Distribution and abundance of the largha seal (*Phoca largha* Pall.) on the coast of Primorye Region (Russia): a literature review and survey report

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Abstract. Long-term studies (1963–2000) of a local population of the largha seal *Phoca largha* in the waters of Primorye Region were reviewed. In winter, largha seals were observed mainly in the southern coast of Primorye (the Peter the Great Bay: PGB). In contrast, abundance was low along the eastern coast of Primorye, where waters were mostly open throughout the winter. In summer and fall, numbers decreased in PGB, whereas those along the eastern coast of Primorye increased. This might reflect seal movements between PGB and the eastern coast. The majority of the coastal haul-out sites were confined to the protected zone of the Far Eastern Marine Reserve in PGB, and seals used PGB haul-out sites year round. The results of seal tagging studies on the Rimskii-Korsakov Islands in PGB, suggest that largha seals are able to move far to the north from PGB, reaching the Sea of Okhotsk waters and the Pacific coast of Hokkaido, Japan. Population size was estimated recently to be about one thousand individuals. Further growth of the population may be limited by incidental take by the trap net fishery in PGB waters in winter, which accounts for up to 10% of annual mortality.

Key words: habitat use, incidental harvest, pack ice, recapture, spotted seal.

The largha seal (*Phoca largha* Pall.) is a representative pinniped in the coastal waters of Primorye Region (Russia), which is located in the western part of the Sea of Japan (Fig. 1). In the 1930s and 1940s, some researchers gathered harvest records of this species in this region, especially its distribution in the Peter the Great Bay (PGB), which is in the southern part of Primorye (e.g., Nikulin 1937; Pikharev 1948). In the mid-1960s, morphological analyses of body length, weight and the total number of trachea segments in mature female largha seals provided evidence that the PGB local population differs substantially from those of the Bering Sea and the Kuril Islands (Kosygin and Tikhomirov 1970). Local abundance in PGB is estimated as not less than one thousand seals, based on aerial surveys (e.g., Trukhin and Kosygin 1988). Thus, the largha seal population in PGB may be the smallest among the eight known populations

described by Shaughnessy and Fay (1977) for the North Pacific Ocean.

There are few publications with only limited descriptions of largha seal ecology in the western part of the Sea of Japan, and most of these are in Russian and not well-known among researchers from other countries. For instance, the mass breeding area in PGB was only first found in 1996–97 (Trukhin and Katin, in press), and the available distribution data for PGB is restricted to the winter-early spring season (January–March), when seals gather for reproduction and molting (Kosygin and Tikhomirov 1970). A systematic review of unpublished and published data for spotted seals in the Primorye region is critical for international conservation and management planning for this highly mobile species (Lowry et al. 2000). As well, understanding the seal distribution during seasons and areas of ice-free waters will

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Fig. 1. The Primorye Region in the western part of the Sea of Japan. The inset map shows the broader geographic location of the study area. The single dashed line shows the border of the Eastern Site of the Far Eastern Marine Reserve. The study area was divided at Cape Povorotnyi (double dashed lines) into two regions; Peter the Great Bay and the eastern coast of Primorye.

provide insights into habitat use, dispersal, and movement patterns.

This study attempts to summarize all available published information about the largha seal distribution along the coast of the Primorye Region, as well as our unpublished data on this species. Special attention is given to habitat use and movement patterns, and we discuss factors influencing the abundance of this population.

Study area

Variation in geographical, oceanographic and biological conditions along the Primorye coast provide seal habitats of varying quality and importance. For analysis we divided the coast of the Primorye Region into two areas: the bay (PGB) and the coastal area (the eastern coast of Primorye) (Fig. 1). The border between the two areas passed across Cape Povorotnyi.

Significant parts of the PGB coast include inlets separated by rocky capes, with numerous reefs and rocks as

haul-out sites. PGB also encompasses numerous islands of various sizes, many of which constitute the Far Eastern Marine Reserve, established in March 1978 (Fig. 1). This Marine Reserve covers 1.15% of PGB area, including some islands and their adjacent waters, and also a narrow part (500 meters) of the continental coast (Zhirmunskiy et al. 1983; Tyurin and Kolmakov 1997).

Along the eastern Primorye coast, the southern part is mainly rocky cliffs abruptly falling into the sea. There are few islands and near-coastal rocks, which are preferable haul-out sites. The northern part of the coast mainly consists of low coastal forest areas, which also provide few suitable haul-out sites.

Average annual air temperature in the study area ranges from 2.9°C in the north to 5.8°C in the south. The lowest air temperatures usually occur in January (Sailing Directions of the North-Western Coast of the Sea of Japan 1984). On and near the coast of Primorye, there are about 130 settlements, including the large centers of Vladivostok City (pop. 630,000) and Nakhodka Town (pop. 160,000) (Fig. 1). The coastal waters of Primorye,

Fig. 2. Largha seal distribution in PGB based on boat census from February 23–28, 1985. Closed circles are locations of single seals and small groups observed.

especially toward the south, are characterized by heavy shipping traffic, and the effects of human activity in Primorye are considerable.

Ice formation

The formation of ice in PGB begins in the northern part of the Amur Bay (Fig. 2) in the second half of November (Yakunin 1987), when ice floes are very thin, and seals can not haul over it. By the middle of December, ice floes become sufficiently thick to support a seal's mass. At that time, ice begins to cover the shallow inlets of the western PGB coast and bays of Russkiy Island, and then, the northern part of the Ussuri Bay (Fig. 2).

The northern parts of the Amur and Ussuri Bays are covered with shore ice in the middle of winter (January). The central part of PGB during this season is occupied by broken ice. The area of floating ice is not significant there because sea currents and strong and constant winds from the north constantly break up the ice fields (Sailing Directions of the North-Western Coast of the Sea of Japan 1984). Complex hydro-meteorological conditions, along with the peculiarities of regional climate, lead to a relatively rapid ice break-up, which usually occurs from February. Ice fragments are transported from the bay to the south, and the dense ice boundary recedes to the north (Fig. 3). The waters of PGB are nearly ice-free by the beginning of March, while the Amur Bay, retains ice

from the middle of November until the end of March or the middle of April.

Waters along the eastern coast of Primorye remain free of ice until the middle of December to the beginning of January, when it begins to appear in the shallow bays of northeastern PGB: Plastun, Terney, and Vladimir Bay (Fig. 1).

Data collection

Data used in this report were obtained in various seasons of 1985–1999. Methods are summarized below, and have been described in greater detail in earlier publications (Kosygin and Tikhomirov 1970; Trukhin and Kosygin 1988; Ashchepkov and Gudkov 2000; Trukhin et al. 2000; Trukhin and Katin, in press).

Method 1: Aerial and boat census

Direct observations were made from 'MI-8', 'MI-2', and 'KA26' helicopters at heights of <100–200 m. During ice-free seasons, helicopters flew along the coastline at distances sufficient for observing largha seals. During the ice season, aerial surveys covered several hundred square kilometers of the ice field areas in PGB. In these areas, transect surveys were carried out at 300–500 m intervals, across the whole ice massif (100% of the ice area) and all largha seals lying on the ice were counted and observed.

The majority of the aerial-surveys were conducted in PGB, and total time of the aerial surveys was 74 hours. Surveys were conducted on February 24, 1984; February 22–April 12, 1985; January 9–April 11, 1986; April 11, 1987 (Trukhin and Kosygin 1988); and on March 4, 19, 28, and August 16 of 1996; October 11, 1997; and on February 26, 28 of 1999. During the ice-free period, some surveys were conducted by boat.

Method 2: Listing the coastal haul-out sites

In order to confirm the location of coastal haul-out sites, all coasts of Primorye were investigated twice using a car in June and July of 1998. After identifying suitable sites for coastal haul-outs, i.e. near the capes, islands, and reefs, we observed these sites using field glasses and conducted interview surveys with local people about the occurrence of seals.

Method 3: Ground based census

To collect data on the population dynamics of largha seals, fixed-point observations were conducted at two representative haul-out sites: the Rimskii-Korsakov Islands (Fig. 2) in the central part of PGB, and Cape Krasnyi (No. 18 in Fig. 4) in the peripheral areas of PGB. We recorded all largha seals observed using binoculars both on the land and in the water. Observations were conducted on the Rimskii-Korsakov Islands between February 14 and March 28 of 1998, when there was no ice, and on Cape Krasnyi between November 5 of 1997 and December 29 of 1998, throughout the year (Trukhin et al. 2000).

Method 4: Tagging survey

We conducted tagging surveys for pups at the Rimskii-Korsakov Islands in PGB, in order to study juvenile movements, body growth and development, and the lactation and juvenile molting periods (Trukhin and I. O. Katin, unpublished data).

Movements of weaned pups (independent from their mother) were observed among different islands in the Rimskii-Korsakov Islands during February–March 1998, using binoculars in the coastal haul-outs of the islands, identifying individuals by their tags. Eighty-three of 135 pups were captured (or observed) repeatedly (from 2 to 14 times), and were measured and weighed when possible (Trukhin and I. O. Katin, unpublished data).

Method 5: Investigation of mortality in trap nets

Human-caused mortality of largha seals in PGB was

investigated by recording the number of largha seals killed in fixed traps for cod during the winter of 1996–1997 on the western shore of PGB (Fig. 2; Narva Bay) (Trukhin and Katin, in press). The total annual mortality due to traps was estimated by extrapolating the observed data to the entire harvest area, based on information about trap numbers from the Ichthyological Department of Primor'ye, Vladivostok.

Seal distribution and ice formation in Peter the Great Bay (PGB)

Except for yearlings, the largha seal molts once a year, which is generally between the breeding season and the two or three months that follow (Bigg 1981). The timing of the immature seal molt precedes that of adults, coinciding with the end of the adult breeding season (Kosygin and Gol'tsev 1971; Shmakova 1978; Trukhin and Katin, in press). Although previous reports describe the breeding season in PGB between February and mid-March (Kosygin and Tikhomirov 1970), recent data show that seals breed there between the middle of January and early April (Trukhin and Katin, in press). This is earlier than other populations in the Sea of Okhotsk and the Bering Sea (in March–April) (Tikhomirov 1966; Trukhin 1988).

Largha seals concentrate in PGB in winter and spring in order to breed and molt both on the ice and land. The spatial-temporal distribution of seals in this season strongly depends on ice conditions. In years of significant ice cover (e.g., the winter of 1984–1985) when the ice edge shifts to the southeast, seals were widely and somewhat evenly distributed around the bay (Fig. 2) (Trukhin and Kosygin 1988). In contrast, during years of poor ice development (winter of 1985–86) or anomalous weak development of the ice cover (winter of 1995–96), largha seals are limited to a narrower distribution bounded mainly in the Amur Bay, northwestern PGB (Fig. 3) (Trukhin, unpublished data by Method 1).

Beginning of ice formation and seal distribution around the breeding season

Largha seals usually appear in the northern part of the Amur Bay in the middle of December, when ice floes are newly formed. At this time, seals form very dense haul-out groups of several hundred animals. The whole PGB population seems to concentrate on the newly formed ice of the Amur Bay (Trukhin et al. 2000). From the end of December to the beginning of January, the area of ice in

Fig. 3. Largha seal distribution during the molting period on the ice of the Amur Bay, based on aerial surveys. A, February 25 of 1986; B, March 11 of 1986; C, March 19 of 1996; D, March 28 of 1996. Shaded areas and dashed lines represent the seal assemblages and ice edges, respectively.

the Amur Bay steadily increases, and ice density increases. Until the middle of January the ice edge sometimes shifts far to the south. The seals leave the zone of dense ice, disappearing from the northern part of PGB. For this period their distribution range is confined to the zone of ice floes along the southern edge of ice massifs (Trukhin, unpublished data by method 1).

During December and January, due to low air and water temperatures, the ice lanes and ice-holes are quickly covered with new ice. During helicopter surveys in the middle of January, a large number of holes were observed in the newly formed ice zone not far from the ice edge around Lomonosov Peninsula (Fig. 2) (Trukhin and Kosygin 1988). Largha seals make these breathing holes from below water (Kosygin and Tikhomirov 1970). Therefore, we could recognize the presence of seals by the holes, even when we could not observe seals on the ice.

In the first half of February, seal activity increases; they begin to haul-out on the ice more often (Trukhin et al. 2000), possibly because of a considerable increase in the air temperature, and the breeding season. The distribution of seals during this period is scattered along the

ice edge. Few groups (large or compact) are seen in the northern part of PGB (Trukhin and Kosygin 1988), and a considerable number of mature seals begin to concentrate on the Rimskii-Korsakov Islands (Fig. 2), where they breed (Trukhin et al. 2000; Trukhin and Katin, in press).

Distribution and Molting

The distribution of seals observed during a boat census from February 23–28 of 1985, appears in Figure 2 (Trukhin and Kosygin 1988 by Method 1). At first there were no dense haul-out sites in the bay. Seals appeared alone on the ice, or were rare in small groups. Immature seals started to molt and to gather on the ice. Seals were relatively widely distributed, and were seldom observed far from the ice edge in the northern part of PGB where the ice cover was very dense. With the decrease of the ice area the seal density in the haul-out sites increased, and the seals, along with the ice, moved further to the north.

Figure 3 depicts the seal distribution on the ice in the Amur Bay during the molting period, based on aerial surveys conducted in February and March of 1986 and

Fig. 4. Coastal haul-out sites of largha seals in PGB (open circles). Refer to Table 1 for haul-out site data. The dashed line shows the border of the Far Eastern Marine Reserve.

March of 1996. The first dense assemblages of largha seals appeared in the Amur Bay from the end of February to the beginning of March, 1986 (Fig. 3A). They were usually initially observed on the coarse-broken ice on the traverse of Russkiy Island. When the ice moved to the south from Russkiy Island into the open part of the bay, it quickly fragmented and ice areas became small. Following the dense ice, seals moved northward (Fig. 3B), and by the middle of March seals concentrated on the margin with the fast shore ice (Fig. 3C). During this period, their distribution usually depended on the ice edge configuration.

Individual groups of molting seals contained as few as several individuals to as many as 200–300. Total number of seals recorded for one day sometimes reached 500–700. Tens of seals were also frequently observed on haul-out sites in the western part of Bosfor Vostochnyi Strait, near the northwestern end of Russkiy Island, to which the isolated ice sheets were conveyed by the eastern winds out of the inlets of the western coast of Russkiy Island.

Throughout February, seals preferred to be in the southern part of PGB, although some occasionally moved to the north, reaching more dense ice on the traverse of Popov and Russkiy Islands.

By the end of March to the beginning of April, ice only remained in the northern part of Amur Bay (Fig. 3D), and most shore ice was broken. Fragments of ice of various sizes and densities were scattered widely over the northern-most part of the bay. Molting seals fre-

quently came out to ice remnants, but the ice remnant area rapidly decreased. Therefore, the haul-out area used by molting largha seals was also proportionally reduced, and the seal density on the ice that remained was increasing (Fig. 3D). However, after around the 20th of March, total seal numbers on the ice were decreasing, seldom reaching two hundred individuals. This may be explained by the fact that the ice remnants were not preferable for the haul-outs, because seals usually avoid wet ice. During this period before the ice disappeared, many seals that had molted migrated from the northern part of the Amur Bay to the islands (mainly, Rimskii-Korsakov Islands), while seals which were molting joined other molting seals on coastal haul-out sites. In this period, adults bred on the Rimskii-Korsakov Islands.

Coastal haul-out sites

Peter the Great Bay (PGB)

Largha seals use some haul-out areas in PGB during both ice-free and ice cover periods (Trukhin et al. 2000; Trukhin and Katin, in press). Figure 4 and Table 1 show the haul-out sites in PGB where seals had been observed by Methods 1, 3, and 5. The majority of the 18 haul-out sites were found on islands, most of which were located in the protected zone of the Far Eastern Marine Reserve.

Table 1 shows the maximum number of animals at each known haul-out site. The number of seals varied among haul-out sites, perhaps reflecting differences in the capacity and location of the haul-out sites. A rela-

Table 1. Coastal haul-out sites of largha seal in the Peter the Great Bay shown in Figure 4.

Location*	Maximum Number	Survey Period		Methods†	Source of Information
		Date/Season	Year		
1** Fal'shiviyi Island	Single ones	Summer	Every year	A, V	Trukhin and Kosygin (1988)
2** Butakov Rocks	100 ≤	July	1988	V	Trukhin and Katin (in press)
3** Vera Island	40	April	1990	V	Trukhin and Katin (in press)
4** Mikhel'son Rocks	60	October, 11	1997	A	(Trukhin unpublished data)
5** Furugel'm Island	20	June	1996	G	Trukhin and Katin (in press)
6** Gel'mersen Rocks	Single ones	Summer	Every year	A, V	Trukhin and Katin (in press)
7 Rocky reefs between the Islands of Malyi and Bol'shoi Gakkel'	35	October, 11	1997	A	(Trukhin unpublished data)
8 Alekseev Island (Reefs)	22	October, 11	1997	A	(Trukhin unpublished data)
9 Astaf'ev Rocks	15	Summer	Every year	A, V	Trukhin and Kosygin (1988)
10** Baklan'i Rocks	150	Early June	1988	V	Trukhin and Katin (in press)
11** Gil'denbrandt Island and the adjacent Durnovo Island and De-Livron Island (Rimskii-Korsakov Is.)	5	Summer	Every year	V	Trukhin and Katin (in press)
12** Matveev Island and the adjacent Matveev Rocks 1–4 (Rimskii-Korsakov Is.)	780	April, 15	1998	V	Trukhin et al. (2000)
13** Kentavr Rocks (Rimskii-Korsakov Is.)	200	April, 15	1998	V	Trukhin et al. (2000)
14 Mouth of the Ryazanovka River and the adjacent coastal area	Single ones	June	1977	G	Trukhin and Kosygin (1988)
15** Stenin Island (Rimskii-Korsakov Is.)	50	July–August	1979–1980	A, V	Trukhin and Kosygin (1988)
16 Kolonna Rock	20	October, 11	1997	A	(Trukhin unpublished data)
17 Lev Rock (near the southern termination of Ricord Island)	10	Early spring	1980	V	Trukhin and Katin (in press)
18 Rocky reefs some 300–500 m off Cape Krasnyi	50	January, 12	1998	G	Trukhin et al. (2000)

* Refer to Figure 4 for locations of the haul-out site.

** These haul-out sites are located on the territory of the Far Eastern Marine Reserve.

† A, Aerial survey; V, Vessel count; G, Ground based count.

tively small number of seals were observed on smaller reefs and rocks, while haul-out sites with large numbers were located in the protected zone of the Far Eastern Marine Reserve (Table 1, Fig. 4). At least 90% of the PGB population, estimated to be about 1,000 seals, (Trukhin and Kosygin 1988; Trukhin 1997), used the Marine Reserve in spring.

The haul-out sites on the Rimskii-Korsakov Islands play an important role in the seals' life history, not only as breeding grounds but also for molting (Trukhin and Katin, in press). When the ice finally disappeared in the northern part of PGB, some seals which had failed to molt on the ice floes, migrated to the Rimskii-Korsakov islands (mainly to Matveev Island), and continued to molt there on the beaches and rocks in early spring.

Eastern coast of Primorye

Along the Eastern coast of Primorye, the number of largha seals has never been high and coastal haul-out sites were few and scattered (Fig. 5, Table 2) (Trukhin, unpublished data by Method 2).

The largest number of haul-outs (200 animals or more) was recorded on Cape Schastliviyi and Cape Severnyi (No. 14 and 16 in Table 2, Fig. 5) in the northern part of the Eastern Primorye. At these sites, seals haul-out on land throughout the year (Voloshina 1998).

At other haul-out sites, the number of seal observed during summer and autumn was generally small, and seals did not necessarily appear every year. A small number of seals appeared episodically near the Capes of Gladkii, Sosunov, Olimpiada, Arka, Bol'shev, Mayachnyi, Signal'nyi, Astashev, Briner, Chetyryokh Skal, Tumannyi, Stolbovoi, and Olarovsky (Table 2, Fig. 5) (Trukhin, unpublished data by Method 2). Typically, they stayed in the water not far from the coast, only rarely hauling out on the coastal rocks during low tide. These areas did not have suitable haul-out sites, and the coast had either a sandy shore, which was closely adjacent to the forest, or high steep rocks abruptly falling to the water.

Along the eastern coast of Primorye, largha seals are usually observed just during summer and fall, and their

Fig. 5. Coastal haul-out sites of largha seals on the eastern coast of Primorye (open circles). Refer to Table 2 for haul-out site data.

abundance during winter and spring is low (Trukhin et al. 2000). This is consistent with other reports of observations (Voloshina 1998), and with the results of interview surveys with the local inhabitants (Trukhin, unpublished data by Method 2).

This scarcity of seals may be explained by the relatively low biomass of fish available there in winter (Dudarev 1996). The brief mass appearance of seals in summer and autumn coincides with the arrival of schools of various fish species which approach the coast for spawning (e.g. herring *Clupea pallasii*, Pacific eastern redfin *Tribolodon brandi*, and rasp *Pleurogrammus azonus*) (Dudarev 1996). For fishermen, the arrival of the largha seal assemblages signals the arrival of fish in the coastal waters.

Seasonal habitat use

Peter the Great Bay (PGB)

In order to investigate the seasonal habitat use of largha seals in PGB, systematic ground-based observations were conducted at two representative haul-out sites: the Rimskii-Korsakov Islands (Fig. 2), and Cape Krasnyi (No. 18 in Fig. 4) (by Method 3). Seasonal changes in the observed abundance were noted.

Fixed-point observations in the Rimskii-Korsakov Islands were conducted from February 14–March 28, 1998. In the second half of February, molting seals were absent from the islands, and we observed only mature seals which have not yet molted and were accompanied by pups. Molting seals first appeared on March 1 on the Kentavr Rock (No. 13 in Table 1, Fig. 4). Seasonal

Table 2. Coastal haul-out sites of largha seal in the eastern coast of Primorye shown in Figure 5.

Location*	Maximum Number	Survey Period		Methods**	Source of Information
		Date/Season	Year		
1 Cape Zolotoy	20	Summer	Every year	I	(Trukhin, unpublished data)
2 Adimi Bay	30	Summer	Every year	I	(Trukhin, unpublished data)
3 Mouth of the Kyuma River	40	Summer	Every year	I	(Trukhin, unpublished data)
4 Mouth of the Peysa River	Single ones	Summer	Every year	I	(Trukhin, unpublished data)
5 Reefs in 15 km to the north of Ust'-Sobolevka Village	50	June, 22	1998	G, I	(Trukhin, unpublished data)
6 Reefs in 5 km to the north of the Zhivopisnaya River mouth	40	June–November	1998	G, I	(Trukhin, unpublished data)
7 Cape Belkin	50	November, February	Every year	I	(Trukhin, unpublished data)
8 Cape Arka	30	Fall	Every year	G, I	(Trukhin, unpublished data)
9 Cape Baranyi	40	Year round	Every year	G, I	(Trukhin, unpublished data)
10 Cape Shants	20	Summer	1998	G, I	(Trukhin, unpublished data)
11 Cape Mosolov	30	June, 20	1998	G	(Trukhin, unpublished data)
12 Cape Pervenets	Single ones	June, 20	1998	G	(Trukhin, unpublished data)
13 Cape Strashnyi	Single ones	June, 20	1998	G	(Trukhin, unpublished data)
14 Cape Severnyi	343	November, 15	1990	G	Voloshina (1998)
15 Cape Blagodatnyi	30	June, 20	1998	G, I	(Trukhin, unpublished data)
16 Cape Schastlivyi	170	November, 17	1990	G	Voloshina (1998)
17 Cape Egorov	10	June, 19	1998	G	(Trukhin, unpublished data)
18 Cape Rassypnoi	25	June, 19	1998	G	(Trukhin, unpublished data)
19 Cape Elagin	Single ones	June, 19	1998	G	(Trukhin, unpublished data)
20 Cape Chernaya Skala	Single ones	June, 18	1998	G	(Trukhin, unpublished data)
21 Reefs of Zerkal'naya Bay	40	May–September	Every year	G, I	(Trukhin, unpublished data)
22 Cape Yuzhnyi	30	June, 18	1998	G, I	(Trukhin, unpublished data)
23 Cape Balyuzek (Vladimir Bay)	10–15	Summer–Fall	Every year	G, I	(Trukhin, unpublished data)
24 Cape Chikhachev	10	May–November	Every year	G, I	(Trukhin, unpublished data)
25 Cape Manevskiy	15–20	June, 17	1998	G	(Trukhin, unpublished data)
26 Cape Srednyaya Skala	15–20	June, 17	1998	G	(Trukhin, unpublished data)
27 Cape Nizhnyy	80	Summer	Every year	I	(Trukhin, unpublished data)
28 Evstafiya Bay 'Glukhiye Kamni'	80	Summer–Fall	Every year	I	(Trukhin, unpublished data)
29 Nerpichiy Island	10	June, 18	1998	G	(Trukhin, unpublished data)
30 Bel'tsov Island	200	September	1996	G	(V. N. Medvedev, personal communication) [†]
31 Khalerpe Island	40	Late Summer	1984	V	Trukhin and Kosygin (1988)
32 Cape Razgradskii	20	October, 11	1997	A	(Trukhin, unpublished data)
33 Reefs near Cape Laplas	7	October, 11	1997	A	(Trukhin, unpublished data)

* Refer to Figure 5 for locations of the haul-out site.

** A, Aerial survey; V, Vessel count; G, Ground based count; I, Interview survey.

† Information from V. N. Medvedev, the State Lazo Reserve.

changes in the number of molting seals at the Rimskii-Korsakov Islands are described in Figure 6. During the first half of March, the number of immature seals didn't exceed 100 individuals, and molting seals were observed on the Kentavr Rock only. The number of seals on the islands increased by March 17, and new haul-out sites appeared on Matveev Rocks 3 and 4 (No. 12 in Table 1, Fig. 4). Seals appeared on Matveev Island, Matveev Rocks 1 and 2, by the end of March, and the number

increased to more than 200 seals. The number of seals molting on the Rimskii-Korsakov Islands reached several hundreds in the first weeks of April (No. 12 and 13 in Table 1), when some adult seals (which may have completed breeding earlier than others) started to molt there (Trukhin et al. 2000). After the molting season, seal numbers decreased in PGB, especially on the Rimskii-Korsakov islands. The decrease continued until autumn, when the number of seals observed at haul-out sites

Fig. 6. Dynamics of the molting largha seal numbers on the Rimskii-Korsakov Islands in March, 1998.

Fig. 7. Dynamics of the largha seal number at Cape Krasnyi between November 5 of 1997 and December 29 of 1998.

began to increase again (Ashchepkov and Gudkov 2000; I. O. Katin, personal communication).

In contrast, the sighting data for Cape Krasnyi, near the eastern boundary of PGB (Fig. 4), describes a different pattern (Fig. 7) (Trukhin et al. 2000). Seals left this area from the middle of March to the middle of May, which coincided with the molting season on the Rimskii-Korsakov Islands where seal numbers were increasing (Fig. 6).

Given this apparent shift in distribution, we propose that seals inhabiting PGB concentrate on the Rimskii-Korsakov Islands for molting in spring. The Rimskii-Korsakov Islands provide suitable haul-out sites, and the Far Eastern Marine Reserve excludes human distur-

bance, two favorable conditions for molting by largha seals.

It may be possible that some PGB seals move to the southern Sea of Japan during the ice-free period. Years ago, two largha seal were harvested near the eastern coast of the Korean Peninsula (Mohr 1965), where the seal is uncommon (Won 1957), but these individuals may have come from the Yellow Sea.

Eastern coast of Primorye

Although largha seal numbers were mostly low in winter at the haul-out sites in this region, seals were more common to the north, at about 45°N (Voloshina 1998). Relatively large coastal haul-out sites along the

Table 3. Resighting data of largha seals born and tagged in the Peter the Great Bay in 1998.

Seal ID	Sex	Tagging		Resighting	
		Date	Location	Date	Location
46	Female	11 Mar. 1998	Matveev Is., Rimskii-Korsakov Is.	2 May 1999	Daikoku Is., Hokkaido, Japan 42°58'N, 145°53'E
92	Female	3 Mar. 1998	2 Stone Is., Rimskii-Korsakov Is.	4 Nov. 1998	Esashi, Hokkaido, Japan 44°50'45"N, 142°30–40'E
106	Male	22 Feb. 1998	De-Livron Is., Rimskii-Korsakov Is.	28 Jan. 1999	Sukhodol Bay, PGB 43°12'N, 132°21'E
132	Female	25 Feb. 1998	Durnovo Is., Rimskii-Korsakov Is.	19 Aug. 1998	Tyulenyi Is., Russia, Sea of Okhotsk (near Sakhalin) 48°38'N, 144°40'E
134	Male	27 Feb. 1998	De-Livron Is., Rimskii-Korsakov Is.	May 1998	Troitsa Bay, PGB 42°39'N, 131°06'E

Severnyi and Schastlivyi Capes (Table 2, Fig. 5: No. 14 and 16, respectively) were used throughout the year, although most seals departed during March and April (Voloshina 1998). There are no islands suitable for pupping there, and largha seals never bred on the mainland. The abrupt spring departure may be related to reproduction and molting opportunities in other areas.

Reproductive isolation of adjacent populations of largha seals in the Sea of Japan has not been assessed. Seals along the Severnyi and Schastlivyi Capes in winter may be related to the Tatar (Mamiya) Strait population (Trukhin and Katin, in press), and therefore move to that region during the March–April breeding season (Dorofeev 1935; Nikulin 1937; Kosygin and Gol'tsev 1971; Voloshina 1998). Molting pups and post-molt pups observed on the northern end of the Primorye Region (Voloshina 1998) may have been carried by ice drifting from the Tatar Strait. Alternatively, as noted above, seals from the Severnyi and Schastlivyi Capes might simply move to PGB for molting (Fig. 7) (Ashchepkov and Gudkov 2000; Trukhin, unpublished data).

Movement patterns of yearling seals

To study juvenile dispersal from PGB breeding grounds, we analyzed the recapture data of largha seals tagged in PGB during February and March of 1998 (by Method 4) (Trukhin et al. 2000).

After the breeding season, we recovered five tagged seals (Table 3), two of which were found in PGB. Three other individuals were found far to the north of the tagging site. One was a dead female (ID. 132, tag recovered by T. Chupakhina) found on Tyulenyi (Robben) Island near the eastern coast of Sakhalin Island. The other female (ID. 92) was caught by a salmon trap net in the near-coastal waters of northeastern Hokkaido, Japan (Mizuno and A. Wada, unpublished data), and the last one (likely ID. 46) was observed at a coastal haul-out site on Daikoku Island, Hokkaido, Japan (Y. Watanabe,

personal communication).

Even yearling seals were capable of migrating far to the northeastern area from PGB, reaching the southern Sea of Okhotsk (Table 3). Distances covered were between 1,000–1400 km, which is consistent with reports of 1,500 km movements between summer and winter habitats, recorded in satellite linked surveys of the Bering Sea (Lowry et al. 1998, 2000).

During the ice-free period, seal populations can overlap at places like Tyulenyi Island (where largha seal ID No. 132 was discovered, Table 3), which the eastern Sakhalin population also uses (Fedoseev 1984). As noted above (ID No. 92, Table 3), largha seals are often incidentally taken in the trap net fisheries near Hokkaido during the autumn salmon migration (Naito and Nishiwaki 1975; Mizuno et al. 2001). It is possible that some seals born in PGB moved to the Okhotsk coasts of Hokkaido and Sakhalin, while other pups remain in PGB, like the two tagged pups noted above. The appearance of tagged seals in various seasons and places suggests that there is no strict orientation of their migration routes, and that the movement of yearling seals is especially unpredictable.

Age-specific distribution

During the breeding period, immature seals had not been observed in the breeding and pupping areas on and around the Rimskii-Korsakov Islands (Trukhin, unpublished data). Kosygin and Tikhomirov (1970) also reported the absence of immature seals on PGB ice in February–March. In Hokkaido waters, immature seals haul out on the Sea of Japan coast between autumn and spring, while seals of various ages inhabit the Nemuro Strait of the Sea of Okhotsk (Mizuno et al. 2001; Mizuno and Ohtaishi 2002). These observations suggest that age-specific factors may influence largha seals movement patterns.

Fig. 8. Distribution of the maximum fast shore ice and the location of stationary trap nets in winter. Shaded areas and asterisks represent shore ice and places of trap nets, respectively.

Historical abundance data and factors affecting population dynamics

The first records of largha seal numbers in PGB were made at the end of the 19th century, when hundreds of seals were observed by hunters on the ice floes near the Rikord and Verkhovsky Islands (Fig. 4), (Ognev 1935). Daily harvests of largha seals there reached 80 or more at the time. Judging from the hunting data in PGB, there were probably several thousand largha seals. However, seal numbers decreased considerably until the 1930s. Seals disappeared from the haul-out sites on the Unkovsky Stones, Askol'd and Verkhovsky Islands. This likely reflects high hunting pressure for seals along the coast that accompanied human population growth in South Primorye.

In 1968, 138 largha seals were counted (with some double-counting possible) during 20 days of ship-based observation. At that time largha seal numbers were roughly estimated as several hundred individuals (Kosygin and Tikhomirov 1970). In 1985–1986, 500–700 largha seals were counted in aerial surveys at the haul-out areas of the Amur Bay (Trukhin and Kosygin 1988). Assuming that some portion of the seal population remained in the water during the survey, the population may have exceeded one thousand, perhaps reflecting some population growth that followed the establishment of the Far Eastern Marine Reserve in 1978.

Relatively good food resources for this fish-eating predator in PGB (Gavrilov et al. 1988; Markevich 1990; Vdovin 1996) could have also influenced largha seal population growth. In the Liaodong Gulf of the Yellow Sea, there is a local population of the largha seal (Huang 1962; Wang 1986, 1988) using an area that is similar in size to that available in PGB. However, largha seal numbers in the Liaodong Gulf exceed 8,000, and regular hunting occurs (Dong and Shen 1991).

For recent abundance estimates, Trukhin (1997) performed an aerial survey of molting seals in the Amur Bay on March 4, 19, and 28 of 1996. This study included all ice-covered waters of the bay. The results suggested no increase in the PGB seal population over the last ten years, and that the population may have been stable around one thousand individuals, in spite of favorable environment conditions, the inhibition of hunting, and the protection of breeding and pupping areas. Given limited data, we can only assume that the population growth in PGB is limited by human factors.

To investigate the effects of human activity on the PGB seal population, the incidental death of largha seals by fishery activity was surveyed in the winter of 1996–97 (Trukhin and Katin, in press; Method 5). In every winter and spring, a below-ice fishery has been carried out in the northwestern part of PGB. Stationary trap nets are set under the fast shore ice to catch mainly saffron cod (*Eleginus gracilis*). Placement of trap nets over-

lapped the areas where largha seals occurred in winter (Trukhin and Kosygin 1988). Attracted by fish, a considerable number of seals are caught by the trap nets and die. Annually, the number of traps in the western part of PGB averaged approximately 15, and the number of dead seals collected in the winter of 1996–97 was 7–10 individuals per trap; 100–150 seals may have been killed (Trukhin and Katin, in press). It is notable that seals killed in traps were predominantly large mature seals.

If the annual loss of largha seals in fishing nets averages 100 animals in PGB, a population of 1,000 could not sustain this 10% mortality. Fedoseev (1974) insists that for persistence or population growth of phocidae (including the largha seal), the annual economic catch should not exceed 4–5% of the total abundance. In other populations in the Sea of Okhotsk and the Bering Sea, annual pup production rates have been estimated as 26.0 to 28.2%, with an associated 3.7% increase in breeding animals, despite the fact that all age classes are subject to commercial harvest pressure (Gol'tsev 1990). Gol'tsev (1990) proposed that limited hunting pressure (<4–5%) on the reproductive segment of a population encourages earlier maturation of young animals, resulting in an increased number of breeding animals.

During the winter of 1996–97, the development of ice cover was poor, in particular, for the fast shore ice (Fig. 8). That may have made traps more accessible, and therefore more deadly for seals, and the mortality that occurred that year may have been unusually high. Regardless, such high levels of human-caused mortality can be particularly devastating to small populations such as that in PGB.

Other factors, such as environmental pollution may also be limiting growth of the PGB population. Future studies of reproductive parameters such as age at first birth and pregnancy rates are needed for a better understanding of largha seal population dynamics.

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References

- Ashchepkov, A. T. and Gudkov, A. I. 2000. The role of the Marine Reserve for preservation of largha-seal population in Peter the Great Bay. *Bulletin of the Eastern Branch, Russian Academy of Sciences* 1: 57–67 (in Russian).
- Belkin, A. N., Kosygin, G. M. and Panin, K. I. 1969. New materials on the characteristics of insularis seals. In (V. A. Arseniev, B. A. Zenkovich and K. K. Chapskiy, eds.) *Marine Mammals*. Pp. 157–175. Akad. Nauk USSR, Moscow (in Russian).
- Bigg, M. A. 1981. Harbour seal *Phoca vitulina* Linnaeus, 1758 and *Phoca largha* Pallas, 1811. In (S. H. Ridgway and R. J. Harrison, eds.) *Handbook of Marine Mammals*, vol. 2: Seals. Pp. 1–28. Academic Press, London.
- Dong, J. and Shen, F. 1991. Estimates of historical population size of harbor seal (*Phoca largha*) in Liaodong Bay. *Marine Sciences* 3: 26–31 (in Chinese).
- Dorofeev, S. V. 1935. Materials on the biology of pinnipeds hunted in spring in the Tatar Strait. *Trudy VNIRO* 3: 217–219 (in Russian).
- Dudarev, V. A. 1996. Some structural peculiarities of fish assemblages and their seasonal distribution on the shelf of northern Primorye. *Izvestiya TINRO* 119: 194–206 (in Russian with English abstract).
- Fedoseev, G. A. 1974. Some results and modern problems of studying the Pinnipeds. In (A. V. Yablokov and L. P. Poznanin, eds.) *Zoology of Vertebrates*. Vol. 5. Pp. 87–137. VINITI, Moscow (in Russian).
- Fedoseev, G. A. 1984. Population structure, recent status and perspectives of use of the ice form pinnipeds in the north part of Pacific Ocean. In (A. V. Yablokov, ed.) *Marine Mammals*. Pp. 130–146. Nauka, Moscow (in Russian).
- Gavrilov, G. M., Pushkareva, N. F. and Strel'tzov, M. S. 1988. Diversity and biomass of the bottom and near-bottom fish in the economic zone of the USSR in the Sea of Japan. In (N. S. Fadeev, ed.) *Variability of Ichthyofauna Diversity, Volume of Generations and Methods of Forecasting Fish Resources in the Northern Pacific*. Pp. 5–8. TINRO, Vladivostok (in Russian).
- Gol'tsev, V. N. 1990. Maturing and reproductive capability of largha seal populations in the Far-Eastern Seas. *Izvestiya TINRO* 112: 108–113 (in Russian with English abstract).

- Huang, S. J. 1962. Pinnipedia. In Economically Important Animals of China. Pp. 414–417. Kexue Chubanshe, Peking (in Chinese).
- Kosygin, G. M. and Gol'tsev, V. N. 1971. Materials concerning the morphology and ecology of largha seals of the Tatar Strait. Trudy AtlantNIRO 39: 238–252 (in Russian).
- Kosygin, G. N. and Tikhomirov, E. A. 1970. Largha seals (*Phoca largha* Pallas) of Peter the Great Bay. Izvestiya TINRO 70: 114–137 (in Russian).
- Lowry, L. F., Burkanov, V. N., Frost, K. J., Simpkins, M. A., Davis, R., DeMaster, D. P., Suydam, R. S. and Springer, A. 2000. Habitat use and habitat selection by spotted seals (*Phoca largha*) in the Bering Sea. Canadian Journal of Zoology 78: 1959–1971.
- Lowry, L. F., Frost, K. J., Davis, R., DeMaster, D. P. and Suydam, R. S. 1998. Movements and behavior of satellite-tagged spotted seals (*Phoca largha*) in the Bering and Chukchi Seas. Polar Biology 19: 221–230.
- Markevich, A. I. 1990. Daily distribution and density of some fish populations in the near-shore area of the Peter the Great Bay. In (V. N. Ivankov, ed.) Biology of Shelf Fish and Migrating Fish. Pp. 16–19. FEB RAS, Vladivostok (in Russian).
- Mizuno, A. W. and Ohtaishi, N. 2002. Cranial features of the spotted seal, *Phoca largha*, in the Nemuro Strait, considering age effects. The Journal of Veterinary Medical Science 64: 137–144.
- Mizuno, A. W., Suzuki, M. and Ohtaishi, N. 2001. Distribution of the spotted seal *Phoca largha* along the coast of Hokkaido, Japan. Mammal Study 26: 109–118.
- Mohr, E. 1965. Über *Phoca vitulina largha* Pallas, 1811 und weissgeborene Seehunde. Zeitschrift für Säugetierkunde, Hamburg. 30: 273–287 (in German).
- Naito, Y. and Nishiwaki, M. 1975. Ecology and morphology of *Phoca vitulina largha* and *Phoca kurilensis* in the southern sea of Okhotsk and northeast of Hokkaido. Rapports et proc. s-verbaux des réunions/conseil permanent international pour l'exploration de la mer 169: 379–386.
- Nikulin, P. G. 1937. Observations on the pinnipeds of the Seas of Okhotsk and Japan. Izvestiya TINRO 10: 49–58 (in Russian).
- Ognev, S. I. 1935. Mammals of the USSR and Adjacent Countries. Vol. 3. Fissipedia and Pinnipedia. Biomedgiz, Moscow-Leningrad, 723 pp. (in Russian).
- Pikharev, G. A. 1948. Trade of the Pinnipeds in the Seas of the Far East., Primizdat, Vladivostok. 48 pp. (in Russian).
- Sailing Directions of the North-Western Coast of the Sea of Japan. 1984. Glavnoye Upravleniye Navigatsii i Okeanografii, Leningrad, 319 pp. (in Russian).
- Shaughnessy, P. D. and Fay, F. H. 1977. A review of the taxonomy and nomenclature of North Pacific harbour seals. Journal of Zoology (London) 182: 385–419.
- Shmakova, G. G. 1978. Seasonal and age-sexual changes of molt terms of seals in the Sea of Okhotsk/Marine Mammals. Pp. 359. Materials of VII-th All-Union Conference, Moscow (in Russian).
- Tikhomirov, E. A. 1966. On reproduction of Phocidae of the north part of the Pacific Ocean. Zoologicheskii Zhurnal 45: 275–281 (in Russian with English abstract).
- Trukhin, A. M. 1988. Materials on the biology of the largha seal of the Bering Sea. In (N. S. Chernyshova, ed.) Nauchno-issledovatel'skie raboti po morskim mlekopitayushchim severnoi chasti Tihogo okeana v 1986/87. Pp. 38–44. All-Union Scientific Research Institute of Fisheries and Oceanography (VNIRO), Moscow (in Russian).
- Trukhin, A. M. 1997. Status of the phocid seals in the Far East Marine Reserve. In (A. V. Zhirmunskii, ed.) III-th Far East Reserve Conference. Pp. 119–120. Dal'nauka, Vladivostok (in Russian).
- Trukhin, A. M., Fominykh, B. E. and Katin, I. O. 2000. Largha seal distribution and migration near Primorye coast/Marine Mammals of Holarctic. Pp. 389–393. Materials of International Conference, Arkhangelsk (in Russian).
- Trukhin, A. M. and Katin, I. O. In press. Largha seals (*Phoca largha* Pallas) in the Far East State Marine Reserve and in the border territories. In: Marine Reserve. V. 2. Investigation. Dal'nauka, Vladivostok (in Russian).
- Trukhin, A. M. and Kosygin, G. M. 1988. Materials about distribution and population of largha seals in the Peter the Great Bay. In (N. S. Chernyshova, ed.) Nauchno-issledovatel'skie raboti po morskim mlekopitayushchim severnoi chasti Tihogo okeana v 1986/87. Pp. 97–103. All-Union Scientific Research Institute of Fisheries and Oceanography (VNIRO), Moscow (in Russian).
- Tyurin, A. N. and Kolmakov, P. V. 1997. Reserve islands of Primorye. In (A. V. Zhirmunskii, ed.) III-th Far East Reserve Conference. Pp. 120–121. Dal'nauka, Vladivostok (in Russian).
- Vdovin, A. N. 1996. Diversity and biomass of fish in the Amur Bay. Izvestiya TINRO 119: 72–87 (in Russian with English abstract).
- Voloshina, I. V. 1998. Structure of the largha seal (*Phoca largha* Pall.) haul-outs and analysis of these haul-outs being used by the animals on the coast of the Sea of Japan. Bulletin of Moscow Society of the Verifiers of a Nature, Dep. Biology 103: 3–8 (in Russian with English abstract).
- Wang, P. 1986. Distribution, ecology and resource conservation of the spotted seal in the Huanghai and Bohai Seas. Acta Oceanologica Sinica 5: 126–133.
- Wang, P. 1988. Survey on the distribution of spotted seal in Bohai Sea. Oceanologia et Limnologia Sinica 7: 7–11 (in Chinese with English abstract).
- Won, H. G. 1957. Hunting Animals of Korea and their Economical Significance. Pp. 16. Publication of the Academy of Sciences of Korean People's Democratic Republic, Pheniyung (in Korean).
- Yakunin, L. P. 1987. The Atlas of Ice Conditions in the Far Eastern Seas in USSR. Ministry of Higher and Middle Special Education of RSFSR, USSR State Committee on hydrometeorology and Control of Natural Environment, Vladivostok. 78pp. (in Russian).
- Zhirmunskii, A. V., Krasnov, E. V., Kurentsova, G. E., Perestenko, L. P. and Shuntov, V. P. 1983. Far East State Marine Reserve. DVNTs AN SSSR, Vladivostok. 57 pp. (in Russian).

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