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**Occurrence, photo ID and killer whales (*Orcinus orca*, Linnaeus, 1758) feeding on catch during longline fishing in the Sea of Okhotsk in 2017**

**PAVEL S. GUSHCHEROV, IGOR A. NABEREZHNYKH, PETR A. TIUPELEEV,  
ANTON A. NOVOZHILOV**



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# Occurrence, photo ID and killer whales (*Orcinus orca*, Linnaeus, 1758) feeding on catch during longline fishing in the Sea of Okhotsk in 2017

PAVEL S. GUSHCHEROV<sup>1</sup>, IGOR A. NABEREZHNYKH<sup>1</sup>, PETR A. TIUPELEEV<sup>1</sup>, ANTON A. NOVOZHILOV<sup>1</sup>

<sup>1</sup> Pacific branch of VNIRO ("TINRO"), 4 Shevchenko Alley, Vladivostok, 690091, Russia

E-mail: [pavel.gushchero@tinro-center.ru](mailto:pavel.gushchero@tinro-center.ru); [tinro@vniro.ru](mailto:tinro@vniro.ru)

## ABSTRACT

Registration of killer whales was carried out while on bottom longline fishing of black halibut in the Sea of Okhotsk in spring-summer period. At least 100 killer whales specializing on feeding on black halibut have been registered. A ratio of longlines attacked by killer whales (21%) to the total number of black halibut longlines is provided. The pictures taken have allowed pre-identification of 19 killer whales. The data collected allow proposing that the killer whales that feed on longline fishing do not have narrow food specialization, which questions the division of killer whales into two ecotypes, while the observed differences in the diets of different families are related to seasonality of food and to possession of skills in specific hunting methods for individual groups.

## INTRODUCTION

The problem of killer whales attacking longline fishery operations is widely known and currently has no decision. The vessels working with bottom longline and nets in the Sea of Okhotsk in black halibut fishing are attacked by killer whales who feed on the fishing gear on regular basis. The number of these attacks increases every year. Currently, according to the observers' data and fishermen oral reports, the negative impact of these animals has significantly increased in all fishery areas of the Sea of Okhotsk except East Sakhalin subzone. The killer whales show high activity in West Kamchatka, Kamchatka-Kuril and east part of North Okhotsk subzones. During the recent years the fishery vessels have to temporarily switch to other fishery objects (cod, macrourus and others) to avoid pursuits by killer whales.

According to observers' data, in 2018-2019 halibut has been successfully caught while no killer whales were around. On killer whales approach the halibut loss during longline raising reached 80-100%. When switching to macrourus, the killer whales kept controlling the raising and presumably ate halibut from by-catch, but did not eat macrourus. It should be noted that killer whales mass preying had not been reported in the Bering Sea before, but by now this problem makes significant adjustments to black halibut catch in this area as well. According to the information from fishery vessels no attacks on longlines has been reported during cod fishery.

At the same time the matter of dividing killer whales into "flesh-eating" and "fish-eating" in the seas of the Far East remains a controversial one; the killer whales' attachment to certain areas including black halibut fishing grounds is poorly studied.

The research has been carried out from March 26 to July 09 2017 in the Sea of Okhotsk on "Vostok-5" longliner to determine occurrence of killer whales, to identify individual groups of killer whales on long line fishery operations, to preliminarily estimate the part of the catch eaten by the killer whales and to refine some parameters of killer whales population structure.

The results of this studies have been partly published during the Tenth “Holarctic marine mammals” conference (Тюпелев и др., 2018).

### **Research method**

The observation of sea surface was carried out under favorable weather conditions in daytime during transit and fishery operations. As there was only one observer aboard the vessel, the officers and the crew helped in detection of marine mammals. The following data were registered on killer whales sighting: date, time, vessel coordinates, activity, sea state and visibility, species, amount and age-sex composition of the group (if possible), distance to the animal, behavior (moving direction, feeding, etc.).

It was not possible to approach the whales as it was not a specialized marine mammals’ survey but rather a fishery expedition. The pictures were taken if the distance to a killer whale was below 1 n. mile.

In case of nighttime fishery operations basing on discovery of halibut heads or jaws remains on the longline and sounds of the animals or in case of significant decrease of fish caught per longline we recorded the fact of killer whales attack without recording any information on their numbers.

## **RESULTS**

### **Occurrence and killer whales feeding on the catch**

During the study period 328 longline stations have been made, among which 149 stations were stationed for black halibut catch, 30 for black halibut and stingray. 47 more stations were made for cod and macrourus with black halibut as by-catch.

The weather conditions and animals’ behavior did not allow taking photo or video shots in some cases. The total of 40 close approaches of killer whales to longlines has been registered during the survey. Among them one approach was during liner stationing, and two approaches were during stationing and raising; one group of 4-5 animals was present during cod longline raising for two days in a row (March 31, 2017 and April 1, 2017), but no cases of fish eating were registered.

The rest 37 of attacks were registered while raising black halibut bottom longlines. Among them 8 longlines have been attacked during nighttime, when the obvious presence of killer whales was assumed according to remains of fish on the hooks, loud blow sounds of the animals, echo sounder readings, significant decrease of black halibut catch. However it was not possible to tell the amount of attacking killer whales at night.

In 29 cases of raising black halibut longlines, the attacks have been carried out during daytime, the killer whales were visually registered in 28 cases. One longline was raised during daytime with single caught halibuts (the catch was only 50 kg); fish with biting marks was recorded, however upon careful visual inspection of the water area no killer whales were found. It is likely that the catch was picked from the hooks while on the bottom, though the longline was placed at a significant depth of 650 m. According to the captain’s words, other vessels have encountered similar situations during previous years as well.

The number of killer whales approaching the longlines varied from 2 to 13 animals. Groups of 2-6 animals accounted for 94% of all the cases, while most frequently groups consisted of 3 animals. Groups of 12-13 animals were registered twice.

The overall number of killer whales visually recorded near longlines was 131-137 animals (Appendix 1, fig. 1). However the total amount of the animals was lower due to double registering of the same group that pursued the vessel for several days and fed on the halibut from the longlines stationed on small distance from one another. Upon trying to distinguish definite groups of killer whales their corrected amount was no less than 100 animals.

In every case of killer whales feeding on a longline the damage was significant (Appendix 1, table 1). From 179 longlines with black halibut 37 (or 21%) were attacked by killer whales. (Тюпелев и др., 2018). The fishermen had to change the fishing area or switch to a different fishing object for eight times during the surveying period. The longest period without killer whales' presence was 10 days; the longlines were usually attacked on 2-5 day of fishing. The ratio of attacked longlines was the lowest in North-Okhotsk subzone – 15,5%, in two other subzones it was twice as high and was 36,4% for West-Kamchatka subzone and 32,1% for Kamchatka-Kuril subzone.

### Photo ID

During the survey in 2017 the total of 2325 pictures of killer whales have been taken (Appendix 1, table 2), 19 killer whales were pre-identified at the photos (Appendix 2, fig. 2 a-t). Currently we are comparing our pictures to Kamchatka killer whales catalog (Burdin et al., 2006), and using “Flukebook” service.

### DISCUSSION

The damage made by killer whales to black halibut fishery in the Sea of Okhotsk is increasing over the recent years. According to different authors, the number of killer whales during black halibut catch achieved up to 25 animals per fishing vessel in some days. The captains of fishing vessels that carry out black halibut fishing in the Sea of Okhotsk inform that the predators are recorded near all vessels in every fishery subzone in the Sea of Okhotsk. Up to 70-80 whales can gather by a vessel at a time. It is obvious that since 1990 the amount of killer whales that specialize on this type of feeding should have increased due to high intelligence of these animals and their ability to learn from each other inside a family or a group (Никулин и др., 2004; Семенов, Смирнов, 2004, 2009).

The ratio of longlines that were fed on to the total number of longlines during April-May 2012 survey was 18 (19%) to 93 (Корнев и др., 2014). The killer whales ate mainly black halibut (with rare cases of feeding on Pacific halibut or damaging macrourus). Using the data collected during the earlier surveys, S. Kornev et al (2014) have calculated the proposed amount of black halibut that could have been eaten by killer whales for the whole Sea of Okhotsk in 2010-2013 during bottom nets and longline fishing. The volumes of fish eaten by the predators were comparable to the commercial harvest during bottom net fishing and on average in 2010-2013 could be up to 1400 tons per year; for longline fishing they were slightly lower – up to 1200 tons per year.

According to S. Kornev (Корнев и др., 2014) during black halibut net fishing killer whales eat about 60% of the catch on average (44,3-75%), which is 1,5 times as high as the estimates, provided by specialists of MagadanNIRO – 35% (Семенов, Смирнов, 2004, 2009), and up to 17% for longline fishing, which is also higher than estimates provided by L. Nikolenko (Николенко, 2010) – 9%.

However the authors (Корнев и др., 2014) note that intensity of killer whales' attacks on fishing gear decreases during summer period, as well as number of the predators itself, though there were no specific observations or calculations regarding this matter. Presumably it can be related to most killer whales specializing on halibut eating near longlines and bottom nets move to locations of salmon gatherings or other mass fish species.

According to some authors (Белонович и др., 2021) 17 individual killer whales (of 5 families) were identified in the Sea of Okhotsk in 2019 and 9 killer whales (of 2 families) were identified in 2020, while both families identified in 2020 were registered in 2019 as well. Closed population model showed an estimate of the number of killer whales that feed on black halibut catch in the Sea of Okhotsk equal to  $133 \pm 45$  animals. When approaching a longliner that carries out black halibut fishing they eat all the catch and pursuit the vessel until it ceases the fishing operation and moves 40 miles or more to a different place or switches to fishing cod which is of no interest to the killer whales. In 2019-2020 maximal period of time without encountering killer whales was 14 days. Repeated killer whales encounters show that only some specific families of killer whales feed on catches in the Sea of Okhotsk. However in their short statement (Белонович и др., 2021) the authors do not provide any data on photo ID.

Our research results do not confirm decrease in pressure of killer whales on longline fishery in summer period. This might be explained by late salmon approach to North coast of the Sea of Okhotsk and West Kamchatka in 2017. At the same time the cases of killer whales attacks on longline catches in subzones located near the West coast of Kamchatka (West-Kamchatks and Kamchtk-Kuril subzones) were twice more frequent than in a more open-sea North-Okhotsk subzone – 37% and 14% correspondingly.

The issue of killer whales feeding on the catch has not yet been resolved so it is still relevant and the prospects for longline fishing are poorly traced without further improvement of ways to protect fish from killer whales (Никулин и др., 2004; Семенов, Смирнов, 2004, 2009; Белонович, Бурканов, 2012). The fishermen use passive methods of protecting the catch – by deceiving the predators. On killer whales' approach the vessel goes a considerable distance (up to 30-50 miles) at maximum speed from the point of meeting with predators to a different longline (Семененко, 2008).

We believe it is worth noting that some scientists divide killer whales by their diet type into “fish-eating” and “flesh-eating” (Bigg, 1982; Ford, Ellis, 1999; Ford et al., 2000; Burdin et al., 2004; Шулежко, 2008; Ivkovich et al., 2010; Filatova et al., 2014), and the main field attributes to distinguish the two ecotypes of killer whales is presence of a notch on the saddle spot and shape of the dorsal fin (Шулежко, 2008).

On the pictures of killer whales made by us in 2017 during the longline fishing in the Sea of Okhotsk we can see that killer whales with various morphoforms of saddle spot and dorsal fin silhouettes take part in feeding on the longlines (Appendix 2, fig. 2). At the same time some of the animals according to the aforementioned criteria (Шулежко, 2008) quite confidently can be attributed to “flesh-eating” killer whales, that presumably eat only marine mammals. If we accept the hypothesis on “flesh-eating” killer whales ecotype existence, how can we explain the fact that they can be encountered on longline fishing and feed on the catch if they are isolated (Филатова и др., 2018) from “fish-eating” killer whales on a population level? Adaptive feasibility of this specialization for an epipelagic animal is unlikely because a killer whale is a smart and strong predator and cannot lock itself into a narrow food niche (Шунтов, 2016). The data obtained during our survey are backed by similar facts established by other researchers (Корнев и др., 2014; Болтнев, 2017). Besides, existing observations allow suggesting that not all killer whales feed on the catch, but only specific families which numbers are increasing (Белонович, 2021). Based on the totality of existing facts and known high productivity of local biocenoses (Шунтов, 2016) we can tell that there are no prerequisites for a narrow food specialization of killer whales in the Sea of Okhotsk. The difference in feeding between different families of killer whales noted by different authors fits well with the hypothesis of Norwegian researchers (Jourdain et al., 2017) on specialized methods of marine mammals hunting that individual families have.

## CONCLUSIONS

The studies allow us to come to several preliminary conclusions:

1. In 2017 the number of longlines attacked by killer whales was 21% of all longlines with black halibut catch. The killer whales do not eat any other fishery objects.
2. During longline fishing of one vessel in 2017 about 100 killer whales were registered. According to photo ID results 19 animals have been pre-recognized. The recorded groups of killer whales most likely specialize on feeding on black halibut catch.
3. The findings cast doubt on the hypothesis of “fish-eating and flesh-eating” ecotypes of killer whales basing on the fact that “flesh-eating” killer whales, distinguished by the notch on the saddle spot and the form of the dorsal fin, were recorded during black halibut fishing. We believe that killer whales of the Sea of Okhotsk have not narrow food specialization and observed differences in diets of different families are associated with seasonality of food and possession of skills in specific hunting methods for individual families.

4. Lowering the negative pressing of killer whales to black halibut catch will require a complex study with use of genetic and acoustic methods, satellite tracking by occurrence and identifying individual animals and families that specialize on black halibut. Provision of recommendations on ways to scare off marine mammals from fishing gear is possible only based on the results of such a study.

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## Appendix 1

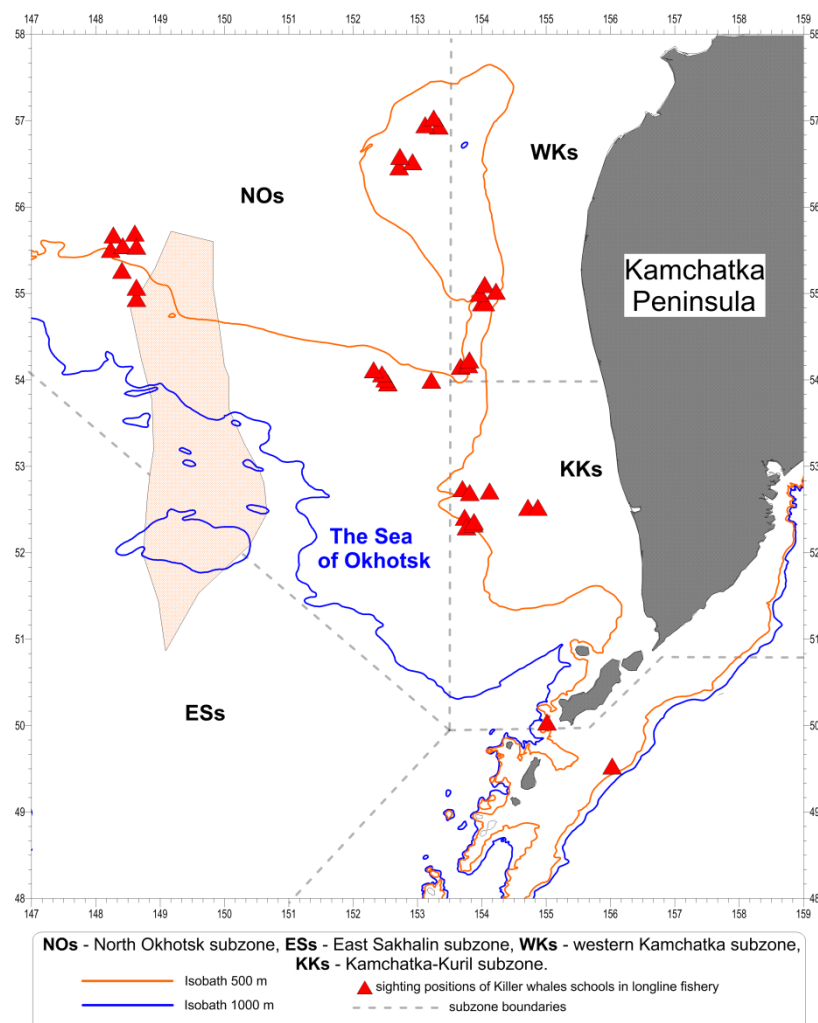


Fig. 1 – Areas of killer whales encounters during longline fishing in the Sea of Okhotsk in spring-summer 2017

Table 1. Ratio of black halibut longlines fed on by killer whales to total amount of black halibut longlines in different subzones in the Sea of Okhotsk in April-July 2017

Subzone	Black halibut			Black halibut and stingrays			Total		
	longlines	fed on		longlines	fed on		longlines	fed on	
		n	%		n	%		n	%
NSO*	99	13	13,1	30	7	23,3	129	20	15,5
KK*	28	9	32,1	0	0	0,0	28	9	32,1
WK*	22	8	36,4	0	0	0,0	22	8	36,4
Total, n	149	30	20,1	30	7	23,3	179	37	20,7

Note\*: NSO – North Sakhalin subzone, KK – Kamchatka-Kuril subzone, WK – West Kamchatka subzone



Table 2 – Provisional number of photo-identified animals of killer whales during the 2017 survey

Date	Number of photos	Number of identified individuals
23.04.2017	41	1
26.04.2017	112	2
24.05.2017	190	1
31.05.2017	246	3
06.06.2017	503	1
10.06.2017	283	3
23.06.2017	328	2
29.06.2017	201	2
02.07.2017	258	3
04.07.2017	163	1

Appendix 2



Figure 2 – Provisional identified of killer whales № 1, 2, 3



Figure 3– Provisional identified of killer whales № 4, 5, 6



Figure 4 – Provisional identified of killer whales № 7, 8, 9



Figure 5 – Provisional identified of killer whales № 10, 11, 12



Figure 6 – Provisional identified of killer whales № 13, 14, 15



Figure 7 – Provisional identified of killer whales № 16, 17, 18



Figure 8 – Provisional identified of killer whales № 19