REPRODUCTIVE CHARACTERISTICS OF GRIZZLY BEARS IN THE KUGLUKTUK AREA, NORTHWEST TERRITORIES, CANADA

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Abstract: Reproduction and survival of grizzly bears (*Ursus arctos*) were studied in the area southwest of Kugluktuk, Northwest Territories, between 1988 and 1995. Thirteen radiocollared female grizzly bears were monitored for up to 7 years in tundra habitat southwest of Kugluktuk. Adult female survival was high (98%); the only 2 adult female mortalities were from intraspecific predation. Mean litter size was 2.3 cubs <1 year old (n = 19), mean birth interval was 2.6 years (n = 8), and the annual natality rate was 0.87 cubs/adult female. Mean reproductive interval between successful litters was 3.3 years (n = 6). First-year cub survival was 81%, and second-year cub survival was 76–84%. Age at first parturition averaged 8.7 years (n = 6), which is later than in other northern grizzly bear populations. However, growth curves indicated that maturity was not delayed by nutrition. The estimated finite rate of population increase (λ) was 1.026. These results indicate that the Kugluktuk grizzly bear population can sustain a small harvest provided that females are protected.

Ursus 10:41–47

Key words: grizzly bears, litter size, reproduction, *Ursus arctos*.

The Inuit of the Kugluktuk area, Northwest Territories (NWT), traditionally have harvested grizzly bears for hides and for food. Legends and recollections of Inuit elders indicate that the grizzly bear has historically been an important resource. It is important to ensure that the harvest of this resource is sustainable in the face of an increasing human population and demand for bear products.

This study was initiated to estimate reproductive parameters of grizzly bears in the Kugluktuk area (age of first reproduction, litter size, cub survival, and breeding interval), and to estimate annual survival of adult females. This information was used to estimate the finite rate of population increase (λ), and hence the potential for the population to sustain a harvest.

Adult female survival has the greatest effect on a population's ability to sustain harvest (Taylor et al. 1987). However, adult survival is generally uniformly high for grizzly bears, so the age of first reproduction, cub survival, breeding interval, and litter size tend to have more influence on rates of population change and the ability to sustain harvest (Bunnell and Tait 1981). As our study area is on the northern fringe of grizzly bear range in North America, we expected that reproduction and cub survival would be low compared to other grizzly bear populations. We also expected bears to be smaller and lighter than in other populations.

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STUDY AREA

The study area covered approximately 18,200 km^2 south and west of Kugluktuk (Fig. 1). Low-lying lacustrine sediments along the Rae and Richardson rivers supported lush shrubland and wet sedge meadow vegetation. The hills to the north and south of the Richardson River rose to 600 m above sea level in a broad, smooth-topped plateau of bedrock outcrops and scattered vegetation. South of Dismal Lakes the uplands were dissected by small rivers and creeks. The valleys supported lush, willow-dominated (*Salix* sp.) shrublands; lichen tundra dominated the uplands. Eskers were common throughout the area. Stands of black spruce (*Picea mariana*) were scattered along the Kendall and Coppermine rivers in the eastern portion of the study area and along the Dease River in the south. Barren-ground caribou (*Rangifer tarandus groenlandicus*) were common through most of the year, peaking during spring migration (May) and post-calving aggregations (late Jun–early Jul). Muskox (*Ovibos moschatus*) were resident in the Rae and Richardson river valleys and were occasionally observed north of Dismal Lake.

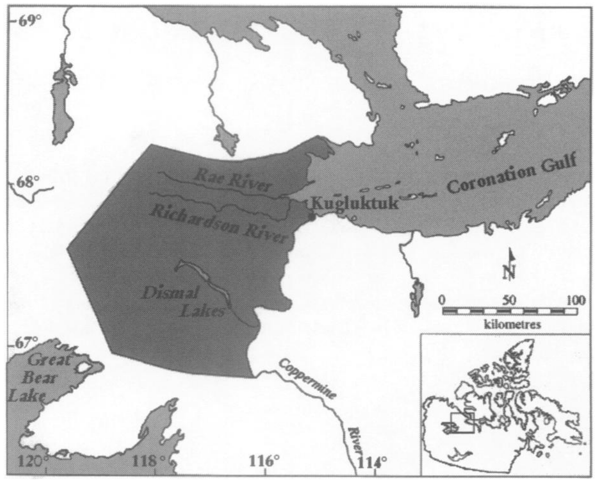

Fig. 1. Location of the grizzly bear study area (shaded area) near Kugluktuk, Northwest Territories, Canada, 1988–95.

A management area for the harvest of barren-ground grizzly bears was established west of Kugluktuk in 1985. A harvest quota was set at 5 bears based on the assumption that past harvest levels, estimated to average 5 bears/year, were sustainable. Harvest regulations permitted the sale of bear hides and other parts and guided hunts by non-native hunters. Aside from the 5-bear quota, bears could also be killed by Inuit for food or by any person in defense of life or property.

The establishment of a quota resulted in a large increase in harvest in 1986 and 1987. Hunters killed bears hoping that they could later obtain a tag and sell the hide, and guided sport hunts began. During these years, hunting was primarily in the fall; consequently 5 adult females were killed. In 1988, the Kugluktuk Hunters' and Trappers' Association agreed that members would only hunt bears in the spring, that guided hunts would be conducted in the spring, and members would only hunt bears when they were in possession of a tag. Kills in defense of life and property were required to be taken from the quota, but because Inuit could still harvest bears for food, the annual harvest sometimes exceeded the quota of 5. However, between 1988 and 1995 the average annual harvest was 5 bears (Northwest Territ. Dep. Resour., Wildl. and Econ. Dev. files, Yellowknife).

METHODS

In late May 1988 and late May 1989 we searched for bears to capture by flying along drainages, ridges, and eskers in a helicopter. Most bears were located by following tracks in the snow. Females with cubs were either still in dens or moved less than single bears, so the 1988 and 1989 captures were biased toward lone females and males. To include females with cubs in the sample, capture effort was switched to late June and early July in 1990 and 1991 and a 2-seat fixed-wing aircraft was used in addition to the helicopter for a more intensive search of the study area.

Bears were darted from a helicopter and immobilized with titelamine hydrochloride and zolazepam hydrochloride (Telazol®, Ayerst Laboratories Inc., Montreal, Que., Can.). Adult females were ear-tagged, lip-tattooed and radiocollared (Telonics Canada Ltd, Winnipeg, Manit., Can.). Males, subadult females, yearlings, and cubs were not collared but were ear-tagged and lip-tattooed for later identification. We measured body weight, heart girth, straight-line body length, skull length, and skull width. Teats of lone females were examined for scars, hair loss, or lactation to differentiate females that previously had or recently lost cubs from nulliparous females. A premolar was collected for age estimation (Stoneburg and Jonkel 1966). Bears were recaptured and collars replaced or removed near the end of the radio battery life.

Radiocollared bears were located from the air in late May or early June of 1988–95. Bears were also located once or twice later in the summer or fall. When bears were observed, we recorded the presence and age of accompanying offspring. Visual sightings of bears and their cubs were easily made in the open tundra habitat. Cubs-of-the-year (COYS), yearlings, and 2-year olds were easily distinguished by their size in relation to the adult female.

Litter size was determined from the number of COYS first observed in the spring or early summer. Cub survival to age 1.5 and 2.5 was determined from sequential observations of the same litters. COYS and yearlings that were not observed with their mother in 2 successive observations were assumed to have died. We defined birth interval (BI) as the number of years between the birth of cubs, including intervals shortened by whole litter loss. Reproductive interval (RI) was the number of years between successful litters (i.e., those surviving to the end of their second summer). Natality was estimated by dividing mean litter size by mean birth interval. Adult female survival rate (s) was calculated from the proportion of collared females surviving from 1 year to the next.

The finite rate of population increase (λ) was estimated from reproductive rates and survival rates (Eberhardt et al. 1994):

$$\lambda^{a} - s\lambda^{a-1} - l_{a}m[1 - (s/\lambda)^{w-a+1}] = 0 \qquad (1)$$

Where, l_a is survival to age at first parturition (a), w is the maximum age considered, and m is the number of female cubs/adult female per year (natality rate x 50% F). We solved for λ by iteration. The parameter w was fixed at 20 years as per Eberhardt et al. (1994) and Hovey and McLellan (1996).

RESULTS

Seven lone female grizzly bears were captured and radiocollared in May 1988 and May 1989 (Table 1). One 4-year-old female was killed by a hunter outside the study area shortly after collaring and was not included in the analyses. Eight more females, including 4 with cubs-of-the-year or yearlings, were radiocollared in 1990 and 1991.

Litter size observed between late May and mid-July averaged 2.26 COYS (SD = 0.81, n = 19). We observed 3 litters of 1 cub, 9 twins, 6 triplets, and 1 quadruplet. Two of the single-cub litters were produced by the same old female (24 and 25 years old at the time of these births). Five of the litter sizes (2 of 3 cubs and 3 of 2 cubs) were not determined until late June or early July.

Mean BI was 2.6 years (SD = 1.1, n = 8) and mean RI was 3.3 years (SD = 0.5, n = 6). The longest observed RI was 4 years, although in 1995 one female had not produced a second litter 4 years after her initial litter. The mean litter size of 2.26 cubs divided by the mean BI of 2.6 years yielded an annual natality rate of 0.87 cubs/adult female.

The mean age of first parturition was 8.7 years (SD = 0.8, n = 6). One bear was observed breeding at age 6, but either she did not produce cubs or the cubs died before the bear was next observed in October the following year. Three bears first produced cubs at 8-years old, 2 at age 9, and 1 at age 10. All bears had cubs by the time they were 10 years old.

Reproduction appeared to continue throughout life, although it may have diminished at older ages. The oldest female in this study produced a cub at age 26 and was observed with a yearling just prior to her death the next year. The fate of the yearling was not known. Although this female was reproductively active after age 22, she contributed little to the population, as 2 litters were lost as COYS and her last cub probably had a low chance of survival on its own.

Of 43 COYS, 35 (81%) survived to 1.5 years; at least 19 of 25 (76%) yearlings were known to have survived to 2.5 years. Second-year survival may have been underestimated. Two females were observed with 2.5-year-old cubs in May, with males in June, and with 2.5-year olds again in August. The estimate of yearling survival would increase to 84% if 2 other females observed first in July without their 2.5-year-old cubs had disassociated from rather than lost their yearlings prior to being observed.

Two radiocollared adult female bears died during the study, giving an average annual adult survival rate of 0.98 (SD = 0.06, n = 7). Both mortalities were in the fall of 1993 and appeared to have been due to intraspecific predation by large grizzly bears. A 27-year old was found

Table 1. Reproductive histories of radiocollared female grizzly bears in the Kugluktuk area, Northwest Territories, 1988–95.

Bear	Year captured	Age at capture (yrs)	Reproductive status by observation year[a]							
			1	2	3	4	5	6	7	8
G501	1988	6	C-NC	O-NC	C-2COY	O-2-1YR	C-2-2YR	O-1COY	O-2COY	O-2-1YR
G502	1988	22	C-NC	O-NC	C-1COY	O-1COY	NO	O-1-1YR	DIED	
G505	1988	7	C-NC	O-NC	C-NC-E	O-3COY	C-3-1YR	O-3-2YR	O-WM	C-E
G507	1988	4	C-NC	KILLED						
G511	1989	8	C-NC	O-3COY	C-1-1YR	O-1-2YR	O-4COY	O-3-1YR	O-3-2YR	
G514	1989	9	C-NC	O-2COY	C-2-1YR	O-1-2YR	C-1-3YR	O-3COY	C-3-1YR	
G517	1989	6	C-NC	O-NC	C-WM-E	O-2COY	O-2-1YR	C-NC	O-WM	
G522	1990	14	C-2-1YR	O-2-2YR	SC					
G524	1990	10	C-2-1YR	O-NC	C-2COY	O-2-1YR	O-2-2YR	C-WM		
G529	1990	13	C-E	SC						
G534	1990	6	C-E-WM	O-NC	C-3COY	O-3-1YR	O-2-2YR	C-WM		
G535	1990	15	C-NC-E	O-2COY	O-2-1YR	O-2-2YR	DIED			
G541	1991	6	C-NC	O-NC-WM	O-2COY	0-1-1YR	C-E			
G543	1991	16	C-2COY	O-1-1YR	O-NC	O-2COY	C-2-1YR			
G549	1991	13	C-3COY	O-3-1YR	C-2-2YR	O-3COY	C-3-1YR			

[a] C = capture, O = observed, NO = not observed, NC = no cubs, E = in estrus, WM = with male, COY = with cubs-of-the-year, 1YR = with 1-year olds, 2YR = with 2-year olds, SC = slipped collar.

dead near its den, which had been excavated by another bear. The other bear was not near a den when she died. Mounds of torn-up vegetation, characteristic of grizzly bear caches (Elgmork 1982), and bear scats containing bear fur and bones were in the areas where both bears died.

No data were available on subadult female survival, so for calculating survival to age of first reproduction we assumed that survival was 0.8 from age 2–5 and was equal to the adult survival rate of 0.98 from age 5–8. These estimates produce a value of 0.33 for l_a. From iterations of eq. (1) with the reproductive and survival rates given above, we estimated $\lambda = 1.026$.

Straight line body length, skull width, and skull length appeared to reach an asymptote by 6 years old, and weight of female bears reached an asymptote by age 8 (Fig. 2, curves fitted by hand). Mean straight line body length, skull width, and skull length of females >6 years old were 154 cm (SD = 6.4), 20.6 cm (SD = 1.5), and 33.3 cm (SD = 2.2), respectively (n = 27). Mean weight of females >8 years old was 112 kg (SD = 18, n = 29).

DISCUSSION

The study area lies at the northern edge of grizzly bear distribution in North America. We anticipated that this would result in low reproduction resulting from small litters, long inter-litter intervals, and delayed age of first reproduction. However, litter sizes in this study were among the largest recorded for grizzly bear populations in Canada and Alaska (Table 2). Moreover, our observations of litters were conducted between late May and mid-July, before which some cub mortality may have occurred, so our estimate of average litter size may have been low. The observation of a litter of 4 COYS produced 1 year after weaning a 2-year old suggests excellent nutrition.

Intervals between litters (BI and RI) were short compared to other studies in Canada and Alaska. RI was similar to that recorded on the Tuktoyaktuk Peninsula (Nagy

Fig. 2. Growth curves (hand-fitted) for grizzly bears in the Kugluktuk area, Northwest Territories, Canada, 1988–95.

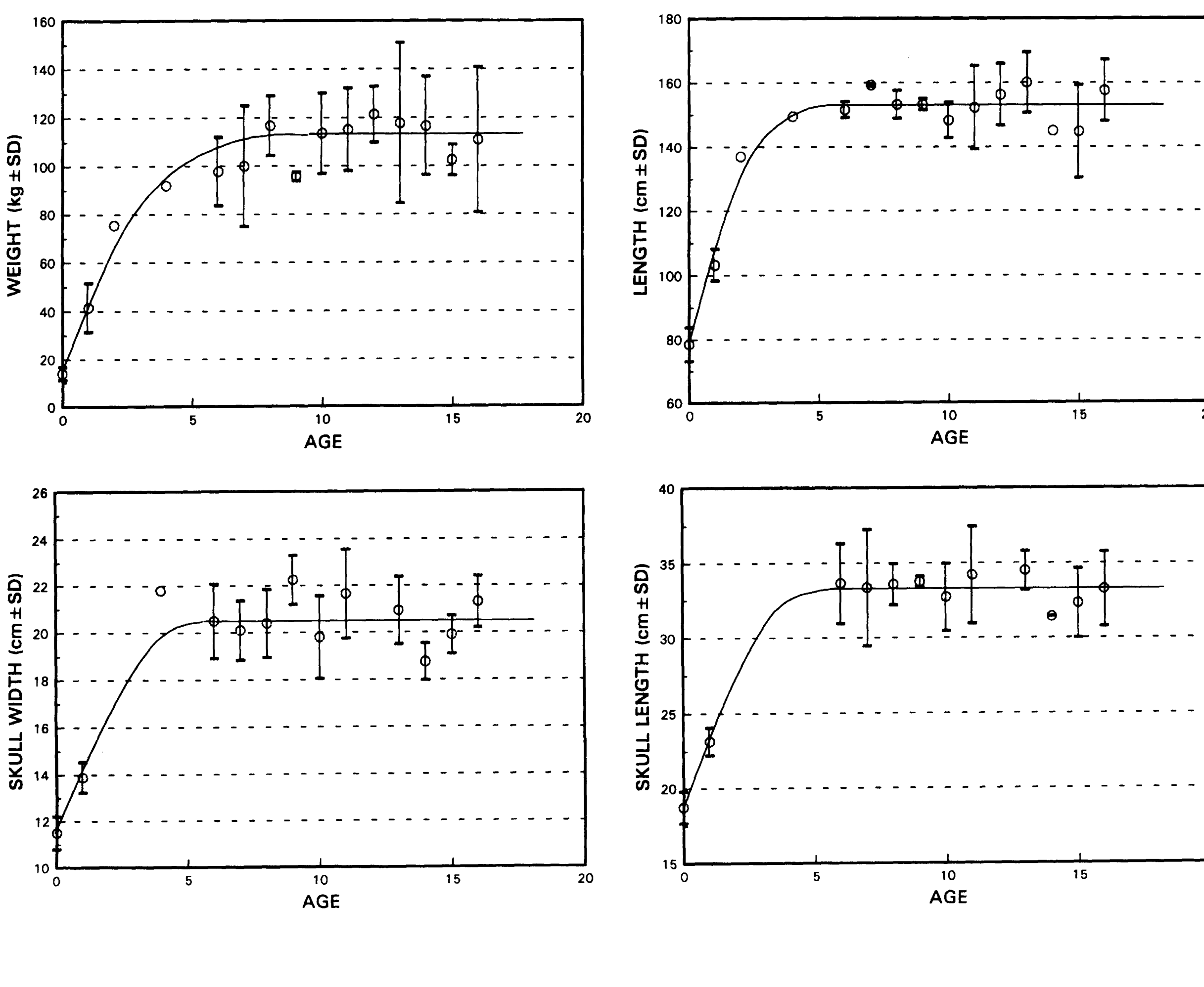

Table 2. Reproduction and survival of selected Canadian and Alaskan grizzly bear populations as reported in literature.

Location	Parameter[a]						Source
	LS	BI	N	RI	FP	AFS	
Kluane, Yukon	1.59	3.1	0.51		7.8		Pearson 1975 cited in Bunnell and Tait 1981
East Brooks Range, Alaska	1.78			4.2	9.6		Reynolds 1976, Reynolds and Hechtel 1980
Mackenzie Mountains, NWT[b]	1.83			3.8	>8		Miller et al. 1982
Tuktoyaktuk Peninsula, NWT	2.30		0.70	3.3	6.4		Nagy et al. 1983*a*
Northern Yukon	2.00			3–4	7.5		Nagy et al. 1983*b*
West Brooks Range, Alaska	1.98			4.1	7.9		Reynolds and Hetchel 1984
SE British Columbia	2.26	2.7	0.85		6.0	0.93	McLellan 1989*a,b*
Anderson Horton rivers, NWT	2.27	2.9	0.78	4.9		0.95	calculated from Clarkson and Liepins 1993
NW Alaska	2.17	3.3	0.66		5.1	0.94	Ballard et al. 1993
McNeil River, Alaska	2.24	3.9	0.57	5.2	6.8	0.93	Sellers and Aumiller 1994
Selkirk Mountains, British Columbia	2.22	3.0	0.74		7.3	0.96	Wielgus et al. 1994
Kananaskis, Alberta	1.40	3.0	0.46		5.5	0.93	Wielgus and Bunnell 1994
Kugluktuk, NWT	2.26	2.6	0.87	3.3	8.7	0.98	this study

[a] LS = litter size, BI = birth or breeding interval, N = natality (LS/BI), RI = reproductive interval, FP = first parturition, AFS = adult female survival.
[b] NWT = Northwest Territories.

et al. 1983*a*) and the north Yukon (Nagy et al. 1983*b*) but was shorter than that observed in the Brooks Range, along the Anderson and Horton rivers, and in the Mackenzie Mountains (Table 2). Clarkson and Liepins (1993) attributed the long RI observed around the Anderson and Horton rivers to predation on COYS by males. No predation on COYS was observed during our study, and only 2 females lost entire litters, both single COYS. Thus, BI's were similar between our study and that in the Anderson and Horton rivers study.

A low number of males in the population may be responsible for the high survival of COYS in our study (Bunnell and Tait 1981). First and second year cub survival observed in this study was higher than the average for southern grizzly bear populations (60–70%, Bunnell and Tait 1985).

The natality rate, which reflects both litter size and BI, indicated that cub production was higher than other northern populations and comparable to that recorded in southeast British Columbia (McLellan 1989*a*). Conversely, age of first parturition was high compared to other northern grizzly bear populations (Table 2). Bears bred around age 6 in the southwest Yukon (Pearson 1975) and around age 7 in the north Yukon (Pearson 1976, Nagy et al. 1983*b*), Tuktoyaktuk Peninsula (Nagy et al. 1983*a*), and Mackenzie Mountains (Miller et al. 1982). We are confident in our estimate of age of first parturition, as all 6 bears were <7.5-years old when captured, none had any scarring on their teats, and none were lactating. One female that was in estrus at age 6.5 did not produce a cub the following year.

Age of first parturition, litter size, and breeding interval are all thought to be related to nutritional condition (Bunnell and Tait 1981). In this study large litters, relatively short birth and reproductive intervals, and high cub survival suggest good nutrition, whereas delayed age of first parturition suggests the opposite. A possible explanation is that adult female nutrition was good, resulting in good cub production, but subadult female nutrition was poor, delaying maturity. This discrepancy could be related to the ability to prey on caribou and muskox. Adult female bears were observed on both caribou and muskox carcasses in the study area, whereas we observed no subadult bears preying on caribou or muskox.

To better evaluate the nutritional status of the population, we compared growth rates and size of adult females with other northern populations. If poor nutrition delayed maturity, asymptotic length and weight should have occurred at a relatively old age. Because we had no data for subadult females <6.5-years old, we were unable to calculate asymptotic weight and lengths using Kingsley et al.'s (1988) procedure. However, it is ap-

parent from hand-drawn growth curves that female bears in our study reached maximum length by age 6 and 90% of asymptotic length by about age 3 (Fig. 2). Kingsley et al. (1988) found that female grizzly bears in other northern grizzly bear populations (Mackenzie Mountains in the Northwest Territories, Arctic Mountains in North Yukon, and West Brooks Range in Northwestern Alaska) reached 90% of asymptotic length around age 4. Unfortunately, mean length from our study is not comparable to the asymptotic length calculated by Kingsley et al. (1988) because we measured straight line lengths and they used contour length.

Asymptotic weight in our study was not reached until age 8 (Fig. 2). This delay after reaching asymptotic length is consistent with observations by Kingsley et al. (1988) on other northern grizzly bear populations. Mean weight of adult females >8 years old was larger than the asymptotic weights that Kingsley et al. (1988) calculated for other northern populations (93–108 kg).

This comparison of female length and weight suggests that nutrition is not delaying maturity of bears in the Kugluktuk area, and at maturity females are large relative to other northern populations. This leaves no apparent explanation for the delay in the age of first parturition.

The estimated finite rate of population increase for the study area ($\lambda = 1.026$) was within the range of other grizzly bear populations. The λ value for the Flathead River drainage was estimated at 1.085 (Hovey and McLellan 1996). For Yellowstone grizzlies, λ was estimated at 1.046 (Eberhart et al. 1994). Wielgus and Bunnell (1994) concluded the population in the Kananaskis area of southern Alberta was stable ($\lambda = 0.99$–1.01), and Wielgus et al. (1994) concluded the same for the Selkirk Mountains of British Columbia and Idaho ($\lambda = 1.00$).

There are several potential biases in the data used to estimate λ for the Kugluktuk grizzly bear population. Litter size may have been underestimated as mortality may have occurred prior to locating animals in the spring. It is likely that any such bias was small as 7 of 19 litters had ≥ 3 cubs and litter size was among the highest recorded for North American grizzly bear populations. Another potential bias was in our estimated age of first parturition. LeFranc et al. (1987) indicated that age of first reproduction corresponded to the age when females attained 95% of their asymptotic length. For our study that would suggest an age of first reproduction of about 5 years as opposed to our observed mean of 8.7 years. Both these potential biases would result in a conservative (low) estimate of λ. In contrast, our estimate of λ could be inflated if inter-litter interval was underestimated. Our estimate was based on only 8 observations and included the reproductive efforts of an old female.

The most significant potential bias in the calculation of λ was with subadult survival. We had no data to support our estimated survival rate of 0.8 from age 2–5, but we believe that it is conservative. This figure is at the low end of the range reported by Bunnell and Tait (1985) for other grizzly bear populations, and Hovey and McLellan (1996) estimated subadult survival to be 0.93 in the Flathead River drainage. Hovey and McLellan (1996) concluded that estimation of λ is very sensitive to subadult survival.

MANAGEMENT IMPLICATIONS

The estimate of λ suggests that the Kugluktuk grizzly bear population is increasing. However, given the assumptions made in the estimation of λ (i.e., stable age distribution and subadult survivorship) and variation around or potential biases in our parameter estimates, this conclusion should be treated cautiously. Through iterating eq. (1) we found that the adult female survival rate (s) must remain above 0.90 to maintain the population. No population size or age–sex composition estimates are available for the study area, so this figure cannot be converted to an allowable harvest of females. However, if the density and sex and age composition for the Kugluktuk area is similar to the Anderson and Horton rivers area to the west (8.2 bears/1,000 km^2, Clarkson and Liepins 1994), adult female harvest through quota or defense kills should average <1/year. This can best be accomplished by the continued ban on fall hunting and by reducing kills of problem bears.

No adult females have been harvested from the study area since 1988, when sport hunts were switched from September to May. Although changing the timing of sport hunts has eliminated the harvest of adult females, subadult females have been killed in defense of life and property in recent years. Management efforts in the Kugluktuk area need to focus on ensuring that the total annual harvest, including defense and subsistence kills, remains within the quota of 5 and that adult females are protected. Future research in the Kugluktuk area should focus on improving estimates of age of first reproduction and survival of adult and subadult females, and obtaining estimates of density and sex–age composition.

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