POLAR BEAR MATERNITY DENNING IN THE BEAUFORT SEA

STEVEN C. AMSTRUP, Alaska Fish and Wildlife Research Center, U.S. Fish and Wildlife Service, 1011 E. Tudor Road, Anchorage, AK 99503
CRAIG GARDNER,[1] Alaska Fish and Wildlife Research Center, U.S. Fish and Wildlife Service, 1011 E. Tudor Road, Anchorage, AK 99503

Abstract: The distribution of polar bears (*Ursus maritimus*) is circumpolar in the Northern Hemisphere, but known locations of maternal dens are concentrated in relatively few, widely scattered locations. Denning is either uncommon or unknown within gaps between known denning concentration areas. The Beaufort Sea region of Alaska and Canada lies in the largest of those gaps. To understand effects of industrial development and proposed increases in hunting, the temporal and spatial distribution of denning in the Beaufort Sea must be known. We captured and radiocollared polar bears between 1981 and 1991 and determined that denning in the Beaufort Sea region was sufficient to account for the estimated population there. Of 90 dens, 48 were on drifting pack ice, 38 on land, and 4 on land-fast ice. The proportion of dens on land was higher (P = 0.029) in later compared with earlier years of the study. Bears denning on pack ice drifted as far as 997 km ($\bar{x}$ = 385 km) while in dens. There was no difference in cub production by bears denning on land and pack ice (P = 0.66). Mean entry and exit dates were 11 November and 5 April for land dens and 22 November and 26 March for pack-ice dens. Female polar bears captured in the Beaufort Sea appeared to be isolated from those caught east of Cape Bathurst in Canada. Of 35 polar bears that denned along the mainland coast of Alaska and Canada 80% denned between 137°00'W and 146°59'W. Bears followed to >1 den did not reuse sites and consecutive dens were 20–1,304 km apart. However, radio-collared bears were largely faithful to substrate (pack-ice, land, and land-fast ice) and the general geographic area of previous dens. Bears denning on land may be vulnerable to human activities such as hunting and industrial development. However, predictable denning chronology and lack of site fidelity indicate that many potential impacts on denning polar bears could be mitigated.

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Polar bears inhabit most ice-covered seas of the Northern Hemisphere (Amstrup and DeMaster 1988). Their distribution is circumpolar, and they normally occur in low densities (1 bear/141–269 km^2) (DeMaster and Stirling 1981, Amstrup et al. 1986, Amstrup and DeMaster 1988). Known locations of maternal birth dens are concentrated in a few, widely scattered locations (Harington 1968, Ramsay and Andriashek 1986). Among the best known denning concentration areas are the Svalbard Archipelago, north of Norway (Larsen 1985); Franz Josef Land, Novaya Zemlya, and Wrangel Island, in Russia (Uspenski and Chernyavski 1965, Uspenski and Kistchinski 1972); and the west coast of Hudson Bay in Canada (Ramsay and Stirling 1990).

Denning is either uncommon or has been overlooked in gaps between known denning concentration areas. The Beaufort Sea region of northern Alaska and Canada lies in the largest of those gaps (Harington 1968:Fig. 2). As many as 2,000 polar bears occur in the Beaufort Sea throughout the year, and ≥140 females should seek dens there each fall (Amstrup et al. 1986). Yet, 11 years of study, plus analysis of historic sightings dating from 1910, revealed only 35 dens (U.S. Fish and Wildl. Serv., unpubl. data). Lentfer and Hensel (1980) suggested that suitable denning habitat along Alaska's north coast was limited. Polar bears are hunted by local native people in Canada and Alaska, and Canadian hunters believed that the harvest in Alaska was being sustained by production of polar bears in Canada (Stirling and Andriashek 1992). Recently, hunting along the nearby Russian coast, where it was banned in 1956 (Uspenski and Belikov 1991), has been proposed. Therefore, the sources of the bears frequenting the Beaufort Sea is an international management concern.

Known denning areas at the start of this project were on land. Lentfer (1975*a*) and Lentfer

[1] Present address: Alaska Department of Fish and Game, P.O. Box 355, Tok, AK 99780.

and Hensel (1980) reported 2 dens and observations of cubs and cub footprints on the pack ice north of Alaska. Larsen et al. (1983) also observed footprints of females with cubs on the pack ice far from land. However, the possibility that polar bears might commonly den on pack ice had not been proposed as an explanation for the dearth of dens between known land-denning areas. In addition, fidelity to denning areas, presumably an indication of limited availability of necessary habitats, has been assumed (Ramsay and Andriashek 1986) but not verified.

Polar bears in dens cannot be hunted legally in Canada, and hunting of bears in dens is discouraged in Alaska. Also, hunting seasons in Canada usually begin after female bears are thought to enter dens (Treseder and Carpenter 1989). Industrial activities are a potential threat to polar bears, especially as they might affect bears in dens (Stirling 1990, Stirling and Andriashek 1992). Temporal as well as spatial management of hunting and industrial activities may be critical to coexistence of polar bears and humans. Yet, knowledge of den entry and emergence, and the duration of denning is limited (Lønø 1970, Lentfer and Hensel 1980, Kolenosky and Prevett 1983, Larsen 1985, Messier et al. 1992). Our objectives were to determine (1) origin of polar bears occurring in the Beaufort Sea, (2) frequency of denning on pack ice relative to land, (3) relative production of females using land and pack-ice dens, (4) polar bear geographic preferences for and fidelity to den sites, and (5) denning chronology.

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METHODS

Field Procedures

We captured polar bears by using immobilizing drugs (phencyclidine hydrochloride [Sernylan®, Park, Davis and Co.], etorphine hydrochloride [M-99®, Lemmon Co.], and tiletamine hydrochloride plus zolazepam hydrochloride [Telazol®, Warner-Lambert Co.]) with projectile syringes fired from helicopters (Larsen 1971, Schweinsburg et al. 1982). Capture protocols were approved by an independent animal care and welfare committee. Up to 55 ($\bar{x} = 30$) female polar bears were captured and radiocollared annually during spring (Mar–May) or autumn (Oct–Nov) from 1981 to 1991. We captured bears throughout the Beaufort Sea, which extends from Point Barrow, Alaska, at approximately 157°W, to Cape Bathurst, Northwest Territories, Canada, at approximately 127°W, and in bordering areas to the east and west. Canadian cooperators captured and radiocollared bears (for us to radiotrack) in the Canadian Beaufort Sea and Amundsen Gulf east of Cape Bathurst. Analyses were concentrated on bears that were captured and denned within the Beaufort Sea and adjacent land areas.

We attached very high frequency (VHF) radio collars to polar bears between 1981 and 1985 and relocated them with aircraft (Fig. 1). After autumn 1985, we mostly deployed ultra high frequency platform transmitter terminals (PTTs) that were relocated by satellite. Sensors on PTTs recorded the animal's location, temperature of the collar, and 2 indices of activity (Fancy et al. 1988). A short-term activity counter recorded the number of seconds of movement during the minute prior to transmission. A long-term activity counter recorded the proportion of time the bear was moving in the 72 hours prior to transmission. Collars carrying PTTs also carried VHF beacons that we located with aircraft.

We located dens of radio-collared polar bears with satellite position fixes, aircraft radio tracking, and visual sightings. Den locations were

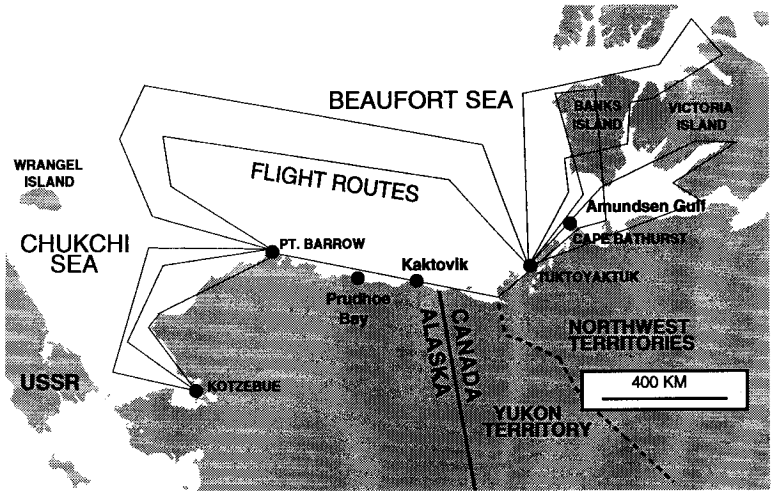

Fig. 1. Approximate radio-tracking routes for polar bears flown 4 times per year, 1983–87, and twice per year, 1988–91. Also shown are place names used in text.

placed in 3 substrate categories: land, either offshore islands or the mainland coast of Alaska and Canada; land-fast ice, sea ice that was frozen to the ocean bottom or attached to ice that was frozen to the bottom, and generally did not move (Parkinson et al. 1987); and drifting pack ice, which was in constant motion. In analyses, dens on land-fast ice were included with land dens. Den locations on land were plotted on 1:63,360 topographic maps. We used Loran-C or very low frequency positioning devices to plot dens found with aircraft on pack ice. Locations recorded for pack-ice dens were those observed at the time of den entry. Dates of den occupation were determined by low-level aerial telemetry and visual observation or by changes in temperature and activity sensors on the PTTs. When a bear entered her den, transmitter temperature increased and remained above freezing (10–40 C warmer than ambient) and both activity counts declined. When a bear left her den, location changed, transmitter temperature decreased, and activity increased. Whenever possible, den locations of bears fitted with PTTs were also verified by aerial telemetry. Unless otherwise stated, we reported results only for dens that were confirmed by consistent PTT temperature and activity output, repeated radio tracking and visual observations, or both. Unconfirmed locations were classified as suspected dens.

We located dens of bears without radio collars (incidental dens) by searching coastal areas, with light aircraft, for openings in the snow. Searches consisted of opportunistic flights related to capture activities during spring and autumn 1981–91. We also flew aerial transect den surveys between Herschel Island, Yukon Territory (69°30′N, 139°30′W) and the Colville River delta (70°30′N, 150°30′W), in spring 1988, 1989, and 1990. A pilot and 1 observer conducted the survey in 1989, and a pilot and 2 observers did the 1988 and 1990 surveys. We flew at altitudes of 50–150 m and speeds of 110–150 km/hour. We scheduled surveys according to previously observed peak periods of emergence from dens. Surveys were divided into areas of high and low probability of encounter according to the 1965–88 distribution of maternal dens and the availability of habitats with snow-catching topography. We flew a transect along the beach and a series of transects parallel to the beach extending 20 km inland. Transects were separated by 0.8 km in high- and 1.6 km in low-probability areas. Mainland coastal bluffs, river channels, and barrier islands were surveyed by flying parallel to the relief features and deviating to search connecting features. We also recorded dens observed by local residents and other scientists.

We determined whether a denning attempt was successful (emergence of ≥ 1 cub) by locating and observing radio-collared females within 30 days of emergence from the den. Success of unmarked bears was determined by ob-

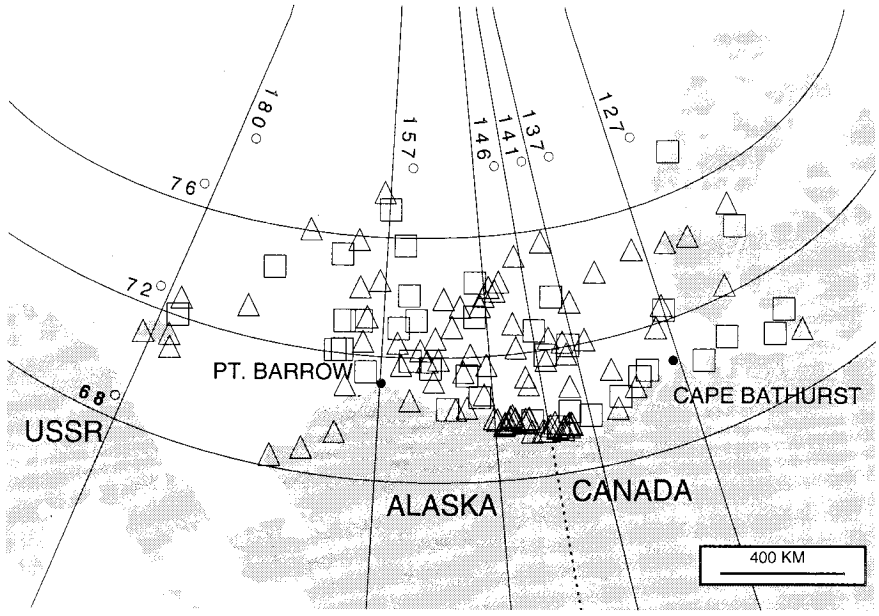

Fig. 2. Suspected (squares) and confirmed (triangles) polar bear maternity dens located by radio telemetry, 1981–91.

servation at the den site or by counting footprints in the snow left by the bears as they abandoned the den.

Analyses

We used 2 methods to test whether the distribution of our capture effort biased the distribution of dens we located by radio telemetry. First, we divided the study area into 4 longitudinal zones and compared the distribution of captures in each zone with the distribution of subsequent denning attempts in each zone with a Chi-square contingency table. Second, we compared locations where bears were captured with locations where they denned with the distribution free Multi-Response Permutation Procedure (MRPP) (Mielke et al. 1981, Biondini et al. 1988).

We evaluated selection of substrate or geographic areas by denning polar bears by comparing the observed distribution of dens on land and on pack ice, and in each of 4 longitudinal zones along the coast, with Chi-square goodness-of-fit tests. Annual variations in denning substrate, differences in distributions of incidental dens and dens located by radio telemetry, fidelity of denning bears to substrate, and fidelity to either the eastern or western half of the study area were examined with Chi-square contingency tables. We tested for deviations from randomness among den entry and emergence dates with the nonparametric runs test (Zar 1984:419). We used the Student's t-test to compare distances between sequential land and pack-ice dens. To evaluate long-term fidelity we used Student's t to compare latitudes and longitudes of incidental dens we found with dens found in the 1970s (Lentfer and Hensel 1980). We compared entry and exit dates and durations in dens for bears on land and pack ice with a 2-factor analysis of variance (ANOVA). We report actual significance levels resulting from statistical tests performed except where $P < 0.001$ and where test statistics calculated for the runs test exceeded table values (Zar 1984:627–635). Differences were significant at $P \leq 0.05$.

RESULTS

Between 1981 and 1991, radio-collared polar bears were followed to 125 suspected maternity dens (Fig. 2). We confirmed 90 of those dens and evaluated success for 59. During the same time interval, we located 31 suspected incidental dens, confirmed 26, and evaluated success for 17. We examined 14 dens on the ground. All were constructed of ice and snow only, and both single- and multiple-chambered dens were observed. Half of examined dens and many oth-

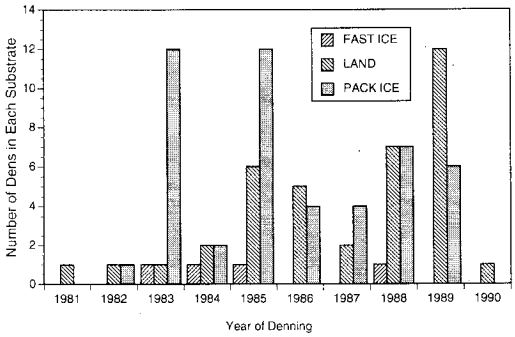

Fig. 3. Numbers of radio-collared polar bears entering confirmed dens on land, fast ice, and pack ice in arctic Alaska and Canada, 1981–90. Years shown are those in which bears entered their dens.

ers were in areas of minimal topographic relief, where denning might not have been suspected without the aid of radio telemetry.

The longitudinal distribution of locations where bears were captured and radiocollared was different than the distribution of locations where they denned ($\chi^2 = 49.35$, 9 df, $P < 0.001$; MRPP: $P < 0.001$). Thus, locations of dens we found were not biased by capture efforts.

Den Distribution by Substrate

We confirmed 48 (53%) dens of radio-collared bears on drifting pack ice, 38 (42%) on land, and 4 (4%) on land-fast ice. When all years were considered, numbers of dens on pack ice and land were not different ($\chi^2 = 0.25$, 1 df, $P = 0.62$). Numbers of dens on land and pack ice appeared to vary among years (Fig. 3). Variations among all years were not significant ($\chi^2 = 13.2$, 9 df, $P = 0.16$), but the proportion of land dens found from 1986 to 1990 was higher than that found from 1981 to 1985 ($\chi^2 = 4.74$, 1 df, $P = 0.029$).

Productivity

We observed 28 radio-collared bears within 30 days of emergence from pack-ice dens. Of those, 16 produced 26 cubs ($\bar{x} = 0.93$/den, SD = 0.90). Twenty-one of 31 land-denning bears, observed within 30 days of emergence, produced 33 cubs ($\bar{x} = 1.1$/den, SD = 0.85). Productivity of females that used pack-ice dens and that of females that denned on land was not different ($\chi^2 = 0.81$, 2 df, $P = 0.66$). The power of this test, however, was only 0.11 because of small sample size.

Table 1. Geographic distribution of polar bear maternal dens, located and confirmed by radio telemetry, along the mainland coast of the Beaufort Sea and adjacent northwestern Alaska, 1981–91.

Longitudinal zones where dens were located	Denning substrates		
	Land[a]	Pack ice	Total[b]
127°00′–136°59′	1	8	9
137°00′–146°59′	28	15	43
147°00′–156°59′	3	14	17
157°00′–166°59′	3	8	11

[a] Includes dens on land-fast ice.
[b] Ten dens east or west of the 127°00′–166°59′ mainland zone are not included.

Geographic Distribution of Dens

Radio-collared polar bears denned between Victoria Island in Canada and Wrangel Island in Russia (Fig. 2). Only 3 bears, enroute to dens, moved between the Beaufort Sea and points east of 127°W. Thirteen bears captured in the Beaufort Sea denned west of 157°W, but only 1 denned on Russian soil.

Dens on land were concentrated in far northeastern Alaska and the northern Yukon Territory of Canada, including Herschel Island. Of 42 land dens, 35 (mainland dens) were along the mainland coast between 127°W and 167°W. The distribution of mainland dens (Table 1) was different among 10° longitudinal zones ($\chi^2 = 56.7$, 3 df, $P < 0.001$).

Of 26 incidental dens known to be on land, 11 were observed from 137°00′W to 146°59′W, 6 were observed from 147°00′W to 156°59′W, and 9 were west of 157°W. This distribution was different from that observed by radio telemetry ($\chi^2 = 11.3$, 3 df, $P = 0.01$), reflecting the higher frequency of incidental dens in western Alaska.

Whereas dens on land were located in a narrow band ranging inland 0.02–61 km, the south and north extremes of pack-ice dens were >700 km apart. The latitudinal range of pack-ice dens was 70°12′N to 77°48′N ($\bar{x} = 73°05′$N, $n = 48$), and 37 dens (77%) were north of 72°N, including 22 (46%) north of 73°N. Bears captured in the Beaufort Sea entered dens on pack ice as far east as 117°18′W and as far west as 178°54′W ($\bar{x} = 146°33′$W, $n = 48$).

Polar bears drifted 19–997 km ($\bar{x} = 357$ km, SD = 246 km, $n = 37$) while in dens on pack ice. Successful females drifted 114–816 km ($\bar{x} = 385$ km, SD = 218 km, $n = 16$). Drift bearings for 34 of 37 dens, for which complete drift information was available, ranged 226–350°. Drifting with the sea ice imparted some risks to

Table 2. Entry and exit dates of polar bears radiotracked to confirmed dens in the Beaufort Sea region (1981–91). Included are bears for which success (production of ≥1 cub) was evaluated within 1 month of den emergence.

Substrate	Success	Den entry dates			Den exit dates			Duration in den (days)		
		n	$\bar{x}$	SD	*n*	$\bar{x}$	SD	*n*	$\bar{x}$	SD
Land	No	8	25 Nov	17.1	8	11 Mar	25.3	8	106	34.1
Land	Yes	20	11 Nov	22.1	18	5 Apr	8.8	18	147	22.3
Pack ice	No	12	19 Nov	22.3	10	8 Mar	35.7	10	112	43.7
Pack ice	Yes	16	22 Nov	20.7	10	26 Mar	13.1	10	130	27.5

denning bears. In winter 1985–86, 6 polar bears in pack-ice dens were swept past Point Barrow and southwest into the Chukchi Sea, due to unusually unstable ice. Only 1 denned successfully.

Fidelity to Den Sites

We followed 27 polar bears to >1 suspected or confirmed maternity den. One radio-collared polar bear was followed to 4 maternal denning sites, 7 were followed to 3 dens each, and 19 to 2 dens. Confirmed sequential dens were separated from their precursors by a mean of 308 km (SD = 262, n = 30). Distances separating sequential land dens were not different from those separating sequential pack-ice dens (t = 0.5, 19 df, P = 0.62).

Bears that denned once on pack ice were more likely to den on pack ice than on land in subsequent years, and vice versa (χ^2 = 4.9, 1 df, P = 0.03). Similarly, bears that denned once east of 146°59′W, the midpoint of the longitudinal range of mainland dens, were more likely to den there than to the west in subsequent years (χ^2 = 5.5, 1 df, P = 0.02). Also, neither latitudes (t = 0.05, P = 0.96) nor longitudes (t = 0.75, P = 0.46) of incidental dens we found in northern Alaska differed from those reported in the 1970s (Lentfer and Hensel 1980; U.S. Fish and Wildl. Serv., unpubl. data).

Denning Chronology

Successful land-denning bears entered dens between 8 October and 24 November and emerged between 13 March and 18 April, for durations of 96–183 days. Successful pack-ice denning bears entered dens between 17 October and 13 December and emerged between 4 March and 29 April, for durations of 81–164 days (Table 2). Duration of land denning did not differ from that of pack-ice denning (F = 0.31, 1 df, P = 0.58), and there was no interaction between success and substrate (F = 1.42, 1 df, P = 0.24). However, successful bears remained in dens longer than bears that did not produce cubs (F = 9.41, 1 df, P = 0.004). Also, entry (n_1 = 16, n_2 = 16, μ = 8, P = 0.005) and exit (n_1 = 16, n_2 = 18, μ = 11, P = 0.05) dates varied in a nonrandom pattern that probably reflected annual variations in weather. Data were insufficient, however, to confirm that relationship.

DISCUSSION

Polar bears commonly den in the Beaufort Sea region. We found >10 dens/year by annually radiocollaring 1.5% of the population (Amstrup et al. 1986). Extrapolation to the estimated population size would account for the total numbers of dens projected for the Beaufort Sea, indicating a population that is not dependent on reproduction from other known denning areas.

Den Distribution by Substrate

Our data suggest denning on pack ice occurs frequently. Lentfer and Hensel (1980) recognized the occurrence of dens on pack ice but suggested that denning on pack ice was limited to bears that could not make it to shore. Larsen et al. (1983) reported footprints of new cubs deep in the pack ice between Greenland and Svalbard but did not discuss whether those cubs might have been born in dens on the pack ice, and Harington (1968) concluded that denning on ice was not preferred.

Radio-collared bears denned on land more often in the latter half of this study than in the first half. Because sample sizes where small, variation in denning substrate we observed among years could be due to chance. We believe, however, that the higher proportion of land denning late in the study is real. We found more incidental land dens than did earlier investigators despite their greater search effort (Lentfer and Hensel 1980; U.S. Fish and Wildl. Serv., unpubl. data). Also, researchers working in the Canadian Beaufort Sea found more dens and evidence of dens on land in the 1980s than during studies conducted there in the 1970s

(Stirling et al. 1988, Stirling and Andriashek 1992). The apparent absence of onshore denning for many years before this study may have resulted from hunting that began with Yankee whalers in the late 1800s and early 1900s (Hanna 1920, Mowat 1984) and continued, after modern firearms became available to local residents, until the 1960s (Leffingwell 1919; Van de Velde 1957, 1971; Stirling and Andriashek 1992). Because polar bears reproduce slowly (DeMaster and Stirling 1981, Taylor et al. 1987, Amstrup and DeMaster 1988), and are largely faithful to denning substrate, even a limited continuing harvest in the early and mid-1900s could have prevented the re-establishment of land denning until now. Increases in numbers of polar bears in the western Chukchi Sea (Uspenski and Belikov 1991) and the large numbers of bears recently reported denning on the mainland Chukchi Sea coast of Russia (Stishov 1991) support the hypothesis of increasing numbers of land dens in Alaska and adjacent areas.

Lentfer and Hensel (1980) concluded that suitable denning habitat along Alaska's north coast is limited due to the lack of topographic relief. Our observations refute that conclusion. If polar bears in the Beaufort Sea region moved as far inland to den as bears do in Hudson Bay (Ramsay and Stirling 1990), they would find substantial variation in elevations, slopes, and aspects. Further, in many areas of the Alaskan North Slope, micro-relief is adequate to catch the snow needed for denning. Finally, factors other than topographic relief apparently affect capture of snow. Several dens were found, only because of telemetry, in an almost imperceptible series of swales, 30 km west of Kaktovik.

Productivity

Reported polar bear litter sizes have varied from 1.58 to 1.9 (Harington 1968, Stirling et al. 1977, Lentfer et al. 1980, Larsen 1985, Ramsay and Stirling 1988). By comparison, production in our study area of about 1 cub/den seems low. However, previous estimates of litter size did not include unsuccessful reproductive attempts. After excluding unsuccessful females, litter sizes we observed within 1 month of den exit averaged 1.6.

Harington (1968), Lønø (1970), and Lentfer and Hensel (1980) suggested that risks in denning on pack ice should make it a less preferred habitat for denning. A polar bear entering a den in pack ice cannot know the nature of habitat, availability of food, or geographic location where she will emerge months later. Also, currents, winds, or other factors related to the dynamics of pack ice can disrupt bears in dens. Polar bears using dens on the pack ice were subjected to risks caused by ice instability and movement, but we did not find that those risks reduced productivity. Low power of the Chi-square tests we performed indicated that conclusions regarding productivity of bears denning on land and pack ice must be viewed with caution.

Geographic Distribution of Dens

Patterns of polar bear denning we observed indicate that polar bears occurring across the mainland coast of Beaufort Sea in Alaska and Canada are from the same population, but female bears occurring east of 127°W may be segregated from those in the Beaufort Sea. Lentfer (1975*b*) concluded that polar bears occurring along Alaska's west coast were members of a population discrete from that along the northern coast. Our data indicated that segregation between bears of northern and western Alaska is less distinct than the segregation at the eastern end of the Beaufort Sea.

The northeastern corner of Alaska and adjacent Yukon Territory coast of northwestern Canada comprised 23% of the longitudinal range of the mainland denning area but accounted for 80% of the total mainland dens. The higher-than-expected use of this area raises management concerns because this part of the Arctic holds promise of large recoverable reserves of hydrocarbons (Weeks and Weller 1984). Overlap of exploration and development activities with polar bear denning and other activities has already occurred, and many of those activities have potential to disrupt polar bear denning (Stirling 1990, Stirling and Andriashek 1992).

Fidelity to Den Sites

The large and predictable concentrations of dens in some regions (Uspenski and Chernyavski 1965, Uspenski and Kistchinski 1972, Larsen 1985, Ramsay and Andriashek 1986, Ramsay and Stirling 1990) indicate high fidelity to maternity denning areas. Polar bears we followed by radio telemetry were faithful to denning substrate and to general geographic areas. They were not faithful, however, to particular places.

Our data on den distribution and fidelity of females to denning areas indicated there are both pack-ice and land-denning bears. Den sub-

strate switching appeared to be limited. This segregation may have begun when some females were prevented from reaching land in the fall. They continued to den on pack ice because of the philopatry we observed.

When all years were considered, denning polar bears preferred some areas over others, but no areas were used by collared bears in all years. Weather, ice conditions, and prey availability, all of which varied annually, probably determined where bears denned. Those annual variations and the long-distance movements of polar bears (Amstrup 1986, Garner et al. 1990) made seasonal recurrence at exactly the same location unlikely.

Limited data indicate that polar bears denning on the west shore of Hudson Bay have higher fidelity to previous denning sites than we observed (Ramsay and Stirling 1990). Polar bears in Hudson Bay are forced to remain on land between July and October of each year because sea ice there melts completely (Stirling et al. 1977, Ramsay and Andriashek 1986). While landlocked, they cannot forage and have much time to seek preferred denning locations. Because polar bears at higher latitudes continue to forage on the drifting pack ice until just before den entry, their locations at den entry time are less predictable.

Denning Chronology

Little information on den entry or emergence dates of polar bears has been available. Larsen (1985) reported that most dens on Svalbard were opened in late March and vacated by mid-April. Lentfer and Hensel (1980) reported late March and early April departure times in Alaska. Kolenosky and Prevett (1983) and Ramsay and Andriashek (1986) reported emergence in late February and early March in Hudson Bay. Lentfer and Hensel (1980) reported polar bears came ashore to den in late October and early November. Messier et al. (1992) reported den entry dates in early September and emergence in March and April for polar bears in the high Canadian Arctic. Those data may indicate a more protracted denning period at higher latitudes than we recorded (Table 2), but Messier et al. (1992) observed only 5 bears, and neither den occupancy nor outcome were visually confirmed.

Initiation of denning depends on sufficient snow accumulation to allow excavation of a den cavity. Timing of sea ice formation can also alter the onset of denning on land or sea ice. For dens on pack ice, entrance times and physical locations are especially dependent on ice type and consolidation. Dens must be in ice stable enough to stay intact for 81–164 days while being pushed by currents for hundreds of kilometers.

MANAGEMENT IMPLICATIONS

Contrary to previous hypotheses (Stirling and Andriashek 1992), substantial polar bear denning occurs in the Beaufort Sea region of northern Alaska and adjacent Canada. Bears that den on pack ice are subject to risks not encountered by bears that den on land. Unstable, moving ice caused early abandonment of dens and, apparently, loss of cubs. However, the persistence of pack-ice denning indicated that those risks are not overwhelming. Conversely, human perturbations, such as hunting or industrial activities, may have a disproportionately high influence on land-denning bears.

Most bears that denned on land selected sites in the northeastern corner of Alaska or adjacent Canada where oil and gas exploration has occurred or is likely (Weeks and Weller 1984, Stirling 1990). Fidelity to denning substrate suggests bear population recovery from perturbations that unequally affect land or pack-ice dens will be slow. For example, the increase we observed in land denning may have resulted from a decline in hunting of denning areas that began decades ago. The potential for disruptions of denning areas, therefore, should be of concern to managers of proposed developments. The absence of site fidelity, however, indicated that denning habitats are not limiting. The chronology of denning is predictable. Therefore, temporal and spatial management of hunting and industrial developments should mitigate many human impacts on denning bears.

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