# The ringed seal (*Phoca hispida*) in the western Russian Arctic

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## ABSTRACT

This paper presents a review of available published and unpublished material on the ringed seal (*Phoca hispida*) in the western part of the Russian Arctic, including the White, Barents and Kara seas. The purpose of the review is to discuss the status of ringed seal stocks in relation to their primary habitat, the history of sealing, and a recent harvest of the species in the region. The known primary breeding habitats for this species are in the White Sea, the south-western part of the Barents Sea, and in the coastal waters of the Kara Sea, which are seasonally covered by shore-fast ice. The main sealing sites are situated in the same areas. Female ringed seals become mature by the age of 6, and males by the age of 7. In March-April a female gives birth to one pup in a breeding lair constructed in the shore-fast ice. The most important prey species for ringed seals in the western sector of the Russian Arctic are pelagic fish and crustaceans. The maximum annual sealing level for the region was registered in the first 70 years of the 20th century: the White Sea maximum (8,912 animals) was registered in 1912; the Barents Sea maximum (13,517 animals) was registered in 1962; the Kara Sea maximum (13,200 animals) was registered in 1933. Since the 1970s, the number of seals harvested has decreased considerably. There are no data available for the number of seals harvested annually by local residents for their subsistence.

The ringed seal (*Phoca hispida*) is the most abundant and widespread marine mammal in the Russian Arctic. The present study reviews published and unpublished material on this species and pays particular attention to sealing.

## HABITAT CHARACTERISTICS (ICE CONDITIONS)

Ice conditions are known to play an important role in the life cycle of the ringed seal. It was therefore considered important to detail ice conditions with special emphasis on shore-fast ice which is the preferred habitat for ringed seal breeding (Fig. 1). In order to describe ice conditions in the different geographical areas, both published materials (Nazintsev 1971, Gudkovich *et al.* 1972, Anon. 1981, Chelingarov and Kadachigov 1981, Dobrovolskiy and Zalogin 1982) and material kindly given to us by Dr. Yu. A. Gorbunov (Arctic and Antarctic Research Institute, Beringa 38, 199397 S. Petersburg, Russia), were used.

### The White Sea

The White Sea (Fig. 2) covers an area of 90,000km$^2$ with an average depth of 67m and maximal depth of 350m. Winter temperatures on the surface average freezing conditions (-0.5°C to -1.9°C), while summer temperatures may reach +14-15°C in some places.

The White Sea is covered with ice every winter. The first ice appears in late October at the mouth of the Mezen River; in the following months it covers the Voronka and Gorlo of the sea near its Terskiy shore. The Voronka is the first to become free of ice, which happens in late March. By late May, the whole sea is usually ice-free, though portions of ice frequently persist through mid-June.

Most of the ice (90%) is drifting ice with a thickness of 35-135cm, and sometimes up to 150cm thick. The ice constantly drifts into the Barents Sea. As a consequence, polynias are often formed in the winter. The shore-fast ice forms a narrow strip along the shore line (Fig.

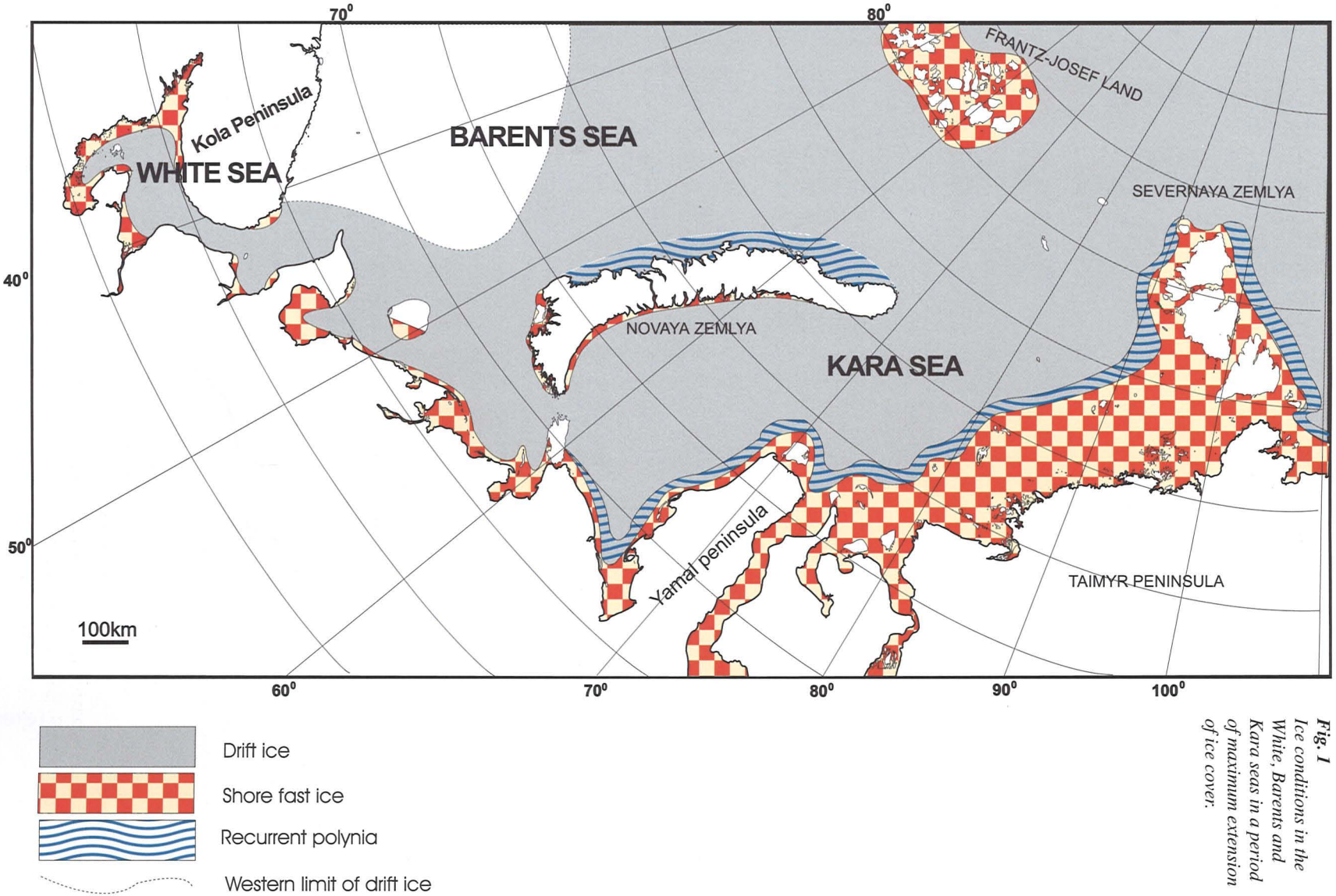


*Fig. 1*
*Ice conditions in the White, Barents and Kara seas in a period of maximum extension of ice cover.*

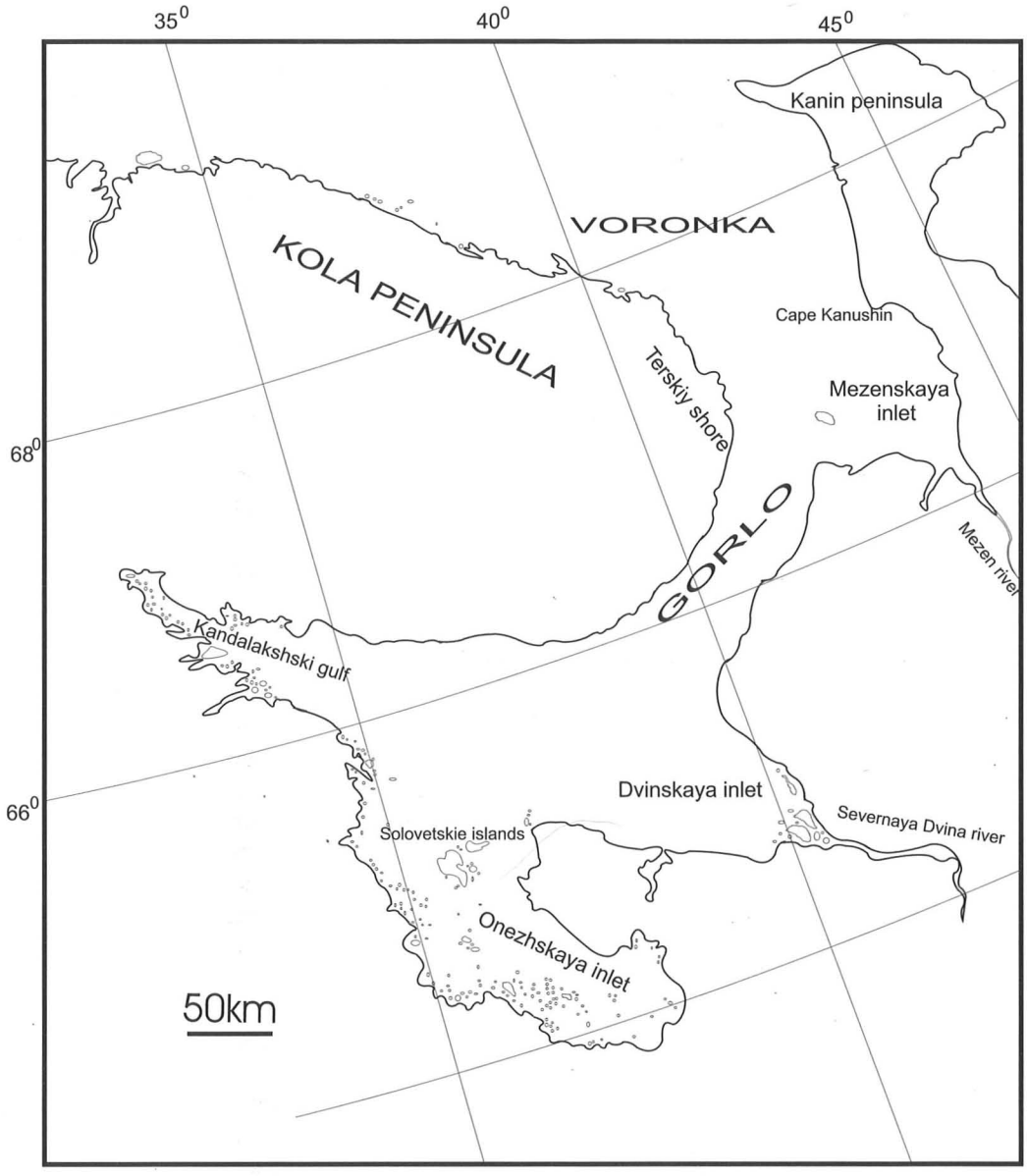


*Fig. 2*
*White Sea.*

1). This ice forms first along the shallow wind-protected areas of the bays and gulfs. Despite considerable differences in the hydrometeorological conditions in the autumn and winter periods in the different regions, the shore ice is almost of the same width in different parts of the sea. The break-up of shore-fast ice normally occurs in the second half of April under the influence of off-shore winds and currents.

**The Barents Sea**

The Barents Sea (Fig. 3) is one of the largest and deepest seas (a maximum depth of 600m) in the Russian Arctic. It is punctuated by Frantz Josef Land, Novaya Zemlya, Kolguev and other islands, and is characterised by the inflow of warm Atlantic waters in the south-west and cold waters from the Arctic basin. Due to the inflow of great masses of Atlantic water, the Barents Sea normally stays ice-free year round along the coast of northern Europe to 75°N. There is no significant ice drift from the Kara Sea.

The ice formation in the north begins in September, in the central regions in October, and in the southeastern regions in November. In the spring and summer periods the young ice rapidly melts. The melting and destruction of the ice cover begin in the south-east areas of

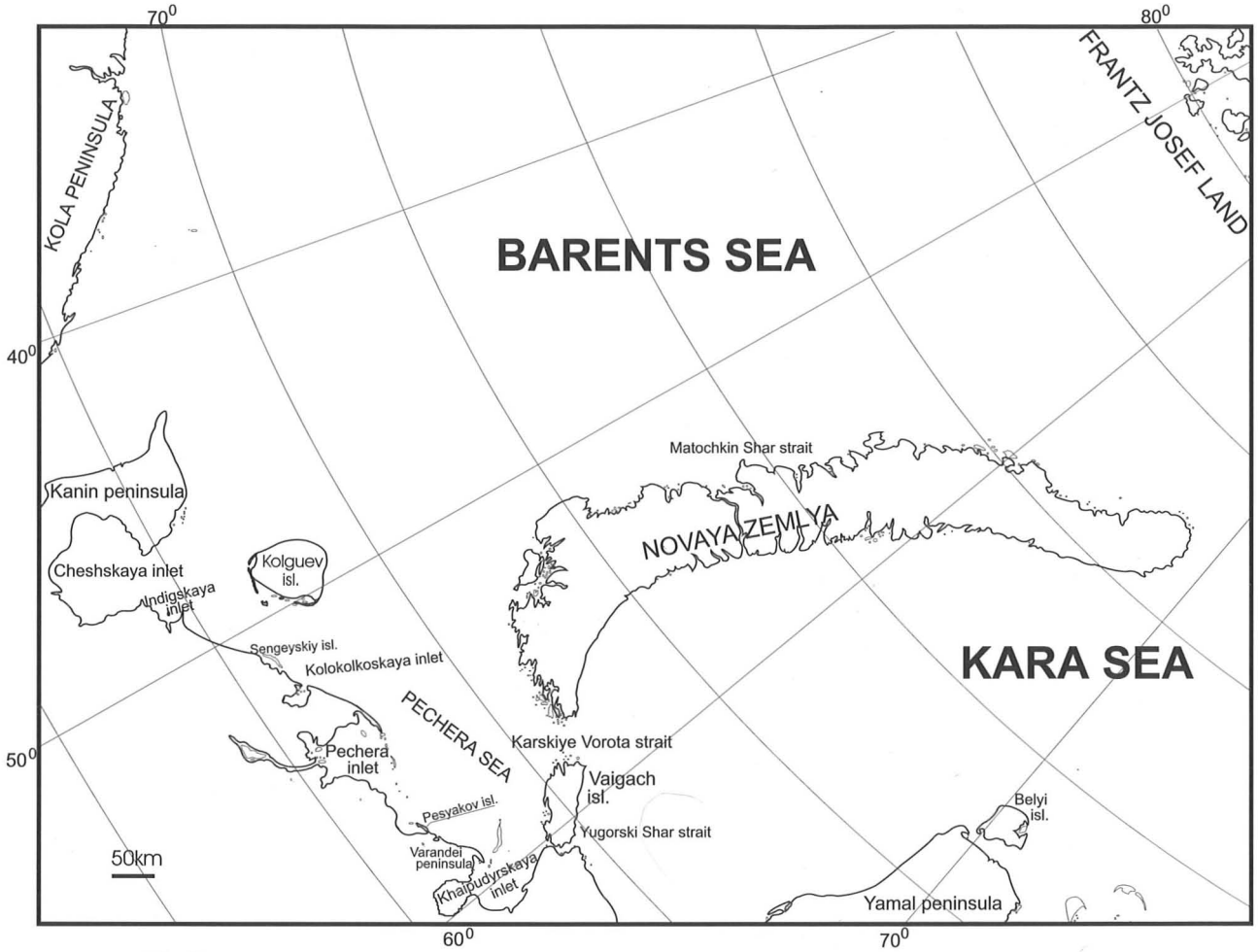


***Fig. 3***
*Barents Sea.*

the Barents Sea. Almost the whole sea, with the exception of the regions adjacent to Novaya Zemlya and Frantz Josef Land, becomes ice-free by late summer.

The shore-fast ice is poorly distributed throughout the area, and in particular near the western shores of Novaya Zemlya (Fig. 1). The shear zone, consisting of extremely hummocked ice, is situated outside the edge of the shore-fast ice and is caused by the impact of drift-ice. In the Pechora Sea, the shore-fast ice lasts 3 to 4 months, breaking open in May or June. In this part of the sea, the ice normally extends 3.5 to 6.5km from the shore, and may in some years extend up to 19km offshore. The mean edge of the shore-fast ice coincides with the 10m isobath. The maximum thickness of the shore-fast ice in April is 100cm.

**The Kara Sea**

The Kara Sea (Fig. 4) is situated in the high Arctic and is directly connected to the Arctic Ocean. Ice is present year-round, and even in summer the surface water remains constant around freezing point. Only in the southern part of the sea does it occasionally reach 3 to 6°C in ice-free areas. The new ice usually forms in the northern parts of the sea in mid-September among the residual ice and gradually disperses towards the south and south-west. The time when ice formation begins varies considerably among years, with a difference of 70 days near Novaya Zemlya, 40 days near the coastal line, and 50 to 60 days in the open areas of the sea.

In the northeastern part of the sea where numerous islets are present to anchor it, the shore-fast ice is widely distributed (Fig. 1). The position

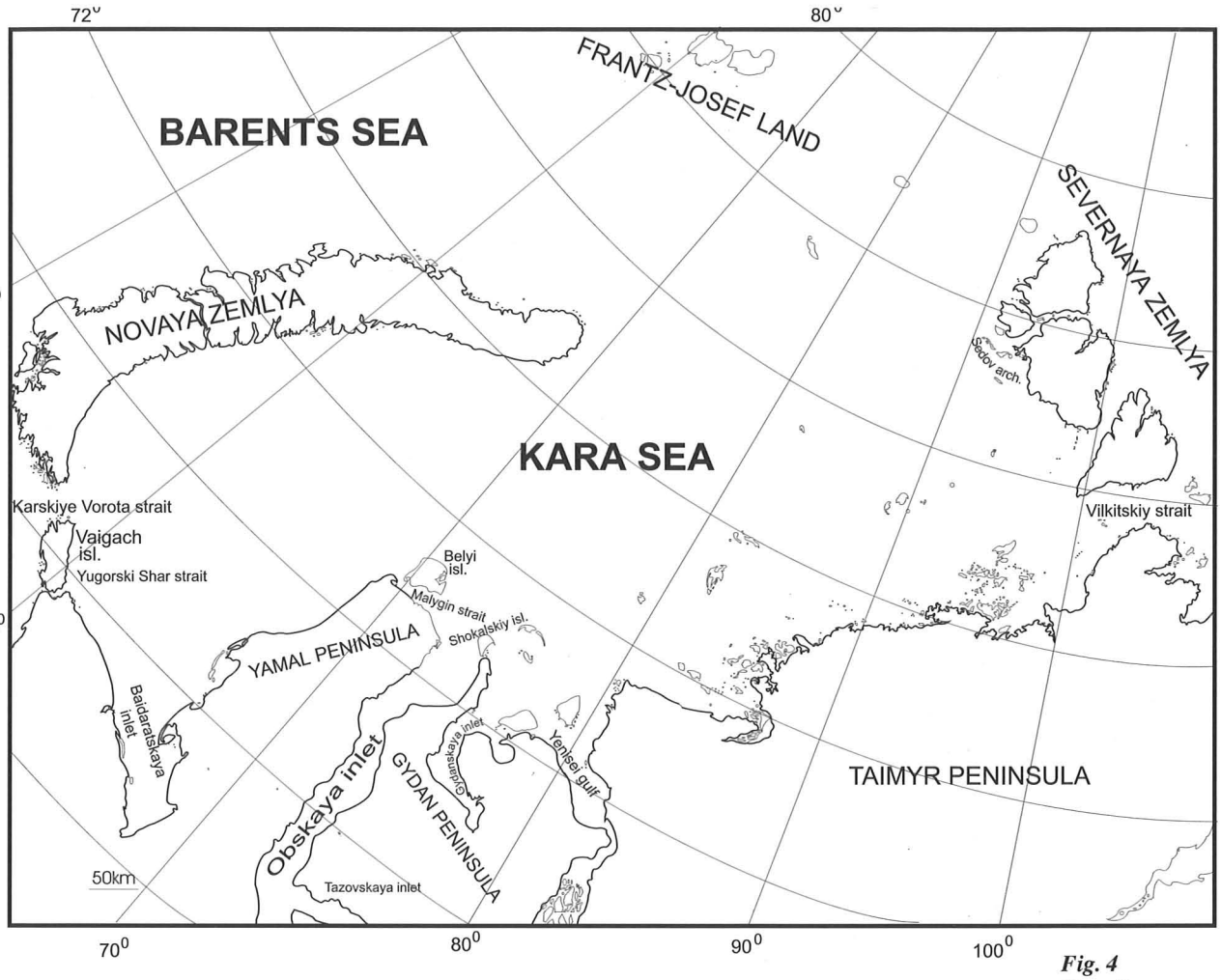


***Fig. 4***
*Kara Sea.*

of the edge of shore-fast ice varies greatly among years. The mean thickness of the shore-fast ice (in May) varies from 110cm in the Yugorskiy Shar Strait to 170cm in the Vilkitskiy Strait (Fig. 4). It is also noteworthy that the thickness of both fast and drifting ice is variable even within restricted areas. The shore-fast ice in the southwestern part of the sea consists of autumn ice. In the northeastern part, it is comprised mostly of young thick ice. Near Severnaya Zemlya, however, the ice is two or several years old. Additionally, in some years old fast ice is found in the channels and bays of Severnaya Zemlya.

The shore-fast ice is more hummocked in the Obskaya Inlet than in the Yenisei Gulf. It is most hummocked near the western shores of Severnaya Zemlya and the Yamal Peninsula. Snow cover is unevenly distributed over the ice, reaching its maximum levels in mid-May. The amount of snow on flat drifting ice fields is one third the thickness of snow covering the shore-fast ice.

The formation of polynias outside the fast ice zone under the impact of off-shore winds is characteristic for the ice cover of the Kara Sea (Fig. 1). Polynias may remain for long periods either as areas of ice-free water or as the zones of new ice formations. Most of the polynias outside the shore-fast ice zone are considered recurrent in the Kara Sea. In the Kara Sea, ice begins to melt in the southwestern part usually in late May; the process gradually expands towards the north-east and north. In the northern part of the sea, the mean time when the ice begins to melt is late June. The duration of ice melting varies considerably between years,

from up to 50 days in the extreme southwestern part of the sea to 30 days in the north.

The shore-fast ice breaks up first from its outer edge and very soon breaks over large areas, often all the way to the coast line. In the southwestern part of the Kara Sea shore-fast ice normally breaks up in the second half of June. Around the islands north of 76°N this normally occurs in the first half of August, while near the mainland coast the ice breaks up in the second half of July. It is noteworthy that in some years the shore-fast ice does not break up at all in some channels and bays of the Severnaya Zemlya Archipelago. In the summer period, the points where the ice melts in the Kara Sea are the areas of ice-free water along the Barents Sea, the estuary zones of the Ob and Yenisei rivers, and in recurrent polynias.

## DISTRIBUTION OF RINGED SEALS

The ringed seal inhabits all seas of the Russian Arctic from the Barents Sea to the Bering Strait. In the Barents Sea, however, the seals are found only in the marginal areas (the southern, eastern, and northern parts of the sea; Fig. 5). No ringed seals inhabit the pelagic zone of the central and western parts of the sea where water is open all the year round (Geptner *et al.* 1976). According to the long-term data from aerial ice surveys, the range of the ringed seal in the region exceeds the commonly accepted one (Geptner *et al.* 1976, Fig. 5). In the Arctic basin ringed seals are observed only in summer; during the winter period observations of seals are scarce due to lack of day light (Belikov *et al.* 1990).

**The White Sea**

Ringed seals are widely dispersed in the White Sea, avoiding only the central parts and remote areas of the Gorlo (Golenchenko 1963, Geptner *et al.* 1976, Lukin 1981, Fig. 2). Seals are often found in the outlets of the rivers running into the sea. In the Dvinskaya Inlet, they occupy all marginal zones southward up to the mouth of the Severnaya Dvina River, although they are rare in the northwestern open area of the inlet.

Ringed seals are found virtually all over the Kandalakshski Gulf, but they are sporadic in the central areas of the gulf. Seals are confined to the northern part of the Onezhskaya Inlet and prefer also its western part which has many islets and is characterized by the complexity of the shore line. In the Mezenskaya Inlet, seals traditionally keep to the coastal zone. Seals are common in the northern areas of the White Sea in summer where they may form herds in the shallow areas (Geptner *et al.* 1976).

Distribution of the ringed seal was studied in the White Sea in 1961 (Golenchenko 1963). The study showed that the animals were most abundant in the Onezhskaya Inlet, the richest feeding grounds. Fewer seals were observed in the Kandalakshski Gulf and along the Terskiy shore. Karpovich (1969) also noted that numbers of ringed seals do not exceed several hundred in the upper part of the Kandalakshski Gulf. In some years (1950, 1953, 1954, 1959, 1962) this area has been inhabited by thousands of individuals. Along the coast line of the Kanin Peninsula, the Konushin Cape, in the Gorlo of the White Sea, and in the Dvinskaya Inlet, ringed seals were observed in small groups (3-5 animals) or as single individuals. Larger groups (50-100 or more individuals) seldom occurred (Golenchenko 1963).

**The Barents Sea**

According to Geptner *et al.* (1976), the ringed seal inhabits the coastal region of the Kola Peninsula. There it prefers areas with complex shore lines more or less protected from heavy wave action. Seals seem to prefer estuary areas in particular. In the southeastern part of the sea, they are spread everywhere from the Voronka in the White Sea to the Karskiye Vorota Strait and the southern part of Novaya Zemlya. The animals show preference for the coastal areas. In the east of the Barents Sea, the seals occur in a narrow strip along the western shores of Novaya Zemlya. The animals avoid open places and protruding capes and prefer inshore bays with uneven shore lines. Ringed seals are also found in the Matochkin Shar Strait. In the northeastern and northern parts of the Barents Sea, the seals inhabit the zone of drifting ice from Novaya Zemlya to Frantz Josef Land.

Ringed seals are concentrated mainly in the southeastern coastal areas of the Barents Sea.

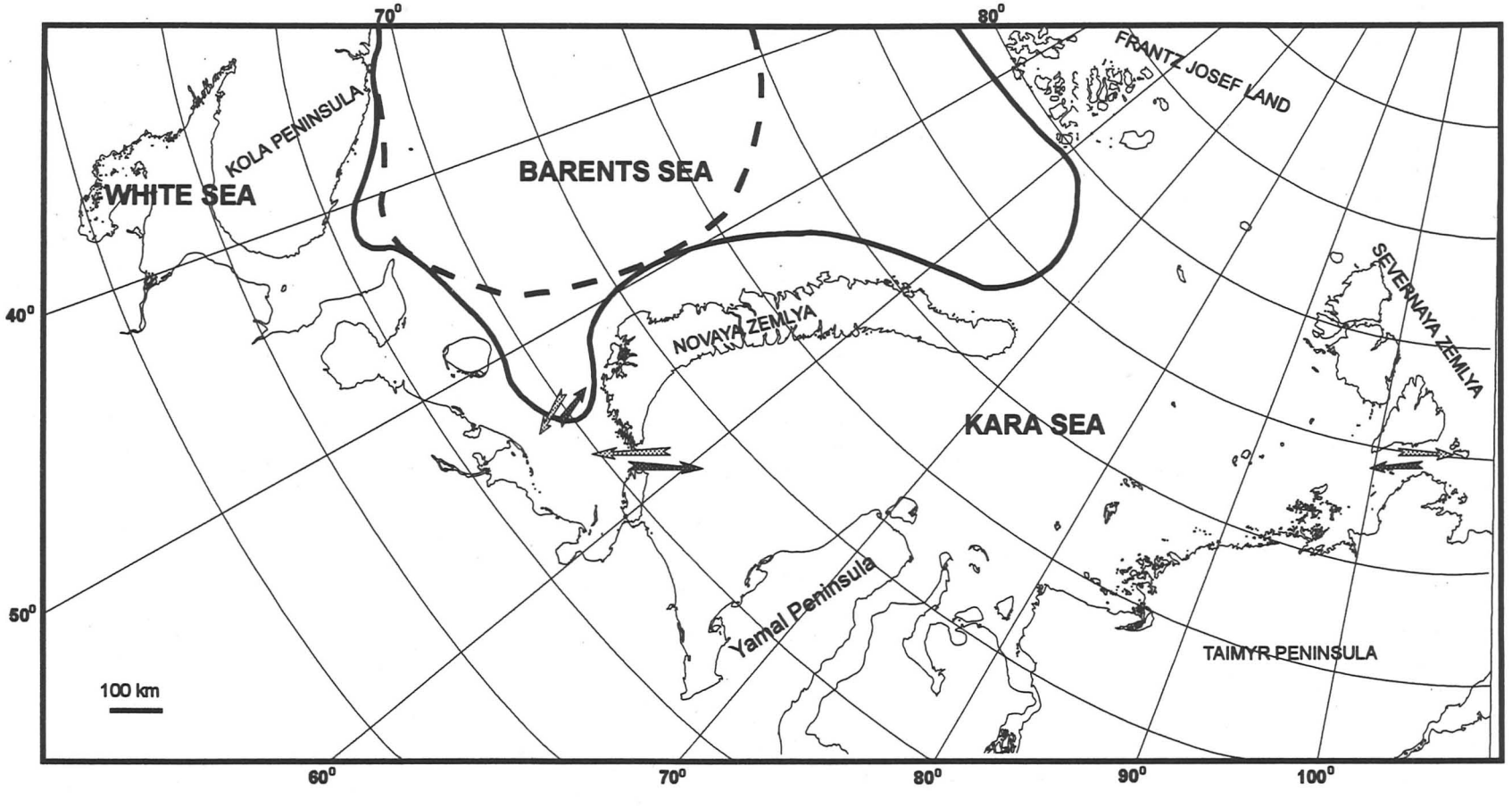


*Fig. 5 Range of the ringed seal in the Western Russian Arctic.*

The concentrations are most notable near the northeastern coast of the Kanin Peninsula, in some areas of the Cheshskaya Inlet, near Sengeyskiy Island, in the Kolokolkova Inlet, the western "mouth" of the Yugorskiy Shar Strait, near the southeastern coast of Kolguev Island, and in skerries of the southern part of Novaya Zemlya (Geptner *et al.* 1976). These concentrations of seals most frequently occur in the autumn and winter months. On the basis of the monthly aerial surveys carried out in 1960, Golenchenko (1963) concludes that the gatherings of seals in May and June are connected with pupping and breeding. These concentrations of seals dissipate in July and August as the animals disperse in search of food. Therefore, the southeastern part of the Barents Sea is one of the most important regions for the reproduction, moulting and feeding of ringed seals.

**The Kara Sea**

The ringed seal inhabits any region of the Kara Sea. Most of the animals, however, keep to the coastal areas from Novaya Zemlya to the Vilkitskiy Strait and Severnaya Zemlya. Seals are found in the Baidaratskaya Inlet and near the western coast of the Yamal Peninsula. Their range expands eastward to include the Obskaya Inlet with most of the Tazovskaya Inlet, as well as marine areas along the mainland coast from Shokalskiy Island to the Vilkitskiy Strait (Geptner *et al.* 1976, Mishin *et al.* 1989). Near Severnaya Zemlya, ringed seals are found along the western and southern coasts of the archipelago (Geptner 1936, Rutilevskiy 1939, Belikov and Randla 1987, Ushakov 1990). According to Rutilevskiy (1939), the greatest number of seals was observed on the ice in the Vilkitskiy Strait during the second half of June, which corresponds to the moulting period. At that time, the density of seals was 0.4 to 8 individuals per 1km$^2$ of flat ice in the strait and coastal zone. Ringed seals concentrate mostly in the 10km coastal belt and occur in lower numbers in the strait. Geptner (1936) reported that a great number of seals was found near the northwestern coast of Taimyr, not far from the Yenisei Gulf. His report was based on his personal observations and interviews with hunters. These findings were confirmed during field studies of polar bears (*Ursus maritimus*) in the Kara Sea in 1994 and 1995 (Belikov and Boltunov, unpublished data).

Winter concentrations of ringed seals are common in the northern part of Yenisei Gulf in the vicinities of the recurrent polynia. A substantial harvest of ringed seals has been conducted in this area. According to Geptner (1936), many seals were observed near the northeastern edge of the Yamal peninsula. We have no consistent data indicating any changes in the ringed seal population in this area.

According to data from aerial ice surveys (Belikov *et al.* 1989), sightings of ringed seals were particularly frequent in the Ob-Yenisei region in winter. Additionally, ringed seals in considerable numbers were observed along the eastern Novaya Zemlya during a 1973 cruise (July-August) (Belikov, unpublished data).

Concentrations of ringed seals and other marine mammals such as bearded seals (*Erignathus barbatus*), and beluga whales (*Delphinapterus leucas*) form near the Sedov Archipelago in the northwestern part of Severnaya Zemlya at the end of summer. This phenomenon was discovered by the first expedition to the Severnaya Zemlya archipelago in 1930-1932 (Ushakov 1990), and was also confirmed by numerous observations by polar pilots, employees of polar stations, and members of scientific expeditions. Belikov and Randla (1987) also found ringed seals common in other parts of the archipelago.

## MOVEMENTS

It is necessary to point out that no special investigations on ringed seal movements (marking-recapture or satellite telemetry) have been carried out in the seas of the Russian Arctic. It is commonly accepted that ringed seals do not undertake long mass migrations. Local movements are determined basically by food availability. Observations of great numbers of ringed seals in particular regions are found in connection with large aggregations of fish (Golenchenko 1963, Geptner *et al.* 1976, Timoshenko 1982, 1984, Mishin *et al.* 1989, Ushakov 1990).

Apparently semi-regular migrations of ringed seals occur in the western region of the Russian Arctic. When the ice period begins, seals migrate from the Kara Sea to the Barents Sea via the Karskiye Vorota and Yugorskiy Shar straits (see Fig. 3). These movements represent not only a search for food, but also for suitable breeding areas, because the conditions in the southeastern part of the Barents Sea are optimal for seal reproduction. A group of seals occupies this region in winter and spring. In late spring and summer the animals follow the northward and eastward withdrawal of the ice edge and move to the northern areas of the Barents Sea and to the Kara Sea (Geptner *et al.* 1976, Lukin 1981). Only a few seals remain in the southeastern Barents Sea during summer (Golenchenko 1963, Lukin 1981). Autumn and winter visits of ringed seals to the shores of Novaya Zemlya, the Kanin Peninsula, the Kolguev and Vaigach islands and other regions of the Pechora Sea, as well as to the northern regions of the White Sea are associated with the spawning of the polar cod (*Boreogadus saida*), sparling (*Osmerus eperlanus*), and navaga (*Eleginus navaga*) (Golenchenko 1963, Geptner *et al.* 1976). These movements are also connected with the changes in ice conditions.

Local movements of ringed seals in the Kara Sea, similar to movements in most of the other regions, are determined by food abundance and changes in ice conditions. When the Gydanskaya Inlet (Fig. 4) is totally covered with ice, animals of the younger age groups move to the clearings in the northern parts of the Kara Sea, while the reproductive part of the population stays in the inlet (Starikov 1990).

According to Rutilevskiy (1939), many ringed seals appear in the Vilkitskiy Strait (Fig. 4) by the end of May, coming from the east. The population peaks in the second half of June. During the end of summer, after the first ice appears in the strait, the seals reverse migrations. Animals leave the region in late March, when the whole strait is covered with ice.

## REPRODUCTION

The ringed seal is one of the few marine mammals whose reproduction is closely associated with the sea ice (shore-fast ice in particular). Favourable ice conditions (stable shore-fast ice with enough snow cover for construction of maternal lairs) are vital for reproduction.

### Construction of a lair

If food is available, ringed seals can live in any type of ice. However, shore-fast ice with snowdrifts deeper than 50cm is necessary for constructing birth lairs (Potelov and Lukin 1975). In the period of autumn ice formation, ringed seals keep to the drifting ice in the coastal zone and avoid open sea areas (Chapski 1940, Lukin 1981). The animals make holes in the young shore-fast ice through which they breath and enter the ice surface. According to Lukin (1981), the animals use their heads to make the holes if the ice is thinner than 2cm. The seals have to keep the breathing holes in the ice constantly open. This, and the fact that they also have to search for food, defines the individual home ranges of animals in winter. The size of the home range depends on the number of breathing holes which can be kept open by an animal. According to Lukin (1981), a seal is able to keep 9 to 11 holes open; the holes must be located 200-300m apart in a territory of about 0.35km$^2$. These calculations were based on the velocity of ice growth up to the thickness of 2cm, a mean swimming speed of the seal of 3-4km/hr, and a mean dive duration of 4-5min. Further observations in the White Sea confirmed these calculations (Lukin 1981) in that ringed seal females maintained 9 or 10 holes in areas ranging from 0.25km$^2$ to 0.50km$^2$.

Adult ringed seal females share some breathing holes, leaving each seal to maintain five holes on average. The density of females in the shore-fast ice is determined by the number of individual home ranges and rarely exceeds 5-6 animals per km$^2$. When the amount of snow over the holes increases, the female widens the holes up to the size of a lair entrance (35-40cm) and forms the base of a snow lair. One of these lairs will house the female during pupping. The other snow lairs, if large enough, serve as additional shelters or breathing holes (Potelov and Lukin 1975). Inside the birth lair with its ice-crusted roof, a particular microclimate is formed. It is characterised by constant air temperature (which is close to the water freezing

temperature) and limited oxygen supplies. The latter forces the female to spend restricted periods in the lair; it stays there only when nursing its pup. The limited gas exchange also forces the 4-5-day old pup to dig additional chambers, which are not covered with the ice crust and therefore have better ventilation (Lukin and Potelov 1978a, Lukin 1980, 1981).

The accumulation of snow cover necessary for lair construction depends upon the roughness of the shore-fast ice. In addition, the type of hummock influences the successful building of the nursing lair (Lukin 1981). Different types of hummock, such as "razdrobleniya" (formed by ice broken to small pieces), "nabivnye" (formed by stratification of ice) and "vzloma" (formed by breaking ice up), appear in different ways. Only the formation of the "vzloma" hummock will leave areas of water ice-free. When these openings are covered by new ice, a seal can make and maintain a hole. After enough snow has accumulated, the seal can build a lair. One more important characteristic of ice is its age. Ringed seals reproduce only on white ice. The surface of such ice is dry enough for the pup (this factor seems to be vital for its survival). No birth lairs were found in the inter-tidal zone and in shallow areas less than 2-3m deep (Lukin 1981).

In the White Sea, the areas of shore-fast ice that are optimal for ringed seal breeding are normally formed in early February and break up in the second half of April. Abnormally early breakage of the shore-fast ice (as was seen in the first half of March, 1977) may cause up to 50% pup mortality (Lukin 1981).

**Breeding areas**

Lukin and Potelov (1978b) analysed the ice conditions in the southeastern part of the Barents Sea and found that, despite the vastness of the region, only some restricted areas are suitable for ringed seal breeding. The shores in the western part of the region are fairly even, and shore-fast ice can be formed only in some particular areas, such as the mouth of the Vostochnaya Kambalnitsa River (the eastern coast of the Kanin Peninsula), the upper parts of the Indigskaya Inlet, the strait between Sengeyskiy Island and the mainland, the Kolokolkova Inlet, and near the southeastern part of Kolguev Island (Fig. 3). The conditions in these regions are optimal for breeding but the extension is limited, so only a small number of seals (about 400) breeds there (Lukin 1981). The most extensive ice areas suitable for seal reproduction are formed annually in the zone of shore-fast ice in the Pechora Inlet. This region seems to accumulate the most female ringed seals, and according to Lukin (1981), about 4,400 females breed in this region.

Extensive shore-fast ice is formed in the Khaipudyrskaya Inlet and near the western shores of the Yugorskiy Peninsula and the Vaigach Island. However, only restricted ice areas (compared to the Pechora Inlet) are suitable for construction of lairs (Lukin and Potelov 1978b). According to Lukin (1981) the area can support about 900 breeding females. He notes that in the White Sea breeding conditions are favourable for 4,000 to 4,500 ringed seal females annually.

The most favourable ice and weather conditions for pupping and rearing of young are assumed to be in the Kara Sea; while the conditions in the Barents and White seas are less favourable (Potelov 1986). Table 1 shows, however, that the relative density of ringed seals in the White Sea appears to be higher than that in the other seas. According to Potelov (1986), the main reason for relatively low numbers of seals in the Barents and Kara seas is the permanent threat from polar bears and Arctic foxes (*Alopex lagopus*). This conclusion, however, has not yet been confirmed.

In late June 1996, a survey of marine mammals was conducted in the waters adjacent to the Yamal and Gydan peninsulas (Boltunov and Chelintsev 1998). In that survey the density of ringed seals hauled out on the ice in the examined area varied from 1.8 animals/km$^2$ in the Malygin Strait to 0.047 animal/km$^2$ on the shore-fast ice north of Belyi Island (Fig. 4). Average density in the whole examined area made up about 0.4 animals/km$^2$. To compare these data with those presented by Lukin (1981) and Potelov (1986) it is necessary to note that the recent figures refer to all sex and age classes of seals occurring in a particular area, while

**Table 1** . Relative density of the ringed seal in the White, Barents, and Kara seas (Potelov 1986).

| Pupping area | Density of ringed seals | |
|---|---|---|
| | holes/km$^2$ | breeding females/km$^2$ |
| The White Sea (1972-1977) | | |
| Kandalakshski Gulf | 11-17 | 1-7 |
| Solovetskiye Islands area | 10-15 | 2-3 |
| Onezhskaya Inlet | 15 | 4.1 |
| The Barents Sea (1979) | | |
| Pechora Inlet | 1.2 | 0.2 |
| Varandey Peninsula region | 2.2 | 0.1 |
| Khaipudyrskaya Inlet | 2 | 0.5 |
| The Kara Sea (1984) | | |
| Yenisei Gulf | 0.5 | 0.4 |
| Pyasina Bay | 0.9 | 0.4 |
| Cape Sterligov region | 0.3 | 0.1 |

Lukin (1981) and Potelov (1986) characterised only the distribution of breeding females.

**Some characteristics of the reproductive biology**

The mating period occurs in spring, beginning at the end (or in the second half) of the lactation period. For seals in the Barents and Kara Seas, mating lasts from late April to mid-May (Chapski 1940). The following data on the reproductive biology of the ringed seal are given by Nazarenko (1965). A sample of 70 females and 43 males was collected in the Cheshskaya Inlet (Fig. 3) in January 1962. The reproductive system was studied along with the routine measurements. Presence of *corpora lutea* in ovaries or pregnancy indicated maturity of females. The data show that the females reach sexual maturity when 6 years old. A total of 56 mature females (older than 5) were examined, 35 of which (62.5%) appeared to be pregnant. Even though the sample size is hardly sufficient for extrapolation to the whole population, the high presence of non-pregnant females seems noteworthy.

While Geptner *et al.* (1976) consider the male ringed seals to be sexually mature at the age of 6, the analyses of 43 shot males in Nazarenko's (1965) sample revealed that all animals younger than 7 years had small testicles containing no sperm.

In the White Sea, southwestern coastal area of the Barents Sea and southeastern areas of the Barents Sea (near the shores of the Novaya Zemlya, the southeastern areas of the Pechora Sea, the Cheshskaya Inlet, near the Timanskiy shore, and in the Yugorskiy Shar Strait, Fig. 3) ringed seals give birth from the middle or end of March to mid-April, and sometimes even later. In the Kara Sea, pupping normally occurs in April (Geptner *et al.* 1976).

New-born pups are about 60cm long and weigh 3.5 - 4kg. Some authors noted that lactation lasted at least one month (Geptner *et al.* 1976, Potelov 1986). However, destruction of shore-fast ice (breeding areas) by storms, tides and ice breakers, will reduce the duration of the nursing period. Other factors decreasing the

length of the nursing period could be low air temperatures along with shallow snow or a sudden increase of air temperature resulting in destruction of the roofs of the lairs (Potelov 1986).

## MOULT

The moulting period is fairly prolonged in one-year-old and older ringed seals. Beginning in late spring, moulting continues throughout the summer. During this period, the seals form loose herds, both in the fast ice and in the drifting ice. In the White, Barents and Kara seas, peak moulting is observed in June and July. Near the western coast of Novaya Zemlya, the moulting ringed seals form "scattered herds" with individuals lying apart on the flat shore-fast ice (Chapski 1940, Ivashin *et al.* 1972, Geptner *et al.* 1976).

The moult starts from the seal's head. Moulting animals may still enter the water, but notable changes occur in their feeding habits. Investigations of stomachs from moulting seals show that they are almost always empty (Chapski 1940, Mishin *et al.* 1989). In captivity moulting ringed seals are found to have 50% reduction in daily food consumption (Mishin *et al.* 1987).

Day-round observations of the ringed seal's haul-out behaviour in the Kandalakshski Gulf of the White Sea (Fig. 2) in April 1974 and 1977 (Potelov 1978) showed that ringed seals begin to form moulting herds when the average daytime air temperature reached 0°C, though most of the seals remain in the water at that time. Later in the moulting period (late April), the haul-out behaviour was not as dependent on air temperature; seals were hauling out even when it was colder than -3°C. Wind conditions also affect the number of hauled-out animals. During strong wind, the number of hauled-out seals may be reduced by 50%; stormy winds force almost all seals to stay in the water. Under normal conditions, the first animals appear on the ice surface at sunrise. The number of seals on the ice reaches its peak in the middle of the day (between 1:00 p.m. and 4:00 p.m.) and then decreases constantly until the evening, when all animals return to the water.

## FORAGING

The most important prey species for ringed seals in the western sector of the Russian Arctic are pelagic fish and crustaceans. Items from other prey groups (molluscs, worms, squid, etc.) are only occasionally found in seal stomachs, and benthic prey species are consumed by ringed seals only in the shallow water areas (Geptner *et al.* 1976). The relative contribution of various prey species to the diet of ringed seals varies seasonally and in relation to the availability of the prey.

### Autumn and winter periods

In the autumn and winter months different fish species are the main food source for ringed seals. The most important is the polar cod (*B. saida*) that undertakes its mass spawning in the coastal waters during this period. These seasonal concentrations of polar cod determine autumn and winter concentrations of ringed seals near the shores of Novaya Zemlya, Vaigach Island, in Cheshskaya Inlet, and along the coasts of the White and Kara Seas (Fig. 3). Concentrations of seals, although in smaller numbers, are found in connection with other schooling fish, such as Atlantic navaga (*E. navaga*) in the Pechora Sea and other regions (Geptner *et al.* 1976, Timoshenko 1982). In the beginning of the century herring (*Clupea* sp.) was commonly found in the stomachs of seals shot near the shores of the Kola Peninsula (Geptner *et al.* 1976).

Timoshenko (1982) analysed stomach contents of 108 ringed seals shot near the southeastern coast of the Barents Sea (Kolokolkova Inlet and area near Sengeyskiy Island, Fig. 3) in December 1981. On average, one stomach contained 33 otoliths (max. 167), mainly from polar cod and navaga. Otoliths from polar cods were found in 59 of the stomachs (89.4%), followed by navaga (42 stomachs, 63.6%) and flounder (species not mentioned by the author; 19 stomachs, 28.8%). The size of the fish found in seal stomachs did not exceed 27cm. The food bulk consisting of fish remains weighed from 600 to 900g.

### Spring and summer periods

In the spring and summer months, the diet of ringed seals in the western seas of the Russian

Arctic is comprised of a variety of crustaceans, such as amphipods (*Parathemisto* sp., *Gammarus* sp., *Gammarocanthus loricatus* and *Anonyx nugax* in particular), mysids (*Mysis oculata*), krill (*Thysanoessa inermis*) and shrimps (Eualus gaimardi). Seals with their stomachs filled only with amphipods (*Parathemisto* sp.) have been found in the Kara and Barents seas (Geptner *et al.* 1976).

**Seasonal variation in blubber content**

In the period from mid-summer to early winter, ringed seals increase their blubber deposits. The seals have usually reached their maximum subcutaneous fat deposits by early winter, whereas they are depleted to the minimum level by summer. A ringed seal does not sink if shot in the water in autumn, winter, and early spring, while in summer a shot seal sinks. Special studies of the seasonal changes of blubber content in ringed seals were carried out in the White and Barents seas from 1970 to 1975 (Timoshenko 1978). The proportion of hide and blubber to total body weight (in %) was used as a condition index. Material was collected from 257 seals of different age and sex classes. This condition index indicates considerable seasonal variation. In September and October it averages 52.3%, decreasing to 42.5% in December and January and to 37.1% in mid-June. According to Timoshenko (1978), the decrease during summer is associated with moulting.

Ringed seal females are usually fatter than males. The condition index of females averaged 43.2% in December-January and 53.8% in September-October. In males, this value averaged 41.7% in December-January and 51% in September-October. No age differences were found for this parameter.

## SEALING AND UTILISATION OF SEALS

**Sealing by indigenous people**

Marine mammals (seals, walruses (*Odobenus rosmarus*), white whales (*Delphinapterus leucas*), narwhals (*Monodon monoceros*) and bowhead whales (*Balaena mysticetus*)) were harvested by indigenous people from the Kola Peninsula to the mouth of the Ob River from 3000-1000 BC to the 16th century (Krupnik 1986). The hunters were ancestors of the Nentzy and Saamii tribes that currently inhabit the northern coasts.

European and Russian sealing was developed in the Barents Sea in the 17-18th centuries, engaging almost all of the local population. During this time sealing by indigenous people declined (Krupnik 1986). Commercial sealing ceased when the resources of walrus and bowhead whales were depleted. Sealing by indigenous people was resumed in the 19th century. By the middle of the 19th century most members of Russian crews sealing in the eastern part of the Barents Sea (near the Novaya Zemlya, Vaigach and Kolguev islands), were indigenous to the Arkhangelsk Province (renamed as the Arkhangelsk Oblast during the Soviet time). Establishment of permanent settlements of the Nentzy was supported by Russian commerce. Nentzy dwellers were involved in the harvest of seals, walruses, polar bears, fur animals and fishing. The Nentzy did not harvest whales. In 1926 and 1927 about 80% of all marine mammals (more than 4,000 ringed seals, 1,500 seals of other species and 50 to 100 walruses and polar bears) harvested in the northeastern part of the Arkhangelsk Province were harvested by the Nentzy.

**Commercial catching**

Sealing by non-native people in the Russian North started in the 12-13th centuries (Ivashin *et al.* 1972). Emigrants from Great Novgorod (capital of a Russian county in the northeastern part of European Russia) settled along the coast. Sealing crews used special boats ("kotch") adapted to ice and reached Novaya Zemlya in the 14-15th centuries. Walrus was the main harvest object in Svalbard, where Russian sealing flourished in the 18th century (sealing teams owned up to 270 boats in the 1790s). Organised commercial whaling (primarily for white whales) and fishing in this area, however, did not start before the early 1930s.

Prior to 1917, hunters of all seaside regions of the Arkhangelsk Province as well as the inhabitants of Novaya Zemlya and Kolguev Island were involved in sealing, which provided the basis for their income (Zhilinskiy 1917).

During the dark period of the year, ringed seals and bearded seals were trapped with nets ("yunda"). During the rest of the year, marine mammals were both trapped and shot (no nets were used on Novaya Zemlya).

Sealing in northern European Russia declined during World War I (1914-1917), and during the Russian October Revolution and Civil War (1917-1921). It was restored in the latter half of the 1920s with the support of the provincial authorities. Old sealing areas were restored and new ones created. The process was particularly intensive on Novaya Zemlya, as a number of sealing areas were organised in the southern part of the archipelago.

The restoration of sealing was ensured by a resolution of the Central Executive Committee of the Russian Federation (5 April 1926) which exempted all residents of the sealing areas from the hunting tax. This affected all regions of settlement and movements of indigenous people. According to the census of 1 October 1928, 5,135 people lived in sealing areas in the tundra of the Arkhangelsk Province and 529 people lived on the islands; 69.9% and 77% of whom, respectively, were native to the region.

The earliest available information on the commercial catch of ringed seals in the Barents and White seas dates back to the end of the 19th century. A total of 3,200 ringed seals were harvested in the Barents Sea in 1894. In 1903, 4,512 ringed seals were harvested in the White Sea. The average annual harvest in the period 1905-1909 in the White Sea was estimated to be 7,504 seals (Nazarenko 1969).

Data on seal catches from the western Russian Arctic in the period between 1910 and 1994 are given in Table 2. It is noteworthy that the numbers given in Table 2 reflect the scale of the sealing conducted only by procurement companies, fish canneries and fishing industries. Local sealing for subsistence needs is not included. Data provided by Nazarenko (1969; Table 2) are based on inquiries, but should probably be corrected upwards with 10 to 15% to account for catches from places where no responses were received. According to Nazarenko (1969), annual fluctuations in the harvest were connected with both variations in density of animals in the sealing areas and harvest management problems. In addition, the number of ringed seals collected by procurement companies tended to decline from west to east. Nazarenko (1969) wrote: "In the White Sea, almost all harvested ringed seals are brought to the procurement companies and, hence, are registered. On the Barents Sea coast, the proportion of officially procured seals declines. And in the Kara Sea, procurement companies collect almost no ringed seals. The main reason for this is the very long distances between the sealing areas and both the procurement companies and human settlements in general. The lack of reported harvest should not be confused with the absence of sealing. Ringed seals are also used for private purposes (baits for Arctic foxes and forage for dogs), and seals harvested under such conditions are not reported in the official statistics. That is why we must carefully consider all information about the harvest of ringed seals in the Kara Sea."

Harvest statistics for the White, Barents and Kara seas for the period between 1960 and 1978 are given by Timoshenko (1984; Table 2). According to Timoshenko (1984), most ringed seals have been harvested in the Dvinskaya and Onezhskaya inlets and Kandalakshski Gulf of the White Sea. Ringed seals were also harvested on the Solovetskiye Islands up to 1978. Most ringed seals were harvested in the three autumn months; they were trapped in nets usually along with navaga and polar cod. The number of harvested ringed seals varies considerably according to season. According to Timoshenko (1984), this is related to the spawning season of fish as well as to weather conditions.

In the Barents Sea, seal catching from the early 1960s to late 1970s took place almost exclusively in the southeastern part: in the Cheshskaya and the Indigskaya inlets, near the Pesyakov and Vaigach islands, and near the Varandey Peninsula (Timoshenko 1984). Most seals were harvested in the Cheshskaya Inlet, near the Sengeyskiy and Kolguev islands, and in the Kolokolkova Inlet. About half of all harvested seals were from this region in some years. The number of seals harvested annually in the same areas differs greatly among years.

**Table 2.** Number of ringed seals harvested in different regions of the Western Russian Arctic.

| Year | Region | | | |
|---|---|---|---|---|
| | White Sea | White and Barents seas | Kara Sea | Barents and Kara seas[1] |
| 1903 | 4512* | | | |
| 1910 | 5527* | | | |
| 1911 | 5500* | | | |
| 1912 | 8912* | | | |
| 1913 | 6521* | | | |
| 1914 | 6557* | | | |
| 1915 | 4306* | | | |
| 1928 | 4800* | | | |
| 1929 | 6500* | | | |
| 1930 | 6800* | | | |
| 1931 | 7450* | | | |
| 1932 | | 2117* | | |
| 1933 | | 12600* | 13200* | |
| 1954 | | 2318* | | |
| 1955 | | 3103* | | |
| 1956 | | 2148* | | |
| 1957 | | 5388* | | |
| 1958 | | 2743* | | |
| 1959 | | 8814* | | |
| 1960 | 3489** | 4714* | 2400* | 1830** |
| 1961 | 1492** | 8802* | 2800* | 4184** |
| 1962 | 5207** | 13571* | 3600* | 5315** |
| 1963 | 2340** | 5059* | | 2551** |
| 1964 | 1401** | 5277* | | 3698** |
| 1965 | 3708** | 5597* | | 3390** |
| 1966 | 2719** | | | 7310** |
| 1967 | 3478** | | | 9274** |
| 1968 | 4936** | | | |
| 1969 | 820** | | | 3887** |
| 1970 | 4711** | | | 2137** |
| 1971 | 2648** | | | 2306** |
| 1972 | 3934** | | | 779** |
| 1973 | 3720** | | | 1386** |
| 1974 | 3065** | | | 1386** |
| 1975 | 2768** | | | 3513** |
| 1976 | 1572** | | | 2556** |
| 1977 | 1225** | | | 1874** |
| 1978 | 1259** | | | 2077** |
| 1985 | 923*** | | | 327*** |
| 1986 | 686*** | | | 454*** |
| 1987 | 1078*** | | | 629*** |
| 1988 | 1376*** | | | 1022*** |
| 1989 | 700*** | | | 77*** |
| 1990 | 680*** | | | 117*** |
| 1991 | 723*** | | | |
| 1992 | 700*** | | | 81*** |
| 1993 | 530*** | | | |
| 1994 | 628*** | | | |

[1]The Barents and Kara seas in the limits of the Arkhangelsk Oblast.
* Nazarenko 1969.
** Timoshenko 1984.
*** Anon. 1994

The main reason for this is the variation in ice and weather conditions that determine the run of polar cod and navaga towards the coast (Timoshenko 1984).

Timoshenko (1984) compared seal harvest data in the 1960s and 1970s for the White, Barents and Kara seas. The ringed seal harvest remained constant in the White Sea (3,000 animals harvested on average annually). In the Barents and Kara seas the harvest declined significantly from 4,600 individuals annually in the 1960s to 2,000 individuals in the period between 1970 and 1978. Timoshenko (1984), like Nazarenko (1969), considers the main reason for the decline to be not a decline in the number of seals, but rather a decreased effort in the sealing industry due to low prices for seal products.

Official data for the period between 1985 and 1994 (Table 2) reflect an abrupt drop in the level of the ringed seal harvest compared with the previous years. In our opinion, this is a result of an underestimation of the seal catch and a deterioration of the general economic situation in the northern regions of Russia. It is noteworthy that recorded figures again reflect only the number of seals obtained by the procurement companies, while many harvested seals are used locally for subsistence needs.

**Utilisation of ringed seals**

No actual changes have occurred in the utilisation of ringed seals since historical times. First the hide with subcutaneous fat ("khorovina") is taken off the harvested animal. Then the liver is extracted and stored in a large amount of salt (for use in preparation of a vitamin concentrate). Glue is prepared from the rear flippers. The hides of ringed and other seals were collected by the procurement companies which supplied tanneries with them for leather and fur processing.

On Novaya Zemlya, each hunter used an average of 10 hides annually for subsistence needs in the late 1930s (Chapski 1940). Pieces of hides were used for sewing waterproof shoes. The Nentzy of the Yamal Peninsula prefer to use the rear part of the hide for this purpose, since the front part has more pores and thus is not so waterproof.

In addition to footwear, mittens, caps, trousers and coats were sewn from the seal hides. Fringes of seal hides were sometimes attached to the fur coats made of buckskins. The hides were used for bags, sacks and belts (though native people preferred belts made of bearded seals (*Erignathus barbatus*) or harp seals (*Phoca groenlandica*) skin). Runners made of the ringed seals hides were attached to skis. Hides, together with the subcutaneous fat, were often used as a bait for Arctic fox.

If the fat was reserved for a storage company, it was not processed but put into barrels, sealed and turned over to the company. Some fat oxidised after long storage which limited its further commercial utilisation. Some fat is used for food, by the native people in particular. In industry, the seal fat has been used for technical purposes and for preparation of margarine and vitamin-rich fat for medical purposes. Meat is salted and then used as forage for pigs; fur animals (foxes, Arctic foxes and minks) were fed with quick-frozen meat and bone stuffing at the fur farms. Hunters also use the meat of harvested animals for their own purposes, both as dog food and for human consumption. The meat is generally consumed immediately and not stored for future use.

After the mid-1980s, the harvest of ringed seals abruptly declined almost all over the European north of Russia, owing to the closure of most of the procurement companies and fish-processing plants. Currently harvested seals are used almost exclusively for private purposes; meat and blubber serve as dog food and baits for Arctic foxes. Most hides are thrown away, although some of them are kept for making shoes and coats.

## CONSERVATION OF THE RINGED SEAL AND ITS HABITATS

According to Chapski (1940), the harvest of ringed seals was not historically controlled by any rules or regulations. That is why many seals "were killed without any use." In his opinion, "though the stock of seals is not subjected to the full game impact, it must be protected as a state property from irrational useless destruction"

(p.69). That is why Chapski suggests necessary game regulations along with the further development of sealing.

At present, the seal harvest is regulated by fishery regulations. Every hunter buying a hunting license is allowed to hunt ringed seals without any restrictions concerning time and place (except in the protected territories). The sole restriction is the prohibition of shooting swimming seals during the period when killed animals sink because of a thin layer of blubber. The establishment of specially protected areas will play an important role in the conservation of ringed seals and other marine mammals. "Zemlya Frantza-Iosifa", a State Nature Refuge of federal status, was established by a decree of the Russian Government in the region of the Frantz Josef Land in 1994. It covers an area of 42,000km$^2$. The refuge is managed by the Arkhangelsk Regional Committee of Nature Protection and Environmental Resources, which is under the jurisdiction of the Russian State Committee of Environmental Protection and Natural Resources. The areas protected in the refuge are the landscapes and their particular components, animal and plant species and communities inhabiting not only the archipelago itself, but also its surrounding marine areas. Commercial and other activities, resulting in disturbance of the ecological balance of terrestrial and marine ecosystems, are prohibited in the refuge. Only regulated tourism and scientific studies are allowed. Ringed seals as well as other marine mammals are protected in the "Kandalakshski" (the White Sea) and "Great Arctic" (the Kara Sea) nature reserves. Protected natural territories encompassing marine areas adjacent to Novaya Zemlya, Severnaya Zemlya and some other regions of the Russian Arctic, are expected to be established in the coming years.

## CONCLUSION

The ringed seal is the most abundant and widespread marine mammal species in the Russian Arctic. Despite this fact, the seals have never been subjected to intensive sealing, in contrast to walruses and harp seals. The probable reason for this is that ringed seals do not form large aggregations during any part of the year, as do some other seal species. Ringed seals were usually harvested along with fishing or in small quantities for local needs. Since the ringed seal is relatively unimportant as a game species and does not seem to be a threatened species, it has been almost neglected by scientists. The numbers and density of the animals are estimated only for limited areas, and migrations have not been studied. Nor has the scale of limited sealing ever been properly assessed. In our opinion, the ringed seal in the western Russian Arctic deserves more scientific attention in order to provide a more complete knowledge of this species.

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