Report

on research works for the study of pollock trawl fishery impact on the condition of seabird populations in the Sea of Okhotsk, collection of statistical and analytical data on presence, interaction with fishing gear and accidental by-catch of seabirds and marine mammals in the pollock trawl fishery in the Sea of Okhotsk during 2014/2015 fishing season

Public version

Client:
Noncommercial Organization “Pollock Catchers Association”

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INTRODUCTION

Trawl fishing plays a leading role in modern commercial fishing industry. One-third of the world's annual catch is produced by mid-water and bottom trawls (Watson et al., 2006). Due to fishing gear universality and simple construction and potential for autonomous (expeditionary) operations, trawl fisheries are currently highly productive and cost-effective. At the same time, wide distribution and large scale of fishing efforts result in potential hazard of this fishery type for seabirds living in areas where fishing expeditions operate. In some areas of the World Ocean, bird mortality in trawls is comparable with or even exceeds mortality rates in long-line fisheries considered more hazardous for birds, and this factor leads to serious adverse consequences for populations of rare bird species (Weimerskirch et al., 2000; Sullivan et al., 2006b; Baker et al., 2007; Watkins et al., 2008).

In general, patterns of trawl fishery impacts on seabird status are understudied. Such studies require a complicated, labor-consuming and expensive process. Standard by-catch monitoring methods (dead bird counting by observers during trawl hauling) are unsuitable here because yield heavily underestimated data (Weimerskirch et al., 2000; Sullivan et al., 2006b; Dietrich, Fitzgerald, 2010). The reason is that the majority of birds die due to collision with taut wires behind the stern – towing warps and trawl control cable; that's why they rarely get caught into the net and lifted to deck. To obtain objective results, special studies need to be organized and engage trained specialists, their main voyage order being specifically ornithological observations (species composition, abundance, behavior, bird by-catch, etc.).

This low level of knowledge fully applies to the winter pollock trawl fishery in the Sea of Okhotsk which is currently one of the world's largest fishing expeditions. Both observations relevant to the problem being discussed and baseline information about modern winter avian population in trawling fleet operating areas are unavailable for this fishery.

The target pollock fishery in the Sea of Okhotsk under the auspices of Pollock Catchers Association (PCA) received in 2013 an international certificate of the Marine Stewardship Council (MSC) (O'Boyle et al., 2013). One of certification criteria is study of fishery impacts on the habitat and condition of aquatic organisms including birds and mammals. In this connection, PCA initiated research works on this subject in 2014/2015 season of the Sea of Okhotsk Pollock Expedition (SOPE).

This report presents first results of these studies performed under a contract with PCA to investigate impacts of the pollock trawl fishery in the Sea of Okhotsk on the condition of seabird populations. They are based primarily on the author's observations during a voyage onboard the BMRT *Moskovskaya Olympiada* (owned by JSC Okeanrybflot) in January – April 2015. Additional ornithological materials were collected by researchers of the Kamchatka Branch of the Pacific Geography Institute who worked in the same expedition under the program of marine mammal by-catch studies: I.A. Usatov onboard the BMRT *Baklanovo* in January – April and S.V. Fomin onboard the BMRT *Pilenga-2* in March – April. More detailed information about these observations is provided below in “Materials and Methods” in several sections of this report. The study method is presented in respective sections and also summarized in Attachment 1. Bird names in this report correspond to the latest national overview of North Eurasia birds (Koblik, Arkhipov, 2014) and their Latin names are provided in Attachment 2.

1. INFORMATION ABOUT VOYAGE ON THE BMRT *MOSKOVSKAYA OLYMPIADA* IN JANUARY – APRIL 2015

General information about the BMRT *Moskovskaya Olympiada*

Vessel type: large freezing factory trawler, Project No. 1288, “Meridian” type.

Designation: fishing for various fish species using bottom and mid-water trawl; processing of main raw food materials into frozen products in processed and non-processed form; processing of by-catch and offal into fish meal; product storage and transfer to transport vessels in fishing area.

Main particulars: length overall 103.7 m; width overall 16.0 m; draft 5.7 m; depth to top deck 10.2 m; depth to lower deck 7.4 m; moulded midship draft 5.9 m; gross tonnage 4347 rt; net tonnage 1304 rt; mean speed 14.3 knots; main engine capacity 2 × 2574 kW. Total volume of three hoppers for catch distribution located in the aft part of fish deck is 40 tons (15 tons in each of two side hoppers and 10 tons in the central hopper).

Port of registry: Petropavlovsk-Kamchatsky.

Yard and year of build: USSR, Nikolaev, 1980.

Crew number: 98.

The vessel is equipped with a mechanized trawling complex, navigation, search and other equipment compliant with current navigation and fishing requirements.

The vessel is equipped with two mid-water trawls of RK–154/1120 m type for pollock fishing. Trawl is operated by towing/trawling, cable and Gilson winches with various pulling force and speed, rope capacity, dimensions and weight. Two Ibercisa MAI-E/600/3200-32/IS electric winches are installed in the aft part of fish deck for trawl warp heave-out and haul-in. Their performance data are as follows:
- electric motor drive 360 hp, 660 rpm;
- rope capacity of drum 3200 m of wire Ø 32 mm;
- pulling force and drum rotational speed ratings:
- first layer (Ø 610 mm) – pulling force 42.5 t, speed 48 m/min,
- middle layer (Ø 1096 mm) – pulling force 24.9 t, speed 81 m/min,
- full drum (Ø 1582 mm) – pulling force 17.6 t, speed 115 m/min.

Some parts of fishing and shipboard equipment and outfit important from the viewpoint of trawl fishery impact on seabirds are addressed below in other sections of this report.

Brief description of the BMRT *Moskovskaya Olympiada* fishing operations during SOPE in 2015

In 2015, the BMRT *Moskovskaya Olympiada* was operating in the pollock fishery in the Sea of Okhotsk during 87 days – from 15 January through 11 April, of which it was fishing during 72 days and the rest 15 days were spent en passage to fishing areas, search for fish aggregations, cargo transfer and bunkering.

The vessel departed from Petropavlovsk-Kamchatsky port on 15 January and via the Fourth Kuril Strait proceeded to the fishing area in Kamchatka-Kuril subzone (61.05.4), where it was operating during 17 January – 1 February in coordinates 51.35-52.90º N; 153.69-155.83º E.

After the first cargo transfer, it continued fishing in West Kamchatka subzone (61.05.2) during 5–19 February in coordinates 57.17-57.76º N; 153.50-154.59º E.

After the second cargo transfer, it continued operating in West Kamchatka subzone during 22 February – 5 March in coordinates 57.70-58.38º N; 154.26-155.77º E.

After the third cargo transfer, it was fishing in North Sea of Okhotsk subzone (61.05.1) during 7–20 March in coordinates 55.19-56.93º N; 149.92-152.31º E.

After the fourth cargo transfer, it was harvesting the remainder of quotas in West Kamchatka and North Sea of Okhotsk subzones during 23–28 March and then proceeded to East

Sakhalin subzone (61.05.3) and operated there during 23 March – 8 April in coordinates 52.27-56.01º N; 143.51-144.81º E. Having used all quotas, the vessel returned to West Kamchatka coast and after cargo transfer completed pollock fishing on 11 April.

After completion of pollock fishing, the author of this report on 11 April moved onboard the freezer vessel TR *Canarian Reefer* that departed to Vladivostok on the next day. The reefer left the Sea of Okhotsk on 14 April via Bussol Strait and then proceeded via Tsugaru Strait. The reefer arrived in Vladivostok on 18 April.

When it was engaged in pollock fishing, the BMRT *Moskovskaya Olympiada* performed trawling on a 24-hour basis. The number of hauls per fishing day was 1 to 5 and averaged at 2.9. A total of 211 hauls was performed during the fishing period. Trawling duration, including urgent hauls, varied in the range of 1 hour 33 minutes to 19 hours 45 minutes. The range of depths surveyed during the voyage varied from 240 to 850 m. All catches were absolutely dominated by pollock. By-catch of other species (mostly herring) did not exceed per cent fractions.

Final data on catch and output by the BMRT *Moskovskaya Olympiada* during SOPE in 2015 are presented in Table 1.1 below.

Table 1.1. Catch and output by the BMRT *Moskovskaya Olympiada* during SOPE in 2015

Product	Net weight (kg)	Fishing subzone	Quota (kg)	Catch (kg)	Remaining quota (kg)
H/G pollock	975326	61.05.4	5300000	5299677	323
Meal from raw fish	5	61.05.4			
Meal from offal	76635	61.05.4			
Pollock roe unscreened, Grade 1-4	29601	61.05.4			
Pollock roe unscreened, off-standard	14306	61.05.4			
H/G pollock	2257816	61.05.2			
Meal from raw fish	83	61.05.2			
Meal from offal	170022	61.05.2			
Pollock roe unscreened, Grade 1-4	120359	61.05.2			
Pollock roe unscreened, off-standard	34523	61.05.2			
H/G pollock	1219944	61.05.1	2000000	1999836	164
Meal from raw fish	55	61.05.1			
Meal from offal	89760	61.05.1			
Pollock roe unscreened, Grade 1-4	98969	61.05.1			
H/G pollock	786896	61.05.3	1290000	1289900	100
Meal from raw fish	28	61.05.3			
Meal from offal	60052	6105.3			
Pollock roe unscreened, Grade 1-4	34155	6105.3			
Pollock roe unscreened, off-standard	14076	6105.3			

2. SPECIES COMPOSITION, SPECIFIC FEATURES AND DENSITY OF BIRD DISTRIBUTION IN THE SEA OF OKHOTSK WATER BASIN IN WINTER BY RESULTS OF SHIP-BASED COUNTING SURVEYS

Winter aspects of the avian population in the Sea of Okhotsk have been studied very little. In fact, information about seabirds in trawl fishing areas contains only general conclusions based on studies performed from fishing vessels in 1960s (Shuntov, 1972, 1998b) and aerial observation results obtained at the turn of 1960s–1970s (Voronov, 1972) and early 1980s (Trukhin, Kosygin, 1986). The composition of winter avian fauna in the near-Kamchatka waters based on results, obtained during a voyage onboard a long-liner in March – April 2005, was briefly described by Yu.B. Artyukhin and co-authors in 2008. As available data are very scarce, a baseline study of the winter avian population of the Sea of Okhotsk is a foremost task.

Materials and methods

In order to obtain baseline information about seabird populations, we undertook quantitative counting surveys from the board of BMRT *Moskovskaya Olympiada* and TR *Canarian Reefe*r performed by one observer on each vessel. Counts were performed only when no trawling operations were in process (during observer's travel to/from fishing area, in vessel's search mode, during passage to cargo transfer locations). In such periods of time, feeding bird aggregations emerging around the vessel during fishing operations dispersed and there was no obvious factor for bird attraction to the vessel during a counting survey.

The transect method was used for bird counting (along routes of certain length and width) developed by U.S. specialists for the Northeast Pacific (Gould, Forsell, 1989). According to this method, count was continuously performed when the vessel was underway in a strip 300 m wide (150 m on each side). The counting route was divided into 10-minute intervals data for which were summed up and a local distribution density value was computed. Observations were made from the wheelhouse (height above sea level is 12 m on the BMRT *Moskovskaya Olympiada* and 15 m on the TR *Canarian Reefer*). The vessel's average speed during counting surveys was 20.7 km/h. A binoculars with magnification power 10 was used to identify bird species and count birds more precisely. Ship coordinates, speed and direction of its movement were registered during the entire counting survey at 15 second intervals using a GPS receiver.

Counts were performed during 16 January – 14 April (Fig. 2.1). The majority of counts took place outside shelf waters. Counts in particular areas were normally performed once during a short time. The only exclusion was the northeastern part of the sea at the entry to Shelikhov Bay where observations were repeated several times during February – April (several cargo transfer operations took place in this location). Total length of surveyed transects was 2478 km and their square area (at a width of 300 m) totaled 743.5 km^2. Total counting time was about 120 hours which is equal to 719 counts during 10 minutes each.

When describing birds, a species was characterized as rare if its average distribution density was 0.01-0.1 individuals/km^2, low-abundant – 0.1-1 ind./km^2, common – 1-10 ind./km^2, abundant – more than 10 ind./km^2. A species' distribution density was characterized by the arithmetic mean M and its standard error SE.

For a more detailed characteristic of the species composition and distribution features for some species, transect counting results are complemented in this section with shipboard observation data collected during trawling and cargo transfer operations. Part of this information is described in more detail in the following sections of this report.

Results and discussion

The species composition and density distributions of seabirds based on shipboard counting surveys are presented in Table 2.1. In total, 7,360 individuals of 17 species belonging to

5 families were counted in transects. A short overview of particular features of bird species distribution in the Sea of Okhotsk waters based on counting survey data is presented below.

Laysan albatross (Fig. 2.2). Rare wintering species. Only six individuals were observed solo in counting transects on 16 January in the Fourth Kuril Strait and contiguous area. However, according to observations made near the vessel's side during trawling operations (see Section 4), this species is rather common to trawl fishery areas off Southwest Kamchatka and sometimes penetrates farther north at least to 55.55° N.

Fulmar (Fig. 2.3). Common species distributed throughout the whole basin of the Sea of Okhotsk. It was always observed during counting surveys except several routes passing mostly amid ice fields. Maximum local abundance values (up to 132 individuals/km^2) were registered in the northeastern part of the sea in the areas of trawl fleet concentrations. This species was also found off North Kurils and Southwest Kamchatka at rather high distribution densities. Of 2398 counted fulmars, slightly more than half (53.0%) of individuals belonged to the white morph and the rest belonged to the dark morph.

Short-tailed shearwater (Fig. 2.4). Rare species. Its noteworthy numbers were observed only on 16 January during passage of the Fourth Kuril Strait: a total of 12 birds was counted with local density reaching 4.5 individuals/km^2. Despite target-specific observations, this species was observed only once in the inner areas of the Sea of Okhotsk – a solo individual was seen on 28 March in the central part of the sea in coordinates 55.94° N; 149.76° E.

Fork-tailed storm petrel (Fig. 2.5). Rare species. A total of 6 solo individuals were counted in transects: two – on 16 January at the entry to the Fourth Kuril Strait, one – on 17 January near Southwest Kamchatka and three – on 26 March in the northern part of TINRO Depression. According to observations of live and dead birds during fishing operations (see Sections 3 and 7), fork-tailed storm petrel regularly penetrates with ocean masses to the northeastern deepwater part of the Sea of Okhotsk rising north at least to 57.65° N.

Slaty-backed gull (Fig. 2.6). Common, widely distributed species, the most typical representative of larids. Its largest aggregations with local distribution densities of up to 23 individuals/km^2 occurred in the northeastern part of the sea amid fishing vessel concentrations. This species often penetrates to discontinuous ice fields and is less frequently observed in open deepwater areas. The great majority of wintering birds is represented by adult individuals and immature individuals with intermediate plumage accounted for 5.4% only (38 of 710 counted individuals).

Vega gull (Fig. 2.7). Low-abundant sparsely distributed species. It was met in all observation areas but rarely and normally solo. Its local distribution density in transects did not exceed 1.9 individuals/km^2. Of 23 counted birds, 20 and 3 respectively were adults and immature individuals with intermediate plumage.

Glaucous-winged gull (Fig. 2.8). Rare species. Only 9 individuals were registered in transects – all in the eastern part of the surveyed area. According to observations of bird aggregations during trawling operations (see Section 3), glaucous-winged gull actively migrates over the whole eastern part of the Sea of Okhotsk in the winter season, with its significant numbers observed off Southwest Kamchatka. Individual birds reach north as far as the boundary of continuous ice at the entry to Shelikhov Bay (at least to 58.53° N). Of birds registered in transects, 7 and 2 respectively were adult and immature individuals.

Glaucous gull (Fig. 2.9). Low-abundant species, one of the most typical representatives of the winter avian population. It is found everywhere, but the majority of wintering birds aggregate in the northeast of the Sea of Okhotsk in areas where trawling fleet activities are high with its local abundance reaching 25 individuals/km^2. It often stays near the edge of ice and rarely met in open waters not covered by fisheries. Its age composition was mostly mature individuals – 85.1% (274 of 322 counted birds).

Ross's gull (Fig. 2.10). Rare species registered during counting surveys mostly in the northern part of the study area. No patterns have been noticed in its migration direction. Thus, a marked migration of gulls directed westward – southwestward was observed on 28 March in the middle part of the Sea of Okhotsk: birds were flying during 1 hour in a dispersed flow (1 to 3 individuals) up to 1.5 km wide. However, several days later – on 5 April, we observed a gull migration off Northeast Sakhalin oriented to north – northwest. The majority of encounters with this species occurred on open water beyond the boundary of ice fields: only 4 of 66 individuals counted in transects were noticed among discontinuous ice.

Kittiwake (Fig. 2.11). Low-abundant species. Its mean density of winter distribution (0.11 individuals/km^2) turned out somewhat overrated because concluding counting surveys performed in near-Sakhalin waters in April obviously coincided with the beginning of this species' spring migrations. Anyway, kittiwake was regularly observed in all fishing areas in January – March as well and in the course of trawling operations 1 to 13 individuals were simultaneously observed near the vessel virtually every day. Kittiwakes penetrate in northern direction to the boundary of continuous ice at the entrance to Shelikhov Bay (to 58.53° N as a minimum). Of 82 birds registered in transects, 80 ones were adults and only 2 ones were yearlings.

Ivory gull (Fig. 2.12). Rare species. Its low averaged density value (0.08 individuals/km^2) is explained first of all by the fact that ivory gull distribution is closely related to ice landscapes and our counting routes passed mostly across open waters. Birds were observed in transects only in the northeastern part of the sea when our routes were passing along the edge of ice fields; we saw only two solo birds in ice free waters. Ivory gulls were only once seen near the vessel during trawling operations. However, their aggregations, unusually large for this species, were observed in two cases during cargo transfer operations in 100 km south of Koni-Pyagino Coast. Cargo transfer areas were located in 120 km from each other. We were in the eastern location on 5-6 March and in the western location on March 21-22. During all these days, we regularly observed flying migrating ivory gulls and dense groups sitting on ice which gathered for night-time or rest. Maximum number of gulls in the field of vision from the ship's board at any one time was 216 and 340 individuals on 6 March and 22 March respectively (Fig. 2.13). The majority of birds flying by during both cargo transfer periods were moving to north – northwest.

Common murre and thick-billed murre (Fig. 2.14). Taken together, both species are common in the winter season. As murre segregation by species was not always possible during transect counts, we summed up data on both species during analysis. However, when credible identification of murres was possible, we registered results separately for each species. Of 727 murres determined by species, 11.7% were common murres and 88.3% were thick-billed murres. In transects, thick-billed murre was definitely more frequently observed farther seawards than common murre, and the latter was regularly observed only on 3 February when approaching the cargo transfer location off Kamchatka coast west of Ust-Khairyuzovo settlement. In general, the largest wintering aggregations of murres were observed in the northern part of the Sea of Okhotsk where their local distribution density reached 98 individuals/km^2. Birds were staying both in the open water and amid ice. Large murre aggregations in the middle part of the sea between Kamchatka and Sakhalin at the edge of the shelf zone were obviously feeding ones. Off the coast of Sakhalin where our vessel operated during 29 March – 6 April, we observed active northward migrations of murres along the edge of ice cover possibly to their nesting grounds on Iona Island.

Pigeon guillemot (Fig. 2.15). Rare species. As guillemot is a typically coastal bird, it was observed only on 3 February when proceeding to the cargo transfer location near Kamchatka coast west of Ust-Khairyuzovo settlement – at 57.45° N. In this area, we counted 39 pigeon guillemot individuals in a 40-minute transect 13.3 km long. Our route was passing over depths of 35-48 m across slush ice fields with large open water areas.

Crested auklet (Fig. 2.16). Common species, one of the most numerous among wintering avian fauna. Its high average abundance value is explained by feeding aggregations registered in transects on 17 and 18 January off Southwest Kamchatka coast (with local density reaching 711 individuals/km^2): we counted here 63.6% of all crested auklets registered in counting routes throughout the Sea of Okhotsk (1658 of 2608 individuals). Groups in this area included up to

400 birds. In northward areas, densities of this species distribution did not exceed 205 individuals/km^2 and separate groups counted 250 individuals. The majority of encounters occurred in ice free waters except several cases registered in ice leads among ice fields.

Least auklet (Fig. 2.17). Rare species. A total of 50 individuals were registered in transects (solo and in groups of 2 to 15 individuals). No massive winter aggregations typical of the Sea of Okhotsk waters in 1960s (Shuntov, 1998b) were found in our study area. Least auklets were more often met off the southwestern coast of Kamchatka, normally together with crested auklets. Along with live birds, we found in this area 3 least auklets on deck (see Section 7) who had crashed into the ship in the night.

Tufted puffin (Fig. 2.18). Rare species. A total of 13 birds were registered who always stayed solo or in pairs. Their local density did not exceed 1.8 individuals/km^2. The majority of encounters occurred off Kuril Islands and Southwest Kamchatka and separate birds were seen in the northeastern part of the sea in February – March. The northern boundary of their distribution in the winter season is 57.59° N.

In addition to above mentioned birds observed in counting routes, another two gull species extremely rare in the Sea of Okhotsk were registered during trawling operations – Thayer's gull and red-legged kittiwake (see Section 3).

In its climatic conditions, the Sea of Okhotsk deeply intruding into the Asian continent shows little difference from Arctic seas, and its harsh climate results in heavy ice conditions. Nonetheless, as observations performed from ships in January – April 2015 show, the modern species composition of wintering seabirds is diverse and avian population abundance is rather high.

According to our data, the winter seabird fauna includes 19 species. Anseriformes birds wintering in the inshore areas of the sea (Podkovyrkin, 1955; Voronov, 1972) are not included in this list because we have met none of them during the voyage. The greatest diversity is characteristic of larids (9 species) and auks (6 species) while 3 families of tube-nosed birds are represented by 4 species only.

According to shipboard counting data, average distribution density of all birds is 10.0 individuals/km^2. Auks (48%), procellariids (33%) and larids (19%) dominate in quantitative terms, while albatrosses and storm petrels account for less than one-tenth per cent of the winter population abundance.

Compared with observations made by V.P. Shuntov (1972, 1998b), total density of the avian population remained at the same level: it was some 10 individuals/km^2 in shelf and continental slope waters in early 1960s. Changes occurred in the quantitative proportion of taxonomic groups: while auks (murres and auklets) absolutely dominated through the sea basin in the past, now they generally maintain their quantitative dominance but are inferior to procellariids (fulmar) and larids (mostly *Larus* genus) in fishing fleet concentration areas.

New species have appeared in the list of wintering birds. While such relatively warm climate birds as fork-tailed storm petrel, kittiwake and puffin earlier spent winter in areas other than the Sea of Okhotsk, now they are met in the deep of winter in the inner areas of the sea and the mouth of Shelikhov Bay. Laysan albatross only in rare cases penetrated from the ocean to the near-Kuril waters in the past, and in the season of our surveys it regularly visited this area and sometimes was noticed farther north. Short-tailed shearwater, red-legged kittiwake and pigeon guillemot were first time ever registered in the inner part of the sea in the winter season. Thayer's gull was registered second time in the Sea of Okhotsk and fifth time in the Russian Far East as a whole which confirms earlier opinion (Artyukhin, Utkin, 2012) that this American species' status in Russian waters should be considered as rare, transient and wintering rather than vagrant.

It should be specially noted that large aggregations of ivory gull – a rare species listed on the Red Data Book of Russian Federation and IUCN Red List – were observed in ice at the entrance to Shelikhov Bay. This gull is aboriginal to high latitudes of the Arctic and comes to Far Eastern seas for wintering. Information about its wintering status in the Sea of Okhotsk is based on interviews (Kosygin, 1985; Shuntov, 1998b), aerial survey data summarized with other small gull species (Trukhin, Kosygin, 1986) and a score of observations of solo individuals in the Sea of Okhotsk coast. The number of these birds counted by us from the ship's board during two cargo transfer operations accounted for 0.8-1.8% of the world's population number estimated at 19-27,000 individuals (BirdLife International, 2012). Possibly, there is a so-called hotspot in this location – a place of vital importance in the life of ivory gulls during their winter migration period. According to criteria of habitats important for birds developed by the International Council for Bird Preservation (BirdLife International, 2010), the mouth of Shelikhov Bay can be considered as a key marine ornithological area of international importance maintaining existence of a considerable portion of the population of a globally threatened species. However, repeated surveys are needed to make a final decision in this issue in order to understand how stable ivory gull aggregations in this area are on a year-to-year basis.

It is hard to discuss all reasons for changes proceeding from observations separated by half a century. Still, one of reasons surely is reducing ice cover. According to observations beginning from early 1970s, ice cover in the Sea of Okhotsk, being subject to multi-year fluctuations, is consistently reducing: its square area shrinks at an average rate of 3.8% per decade (Japan…, 2014). Moreover, hydrological and meteorological processes in the Sea of Okhotsk followed an abnormal scenario in the winter season of 2014/2015 which resulted in an absolute minimum of its ice cover over the whole series of observations beginning from 1972 (Varkentin, Kolomeytsev, 2015). Bird living conditions in the Sea of Okhotsk in winter are largely governed by the condition of its ice cover; therefore, such specific seasonal features naturally resulted in high species diversity and wide distribution of birds over the sea basin.

In summary, ship-based observations performed during SOPE in 2015 yielded substantial additional knowledge about the Sea of Okhotsk avian population in the winter season. This shows that vessels engaged in pollock fisheries can be successfully used both for study of fishery impacts on seabird condition and for collection of baseline information about bird populations in fishing areas.

Table 2.1. Composition of avian fauna and density of bird distribution (individuals/km^2) in the Sea of Okhotsk basin according to results of ship-based transect counting surveys in January – April 2015

Species	Distribution density	
	M	SE
Diomedeidae family		
Laysan albatross	0.01	<0.01
Procellariidae family		
Fulmar	3.32	0.34
Short-tailed shearwater	0.02	0.01
Hydrobatidae family		
Fork-tailed storm petrel	0.01	<0.01
Laridae family		
Slaty-backed gull	1.04	0.08
Vega gull	0.03	0.01
Glaucous-winged gull	0.01	<0.01
Glaucous gull	0.52	0.06
Ross's gull	0.09	0.03
Kittiwake	0.11	0.02
Ivory gull	0.08	0.03
Alcidae family		
Common murre and thick-billed murre	1.44	0.22
Pigeon guillemot	0.05	0.04
Crested auklet	3.24	1.30
Least auklet	0.06	0.03
Tufted puffin	0.02	0.01
All species	10.04	1.38

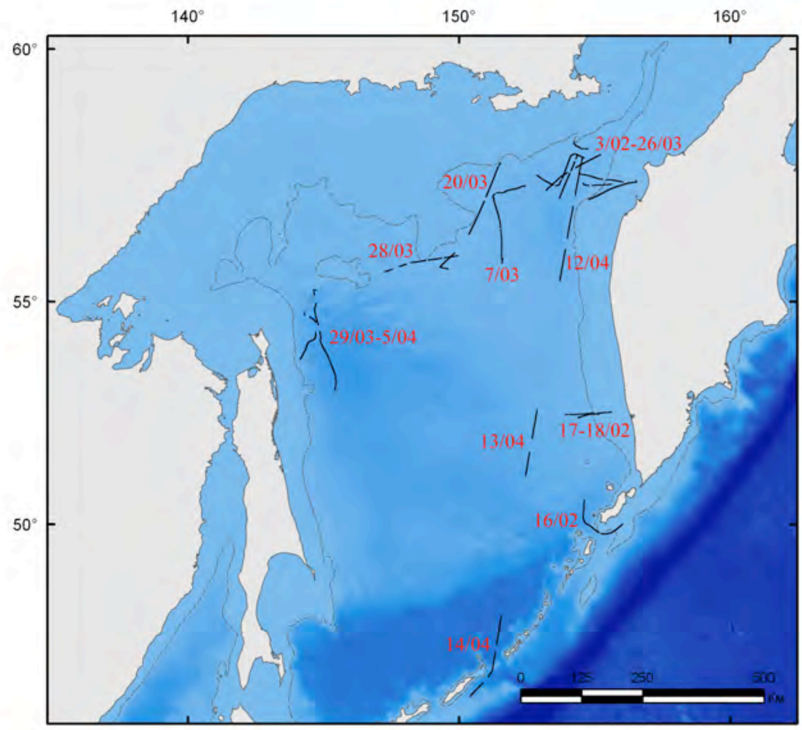


Fig. 2.1. Transect locations (solid lines) and dates of counting surveys in the Sea of Okhotsk in January – April 2015 performed from board of the BMRT *Moskovskaya Olympiada* and TR *Canarian Reefer*. 200-meter depth contour is shown by dotted line.

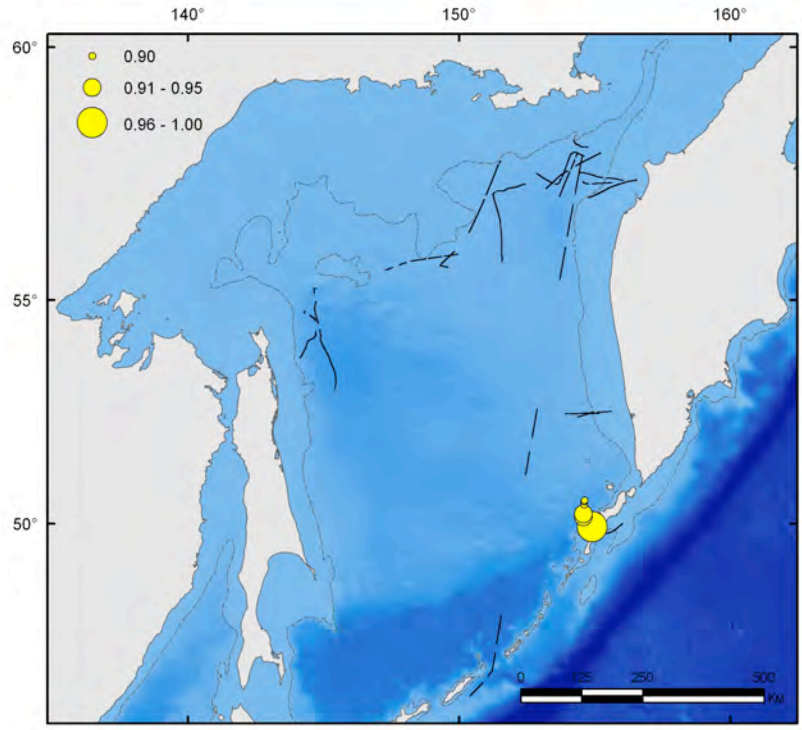


Fig. 2.2. Laysan albatross distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

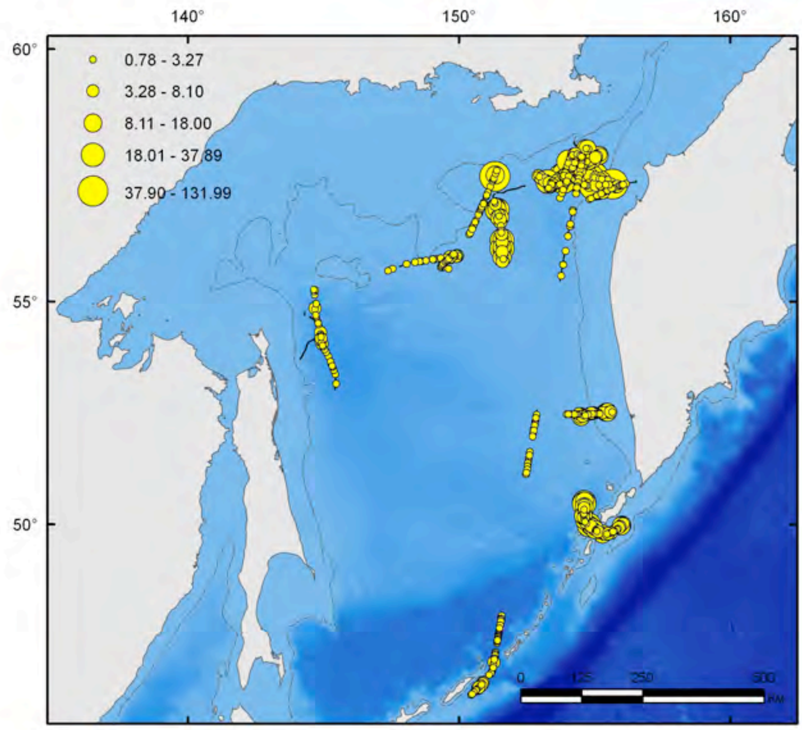


Fig. 2.3. Fulmar distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

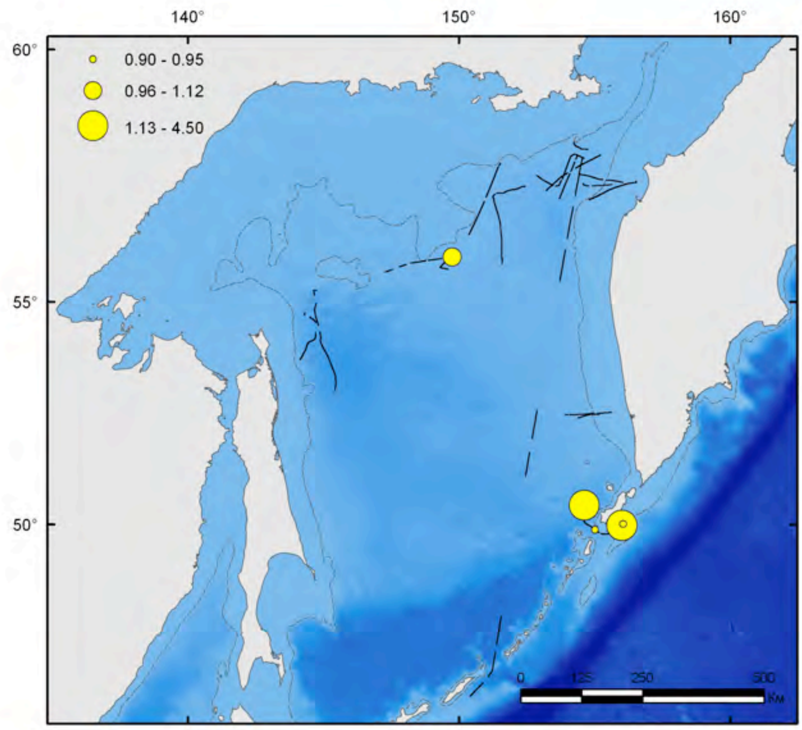


Fig. 2.4. Short-tailed shearwater distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

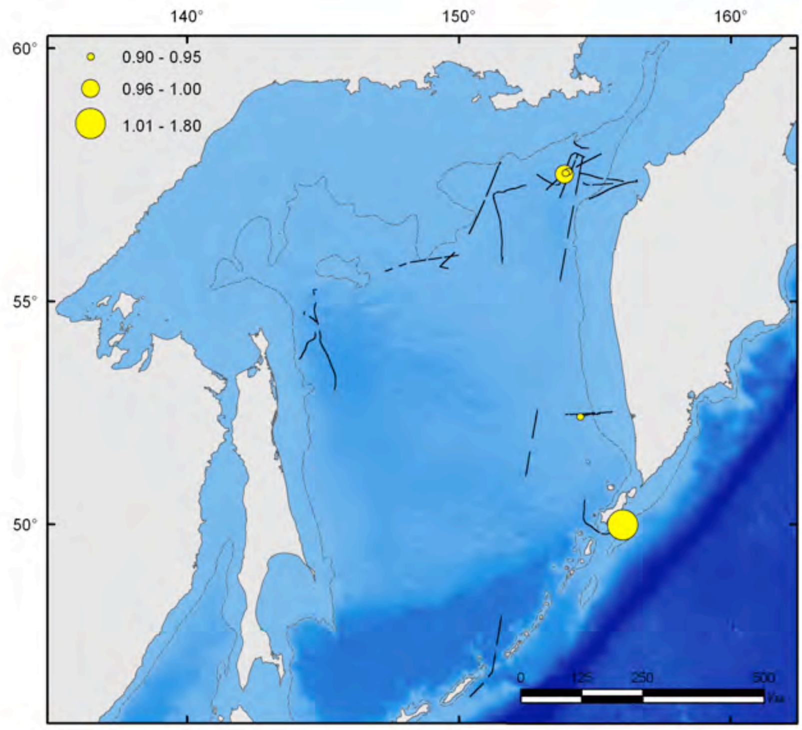


Fig. 2.5. Fork-tailed storm petrel distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

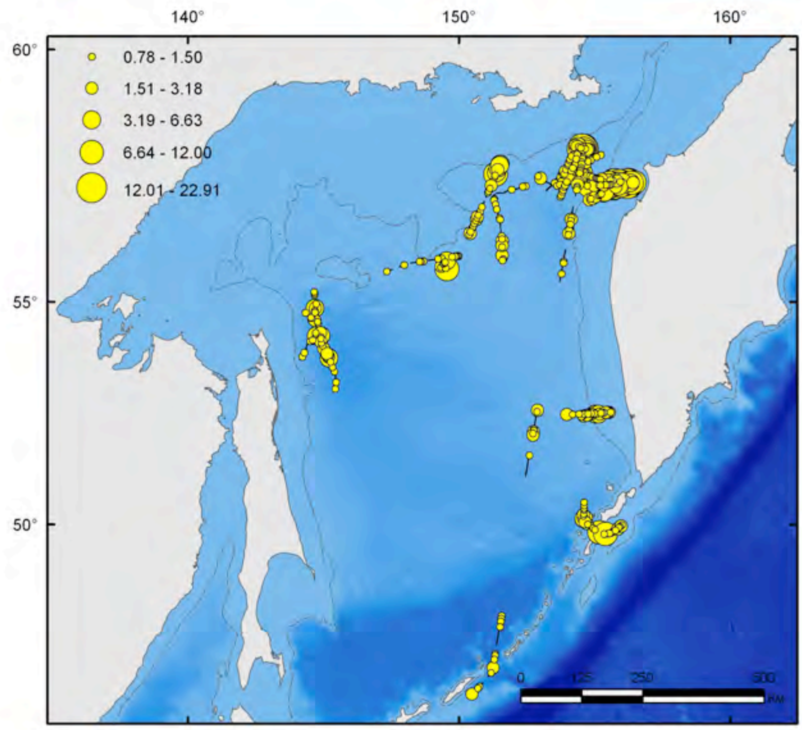


Fig. 2.6. Slaty-backed gull distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

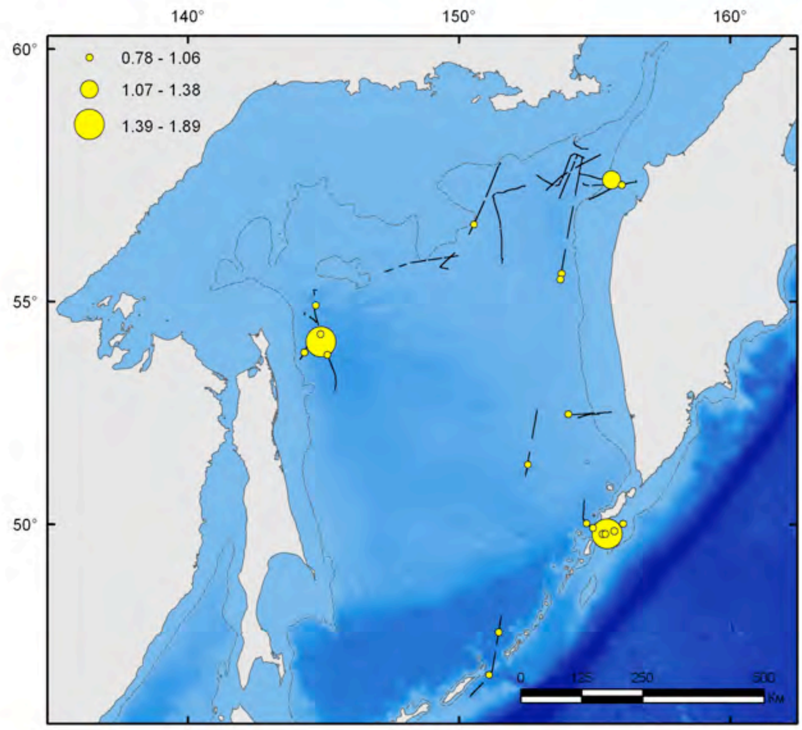


Fig. 2.7. Vega gull distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

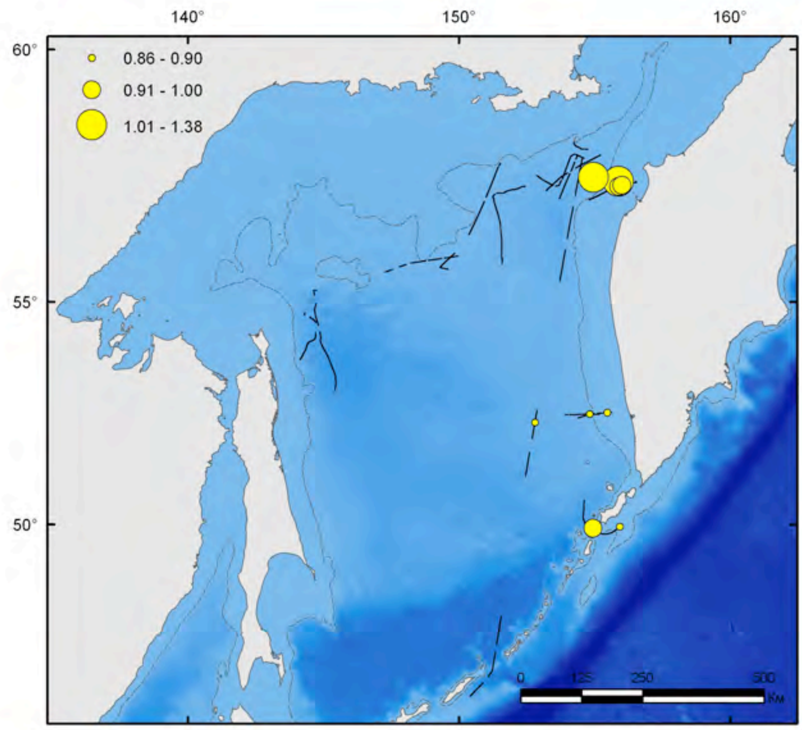


Fig. 2.8. Glaucous-winged gull distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

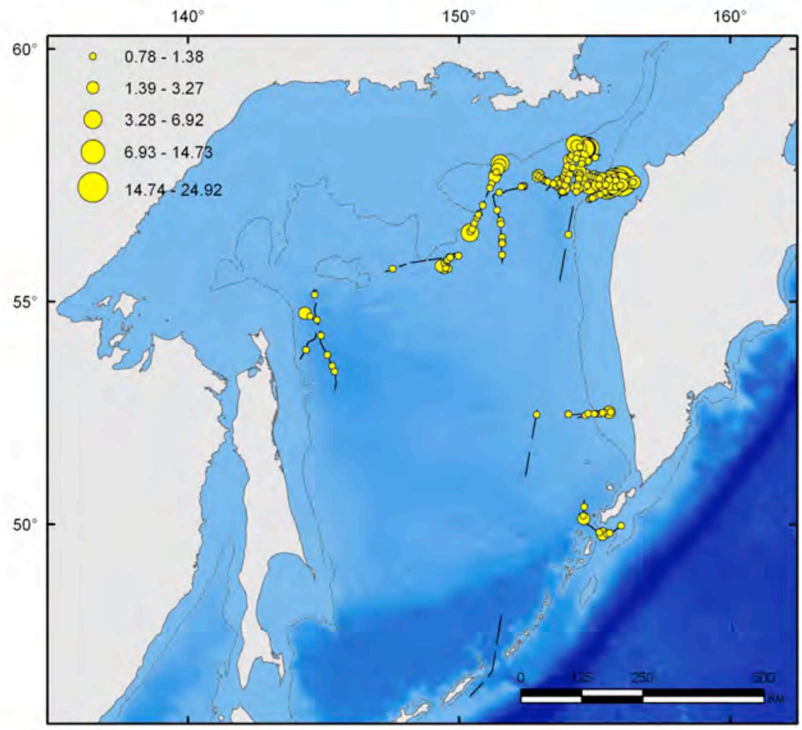


Fig. 2.9. Glaucous gull distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

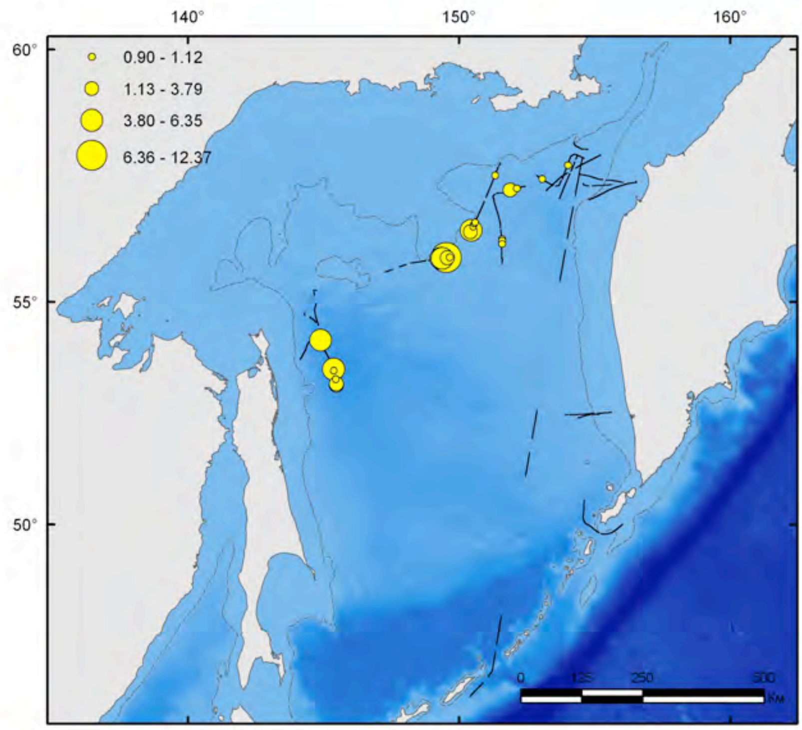


Fig. 2.10. Ross's gull distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

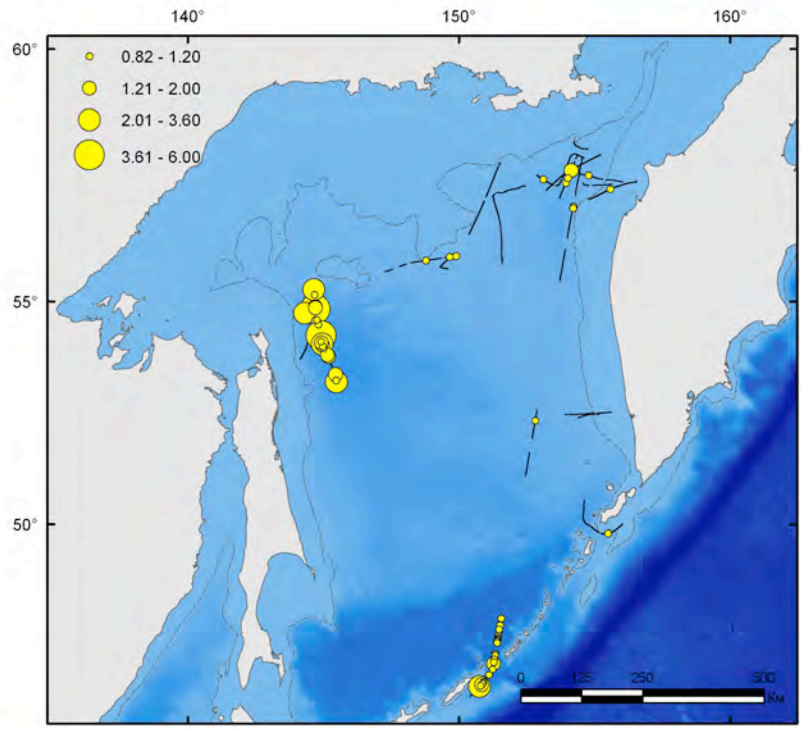


Fig. 2.11. Kittiwake distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

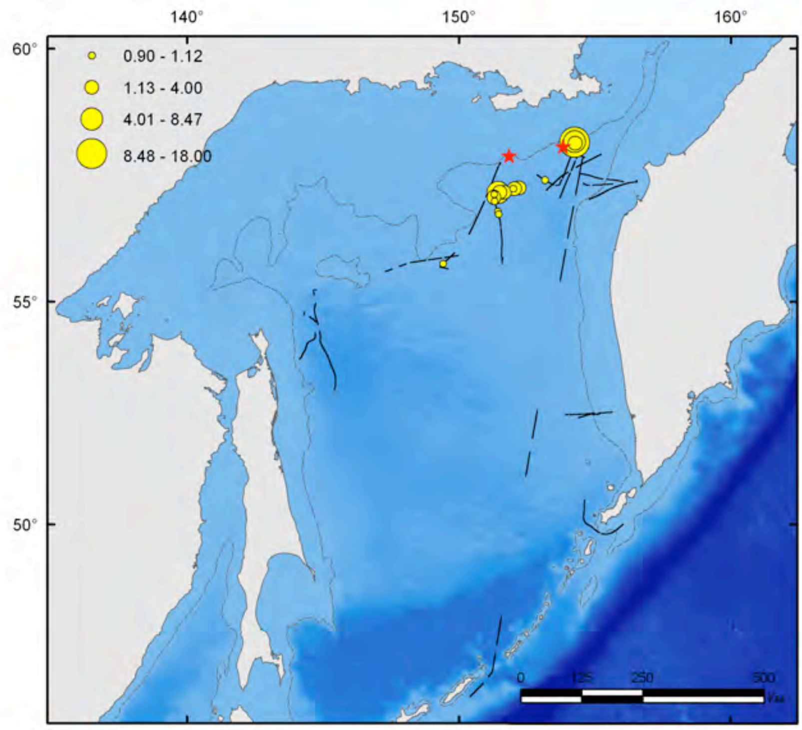


Fig. 2.12. Ivory gull distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line. Locations of gull aggregations during cargo transfer operations on 5-6 and 21-22 March are shown by stars.

Fig. 2.13. A fragment of the ivory gull aggregation in which 340 individuals were counted. The BMRT *Moskovskaya Olympiada*, 22 March 2015.

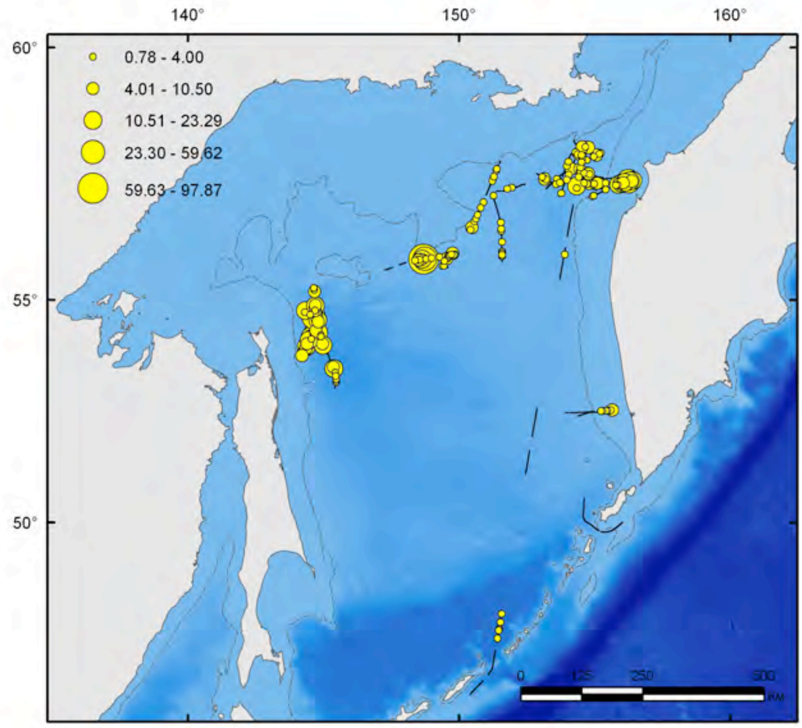


Fig. 2.14. Common murre and thick-billed murre distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

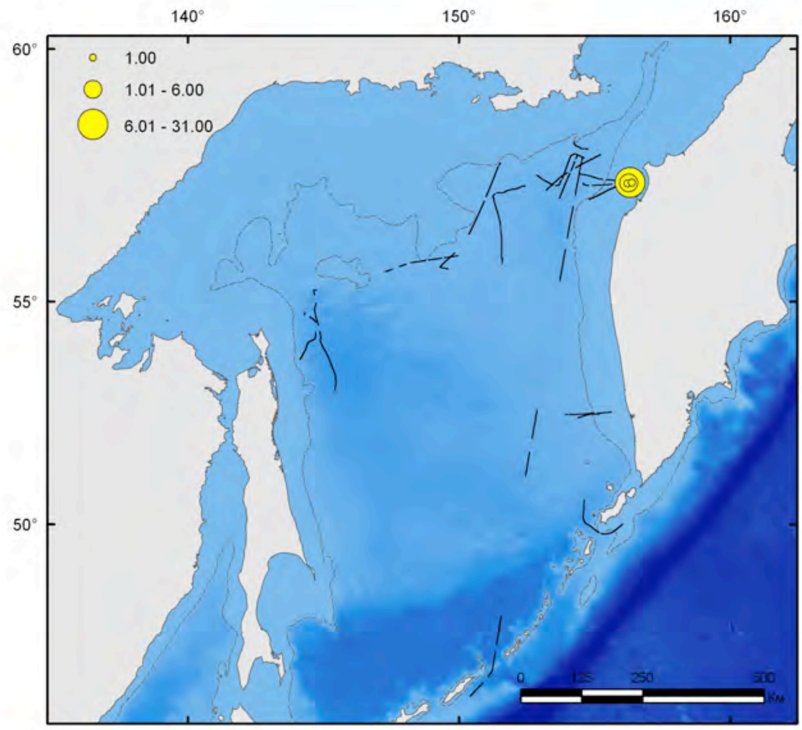


Fig. 2.15. Pigeon guillemot distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

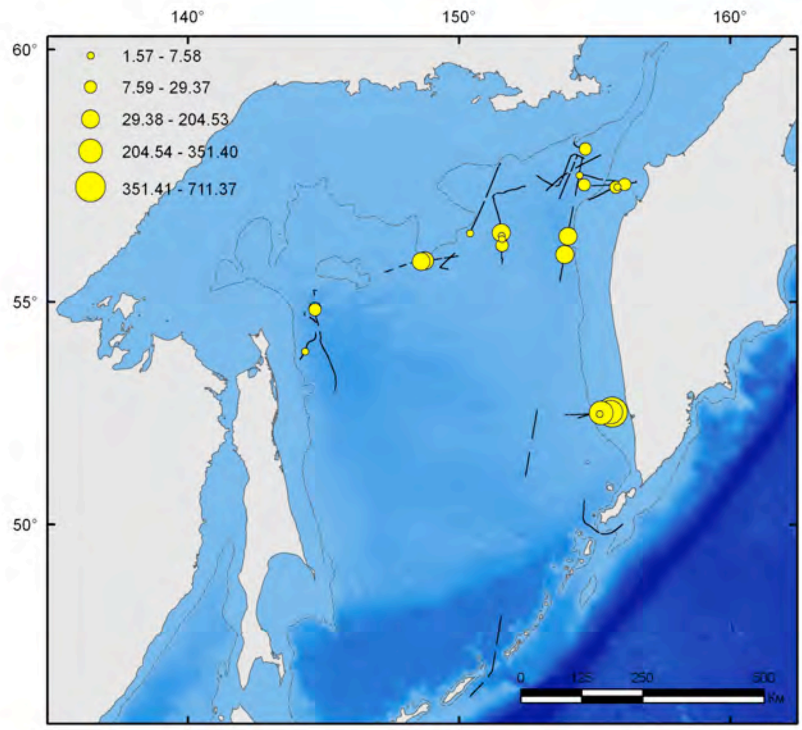


Fig. 2.16. Crested auklet distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

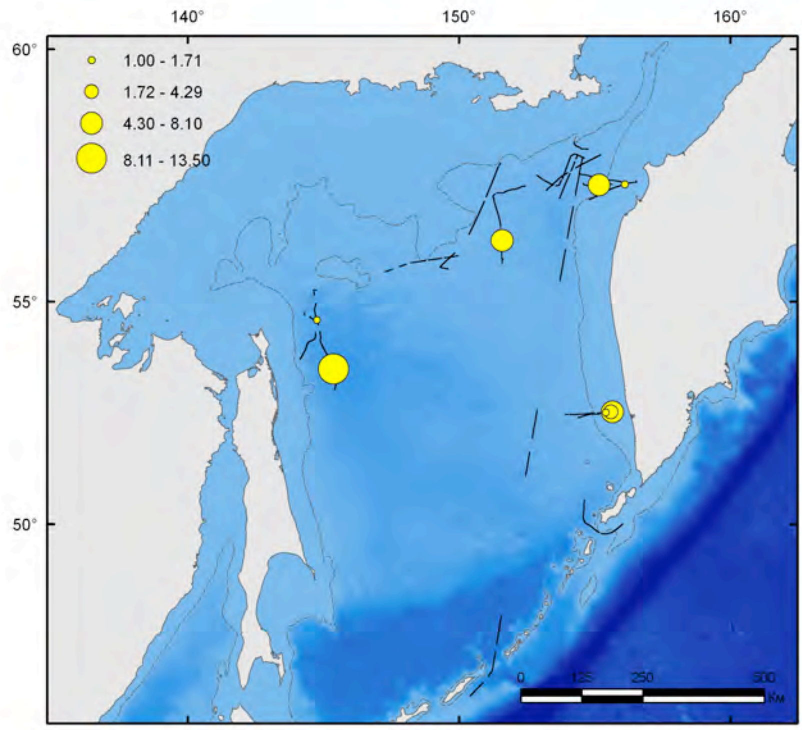


Fig. 2.17. Least auklet distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

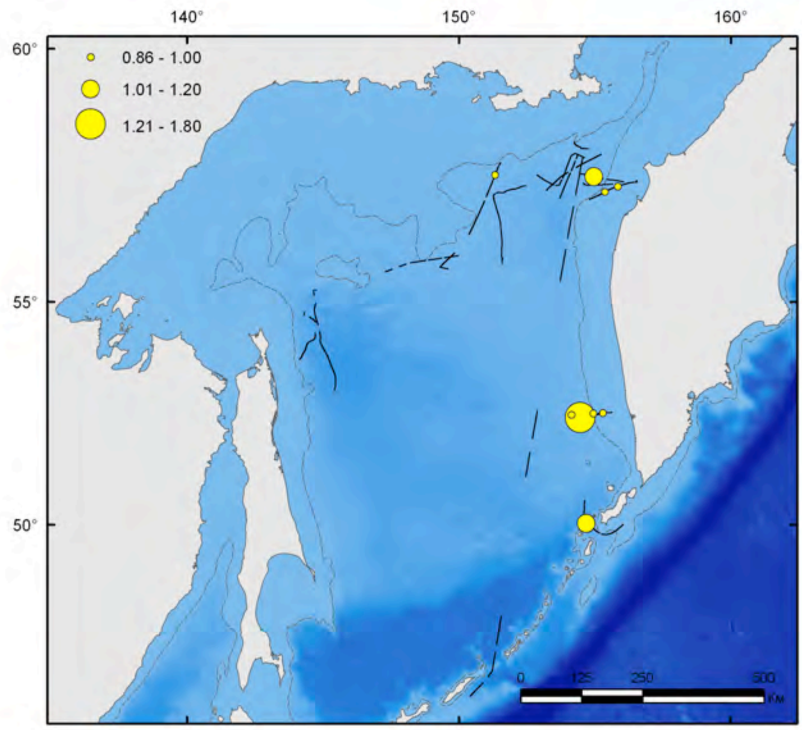


Fig. 2.18. Puffin distribution and density (individuals/km^2) in the Sea of Okhotsk in January – April 2015 by results of ship-based transect counting surveys. 200-meter depth contour is shown by dotted line.

3. SPECIES AND QUANTITATIVE COMPOSITION OF SEABIRDS IN AGGREGATIONS AROUND TRAWLERS DURING COMMERCIAL FISHING OPERATIONS

Materials and methods

During the whole voyage on board the BMRT *Moskovskaya Olympiada*, regular observations of the water area around the vessel were performed using a binoculars with magnification power 10 in order to estimate the total number of birds by species within sight. Low-abundant species were counted by individuals and abundant species were counted by test area method (in tens or hundreds). The quantitative proportion of gull species in large gull aggregations was found by selective computation method. The percentages of two color morphs among fulmars were determined in the same way. We tried to perform counting surveys during offal release operations when birds were stronger attracted to the ship and accuracy of results increased.

We used indicators of the maximum abundance of birds during a day for characterization of aggregations. During analysis, we used count results only on those days when trawling was performed in daylight ($n = 62$). We did not include count data on total bird abundance around the ship, gathered on days of passage and cargo transfer, in our estimations.

Results and discussion

Observations made during trawling operations showed that fishing vessels attract virtually all tube-nosed and larid birds belonging to the species registered during SOPE in 2015 (see Section 2). When all these birds stay near the vessel, their either pick offal or grab small fish from trawls.

In most cases, the bulk of such aggregations consisted of fulmars (Table 3.1). They dominated in all fishing areas except East Sakhalin subzone (Fig. 3.1). There were more fulmars off Southwest Kamchatka than in other fishing areas (Kruskal-Wallis test: $H = 32.361$, $df = 3$, $p < 0.001$) – up to 16,000 fulmars simultaneously gathered near the ship in the third 10-day period of January. In the northeastern part of the Sea of Okhotsk, maximum concentrations around the ship did not exceed 4,000 individuals in North Sea of Okhotsk subzone and 5,000 individuals in West Kamchatka subzone (Fig. 3.2).

The ratio of light and dark morphs in fulmar aggregations was equal in the northernmost operating area at the entrance to Shelikhov Bay where fishing is performed at the ice edge – 51% and 49% respectively. Dark individuals dominated in the rest areas varying from 71% in North Sea of Okhotsk subzone to 82% in Kamchatka-Kuril subzone and 95% in East Sakhalin subzone.

Besides fulmar, other tube-nosed birds repeatedly observed in aggregations were Laysan albatross – 1 to 5 individuals per day (more detailed information about this species is provided in Section 4) and, on one occasion, – fork-tailed storm petrel (on 8 March in coordinates 55.35° N; 151.89° E, a solo bird was picking up small offal pieces flying near the stern).

The second-largest group of birds, gathering near the ship, in terms of abundance was large white-headed gulls belonging to *Larus* genus: slaty-backed gull, Vega gull, glaucous-winged gull, glaucous gull and, on one occasion, Thayer's gull (Table 3.1). These birds aggregated near the ship on all fishing days but their number was broadly varying. Distribution of values was statistically significant for fishing areas (Kruskal-Wallis test: $H = 28.095$, $df = 3$, $p < 0.001$). Same as for fulmar, the largest aggregations were observed during operations in the Kamchatka-Kuril subzone (50 to 9,000 birds averaging at 4,012). Gull abundance is noticeably lower in the northeastern part of the sea – 100 to 4,000 individuals averaging at 698 and in the northwestern part of the sea – 200 to 1,400 individuals averaging at 600. These birds were the least abundant in the high sea waters of North Sea of Okhotsk subzone – 50 to 300 averaging at 135 individuals per day (Fig. 3.3).

Among larid birds, slaty-backed gull was dominating everywhere reaching up to 83-85% in the western and central parts of the surveyed area (Fig. 3.4). The numbers of glaucous gull, an Arctic species arriving in the Sea of Okhotsk for wintering, considerably grew near ice in vicinity of Shelikhov Bay (up to 37% of all gulls). Glaucous-winged gull, an American species, was observed in appreciable numbers (16%) only off Southwest Kamchatka – in the area adjacent to its main wintering locations in the Asian part of its distribution area in Kamchatka-Kuril waters. Vega gull numbers in aggregations were normally within several individuals in the north of the study area and within several scores in its southeast. Thayer's gull was met on a single occasion – an adult bird was photographed during trawling run on 25 January off the southernmost tip of Kamchatka in coordinates 51.40° N; 154.76° E. It was flying behind the stern among the mass of other gulls and fulmars feeding on offal.

Of other species, only kittiwake was regularly keeping near the ship – several individuals (maximum 12-13 birds) were normally registered almost every day. Its largest aggregations counting 50 individuals each on 6 and 7 April near Kashevarov Bank were already a sign of the beginning of this species' spring migrations (Fig. 3.5).

On several occasions, we observed red-legged kittiwakes during trawling operations – these were first ever visual registrations of this species in the Sea of Okhotsk in winter (Table 3.1; Fig. 3.5). During 8-11 March in an area west of TINRO Depression, 1 to 9 individuals were keeping near the ship in the daylight picking up offal. After that, we observed solo birds during a short time on two occasions: on 18 March in 150 km north of the first encounter location and on 6 April on the southwestern side of Kashevarov Bank. All observed birds were adult. These observations confirm recent information obtained through bird tracking using geolocators about red-legged kittiwake penetration into the Sea of Okhotsk in winter (Orben et al., 2015).

It was unusual to see Ross's gulls near the ship who were feeding on discharged offal because this is the only gull species avoiding approaching vessels engaged in seal-hunting and fishing operations (Divoky, 1976; Trukhin, Kosygin, 1987; Yu.B. Artyukhin, unpublished data). A total of 6 encounters were registered – 1 to 4 individuals a day in different fishing areas (Fig. 3.6).

Ivory gull was seen only once during trawling operations – on 17 February in West Kamchatka subzone: the bird was flying for a short time behind the stern and grabbing fish offal discharged by the trawler's factory from the water surface. In the same area, we repeatedly observed in passage and during cargo transfer that ivory gulls approached the ship in search for food and sometimes picked up offal.

Auks normally avoid approaching fishing vessels. Of 6 wintering species, intentional approach to the ship was observed for thick-billed murre only. This species was regularly met in operating areas but we saw during two days only (17 March and 7 April) as murres landed on the ship's wake and started diving obviously picking up lost small fish or offal discharged from the factory.

In summary, various seabird species continuously concentrate around ships in the winter pollock trawl fishery in the Sea of Okhotsk, primarily tube-nosed and larid birds. The species and quantitative composition of such aggregations is quite dynamic in spatial and temporal terms. The largest (in abundance terms) and the richest (in terms of a set of species) concentrations emerge in Kamchatka-Kuril subzone where many strayed or wind-blown birds normally wintering in ocean waters are present. In this area, we observed multi-species aggregations counting up to 23,000 individuals around one ship only and, in total, hundreds of thousands of birds possibly may simultaneously gather in trawling fleet concentration areas. Total abundance of birds in fishing areas remote from the ocean is lower by an order of magnitude.

Bird proportions in near-ship communities are formed under influence of biotopic preferences of species. Pelagic fulmar absolutely dominates in deep-sea waters and the ratio of large white-headed gulls preferring mostly coastal conditions grows closer to land and near the ice edge.

The size of aggregations around trawlers is also affected by weather conditions. When powerful cyclones pass across the fishing area, the number of birds, particularly gulls, considerably declines: birds are likely to go closer to the coast where they wait out unfavorable conditions (for instance, 1,300 to 9,000 gulls gathered around the *Moskovskaya Olympiada* at the very beginning of its voyage in Kamchatka-Kuril subzone but, after a heavy storm occurred on 28 January, only 50 to 300 birds were observed near the ship during 4 next days).

In general, it can be stated that the annual pollock expedition in the Sea of Okhotsk is a powerful factor for emergence of large wintering aggregations of various seabird species providing a feeding source for them – fish processing waste discharged to the sea.

Table 3.1. Number of birds (individuals/ship-day when fishing) counted around the ship during trawling operations.

Species	Subzone							
	05.1 (n = 14)		05.2 (n = 27)		05.3 (n = 8)		05.4 (n = 13)	
	M	SE	M	SE	M	SE	M	SE
Laysan albatross	0.5	0.3	0	–	0	–	1.3	0.4
Fulmar	1319.6	325.5	1374.1	254.7	390.6	242.4	9015.4	1064.7
Fork-tailed storm petrel	0.1	–	0	–	0	–	0	–
Gulls of *Larus* genus	135.0	22.0	698.1	147.4	600.0	137.3	4011.5	949.7
Ross's gull	0.6	0.3	0	–	0.4	–	0.1	–
Kittiwake	2.3	0.5	3.4	0.6	16.6	7.3	1.0	0.4
Red-legged kittiwake	1.3	0.7	0	–	0.1	–	0	–
Ivory gull	0	–	<0.1	–	0	–	0	–
All species	1459.4	318.0	2075.6	292.2	1007.8	365.3	13029.3	1711.0

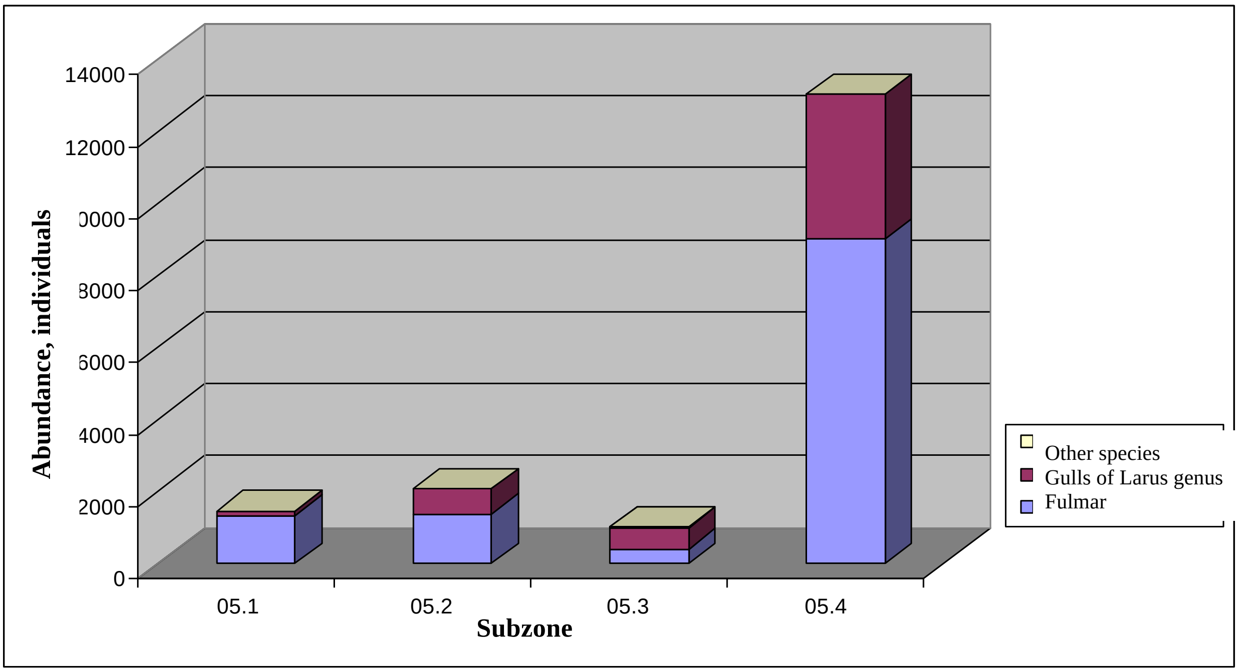


Fig. 3.1. Bird composition and abundance in aggregations around the ship during trawl hauling in different fishing zones.

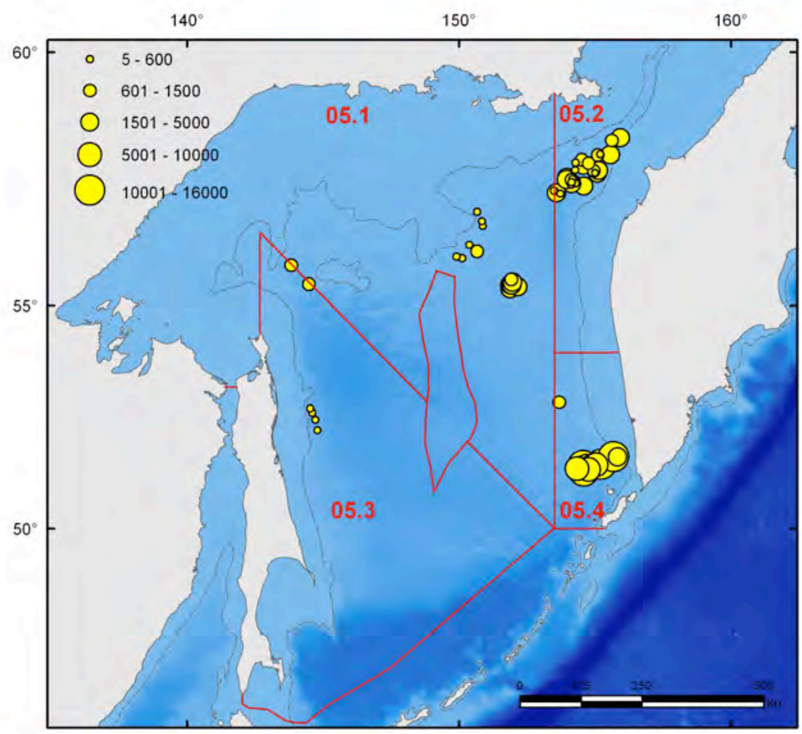


Fig. 3.2. Distribution of fulmar aggregations around the ship (maximum number per day, individuals). Boundaries of fishing subzones are shown by a solid line and 200-meter depth contour is shown by a dotted line.

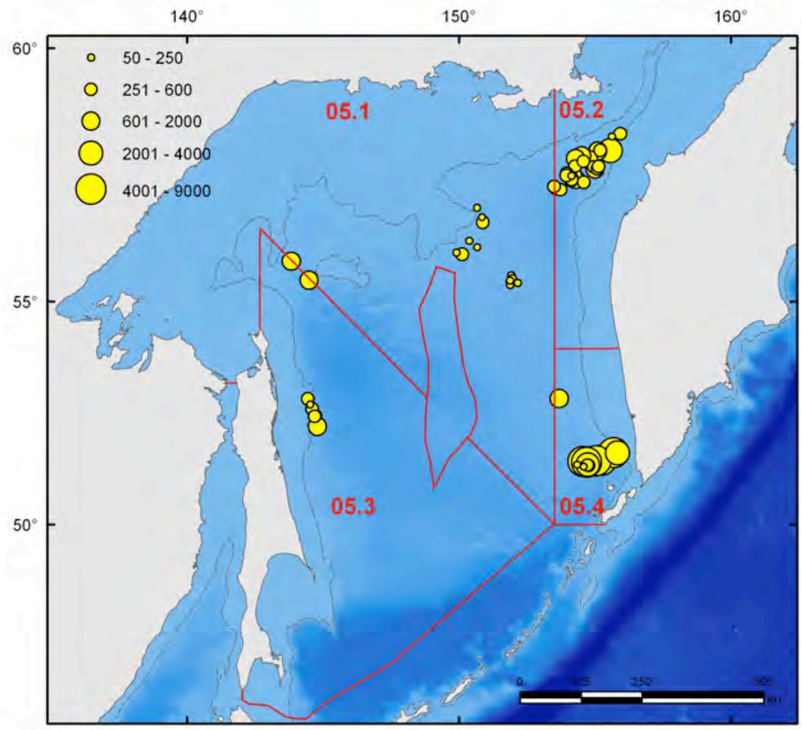


Fig. 3.3. Distribution of gulls of *Larus* genus aggregations around the ship (maximum number per day, individuals). Boundaries of fishing subzones are shown by a solid line and 200-meter depth contour is shown by a dotted line.

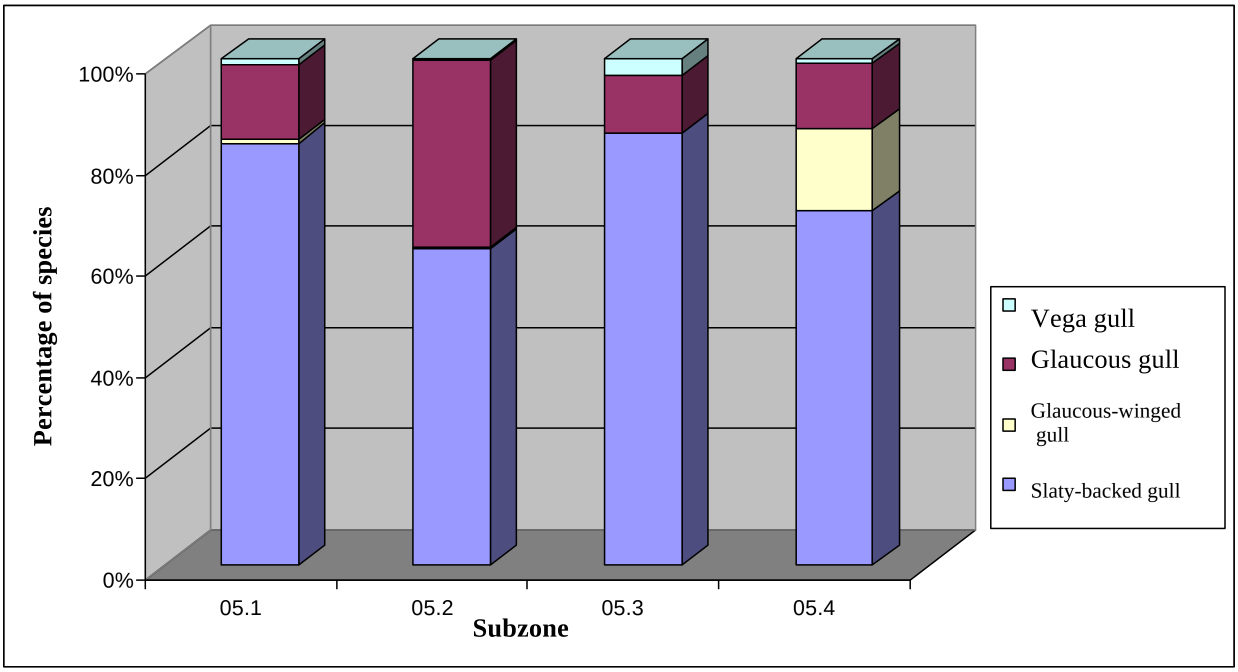


Fig. 3.4. Species composition of gulls of *Larus* genus in aggregations around the ship during trawl hauling in different fishing zones.

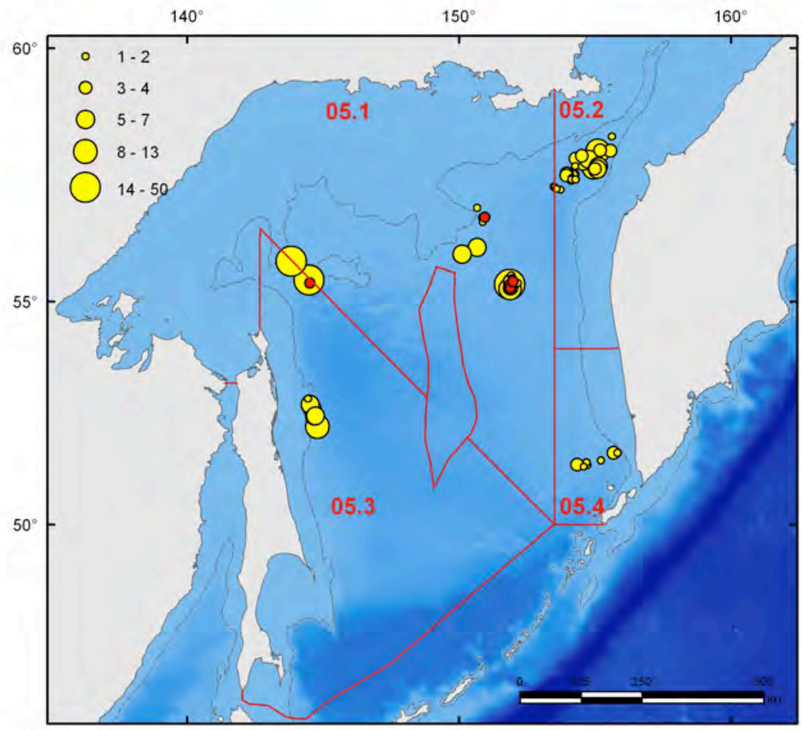


Fig. 3.5. Distribution of kittiwake (yellow dots, maximum number per day, individuals) and red-legged kittiwake (red dots) in bird aggregations around the ship. Boundaries of fishing subzones are shown by a solid line and 200-meter depth contour is shown by a dotted line.

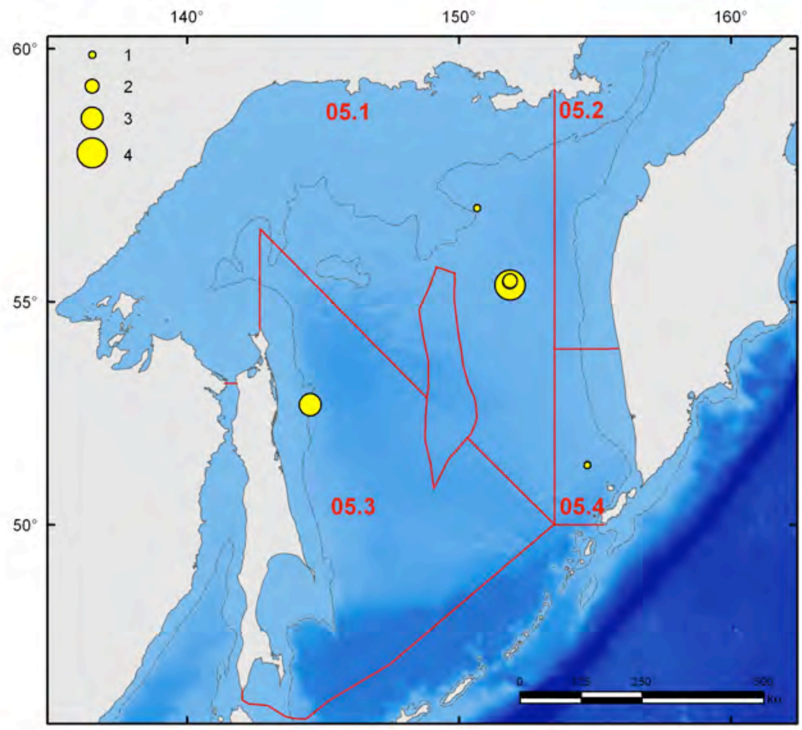


Fig. 3.6. Ross's gull distribution (maximum number per day, individuals) in bird aggregations around the ship. Boundaries of fishing subzones are shown by a solid line and 200-meter depth contour is shown by a dotted line.

4. NATURE OF PRESENCE OF NORTH PACIFIC ALBATROSS SPECIES IN THE SEA OF OKHOTSK

When assessing impacts of marine living organism fisheries on the condition of bird populations in the North Pacific, special attention is normally given to three protected albatross species living in this region (short-tailed albatross, Laysan albatross and black-footed albatross). These birds are recognized extremely vulnerable to adverse effects of fisheries. Such life cycle features typical of seabirds as late maturity and low birth rate and particularly marked in albatrosses. These factors are compensated by their long life span and high survivability rate (Croxall, Gales, 1998). As a result, death in fishing gear may have drastic consequences for albatross populations.

Materials and methods

Information about albatross distribution in the Sea of Okhotsk was collected by 3 observers based on the BMRT *Moskovskaya Olympiada*, BMRT *Baklanovo* and BMRT *Pilenga-2*. During the entire voyage, each observer, using a binocular, periodically observed the water area around the vessel within sight during fishing operations and all passages (including passage onboard transport vessels) to register albatrosses. They registered the following information in each case: species, date and time, coordinates of encounter, number of observed individuals and age. When observing birds during trawling operations, specifics of their behavior were noted to assess probability of their contacts with fishing gear.

Observations in the Sea of Okhotsk and contiguous oceanic waters near Kuril Islands were performed during 16 January – 27 April (a total of 239 ship-days afloat for 3 vessels).

Results and discussion

Short-tailed albatross is an endemic species in the North Pacific with a dramatic fate. At the turn of the 20th century, Japanese feather traders hunted for these birds so intensively in their nesting grounds that this species, quite abundant before, was deemed extinct. Fortunately, a colony consisting of several couples survived in Torishima Island of Izu Islands and from here recovery of this species began in 1950 (Hasegawa, DeGange, 1982). Due to appropriate measures taken, short-tailed albatross has been saved and its population is currently recovering. However, despite this growth, its current total abundance all over the world is 3,400 individuals only or less than 1% of its historical abundance (Deguchi et al., 2013). As a result, short-tailed albatross remains in the IUCN Red List, although its category was changed in 2000 from endangered (EN) to vulnerable (VU); it is also listed in Red Data Books of Russian Federation and several Far Eastern administrative regions (category 1 – endangered species).

Short-tailed albatross main nesting grounds are found in Torishima Island and Senkaku Islands in the south of the East China Sea. Its breeding period is October – June. Adult birds spend all the rest time at sea far from their colonies. The percentage of immature birds is high in its population as albatrosses normally start nesting at the age of 6 years. Juvenile birds migrate in the sea all year round and start visiting nesting areas at the age of 3-4 years (Hasegawa, DeGange, 1982). Therefore, short-tailed albatrosses spend a significant portion of their life at sea. They move all around the North Pacific north of the zone of trade winds both in deep-water and shelf areas but tend to marginal areas of the ocean and seas. Generalized data obtained through visual registration (Piatt et al., 2006) and satellite telemetry (Suryan et al., 2006, 2007) show that albatrosses keep primarily along the edge of the continental shelf and underwater slope above depths of 150-200 m.

Russia’s Far Eastern seas are an area of short-tailed albatross traditional migrations. In the past, this species was distributed from the south of Chukchi Sea to southern borders of Russian territory. In the period of its catastrophic condition, its area of migrations and occurrence rate has considerably reduced (Shuntov, 1998a). Still, territorial waters and the 200-mile Exclusive Economic Zone (EEZ) of Russian Federation continue being of principal importance for short-tailed albatross as an area of year-round migrations of immature birds and migrations of adult birds between breeding seasons. According to growing numbers of visual registrations after mid-1990s (Artyukhin, 2011), short-tailed albatross is currently recovering its historical distribution area in the Russian Far East. Migrating birds are regularly and in growing numbers observed off Kuril Islands and Commander Islands, along the western coast of Kamchatka and in vicinity of the Navarin Canyon in the Bering Sea.

During the time after its repeated discovery (1950-2014), short-tailed albatrosses were visually registered in Russian Far Eastern seas on more than 150 occasions and totaled more than 500 individuals (Fig. 4.1). The database of registered encounters is based on Yu.B. Artyukhin's observations and more than 40 others sources of information (publications, electronic reports, databases, personal communications by observers, photographs).

Short-tailed albatrosses were observed during this period in the Sea of Okhotsk and contiguous waters of the Pacific and Sea of Japan 69 times – a total of 128 individuals. As a rule, these were solo birds but aggregations counting up to 11 individuals (average group size is 1.9 individuals) were repeatedly emerging near fishing vessels. Birds were observed during April through October, with no visual registrations documented in winter. More than half registered albatrosses (58.7%) were juvenile (*juv–imm*) and the rest were mature (*subad–ad*).

During the period of our study in January – April 2015, none of 3 observers has seen short-tailed albatrosses in the Sea of Okhotsk. The only registered case occurred on 15 April from board of the TR *Canarian Reefer* when it was passing a control point at the southern border of RF EEZ: at 12:34 (Kamchatka time) a 3-4-year-old bird flew near the vessel in southern direction in coordinates 43.099° N; 146.279 E (Fig. 4.1).

The absence of short-tailed albatross visual registrations in the Sea of Okhotsk in winter does not prove at all that this species does not occur in target pollock fishery areas during the winter fishing expedition. Evidence of that is tracking results for juvenile 1-3 year-old albatrosses marked with satellite transmitters before leaving their nests (O'Connor, 2013). Remote telemetry data vividly demonstrate that albatrosses during first years of their life cycle migrate around the Sea of Okhotsk and contiguous Pacific waters on a year-round basis (Fig. 4.2). In the summer-autumn period, they spend a significant portion of time in near-Kamchatka waters along the outer edge of the shelf zone in fishing fleet concentration areas which is well consistent with visual observation results. In winter, their migration area shifts to south toward Kuril Islands but remains within Kamchatka-Kuril subzone. During SOPE 2015, this area was covered by two BMRT-type vessels – *Moskovskaya Olympiada* and *Baklanovo* but for a short time only (16 January – 01 February) which was likely to be insufficient for registration of such a rare species as short-tailed albatross.

Laysan albatross is the most numerous albatross in Far Eastern seas. Its main nesting colonies accommodating more than 99% of its worldwide population are found in Hawaii Islands (largest ones are found on Midway and Laysan) and small numbers nest in Ogasawara (Bonin) Islands south of Japan, Guadalupe Island and Revillagigedo Islands off Mexican coast. Its migration area encompasses the whole temperate zone of the North Pacific including the high sea waters of the Bering Sea and Sea of Okhotsk (Shuntov, 1998b; Hyrenbach et al., 2002).

Similarly to short-tailed albatross, this albatross heavily suffered from feather traders in the past. 36,000 individuals were breeding in Hawaii colonies in early 1920s and, after hunting for Laysan albatross was stopped, its numbers rose to 564,000 by mid-century (Rice, Kenyon, 1962). Its current nesting worldwide population is 1.18 million individuals (Arata et al., 2009). In late 1990s – early 2000s, a drop was observed in the number of breeding birds in main Hawaii colonies and, because of that, IUCN assigned it a vulnerable (VU) status in 2004 but changed it to a near threatened (NT) status in 2010.

Laysan albatross migrates in Russian waters regularly and in large numbers. It is more common in the summer-autumn period in the Bering Sea, Sea of Okhotsk and ocean waters penetrating to the Sea of Japan on rare occasions. As breeding season begins in November, its abundance starts declining but part of birds stay migrating in winter in Pacific waters off Kamchatka, Commander Islands and Kuril Islands (Shuntov, 1998b).

As was discussed in Section 2, in the past time Laysan albatross visited Sea of Okhotsk waters in winter only sometimes. During SOPE 2015, we repeatedly observed it in the southern part of Kamchatka-Kuril subzone and in North Sea of Okhotsk subzone at 55.55° N (Fig. 4.3). First registrations of this species were made on 16 January from board of the *Baklanovo* and the *Moskovskaya Olympiada* on the Pacific side of Paramushir Island in vicinity of the Fourth Kuril Strait – 9 solo birds in counting survey transects. It should be added that S.V. Fomin observed a large number of Laysan albatrosses (up to 30 individuals near the ship) on 09 March along the Pacific side of Paramushir Island from board the transport vessel TR *Korsakov* on its way to the fishing area.

In the Sea of Okhotsk, Laysan albatrosses were observed almost every day during trawl hauling from 17 January to 01 February (1 to 5 or an average of 1.9 individuals per day) from board of the *Moskovskaya Olympiada* and the *Baklanovo* during their operations in Kamchatka-Kuril subzone. In North Sea of Okhotsk subzone, albatrosses appeared near the *Moskovskaya Olympiada* when it was fishing every day during 08-11 March – 1 to 3 or an average of 1.8 individuals per day.

Black-footed albatross. This species has much in common with Laysan albatross in terms of distribution and breeding biology. Its main nesting grounds (95% of the world’s population) are found in the Hawaii Islands and smaller colonies are found in islands south of Japan. Its migration area encompasses the greater portion of subtropical and temperate zones excluding shelf waters. Its current worldwide nesting population counts 122,600 individuals (Agreement…, 2010). Because of frequent deaths in pelagic long-line fisheries, this species had an endangered status (EN) in the IUCN Red List before 2012 but currently it status was lowered to vulnerable (VU).

As black-footed albatross is a warmer-climate bird compared with Laysan albatross, it migrates in Far Eastern seas mostly in the summer-autumn season and its distribution is more limited. It is observed in the Sea of Okhotsk primarily in areas of oceanic mass inflow. It is believed that black-footed albatross does not stay in Russian waters in the winter, i.e. in its breeding season (Shuntov, 1998b).

During SOPE 2015, none of 3 observers saw black-footed albatrosses within the Sea of Okhotsk. The only adult individual was observed on 15 April from board of the TR *Canarian Reefer* during its stopover in a control point at the southern border of Russian EEZ (same place where short-tailed albatrosses were observed). Based on this fact, we can state that occasional birds visit Russian waters in the winter along the ocean side of Kuril Islands. However, we do not have any information about presence of this species directly in the Sea of Okhotsk, to say nothing of its northern part where the bulk of pollock is harvested. Satellite tracking data on birds nesting in Hawaii Islands (Hyberbach et al., 2002) also show that they spend winter outside the boundaries of Russian Far East seas.

In summary, only one of three North Pacific albatross species was registered during observations in SOPE fishing areas in January–April 2015 – Laysan albatross which regularly aggregated around trawlers in the southern part of Kamchatka-Kuril subzone. We have not registered short-tailed albatross except one occasion in the ocean at the southern border of Russian EEZ. The reasons are its population’s low abundance and short duration of our observations in the area where probability of its migrations is the highest – opposite North Kuril straits. Still, we can suppose that short-tailed albatross is present in the Sea of Okhotsk in the winter proceeding from the fact of presence of its close relative – Laysan albatross and based on satellite telemetry data proving winter migrations of juvenile birds in the near-Kuril waters of the Sea of Okhotsk. In order to find out specific features of distribution in fishing areas of such a rare species as short-tailed albatross, a wide temporal and spatial coverage of trawling fleet’s fishing operations through observations during the seasonal pollock run is required. A priority area of such observations is Kamchatka-Kuril fishing subzone.

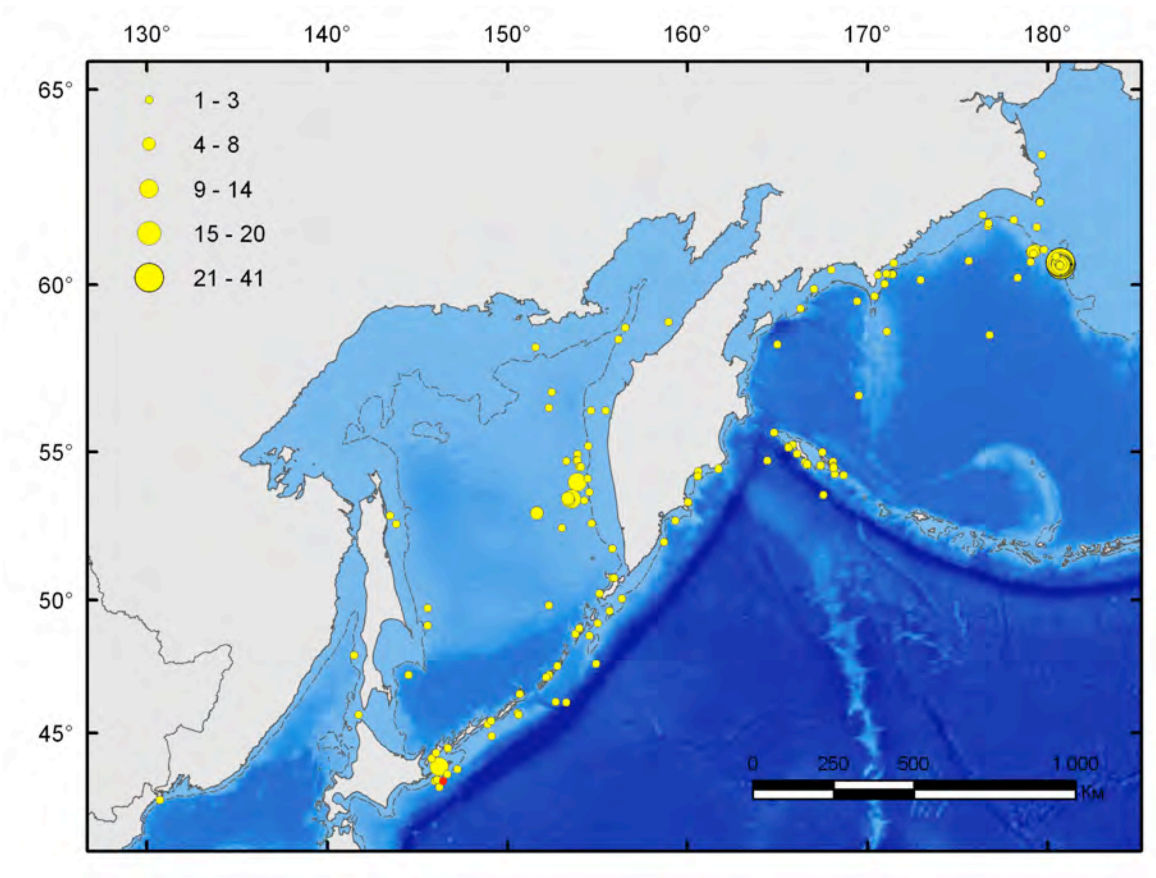


Fig. 4.1. Distribution of short-tailed albatross (individuals) in Russian Far East seas in 1950–2014. Red dot shows the location where short-tailed albatross was registered on April 15, 2015.

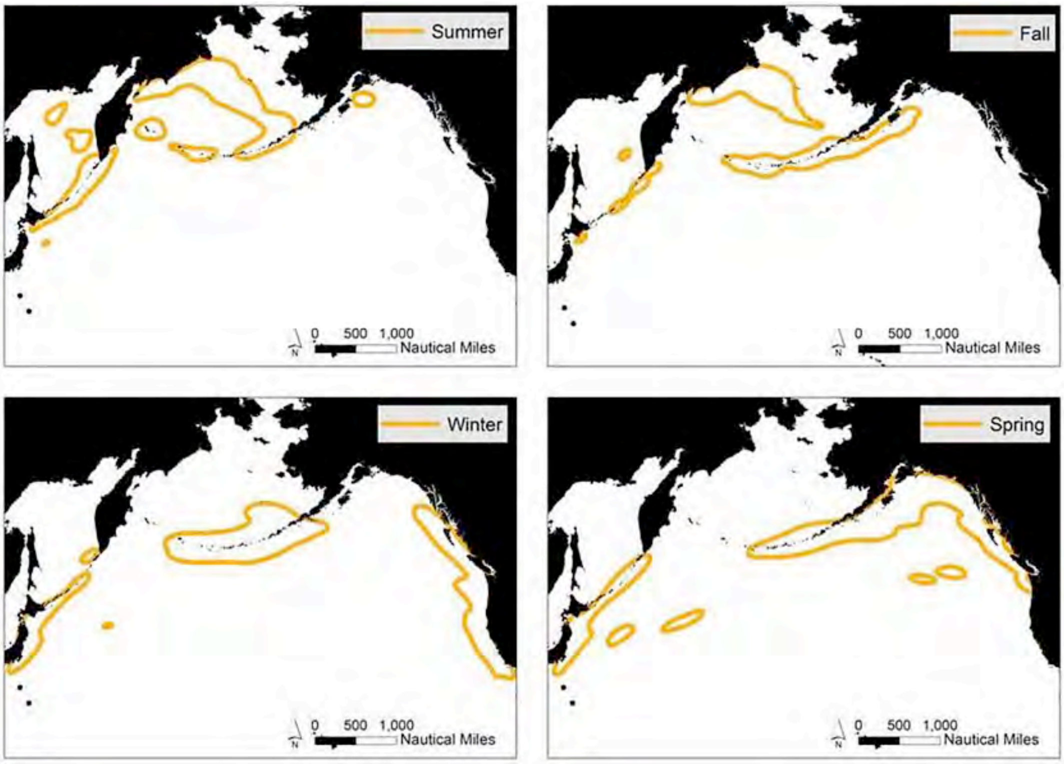


Fig. 4.2. Seasonal distribution of juvenile short-tailed albatrosses in the North Pacific according to satellite telemetry data (50% distribution density – Kernel density; n = 41; 2008-2012; see: O'Connor, 2013).

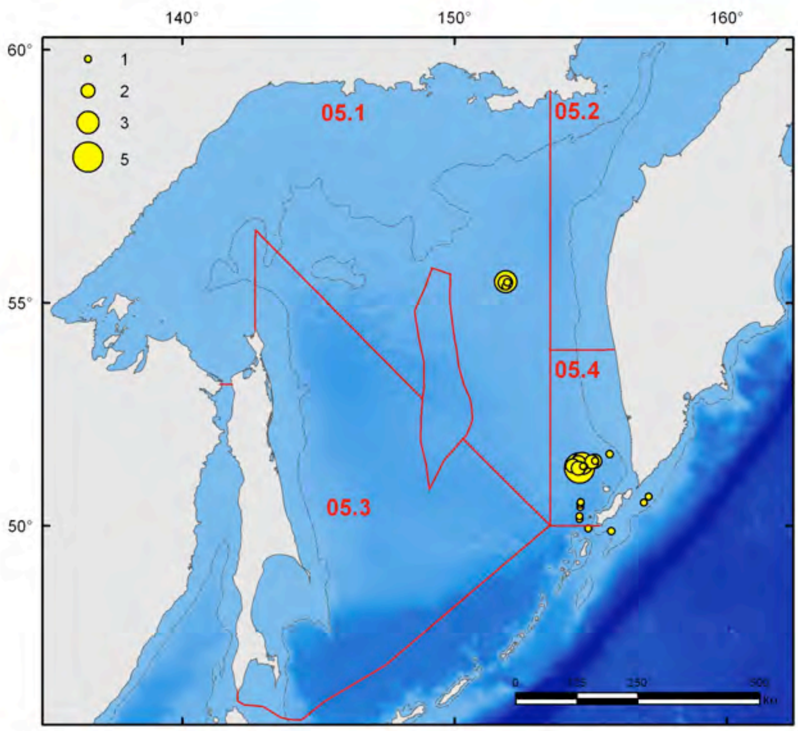


Fig. 4.3. Distribution of Laysan albatross (individuals) in the Sea of Okhotsk in January–April 2015 according to ship-based counting surveys in transects and observations during trawl hauling. Boundaries of fishing subzones are shown by a solid line and 200-meter depth contour is shown by a dotted line.

5. SPECIFIC FEATURES OF SEABIRD INTERACTION WITH TRAWL FISHING GEAR

The frequency of bird contacts with trawl fishing gear largely depends on specific features of its design and operation. The greatest hazard for birds from ships operating in SOPE is warps – 2 wires passing from otter boards to winches on ship's stern and connecting cable between depth and trawl opening control unit. A "RK-154/1120 m" mid-water trawl (2 units) was used on board the BMRT *Moskovskaya Olympiada* during SOPE 2015 and trawl control unit was Furuno TS-331A cabled depth sounder with CS-400 catch sensors (Table 5.1).

Materials and methods

We used approaches proven by similar works in other Pacific areas (Wienecke, Robertson, 2002; Sullivan et al., 2006b; Watkins et al., 2008; Melvin et al., 2011) to collect information about behavioral specifics of birds during trawling operations. Observations were performed during the entire voyage on board the BMRT *Moskovskaya Olympiada*. We counted the number of bird collisions with trawl's ropes/net panels and with wires – trawl control cable, right and left warps during the three stages of fishing operation – heaving out, trawling and hauling. Observations were made from trawl master's bridge or fishing deck at ship's stern during a certain period of time in the daylight. Duration of one observation at trawling stage normally was 30 minutes (several observations were made per fishing operation) and observation was continuous at heave-out and hauling stages.

Contacts with fishing gear were recorded separately by bird species or groups for each type of trawl outfit (ropes/net panels, right warp, left warp, depth sounder cable). Consequences of bird's collision with fishing gear were registered as follows: light contact – no threat to life, heavy contact – lethal case. A total of 10 interaction types were determined (for types 1-4, any collision of birds with ropes/net panels, except warps and depth sounder cable; landing of gulls on cod-end floating on the water surface was not considered as contacts):

1 – light contact of swimming bird with trawl (no adverse consequences);
2 – heavy contact of swimming bird with trawl (death is highly possible, bird may drown);
3 – light contact of flying bird with trawl (no adverse consequences);
4 – heavy contact of flying bird with trawl (death is highly possible due to a strong impact);
5 – light contact of swimming bird with warp or depth sounder cable (no adverse consequences);
6 – heavy contact of swimming bird with warp or depth sounder cable (death is highly possible, bird sank and is not seen on surface);
7 – light contact of flying bird with warp or depth sounder cable (no adverse consequences);
8 – heavy contact of flying bird with warp or depth sounder cable (death is highly possible due to a strong impact);
9 – bird caught in the net (and died);
10 – bird crashed by cod-end during trawl hauling.

For each observation round, we determined a score of intensity for offal discharge from trawler's factory by adding two scores for starboard and portside scuppers (0 – no offal discharge, 1 - little offal and/or intermittent discharge, 2 – much offal and continuous discharge).

During each observation round at the trawling stage, we counted birds two times – before its start and immediately after its end. We counted all birds in a semi-sphere with a radius of 100 m from ship's stern. Species were identified at the following species or group level: albatrosses (each individual identified by species), fulmars, procellariids, large white-headed gulls of *Larus* genus, kittiwakes (identified by species). We used an average value of two counting rounds for further estimations.

We registered weather conditions for each observation round at the trawling stage: wind (direction and force), sea state, cloud cover, atmospheric pressure, precipitation if any, air

temperature, visibility). Also, we registered a relative wind direction – the angle between ship's course in the following 4 sectors:
1 – wind blows to ship's bow (90º from bow – 45º to each side);
2 – wind blows to starboard (90º from starboard – 45º each from perpendicular);
3 – wind blows to stern (90º from stern – 45º to each side);
4 – wind blows to portside (90º from portside – 45º each from perpendicular);
0 – light air, no marked direction.

In total, we performed 579 observation rounds (105 during trawl heave-out, 116 during trawling and 358 during hauling) with a total duration of 280.7 hours in order to study specifics of bird interaction with trawl fishing gear from board of the BMRT *Moskovskaya Olympiada*.

Definitions used in description of fishing operations

Trawling – fishing operation duration of which is measured from the beginning of trawl heave-out (command "Trawl is out") to the end of trawl hauling (cod-end lifting to deck).

Trawl heave-out – the stage of trawling between command "Trawl is out" and the end of warp heaving out (warp winches stopped).

Trawl hauling – the stage of trawling between the beginning of warp heaving in (startup of trawl winches) and cod-end lifting to deck (Gilson winches stopped).

The stage of trawling (catching process) – the stage between the end of trawl heaving out and beginning of trawl hauling.

The period during which the trawl was found in so-called "cooler" (when it was raised from the trawling horizon to a depth of 70-100 m to avoid its overfilling, normally with warps heaved out at 250 m, and kept behind stern till being hauled to deck) was included in the trawling stage in our ornithological stage. At this time, ship's speed, position of warps and depth sounder cable remained roughly same as at fishing gear's position in the trawling horizon; therefore, from the viewpoint of impact on bird behavior, trawl's position in the "cooler" was the same as during the fish catching process. Accordingly, the duration of hauling phase in such cases was determined from the beginning of trawl lifting from the "cooler" not from the trawling horizon.

Results and discussion

On the BMRT *Moskovskaya Olympiada,* warps immerse into the water during trawling at a distance of about 10 m from its stern and trawl control cable – at a distance of 30 m on average (Fig. 5.1). As a result, there is a zone behind the stern 8 m wide (distance between warps) and up to 30 m long in which birds are exposed to potential collision with wires (Fig. 5.2). When crossing this zone, birds sometimes fail to notice the depth sounder cable which is relatively thin and may crash into it (Fig. 5.3). When birds picking up offal swim under the taut wire, they are exposed to drowning hazard: if the bird's wing wraps a wire in process of flapping, it is unable to release its wing because of water pressure and submerges deep into the water (Fig. 5.4).

A total of 1443 bird contacts with fishing gear were recorded during 579 observation rounds. A flying gull's light collision with the rope/net part of the trawl (type 3) was observed in one case only; all other contacts were collisions with wires – warps and depth sounder cable (types 5-7, Table 5.2).

The greatest hazard for birds during all stages of fishing operations was posed by the trawl control cable – frequency of bird collisions with this cable is considerably higher than with warps (Table 5.2). This is natural enough because the length of the depth sounder cable behind stern is three times larger than that of warps; furthermore, it is roughly three times thinner which makes it less visible for birds. Difference in bird contact frequency between two warps is measured by an order of magnitude which is explained by specifics of the technological process used at the factory of the BMRT *Moskovskaya Olympiada*: the bulk of offal is discharged via portside scuppers; that’s why bird concentrations on the ship’s portside are several times larger and more stable than on the opposite side.

The frequency of collisions with the depth sounder cable at the trawling stage is approx. 5 times higher than during trawl heaving out and hauling (Table 5.2). Such difference is explained by the fact that trawl heaving out and hauling is accompanied by active movements of people on the stern, various sudden metal striking sounds, sound of operating winches which periodically frighten birds and make go away from the ship and, as a result, they spend less time in the zone of potential contacts with trawl outfit.

The vast majority of collisions with wires were registered for fulmars (97.5%) and gulls accounted for only 36 out of 1442 contacts (Table 5.2). Besides fulmars and large gulls, we regularly registered during observations from the *Moskovskaya Olympiada* within 100 m from its stern also kittiwakes and, on rare occasions, red-legged kittiwakes and Laysan albatrosses but none of the latter species had any contacts with trawl outfit. However, S.V. Fomin several times observed from board the BMRT *Pilenga-2* light contacts between kittiwakes feeding on offal near the ship’s stern and depth sounder cables. Normally, flying gulls easily avoid collision with wires because of their well-maneuvered flight contrary to fulmars whose flight is more linear.

All registered contacts for gulls were light contacts with depth sounder cable (2 contacts afloat and 34 contacts in flight). For fulmars, types of contact greatly differed between warps and trawl control cable. Collisions with depth sounder cable occurred more frequently with flying birds (75.5%) than with those sitting on the water, while this situation reversed for warps: in 61.6% of cases fulmars contacted with wires being afloat in the process of feeding on offal.

Of all registered direct contacts, we assess only 8 cases (0.6%) as heavy contacts, i.e. resulting in bird’s death. All such cases occurred with fulmars who drowned after getting under the depth sounder cable (7 individuals) or, in one case, under the left warp.

The frequency distribution of bird collisions with wires at the trawling stage greatly differed by fishing areas (Kruskal-Wallis test: for fulmars $H = 202.005$, $df = 3$, $p < 0.001$; for gulls $H = 23.716$, $df = 3$, $p < 0.001$). Fulmars much more frequently collided with wires in Kamchatka-Kuril subzone – at an average rate of 8.35 (SE 1.62) contacts/hour – than in other areas. A similar picture was observed for large gulls 0.22 (SE 0.14) contacts/hour off Southwest Kamchatka and considerably lower in other areas (Fig. 5.5).

A similar pattern revealed itself in the numbers of these birds determined during each observation round within 100 m from the ship’s stern (Kruskal-Wallis test: for fulmars $H = 174.806$, $df = 3$, $p < 0.001$; for gulls $H = 70.838$, $df = 3$, $p < 0.001$). The number of birds feeding near the ship was at its largest in Kamchatka-Kuril subzone: 653.7 (SE 43.2) on average for fulmars and 198.6 (SE 32.2) on average for gulls (Fig. 5.6).

It is hard to escape a conclusion about a close relation between the frequency of bird collisions with fishing gear and the number of birds gathering around trawlers for feeding on offal. Indeed, such relation is confirmed on the example of observations in Kamchatka-Kuril subzone both for fulmars ($p < 0.01$) and gulls ($p < 0.001$) (Fig. 5.7).

Therefore, any significant difference in bird interaction with fishing gear is largely explained by the size of bird aggregations in pollock trawl fishing areas which, in turn, depends on distribution of various birds in the Sea of Okhotsk in the winter season (see Section 2). Thus, virtually no collisions with fishing gear were registered for fulmars in West Kamchatka and East Sakhalin subzones where their numbers are low because vessels have to fish in ice conditions.

It is important to note that some devices are used during operations in ice to sink the depth sounder cable and warps as close to the stern as possible to avoid their damage by ice (see Section 10). As a result, the area of contacts between birds and wires decreases so much that probability of collision becomes minimal.

As we repeatedly stressed, catch processing waste is a basis of massive bird aggregations around trawlers. Consequently, bird numbers around the ship and the number of their interactions with fishing gear should depend on the intensity of offal discharge from trawler’s factory. The outcome of observations of fulmar behavior in Kamchatka-Kuril subzone statistically significantly ($p < 0.05$) confirms this relationship (Fig. 5.8). It should be noted, however, that availability of offal accessible to birds not always results in their interaction with fishing gear. Birds approach close to ships when they are short of food and have to compete toughly for food. In locations where scores of trawlers are simultaneously fishing in a limited area, offal quantities discharged into the sea are excessive for full consumption by birds. Birds disperse over such area, feed in diffuse groups and do not "crowd" near scuppers under the ship's side. We repeatedly observed such situation during fishing, for instance, in West Kamchatka subzone.

Climatic and weather conditions produce various effects on the ecology and behavior of seabirds (Schreiber, 2002). Of weather parameters registered during each observation round, only wind credibly affected the frequency of fulmars' contacts with trawl outfit – a parameter which strongly affects the flight of procellariid birds. The BMRT *Moskovskaya Olympiada* discharges offal mostly from its portside where birds picking up offal permanently gather. The trajectory of fulmar's approach to portside scuppers is normally upwind and, therefore, changes depending on wind direction. Hence, there is significant difference in the number of contacts with trawl wires (Kruskal-Wallis test: $H = 22.551$, $df = 4$, $p < 0.001$). Warps and depth sounder cable pose the greatest hazard when wind blows to the ship's portside (sector 4) and birds have to approach the offal discharge location from starboard and cross the zone with taut wires extending to the trawl. And, vice versa, the smallest number of collisions occurs when wind blows from the ship's starboard (sector 2) and when wind force is "light air" when fulmars generally reduce their flying intensity (Fig. 5.9).

Table 5.1. A characteristic of trawl outfit and specifics of the position of warps and trawl control cable on the BMRT *Moskovskaya Olympiada*.

Model / value	Model / value
Trawl make	RK-154/1120 m
Depth sounder model	Furuno TS-331A
Distance from warp to stern corner, m	2.5
Distance between warps, m	8.0
Height of warp block on the stern, m	6.0
Distance from stern to warp entry into the water, m	10.0
Height of depth sounder cable block on the stern, m	8.0
Distance from stern to depth sounder cable entry into the water, m	30.0
Warp diameter, mm	32.0
Depth sounder cable diameter, mm	9.4

Table 5.2. Number of seabird interactions with wires (warps and depth sounder cable) at different stages of fishing operations.

Wire type	Type of interaction	Fulmar	Gull	Total	Contacts/hour
HEAVE-OUT 105 observation rounds; 35.2 hours					
Right warp	Light afloat	1	0	1	0.003
	Lethal afloat	0	0	0	0.000
	Light in flight	0	0	0	0.000
	Lethal in flight	0	0	0	0.000
	Total	1	0	1	0.003
Left warp	Light afloat	8	0	8	0.025
	Lethal afloat	0	0	0	0.000
	Light in flight	1	0	1	0.005
	Lethal in flight	0	0	0	0.000
	Total	9	0	9	0.029
Depth sounder cable	Light afloat	7	0	7	0.025
	Lethal afloat	0	0	0	0.000
	Light in flight	58	4	62	0.226
	Lethal in flight	0	0	0	0.000
	Total	65	4	69	0.251
HAUL-OUT 116 observation rounds; 73.2 hours					
Right warp	Light afloat	0	0	0	0.000
	Lethal afloat	0	0	0	0.000
	Light in flight	4	0	4	0.028
	Lethal in flight	0	0	0	0.000
	Total	4	0	4	0.028
Left warp	Light afloat	4	0	4	0.024
	Lethal afloat	0	0	0	0.000
	Light in flight	2	0	2	0.014
	Lethal in flight	0	0	0	0.000
	Total	6	0	6	0.038
Depth sounder cable	Light afloat	6	1	7	0.036
	Lethal afloat	0	0	0	0.000
	Light in flight	42	2	44	0.240
	Lethal in flight	0	0	0	0.000
	Total	48	3	51	0.276
TRAWLING 358 observation rounds; 172.3 hours					
Right warp	Light afloat	8	0	8	0.011
	Lethal afloat	0	0	0	0.000
	Light in flight	18	0	18	0.024
	Lethal in flight	0	0	0	0.000
	Total	26	0	26	0.035
Left warp	Light afloat	220	0	220	0.301
	Lethal afloat	1	0	1	0.001
	Light in flight	126	0	126	0.172
	Lethal in flight	0	0	0	0.000
	Total	347	0	347	0.475
Depth sounder cable	Light afloat	228	1	229	0.316
	Lethal afloat	7	0	7	0.010
	Light in flight	665	28	693	0.955
	Lethal in flight	0	0	0	0.000
	Total	900	29	929	1.283

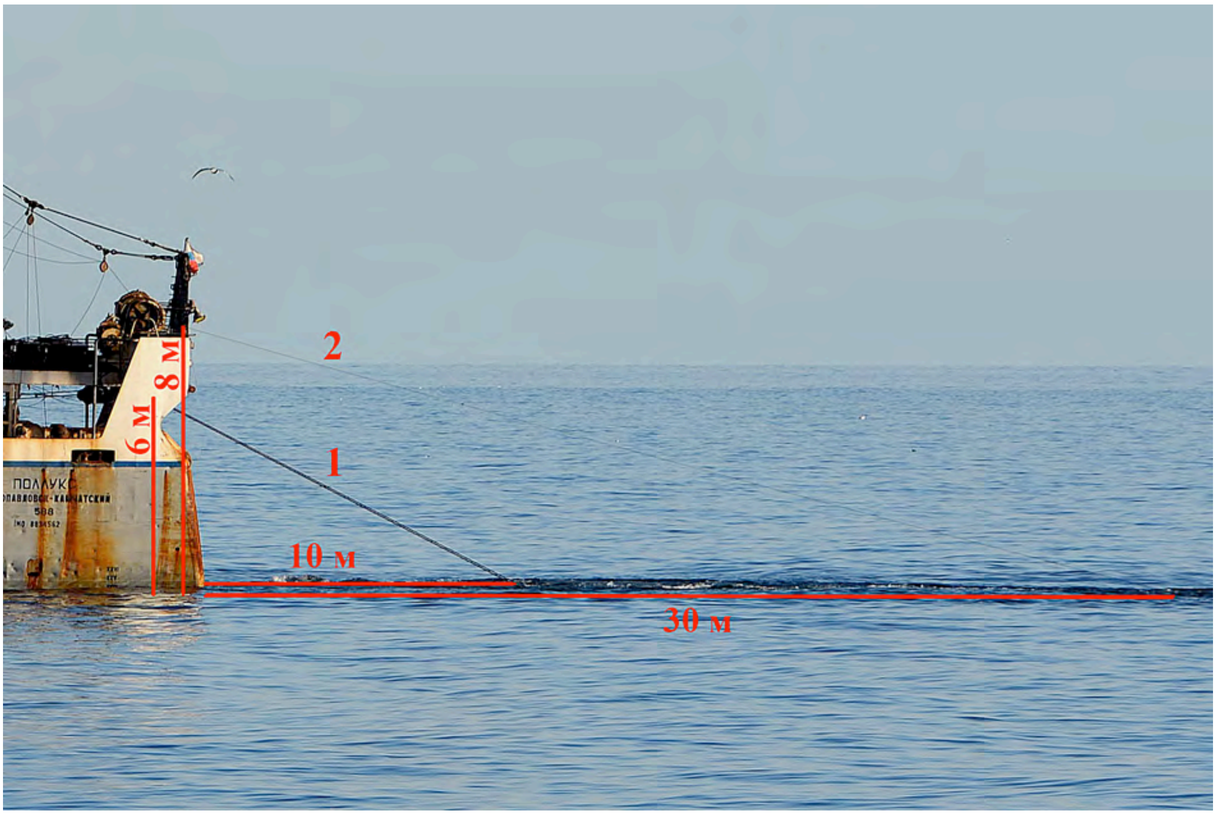


Fig. 5.1. Position of warps (1) and depth sounder cable (2) during trawling on BMTR-type vessels.

Fig. 5.2. Position of warps and depth sounder cable during trawling and bird distribution along the wake of the BMRT *Moskovskaya Olympiada* (view from trawl master's bridge): 1 – left warp, 2 – right warp, 3 – depth sounder cable, 4 – depth sounder cable block.

Fig. 5.3. Flying fulmar collides with depth sounder cable. The BMRT *Moskovskaya Olympiada*, January 23, 2015.

Fig. 5.4. Fulmar has got under the left warp during feeding on catch processing waste. The BMRT *Moskovskaya Olympiada*, February 01, 2015.

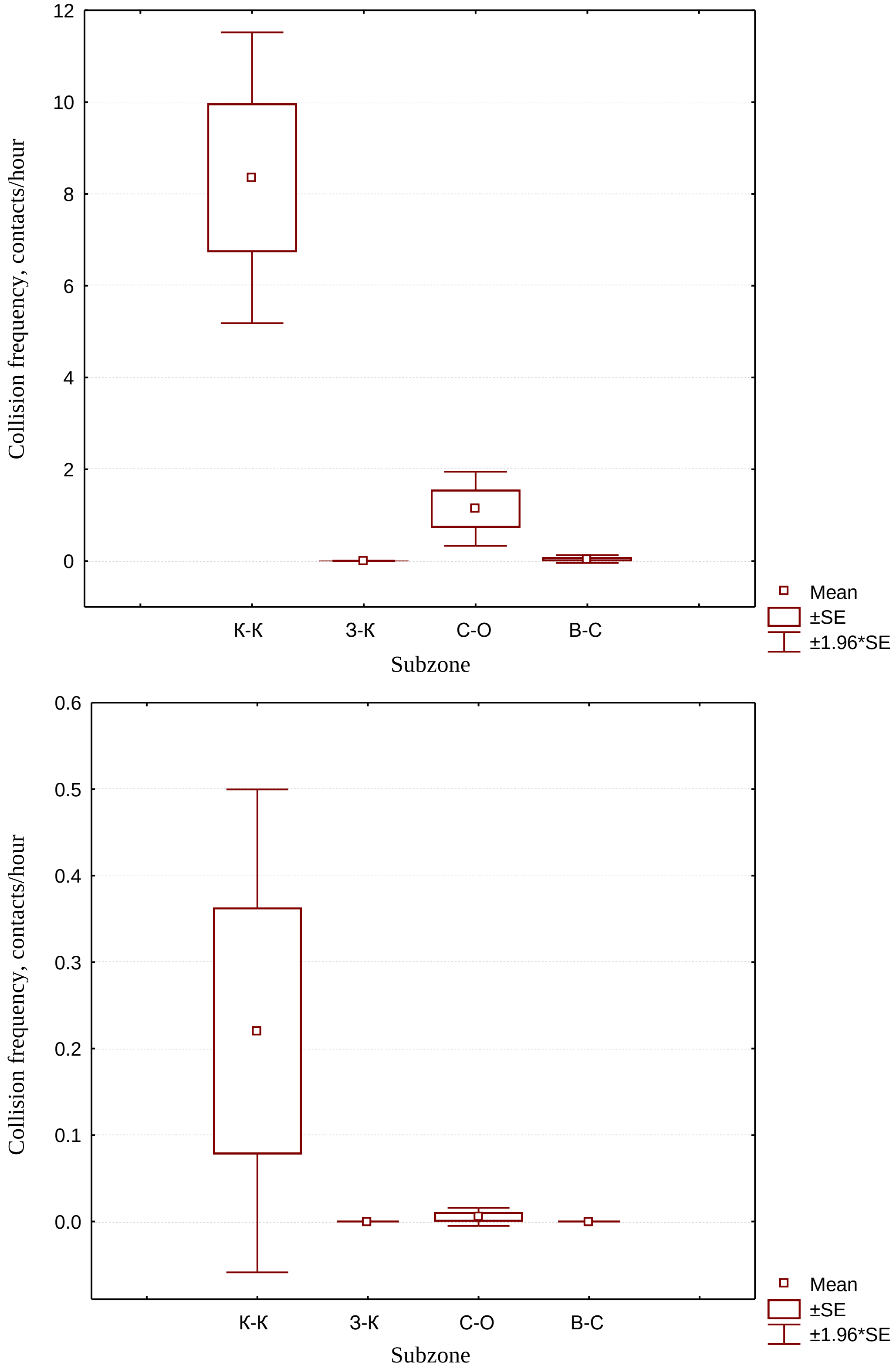


Fig. 5.5. Frequency of fulmars (top) and gulls (bottom) collisions with wires (warps and depth sounder cable) at the trawling stage in different fishing subzones (K-K = Kamchatka-Kuril, 3-K = West Kamchatka, C-O = North Sea of Okhotsk, B-C = East Sakhalin).

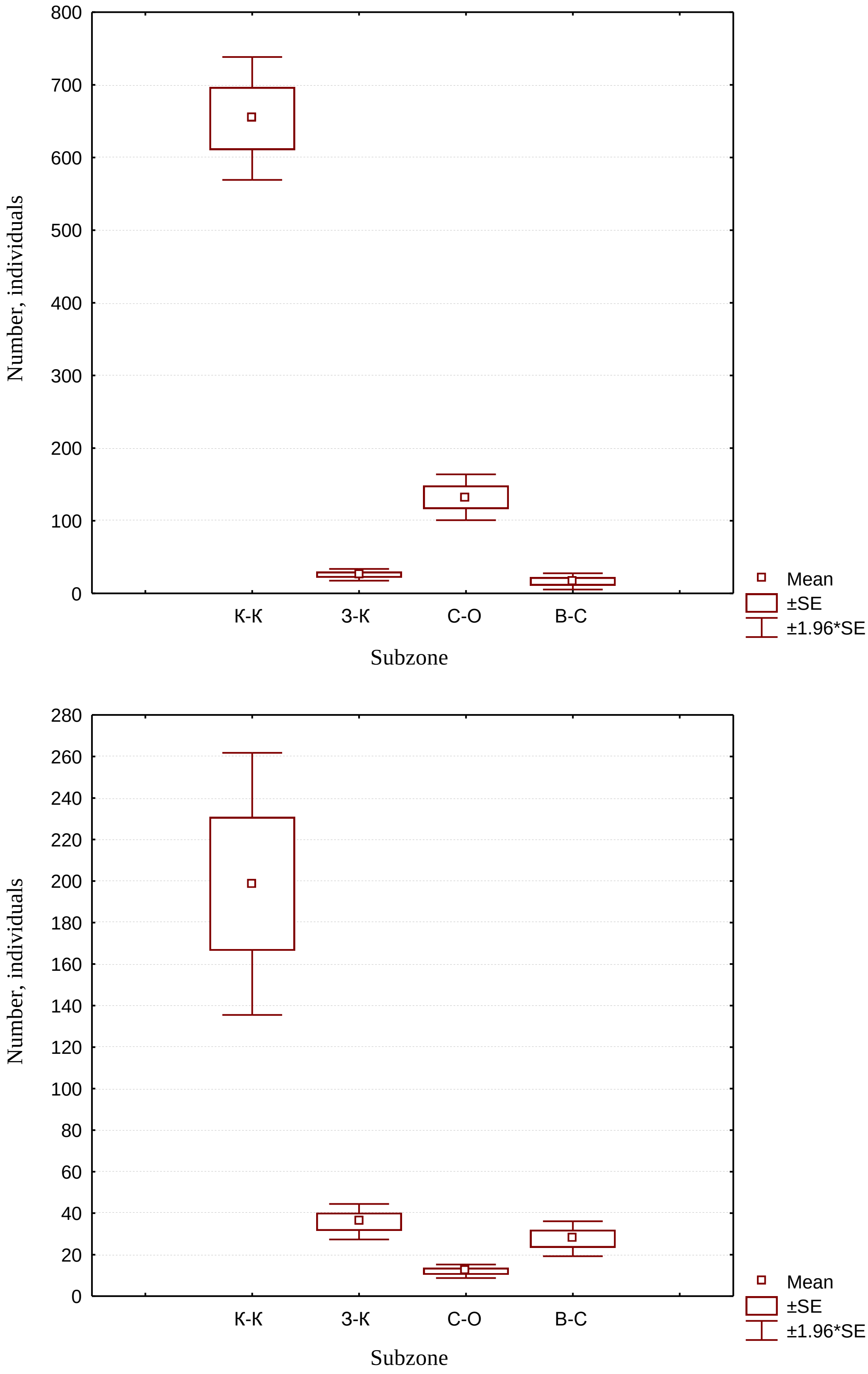


Fig. 5.6. Numbers of fulmars (top) and gulls (bottom) within 100 m from the ship's stern during observations of bird collisions with wires (warps and depth sounder cable) at the trawling stage in different fishing subzones (K-K = Kamchatka-Kuril, 3-K = West Kamchatka, C-O = North Sea of Okhotsk, B-C = East Sakhalin).

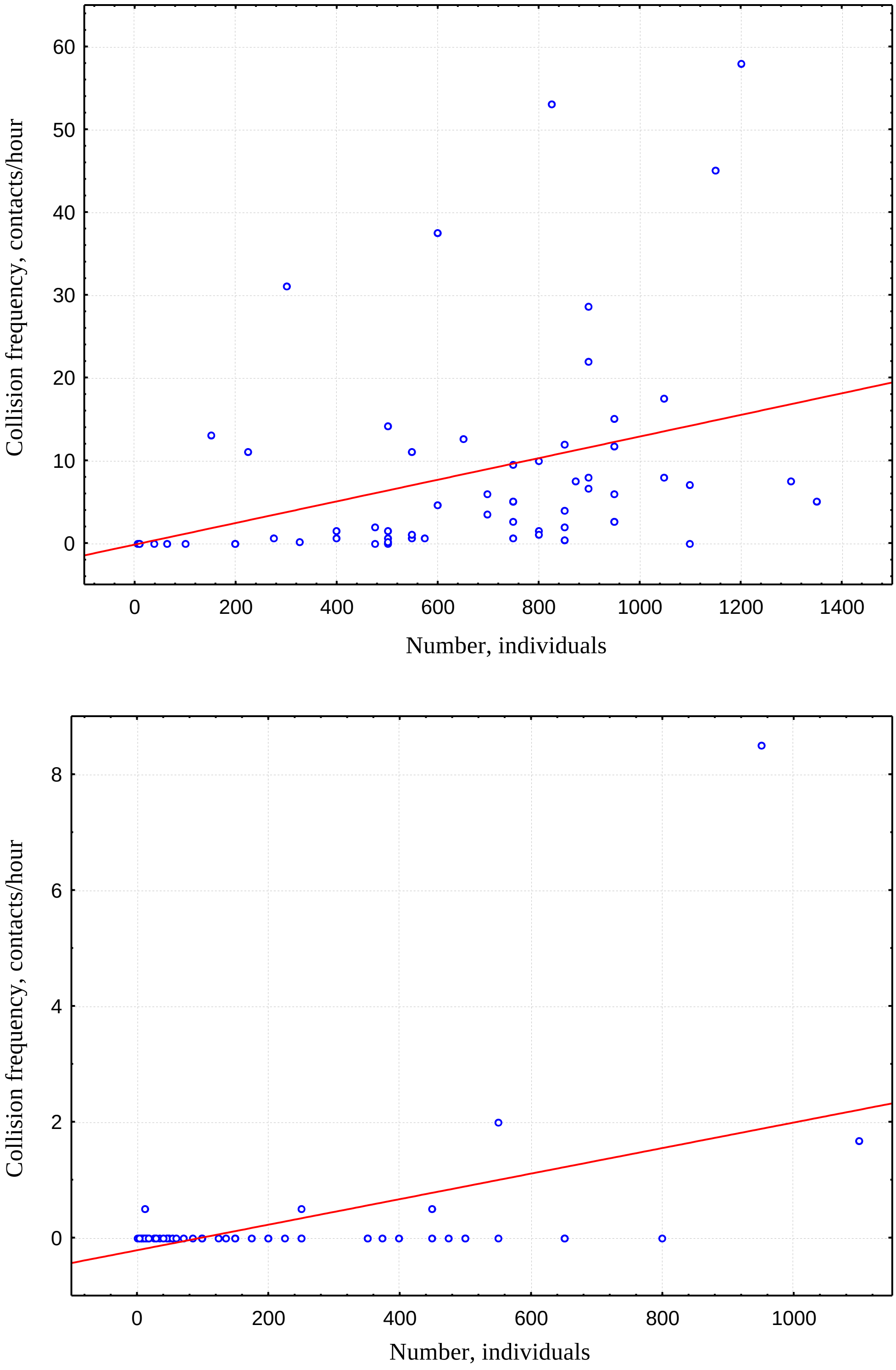


Fig. 5.7. Frequency of fulmars (top) and gulls (bottom) collisions with wires (warps and depth sounder cable) vs. their numbers within 100 m from the ship's stern at the trawling stage in Kamchatka-Kuril subzone.

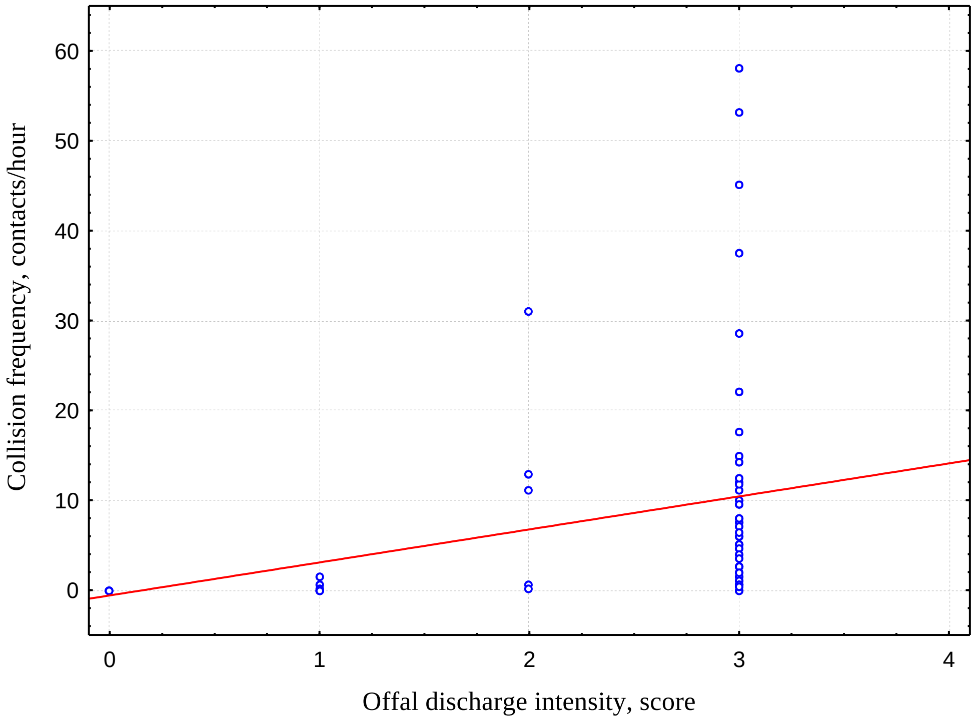


Fig. 5.8. Frequency of fulmar collisions with wires (warps and depth sounder cable) vs. offal discharge intensity at the trawling stage in Kamchatka-Kuril subzone (see comments in the text).

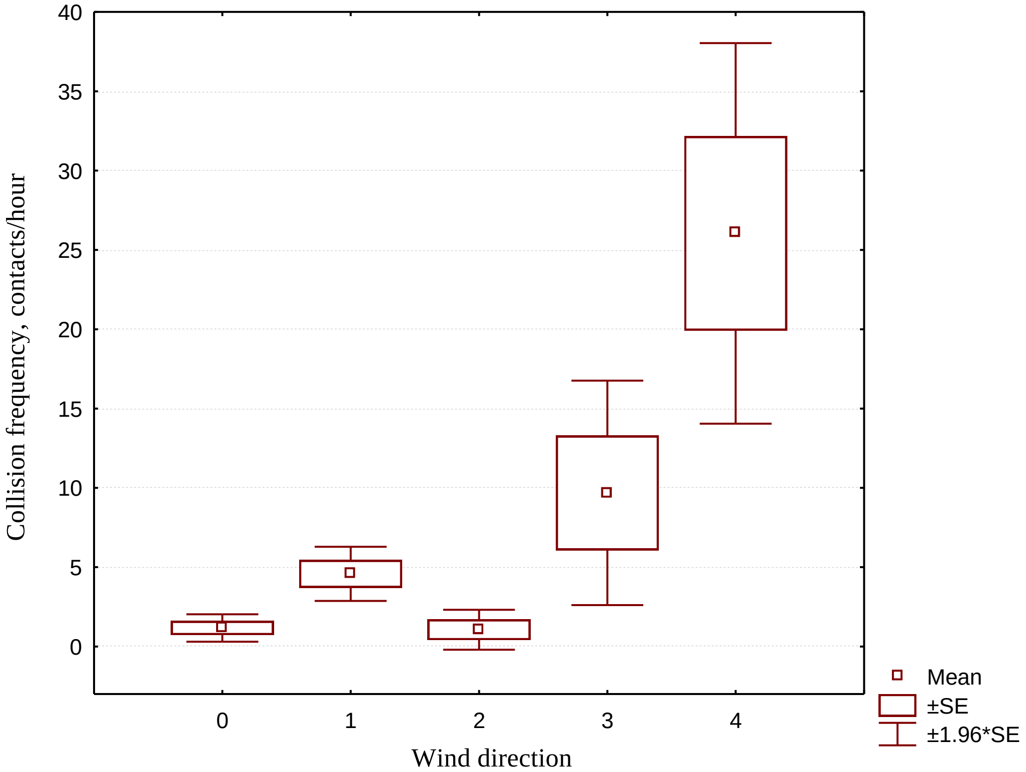


Fig. 5.9. Frequency of fulmar collisions with wires (warps and depth sounder cable) at different wind directions relative to ship's heading at the trawling stage in Kamchatka-Kuril subzone (see comments in the text).

6. SEABIRD MORTALITY IN FISHING GEAR IN THE TRAWL FISHERY DURING THE SEA OF OKHOTSK POLLOCK EXPEDITION IN 2015

In this section, we will attempt to evaluate the rate of seabird mortality resulting from their direct interaction with trawl fishing gear. Although the findings presented below are based on a limited sampling selection, such expert estimations are very important because they first time ever give a quantitative assessment of potential hazards from the winter pollock fishery for birds living in trawling fleet operating areas.

Materials and methods

In order to evaluate the rate of bird mortality in fishing gear, we have collected all accessible information about bird death during fishing operations. Information about birds caught directly into the bag of the trawl was collected during all trawling runs both by us and by crew members (trawl masters and hopper operators) who, being requested by us to do so, watched catch distribution between hoppers and delivery to the factory. Lethal cases of collision with the rope/net part of the trawl, warps and depth sounder cable were registered by us during daylight observations of specifics of bird interaction with fishing gear (see Section 5). In the process of trawl hauling out, we carefully inspected warps and depth sounder cable to detect entangled dead birds.

Information about bird death cases was collected by observers on 3 BMRT-type vessels. However, only results obtained by this report's author on board the BMRT *Moskovskaya Olympiada* were used for extrapolation estimates of mortality. The reason is difference in techniques used for observation of seabird and mammal by-catch. The specialists who worked on board the BMRT *Baklanovo* and BMRT *Pilenga-2* under a program of animal by-catch studies and collected ornithological materials in parallel, being focused on their specific tasks, were giving more attention to observations during trawl heaving out and particularly trawl hauling out than during trawling stage. This leads to underestimation of bird mortality because the majority of bird interactions with fishing gear occur at the trawling stage (see Section 5).

Visual counting data on dead birds collected in the daylight were extrapolated to a whole day, i.e. to total duration of all hauls performed during a ship-day when fishing. Based on our observation results (see below), such approach seems quite acceptable. Mortality was registered in our study for fulmars only and extrapolation of daylight observations to night-time hauls is acceptable in their case. Fulmars are actively feeding during the night time (Hatch, Nettleship, 1998) and, due to this reason, they are found in by-catch in bottom long-line fisheries in the North Pacific at night as frequently as during the day (Melvin et al., 2001; Artyukhin et al., 2006).

We computed mortality rates based on average value M and 95% confidence interval CI separately for fishing subzones by multiplying weighted death frequency averages (number of individuals dying per 24 hours) by the number of ship-days when fishing for large-tonnage fleets summed up by data of ship daily reports (SDR) in the "Monitoring" Industry System provided by the Kamchatka branch of the Center for Fisheries Monitoring and Communication under PCA's order. Fishing efforts were estimated for fishing modes "Commercial Fishery" and "Inshore Fishery" in 4 fishing subzones for two groups of vessels (Table 6.1). These vessel types were large-tonnage: extra large (BATM, BMRT, RTM), large (RKTS, RTMKS, RTMS) and harvesting (MRKT); and medium-tonnage – mid-size vessels (SDS, SRTM, SRTR, STR, TSM). Fishing period in North Sea of Okhotsk, West Kamchatka and Kamchatka-Kuril subzones was determined in accordance with the Fishing Rules for Far Eastern Fishery Basin. Fishery end date for East Sakhalin subzone where fishing was continued after the end of our studies was assumed as 17 April – the last ship-day when fishing for the BMRT *Pilenga-2,* one of three vessels on which observers were based. In these fishing subzones, large-tonnage vessels were fishing only within their commercial quotas and medium-tonnage vessels additionally operated in the inshore fishery mode during 83 out of 2,633 ship-days.

Altogether, bird mortality observations from board the BMRT *Moskovskaya Olympiada* were performed during 64 ship-days when fishing or 1.2% of large-tonnage trawling fleet's fishing efforts during SOPE 2015.

Results and discussion

A total of 12 cases of fulmar death in fishing gear were registered during the entire observation period: 11 individuals (8 and 3 of dark and light morphs respectively) – from board the BMRT *Moskovskaya Olympiada* and 1 (light morph) from board the BMRT *Pilenga-2* (Table 6.2). No lethal cases after interaction with trawl were registered for other seabird species. All lethal cases occurred due to the bird's contact with the trawl control cable except one case when the bird drowned after the left warp.

It is noteworthy that only 4 of these 12 individuals were noticed during trawl hauling out (all were entangled in the depth sounder cable). Only one dead bird was entangled so tightly that remained on the cable after being lifted to deck and all the rest were washed off by waves after emerging on the surface before approaching the stern ramp.

The rate of fulmar mortality in fishing gear was at its highest in Kamchatka-Kuril subzone (3.6 individuals/ship-day when fishing on average), where maximum concentrations of this species were observed during trawling (Table 6.3). 2 lethal cases were registered in North Sea of Okhotsk subzone which yielded an average rate of 0.7 ind./ship-day when fishing. No bird death cases were registered from board the BMRT *Moskovskaya Olympiada* in other fishing areas but S.V. Fomin registered 1 fulmar from board the BMRT *Pilenga-2* in West Kamchatka subzone who died due to contact with the depth sounder cable. Such distribution of relative mortality parameters between fishing subzones is quite expectable because it ensues from spatial specifics of bird interaction with fishing gear described in the preceding section. Birds died considerably more frequently in massive concentrations of vessels off Southwest Kamchatka and more rarely – in northerly and western areas where bird aggregations were smaller and, moreover, vessels had to operate in ice conditions with deeper positioned depth sounder cables.

In general, direct lethal contacts of birds with fishing gear are obviously rather rare events in the winter pollock trawl fishery, they are sporadic in temporal and spatial terms and heavily depend on vessel types and fishing areas. Monitoring surveys of by-catch should be continued, with more even and wider coverage of fishing efforts by observers, to obtain an accurate and objective estimate of mortality rate.

Table 6.1. Fishing efforts (ship-days when fishing) and catch (tons) in the winter pollock trawl fishery in the Sea of Okhotsk in January – April 2015.

Subzone (fishing period)	Large-tonnage vessels			Medium-tonnage vessels		
	Number of ships	Number of ship-days	Catch	Number of ships	Number of ship-days	
51.1 (1.01-9.04)	79	1820	244351	45	794	45405
51.2 (1.01-31.03)	78	2817	350567	44	1574	91745
51.3 (1.01-17.04)	24	136	18395	8	65	4922
51.4 (1.01-31.03)	42	456	31076	25	200	11319

Table 6.2. Registered cases of fulmar death due to collision with wires (warps and depth sounder cable) in the pollock fishery in the Sea of Okhotsk in January – April 2015.

Subzone	Date	No. of indiv.	Wire type	Cause of bird death
BMRT *Moskovskaya Olympiada*				
05.4	24.01	1	DS cable	Entangled with wing, found during trawl haul-out on DS cable close to the sounder itself, lifted to deck
05.4	25.01	1	DS cable	Lethal contact of swimming bird with cable, not found during trawl haul-out
05.4	26.01	3	DS cable	Lethal contact with cable when swimming for all 3 birds, none was found during trawl haul-out
05.4	27.01	1	DS cable	Lethal contact of swimming bird with cable; probably the same bird was noticed entangled by its wing in DS cable close to the sounder itself, washed off by waves when appeared on the sea surface
05.4	29.01	1	DS cable	Lethal contact of swimming bird with cable, not found during trawl haul-out
05.4	30.01	1	DS cable	Found during trawl haul-out on DS cable close to the sounder itself, washed off by waves when appeared on the sea surface
05.4	01.02	1	Left warp	Lethal contact of swimming bird with warp, not found during trawl haul-out
05.1	08.03	1	DS cable	Found during trawl haul-out entangled in DS cable being held by broken plies in ~630 m from the sounder, washed off by waves when appeared on the sea surface
05.1	09.03	1	DS cable	Lethal contact of swimming bird with cable, not found during trawl haul-out
BMRT *Pilenga-2*				
05.2	15.03	1	DS cable	Found during trawl haul-out on DS cable close to the sounder itself, washed off by waves when approaching stern ramp

Table 6.3. Relative data on fulmar mortality in fishing gear according to observations from board the BMRT *Moskovskaya Olympiada* in the pollock trawl fishery in the Sea of Okhotsk in January – April 2015 (individuals/ship-day when fishing).

Subzone	Number of ship-days	M	±CI
05.1	14	0.70	1.03
05.2	26	0	-
05.3	11	0	-
05.4	13	3.64	3.32

7. OBSERVATIONS UNDER THE RESEARCH PROGRAM "MONITORING OF PRESENCE, INTERACTION WITH FISHING GEAR AND ACCIDENTAL BY-CATCH OF STELLER SEA LION AND OTHER MARINE MAMMAL SPECIES IN THE POLLOCK TRAWL FISHERY IN THE SEA OF OKHOTSK IN 2014/2015 FISHING SEASON".

In parallel with ornithological surveys, observations were performed during the entire voyage to address the problem of by-catch of Steller sea lion and other marine mammals in the pollock trawl fishery in the Sea of Okhotsk. According to the program developed by V.N. Burkanov, team leader in these studies, works were focused on the following key areas of interest:

1) study of species composition, distribution and abundance of mammals in the winter period;

2) study of mammals' behavior near fishing vessels, their interaction with vessels and fishing gear, accidental trapping and death in fishing gear.

Materials and methods

Information collection methods are described in detail in the above said program and omitted in this paper. We briefly describe only the scope of performed works and summarized results of visual registration of marine mammals from board the ship and also present testing results of the photo recorder used for registration of animals caught in the trawl.

Visual observations were performed on January 16 – April 09 from board the BMRT *Moskovskaya Olympiada* during pollock fishery and on April 12-14 from board the TR *Canarian Reefer* during passage from the fishing area to Vladivostok. A total of 240 observation rounds were completed with a total duration of 708.5 hours of which about 120 hours were abundance counting surveys in transects with a total length of 2,478 km.

In accordance with the program, we interviewed crewmen who worked in fisheries in the Sea of Okhotsk in previous years, filled in 7 questionnaires and copied video materials on encounters with and by-catch of mammals.

All materials collected under the program on by-catch of Steller sea lion and other marine mammals as well as associated information about fishing operations of the BMRT *Moskovskaya Olympiada* during pollock fishing were handed over to V.N. Burkanov for analysis and use in his report on relevant subject.

Results and discussion

Final results on occurrence of mammals in the sea are presented in Table 7.1. No cases when Steller sea lion and other mammal species were caught in the trawl have been registered during the entire voyage (according to control visual observations and photo recorder data covering all hauls).

<u>Testing results for PlotWatcher PRO photo recorder</u>

In order to try usage of technical means in collection of information about Steller sea lion by-catch, we tested a photo recorder based on PlotWatcher PRO camera. It was complete with 8 Ni-Mn batteries (AA, 2500 mAh), memory card SD 32 Gb, charger, software for copying and viewing of records on computer.

The recorder was installed in the beginning of the voyage on January 18 and operated on a 24-hour basis till the end of pollock fishing on April 08. Initially (till January 27), records were made at 10-second intervals and after that and till the end of the voyage – every 5 seconds. Total volume of archived data obtained during the recorder's operating time was 95 Gb.

The recorder was installed on trawl master's bridge at a height of 4 m from fish deck level. It was mounted using a collar from a double strip of galvanized tin 25 mm wide with a rubber backing strip. In order to ensure required position of the camera, we welded a 30-cm-long piece of tubing to the lamp stand on the front edge of the bridge at an appropriate angle (Fig. 7.1). The camera lens covered the whole width of fish deck at the level of three catch hopper covers including the area on front of the stern ramp (Fig. 7.2). It took 3-4 hours to install the camera including clamp fabrication and welding works. Photo recorder installation and operation was agreed with the ship master and crewmen assigned by the master assisted in its installation. Its location was discussed with trawl team members such that no deck operations might affect and damage the installed camera.

Battery changing and record copying was normally performed during each cargo transfer operation – we did not wait for memory card filling and battery outage. All records were regularly viewed to detect marine mammals in catch during trawl hauling-out and catch pouring.

No cases of sea lion capture in trawl were registered during the voyage on board the BMRT *Moskovskaya Olympiada*, both in the course of visual observations in process of fishing operations and by results of viewing all records made by the camera. Although we did not have an opportunity to see directly on the record how the situation with sea lion capture in the trawl looks via the camera lens, it can be concluded that photo recorders of PlotWatcher PRO are quite suitable for collecting information about mammals by-catch in the pollock trawl fishery. Application of such devices on board the ship allows for 100% coverage of fishing operations during the entire voyage and for collection of additional associated information, e.g. on frequency and temporal distribution of trawling runs and on duration of their different stages. Such camera can be operated both by observers based on this ship and crewmen familiarized with its operating instruction.

Undoubted advantages of PlotWatcher PRO recorder include:

1) Simple and easy operation. Camera installation on board the ship poses no particular difficulty if a prefabricated collar is available. Setup of recording parameters on the camera is simple and clear. Periodic inspection of the camera, change of batteries and data storage elements takes little time. Software allows for quick viewing of records on computer.

2) Highly autonomous operation. Battery charge is consumed in an economic manner: for instance, the level of charge in 4 Ni-Mn batteries reduced from 61% to 42% during 15 days of continuous operation (March 6-21) at below-zero temperatures. Memory card was filled also in an economic manner: the volume of a full-day record (17,280 shots in a single file) made with 5-second intervals was normally less than 2 Gb.

3) Informative content of its display. The recorder's display shows battery charge level and remaining volume on memory card which allows for easy control of the time of their replacement.

4) Resolution of picture is sufficient for detection of Steller sea lion capture in the trawl.

Still, a number of disadvantages were noted on the model being tested:

1) Low quality of the front glass covering the lens. It is obviously eroded by sea salt and easily scratched during removal of splash, snow and soot. As a result, this glass has become opaque by the end of the voyage and sharpness of records deteriorated (this glass has to be replaced after the voyage).

2) During a heavy snowfall, particularly if snow is wet, the lens becomes covered with snow and part of records may turn out unreadable until the snow film disappears or is removed.

3) As there is no external lens hood, the lens (or, more exactly, its safeguarding outer glass) is not protected against snow and splash; furthermore, intervals occur during recording in back solar lighting on which quality of image declines because of exposure.

4) Resolution is sufficient to detect animals of Steller sea lion size on records. However, it is unclear whether it will be high enough to read the animal's mark number when quality of image is worse (more granular) due to dim lighting than in the daylight.

Recommendations on use of photo recorders on ships are as follows:

1) The following set of materials and equipment is required per one ship for autonomous collection of information about Steller sea lion:

- 2 PlotWatcher PRO photo recorders,
- 2 x 8 = 16 batteries,
- battery charger,
- memory cards sufficient for operation of both recorders during the entire voyage;
- a set of lens cleaning materials,
- recorder operating manual in Russian language,
- software for copying and viewing of records on computer,
- 2 collars for recorder mounting.

2) It is better to use 2 recorders simultaneously for recording from different points. One camera should be installed to provide a close-up view of the aft deck where catch is poured, e.g. as it was on board the *Moskovskaya Olympiada*. The second camera should be installed in the central part of fish deck and oriented toward the stern, for instance, near winch operator's cabin – this place offers a good view and convenient access for maintenance (Fig. 7.1). It is not recommended to install the second camera in the fore part of deck close to wheelhouse because image from this point is too small (lens angle is too wide). Furthermore, a portion of deck is blocked from here by the front part of the cod-end when it is lifted for fish pouring. Another disadvantage of such location is that an exhaust from the freezing room opens at boat deck level on both sides and steam partly covers this portion of the deck worsening visibility at stern when observing from wheelhouse.

3) A broad metal collar is required to rigidly secure the camera during its entire operating period. The collar width may be taken according to the size of slots on the camera (25 mm) and its diameter should be suitable for mounting on pipes Ø40-60 mm. A rubber gasket should be laid on the inner side of the collar along its entire length. Collars are fixed by one or two long (to be suitable for mounting on pipes of different diameters) bolts with nuts through holes. Factory-made plumbing collars with a longitudinal tapping screw are not suitable because cannot ensure sufficient strength of mounting connection.

4) The camera mounting location should be clear of guys and wires moving during fishing operations and cargo handling works. A free and safe access to the recorder is required for its regular inspection and maintenance.

5) The camera should be installed in an elevated point such that its lens was directed at a downward angle for partial protection against snow, splash and soot.

6) The shooting mode should be enacted 24 hours a day to register all activities with each hauled trawl on deck from its haul-out to the end of catch pouring and next heaving out. A minimum shooting interval is 5 seconds.

7) A set of cleaning aids is required to remove soot, snow and salt from the lens protective glass with least possible damage (brushes, swabs, liquids or wet napkins suitable for use at freezing temperatures – liquids shall not freeze up during glass wiping).

8) The camera lens should be regularly cleaned during the voyage, particularly during lasting snowfalls. Proper attention should be given to the level of battery charge and remaining free space on the memory card for their timely replacement.

9) When monitoring is performed by crewmen, it is not necessary to download records to computer – you may just provide a sufficient number of memory cards to be replaced as they become full. However, camera performance after its installation on the ship should be checked on computer by making trial records prior to the beginning of fishing operations. Before the voyage, persons responsible for cameras should be given appropriate consultations on camera installation and operation, specific operating features of Ni-Mn batteries and software, etc.

Table 7.1. Visual registration of marine mammals in the Sea of Okhotsk from board the BMRT *Moskovskaya Olympiada* and TR *Canarian Reefer* in January – April 2015.

Species	Date	Time	Coordinates	Number (individuals)
Sperm whale	January 16, 2015	16:54	N50.39757 E154.62668	1
Minke whale	January 20, 2015	13:39	N52.80167 E153.71675	1
Minke whale	January 20, 2015	17:28	N51.62372 E155.49834	1
North Pacific right whale	January 23,2015	14:45	N51.48238 E155.24470	1
Finback whale	January 30,2015	12:15	N51.36476 E154.48482	1
Steller sea lion	February 03, 2015	16:35	N57.43746 E156.29277	1
Northern fur seal	February 03, 2015	15:20	N57.37490 E155.89742	2
Northern fur seal	February 03, 2015	15:31	N57.38563 E155.95425	1
Northern fur seal	February 03, 2015	15:55	N57.40753 E156.08223	1
Northern fur seal	February 03, 2015	16:55	N57.44688 E156.40076	1
Dall’s porpoise	February 05, 2015	10:47	N57.39582 E155.18957	6
Dall’s porpoise	February 05, 2015	10:58	N57.39446 E155.12332	3
Dall’s porpoise	February 05, 2015	12:10	N57.39845 E154.68628	6
Minke whale	March 05, 2015	12:52	N58.25557 E154.27722	1
Steller sea lion	March 05, 2015	13:35	N58.26111 E154.30304	1
Steller sea lion	March 05, 2015	14:54	N58.26052 E154.32900	5
Northern fur seal	March 05, 2015	12:58	N58.25651 E154.28088	2
Steller sea lion	March 05, 2015	18:30	N58.23773 E154.33850	1
Steller sea lion	March 06, 2015	18:45	N58.12857 E153.91119	2
Dall’s porpoise	March 07, 2015	16:22	N56.41891 E151.57383	5
Dall’s porpoise	March 20, 2015	18:47	N57.59759 E151.34558	2
Ribbon seal	March 21, 2015	11:03	N57.93314 E151.83692	1
Minke whale	March 21, 2015	10:40	N57.93193 E151.83533	2
Steller sea lion	March 21, 2015	8:32	N57.92634 E151.82943	2
Steller sea lion	March 21, 2015	10:05	N57.92992 E151.83491	1
Minke whale	March 21, 2015	14:32	N57.94112 E151.85644	1
Steller sea lion	March 21, 2015	12:20	N57.93665 E151.84702	1
Steller sea lion	March 21, 2015	18:59	N57.96213 E151.83586	2
Steller sea lion	March 22, 2015	9:02	N57.97083 E151.84350	4
Steller sea lion	March 22, 2015	12:08	N57.97584 E151.86442	8
Steller sea lion	March 22, 2015	18:50	N57.92203 E151.95410	2
Steller sea lion	March 23, 2015	8:30	N57.74836 E152.26288	1
Steller sea lion	March 23, 2015	9:40	N57.73574 E152.39326	3
Dall’s porpoise	March 23, 2015	13:03	N57.49978 E153.14034	5
Dall’s porpoise	March 23, 2015	15:03	N57.43712 E153.74154	3
Whale of unknown species	March 23, 2015	14:54	N57.41103 E153.72194	1
Dall’s porpoise	March 23, 2015	15:42	N57.54693 E153.84395	7
Dall’s porpoise	March 23, 2015	15:52	N57.57674 E153.86593	3
Dall’s porpoise	March 23, 2015	15:57	N57.59166 E153.87661	4
Dall’s porpoise	March 23, 2015	16:02	N57.60655 E153.88690	8
Dall’s porpoise	March 23, 2015	16:17	N57.65142 E153.91763	5
Dall’s porpoise	March 23, 2015	17:29	N57.86742 E154.06667	7
Dall’s porpoise	March 23, 2015	18:27	N58.00918 E154.25916	7
Northern fur seal	March 24, 2015	9:05	N57.77033 E155.23388	1
Northern fur seal	March 24, 2015	11:17	N57.75743 E155.22257	1
Steller sea lion	March 24, 2015	13:10	N57.85400 E155.34337	2
Steller sea lion	March 24, 2015	15:37	N57.97545 E155.49052	7
Finback whale	March 26, 2015	18:35	N57.32535 E153.29232	2
Larga seal	March 29, 2015	8:49	N54.74639 E144.31389	2

Table 7.1 (continued).

Species	Date	Time	Coordinates	Number (individuals)
Larga seal	March 29, 2015	9:05	N54.72646 E144.33540	2
Larga seal	March 29, 2015	9:05	N54.72642 E144.33616	2
Larga seal	March 29, 2015	9:35	N54.70958 E144.42321	3
Larga seal	March 29, 2015	10:10	N54.69546 E144.49781	2
Ribbon seal	March 29, 2015	15:18	N54.27610 E144.73515	2
Ribbon seal	March 29, 2015	15:26	N54.26591 E144.74141	1
Ribbon seal	March 29, 2015	17:16	N54.06614 E144.40708	1
Ribbon seal	March 29, 2015	17:58	N53.94333 E144.33143	1
Larga seal	March 29, 2015	15:43	N54.22761 E144.70748	2
Larga seal	March 29, 2015	15:54	N54.19898 E144.67888	2
Ribbon seal	March 29, 2015	19:20	N53.78161 E144.15748	1
Larga seal	March 30, 2015	10:02	N52.96731 E144.45703	2
Larga seal	March 30, 2015	10:37	N53.00078 E144.45564	3
Ribbon seal	March 30, 2015	15:14	N52.86930 E144.46385	1
Ribbon seal	March 30, 2015	17:40	N52.72203 E144.52514	1
Ribbon seal	March 31, 2015	8:47	N52.59147 E144.58497	1
Ribbon seal	March 31, 2015	9:01	N52.60444 E144.59056	1
Northern fur seal	March 31, 2015	9:20	N52.62167 E144.60595	2
Steller sea lion	April 07, 2015	10:45	N55.89612 E143.67867	3
Steller sea lion	April 07, 2015	12:25	N55.83833 E143.77643	2
Steller sea lion	April 07, 2015	16:40	N55.99733 E143.51747	18
Dall’s porpoise	April 09, 2015	10:33	N57.68782 E154.15502	3
Dall’s porpoise	April 09, 2015	11:20	N57.83517 E154.27016	2
Dall’s porpoise	April 12, 2015	9:44	N57.58179 E154.44135	4
Dall’s porpoise	April 12, 2015	10:41	N57.37117 E154.36551	7
Dall’s porpoise	April 12, 2015	11:08	N57.27015 E154.32973	10
Dall’s porpoise	April 12, 2015	11:10	N57.26272 E154.32703	22
Dall’s porpoise	April 12, 2015	11:22	N57.21730 E154.31890	5
Finback whale	April 12, 2015	8:25	N57.87014 E154.54312	1
Dall’s porpoise	April 12, 2015	18:10	N55.75352 E153.83903	2
Baird’s beaked whale	April 12, 2015	17:20	N55.93714 E153.89139	6
Finback whale	April 12, 2015	17:35	N55.88252 E153.87456	2
Dall’s porpoise	April 13, 2015	13:44	N51.48823 E152.56901	3
Dall’s porpoise	April 13, 2015	14:15	N51.37556 E152.54024	5
Sperm whale	April 14, 2015	14:42	N46.38988 E151.24332	1

Fig. 7.1. PlotWatcher PRO photo recorder installed on the BMRT *Moskovskaya Olympiada*: 1 – recorder mounted on the front edge of trawl master's bridge on a pipe piece welded to lamp stand; 2 – winch operator cabin (recommended location for the second recorder unit).

Fig. 7.2. Image from PlotWatcher PRO photo recorder used on the BMRT *Moskovskaya Olympiada* during SOPE 2015.

8. INTERNATIONAL EXPERIENCE OF SEABIRD MORTALITY REDUCTION IN TRAWL FISHERIES AND POTENTIAL FOR ITS USE IN RUSSIAN CONDITIONS

New Zealand specialists were the first in the field of development of methods for reduction of bird mortality in fishing gear – they were the first to highlight this problem in 1990s and start searching for its solution. Due to this reason, the bulk of internationally available recommendations originate from trawl fisheries operating in the near-Antarctic waters of the Southern Ocean and the Patagonian Shelf of South America (Roe, 2005; Sullivan et al., 2006a; Bull, 2007, 2009; González-Zevallos et al., 2007; Cleal et al, 2013). As for the Northern hemisphere, bird mortality mitigation methods were tested only in one study in pollock fishing by mid-tonnage fleets in the eastern part of the Bering Sea (Melvin et al., 2004, 2011).

Some valuable practical experience on solution of this problem has been accumulated to date. A number of overviews were published which summarize descriptions of methods to reduce bird mortality in trawls (Bull, 2007, 2009; Løkkeborg, 2008, 2011). Sources of information containing practical results in this area of focus are available at website "Consortium for Wildlife Bycatch Reduction" (http://bycatch.org). The most effective methods are described at website "BirdLife International" (http://www.birdlife.org) – an international nongovernmental organization handling a global program on reducing seabird by-catch in the World Ocean.

Methods for reducing bird mortality in the course of marine aquatic organisms harvesting by trawl fishing gear can be grouped into several categories.

1. Control of by-catch and catch processing waste discharges to reduce attractiveness of ships for birds (Abraham et al., 2009; Pierre et al., 2010).

2. Restrictive measures.

a) Imposition of a ban on use of trawl control devices with a cable connection posing the greatest danger to birds. Cable-free echo sounders are compulsory for use in some trawl fisheries in the Southern Ocean (Bull, 2009). However, U.S. specialists (Dietrich, Melvin, 2007) believe that, in addition to additional direct costs, refusal from use of cable echo sounder may cause an opposite effect: traditional equipment has a number of advantages and its replacement may potentially lead to reduced catches per effort and growth of fishing efforts thus affecting bird mortality rates.

3. Devices reducing frequency of bird collisions with trawl wires – warps and echo sounder cable.

a) Barriers preventing access of birds to scuppers from which offal is discharged (Fig. 8.1).

b) Streamer lines creating a corridor along trawl wires closed for birds; if they are sufficiently long, they may be used for coverage of trawl contol cable as well (Fig. 8.2).

c) Devices attached to trawl wires to make them more conspicuous and scaring for birds. They may be used both on warps and on echo sounder cable in various shapes from different materials – plastic tubes, hoses, cones (Fig. 8.3 and 8.4a). Buoys attached by a lead to the cable may be used for the same purpose (Fig. 8.4b).

4. Reduction of the distance at which echo sounder cable starts submerging into the water which reduces the zone of its potential contacts with birds – this can be achieved by cable roving through an additional snatch block (Fig. 8.5).

5. Methods preventing bird capture into the netting part of trawl when it is found in the near-surface layer:

a) Trawl cleaning from fish remnants before heaving out.

b) Additional weights on the netting part to accelerate its submersion.

c) Binding together of the netting part with thin cords spaced at 5 m to prevent its opening before submersion deeper into the water.

The above mentioned methods were tested in different areas of the World Ocean in trawl fisheries of various types. There is no a universal method solving the problem of seabird mortality in fishing gear. Method selection depends on many factors: fishing area and target species, type of vessel and fishing gear, crew experience, season and time of the day, weather conditions, etc. It is important for such selected methods to be cost effective, environmentally harmless, safe in operation and not hampering the fishing process.

Some experts believe that streamer lines are the most optimal in terms of efficiency, low cost and easy operation. Due to their high efficiency, these devices are currently widely used in long-line fisheries in many areas of the World Ocean. Similar experiences in streamer production and operation are available in the Russian Far East as well (Artyukhin et al., 2013, 2014a).

The operation of streamer lines at sea is not difficult and their design is rather simple, that's why their fabrication is non-labor intensive and inexpensive. Factory-made elastic plastic tubes are used as streamers in foreign-made devices. Such elements are not produced in Russia but can be successfully replaced by other accessible materials (Artyukhin et al., 2014b).

According to findings of the above mentioned study by U.S. specialists in the pollock fishery in the Bering Sea (Melvin et al., 2004, 2011), use of an additional snatch block for echo sounder cable submersion closer to the stern has been recognized a promising method. During SOPE 2015, we saw similar systems on SRTM-type vessels *Mys Levenorn*, *Viluchinsky* and *Victoria-1* on which echo sounder cables entered into the water closer to the stern than warps (Fig. 8.6).

When operating in ice conditions, large-tonnage trawlers also permanently use special devices to prevent wire damage from ice floes. In particular, the BMRT *Moskovskaya Olympiada* (same as other vessels of this type) used a weight (a bundle of chains weighing 900 kg) suspended via a block on the first lead. As a result, the distance between the cable submersion point and the stern shortened from 30 to 5-6 m. In close pack ice, they additionally used warp straps – brought warps closer to each other by winches using snatch blocks with a flap panel (SSE-10, cargo lifting capacity 25 tons) attached to warps. In this case, the distance between warps reduced from 10 to 5-6 m (Fig. 8.7).

It is clear that use of such devices by fishermen is dictated by ice conditions rather than care for birds. Anyway, regular use of devices for submersion of echo sounder cables posing the greatest danger to birds can be recommended also for mitigation of bird mortality effects in the pollock trawl fishery in the Sea of Okhotsk.

In general, each of above mentioned methods has its merits and demerits as well as specifics of use depending on vessel type. Therefore, any recommendations should be necessarily preceded by practical experiments in real conditions.

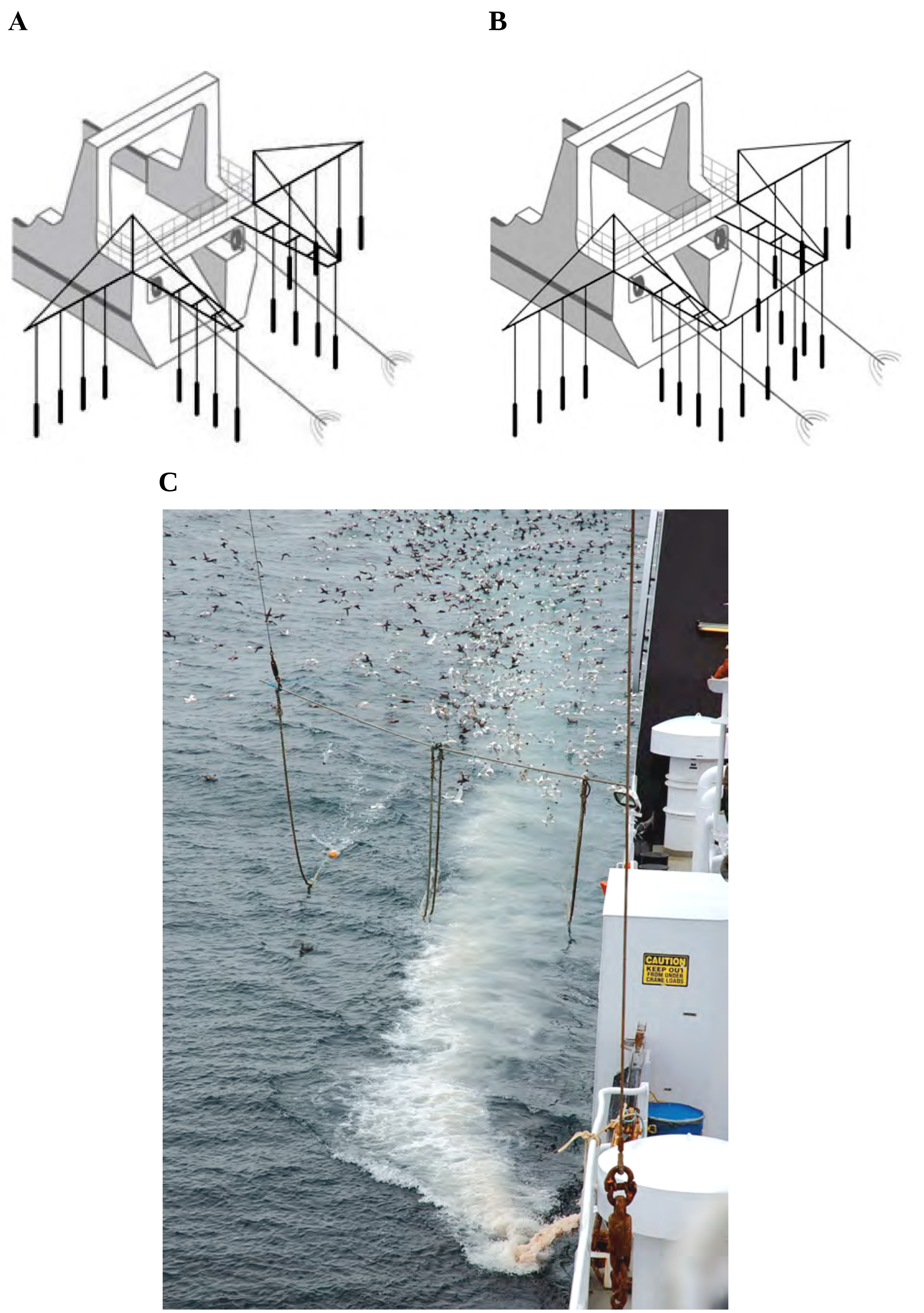


Fig. 8.1. Barriers blocking for birds access to offal discharge point and warps: A – brady baffler (see: Sullivan et al., 2006a; Bull, 2009), B – burka baffler (see: Bull, 2009), C – warp booms (see: Melvin et al., 2004).

A

B

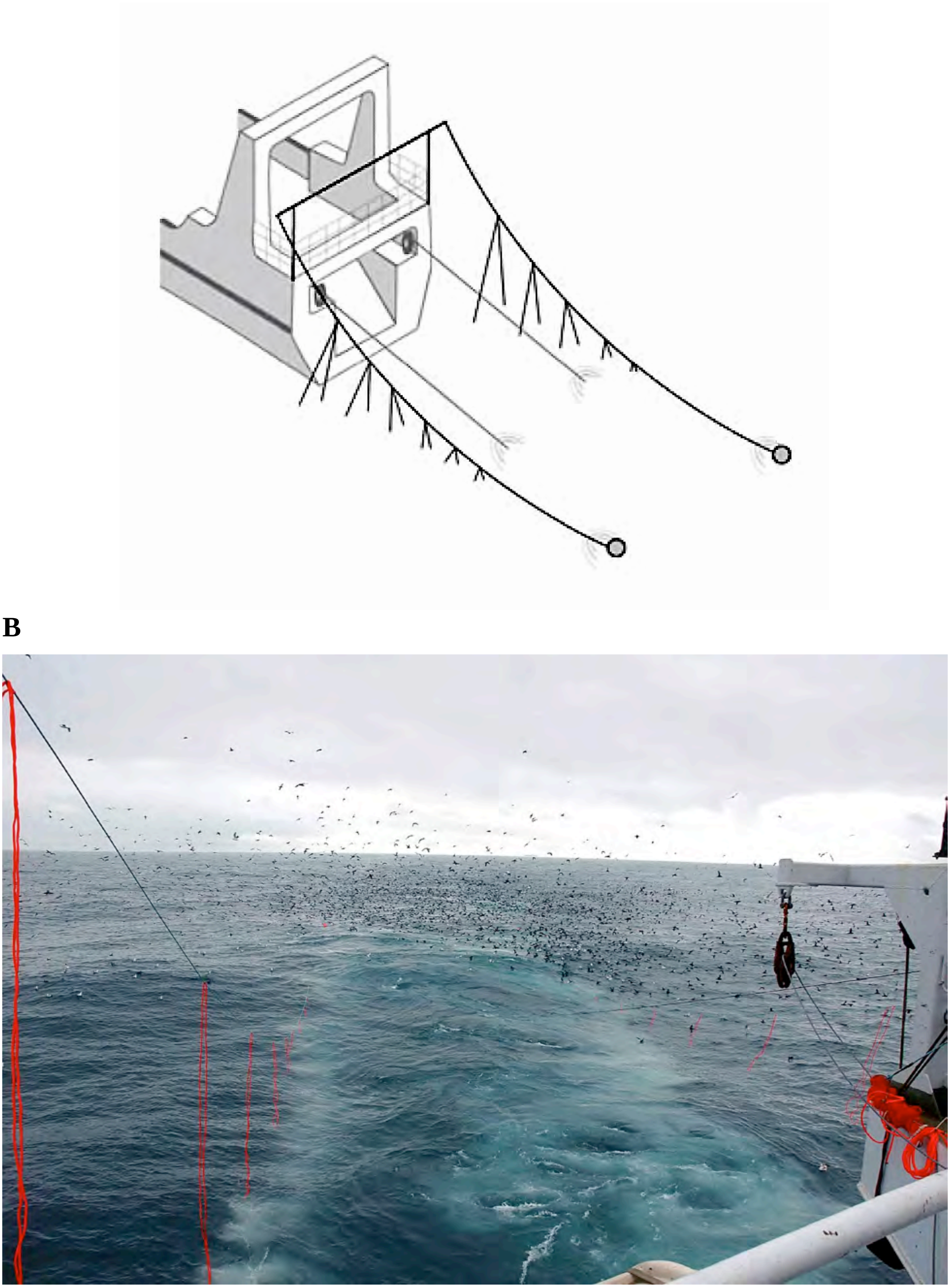
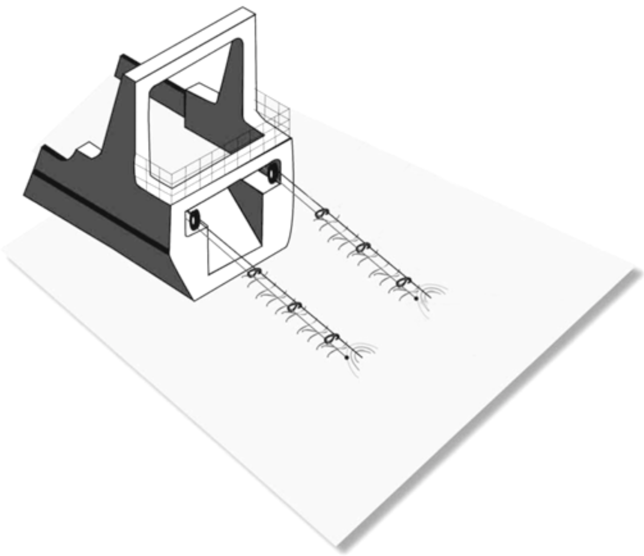
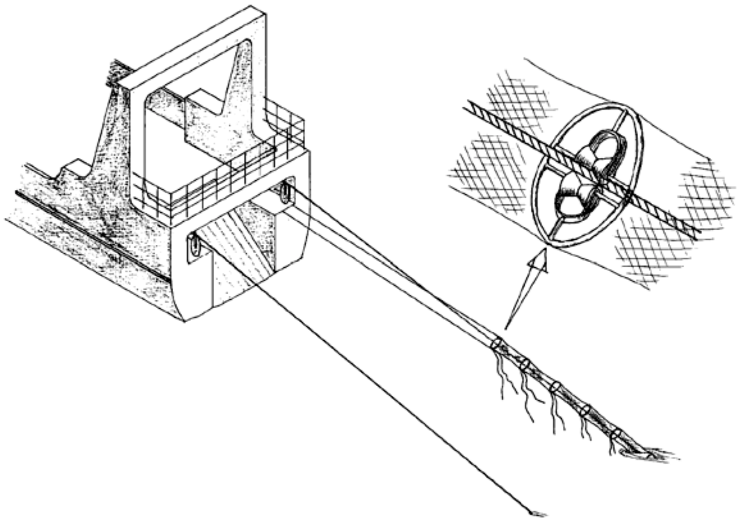


Fig. 8.2. Streamer lines – devices scaring birds from warps and trawl control cable: A – bird-scaring lines (see: Sullivan et al., 2006a; Bull, 2009), B – streamer lines (see: Melvin et al., 2004).

A



B



C

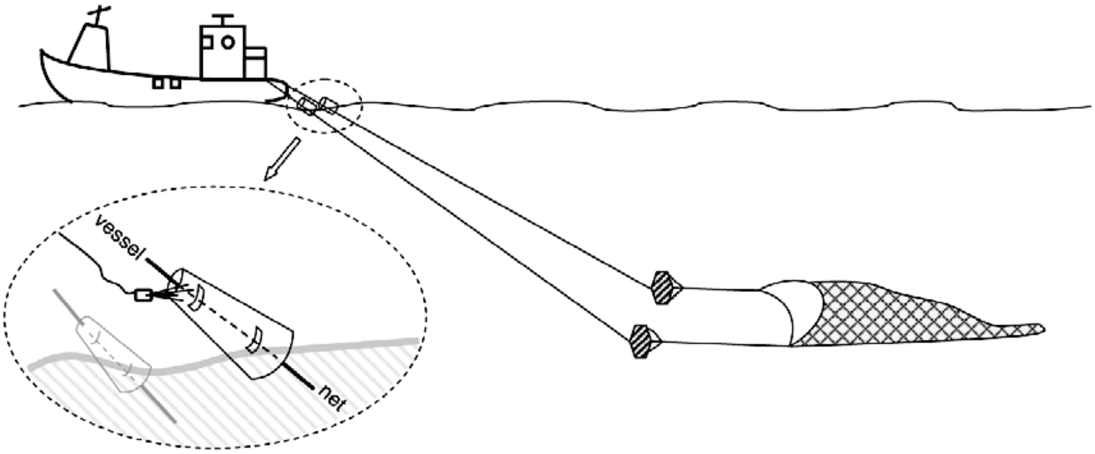


Fig. 8.3. Devices preventing bird collision with warps: A – warp deflector (see: Cleal et al., 2013), B – warp scarer (see: Sullivan et al., 2006a), C – plastic cones (see: González-Zevallos et al., 2007).

A

B

Fig. 8.4. Devices preventing bird collision with trawl control cable: A – third-wire sleeve (streamer lines are additionally installed on sides), B – hollow hard buoy (see: Melvin et al., 2004).

Fig. 8.5. Trawl control cable submersion by roving it through a lead-off block – third-wire snatch block (see: Melvin et al., 2004).

Fig. 8.6. Trawl control cable submersion on the SRTM Mys Levenorn. Sea of Okhotsk Pollock Expedition of 2015.

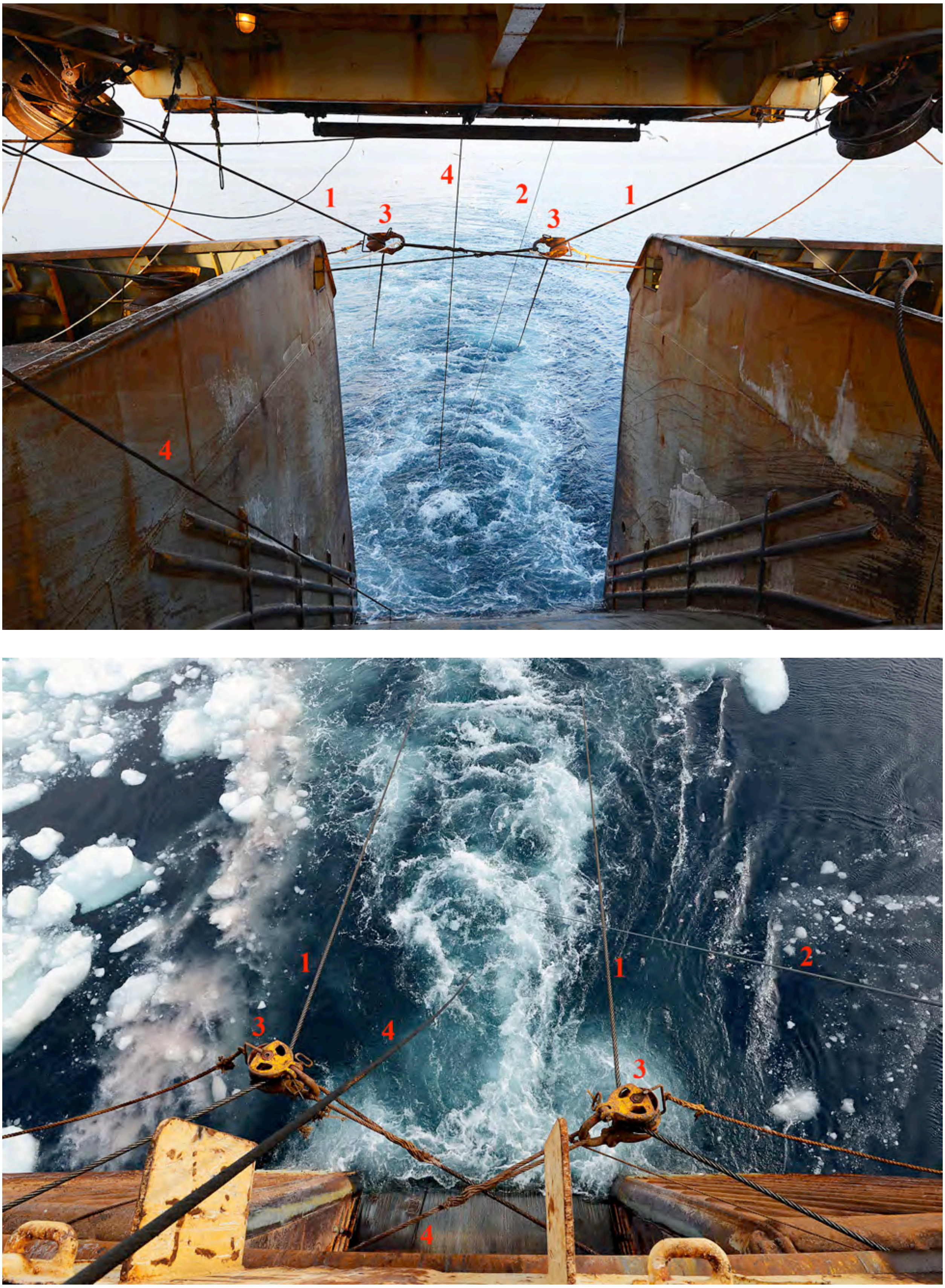


Fig. 8.7. Warp strapping and depth sounder cable submersion in ice conditions on the BMRT *Moskovskaya Olympiada* (top – view from fish deck, bottom – top view from trawl master bridge): 1 – warps, 2 – depth sounder cable, 3 – snatch blocks, 4 – wire with sunken weight. Sea of Okhotsk Pollock Expedition of 2015.

CONCLUSION

It was found by results of observations performed during the Sea of Okhotsk pollock expedition in January – April 2015 that the winter seabird fauna in trawling fleet operating areas includes 19 species. According to shipboard transect counting data, average distribution density of birds is 10.0 individuals/km^2. Auks (48%), procellariids (33%) and larids (19%) dominate in quantitative terms, while albatrosses and storm petrels account for less than 0.1% of the winter bird population.

Different marine bird species continuously aggregate around trawlers and pick up catch processing waste and small fish from trawls. The species and quantitative composition of such aggregations is quite dynamic in spatial and temporal terms. The largest (in abundance terms) and the richest (in terms of a set of species) concentrations emerge in Kamchatka-Kuril subzone where many strayed or wind-blown birds, normally wintering in ocean waters, are present. The bulk of such aggregations consisted of fulmars dominating in all fishing areas except East Sakhalin subzone. The second-largest group of birds in terms of abundance was large white-headed gulls belonging to *Larus* genus, mostly slaty-backed gull which accounts for 83-85% in the western and central parts of the study area.

Of three North Pacific albatross species, only one species was registered – Laysan albatross which regularly concentrated around trawlers in the southern part of Kamchatka-Kuril subzone. No short-tailed albatrosses were observed but their presence in the Sea of Okhotsk in the winter can be assumed based on the presence of Laysan albatross, a closely related species, and satellite telemetry data.

The findings of observations of bird interaction with trawl fishing gear show that the greatest hazard for birds are wires – warps and particularly the trawl control cable. The frequency of collisions with the cable during fishing is approx. 5 times higher than during trawl heaving out and haul-out. The majority of collisions with wires were registered for fulmars (97.5%) and the rest – for large gulls. Only 8 cases (0.6%) of all registered direct interactions resulted in bird’s death. All such cases occurred with fulmars who drowned after getting under the depth sounder cable (7 individuals) and, in one case, under the left warp.

The frequency distribution of bird collisions with wires greatly differed by fishing areas. Much more contacts with wires were observed in Kamchatka-Kuril subzone (8.35/hour for fulmars and 0.22/hour for gulls) than in the rest fishing areas. It was confirmed that the frequency of bird collisions with wires is related to their abundance near the ship which, in turn, depends on distribution patterns of different bird species in the Sea of Okhotsk in the winter. The frequency of contacts also credibly depends on the intensity of catch processing waste discharges and on wind direction relative to the ship’s course.

The results of bird observations during SOPE 2015 reflect the situation only in this particular fishing season. Our expert judgments on mortality are underrated because do not take into account fishing efforts of mid-tonnage trawling fleets. Furthermore, they do not reflect a typical situation in year-to-year terms because, due to anomalous hydrological and meteorological processes in the winter season of 2014/2015 in the Sea of Okhotsk, the pollock fishery was proceeding under a non-typical scenario essentially differing from previous years. In particular, pollock harvesting intensity in Kamchatka-Kuril subzone in 2015 was low, although it is in this fishing area that highest bird mortality rates are registered and trawling fleets pose the greatest potential danger for albatrosses.

Proceeding from our findings, we can state that the certified pollock trawl fishery is a strong factor forming mass winter aggregations of various seabird species in the Sea of Okhotsk. On the one hand, catch processing waste discharged overboard from trawlers supports life activities of this huge bird community steadily providing food for them in a difficult season. On the other hand, birds die from collisions with fishing gear and due to ecological light pollution created by trawling fleets. This problem needs to be addressed specifically because of significant bird mortality rates. A study of its particular aspects is important from the viewpoint of search for potential mitigation measures and for wide communication of the nature of this problem to living aquatic resource users. Monitoring surveys should be continued with more even and wider coverage of fishing efforts by observations to obtain an objective characteristic of the impact of the target pollock fishery in the Sea of Okhotsk on the condition of bird populations.

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ATTACHMENT 1

Content and methods of field observations during research works on bird mortality monitoring in the target pollock trawl fishery in the Sea of Okhotsk

1. Collection of relevant information about ship's equipment and fishing operations

This includes a characteristic of fishing gear used on the ship, description of its outdoor lighting system and registration of trawling parameters. Data should be entered into forms "Depth Sounder Cable and Warps", "Lighting" and "Trawling Runs"[1].

2. Collection of information about species and quantitative composition of marine birds in fishing areas

2.1. Bird counting around the ship in the process of fishing operations

The maximum total number of birds belonging to all species around the ship should be evaluated during each ship-day when fishing. To this purpose, observer views the whole water area within visibility limits using a binocular and counts birds by sectors (180° behind the stern and 90° on ship's sides). It is preferable to perform counting when catch processing waste is being discharged because birds gather around the ship at this time. If observer notes that the number of birds has significantly grown during the day, he/she should perform a repeated counting round to obtain a maximum value of bird abundance for this day. The most convenient location for bird counting is trawl master's bridge on the stern, from one corner of which observer can sweep the whole area behind the stern and along one ship's side; then he/she can move to the other side and view the remaining sector from the other side. Species are identified at the level of the following species/groups: albatrosses (to be identified by species – short-tailed, Laysan or black-footed), fulmars, procellariids, large gulls of *Larus* genus, kittiwakes (to be identified by species – black-legged kittiwake or red-legged kittiwake) and other species. If it is difficult to distinguish between gulls and kittiwakes, they can be counted as one group. Counting results should be entered into the form "Total Number".

In addition, counts should be performed twice during each round of observations of bird interaction with fishing gear at the trawling stage (see paragraph 3 below) – before start and immediately after end of observations. All birds should be counted within a semi-sphere with a radius of 100 m from the ship's stern. Species should be identified in the same manner as when counting total bird abundance around the ship. Counting results should be entered into the form "Number and Contacts".

2.2. Visual observations of rare bird species

The water area around the ship within visibility limits should be periodically viewed using a binocular during fishing operations, all passages and cargo transfer operations in order to registered rare bird species entered in the IUCN Red List (short-tailed, Laysan or black-footed albatrosses, red-legged kittiwake, ivory gull). Such observations should be performed several times a day, preferably in prolonged rounds as the number of birds may considerably change during the day. It is important to identify species of all detected albatrosses using an identification manual.

The following parameters should be registered for each encounter with a rare species:

- date, time and coordinates of observation,
- number of registered individuals,
- age should be registered for short-tailed albatross – one of three main stages: 1) fully dark juvenile individual in a nesting plumage, 2) immature individual in a speckled intermediate plumage, 3) adult individual in a final black-and-white plumage,

[1] Electronic blanks for filling-in are available in Excel file "Content and methods of field observations_FORMS".

- during observation in the trawling process, specifics of its behavior should be noted from the viewpoint of potential collision with fishing gear.

All observed rare species should be photographed if possible (for further verification of species identification and age). If the bird is caught in the trawl, it is preferable to preserve (freeze) its whole carcass for further investigation and handover to a scientific collection.

Virtually all short-tailed albatrosses and some individuals of other species have metal rings on their legs. Some birds are additionally marked by plastic colored rings (short-tailed albatrosses more frequently have a white or red ring but the ring may also be black, yellow or green; the number on it consists of three characters – 3 digits or 1 letter and 2 digits). When detecting birds with such marks, it is preferable to read this number or take a photo of it.

Observation results should be entered into the form "Rare Species".

3. Collection of information about bird interaction with trawl fishing gear

The number of bird collisions with trawl's ropes/net panels and with wires – right and left warps and trawl control cable should be counted in the daylight from trawl master's bridge at the stern during the three stages of a fishing operation (heaving out, trawling and hauling out). Consequences of each collision were registered (light contact – no threat to life, heavy contact – lethal case). 10 interaction types were determined (for types 1-4 – any collision of birds with ropes/net panels, except warps and depth sounder cable; landing of gulls on cod-end floating on the water surface was not considered as contacts):

1 – light contact of swimming bird with trawl (no adverse consequences);
2 – heavy contact of swimming bird with trawl (death is highly possible, bird may drown);
3 – light contact of flying bird with trawl (no adverse consequences);
4 – heavy contact of flying bird with trawl (death is highly possible due to a strong impact);
5 – light contact of swimming bird with warp or depth sounder cable (no adverse consequences);
6 – heavy contact of swimming bird with warp or depth sounder cable (death is highly possible, bird sank and is not seen on surface);
7 – light contact of flying bird with warp or depth sounder cable (no adverse consequences);
8 – heavy contact of flying bird with warp or depth sounder cable (death is highly possible due to a strong impact);
9 – bird caught in the net (and died);
10 – bird crashed by cod-end during trawl hauling.

Bird species should be identified in the same manner as when counting total bird abundance around the ship. Duration of each observation round should be registered. Recommended duration is as follows:

- heaving out – during the whole stage, between command "Trawl is out" and the end of warp heaving out (warp winches stopped);
- trawling – depending on duration of this stage, 1 to 3-4 observation rounds 30 minutes each with intervals at least 30 minutes;
- haul-out – between the beginning of warp heaving-in and trawl lifting to deck.

During the trawl haul-out process, it is important to watch appearance of otter boards and trawl control unit from the water, because an entangled dead bird may be shifted on the wire to the distal end. When the echo sounder lying on the panel appears on the sea surface, it should be inspected using a binocular before the dead bird is washed off by waves.

For each observation round, we registered the intensity of catch processing waste discharge from trawler's factory (0 – no offal discharge, 1 - little offal and/or intermittent discharge, 2 – much offal and continuous discharge) and specified ships' side from which it was discharged. We also registered the number of other trawlers operating within visibility limits and meteorological conditions: wind (in the cardinal directions and force in m/sec), sea state, cloud cover, atmospheric pressure, precipitation if any, air and water temperature, visibility. Also, we registered a relative wind direction – the angle from between ship's course: 1 – wind blows to ship's bow (90º from bow – 45º to each side); 2 – wind blows to starboard (90º from starboard –

45º each from perpendicular); 3 – wind blows to stern (90º from stern – 45º to each side); 4 – wind blows to portside (90º from portside – 45º each from perpendicular); 0 – light air, no marked wind direction.

Results of each observation round should be entered into the form “Number and Contacts”.

4. Bird mortality monitoring

4.1. Collection of information about bird death cases in fishing gear

Data on the species composition and number of dead birds should be collected for each trawling operation. It is necessary to make arrangements with the shop master, trawl masters and hopper operators that birds found during catch pouring and fish delivery to the processing plant should be put aside for further inspection by observer. Warps, depth sounder cable, otter boards and panel with the echo sounder should be attentively inspected during trawl haul-out to detect entangled dead birds.

Data should be entered into the form “Mortality in Fishing Gear”.

4.2. Collection of information about bird mortality associated with trawl fishing caused by collision with ship’s rigging

As such collisions occur mostly in the night time, observers should every morning inspect all open deck areas on board the ship to search for dead birds (upper deck with boat decks, foredeck, upper and lower bridges). Found dead birds should be registered by species and, where appropriate, cause of their death should be stated. If any dead birds are found, weather conditions of the past night should be recorded. It should be indicated if there are any dogs on the ship.

Data should be entered into the form “Incidental Mortality”. Each line in this table corresponds to a full night-time period, i.e. one entry includes data collected in the evening of the preceding day and night of the current day. If the bird died in the daylight, it is included in data for the current day.

It is preferable to photograph dead birds found in fishing gear and on deck (with an exact date and time set on the camera) for further verification of its species identification and age. The head, spinal surface of the body and both sides of unfolded wings should be photographed for juvenile individuals of large gulls. Information about photo shooting should be electronically entered into the column “Comments”.

If the dead bird has a ring on its leg, it should be identified by species, photographed, and the ring should be retained (data from it should be copied to a diary to prevent loss of information if the ring is lost). If the bird is live, data on its ring should be copied (without removing it), the bird should be photographed and released.

5. Recording of weather conditions

In addition to observation rounds during the trawling process (see paragraph 3), meteorological conditions should be registered every day during passage and cargo transfer operations. Data should be entered into the form “Weather Conditions”.

6. Registration of the duration of daylight period

Sunrise and sunset times in the area of fishing operations should be recorded using a GPS receiver every ship-day when fishing. Data should be entered into the form “Duration of Daylight Period”.

ATTACHMENT 2

Names of bird species mentioned in this report

English name	**Latin name**
Short-tailed albatross	*Phoebastria albatrus*
Black-legged albatross	*Phoebastria nigripes*
Laysan albatross	*Phoebastria immutabilis*
Fulmar	*Fulmarus glacialis*
Short-tailed shearwater	*Puffinus tenuirostris*
Fork-tailed storm petrel	*Oceanodroma furcata*
Slaty-backed gull	*Larus schistisagus*
Vega gull	*Larus vegae*
Glaucous-winged gull	*Larus glaucescens*
Thayer's gull	*Larus thayeri*
Glaucous gull	*Larus hyperboreus*
Ross's gull	*Rhodostethia rosea*
Black-legged kittiwake	*Rissa tridactyla*
Red-legged kittiwake	*Rissa brevirostris*
Ivory gull	*Pagophila eburnea*
Common murre	*Uria aalge*
Thick-billed murre	*Uria lomvia*
Pigeon guillemot	*Cepphus columba*
Crested auklet	*Aethia cristatella*
Least auklet	*Aethia pusilla*
Tufted Puffin	*Lunda cirrhata*