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PAST AND PRESENT STATUS OF POLAR BEARS IN ALASKA

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Polar bears (*Ursus maritimus*) are distributed throughout most ice-covered seas of the northern hemisphere but occur in low densities. They have a long period of delayed maturation, small litter sizes, and a long reproductive interval (Lentfer et al. 1980, DeMaster and Stirling 1981). Polar bears compensate for low productivity with long life-spans (Taylor 1982).

Recent and future events in arctic regions may disrupt the survival strategy of polar bears. The discovery of the world's tenth largest oil field at Prudhoe Bay, land disposals resulting from the Alaska Native Claims Settlement Act of 1971, which was spawned by that discovery, and concomitant increases in wealth have resulted in dramatic changes in populations of humans in Alaska's arctic. Human numbers in the Arctic Slope Region increased 57% during 1960–1980, 23% during 1980–1983, and continue to rise (Alaska Dep. Labor 1984). With the establishment of new villages, people also live in previously uninhabited locations. Up to 40% of the remaining oil and gas in the United States may be in this region, and most of that is in offshore areas (Weeks and Weller 1984). Consequently, growth in human numbers and activities in polar bear habitat will continue.

Industrial activities may threaten the security of polar bears directly and indirectly. The most important indirect threat is increased hunting. The influx of cash, as a result of oil and gas development, into previously cash-poor areas will continue to improve efficiency of harvest of polar bears. Hunting is the most significant human cause of polar bear mortal-

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ities, and with increased numbers of local residents, that will likely continue. The Marine Mammal Protection Act (MMPA) of 1972 took management of polar bears in Alaska from the Alaska Department of Fish and Game (AFG) and vested it with the U.S. Fish and Wildlife Service (USFWS). MMPA also prohibited restrictions on the take by native peoples and requirements for reporting harvests. Therefore, possible increases in harvest must be viewed with concern.

Pipelines and roadways may prevent female polar bears from moving to and from inland denning areas. This may force them to den in less desirable locations. Also, human activities may cause bears to abandon established dens before cubs are ready to leave (Belikov 1976, Amstrup In press). Industrial activities such as seismic testing on the ice may also directly affect ringed (*Phoca hispida*) and bearded seals (*Erignathus barbatus*) upon which polar bears depend for food. Harassment will increase as will direct altercations between humans and bears. Their curiosity, lack of fear, and other behavioral characteristics are likely to lead polar bears into compromising situations as humans increasingly invade their habitats (Amstrup 1984).

Contamination of ice, water, food species, and bears themselves by oil and other toxic chemicals may increase. The effects of low levels of contamination may not be obvious, but high levels are fatal (Oritsland et al. 1981). Ice-breaking vessels are used to keep areas free of ice for extended periods, even in winter. Natural open water areas attract seals and polar bears which feed upon them (Stirling and Cleator 1981). Thus, areas kept open by vessel traffic may also attract bears and their prey. Bilge oil and other contaminants could soil attracted animals, and cessation of vessel activities could entrap seals and necessitate long movements by bears that might not have been there under natural circumstances.

The fate of an animal population is determined by the overall level of stress faced by its members (Levy 1983). Human causes of stress within polar bear populations must be added to the existing stresses occurring in the arctic. Increases in hunting, contamination, anxiety (due to motor vehicle traffic or harassment), and reductions in food availability, none of which might be significant alone, could combine with nature's extremes to create real problems for polar bears. Such problems can only be averted by understanding the status, history, and dynamics of populations affected. In this paper, we review 4 population indices and related information to understand trends

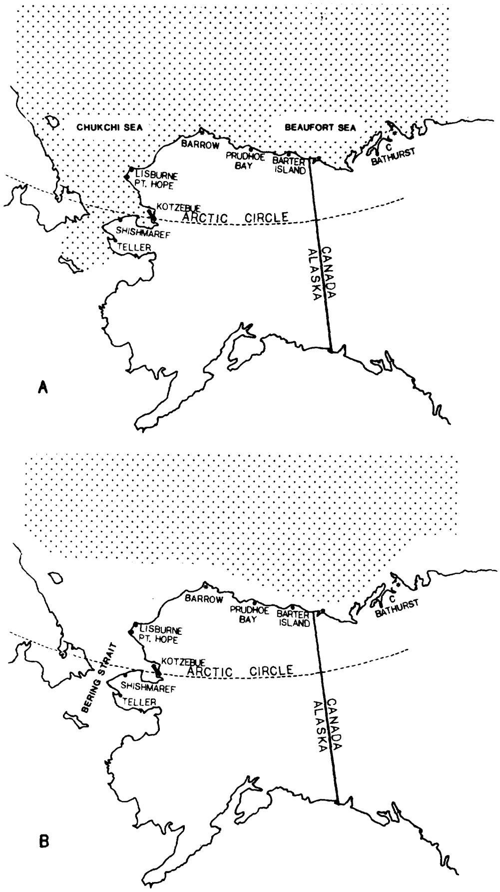

Fig. 1. Approximate maximum southern extension of polar bear range in Alaska during winter (a), and the approximate maximum northern retreat of polar bear range during summer (b).

Table 1. Estimated polar bear population sizes in the Beaufort Sea (1972–1983) calculated from mark-recapture data by the procedure of DeMaster et al. (1980) for survival rates of 0.82, 0.88, and 0.94. Variance of survival rates is preset at 0.00375.

	No. of bears			Survival rates					
				0.82		0.88		0.94	
Year	Captured	Recaptured	Released	$\hat{N}$	SD	$\hat{N}$	SD	$\hat{N}$	SD
1972	134	12	132	1,669	562	1,998	666	2,384	788
1973	21	4	20	1,160	575	1,381	684	1,646	815
1974	179	28	179	1,242	373	1,570	466	1,980	583
1975	118	21	116	1,591	463	1,961	580	2,434	730
1976	110	29	110	1,176	334	1,482	430	1,883	558
1977	20	7	18	916	373	1,186	490	1,551	651
1978	42	12	41	952	390	1,312	544	1,822	764
1979	42	9	42	1,152	549	1,659	800	2,411	1,178
1980	41	10	41	940	460	1,402	702	2,118	1,082
1981	43	4	43	2,296	1,482	3,527	2,329	5,533	3,722
1982	108	26	107	860	405	1,342	676	2,162	1,146
1983	98	14	96	1,654	766	2,489	1,276	3,958	2,207
Mean	80	15	79	1,301	561	1,776	803	2,490	1,185

in Alaska's polar bear populations during the past 28 years. We also analyze past and present effects of hunting and speculate on prospects for hunting in the future.

METHODS

During 1956–1972, polar bear hunters were required to report kills to AFG. Because of MMPA, minimal voluntary information on the polar bear harvest in Alaska was secured during 1972–1980. USFWS increased efforts to collect data on the harvest of polar bears in Alaska after 1980.

In spring 1966, AFG surveyed polar bears near Barrow, Alaska. Each spring after 1966 (except 1973), AFG or USFWS marked and recaptured polar bears in the Beaufort or Chukchi seas adjacent to Alaska (Fig. 1). The Canadian Wildlife Service did similar research in the eastern Beaufort Sea during 1970–1979 and in 1983 (Stirling et al. 1975; I. Stirling et al., unpubl. data; D. Andriashek, Can. Wildl. Serv., unpubl. data). Lentfer (1968), Larsen (1971), Stirling et al. (1980), and Schweinsburg et al. (1982) described capture and marking of polar bears. Some adult females captured in the Beaufort Sea were fitted with radio collars, and minimum population boundaries were established by relocating instrumented bears from aircraft.

Each year after 1966, new captures and recaptures were tallied for studies of population dynamics. Teeth were removed from captured bears and cementum annuli were counted for age determination (Stirling et al. 1975, Hensel and Sorensen 1980). We used log-linear regression of age structure data and a truncated Chapman-Robson procedure (Seber 1973:395, 418) to estimate mortality rates needed for multi-year mark-recapture population estimates.

Four independent methods were used to estimate size and trend of polar bear populations: (1) Population size estimates were derived from multi-year mark-recapture data using methods of DeMaster et al. (1980). (2) During 1976 and 1981–1983 observations of bears marked previously during the same season were recorded. This allowed derivation of single season mark-recapture population estimates (Seber 1973:130–138). (3) Between 1956 and 1969, trophy hunters using aircraft reported numbers of bears sighted/hour of flight to AFG. Hunting areas and kill locations were plotted, and numbers, sexes, and, after 1966, ages of harvested bears were recorded. (4) Sightings/hour of flight by researchers attempting to catch and mark polar bears were recorded between 1966 and 1984. Densities (km^2/bear) of polar bears were estimated from (3) and (4).

RESULTS

Population Size

During 1967–1983, 880 polar bears were captured, tagged, and released in the Alaskan Beaufort Sea (Fig. 1). An additional 241 bears were tagged along the mainland coast of the Canadian Beaufort Sea west of Cape Bathurst, Northwest Territories. During 1981–1983, 64 adult and subadult females captured in the Beaufort Sea were fitted with radio collars and nearly 500 relocations were obtained. Most radio-collared bears that were monitored for ≥1 year moved extensively in the southern Beaufort Sea, suggesting bears occupying the area

Table 2. Sex-, age-, and period-specific annual mortality rates of polar bears in the Beaufort Sea as determined by 2 estimators, 1967–1982.

		Period									
		1967–1974					1975–1982				
Sex	Age classes	n	Least squares[a]	r^2	Chapman-Robson[b]	SD	n	Least squares[a]	r^2	Chapman-Robson[b]	SD
Female	1–5	155	0.06	0.64	0.06	0.03	99	0.18	0.28	0.18	0.05
	1–10	264	0.09	0.58	0.07	0.02	169	0.05	0.16	0.07	0.03
	5–16	167	0.26	0.90	0.20	0.04	120	0.16	0.72	0.13	0.04
	5–10	138	0.13	0.44	0.10	0.04	89	0.01	0.01	0.01	0.02
	1–16	293	0.19	0.86	0.13	0.03	200	0.12	0.68	0.11	0.03
Male	1–5	124	0.14	0.26	0.16	0.04	80	0.13	0.23	0.13	0.05
	1–10	159	0.24	0.85	0.21	0.04	134	0.12	0.43	0.10	0.09
	5–16[c]						90	0.14	0.63	0.14	0.05
	5–10	56	0.31	0.88	0.29	0.08	64	0.18	0.34	0.15	0.06
	1–16[c]						158	0.13	0.72	0.12	0.04

[a] Seber 1973:395.
[b] Seber 1973:418.
[c] During 1967–1974 only 4 males >10 years old were captured.

between Barrow and Cape Bathurst are members of the same population. Knowledge of the movements of polar bears throughout this area allowed us to combine the mark-recapture data collected from many locations in the mainland Beaufort Sea (Barrow to Cape Bathurst).

The mean estimated population during 1972–1983 was 1,776 animals (SD = 803) if an annual survival rate of 0.88 was assumed for bears of all ages (Table 1). Estimates ranged from 1,186 to 3,527. One standard deviation either side of the 12-year mean bracketed all but the 1981 estimate. If the apparently aberrant entry for 1981 was deleted, the mean estimate was 1,617 (SD = 664). Bracketing the estimate by assuming survival rates of 0.82 and 0.94, the lowest and highest that seemed reasonable, yielded mean population sizes of 1,300 and 2,500. A simple estimate based upon the fraction of the population marked yielded a similar result. Twenty percent of all bears captured after 1972 were previously marked. If annual survival of bears marked in prior years was 88% (Table 2), 355 marked bears should have been available for capture in the Beaufort Sea in 1983. Therefore, if 20% of the population was marked, the population size in 1983 should have been 1,775.

Because movements of female bears may be representative of the population (Lentfer 1983), the density of polar bears in the Beaufort Sea can be surmised from evaluation of radiotelemetry data. Radio-collared females moved extensively to the east and west, but spent little time farther than 280 km north of the coast. A strip of sea ice habitat 280 km wide between Point Barrow and Cape Bathurst encompasses about 350,350 km^2. Applying our mean population estimates to this area yielded densities of 1 bear/141–269 km^2 of sea ice, if survival rates between 0.82 and 0.94 are assumed.

Polar bears also occur in the Chukchi Sea

Table 3. Estimated densities of polar bears, derived from Schnabel population estimates (Seber 1973:130–138), for selected locations in Alaska during spring 1976, 1981, and 1982 and autumn 1983.

Location	Year	$\hat{N}$ (90% CI)	km^2/bear
Point Barrow[a]	1976	126 (68–348)	75
Cape Lisburne[b]	1976	151 (103–665)	129
Cape Lisburne[c]	1981	77 (45–300)	211
Barter Island[c]	1982	125 (94–232)	149
Barter Island/ Prudhoe[c]	1983	91 (71–167)	189

[a] J. R. Gilbert, U.S. Fish and Wildl. Serv., unpubl. data.
[b] T. Eley, U.S. Fish and Wildl. Serv., unpubl. data.
[c] S. C. Amstrup, U.S. Fish and Wildl. Serv., unpubl. data.

Table 4. Estimated densities of polar bears as determined from records of aerial sightings made by trophy hunters (Harbo and Vogelsang 1960, Harbo 1961, Erickson 1962, Lentfer et al. 1967, Lentfer et al. 1968, Lentfer and Miller 1969, Lentfer 1970) for selected locations in Alaska, 1959–1969.

Location	Years (No.)	Bears seen	Hours flown	km²/bear[a]
Chukchi Sea				
Teller	4	929	1,287	104
Shishmoref	1	55	84	115
Kotzebue	7	1,976	3,435	131
Point Hope	3	121	363	225
Beaufort Sea				
Barrow	7	793	2,075	197
Colville River	2	59	428	545

[a] [(number of hours flown)(approximate speed of 167 kph)(estimated width of 0.45 km)]/(number of bears seen).

adjacent to western Alaska, and they occur seasonally south of the Bering Strait (Fig. 1). During 1968–1983, 266 bears were marked near Cape Lisburne on the Chukchi Sea coast. Three single season population estimates for the Beaufort Sea and 2 for the Chukchi Sea were calculated (Table 3). Estimated densities were 1 bear/75–211 km^2.

Between 1959 and 1969, 3,933 polar bears were observed by airborne hunters during 7,672 hours of flying. Earlier, Scott et al. (1959) reported that polar bear trophy hunters saw 458 bears in 841 hours of aerial hunting time during 1956–1958. Scott et al. (1959) established belt transects by assuming an aircraft speed of about 167 km/hour and a 0.45-km strip width, and calculated that hunters searched 35,095 km^2 yielding 1 bear/138 km^2. During 1959–1969 airborne hunters saw 1 bear/147 km^2 in similar belt transects (Table 4). Hunter reports from the Chukchi Sea suggested higher densities of bears near the Bering Strait than in more northern areas (Table 4). Hunters from Teller and Kotzebue had the highest bear observation rates, and those from Point Hope observed fewer bears. Hunters from Barrow usually encountered more bears than hunters from Point Hope.

Table 5. Trends in estimated densities of polar bears as determined from records of aerial sightings made by the authors in selected locations in Alaska, 1966–1984.

Year	Location	km²/bear[a]
1966[b]	Barrow	178
1967	Barrow	208
1968	Bering Strait	376
1968	Lisburne	236
1968	Barrow	238
1970	Barrow	301
1971	Barrow	353
1972	Barrow	226
1974	Barrow	233
1975	Barrow	212
1975	Barter	196
1976[b,c]	Barrow	207
1976	Barrow	120
1980[d]	Barrow	120
1981	Lisburne	156
1982	Barter, Prudhoe	135
1983	Lisburne	225
1983	Barter, Prudhoe	304
1983	Barter, Prudhoe	170
1984	Barter, Prudhoe	76

[a] [(number of hours flown)(approximate speed of 167 kph)(estimated width of 0.45 km)]/(number of bears seen).
[b] Bears seen during aerial surveys, but not captured. In all other operations shown nearly all bears seen were captured and marked at time and place of sighting.
[c] R. J. Hensel, U.S. Fish and Wildl. Serv., unpubl. data.
[d] F. E. Sorensen and M. K. Taylor, U.S. Fish and Wildl. Serv., unpubl. data.

During 1966–1984, 1,147 polar bear observations were recorded in 3,096 hours of flying. The procedure of Scott et al. (1959) suggested approximate recent densities of 1 bear/150 km^2 (Table 5). Belt transect estimates derived from research in the Chukchi Sea indicated densities similar to those in the Beaufort Sea (Table 5).

Population Trend

Numbers of polar bears adjacent to Alaska in 1984 were similar to numbers in 1956. However, populations were not stable through the intervening period. Belt transect data from the research program (Table 5) suggested a decline in density by the late 1960s. Densities of bears estimated by researchers in the mid- and late 1960s appeared lower than those reported by hunters during the late 1950s and

Table 6. Approximate harvest of polar bears in Alaska 1961[a]–1984. Figures are minimal, particularly after 1973 when implementation of the Marine Mammal Act made reporting voluntary.

	Chukchi Sea		Beaufort Sea		Chukchi and Beaufort combined		
						Females	
Year	Total[b]	Females	Total[b]	Females	Total[b]	No.	%
1961	118	32	30	8	148	40	27
1962	143	39	56	21	199	60	30
1963	138	22	50	16	187	38	20
1964	195	35	60	24	255	59	23
1965	205	42	93	26	298	68	23
1966	272	56	133	44	405	100	25
1967	140	20	83	26	223	46	21
1968	249	52	75	27	324	79	24
1969	217	49	71	25	288	74	26
1970	244	46	91	42	335	88	26
1971	165	41	49	19	214	60	28
1972	182	29	57	14	239	43	18
1973	17	8	19	9	36	17	47
1974	35	12	13	5	48	17	35
1975	115	51	31	15	146	66	45
1976	145	63	22	10	167	73	44
1977	89	40	25	16	114	56	49
1978	36	16	23	4	59	22	37
1979	16	6	13	5	29	11	38
1980	52	15	29	8	81	23	28
1981	92	32	9	3	101	35	35
1982	46	12	7	2	53	14	26
1983	152	51	17	6	169	57	34
1984	166	47	15	3	181	50	28

[a] The mean harvest from the Chukchi and Beaufort seas (pooled data) was 117/year during 1925–1953. Pooled annual harvests were 100 in 1954, 128 in 1955, 135 in 1956, 206 in 1957, 128 in 1958, 250 in 1959, and 162 in 1960.

[b] Includes bears of unknown sex.

Table 7. Trends in estimated densities of polar bears as determined from records of aerial sightings by trophy hunters in Alaska, 1956–1969 (Scott et al. 1959, Harbo and Vogelsang 1960, Harbo 1961, Erickson 1962, Erickson and Somerville 1965, Lentfer et al. 1967, Lentfer et al. 1968, Lentfer and Miller 1969, Lentfer 1970).[a]

Year	km²/bear[b,c]
1956–1958	138
1959	80
1960	138
1961	157
1962	152
1963	88
1964	97
1966	145
1967	199
1968	110
1969	144

[a] Reported number of hours flown was multiplied by 2 because aircraft flew in pairs. Original reports recorded flight times for each pair only.

[b] [(number of hours flown)(approximate speed of 167 kph)(estimated width of 0.45 km)]/(number of bears seen).

[c] 1965 data were not reported.

early 1960s, and researchers encountered significantly fewer bears/hour of flying between 1967 and 1974 than after 1975 ($t = 2.93$, $P < 0.005$). The trophy harvest, which attained major proportions by the mid-1960s (Table 6), was the apparent cause of this decline. Although numbers of bears observed/hour flown by hunting guides held stable, records were not kept after 1969 because guides, fearing more stringent quotas, were suspected of reporting more bears than they saw (Lentfer 1972). If this happened, and their reports indicated stability (Table 7), numbers of bears were actually decreasing.

There are other indicators that polar bear density declined as a result of harvest. Ages of bears killed, especially in the Beaufort Sea, declined between 1966 and 1972 (Table 8). Fewer bears were encountered by research teams between 1967 and 1974 than in later years, and bears captured then (particularly males) were younger than those captured after 1975 (Fig. 2). Also, mortality rates estimated for most age groups and particularly for older bears were higher during the trophy-hunting era than afterwards (Table 2). The distribution of kills also indicated a decline in the availability of polar bears. In 1959, trophy hunters made kills a mean distance of 84 km from the Alaskan coast. Distances flown by hunters increased annually until 1967, the last hunting season when such data were tabulated. Hunters flew a mean 158 km offshore to make their kills that year.

DISCUSSION

Population Size

Lentfer (1974) and Stirling et al. (1975) concluded from recaptures of marked animals and tags returned by hunters that many bears

Table 8. Sex-specific trends in mean age, based on tooth cementum layering, of polar bears harvested in 2 locations in Alaska, 1966–1972.

	Males		Females	
Location	n	$\bar{x}$	n	$\bar{x}$
Chukchi Sea				
1966	77	8.8	15	6.9
1967	46	7.0	12	6.0
1968	97	7.7	11	7.1
1969	116	6.2	29	5.3
1970	163	6.3	30	5.9
1971	91	6.6	24	5.5
1972	127	6.3	20	5.2
Beaufort Sea				
1966	33	9.0	14	5.9
1967	29	6.9	10	6.6
1968	56	6.6	45	6.0
1969	48	6.7	36	5.4
1970	32	5.9	29	6.9
1971	19	4.8	16	3.1
1972	52	5.7	26	5.4

occurred in the same geographic areas each spring, and that movements of bears between Alaska and Canada were limited. Strong seasonal fidelity would violate the assumption of equal probability of capture (Caughley 1977: 134) because researchers returning to relatively few logistics bases each spring would be predisposed to catching previously marked bears. However, bears instrumented in the central and eastern Beaufort Sea moved throughout large portions of the area between Barrow and Cape Bathurst. Also, they were seasonally faithful only to large regions such as the eastern or western sectors of the Beaufort Sea rather than to specific areas. Therefore, during the 12 years of our study, equal probability of capture was approached, if not achieved.

We are comfortable with the estimates of survival used in our population projections. However, several caveats must be noted. Prior to 1981, family groups were sought more actively than other classes of bears during Alaskan tagging studies. Thus the early capture sample was biased against independent subadults and other single bears and could have

Fig. 2. Age distribution of polar bears captured in the Alaskan Beaufort Sea, 1967–1982. Sample sizes are shown in columns. Age group representation differed between the 2 time periods for males ($\chi^2 = 27.2$, 7 df, $P < 0.005$), but not for females ($\chi^2 = 10.9$, 7 df, $P = 0.16$), and fewer males ≥ 11 years old were captured during 1967–1974 than expected (P[Bonferroni] < 0.05, [Neu et al. 1974]).

caused an artificially old estimated age structure and too high an estimated survival rate for females. This would result in positively biased population estimates.

Because of variation in sample sizes, some estimates of survival were not precise. However, in many of the categories, there was little variation about the regression line and standard deviations were small. Survival rates (which included natural and human-caused mortalities) of 0.87 and 0.89 were calculated for males and females aged 1–16 (Table 2). Both estimation methods gave similar results and agreed with the estimate (0.88) calculated for the Canadian Beaufort Sea (Stirling et al. 1976, DeMaster et al. 1980). Survival rates calculated for some age groups were higher. On the other hand, survival of cubs and yearlings may be lower than shown in Table 2 (DeMaster and Stirling 1984, Larsen 1985).

Estimating survival from age structure data yields an estimate of survival/population growth rate (Caughley 1977:119). Thus when a population is declining, the estimated survival rate would appear higher than it actually is. Using that inflated estimate could lend an upward bias to population estimates. Also, mark-recapture population estimates are strongly influenced by small changes in assumed survival rate. Survival rate was used in our population estimates to determine how many marked animals were in the population at any sampling period. Because the estimates are simply ratios of marked to unmarked bears, the survival rate assumed had a profound effect on the outcome (Table 1).

Schnabel (Seber 1973:130–138) estimates require that the population is closed. J. R. Gilbert (USFWS, unpubl. data) reported that movement of many bears through his sample area violated that requirement and inflated population estimates. However, movements of polar bears may have been more of a problem for Gilbert than in other studies (Table 3). Later search efforts covered larger areas and shifted with ice conditions (and presumably bear distribution). Also, rather than arbitrarily preselecting an area, as Gilbert did, the geographic areas to which other single season estimates applied were determined by the outermost points where bears were observed. Variances of our single season estimates were large, and confidence in any one of them would necessarily be low. However, the estimates were fairly consistent over time. Single season density estimates from the Beaufort Sea were also similar to those from the Chukchi Sea, and both were similar to density estimates derived from multi-year methods.

Belt transect estimates could have underestimated density because all bears within 0.22 km either side of the flight line may not have been seen. On the other hand they almost certainly overestimated density because both biologists and trophy hunters concentrated search activities where bears were previously encountered, and in areas of "better habitat" where densities were undoubtedly higher. Also, much of the flying time was spent following bear tracks in the snow. Under most circumstances, snow tracking provides more encounters with polar bears than random searches of even the best habitats. The degree to which these circumstances biased our estimates is unknown, as are effects of different observers searching different areas under variable conditions. However, density estimates from the late 1950s are similar to those in the early 1980s; and despite some questions about reliability of these as isolated estimates, both belt transect estimates were similar to single season and multi-year mark-recapture estimates.

Population Trend

Except for multi-year estimates (Table 1), our results suggest a decline in polar bear numbers from 1958 to 1972, some recovery in the late 1970s, and apparent stability since then. The failure of multi-year estimates to detect an obvious trend in numbers could result from caveats previously discussed, or from the relatively shorter time interval for which these estimates were available. Also, most of the early mark-recapture work in the Alaskan Beaufort Sea was conducted concurrently with trophy hunting near Barrow. Thus, the portion of the polar bear population most likely to show the impact of the heavy hunting (those animals with spring activity areas near Barrow) was also the portion counted during the research program. Whereas belt transect data from the Barrow area reflected localized reductions, multi-year mark-recapture estimates averaged impacts to the population over the whole Beaufort Sea and over longer periods of time. Therefore, reductions near Barrow, which may have been pronounced, were only detectable in diluted form by mark-recapture analyses.

Multi-year estimates may also have been less sensitive to trends because they were based upon "average" survival rates. Annual sample sizes were so small and representation in the many age classes so varied that we could estimate survival only by grouping several years of age-distribution data. Thus, our estimates were derived from the means of several individual time-specific life tables. This approach requires a stationary population (Seber 1973:400). Not only was our population probably not stationary during this interval, but its deviation from stationary would have masked lower survival rates when other (than multi-year) indices suggested lower populations. If mortality rates before 1974 were as shown in Table 2, a more reasonable trend estimate might be derived if a survival rate of 0.82 was used during 1972–1974 and 0.88 thereafter (Table 1). This would show an increase in the late 1970s corresponding to other indices.

General insensitivity of multi-year mark-recapture analyses to small numerical changes probably also contributed to apparent discrepancies between mark-recapture and belt transect results. DeMaster et al. (1980) emphasized the sensitivity of their method to sample size. Considerable variation in representation within and between age classes was included in each of our annual samples. Also, due to sample size limitations, the recapture or failure to recapture just 1 previously marked family group could have had substantial impact on some annual population estimates. The same kinds of annual variation in samples plagued estimates of survival rates.

Abnormally heavy ice covered much of the eastern Beaufort Sea during the winter of 1973–1974. This resulted in major declines in numbers and productivity of polar bears and ringed seals in 1975 (Stirling et al. 1975, 1977, 1982; DeMaster et al. 1980). This decline was documented by several indices in the eastern Beaufort Sea, yet was not apparent in our analyses of the Beaufort Sea population as a whole (Table 1). Three factors appear to clarify this possible discrepancy. First, there is some evidence that more seals and polar bears than usual moved into the western Beaufort Sea to avoid poor conditions in the east (Stirling et al. 1977, Lentfer 1983). Also, our data suggest this timing coincided with the early stages of recovery from the large trophy harvest. Third, although cubs were nearly absent from the capture sample in the eastern Beaufort Sea during springs of 1974 and 1975, they occurred frequently in samples from the Barrow area. Captures of yearlings near Barrow in 1974 and 1975 were reduced, however. Therefore, poor conditions prevalent in the east appeared to moderate in the west to the point where survival, but not production of young, was influenced. Thus, numerical declines in the eastern Beaufort Sea may have been compensated in our analyses by movement of some of those animals to western sectors of the Beaufort Sea, by amelioration of the causes of the declines in western sectors, by dilution, and by in-progress recovery from earlier overhunting in western sectors.

Taylor (1982) suggested that apparent recent stability of polar bear numbers in the Beaufort Sea depended upon immigration from the Chukchi Sea. Our data, however, suggest immigration to the Beaufort Sea population is limited. Between 1967 and 1974, only 4 males older than 10 years were captured. This compares with 26 (15%) of the males captured after 1975 (Fig. 2). The 11-year harvest, mostly near Barrow, of 287 male bears had all but eliminated old males from the Beaufort Sea by 1967. This condition persisted for years even in the Canadian Beaufort Sea, where the ages of polar bears taken by Inuit hunters also increased during the late 1970s (I. Stirling, unpubl. data). Likewise, the drop in production and survival of young caused by heavy ice in the Beaufort Sea in 1974 (Stirling et al. 1975, 1977, 1982; DeMaster et al. 1980) resulted in weak cohorts detectable in captures in subsequent years. Even though the effect of the poor conditions in 1974 appeared to moderate to the west, poor survival of yearlings over the whole Beaufort Sea in 1974 resulted in fewer than expected 2 year olds captured in 1975, and fewer than expected 3 year olds captured in 1976 (P[Bonferroni] < 0.05 [Neu et al. 1974]). Too few bears were captured in Alaska in 1977 and 1978 to see trends in particular age classes. However, weak cohorts from 1974 were traceable in the Canadian sector through 1979 (I. Stirling, unpubl. data). These data indicate that the Beaufort Sea polar bear population is small, and that it receives little immigration from surrounding areas.

Factors other than decreased densities could have reduced encounters between scientists and polar bears through the mid-1970s. For example, turbine helicopters may have been more effective than those with reciprocating engines, which were used in the earliest years of the program, and personnel gained experience with time. However, increases in density were not obvious until 1975 (Table 5), despite the fact that methods were well established by 1971, and turbine helicopters were used exclusively thereafter.

Similar arguments might also be raised to explain expanding search areas of trophy hunters. Improved equipment, including long range gas tanks and better radios, as well as availability of better weather information allowed some guides to hunt farther offshore than they might have in earlier years. Also, some guides glamorized hunts in the Chukchi Sea by offering clients a chance to kill a bear within sight of the great cliffs along the Siberian coast. However, the quest for trophy bears remained foremost. Economics argued that most guides went no farther than necessary to find trophy bears, and steadily increasing distances to kill sites suggested that densities of polar bears had been reduced.

IMPLICATIONS

In recent years, we have not detected changes in numbers of polar bears in the Beaufort Sea region. Despite this indication that birth and death rates are now similar, pressure to increase quotas in the Canadian sector continues, and in Alaska there are no limits on the take. Between 1961 and 1972, the period of accurate harvest data on trophy hunting in Alaska, the harvest consisted of 75% male bears. Although statewide annual harvests during that period usually exceeded 200, the mean take of females was only 63 (Table 6). The reported annual take of females after 1972 was lower, but as it declined, the number of harvested bears for which sex was not reported increased. In 1981 and 1982, hunters reported that 56% of 41 litter members killed were males; only 15% were females and sex was reported unknown for 29% (S. Schliebe, USFWS, unpubl. data).On the other hand, 55% of 295 litter members captured during mark-recapture studies from 1967 to 1983 were females. It is unlikely that the sex ratio of litter members harvested differed so much from the sex ratio of live-captured litter members. Such discrepancies do not appear to occur in Canada, where harvest reporting is mandatory. Therefore, biased or inaccurate voluntary reporting in Alaska seems likely. The bias in reporting the harvest of litter members is probably carried over to other ages of animals killed in Alaska. Therefore, many harvested bears of other age groups reported as "sex unknown" were probably females.

Even if the existing harvest situation has allowed the polar bear population in the Beaufort Sea to maintain itself, that could change. Some pregnant females and family groups are taken from maternity dens along Alaska's coast each year. Thus, existing hunting strategies can hit the most critical segment of the population. Also, large numbers of female bears are periodically vulnerable when they concentrate at certain coastal locations to scavenge on dead marine mammals (principally bowhead whales [*Balaena mysticetus*] and walruses [*Odobenus rosmarus*]). For example, in October 1980 at least 22 polar bears were killed when they came to scavenge on a bowhead whale beached by Eskimo hunters at Barter Island in Alaska's eastern Beaufort Sea (S. Schliebe, unpubl. data). S. C. Amstrup (unpubl. data) captured and marked 43 bears near Barter Island between 18 October and 7 November 1981, and estimated that at least 75 were congregated near the remains of 3 whales on the beach. Although polar bears were available to Barter Island hunters in the autumn of 1981, few were killed. The kill of polar bears in Canada is limited by quota, but there are no harvest limits for native peoples in Alaska. More bears are available to hunters in the Alaskan Beaufort Sea than are killed each year. Therefore, philosophical or economic changes could increase harvests, and managers could not respond with regulatory changes.

The apparent recent decline in the survival of young females and their lower representation in the age groups 3–5 (Table 2, Fig. 2) is also disturbing. The low r^2 value for the estimate of survival for females aged 1–5 suggests great variability about the regression line. Thus, the calculated mortality rate (0.18) may not be accurate. If recruitment of females through the subadult age classes has declined, however, actual survival rates of older females would be lower than those calculated (Ricker 1975:37–38). Population size estimates would then be exaggerated. This is of special interest if hunting and other mortality factors increase in the future.

The indicated mortality rate of 0.01 for females aged 5–10 is impossibly low and may substantiate concerns about underestimation of mortality rates of females older than 5 years (Table 2). This anomaly may be partly explained by sample size problems. Also, more females aged 6–8 are encumbered with cubs of the year than any other age group, and such females are underrepresented in spring capture samples (Lentfer et al. 1980). A low representation of those age groups in the capture sample results in high calculated survival in the 5–10 bracket because females aged 9–10 were commonly captured with yearlings and 2 year olds. On the other hand, we cannot overlook the concentration of recent hunting efforts near shore. S. C. Amstrup (unpubl. data) and I. Stirling et al. (unpubl. data) observed that family groups frequent coastal and shorefast ice areas and are particularly vulnerable to current coastal hunting strategies. Only 2 of the 43 bears captured near Barter Island in autumn 1981 were adult males. The remainder were independent subadults and females accompanied by young. The portion of the harvest of the preceding year for which sex and age could be determined also was mainly family groups, and contained no adult males (S. Schliebe, unpubl. data). The vulnerability of females and family groups to the existing pattern of hunting along the coast is further substantiated by the observation that the mean age of female polar bears taken exceeded the mean age of males in the harvest (S. Schliebe, unpubl. data).

Available evidence suggests the polar bear population in the Beaufort Sea cannot absorb much of an increase in mortalities of females. If our estimate of about 2,000 bears in the Beaufort Sea is correct and the age structure is accurately represented by our catch data, there are only 511 ([101 females aged $\geq$6/395 bears captured] $\times$ 2,000) females of reproductive age ($\geq$6 years) in the Beaufort Sea population (Fig. 2). Additionally, if the mean breeding interval for adult female polar bears is 3.6 years (Lentfer et al. 1980), then 142 ([1/3.6] $\times$ 511) females should den each fall and emerge with new cubs the following spring. If females with litters survive, a litter size of 1.47 for 2.5 year olds (Lentfer et al. 1980; S. C. Amstrup, unpubl. data) and an even sex ratio would mean 104 (142 $\times$ [1.47/2]) 2.5-

year-old females become independent each summer. If those females survive at an annual rate of 0.82 until the age of 5, and if 0.88 of 5 year olds live to be 6 (Table 2), then only 56 ([$104 \times 0.82^{2.5}$] $\times$ 0.88) females enter the breeding population annually. If there are about 511 breeding age females in the Beaufort Sea population, an annual survival rate of 0.88 would account for the loss of 61 each year. Clearly, there has been little or no excess recruitment of females to the Beaufort Sea in recent years, and legislation that would allow management actions to protect females is needed.

SUMMARY AND CONCLUSIONS

Four independent procedures for estimating population size suggested the number of polar bears in Alaska in 1984 was similar to the number in 1956, and that polar bears have probably never been more numerous in most Alaskan waters than 1 bear/137–240 km^2. Independently, each of these estimators is weak because of sample size limitations, possible violation of assumptions, or large variances. However, we believe the degree of agreement between them is significant.

Numbers of polar bears in Alaska apparently declined by the end of the trophy hunting period in 1972. Some recovery occurred during the mid- and late 1970s, and numbers appear to have been relatively stable since then.

Radio-tracking data suggest that polar bears occupying the area between Point Barrow, Alaska, and Cape Bathurst, Northwest Territories, Canada, are members of the same population. Mark-recapture data suggest the size of this population is 1,300–2,500 bears (Table 1). Limited information from the Chukchi Sea suggests winter-spring densities are similar to those in the Beaufort Sea. Densities of bears in the Bering Strait region may be higher in late winter and early spring, but are highly variable seasonally and dependent entirely on the conditions and motion of the ice.

We are concerned about the future of polar bears in the Beaufort Sea for several reasons. First, our estimates suggest stability in recent years, but the population is small. A small, isolated population with low reproductive potential is vulnerable to natural and human-caused perturbations. Second, despite many years of study, our knowledge of polar bear population dynamics is rudimentary. We cannot rule out the possibility that our assessment of stability was in error, and with a small population there is little latitude for error. Also, hydrocarbon exploration and development have allowed unprecedented increases in human numbers in coastal areas of the Beaufort Sea, and habitat is changing at an accelerating rate. As a result, opportunities for encounters between polar bears and humans are increasing. There is potential for a change in philosophy among increasingly numerous and mobile local people, a change in value of polar bear parts (e.g., hides, gall bladders), or development-related phenomena (such as an oil spill) to increase the human-caused mortalities of polar bears in the Beaufort Sea. The Beaufort Sea population can sustain little if any increase in mortalities of females. Because we currently have no regulatory ability to protect females and young in Alaska, this potential for adverse change cannot be overlooked.

Notwithstanding the above conclusions, the harvest of polar bears in Alaska has a long history, and polar bears must be recognized as a valuable renewable resource. During the period of trophy hunting, 75% of the polar bear harvest was males, demonstrating that a managed hunt can protect females and concentrate on males. Airborne hunters could observe several bears in a brief time period, and were highly selective of animals they harvested. Present-day hunting from the ground is more limited in that regard; however, 3 simple regulations could again protect most females and their young. Immature polar bears accompany their mothers until the age of 2.5 (Lentfer et al. 1980). Therefore females are encumbered by cubs during most of their adult lives. Single adult females are usually pregnant and will occupy maternity dens during December–April, at which time they emerge with new cubs (S. C. Amstrup, unpubl. data). Thus, if it were unlawful to harvest females accompanied by their young, most adult females would be protected. Further, most single females could be protected if it were unlawful to remove bears from dens, and if polar bear hunting was disallowed before 15 December (by which time most single females would be in dens). Reducing the losses of females to hunting would decrease the vulnerability of the population to both natural and human-caused perturbations. Also, because large numbers of adult males may suppress growth rates in bear populations (Kemp 1976, McCullough 1981, Young and Ruff 1982, Larsen 1985), a harvest concentrating on males may have some compensatory benefits, including the possibility of an increased take.

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