DISPERSAL PATTERNS OF MATERNAL POLAR BEARS FROM THE DENNING CONCENTRATION ON WRANGEL ISLAND

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Abstract: Twenty-one female polar bears (*Ursus maritimus*) accompanied by cubs of the year were fitted with satellite transmitters upon emergence from maternal dens on Wrangel Island during spring 1990. Movements during the following year indicated no subsequent geographic segregation in the Chukchi or East Siberian seas of females that denned in various regions of Wrangel Island. Movements encompassed the eastern half of the East Siberian Sea, the entire Chukchi Sea, extreme western portions of the Beaufort Sea, and portions of the Bering Sea lying north of Saint Matthew Island. One-third of the marked females over-wintered in the active shear zone, which lies along the northern shoreline of the Chukotka Peninsula in Soviet territory.

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Wrangel Island in the eastern Russian arctic is known as a denning concentration area for maternal polar bears (Uspenskii and Kistchinski 1972, Belikov 1977, Belikov et al. 1977, Belikov 1980). Lentfer (1975) first proposed, and Garner et al. (1990) later documented that the polar bear population in western Alaska was shared with Russia. Females captured in western Alaska have denned on Wrangel Island (Garner et al. 1990). In contrast, few dens have been recorded on the western coast of Alaska (Lentfer and Hensel 1980, Amstrup and Gardner 1994) and most dens recorded in the Beaufort Sea have been on drifting sea ice (Amstrup 1987). Lentfer (1983) indicated that movement patterns of females that den on Wrangel Island were important in determining the population ecology of the Chukchi population.

A cooperative U.S.-U.S.S.R. polar bear research program was initiated in 1989, and during spring 1990 U.S. and Soviet scientists marked females emerging from maternity dens on Wrangel Island. Data presented in this paper characterize movement patterns of those maternal females and test the hypothesis that bears denning in discrete regions of the island are members of subpopulations that remain segregated throughout the year.

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STUDY AREA

The study area consisted of Wrangel Island and the seasonal and permanent polar pack ice in the Bering, Chukchi, and East Siberian seas (Fig. 1). Wrangel Island lies approximately 140 km northeast of the Russian mainland. The climate is harsh with temperatures below -30°C being common during winter. Northerly winds exceeding 30 km/hr are typical during winter and are responsible for the southeasterly flow of the ice pack during winter and spring.

Ice conditions in the Bering and Chukchi seas change in a cyclic pattern and polar bear distributions are influenced by these seasonal ice movements (Burns et

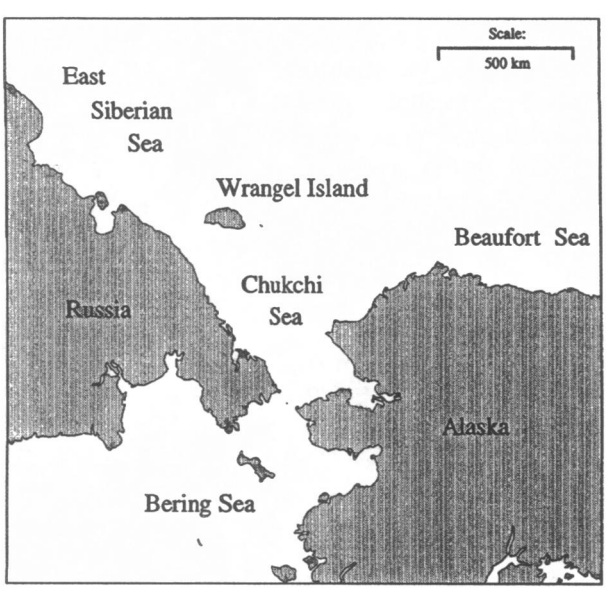

Fig. 1. Study area in U.S. and Russian territory.

al. 1981, Garner et al. 1990). The winter ice pack in the Bering and Chukchi Seas is dynamic, as the southerly flow in the Chukchi Sea is compressed between the Seward Peninsula of Alaska and the Chukotka Peninsula of Russia. In late summer, when the ice pack is at a minimum, the entire Bering Sea and most of the Chukchi and East Siberian Seas are ice-free.

METHODS

Capture and Marking

Bears were captured during 26 March-2 April 1990 using helicopter immobilization procedures (Lentfer 1968, Larsen 1971, Schweinsburg et al. 1982) and remote projectile injection of Telazol (Haigh et al. 1985, Stirling et al. 1989). Tranquilized bears were measured and weighed, blood-samples were obtained, and a vestigial premolar tooth was extracted for aging by cementum annuli (Hensel and Sorensen 1980). Cubs of the year (COY) were measured, weighed, and marked with ear tags and lip tattoos. Physical condition of each female was estimated visually based upon the level of subcutaneous fat present.

Adult females were fitted with satellite telemetry collars (Telonics Inc., Mesa, Arizona) that transmitted for 7 hours every 3 days. The satellite telemetry system has been described in detail by Fancy et al. (1988) and Harris et al. (1990). Telemetry locations provided by the Argos Data Collection and Location System (Argos) are assigned a location quality code of 0-3 representing a presumed level of precision (Harris et al. 1990). Precision (i.e., standard deviation of a series of locations of stationary transmitters), as reported by Argos, was 1,000, 350, and 150 m for location quality codes 1, 2, and 3, respectively. Precision was undetermined for location quality code 0. No data are available for determining locational error of ice-based satellite collars. For this study, 1 location per bear per 3-day duty cycle was selected based upon the highest location quality code available. When ≥ 2 locations within a day had equal quality codes, the location closest to the previous day's location was selected. Expected battery life was 18 months, although realized battery life usually was shorter (Garner et al. 1989).

Dispersal, Movements, and Post-Denning Distribution

Bears were categorized on the basis of their capture location within 3 subregions of Wrangel Island (eastern, central, or western; Fig. 2). The direction of initial dispersal from the island was the bearing from the capture location of each bear to the first location of the bear during May and was calculated using the arc of the great circle connecting the 2 points (Buchanek and Bergin 1976:248). The mean direction of initial dispersal for bears marked within each subregion was calculated and tested for differences between subregions using Rayleigh's z statistic (Batschelet 1981, Zar 1984:443). Subsequent temporal geographic distributions of bears relative to their capture locations were examined by plotting the first location of each bear during each month from May 1990 through March 1991.

Five seasonal categories were established for analytical purposes based upon the temporal dynamics of sea ice (immediate post-denning, receding ice, minimum ice, advancing ice, and maximum ice). The immediate post-denning period included the months of March and April, which may be a critical period for family groups as the female must obtain sufficient food to replace her depleted fat reserves and to sustain rapid cub growth. The remaining 4 periods represent broad categories of sea ice conditions during 1990 and early 1991: receding ice, 1 May through 15 August; minimum ice, 16 August through 15 October; advancing ice, 16 October through 31 December; maximum ice, 1 January through 31 March 1991. The cumulative distance moved by each bear during each period was calculated by summing the great circle distances between consecutive locations (1 location per 3-day duty cycle).

Proximity to Ice Edge

The extent of ice coverage and the position of the edge of the polar ice pack were determined for 19 dates between 1 April 1990 and 12 February 1991 using weekly ice summaries prepared by the Navy-National Oceanic and Atmospheric Administration Joint Ice Center (JIC). Dates were selected at approximately 2-4 week intervals during relatively cloud-free periods. The ice edge was defined as the boundary between ice-free waters and areas with at least some ice (based on JIC classification). This information was plotted on a base map, digitized, and entered into the ARC/INFO Geographic Information System. The location of each bear within ± 3 days of a set of ice edge data was plotted with the corresponding ice edge data. The distance from each of these bear locations to the nearest ice edge was determined using ARC/INFO routines.

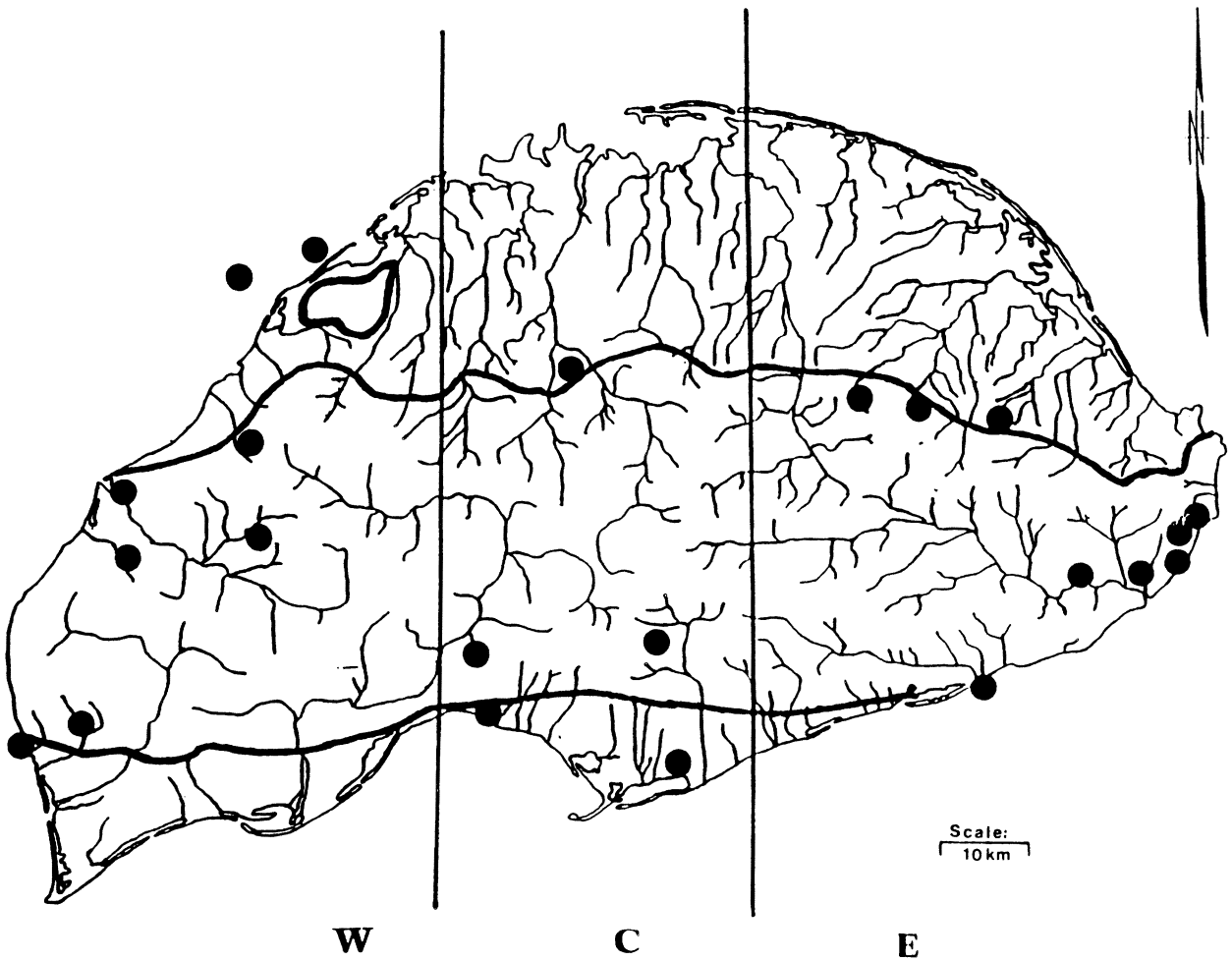

Fig. 2. Wrangel Island showing capture locations (large dots), mountainous areas (enclosed by dark lines), and the 3 subregions of the island (east, central, and west).

RESULTS

Capture and Marking

Twenty adult female polar bears and 39 accompanying COYs (mean litter size = 1.96 COYs) were captured between 26 March and 2 April 1990 (Table 1). In addition, 1 nonlactating female and 1 lactating female not accompanied by COYs were also captured. All captures occurred on Wrangel Island or on the shore-fast ice adjacent to the island. All adult females were fitted with satellite collars; however, 1 collar failed immediately, reducing effective sample size to 21.

Dispersal, Movements, and Post-Denning Distribution

Initial dispersal of bears from the denning areas on Wrangel Island indicated that subregional differences existed. Bears captured in the eastern subregion of Wrangel Island (Fig. 3) initially dispersed toward the east (mean bearing = 99°, Rayleigh's $z = 5.307$, $n = 9$, $P < 0.005$). However, initial dispersal from the central (100°) and western (246°) subregions were not significantly different from a random distribution of bearings ($z = 2.333$ and 0.941; $n = 5$ and 7, for central and western subregions, respectively; $P > 0.10$). Three of 5 bears from the central subregion dispersed toward the east, whereas no bears from the western section dispersed to the east. Conversely, no bears from the central or eastern subregions dispersed to the west, whereas 3 of 7 bears from the western subregion dispersed to the west.

Similar differences in distributional patterns between bears marked within the various subregions were evident during May, June, and July. During this period, 12 of 14 bears from the eastern and central

Table 1. Characteristics of female polar bears marked on Wrangel Island, spring 1990.

Animal number	Age	No. COYs	Tracking period Start date	Tracking period End date	Comments
6777	7	1	30 Mar 90	1 Jul 91	collar failed
6787	8	0	2 Apr 90	2 Apr 90	collar failed
6864	11	2	25 Mar 90	6 Feb 91	lost COYs, denned 91
6865	23	3	26 Mar 90	22 Aug 90	collar failed
6866	17	0	26 Mar 90	20 Jun 91	collar failed
6867	12	2	26 Mar 90	15 Jul 90	collar failed
6868	10	2	26 Mar 90	22 Sep 90	collar failed
6869	17	2	27 Mar 90	22 Sep 90	collar failed
6870	10	2	27 Mar 90	30 Oct 90	
6871	18	2	27 Mar 90	31 Mar 91	lost COYs, denned 91
6872	11	2	27 Mar 90	29 Mar 91	1 yrlg, shot Mar 91
6873	7	2	28 Mar 90	31 Jul 90	collar failed
6874	8	2	28 Mar 90	29 Mar 91	
6875	9	2	28 Mar 90	31 Mar 91	lost COYs, recap 91
6876	6	2	29 Mar 90	28 Mar 91	lost COYs, recap 91
6877	5	1	29 Mar 90	18 Oct 90	collar failed
6878	12	2	29 Mar 90	24 Dec 90	lost COYs, denned 91
6879	10	3	29 Mar 90	24 Mar 91	lost COYs, denned 91
6880	12	2	29 Mar 90	30 Sep 90	collar failed
6881	9	2	30 Mar 90	31 Mar 91	2 yrlg, recap 91
6882	10	2	1 Apr 90	31 Mar 91	lost COYs, shot Mar 91
6883	7	1	1 Apr 90	10 Jan 91	collar failed

subregions were located southeast or east of Wrangel Island, whereas 5 of 7 bears captured in the western subregion were found along the western coast of the island or to the south (Fig. 4). Short-term exceptions to this pattern existed with 1 central bear moving west, 1 western bear moving east, and 1 central and 1 western bear moving north during May. However, by 1 September these differences had disappeared, when

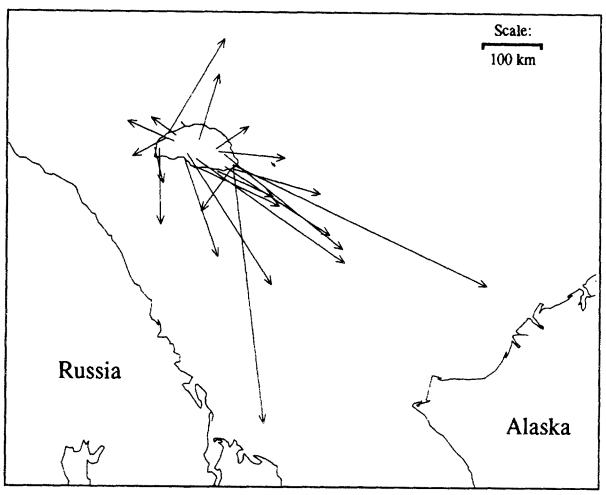

Fig. 3. Initial dispersal of maternal females from the denning concentration on Wrangel Island, spring 1990.

all but 2 bears occupied a similar area along the edge of the ice pack to the north of Wrangel Island. The 2 exceptions were 1 bear on Wrangel Island and another bear on the Chukotka mainland east of Pevek, both apparently stranded when the ice pack receded rapidly during August.

Average cumulative distances moved and 24-hr rates of movement by marked bears varied throughout the year, with the shortest distances and daily rates of movement recorded during the immediate post-denning period (Table 2). Distances and rates were highest during the periods of receding and advancing ice, especially during November. Distances and rates of movement were intermediate during the 2 periods of relatively stable ice conditions (minimum and maximum ice).

Eight bears carried functional radios and were monitored >300 days during the year following capture on Wrangel Island (Table 3). The average total annual distance moved was 6,022 km (SE = 388 km), which is higher than the annual movement of 5,542 km reported for bears marked in western Alaska (Garner et al. 1990).

All 8 females monitored >300 days were accompanied by 2 COYs at the time of initial capture, but only 1 female was accompanied by 2 yearling cubs when recaptured during spring 1991 (Table 1). Two females were alone when recaptured during spring 1991, while another female was captured with 2 COYs in a den on Wrangel Island during spring 1991. Another female was reportedly alone when shot at Point Hope, Alaska, in late March 1991. One female was

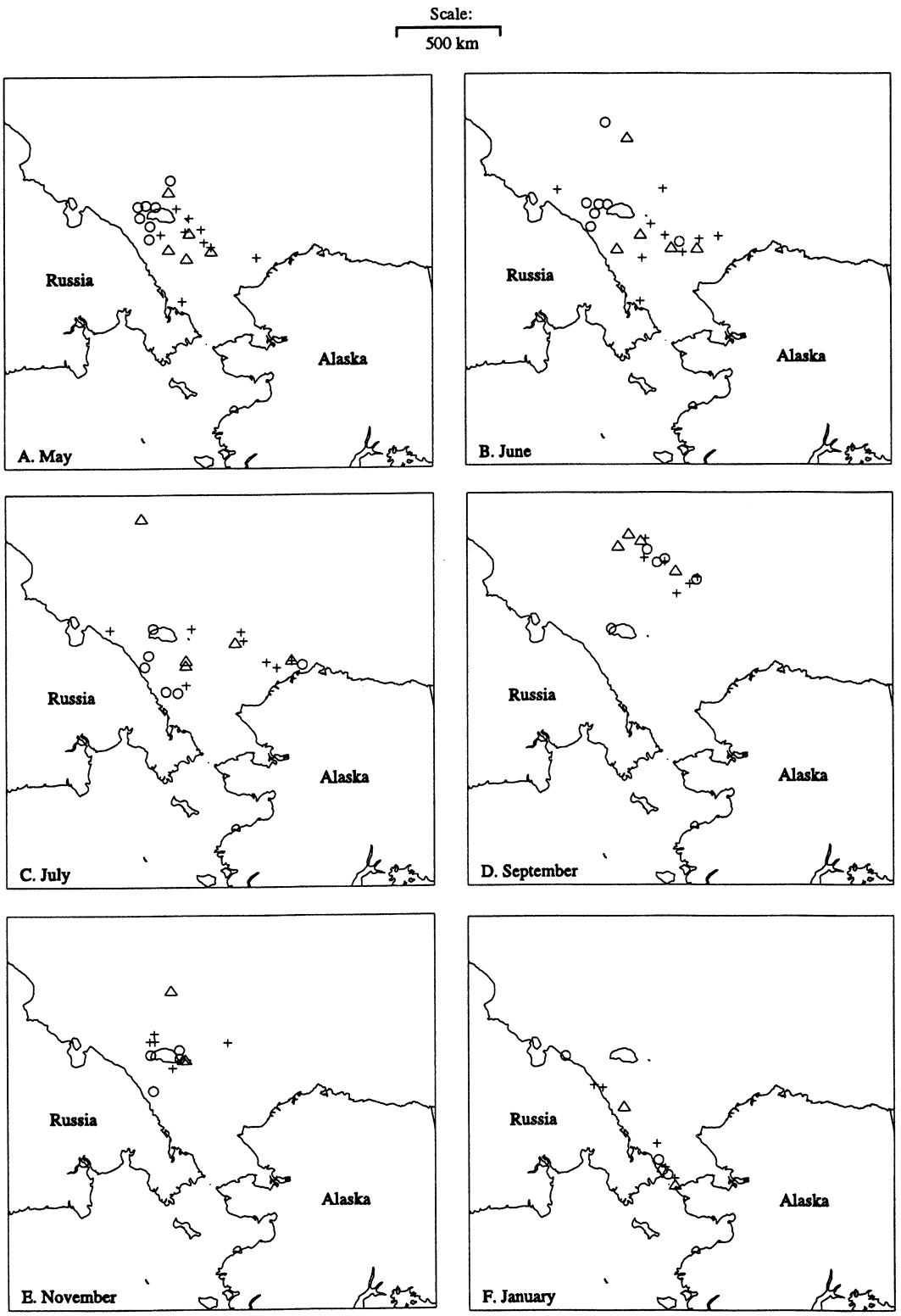

Fig. 4. Distribution of female polar bears originally marked in eastern (crosses), central (triangles), western (circles) subregions of Wrangel Island on selected dates: A. 1 May 90 B. 1 Jun 90 C. 1 Jul 90 D. 1 Sep 90 E. 1 Nov 90 F. 1 Jan 91.

Table 2. Monthly and seasonal cumulative movements and average rates of movement between March 1990 and March 1991 for maternal female polar bears marked on Wrangel Island.

Month/period	No. bears	Cumulative distance (km) mean	Cumulative distance (km) SE	Rate of movement (km/24 hr) mean	Rate of movement (km/24 hr) SE
Post-denning[a]	21	270.9	28.5	8.5	0.9
Mar 90	19	26.2	8.3	7.6	2.6
Apr 90	21	247.2	26.6	8.6	0.9
Receding ice[b]	21	1,399.1	85.5	13.9	0.6
May 90	21	341.9	24.5	11.1	0.8
Jun 90	21	440.5	33.7	15.3	1.1
Jul 90	20	454.9	37.9	15.2	1.0
Aug 90	17	530.2	55.9	17.8	1.6
Minimum ice[c]	17	990.2	96.5	18.5	1.5
Sep 90	16	541.9	48.0	17.3	1.4
Oct 90	14	481.4	47.6	16.3	1.5
Advancing ice[d]	14	1,286.2	150.3	18.9	1.3
Nov 90	12	798.9	51.2	26.4	1.8
Dec 90	11	425.4	49.2	14.0	1.5
Maximum ice[e]	11	1,054.4	214.5	12.9	2.2
Jan 91	11	379.9	73.7	11.9	2.1
Feb 91	10	344.1	74.3	15.6	3.6
Mar 91	9	422.0	83.1	14.2	2.9

[a] 26 Mar-1 May 1990.
[b] 1 May-15 Aug 1990.
[c] 16 Aug-15 Oct 1990.
[d] 16 Oct-31 Dec 1990.
[e] 1 Jan-31 Mar 1991.

accompanied by 1 yearling when recaptured during March 1991, but this female was shot at Gambell, Alaska, 2 weeks after recapture. Two of the 8 females were not observed after initial capture in 1990, and the fate of their cubs is unknown.

Proximity to Ice Edge

Mean distance from bears to the edge of the ice (Table 4) decreased from 1,120 km on 1 May (when bears were on Wrangel Island and the ice pack was near its maximum extent) to 55 km (excluding 2 bears that were stranded on land when the ice pack receded) on 4 September 1990 (the approximate minimum extent of ice coverage). Mean distance then increased to 715 km by 12 February 1991 as 4 bears followed the ice

Table 3. Minimum distances traveled between March 1990 and March 1991 by 8 female polar bears that did not den during winter 1990-91.

Bear number	Total days	Tracking period	Minimum total distance (km)
6864	318	25 Mar 90-6 Feb 91	5,443.4
6870	369	27 Mar 90-31 Mar 91	4,947.6
6872	378	27 Mar 90-29 Mar 91	7,141.3
6874	366	28 Mar 90-29 Mar 91	7,659.6
6875	368	28 Mar 90-31 Mar 91	6,282.2
6876	364	29 Mar 90-28 Mar 91	6,764.3
6881	366	30 Mar 90-31 Mar 91	5,247.7
6882	364	1 Apr 90-31 Mar 91	4,691.8

Table 4. Average distance from marked bears to the nearest ice edge for selected dates between April 1990 and February 1991.

Date	*n* Bears	Distance to ice edge (km) Mean	SE	Minimum	Maximum
1 Apr 90	21	1,039.9	5.4	991.5	1,087.5
1 May 90	21	1,120.2	21.9	860.4	1,322.7
1 Jun 90	21	920.0	38.8	569.2	1,366.3
19 Jun 90	21	377.2	16.3	216.6	557.6
3 Jul 90	21	377.2	16.3	216.6	557.6
10 Jul 90	19	115.1	20.0	1.9	292.0
31 Jul 90	17	75.1	18.5	8.2	255.1
14 Aug 90	15	63.2	12.9	6.6	170.2
21 Aug 90	15	77.8	7.6	34.9	137.1
28 Aug 90	11	57.4	11.9	1.7	135.8[a]
4 Sep 90	14	55.0	10.4	11.9	160.3[a]
9 Oct 90	13	61.8	9.3	19.4	114.4[a]
16 Oct 90	13	159.5	13.4	41.8	222.4
22 Oct 90	13	118.6	16.5	49.2	266.4
13 Nov 90	12	203.8	34.6	85.4	490.8
27 Nov 90	12	469.6	97.8	15.9	1,190.3
11 Dec 90	11	586.0	87.7	398.5	1,387.0
8 Jan 91	10	707.0	32.8	602.5	933.0
12 Feb 91	8	715.1	81.1	477.0	1,125.6

[a] Bear numbers 6871 and 6880 were stranded on land during this time period and omitted from calculation of mean distance to the ice edge.

edge south through the Bering Straits to the vicinity of St. Lawrence Island, while others remained on sea ice of the Chukchi Sea along the coast of the Chukotka Peninsula or denned on Wrangel Island or on the northern coastline of the Chukotka Peninsula. Variability in distance also was lowest during August and September, when bears were found closest to the edge of the ice pack.

DISCUSSION

Polar bear cubs are well adapted to survive arctic conditions at the time of den emergence (Blix and Lentfer 1979), provided that the maternal female can obtain sufficient nutrients for body maintenance and rapid growth of her cubs. Time of attendance at the den site after the den is opened by the female may be an indication of the level of nutrient depletion in the maternal female. In Svalbard, time of den attendance averaged 2 weeks, with 1 female remaining at the den for 27 days (Hansson and Thomassen 1983). Kolenosky and Prevett (1983) reported a 2-to 3-week den attendance period along the northern coast of Ontario. In contrast, Uspenskii and Kistchiniski (1972) reported den attendance times varied from 1 to 7 days on Wrangel Island. In the current study, 14 of the 20 captured maternal females were in poor or very poor physical condition, and females moved rapidly away from the denning area onto the sea ice. However, the time between when they first opened or emerged from the maternal den and when they were captured was not known.

Movement rates of marked females was low during this initial dispersal period from the maternal denning area on Wrangel Island. During this period, bears used sea ice habitats in the vicinity of Wrangel and Herald Islands, and more distant sea ice habitats to the southeast of the 2 islands (Fig. 3). Differences in the initial dispersal direction were likely due to bears taking the most convenient route off the island, similar to the direct routes reported for coastal Ontario (Kolenosky and Prevett 1983) and northeastern Manitoba (Ramsay and Andriashek 1986). However, the tendency of bears to remain near the western coast of Wrangel Island while bears to the east moved farther offshore may indicate the presence of a nearby food source on the west side of the island that is probably not present on the east side. Prey species in these areas are assumed to be in sufficient numbers to sustain the maternal females and their cubs; however, no data are available to confirm this assumption. Of 10 family groups accompanied by 21 COYs captured on Wrangel Island during spring 1990 whose fate is known by recapture, resighting, or evident denning the following winter, only 3 COYs survived to 1 year of age (Table 1). This low survival of cubs may be related to the poor physical condition of many of the maternal females captured on Wrangel Island during spring 1990 or a lack of available prey during the immediate post-denning period. Uspenskii and Kistchinski (1972) and Belikov et al. (1977) reported that maternal females sometimes ate their cubs when food sources were not readily available.

Seasonal distribution patterns indicated that marked bears spread across the southern Chukchi Sea during early summer, then remained in an area north of the Chukotka Peninsula between Kuluchin Bay and the Bering Straits until the ice edge receded into the area (Fig. 5). The marked bears then moved north as the ice receded during summer. Unlike polar bears in Hudson Bay that become stranded on land during summer (Stirling et al. 1977, Latour 1981, Lunn and Stirling 1985), most polar bears in the Chukchi Sea remain on the sea-ice throughout the year (Garner et al. 1990; Fig. 5 this study).

Smallest distances to ice edge and least variability in distance during late summer indicate either that the ice edge itself provides good habitat, or that the best habitats are the active ice areas of the Chukchi Sea, relative to the permanent ice pack. The minimum extent of the ice pack in August and September 1990 was located farther north than in most years. This far northern retreat of the ice pack may have influenced movements of marked bears, as evidenced by the congregation of bears near the ice edge in September and the 2 bears that were stranded on land when the ice suddenly retreated in August 1990. The value of the habitat at the edge of the ice pack relative to the permanent pack of the Chukchi Sea is unknown. However, the speed with which marked bears moved southward when ice advanced back into the southern Chukchi Sea in November suggests that the active ice may provide better foraging conditions or more abundant prey than the permanent pack ice. If this hypothesis is correct, then years when the pack ice retreat is exceptionally great may reduce foraging opportunities, and perhaps cub survival.

The broad geographic area occupied by polar bears of the Bering and Chukchi Seas, the seasonal diversity and dynamic nature of the sea ice habitat, and the remoteness of the area present challenges to studies using traditional methods. However, the need for such studies is evidenced by the low cub survival in this study and the vulnerability of adult bears to human-

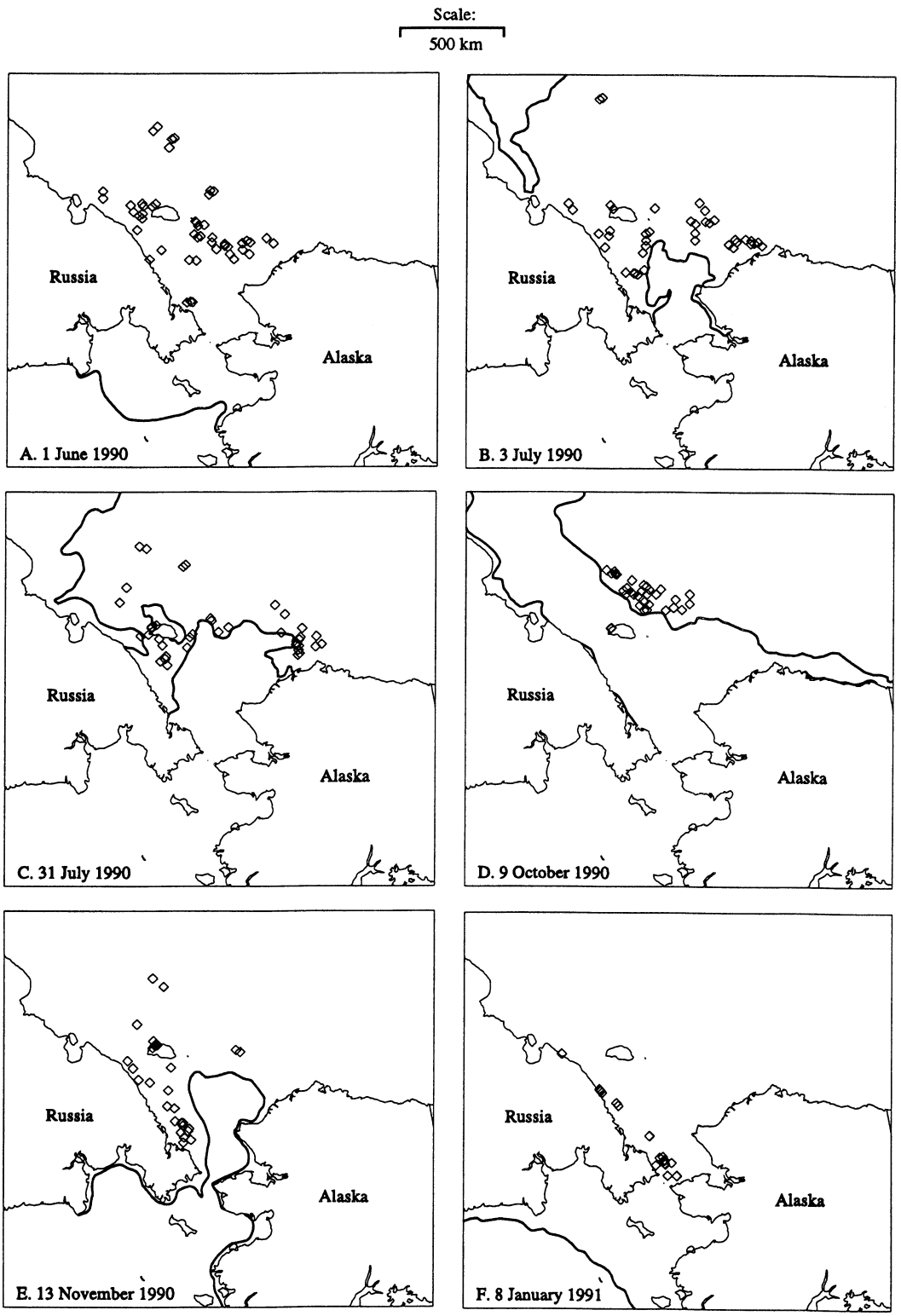

Fig. 5. Distribution of marked female polar bears (squares) relative to the ice-edge (heavy line) on selected dates: A. 1 Jun 90 B. 3 Jul 90 C. 31 Jul 90 D. 9 Oct 90 E. 13 Nov 90 F. 8 Jan 91.

induced pressures, including harvest. If the congregation of bears near the ice edge during late summer is a common occurrence, then this period would be the most opportune time to conduct surveys to estimate population size and recruitment. Such a survey could serve as a basis for management decisions and to direct further research.

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