

GRIZZLY BEAR POPULATION ESTIMATE AND CHARACTERISTICS IN THE ANDERSON AND HORTON RIVERS AREA, NORTHWEST TERRITORIES, 1987-89

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Abstract: A population estimate of 141 (95% CI, 131-276) grizzly bears (>2 yrs old) was determined using a modified Lincoln-Petersen estimate. Reducing the number of marks available in the study area by 10%/year to compensate for lack of population closure resulted in a population estimate of 127 (95% CI, 118-248) bears (>2 yrs old). Bear densities in the study area were 9.1 bears/1,000 km² for the standard Lincoln-Petersen estimate and 8.2 bears/1,000 km² for the adjusted Lincoln-Petersen estimate. During the 3-year research period, 154 bears (97 females, 57 males) (all ages) were captured and marked. The sex ratio of the population for all ages was 67% females and 33% males. A minimum population estimate of 102 bears (67 females, 35 males) (>2 yrs old) was calculated for the study area by only including captured bears. Bear distribution throughout the study area was clumped with bears concentrating along river and creek valleys. Fourteen bears from the area died during the research period.

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Grizzly bears are found throughout the mainland Inuvialuit Settlement Region and are a valuable natural resource to the local people. Inuvialuit harvest grizzly bears for their hides or conduct guided sport hunts (Graf et al. 1992, Renewable Resour. GNWT, unpubl. rep.). To ensure implementation of sustainable quotas and long-term survival of the grizzly bear population local hunters' and trappers' committees and management boards felt further research was necessary in the settlement region.

Past research on grizzly bears in the Inuvialuit Settlement Region has focused on their ecology, population distribution, densities, and impacts of development (Slaney 1974, 1975; Harding 1976; Harding and Nagy 1977; Nagy et al. 1983a, 1983b; Mychasiw and Moore 1984; Clarkson et al. 1988, Renewable Resour. GNWT, unpubl. rep.). Northern grizzly bear populations cannot sustain high mortality rates because of their low densities and low reproductive rate (MacPherson 1965, Stirling et al. 1976, Bunnell and Tait 1980, Nagy et al. 1983b).

If grizzly bears are hunted in an area it is important to ensure that the harvest is sustainable. In 1986 the Wildlife Management Advisory Council (Northwest Territories) (WMAC [NWT]) and the Inuvialuit Game Council (IGC) approved a mark-recapture study in the Anderson and Horton rivers area to help decide if the existing annual quota of 5 bears for the area is sustainable.

Conducting a grizzly bear population estimate has required the assistance and cooperation of many people. We are grateful to everyone who contributed to the project. Members of the WMAC (NWT), IGC and Hunters' and Trappers' Committees of Tuktoyaktuk, Paulatuk, and Inuvik have contributed to the research with their interest, cooperation, and information. During fieldwork the assistance received from local

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STUDY AREA

The study area (15,500 km²) is centered around the northern reaches of the Anderson and Horton rivers and falls within the Inuvialuit Settlement Region (The Western Arctic [Inuvialuit] Claims Settlement Act Inuvialuit Final Agreement, 1984) (Fig. 1). Classified as a polar continental climatic region, the area has long periods of extreme cold in winter, short cool summers, and light precipitation (Atmospheric Environment Service 1982). There are 2 physiographic regions in the study area: Arctic Coastal Plain and Interior Plateaus and Plains (Mackay 1963).

The predominant vegetation communities include sedge tundra, shrub tundra, forest-tundra transition, and open forest (Watts 1986). A variety of arctic wildlife species inhabit the study area (Zoltai et al. 1979).

METHODS

Population Estimate

To derive a mark-recapture population estimate, the

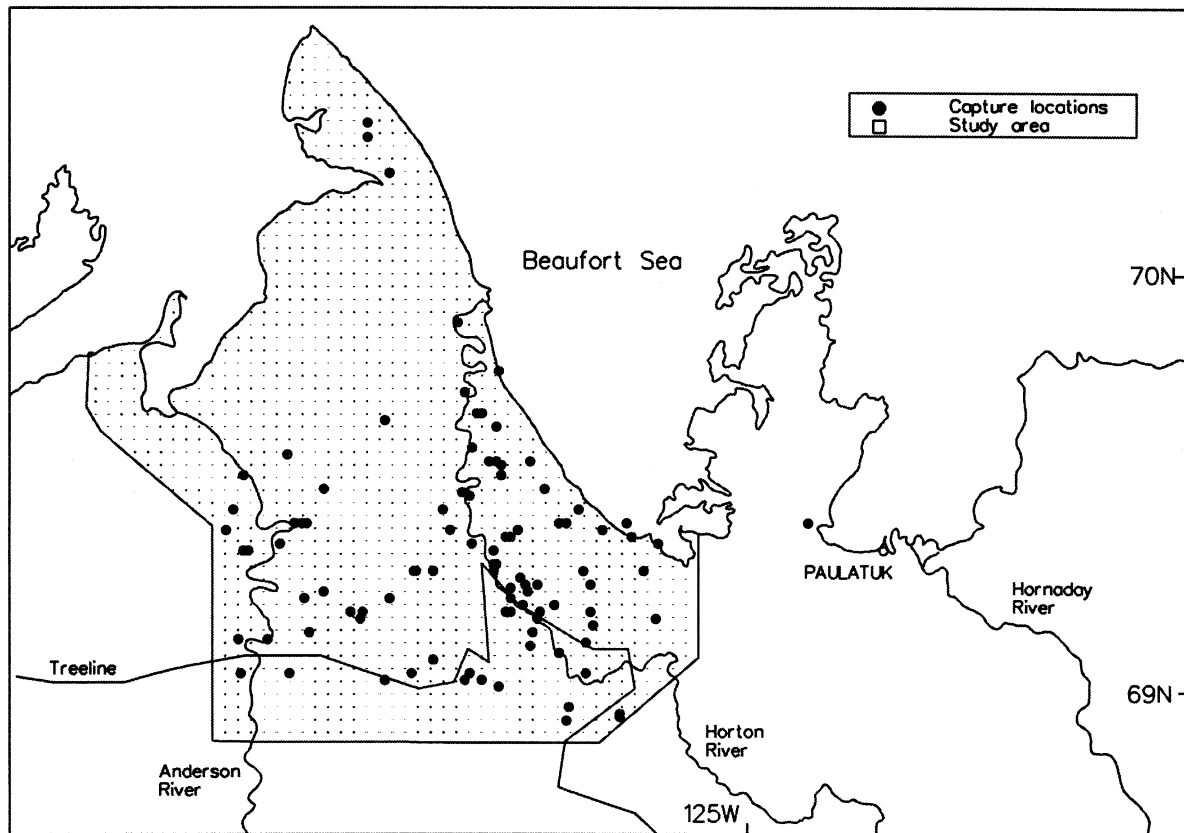


Fig. 1. Grizzly bear research study area and initial capture locations in the Anderson and Horton rivers area, Northwest Territories, 1987-89.

study area was searched during the first 2 weeks in June and an attempt made to capture all unmarked bears. Bears were captured in 1987 and 1988 to provide a sample of marked bears for the 1989 capture program (Stirling et al. 1975). A fixed-wing aircraft (Cesna 185/206 or Supercub) (approximately 100 hrs/yr) and Bell 206b helicopter (approximately 60 hrs/yr) were used for search and capture work. The study area was searched achieving total coverage in all years. To simplify search procedures in 1989 the study area was subdivided into 19 quadrats based on identifiable topographical features.

Bears were immobilized from a helicopter with disposable darts (Pneu-Dart, Williamsport, Pa, USA). Telazol (Wildlife Labs, Fort Collins, Colo., USA) was used at a concentration of 166 mg/ml to immobilize all bears except cubs-of-the-year (COYs). Cubs-of-the-year were captured on the ground with dip nets and hand injected with 0.5 cc of Telazol at a concentration of 88 mg/ml.

Captured bears were weighed, measured, and marked using standard procedures (Reynolds 1974, Nagy et al. 1983b). A premolar was removed from bears > 1 year old for cementum analysis (Stoneberg and Jonkel 1966, Pearson 1975). Twenty milliliters of whole blood were collected and the serum separated for disease analysis (Clarkson and Liepins 1989b). Bears were marked with numbered ear tags (Western Industrial Research Centre, Edmonton, Alberta), colored ear flags (Reynolds 1974, Clarkson and Liepins 1989a), and lip tattoos. The ear flags identified individual bears, or the sex and age class of bears, without recapturing them.

A sample of 15-20 bears were radiocollared and monitored to: (1) identify a boundary for the population estimate based on bear movements and (2) determine if collared bears were in the search area during mark-recapture work. Radio-collared bears were monitored 4 to 5 times during their active period from May to October and at least once during the capture effort each year. The location, habitat, and activity of the bears

were recorded for each telemetry location.

Population estimates were derived for June 1988 and 1989 for bears >2 years old using a modified Lincoln-Petersen equation with a 95% Confidence Interval (CI) (Begon 1979, Krebs 1989, Pollock et al. 1990). Marked bears that were harvested before the 1989 capture effort were not included in the estimate calculations.

Because the study area was not closed and marked bears may have left the area or died between capture programs, an adjusted mark-recapture estimate was calculated by reducing the number of marked bears available for recapture by 10%/year. Reducing the number of marks by 10%/year is an approximation based on several factors: (1) 50% of the study area boundary is closed because of the Arctic Ocean, (2) 40% of the study area boundary lies along the treeline, (3) no emigration of radio-collared adult female bears was detected, (4) 58% of the marked bears (>2 yrs old) were adult females, which show a high degree of fidelity to their annual ranges, and (5) any hunter-caused or known natural mortality of marked bears were subtracted from the marks available.

Minimum Population Estimate and Standing Sex and Age Composition

A minimum population estimate and sex and age composition were determined by including bears (>2 yrs old) that were captured in the study area (Miller and Ballard 1982, Pearson 1975). Bear ages were backdated to 1987. The minimum population estimate assumes that bears captured in 1988 and 1989 were present in 1987. No adjustments are made for births or deaths in the population. Cubs-of-the-year in 1988 and COYs and yearlings in 1989 were not included. Composition by age class (COYs, yearlings, 2-yr-olds, subadults [3- and 4-yr-olds], and adults [5+ -yr-olds]) is summarized from the standing sex and age distribution. Bears were considered adults at 5 years old as females were in breeding condition at this age.

Population Density and Distribution

Population densities were calculated by dividing the study area by the mark-recapture population estimates for the area. Data is presented in bears/1,000 km² for comparison with other northern grizzly bear population densities.

The distribution of marked bears throughout the study area was determined by analyzing the initial capture locations of bears (>2 yrs old) captured in May or June from 1987 to 1989. Bear distribution in the study area was analyzed to determine if it was

random, clumped, or uniform (Ludwig and Reynolds 1988: 24). A grid system was laid on the study area and bear locations/quadrat were determined and analyzed. Each quadrat was approximately 220 km². Only quadrats that were ≥50% within the study area were included in the analysis.

Mortality

The location, sex, age, and any marks (ear tags, ear flags, or collars) of bears harvested in or near the study area during 1987-89 were recorded. When possible, the lower jaw, or skull was purchased from the hunter and a premolar removed for cementum analysis. Incidents of natural mortality were monitored by locating radio-collared bears from May to November.

RESULTS

Population Estimate

An estimate of 141 (95% CI, 131-276) grizzly bears (>2 yrs old) was determined by including all marked bears excluding known mortalities (Table 1). The population estimate that was adjusted for lack of closure was 127 (95% CI, 118-248) bears (>2 yrs old) (Table 2).

Minimum Population Estimate and Standing Sex and Age Composition

The minimum population estimate in June 1987 was 102 bears (67 females, 35 males) (>2 yrs old) (Table 3). During the research period there were 154 bears (97 females, 57 males) (all ages) captured and marked. Cubs-of-the-year and yearlings were not included in the population estimates or the minimum population estimate because of their high annual mortality rate. Although the Anderson and Horton rivers area population had a high percentage of females, the variation was not large enough to be significant ($0.20 \leq P \leq 0.30$) (Chi-square Test for Independence, Gibbons 1985).

The age-class composition of the population was 15% COYs, 8% yearlings, 8% 2-year-olds, 10% subadults, and 63% adults. The median ages were 11.3 years for adult females and 11.0 years for adult males (Table 3).

Population Density and Distribution

Population densities for the Anderson and Horton rivers area were estimated at 9.1 bears/1,000 km² (95% CI, 8.5-17.8) (all marks) and 8.2 bears/1,000 km² (95% CI, 7.6-16.0) (marks reduced by 10%/yr) (Tables 1 and 2). These densities should be viewed with

Table 1. Grizzly bear (> 2 yrs old) population estimate for the Anderson and Horton rivers area, 1987-89.

Date	Unmarked bears	Marked bears obs/cap ^c	Total bears obs/cap	Marks lost ^a	Marks available	L-P ^b Estimate	95% CI		Density bears/1,000 km ²	Density 95% CI bears/1,000 km ²	
							Lower	Upper		Lower	Upper
June 1987	38	-	38	-	-	-	-	-	-	-	-
June 1988	32	12	44	2	36	127	77	216	8.2	5.0	13.9
June 1989	49	38	87	6	62	141	131	276	9.1	8.5	17.8

^a Radio-collared bears that have died or left the study area.

^b Lincoln-Petersen estimate.

^c Observed/captured.

caution because they are average densities for the entire study area. It was evident during capture work and subsequent monitoring of radio-collared bears that river valleys and associated tributaries had much higher bear densities than flat tundra plains (Figs. 1 and 2). Statistical analysis (Negative Binomial Distribution) of grizzly bear capture locations showed that the bears were in a clumped distribution pattern (variance = 4.60, \bar{x} = 1.48, k [degree of clumping] = 0.64) (Ludwig and Reynolds 1988:24).

Mortality

Fourteen (8 marked, 6 unmarked) grizzly bear mortalities were recorded during 1987-89. Nine bears (median age 8 yrs) were taken by hunters: 4 by hunters from Tuktoyaktuk and Paulatuk and 5 by guided nonresident sport hunters. One 5-year-old female was shot in defense of life and property. Four radio-collared females (3 adults, 1 subadult) died of natural causes. Site investigations suggested that all 4 collared bears had been killed by another bear (presumably an adult male based on bite marks found on the bear carcasses). A male bear was found feeding on 1 of the collared females.

DISCUSSION

The population estimates and their corresponding densities of 9.1 bears/1,000 km² (95% CI, 8.5-17.8) and 8.2 bears/1,000 km² (95% CI, 7.6-16) falls within the range of grizzly bear density estimates for northern areas (Table 4). The wide range of bear densities throughout Alaska, Yukon, and Northwest Territories is a function of different bear habitats, past harvesting pressures, study area size, and population estimate techniques. This makes the comparison or extrapolation of data between areas difficult and further supports the need for area-specific research to address management concerns. Had managers assumed the Anderson and Horton rivers area had the same population density as the Northern Yukon (26.7 bears/1,000 km², Nagy et al. 1983a) the population density would have been overestimated by approximately 300%.

When determining a population and density estimate for barren-ground grizzly bears, several problems are encountered. Bear densities are low and logistics of working in remote areas makes research expensive. Study areas are not closed and compensating for lack of closure is difficult. Bear distribution throughout an

Table 2. Adjusted grizzly bear (> 2 yrs old) population estimate for the Anderson and Horton rivers area, 1987-89.

Date	Unmarked bears	Marked bears obs/cap	Total bears obs/cap	Marks lost ^a	Marks avail.	Adjusted marked bears ^b	L-P ^c Estimate	95% CI		Density bears/1,000 km ²	Density 95% CI bears/1,000 km ²	
								Lower	Upper		Lower	Upper
June 1987	38	-	38	-	-	-	-	-	-	-	-	-
June 1988	32	12	44	2	36	32	115	69	195	7.4	4.5	12.6
June 1989	49	38	87	6	62	56	127	118	248	8.2	7.6	16.0

^a Radio-collared bears that have died or left the study area.

^b The number of marked bears that were reduced by 10% to compensate for possible death and emigration because the study area is not closed.

^c Lincoln-Petersen estimate.

Table 3. Standing sex and age distribution of grizzly bears captured in the Anderson and Horton rivers area, 1987-89.

Age ^a	Males	Females	Total	% of population
0	3	16	19	15
1	3	7	10	8
2	4	6	10	8
3	2	3	5	4
4	0	8	8	6
5	2	7	9	7
6	3	4	7	5
7	1	5	6	5
8	3	5	8	6
9	6	4	10	8
10	2	6	8	6
11	1	5	6	5
12	1	1	2	2
13	1	4	5	4
14	3	2	5	4
15	1	4	5	4
16	0	0	0	0
17	2	2	4	3
18	1	0	1	1
19	0	0	0	0
20	1	0	1	1
21	0	0	0	0
22	1	0	1	1
Unknown	0	1	1	1
Total	41	90	131	100

^a All ages were backdated to June 1987.

area is usually clumped because of changes in habitat and available food resources. Adult and subadult males move over large areas which may take them out of the study area after they are marked (Nagy et al. 1983a, Reynolds 1993). The effects of clumped distributions and possible movements in and out of the study area were reduced by searching for bears over a large study area. The wide range of habitat types made it difficult to select a smaller study area and conduct a more intensive effort as done by Miller et al. (1987) and Ballard et al. (1988, 1990). The level of accuracy gained by a more intensive population estimate may be

Table 4. Densities of northern grizzly bear populations in Alaska, Northwest Territories, and Yukon.

Area (Source)	Population density	
	km ² /bear	bears/1,000 km ²
Southwestern Yukon (Pearson 1975)	22.8	43.9
Upper Susitna River, Alaska	35.8	27.9
Northern Yukon (Nagy et al. 1983a)	37.4	26.7
Denali National Park, Alaska (Dean 1976)	24.4-38.5	41.0-26.0
Interior Alaska (Miller and Ballard 1982)	41	24.4
Western Brooks Range, Alaska (Reynolds and Hechtel 1984)	42-44	23.8-22.7
Northwest Alaska (Ballard et al 1990)	51	19.6
Northcentral Alaska (Reynolds et al. 1987)	96	10.4
Anderson and Horton Rivers, Northwest Territ. (this study)	110-122	9.1-8.2
Mackenzie Mountains, Northwest Territ. (Miller et al. 1982)	114	8.7
Eastern Brooks Range, Alaska (Reynolds 1976)	148-260	6.8-3.8
Tuktoyaktuk Peninsula, Northwest Territ. (Nagy et al. 1983b)	211-262	4.7-4.2

lost in the extrapolation of the estimate to the overall area. A population estimate for a larger area reduces bear movement-related biases, especially when dealing with low-density populations (Reynolds 1993).

A Lincoln-Petersen estimate has assumptions that must be satisfied or qualified to ensure that the resulting population estimate is accurate (Stirling et al. 1975, Otis et al. 1978, White et al. 1982, Miller et al. 1987, Pollock et al. 1990):

1. The population is closed.
2. Animals do not lose their marks during the study period and all marks are correctly recorded.
3. Each animal has a constant, equal, and independent probability of capture.
4. The ratio of marked to unmarked animals is the same throughout the population during resampling.

Satisfying all of the assumptions is rarely realized in field situations (White et al. 1982, Miller et al. 1987). The first assumption that the population is closed was partially met in our estimate. The Arctic Ocean

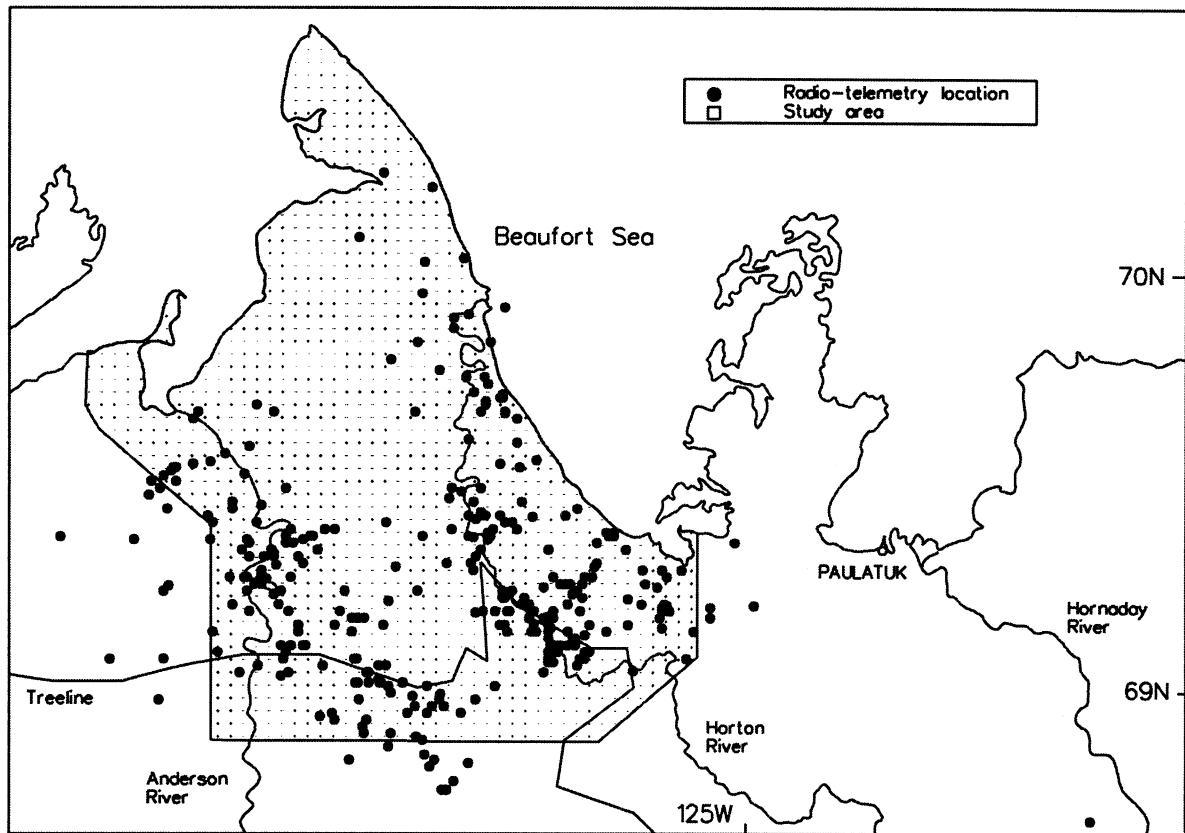


Fig. 2. Grizzly bear radio-telemetry locations in the Anderson and Horton rivers area, June 1987-June 1989.

restricted bear movement along approximately 50% of the study area boundary. Monitoring radio-collared bears showed that they did not generally travel out of the study area. Ninety-three percent of the radio-collared bear locations were in the study area ($n = 366$) (Fig. 2).

The boundary of the search area was not altered during the 1988 or 1989 capture programs because it approximated the boundary around the collared bears. Bear capture and telemetry locations were concentrated in the river drainages and bears rarely travelled outside the search area (Figs. 1 and 2). However, 86% ($n = 366$) of the telemetry locations were from collared adult females that typically have smaller ranges than adult males or subadults (Nagy et al. 1983b). The bear locations outside of the study area were from 2 adult females and 1 adult male (Fig. 2). All radio-collared female bears were inside the study area during the capture program in 1989. Two collared male bears found outside the search area during the mark-recapture work in 1989 were excluded from population estimate

calculations. Some marked bears may have left the study area after being captured and therefore bias the population estimate. However, the movement patterns of radio-collared bears in the study area suggests that there was minimal emigration of marked bears, especially in the adult female age class (Fig. 2).

Bears are harvested by hunters from Tukttoyaktuk and Paulatuk in areas adjacent to the study area. The harvest in the last 5 years has been 71% males ($n = 34$) (Graf et al. 1992). Since 1987 there have been no reported marked bears taken by hunters in areas adjacent to the study area. This further suggests that the amount of emigration of marked bears is minimal. During the research period there were 9 bears taken by hunters in the study area and 4 were marked.

The number of marked bears was reduced by 10%/year for an adjusted mark-recapture estimate to compensate for marked bears that may have left the study area or died between the first, second, and third capture programs. The 10%/year reduction is an approximation based on several factors identified in the

Methods. Ensuring that the number of marked bears available for recapture used in the Lincoln-Petersen equation is close to the actual number of marked bears in the study area is difficult when the study area is not closed.

Assumption 2 was adequately met during the mark-recapture research as any bear that did not have ear flags was captured and checked for ear tags and tattoos before it was marked.

The third assumption is difficult to satisfy (Ballard et al. 1988, Otis et al. 1978). During the mark-recapture work in 1988 and 1989, most marked bears ran in response to helicopter noise violating the assumption concerning constant and equal probability of capture. In some situations this movement may have made the bears more visible. In other cases bears may have moved beyond the immediate search area.

Independent sightability is violated when considering females with young >2 years old, subadult siblings that remain together, and paired adults during the breeding season. However, this should be similar for both marked and unmarked animals and therefore reduce the impact of the bias on the population estimate. Sightability throughout the study area was good as most of the area was above treeline and search efforts were conducted before leaves emerged on shrubs. In 1989, 61% of the available marked bears in the study area were resighted.

Assumption 4 was adequately met during the mark-recapture research as the entire study area was searched each year and all untagged bears were captured and marked. The ratio of marked to unmarked bears should have been the same throughout the study area.

The population estimates and associated densities could have been improved by: (1) establishing quadrats in the first 2 years of the study to ensure systematic coverage of the study area, (2) ear flagging or ear tagging each bear so that individuals could be identified from the helicopter to ensure against duplicate sightings, (3) radio-collaring and monitoring adult male and subadult bears to determine their distribution, movement patterns, and presence in the study area during and between the capture programs, and (4) conducting the population estimate over 2 years to reduce the number of variables (birth, death, emigration) that may affect the bear population in the area.

The standing age and sex composition of the population was similar to that of the Northern Yukon (Nagy et al. 1983a). The Northern Yukon population was considered to be stable and experiencing low harvest levels (Nagy et al. 1983a: 34). The age

composition shows a 47% COY mortality rate when the percentage of COYs in the population are compared with the yearling and 2-year-old age classes (Table 3). The minimum population estimate of 102 bears (>2 yrs old) is within 72% (all marks) and 80% (adjusted marks) of the 2 population estimates and suggests that a large proportion of the bears in the study area were marked by the end of the third capture program.

Bears were distributed throughout the study area; however, their distribution pattern was clumped, indicating that they are concentrating in certain habitats. Habitats with higher bear densities are likely more productive areas for bear food species. In our study area, creek and river valleys and associated tributaries had higher bear densities than flat tundra plains. The spacial distribution of bears in an area is an important consideration when calculating bear densities or extrapolating those densities to the entire management area. Had we selected a smaller study area (1,500 to 2,500 km²) within the overall management area we could have easily over or under estimated the bear population in the area. Small study areas may be useful in areas where bear densities are homogeneous throughout a management area. A review of the literature did not identify any researchers who had analyzed the pattern of bear distribution in their study area so no comparisons are made with other areas.

CONCLUSIONS

1. The mark-recapture estimate of 127 bears (95% CI, 118-248) and associated density of 8.2 bears/1,000 km² (95% CI, 7.6-16.0) are the most suitable estimates for the study area as they were taken in 1989 when the marked bear sample was greatest and they compensate for potential loss of marks between the capture periods.
2. Bear density in the Anderson and Horton rivers area was within the range of densities found for northern grizzly bear populations.
3. The sex and age structure for bears in the Anderson and Horton rivers area was similar to the Northern Yukon which was considered to be a stable population experiencing low harvest.
4. Bear distribution in the study area was clumped (variance = 4.60, \bar{x} = 1.48, k = 0.64). Considering the distribution pattern of bears in an area is important to the overall density estimate and management of bears in the area.
5. A larger study area helps provide a more accurate assessment of the standing sex and age composition of bears in the area.

6. Radio-collared adult females showed a high degree of fidelity to their annual ranges within the study area.

7. Male predation on adult females was the most common natural mortality of radio-collared females.

8. Population and density estimates could be improved by marking each bear with a numbered ear flag that is individually identifiable from a helicopter, and conducting the mark-recapture estimate over a 2-year period to minimize the number of variables that may affect the population estimate.

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