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Observations of Ringed Seal (*Phoca hispida*) in the Nearshore Waters of the Chukotka Peninsula

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ABSTRACT. Despite the importance of ringed seals in the regional economy of the Chukotka Autonomous District, with the end of the commercial fishery, research on the ringed seal in Russia has almost completely ceased. The coastal zone of the Chukotka Peninsula, where the Native people hunt for seals, has seen very little research. This paper is devoted to the study of the modern distribution and habitat of the ringed seal (*Phoca hispida*) in the coastal waters of Chukotka. Observations of ringed seals were carried out simultaneously with observations of other species of marine mammals from posts located on the coast of the Chukotka Peninsula in 1993–96, 1998–2000, 2002–05, and 2010–11. Field studies provided information on the spatial and seasonal distribution, movements, and relative abundance of the ringed seal in the coastal zone. In winter, seals were found on the drifting ice in the southern coastal area of the northern part of the Gulf of Anadyr, and on fast ice and its edge in the bays of the eastern part of the Chukotka Peninsula. In spring, the main aggregations of ringed seals were observed on fast ice in Senyavin Strait, Lavrentiya Bay, and Tkachen Bay. The migration of immature seals to the Chukchi Sea was noted. In summer, animals were distributed in the coastal zone of the entire Chukotka Peninsula, but their relative number decreased by 85%. In late autumn, the main aggregations of seals were observed on the young ice of Lavrentiya Bay, in Senyavin Strait, and in Tkachen Bay. The landfast ice of the eastern coastal zone of Chukotka Peninsula is one of the main areas for the reproduction of ringed seals in the Bering Sea.

Key words: ringed seal; shore-based visual observations; Chukotka Peninsula; Gulf of Anadyr; Chukchi Sea; distribution; migration

RÉSUMÉ. Malgré l'importance du phoque annelé dans l'économie régionale du District autonome des Tchouktches, avec la fin de la pêche commerciale, la recherche sur le phoque annelé en Russie a presque entièrement cessé. La zone côtière de la péninsule des Tchouktches, où les Autochtones chassent le phoque, a fait l'objet de très peu de recherche. Cet article porte sur l'étude de la répartition moderne du phoque annelé (*Phoca hispida*) et de son habitat dans les eaux côtières des Tchouktches. Les observations de phoques annelés ont été effectuées en même temps que les observations d'autres espèces de mammifères marins à partir de postes d'observation situés sur la côte de la péninsule des Tchouktches en 1993–1996, 1998–2000, 2002–2005 et 2010–2011. Des études sur le terrain ont permis d'obtenir des renseignements sur la répartition spatiale et saisonnière, les déplacements et l'abondance relative du phoque annelé dans la zone côtière. En hiver, les phoques ont été aperçus sur la glace en dérive de la zone côtière sud de la partie nord du golfe d'Anadyr de même que sur la glace rapide et sur les lisières de glace des baies de la partie est de la péninsule des Tchouktches. Au printemps, les principales agrégations de phones annelés ont été observées sur la glace rapide du détroit de Senyavin, de la baie de Lavrentiya et de la baie de Tkachen. La migration des phoques immatures vers la mer des Tchouktches a été notée. L'été, ces bêtes étaient réparties dans la zone côtière de toute la péninsule des Tchouktches, mais leur nombre relatif diminuait de 85 %. Vers la fin de l'automne, les principales agrégations de phoques ont été observées sur la jeune glace de la baie de Lavrentiya, du détroit de Senyavin et de la baie de Tkachen. La glace de rive de la zone côtière est de la péninsule des Tchouktches est l'un des principaux lieux de reproduction du phoque annelé dans la mer de Béring.

Mots clés : phoque annelé; observations visuelles à terre; péninsule des Tchouktches; golfe d'Anadyr; mer des Tchouktches; répartition; migration

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INTRODUCTION

The ringed seal (*Phoca hispida*) is the smallest Arctic pinniped. This species is well adapted to life both in the landfast ice and in drifting ice (Kelly and Quakenbush, 1990; Smith et al., 1991; Frost et al., 2004; Crawford et al., 2012). It is the typical and most numerous inhabitant of the coastal waters of the Chukotka Peninsula, both in the Bering Sea and the Chukchi Sea (Fedoseev, 1965; Heptner et al., 1976). Until recently, the specific features of ringed seal habitat in the waters of the Chukotka Peninsula remained poorly understood. Despite the great importance of the ringed seal as a food source for Native peoples, after the commercial hunt for pelagic pinnipeds ended, research in Russia on the species ceased. The nearshore zone, where the Natives of Chukotka engage in hunting is almost untouched by research, with the exception of the investigation by Fedoseev (1965). The available information, based on the results of aerial surveys (Fedoseev, 1966, 1979) and on the results of commercial pelagic marine mammal hunting (Kosigin, 1966; Fedoseev, 2005), is devoted to ringed seals inhabiting drifting ice. Aerial surveys were designed to obtain multispecies information from the largest possible area, so due attention has not been paid to coastal areas with landfast ice, where ringed seals are concentrated during the breeding and molting periods. Commercial pelagic marine mammal hunting was conducted among the drifting ice. Therefore, until recently, there has been no information about ringed seals offshore of the Chukotka Peninsula. Only recently was an aerial survey of the ringed seals in the northern coastal zone of the Chukotka Peninsula conducted (Chernook et al., 2019).

As is well known, marine mammal hunting is one of the oldest occupations of the coastal inhabitants of Chukotka.

To provide the vital needs for survival, marine mammal hunters must be able to confidently distinguish marine animal species, know the features of the animal's habitat, and be observant. In this study, an attempt is made to combine the knowledge of sea hunters and scientific approaches, in order to prepare up-to-date information on the distribution, seasonal movements, and behavior of ringed seals offshore of the Chukotka Peninsula.

The article is part of a series of publications on the results of observations of marine mammals in the coastal waters of the Chukotka Peninsula conducted from 1990 to 2011 (Melnikov et al., 2007; Melnikov, 2017, 2020).

METHODS

Observation of ringed seals was conducted concurrently with observation of other marine mammal species. In some years, up to 30 Native observers were employed at this task, although only one or two observers were involved at the start and end of the work. Some watched from observation posts in Native villages on shore, and others from motorboats during hunting trips to obtain marine mammals as food and other needs of the Native population (Fig. 1, Table 1). Observations were conducted mainly from April through November, but some were conducted year-round.

Visual observations were made with binoculars, with observers taking note of elevation of the observation perch, duration of observations, observation conditions (direction and force of wind, visibility, presence or absence of whitecaps), percentage ice cover, number of marine mammals sighted, their approximate distance from shore, location on the ice surface or in the water, and swim direction.

In the course of the observations, the hunters employed on the project gained experience, which was evident in their improved performance. Organization also improved as work progressed. The most extensive research efforts occurred in 1994–96, and then in 2000, 2002, 2003, and 2005 (Table 1). The relative lack of data collected in 1993 was due basically to the lack of experience of the observers, while poor organization was responsible for the lack of data in 1997 and scanty information for 1998. In 2010–12, low effort occurred.

The seemingly simple task of recording the length of time an observer conducted observations on any particular day turned out to be a difficult organizational issue. It would take only 30 min of actual observation time to determine the species and the number of animals in the sector of observation, yet most observers working in the villages listed the duration of observations as the length of the working day. Since observations were conducted sporadically, the reported duration of observations obviously bore little relation to reality. However, a hunter's own observations are always augmented by information received from other people in the village looking out to sea. For these reasons, observers found it difficult to calculate observation time: some recorded the time they spent looking through binoculars; others, the time spent on shore; and still others, the length of the working day. Observers sitting in a boat during a hunting expedition may have been hampered by a low vantage point limiting their field of vision. On the other hand, they were constantly on the move, and all members of the crew watched out for marine mammals, often from dawn till dark. Information, however, is recorded in the logbook only at the end of the working day, is always integrated, and the observers usually put the length of time they spent at sea as their observation time, which is often as long as 18 hours. But even during hunting trips, observations were not conducted steadily throughout the day, given the interruptions for actual hunting activity and the work connected with getting the harvested animals back to shore, when the observers' attention was focused on their take. For all these reasons, we were obliged to regard each count from one observer-day (observation) with acceptable and good weather as an observation, without regard to the duration or intensity of search. Our fundamental unit for analysis was therefore the number of seals per observation. During analysis, data were normalized to the unit (number of seals/number

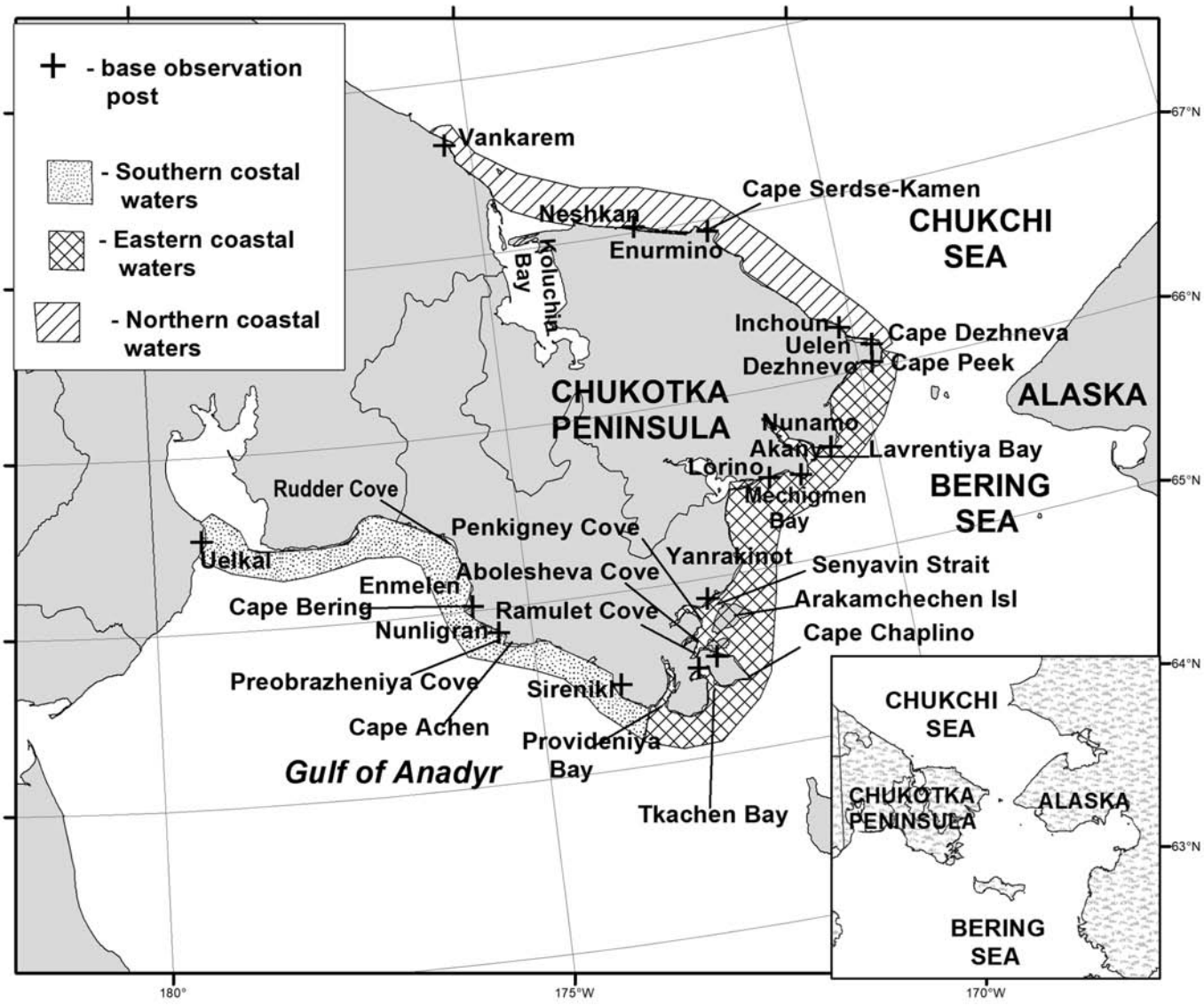

FIG. 1. Study area showing all base observation posts from which ringed seals were observed along the Chukotka coast. Because of spatial differences in conditions, the data obtained from individual observation points were analysed by area: Gulf of Anadyr, Bering Sea, and Chukchi Sea.

TABLE 1. Timing and numbers of ringed seal observations in the coastal waters of the Chukotka Peninsula.

Years Years	Number of observers	Start date	End date	Total observation days
1990	1	14 June	1 December	77
1991	1	30 June	10 December	78
1993	3	30 May	29 November	217
1993	5	5 May	30 November	589
1994	26	1 April	27 December	4180
1995	28	1 June	31 December	5288
1996	30	1 January	30 November	5537
1998	9	1 April	30 December	1516
1999	19	1 April	30 November	3318
2000	20	1 April	30 December	4300
2002	29	1 March	30 November	4674
2003	29	1 March	28 November	4262
2004	9	1 April	28 December	662
2005	20	1 April	26 September	1512
2010	2	28 May	30 November	120
2011	3	18 May	28 November	145
2012	2	1 May	13 December	229

of observations) to provide an average for village, region, or period of time. Of the sighting data associated with each count, we used only swim direction, location on an ice surface or in water, and percentage ice cover. These variables were assessed subjectively by the observers.

Since most villages in neighboring areas had several observers working independently of one another, we averaged the data from all the observers in one area. Statistical and cartographic analysis of the obtained results was carried out using Microsoft Office Excel, GrafPad Prism, ArcMap 10.3.1. Kernel densities were calculated using the program Spatial Analyst Tools in Arc Tool Box of ArcMap 10.3.1.

Because of spatial differences in conditions, the data were analyzed separately in three areas from south to north (Fig. 1): 1) Gulf of Anadyr: The coastal waters of the southern Chukotka Peninsula, including the northern part of the Gulf of Anadyr; 2) Bering Sea: The coastal waters

of the eastern Chukotka Peninsula, including the extreme northwestern waters of the Bering Sea, adjacent to the Bering Strait; and 3) Chukchi Sea: The coastal waters of the northern Chukotka Peninsula, including the southwestern waters of the Chukchi Sea.

RESULTS

Winter (January–March)

Gulf of Anadyr: In winter near the southern coast of the Chukotka Peninsula, fast ice forms only in closed bays, such as the small Preobrazheniya and Rudder Coves and Kresta Bay. In addition, the landfast ice is kept off the coast to the north of Cape Bering. In the winter months (January–March) in the southern coastal area, observers recorded 2.3 individuals on average and up to 100 individuals per day (Table 2, Fig. 2). The largest number of ringed seals was recorded in the area of the village of Uelkal, located at the outlet of Kresta Bay. Here, in March 2002, an average of 11.9 and up to 50 individuals per day were counted. On the landfast ice and in the unfrozen patch of water between Cape Bering and Rudder Cove, an average of 2.3 seals and up to 100 individuals were counted per day.

In the northeastern part of the Gulf of Anadyr, where fast ice is almost absent or forms for a short period, ringed seals were seen both on the drifting ice and in the water. An average of 1.6 individuals with a maximum of 50 per day were recorded here.

TABLE 2. Mean, maximum number, and standard error (SE) of ringed seals in the waters of the Chukotka Peninsula, depending on the season and region.

Area	Season	Mean	Maximum	SE	Number of observations
Gulf of Anadyr					
	Winter	2.3	100	0.2	875
	Spring	4.2	300	0.2	3114
	Summer	2.2	500	0.2	3187
	Autumn	1.4	200	0.2	1847
Bering Sea					
	Winter	11.3	80	0.6	363
	Spring	46.6	3000	3.3	3495
	Summer	3.1	500	0.3	3365
	Autumn	12.0	2000	1.6	1790
Chukchi Sea					
	Spring	9.1	300	0.4	2047
	Summer	3.5	200	0.2	2666
	Autumn	4.0	300	0.5	1065

Bering Sea: The eastern part of the Chukotka Peninsula is characterized by a large number of bays and straits, in which landfast ice forms. From January to March, ringed seals were seen not only on the fast ice in the bays and coves, but also, mainly at the edge of the landfast ice, both on the ice and in the water of the polynia (Table 3). The most numerous animals were in the northern part of the Senyavin Strait and the eastern part of the Tkachen Bay (Fig. 3a, b). From individuals to several dozen animals were observed in good weather; on average, 11. 3 seals per day were seen and up to a maximum of 80 (Table 2). In Senyavin Strait and Tkachen Bay, as well as near Dezhnevo, ringed seals were also found near holes in

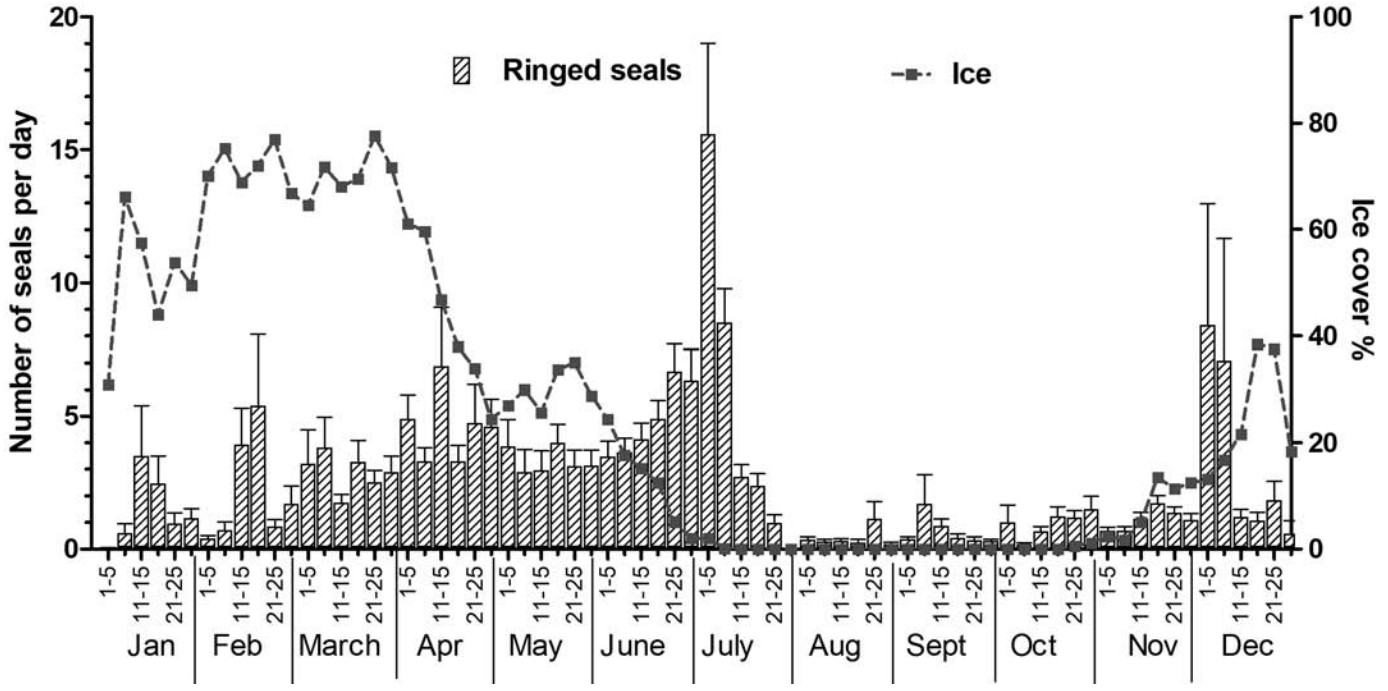

FIG. 2. Relative number of ringed seals in the southern coastal waters of the Chukotka Peninsula (Gulf of Anadyr) from January to December, by month. Data were averaged for all years of observations. Each bar represents five days (or occasionally six days in a longer month). Lines above columns denote the standard error. The dashed lines and boxes show the percent ice cover.

TABLE 3. Number and percentage of ringed seals recorded in the water, on the ice, or at the ice edge on the eastern coast of the Chukotka Peninsula during the winter and spring months for all years of observation.

	In water		On ice		At the ice edge (water + ice)	
Month	#	%	#	%	#	%
January–March	45	1.4	1327	42.6	1745	56.0
April	444	5.5	5437	67.2	2207	27.3
May	2377	3.8	58320	93.3	1820	2.9
June	4163	5.2	75385	94.2	485	0.6

the ice. On the drifting ice, seals were seen only at Cape Chaplino. The relative abundance of ringed seals in the eastern coastal region remained relatively stable in January–March (Fig. 4). Observers reported that the stomachs of the captured animals contained shrimps and Arctic cod (*Boreogadus saida*).

Chukchi Sea: In January, the ringed seal was recorded only in 1996 in the Chukchi Sea, after a long and warm autumn in 1995 (Fig. 3a). The animals were found in cracks in the ice, in open water, and hauled out on thin, newly formed ice. In February 1994, a ringed seal was observed in the breathing holes of a freezing crack. Seals were rarely seen in March and only in the Uelen area beside open leads in the fast ice. For the entire January–March period of observations, no ringed seals were found in the Chukchi Sea west of Uelen.

Spring (April–June)

Gulf of Anadyr: In the northern part of the Gulf, seals were found mainly in areas with stable ice cover: Preobrazhenie Cove, Rudder Cove, the shallow waters to the north of Cape Bering, and at the outlet of Kresta Bay (Fig. 5). On average, 4.2 seals per day were counted in the Gulf of Anadyr in the spring, with a maximum of 300 (Table 2). In April, 88% of seals were seen on the ice, in May, 80%, and in June, only 46% (Table 4). Observers noted that in the morning the animals left the fast ice and moved to the sea, and then, in the evening, returned to the previous place. At the northeastern outlet of the Gulf of Anadyr, where there is no stable ice cover, ringed seals were seen mainly on drifting ice. Here, in June, 92% of the animals that were in the water moved to the east and northeast to the exit of the Gulf. Mainly Arctic cod was found in the stomachs of captured seals.

Bering Sea: In the eastern coastal waters of the Chukotka Peninsula, in April, ringed seals were recorded along the entire shore, including the southwestern part of the Bering Strait (Fig. 5). Seals were seen mainly on the ice near cracks and holes, as well as on the edge of the landfast ice (Table 3). Animals were numerous in the bays of Tkachen (up to 300 individuals per day), Lavrentia (up to 60 individuals per day), and especially at the northern entrance of the Senyavin Strait, where thousands of seals were observed on the ice in some years. From 12 April to 18 April 2009, 2000–3000 animals were counted here daily. In the eastern part of the Senyavin Strait on 12 April 2003, about 1000 animals were seen on the surface of young ice at a crack in the fast ice. Observers noted numerous tracks of wolverines and foxes that went onto the ice, as well as traces of seal pups being dragged to the shore. Gobies and shrimps were found in the stomachs of captured ringed seals.

In May, lairs and breathing holes of ringed seals were opened in the ice. As cracks appeared in the fast ice, seals were found at the cracks or near breathing holes. A maximum number of 300 individuals was recorded in May on the ice of Tkachen Bay. In Lavrentiya Bay, 400 ringed seals lay on the ice in combination with spotted seals (*Phoca largha*). Up to 15 pairs of females with pups were also found here. During May of all years, an average of 96% of the seals in Tkachen Bay basked on the ice surface, as did 90% of the ringed seals in Lavrentiya Bay. In May, the proportion of animals counted at the edge of the fast ice decreased to 3%. The basking seals moved from the landfast ice to deeper in the bays (Table 3). The most numerous group remained in Senyavin Strait where, on 30 and 31 May 2003 on the surface of the fast ice, 3000–4000 individuals were counted. Eight seals were observed basking at one hole in the ice. On the surface of drifting ice, ringed seals were recorded only at the northern entrance of the Senyavin Strait. At the end of the month, seals appeared on the ice of the lagoon of the Mechigmen Bay. In the southwestern part of the Bering Strait, solid, stable ice remains only in the Dezhnev Bay. Here, observers recorded individual seals and as many as several dozen seals (maximum of 60) in the

TABLE 4. Number and percentage of ringed seals recorded on the ice, in the water, or in unspecified locations[1] off the Chukotka Peninsula in spring.

Month	Gulf of Anadyr					Bering Sea					Chukchi Sea				
	In water		On ice		Unspecified	In water		On ice		Unspecified	In water		On ice		Unspecified
Month	#	%	#	%	#	#	%	#	%	#	#	%	#	%	#
April	367	12	2634	88	854	929	12	7031	88	940	365	45	440	55	270
May	714	20	2841	80	78	2954	5	59554	95	2071	1077	20	4415	80	1108
June	3437	54	2956	46	782	4163	5	75868	95	4520	2689	27	7437	73	988

[1] Since the unspecified locations are considered missing data, percentages were only calculated for the number of seals observed in the water or on the ice.

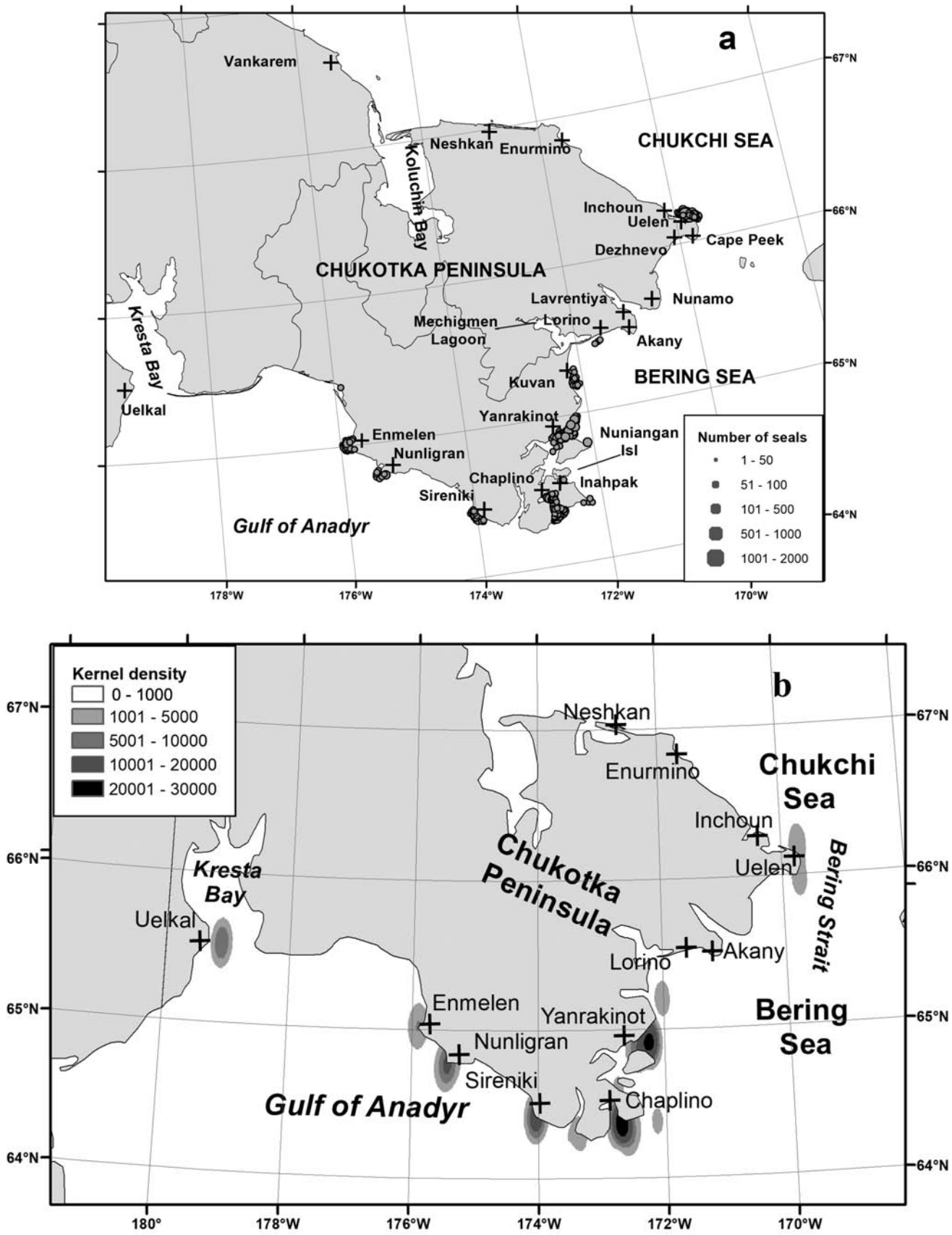

FIG. 3. Ringed seal distribution in the coastal waters of the Chukotka Peninsula: a) from January to March 1996, which was the year when the highest number of seals were counted, and b) kernel density for all years of observation. No observations from Uelkal village were made from January to March in 1996. The crosses mark the locations of village observation posts along the coast.

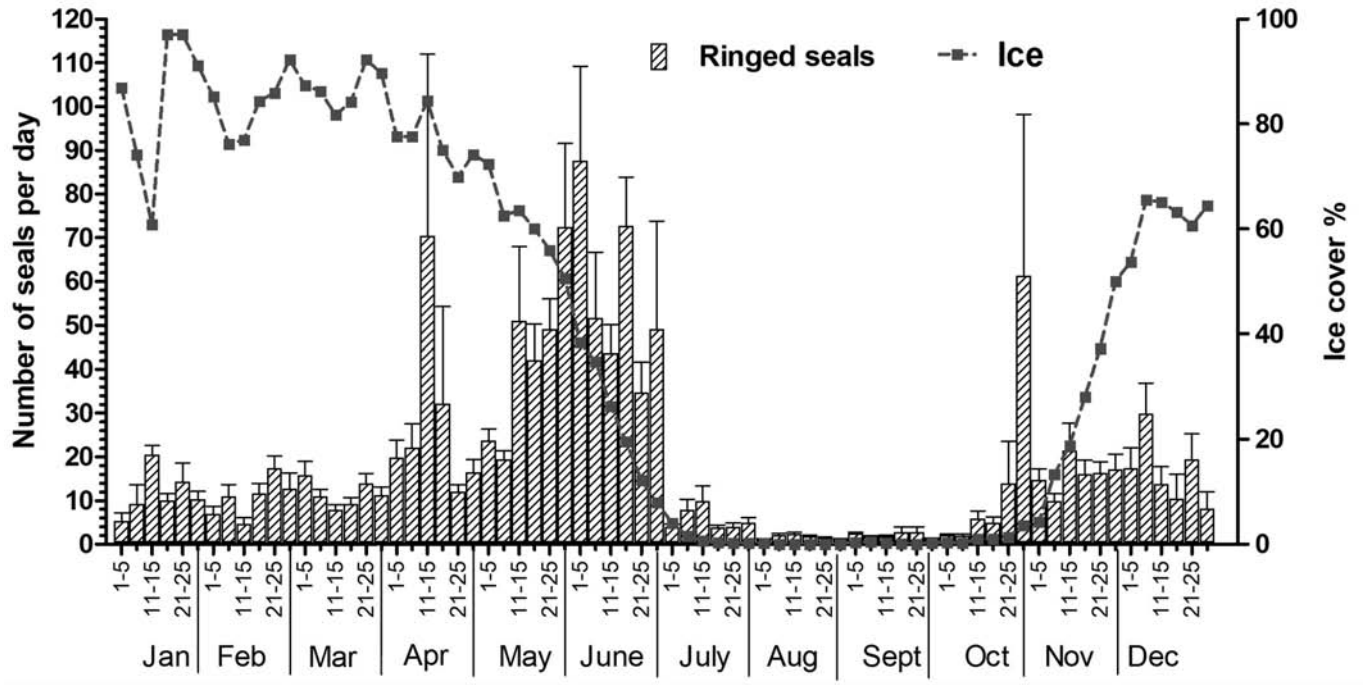

FIG. 4. Relative number of ringed seals in the eastern coastal waters of the Chukotka Peninsula (Bering Sea) from January to December, by month. Data were averaged for all years of observations. Each bar represents five days (or occasionally six days in a longer month). Lines above columns denote the standard error. The dashed lines and boxes show the percent ice cover.

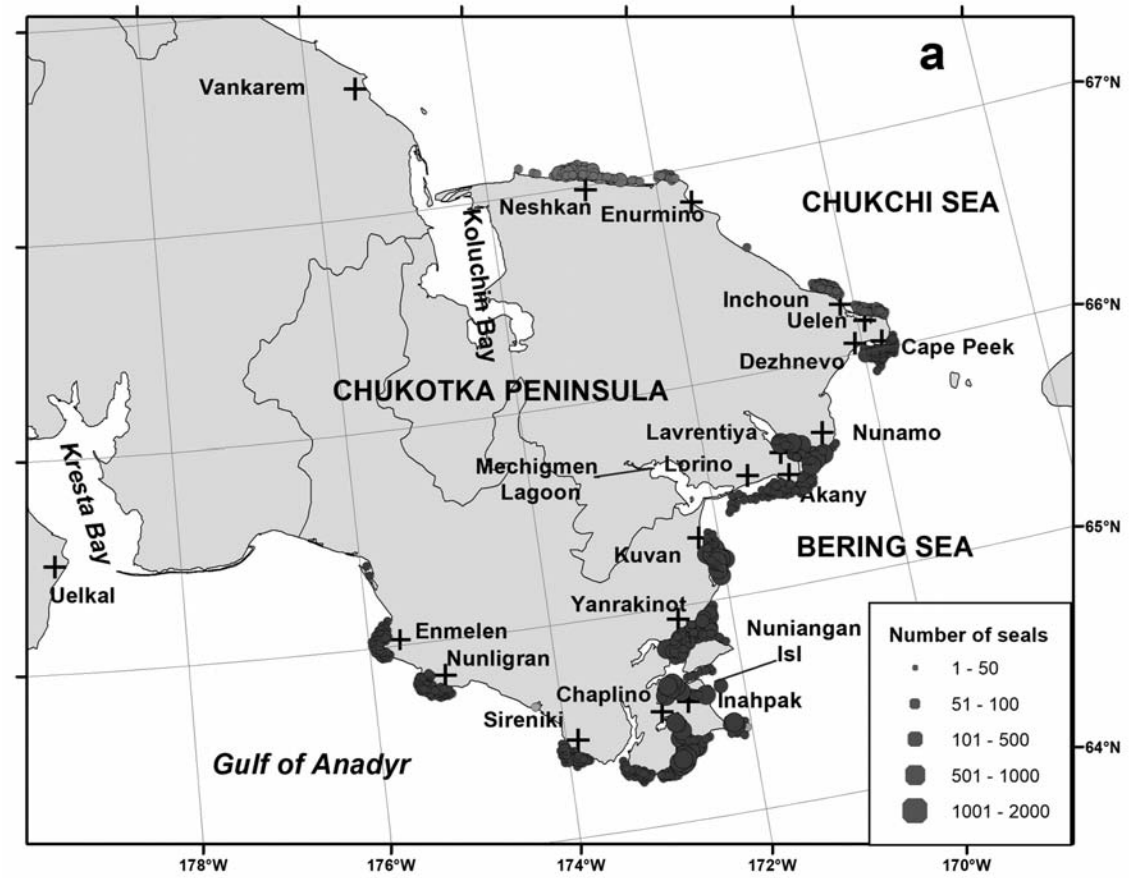

FIG. 5. Ringed seal distribution in the coastal waters of the Chukotka Peninsula: a) April–June 1996, b) April–June 2002, which was the year when the highest number of seals were counted, and c) kernel density for all years of observation. No observations from Uelkal village were made from January to March in 1996. The crosses mark the locations of village observation posts along the coast.

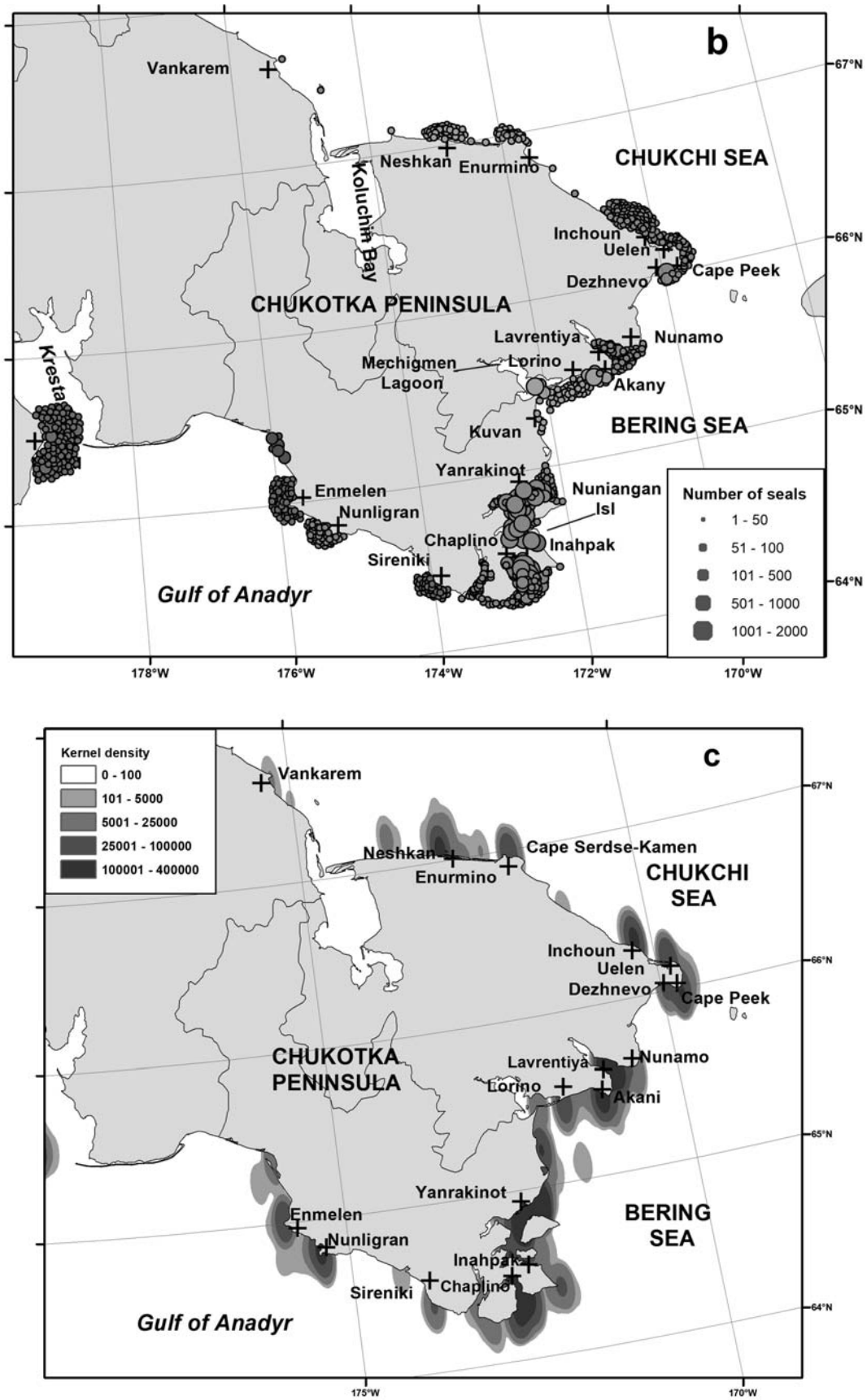

FIG. 5 – *continued*: Ringed seal distribution in the coastal waters of the Chukotka Peninsula: a) April–June 1996, b) April–June 2002, which was the year when the highest number of seals were counted, and c) kernel density for all years of observation. No observations from Uelkal village were made from January to March in 1996. The crosses mark the locations of village observation posts along the coast.

stable fast ice. Animals were rarely seen on the drifting ice. Observers noted the movement of small (young) ringed seals to the Bering Strait. The animals moved in open water along the edge of the fast ice or along the coast. In Dezhnev Bay, 45% of the ringed seals were counted on the surface of fast ice and 55% in the water.

In June (Fig. 5), off the eastern shore of the Chukotka Peninsula, ringed seals were hauled out, both on deteriorating fast ice and on drifting floes. Observers noted that at night the animals went to the sea and returned in the morning, diving under the fast ice, where the Arctic cod remained. In the depths of the bays, 95%–98% of the individuals were recorded. In Tkachen Bay in June, up to 1000 individuals were counted on ice and in Lavrentiya Bay up to 2500 animals were counted. In Lavrentiya Bay in 1994, 2000, and 2002, ringed seals were observed basking together with spotted seals. In Mechigmen Bay, up to 30% of the animals were in the water, moving along the edge of the fast ice in the Bering Strait. In June, at the southwestern entrance of the Bering Strait, 40% of the seals were on the surface of drifting ice, which was carried by the dominant current into the strait. As in May, observers noted that it was mainly young (small) ringed seals that moved into the strait. In general during spring, 88% of ringed seals were on the ice surface of the east shore zone of Chukotka Peninsula. The proportion of seals on the ice, in the water, and at the ice edge varied significantly, especially at the edge. In April, 27% of seals were at the edge of the fast ice, whereas in June, less than 1% of ringed seals were seen at the edge of the fast ice (Table 3). Overall, on average, from April to June for all years of effort on the eastern coast of the Chukotka Peninsula, an average of 46.6 seals and up to 3000 ringed seals were observed per day (Table 2).

Chukchi Sea: In April, cracks and open-water channels appeared beyond the fast ice edge in the area of the villages of Uelen and Inchoun and seals immediately appeared in the water. The relative number of ringed seals increased rapidly (Fig. 6). During this period, 70% of ringed seals were observed on ice and 30% in water of the cracks and the channel. In May, a noticeable movement of animals occurred to the north and northwest in the open water channel. Observers noted that this movement was distinctly by small animals. In June in typical years, in the area of the Uelen and Inchoun, there was an intense destruction of shore-fast ice. During this period, ringed seals were seen both in the water (60%) and on the drifting ice (40%) in this area. Singles and small groups of up to 40 animals were seen on the ice. During this month, as in May, the presence small animals swimming along the coast to the north and northwest in the water, was noticeable. The harvested ringed seals had shrimp and Arctic cod in their stomachs.

In the western part of the Chukchi Sea, in the area of the observation points at Enurmino and Neshkan, approximately 50% of the ringed seals were seen in April on the ice and 50% in the open water of cracks beyond the fast ice edge. Up to 48 seals were counted in the water of the channel and up to 20 seals on ice. In May, the proportion changed dramatically, with 90% of the ringed seals observed on the ice surface, usually as singles or in small groups of up to 30 individuals. In both May and June, 94% of seals were observed on the ice surface, basking alone or in small groups of three to four seals at holes on ice floes.

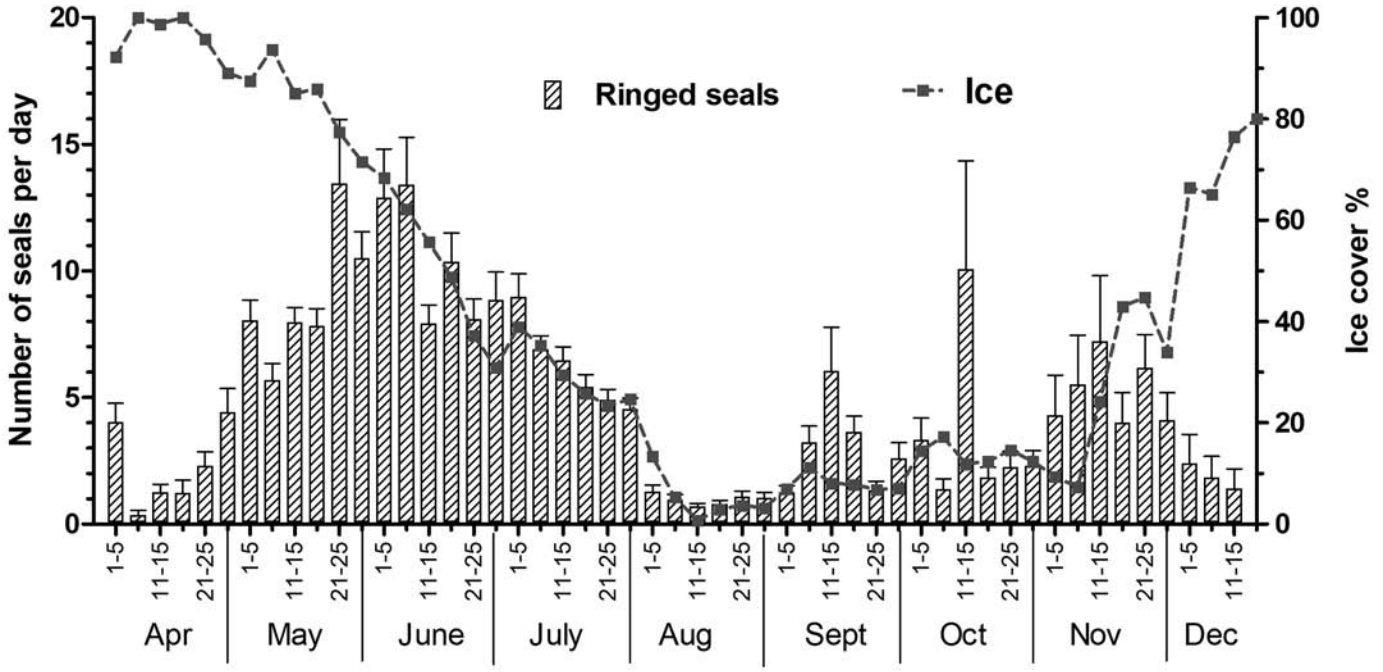

FIG. 6. Relative number of ringed seals in the northern coastal waters of the Chukotka Peninsula (Chukchi Sea) from January to December, by month. Data were averaged for all years of observations. Each bar represents five days (or occasionally six days in a longer month). Lines above columns denote the standard error. Ringed seals were not seen during the winter months, except in January 1996.

A maximum number of about 300 animals was recorded on 4–6 June 2003 on the ice between the village of Neshkan and Cape Jenretlen, southeast of the mouth of the Koluchin Bay. In June, observers sometimes saw seal pups near holes. For the entire period of work, four pups were observed.

In April–June for all the years of observations in the Chukchi Sea, an average of 9.1 individuals were counted and up to 300 ringed seals per day were observed (Table 2).

Summer (July–September)

Gulf of Anadyr: In July, the relative number of ring seals in the north part of the Gulf gradually decreased (Figs. 2, 7). In the northwestern area of Uelkal at the exit of Kresta Bay in early July in 2002 and 2003, ringed seals were counted both on the drifting ice being carried out of the gulf and on the deteriorating ice of the lagoons, where up to 70 seals were counted. In the area of Cape Bering and Rudder Cove, ringed seals remained in the water near the coast in July, both individually and in small groups. A maximum of 150 individuals were observed in groups. The animals moved in the direction of the exit from the Gulf of Anadyr. The movement of up to 120 seals per day was also recorded in the area of Preobrazheniya Cove and at Cape Achen. In July near the village of Sireniki at the exit of the Gulf of Anadyr, the ringed seals were seen singly and in small groups leaving the northeastern part of the gulf. A maximum of 40 individuals were observed here in one day. In August and September, the relative abundance of ringed seals in the northern part of Gulf of Anadyr decreased (Fig. 2). No directional movement was noted; the animals, singly and in small groups, stayed near the shore. Sometimes, in the area of Rudder Cove and to the west of it, the ringed seals, together with spotted seals, formed groups of up to 200 animals (10 September 1995), possibly feeding on schools of fish.

In general, in the summer time, the number of ringed seals in this area decreased by 50% compared to the spring period (Table 2).

Bering Sea: In July, the number of ringed seals near the eastern shore waters of the Chukotka Peninsula sharply declined (Fig. 4). During this period, observers saw ringed seals mainly near the coast. In July near open areas of the coast, up to 90% of seals moved towards the Bering Strait. In the bays and in Senyavin Strait, a particular direction in the movement of animals was not noticeable. In August, singles and small groups of animals were distributed along the entire east coast. At the mouths of rivers and in lagoon channels, the ringed seals, together with spotted seals, formed small groups of up to 25 individuals. In Penkigney Cove, Mechigmen Bay and on Nuniangan Island (Fig. 7a), small coastal haul-outs with spotted seals were recorded. In September, ringed seals were still scattered along the entire eastern coast, forming groups of up to several dozen

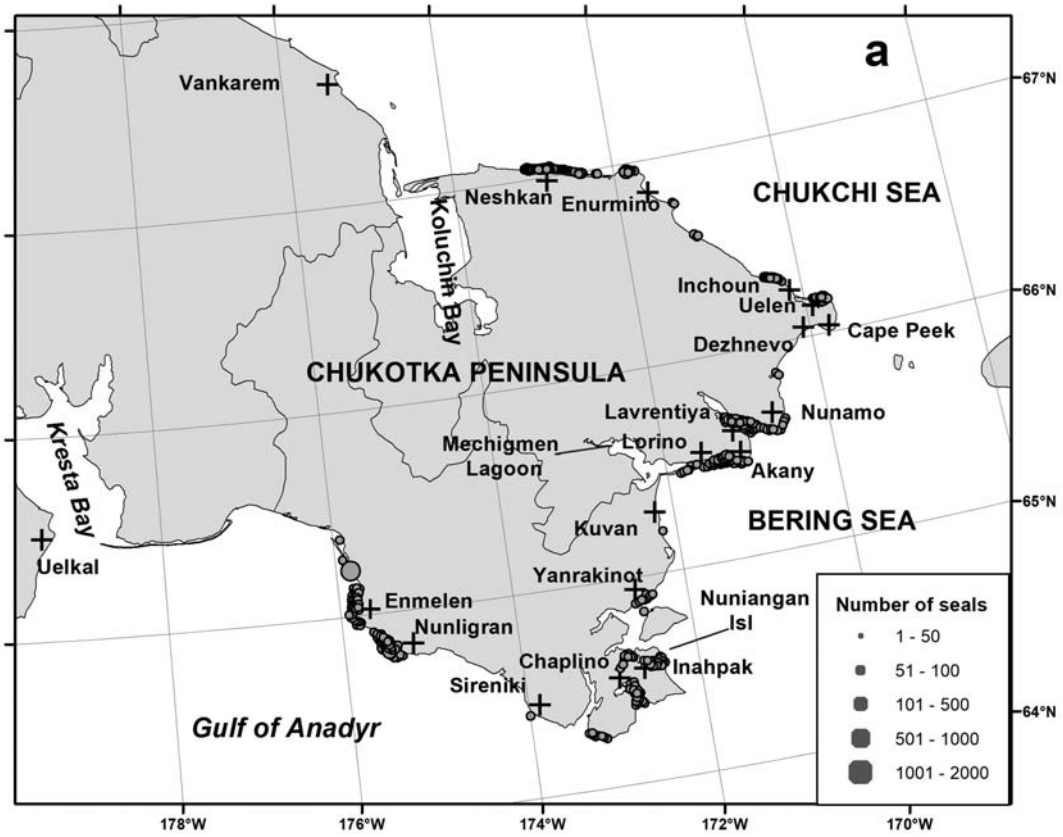

FIG. 7. Summer distribution of ringed seals in the coastal waters of the Chukotka Peninsula: a) July–September 1995, b) July–September 2003, and c) kernel density for all years of observation.

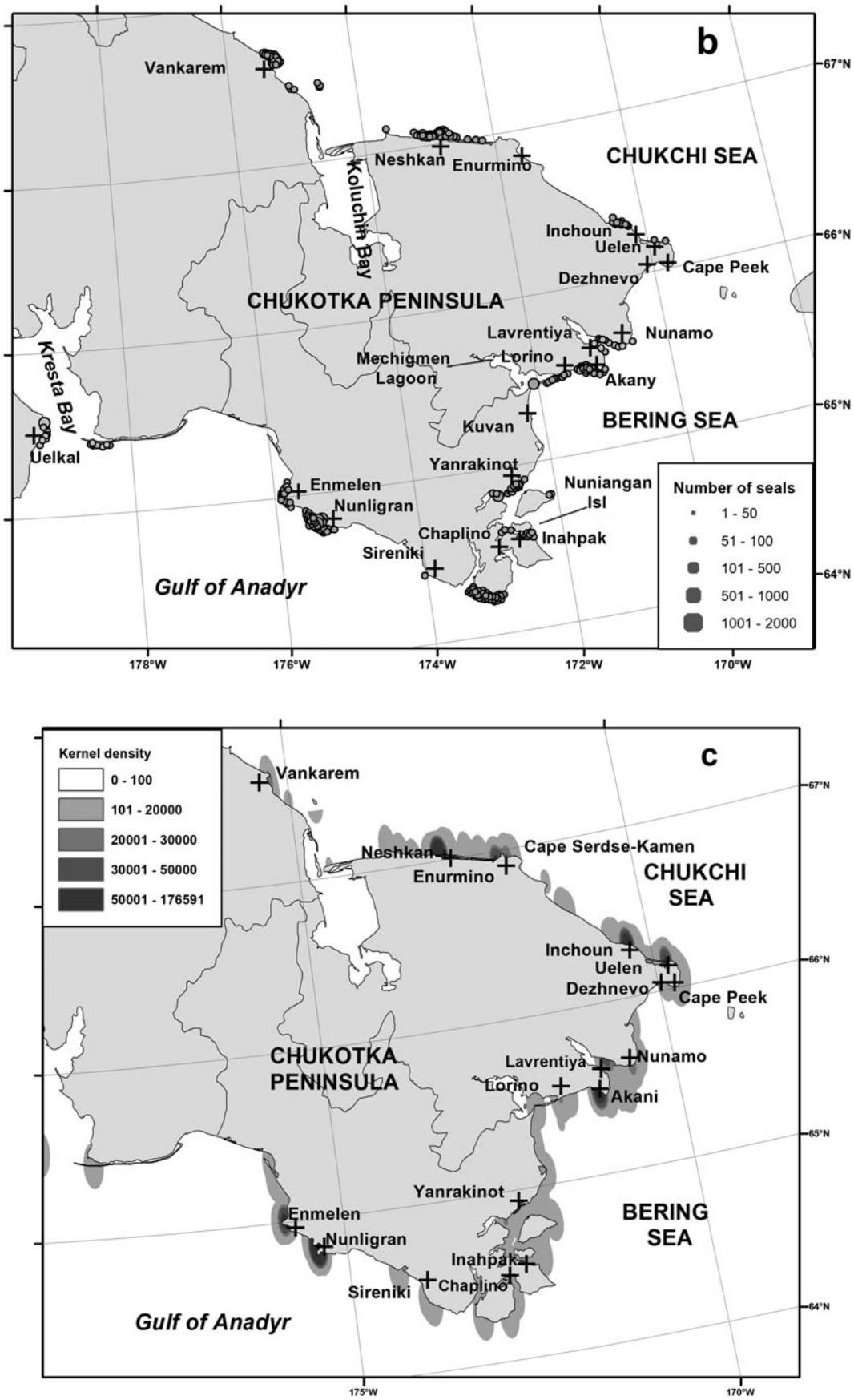

FIG. 7 – *continued*: Summer distribution of ringed seals in the coastal waters of the Chukotka Peninsula: a) July – September 1995, b) July – September 2003, and c) kernel density for all years of observation.

individuals in the channels of lagoons and river mouths. The animals continued to haul out on the shallows and rocks of the Penkigney and Ramulet Coves, Mechigmen Bay, Lavrentiya Bay, and Kinkay Island (Fig. 7a). The largest haul-out of 200 animals was recorded in Mechigmen Bay. On the water, an aggregation of up to 200 ringed seals was observed on 13 September 2003 in the shallow waters of Penkigney Cove. Overall, from July to September of all years, only 3.1 seals on average per day and a maximum of 500 ringed seals were observed (Table 2).

Chukchi Sea: In some years, broken drifting ice remains in July near the villages of Uelen and Inchoun. Only occasionally did the observers see small haul-outs on the ice (up to 10 individuals). About 80% of ringed seals in open water moved in northerly and northwesterly directions among the ice floes. Sometimes the animals moved in the surf zone. In the western part of the Chukchi Sea near the villages Neshkan and Enurmino, ice cover destruction intensified in July. At this time, observers saw up to several dozen seals, mainly hauled out (85%) on the drifting ice. In cold years, such as the summer of 1994 when the ice did not leave the coast, observers counted up to 200 animals on the ice surface. No particular movement of animals in one direction in this area was visible in July. In August, ringed seals were observed singly and in groups of up to 10 individuals along the entire northern coast of the Chukotka Peninsula. Observers did not see any ringed seals on broken drifting ice and could not discern any noticeable direction in the movements of animals, neither in the western part of the Chukchi Sea nor at the entrance to the Bering Strait. As in August, in September of typical years in the Neshkan-Enurmino area, if there was no ice, the ringed seals were still observed singly and in small groups near the coast and in the straits of the lagoons. If ice developed, there was no significant increase in the number of animals. But in the Uelen-Inchoun area in September, the relative abundance of ringed seals increased markedly, especially with the approach of drifting ice. However, there were no seals on the ice; instead, up to 200 seals were observed moving toward the Bering Strait in the water during the day time. Observers repeatedly noted that these were small, probably young animals.

In general, from July to September for all years in the northern coastal waters of the Chukotka Peninsula, 3.5 seals on average and a maximum of 200 individuals were observed per day (Table 2).

Autumn (October–December)

Gulf of Anadyr: In the northern part of the Gulf in October, ringed seals were distributed singly and in small groups along the entire southern coast of the Chukotka Peninsula. The observers met small groups of up to two dozen seals in the channels of the lagoons and river mouths. No haul-outs on the shore were recorded. In November of some years, ice appeared only in the extreme northwestern part of the Gulf of Anadyr. Despite the appearance of ice, no ringed seals were observed on the ice. Singly and in small groups, the ringed seals remained in the water along the entire southern coast of the Chukotka Peninsula. In December, ice appeared only in coves and areas protected from winds. Single seals were seen both in the water and on the ice. Sometimes it was possible to count up to 10 animals on the ice. In general, in the autumn period in the northern part of the Gulf of Anadyr, an average of 1.4 seals and a maximum of 200 ringed seals were counted per day (Table 2).

Bering Sea: Individual or small groups of ringed seals left the southwestern part of Bering Strait in October (Fig. 8). During the five hours of daylight, it was possible to observe up to 60 seals moving south at 100–500 m from shore. In the area of the Nunamo and Akany Capes, the seals also moved individually and in small groups near the coast to the south. A maximum of 30 seals were counted in this area. In Senyavin Strait and its coves, ringed seals formed aggregations in open water in October; in October 2000, up to 2000 individuals were counted here. On the pebble spits, ringed seals were observed together with spotted seals. To the south of Senyavin Strait in Tkachen Bay and southward, only singles and small scattered groups of up to 15 seals were observed. In November, ringed seals were still leaving Bering Strait. In the area of the Lavrentiya and Mechigmen Bays, the animals were distributed singly and in small groups at a distance of 100–300 m from the shore. During the five hours of daylight, up to 50 individuals were observed here. It should be noted that with the appearance of ice, the seals were observed in open water among the ice but did not haul out on the ice. No particular direction of movement of the seals was observed. In the area of Senyavin Strait, the number of ringed seals increased markedly.

With the appearance of ice in bays and lagoons, mixed haul-outs of ringed and spotted seals formed on the ice. If there was open water in the ice, animals were seen both in the water and on the ice surface. The largest haul-out of about 200 seals was registered on 30 November 1995 in Penkigney Cove. In the absence of ice, small haul-outs were found on the spits near the lagoons and in the Penkigney, Abolesheva, and Rumulet Coves. In Tkachen Bay, seals began to gather before the appearance of ice. With the appearance of ice capable of withstanding the weight of the animal, ice haul-outs were formed near the polynyas and at the edge of the ice. In December, as in November, ringed seals were recorded in the coves of Senyavin Strait and in Tkachen Bay. In these bays, observers counted up to 200 animals in the open water and on the ice at the edge. Near open areas of the coast, up to 50 individuals on young ice were recorded.

Overall, in the autumn period in the bays and coves of the eastern coast of Chukotka, an average of 12 individuals per day and a maximum of 2000 ringed seals were counted (Table 2).

Chukchi Sea: In the western part of the Chukchi Sea (Neshkan-Enurmino area), intense ice formation occurs

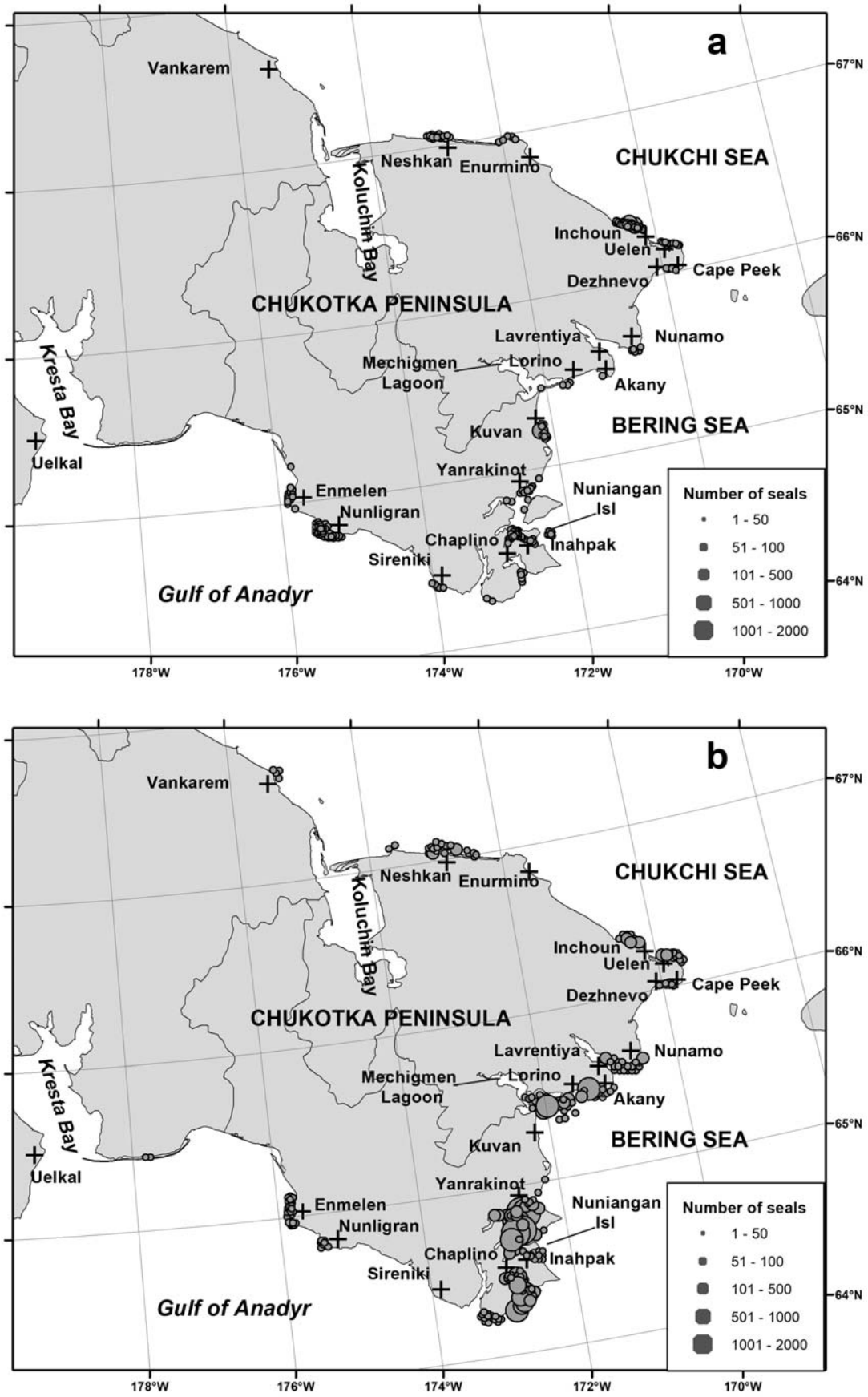

FIG. 8. Autumn distribution of ringed seals in the coastal waters of the Chukotka Peninsula: a) October–December 1994, b) October–December 2003, and c) kernel density for all years of observation.

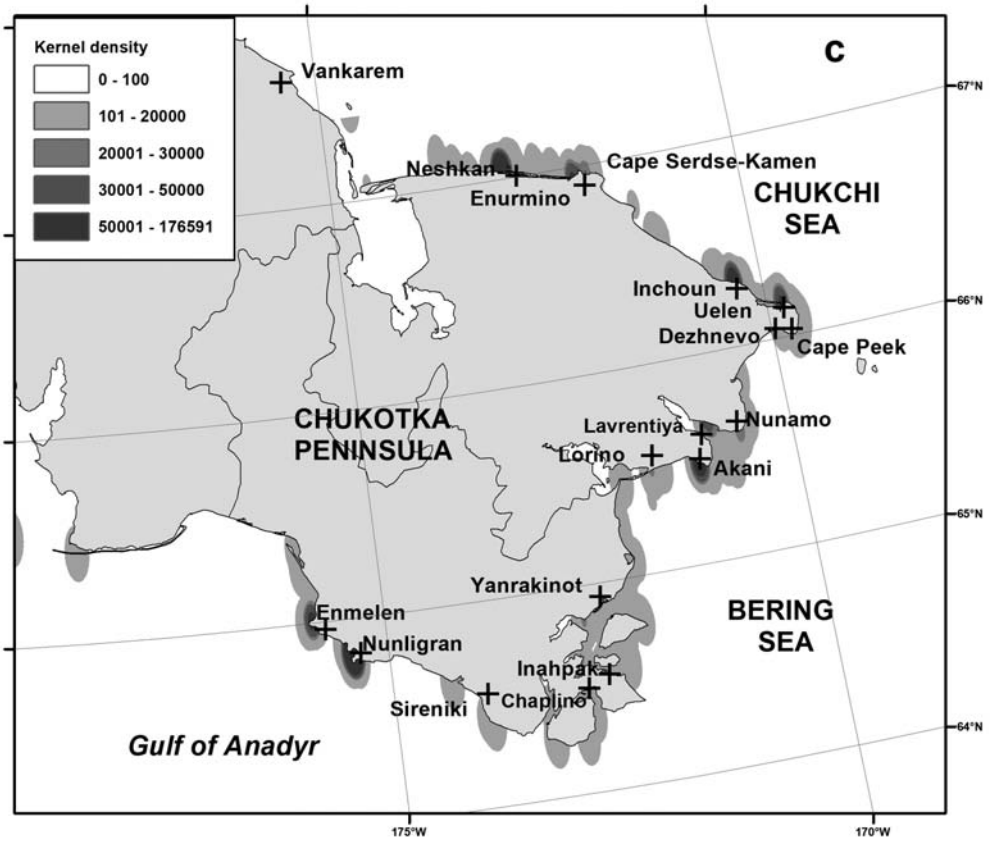

FIG. 8 – *continued*: Autumn distribution of ringed seals in the coastal waters of the Chukotka Peninsula: a) October–December 1994, b) October–December 2003, and c) kernel density for all years of observation.

in November of typical years (Figs. 6, 8). During autumn, seals were seen offshore on the ice, in breathing holes in young ice, and in the water. In areas of no ice in October, the animals moved singly and in small groups along the coast to the east. In the Uelen-Inchoun area, a few to several dozen ringed seals were observed during five hours of daylight time. The animals moved to the Bering Strait among the floating ice. When the sea surface was covered by ice during calm weather, up to 300 seals were observed on the ice surface. In general, for all the years of observations in the autumn period in the northern offshore of the Chukotka Peninsula, four individual ringed seals were counted on average per day.

DISCUSSION

In winter, as in other regions of the Arctic (Hammill and Smith, 1989; Kelly and Quakenbush, 1990; Smith et al., 1991), the ringed seal is found on a strip of land-fast ice in the coastal areas of the Chukotka Peninsula. The habitation of the ringed seal on the fast ice is due to the need for a stable platform to establish hidden lairs to give birth and breed pups. In addition, the fast ice provides availability of food, such as Arctic cod and saffron cod (*Eleginus gracilis*), which remain under the ice. These fish species are associated with sea ice and are concentrated near the coast for spawning (Andriyashev et al., 1980; Bradstreet, 1982; Bradstreet and Cross, 1982; Welch et al., 1993). It is known that the characteristics of ice, weather, and time factors affect the distribution and abundance of seals (Fedoseev, 1965; Burns, 1970; Hammill and Smith, 1989; Frost et al., 2004). The living conditions of the ringed seal in the various waters of the coast of the Chukotka Peninsula differ significantly. In the northern part of the Gulf of Anadyr where the coastline is slightly indented, drifting gray-white ice covered with a thin layer of snow is predominant in winter. Such ice is unsuitable for the reproduction of ringed seals (Lukin, 2013). At open coastal areas, under the influence of northerly winds, a polynya is formed and young ice is constantly carried by the wind to the south (Niebauer and Schell, 1993; Bogoslovskaya and Votrogov, 1981). For this reason, in the northern part of Gulf of Anadyr, winter habitat conditions for the ringed seal are unfavorable. During the breeding season, the ringed seal prefers to dwell in Kresta Bay and in the area of the Preobrazheniya and Rudder Coves.

In contrast to the southern coast, in the eastern offshore waters of the Chukotka Peninsula, bays such as Provideniya, Tkachen, Lavrentiya, and Mechigmen as well as coves open into Senyavin Strait. In all these bays and coves fast ice forms and is covered by a thick layer of snow. This condition is convenient for the ringed seal to make lairs and breathing holes. The fast ice on the eastern coast

of the Chukotka Peninsula is not only stable and safe, but also apparently rich in food for ringed seals. Our observers have repeatedly pointed out accumulations of Arctic cod under the ice.

In the northern coastal area of Chukotka, with the exception of the Koluchin Bay, there are no bays and coves. For the most part, the shores are sandy spits, separating shallow lagoons from the sea. These lagoons freeze over in winter. The fresh ice of the lagoons is much harder than the sea ice, so it is difficult for seals to maintain lairs and breathing holes. The ice of the coastal zone of the Russian part of the Chukchi Sea is heavily compressed during formation and forms hummocks under the influence of the strong winds and the countercurrent from the Long Strait (far to the north). A hummocky, narrow fast ice strip forms along the coast and ice layering clogs the water column to the bottom. Drifting ice is located behind the fast ice. The dynamic habitat of dense, drifting ice is dangerous even for a highly adapted species like the ringed seal. All these factors have a negative effect on the conditions of winter habitation of seals in the northern coastal area of the Chukotka Peninsula. Because of the ice and weather conditions, this area is minimally inhabited by ringed seals. These complex habitat conditions explain why observers did not see ringed seals in January–March in the Chukchi Sea.

On the eastern coast of the Chukotka Peninsula, in winter and early spring, ringed seals are seen mainly at the edge of fast ice, both on the ice and in water. Habitation on the edge of the fast ice allows seals not to waste energy for maintaining breathing holes. Animals may use food located both under the ice and in open water. From the edge of the fast ice, the ringed seal can move back and forth from the zone of drifting ice. In the Canadian Arctic, ringed seals are also mainly found at the edge of the fast ice during winter (Bradstreet, 1982; Bradstreet and Cross, 1982; Teilmann et al., 1999). According to these authors, the high concentration of seals on the ice edge in winter is associated with food conditions, since the highest biological productivity is observed near the ice edge. Fedoseev (1965) indicated that mainly young immature animals inhabit the edge of the fast ice, while adult animals inhabit the landfast ice.

In spring, as well as in winter, the ringed seal is most abundant in the eastern coastal area of the Chukotka Peninsula. During the molting (basking) period, seals need to maintain a high temperature of the skin by spending a long time warming in the sun on a solid substrate (Freltz and Fay, 1966; Kelly and Quakenbush, 1990). During the basking period, the ringed seal forms numerous haul-outs on the ice surface at cracks and holes in the fast ice of the bays and coves of the eastern coastal area. On calm sunny days, the number of animals on the ice surface can increase tenfold and reach several thousand. Landfast ice remains the longest in the bays. Therefore, on the fast ice of the bays of the eastern coast of the Chukotka Peninsula, apparently, as the drifting ice breaks down, animals arrive from other areas of the Bering Sea. Thus, the bays and straits of the eastern coastal zone of the Chukotka Peninsula are one of the main breeding and molting areas for ringed seals in the Bering Sea. In summer, animals are distributed in the coastal zone of the entire Chukotka Peninsula but their numbers decrease by 50% in the Gulf of Anadyr and by 85% in the Bering Sea compared to the spring time (Table 2).

In the northern coastal area, cracks in the ice and open-water channels are of great importance in the life of ringed seals. Whenever any break occurs, ringed seals immediately appear in the dense ice.

Seasonal increases or decreases in the ice surface and the movement of the ice edge to the north in spring and to the south in autumn require ringed seals to seasonally migrate. Satellite tagging of seals has shown that in the waters of Svalbard, young and mature ringed seals use different strategies during the summer feeding period in open water. Sexually mature animals feed within 100 km of their winter habitat and return to the same place where they lived during the previous season. Young seals travel long distances to the edge of the pack ice in search of food (Freitas et al., 2008). Satellite telemetry of ringed seals tagged in Kotzebue Bay of the Alaskan part of the Chukchi Sea revealed that in November and December immature ringed seals left the Chukchi Sea as the ice cover increased and moved south into the Bering Sea. They then returned north in the spring as the ice edge retreated. The adults stayed in the Chukchi Sea and northern Bering Sea, making only local movements (Crawford et al., 2012). This study has shown that the seasonal migration of small ringed seals, probably young, is observed in the coastal area of the Chukotka Peninsula. The movement of small ringed seals is evident at the southern entrance to the Bering Strait, as well as in the area of the points of Uelen and Inchoun. These observations confirm seasonal migrations of young, immature animals. The fact that migration of adult animals in the coastal area of the Chukotka Peninsula has not been observed confirms results from earlier studies that adult ringed seals breeding in fast ice feed near the breeding area and do not make long migrations (Kelly et al., 2010). Nevertheless, in summer and early autumn, the relative abundance of ringed seals in the coastal area decreases (Figs. 2, 4, 6). A significant decrease in the number of ringed seals in the eastern and southern coastal areas of the Chukchi Peninsula indicates that some of the sexually mature animals may also go to the Chukchi Sea. This movement happens, apparently, after the destruction of the fast ice and the end of the molt. Thus, our observations confirm the previously obtained information (Kelly et al., 2010) that immature and sexually mature animals use different habitat strategies. Immature animals make long seasonal migrations, while mature animals adhere to areas of winter habitat and breeding.

The proportion of ringed seals observed on the ice surface, especially in spring (when surveys are usually carried out), can rapidly change tens of times, not only depending on the season and year, but even on the day

(Kelly and Quakenbush, 1990; Born et al., 2002; Bengston et al., 2005). According to our observations, the proportion of seals in the water and on the ice in April was the same in the southern and eastern coastal areas of Chukotka, 12% and 88%, respectively (Table 4). At the same time, 45% of ringed seals were seen in the water of cracks and polynias and only 55% on the ice in the northern coastal area. In May, the proportion of animals observed in the water and on the ice was the same in the southern and northern coastal areas: 20% on the water and 80% on the ice. In the eastern coastal area, at this time, 95% of the seals were on the ice surface. In June, in the southern coastal area, 54% of the ringed seals stayed in the water as the ice broke, whereas in the eastern coastal area, 95% of seals were still seen on the ice surface at this time. In the Chukchi Sea in June, about a third of the animals (27%) remained in the water of cracks and polynias, the rest on ice. At the same time, it should be kept in mind that on calm, sunny days, the number of animals on the ice surface can increase tenfold. On such days, to warm up in the sun, perhaps the entire population of molting ringed seals that currently live in this area gathers on the surface of the ice.

Consequently, the proportions of animals that are visible on the ice surface and those in the water that are hidden when viewed from an airplane can vary not only depending on the timing of the work, but also on the characteristics of the ice regime of a particular area.

CONCLUSION

The eastern coastal zone of the Chukotka Peninsula is one of the main reproduction areas for ringed seals wintering in the Bering Sea. In such bays as Lavrentiya, Mechigmen, as well as in Tkachen Bay and Senyavin Strait, a stable ice cover is formed, covered a thick layer of snow—a necessary condition for ringed seals to give birth and suckle their young under the snow. The fast ice off the eastern coast of Chukotka is not only stable and safety but also potentially rich in food for seals.

Our data confirm the migration of immature ringed seals after wintering from the Bering Sea following the retreating ice to the Chukchi Sea and, as ice sets in autumn, from the Chukchi Sea back to the Bering Sea. There is no seasonal movement of adult seals in the coastal zone of the Bering Sea waters of Chukotka Peninsula. However, in summer and early autumn, the relative abundance of ringed seals is low, which indicates that some of the sexually mature animals may also go to the Chukchi Sea for feeding.

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