Federal Fishery Agency

Federal State Budgetary Research Institution

Kamchatka Research Institute of Fisheries and Oceanography

(FSBRI "KamchatNIRO")

"APPROVED"

FSBRI "KamchatNIRO" Acting Director, Cand. Sc. (Eng.)

____________________ M.N. Kovalenko

__________________ ____, 2017

REPORT

(Contract No. 18/16-NIR dated November 23, 2016)

Assessment of Pollock Fishery Direct (Accidental By-catch and Death of Animals in Fishing Gear) and Indirect (Capture of Pollock as Potential Feeding Source) Impacts on Steller Sea Lions in the Northern Part of the Sea of Okhotsk

Petropavlovsk-Kamchatsky, 2017

AUTHORS

Name	Position, academic degree	Pages and numbers of sections prepared by author	Author's signature
Kornev S.I.	Head of Marine Mammals Laboratory, Cand. Sc. (Biol.)	Pages 1-82, 130-145; Sections 1-6, 9-10	
Varkentin A.I.	Head of Marine Biological Resources Department, Acting Head of Marine Commercial Fishes Laboratory, Cand. Sc. (Biol.)	Pages 83-103, Section 7	
Blokhin I.A.	Junior Research Fellow, Hydrobiology Laboratory	Pages 104-119, Section 8	

TABLE OF CONTENTS

INTRODUCTION..5

RESULTS...……………………..6

1. Review of Russian and foreign scientific literature on Steller sea lion diet in different seasons and pollock's role in it…………………………………....................6

1.1. Methods used for study of the diet of Steller sea lions……...........................6

1.2. Seasonal differences in the diet of Steller sea lions...7

1.3 Year-to-year differences in the diet of Steller sea lions....................................8

1.4. The diet of Steller sea lions vs. the dynamic of their abundance.......................8

1.5. Determination of the size of pollock eaten by Steller sea lions........................9

1.6. Gender differences in the diet of Steller sea lions………...........................9

1.7. Review of studies on the diet of Steller sea lions in Russian waters...............10

1.8. Prey competition between Steller sea lion and northern fur seal…………....11

2. Current status of Steller sea lion stock in study area…………………………......12

3. Expert judgment on Steller sea lions' total demand for feeding sources and relative importance of pollock in such sources……..14

4. North Sea of Okhotsk pollock catch volumes and structure of its fishery during last 5-10 years, current status of its stock…………………...21

5. Expert judgment on pollock fishery direct and indirect impacts on Steller sea lions in the northern part of the Sea of Okhotsk…..26

6. Observations on distribution, abundance and behavior of Steller sea lions and other marine mammals in pollock trawl fishery areas in the northern part of the Sea of Okhotsk in January – April 2017……………….………......................29

6.1. Species and quantitative composition, spatial distribution of marine mammals in trawl fishery areas in the Sea of Okhotsk in January – April 2017….................29

6.2. Specific features of marine mammal behavior near fishing vessel................40

7. Collection of photo and video materials……………………….........................48

CONCLUSION..48

REFERENCES………………………………………….....................................50

ABSTRACT

This report contains 57 pages, 10 tables, 23 figures, 61 reference sources, 2 appendices.

MARINE MAMMALS, STELLER SEA LION, POLLOCK, DISTRIBUTION, ABUNDANCE, STOCK, BY-CATCH, FISHERY, CONSUMPTION

The purpose of this study is to make an expert judgment on direct (accidental by-catch and death of animals in fishing gear, etc.) and indirect (capture of pollock as a potential feeding source) impacts of the pollock fishery on Steller sea lions in the northern part of the Sea of Okhotsk.

We have used generally accepted methods for marine mammal count surveys and observed Steller sea lion behavior near ships using direct recording method.

We have reviewed existing literary sources on the diet of Steller sea lions both in the American continent and in Russia and the current status of their populations in Russian waters, made an expert judgment on potential consumption of pollock by Steller sea lions in the Sea of Okhotsk, made an assessment of pollock trawl fishery impacts on Steller sea lions in the Sea of Okhotsk, performed observations on marine mammal occurrence near fishing vessels and Steller sea lion by-catch in the pollock fishery, collected photo and video materials on Steller sea lions' behavior near a fishing vessel in study areas in January – April 2017.

INTRODUCTION

This study has been performed in accordance with Contract No. 18/16-NIR dated November 23, 2016 between FSBRI “KamchatNIRO” and NCO “Pollock Catchers Association” as part of annual auditing processes for certification by MSC of the pollock fishery in the northern part of the Sea of Okhotsk and focused on the following subject: “Assessment of pollock fishery direct (accidental by-catch and death of animals in fishing gear, etc.) and indirect (capture of pollock as a potential feeding source) impacts on Steller sea lions in the northern part of the Sea of Okhotsk”.

The key objective of this study was an expert judgment on direct (accidental by-catch and death of animals in fishing gear, etc.) and indirect (capture of pollock as a potential feeding source) impacts of the pollock fishery on Steller sea lions in the northern part of the Sea of Okhotsk.

The following tasks have been formulated to achieve this objective:

— review available Russian and foreign scientific literature on the diet of Steller sea lions in different seasons and the role of pollock in it;

— where possible, collect biological samples (feces, stomachs) of Steller sea lion for analysis of its diet in the winter–spring season in pollock fishery areas in the Sea of Okhotsk;

— ensure coordination of biological sample (feces, stomachs) collection with scientific observers from fishery research institutes based onboard other fishing vessels;

— prepare a brief instruction for observers on collection of mammal marine information in fisheries in the Russian Far East waters;

— make an expert judgment on total demand of Steller sea lions for feeding sources and relative importance of pollock in such sources;

— provide details on the current status of Steller sea lion stock in the study area;

— provide details on the North Sea of Okhotsk pollock stock condition, catch volumes and structure of its fishery during last 5–10 years;

— make an expert assessment of pollock fishery impacts on the feeding sources of Steller sea lions in the northern part of the Sea of Okhotsk and assess potential relation between the pollock fishery and variability of Steller sea lion populations in this area (based on available literature sources);

— perform observations on the distribution, abundance and behavior of Steller sea lions and other marine mammal species in pollock trawl fishery areas in the northern part of the Sea of Okhotsk in January – April 2017;

— register cases of capture and death of animals during trawl fishing operations, if any;

— collect photo and video materials relevant to the subject of our study.

RESULTS

1. Review of Russian and foreign scientific literature on Steller sea lion diet in different seasons and pollock's role in it

Review of Russian and foreign scientific literature on Steller sea lion diet in different seasons and pollock's role in it was accomplished at the first stage of the research. The report on this stage was handed over to the customer. Only the main results of the research are included in this final report.

1.1. Methods used for study of the diet of Steller sea lions

Before 1970s, the key method for identification of food types and quantities consumed by Steller sea lions was their killing and examination of the contents of their stomachs. Fish was whole in their stomachs quite often but more frequently researchers had to identify fish species by leftovers of "semi-digested food" and by otoliths.

After Steller sea lions reduced their abundance in almost all populations and were classified as a protected and rare species, researchers started applying more humane study methods: analysis of feces (scat, food samples) collected at rookeries or bachelor haul-outs.

Otoliths and solid non-digested skull structures or skeleton remnants were used for determination of food types. Washed and dried parts of fish and other food types were compared with samples of fish otoliths and other bones, octopus and squid beaks available in collections of various research institutes. Regression formulas and correlations were developed for fish size identification by their remnants.

The occurrence rate of food types continues remaining the most widely used method for identification of food types consumed by Steller sea lions. It is determined as a ratio of a particular species registered in samples to all species in the collection of food samples collected from a particular study area or region expressed in per cent.

The second method used somewhat less frequently is typical occurrence or "split-sample" frequency (Olesiuk et al., 1990; Olesiuk, 1993). This method evaluates a relative proportion of food components in the whole bolus. It allows for assessment of both occurrence rate, specific composition of prey and, to some degree, its quantitative composition.

The dietary diversity index (DDI) is also used and defined as a ratio of several food types eaten by a Steller sea lion in a particular rookery or study area to the whole list of its most frequently registered food types. Normally, it is 7–8 species and sometimes up to 13 species. This index is expressed in whole numbers. It cannot exceed the number in the overall list of species taken for diet comparison.

The advanced methods of study of the diet of Steller sea lions include telemetry or satellite transmitters attached to live animals. Data obtained from such transmitters provide details about duration of foraging migrations as rather universal "index" characterizing variation of the abundance of feeding resources in the foraging areas of animals. Important parameters for such analysis are dive depth, dive frequency and other data. Tags are attached to lactating females which have to come back periodically to feed pups depending on them.

Juvenile individuals who have started foraging independently and stopped being dependent on their mother's milk are of particular interest. Some authors (Pascual, Adkison 1994; York, 1994; Holmes, York, 2003) believe that a low survivability rate of 1–2-year-old individuals may be one of important factors of the reduction of Steller sea lion abundance. Juvenile sea lions have energy demand twice higher than adult animals (Winship et al., 2002) and because of that cannot stay at sea for a long time and make deep dives (Richmond et al., 2006).

A promising method is use of portable autonomous video cameras attached to the animal's back and shooting all foraging migrations, prey search and directly foraging activities.

Although yielding accurate and comparable results, all these instrumental methods have the same disadvantage – they are expensive and require special staff training, and the process of attaching and retrieving equipment (tags, transmitters, cameras, etc.) to/from animals is quite complicated.

State-of-the-art methods for dietary studies also include genetic and biochemical analysis and trophic level determination.

1.2. Seasonal differences in the diet of Steller sea lions

Seasonal differences in the diet of Steller sea lions were addressed in detail in writings of E.H. Sinclair and T.K. Zeppelin (2002) and E.H. Sinclair et al. (2013). They describe key components of the diet of Steller sea lions living in Alaska Bay and Aleutian Islands in summer and winter seasons.

According to these studies, the key prey species are pollock and greenling. These species were staying in the coastal area all year round and were common food for Steller sea lions.

1.3 Year-to-year differences in the diet of Steller sea lions

A number of researchers (Sinclair, Zeppelin, 2002; Sinclair E.H. et al., 2013) have found out that Steller sea lions belonging to their western stock did not feed on pollock in 1958–1969, with their diet consisting largely of capelin (*Mallotus villosus)*, Pacific sand lance, cephalopods, herring, greenlings, rockfishes and Pacific salmons.

In 1990–2009, capelin accounted for as little as 5% of the diet of Steller sea lions in Alaska and Aleutian Islands. Salmons were present in their diet in earlier studies although not with high frequencies. The presence of flatfish, particularly arrowtooth flounder, in the diet of Steller sea lions in Alaska Bay was significantly higher in 1990–2009 than in any other studies. Cephalopods were among key prey items in all years of studies.

In total, 87 species of aquatic organisms were registered (identified) in the diet of Steller sea lions during 1999–2009, of which 13 ones are considered as key species because were registered at frequencies above ≥ 5%: arrowtooth flounder, pollock, greenling, cod, Pacific sand lance, Pacific herring, cephalopods, salmons, Irish lord, Pacific sandfish, rock flounder, rockfish and snailfishes.

In general, Steller sea lions feed on the most abundant fish and cephalopod mollusk species living near rookeries on which they stay.

Pollock's role in the diet of Steller sea lions in the winter season in most of its habitats off Alaska and Aleutian Islands was very significant in 1990–2009 and varied from 46% to 90%. In the summer season, pollock also accounts for the greater portion of the diet of Steller sea lions belonging to the species' western population.

The role of cod noticeably grew in Steller sea lions' winter diet in 2000–2009 in all areas under consideration (up to 57.5%).

Adult females and juveniles feature a wider nutrition spectrum.

1.4. The diet of Steller sea lions vs. the dynamic of their abundance

R.L. Merrick et al. (1997) suggested a hypothesis on a relationship between Steller sea lions' diet and reduction of their populations in Alaska. Proceeding from a high area-to-area correlation between diet diversity and abundance variation in Steller sea lion populations, he supposed that the condition of Steller sea lion populations in Alaska was explained by diversity of its diet in 1980–1990.

It looks like at least two key prey species should be available for wellbeing of the Steller sea lion stock (e.g. pollock and greenling as was the case observed in the eastern part of Aleutian Islands in 1990–1993 or pollock and capelin – in vicinity of Kodiak Island in 1975–1978).

The above said author found out that when the diet of Steller sea lions became less diverse in Alaska Bay, their stock abundance abruptly decreased at the same time. They supposed that such a diverse diet of Steller sea lions is their adaptation to changing environmental conditions including variations of the stock condition of their prey items.

Therefore, according to this author, a population with a more diverse diet is better adapted in case of a sudden shortage of some diet components than a population which would have been feeding on primarily one or two species.

1.5. Determination of the size of pollock eaten by Steller sea lions

T.K. Zeppelin et al. (2004) performed a study on determination of the size of two key species in the diet of Steller sea lions – pollock and greenling – by the size of bone remains recovered from their scat.

In addition to an important methodological component of this paper, it presents first time ever the sizes of two fish species (pollock and greenling) consumed by Steller sea lions.

The length of pollock consumed by Steller sea lions of their western stock varied in the range of 3.7 to 70.8 cm (average=39.3 cm, SD=14.3, n=666) and that of greenling was 15.3 to 49.6 cm (average=32.3 cm, SD=5.9, n=1685).

The size of fish is important for understanding of the foraging behavior of animals, spatial and temporal variations of their diet.

Studies on relative distributions of size frequency of fish, eaten by Steller sea lions of the western stock and caught commercially, found that these groups significantly overlap (68% for pollock and 53% for greenling). Similar tendencies were observed for the eastern stock as well.

These facts show that there may be kind of competition between Steller sea lions and commercial fisheries aggravating against the background of declining prey resources.

1.6. Gender differences in the diet of Steller sea lions

A.W. Trites and D.G. Calkins (2008) studied food samples for mature males at bachelor rookeries and for females at breeding rookeries in Forester Island (June and July 1994–1999) to see if there is any difference in the diets of bulls and breeding females.

Females were consuming, in roughly equal proportions, Gadids, salmons and small-size fishes (herring, smelt, sand lance) and, in a lesser degree, rockfish, flounders and cephalopod mollusks. Their diet did not differ much from area to area.

Compared with females, males were consuming much less salmons and more pollock, flounders and rockfish. Furthermore, it was found that they consumed pollock of larger sizes than females did. This difference in diets may reflect gender differences in their feeding areas or differences in hunting skills resulting from different physical sizes of a male and a female.

Be that as it may, diet diversity (DDI) generally did not differ much between males (5.11) and females (5.35). Except pollock, males and females were eating same fishes of roughly same sizes.

One possible explanation of the observed diet differences between Steller sea lion males and females is that males need a diverse combination of fish being consumed to satisfy their higher energy demand. Energy-based modeling shows that a male needs some 25–40 kg of prey per day while a female needs 10–20 kg.

Another different feature in the diets of sea lion males and females is that their morphometric differences affect their capacity to catch different prey items. Mature males are roughly 2.5 times larger than females. For instance, salmon may be too fast and agile to be effectively caught by large males. Other specific features are that males are able to dive deeper than females and have access to various fish aggregations (schools).

1.7. Review of studies on the diet of Steller sea lions in Russian waters

There are few writings on the diet of Steller sea lions in Russia. First studies on this subject were performed in Kuril Islands (Belkin, 1966; Panina, 1966; Perlov, Panina, 1969; Perlov, 1975). Steller sea lions' diet was studied by the contents of their stomachs.

In terms of occurrence rate, dominant prey items in their diet in 1960s–1970s were pollock (63.4%), octopus and Komandor squid (up to 28%), however, the latter accounted for a much smaller portion of the diet in quantitative terms than greenling.

Octopuses and pollock were dominant prey in the southern part of Kuril Islands, pollock only in their middle part, and pollock and greenling in the northern part.

Although the list of species found in the diet of Steller seas lions in 1960s–1970s is incomplete, a leading role of pollock and greenling in their diet in Kuril Islands is clearly seen.

In 2000–2003, D.N. Waite and V.N. Burkanov (2006) were studying the diet of Steller sea lions in the Far Eastern waters. They identified 83 species in their diet. Of this number, the following 10 most frequently occurring prey items were singled out: Atka mackerel *(Pleurogrammus monopterygius*), pollock *(Theragra chalcogramma),* Pacific salmons (*Oncorhynchus sp.*), sculpins (*Cottidae*), cephalopod mollusks, Pacific sand lance *(Ammodytes hexapterus*), Pacific herring

(*Clupea pallasii*), smoothtongue (*Leuroglossus shmidti*), snailfishes (*Liparidae*) and Pacific cod (*Gadus macrocephalus*).

The key prey items in the diet of Steller sea lions in Russian waters are greenling and pollock. The occurrence rate of the latter species varies from 6.5% at bachelor rookeries in North Kuril Islands to 68% in Yamsky Islands in the north of the Sea of Okhotsk.

Atka mackerel plays an important role in their nutrition. Its occurrence rate varied from 69.5% to 98.1% of Southwest Kamchatka and North Kuril Islands. Pacific salmons were present only in 14.6% of scat samples near Southwest Kamchatka during the summer but this figure grew to 58.7% in the autumn.

The diet of Steller sea lions in the Far Eastern region is comparable with that of their western stock in Alaska (Sinclair E.H. and T.K. Zeppelin, 2002). Same as in Aleutian Islands, greenling, pollock and salmon are common prey items for Steller sea lions.

The hypothesis on reduced abundance of Steller sea lions due to lower diversity of their diet (Merrick at al., 1997) was not confirmed by materials on their diet in Russian waters (Waite, Burkanov, 2006). By data of these authors, the number of Steller sea lions abruptly decreased at some rookeries with the highest prey diversity levels.

Instead of the simple method of species occurrence and dietary index for assessment of Steller sea lions' feeding habits, these authors suggest using a more comprehensive indicator – Diet Quality Index comprising sizes and number of consumed prey individuals, hydrolyzing correction factors (Tollit et al., 2004) and nutritional quality of each prey item.

In their opinion, the population structure of Steller sea lions should be addressed first of all and only then their diets should be compared between locations, age classes, genders and breeding statuses.

1.8. Prey competition between Steller sea lion and northern fur seal

Inter-species competition for prey resources arises in breeding areas of sympatric sea lions and northern fur seals (Waite at al., 2012). There are quite many such locations in the Far East where these two species live almost together in same rookeries.

For instance, food spectra and prey sizes of the diets of Steller sea lions and northern fur seals significantly overlap in Lovushki Islands and Srednego Islands. Sea lions and juvenile fur seals were feeding primarily on greenling and breeding fur seals were feeding on cephalopod mollusks, salmons, greenling and smoothtongue.

2. Current status of Steller sea lion stock in study area

In late 20th century – early 21st century, the number of Steller sea lions in Russian waters reduced from approx. 115,000 to 15,000 individuals (in terms of direct absolute count) or by 87% (Burkanov and Loughlin, 2005).

The abundance of this species was decreasing in Kuril Islands during 1970–1980. In some parts of its geographic range, the situation was, on the contrary, positive (Kuril Islands, islands and coast in the northern part of the Sea of Okhotsk, Sakhalin Island) (Burkanov et al., 2006).

According to direct count surveys in rookeries, there were 5,149 adults and 2,252 pups in Kuril Islands in 2005 (Burkanov et al., 2006). In 2013, the figures were as follows: 5,978 adults, 2,604 live and 142 dead pups in vicinity of Sakhalin Island and in the northern part of the Sea of Okhotsk, of which 2,588 adults, 1,010 live and 57 dead pups in areas adjacent to Sakhalin Island and 3,390 adults, 1,594 live and 85 dead pups in the northern part of the Sea of Okhotsk (Burkanov et al., 2015).

By results of Steller sea lion rookery surveys in 2015, researchers observed reductions of pup numbers in all locations, particularly in Kuril Islands – 22% fewer on 2011 (Burkanov et al., 2016).

It is not unlikely that some animals from any region of this species' geographic range in Asia may be present in the northern part of the Sea of Okhotsk in winter.

In order to assess Steller sea lion impact on pollock resources in the northern part of the Sea of Okhotsk, we should address animals living in Kuril Islands, Kamchatka, Sakhalin, islands and coast in the northern part of the Sea of Okhotsk which is confirmed by results of observations from fishing vessels performed in January – April 2017 during the pollock fishing season when all observed tagged Steller sea lions were from these areas (Iona Island, Raikoke Island (Kurils), Tuleniy Island) (see below).

According to expert judgments, total number of Steller sea lions currently living in areas belonging to the Sea of Okhotsk Basin is approx. 24.0 thsd head (Table 2.1–2).

Table 2.1. Total number of Steller sea lions living in areas belonging to Sea of Okhotsk Basin based on pup numbers

Region	Pups	Coefficient	Total Steller sea lions (pups and adults)
Northern part of the Sea of Okhotsk	1,679	4.5	7,556

Sakhalin	1,067	4.5	4,802
Kuril Islands	2,422	4.5	10,899
Kamchatka*	85		692
Total	5,253		23,949

Note. Data on pups and bulls were taken from (Burkanov et al., 2006; 2015; 2016). Estimated coefficient 4.5 was taken from (Calkins, Pitcher, 1982).

* Data on Kamchatka were taken from papers written by V.N. Burkanov et al. (2006, 2015): total number of Steller sea lions (pups and adults) for Kamchatka (692) includes 85 pups, 31 bulls and 576 animals above than 1 year of age and older, according to direct count survey data. It is not possible to estimate their total number in Kamchatka by the number of their pups because there is only one small breeding rookery in the peninsula – Cape Kozlov, and most rookeries are attended by bachelors only. That's why we have used direct count data.

Table 2.2. Estimated number of Steller sea lions living in areas belonging to Sea of Okhotsk Basin by age groups

Region	Pups	Adults >1+	Bulls	Total
Northern part of the Sea of Okhotsk	1,679	5,627	250	7,556
Sakhalin	1,067	3,681	54	4,802
Kuril Islands	2,422	7,720	757	10,899
Kamchatka	85	576	31	692
Total	5,253	17,604	1,092	23,949

Note. Final data were taken from Table 2.1 above; data on pups and bulls were taken from literature (Burkanov et al., 2006; 2015; 2016).

When estimating aquatic living resource consumption by Steller sea lions in the Sea of Okhotsk, we will take into account only adult animals and juveniles who have started foraging independently which normally occurs at the age of one year and more (Perlov, 1975; Trites et al. 2006 and others). Pups at the age under one-year feed on maternal milk (sometimes till the age of 2 years and more, Calkins and Pitcher, 1982 and others); that's why we ignored them in our estimations of prey consumption by Steller sea lions in the Sea of Okhotsk.

3. Expert judgment on Steller sea lions' total demand for feeding sources and relative importance of pollock in such sources

Due to their high abundance, marine mammals are one of major consumers at the highest trophical level in the sea (Sobolevsky, 1983). At the same time, food consumption by fishes and large invertebrates in the World Ocean greatly exceeds consumption by marine mammals due to their abundance (Shuntov, Ivanov, 2015). However, the role of such predators as marine mammals in ecosystems is not limited by numbers of consumed live organisms. They are known to have positive effects on natural selection for prey species which include fishes, cephalopod and some invertebrates.

Having a total biomass of approx. 25 million tons (more than half of which is sperm whales), marine mammals annually consume some 150 million tons of food in the Pacific Ocean or roughly three times more than catches harvested by commercial fisheries (Trites et al., 1997).

Upon summarizing data from various sources, V.P. Shuntov and O.A. Ivanov (2015) estimated annual volumes of fish and invertebrates consumed by marine mammals in three Far Eastern seas. These figures are as follows: early 20th century — 14.6–18.2 million tons, late 1970s — 12.3–15.1 million tons, prior to commercial fishery period — 22.7–28.8 million tons, early 21st century — 24.0–24.7 million tons (with additional 3.0–5.0 million tons in the waters off Kuril Islands and 27.0–29.5 million tons in the waters off Kamchatka). Current annual consumption of marine live resources by marine mammals in Far Eastern seas reaches high values (Table 3.1).

Table 3.1. Current annual food consumption by marine mammals in Far Eastern seas, near-Kuril and near-Kamchatka oceanic waters, millions of tons (Shuntov and Ivanov, 2015)

Sea of Okhotsk	Bering Sea	Sea of Japan	Near-Kuril and near-Kamchatka oceanic waters	Total
8.2–8.6	15.6–15.7	0.2–0.4	3.0–5.0	27.0–29.7

As estimated by G.A. Fedoseev (2005), ice forms of seals were consuming 4.33 million tons of fish invertebrates in the Sea of Okhotsk by early 2000s (ringed seal – 0.90 million tons, spotted seal – 0.68 million tons, ribbon seal – 1.57 million tons, bearded seal – 1.18 million tons). Eared seals – fur seal and Steller sea lion – accounted for as little as 0.18 million tons at that time. According to unpublished estimates by A.E. Kuzin (incorporating literature data and adjustments by V.P. Shuntov and O.A. Ivanov (2015)), cetaceans were consuming 3.73 to 4.12 million tons of fish in the Sea of Okhotsk in early 2000s.

Total food consumption by marine mammals in the Sea of Okhotsk in early 2000s was reaching 8.24 to 9.05 million tons. These estimates are significantly higher than in 1970s and 15–20% higher than data for the early 20th century (Shuntov, Ivanov, 2015).

Estimated data on consumption of aquatic organisms by marine mammals are important both for understanding of their role in marine ecosystems and for improvement of effective management of biological resources (Sobolevsky, 2013).

To estimate total demand of Steller sea lions for prey, we need data on their abundance, daily ration and feeding intensity round the year.

There is little data on daily rations of Steller sea lions in literature sources and none at all for the northern part of the Sea of Okhotsk. Unfortunately, dedicated studies on collection and further laboratory analysis of biological samples (feces, stomachs) of Steller sea lions planned on board the BATM Baklanovo for January – April 2017 to investigate the diet of Steller sea lions in pollock fishery areas in the Sea of Okhotsk in the winter–spring season failed as no Steller sea lions had been captured.

The majority of researchers believe that Steller sea lions consume an equivalent of 5–7% of their own weight per day (Scheffer, 1950; Spalding, 1964; Perlov, 1975; Sobolevsky, 1983). Table 3.2 shows estimated daily consumption of food by Steller sea lions of various categories based on literature data on their mean weight.

Table 3.2. Estimated daily consumption of food by Steller sea lions of various categories

Category of animals	Mean body weight, kg	Mean daily demand for food		Maximum daily demand for food	
		% of body weight	kg	% of body weight	kg
Bulls	722	5	36.0	7.0	50.5
Mature females	272	5	13.6	7.0	19.0
Juveniles	130	8	10.4	11.0	14.3
Other	302	5	15.0	7.0	21.0
All except bulls, mean value	234.7	5	13.0	8.3	18.1

Note. Mean body weight was taken for all categories of animals from the “Reference Book on Parameters of Pacific Pinnipeds, 1979”; daily demand for food was taken from writings of Perlov, 1975; Sobolevsky, 1983; Spalding, 1964; mean consumption for juvenile animals was taken from Calkins et al, 2013.

Based on mathematic modeling results, A. Winship and A. Trites (Winship, Trites, 2003) estimated daily demand separately for mature Steller sea lion males and females. According to their estimates, males require approx. 25–40 kg of food per day and females require 10–20 kg (depending on the season and provided that they consume the same mixed food).

In our estimates, we assume daily demand at 25–40 kg per day for bulls and 10–20 kg per day for all other age and gender groups as the most credible data checked using a mathematical model (Winship, Trites, 2003).

Based on the known number of Steller sea lions, mean body weight for each category, number of days of their stay in the Sea of Okhotsk, we can calculate a total volume of food consumed by them during a year by the following formula:

$B = N \times C \times D$, where

B – biomass of food consumed during a year, thousands of tons;

N – number of Steller sea lions, thousands of individuals;

C – daily ration of one animal, kg;

D – number of days.

Our calculated results are presented in Table 3.3. According to our estimates, annual consumption of food by Steller sea lions in the Sea of Okhotsk is approx. 141.2 thsd tons.

E.I. Sobolevsky writes in his paper (1983) that 18–20,000 Steller sea lions annually consume some 70–77 thsd tons which is almost two time less than our estimate (Table 3.4). This is explained by the fact that this author used a mean weight of a Steller sea lion equal to 217 kg and daily consumption of 10.8 kg (5% of body weight) which is lower than the parameters used by us (see Table 3.3).

Steller sea lion belongs to species characterized by a varying proportion of pelagic and bottom aquatic organisms in its diet. More than 50 fishes and cephalopod mollusks have been observed in the diet of Steller sea lions in the Russian Far Eastern seas (Waite, Burkanov, 2006). According to data of I. Usatov and V.N. Burkanov (2016), the following species dominated in occurrence terms in the diet of Steller sea lions in 22 rookeries in 2004–2008: Atka mackrel (*Pleurogrammus monopterygius)* (64.8%), pollock *(Theragra chalcogramma)* – 44.3%, Pacific salmons *Oncorhynchus sp.* (20.5%), Irish lords *(Hemilepidotus sp.)* (20.4%) and sand lance *(Ammodytes hexapterus)* (15.8%). These authors also pointed out that, unlike in other regions, the bulk of Steller sea lions' diet in the Sea of Okhotsk was pollock and herring.

A similar difference in the diet of Steller sea lions was observed in Commander Islands as well. In general, a whole number of Russian and foreign specialists highlighted an important role of pollock in the diet of Steller sea lions in different parts of its geographic range (Belkin, 1966; Panina, 1966; Perlov, 1975; Merrik et al. 1997; Sinclair, Zeppelin, 2002; Waite, Burkanov, 2006; Sinclair et al., 2013; Trites, Calkins, 2008; Usatov, Burkanov, 2016 and others). Be that as it may, Steller sea lion is by far not the only marine mammal animal in whose diet pollock is a key component. At least four other pinniped species (northern fur seal, spotted seal, ribbon seal, Kuril harbor seal) and at least 8 cetacean species (finback whale, sei whale, Minke whale, humpback whale, beluga, Dall's porpoise, killer whale, Pacific white-sided dolphin) also feed on this fish (Sobolevsky, 1983; Shuntov, Ivanov, 2015).

Table 3.3. Estimated annual demand of Steller sea lions for food broken down by Sea of Okhotsk areas (thsd tons)

Category of animals	Total number per region	Daily demand, min	Daily demand, max	Duration of stay in the Sea of Okhotsk	Northern part of the Sea of Okhotsk		Sakhalin		Kuril Islands		Kamchatka		Total amount of food	
	thsd individuals	kg	kg	days	min	max	min	max	min	max	min	max	min	max
Bulls	1.092	25	40	330	2.1	3.3	0.4	0.7	6.2	10.0	0.3	0.4	9.0	14.4
Adults > 1+	17.604	10	20	360	20.3	40.5	13.3	26.5	27.8	55.6	2.1	4.1	63.4	126.7
Total	18.696				22.3	43.8	13.7	27.2	34.0	65.6	2.3	4.6	72.4	141.2

Note. The number of Steller sea lions in the above table was taken from literature (Burkanov et al., 2006; 2015; 2016) and a correction factor of 4.5 on the number of pups was used (Calkins, Pitcher, 1982). The period of stay in the Sea of Okhotsk for bulls was reduced by the duration of their harem period when they don’t eat most of time and remain on the shore; for other categories it was taken at 360 days.

Table 3.4. The number of pinnipeds and sea otter in the Sea of Okhotsk and their annual demand for food in late 1970s (Sobolevsky, 1983)

Species	Number, thsd individuals	Biomass, thsd tons	Consumed food, thsd tons				
			fish	of which salmons	cephalopods	plankton and other items of diet	Total amount of food consumed per year, thsd tons
Fur seal	170—180	6.2—6.5	39—48	2—2.4	19—27	—	58—75
Steller sea lion	18—20	3.9-4.2	42—46	—	28—31	—	70—77
Spotted seal	190	11.4	164	5	41	—	205
Ringed seal	543	19	51—68	—	—	274	325—342
Ribbon seal	345	19	171—239	—	34—51	51—85	256—375
Bearded seal	190	34	92—123	—		492	584-615
Kuril harbor seal	2	0.13	1.4-1.6	—	0.5	0.2	2.1-2.3
Sea otter	7	0.14	0.3	—		2.2	2.5
Total	1,465—1,477	93.8—94.4	561.0—690.0	7	123.0—151.0	819.0—853.0	1,503.0—1,694.0

In our study, we have analyzed actual data available in literature on Steller sea lions' feeding habits in various areas of the Sea of Okhotsk (northern part of the Sea of Okhotsk, Kuril Islands, Kamchatka) and rookeries (Belkin,1966; Panina,1966; Perlov, Panina 1969; Perlov, 1975; Waite, Burkanov, 2006; Usatov, Burkanov, 2014) to estimate the percentage of pollock in their diet.

According to data of Waite and Burkanov (2006), the occurrence rate of pollock in the bolus was 65.2% in the northern part of the Sea of Okhotsk, 62.4% near Kamchatka, 38.4% in North Kuril breeding rookeries. It is likely that pollock dominance in the diet of Steller sea lions is explained by its abundance in shelf ichthyocenoses where its percentage may reach 95–98% in some areas (Shuntov et al., 1993).

Similar data on pollock's role in the diet of Steller sea lions are provided in the study of R.L. Merrik et al. (1997) for Alaska Bay. Same as in the northern part of the Sea of Okhotsk, pollock dominates in ichthyocenoses in this area (Sinclair, Zeppelin, 2002; Trites, Calkins, 2008). Accordingly, its percentage in the diet of Steller sea lions was high and averaged at 66.5%. In the eastern part of Aleutian Islands and in the central part of the Bering Sea where pollock is less abundant this percentage was 32.2% and 40.2% respectively.

We have assumed data on pollock occurrence in the diet of Steller sea lions obtained earlier by a number of authors (Belkin, 1966; Panina,1966; Perlov, Panina 1969; Perlov, 1975; Waite, Burkanov, 2006) as a baseline and made our expert judgment on pollock percentage in the diet of Steller sea lions in the Sea of Okhotsk (Table 3.5).

Table 3.5. Expert data on pollock's role in the diet of Steller sea lions by areas of the Sea of Okhotsk (%)

Area	Northern part of the Sea of Okhotsk	Sakhalin	Kuril Islands	Kamchatka
Pollock	65	50	40	60

Knowing pollock percentages in the diet of Steller sea lions, we can estimate its annual consumption in biomass terms (Table 3.6).

Table 3.6. Expert judgment of annual pollock consumption by Steller sea lions in the Sea of Okhotsk (thsd tons)

Species	Northern part of the Sea of Okhotsk		Sakhalin		Kuril Islands		Kamchatka		Total in the Sea of Okhotsk	
	min	max	min	max	min	max	min	max	min	max
Pollock	14.5	28.5	6.8	13.6	13.6	26.23	1.4	2.73	36.4	71.1

Therefore, current annual pollock consumption by Steller sea lions in the Sea of Okhotsk may vary, according to our expert judgment, in the range of 36.4 to 71.1 thsd tons per year while total consumption of all aquatic organisms varies in the range of 72.4 to 141.2 thsd tons per year (see Table 3.3).

Using somewhat underrated data on pollock consumption by Steller sea lions, E.I. Sobolevsky earlier (1983) had estimated that all seal species (fur seal, Steller sea lion, bearded seal, ringed seal, spotted seal, ribbon seal) annually consume at least 240–280 thsd tons of pollock in the Sea of Okhotsk which accounts for about 6–7% of its total biomass (as of early 1980s). Including pollock consumption by cetaceans, total biomass of pollock consumed by all marine mammal species in the Sea of Okhotsk was reaching 330 to 350 thsd tons per year or 8–9% of its total biomass (Sobolevsky, 1983).

It should be noted that pollock's role in the diet of Steller sea lions in the Sea of Okhotsk grows during the winter–spring period which is explained first of all by pollock's pre-spawning migrations to its spawning grounds and its dense aggregations. A similar situation is typical of other Steller sea lion habitats, in particular, Alaska Bay and East Aleutian Islands (Sinclair, Zeppelin, 2002; Sinclair et al., 2013).

Based on studies of pollock consumption by Steller sea lions, it was proven that the majority of their prey were individuals of commercial sizes (68%) (Zeppelin et al, 2004).

In addition to pollock, herring is also important in the diet of Steller sea lions in the Sea of Okhotsk (Usatov, Burkanov, 2016), greenling, salmons and cephalopod mollusks in Kuril Islands and Southwest Kamchatka (Waite, Burkanov, 2006; Usatov, Burkanov, 2016).

4. North Sea of Okhotsk pollock catch volumes and structure of its fishery during last 5-10 years, current status of its stock

According to the current understanding, the North Sea of Okhotsk is populated by a single pollock grouping within the North Sea of Okhotsk, West Kamchatka, Kamchatka–Kuril subzones and in the high seas (61.52) which has a complicated intra-population structure (Shuntov et al., 1993; Zverkova, 2003). Recent results obtained through population studies using new more precise genetic methods based on molecular markers show that there are no inhomogeneous pollock populations in the northern part of the Sea of Okhotsk (Savenkov et al., 2012).

The breeding part of the North Sea of Okhotsk pollock population includes several breeding centers located on the West Kamchatka shelf, in shallow waters of the northern central portion of the sea (Lebed Rise, Pritauiskaya Area) and in Shelikhov Bay (in the end part of the Shelikhov Trough, 30-40 miles from Yamsky Islands) (Fig. 4.1) (Fadeev, 1981, 1987; Fadeev, Smirnov, 1994; Shuntov et al., 1993; Zverkova, 2003; Ovsyannikov, 2011). Significantly smaller spawning activities are observed in the periphery of the population – waters to northwest and southwest of Iona Island and off East Sakhalin. A specific feature of North Sea of Okhotsk pollock is redistribution of juveniles during their first years of life (Temnykh, 1989; Shuntov et al., 1993; Avdeev, Ovsyannikov, 2001; Fadeev, 2001; Avdeev et al., 2005; Avdeev, Ovsyannikov, 2006; Avdeev et al., 2008; Ovsyannikov, 2011). Pollock under two years of age inclusive is distributed in vicinity of major spawning areas on the shelf except Shelikhov Bay where one-year-old pollock is distributed in the southern part of a deepwater trough. Pollock at the age between one and two years migrates from spawning areas toward the continental slope. Thereafter, pollock juveniles continue migrating seawards and the age of 4 become distributed above large depths. In the spring season, more than 80% of 2-4-year-old individuals stay in vicinity of TINRO Basin, with smaller aggregations observed in vicinity of Deryugin Basin, Southwest Kamchatka and East Sakhalin. The direction and extent of juvenile migrations from breeding areas to nursery areas depends on the location of spawning grounds relative to TINRO Basin. Spawning migrations from the single aggregation of juveniles to breeding areas are observed for maturing pollock. The feeding area of mature fish encompasses virtually the whole sea basin.

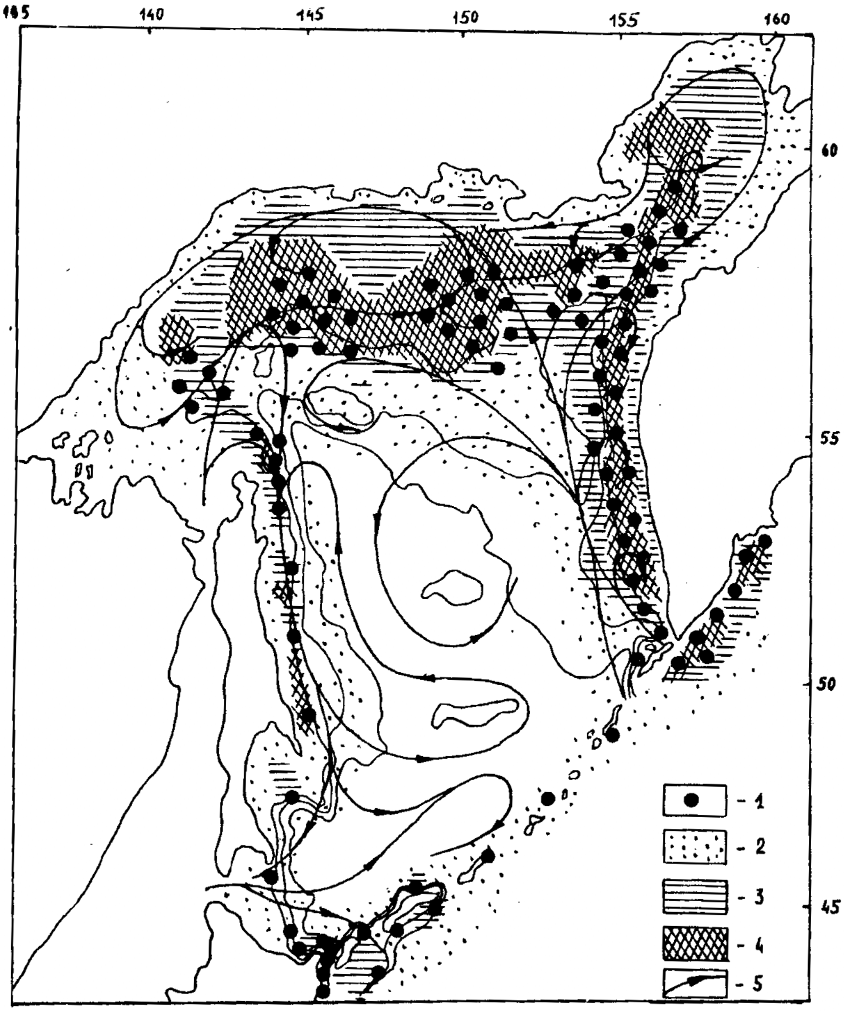


Figure 4.1. Averaged map of the breeding part of the pollock geographic range in the Sea of Okhotsk: 1 — spawning grounds, 2–4 — floating roe, intensity of shading corresponds to density of concentrations, 5 — generalized pattern of sea currents.
Depth contours of 200, 500 and 1000 m are shown by a solid line (Shuntov et al., 1993)

Based on the assumption that North Sea of Okhotsk pollock is characterized by a single population status, stock assessment and catch determination has been performed since 2007 for the whole population and then the estimated value was distributed between above mentioned subzones with account for predicted stock distribution, fishery specifics and life-cycle distribution of fish (Smirnov, Avdeev, 2001).

The pollock fishery in the Sea of Okhotsk dates back to 1950s. Initially, pollock was harvested by Japanese and Korean fishermen, and Russian fishermen started harvesting pollock in 1963. The main fishing area in the initial period was the West Kamchatka shelf, namely, the area lying south of the 54th latitude (Kamchatka-Kuril subzone) which was solely used before 1984 due to the-then Fishing Rules. During 1963-2016, pollock catch in the West Kamchatka and Kamchatka-Kuril subzones was varying in the range of 2 thsd tons (1963) to 1340 thsd tons (1974) (Fig. 4.2).

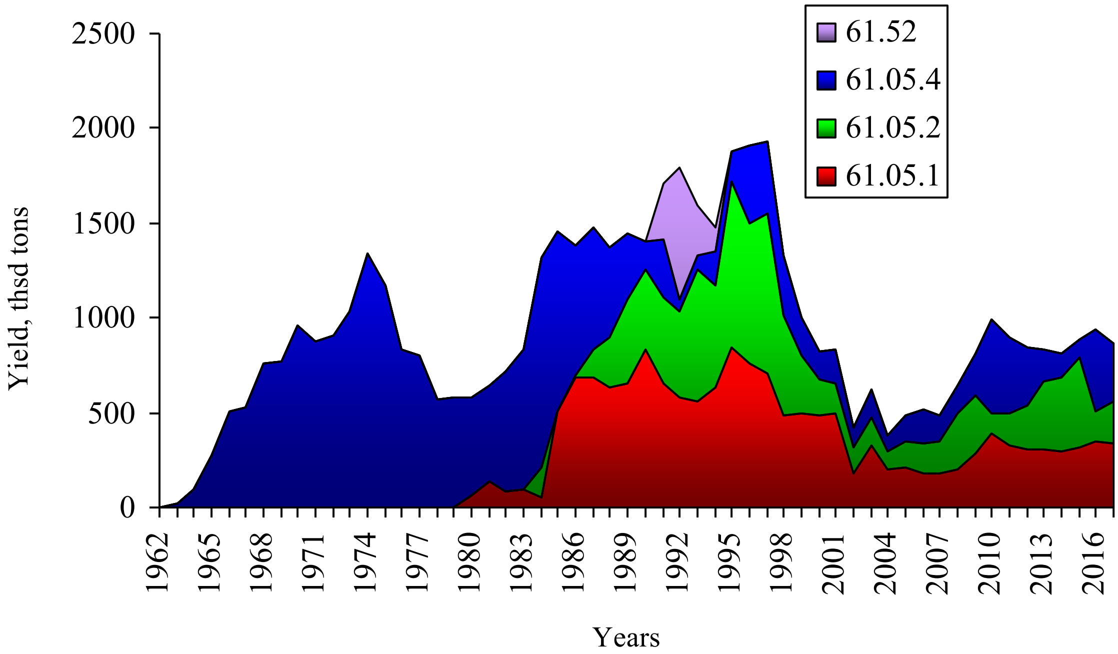


Figure 4.2. Dynamic of pollock yield in the North Sea of Okhotsk in 1962-2017

The pollock fishery in the North Sea of Okhotsk subzone dates back to 1977. Before 1984, yield in this area varied in the range of 0.2 to 100 thsd tons or within 17.2% of total yield in the entire sea. The importance of this area has greatly increased since 1985. Maximum yield of 847.6 thsd tons was registered here in 1995.

During 1990s, active pollock fishing operations were concentrated in the enclave, however, data are available for 1991-1994 only. Total catch in this area in 1992 amounted to some 693 thsd tons.

A record high yield in the above said fishing subzones registered during the history of pollock fishery in the North Sea of Okhotsk was 1,925 thsd tons in 1997. After that, due to an abrupt stock decrease, it had dropped more than 5 times by 2004 (Fig. 5.2). Yield began increasing after 2005 and reached 990 thsd tons in 2010. Due to reducing pollock stocks in the North Sea of Okhotsk since 2011, cumulative TAC and, accordingly, yield was decreasing. TAC and yield has been growing since 2015 and in 2016 amounted to 966.7 and 942.7 thsd tons respectively (rate of TAC use was 97.5%).

More details on the pollock fishery structure with a focus on 10 last years and analysis of the 2017 fishing season compared with the fishing seasons of preceding years are provided in the Report, prepared under Contract No. 13/17-NIR dated 15.05.2017 between FSBRI “KamchatNIRO” and NCO Pollock Catchers Association as part of annual audit under MSC certification procedures for the pollock fishery in the North Sea of Okhotsk, and focused on the following subjects: “Analysis of efficiency of the pollock fishery strategy in North Sea of Okhotsk" and "Uncertainty considerations for pollock stock assessment and TAC planning in the North Sea of Okhotsk".

As for the current condition of the pollock stock in the northern part of the Sea of Okhotsk, model-based estimates show that as of early 2016 total stock biomass and spawning stock biomass was 9.79 and 6.04 million tons respectively which corresponds to an above-average level. Briefly characterizing the pollock stock dynamic by results of model-based estimates (Fig. 4.3), we can state that the spawning stock biomass was growing in recent years and this trend will persist in the nearest future. The same picture is observed for the total stock biomass. This is explained by mass maturation of the year 2011 class (Fig. 4.4) the abundance of which we had slightly underestimated earlier. Furthermore, data on the age composition of catches and the age structure of the stock based on data of trawling surveys performed by TINRO-Center are indicative of high abundance of the year 2013 class.

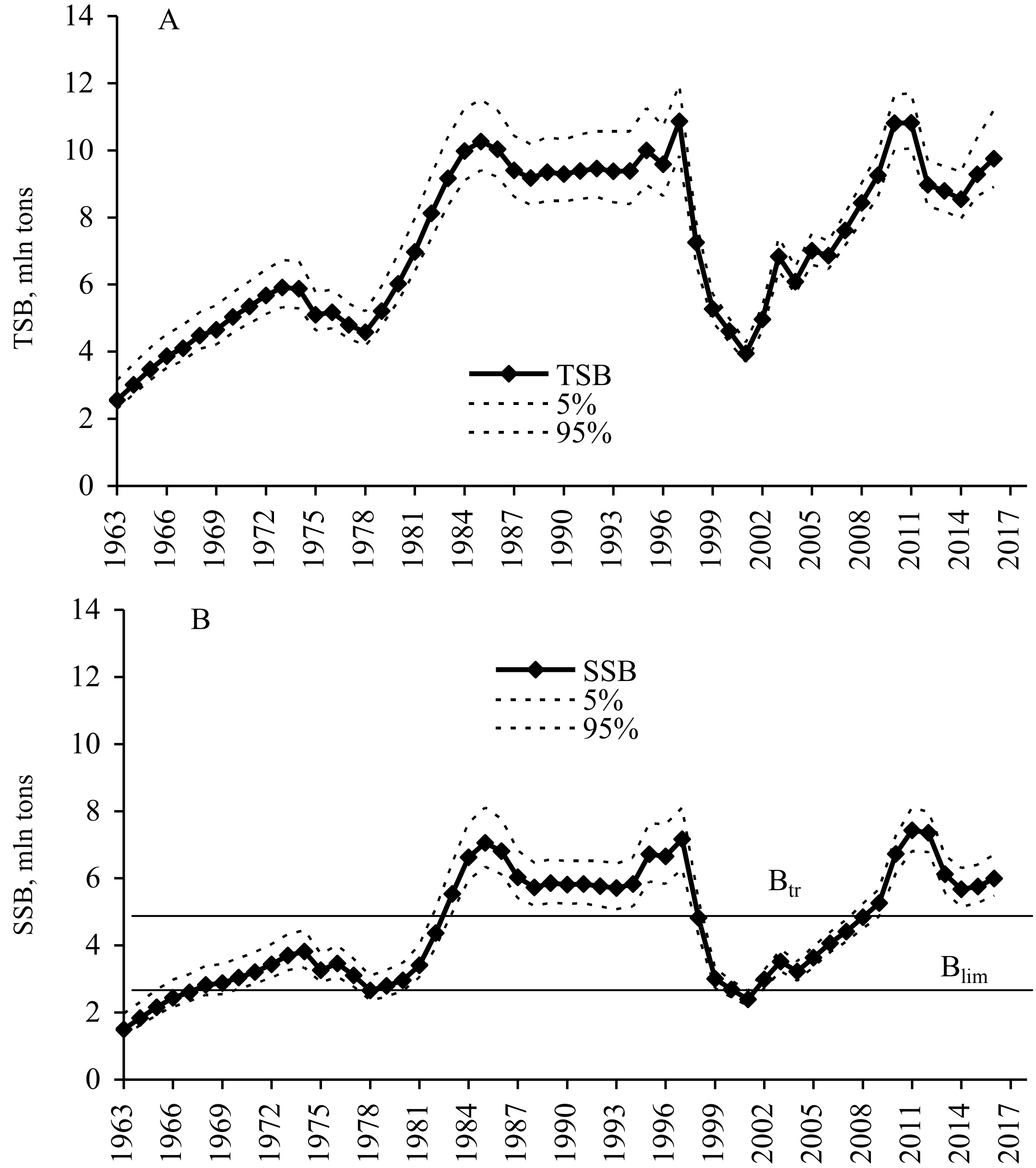


Figure 4.3. Year-to-year dynamic of Total Stock Biomass (TSB) (A) and Spawning Stock Biomass (SSB) (B) of the North Sea of Okhotsk pollock stock, bootstrap distribution percentilesy of estimates

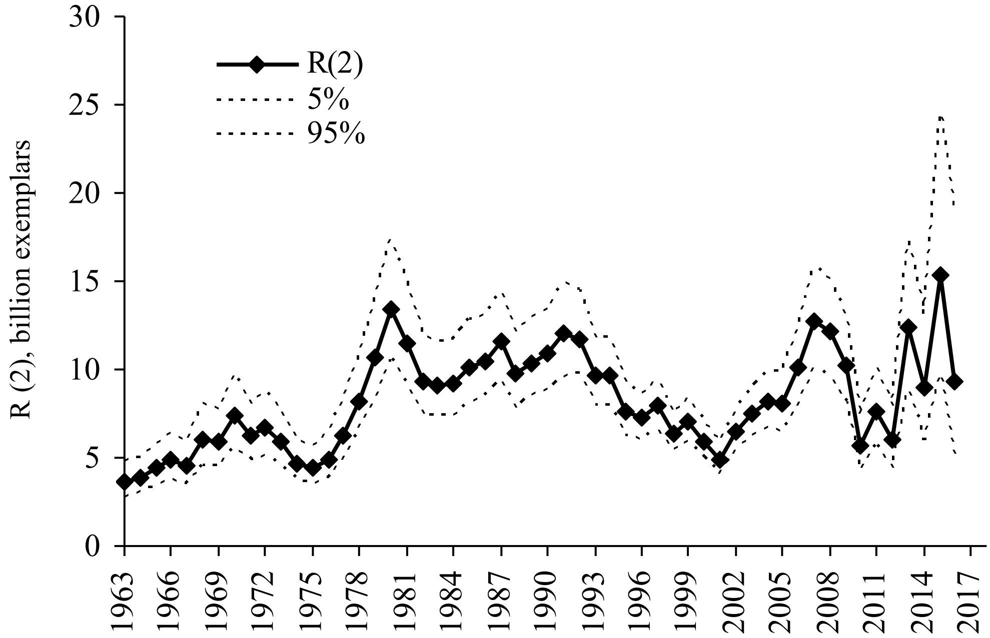


Figure 4.4. Year-to-year dynamic of recruitment numbers and bootstrap distribution percentiles of its estimates

According to expert judgments presented in the preceding chapter, Steller sea lions annually consume 36.4 to 71.1 thsd tons of pollock in the Sea of Okhotsk which amounts to less than 1% of this species' total stock biomass in 2016.

Given that weighted average of the yearly natural loss of North Sea of Okhotsk pollock due to all environmental factors is roughly 19%, our estimates of pollock mortality due to consumption by Steller sea lions look quite adequate.

5. Expert judgment on pollock fishery direct and indirect impacts on Steller sea lions in the northern part of the Sea of Okhotsk

Upon analysis of reasons for decreasing Steller sea lion numbers in Alaska and Aleutian Islands, a number of authors concluded that these animals have been affected by a set of adverse factors such as overhunting before 1970s, killer whale attacks, death in trawls and nets, diseases and some other factors (Perez, Loughlin, 1991; Springer at el, 2008).

However, many researchers believe the key factor of an abrupt reduction of sea lion abundance in the Pacific occurring at the end of the 20th century is changes in its feeding sources caused by the year-to-year stock dynamic and distribution of main prey items due to both environmental factors and fishery impacts (Merrick et al, 1995; Calkins et al., 1998; Loughlin, York, 2000 et al.)

Fishery impacts on marine mammals may be both direct (accidental by-catch and death from fishing gear, injuries inflicted to animals during fishing, etc.) and indirect (catch of aquatic organisms – feeding sources for Steller sea lions).

a) direct fishery impact

According to observations made by a specialist of FSBRI “KamchatNIRO” onboard a fishing vessel during the pollock fishing season in the Sea of Okhotsk in this years, 4–6 on average and sometimes up to 35 and more Steller sea lions gather near virtually every vessel performing fishing operations. They eat fish falling out from trawls, pluck out fish caught in mesh, feed on fish processing waste (heads, liver, internal organs, small fish, etc.) released from scuppers. Such animals sticking to vessels during the pollock fishing season most likely cease catching prey themselves.

Given that 146 trawlers operated in the target pollock trawl fishery in this year’s fishing season and another 42 ships were harvesting pollock by Danish seines, the total number of Steller sea lions feeding in this manner may reach several thousand individuals. The majority of Steller sea lions encountered near vessels in 2017 (more than 60%) were mature bulls and half-bulls. Juvenile animals were also observed.

In January 2017, in 6 out of 8 cases (75%) in Kamchatka-Kuril subzone (61.05.4) Steller sea lions were encountered in the night time from 00:25 to 03:20, and 65 individuals out of 68 ones registered in this subzone in January (95.6% of the total number of Steller sea lions) were observed in the night time.

The duration of Steller sea lions’ presence near a drifting vessel varied from 1 hour to one day and even more. Cases were registered when animals continued staying near vessels processing no fish. Probably, Steller sea lions may warm themselves in the water flowing from scuppers which is warmer than the sea water.

16 observers from three Far Eastern fishery research institutes working in the pollock fishery in the Sea of Okhotsk in January – April 2017 reported 4 cases when Steller sea lions were captured in trawls: one adult bull was live and released without any harm, other 3 animals (all bulls) were dead.

An occurrence rate of Steller sea lion capture by fishing gear during the whole fishing season (January 01 through April 09) and by all vessels of the fishing expedition including Danish seine catchers can be roughly estimated as follows.

The above said cases of capture were registered by observers reviewing a total of 1,035 fishing operations. All vessels of the fishing expedition performed 23,447 fishing operations during this period of time. Proceeding from these figures, we can calculate that some 91 animals might be theoretically captured by fishing gear which accounts for 0.4% of their total number. The resulting figure looks heavily overrated (at least two times) but even such mortality is insignificant and cannot produce any adverse effects on the abundance and condition of Steller sea lions living in the regions of the Sea of Okhotsk Basin. Natural mortality of adult Steller sea lions in a breeding rookery is somewhat higher and amounts to as little as 0.5% for adult animals (Altukhov et al., 2012; Permyakov, 2014).

Accidental by-catch of Steller sea lions is also observed in the herring fishery. Thus, their potential loss in 2002 by results of estimation of the total number of Steller sea lions captured in trawls by all vessels during the herring fishery in the Bering Sea turned out to be 18–70 individuals (CI 95%) (Burkanov et al., 2006). In the opinion of these authors, death of such number of males hardly affects their abundance.

To obtain more credible results of Steller sea lion by-catch in the pollock fishery in the Sea of Okhotsk, relevant studies should be further continued including surveys on board different vessel types with different fishing gear types and using state-of-the-art video registration instruments (automatic photo recorders).

b) indirect fishery impact

There is quite much evidence in literature that feeding sources (aggregations of schooling fishes) of Steller sea lions may be significantly depleted due to intensive fishing activities and, as a result, they may leave such areas, another reason being harassment. As the abundance of prey (fish) and its size reduces and in case of changes in distribution and composition of communities, competition for prey may increase (Tites et al., 1997; Hui, 2011).

As was stated above, the pollock stock in the northern part of the Sea of Okhotsk is currently at a higher-than-medium level and its biomass amounts to some 9.79 million tons. Total pollock catch is some 960 thsd tons or as little as 9.8% of its biomass.

In this context, it is worth saying that since 2007 stock condition forecasts and TACs planning for this stock for 2 years ahead have been performed using a mid-term prediction method within the precautionary approach to fish resource management (Babayan, 2000). To this purpose, a zonal scheme was developed for fishery management processes and biologically permissible limits for stock exploitation were evaluated (spawning biomass and fishing mortality reference points). Recommended catch depends on stock condition which makes overfishing impossible.

We believe that, given such total stock biomass and yield of pollock, there is no ground for discussions about shortage of feeding sources for Steller sea lions. It is important to emphasize that, according to our observations, a considerable portion of Steller sea lions just “parasitize” during the winter-spring fishing season feeding primarily on fish processing waste, fish fallen out from fishing gear and, therefore, meet no food shortages, at least in this period.

Unfortunately, such data are unavailable for other periods, in particular, for the period of summer Danish seine fishery off West Kamchatka and during the so-called B (autumn-winter) season of the target pollock trawl fishery. Special studies on this issue will be required in the future and, furthermore, locations should be identified where the majority of Steller sea lions from near-by rookeries in the Sea of Okhotsk forage and whether such locations coincide with areas where fishing vessels perform trawling operations. In that case, we will find out if there is competition for pollock resources between fisheries and Steller sea lions in some parts of the Sea of Okhotsk or not.

6. Observations on distribution, abundance and behavior of Steller sea lions and other marine mammals in pollock trawl fishery areas in the northern part of the Sea of Okhotsk in January – April 2017

6.1. Species and quantitative composition, spatial distribution of marine mammals in trawl fishery areas in the Sea of Okhotsk in January – April 2017

Observations were performed by A.I. Blokhin, junior research fellow of FSBRI "KamchatNIRO" on board the BATM *Baklanovo* in January – first half of April 2017 in the northern part of the Sea of Okhotsk during the pollock fishing season.

Ice conditions in this year were markedly different from preceding years. Areas covered with ice in previous years were ice free in this year, and true seals normally populating ice fields with high densities in this period and breeding in pollock fishing areas (spotted seal, ribbon seal, ringed seal and others) moved to sea areas covered with ice. Steller sea lions normally taking rest on ice floes in the same areas had no place for rest which might affect their abundance in fishing areas. Furthermore, it is much easier to register animals lying on ice than staying in the open water and virtually invisible even amid small waves at some distance from the ship. Therefore, we can state that conditions for our marine mammal count survey in this year were more difficult and we might potentially underestimate the number of ice forms of seals and Steller sea lions in areas earlier covered with ice but ice free in this year.

Marine mammals were registered on 203 occasions during the study period. They were observed solo or in groups of 2 to 79 individuals. A total of 1,306 individuals were registered. They belonged to 11 species (Table 6.1.1). In three cases, cetaceans were not identified by species (in two cases they were live and in one case it was a dead animal drifting on the surface).

The most frequently occurring and most abundant species in pollock and herring fishery areas was Steller sea lion (46.8% of all encounters and 48.5% of the total number). Northern fur seal ranked second in occurrence terms (13.3%) but it was normally observed as solo individuals, rarely as groups of 2 to 3 animals and only in one case 7 individuals were simultaneously observed near the ship; that's why it accounts for only 3.8% of the total number. Spotted seal ranked third in occurrence terms – 8.9% and accounted for 21.1% of all encountered animals which is a second-largest percentage. Minke whale ranked fourth – 8.4% in occurrence terms and 2.2% of the total number. Ribbon seal was fourth in occurrence terms (7.9%) and third in abundance terms (16.5%). It was followed by Dall's porpoise (6.9% and 5.3% respectively) and North Pacific right whale (2.5% and 1.1% respectively). The remaining species were characterized by an occurrence rate of about 1% and accounted for less than 1% of the total number (see Table 6.1.1).

Table 6.1.1. Species and occurrence rate of marine mammals in the Sea of Okhotsk in January – April 2017

Item No.	Species	Occurrence rate based on the number of encounters, %	Percentage of species, %
1	Dalls' porpoise (*Phocoenoides dalli*)	6.9	5.3
2	Sperm whale (*Physeter catodon*)	1.0	0.5
3	Ringed seal (*Pusa hispida*)	1.0	0.2
4	Killer whale (*Orcinus orca*)	0.5	0.1
5	Ribbon seal (*Histriophoca fasciata*)	7.9	16.5
6	Spotted seal (*Phoca largha*)	8.9	21.1
7	Minke whale (*Balaenoptera acutorostrata*)	8.4	2.2
8	Northern fur seal (*Callorhinus ursinus*)	13.3	3.8
9	*Steller sea lion (*Eumetopias jubatus*)	46.8	48.5
10	*Finback whale (*Balaenoptera physalus*)	1.5	0.3
11	*North Pacific right whale (*Eubalaena japonica*)	2.5	1.1
12	Whale (species not identified)	1.0	0.2
13	Dead rorqual (probably finback or sei whale)	0.5	0.1

*- species listed on the Red Book of Russian Federation

As our observer was unable to change the heading of the ship on board which he was based or duration of stay in any particular area, he recorded encounters with animals only in those locations and in that period of time where and when that ship was staying within the Sea of Okhotsk. In this connection, results of our survey of the spatial distribution and relative abundance of marine mammal species in pollock fishing areas have been largely affected by the ship's fishing activities. Dark spots in Figure 12 below reflect both more frequent encounters and duration of the ship's stay in this location and ice conditions in its operating area. If the ship was engaged in fishing or transferring its produce in ice, the number of encounters with mammals was immediately increasing. The number of encounters with spotted seals and Steller sea lions increased closer to shore during cargo transfer, and ribbon seals were present in more seaward ice-covered areas in addition to spotted seals and Steller sea lions. A more detailed description of encounters with individual marine mammal species is provided below.

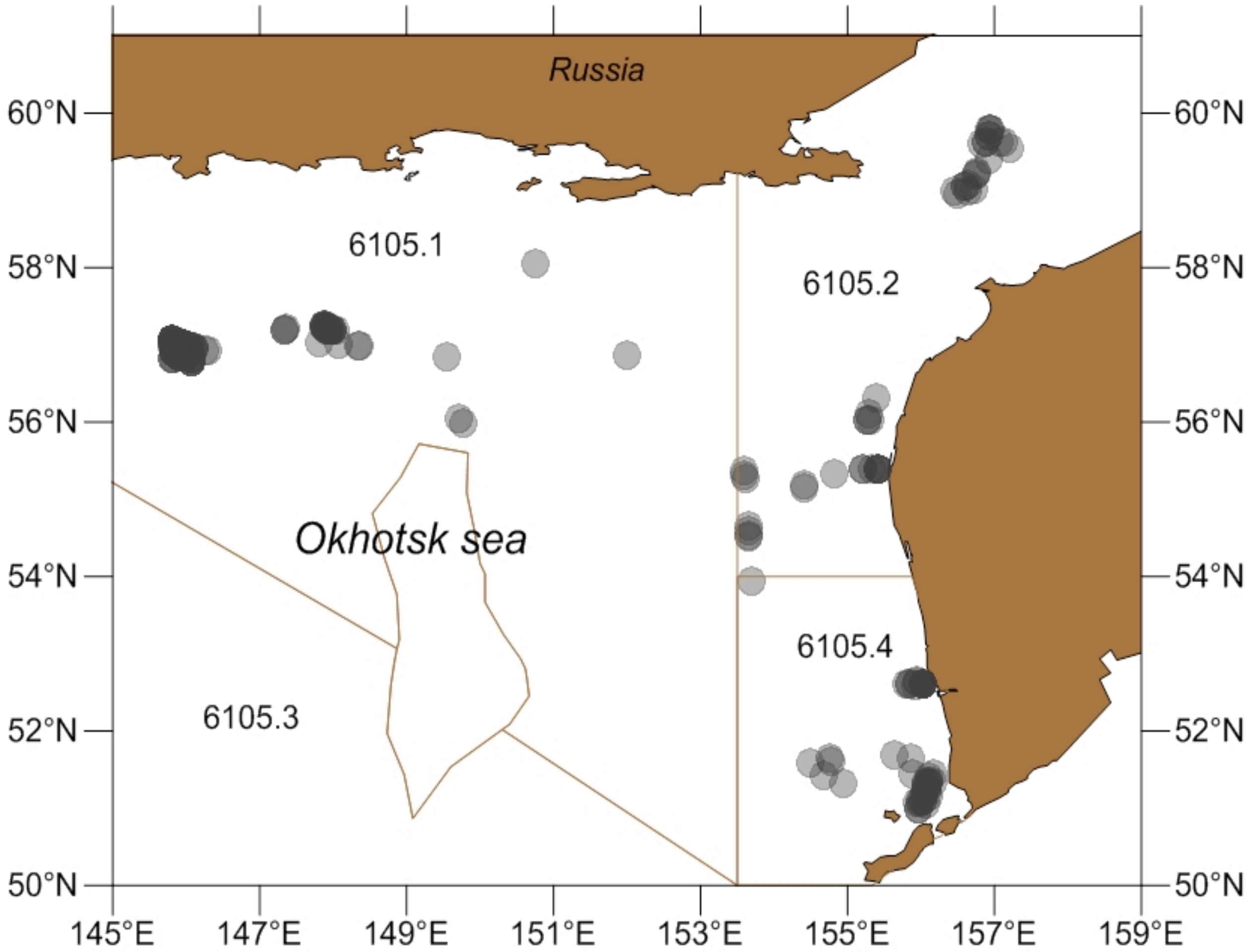


Figure 6.1.1. Locations of encounters with marine mammals (all species) in the Sea of Okhotsk in January – April 2017

** - Hereinafter, the coloring intensity of dots indicate the number of encounters. Animals were encountered more frequently in darker spots.*

Steller sea lions.

Steller sea lions were registered in all locations where the ship carrying the observer was operating. In total, these animals were encountered in 95 cases. Steller sea lions were observed both in ships' immediate vicinity and at a distance from them, afloat in the water and at rest on ice. Roughly in 36.8% of cases, animals were moving solo or in groups of up to 3 individuals. In 43% of cases, they were met in groups of 4 to 10 individuals and in 20% of cases their groups counted more than 10 individuals (Table 6.1.2).

Table 6.1.2. Occurrence of Steller sea lion groups in January – April 2017

Number of animals in group	Occurrence of groups, %	Number of groups	Total number of animals in these groups
1-3	36.8	35	71

4-10	43.2	41	244
11-35	20.0	19	318
TOTAL		**95**	**633**

It should be noted that the majority of encounters with Steller sea lions took place in vicinity of their shore rookeries and in sea areas covered with ice (Fig. 6.1.2).

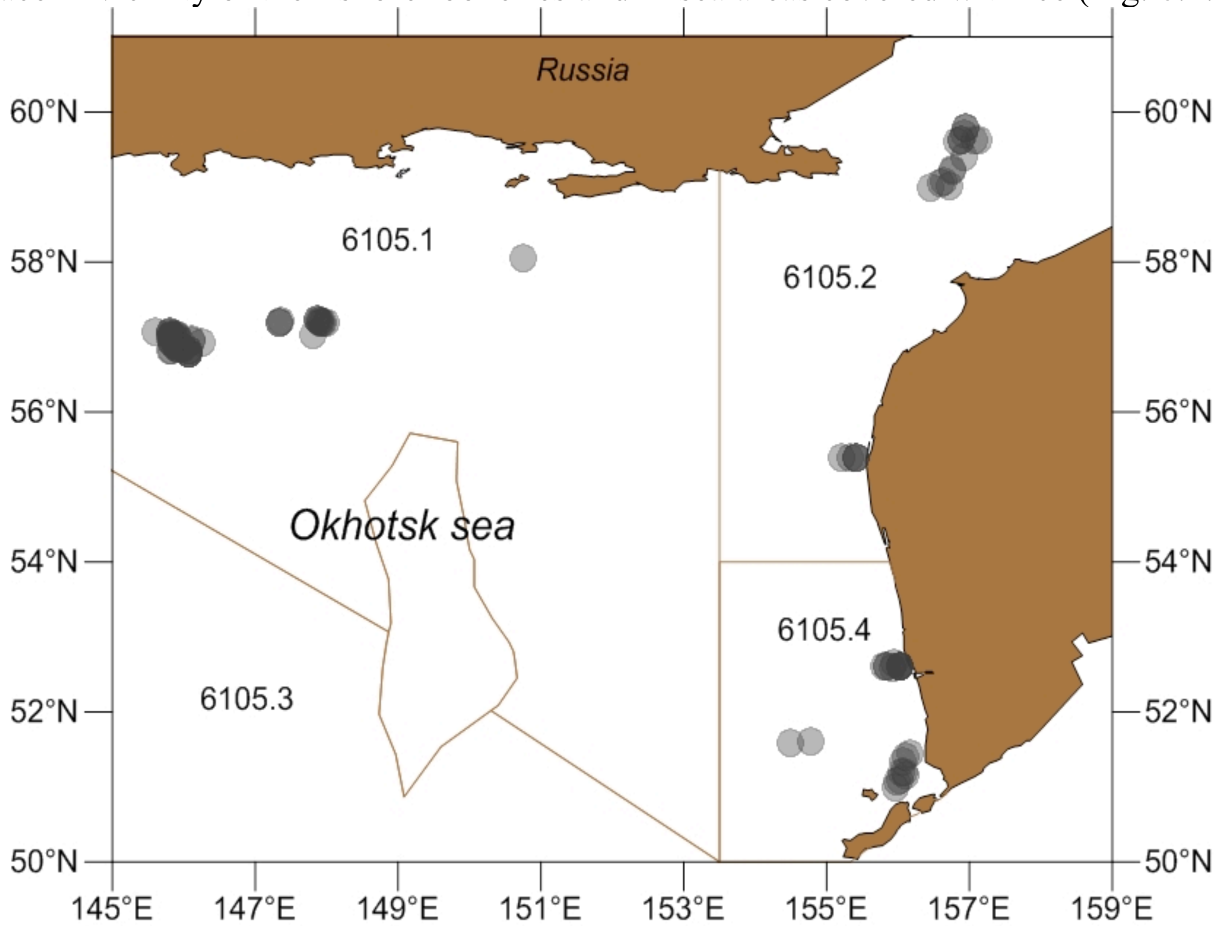
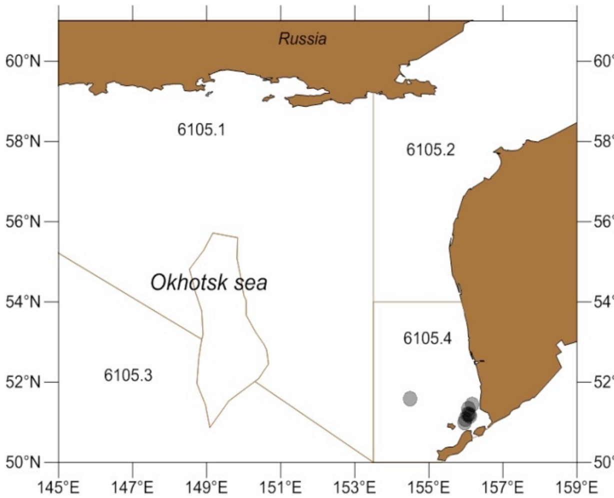


Figure 7.1.2. Locations where Steller sea lions were observed in the Sea of Okhotsk in January – April 2017

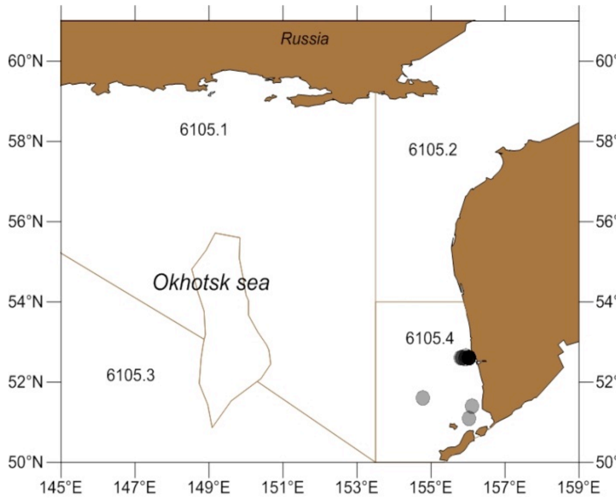
It should be noted that the ship carrying our observer was operating in the same area for a long time and the same individuals might be repeatedly included in the number of encounters and in total number of identified animals. It is likely that animals migrate in the Sea of Okhotsk and the same animals may be registered in its different areas, for instance, tagged male И461 was registered on March 16, 2017 during cargo transfer in coordinates 57°13’7 N 147°55’7 E, and on March 28, 2017 is was repeatedly observed in 53 miles from the place of the preceding encounter with it in coordinates 56°50’5 N 146°04’4 E.

That’s why the above figures should be considered as data on relative abundance of animals in pollock and herring fishing areas. They do not reflect the real number of Steller sea lions. Data collection methods for marine mammals are not suitable for any estimates on their abundance.

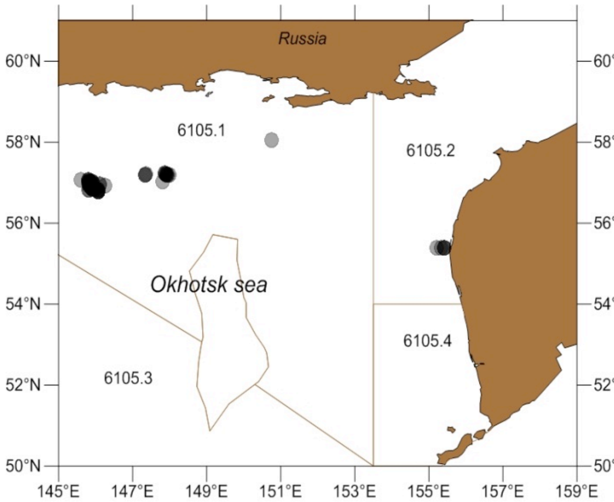
Maps of Steller sea lion encounters by months and a graph of encounters during the voyage are shown in Fig. 6.1.3–4.



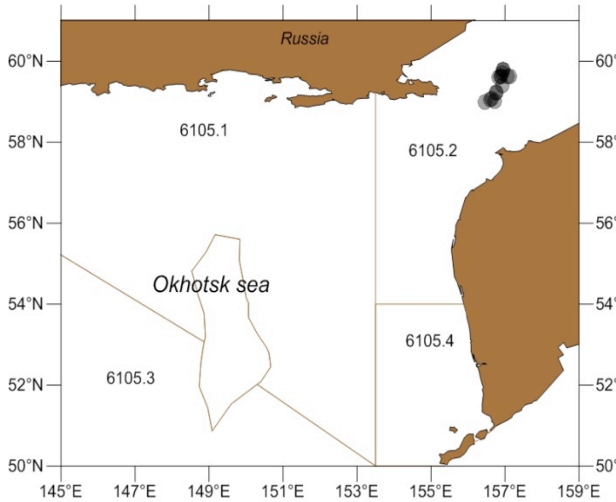
a) January



b) February



c) March



d) April

Figure 6.1.3. Locations where Steller sea lions were observed in the Sea of Okhotsk, by months January – April 2017

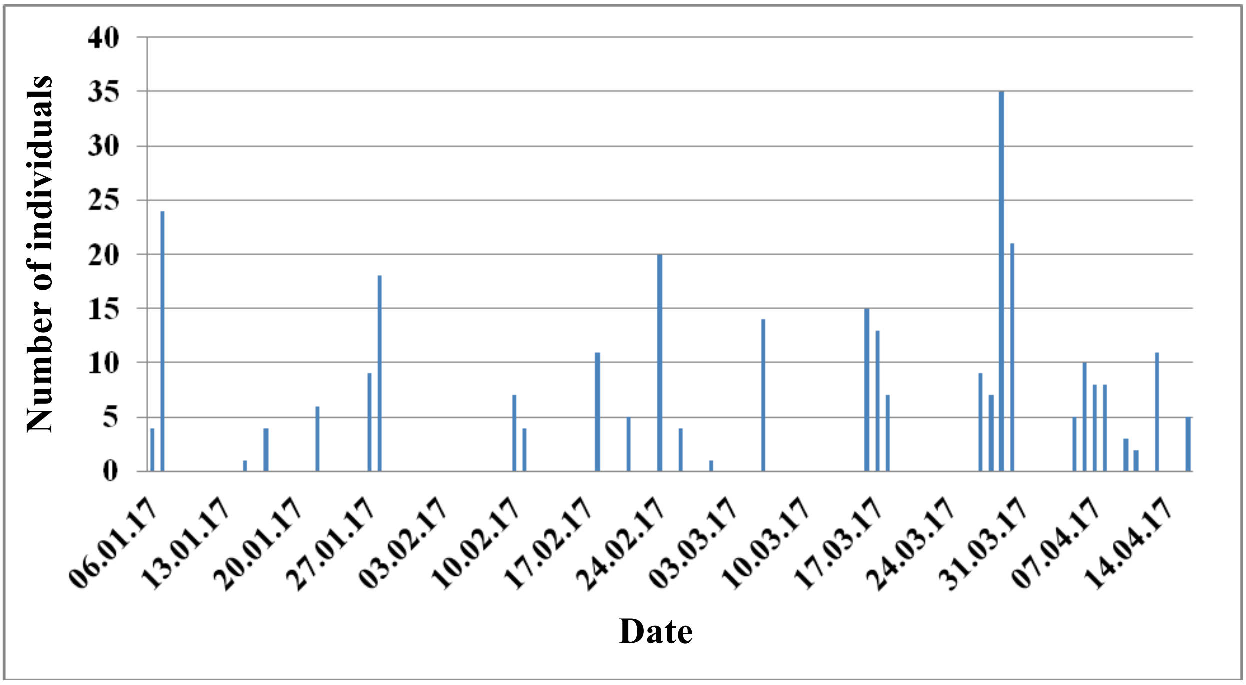


Figure 6.1.4. Encounters with Steller sea lions in January – April 2017

Northern fur seal

This species was met mostly amid ice in the northern part of the Sea of Okhotsk in the North Sea of Okhotsk subzone (61.05.1) and only in one case an adult male was encountered in Kamchatka-Kurile subzone (61.05.4) near Oktyabrsky settlement when the ship was engaged in cargo transfer operations in the transport corridor (Fig. 6.1.5). The animal sat on ice in 2 miles from the ship. In one case, a northern fur seal was swimming by the ship's side when the ship was engaged in herring fishing in Shelikhov Bay (subzone 61.05.2).

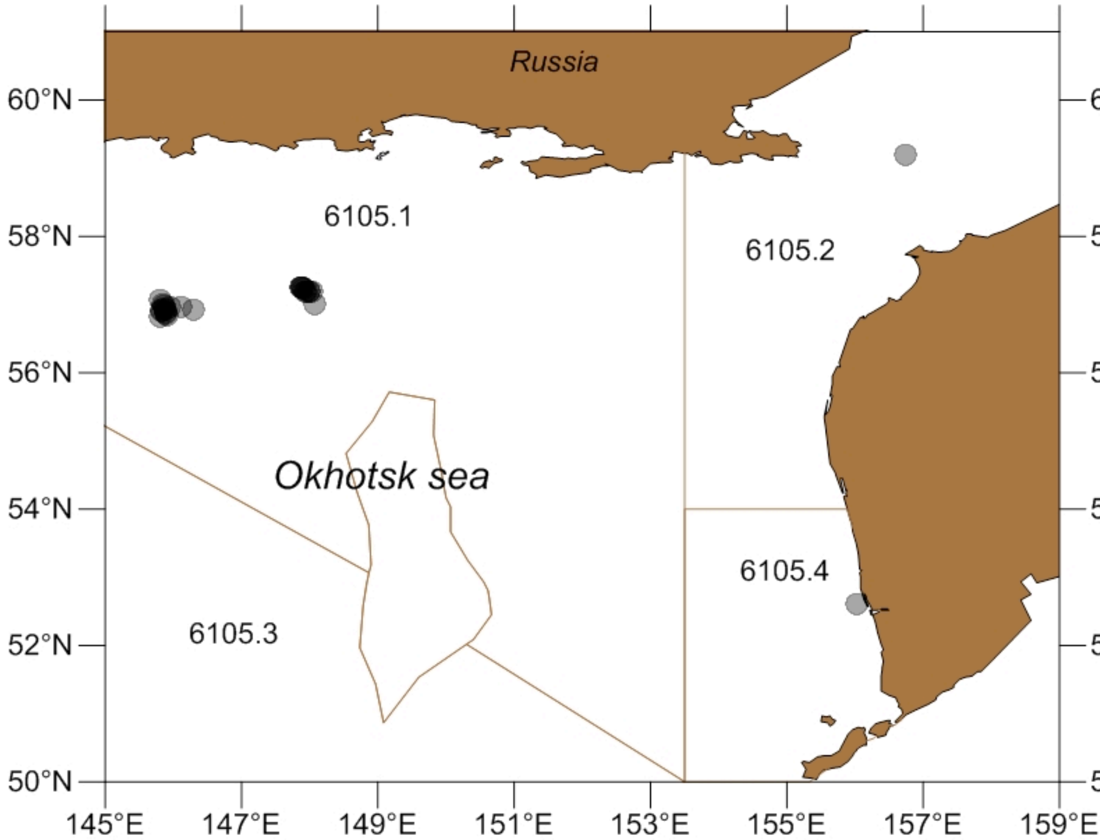


Figure 6.1.5. Locations where northern fur seal was observed in the Sea of Okhotsk in January – April 2017

In total, 50 fur seals were encountered on 27 cases. More than in half cases, these were solos (15 cases or 56% of encounters), roughly in 1/3 cases they were met in pairs (8 cases or 30% of encounters) and in 15% of cases there were more than 2 individuals. The maximum number of animals in a group was 7. Fur seals were observed on ice only two times, in all other cases they were in the water.

Spotted seal

This species was met in three fishing areas (Fig. 7.1.6). Animals were observed only in locations with a consolidated ice cover: 42 individuals were counted around the ship during 2 days in the course of a cargo transfer operation in vicinity of Oktyabrsky settlement and 22 individuals were counted also during 2 days in the course of a cargo transfer operation in vicinity of Sobolevo settlement. The majority of animals were registered in the North Sea of Okhotsk subzone on March 27, 2017 when the ship was fishing for pollock in an area with an intact ice cover during three days. 210 individuals were registered during this period. The maximum number of spotted seals observed around the ship at any one time was 79. One individual lying on an ice floe was registered on March 29, 2017. All animals were met either on ice or in the water amid ice.

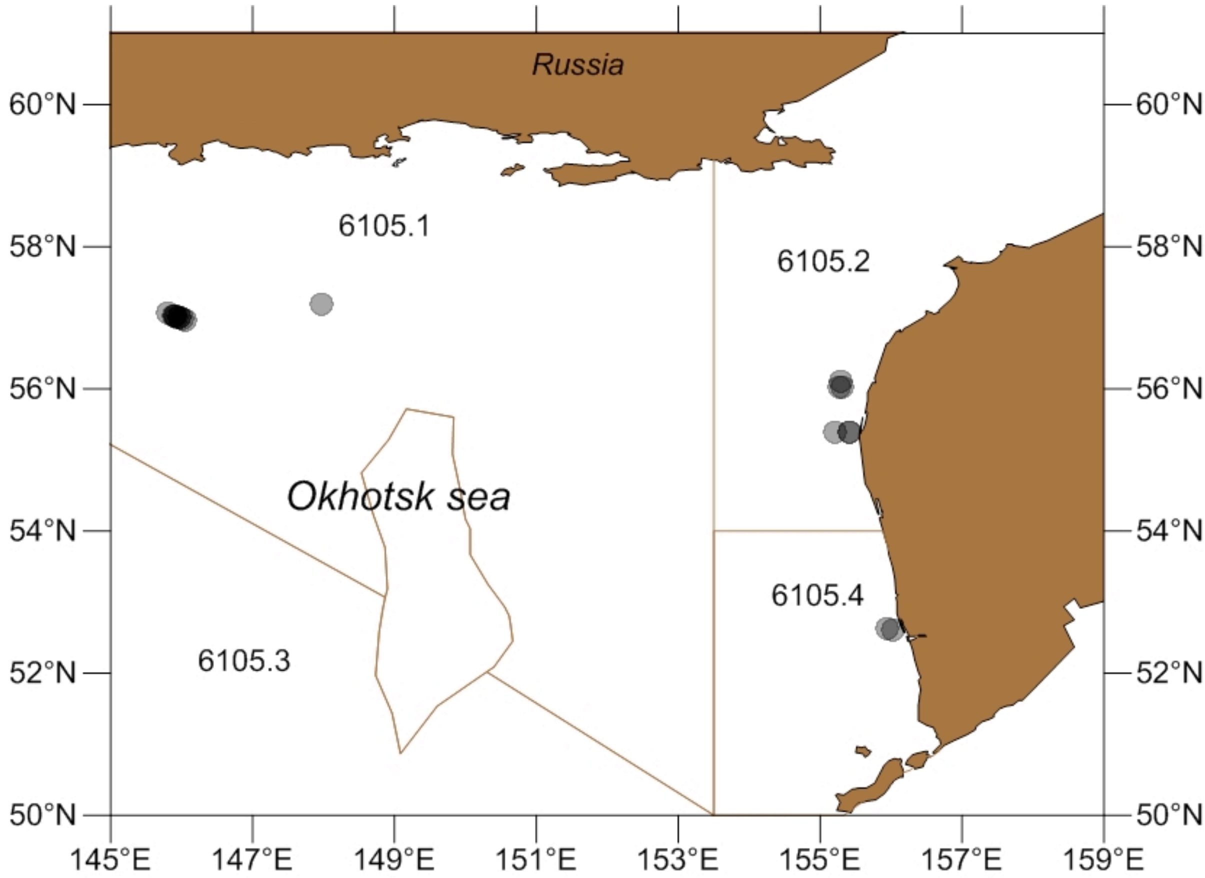


Figure 6.1.6. Locations where spotted seal was observed in the Sea of Okhotsk in January – April 2017

Ribbon seal

The spatial distribution of ribbon seal in 2017 was very similar to that described above for spotted seal, the only exception being that ribbon seals did not come close to shore into transport corridors (Fig. 6.1.7). Both species belong to ice forms of seals and tend to be near strong dense ice in this period where they give birth to their young and rear pups in March – April. In total, 216 ribbon seal individuals were registered. They were observed in the North Sea of Okhotsk subzone during 27–30 March – 206 individuals were encountered on 27 March, the first day of the ship's arrival in an area with a dense ice cover, and up to 48 were staying around the ship simultaneously. On next days, 28–30 March, when the ice was broken by the ship, other ships arrived and started trawling along the same routes and, accordingly, harassment factor abruptly grew, only 7 encounters with a total of 10 ribbon seals occurred.

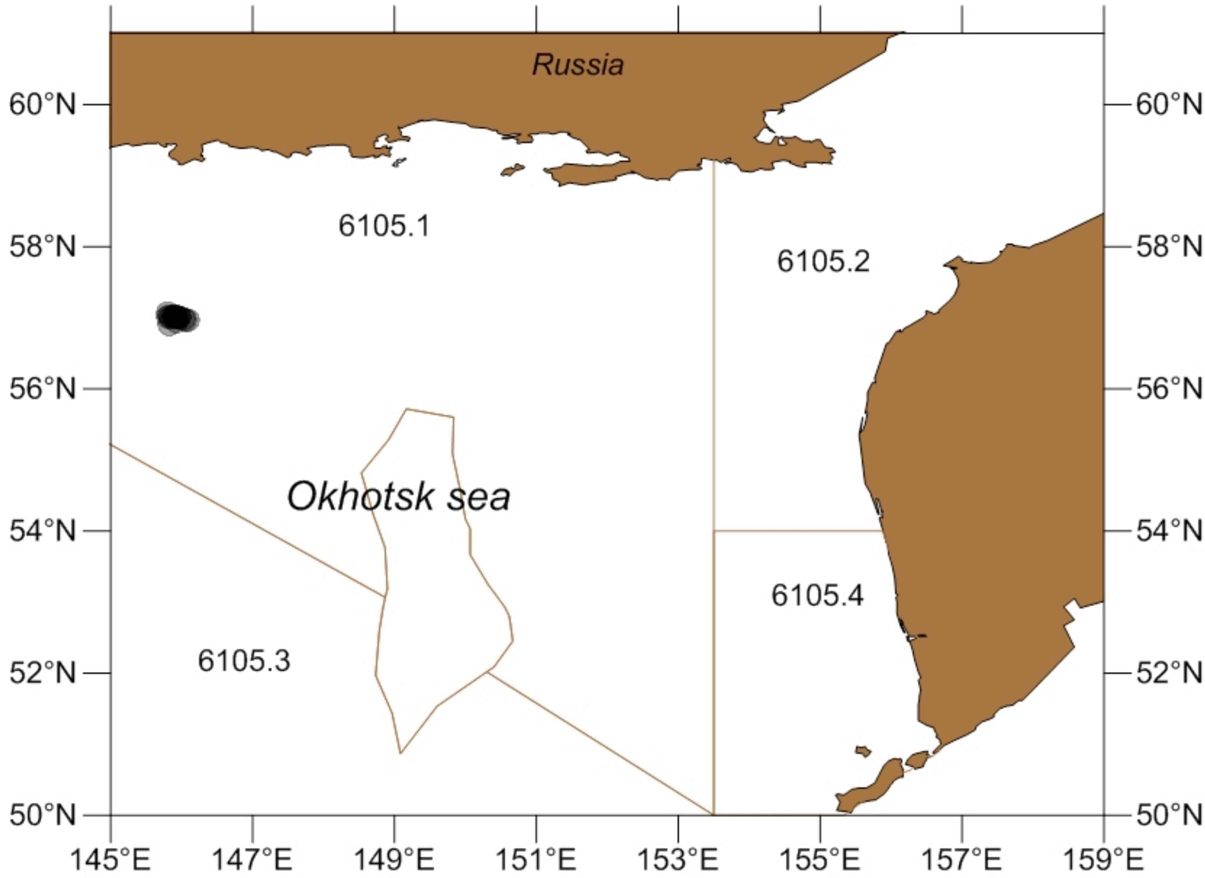


Figure 6.1.7. Locations where ribbon seal was observed in the Sea of Okhotsk in January – April 2017

In addition to pinnipeds, 6 cetacean species were encountered in pollock trawl fishing areas in the Sea of Okhotsk in January – April 2017. Three of them belonged to baleen whales (Mysticeti): Minke whale, finback whale and North Pacific right whale, and three others belonged to toothed whales (Odontoceti): Dall's porpoise, sperm whale and killer whale.

Dall's porpoise

Dall's porpoise is the most abundant cetacean species in pollock fishery areas in the Sea of Okhotsk (Fig. 6.1.8). A total of 69 individuals were encountered on 14 occasions: 7 times in subzone 61.05.2, 6 times in subzone 61.05.4 and one time in subzone 61.05.1. The size of groups varied from 1 to 14 individuals averaging at 4.9 individuals.

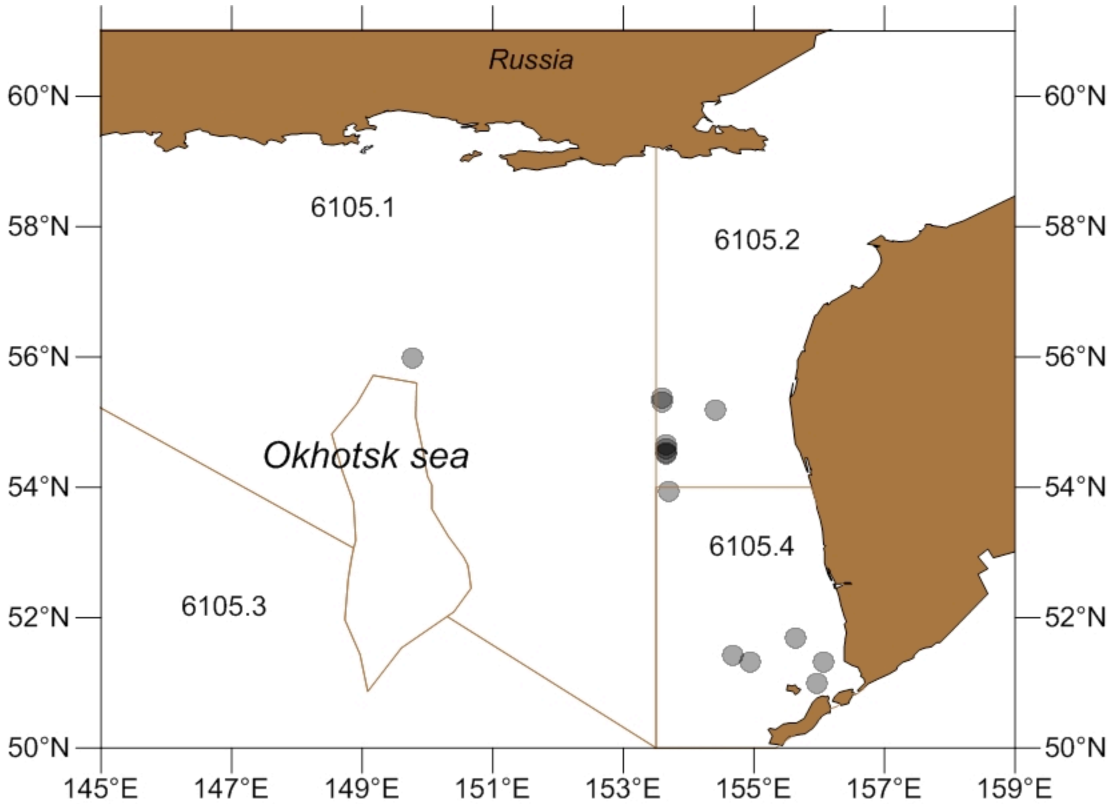


Figure 6.1.8. Locations where Dall's porpoise was observed in the Sea of Okhotsk in January – April 2017

Minke whale

This species ranked first among cetaceans in occurrence terms and second in abundance terms after Dall's porpoise. This is one of widespread cetacean species. Its spatial distribution during the fishery does not reflect distribution of efforts on marine mammal observations. Although the majority of trawling operations were performed by ships in Kamchatka-Kuril subzone, Minke whales were encountered in this fishing area only 4 times and their total number was 7. West Kamchatka subzone is leading in terms of Minke whale encounters – 8 cases and 12 animals, and 10 Minke whales were encountered on 5 occasions in the North Sea of Okhotsk subzone (Fig. 6.1.9).

In 47% of cases, these were solo animals, in 35% of cases they were in pairs and groups of three individuals were registered in 18% of cases.

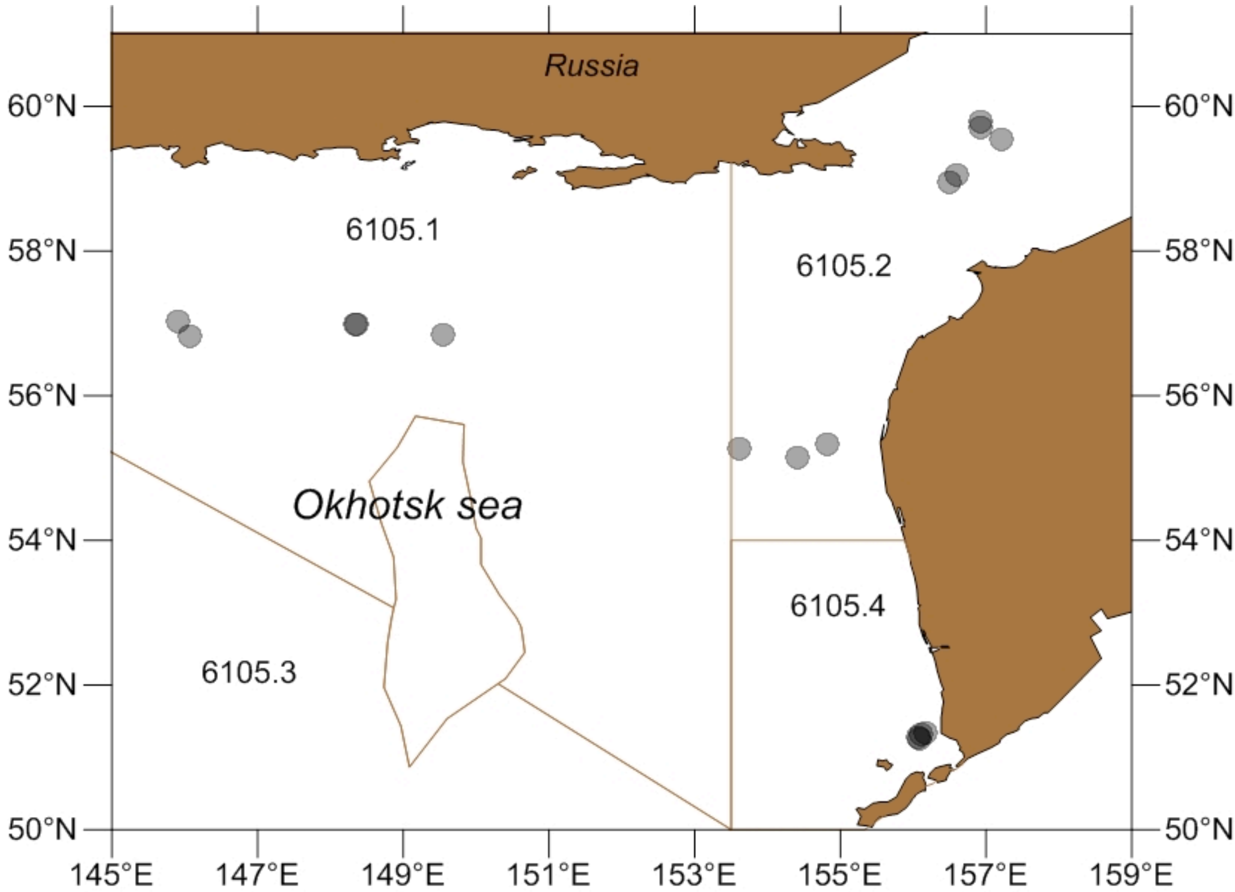


Figure 6.1.9. Locations where Minke whale was observed in the Sea of Okhotsk in January – April 2017

North Pacific right whale

During the whole observation period, North Pacific right whale was met 5 times near the southern boundary of Kamchatka-Kuril subzone in vicinity of Atlasov Island (Fig. 6.1.10). As a group of 3 individuals was observed in each case, it can be supposed that it was the same group (a family) staying in the same area for a long time.

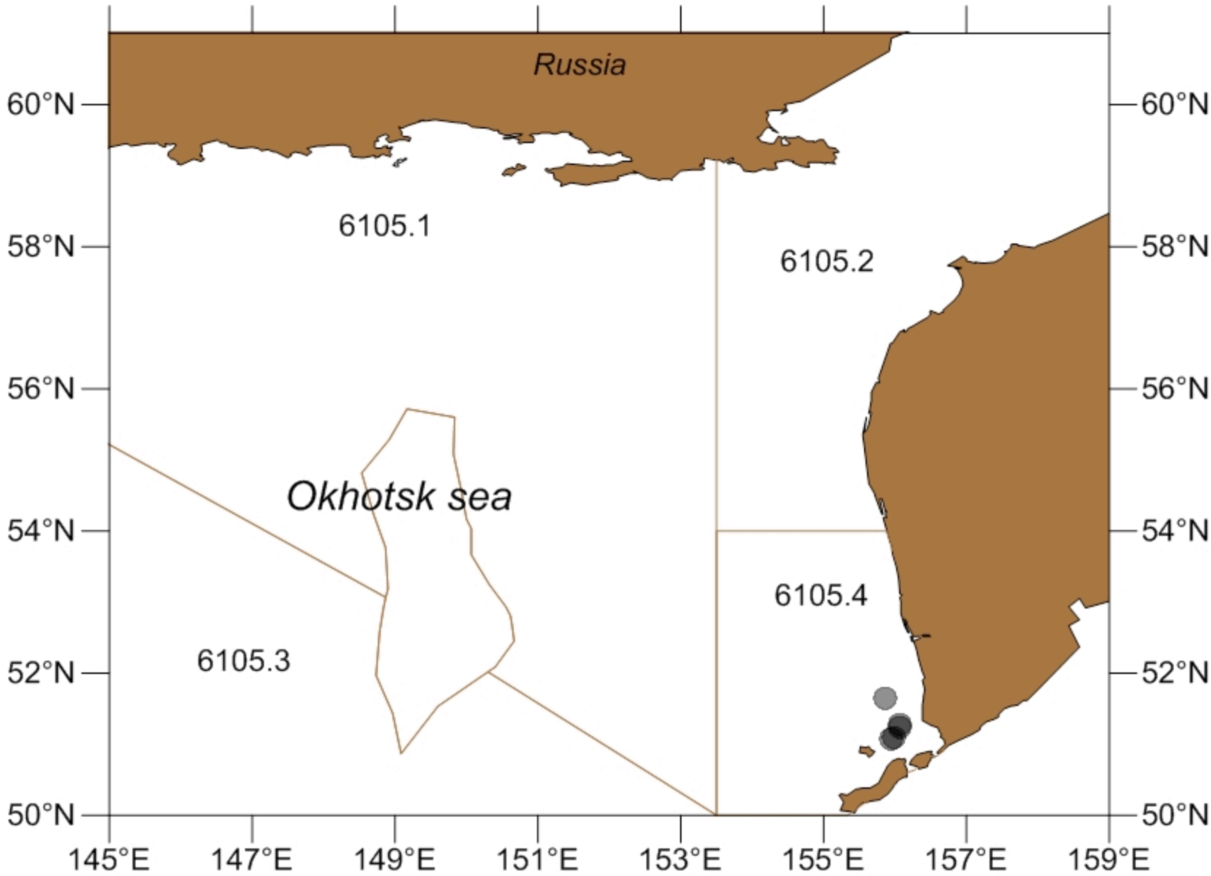


Figure 6.1.10. Locations where North Pacific right whale was observed in the Sea of Okhotsk in January – April 2017

Killer whale, sperm whale, finback whale

These animals were encountered in pollock fishing areas in the Sea of Okhotsk a few times during the whole season (1 to 3 times). Killer whale was encountered once (one individual, March 14, 2017) in the North Sea of Okhotsk subzone. Sperm whale was registered twice – 2 and 5 individuals (20 January and 26 February) near the southern boundary of Kamchatka-Kuril subzone. These animals were keeping at a distance of 2 to 7 km near a seabed drop-off. Finback whales were encountered on three occasions: 2 times in Kamchatka-Kuril subzone – 12 January and 13 February (two individuals and one individual respectively) and one time in West Kamchatka subzone – April 04, 2017 in Shelikhov Bay in passage to the herring fishery area.

6.2. Specific features of marine mammal behavior near fishing vessel

The vast majority of marine mammals encountered in the Sea of Okhotsk in the pollock trawl fishery did not show any reaction to or any noticeable interest in operating fishing vessels either during fish catching or fish processing. In terms of their interaction with vessels engaged in trawl fishing for pollock, marine mammals can be brought together into two groups: species indifferent or neutral to pollock fishery and species dependent on or somehow interacting with pollock fishery.

5 cetacean species could be included in the first group: Dall’s porpoise, killer whale, sperm whale, finback whale and North Pacific right whale. It should be noted

that all these species were encountered extremely rarely – 1 to 5 times during the whole observation period. Detection of these animals was not related with their interest in human economic activities. The above said animals live in those areas of the Sea of Okhotsk where pollock fishery is performed. Only Dall's porpoise was met near vessels quite often. These animals were observed on 14 occasions (6.9% of all encountered marine mammals). A typical common feature for all species was a short duration of the encounter and moving away from the vessel to a large distance. Only Dall's porpoises were approaching vessels closer than 100 meters – they changed direction of their movement and swam toward the vessel. However, such behavior is typical of this species and has no relation to the fact that the vessel was engaged in fishing. In most cases, Dall's porpoises approached the vessel in passage when its speed was above 10 knots and accompanied it for some time, playing and swimming in front of its stem. Porpoises often approach vessels (not only fishing ones) and accompany them for some time.

Steller sea lion, Minke whale, northern fur seal, spotted seal and ribbon seal could be included in the groups of marine mammals dependent on or interacting with a fishing vessel. These animals showed interest in the fishing vessel and reacted to its appearance in some way. As their behavior and character of interaction with the vessel was specific for different animal species, we will briefly discuss these relationships separately for each species.

Minke whales were met near the ship in 17 cases. They were the only cetacean species markedly reacting to a fishing vessel and changing their behavior. In half of all cases, this whale appeared in the ship's immediate vicinity during its operations relating to trawl hauling (Fig. 6.2.1).

Figure 6.2.1. A Minke whale approaches the ship during trawl hauling (photo by I.A. Blokhin)

Normally, this whale can be seen on the surface only one time during observations and rarely two or more times. A typical feature of Minke whale's behavior near fishing vessels was that it was following astern the ship for a long time (sometimes up to 15 minutes), behind or above its trawl, repeatedly surfacing roughly at the same distance from the ship.

It was most likely feeding on small fish falling out from the trawl or passing through its meshes and slightly stunned. Normally, they were solo animals. No adverse effects of fishing gear or vessels on these whales (collision, entangling, injury, etc.) have been identified. All animals were encountered in the daytime.

Steller sea lions were the most abundant marine mammal during the pollock fishery and most actively revealed interest in operating vessels which was reflected in their behavior. They purposefully approached vessels, were regularly present near them and feeding on fish falling out from trawls or offal discharged from scuppers (Fig. 6.2.2).

Of trawl hauling operations witnessed in the daytime (87 hauls), Steller sea lions were present in 24 cases. When the ship was operating in ice, Steller sea lions were present at virtually every haul. The mean number of animals present during hauls was 3–4 individuals and sometimes reached 10–12 individuals (Fig. 6.2.3).

Figure 6.2.2. Steller sea lions feeding on small fish and offal near scuppers. The ship is adrift (photo by I.A. Blokhin)

Figure 6.2.3. A group of Steller sea lions approached the floating cod-end during trawl hauling (photo by I.A. Blokhin)

Steller sea lions approached vessels both during any fishing operation and lying adrift for catch processing. In the latter case, animals stayed near the vessel for several hours feeding on offal.

Steller sea lions might be present near the ship in any time of the day because fishing was performed on a 24-hour basis. In January 2017, of 8 encounters with Steller sea lions in Kamchatka-Kuril subzone, 6 ones (75%) occurred in the night time during 00:25 to 03:20, and, of 68 individuals registered in this subzone in January, 65 ones (95.6%) were encountered in the night time. Steller sea lions approached the ship in groups of 4 to 24 animals and accompanied the ship engaged in trawling at a speed of 3–4 knots feeding on small fish and pollock offal. They accompanied the ship during 15–20 minutes to several hours. As soon as the ship changed its trawling mode (increased speed for U-turn, performed circulation, etc.), Steller sea lions left it and departed toward the nearest ship engaged in fish catching. It was noted that when the ship increased its speed to 5–6 knots Steller sea lions immediately fell behind – it is likely that maintaining such speed and feeding was inconvenient for them.

Also, Steller sea lions approached the ship during any operation, even during frozen product transfer to a reefer, but, upon seeing that the ship was not processing fish, they immediately left and went farther to other vessels.

Northern fur seal. In most cases, fur seals stayed at a distance of about 500 m from the ship or nearer. They were normally indifferent to presence of fishing vessels. Their behavior did not change and was not dependent on fishing operations being performed by the ship. In most cases, they were active – moving in the water, surfacing at a varying distance from the ship, staying on the surface for a short time stretching their necks and looking around, then diving again (Fig. 6.2.4).

In one case, a fur seal was purposefully moving toward a ship lying adrift and processing its catch. The animal approached the ship, tasted some floating offal pieces (pollock liver) and, without lingering near scuppers, which is typical of Steller sea lions, swam away (Fig. 6.2.5).

Fur seals live in pollock fishing areas and this fish is common in their diet. However, they appear near vessels accidentally in most cases, possibly because their feeding areas coincide with pollock trawl fishing areas.

Figure 6.2.4. Northern fur seal looking around (photo by I.A. Blokhin)

Figure 6.2.5. Northern fur seal feeding on fish offal. The ship is adrift (photo by I.A. Blokhin)

Spotted seal. This true seal was encountered 18 times near fishing vessels during the pollock fishing season (8.9% of all encounters with marine mammals), a total of 276 individuals were registered. Animals were staying on ice at a distance of 200 m to 2 km from the ship (Fig. 6.2.6–7).

Figure 6.2.6. A group of spotted seals on ice (photo by I.A. Blokhin)

Figure 6.2.7. A spotted seal pup trying to escape in the water from an approaching ship (photo by I.A. Blokhin)

They did not show any interest to a fishing vessel but vessels operating in their breeding area noticeably harassed them. When a vessel approached, they gradually became agitated and escaped into the water. If there was a family group on an ice floe, adults were normally leaving it first and the pup was the last one.

Pollock fishery is normally performed by tens of vessels in the same area. If fishing takes place in spotted seal's breeding areas, all these vessels repeatedly cross their haul-out locations and animals are continuously harassed. No other adverse effects of fishing fleet operations on spotted seals (injury, collision with fishing gear, etc.) have been registered.

Ribbon seal. Ribbon seals were encountered 16 times near fishing vessels in pollock fishing areas (7.9% of all encounters with marine mammals), a total of 216 individuals were registered. These animals were detected by the observer around the ship at a distance of 100 m to 2 miles. Their behavior was similar to that of spotted seals. Both species were indifferent to the ship's fishing operations and never observed feeding near scuppers or trawls. Ribbon seal family groups were registered much less frequently than for spotted seals. The encountered animals were normally solo individuals, both adults and pups (Fig. 6.2.8).

Figure 6.2.8. An adult ribbon seal is ready to dive into the water in case of danger (photo by I.A. Blokhin)

In that period when the ship was operating in ice (late March), only newly molted pups were encountered. Unlike spotted seals, ribbon seals let the ship approach them much closer and pups avoided diving into the water "till the last moment" and, when making sure that the ship was passing in 30–40 meters, were noticeably anxious and rushing around the ice floe but did not step down into the water (Fig. 6.2.9). Pups went down into the water only when the ship was heading directly toward the ice floe or the passing ship or other ice floes disturbed by it went into contact with the ice floe with their haul-out.

Figure 6.2.9. A ribbon seal pup waiting “till the last moment” (photo by I.A. Blokhin)

No cases of ribbon seal injury due to contacts with vessels or fishing gear were registered in 2017.

7. Collection of photo and video materials

In the course of monitoring activities in the pollock fishery in January – April 2017, observers took pictures of marine mammals encountered near fishing vessels virtually every day. Collected materials include more than 300 photos of marine mammals, 5 video fragments on behavior of Steller sea lions and other marine mammals near fishing vessels.

CONCLUSION

This paper presents results of our review of Russian and foreign scientific literature sources on the diet of Steller sea lions in different seasons and pollock’s role in it.

According to expert judgments, total number of Steller sea lions currently living in Kuril Islands, Sakhalin, Kamchatka, islands and coast of the northern part of the Sea of Okhotsk is approx. 24 thsd heads including some 19 thsd individuals older than one year.

According to our estimates, annual consumption of food by Steller sea lions in the Sea of Okhotsk is approx. 141.2 thsd tons of which 36.4 to 71.1 thsd tons is pollock. Pollock's role in the diet of Steller sea lions in the Sea of Okhotsk grows in the winter–spring season which is likely to be explained highly dense pollock aggregations arising in this period. In addition to pollock, an important feeding source for Steller sea lions in the Sea of Okhotsk in another abundant pelagic species – herring.

Fishery impacts on marine mammals may be both direct (accidental by-catch and death from fishing gear, etc.) and indirect (catch of pollock as a potential feeding source). According to our estimates, Steller sea lion mortality due to accidental by-catch accounts for 0.4% of their total number. The resulting figure looks heavily overrated but even such mortality is insignificant and cannot have any adverse effects on the abundance and condition of Steller sea lions living in the regions of the Sea of Okhotsk Basin.

The pollock stock in the northern part of the Sea of Okhotsk is currently at a higher-than-medium level and its biomass amounts to some 9.79 million tons. Total pollock catch is some 960 thsd tons or as little as 9.8% of its stock biomass.

We believe that, given such total stock biomass and yield of pollock, there is no ground for discussions about shortage of feeding sources for Steller sea lions. It is important to emphasize that, according to our observations, a considerable portion of Steller sea lions just "parasitize" during the winter-spring fishing season feeding primarily on fish processing waste, fish fallen out from fishing gear and, therefore, meet no food shortages, at least in this period.

To obtain more credible results on Steller sea lion by-catch in the pollock fishery in the Sea of Okhotsk, relevant studies should be further continued including surveys on board different vessel types with different fishing gear (types of trawls and Danish seines) and using state-of-the-art video registration instruments (automatic photo recorders).

According to data of special surveys performed during the pollock fishing season in 2017 on board the fishing vessel BATM *Baklanovo*, marine mammals were registered in its immediate vicinity 203 times and included 1,306 individuals belonging to 11 species. The most frequently occurring and abundant species in pollock and herring fishing areas was Steller sea lion (46.8% of the total number of encounters and 48.5% of the total number of individuals). It was followed in a descending order by northern fur seal (13.3%), spotted seal – 8.9%, Minke whale – 8.4%, ribbon seal – 7.9%, Dall's porpoise – 6.9%, North Pacific right whale – 2.5%. The occurrence rate of other species – sperm whale, killer whale, ringed seal, finback whale – was about 1%. Three marine mammal species – Steller sea lion, finback whale and North Pacific right whale – are rare protected species and listed in the Red Book of Russia. Other species are common and their abundance and stock condition raises no concern.

Spatial (across the sea) and temporal (during the season) distribution of marine mammals was extremely uneven and directly related to the ship's route and duration of its stay in a particular area.

Of 11 species encountered in pollock fishing areas, 4 species interacted with fishing vessels. 2 species – Steller sea lion and Minke whale – showed marked interest in fishing vessel activities: when meeting a vessel, these animals changed the direction of their movement approaching to a sailing or drifting vessel, followed it during trawl hauling or trawling operation, fed on fish falling out from the trawl or fish offal, or lingered near vessels for some time. 2 other species – spotted seal and ribbon seal – were indifferent to a vessel's fishing activities but fishing fleet operations at the edge of ice cover noticeably harassed them, because all ice forms of seals start their breeding period (birth of litter and mating) in the spring.

REFERENCES

Avdeev G.V., Ovsyannikov E.E. 2001. Distribution of pollock year classes during first years of life in the eastern part of the Sea of Okhotsk // TINRO Proceedings. Vol. 128. Part 1. P. 250–258.

Avdeev G.V., Ovsyannikov E.E. 2006. Stock assessment of North Sea of Okhotsk pollock by results of ichthyoplankton surveys in 2005 // TINRO Proceedings. Vol. 145. P. 120–145.

Avdeev G.V., Ovsyannikova S.L., Ovsyannikov E.E. 2005. Pollock stock assessment in the northern part of the Sea of Okhotsk pollock by results of ichthyoplankton surveys in 2004 // Fishery Issues. Vol. 6. No. 22. P. 298–325.

Avdeev G.V., Ovsyannikov E.E., Ovsyannikova S.L., Zhigalov I.A. 2008. Some features of the spawning behavior of North Sea of Okhotsk pollock in 2004–2006 // TINRO Proceedings. Vol. 152. P. 80–92.

Altukhov A.V., Permyakov P.A., Andrev R.V., Burkanov V.N., Calkins D.G., Trukhin A.M., Zhelat T.S. 2012. Mortality of adult Steller sea lions at breeding rookeries of the Russian Far East in 2002-2010 // Marine Biology. Issue 38. No. 6. P. 442-447.

Artyukhin Yu.B., Burkanov V.N. 1999. Sea birds and mammals of the Far East of Russia: field identification guide. M.: AST. 215 p.

Belkin A.N. 1966. Summer distribution, resources, hunting prospects and some features of the biology of Steller sea lion living in Kuril Islands // TINRO. Vol. LVIII. P. 69 -95

Burdin A.M., Filatova O.A., Khoyt E. 2009. Marine mammals of Russia. monograph. Kirov. JSC Kirov Oblast Printing House. 208 p.

Burkanov V.N., Altukhov A.V., Belobrov R.V., Blokhin I.A., Vertyankin V.V., Waite D.N., Calkins D.G., Kuzin A.E., Loughlin T.R., Mamaev E.G., Nikulin V.S., Permyakov P.A., Purtov S.Yu., Trukhin A.M., Fomin V.V., Zagrebelny S.V. 2006. Brief results of Steller sea lion (*Eumetopias jubatus*) count surveys in the waters of Russia in 2004-2005. Marine mammals of the Holarctic // Collection of scientific writings based on materials of the IV International Conference. St. Petersburg, September 10–14, 2006. P. 111–116.

Burkanov V.N., Trukhin A.M., Johnson D. 2006. Accidental by-catch of Steller sea lions (*Eumetopias jubatus*) in the herring (*Clupea harengus*) trawl fishery in the western part of the Bering Sea. Marine mammals of the Holarctic // Collection of scientific writings based on materials of the IV International Conference. St. Petersburg, September 10–14, 2006. P. 117-119.

Burkanov V.N., Artemyeva S.M., Isono T., Permyakov P.A., Tretyakov A.V., Hattori K. 2015. Brief results of a Steller sea lion (*Eumetopias jubatus*) rookery survey in the northern part of the Sea of Okhotsk and near Sakhalin Island coast in 2013. Marine mammals of the Holarctic // Collection of scientific writings based on materials of the VIII International Conference. St. Petersburg, September 22–27, 2014. P. 108–112.

Burkanov V.N., Vertyankin V.V., Laskina N.B., Mamaev E.G., Nikulin V.S., Ryazanov S.D., Tretyakov A.V., Usatov I.A., Fomin S.V. 2016. A survey of Steller sea lion (*Eumetopias jubatus*) rookeries in 2015: reduction of litter numbers in all locations. Marine mammals of the Holarctic // Collection of scientific writings based on materials of the IX International Conference. Astrakhan, October 31 – November 05, 2016. P. 23.

Zverkova L.M. 2003. Pollock. Biology and stock condition // Vladivostok: TINRO. 248 p.

Ovsyannikov E.E. 2011. The spatial distribution dynamic of pollock roe and juveniles in the northern part of the Sea of Okhotsk // Author’s abstract of a thesis for Cand. Sc. (Biol.) degree. Vladivostok. 20 p.

Panina G.K. 1966. On the diet of Steller sea lion and seals in Kuril Islands // TINRO. Vol. LVIII. P. 235 -236

Perlov A.S. 1975. The diet of Steller sea lions in Kuril Islands // Ecology. P. 106-108.

Perlov A.S. 1996. Hunting for Steller sea lions as one of key reasons for their decreasing abundance. TINRO Proceedings. Vol. 121. P.143-149.

Perlov A.S., Panina G.K. 1969. Materials on Steller sea lion feeding habits in Kuril Islands // 4th All-Union Meeting on Marine Mammal Studies. M. P. 177-179.

Permyakov P.A. 2014. The demography and reasons for mortality of Steller sea lion *(Eumetopias jubatus)* of the breeding grouping on Chirpoy Brother Island (Kuril Islands). Author's abstract of a thesis for Cand. Sc. degree. Vladivostok. 20 p.

Savenkov V.V., Shpigalskaya N.Yu., Varkentin A.I., Pilganchuk O.A., Kustova A.S., Saravansky O.N. 2012. Polymorphism of population–genetic markers of pollock in the northern part of the Sea of Okhotsk // Materials of the All-Russia Scientific Conference devoted to the 80th anniversary of KamchatNIRO. Petropavlovsk-Kamchatsky: KamchatNIRO. P. 439–447.

Sobolevsky E.I. 1983. Marine mammals of the Sea of Okhotsk, their distribution, abundance and role as consumers of other animals // Marine Biology. No. 5. P. 13–20.

Temnykh O.S. 1989. The functional structure of pollock's geographic range in the Sea of Okhotsk // Marine Biology. No. 6. P. 22–30.

Tikhomirov E.A. 1964. On Steller sea lion distribution and hunting in the Bering Sea and contiguous areas of the Pacific Ocean // TINRO Proceedings. Vol. LII. P. 287-291.

Usatov I.A., Burkanov V.N. 2016. The diet of Steller sea lion (*Eumetopias jubatus*) in the waters of the Far East of Russia in 2004-2008. Marine mammals of the Holarctic. Collection of abstracts based on materials of the IX International Conference. Astrakhan, October 31 – November 05, 2016. P. 91.

Shuntov V.P. 2001. The biology of Russian Far Eastern seas: monograph. Vladivostok: TINRO-Center. Vol. 1. 580 p.

Shuntov V.P., Ivanov O.A. 2015. Marine mammals in macro ecosystems of Far Eastern seas and contiguous North Pacific waters // TINRO Proceedings. Vol. 181. P. 57-76

Shuntov V.P., Volkov A.F., Temnykh O.S., Dulepova E.P. 1993. Pollock in the ecosystems of Far Eastern seas. Vladivostok: TINRO. 426 p.

Fadeev N.S. 1981. Pollock breeding season and spawning migrations // The ecology of pollock, its resources and fishery. Vladivostok: TINRO. P. 3–18.

Fadeev N.S. 1987. Pollock spawning grounds and breeding season in the northern part of the Sea of Okhotsk // The population structure of pollock, its abundance dynamic and ecology. A collection of scientific writings. Vladivostok: TINRO. P. 5–22.

Fadeev N.S. 2001. Strength of North Sea of Okhotsk pollock year classes // Fishery Issues. Vol. 2. No. 2 (6). P. 299–318.

Fadeev N.S., Smirnov A.V. 1994. Pollock distribution, migration and resources // Fisheries Journal. No. 3. P. 33–37.

Fedoseev G.A. 2005. The population biology of ice forms of seals and their role in North Pacific ecosystems. monograph. Magadan: MagadanNIRO, 179 p.

Angliss and Lodge. 2004. Alaska marine mammal stock Assessments, 2003. NOAA Technical Memorandum NMFS-AFSC-144. pp. 1-8.

Bickham, J. W., J. C. Patton, & T. R. Loughlin.1996. High variability for control region sequences in a marine mammal: Implications for conservation and biogeography of Steller sea lions *(Eumetupias jubatus)*. Journal of Mammalogy, 77:95-108.

Burkanov V. N., Loughlin T.R. 2005. Distribution and Abundance of Steller Sea Lions, *Eumetopias jubatus*, on the Asian Coast, 1720's–2005. Marine Fisheries Review/ Vol. 67. № 2. 62 p.

Calkins D.G., Pitcher K.W.1982. Population assessment, ecology and trophic relationships of Steller sea lion in the Gulf of Alaska. pp 447-546 in Environmental assessment on the Alaskan continental shelf. U.S. Depart. Of Commerce and U.S. Depart. of Interior, Final Rep. of Principal Investigators, Vol. 19.

Calkins D.G., Atkinson S., Mellish Jo-Ann, Waite J. N., Carpenter J. R. 2013. The pollock paradox: Juvenile Steller sea lions experience rapid growth on pollock diets in fall and spring. Journal of Experimental Marine Biology and Ecology 441 (2013) 55–61.

Fiscus C., Baines G. 1966. Food and Feeding Behavior of Steller and California Sea lions. J. Mammology. 47. № 2.

Goto, Y., & Shimazaki, K. 1998. Diet of Steller sea lions off the coast of Rausu, Hokkaido, Japan. Biosphere Conservation, 1/ 141-148.

Holmes E.E., York AE. 2003. Using age structure to detect impacts on threatened populations: a case study with Steller sea lions. Conserv Biol 17: 1794−1806/

Hui TCY, Gryba R, Gregr E.J., Trites A.W. 2015. Assessment of Competition between Fisheries and Steller Sea Lions in Alaska Based on Estimated Prey Biomass, Fisheries Removals and Predator Foraging Behaviour. PLoS ONE 10(5): e0123786.doi:10.1371/journal.pone.0123786/

Loughlin, T. R. 1997. Using the phylogeographic method to identify Steller sea lion stocks. Pp. 329-341, *In* A. Dizon, S. J. Chivers, and W. Perrin (eds.), Molecular genetics of marine mammals, incorporating the proceedings of a workshop on the analysis of genetic data to address problems of stock identity as related to management of marine mammals. Soc. Mar. Mammal., Spec. Rep. No. 3.

Loughlin T.R. 1998. The Steller sea lion: A declining species. Biosphere Conservation 1 (2): 91-98/

Loughlin T.R. and A.E. York. 2000. An accounting of the sources of Steller sea lion mortality. Mar. Fish. Rev. 62(4): 40-45.

National Marine Fisheries Service (NMFS) .2008. Recovery plan for the Steller sea lion (*Eumetopias jubatus)*. Revision. National Marine Fisheries Service, Silver Spring, MD

Merrick R.L., M. Chumbley K., Byrd G.V. 1997. Diet diversity of Steller sea lions *(Eumetopias jubatus)* and their population decline in Alaska: a potential relationship**.** Can. J. Fish. Aquat. Sci. 54: 1342.1348.

Merrick R.L., Loughlin T.R., Calkins D.G. 1987. Decline in abundance in the northern sea lion, *Eumetopias jubatus* in Alaska, 1956–86. Fishery Bulletin Vol. 85. No. 2/ 351–365.

Olesiuk, P.F. 1993. Annual prey consumption by harbor seals (*Phoca vitulina*) in the Strait of Georgia, British Columbia. Fishery Bulletin. 91. 491-515.

Olesiuk, P. F., Bigg, M. A., Ellis, G. M., Crockford, S. J., & Wigen, R. J. 1990. An assessment of the feeding habits of harbour seals (*Phoca vitulina*) in the Strait of Georgia, British Columbia, based on scat analysis (Canadian Technical Report of Fisheries and Aquatic Sciences No. 1730). Ottawa: Department of Fisheries and Oceans. 135 pp.

Owen J.F., J.R. Merrick. 1994. Analysis of coastal middens in south-eastern Australia: Sizing of fish remains in holocene deposits. J. of Archaeol.Sci. 21: 3-10.

Pascual M.A., Adkison M.D. 1994. The decline of the Steller sea lion in the northeast Pacific: demography, harvest or environment. Ecol Appl 4: 393−403/

Pendleton GW, Pitcher KW, Fritz LW, York AE and others. 2006. Survival of Steller sea lions in Alaska: a comparison of increasing and decreasing populations. Can J Zool 84: 1163−1172.

Pitcher, K.W. 1981. Prey of the Steller sea lion, *Eumetopias jubatus*, in the Gulf of Alaska. Fishery Bulletin. 79. 467-472.

Pitcher K.W., Olesiuk P.F., Brown R.F., Lowry M.S. and others. 2007. Abundance and distribution of the eastern North Pacific Steller sea lion (*Eumetopias jubatus)* population. Fish Bull 107: 102−115.

Pitcher K.W. and Calkins D.G. 1981. Reproductive biology of Steller sea lions in the Gulf ofAlaska. J. Mammal. 62:599-605.

Raum-Suryan K.L., Pitcher K.W., Calkins D.G., Sease J.L., Loughlin T.R. 2002. Dispersal, rookery fidelity and metapopulation structure of Steller sea lions (*Eumetopias jubatus)* in an increasing and a decreasing population in Alaska. Mar Mamm Sci 18: 746−764.

Riedman M. 1990. The Pinnipeds. Seals, Sea lions, and Walruses. University of California Press, 439 p.

Sinclair E. H. and T. K. Zeppelin. 2002. Seasonal and spatial differences in diet in the Western Stock of Steller sea lions (*Eumetopias ju*batus). J. Mamm. 83(4):973-990.

Sinclair E. H., Johnson D. S., Zeppelin. T. K. and Gelatt T.S. 2013. Decadal variation in the diet of Western Stock Steller sea lions (*Eumetopias jubatus*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS- AFSC-248, 67 p.

Spalding D.1964. Comparative Feeding Habits of the Fur seal, Sea lion and Harbor seal on the British Columbia Coast.Bull. Fish. Res.Board Canada, № 146.

Scheffer V. 1950. The food of the Alaska fur seal. Fish and Wildlife Service U.S. Department of the Interior, 329 p.

Sease J.L., Taylor W., Loughlin T.R., Pitcher K.W. 2001. Aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska, June and July 1999 and 2000.: U.S. Department of Commerce, NOAA Technical Memo NMFS-AFSC-122.

Sease, J.L and T.R. Loughlin. 1999. Aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska, June and July 1997 and 1998. U.S. Dep. Commer., NOAA Tech.Memo. NMFS-AFSC-100, 61 p.

The Decline of the Steller Sea Lion in Alaskan Waters: Untangling Food Webs and Fishing Nets 2003. Committee on the Alaska Groundfish Fishery and Steller Sea Lions, National Research Council. http://www.nap.edu/catalog/10576.html

Trites A.W., Christensen V., Pauly D. 1997. Competition Between Fisheries and Marine Mammals for Prey and Primary Production in Journal of Northwest Atlantic Fishery Science December 1997, Vol. 22: 173–187 DOI: 10.2960/J.v22.a14

Trites A.W., Miller AJ, Maschner HDG, Alexander MA, Bograd SJ, Calder JA, et al. 2007. Bottom-up forcing and the decline of Steller sea lions (*Eumetopias jubatus)* in Alaska: assessing the ocean climate hypothesis. Fisheries Oceanography 16: 46–67.

Trites A. W. and Calkins D. G. 2008. Diets of Mature Male and Female Steller Sea Lions (*Eumetopias jubatus*) Differ and Cannot Be Used as Proxies for Each Other.2008. *Aquatic Mammals* 2008, *34*(1), 25-34, DOI 10.1578/AM.34.1. 25.

Trites A.W., Donnelly C.P. 2003. The decline of Steller sea lions *Eumetopias jubatus* in Alaska: a review of the nutritional stress hypothesis. Mammal Rev 33: 3−28.

Waite, J.N., Burkanov, V.N. 2006. Steller Sea Lion Feeding Habits in the Russian Far East, 2000-2003. Alaska Sea Grant College Program, University of Alaska Fairbanks. 223-235.

Waite, J.N., Burkanov, V.N., Andrews, R.D. 2012a. Prey competition between sympatric Steller sea lions (*Eumetopias jubatus*) and northern fur seals (*Callorhinus ursinus*) on Lovushki Island, Russia. Canadian Journal of Zoology 90, 110-127.

Waite, J.N., Trumble, S.J., Burkanov, V.N., Andrews, R.D. 2012b. Resource partitioning by sympatric Steller sea lions and northern fur seals as revealed by biochemical dietary analyses and satellite telemetry. Journal of Experimental Marine Biology and Ecology: 2006-45 416-417, 41-54.

Winship, A.J., & Trites, A.W. 2003. Prey consumption of Steller sea lions (*Eumetopias jubatus*) off Alaska: How much prey do they require *Fishery Bulletin, 101*,147-167.

Winship A.J., Trites A.W., Calkins D.G. 2001. Growth in body size of the Steller sea lion (*Eumetopias jubatus)*. J Mammal 82: 500−519.

Zeppelin T.K., Dominic J. Tollit D.J., Call K. A., Orchard T.J., Gudmundson C.J. 2004. Sizes of walleye pollock *(Theragra chalcogramma*) and Atka mackerel (*Pleurogrammus monopterygius*) consumed by the western stock of Steller sea lions (*Eumetopias jubatus*) in Alaska from 1998 to 2000. Fish. Bull. 102:509–521

York A.E., R.L. Merrick and T.R. Loughlin. 1996. An analysis of the Steller sea lion metapopulation in Alaska. Chapter 12, Pp. 259-292, *In* D. R. McCullough (ed.), Metapopulations and wildlife conservation. Island Press, Covelo, California.

York A.E. 1994. The population dynamics of the northern sea lions, 1975-85. Mar Mamm Sci 10: 38−51.

APPENDICES

1. Originals of translated English papers for the overview of literature:
(separate files are attached hereto)

1. Sinclair, E. H., and T. K. Zeppelin. 2002. Seasonal and spatial differences in diet in the Western Stock of Steller sea lions (*Eumetopias jubatus*). J. Mamm. 83(4):973-990

2. E.H. Sinclair, D. S. Johnson, T. K. Zeppelin, and T. S. Gelatt. 2013. Decadal variation in the diet of Western Stock Steller sea lions (*Eumetopias jubatus*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS- AFSC-248, 67 p

3. Merrick R. L., M. Chumbley K., Byrd G. V. 1997. Diet diversity of Steller sea lions (Eumetopias jubatus) and their population decline in Alaska: a potential relationship**.** Can. J. Fish. Aquat. Sci. 54: 1342.1348 (1997)

4. Tonya K. Zeppelin, Dominic J. Tollit, Katherine A. Call,Trevor J. Orchard, Carolyn J. Gudmundson. Sizes of walleye pollock *(Theragra chalcogramma*) and Atka mackerel (*Pleurogrammus monopterygius*) consumed by the western stock of Steller sea lions (*Eumetopias jubatus*) in Alaska from 1998 to 2000. Fish. Bull. 102:509–521 (2004).

5. Andrew W. Trites and Donald G. Calkins Diets of Mature Male and Female Steller Sea Lions (*Eumetopias jubatus*) Differ and Cannot Be Used as Proxies for Each Other. 2008. *Aquatic Mammals* 2008, *34*(1), 25-34, DOI 10.1578/AM.34.1.2008.25).

6. Jason N. Waite и Vladimir N. Burkanov 2006. Steller Sea Lion Feeding Habits in the Russian Far East, 2000-2003.
Alaska Sea Grant College Program • AK-SG-06-01, 2006 pp 1-12)

7. J.N. Waite, V.N. Burkanov, and R.D. Andrews. 2012. Prey competition between sympatric Steller sea lions (*Eumetopias jubatus*) and northern fur seals (*Callorhinus ursinus*) on Lovushki Island, Russia) Can. J. Zool.90: 110–127 (2012)

2. Photos (300) and video films (4)
(separate files are attached hereto)