estimated population. A mean annual harvest rate of 11-12% of probable population was calculated for bears > 2 and 8% for adult radio-collared females (Reynolds 1990:11). Both sets of harvest rates are high, relative to estimates of sustainable harvest rates (Miller 1990c, LeFranc 1987).

Corrected Percentage of Marked Bears Shot

The above method for estimating harvest rate underestimates the actual value. The numerator for this rate is the number of marked bears identified in the harvest. This number is a minimum number because of the likelihood that some marked bears are not recognized when their hides are sealed. Most bears are sealed by a biologist, but others are sealed by enforcement officers, secretaries, or others who are probably more likely to miss or fail to record marks. Ear tags are difficult to miss, but are frequently shed. In 1990, 11 bears were recaptured and 8 ear tags were missing (36%) (Table 1). These 11 bears were last captured in 1986 or 1987 (Table 1) when all had 2 ear tags.

The denominator for the percentage of bears killed is the total number of bears marked and not previously recorded as shot. This value does not include bears marked as cubs and yearlings, unless these were subsequently recognized as marked bears in the harvest. In these few cases, they are included as having been available to be shot in years in which they were legal to hunt (at least 2 years old). In spite of this, the denominator is doubtless inflated as not all marked bears are available to hunters. This is because (1) some bears killed by hunters have been not recognized as marked when sealed and are therefore still included as "available" (see above); (2) some marked bears have been killed and not retrieved by hunters or have died from natural mortality but are still listed as "available" since they did not appear in the harvest; and (3) in each year from 1980 to 1987, new bears were marked following spring hunting seasons; these marked bears were available, as marked bears, to hunters only during the following fall season which inflates the number of marked bears "available" during the whole year.

During this reporting period I made an unsuccessful effort to correct the number of marked bears available by reducing the denominator by a factor reflecting points 1 and 2 above. This would involve reducing the number of marked bears available by some percentage each year. In order to establish what this percentage should be, I examined the number of marks applied in 1978 and 1979 that never appeared or were recognized in the harvest. Of 53 marks applied to bears >2.0 years-old in these years (25 females and 28 males), 47% never appeared in the harvest (29% of the males and 68% of the females). In these data, marked females stopped appearing in the harvest 6 years after marking, compared with 9 years for males (Fig. 7). No bear marked in 1978 or 1979 has appeared in the harvest during 1987 through spring 1990, and it is reasonable to assume that very few more will appear. Correspondingly, one estimate of the annual percentage by which to reduce the denominator to correct for marked bears that are no longer "available" to hunters is 47% never reported/9-year period since marking when marked bears stopped appearing or 5%/year. The corresponding value for males would be 8%/9 years or 1%/year and for females it would be 68%/6 years or 11%/year.

I made an effort to apply these correction factors to the number of bears marked since 1980 that were still "available" to hunters. This effort was unsuccessful. The number of females calculated to be "available" reached zero too early, when many radio-marked females were known to be still be available (Table 2). For bears marked since 1980, I concluded that the 1978 and 1979 data were inappropriate, at least for females, to use in the manner outlined above to calculate a correction to the number of marked bears available to hunters. This may result from higher-than-normal natural mortality among the females captured in 1978 and 1979, because many of these bears captured in 1978 and all those captured in 1979 were transplanted from their home ranges (Miller and Ballard 1982). These transplanted bears may have had atypically high natural mortality rates. Also, many of the bears captured in 1978 and 1979 were in areas relatively more accessible to hunters than those captured as part of Su-hydro studies during 1980-85.

Even if it can not be correct, it is clear that not all the bears marked are still available to hunters and the denominator of the harvest rate calculation is inflated. Since males are shot at a faster rate than females (Fig. 7), the denominator is more inflated for females than for males. This means that the estimated harvest rate is more underestimated for females than it is for males. This clearly has management significance, because rate of population growth or decline is very sensitive to harvest rate of adult females (Knight and Eberhardt 1984, Taylor et al. 1987, Miller 1990c, Reynolds 1990).

Another way to correct the observed percentage of marked bears shot is to include in the numerator the radio-marked bears that were suspected to have been shot, based on their disappearance during hunting season. Marked bears for which there are no data available can also be excluded from the denominator. Using this procedure, the maximum harvest rate was 21% in 1984 and 37% in 1989 (average = 13.5) (Table 2).

Cub Survivorship Rates and Trends

Kaplan-Meier Approach:

Brown bear cub mortality rates were evaluated by inspection of litters of radio-marked females. Cubs that disappeared from litters before emergence from dens as yearlings were assumed to have died. Previously, mortality rates were calculated using MICROMORT as recommended by Heisey and Fuller (1985) (Miller 1988). In this report these rates are recalculated using the Kaplan-Meier approach recommended by Pollock et al. (1989). The Kaplan-Meier procedure is preferred for these data, because it permits data to be censored when marks are lost and also permits addition of new marks (Pollock et al 1989). Compared with calculations using MICROMORT, the Kaplan-Meier approach generated lower mortality estimates for the same data.

For data collected since 1978, survivorship of COY in litters of radio-marked females was 0.70 (95% CI = 0.61-0.79) (Table 3). Survivorship rates were also calculated for individual years to see if there was evidence of a trend over time (Table 3). Such a trend might occur if the heavy hunting pressure discussed above resulted in a compensatory increase in cub survivorship. Based on available data no trend correlated with time is evident (Fig. 8).

These results were presented in a manuscript cautioning managers of exploited bear populations not to assume that increased hunting pressure will result in compensatory increases in cub survivorship (Miller in press). Fig. 8 is part of this manuscript. This manuscript is not appended to this report because it should have been printed (Wildl. Soc. Bull. 18[4]) prior to this report. Research on whether hunting mortality is compensatory or additive to other sources of mortality is ongoing in an Alaska Range study of a heavily-hunted population (Reynolds

1990) and in a comparison of hunted and unhunted populations on the Alaska Peninsula (ADF&G files). Both studies should provide valuable additional insights to this question.

Percent Mortality Approach:

Percent mortality calculations may be biased in comparison to survivorship calculations because of lack of simultaneous marking and inconsistent survivorship rates between intervals (Heisey and Fuller 1985). Regardless, such rates are frequently reported and are reported here for comparison (Table 4). For this analysis, cubs and yearlings that disappeared from litters were assumed to have died. This is a reasonable assumption, because only one case of apparent weaning of yearlings was observed in GMU 13. In spring 1987, a large yearling (#475) was associated with a breeding pair of adults that included a female (#472) that had recently lactated. This bear was identified as a yearling, based on incompletely erupted canines. Although rare, 2 additional cases of yearling weaning were reported in north slope studies (Reynolds, pers. commun.), but none in Alaska Range studies (Reynolds 1990). Although most were marked, none of the cubs or yearlings classified as mortalities (based on their disappearance from litters) in GMU 13 were subsequently recaptured or shot by hunters.

Percent mortality was expressed during the period from emergence from one den to emergence from another den the following year ("complete data"). Incomplete data resulted when the litter was observed just prior to den entrance but not at exit the following spring because of infrequent monitoring schedules ("incomplete" data). Mortality of newborn cubs was 33% (_n_ = 98 with complete data, 107 including some with incomplete data) (Table 4). This is about the same as the 29% (_n_ = 52) reported in a study on the opposite (north) side of the Alaska Range (Reynolds 1990). Mortality of yearlings was 16% (_n_ = 57 with complete data) or 15% (_n_ = 67 including 10 with incomplete data) (Table 4). These rates are apparently higher than the 7% (_n_ = 45) reported for yearlings by Reynolds (1990).

<u>Reproductive Biology</u>

Reproductive biology for radio-marked brown bears in GMU 13 was previously presented by Miller (1987, 1988). These data are updated here. Miller (1990_a_) presented estimates of periods of time required to obtain accurate estimates of reproductive parameters based on simulation studies.

Litter Size and Sex Ratio:

Estimates of mean litter size have changed little since these data were first compiled by Miller (1987), and simulation studies reveal that this parameter is the quickest to accurately estimate (Miller 1990_a_). For 64 litters containing 133 spring cubs, mean litter size was 2.1 (range = 1-4) (Table 5). For 56 litters containing 102 yearlings, mean litter size was 1.8 (1-3) (Table 6). For 32 litters containing 56 2-year-olds, mean litter size was 1.8 (1-3) (Table 7).

Sex and other characteristics of cub and yearling brown bears is presented in Tables 8 and 9, respectively. Young bears were last captured in 1987, so these data are the same as presented in Miller (1988). Sex ratio of cubs captured in late May and early June was 18 males:15 females (Table 8). Sex ratio of yearlings first captured during the same period was 17 males:9 females (Table 9). Neither sex ratio was different from 50:50 (Chi square test, $\underline{P} = 0.60$ and 0.12, respectively).

Age at First Reproduction:

Little additional data on age at first reproduction has been obtained since Miller (1988:Table 14), because new subadult bears have not been marked since 1987. Based on ages estimated by counting cementum annuli, 25%, 55%, and 89% of females in GMU 13 produced their first litters at age 4, 5, and 6, respectively (Table 10). One bear (#407) had not produced a observed litter from age 4 to 8; her radio failed before she could be found following her exit from her den at age 9. Excluding observations of older bears that were never observed producing a litter ("complete" data), mean age at first reproduction was 5.35 years (Table 10). If it is assumed that bears with "incomplete data" produced their litters in the year following the last year we observed them, mean age at first litter production was 5.6 years (Table 10).

Actual age at first litter production may be younger than this because litters may be lost prior to first observation of the bear following emergence from dens. However, effective age at first production of a litter that is successfully weaned may be older than these means because if young females more frequently loose entire litters than older, more experienced females.

Reproductive Interval:

Reproductive interval is the most important parameter to estimate in terms of productivity of polar bear and brown bear populations (Taylor et al. 1987, Miller 1990<u>a</u>). These data also accumulate slowly (Miller 1990<u>a</u>). When these data were last compiled (Miller 1987:Table 22), only 17 complete and 14 partially complete intervals had been observed following 6 years of intensive study. Approximately twice that many are now available with 4 more years of less intensive work. Individual reproductive histories for radio-marked females in GMU 13 are provided in Table 11. Reproductive intervals based on these histories are provided in Table 12.

A bear that produces a litter of cubs that does not surivive will frequently breed again and have another litter the following year. In these cases a "reproductive interval" of 1 year is generated. Such "intervals" are meaningless in a management sense, because they bear no relationship to the interval with which litters are successfully weaned. For bears that had previously successfully produced a litter, reproductive interval was defined as the period between weaning of the earlier litter and the next successful weaning of a litter (Miller 1987:33).

This definition will not work for young bears producing their first litters, because they have not had an opportunity to wean an earlier litter. For these bears their first reproductive interval was defined as the period from production of the first litter we saw and the next successful weaning of a litter (Miller 1987:33). Intervals for young bears (<7 years old) first captured when accompanied by yearlings were assumed to have begun the previous year (this assumption will underestimate an interval by a year in cases where an earlier litter was lost). My definition for first intervals is 1 year less than that used by Reynolds (1990), which starts from first successful breeding.

A 3-year period of dependence was observed in 28 cases when offspring separated from their mothers at age 2.3 (Table 11). A 4-year period of dependence was observed in 2 cases when females entered dens with 2-year-old offspring and separated from these offspring the following spring (1984 litter with #337 and 1985 litter with #283) (Table 11). A 2-year period of dependence was observed with the apparent weaning of a yearling by #472, discussed above. This was treated as a 2-year interval, although the previous history of #472 was unknown. Weaning of yearlings must be rare; in 12 years of spring capture efforts in GMU 13, no yearling unaccompanied by its mother has been captured.

Using only the 30 complete intervals observed to date, reproductive interval was 3.3 years (range = 2-8). An additional 14 intervals can be included by assuming current litters will be weaned when they reach age 2. Including these, provides a mean interval of 3.75 years (Table 12). Intervals >3 years resulted from loss of a complete litter or skipping of year(s) between weaning of a litter and production of the next. Counting complete and incomplete intervals, 26 of 44 (59%) were 3 years, which represents weaning of a litter at age 2 without losing a previous litter or skipping a year.

The remaining radio-marked bears are getting old, and productivity may be declining for these individuals. Bear #337 weaned her last litter in 1987 when she was approximately 20; she has had no more cubs through the spring of 1990 (Table 11). Similarly, #423 weaned a litter in 1986 when she was approximately 22, lost a litter of cubs in 1987, and has had no cubs since (Table 11). In calculating mean reproductive interval, these bears are counted as having incomplete intervals of 6 and 7 years, respectively (Table 12). This is what their next intervals will be if they have cubs next year (1991) and wean these at age 2 in 1993.

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Figure 7. Trend in percent of brown bears marked in 1978 and 1979 that were not reported harvested.

Figure 8. Trend in cub survivorship during a period when bear populations were declining as a result of heavy harvests.

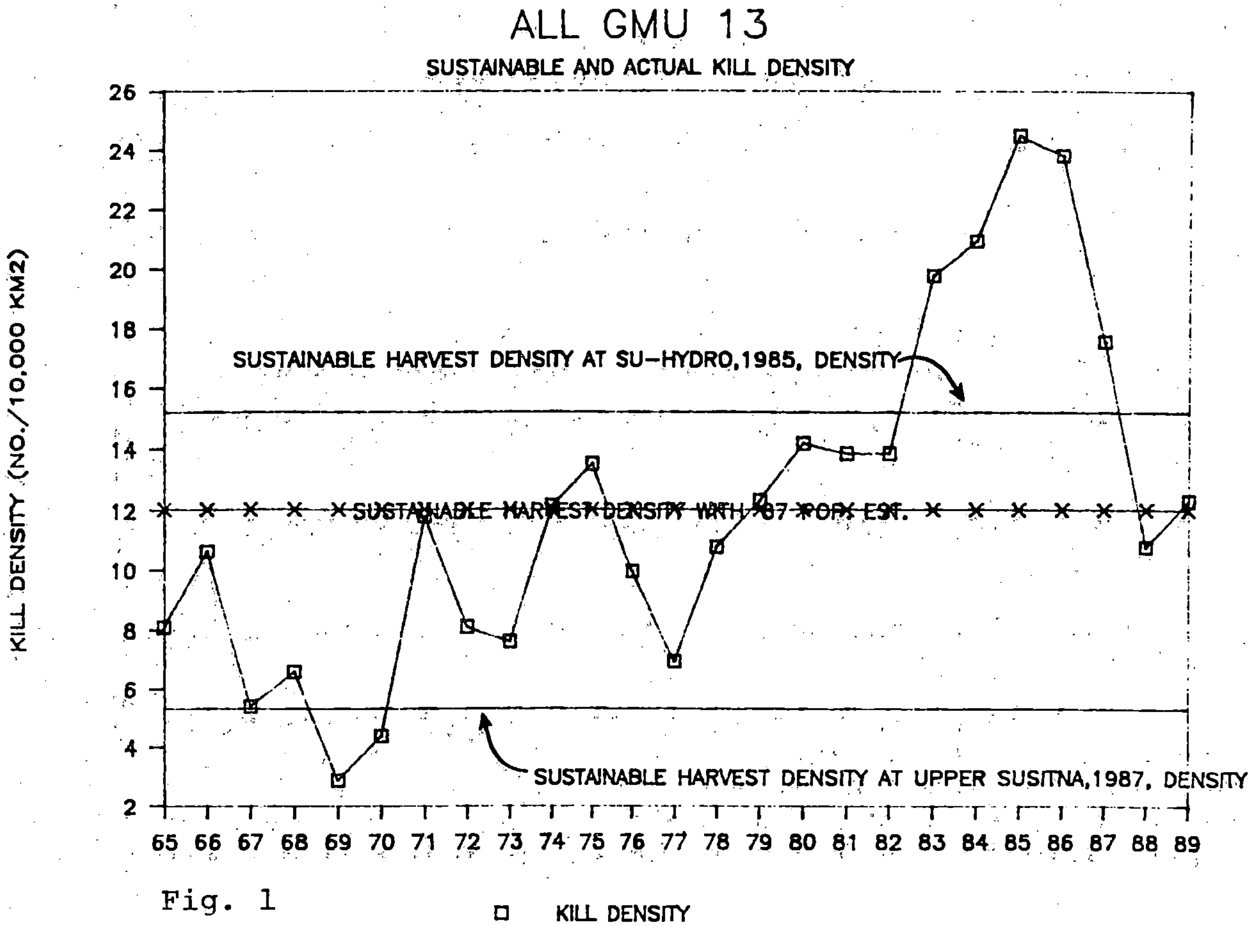
ALL GMU 13
SUSTAINABLE AND ACTUAL KILL DENSITY
KILL DENSITY (NO./10,000 KM2)
SUSTAINABLE HARVEST DENSITY AT SU-HYDRO,1985, DENSITY
SUSTAINABLE HARVEST DENSITY WITH '87 POP. EST.
SUSTAINABLE HARVEST DENSITY AT UPPER SUSITNA,1987, DENSITY
KILL DENSITY

Fig. 1

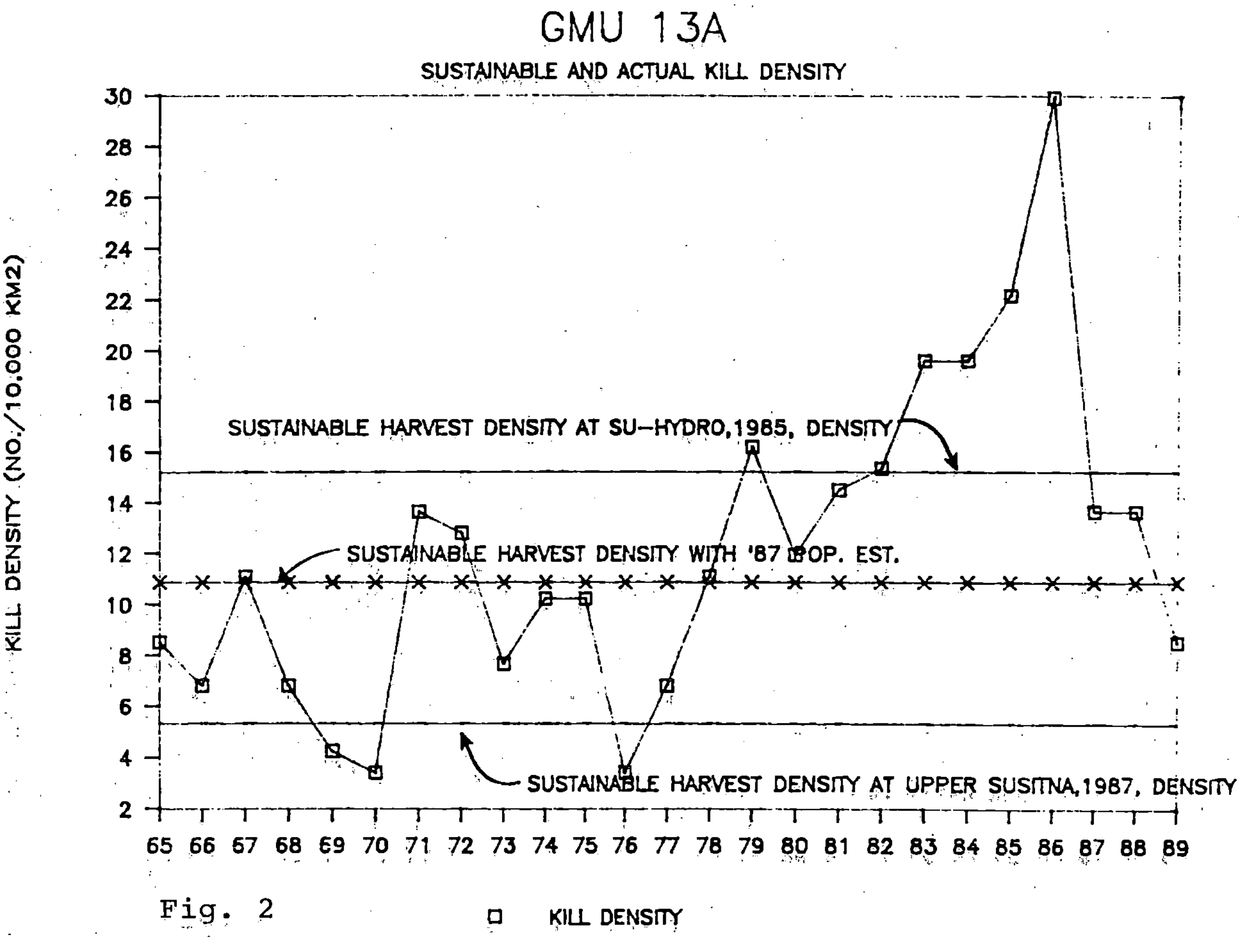
GMU 13A
SUSTAINABLE AND ACTUAL KILL DENSITY
KILL DENSITY (NO./10,000 KM2)
SUSTAINABLE HARVEST DENSITY AT SU-HYDRO,1985, DENSITY
SUSTAINABLE HARVEST DENSITY WITH '87 POP. EST.
SUSTAINABLE HARVEST DENSITY AT UPPER SUSITNA,1987, DENSITY
KILL DENSITY

Fig. 2

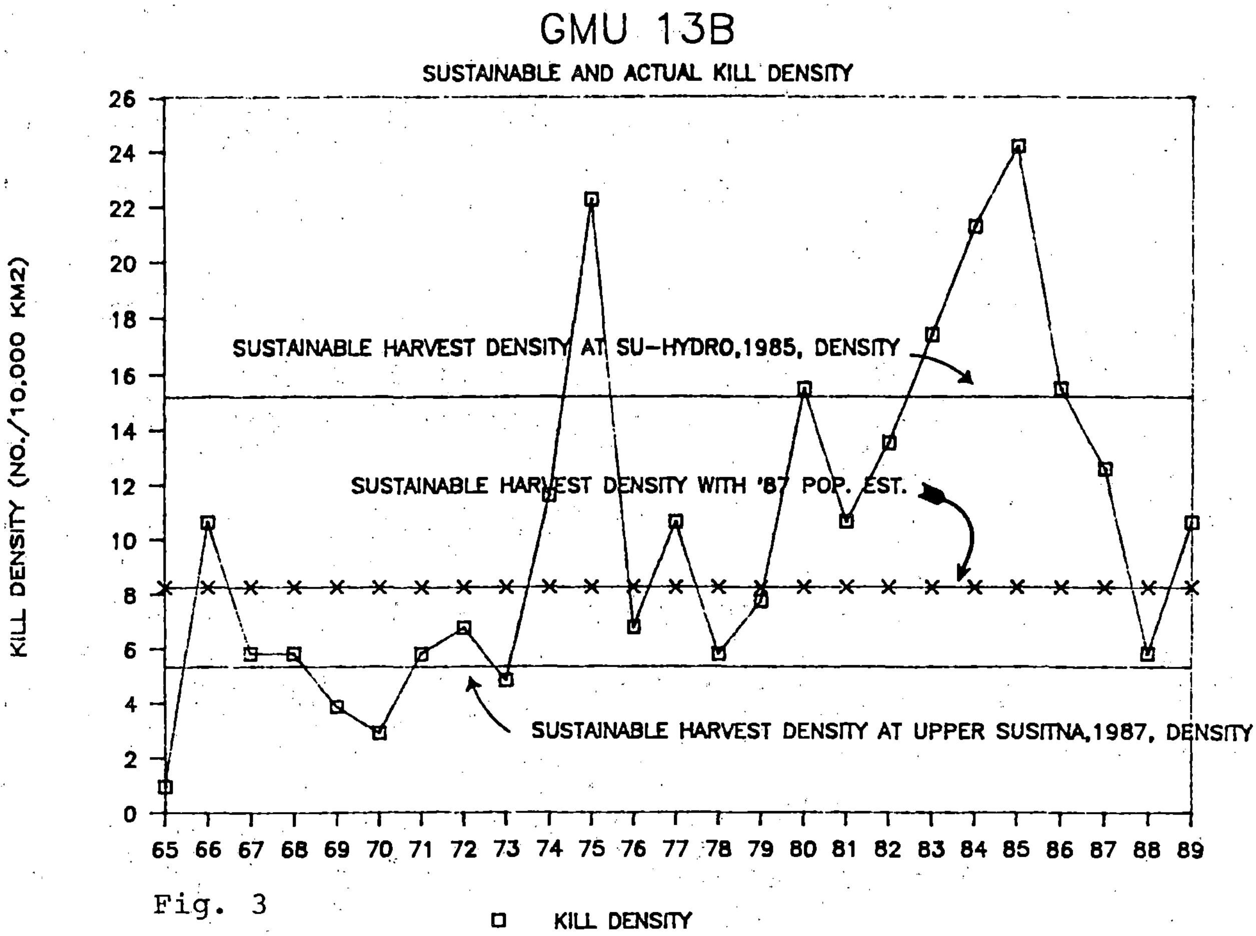
GMU 13B
SUSTAINABLE AND ACTUAL KILL DENSITY
KILL DENSITY (NO./10,000 KM2)
SUSTAINABLE HARVEST DENSITY AT SU-HYDRO,1985, DENSITY
SUSTAINABLE HARVEST DENSITY WITH '87 POP. EST.
SUSTAINABLE HARVEST DENSITY AT UPPER SUSITNA,1987, DENSITY
KILL DENSITY

Fig. 3

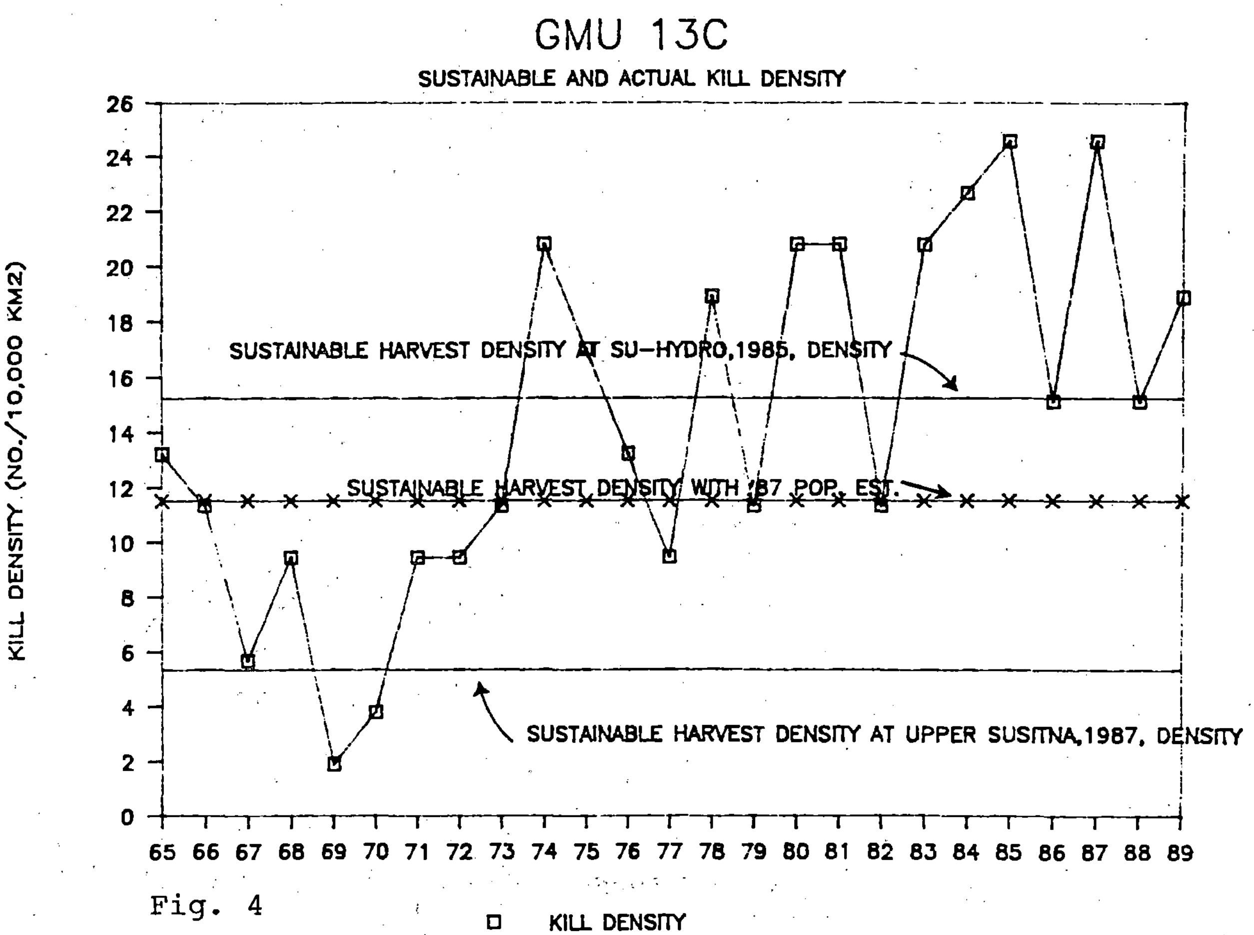
GMU 13C
SUSTAINABLE AND ACTUAL KILL DENSITY
KILL DENSITY (NO./10,000 KM2)
SUSTAINABLE HARVEST DENSITY AT SU-HYDRO,1985, DENSITY
SUSTAINABLE HARVEST DENSITY WITH '87 POP. EST.
SUSTAINABLE HARVEST DENSITY AT UPPER SUSITNA,1987, DENSITY
KILL DENSITY

Fig. 4

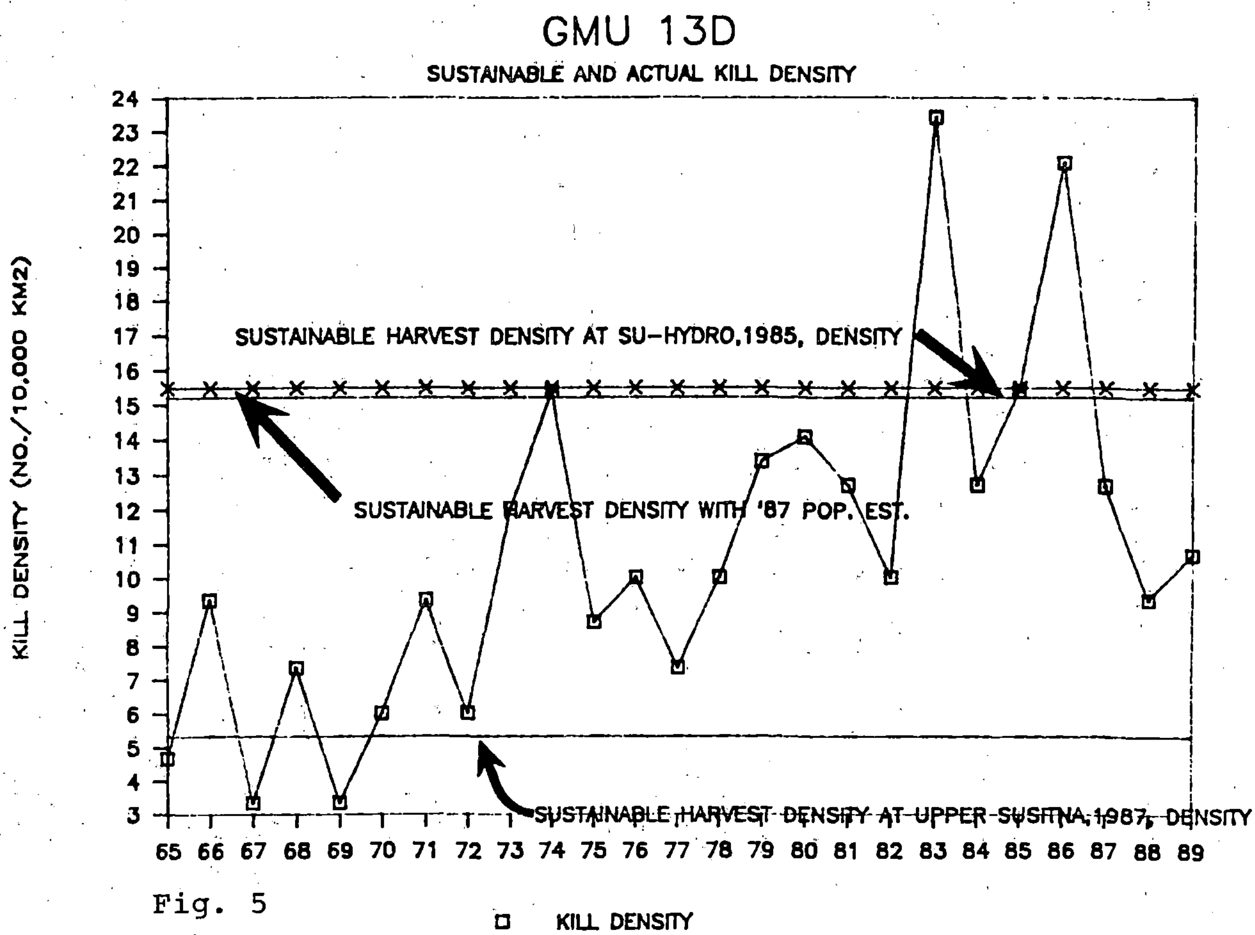
GMU 13D
SUSTAINABLE AND ACTUAL KILL DENSITY
KILL DENSITY (NO./10,000 KM2)
SUSTAINABLE HARVEST DENSITY AT SU-HYDRO,1985, DENSITY
SUSTAINABLE HARVEST DENSITY WITH '87 POP. EST.
SUSTAINABLE HARVEST DENSITY AT UPPER SUSITNA,1987, DENSITY
KILL DENSITY

Fig. 5

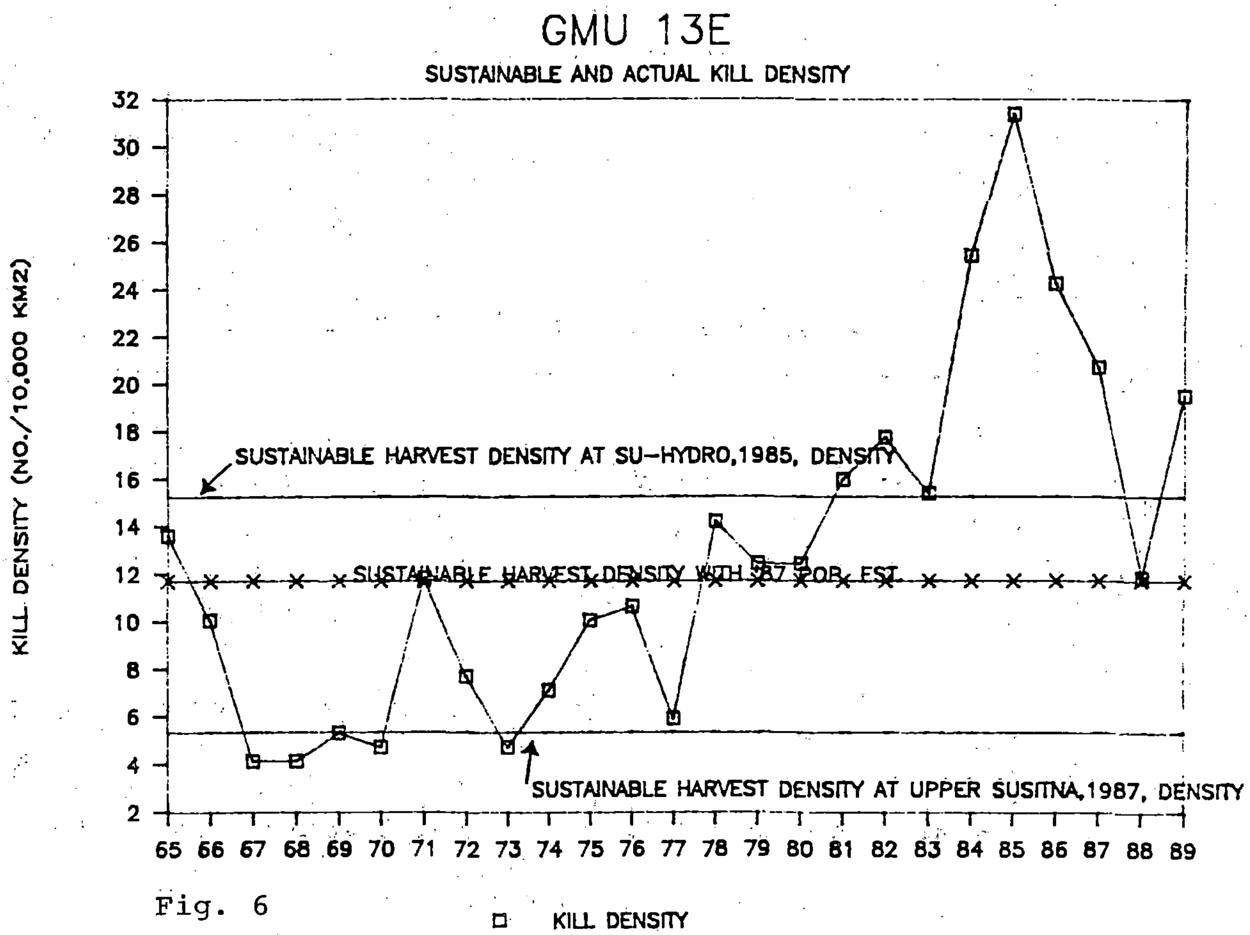
GMU 13E
SUSTAINABLE AND ACTUAL KILL DENSITY
KILL DENSITY (NO./10,000 KM2)
SUSTAINABLE HARVEST DENSITY AT SU-HYDRO,1985, DENSITY
SUSTAINABLE HARVEST DENSITY WITH '87 POP. EST.
SUSTAINABLE HARVEST DENSITY AT UPPER SUSITNA,1987, DENSITY
KILL DENSITY

Fig. 6

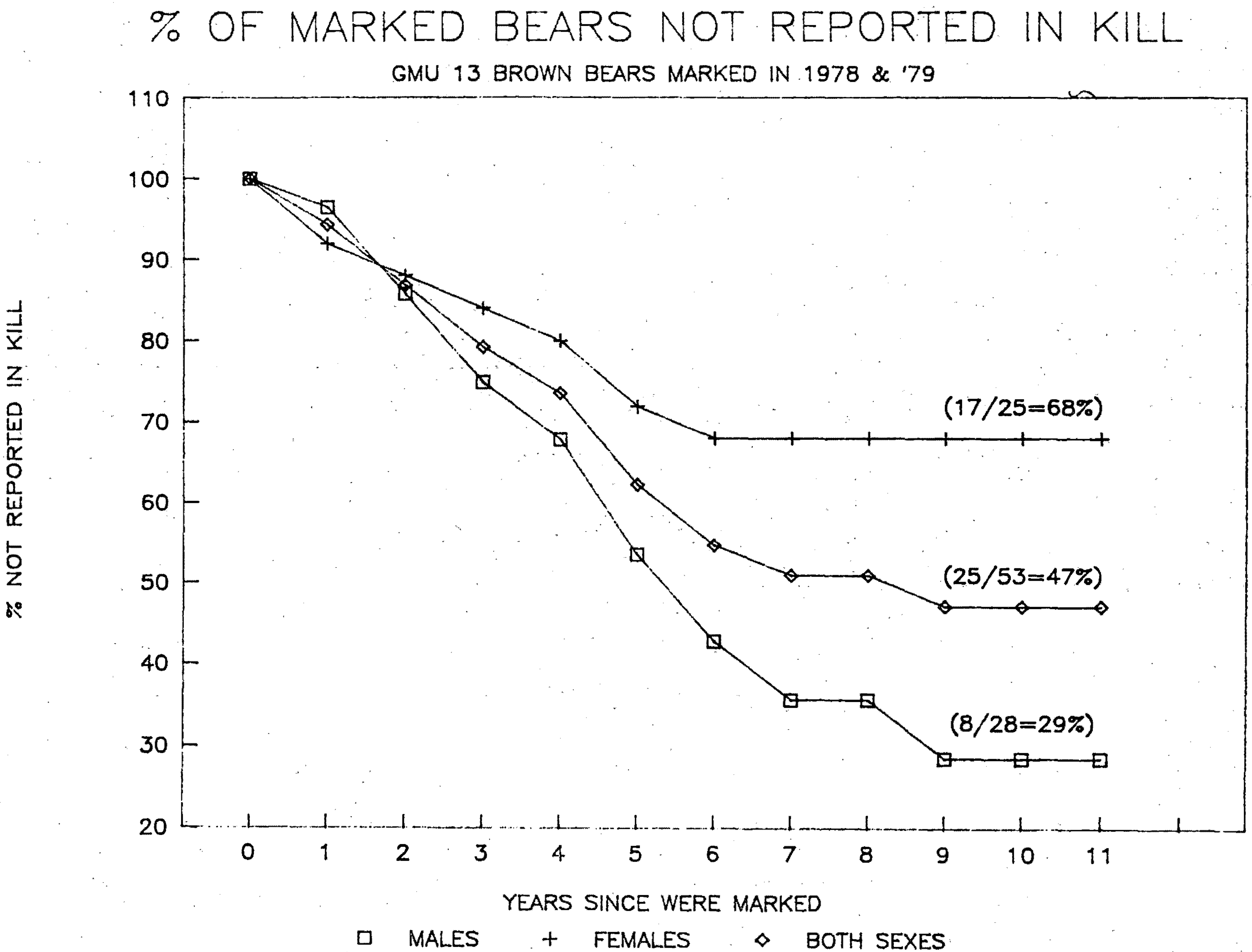
% OF MARKED BEARS NOT REPORTED IN KILL
GMU 13 BROWN BEARS MARKED IN 1978 & '79
% NOT REPORTED IN KILL
110
100
90
80
70
60
50
40
30
20
0
1
2
3
4
5
6
7
8
9
10
11
(17/25=68%)
(25/53=47%)
(8/28=29%)
YEARS SINCE WERE MARKED
MALES
FEMALES
BOTH SEXES

Fig. 7

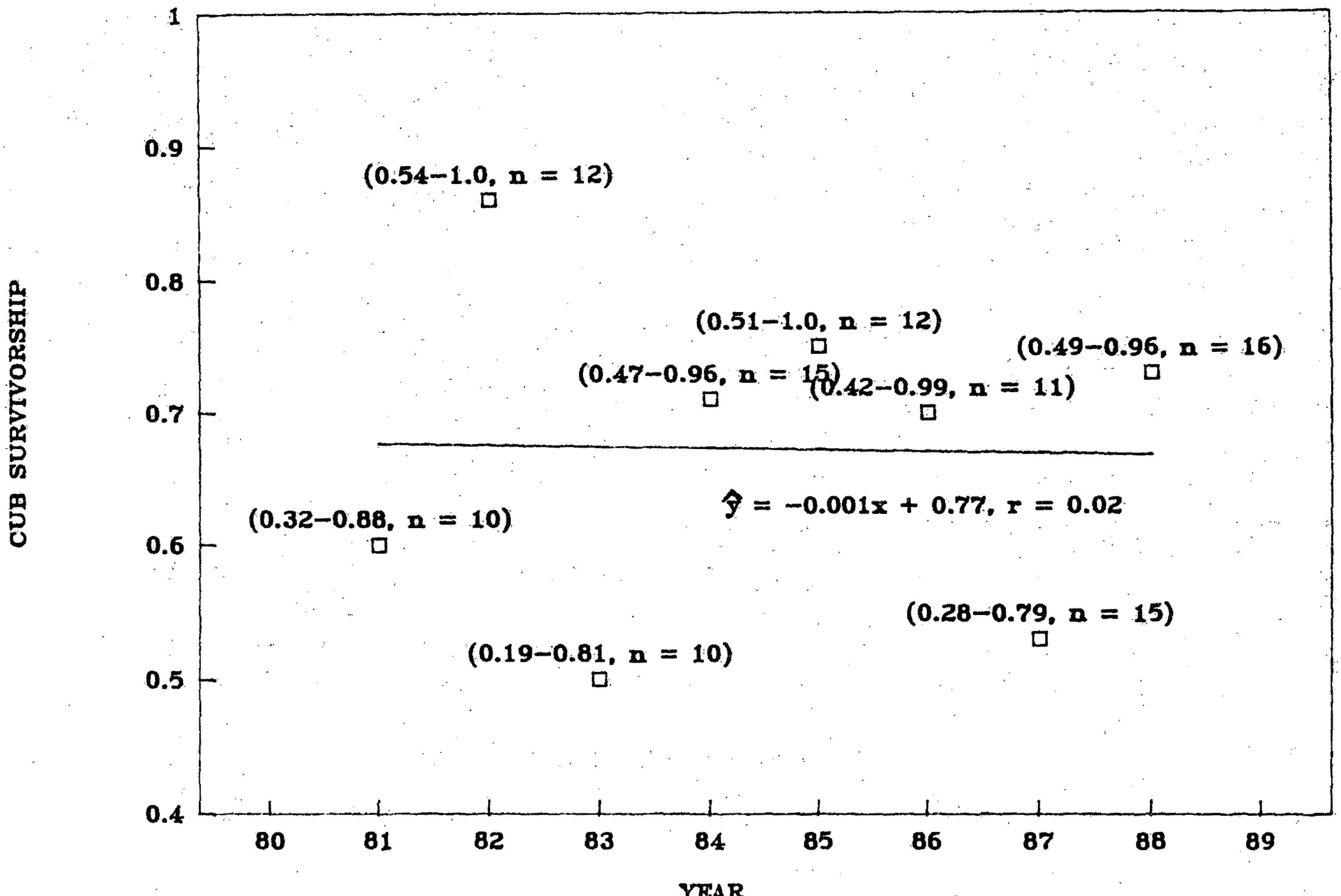
CUB SURVIVORSHIP
1
0.9
0.8
0.7
0.6
0.5
0.4
(0.54–1.0, n = 12)
(0.51–1.0, n = 12)
(0.49–0.96, n = 16)
(0.47–0.96, n = 15)
(0.42–0.99, n = 11)
$\hat{y} = -0.001x + 0.77, r = 0.02$
(0.32–0.88, n = 10)
(0.28–0.79, n = 15)
(0.19–0.81, n = 10)
80
81
82
83
84
85
86
87
88
89
YEAR

Fig. 8

Table 1. Brown bears captured in GMU 13 studies 1980-June 1990. RpSMIL07/pg1

Tattoo	Capture Sex	Age	Wt.	Date	Frequency	Serial #	Ear Tags	Comments
(277)	F	10.5	225*	4/10/80			1065/1066	w/2 ylgs, not marked, collar shed 80/81 den
(278)	M	9.5	375*	4/19/80			-- --	capture mortality
(279)	M	9.5	400*	4/20/80			1100/1099	collar shed by 6/12/80, recaptured 5/18/83, shot 9/84
280	M	5.5	300*	4/20/80			1097/1098	recollar next spring
214	M	4.5	300*	4/22/80			1072/1071	collar shed 9/9/80, recaptured 6/85
281	F	3.5	250*	4/22/80			16175/15950	not turgid, see 5/81 recapture
282	M	4.5	325*	4/22/80			1079/1080	see 6/82 recapture
283	F	12.5	280*	4/22/80			690/689	w2 @2.5: 284 and 285
(284)	M	2.5	180*	4/22/80			1074/1073	w/283 see 5/5/81 recapture
285	M	2.5	180*	4/22/80			687/688	w/283
286	M	3.5	264	5/1/80			1081/1082	
292	F	3.5	174	5/2/80			1322/1321	Turgid, shot 5/89
(293)	M	(3.5)	277	5/2/80			1116/1115	recaptured 8/81, 5/83, shot spring '85
(294)	M	10.5	607	5/2/80			-- --	died on 8/6/81 recapture
(295)	M	12.5	589	5/3/80			1303/1304	collar shed by 5/4/80
299	F	13.5	285	5/4/80			1109/1110	w/2 ylgs, turgid, recaptured 5/7/81
(297)	M	1.5	65	5/4/80			(1301/1302)	w/299, shot by hunter on 9/18/81
298	M	1.5	65	5/4/80			1318/1317	w/299
306	F	3.5	163	5/4/80			1319/1320	turgid
(308A)	M	6.5	480	5/6/80			(1126/1125)	shot 9/83
(308B)	F	5.5	240	5/6/80			1096/1095	turgid(?) - died on 8/6/81 recapture
(309)	M	12.5	600	5/6/80			(1117/1118)	collar shed by 5/14/80, recaptured 6/85, shot spring '90
(312)	F	10.5	319	5/7/80			1312/1311	w/311
(311)	M	2.5	227	5/7/80			-- --	w/312, shot on 9/16/80
313	F	9.5	286	5/7/80			1119/1120	w/314 @2.5
314	F	2.5	154	5/7/80			(1049/1050)	w/313, recaptured 6/1/85, 6/87
315	F	2.5	90*	5/7/80			1127/1128	alone, recaptured 5/18/83
(284#2)	M	3.5	125	5/5/81			(1074/1073)	near 283 w/2c, shot by hunter of 5/18/81
(331)	F	6.5	172	5/5/81			(1296/1295)	w/332 and 333, died August 1982
(332)	M	2.5	79	5/5/81			(1215/1216)	w/331 and 333, shot by hunter on 9/5/82
(333)	M	2.5	67	5/5/81			(1240/1239)	w/331 and 332, shot by hunter on 9/3/81

continued on next page

Tattoo	Sex	Capture Age	Wt.	Date	Frequency	Serial #	Ear Tags	Comments
334	F	10.5	325	5/5/81			1292/1291	estrus, missing in 1982
335	F	3.5	194	5/5/81			1220/1219	recaptured 5/14/83 and 6/86, age changed + 1 '83 tooth
281#2	F	4.5	--	5/6/81			1201/1202	estrus? recaptured 5/15/83
283#2	F	13.5	261	5/6/81			1089/1090	w/338 and 339 @ 0, recaptured 5/14/83
338	F	0.5	12	5/6/81			1224/1223	w/283, sex switched to female
(339)	M	(0.5)	13	5/6/81			1222/1221	w/283, recaptured 6/85, sex switched to male; shot 9/85
312#2	F	11.5	280	5/6/81			1300/1299	w/2c @0.5 (not captured), recaptured 5/14/83
313#2	F	10.5	284	5/6/81			1120/1119	w/336, recaptured 5/14/83
336	F	0.5	--	5/6/81			1237/1238	w/313, not drugged (abandoned)
337	F	13.5	321	5/6/81			1294/1293	w/3c reunited on 5/9/81, recaptured 5/14/83
340	F	3.5	190	5/6/81			1225/1218	not estrus, recaptured 5/15/83, Rt. eartag replaced 5/90
280#2	M	6.5	394	5/7/81			1097/1267	w/F 341, recaptured 5/16/83
(341)	F	6.5	224	5/7/81			(1208/1207)	w/M 280, collar failed, recaptured 6/82; died in 88/89 den
299#2	F	14.5	291	5/7/81			1109/1110	w/2 @2.5 (297 and 298 - not recaptured), not estrus, recaptured 8/6/81
(342A)	M	2.5	220	5/7/81			1228/1227	alone, see 5/25/82 recapture, died 7/84
344	F	5.5	--	5/8/81			1204/1203	w/2 cubs subsequently, recaptured 5/14/83
(345)	M	7.5	495	5/8/81			-- --	capture mortality
(308B)#2	F	6.8	--	8/6/81			-- --	recapture mortality
299#3	F	14.8	--	8/6/81			1109/1110	collar replaced, recaptured 5/18/81
(293#2)	M	(4.8)	--	8/6/81			1115/1116	collar replaced, recaptured 5/18/83, shot spring '85
(294#2)	M	11.8	--	8/6/81			-- --	recapture mortality
347	M	14.8	500*	8/6/81			(1234/1233)	collar shed 9/81, recaptured 6/9/85
(342A#2)	M	3.5	250*	5/25/82			1228/1227	collar replaced, died 7/84
(373)	M	9.5	450*	6/11/82			-- --	no tattoo, w/G283 (F), collar shed 6/83
282#2	M	6.5	350*	6/11/82			529/1643	recapture of marked bear, shed collar, recaptured 5/84 & 6/86
(379)	F	(5.5)	300*	6/11/82			(1595/1585)	w/2@c, Downstream study, shot 9/85
(380)	F	15.5	275*	6/12/82			(1588/532)	w/2@1, not captured, shot 9/83
(381)	F	(3.50	200*	6/12/82			(533/1592)	alone, recaptured 5/18/84 & 6/86, shot 9/89

continued on next page

Table 1. Continued

Tattoo	Sex	Capture Age	Wt.	Date	Frequency	Serial #	Ear Tags	Comments
313#3	F	12.5	300*	5/15/83		6259	same	w/2@1
382	M	1.5	66	5/14/83		12546	2135/2134	w/313 and 383, recaptured 5/18/84, implant
(383)	F	1.5	53	5/14/83		12542	(2490/2491)	w/313/ and 382, died unknown causes, implant
283#3	F	15.5	--	5/14/83		(6340)	same	w/cub #3, recaptured 6/86
(003)	F	0.5	--	5/14/83		1024	(1360/1359)	w/283, special cub collar, no tattoo, cub eaten
337#2	F	15.5	--	5/14/83		6309	same	w/385@2
385	F	2.5	60	5/14/83		(15210-12548)	(1695/1694)	w/337, breakway & implant, recaptured 6/85, tags replaced
(312#2)	F	13.5	350*	5/14/83		(6342)	(1299/1300)	w/386@2, died 5/16/84
386	M	2.5	200*	5/14/83		15212-12545(Imp)	2146/2141	w/312, breadway 5B collar, dispersed, implant
344#2	F	7.5	325*	5/14/83		10445	same	w/2@0, not captured
335#2	F	5.5	--	5/14/83		--	same	no radio in chopper
335#3	F	5.5	236	5/16/83		(15276)	same	alone, one year added to '81 age based on '83 tooth
388	F	14.5	450*	5/14/83		(6988)	(2478/2477)	w/388 and 289@2, recaptured 5/16/84 & 6/86, ear tags gone 5/90
(389)	M	(2.5)	135	5/14/83		(15214-12544)	2170/2171	w/388 and 390, breakaway 5B collar, died 10/83, implant
390	M	2.5	125*	5/14/83		15211-12543	2148/2147	w/38 and 389, breakaway 5B collar-shed, implant
340#2	F	5.5	250*	5/15/83		(15285)	same	recaptured 5/17/84, collar replaced 6/85
384	F	12.5	300*	5/15/83		15279	2499/2500	w/391, 392, 393@2
(391)	M	2.5	140*	5/15/83		(15213)	(2078/2079)	w/384 et al., breakaway 5B collar, shot 9/84
(392)	M	2.5	140*	5/15/83		(15246)	(2111/2110)	w/384 et al., breakaway 4B collar, shot 5.84
393	F	2.5	105	5/15/83		15247	1589/1598	w/384 et al., breakaway 4B collar
(293#3)	M	(6.5)	439	5/15/83		15291	same	--, shot spring '85
(394)	F	6.5	250*	5/15/83		(15277)	(1693/1692)	w/cub #4, shot 9/84
(004)	F	0.5	10	5/15/83		--	(1358/1357)	w/394-chewed on, no tattoo, died later
(395)	F	3.5	175*	5/15/83		(15289)	(2415/2416)	alone, regular 6B collar, shot 9/4/83
281#3	F	6.5	325*	5/15/83		(15284)	same	w/2@0 (#5 and #6), recollared 5/17/84
(005)	M	0.5	8.5	5/15/83		(1023)	(1350/134)	w/281, expandable cub collar, no tattoo, eaten
(006)	F	0.5	8.3	5/15/83		(1026)	(1346/1345)	w/281, expandable cub collar, no tattoo, eaten
280#3	M	8.5	482	5/16/83		(15290)	same	recaptured 6/85
396	F	13.5	274	5/16/83		(14885)	1685/1684	w/2@2, (397, 398), recaptured 6/86
(397)	F	(2.5)	132	5/16/83		--	(2493/2492)	w/396, recaptured 6/4/85, shot 9/85
(398)	F	(2.5)	135*	5/16/83		--	2105/2104	w/396, shot 6/86

continued on next page

Tattoo	Sex	Capture Age	Capture Wt.	Capture Date	Frequency	Serial #	Ear Tags	Comments
(399)	M	(9.5)	600*	5/17/83		(15278)	2087/2108	recaptured 5/15/84, shot 5/87
400	M	20.5	542	-5/17/83		(15281)	2132/2133	recaptured 5/18/84
299#4	F	16.5	275*	5/18/83		15283	same	w/3@0, darted in den, recaptured 5/15/84
418	M	0.5	13*	5/18/83		1024	1347/1348	w/G299, special cub collar, shed 10/83, old #7
419	M	0.5	13*	5/18/83		1025	1342/1343	w/G299, special cub collar, old #8
(417)	M	0.5	13*	5/18/83		1022	(536/535)	w/G299, special cub collar, shed 7/83, old #9
(279#2)	M	12.5	700*	5/18/83		(10339)	1653/1100	recapture, previous shed collar, recaptured 5/16/84
315#2	F	5.5	203	5/18/83		15288	same	estrus, alone, just marked previously
403	F	6.5	275*	5/18/83		15275	1564/1565	w/2@0, not captured, Downstream
407	F	4.5	220*	5/19/83		2905	2401/1543	alone, downstream, recaptured 6.85
299#5	F	17.5	308	5/15/84		same	w/3@1,	417-419
(417#2)	M	1.5	94	5/15/84		12080	same	w/G299 & siblings, small implant, shot 5/86
418#2	M	1.5	86	5/15/84		12081	same	w/G299 & siblings, large implant
419#2	M	1.5	84	5/15/84		12076	same	w/G299 & siblings, small implant
(399)#2	M	(10.5)	662	5/15/84		(6405)	same	alone, shot 5/87
388#2	F	15.5	400*	5/16/84		same	same	w/2c. replaced 6/86
(16)	M	0.5	--	5/16/84		(1389)	(1389/1390)	w/G388, capture-induced separation, died/shed 6/84
(17)	F	0.5	00	5/16/84		(1623)	(40/50)	w/G388, capture induced separation, died 5/84
312#3	F	14.5	300*	5/16/84		(6332)	same	w/3c, old and new radio failures, capture mortality on 5/17/84
(279#3)	M	13.5	800*	5/16/84		(6339/18884)	same	large implant, shot 9/84
281#4	F	(7.5)	350*	5/17/84		(6407)	same	w/2c, recaptured 6/87
(21)	M	0.5	14	5/17/84		(1703)	1386/1383	w/G281, drowned?
(22)	M	0.5	14	5/17/84		(1710)	(1385/1384)	w/ G281, killed by BrB
337#3	F	16.5	325	5/17/84		same	same	w/2c, recaptured 6/85
08	F	0.5	12	5/17/84		1708	(1338/1337)	w/337, shot spring '90
09	F	0.5	12	5/17/84		1711	1340/1339	w/337
340#3	F	6.5	375*	5/17/84		same	same	w/2c, recaptured 6/85, 6/87
(23)	F	0.5	17	5/17/84		1713	45/28	w/340, shot 4/89, sex determined @ sealing
24	?	0.5	14	5/17/84		1706	44/27	w/340

continued on next page

		Capture						
Tattoo	Sex	Age	Wt.	Date	Frequency	Serial #	Ear Tags	Comments
420	F	19.5	350*	5/17/84		6335	2447/2057	w/2@1, one is 421
421	M	1.5	78	5/17/84		3984/1886	1644/2086	w/420 & uncaptured sibling. Large implant, female sibling, 437, captured 6/85, shot 9/88
422	M	4.5	205	5/18/84		18716	2136/2137	alone near camp
381#2	F	(5.5)	263	(5/18/84)		(6341)	same	alone, collar replaced on 6/86, shot 9/89
400#2	M	21.5	600*	5/18/84		6325	same	alone
382#2	M	2.5	148	5/18/84		(15289)	same	w/G313, old implant = 8.110, breadaway, picked up 6/86
423	F	21.5	300*	5/18/84		(6306)	none	w/4c, drug problem, recaptured 6/86
25	M	0.5	7	5/18/84		1712	39/32	smalles cub 2/G423
--	F	0.5	--	5/18/84		--	49.48	other sibling w/G423 not marked or sexed
425	F	14.5	--	6/01/84		(6344)	2486/2413	w/282 M, recaptured 6/86, 3 teeth misplaced
282#3	M	8.5	--	6/01/84		(--)	same	w/425, recapture of shed collar, recaptured 6.86
342#3	M	5.6	--	7/28/84		--	--	capture mortality
(427)	M	(3.5)	195	6/01/85		(6322)	(1697/2113)	rot-away canvas spacer used, shoat 9/19
(398#2)	F	(4.5)	200*	6/01/85		(6315)	same	396's offspring @2 in 1983, shot 6/86
314#2	F	7.5	285*	6/01/85		(6352)	same/2498	w/1@1, @2w/G313 on 5/80; litter at age 6, replaced 6/87
(429)	F	(1.5*)	104	6/01/85		--	(1514/1518)	w/G314 breakaway collar, shot 9/86
(341#2)	F	10.5	--	6/03/85		(6287)	2174/1372	old collar failed, added new tags to old, replaced 6/87
214#2	M	9.5	600*	6/03/85		(xx46)	(1071/1649)	previously shed collar, recaptured 5/86
437	F	2.5	175*	6/03/85		1036	2082/2083	w/G421, probably sibling, rot-away collar
(309/440#2)	M	17.5	700*	6/04/85		(6298)	(2193/1523)	old collar shed, tattoo 440 in upper left, breakaway, shot spring '90
(442)	M	(13.5)	750*	6/04/85		--	(1627/2117)	"Harley" yellow flag in rt. ear, shot 9/86, ear tag gone
443	M	8.0*	400*	6/04/85		--	2172/--	red flat in right, blond
(397#2)	F	(4.5)	300*	6/04/85		6449	(1534/1597)	estrus w/443, was w/G396 in 1983@2, shot 9/85
447	F	7.5	400*	6/05/85		10337	2430/2429	--, breakaway
347#2	M	18.5	650*	6/09/85		--	2184/2181	orange flags in ears, old eartags gone
(339/ 450#2)	M	(4.5)	150*	6/09/85		--	(1221/2130)	originally captured in 1981 @Ow/G283, sexed as F, switched w/sex of sibling? tattoos = 450, shot 9/85
385#2	F	4.5	130*	6/09/85		--	1507/1592	green flag on visual drop-off, old ear tags replaced
407#2	F	6.5	200*	6/09/85		same	same	alone drop-off feature added to collar

continued on next page

	Capture							
Tattoo	Sex	Age	Wt.	Date	Frequency	Serial #	Ear Tags	Comments
337#4	F	17.5	200*	6/09/85		6440	same	w/2@1 - these have no collars
273#2	F	9.5	200*	6/09/85		(6342)	same	age=3 in 1979, transported, returned, collar replaced, see 6/87
340#3	F	17.5	250*	6/10/85		(6333)	same	replaced collar, w/2@1, recaptured 6/87
280#4	M	10.5	400*	6/10/85		--	same	collar removed
388#3	F	17.5	425*	6/05/86		(6348)	same	w/2@1, not captured, collar replaced
335#4	F	8.5	300*	6/05/86		(6288)	same/2481	w/1@2=G466, collar replaced
466	F	2.5	150*	6/05/86		--	2097/2056	w/mom-335
396#2	F	16.5	300*	6/06/86		(6343)	same	estrus, collar replaced
381#3	F	(7.5)	225*	6/06/86		(15285)	--/same	w/2@1, not captured, collar replaced, shot 9/89
214#3	M	10.5	600*	6/06/86		--	none/2062	collar removed
283#4	F	18.5	300*	6/06/86		(6340)	same	w/2@1, not captured, collar replaced
423#2	F	22.5	275*	6/06/86		(6306)	1540/1541	w/3@2, not captured, collar replaced
425#2	F	16.5	250*	6/06/86		6449	same	w2@1, not captured, last tooth pulled, collar replaced, lost 9/89
282#4	M	10.5	550*	6/06/86		--	2129/same	alone, collar removed, neck bad
340#4	F	19.5	342	6/05/87		(6293)	same	alone, replaced collar
337#5	F	19.5	288	6/05/87		(27816)	same	estrus, replaced collar
281#5	F	10.5	300*	6/05/87		(27814)	same	estrus, replaced collar
314#3	F	9.5	320*	6/05/87		(6295)	2498/3071	w/3@0, left ear tag and collar replaced
273#3	F	11.5	300*	6/05/87		(27821)	676/3082	w/3@0, replaced left ear tag, replaced collar
001	F	0.5	16	6/05/87		--	581/584	w/273 & uncaptured sibling
002	M	0.5	18	6/05/87		--	585/578	w/273 & uncaptured siblind
341#3	F	12.5	313	6/05/87		(6324)	same	w/1@1, replaced collar, died in 88/89 den
340#5	F	22.5	---	5/27/90		6350	215/214(R)	replaced collar and rt. eartag
388#4	F	21.5	---	5/27/90		6440	181/183(R)	replaced collar and 2 missing eartags
335#5	F	12.5	---	5/27/90		15286	same	w/2@1, not captured; replaced radio
281#6	F	13.5	---	5/27/90		19048	same	Estrus, replaced collar
273#4	F	14.5	---	5/27/90		19049	same/320(Y)	Estrus, replaced collar & rt. eartag
314#4	F	12.5	---	5/27/90		19045	same	w/1 coy capt.-induced separation, replaced collar
423#3	F	26.5	---	5/27/90		6353	same/212(W)	estrus, replaced collar & rt. eartag
337#6	F	22.5	---	5/27/90		6346	304/213(W/R)	alone, replaced collar & both eartags

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Tattoo	Sex	Capture Age	Wt.	Date	Frequency	Serial #	Ear Tags	Comments
283#5	F	22.5	---	5/27/90		19020	same/193(R)	w/2@1, replaced collar & rt. eartag
396#3	F	20.5	---	5/27/90		19046	same	w/3@1, replaced collar
460#2	F	15.5	---	5/27/90		6322	same	w/2@1, replaced collar

Brown bears captured in upper Susitna River studies, 1986 and 1987.

Tattoo	Sex	Capture Age	Wt.(lbs.)	Date	Frequency	Serial #	Ear Tags	Comments
453	F	4	250*	6/3/86		6345	2443/2363	w/2@0, lost 1c but successfully reintroduced next day
468	F	0.5	15	6/3/86		--	562/561	w/G453
--	F	0.5	17	6/3/86		--	558/559	w/G453
454	F	4	175*	6/3/86		6278	2358/2353	alone, no tattoo
455	M	8	525	6/3/86		6351	(2058/1700)	alone, drop-off collar, removed all tags 6/87, shot 9/89
456	F	6	250*	6/4/86		(15290)	(2441/2352)	w/2@0, one captured, shot 5/87
--	M	0.5	33	6/4/86		--	551/552	w/uncaptured sibling & 456
457	M	7	525	6/4/86		15291	(2129/2066)	w/458, drop-off collar, removed all tags 6/87
458	F	17	200*	6/4/86		6443	2421/2446	w/457, drop-off collar, shed, shot spring 1989
459	F	3	100*	6/4/86		--	2435/2407	alone, recaptured 6/87
460	F	7	300*	6/4/86		6349	560/564	w/2@0, no ear flags, roto tags
--	M	0.5	30	6/4/86		--	--	capture mortality
--	F	0.5	30	6/4/86		--	553/554	w/460 & sibling, shot 9/88
461	F	5	275*	6/5/86		15284	1529/2427	w/1@0
--	M	0.5	26	6/5/86		--	567/555	w/461
462	F	7	275*	6/5/86		6298	2412/2487	w/1@1, magnet left on? in '86, okay in '87
463	M	1.5	90*	6/5/86		--	2193/2198	w/G462
464	M	2	150*	6/5/86		--	2185/2177	alone
465	F	3	250*	6/5/86		(6309)	1525/2442	alone, collar removed 6/87

continued on next page

	Capture							
Tattoo	Sex	Age	Wt.	Date	Frequency	Serial #	Ear Tags	Comments
466	F	2	150*	6/5/86		--	2097/2056	offspring w/G335 (Su-Hydro)
467	M	3	190	6/5/86		--	2144/2138	alone
468	F	1	70	5/30/87		27826	558/559	w/mom 453 & sibling, glue-on transmitter
459#2	F	4	198	5/30/87		6344	(same)	alone, rot-awaw collar, shed summer '88
						27827		glue-on radio (mod. 300)
469	F	6	275*	5/30/87		19053	2364/2424	w/2@1, '85 radio
						1023		glue-on transmitter (mod. 200), 19-50ppm
470	M	2	185	5/30/87		(3.930**)	2176/2179	alone, glue-on transmitter
470#2	M	2	--	6/8/87		--	--	removed transmitters, shot 9/87
471	M	5	450*	5/30/87		--	2099/1699	w/girlfriend 472
471#2	M	5	--	6/8/87		--	--	removed radio
472	F	12	375*	5/30/87		--	3076/3045	estrus, w/boyfriend (471) and 1@1 (475)
472#2	F	12	--	6/8/87		--	--	removed radio
473	F	6	295	5/30/87		--	3075/3045	alone
473#2	F	6	--	6/8/87		--	--	removed radio, shot 9/88
474	M	3	335	5/31/87		6302	2512/2658	alone, '85 radio
						27828	--	glue-on radio (mod. 300)
475	M	1	70*	5/31/87		1022	2637/2504	w/472 and stepdad, glue-on radio
475#2	M	1	--	6/8/87		--	--	removed transmitter, checked teeth
476	M	2	150*	5/31/87		19048	2067/2065	w/477 (sibling?)
						27852	--	
476#2	M	2	--	6/8/87		--	--	removed transmitters
477	F	2	125*	5/31/87		--	2654/2699	w/476 (sibling?)
477#2	F	2	--	6/8/87		--	--	removed radio, shot 9/87
478	F	9	340*	6/1/87		X988	3026/3046	w/2@1
						1700	--	glue-on radio (mod. 300)
479	M	2	224*	6/4/87		--	2503/2681	alone
479#2	M	2	--	6/8/87		--	--	removed collar
480	M	2	205	6/4/87		--	2649/2635	alone
480#2	M	2	--	6/8/87		--	--	removed collar
481	F	14	282	6/5/87		6287	3016/3064	w/3@1, old '85 radio
482	F	7	300*	6/6/87		--	3093/3080	w/3@1

continued on next page

Table 1. Continued

	Capture							
Tattoo	Sex	Age	Wt.	Date	Frequency	Serial #	Ear Tags	Comments
482#2	F	7	--	6/8/87		--	--	removed radio
457#2	M	8	600*	6/7/87		--	--	removed collar & ear tags, both badly infected
455#2	M	9	550*	6/8/87		--	--	removed collar & ear tags, both badly infected
465	F	4	310*	6/8/87		--	(same)	alone, removed collar

* Weight estimated, ( ) indicates shed, or removed collar or dead bear, # recapture, - collar or mark replaced subsequently, last tattoo = 425, last cub = #25.

* estimated

** glue-on transmitter

Table 2. Status of brown bears first marked during GMU-13 studies, 1980-1987. (A=alive, ND=no data available, F=shot in fall season, SP=shot in spring season). ND in year of capture indicates bear was not collared or soon shed its collar and no subsequent data were collected.

Bear ID	Sex/Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1980 captures													
277	F/10 in '80	A	ND	ND	ND	ND	ND	ND	ND	ND			
279	M/9 in '80	A	A	A	A	Shot-F	--	--	--	--	--		
280	M/5 in '80	A	A	A	A	A	A	ND	ND	ND	ND		
281	F/3 in '80	A	A	A	A	A	A	A	A	A	A		
282	M/4 in '80	A	A	A	A	A	A	A	ND	ND	ND		
283	F/12 in '80	A	A	A	A	A	A	A	A	A	A		
284	M/2 in '80	A	Shot-SP	--	--	--	--	--	--	--	--		
286	M/3 in '80	A	A	A	A	Shot-F	--	--	--	--	--		
292	F/3 in '80	A	A	A	A	A	A	A	A	A	Shot-SP		
293	M/3 in '80	A	A	A	A	ND	Shot-SP	--	--	--	--		
294	M/10 in '80	A	Died-Aug.	--	--	--	--	--	--	--	--		
295	M/12 in '80	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
299	F/13 in '80	A	A	A	A	A	ND	ND	ND	ND	ND		
297	M/1 in '80	A	Shot-F	--	--	--	--	--	--	--	--		
306	F/3 in '80	ND	ND	ND	ND	ND	ND	ND	ND	ND			
308a	M/6 in '80	A	A	A	Shot-F	--	--	--	--	--	--		
308b	F/5 in '80	A	Died-Aug.	--	--	--	--	--	--	--	--		
309	M/12 in '80	A	A	A	A	A	A	ND	ND	ND	ND	Shot-SP	
311	M/2 in '80	Shot-F	--	--	--	--	--	--	--	--	--		
312	F/10 in '80	A	A	A	A	Died-NS	--	--	--	--	--		
313	F/9 in '80	A	A	A	A	A	Shot-F	--	--	--	--		
314	F/2 in '80	A	A	A	A	A	A	A	A	A	A		
315	F/2 in '80	A	A	A	A	A	A	Shot-SP	--	--	--		
1981 captures													
331	F/6 in '81	--	A	Died-Aug.	--	--	--	--	--	--	--		
332	M/2 in '81	--	A	Shot-F	--	--	--	--	--	--	--		

(continued)

Bear ID	Sex/Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
333	M/2 in '81	--	Shot-F	--	--	--	--	--	--	--	--		
334	F/10 in '81	--	Lost-Sept shot?	--	--	--	--	--	--	--	--		
335	F/2 in '81	--	A	A	A	A	A	A	A	A	A		
337	F/13 in '81	--	A	A	A	A	A	A	A	A	A		
339	M/0 in '81	--	Cub	Ylg	A	A	Shot-F	--	--	--	--		
340	F/3 in '81	--	A	A	A	A	A	A	A	A	A		
341	F/6 in '81	--	A	A	A	A	A	A	A	A (Den death)	--		
342a	M/2 in '81	--	A	A	A	Died-NS	--	--	--	--	--		
344	F/5 in '81	--	A	A	A	Lost Sept shot?	ND	ND	ND	ND	ND		
347	M/14 in '81	--	A	A	A	A	A	ND	ND	ND	ND		
214***	M/2 in '78	A	A	A	A	A	A	A	ND	ND	ND		
273***	F/3 in '79	A	A	A	A	A	A	A	A	A	A		

1982 captures

Bear ID	Sex/Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
379**	F/5 in ;82	__	__	A	A	A	Shot-F	--	--	--	--		
380	F/15 in '82	--	--	A	Shot-F	--	--	--	--	--	--		
381	F/3 in '82	--	--	A	A	A	A	A	A	A	Shot-F		

1983 captures

Bear ID	Sex/Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
385	F/2 in '83	--	--	--	A	A	A	ND	ND	ND	ND		
386	M/2 in '83	--	--	--	A	Shot-SP	--	--	--	--	--		
388	F/14 in '83	--	--	--	A	A	A	A	A	A	A		

(continued)

Bear ID	Sex/Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
389	M/2 in '83	--	--	--	A, Died Oct.	--	--	--	--	--	--		
390	M/2 in '83	--	--	--	A	ND	ND	ND	ND	ND	ND		
384	F/12 in '83	--	--	--	A	Lost in Sept.-shot?	ND	ND	ND	ND	ND		
391	M/2 in '83	--	--	--	A	Shot-F	--	--	--	--	--		
392	M/2 in '83	--	--	--	A	Shot-SP	--	--	--	--	--		
393	F/2 in '83	--	--	--	A	ND	ND	ND	ND	ND	ND		
394	F/6 in '83	--	--	--	A	Shot-F	--	--	--	--	--		
395	F/3 in '83	--	--	--	Shot-F	--	--	--	--	--	--		
396	F/13 in '83	--	--	--	A	A	A	A	A	A	A		
397	F/2 in '83	--	--	--	A	A	Shot-F	--	--	--	--		
398	F/2 in '83	--	--	--	A	A	A	Shot-SP	--	--	--		
399	M/9 in '83	--	--	--	A	A	A	A	Shot-SP	--	--		
400	M/20 in '83	--	--	--	A	A	A	ND	ND	ND	ND		
403**	F/6 in '83	--	--	--	A	A	A	A	A	ND	ND		
407**	F/4 in '83	--	--	--	A	A	A	A	A	ND	ND		
<u>1984 captures</u>													
420	F/19 in '84	--	--	--	--	A	A	A	ND	ND	ND		
421	M/1 in '84	--	--	--	--	--	--	A	A	Shot-F	--		
422	M/4 in '84	--	--	--	--	A	Died-SP	--	--	--	--		
423	F/21 in '84	--	--	--	--	A	A	A	A	A	A		
425	F/14 in '84	--	--	--	--	A	A	A	A	A	A Shot?		
382	F/2 in '84	--	--	--	--	A	A	ND	ND	ND	ND		
417	M/1 in '84	--	--	--	--	--	A	Shot-SP	--	--	--		
023	F/0 in '84	--	--	--	--	Coy	Ylg	A	A	A	Shot-SP		
008	F/0 in '84	--	--	--	--	Coy	Ylg	ND	ND	ND	ND	Shot-SP	

(continued)

Bear ID	Sex/Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
<u>1985 captures</u>													
427	M/3 in '85	--	--	--	--	--	A	Shot-SP	--	--	--		
429	F/1 in '85	--	--	--	--	--	A	Shot-SP	--	--	--		
437	F/2 in '85	--	--	--	--	--	A	A	ND	ND	ND		
442	M/13 in '85	--	--	--	--	--	A	Shot-SP	--	--	--		
443	M/A in '85	--	--	--	--	--	A	ND	ND	ND	ND		
447	F/7 in '85	--	--	--	--	--	A	Shed collar	ND	ND	ND		
<u>1986 captures</u>													
453	F/1 in '86	--	--	--	--	--	--	A (coy)	A(Ylg)	A(@2)	Shot-SP		
454	F/4 in '86	--	--	--	--	--	--	A	A (coy)	ND	ND		
455	M/8 in '86	--	--	--	--	--	--	A	A	ND	Shot-F		
456	F/6 in '86	--	--	--	--	--	--	A	Shot-SP	--	--		
457	M/7 in '86	--	--	--	--	--	--	A	A	A	Shot-F		
458	F/18 in '86	--	--	--	--	--	--	A	A(coy)	A(coy)	ND	Shot-SP	
459	F/3 in '86	--	--	--	--	--	--	A	A	A	ND		
460	F/7 in '86	--	--	--	--	--	--	A(coy)	A(ylg)	A	A(coy)		
460a	F/0 in '86	--	--	--	--	--	--	A(w/460)	A(w/460)	Shot-F	--		
461	F/5 in '86	--	--	--	--	--	--	A	A(coy)	A(ylg)	ND		
462	F/10 in '86	--	--	--	--	--	--	A(ylg)	A(coy)	A(ylg)	A		
465	F/3 in '86	--	--	--	--	--	--	A	A	ND	ND		
467	M/3 in '86	--	--	--	--	--	--	A	ND	ND	ND		
<u>1987 captures</u>													
469	M/6 in '87	--	--	--	--	--	--	--	A(ylg)	ND	ND		
470	M/2 in '87	--	--	--	--	--	--	--	Shot-F	--	--		

(continued)

Bear ID	Sex/Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
471	M/1 in '87	--	--	--	--	--	--	--	A	ND	ND		
472	F/12 in '87	--	--	--	--	--	--	--	A	ND	ND		
473	F/6 in '87	--	--	--	--	--	--	--	A	Shot-F	--		
474	M/3 in '87	--	--	--	--	--	--	--	A	ND	ND		
476	M/2 in '87	--	--	--	--	--	--	--	A	ND	ND		
477	F/2 in '87	--	--	--	--	--	--	--	Shot-F	--	--		
478	F/9 in '87	--	--	--	--	--	--	--	A	ND	ND		
479	M/2 in '87	--	--	--	--	--	--	--	A	ND	ND		
480	F/2 in '87	--	--	--	--	--	--	--	A	ND	ND		
481	F/14 in '87	--	--	--	--	--	--	--	A(ylg)	A	ND		
482	F/7 in '87	--	--	--	--	--	--	--	A(ylg)	ND	ND		
A. Max. no. marked bears potentially alive in year, includes ND. Excludes tagging and natural mortalities and ND for coy or yrlgs when originally marked. (M:F)		25(14:11)	32(15:18)	30(11:19)	46(19:27)	48(17:31)	48(18:30)	52(14:38)	59(16:43)	55(14:41)	51(13:38)	45(11:34)	
B. No KNOWN shot in year (M:F)		1(1:0)	3(3:0)	1(1:0)	3(1:2)	6(5:1)	5(2:3)	6(3:3)	4(2:2)	3(1:2)	6(2:4)		
Min. % known shot (B/A)		4%	9%	3%	7%	13%	10%	12%	7%	6%	12%		
	males	18%	20%	9%	5%	29%	11%	20%	13%	7%	15%		
	females	0	0	0	7%	3%	10%	8%	5%	5%	11%		
C. No. known shot plus suspected (unreported) shot in year (M:F).		1(1:0)	4(3:1)	1(1:0)	3(1:2)	8(5:3)	5(2:3)	6(3:3)	4(2:2)	3(1:2)	7(2:5)		

Table 2. (Cont.)

Bear ID	Sex/Age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Probable min. % shot (C/(A-suspects)		4%	13%	3%	7%	17%	11%	11%	7%	6%	15%		
D. No. bears known alive (excludes ND, died, lost, cubs, or ylgs).		23	29	28	43	39	40	42#	45#	26	19		
Probable % shot (C/D)		4%	14%	4%	7%	21%	13%	14%	9%	12%	37%		
Cumulative % shot (based on bear-years available, from row A and C).		4%	9%	7%	7%	9%	10%	10%	9%	9%	9%		

Not Included:

Subadults @2 in 1980: 285;
1983: 397 & 398 both recaptured in 1985
1986: 464, 466
Subadults @1 in 1980: 298;
1983: 383;
1984: 418, 419
1986: 463
1987: 468, 475

* G373 (M@9 in 1982) not included as it shed its collar and had no ear tags or tattoo, so was not recognizable as a marked bear subsequently.

** Downstream study area

*** Captured earlier as part of studies outside of Su-Hydro area.

\# Not all were available during whole year as tagging was done after the spring hunting season.

Table 3. Susitna brown bear cub mortality rates, 1978 to spring 1990, calculated using Kaplan-Meier procedures (Pollock et al. 1989).

ALL CUBS, ALL YEARS, 1978-1989

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
1	5/1-5/7	92		1.000		5	0.000	1.000	1.000
2	5/8-5/15	97	1	0.990		2	0.000	0.970	1.010
3	5/16-5/23	98	3	0.959		7	0.000	0.921	0.998
4	5/24-5/31	102	10	0.865		5	0.001	0.804	0.927
5	6/1-6/7	97	5	0.821			0.001	0.752	0.890
6	6/8-6/15	92	2	0.803			0.001	0.730	0.876
7	6/16-6/23	90		0.803			0.001	0.729	0.877
8	6/24-6/30	90		0.803			0.001	0.729	0.877
9	7/1-7/31	90	6	0.749	4		0.002	0.672	0.827
10	8/1-8/31	80	1	0.740	3		0.002	0.657	0.823
11	9/1-9/30	76	1	0.730	6		0.002	0.645	0.816
12	10/1-10/31	69		0.730			0.002	0.641	0.820
13	11/1-4/30	69	3	0.699	5		0.002	0.608	0.789
TOTAL CUBS =				111					

CUBS during 78 and 79

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
1	5/1-5/7	3		1.000			0.000	1.000	1.000
2	5/8-5/15	3		1.000			0.000	1.000	1.000
3	5/16-5/23	3		1.000		3	0.000	1.000	1.000
4	5/24-5/31	6		1.000			0.000	1.000	1.000
5	6/1-6/7	6	2	0.667			0.025	0.359	0.975
6	6/8-6/15	4		0.667			0.037	0.289	1.044

continued on next page

Table 3. Continued.

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
7	6/16-6/23	4		0.667			0.037	0.289	1.044
8	6/24-6/30	4		0.667			0.037	0.289	1.044
9	7/1-7/31	4		0.667			0.037	0.289	1.044
10	8/1-8/31	4		0.667	1		0.037	0.289	1.044
11	9/1-9/30	3		0.667			0.049	0.231	1.102
12	10/1-10/31	3		0.667			0.049	0.231	1.102
13	11/1-4/30	3	2	0.222			0.013	0.000	0.444
TOTAL CUBS =				6					

CUBS during 80 and 81, all mortalities were in 1981

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
1	5/1-5/7	5		1.000		5	0.000	1.000	1.000
2	5/8-5/15	10	1	0.900			0.008	0.724	1.076
3	5/16-5/23	9		0.900			0.009	0.714	1.086
4	5/24-5/31	9		0.900			0.009	0.714	1.086
5	6/1-6/7	9		0.900			0.009	0.714	1.086
6	6/8-6/15	9		0.900			0.009	0.714	1.086
7	6/16-6/23	9		0.900			0.009	0.714	1.086
8	6/24-6/30	9		0.900			0.009	0.714	1.086
9	7/1-7/31	9	1	0.800			0.014	0.566	1.034
10	8/1-8/31	8	1	0.700			0.018	0.434	0.966
11	9/1-9/30	7		0.700			0.021	0.416	0.984
12	10/1-10/31	7		0.700			0.021	0.416	0.984
13	11/1-4/30	7	1	0.600			0.021	0.319	0.881
TOTAL CUBS =				10					

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Table 3. Continued SUCUBMOR\pg3

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
CUBS during 1982									
1	5/1-5/7	7		1.000		5	0.000	1.000	1.000
2	5/8-5/15	7		1.000			0.000	1.000	1.000
3	5/16-5/23	7		1.000			0.000	1.000	1.000
4	5/24-5/31	7	1	0.857			0.015	0.617	1.097
5	6/1-6/7	6		0.857			0.017	0.598	1.116
6	6/8-6/15	6		0.857			0.017	0.598	1.116
7	6/16-6/23	6		0.857			0.017	0.598	1.116
8	6/24-6/30	6		0.857			0.017	0.598	1.116
9	7/1-7/31	6		0.857	2		0.017	0.598	1.116
10	8/1-8/31	4		0.857			0.026	0.540	1.175
11	9/1-9/30	4		0.857			0.026	0.540	1.175
12	10/1-10/31	4		0.857			0.026	0.540	1.175
13	11/1-4/30	4		0.857			0.026	0.540	1.175
TOTAL CUBS =				12					

CUBS during 1983

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
1	5/1-5/7	8		1.000			0.000	1.000	1.000
2	5/8-5/15	8		1.000	2		0.000	1.000	1.000
3	5/16-5/23	10	1	0.900			0.008	0.724	1.076
4	5/24-5/31	9	2	0.700			0.016	0.450	0.950
5	6/1-6/7	7		0.700			0.021	0.416	0.984
6	6/8-6/15	7		0.700			0.021	0.416	0.984
7	6/16-6/23	7		0.700			0.021	0.416	0.984
8	6/24-6/30	7		0.700			0.021	0.416	0.984
9	7/1-7/31	7	1	0.600			0.021	0.319	0.881

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Table 3. Continued

SUCUBMOR\pg4

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
11	9/1-9/30	6	1	0.500			0.021	0.217	0.783
10	8/1-8/31	6		0.600			0.024	0.296	0.904
12	10/1-10/31	5		0.500			0.025	0.190	0.810
13	11/1-4/30	5		0.500			0.025	0.190	0.810
TOTAL CUBS =				10					

CUBS during 1984

PERIOD	DATES	NO. RISK	NO. DEATHS	SURVIVAL	CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
1	5/1-5/7	11		1.000			0.000	1.000	1.000
2	5/8-5/15	11		1.000			0.000	1.000	1.000
3	5/16-5/23	11	1	0.909	4		0.007	0.747	1.071
4	5/24-5/31	14	2	0.779			0.010	0.587	0.971
5	6/1-6/7	12		0.779			0.011	0.572	0.986
6	6/8-6/15	12		0.779			0.011	0.572	0.986
7	6/16-6/23	12		0.779			0.011	0.572	0.986
8	6/24-6/30	12		0.779			0.011	0.572	0.986
9	7/1-7/31	12	1	0.714			0.012	0.498	0.930
10	8/1-8/31	11		0.714			0.013	0.489	0.940
11	9/1-9/30	11		0.714	2		0.013	0.489	0.940
12	10/1-10/31	9		0.714			0.016	0.465	0.964
13	11/1-4/30	9		0.714			0.016	0.465	0.964
TOTAL CUBS =				15					

CUBS during 1985

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
1	5/1-5/7	12		1.000			0.000	1.000	1.000

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Table 3. Continued.

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
2	5/8-5/15	12		1.000			0.000	1.000	1.000
3	5/16-5/23	12		1.000			0.000	1.000	1.000
4	5/24-5/31	12	2	0.833			0.010	0.641	1.026
5	6/1-6/7	10	1	0.750			0.014	0.518	0.982
6	6/8-6/15	9		0.750			0.016	0.505	0.995
7	6/16-6/23	9		0.750			0.016	0.505	0.995
8	6/24-6/30	9		0.750			0.016	0.505	0.995
9	7/1-7/31	9		0.750			0.016	0.505	0.995
10	8/1-8/31	9		0.750			0.016	0.505	0.995
11	9/1-9/30	9		0.750			0.016	0.505	0.995
12	10/1-10/31	9		0.750			0.016	0.505	0.995
13	11/1-4/30	9		0.750			0.016	0.505	0.995
TOTAL CUBS =				12					

CUBS during 1986, 2 cubs of shot mother not counted, 2 probable others considered censored

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
1	5/1-5/7	8		1.000			0.000	1.000	1.000
2	5/8-5/15	8		1.000			0.000	1.000	1.000
3	5/16-5/23	8		1.000			0.000	1.000	1.000
4	5/24-5/31	8		1.000	3		0.000	1.000	1.000
5	6/1-6/7	11		1.000			0.000	1.000	1.000
6	6/8-6/15	11	2	0.818			0.011	0.612	1.024
7	6/16-6/23	9		0.818			0.014	0.590	1.046
8	6/24-6/30	9		0.818			0.014	0.590	1.046
9	7/1-7/31	9		0.818			0.014	0.590	1.046
10	8/1-8/31	9		0.818			0.014	0.590	1.046
11	9/1-9/30	9		0.818	2		0.014	0.590	1.046

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Table 3. Continued

SUCUBMOR\pg6

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
12	10/1-10/31	7		0.818			0.017	0.560	1.077
13	11/1-4/30	7	1	0.701			0.021	0.417	0.985
TOTAL CUBS =				11					

CUBS during 1987

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
1	5/1-5/7	15		1.000			0.000	1.000	1.000
2	5/8-5/15	15		1.000			0.000	1.000	1.000
3	5/16-5/23	15		1.000			0.000	1.000	1.000
4	5/24-5/31	15	3	0.800			0.009	0.619	0.981
5	6/1-6/7	12	2	0.667			0.012	0.449	0.884
6	6/8-6/15	10		0.667			0.015	0.428	0.905
7	6/16-6/23	10		0.667			0.015	0.428	0.905
8	6/24-6/30	10		0.667			0.015	0.428	0.905
9	7/1-7/31	10	2	0.533			0.013	0.308	0.759
10	8/1-8/31	8		0.533			0.017	0.281	0.786
11	9/1-9/30	8		0.533			0.017	0.281	0.786
12	10/1-10/31	8		0.533			0.017	0.281	0.786
13	11/1-4/30	8		0.533			0.017	0.281	0.786
TOTAL CUBS =				15					

CUBS during 1988

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
1	5/1-5/7	16		1.000			0.000	1.000	1.000
2	5/8-5/15	16		1.000			0.000	1.000	1.000

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Table 3. Continued

SUCUBMOR\pg7

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
3	5/16-5/23	16	1	0.938			0.003	0.823	1.052
4	5/24-5/31	15		0.938			0.004	0.819	1.056
5	6/1-6/7	15		0.938			0.004	0.819	1.056
6	6/8-6/15	15		0.938			0.004	0.819	1.056
7	6/16-6/23	15		0.938			0.004	0.819	1.056
8	6/24-6/30	15		0.938			0.004	0.819	1.056
9	7/1-7/31	15	1	0.875	2		0.006	0.718	1.032
10	8/1-8/31	12		0.875			0.008	0.700	1.050
11	9/1-9/30	12	2	0.729			0.012	0.514	0.944
12	10/1-10/31	10		0.729			0.014	0.494	0.964
13	11/1-4/30	10		0.729			0.014	0.494	0.964
TOTAL CUBS =				16					

CUBS during 1989

PERIOD	DATES	NO.@ RISK	NO. DEATHS	SURVIVAL	NO. CENSORED	NO. ADDED	VAR(SURV)	LOWER CL	UPPER CL
1	5/1-5/7	5		1.000			0.000	1.000	1.000
2	5/8-5/15	5		1.000			0.000	1.000	1.000
3	5/16-5/23	5		1.000			0.000	1.000	1.000
4	5/24-5/31	5		1.000			0.000	1.000	1.000
5	6/1-6/7	5		1.000			0.000	1.000	1.000
6	6/8-6/15	5		1.000			0.000	1.000	1.000
7	6/16-6/23	5		1.000			0.000	1.000	1.000
8	6/24-6/30	5		1.000			0.000	1.000	1.000
9	7/1-7/31	5		1.000			0.000	1.000	1.000
10	8/1-8/31	5		1.000			0.000	1.000	1.000
11	9/1-9/30	5		1.000			0.000	1.000	1.000
12	10/1-10/31	5		1.000			0.000	1.000	1.000
13	11/1-4/30	5		1.000			0.000	1.000	1.000
TOTAL CUBS =				5					

Table 4. Summary of known losses from radio, marked brown bear litters of cubs and yearlings in GMU 13.

Year of emergence	Losses of cubs	Losses of yearlings
1978	2 of 3 lost (G207)[b]	0 of 3 lost (G221, G220)
1979	2 of 3 lost (231)[c]	0 of 1 lost (G207)[d]
1980	no data	0 of 4 lost (G299, G277)[e]
1981	4[f] of 10 lost (G312, G313, G283, G337, G344)	no data
1982	1[g] of 5 lost (G299, G313, G379)	4 of 8 lost (G312, G283, G337, G344, G380)[h]
1983	6[i] of 11 lost (G283, G344, G299, G281, G394, G403)	2 of 4 lost (G379, G313)[j]
1984	4 of 15 lost (281, 337, 335, 340, 384[k], 396, 423)	1 of 7 lost (299, 344, 403[l], and 420)
1985	3 of 12 lost (283, 281, 381, 396, 425, 388	1 of 10 lost (314, 335, 340[l], 423, 337)
1986	4 of 13 lost (341, 447[l], 420 403, 453, 456, 460)	2 of 10 lost (281, 381, 388, 283, 425, 462)
1987	7 of 15 lost (273, 314, 340, 423, 458, 461, 462)	0 of 6 lost (341, 453, 460, 481[m])
1988	2 of 15 lost (281, 335, 340, 338, 381, 425, 458[l]	0 of 7 lost (273, 314, 462)
1989	0 of 5 lost (396, 460)	0 of 7 lost (281, 340[l], 388, 335)
1990 (Thru June)	? of 5 lost (283, 314, 461)	? of 7 lost (283, 460, 396)
Totals (Thru '89)	35 of 107 lost = 33%	10 of 67 lost = 15%
Excluding possible capture-related deaths and incomplete data:		
	32 of 98 lost = 33%	9 of 57 lost = 16%

continued on next page

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

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

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

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

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

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

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

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

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

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

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

[l] Last observation in Sept.-October.

[m] 2 of 3 yearlings, at least, survived to exit, assumed all 3 did.

NBRNT5/pgl
Updated 6/90

Table 5. Summary of Nelchina Basin brown bear litter size data for cub-of-the-year (based on spring observations of radio-collared bears), 1978-90(spring).

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

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Table 5. Continued.

Bear ID (year-age)	Litter Size (COY) (year)	Comments	Usable Summary
312 (1984, 14)	3 (1984)	Capture-related losses (collared)	none
283 (1981, 13)	2 (1981)	Weaned 2@2 in 1980, lost 1 cub by 9/1 other lost as ylg.	1 of 2 lost
283 (1983, 15)	1 (1983)	Killed by brown bear by 5/17/83, cub was collared	1 of 1 lost
283 (1985, 17)	2 (1985)	Both survived to den exist	0 of 2 lost
283 (1990,22)	2 (1990)	-----	-----
337 (1981, 13)	3 (1981)	Cubs and female reunited, 1 cub lost in 81/82 den, other 2 survived to exit (1 weaned in 1983, other lost as ylg).	1 of 3 lost
337 (1984, 16)	2 (1984)	Both survived to den exit, collared cubs	0 of 2 lost
344 (1981, 5)	2 (1981)	Both lost in '82 as yearlings	0 of 2 lost
344 (1983, 7)	2 (1983)	Lost 1 in early July - other survived to den exit.	1 of 2 lost
379 (1982, 5)	2 (1982)	Both survived	0 of 2 lost
341 (1982, 7)	2 (1982)	Survived until 7/15/82 when bear was lost	none

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Table 5. Continued.

Bear ID (year-age)	Litter Size (COY) (year)	Comments	Usable Summary
341 (1986, 11)	1 (1986)	Survived	0 of 1 lost
299 (1982, 15)	1 (1982)	Bear weaned 2@2 in 1981, cub lost by 6/9/62.	1 of 1 lost
299 (1983, 16)	3 (1983)	All cubs collared, alive to den exist.	0 of 3 lost
281 (1983, 6)	2 (1983)	Both killed by brown bear by 6/1/83, cubs collared.	2 of 2 lost
281 (1984, 7)	2 (1984)	Lost both in May, 1 suspected killed by brown bear, other unknown (accidental drowning?), collared cubs.	2 of 2 lost
281 (1985,8)	2 (1985)	Lost 1 in June, other survived	1 of 2 lost
281 (1988, 11)	2 (1988)	Both survived	0 of 2 lost
394 (1983, 6)	1 (1983)	Lost (capture related?) by 5/16, bred	1 of 1 lost (capture related?)
403 (1983, 6)	2 (1983)	Lost 1 in Sept., other ok to den exit	1 of 2 lost
403 (1986, 9)	3 (1986)	2 survived to exit	1 of 3 lost
384 (1984, 13)	2 (1984)	Survived to September at least	0 of 2 lost

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Table 5. Continued.

Bear ID (year-age)	Litter Size (COY) (year)	Comments	Usable Summary
396 (1984, 14)	1 (1984)	Lost in May	1 of 1 lost
396 (1985, 15)	1 (1985)	Lost both in June, bred	2 of 2 lost
396 (1989, 19)	3 (1989)	All survived, very large	0 of 3 lost
335 (1984, 6)	2 (1984)	Both survived to den exit	0 of 2 lost
335 (1988, 10)	2 (1988)	Survived	0 of 2 lost
340 (1984, 6)	2 (1984)	Both survived to den exit, collared cubs.	0 of 2 lost
340 (1987, 9)	3 (1987)	Lost all in early summer, bred	3 of 3 lost
340 (1988, 10)	2 (1988)	Lost 1 in summer	1 of 2 lost
388 (1984, 15)	2 (1984)	Capture-related losses (collared)	none
388 (1985, 16)	2 (1985)	Survived to den exit	0 of 2 lost
388 (1988, 19)	2 (1988)	Survived to exit	0 of 2 lost
423 (1984, 21)	4 (1984)	One died in July (collared), others ok to den exit.	1 of 4 lost

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Table 5. Continued.

Bear ID (year-age)	Litter Size (COY) (year)	Comments	Usable Summary
423 (1987, 24)	1 (1987)	Lost in early summer	1 of 1 lost
381 (1985, 6)	2 (1985)	Survived to exit	0 of 2 lost
381 (1988, 9)	3 (1988)	Survived to exit	0 of 3 lost
396 (1985, 16)	2 (1985)	Lost in June	2 of 2 lost
425 (1985, 14)	2 (1985)	Survived	0 of 2 lost
425 (1988, 17)	1 (1988)	Lost in June	1 of 1 lost
425 (1989, 18)	2 (1989)	Suspect shot in fall	none
447 (1986, 8)	2 (1986)	Lost contact (shed collar)	none
420 (1986, 21)	2 (1986)	Both lost in mid-summer	2 of 2 lost
273 (1987, 11)	3 (1987)	Survived to exit	0 of 3 lost
314 (1987, 9)	3 (1987)	Lost 1 in late summer, other survived	1 of 3 lost
314 (1990, 12)	2 (1990)	Lost 1 in May naturally, other capture loss	1 of 1 lost
453 (1986, 4)	2 (1986)	Both survived to exit	0 of 2 lost

continued on next page

Table 5. Continued.

Bear ID (year-age)	Litter Size (COY) (year)	Comments	Usable Summary
454 (1987, 5)	2 (1987)	Unknown survival (shed collar)	none
456 (1986, 6)	2 (1986)	Cubs lost in den?	2 of 2 lost
458 (1987, 18)	1 (1987)	Lost in mid-summer	1 of 1 lost
458 (1988, 19)	3 (1988)	Survived thru Sept., shed in spring	0 of 3 lost ?
460 (1986, 7)	2 (1986)	1 lost due to capture	none
460 (1989, 10)	2 (1989)	Survived to exit	0 of 2 lost
461 (1986, 5)	1 (1986)	Lost due to capture	none
461 (1987, 6)	2 (1987)	1 lost in mid-summer, other survived	1 of 2 lost
461 (1990, 9)	2 (1990)	----	----
462 (1987, 8)	2 (1987)	Survived	0 of 2 lost

<u>Summary</u>

No. of cubs	No. of litters	mean litter size (range)	
133	64	2.1 (1-4)	39 of 107 cubs lost in first year of life = 36.4% (2 of these possibly capture-related).

Table 6. Summary of Nelchina Basin brown bear litter size data for litters of yearlings (based on spring observation of radiio-collared bears), 1978-1990(spring).

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

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Table 6. Continued.

Bear ID (year-age)	LITTER SIZE (ylgs.) (year)	COMMENTS	SUMMARY
274 (1979, 11)	1 (1979)	Transplanted, no radio	none
207 (1978, 11)	1 (1979)	Survived until 9/12/79	0 of 1 lost
231 (1978, 12)	1 (1979)	Survived until 8/79	none
213 (1978, 10)	1 (1978)	Apparent ylg. was not captured, had cubs following year	1 of 1 lost (capture related?)
277 (1980, 10)	2 (1980)	Ylgs. visually aged, not captured, survived to enter den, no exit data as bear shed collar in den	0 of 2 lost
299 (1980, 13)	2 (1980)	Both survived, weaned next year	0 of 2 lost
299 (1984, 17)	2 (1984)	Survived with internals to exit from den	0 of 3 lost
312 (1982, 12)	1 (1982)	Survived, weaned next year	0 of 1 lost
281 (1986, 9)	1 (1986)	Survived, weaned next year	0 of 1 lsot
281 (1989, 12)	2 (1989)	Survived	0 of 2 lost
283 (1982, 140	1 (1982)	Lost by 5/18/82	1 of 1 lost
283 (1986, 18)	2 (1986)	Survived, weaned next year	0 of 2 lost
337 (1982, 14)	2 (1982)	Lost 1 by 6/17/82, other survived	1 of 2 lost

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Table 6. Continued.

Bear ID (year-age)	LITTER SIZE (ylgs.) (year)	COMMENTS	SUMMARY
337 (1985, 17)	2 (1985)	Survived to den exit	0 of 2 lost
380 (1982, 15)	2 (1982)	Both survived to den entrance, at least 1 exited den and was weaned	0 of 2 lost
344 (1982, 6)	2 (1982)	Lost 1 by 6/17, other by 7/26/82	2 of 2 lost
344 (1984, 8)	1 (1984)	Lost 1 in May, sibling lost year before	1 of 1 lost
313 (1983, 120	2 (1983)	Lost 1 (surgery related?) by 6/2/83, other survived through October	0 of 1 lost
379 (1983, 6)	2 (1983)	Lost 1 in June-September period	1 of 2 lost
420 (1984, 19)	2 (1984)	Survived to den exit	0 of 2 lost
314 (1985, 7)	1 (1985)	Survived to den exit	0 of 1 lost
335 (1985, 7)	2 (1985)	1 lost in June, other survived to exit	1 of 2 lost
340 (1985, 7)	2 (1985)	Survived to October at least	0 of 2 lost (?)
340 (1989, 11)	1 (1989(	Survived through October at least	0 of 1 lost (?)
381 (1986, 7)	2 (1986)	Survived, weaned next year	0 of 2 lost
381 (1989, 10)	3 (1989)	Mother shot in fall	0 of 2 lost

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Table 6. Continued.

Bear ID (year-age)	LITTER SIZE (ylgs.) (year)	COMMENTS	SUMMARY
388 (1986, 17)	2 (1986)	Survived, weaned next year	0 of 2 lost
388 (1989, 20)	2 (1989)	Survived to exit	0 of 2 lost
403 (1984, 7)	1 (1984)	Survived through November at least	0 of 1 lost
403 (1987, 10)	2 (1987)	--	--
423 (1985, 22)	3 (1985)	All survived to den exit	0 of 3 lost
425 (1986, 15)	2 (1986(	Both lost in mid-summer - possibly capture related. Not seen until 6 weeks following capture. Bred in 1987.	none
341 (1987, 12)	1 (1987)	Survived	0 of 1 lost
453 (1987, 5)	2 (1987)	Survived to exit	0 of 2 lost
460 (1987, 8)	1 (1987)	Survived until September, assume weaned at 2 as was shot the next fall	0 of 1 lost
460 (1990, 11)	2 (1990)	--	--
469 (1987, 6)	2 (1987)	Survived until mid-summer	--
472 (1987, 12)	1 (1987)	Collar removed, lost control	none
478 (1987, 9)	2 (1987)	--	--

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Table 6. Continued.

Bear ID (year-age)	LITTER SIZE (ylgs.) (year)	COMMENTS	SUMMARY
481 (1987, 14)	3 (1987)	At least 2 survived to exit	0 of 2 lost (?)
482 (1987, 7)	3 (1987)	Collar removed, lost contact	none
273 (1988, 12)	3 (1988)	Survived	0 of 3 lost
314 (1988, 10)	2 (1988)	Survived	0 of 2 lost
335 (1989, 11)	2 (1989)	Survived	?
396 (1990, 22)	3 (1990)	--	--
461 (1988, 8)	1 (1988)	?	?
462 (1988, 9)	2 (1988)	Survived	0 of 2 lost

Summary

No. of yearlings	No. litters	mean litter size (range)	
102	56	1.8 (1-3)	8 of 64 lost = 12.5% (1 loss possibly capture-related)

Table 7. Summary of Nelchina Basin bear litter size date for litters of 2-year-olds (based on observations of radio-collared bears).

Bear Id (year-age)	2-year-old LITTER SIZE (year)	Comments
204 (1978,7)	2 (1978)	weaned by 6/19/78, bred
281 (1987, 10)	1 (1987)	weaned by 6/5
281 (1990, 13)	2 (1990)	weaned, bred
283 (1980, 12)	2 (1980)	weaned in mid-Jine, bred, new litter next year
283 (1987), 19)	2 (1987)	2(+?) still with mother in '88, weaned next year
312 (1980, 10)	1 (1980)	weaned right after capture in May, new litter in 1981
312 (1983, 13)	1 (1983)	weaned by 6/13, bred
313 (1980, 9)	1 (1980)	weaned by May, bred, new litter in 1981
313 (1984, 13)	1 (1984)	weaned in May, bred
220 (1978, 5)	1 (1979)	weaned by 6/17, bred
221 (1978, 8)	2 (1979)	--
269 (1979, 16)	2? (1980)	--
299 (1980, 13)	2 (1981)	weaned in 5/81, new litter in 1982
337 (1983, 15)	1 (1983)	weaned by 5/15, bred
337 (1986, 18)	2 (1986)	still with mother in 86/87 den, weaned next year
381 (1987, 8)	2 (1987)	weaned in spring
384 (1983, 12)	3 (1983)	weaned by 6/13, one of these 3 may not have been part of this litter, bred
388 (1983, 14)	2 (1983)	weaned by 6/13, bred
388 (1987, 18)	2 (1987)	weaned by 6/23

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Table 7. Continued.

Bear Id (year-age)	2-year-old LITTER SIZE (year)	Comments
388 (1990, 21)	2 (1990)	weaned, bred
396 (1983, 13)	2 (1983)	weaned by 6/1, bred
331 (1981, 6)	2 (1981)	weaned by 6/15, bred, no cubs in 1982, died in 1982 (reason?)
379 (1984, 7)	1 (1984)	apparently weaned cub (time?), bred
314 (1986, 8)	1 (1986)	weaned
314 (1989, 11)	2 (1989)	weaned
420 (1985, 20)	2 (1985)	weaned in May
423 (1986, 23)	3 (1986)	weaned
335 (1990, 12)	2 (1990)	--
341 (1988, 13)	1 (1989)	--
453 (1988, 6)	2 (1988)	shot in fall
461 (1989, 10)	2 (1989)	weaned, no more data
481 (1988, 15)	2 (1988)	??

Summary

No. of 2-year-olds	No. of litters	Mean litter size (range)
56	32	1.8/1-3

Table 8. Morphometrics of brown bear cubs-of-the-year handled in GMU 13, 1978-87.

Cub ID	Mother's ID	Date Handled	Sex	Wt(lbs)	Comments
001	G213	22 May 1979	M	10.0	transplanted see Spraker
002	G213	22 May 1979	M	10.0	et al. (1981)
--	G207	27 May 1978	M	12.0	see Spraker, et al. (1981)
--	G207	27 May 1978	F	12.0	
G338	G283	6 May 1981	M	12.0	ear tagged
G339	G283	6 May 1981	F	13.0	ear tagged
G336	G313	6 May 1981	F	--	cub abandoned?, ear tagged
003	G283	14 May 1983	F	--	collared
004	394	15 May 1983	F	10.0	neck=230mm, ear tagged
005	G281	15 May 1983	M	8.5	collared
006	G281	15 May 1983	F	8.3	collared
418	G299	18 May 1983 (den)	M	over 10.0	neck=225mm, collared
419	G299	18 May 1983 (den)	M	over 10.0	neck=245mm, collared
417	G299	18 May 1983 (den)	M	over 10.0	neck=225mm, collared
016	G388	16 May 1984	M	13.5	collared, 13.5 lbs (5/29/84
017	G388	16 May 1984	F	-	collared
021	G281	17 May 1984	M	14.0	collared, neck=250mm
022	G281	17 May 1984	M	13.5	collared
008	G337	17 May 1984	F	12.3	collared, neck=220mm
009	G337	17 May 1984	F	11.5	collared, neck=230mm
023	G340	17 May 1984	?	16.5	collared
024	G340	17 May 1984	?	14.0	collared
025	G423	18 May 1984	M	7.0	collared, smallest of 4 in litter
---	G423	18 May 1984	F	-	not collared
018	G312	16 May 1984	F	17.0	collared
019	G312	16 May 1984	M	16.0	collared
020	G312	16 May 1984	M	17.0	collared
---	G453	3 June 1986	F	15.0	ear tagged
---	G453	3 June 1986	F	17.0	ear tagged
---	G456	4 June 1986	M	33.0	ear tagged

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Table 8. Continued.

Cub ID	Mother's ID	Date Handled	Sex	Wt(lbs)	Comments
---	G460	4 June 1986	M	30.0	capture mortality
---	G460	4 June 1986	F	30.0	ear tagged
---	G461	5 June 1986	M	26.0	ear tagged
---	G273	5 June 1987	F	16.0	ear tagged
---	G273	5 June 1987	M	18.0	ear tagged

Totals: 18 males and 15 females: $X^2 = 0.27$, 1.2.d.f., $\underline{P} = 0.60$

Table 9. Morphometrics of brown bears first handled as yearlings in GMU 13, 1978-1990.

Ylg ID	Mother's ID	Date Handled	Sex	Wt(lbs)	Comments
G232	G234	23 June 1978	F	100(est.)	Spraker, et al (1981)
G235	G234	23 June 1978	F	100(est.)	
G238	G240	23 May 1979	M	95	transplanted, see
G239	G240	23 May 1989	F	65	Ballard et al. 1980
G245	G244	24 May 1979	F	46	transplanted, op cit.
G252	G251	27 May 1979	M	134	transplanted, op cit.
G253	G251	27 May 1979	M	139	
G256	G254	27 May 1979	M	47	transplanted, op cit.
G257	G254	27 May 1979	M	47	
G262	G261	2 June 1979	M	90	transplanted, op cit.
G263	G261	2 June 1979	M	87	
G270	G269	6 June 1979	F	100	transplanted, op cit.
G271	G269	6 June 1979	F	95	
G275	G274	7 June 1979	M	68	transplanted, op cit.
G297	G399	4 May 1980	M	65	tagged
G298	G399	4 May 1980	M	65	tagged
G382	G313	14 May 1983	M	66	implant transmitter
G383	G313	14 May 1983	F	53	implant transmitter, died
G417	G299	15 May 1984	M	94	implant transmitter, (small)
G418	G299	15 May 1984	M	86	implant transmitter, (large)
G419	G299	15 May 1984	M	84	implant transmitter, (small)
G421	G420	17 May 1984	M	78	sibling not captured, large implant and breakaway.
G429	G314	1 June 1985	F	104	breakaway collar, shot 9/86.
G463	G462	5 June 1986	M	90(est.)	ear tagged
G468	G453	30 May 1987	F	70(est.)	glue on radio
G475	G472	31 May 1987	M	75(est.)	glue on radio

Totals: 17 males and 9 females: $X^2 = 2.46$, 1d.f., $\underline{P} = 0.12$.

Table 10. Age at first reproduction for GMU 13 brown bears.

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

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Table 10. Age at first reproduction for GMU 13 brown bears.

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

[a] The following calculations exclude all question marks.

AGE	3	4	5	6	7	8	9
# sub-adults	12	15	10	3	1	1	0
# 1st litters	0	5	7	6	1	0	1
# >1st litters	0	0	5	17	26	32	33
% adults	0.0	25.0	54.5	88.5	96.4	97.0	100.0

Mean age of first litter = 5.35 years.

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

AGE	3	4	5	6	7	8	9
# sub-adults	11	15	8	3	1	1	0
# 1st litters	0	5	6	9	3	0	1
# >1st litters	0	0	5	17	26	32	33
% adult	0.0	25.0	57.9	89.7	96.7	97.0	100.0

Mean age of first litter = 5.58 years

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

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

Table 11. Brown bear offspring survivorship and weaning, GMU 13 studies, (excludes bears transplanted in 1979).

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

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Table 11. Continued.

Year	Mother's ID (age in year when first captured) G312 (10 in 1980)	G299 (13 in 1980)	G313 (9 in 1980)	G283 (13 in 1980)	G281 (3 in 1980)
1980	weaned 1 @ 2 in May, breeding not observed	2 of 2 ylgs. survived May-Oct.	weaned 1 @ 2 in May, bred	weaned 2 @ 2 in June, bred	not estrous
1981	1 of 2 cubs lost in June, other survived May-Oct.	weaned 2 @ 2 in May and bred	1 @ 0 lost in May (capture related?)	1 of 2 cubs lost in Aug., other survived	estrous, bred
1982	yearling survived	lost 1 of 1 @ 0 in June	2 @ 0 survived	lost 1 @ 1 in May, bred	alone, bred
1983	weaned 1 @ 2 in June, bred, offspring = G385, transmitted	3 @ 0 survived (w/collars)	1 @ 1 lost in June (transmitted internally), sibling survived	lost 1 @ 0 in May, bred, lost cub had transmitter	2 @ 0 lost in May (bear predation), not seen breeding
1984	w/2 @ 0-bear killed in May	3 @ 1 survived (w/internals)	1 @ 2 weaned in May, shot	alone, bred	2 @ 0 lost in May, bred
1985	--	weaned 2-year-olds, collar failed?	--	2 @ 0, survived	2 @ 0, 1 lost in June, other survived
1986	--	ND	--	2 @ 1, survived	1 @ 1, survived
1987				2 @ 2 survived into den	1 @ 2 weaned
1988	--	ND	--	2 @ 3 weaned	2 @ 0, survived
1989	--	ND	--	2 @ 0	2 @ 1
1990 (to June)	--	ND	--	2 @ 1	2 @ 2 weaned in May, bred

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Table 11. Continued

Year	Mother's ID (age in year when first captured)					
	G331 (6 in 1981)	G341 (6 in 1981)	G337 (13 in 1981)	G344 (5 in 1981)	G335 (3 in 1981)	G340 (3 in 1981)
1981	2 @ 2 weaned in May, bred	alone, bred in May	lost 1 @ 0 in winter den, 2 survived	2 @ 0 survived	weaned from mother	alone
1982	no cubs, bred, died in July (reason?)	had 2 @ 0 thru July, bear missing subsequently	lost 1 @ 1 in June, other survived	lost 1 @ 1 in May, lost other in early July	alone, bred	alone
1983	--	no data	weaned 1 @ 2 in May, bred	2 @ 0, lost 1 by late June, other survived	alone, bred	alone
1984	--	no data	w/2 @ 0, collared, both survived	1 @ 1 lost in May, bear lost in July	w/2 @ 0 thru Oct.	w/2 @ 0, survived
1985	--	alone	w/2 @ 1, survived	ND	2 @ 1, 1 lost in June	2 @ 1 survived to den entrance
1986	--	w/1 @ 0	w/2 @ 2	ND	1 @ 2 weaned	alone, assume weaned young

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Table 11. Continued

Year	G331 (6 in 1981)	G341 (6 in 1981)	G337 (13 in 1981)	G344 (5 in 1981)	G335 (3 in 1981)	G340 (3 in 1981)
	Mother's ID (age in year when first captured)					
1987	--	w/1 @ 1	2 @ 3, weaned	ND	alone, bred	3 @ 0, all lost early in summer bred
1988		w/1 @ 2 in May, mom died in 88/89 den	alone	ND	w/2 @ 0	w/2 @ 0, 1 lost in summer
1989	ND	--	alone	ND	w/2 @ 1	w/1 @ 1 thru October, lost in den? mom skinny
1990 (to June)	ND	--	alone, not lactating	ND	w/2 @ 2	alone; breeding on 5/12

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Table 11. Continued.

Year	Mother's ID (age in year when first captured)					
	G380 (15 in 1982)	G394 (6 in 1983)	G384 (12 in 1983)	G379 (5 in 1982)	G388 (14 in 1983)	G381 (3 in 1982)
1982	2 @ 1 survived until denning, one may have died in den	no data	no data	2 @ 0 survived	no data	alone
1983	at least 1 @ 2 weaned in May, possibly both shot in Sept.	lost 1 @ 0 in May (?capture-related possible?),bred	weaned 2 or 3 @ 2 in June, bred	1 of 2 survived lost 1 (June - Sept.)	weaned 2 @ 2	alone, bred
1984	--	alone, shot	w/2 @ 0 thru Sept., missing	probably weaned 1 @ 2 after May 23	w/2 @ 0, capture-related cub loss, bred	alone, bred
1985	--	--	ND	alone, shot	w/2 @ 0, survived	w/2 c, survived
1986	--	--	ND	--	w/2 @ 1, survived	w/2 @ 1, survived
1987					w/2 @ 2 weaned	w/2 @ 2, weaned
1988	--	--	ND	--	w/2 @ 0	w/3 @ 0

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Table 11. Continued.

Year	Mother's ID (age in year when first captured) G380 (15 in 1982)	G394 (6 in 1983)	G384 (12 in 1983)	G379 (5 in 1982)	G388 (14 in 1983)	G381 (3 in 1982)
1989	--	--	ND	--	w/2 @ 1	W/3 @ 1, mom shot in fall
1990 (to June)	--	--	ND	--	2 @ 2 weaned bred	--

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Table 11. Continued.

Year	Mother's ID (age in year when first captured) G396 (13 in 1983)	G403 (6 in 1983)	G420 (19 in 1984)	G423 (20 in 1984)	G425 (14 in 1984)	273 (3 in 1979)	314 (7 in 1985)
1983	weaned 2 @ 2 in May, bred	2 @ 0 thru Aug. lost 1 in Sept.	no data	no data	no data	--	--
1984	lost litter of 1 @ 1 in May, breeding?	w/1 @1, lost after Apr.	w/2 @ 1, survived	4 @0, one lost in July, others survived to Oct.	alone, bred	--	--
1985	2 @ 0 lost in June	?	weaned 2 in May	3 @ 1 survived	w/2 cubs, survived	alone	1 @ 1 survived
1986	alone, bred	w/3 @ 0	w/2 @ 0, both lost in June	3 @ 2 weaned in May	w/2 @ 1, lost in June-July	alone	1 @ 2 weaned in May-June
1987	alone, bred	w/2 @ 1	no data	w/1 @ 0, lost in early summer	alone, bred	w/3 @ 0	3 @ 0, 1 lost in mid-summer
1988	alone, bred	ND	ND	alone	w/1 @ 0, lost in May	3 @ 1	2 @ 1
1989	w/3 @ 0	ND	ND	alone	w/2 @ 0 thru July suspect mom shot in fall	2-3 @ 2 thru Oct.	2 @ 2 weaned in May

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Table 11. Continued.

Year	Mother's ID (age in year when first captured)						
	G396 (13 in 1983)	G403 (6 in 1983)	G420 (19 in 1984)	G423 (20 in 1984)	G425 (14 in 1984)	273 (3 in 1979)	314 (7 in 1985)
1990 (to June)	w/3 @ 1	ND	ND	alone	ND	breeding	2 @ 0, lost, mid-May, lost other because of capture in late May

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Table 11. Continued.

Year	Mother's ID (age in year when first captured)		
	453 (4 in 1986)	458 (17 in 1986)	460 (7 in 1986)
1985	--	--	--
1986	w/2 @ 0	alone, bred	w/2 @ 0, 1 lost
1987	w/2 @ 1	w/1 @ 0, lost in June, bred	w/1 @ 1 thru Sept.
1988	w/2 @ 2 in May, later?	w/3 @ 0, shed	alone assumed weaned 1 @ 2 in May (the 2-yr-old shot in Sept.)
1989	shot 4/17	ND	w/2 @ 0
1990 (thru June)	--	shot 5/90	w/2 @ 1

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Table 11. Continued.

Year	Mother's ID (age in year when first captured)		
	461 (5 in 1985)	462 (7 in 1986)	481 (13 in 1986)
1986	w/1 @ 0, lost, capture related?	w/1 @ 1, weaned in June?, bred	--
1987	w/2 @ 0, 1 lost in mid-summer	w/2 @ 0	w/3 @ 1 in June
1988	w/1 @ 1 thru Sept.	2 @ 1	w/2 @ 2 in May, failed
1989	assume weaned, 1 @ 2 - ND	w/2 @ 2 - weaned, bred	ND
1990 (to June)	w/2 @ 0	missing 5/90	ND

(continued on next page)

Table 12. Summary of reproductive intervals for brown bears by bear ID. Based on data in Table 11, this report. Year of litter and reason for intervals >3 years are indicated in parentheses-"lost" means lost complete litter at age coy unless otherwise indicated.

ID OF BEARS WITH COMPLETE INTERVALS OF:

2 Years	3 Years		4 Years	5 Years	8 Years
472**(85)	220(77)**	335(84)	313(82, 1 lost)	281(85, 2 lost)	283*(85, 1 lost @ age 1;
	221(77)**	340(84)	299(83, 1 lost)		1 lost @ age 0;
	314(84)**	312(81)	337(84, weaned @age=3)		1 skipped
	380(81)**	337(81)			
	420(83)**	337b(84)			
	379(82)	388*(85)			
	423(84)	381*(85)			
	299(79)**	281(88)			
	388(88)	403(83)			
	314(87)	453(86)			
	460(86)	461(87)			
	462(87)	481**(86)			

(continued on next page)

Table 12. Continued

INCOMPLETE INTERVALS THAT WILL BE AT LEAST THE INDICATED LENGTH:

3Years	4 Years	5 Years	6 Years	7 Years	8 Years
283(89)	420(87, lost 1)	403(1 lost @ age 1)	337(91, skipped 3)	344(85, lost 2 @ age 1)	396(89, lost 2 & skipped 2)
460(89)	331(83, skipped 1)	458(88, lost 1 skipped 1)		423(91, lost 1 skipped 3	
	341(86, skipped 1)			425(89, lost 1 @ age 1 and 1 @ 0, skipped 1)	
	335(87, skipped 1)				
	340(88, lost 1)				

* Will be a complete interval when 2-year-olds are weaned in 1987.
** Litter was first observed when composed of 1-year-olds

SUMMARY:

AVERAGE REPRODUCTIVE INTERVAL

Complete Intervals Only (N = 30)	3.3 years
Incomplete Intervals Only (N = 14)	4.71 years
Complete and Incomplete (N = 44)	3.75 years

Appendix A. Portion of a manuscript in preparation that discusses trends in GMU 13 Brown bear populations.

ANALYSIS OF AN EFFORT TO INCREASE MOOSE CALF SURVIVORSHIP BY INCREASED HUNTING OF BROWN BEARS IN SOUTHCENTRAL ALASKA

INTRODUCTION

Wildlife management agencies sometimes adopt policies which are implicit or explicit tests of ecological hypotheses. Too often these hypotheses are not clearly stated and results of the tests are not adequately reported (Macnab 1983). One frequent consequence is that the public and some biologists who were aware of the hypothesis when policies were adopted, tend to assume that it was verified when they are not informed differently. Such assumptions form a background of "knowledge" in the profession that may be nothing more than postulation and impression (Macnab 1983).

Sometimes the results of these management experiments are not reported because the hypothesis turned out to be incorrect and the investigator was disinclined to report a negative results even though valuable lessons could be learned from them (Macnab 1983). At other times researchers may judge the results to be insufficiently clear-cut to be accepted by journals. In either case, misinformation may be perpetuated and management based on misconception may continue longer than it should or would if managers had access to all pertinent analyses.

In this context I report the results of a management experiment designed to improve the survivorship of moose calves through liberalized hunting regulations for brown bears in a portion of southcentral Alaska. The implicit hypothesis of this management experiment was that moose calf survivorship would increase as bear numbers declined and that moose populations would increase as a result.

In order to test this implicit hypothesis, I present evidence on trends in bear, moose, and wolf populations. Convincing evidence on trends in bear populations is especially difficult to obtain (Harris 1986, Miller 1990b). Correspondingly, major emphasis is placed on establishing that a decline in bear numbers occurred. The intensive work on bears accomplished in the studied portion of southcentral Alaska, provided better indicators of trend than are generally available to bear population managers.

Acknowledgements--GMU 13 management biologist R. Tobey helped in many aspects of this study, most notably in conducting the moose composition surveys and helping in the moose and bear census projects. Special recognition is given to S. Eide, L. Pamplin, K. Schneider, R. Somerville, D. Timm, and J. Vania under whose supervision aspects of this work was accomplished and to D. McAllister who assisted in field aspects of the bear studies.. Many other ADF&G staff participated in 1 or more of the studies which were used to develop this report. Most of the studies cited in this report were funded by Federal Aid in Wildlife

Restoration Projects, most recently project W-22-6. Other aspects of this work were funded by the Alaska Power Authority and the Alaska Dept. of Fish and Game (ADF&G).

BACKGROUND

Following a series of hard winters in the early 1970s, moose populations declined in southcentral Alaska (Ballard et al. in press). Even though subsequent winters were normal, moose numbers remained low. The ADF&G undertook a research program designed to clarify the reasons for the slow recovery of moose in a popular hunting area just south of the Alaska Range known as Game Management Unit (GMU) 13 (Fig. 1). In this unit, moose calf:cow ratios observed during fall composition counts were low leading to speculation that predation by wolves (Canis lupis) was limiting recruitment. Experiments were designed and conducted that involved wolf reduction in selected areas and comparisons of moose recruitment in these areas with control areas. These experiments indicated that wolf predation was not the primary factor limiting moose population growth (Ballard et al. 1981 and 1987, Ballard and Larson 1987; Ballard et al. in prep.). Similar studies in other areas with different ecological conditions (primarily much lower moose densities or fewer bears) found wolf predation limited recovery of depressed moose populations (Gasaway et al. 1983, Boertje et al. 1987 and 1988)

In GMU 13, studies of radio-marked moose calves revealed that many were being killed by brown bears and studies of radio-marked bears revealed that some were killing many moose calves in early spring (Ballard et al. 1980, Ballard and Larsen 1987, Ballard et al. 1988). These findings led to a 1979 study in which bear numbers were reduced, by transplanting bears, in a study area that included moose Count Area (CA) 3 in the northern portion of GMU 13 (Fig. 1). Following a temporary reduction in spring bear density of an estimated 60% (Miller and Ballard 1982a), calf:cow ratios increased significantly from the historical pattern and in comparison with adjacent areas where bear density was unaffected (Ballard and Larson 1987, Ballard and Miller 1988). In CA 3, calf:cow ratios went from 32 calves/100 cows in the year prior to the transplant to 52 calves/100 cows in the fall of 1979 following the transplant. In the fall of the following year (1980), the proportion of yearling bulls in the herd increased (ADF&G unpublished data), this indicated high survival of the 1979 calf cohort for at least 1.5 years. An estimated 60% of the radio-marked bears that were transplanted out of the study area returned following the period of high moose calf vulnerability (Miller and Ballard 1982b). In 1980 and in subsequent years, calf:cow ratios in this area declined to pretransplant levels (Ballard and Larsen 1987).

These findings resulted in wide-spread support for reduction of bear density through liberalized hunting regulations in GMU 13 and elsewhere. A research project was proposed in which hunting would be liberalized in just a portion of GMU 13 leaving the rest as a control area. This proposal was opposed by anti-hunting organizations as well as by many moose hunters with the result that bear hunting regulations were liberalized throughout all GMU of 13. Subsequently, the Alaska Board of Game lengthened bear hunting seasons in nearby units to coincide with seasons in GMU 13. The result was that increased brown bear harvests became geographically widespread throughout southcentral Alaska (Miller 1989). This occurred without the establishment of specific population objectives for either moose or bears and without a specific program in place by which to evaluate the effect of increased bear hunting on moose populations.

Staff of ADF&G were able to obtain additional information on moose and bear populations during other projects. These included bear, moose, wolf, and caribou studies designed to evaluate the impact of a proposed hydroelectric project in the center of GMU 13 (1980-1985), routine fall composition counts of moose populations, and routine information on harvested bears provided by hunters. Based on a suspicion that increased bear harvests had led to a marked population decline, ADF&G also conducted a bear density estimate in CA 3 in 1987 (Miller 1988 and 1990a). Except for this work, the moose and bear studies reviewed here were not designed to test the implicit hypothesis behind the liberalized bear hunting. However, they provide some insights which can be used to evaluate the hypothesis and guide managers considering similar programs elsewhere.

STUDY AREA AND METHODS

This study was conducted in GMU 13 (Fig. 1), an area of 59,154 km^2 about a third of which is above 1,220 m (4,000 feet) elevation. The unit is approximately centered on 61^0 N. and 147^0E. This is a popular hunting area between the population centers of Fairbanks and Anchorage with highways on or near its complete periphery (Fig. 1). GMU 13 is bordered on the north by the crest of Alaska Range, on the east by the Wrangell Mountains, on the south by the Chugatch Mountains, and includes the northern portion of the Talkeetna Mountain Range. The Susitna River is a major drainage that runs south from the Alaska Range, turns west in the northern portion of GMU 13 and forms part of the western boundary of the unit (Fig. 1). Lowlands and riparian habitats are forested primarily with spruce (_Picea glauca_ and _P. mariana_) or alder (_Alnus ruba_) while upland shrub zones (such as the flatlands forming the bulk of CA 3) are and dominated by dwarf birch (_Betula nana_), and willow (_Salix_ spp.). Vegetation at higher elevations is open tussock grasslands or, above about 1,500 m rock and snow or glaciers. Most of the unit below 1,200 m elevation is occupied by moose. Most of the annual range occupied by the Nelchina caribou (_Rangifer tarandus_) herd is in GMU 13. The predominant predators are brown bears and wolves. In localized areas, especially along rivers, black bears (_Ursus americanus_) are common (Miller 1987, Miller et al. 1987, Tobey 1989).

Intensive predator prey work has been conducted in this area since 1975. Reports on this work form the basis of the analysis presented here and the procedures utilized are presented in detail in the reports cited. Autumn moose sex-age composition surveys are conducted from fixed-wing aircaft at an intensity of about 0.4 min/km^2 in permanently-defined count areas throughout the unit. These are usually conducted following the first autumn storms which covers the ground with snow. This typically happens during late October-early December before moose shed their antlers. Stratified random sampling techniques (Gasaway et al. 1986) were used to obtain moose density estimates and capture-recapture techniques using telemetry to correct for lack of population closure (Miller et al. 1987) was used to obtain bear density estimates. Population estimates for larger geographic areas were obtained by subjective extrapolation from these density estimates in 1987 (Miller 1990b). Harvest data for bears was obtained from a mandatory check station for successful hunters during which a tooth is extracted from the skull for subsequent aging by counting cementum annuli and information on effort, transportation, and area hunted is obtained. Bear harvest density was obtained by dividing reported bear harvest by total surface area including high elevation and glaciated areas not utilized by bears. Sustainable harvest rates were estimated to be a maximum of 8% of the population of bears > 2.0-years-old based on reproductive parameters estimated during 10 years of study of radio-marked bears in northern GMU 13 (Miller 1987, 1988), on conservative estimates of natural mortality rates, and a simple deterministic model (Miller 1988). Data from moose hunters was obtained from a mandatory report required from successful and unsuccessful moose hunters.

RESULTS

Trends in Bear Populations

<u>Bear Harvests</u>. During 1961-1979, brown bear hunting regulations were conservative in south-central Alaska including GMU 13. There was no spring hunting season, fall seasons varied from 21 to 40 days and, during the 1970's, bag limits were 1/4 years (Table 1). During the 1970's, annual harvests averaged 58 bears in the whole unit and there was a gradual trend toward increasing harvests (Table 1). Annual harvests increased dramatically following the initiation of the spring season in 1980, expansion of this season in 1982 and 1983, expansion of fall seasons in 1980 and 1982, and increase in bag limit in fall 1982 (Table 1). An average of 131.8 bears were taken annually during the 1983-1986 period when regulations were most liberal (Table 1). Following a reduction in bag limit for fall 1987, number of bears harvested declined (Table 1).

The increased take was not uniformly distributed throughout the unit. There was relatively little increase in eastern portions of the unit (Subunit 13D) that were forested making it difficult for hunters to spot bears from the air or where access was limited by lack of aircraft landing strips or ATV trails. The bulk of the increased harvest came from central portions of the unit (Miller 1988) where most moose and caribou hunting occurs.

A bag limit of 1 per year instead of 1 per 4 years encouraged bear hunting incidental to ungulate hunts as hunters had little incentive to not fill their bear tags with the first bear they saw. Encouragement of such killing was the Board of Game's motive for increasing the bag limit in 1982. Problems with misreporting locations of kill that resulted from the bag limit change caused the Board of Game to return the bag limit to 1 per 4 years in fall 1987. Concerns over excessive harvests led the Board of Game to reduce the fall season by 10 days in 1990 (Table 1).

Bear Hunter Effort. There is no direct measure of trend in bear hunting effort, but effort certainly increased in GMU 13. Statewide, the number of brown bear tags sold increased from 4,275 in 1978 to 8,046 in 1987 (ADF&G unpublished data). Many moose and caribou hunters in GMU 13 also hunted brown bears. Returns from a questionnaire mailed to purchasers of brown bear tags in 1985 and 1986 revealed that 61% of respondents reporting hunting brown bears during fall seasons in GMU 13 (n = 1,599) purchased their tags so they could take a bear if the opportunity occurred during a hunt for some other species of game (ADF&G unpublished data). Moose hunting seasons in GMU 13 did not change during the 1980's, however, the average number of moose hunters increased 45% from the period 1975-1979 (annual average number of hunters = 2,762 [2,377-3,122]) to 1984-1988 ($\bar{x}$ = 4,006 [3,426-4,495]) (ADF&G unpublished data). The number of caribou hunting permits issued also increased by over 50% during this period.

Trends in Bear Density. There are 3 brown bear density estimates in GMU 13, all accomplished using capture-recapture techniques in the spring. Two of these estimates are for the area which includes CA 3 (Fig. 1). This area is bisected by the Denali Highway and because of easy access is heavily hunted by both bear and ungulate hunters. The first density estimate was obtained in 1979 as part of the bear transplant operation (Miller and Ballard 1982a); this estimate was adjusted downward by Miller (1990a) to make it more directly comparable with an estimate obtained during 1987 in a portion of the 1979 area. Because of differences in techniques, the 1979 estimate had high variance compared to the 1987 estimate (Miller 1990a). A second density estimate was obtained in 1985 in an adjacent area where a dam was proposed. Here, the carrying capacity of the bear habitat was subjectively assessed as being roughly equivalent to the Denali Highway area (Miller 1990a). In this area bear hunters use primarily aircraft for access and bear hunting pressure was less intensive than in CA 3 which is accessible by highway vehicle (Miller 1990a). Both the 1985 and 1987 estimates were made using replicated capture-recapture searches and radio-telemetry to obtain population closure (Miller et al. 1987).

These 3 bear density estimates were compared by Miller (1990a). Brown bear density for bears older than 2.0 years in CA 3 was estimated at 10.5 bears 2.0-years-old/1,000 km^2 in 1979 (95% CI = 25.7-6.0) compared to 6.7 bears/1,000 km^2 in 1987 (95% CI =10.1-5.2), a reduction in bear density of about 36% in 7 years. This is a minimum estimate of the decline because of the downward adjustment to the 1979 estimate. The 1985 density estimate in the nearby dam study area without road access was 19.1 bears > 2.0/1,000 km^2 in 1985 (95% CI = 23.2-16.7). The density in this roadless area was 285% higher than the 1987 estimate in CA 3 (P = 0.04) (Miller 1990a). If the lower limit of the 95% CI for the 1985 estimate is compared to the upper limit of the CI for the 1987 estimate, the density in CA 3 was 40% lower than in the interior area. If we are correct that these 2 areas have equivalent carrying capacities for bears, this represents a minimum estimate of the hunter-induced decline in bear density.

Bear Kill Density. Kill density has been over twice as high in the Denali Highway area (10.1 bears killed/1,000 km^2/year) as in the more remote area during 1981-1988 and has been higher since the early 1970's (Miller 1990a). Prior to 1980, the bear harvest along the Denali Highway may have been subsidized by immigration of bears from more lightly hunted surrounding areas such as the dam study area. With the increased harvest in these formerly remote areas brought about by expanded seasons and bag limits, it may be that these areas could no longer subsidize the Denali Highway harvest with immigrants (Miller 1988). This may have caused or contributed to the decline in kill density observed in the Denali Highway area since 1985 (Miller 1988, 1990a, Fig. 2).

Actual and Sustainable Harvest Rate Comparisons. In addition to the above indicators of a bear population decline in GMU 13, a population decline was inferred from comparisons of sustainable harvest estimates with reported harvests. Using a population estimate for all of GMU 13 and the estimated 8% maximum sustainable harvest rate for bears > 2.0-years old, the GMU 13 population in 1987 could sustain an annual harvest of no more than 24-29 females older than 2.0 (Miller 1988). Actual reported harvests in the whole unit during the peak harvest years of 1984-1986 averaged 60 females >2.0. For females older than 5.0, sustainable annual harvests were estimated as 21 bears and average harvests of 33 were reported (Miller 1988). Since the eastern portion of the unit experienced little increase in harvest following liberalization of regulations, the most accessible portions of the unit must have been even more heavily overharvested than indicated by these unit-wide calculations.

In subunit 13E which includes CA 3 and the dam study area, kill density has exceeded sustainable levels since 1978 (Fig. 2). Since this subunit includes both accessible and relatively inaccessible areas, kill density must have exceeded sustainable levels in accessible areas like CA 3 even more than illustrated in Fig. 2. Although sustainable kill density is illustrated as a flat line in Fig.2, it should decline following years when actual kill density exceeds sustainable levels.

Using a regression of sex ratio in kill on age class (Fraser et al. 1982), exploitation rate for all of GMU 13 was estimated as 20% of bears aged 2-17 using data from fall seasons during 1980-1987 (Miller 1988). Although higher than sustainable levels, this estimate is clearly an underestimate of actual harvest rate because females accompanied by cubs or yearlings are legally protected. The estimated maximum sustainable harvest rate using the deterministic model was estimated to be much less: 8% of the population older than 2.0 or (5.8% of the females older than 2.0) (Miller 1988 and 1990a). Differences between reported kill density and the estimated 1987 sustainable kill density is illustrated in Fig. 2.

Another estimate of minimum harvest rate was obtained from hunter returns of bears marked in the remote portion of GMU 13 where the 1985 density estimate was obtained. Between 1980 and 1986 an annual average of 8.9% of marked bears were shot and reported by hunters (range = 3% in 1982 to 15% in 1986) (Miller 1987, in press[a]). Since the minimum harvest rate estimate exceeded the maximum sustainable harvest rate presented above even in the remote portion of the unit where most marked bears occurred (Miller 1987), there can be little doubt that kill rates were much higher than sustainable levels in more accessible areas such as along the Denali Highway. Harvest rate estimated in this way is a minimum estimate because marks are not discovered on all bears reported by hunters, wounding losses, and natural mortalities. Only half of all the bears marked in earlier studies during 1978 and 1979 have been reported taken by hunters, all were taken prior to 1986 (Miller 1987, in press[a]).

Harvest Composition Analysis. Trend in bear populations is difficult to detect from sex and age composition of harvest data and changes in harvest composition may lag far behind changes in population status (Harris 1984, Harris and Metzgar 1987a and 1987b, Miller and Miller 1988, Miller 1990). However, because males tend to be more vulnerable to hunters than females (Bunnell and Tait 1980, 1981), increasing harvest rate is typically correlated with higher proportions of females in the harvest (Fraser et al. 1982, Kolenosky 1986, Harris and Metzgar 1987a). During 1970-1980 females constituted 43.4% of harvests (annual average = 42%) compared to 51.2% during 1983-1988 (annual average = 51%). During these periods females constituted an even higher proportion of the harvest of adult bears (older than 5). During 1983-1988, 61.1 percent of all adults harvested were females (annual average = 61%) compared to 49% during 1970-1980 (annual average =49%) (ADF&G unpublished data).

Population Composition. Composition of bear populations may change in response to heavy hunting pressure, typically sex ratio become biased in favor of females, age of males declines (Jonkel and Cowan 1971, Beecham 1980, Kolenosky 1986, Reynolds and Hechtel 1988), and age of females may increase slightly (Harris 1984). The male:female ratio in the population for bears older than 5.0 was estimated from the number of bears present at least once in the search area during each of the 3 density estimates described above. In 1979, 1985, and 1987 study areas, number of males per 100 females was, respectively, 113, 77, and 38 (Miller 1988). Because males move greater distances this estimation procedure will cause a bias in favor of males. This bias was more extreme during the 1979 estimate because density estimation efforts continued for a longer period.

Mean age of males in the population during these 3 density estimates also was also consistent with a hypothesis of increasing exploitation. In CA 3, mean age of males (> 2.0 years-old) was younger in 1987 ($\bar{x}$ = 4.3, _n_ = 8) than in 1979 ($\bar{x}$ = 6.4, _n_ = 19) (_t_ test, _P_ = 0.12). The mean age of males in 1987 was also younger than in the more remote area studied in

1985 ($\bar{x}$ = 9.7, n = 14) (t test, P = 0.01). Mean age of females was not significantly different in CA 3 in 1979 ($\bar{x}$ = 7.0 [n = 15]) than in 1987 ($\bar{x}$ = 10.0 [n = 10]) or in the remote area ($\bar{x}$ = 10.2 [n = 17]) (t test, P > 0.19). Although these age differences are not statistically significant for females, they are in the direction that would be expected if subadult females were being heavily harvested leaving few to enter the adult age classes where they are periodically protected from hunters by virtue of having litters. This is what we suspect is happening, the age of adult females in the population is gradually getting older in response to heavy harvests of subadult females.

Even though the population composition changed to predominantly female, there was no evidence suggesting an increase in survivorship of cubs of radio-marked females (Miller 1988). Increased cub survivorship when males have been depleted has been suggested as a density-dependent compensatory mechanism which could partially counteract effects of heavy hunting (McCullough 1981, Young and Ruff 1982, Stringham 1983) but should not be counted on to do so (Ruff 1982, Miller in press [b]). Using the technique of Pollock et al. (1989), annual cub mortality rate between emergence from natal dens to emergence from their next den was 0.31, through July it was 0.26 (Miller in press [a]). No trend in cub survivorship rates over the period of bear density reduction was observed (Miller 1988, in press [b]).

Subjective Impressions. Although little confidence can be placed on subjective impressions indicating changes in bear density, 2 biologists (the senior author and area management biologist R. Tobey) and one hunting guide and pilot (A. Lee) who participated in both the 1979 and 1987 bear density estimates felt that bears were much less abundant in 1987. Two hunting guides with a long history in the region which includes CA 3 also reported significant declines in bear density and an increase in hunting effort (R. Halford and D. Gratias, pers. comun.).

Habitat Changes. Although difficult to quantify, trends in human use of brown bear habitat over the last 2 decades have probably resulted in increased avoidance reactions by bears that have contributed to reductions in bear density in GMU 13. Land disposal programs by the State of Alaska have encouraged cabin building and human presence in formerly remote areas. New placer gold mines, some heavily capitalized, have been developed including one in CA 3 that seasonally employed up to 150 people on site. The increased use of all-terrain vehicles has also resulted in greatly improved access and use of formerly isolated areas.

Summary of Historic and Current Trends in Bear Populations. Although direct evidence is lacking, bear populations were probably significantly reduced in GMU 13 and elsewhere in Alaska during the 1950's as a result of wolf poisoning programs undertaken by the federal government prior to Alaskan statehood. Subsequently bear populations appeared to recover gradually following cessation of predator poisoning programs, light hunting pressure, and conservative hunting regulations. Hunting pressure increased in the 1970's slowing the rate of bear population growth and, perhaps, starting a decline in bear numbers in accessible areas such as along the Denali Highway. Construction of the Trans-Alaskan Oil pipeline across the eastern portion of GMU 13 during the mid 1970's probably contributed to increased hunting. Liberalized bear hunting regulations implemented during 1980-1982 caused bear populations to decline throughout the unit except, in western portions which are difficult to hunt. Most of the increase in harvest originated in remote areas that were lightly hunted prior to the 1980. Current harvests are at about the same level as during the late 1970's but, because the population base is smaller, probably still exceeds sustainable harvest levels. Although bag limits in GMU 13 have returned to levels of 1961-1982, seasons remain much more liberal than prior to 1980 (Table 1). During the 1980's, brown bear hunting effort has doubtless increased and hunter technology (use of airplanes and all-terrain vehicles) has improved. Regardless of these trends, there remains significant local opposition to adoption of more conservative regulations. There is support for efforts to encourage additional brown bear harvests in GMU 13 by returning to a 1/year bag limit and elimination of the $25 tag fee for resident brown bear hunters.

Appendix B. Simulated fall moose calf:cow ratios following reduced spring mortality of moose neonates.

TO: Warren Ballard
Research Biologist
Div. Wildlife Conservation
Anchorage

DATE: Jan. 22, 1989 (revised in 1990)

TELEPHONE NO: 267-2203

FROM: Sterling Miller
Game Biologist
Div. Wildlife Conservation
Anchorage

SUBJECT: Simulated impacts of reduced bear predation on fall moose calf:cow ratios--Revisited

This memo presents simulation results illustrating whether moose calf:cow ratios in fall composition counts would increase if spring calf survival increased due to decreased bear densities. This analysis was done to evaluate whether the absence of increased moose calf:cow ratios in GMU 13 indicates a failure of the bear reduction program to increase moose calf survivorship.

THE HYPOTHESIS

As we discussed on the phone, one hypothesis is that increasing calf survivorship would not be reflected in increasing calf:cow ratios. This could occur because increased calf survivorship would result in more subadult cows which have lower productivity than adult cows. Since subadult cows cannot be distinguished from adult cows in composition flights, increased calf survivorship might not be reflected in increased calf:cow ratios. The simulations described below indicate that fall compositions counts should result in higher calf:cow ratios when moose calf survival is increasing.

THE MODEL

I made 2 modifications of my LOTUS population model to look at this question:

A. In the first set of simulations, spring calf survivorship increased during each simulation year by 5%. I believe these simulations most accurately reflect the situation where bears are being progressively reduced by heavy hunting. These simulations produced the set of curves illustrated in Figure 1. The top line of Figure 1 illustrates the case where yearlings are classified as subadults (with productivity of 0.1 calves/cow) and all other age classes are classified as adults (with productivity of 1.2). In additional simulations, the age at which cows became fully adult was successively increased by one year to produce the family of curves illustrated in Fig. 1. In the bottom curve illustrated, cows didn't become adult until age 8, all younger cows had productivity of 0.1.

B. In the second set of simulations, spring calf survivorship was increased in simulation year 1. During subsequent simulation years, calf survival remained at that heightened level. This model illustrates what would happen if there was an abrupt change in bear predation resulting from a sudden decline in bear abundance and predation on calves. Such a decline might have resulted from our bear transplant experiment in 1979 if all transplanted bears did not return or were not replaced by immigration. For these simulations I established a stable population with spring calf survivorship set at 0.3 (flat line on the bottom of Fig. 2). The family of curves illustrated in Fig. 2 resulted from changing spring calf survivorship in simulation year 1 from this value to 0.4, 0.5, 0.6, 0.7, and 0.8.

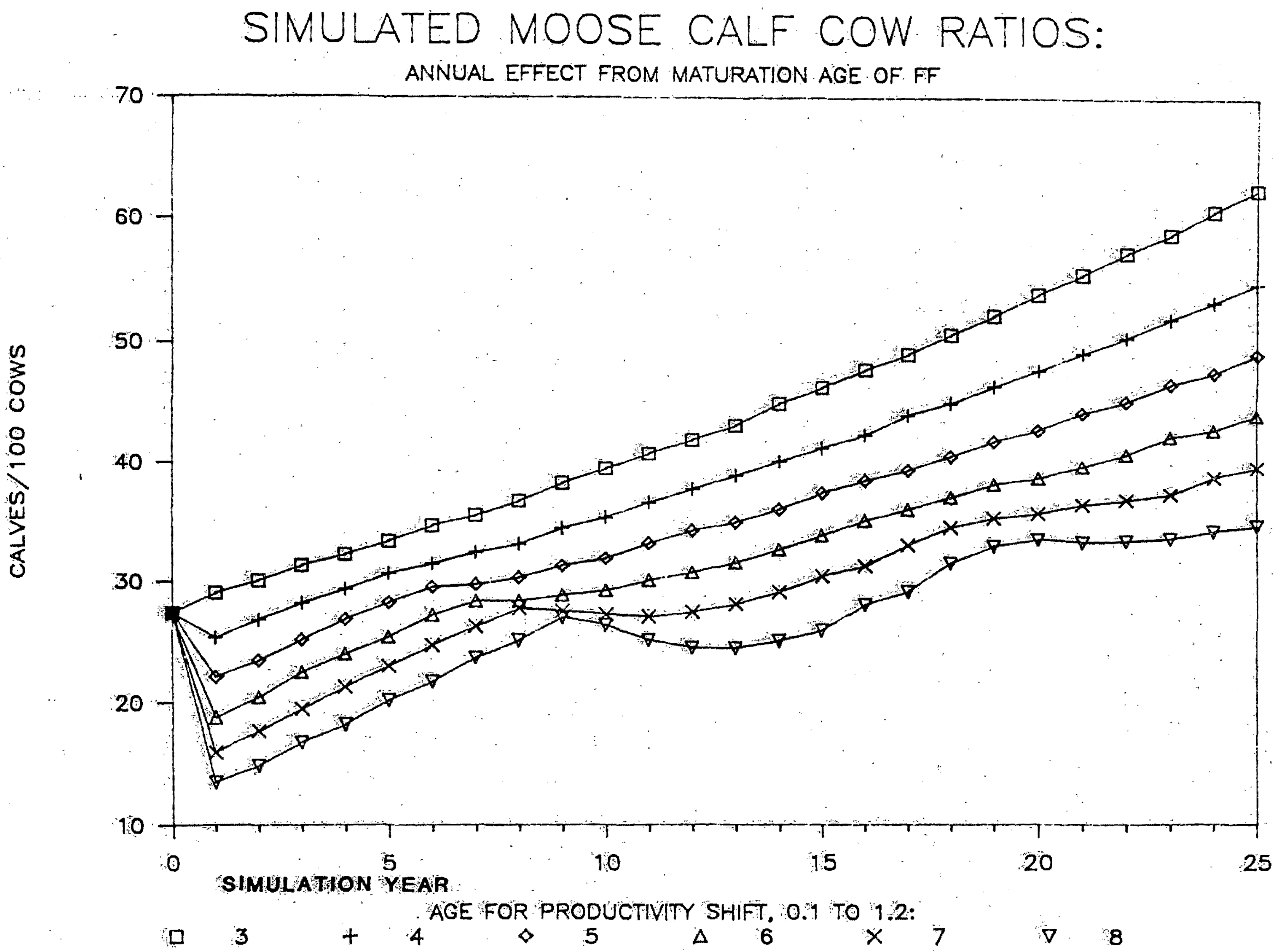
RESULTS FROM CONTINUOUSLY INCREASING CALF SURVIVAL

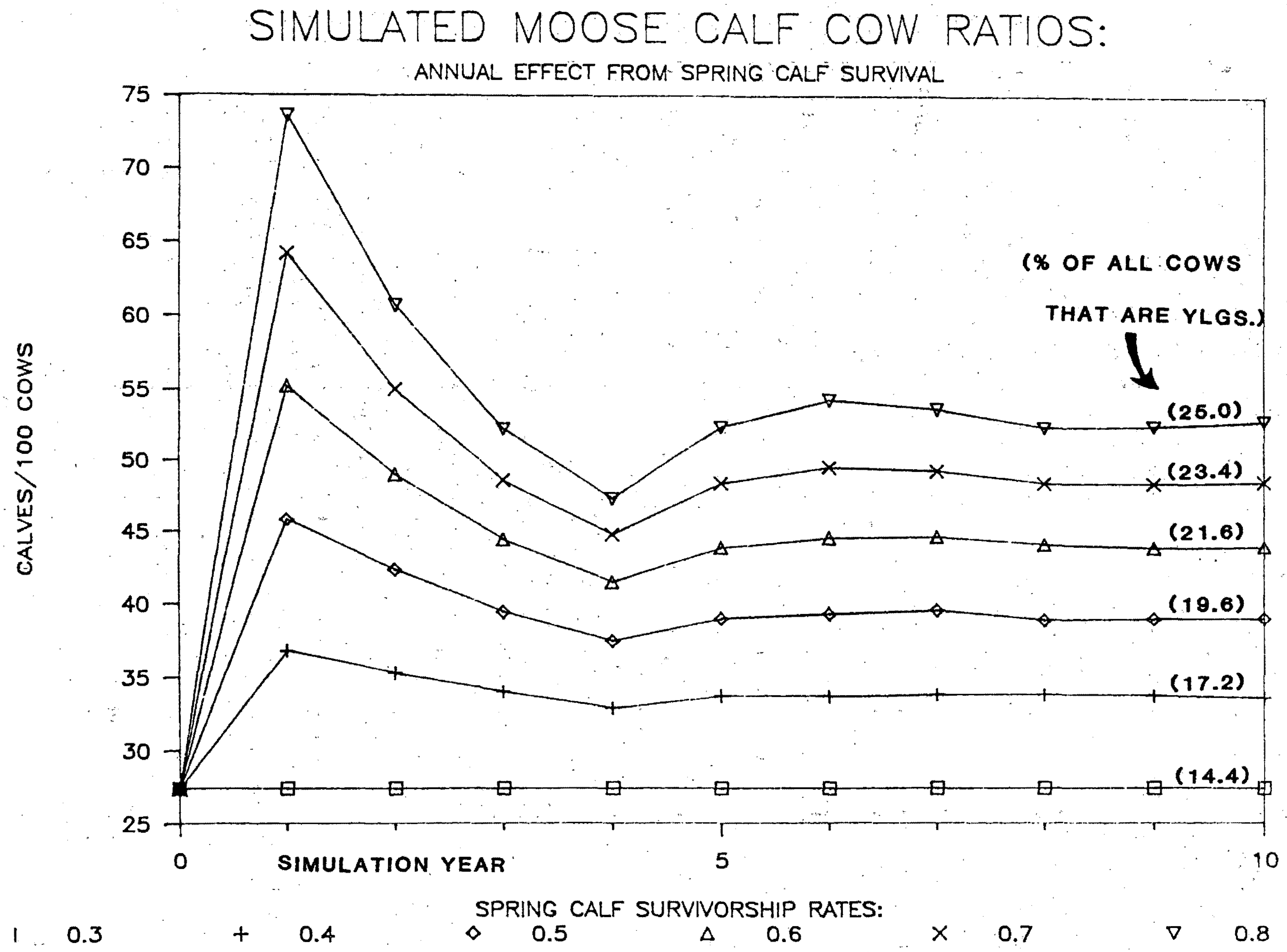
A continuous increase in calf:cow ratios results when spring calf survivorship increases by a constant percentage each year (Fig. 1). Delaying the age of female maturity results in a decline in calf:cow ratios during simulation year 1 followed by a progressive increase during subsequent years (Fig. 1). <u>I conclude that moose calf cow ratios should increase where there moose calf survival is increasing continuously because of declining predator densities.</u> Under conditions modeled, where such increases are not observed it is reasonable to conclude that moose calf survival has not increased.

RESULTS FROM A ONE TIME CHANGE IN MOOSE CALF SURVIVAL

Calf cow ratios increase dramatically during the first year calf survivorship is increased (Fig. 2). During subsequent years of elevation calf survival at this same elevated level, calf:cow ratios decline for a few years. This decline results from the increased number of subadult cows as suggested in the above hypothesis. However, the more significant result of these simulations is that in spite of this decline from peak levels obtained in simulation year 1, calf:cow ratios remain significantly higher than under initial conditions. <u>With higher and but stable calf survival you should get higher calf:cow ratios.</u> Also, there is a direct relationship between stabilized calf:cow ratios and spring calf survivorship. <u>The higher the spring calf survivorship, the higher the calf:cow ratios.</u>

Based on these simulations I conclude that increased survival of moose calves resulting from decreased abundance of bears should result in increased calf:cow ratios. Of course, this increase would not occur if calves saved from bears were lost to other predators or natural mortality.


SIMULATED MOOSE CALF COW RATIOS:
ANNUAL EFFECT FROM MATURATION AGE OF FF
CALVES/100 COWS
70
60
50
40
30
20
10
0
5
10
15
20
25
SIMULATION YEAR
AGE FOR PRODUCTIVITY SHIFT, 0.1 TO 1.2:
□ 3
+ 4
◇ 5
△ 6
× 7
▽ 8


SIMULATED MOOSE CALF COW RATIOS:
ANNUAL EFFECT FROM SPRING CALF SURVIVAL
CALVES/100 COWS
75
70
65
60
55
50
45
40
35
30
25
0
SIMULATION YEAR
5
10
(% OF ALL COWS
THAT ARE YLGS.)
(25.0)
(23.4)
(21.6)
(19.6)
(17.2)
(14.4)
SPRING CALF SURVIVORSHIP RATES:
0.3
0.4
0.5
0.6
0.7
0.8

Appendix C. Estimated brown bear population in GMU 13 by Subunit.

APPENDIX C

MEMORANDUM

STATE OF ALASKA
DEPARTMENT OF FISH AND GAME

TO: Bob Tobey
Area Biologist
Wildlife Conservation
Glennallen

DATE: July 16, 1987

THRU:

TELEPHONE: 267-2179

FROM: Sterling Miller
Wildlife Biologist
Wildlife Conservation
Anchorage

SUBJECT: GMU 13 Brown Bears: A preliminary population estimate
POPEST13.DOC

Based on the stratification of GMU 13 you, Warren and I did on 15 July, I have come up with a bear population estimate for GMU 13. As you recall we assigned stratification factors to portions of the unit based on the 1985 density estimate in the Su-Hydro area (Factor "A") or the 1987 density estimate in the upper Susitna (factor "B"). I believe this is a better estimate than could be obtained by simple extrapolation of one density value to the whole of GMU 13.

In calculating the area within each strata I subtracted out the ice field and glaciers (white areas on the 1:250,000 scale maps). This resulted in elimination of 6.1% of GMU 13 as non-bear habitat. A more precise estimate of bear habitat in the unit could be obtained by calculating the area within each strata below 5,000 feet elevation.

Additional range for the extrapolated estimate could be obtained by using upper and lower limit values for each of the factors (i.e. the 95% CI for factor A is 12-15.3 mi^2/bear and, for factor B, it is 25-45 mi^2/bear).

Ongoing refinement of factor B, the 1987 estimate, will result in an altered, and slightly increased, population estimate using these stratification factors.

The preliminary GMU 13 brown bear population estimate based on this exercise is 1161-1295 bears of all ages or 779-867 bears older than 2 (Table 1). A large portion of this estimate comes from 13D where we have no direct data. We did this stratification in a hurry and shouldn't lock ourselves into it. I encourage Bob especially to continue to think about this method of extrapolating from the density estimates and we'll redo this next time we have an opportunity.

cc: Karl Schneider
Warren Ballard
Greg Bos

Table 1. Estimated number of brown bears in GMU 13 based on stratified extrapolation from 1985 and 1987 density estimates. Percentages indicate amount of area considered to be "bear habitat" (excludes snow fields and glaciers).

Factor	Density estimate (mi^2/bear) All bears	Density estimate (mi^2/bear) only bears >2.0	Basis
A	13.8	20.3	1985 Density Estimate
B	35	55	1987 Density Estimate

Subunit	Polygon Area(mi^2)	Stratification factor	Est. number bears (all ages)	Est. number bears(>2.0 only)
13C	889	(1)A	64	44
13C	1119	(1.5)B	48	31
Total	2008		112	75
2044	98.2%			
13B	228	(1.5)B	10	6
13B	543	(1)A	39	27
13B	43	(1)A	3	2
13B	2263	(1.1)B	71	45
13B	503	(1.5-2)B	22-29	14-18
Total	3580		145-152	94-98
3987	89.8%			
13E	708	(1.1)B	22	14
13E	727	(1.5-2)B	31-42	20-26
13E	1058	(0.5-1)A	38-77	26-52
13E	1030	(0.5)A	37	25
13E	2910	(1)A	211	143
Total	6433		339-389	228-260
6530	98.5%			
13A	750	(1)A	54	37
13A	1050	(1-1.2)A	76-91	52-62
13A	1301	(1.25)B	46	30
13A	1344	(0.5)A	49	33
Total	4445		225-240	152-162
4528	98.2%			
13D	731	(1.5)B	31	20
13D	4270	(1-1.2)A	309-371	210-252
Total	5001		340-402	230-272
5771	86.7%			
All 13	21467		1161-1295	779-867
22857	93.9%			

Table 1. Summary of brown bear regulations and harvests in Alaska's GMU 13, 1961-1990.

Calendar Year	Bag limit	Spring season	Fall season	Total No. days	Spring kill	Fall kill	Total kill
1961	1/year	none	9/1-9/30	30	0	42	42
1962	1/year	none	9/1-9/30	30	0	32	32
1963	1/year	none	9/1-9/30	30	0	43	43
1964	1/year	none	9/1-9/30	30	0	38	38
1965	1/year	none	9/1-10/15	30	1	47	48
1966	1/year	none	9/1-9/30	30	0	63	63
1967	1/year	none	9/1-9/30	30	0	32	32
1968	1/4years*	none	9/15-10/15	21	0	39	39
1969	1/4years	none	9/20-10/20	31	0	17	17
1970	1/4years	none	9/15-10/5	21	0	26	26
1971	1/4years	none	9/1-10/5	35	0	70	70
1972	1/4years	none	9/10-10/10	31	0	48	48
1973	1/4years	none	9/10-10/10	31	0	45	45
1974	1/4years	none	9/1-10/10	40	0	72	72
1975	1/4years	none	9/1-10/10	40	0	80	80
1976	1/4years	none	9/1-10/10	40	0	59	59
1977	1/4years	none	9/1-10/10	40	1	40	41
1978	1/4years	none	9/1-10/10	40	2	62	64
1979	1/4years	none	9/1-10/10	40	0	73	73
1980	1/4years	5/10-5/25	9/1-10/31	56	15	69	84
1981	1/4years	5/10-5/25	9/1-10/31	77	24	58	82
1982	1/year*	4/25-5/25	9/1-12/31	153	23	59	82
1983	1/year	1/1-5/31	9/1-12/31	273	36	81	117
1984	1/year	1/1-5/31	9/1-12/31	273	47	77	124
1985	1/year	1/1-5/31	9/1-12/31	273	54	91	145
1986	1/year	1/1-5/31	9/1-12/31	273	45	91	136
1987	1/4years*	1/1-5/31	9/1-12/31	273	46	58	104
1988	1/4years	1/1-5/31	9/1-12/31	273	19	48	67
1989	1/4year	1/1-5/31	9/1-12/31	273	25	52	77
1990	1/4year	1/1-5/31	9/10-12/31	263	40	--	--

* Starting July 1 of year.

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