POLAR BEARS OF THE SEVERNAYA ZEMLYA ARCHIPELAGO OF THE RUSSIAN ARCTIC

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Abstract: The Severnaya Zemlya Archipelago was visited by Russian explorers during 1930–32, and observations of polar bears (*Ursus maritimus*) were first recorded incidental to expedition members hunting polar bears for food and fur. A joint Russian, Norwegian, and U.S. research effort on polar bear ecology in the Severnaya Zemlya Archipelago was initiated in 1991. A total of 11 bears were captured, including 5 adult females which were fitted with satellite collars. Two satellite collars failed soon after deployment (≤25 locations), but 3 units functioned for an extended period of time (>50 locations). A majority of the movements were confined to the eastern Kara Sea, but 1 bear moved into the western Laptev Sea before returning to the eastern edge of the Kara Sea near Cape Cheluskin. One bear had a very restricted movement pattern closely associated with the 2 northwestern islands in the Severnaya Zemlya group (Komsomolets and Pioner Islands). The combined locations for the 5 collared bears depict an overall range that is centered around the Severnaya Zemlya Archipelago. Minimum estimates of distances traveled for 3 bears with >50 locations averaged 4,183 km. The daily rates of movement for the study period varied between bears and ranged between 6.4 and 14.7 km/day. The rate of movement during minimum sea ice cover was the highest (12.7 km/day) for 4 defined periods, while rates of movement for the other 3 periods were very similar (8.5–9.3 km/day). Polar bears in this region of Russia do not move long distances to maintain contact with the sea ice, in contrast to polar bears in the Chukchi Sea in eastern Russia which move over large areas to maintain contact with the sea ice throughout the year.

Ursus 10:33–40

Key words: Kara Sea, Laptev Sea, movements, polar bear, sea ice, Severnaya Zemlya, *Ursus maritimus.*

The Severnaya Zemlya Archipelago was discovered in September 1913 by a Russian hydrographic expedition, but only the approximate shape of the eastern shore of the archipelago was mapped. The first expedition to map the Severnaya Zemlya Islands occurred during 1930–32. The archipelago was uninhabited prior to this effort. The 4-man expedition was based on Domashni Island, a small island in the western part of the archipelago. Mapping was accomplished during 2 trips by researchers that circumnavigated the islands using dog teams and sleds. The diet of expedition team members and dogs included the meat of ringed seals (*Phoca hispida*), white whales (*Delphinapterus leucas*), and polar bears (*Ursus maritimus*). Urvantsev (1935:122) summarized information collected on polar bears during the expedition:

> In winter, approximately from December to March, when sea surface is frozen, polar bears move south of Severnaya Zemlya. However some bears stay in the region. In the second year of the expedition, ice conditions were not so hard as a year before, there was a lot of open water and bears were met more often. Maternity dens were found only in the southern part of Severnaya Zemlya. Total 105 bears were hunted during the expedition, 66 were adult males, 24 single females, 6 females with cubs, and 9 cubs. No bears were hunted in January, 1 in February, 15 in March, 11 in April, 14 in May, 11 in June, 9 in July, 15 in August, 14 in September, 9 in October, 4 in November, and 2 in December. A total of 78 of all bears killed were in a vicinity of the expedition base. High number of bears killed in August and September was not conditioned by especially high density of bears in these months. The cause was that this was time for getting food supply before wintering. Bears were met more often in May when they migrated north from the Taimyr Peninsula shore. In this month paths of bear's tracks of north direction were observed near western capes of Komsomolets and Pioner islands.

Additional information on polar bears of the region has been obtained by polar station personnel on the mainland shore and within the islands. Almost all information on

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polar bears was obtained incidental to bear hunting. During the initial development of this region, polar bears were considered harmful animals that damaged human property (Koshkin 1937). Normally, bears were killed when they approached polar stations and settlements, and there was little effort to hunt bears on the sea ice. Polar bears visited settlements in the region during all seasons, but observations were rare during winter. The dearth of observations may be attributable to both females and males using over-winter dens, as reported by Popov (1939) and Rutilevski (1939) in the Taimyr Peninsula area. According to Rutilevski (1939) all bears used dens, but the duration of denning appeared to depend on age, sex, and status of the animals. Young bears weaned the previous spring and adult males stay in dens about 50 days. Females with yearling cubs stay in dens about 100 days, while barren females occupy dens for 115–125 days. Parturient females remain in maternity dens for 160–170 days.

The distribution and migration of polar bears in the Severnaya Zemlya region appear dependent on ice conditions and abundance of prey species (primarily ringed seals and bearded seals, *Erignathus barbatus*). It is believed that the majority of polar bears move north following the receding ice during the summer months and return south during early winter with the advancing ice. In addition, bears searching for seals move locally (Kirpichnikov 1938, Popov 1939, Rutilevski 1939). Some bears remain in restricted areas, often associated with shoreline or islands. Rutilevski (1939) reported that polar bears were observed near Cape Cheluskin throughout the year. Ice conditions of the Vilkitski Strait may determine the presence of bears near Cape Cheluskin by influencing the abundance of prey. In May and June, bears moved west along the shoreline where seals are abundant in the fast ice. During 1933 approximately 350–400 bears passed near Cape Cheluskin, and 53 bears were killed there between October 1932 to 10 September 1933. Polar bear hunting in the archipelago continued incidental to other activities through 1956, when hunting of polar bears was prohibited throughout the entire Russian Arctic due to concerns of population depletion.

The first organized Russian research on polar bears in the Severnaya Zemlya Archipelago was conducted in 1982 when the 4 largest islands were surveyed during a 4-day period. Seven dens were found, and females with cubs occupied 3 (Belikov and Randla 1987). The survey was not replicated and occurred during a portion of the den emergence period; therefore, extrapolation to total denning population during the 1981–82 winter is not possible.

A joint research project between Russian, Norwegian, and American scientists on polar bear ecology in the Severnaya Zemlya Islands of the east-central Russian Arctic was initiated during May 1991. The objective of the research was to determine movement patterns of polar bears near the Severnaya Zemlya Archipelago and to define the areas occupied by this population.

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STUDY AREA

The study area consisted of the Severnaya Zemlya Archipelago and the seasonal and permanent polar pack ice in the adjacent Laptev and Kara Seas (Fig. 1). The archipelago lies approximately 50 km north of the Taimyr Peninsula on the Russian mainland. The climate is harsh with winter temperatures frequently below -30 C, accompanied by prevailing northerly winds often exceeding 30 m/sec.

Ice conditions in the Laptev and Kara Seas are severe, with ice forming during early September (Fig. 1A) in the presence of the remaining remnant ice. In Vilkitski Strait, the average ice accumulation in October–January is 7–11 cm/10 days; in February–April, 5–7 cm/10 days; and in May, 1–3 cm/10 days. Ice thickness near Cape Cheluskin by 1 January is approximately 88 cm, by 1 March, 140 cm, and by 1 June, 172 cm.

Shorefast ice is usually completely formed by Sep.–Oct. and persists through June. In the northeastern Kara Sea, fast ice is extensive because of numerous islands. Along the eastern coasts of the archipelago, the shorefast ice zone is comparatively narrow (Fig. 1B). Multi-year ice as well as icebergs are often included in fast ice along the shores of the archipelago. In some years multiyear fast ice occurs in bays and straits of the archipelago. Ice cover consists mainly of ice formed during fall. The proportion of 2-year and multiyear ice in fields is about 3–5%. Hummocked ice is more common near shore.

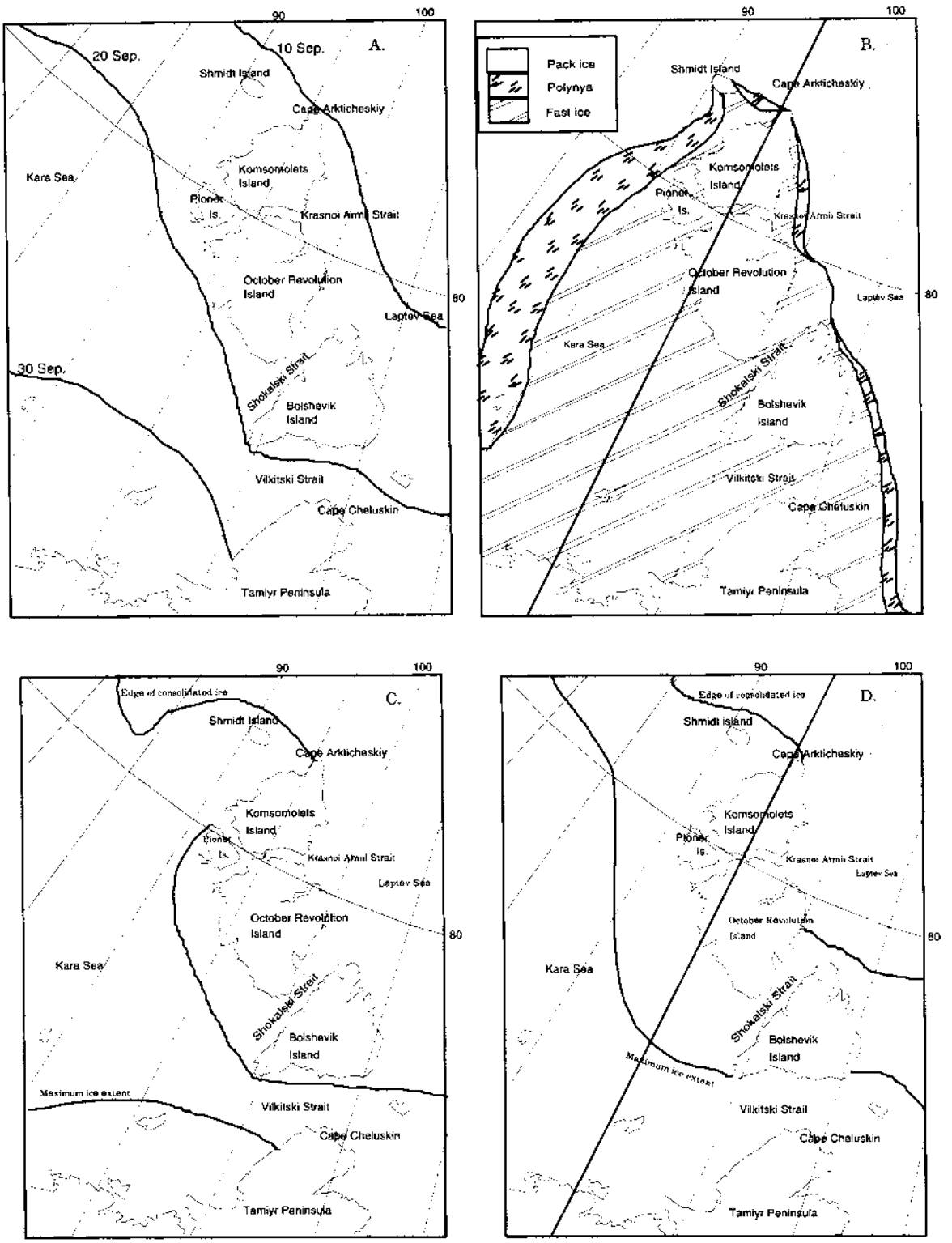

Fig. 1. Average seasonal sea ice conditions in the Severnaya Zemlya Archipelago, Russia. A. Periods of stable ice formation. B. Limits of fast ice and polynyas at the end of May. C. Position of southern ice edge and southern edge of consolidated ice during late August. D. Position of southern edge of remnant and solid remaining ice in late September.

Winds perpendicular to the shoreline cause the appearance of polynyas, which may be ice free or covered by young ice. In February–June, polynyas are present about 50% of the time to the west of the archipelago. East of the Severnaya Zemlya Archipelago, polynya occurrence decreases from 90% in February to 20% in June.

In Vilkitski Strait, the sea ice usually begins melting by mid-June, and near Cape Arcticheski, during late June. By the end of June about 10–20 cm of the sea ice has melted. By mid-August almost all of the shorefast ice is broken. However, the Severnaya Zemlya region usually does not become completely ice free. Remnant ice fields, which include solid ice, remain near the eastern and western sides of the archipelago through the end of summer (Figs. 1C and 1D). The active process of ice breakup takes place during summer. In August, 10–30% of the area may remain ice covered in the region. This ice cover usually consists of fragments of ice fields and broken ice.

METHODS

Capture and Marking

Bears were captured 10–15 May 1991 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, weighed using a spring scale, blood-samples were drawn, and a vestigial premolar tooth was extracted for aging by counts of cementum annuli (Hensel and Sorensen 1980). Cubs-of-the-year (COYs) were measured, weighed, and marked with ear tags and lip tattoos.

Adult females were marked with lip tattoos and ear tags and fitted with satellite telemetry collars (Telonics Inc., Mesa, Ariz.) that transmitted for 7 hours every 5 days (2 bears) or 6 hours every 6 days (3 bears). The satellite telemetry system has been described in detail by Fancy et al. (1988) and Harris et al. (1990). One location/bear per 5- or 6-day duty cycle was selected based upon procedures described by Arthur et al. (1998). Expected battery life was 24 months, although realized battery life usually was shorter (Garner et al. 1989).

Movements and Sea Ice Information

Data were pooled into 4 seasonal categories for analysis based on the temporal dynamics of sea ice in the Severnaya Zemlya region (maximum ice, receding ice, minimum ice, and advancing ice). The 4 periods represent broad categories of sea ice conditions during 1991–93: maximum sea ice 16 October–31 May; receding sea ice 1 June–15 July; minimum sea ice 16 July–15 September; and advancing sea ice 16 September–15 October. Cumulative distance moved by each bear was calculated by summing the great circle distances between consecutive locations (1 location/5- or 6-day duty cycle).

Daily rates of movement (km/24 hours) were calculated from the movement data by dividing the distance between consecutive locations for a bear by the time interval in hours. Rates of movement were tested for differences between individuals and seasons using analysis of variance procedures (ANOVA; Steel and Torrie 1980). When differences were detected, the Student-Newman-Kuel (S-N-K) multiple comparison test procedure was used to define which differences were significant (Steel and Torrie 1980).

Concurrent ice information was synthesized from ice data collected during aerial ice reconnaissance surveys conducted by the Russian Hydrometerological Service, and remotely sensed ice data that was collected by Russian satellites. Information was summarized using the standardized Russian procedures for interpretation of sea ice data (Volkov 1981) and plotted on maps for comparison to polar bear movements.

RESULTS

Capture and Marking

Four adult female polar bears and 6 accompanying COYs (mean litter size = 1.5, SE = 0.29) were captured (Table 1). In addition, 1 non-lactating female (N7988) accompanied by 2 adult males was also captured. Two bears were collared near the southwestern region of the Severnaya Zemlya Islands, while the remaining 3 bears were collared farther south near the Russian mainland (Fig. 2). Bear densities were low with a total of 23 bears (including COYs) sighted during 59 hours and 20 minutes of aerial searching.

Movements and Sea Ice Information

Cumulative distances moved for 3 bears that were tracked for >1 year were similar (Table 2), but the daily rates of movement differed between bears (ANOVA, $P < 0.0005$). Multiple comparison tests (S-N-K, $P < 0.05$) indicated that bear N7982 moved at a higher daily rate than the other 4 bears (Table 2), but the reason for this difference is unknown. Daily movement rates of the non-lactating female (N7898) did not differ from movement rates of 3 females captured with cubs-of-the-year (N7980, N7984, and N7986; Table 2). Rates of movement between seasons (Table 3) also differed (ANOVA,

Table 1. Characteristics of bears captured and marked near the Severnaya Zemlya Archipelago, Russia, May 1991.

Animal No.	Age/sex	Weight (kg)	Length[a] (cm)	Chest girth (cm)	Date
N7980	10/F	148	218	119	10 May
N7981L	COY[b]/M	10	79	50	10 May
N7981R	COY/M	9	74	44	10 May
N7982	8/F	160	207	116	11 May
N7983	COY/F	14	70	48	11 May
N7984	7/F	185	194	122	14 May
N7985	COY/M	20	105	65	14 May
N7986	13/F	192	193	128	15 May
N7987R	COY/F	28	112	66	15 May
N7987L	COY/M	32	112	66	15 May
N7988[c]	4/F	160	174	116	15 May

[a] Length for adults is straight line; length for COYs is total length.
[b] Cubs of the year.
[c] Non-lactating female.

$P = 0.085$), with rates of movement during the period of minimum ice cover higher than the other 3 periods (S-N-K, $P < 0.05$).

The majority of the movements were confined to the eastern Kara Sea, but 3 bears (N7982, N7984, and N7988) did move into the western Laptev Sea, with 2 returning to the Kara Sea prior to collar failure (Fig. 2A–E). One bear (N7988) moved east into the Laptev Sea before returning to the eastern edge of the Kara Sea near Cape Cheluskin, where the collar apparently failed (Fig. 2E). One bear (N7980) had restricted movements (Fig. 2A) that were closely associated with Komsomolets and Pioner Islands. The combined locations for the 5 collared bears depict a overall range that is centered around the Severnaya Zemlya Archipelago (Fig. 2F).

Ice Conditions

During spring 1991 the limits of shorefast ice in the Severnaya Zemlya Islands archipelago were similar to the average condition (Fig. 1B). Fast ice along the western archipelago included considerable portions of second year ice. Drift ice was also composed of up to 80% second year ice. In April–June 1991 polynyas were not present beyond the shorefast ice zone west and east of the archipelago. A zone of open water and remnant ice east of Severnaya Zemlya Archipelago and in Velkitski Strait appeared during early July.

Shorefast ice in the western entrance to Vilkitski Strait was partly broken by mid-July and was completely broken by the end of July. The strait was completely broken by mid-August. During summer 1991, fast ice in Shokalski and Krasnoi Armii Straits near Pioner Island and around Sedov Island was not broken. Throughout the entire summer, solid ice approached either the western or eastern side of the archipelago, depending on the wind direction. During early September, ice began forming among solid remaining ice and by the end of September was forming among remnant ice. In winter 1991–92, ice growth was more intensive than usual. For instance, fast ice near Cape Cheluskin during the whole winter was 20–25 cm thicker than average.

Fast ice was formed to usual limits by early January 1992 in the archipelago including Vilkitski Strait (Fig. 1B), with little change until ice-breakup. No polynyas were present beyond the fast ice during January and February 1992. During March–April 1992, only limited polynyas were observed. By May–July 1992, an extensive zone of remnant ice and open water appeared beyond the fast ice zone both west and east of the archipelago. The fast ice zone in Vilkitski Strait was broken by 1 August 1992, and by mid-August it was broken in the western entrance of the strait. In summer 1991 and 1992, fast ice in Shokalski and Krasnoi Armii Straits, near Pioner and Komsomolets Islands and around Sedov Island, was not broken. Ice formation began early in autumn 1992 (Fig. 1A): among solid ice by 1 September and among remnant ice by mid-September.

DISCUSSION

Although sample size is small, movements of polar bears in this region of the Russian Arctic appears to be of 2 types: bears that remain closely associated with land (islands or shoreline), and individuals who remain on sea ice during a majority of the year. Bears N7980, N7984, and N7986 displayed the landform-based movement pattern (Fig. 2A, C), while bears N7982 and N7988 had a more ice-related movement pattern (Fig. 2B, E). Bear

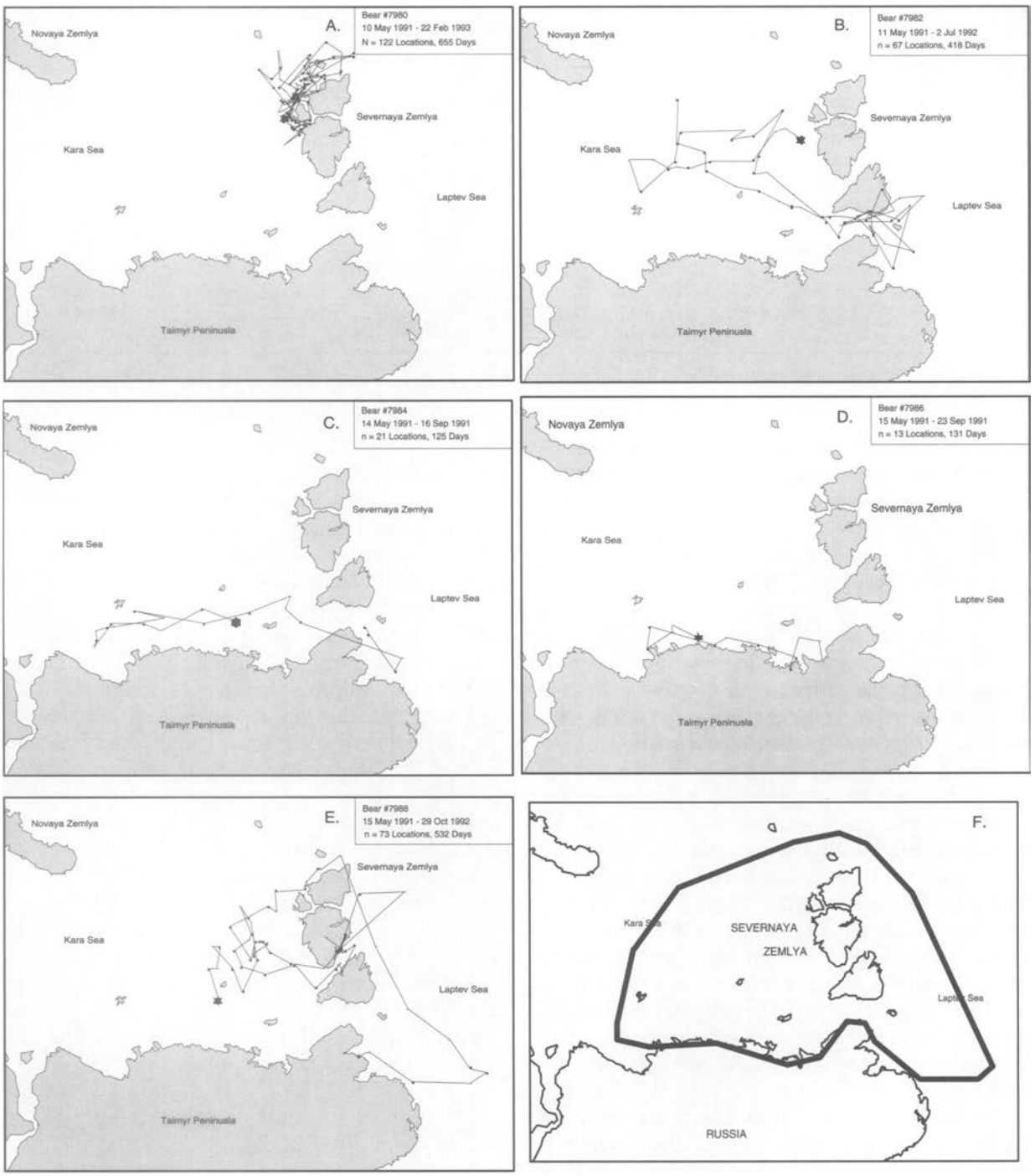

Fig. 2. Movements of female polar bears in the Severnaya Zemlya Archipelago, May 1991–Feb 1993, as determined by satellite telemetry. A–E. Individual bear movementss (star denotes capture location). F. Cumulative area encompassed by movements of 5 collared female polar bears in the Kara and Laptev Seas, May 1991–Feb 1993.

Table 2. Movement characteristics of female polar bears near the Severnaya Zemlya Archipelago, Russia, 1991–92.

Animal no.	Number of locations	Total distance (km)	Number of days tracked	Mean rate of movement km/day(SE)
N7980	122	4,028	655	6.1 (0.62)a[a]
N7982	67	4,098	418	14.1 (0.84)b
N7984	21	1,746	125	8.9 (1.53)a
N7986	13	876	131	9.7 (1.97)a
N7988[b]	57	3,493	532[c]	10.4 (0.91)a

[a] Mean rates of movement with different letters are statistically different (Student-Newman-Kuel, $P \leq 0.05$).
[b] Non-lactating female at capture, but was in a maternity den from 1 November 1991 through 8 April 1992 (161 days).
[c] Total movement is based on a 371-day period, with the denning period deleted.

Table 3. Daily rates of movement by ice season for female polar bears near the Severnaya Zemlya Archipelago, Russia, 1991–92.

Ice season	Number locations	Rate of movement (km/day)	
		mean	SE
Recede	53	9.3a[a]	0.94
Minimum	70	12.5b	0.81
Advance	31	7.5a	1.21
Maximum	121	9.9a	0.62

[a] Mean rates of movement with dissimiliar letters are different (Student-Newman-Kuel, $P \leq 0.005$).

N7980 had very restricted movements during the 655-day tracking period and was associated with fast ice near Komsomolets and Pioner Islands and the adjacent polynya that is normally present northwest of the 2 islands (Fig. 1B). Bear N7988 appeared to have denned along the shoreline of October Revolution Island in the Shokalski Strait during winter 1991–92, according to sensor data. This bear made the most extensive movement of the 5 collared bears into the Laptev Sea and was moving toward the Kara Sea when the collar failed during October 1992 (Fig. 2E).

Polar bear movements in other regions are influenced by sea ice distribution and type (Garner et al. 1994*b*). In contrast to the dynamic nature of the sea ice in the Chukchi Sea, the sea ice of the Kara and the Laptev seas is more stable, and polar bears in this region of Russia do not need to move long distances to maintain contact with the sea ice as they do in the Chukchi Sea in eastern Russia (Garner et al. 1990, 1994*a*). However, higher average daily movement rates for both areas (12.5 km/day for Severnaya Zemlya; 18.5 km/day for the Chukchi Sea, Garner et al. 1994*a*) were recorded during the portion of the year with minimum ice cover, suggesting similar habitat use strategies during this time period for the 2 areas. In contrast, female polar bears in the Viscount Melville Sound region of the Canadian Arctic had movement rates of 6.9 km/day (SE = 5.9) to 8.8 km/day (SE = 6.3) from April through October (data derived from Messier et al. 1992, Table IV). Messier et al. (1992) speculated that this increased movement during the summer months was related to the period of hyperphagia when seals were most vulnerable to predation.

Rates of movement of Severnaya Zemlya Archipelago bears during the receding, minimum, and maximum ice periods were approximately one third less than those reported for bears in eastern Russia (Garner et al. 1990), while the rate of movement by Severnaya Zemlya Archipelago bears during the advancing ice period was less than half the rate of bears in the Chukchi Sea (7.5 compared to 18.9 km/day, respectively). These differences are likely related to differences in the sea ice regime for the regions, with the ice extent in the Chukchi Sea region having a difference of approximately 1,400 km between maximum ice cover and minimum ice cover (Garner et al. 1990).

The area defined by movements of these 5 collared bears indicate a population centered around the Severnaya Zemlya Achipelago (Fig. 2F). Earlier speculation that the Laptev and Kara Seas were comprised of separate populations of polar bears are not supported by these data. However, these data are biased because the capture effort was limited to bears associated with the archipelago and northeastern portions of the Kara Sea along the coast of the Taimyr Peninsula. The western and eastern boundaries of the population cannot be defined until further research occurs in the Laptev Sea and western portions of the Kara Sea.

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