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ORIGINAL ARTICLES

Winter Seabird Populations in Open Waters of the Sea of Okhotsk

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Abstract—Shipboard observations were conducted during the Sea of Okhotsk walleye pollock expedition in January–April 2015. The surveys showed that the modern winter avifauna of the open waters of the Sea of Okhotsk includes at least 19 species of seabirds. According to transect survey data, the average distribution density of all birds was 10.0 ind./km^2. Alcids (47.9%), procellariids (33.1%), and larids (18.8%) dominated among the winter populations, while albatrosses and storm petrels each accounted for 0.1%. The short-tailed shearwater, fork-tailed storm petrel, black-legged kittiwake, red-legged kittiwake, pigeon guillemot, and tufted puffin were recorded in the inner part of the sea in the winter for the first time. The changes in seabird populations might be due to a significant reduction in the ice cover of the Sea of Okhotsk.

Keywords: seabirds, abundance, distribution, shipboard surveys, ice cover, Sea of Okhotsk

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INTRODUCTION

The Sea of Okhotsk juts deeply into the mainland and is located in a harsh climatic zone; it is the coldest of the Far Eastern seas of Russia. This sea has a well-developed seasonal ice cover, reaching nearly 100% in some years. The duration of the ice season in different sea areas varies from 3 to 9 months; the maximum distribution of the ice cover is observed in the first half of March [19, 38]. The winter seabird populations of this vast area (1 603 200 km^2, according to [35]) have been studied rather poorly. For open waters, there are only generalized descriptions of the species composition and distribution of birds based on shipboard observations during the 1960s [47–49, 51]. Aerial surveys of wintering birds along the coasts of Sakhalin and the Kuril Islands were carried out in 1967–1971 [9–13]. In 1982–1984, while conducting aero-visual surveys of marine mammals, Trukhin and Kosygin [45] collected materials of birds wintering in ice-covered areas of the Sea of Okhotsk. There is fragmentary information from land-based surveys of seabirds and waterfowl (ducks) wintering mainly in the coastal zone [15, 21, 23, 25–27, 29, 33, 34, 36, 37, 39, 42, 43].

In Arctic and subarctic latitudes, ice conditions have a large and diverse impact on the vital activities of seabirds, including the composition and distribution of their wintering aggregations [52, 58, 60]. Since the late 1970s, the Sea of Okhotsk has experienced a steady reduction in the ice cover area [40]. It should be expected that during this period changes also occurred in winter bird populations; however, there is no information on the current status of their wintering grounds in the open waters of the Sea of Okhotsk.

Since 1962, commercial fishing of the walleye pollock *Theragra chalcogramma* (Pallas, 1814) has been conducted in the Sea of Okhotsk in the winter. This is one of the world's largest fishing expeditions, with a record catch reaching 2 million tons per year. In 2013, under the auspices of the Pollock Catchers Association Noncommercial Organization (NCO), the specialized trawl fishery for pollock in the Sea of Okhotsk gained Marine Stewardship Council (MSC) certification [62]. One of the criteria for certification is a study of the effects of fishing activities on the habitats and the status of marine invertebrates, birds, and mammals. In this regard, the association has initiated research on the impact of trawl fishing on the status of seabird populations. For this purpose, the species and quantitative composition of wintering avifauna, as well as the distribution of birds in the open waters of the Sea of Okhotsk were studied in the winter season of 2014–2015.

MATERIALS AND METHODS

Bird counts were carried out from January 16 to April 14, 2015 mainly from onboard a BMRT (a large freezer trawler). Observations were conducted from the wheelhouse (12 m above sea level) at an average speed of 21 km/h; a minor final part of the surveys was performed from the bridge of a reefer ship (15 m above sea level). The coordinates of the ship's position, as well as the speed and direction of movement, were

Table 1. The composition of avifauna in open waters of the Sea of Okhotsk in January–April 2015 from 719 shipboard transect surveys

Species	Counted on transects (ind.)	Density, ind./km^2	
		M	SE
Laysan albatross	6 (0.8)	0.01	<0.01
Northern fulmar	2398 (64.5)	3.32	0.34
Short-tailed shearwater	13 (0.7)	0.02	0.01
Fork-tailed storm petrel	6 (0.7)	0.01	<0.01
Slaty-backed gull	710 (46.7)	1.04	0.08
Vega gull	23 (2.9)	0.03	0.01
Glaucous-winged gull	9 (1.3)	0.01	<0.01
Glaucous gull	322 (26.4)	0.52	0.06
Black-legged kittiwake	82 (12.0)	0.11	0.02
Ross's gull	66 (3.3)	0.09	0.03
Ivory gull	36 (2.2)	0.08	0.03
Common and Brünnich's guillemots	979 (23.6)	1.44	0.22
Pigeon guillemot	39 (0.6)	0.05	0.04
Crested auklet	2608 (3.1)	3.24	1.30
Least auklet	50 (1.1)	0.06	0.03
Tufted puffin	13 (1.5)	0.02	0.01
All species	7360 (90.4)	10.04	1.38

The number in parentheses is the proportion of 10-min transects (%) where birds were counted; M, mean value; SE, standard error.

recorded with a GPS receiver at 15-s intervals throughout the survey. All surveys were carried out outside the periods of trawling (during transfer to and from fishing grounds, at periods when the ship operated in the search regime, during transit to transshipment points for product offloading). Birds were counted only after their foraging aggregations, which formed around the ship during trawling and catch processing, had dispersed. The survey used the transect method [56], by which birds were continuously recorded in a 300-m wide strip (150 m on each side) while the ship was moving. When calculating the bird density, the route was divided into 10-min intervals; the data obtained for an interval were summarized and averaged. From these values, the average distribution density (M) and the error of the mean (SE) were subsequently calculated for each species of birds. When preparing schematic maps that reflect the distribution density of species in the studied area, the results of counts were summed and averaged over an interval of 1 h.

The total length of the transects was 2478 km, their total area was 743.5 km^2, the total duration of the surveys was approximately 120 hours (719 counts of 10 min each). The counting routes, as a rule, ran outside the shelf waters.

The observations began on January 16–18 at the entrance to the Sea of Okhotsk through the Fourth Kuril Strait and off southwestern Kamchatka. Transect surveys were mainly performed in the northeastern part of the sea in the period from February 3 to March 28. Then, until April 5, observations were conducted to the northeast of Sakhalin Island, where fishing operations were completed; on April 12–14 the final series of surveys was carried out after transfer to a reefer ship during transition to the Bussol Strait. For a more complete characterization of the avifauna composition and distribution patterns of some species, transect counts were supplemented by observations from shipboard during trawling, as well as during offloading of fish products to reefer ships in loose-ice fields near the open-water boundary.

RESULTS

Transect surveys of the Sea of Okhotsk in January–April 2015 counted 7360 individuals of 17 species of typical seabirds belonging to five families (Table 1). The Laysan albatross *Phoebastria immutabilis* (Rothschild, 1893) was only observed six times during surveys: single birds were recorded on January 16 in the Fourth Kuril Strait and adjacent waters. However, later, in southwestern Kamchatka, it was noted during trawling almost daily (one to five individuals per day) until February. In the TINRO Basin area to 55.55° N, one to three individuals of this species appeared daily near the trawler from March 8 to 11.

The northern fulmar *Fulmarus glacialis* (Linnaeus, 1761) was regularly encountered, with the exception of

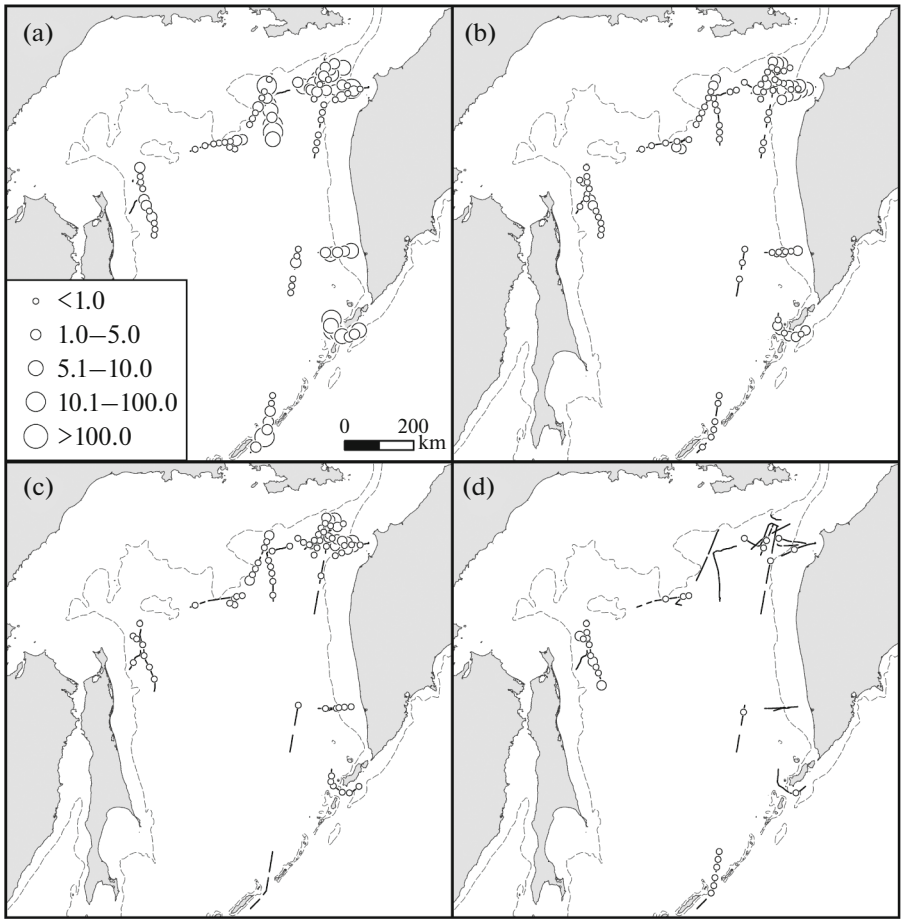

Fig. 1. The distribution of seabirds in open waters of the Sea of Okhotsk based on shipboard surveys in January–April 2015 (ind./km^2 on 1-h transects). (a) Northern fulmar; (b) slaty-backed gull; (c) glaucous gull; (d) black-legged kittiwake. Solid lines indicate bird count transects; dashed line indicates a 200-m isobath.

routes that passed within the ice-covered areas. The maximum values of local density (up to 132 ind./km^2 on a 10-min transect) were recorded in the northeastern part of the sea in areas where the trawling fleet was concentrated. The density of this species was also fairly high in waters adjacent to the northern Kuril Islands and southwestern Kamchatka (Fig. 1a). Of the 2398 northern fulmars counted on transects, slightly more than half (53%) were the light morph birds. In aggregations that formed around the ship during trawling and catch processing, the ratio of light and dark morphs was approximately equal in the northernmost area in this study opposite the neck of Shelikhov Bay, where fishing was conducted at the ice edge (51 and 49%, respectively). In other areas, dark individuals prevailed: 71% in the central part of the sea, 82% in the southwest of Kamchatka, and up to 95% in the area from northeast of Sakhalin to Kashevarov Bank.

The short-tailed shearwater *Puffinus tenuirostris* (Temminck, 1835) was recorded in noticeable numbers only on January 16 during passage through the Fourth Kuril Strait (12 birds with a local density of up to 4.5 ind./km^2). In inner areas of the Sea of Okhotsk, despite targeted observations, a single individual was only seen on March 28 (55.94° N, 149.76° E).

Six single individuals of the fork-tailed storm petrel *Oceanodroma furcata* (Gmelin, 1789) were recorded on transects: two were seen on January 16 at the entrance to the Fourth Kuril Strait; one occurred on January 17 off southwestern Kamchatka; and three were observed on March 26 in the northern part of the TINRO Basin. As suggested by these observations and finds of fork-tailed storm petrels that crashed at night on the ship's deck superstructure ($n = 14$), this species regularly penetrates the northeastern deepwater part of the Sea of Okhotsk, reaching north as far as 57.65° N.

The slaty-backed gull *Larus schistisagus* Stejneger, 1884 is the most characteristic representative of larids. The largest aggregations (up to 23 ind./km^2 on a 10-min transect) formed in the northeastern part of the sea in areas where a large number of fishing vessels were concentrated (Fig. 1b). This species often penetrated loose-ice areas and was occasionally encountered in open deep-water areas. Most of the wintering

birds were adults; the proportion of gulls in immature plumages was only 5.4% (38 out of 710 counted individuals). The Vega gull *Larus vegae* Palmén, 1887 was found in all areas of observation, but rarely, and, as a rule, singly. The distribution density of this species on 10-min transects did not exceed 1.9 ind./km^2. Of the 23 birds recorded, 20 were adults and three were immatures. The glaucous-winged gull *Larus glaucescens* Naumann, 1840 was observed on transects nine times in the eastern part of the studied region only. Judging from observations on bird aggregations near the ship during trawling, this species actively occupies the entire eastern part of the Sea of Okhotsk during the winter and is numerous off the coast of southwestern Kamchatka, where its proportion among *Larus* was up to 16%. To the north, individual birds penetrated as far as the border of the continuous ice cover at the entrance to Shelikhov Bay (at least to 58.53° N). Among the birds recorded on transects, seven individuals were adults and two individuals were immatures.

The glaucous gull *Larus hyperboreus* Gunnerus, 1767 is one of the most typical representatives of the winter bird populations. It is ubiquitous, but most of the wintering birds concentrate in the northeast of the Sea of Okhotsk in areas of high fishing activity of the trawling fleet (Fig. 1c), where the species density on 10-min transects reached 25 ind./km^2. This species often occurred along the ice edge, rarely in open waters where there was no fishing activity. Predominantly mature birds were encountered; their proportion was 85.1% (274 out of 322 counted individuals).

The average distribution density of the black-legged kittiwake *Rissa tridactyla* (Linnaeus, 1758) was somewhat overestimated (0.11 ind./km^2; Table 1), because the final surveys that were carried out in early April in waters off Sakhalin occurred at the beginning of its spring migration (Fig. 1d). However, in January–March, the black-legged kittiwake was regularly encountered in all fishing areas; during trawling, it was observed near the ship almost daily, from one to 13 individuals at a time. To the north, the black-legged kittiwake was found as far as the boundary of the continuous ice cover at the entrance to Shelikhov Bay (to 58.53° N). Among the birds recorded on transects, 80 individuals were adults and only two individuals were under 1-year old.

The Ross's gull *Rhodostethia rosea* (MacGillivray, 1824) is a rare species; during surveys, it was mainly found in the northern part of the region (Fig. 2a). No trends in the direction of movements of this species could be identified. Thus, on March 28, a dispersed flow of Ross's gulls up to 1.5 km wide was observed (1 to 3 ind. at a time) in the middle part of the Sea of Okhotsk, moving for 1 hour west–southwestward. However, on April 5, to the northeast of Sakhalin, Ross's gulls were seen flying north–northwest. Most of the encounters with this species occurred in clear water beyond the border of ice fields. Only four of the 66 specimens counted on transects were recorded within the loose ice; one more bird was observed when the ship was in the ice for fish product transshipment.

The low average density of the ivory gull *Pagophila eburnea* (Phipps, 1774) on transects (0.08 ind./km^2; Table 1) is primarily due to the fact that the distribution of this species is closely related to ice landscapes [55], while our counting routes mostly passed through ice-free waters. On transects, the ivory gull was only noted in the northeastern part of the sea, when surveys were conducted along the edge of ice fields. In ice-free water, only two single birds were recorded; another ivory gull was observed near the ship during trawling. However, unusually large aggregations of this species were found during two transshipments of fish products within the ice fields, at 100 km south of the Koni-Pyagin coast. The transshipment points were located approximately 110 km from each other (Fig. 2b): on March 5–6 at the eastern point and on March 21–22 at the western point. During these days, we regularly observed transiting ivory gulls, as well as their dense groups that gathered on the ice for night and day rest. Using photography, we determined the maximum number of gulls that were simultaneously in the field of view on March 6 and 22, which was 216 and 340 ind., respectively. During both transshipments, the birds were mainly moving north–northwestward.

When conducting transect surveys, identification to species of the common guillemot *Uria aalge* (Pontoppidan, 1763) and Brünnich's guillemot *Uria lomvia* (Linnaeus, 1758) is not always possible; therefore, the data were summed for these species. However, in cases when the guillemots could be reliably identified, each species was counted separately. Of the 727 guillemots that were identified to the species level, 11.7% were *U. aalge* and 88.3% were *U. lomvia*. On the transects, *U. lomvia* was found seaward more often, compared to *U. aalge*; the latter species was regularly observed only on February 3, when approaching the Kamchatka coast opposite the settlement of Ust-Khairyuzovo for product transshipment. The most massive wintering aggregations of guillemots were encountered in the northern part of the Sea of Okhotsk, where their distribution density on 10-min transects was up to 98 ind./km^2 (Fig. 2c). The birds occurred not only in ice-free areas, but also within the ice fields. Large, obviously feeding aggregations of guillemots were noted in the middle part of the sea between Kamchatka and Sakhalin along the edge of the shelf zone. Off the northeastern coast of Sakhalin, where the trawler operated from March 29 to April 6, the guillemots were observed actively moving northward along the ice edge, apparently to breeding grounds on Iona Island.

The pigeon guillemot *Cepphus columba* Pallas, 1811 is a purely coastal bird; therefore, it was only found at shallow waters on February 3, when approaching the Kamchatka coast west of the settlement of Ust-

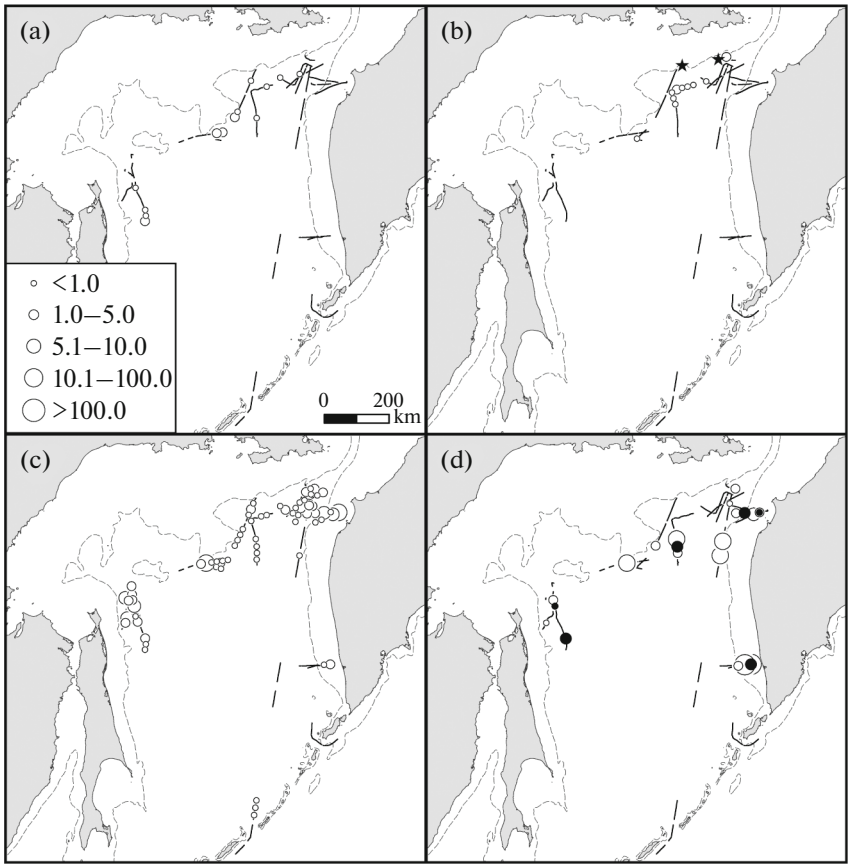

Fig. 2. The distribution of seabirds in open waters of the Sea of Okhotsk based on shipboard surveys in January–April 2015 (ind./km^2 on 1-h transects). (a) Ross's gull; (b) ivory gull (asterisks indicate aggregations observed at transshipment points on March 5–6 and 21–22); (c) common and Brünnich's guillemots; (d) crested auklet (blank circles) and least auklet (black circles). Solid lines indicate bird count transects; dashed line indicates a 200-m isobath.

Khairyuzovo (57.45° N) for reshipment. On a 40-min transect that was 13.3 km long, 39 pigeon guillemots were counted, which occurred above depths of 35–48 m in sludge ice fields with large ice-free areas.

The crested auklet *Aethia cristatella* (Pallas, 1769) is one of the most common species of the wintering avifauna. The high average abundance of the crested auklet was due to feeding aggregations on transects on January 17 and 18 off the southwestern coast of Kamchatka (up to 711 ind./km^2): in this area we recorded 63.6% of the total number of birds of this species observed on counting routes in the Sea of Okhotsk (1658 out of 2608 individuals). The abundance of groups in the area reached 400 individuals. In the more northern areas, the density of the crested auklet did not exceed 205 ind./km^2 on 10-min transects, with up to 250 birds in individual clusters (Fig. 2d). Most of the encounters occurred in ice-free waters, with the exception of a few cases at openings within ice fields.

On transects, 50 individuals of the least auklet *Aethia pusilla* (Pallas, 1811) were counted; these were single birds and small groups of 2–15 individuals. Massive wintering aggregations characteristic of the 1960s [49] were not found in our study. Least auklets were more often found off the coast of Kamchatka, as a rule, together with crested auklets (Fig. 2d). Here, in addition to live birds, three individuals were found that had crashed at night on the ship's deck superstructure.

We recorded 13 tufted puffins *Lunda cirrhata* (Pallas, 1769), which occurred singly or in small groups of two individuals. The local density on 10-min transects did not exceed 1.8 ind./km^2. Most of the encounters took place in waters off the Kuril Islands and southwestern Kamchatka; in February–March, single birds were occasionally seen in the northeastern part of the sea. The northern distribution limit of this species in the winter is 57.59° N.

In addition to the above birds recorded on counting routes, two rare species of gulls were observed during trawling. In a single case, an adult Thayer's gull *Larus thayeri* Brooks, 1915 that was flying astern among other birds was photographed on January 25 off the southern coast of Kamchatka (51.40° N, 154.76° E). During fishing, the red-legged kittiwake *Rissa brevirostris* (Bruch, 1853) was observed several times. From March 8 to 11, one to nine individuals of this species

kept near the ship during daylight hours to the west of the TINRO Basin; single birds were then observed flying two times: on March 18, 150 km to the north of the first encounter place and on April 6 at the southwestern side of Kashevarov Bank. All the red-legged kittiwakes were adults.

DISCUSSION

In terms of its climatic features, the Sea of Okhotsk differs little from the Arctic seas in winter. This determines the harsh conditions for wintering birds [50]. However, shipboard observations that were carried out in January–April 2015 revealed a diverse species composition and fairly high population density of wintering seabirds. According to our data, the modern winter avifauna of open waters of the Sea of Okhotsk includes at least 19 species. Larids (nine species) and alcids (six) are the most diverse; only four species of the three families of Procellariiformes were found. This list does not include the short-tailed albatross *Phoebastria albatrus* (Pallas, 1769) [65] and the Iceland gull *Larus glaucoides* Meyer, 1822 [21, 26] that stray to the Sea of Okhotsk, as well as cormorants and sea ducks that winter in the coastal area [45, 47, 51], which were not encountered during the voyage.

According to transect counts, the average distribution density of birds of all species is 10 ind./km^2 (Table 1). Alcids (47.9%), procellariids (33.1%), and larids (18.8%) dominate quantitatively, while albatrosses and storm petrels each account for 0.1% of the winter population. Compared to the data of Shuntov [47], the total population density of birds has not changed: in the 1960s, it was also approximately 10 ind./km^2 in waters of the shelf and continental slope. However, there have been changes in the proportions of taxonomic groups. In the past, the entire Sea of Okhotsk was absolutely dominated in the winter by alcids (guillemots and auklets), which are diving birds that are affected by plankton and fish depletion in sea surface layers to a lesser extent. At present, the species of this group as a whole are slightly predominant numerically, but in areas where the fishing fleet is concentrated they are surpassed by procellariids (northern fulmar) and larids (mainly members of the genus *Larus*). These birds forage for food in the surface water; therefore, their massive winter aggregations in the Sea of Okhotsk are formed due to the large-scale pollock fishery. In the difficult season of the year, waste from catch processing provides a reliable source of food for northern fulmars and gulls that gather around vessels [2]. It is pertinent to add that Shuntov carried out the surveys in the 1960s that witnessed the establishment of an intensive fishery for pollock in the Sea of Okhotsk. In these years, fishing was only limited to the western coast of Kamchatka; hence, the volume of catches and the number of fishing vessels were significantly lower than the current level [6, 46].

In addition, changes were found in the distribution of color morphs of the northern fulmar. In the 1960s, during the winter light morph birds were mostly found in the Sea of Okhotsk: up to 95% around Iona Island and 75% off the northern coast of the Kuril Islands [51]. At present, the ratio of light and dark morphs has leveled off; the latter morph has massively advanced to the northern part of the sea. A marked decline is observed in the abundance of the least auklet, which was present earlier along the entire perimeter of the sea [49], often in numbers of more than 10 ind./km^2. The abundance of this species in the main Okhotsk Sea colony located on Matykil Island (Yamskie Islands) was 5.5 million individuals in 1988 [31], while in 2006 it was 2 times lower [28]. The former result is considered to be greatly overestimated [49, 51]. Recent data indicated a decline in the abundance of small alcids, that is, the crested auklet, the ancient murrelet *Synthliboramphus antiquus* (Gmelin, 1789), and the parakeet auklet *Aethia psittacula* (Pallas, 1769) on Talan Island [1, 16–18]; hence, it can be supposed that the rare records of the least auklet in our surveys reflect actual negative changes in the numbers of this species.

Several more species were added to the wintering avifauna. While relatively heat-loving birds such as the short-tailed shearwater, fork-tailed storm petrel, black-legged kittiwake, and tufted puffin previously spent the winter in waters of the Pacific Ocean [47], at the height of the winter of 2014–2015 we observed them in inner areas of the Sea of Okhotsk as far as the entrance to Shelikhov Bay. In the past, the Laysan albatross only infrequently penetrated the western coast of the Kuril Islands [47], but during our surveys it regularly visited these waters and strayed far north. The finding of the pigeon guillemot off the northwestern coast of Kamchatka shifts its winter range almost 500 km northward in the Sea of Okhotsk, because earlier the wintering grounds of this species were only known in the south of Kamchatka [30, 49]. The red-legged kittiwake was noted in the winter period for the first time, thus confirming the geologger data on penetration of this species into the Sea of Okhotsk in the winter [63, 64]. The records of the Thayer's gull, which are the second for the Sea of Okhotsk and the fifth for the entire Far East of Russia [4, 5], support our view that the status of this American species in Russian waters is not a vagrant, but rather a rare migratory and wintering species.

The finding of large aggregations of ivory gull in ice-covered areas at the entrance to Shelikhov Bay is noteworthy. This rare autochthonous high-Arctic species is listed in the Red List of the International Union for Conservation of Nature and in the Red Data Book of the Russian Federation. The first information on the winter occurrence of this species in the Sea of Okhotsk [32, 47, 49] was based on interviews with people. Direct observations of this species are limited to aerial surveys in ice-covered areas, which did not separate it from other small gulls [45], as well as to rare

encounters of single birds on land in the winter–spring period [7, 8, 14, 20, 22, 24, 37, 44]. Our discovery of large wintering flocks of the ivory gull is an extraordinary phenomenon not only for Russian waters, but also for its entire range. Obviously, the water area along the Koni-Pyagin coast to the entrance to Shelikhov Bay is a "hotspot," a place that has an important role for ivory gulls during wintering in the Sea of Okhotsk. Due to the high dynamics of the water, zones of permanently loose ice are formed here under the influence of the powerful stationary Yamsk upwelling and strong tidal currents; therefore, feeding conditions are apparently favorable. This region can be preliminarily considered as a Marine Important Bird Area (IBA) of international importance that supports a significant part of the species population. However, a final decision on the inclusion of the area in the Marine IBA Catalog of the Russian Far East [3] can be made after repeated surveys to determine whether the ivory gull aggregations are stable.

Based on observations in the open waters of the Sea of Okhotsk separated by an interval of half a century, it is difficult to determine all the causes of changes in the bird populations since the 1960s. However, one of them can be identified with certainty, that is, the reduction in the ice cover of the Sea of Okhotsk. Since the 1970s–1980s, there has been a continued tendency in the region for the ice cover to decrease steadily at a rate of approximately 5% per decade. Moreover, in the winter season of 2014–2015, the hydrometeorological processes in the Sea of Okhotsk followed an anomalous scenario, with the absolute minimum of ice cover (26.5%) recorded in the region over the observation period from 1929 to 2015, and taking the reconstructed data over the past 134 years into account [40, 41]. The habitat conditions of birds in the Sea of Okhotsk are largely determined by ice conditions [67]; therefore, the extremely mild winter of 2014–2015 was conducive to the high species diversity and wide distribution of not only typical wintering birds, but also of a number of heat-loving species that usually leave the sea.

Studies in the northern part of the Pacific Ocean and the adjacent Arctic waters also show that ice melting and changes in the temperature background in recent decades have led to significant alterations in the structure of bird populations and shifts in the boundaries of their marine migration range [53, 54, 57, 59, 61, 66].

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interests. The author declares that he has no conflict of interest.

Statement on the welfare of animals. This article does not contain any studies involving animals performed by the author.

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