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Date: 03.12.2021

Photo-identification of gray whales (Eschrichtius robustus) off the northeast coast of Sakhalin island in 2020

Фотоидентификация серых китов (Eschrichtius robustus) у северо-восточного побережья о. Сахалин в 2020 г.

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PHOTO-IDENTIFICATION OF GRAY WHALES (ESCHRICHTIUS ROBUSTUS)

OFF THE NORTHEAST COAST OF SAKHALIN ISLAND

IN 2020

Photo by A. Bobkov

Yu.M. Yakovlev, O.M. Tyurneva, Peter van der Wolf

prepared for

Exxon Neftegas Limited

and Sakhalin Energy Investment Company Ltd.

VLADIVOSTOK

2021

ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ УЧРЕЖДЕНИЕ НАУКИ
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«____» _____ 2021 г.

О Т Ч Е Т

О НАУЧНО-ИССЛЕДОВАТЕЛЬСКОЙ РАБОТЕ

ФОТОИДЕНТИФИКАЦИЯ СЕРЫХ КИТОВ (*ESCHRICHTIUS ROBUSTUS*) У СЕВЕРО-ВОСТОЧНОГО ПОБЕРЕЖЬЯ О. САХАЛИН В 2020 ГОДУ

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Владивосток, 2020 г.

FEDERAL PUBLICLY FUNDED RESEARCH INSTITUTION
NATIONAL SCIENTIFIC CENTER OF MARINE BIOLOGY NAMED AFTER
A.V. ZHIRMUNSKY OF THE FAR EASTERN BRANCH OF THE RUSSIAN ACADEMY OF SCIENCES (NSCMB of the FEB RAS)

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_____ 2021
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R E P O R T

ON RESEARCH WORK

PHOTO-IDENTIFICATION OF GRAY WHALES *(ESCHRICHTIUS ROBUSTUS)* OFF THE NORTHEAST COAST OF SAKHALIN ISLAND IN 2020

Project supervisor:
_____ Yu. M. Yakovlev

Vladivostok, 2020

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SUMMARY

Report contains 70 pages, 8 figures, 11 tables, and an Appendix

REPORT ON RESEARCH WORK – PHOTO-IDENTIFICATION OF GRAY WHALES (ESCHRICHTIUS ROBUSTUS) OFF THE NORTHEAST COAST OF SAKHALIN ISLAND IN 2020

PHOTO-IDENTIFICATION, COUNT, GRAY WHALES, ESCHRICHTIUS ROBUSTUS, PILTUN AREA, OFFSHORE AREA, NORTHEAST SAKHALIN

Photographic identification surveys have been conducted off the northeast coast of Sakhalin Island since 2002 as part of the comprehensive multi-annual Western gray whale (*Eschrichtius robustus*) monitoring program being implemented on commission from Exxon Neftegas Limited and Sakhalin Energy Investment Company Ltd. In 2018-2019, Gazpromneft-Sakhalin LLC also participated in this project. To date, a large body of scientific data in the two known feeding areas of these animals (Piltun and Offshore) off the northeast coast of Sakhalin Island was gathered. Surveys conducted in 2020 are described in this report and compared with the results from previous years. The multi-year studies of gray whales have yielded valuable data on these animals, which use the coastal area off northeastern Sakhalin as their feeding grounds during the summer/fall period.

From 2002 through 2013, the photo- and video-identification of gray whales was primarily conducted by one team based on vessels using launch boats. In 2014–2016, an onshore camp was set up for the second boat team, and efforts were made to collect photographic materials directly from shore. The south and north onshore vehicle-based teams moved along the coast collecting data on the animals feeding in shallow waters, and the boat-based teams performed photographic surveys in deeper waters of the Piltun and Offshore feeding areas. In 2017-2020, the vehicle-based teams used the unmanned drones as an additional means to photograph the whales.

Three photo-ID teams took part in the field studies in 2020. The efforts of the vessel-based team were focused on the Offshore feeding area, where 149 whales (6 of which were also sighted in the Piltun feeding area) were recorded.

In the Piltun area, the vessel-based team photographed 9 whales, two of which were not seen by other teams.

In the Piltun area, two vehicle-based teams recorded 30 whales. The south vehicle-based teams identified 25 gray whales, while the north team photographed 24 individuals. A total of 175 whales were recorded during the 2020 field work season within their known animal feeding areas off the coast of Sakhalin Island.

Annual gray whale records are affected by the scope of work (effort) and the number of animals present in the study area, which varies from season to season. This is clearly seen when comparing the study results of 2019 and 2020. In 2020, the field season lasted two months from 28 July to 29 September. In 2019, two teams that worked in the Offshore area and six teams that worked in the Piltun area recorded 193 whales (147 in the Offshore area and 92 in the Piltun area) within the four-month monitoring period (from early June to late September). The significant difference in the records for the Piltun area is attributed to the lack of data during the early observation period, when the majority of adults recorded were later sighted in the Offshore area.

Eleven new whales, including 9 calves, were identified during the 2020 field studies. Two new adult whales were sighted in the Offshore area. Currently the Sakhalin gray whale catalogue comprises 332 identified individuals.

From 2002 to 2020, 320 whales were recorded in the Piltun area, of which 145 had never been encountered in the Offshore area. This number included calves and young whales up to four years old. Eight whales were identified in the Offshore area in 2020 for the first time, but they had been sighted in the Piltun area in previous years. Only nine whales were sighted exclusively in the Offshore area. One whale was photographed north of Cape Elizaveta (180 km away from the Piltun lighthouse) in 2005 and has not been seen since. In all the years of study, 12 whales have been encountered near Okha (90 km north of the Piltun lighthouse), and all of them have also been seen in other areas. In 2015, two whales were sighted in the waters off the Vostochny wildlife refuge (250 km south of the Piltun lighthouse) and since then have not been encountered anywhere by our teams. However, according to A. M. Burdin, one of them was encountered in Olga Bay (Kamchatka Peninsula) (Burdin et al. 2017).

Mother-calf pairs were recorded in the Piltun feeding area only. The number of calves varies from year to year. The smallest observed number of calves was four in 2004 and 2005, and the largest number was 22 calves in 2019. In 2020, 7 mother-calf pairs and two unassociated calves were recorded off the coast of Sakhalin. The first pairs were photographed on 28 July in the southern part of the Piltun area. All calves were in good physical condition.

The use of the unmanned drones in the Piltun area helped to obtain good quality images, but did not increase the number of individual animals recorded. (Tyurneva et al., 2019a).

According to long-term observations, the weaning of calves usually begins in mid-August and continues until mid-September. In 2020, the last mother-calf pair was sighted on 9 September. In the next days of the observations, the calves were sighted alone or in other groups. After the breakup of pairs, six of the seven mothers identified in the Piltun area were encountered in the Offshore area. The unmanned drones in the Piltun area helped better identify both mother-calf pairs and calves in other groups. Photographing from height illustrated the difference in length of calves and grown whales bodies. All identified calves were observed to procure food independently after weaning.

Observations from 2003 through 2020 showed that the physical condition of most of the whales improves over the course of the season.

Based on the reproductive capacity, the number of animals observed, and their ability to recover after a period with an insufficient diet, one can conclude that the Sakhalin group of gray whales is in good condition, and the number of whales is increasing, which is consistent with the latest assessment of this group by Justin Cooke (Cooke, 2019).

INTRODUCTION

The western subpopulation of the gray whale *(Eschrichtius robustus)* was classified by the International Union for Conservation of Nature (IUCN) as an endangered species (IUCN, 2019), Cooke et al., 2018), and was listed as Sea of Okhotsk population with status endangered species on the Russian Federation Red Book (Category 1, The Red Book, 2001, 2018, 2020). According to the latest estimate, which is based on the photo ID data under the MSNBC and RGWP programs, as well as on other studies spanning from 1995 to 2018, the gray whale subpopulation feeding off Sakhalin and Kamchatka has increased by 4.3–5.3% annually over the last 20 years to 2018, and by 2019 its number reached 231 whales (90% CI 219-245), excluding yearlings (Cooke, 2019).

Exxon Neftegas Limited (ENL), the operator of the Sakhalin-1 Consortium, and Sakhalin Energy Investment Company Ltd. (Sakhalin Energy), the operator of the Sakhalin-2 project, are performing commercial development of oil and gas reserves on the continental shelf off northeast Sakhalin Island, in the Sea of Okhotsk. Operations as part of these projects are being conducted close to summer feeding grounds of the Sakhalin gray whales. Russian Federation Government authorities recommended that both Companies should conduct a regular gray whale monitoring. Gazpromneft-Sakhalin, LLC (Gazpromneft-Sakhalin), Ayashsky license block operator and the Sakhalin-3 project operator, joined the program in 2018 and 2019, which expanded the ability to implement vessel photo-ID studies in the Offshore feeding area. In 2020, these studies were conducted by two operators.

As part of the Sakhalin gray whales monitoring program, the photo-identification surveys of gray whales started in 2002. Since the onset of the study, photo-ID surveys were conducted each summer/fall during their feeding period. Multi-year studies yielded valuable data on these animals, which use the coastal area of northeast Sakhalin Island as their feeding grounds. Study of the group of whales is also necessary for development of the respective measures to mitigate impact on the Sakhalin feeding group of gray whales.

From 2002 through 2013, photo-and video-identification of gray whales was conducted by one team based on vessels using launch boats. In 2014, an onshore camp was set up for the second boat team, and efforts were made to collect photographic materials from shore. In this case, the team was moving along the coastline on a vehicle and took photos of whales upon detection. The experience was successful, and in 2015, capabilities of shore-based photo-identification were used in addition to photo-identification from the boats. In 2016, the south shore-based team tried to

collect photo- and video material using unmanned drones. Acquired images were of good quality to identify whales, and in 2017, two shore-based teams (northern and southern) started to use DJI Phantom 4Pro drones for photo-identification. This allowed teams to not only obtain quality images of whales, but also to collect additional data, for example, about mother-calf pairs (Tyurneva et al., 2019a).

In 2020, the photo-identification studies of gray whales were conducted in August and September in accordance with the *2020 Program of Gray Whale Monitoring off the North-East Coast of Sakhalin Island* developed by ENL and Sakhalin Energy. The studies were duly endorsed by the federal executive agencies – the Ministry of Natural Resources and Ecology of the Russian Federation (Russian Minprirody), the Federal Service for Natural Resource Use Oversight (Rosprirodnadzor), and Federal Fisheries Agency (Rosrybolovstvo).

The study of individual animals provides information on demography, social structure, and other aspects of the ecology of this species. In the long term, it also provides information to assess the Sakhalin group status and health. Photo-identification addresses the current population status and the need to develop appropriate mitigation measures, and makes it possible to monitor the effectiveness of such measures. More detailed objectives of the photo-ID studies under the Joint Monitoring Program are summarized below.

The objectives of the Gray Whale photo-ID study off the northeastern coast of Sakhalin were as follows:

1. Update the photo-ID catalogue by taking photo and video imagery of each gray whale individual;
2. Assess the body and skin condition of individual animals;
3. Assess affinity of different individuals for the feeding areas off northeastern Sakhalin;
4. Describe feeding group demographics and structure;
5. Describe habitat use (including seasonal and annual movements of individual gray whales within and between feeding areas);
6. Assess the number of mother-calf pairs, their body condition, use of habitat, and determine separation dates for such pairs.

This report provides an overview of the results of gray whale photo-ID survey in 2020. For a comparative analysis, this report uses data and results taken from photo-identification reports under the auspices of the Joint Monitoring Program for past years of studies (Yakovlev and Tyurneva, 2003, 2004, 2005, 2006, 2008; Tyurneva et al., 2019b; Yakovlev et al., 2007, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017; Tyurneva et al., 2018, Yakovlev et al., 2015, 2019).

1. MATERIALS AND METHODS

1.1. Study Area and Field Work Methods

The studies encompass the two summer-fall gray whale feeding areas off the coast of Sakhalin Island in the Sea of Okhotsk – the Piltun area, stretching 120 km along the shore of Piltun Bay (52°25' N–53°30' N), where the whales feed primarily at depths of less than 20 m, and the Offshore area, located farther offshore from Chayvo Bay (51°40' N–52°30' N, 143°20' E – 144°10' E)) at depths of 35–60 m (Maminov and Yakovlev, 2002; Yakovlev et al., 2009). Photo-identification data were collected from 28 July through 29 September (Figures A1, A3).

In 2020, the photo-ID data was collected by three photo-ID teams from two different platforms:

1) Vessel-based studies were conducted from 2 August to 28 September from the field operations support vessels (team lead – A. Yu. Yakovlev). The work of the vessel-based teams was conducted from an FRC boat with a water-jet motor, or from the vessel. The detailed methods of field studies conducted by the vessel-based photo-ID team are set out in the annual report (Yakovlev et al., 2013a).

2) The onshore photo-ID studies in the Piltun area were conducted by two onshore vehicle-based teams, which moved along the coast in the south and north directions (relative to the mouth of Piltun Bay), taking imagery of the whales they encountered directly from shore. Photo-ID was conducted from 28 July through 28 September in the area adjacent to Piltun Bay, offshore northeast Sakhalin Island. The first team operated in the north (team lead – A. Bobkov), the second team operated in the south (team lead – Peter van der Wolf).

Onshore photo-ID surveys were conducted in good weather: mandatory condition of over 500 meters visibility and Beaufort sea state not exceeding 5. A detailed description of onshore photo-ID methods is provided in the 2016 report (Yakovlev et al., 2016).

Since 2017, unmanned drones DJI Phantom 4Pro were used for photo-ID purposes. They recorded high-quality JPEG photographs with maximum resolution 5472 x 3648 pixel, and also 4K video records with resolution 3840 x 2160 pixel. Often, both photo camera and drone were used for whales recording. During operations one of team members acted as a controller helping the

drone operator to find whales. The drones recorded at a distance of about 800 meters from the shore with a standard flight height above 10 m.

Photographs collected by photo cameras and drones were saved on SDXC memory cards.

Shore-based teams used Fujinon 7x50 binoculars and Celestron 20-60 x 60 mm telescopes to scan the sea surface to find whales for further recording.

All data were recorded and saved according to a procedure common for all the teams.

1.2. Laboratory Methods

During lab processing of the photos, each photo obtained during a season was studied for the purpose of matching it with a specific individual. In this case, standard photo-ID methods were used which are described in Special Issue No. 12 of the International Whaling Commission (Hammond et al., 1990).

After all individuals were identified from the photographs and supplied with a detailed description of the animal with its catalogue number, the best available photos for each whale were selected. The whales encountered for the first time were assigned new catalogue numbers if a high-quality image of the right side of the animal was available. Afterwards all data were entered into a database. A catalogue of identified individuals was prepared for each study year and used as the basis for compiling a master catalogue that is updated yearly. The whale identification procedure is described in detail in Yakovlev et al., 2013.

Photos obtained using drones of the whale body taken from height made it necessary to update the catalogue, as unique marks of animals known to the experts became hidden under water. Thus, a new fifth aspect appeared in whale catalogue – “Back”. Three experts verified proper whale identification.

An index-based system was used to categorically represent confidence in mother and calf classifications (Yakovlev et al., 2013).

2. SURVEY RESULTS

2.1. Field Work Results

General information on the vessel-based team efforts during survey is summarized in Table 1. The information on work areas and scope, as well as other survey data, are provided in Table A1. Depth measurements were conducted while acquiring imagery from a boat at whale sighting locations in the Offshore and Piltun areas.

Table 1. Vessel-based Photo-ID Effort off Sakhalin Island during the 2020 Expedition (Field Data)

Area	Vessel-based team (VT)				
	Work days	Number of missions*		Number of groups	Number of whales
		M	M0		
Piltun	4	2	2	17	23
Offshore	10	2	13	143	328
Total	14	19		160	351

* Note:
M – a standard photographic identification mission conducted using a motorboat;
M0 – gray whales were photographed from a vessel.

The duration of the mission, the number of whale sightings during a mission, the number of observed whales in a group, the duration of each sighting, etc., were recorded during study in the respective database section. In total, the vessel-based team photographed 351 animals including repeated sightings (field data).

Information on the efforts of the onshore vehicle-based teams is provided in Table 2. The vehicle-based teams photographed 289 animals, including repeated sightings (field data).

Table 2. Work Scope and Data Collected by Onshore Vehicle-Based Photo-ID Teams in 2020 (Field Data)

Area of operation	South Vehicle-Based Teams			North Vehicle-Based Teams		
	Work days	N of whale groups	N of whales	Work days	N of whale groups	N of whales
Piltun	38	92	213	26	56	76

Detailed descriptions of the study areas are provided in past years' reports.

A total of 15,234 photographs were taken by the three teams during the 2020 field season. The total number of whales recorded, including repeated sightings of the same whale during different missions, was 640 (field data)[1].

2.2. Identification of Whales and Number of Individuals

All data obtained during the 2020 field season was processed and compared with data from previous years.

Compiling the annual and master gray whale catalogues was one of the tasks of the photo-ID operations. The quality of the gray whale identifications in subsequent encounters was contingent upon the thoroughness of the aspects documented in the catalogues. Not every whale in the catalogue contains images of all four aspects (i.e. the right side, the left side, the dorsal and the ventral sides of fluke). The likelihood of obtaining complete coverage of all four aspects of each whale increases each year as new photographs are added to the catalogue.

Images of the backs of 113 animals taken from drones were included in the 2002-2020 catalogue. Drone photo-ID improved capturing different aspects of a whale body, as often whales were under water and did not appear on surface. Provided that water was clear, it was possible to identify such animals. Drones also made it possible to add to the catalogue the images of the fluke dorsal side of young whales encountered only in the area of the Piltun Bay.

2.2.1. Identification of Whales and the Number of Animals off the Northeastern Coast of Sakhalin Island

Data regarding the number of whales identified off northeast Sakhalin Island in 2002-2020 are presented in Figure 1 and Table A2.

[1] The major difference between field and laboratory gray whale recording data can be explained by the fact that the teams cannot identify the left and right sides of the same animal in field conditions, and record it as different animals. Also, not all animals in the photos can be identified due to the low quality of images obtained from a large distance away.

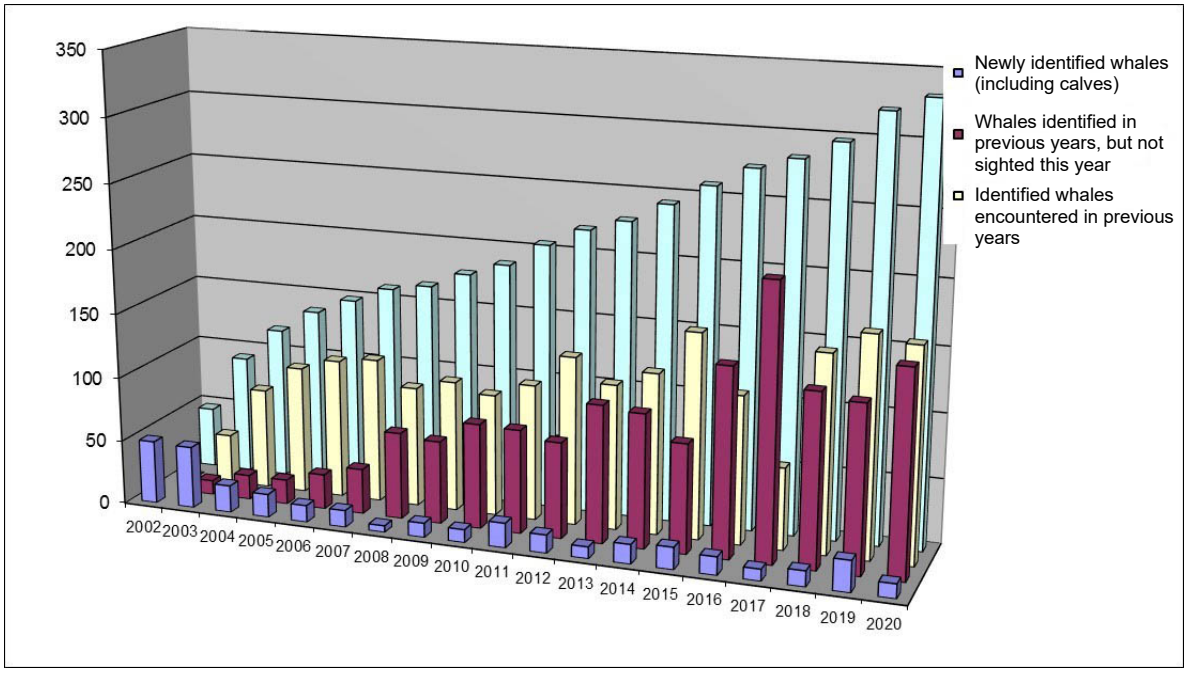


Figure 1. Number of Gray Whales Recorded in the Catalogue and Identified in 2002-2020 off the NE coast of Sakhalin Island

Based on the results of the laboratory processing of the photographs collected by the field research teams during the field season of 2020, 175 individuals were identified in the Piltun and Offshore feeding areas. The total number included 11 new whales, of them 9 calves and two adult whales, sighted in the Offshore area. Based on the new data, the master catalogue of gray whales recorded off Sakhalin contains photos of 332 whales (Table A2).

2.3. Mother-Calf Pairs

In 2020, 9 calves were identified with the majority of them (7) observed with their mother. All 7 mothers were encountered in the Offshore feeding area in 2019 when they were pregnant. All mothers and calves were assigned confidence indices (Yakovlev et al., 2013). The results of classification are presented in Table 3.

Table 3. Sighting Frequency of Mother-Calf Pairs and Calves Encountered without Mothers off Sakhalin Island in 2020, with the Assigned Confidence Indices*

Number of calf in master catalogue KOGW###	Number of monitoring days	Calf identification confidence index	Number of mother in master catalogue KOGW###	Number of monitoring days (mother with calf)	Mother identification confidence index
322	27	A	063	13	I
323	12	A	168	2	I
324	18	A	097	13	I
325	12	A	005	8	I
326	13	A	019	2	I
327	6	A	107	1	II
328	16	A	027	1	II
329	10	A	-	-	-
330**	1	C	-	-	-

Note:

* The system for determining the confidence indices for calves (from A to C) and their mothers (from I to III) identification is based on a visual assessment of the external attributes inherent in calves, and on the number of sightings in a pair with an adult whale, see Section 3.5.6, Vol. I, 2013 Report (Yakovlev et al., 2013).

** Whale KOGW330 was not sighted in pair with a mother; it was sighted once and not in a calf group, however, photos taken using an unmanned drone show clearly discernible attributes of a calf.

The use of drones allowed to improve the identification accuracy both for mother-calf pairs and solitary calves. Aerial photographs allow for positive identification of body length differences between calves and adults that were more challenging to observe from shore given the low elevation of onshore observation points. In addition, we were able to record calves feeding on their own.

The first mother-calf pair was recorded on 28 July. The last time a mother-calf pair was sighted on 9 September. Calf KOGW329 whose mother was not identified was encountered on several occasions, both in the company of other mothers and in other groups, which is why it could be identified as a calf with greater confidence (Table 3).

In 2020, female KOGW168, which was born in 2009 (11 years old), arrived to the Sakhalin coast with a calf for the first time. Interestingly, her mother KOGW097 also brought a nursing calf in 2020.

The data from the previous years show that the mother-calf pairs break-up starts approximately in mid-August and continues through mid-September. In the 2020 season, the

timing of the pairs break-up did not differ from long-time average annual. As can be seen from Table 4, of the 7 identified nursing mothers of the current season, 6 were recorded in the Offshore feeding area at a later time.

Table 4. Intra-Seasonal Migration of Mothers that Arrived with Calves in 2020.

Whale number	Date of first sighting in the survey area	
	Piltun Area	Offshore Area
063	28 July	-
168	29 July	4 August
097	30 July	28 September
005	9 August	9 September
019	31 July	17 August
107	28 July	10 August
027	31 July	26 August

According to our research, the interval between births for mothers varies from year to year, ranging from two to three or more years. 41 mothers from the Sakhalin Catalogue were recorded between 2002 and 2020 that came with calves to the feeding areas off Sakhalin and Kamchatka (Yakovlev et al., 2008, 2009, 2010, 2011, 2012; Tyurneva et al., 2009, 2010, 2011, 2012). Of those, 28 mothers were recorded with calves on two or more occasions (Table A5). Since we have regularly observed the young of the year without mothers, we obviously cannot account for all females who gave birth to calves in the current year. For example, female KOGW047 was sighted with a calf in 2016. In 2018 and 2019 she was sighted near other mother-calf pairs and calf groups throughout the season, but was not recorded in a stable pair with a calf. Whale KOGW095 (a calf in 2004) was also encountered alongside pairs and calves throughout almost the entire field season (Table A5). Females clearly showed a poor body condition (Class 4). It is possible that their unidentified calves have already switched to independent feeding, and we were unable to trace a connection between them.

2.4. Frequency of Sightings, Ages, and Movement of Identified Whales between Known Feeding Areas off Sakhalin Island

Generally, the same individuals come to Sakhalin every year for feeding. Some of these whales were re-sighted several times within a season and in different years, while others were recorded only once within a long period of time or new to the catalogue. We suggested that due to

the fact, that researchers cannot record all whales that come here for feeding, analyzing the 2002-2020 data on the return of known individual whales, we should consider only those individuals that were recorded at least once every three years as regularly-sighted whales (new whales 2020 were not counted). Therefore, as of 2020, we identified a group of 182 whales that regularly come for feeding to the offshore area of Sakhalin Island. Thirty-four whales were recorded in this area at intervals greater than three years; this group was classified as rarely-sighted whales (Table A4). Of all the known whales in the master catalogue, 104 individuals were encountered off Sakhalin during one season only and not encountered during the following years. Of those, 77 individuals were recorded as young of the year (Table A5). Whale KOGW126 was found dead in 2009.

In 2020, two mature whales, which were new for the Sakhalin catalogue, were encountered in the Offshore area.

A total of 525 whale sightings, including repeated sightings (encounters), and 175 individual whales were identified among the whales photographed by three teams off Sakhalin during the 2020 season (Table 5). These data make it possible to determine the whale re-sighting rate (RR) for the season.

Table 5. Gray Whale Identification off Northeastern Sakhalin by Research Teams in 2020

Area	**Vessel-based teams**		**South vehicle-based team**		**North vehicle-based team**		**Total**	
	Whales identified including re-sightings	Total whales identified	Whales identified including re-sightings	Total whales identified	Whales identified including re-sightings	Total whales identified	Whales identified including re-sightings	Total whales identified
Piltun	14	9	143	25	67	24	224	32
Offshore	301	149	-	-	-	-	301	149
Total	315	158	143	25	67	24	525	175
RR		**1.99**		**5.72**		**2.79**		**3.00**

The animals were recorded in the Piltun area along the coast at depths of 4 – 22 m and in the Offshore area at depths of 49–64 m (Figure A1, Table A1).

The high RR rates presented by the onshore vehicle-based teams suggest that the whales were observed in the Piltun area mainly in stable groups, which, according to the collected data, consisted mainly of juvenile whales and mothers with calves. The major congregations of animals were registered north and south of the Piltun Lagoon estuarial zone (Figure A1).

Table 6. Frequency of Resightings of Individual Gray Whales (IDW) Photographed by All Teams off Sakhalin Island in 2020 (excluding temporary whales)

Number of an individual whale sightings (A)	Number of whales with this number of sightings (B)	Total number of whale sightings (AxB) *
1	64	64
2	52	104
3	22	66
4	13	52
5	4	20
6	3	18
7	3	21
8	2	16
9	2	18
10	1	10
12	4	48
13	1	13
14	1	14
16	1	16
18	1	18
27	1	27
Total	**175**	**525**

The average number of sightings per individual for the 2020 season was 3.00 (Table 7).

Table 7. Frequency of Sightings of Gray Whales

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Number of whale sightings	66	154	228	384	385	675	275	297	207	248	374	226	682	768	778	374	545	2020	525
Number of IDWs per year	49	86	99	117	121	125	98	112	104	124	144	121	139	175	128	72	155	193	175
Average number of IDW encounters during the season	1.35	1.79	2.3	3.28	3.18	5.4	2.81	2.65	1.99	2	2.6	1.87	4.91	4.39	6.08	5.19	3.52	10.47	3.00

Significant differences in gray whale re-sightings between 2019 and 2020 are due to the larger number of teams and the extended 2019 field season.

Whale movement patterns between the coastal (Piltun, including Chayvo) and the Offshore feeding areas have been studied based on resightings of identified animals in both areas over the entire survey period of 2002-2020 (Figure A1, Tables A4, A5).

2.4.1. Offshore Feeding Area

Favorable weather conditions and vessel work schedules made it possible for a successful program in 2020 (Table 5). The volume and informative value of the data acquired was the most significant in all of the survey years. In 2020, 301 encounters with gray whales were recorded in the Offshore area based on the laboratory data (Table 1, Table 5, Figure 2, Figure A1).

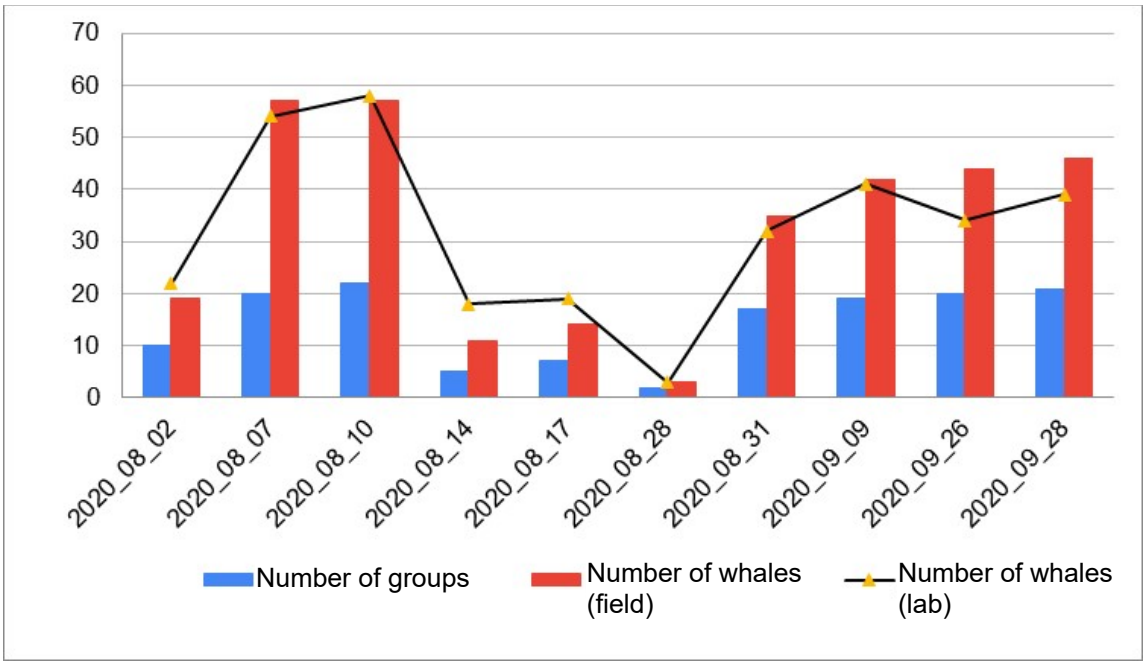


Figure 2. Registration of Gray Whales by the Vessel-Based Team for Each Day of Photo-ID Surveys and Number of Identified Gray Whales for Each Day of Photo-ID Surveys (laboratory determination)

The vessel-based team focused their efforts on collection of data in the Offshore area, except surveying in the seaward part of Piltun area for four work-days (August 4, 13, 26 and 27). As can be seen in Figure 2, whales in the Offshore area were sighted through all monitoring period. The maximum of data was collected on August 7 and 10. A large amount of data collected was also recorded every work day in September (Figure 2, Figure A1)

During the 2020 field season, 149 whales were recorded in the Offshore area, of which 10 were encountered for the first time in deep waters (8 whales that had been observed only in the Piltun Area in the previous years and 2 whales were never photographed before). Of the total number of animals identified, 143 were recorded only in the Offshore area (Figure 3, Tables A3, A4).

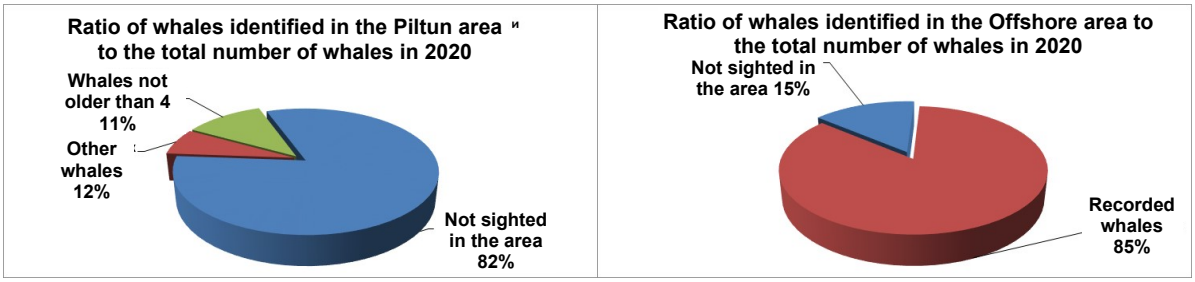


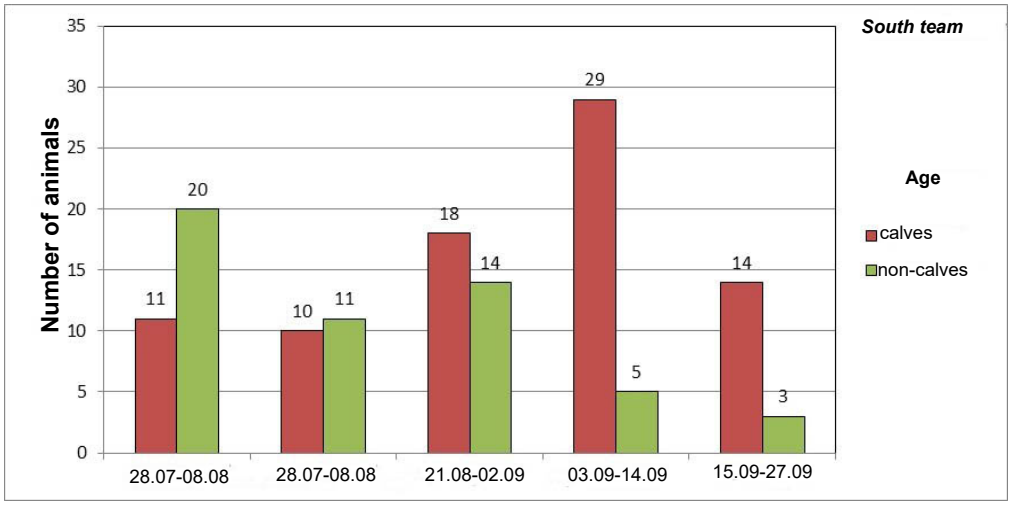
Figure 3. The proportion of whales sighted in the Piltun and Offshore Feeding Areas vs. the Total Number of Identified Whales in 2020.

Annual registrations of gray whales depend not only on the performed scope of work (efforts), but also on the number of animals present in the survey area, that varies between the seasons. In 2020, the field season was successful in the Offshore area, but the efforts in the Offshore area in the 2020 season were lower than in the 2019 season both in terms of observation timeframe and number of observation days, though the number of observed whales was higher than during the surveys of previous years (147 whales in 2019). Of all years when surveys were conducted, 2016 and especially 2017 seasons should be reviewed separately, when the weather conditions and a tight schedule of work onboard support vessels did not allow the vessel crew to complete the entire scope of surveys planned for the Offshore area. Therefore, the total number of whales identified in 2016 and 2017 was less than the number of whales recorded during the dedicated vessel-based surveys in the Offshore area, when 32 to 70 animals were recorded during a work day. (Joint Program, 2018). (Tables A3, A4).

In 2020, the same as in all previous study years, the research teams did not observe any young whales (up to 4 year old), calves, or mother-calf pairs in the Offshore feeding area.

2.4.2. Piltun Area

A total of 224 whales, including repeated sightings, were photographed in the Piltun area in 2020 by two shore-based and one vessel-based teams.



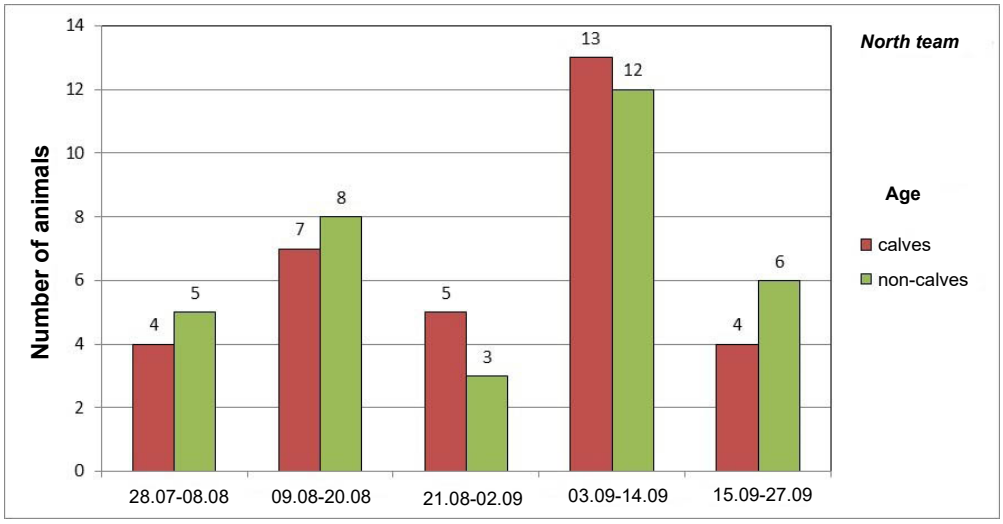


Figure 4. Recording of Sightings of Calves and Animals Older than 1 year in the Piltun Feeding Area for the 2020 Field Season by the South and North Vehicle-Based Teams

Data shown in Figure 4 indicates the number of gray whales recorded for 12-day intervals in the Piltun feeding area throughout the entire field season. The data are shown separately for calves and non-calves (i.e., for whales older than one year). In the southern part of the Piltun area, the number of sightings of whales older than one year was lower in September which is partially explained by movement of mothers into the Offshore area. In the northern part of the Piltun area, the ratio of sightings of calves and non-calves was more balanced. The maximum number of whale sightings both in the southern and northern parts occurred in the first half of September (Figure 4).

A total of 32 individual animals were sighted in the Piltun feeding area, which was the lowest number of sightings in the Piltun area over the entire survey period, except 2002. Over the

last ten years, the highest number was recorded in two years – 2015 (118) and 2011 (105). In 2019, 92 whales were identified, of which 22 were calves (Figure 5, Tables A3, A4). All these three years are characterized by the long field seasons, the largest number of field photo-ID teams, and favorable weather conditions. If the data for August and September of 2019 and 2020 are compared, than a similar trend is observed in the shallow-water area. Adult whales moved for feeding to the deep-water areas in June-July, and only calves and two-three year old animals, and some of the nursing females remained in the Piltun area in August-September.

Six whales were identified both in the Piltun and Offshore areas over the 2020 field season (Figure 5, Tables A3, A4). All of them were recorded as mothers that arrived with calves in the current year.

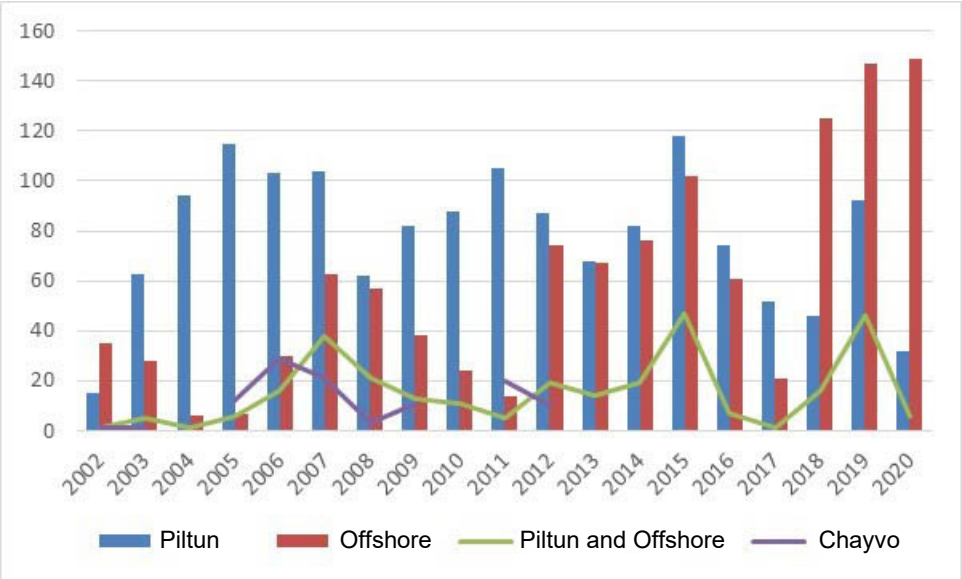


Figure 5. Number of whales sighted in the feeding areas off NE Sakhalin Island and the number of animals sighted annually in both areas (2002 through 2020)

From 2002 to 2020, 320 whales (96.4% of all known whales in the catalogue) were sighted in the Piltun feeding area, of which 145 whales (43.7% of all those known in the catalogue) were not recorded in the Offshore feeding area. This quantity predominantly includes calves and young whales no older than four. Nine whales were sighted only in the Offshore feeding area, including two new whales in 2020 (Figure 6).

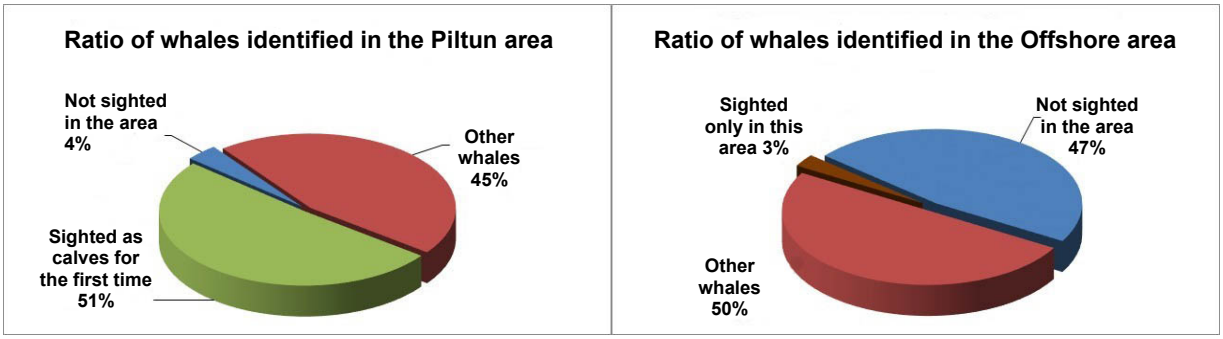


Figure 6. Percentage of gray whales sighted in the Offshore and Piltun areas throughout all study years (2002–2020)

Over the past 19 years of monitoring, 51% of the known whales were recorded as calves (Table A5). Therefore, the age of 170 whales from the Sakhalin Gray Whale Master Catalogue is known. Of those, 77 whales (9 calves identified in 2020 are not included in this number) were sighted off Sakhalin only once when they were less than one year old (Table A4). A total of 175 whales have been recorded in the Piltun and Offshore feeding areas both during the same season and in different years (Figure 5, Figure 6, Table A4). Fifty two whales among the animals identified in the Piltun area for the first time as yearlings were also sighted in the Offshore area in later years. Whale KOGW050 known since 2003 and repeatedly identified as a nursing female in different years of research, was encountered in the Offshore area in 2020 for the first time. Two mothers that repeatedly brought calves to the Piltun area were never sighted in the Offshore area (Tables A4, A5).

Calves and young whales potentially cannot feed at great depths and always observed in the nearshore Piltun feeding area at depths ranging from 4 to 15 meters, For this reason, we believe that the adult whale movements between the shallow and deep-water feeding areas are a common occurrence and depend on the presence of available food, as well as on the physical abilities of the whales.

One whale was photographed north of Cape Elizaveta in 2005 and has not been seen since. In all the years of the study, 12 whales have been encountered near Okha, and all of them have also been seen in other areas. In 2015, two whales were sighted in the waters off the Vostochny wildlife refuge, and since then have not been encountered in the Piltun and Offshore areas.

2.5. Body Condition

2.5.1. Body Weight

In 2020, the body condition (BC) of 108 individuals was assessed based on the acquired photos. Of them, 28 whales (25.9%) with poor BC were identified, including 7 nursing mothers (Tables 8, 9).

In the Piltun feeding area, all mothers in the mother-calf pairs, whose BC we managed to assess, were clearly underweight (BC class 3, 4). At the same time, as in previous years, all the calves recorded in 2020 were well fed (BC 0).

A decrease in sightings of whales with poor BC was noted by the end of the observation period (Figure 7, Figure 4).

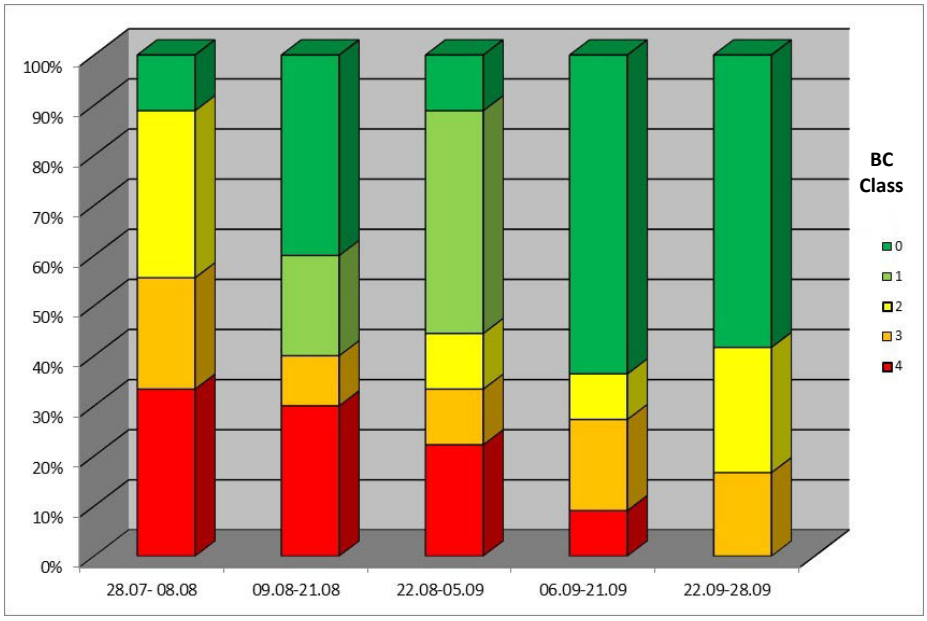


Figure 7. Percentage of Photo-identified Gray Whales within Each Body Condition (BC) Class Relative to the Total Number of Whales Recorded during the 2020 Field Season in the Piltun Area.

In general, the whales identified in the Offshore feeding area had good body condition from the start of the season (Figure 8). Occurrence of whales with BC Class 3-4 is explained by movement of mothers previously identified in the Piltun area as mothers with calves.

Table 8. Body Condition of Gray Whales off Sakhalin Island in 2020.

BC Class	Number of Whales in Each BC Class in 2020	Percentage of Whales in Each BC Class Recorded in 2020
0	54	50.0
I	26	24.1
II	20	18.5
III	5	4.6
IV	3	2.8

Notes:
- The body condition of 108 whales could be determined using photographs.
- Classes 0, I – animals with normal body condition
- Classes II, III, and IV – animals with poor body condition (highlighted green).
- If a whale had high value for BC class during the first encounter, but BC improved during the subsequent sightings, we used the BC data recorded during the last sighting.

Table 9. Number of Whales with Poor Body Condition (BC) Sighted Off Sakhalin Island from 2003-2020

Year	Total Identified Whales	Total Whales with Poor BC	Percentage of Total Recorded Whales with Poor BC	Number of Nursing Mothers Recorded in Given Year
2003	86	15	17.4%	9
2004	99	11	11.1%	3
2005	117	10	8.5%	3
2006	121	20	16.5%	3
2007	125	13	10.4%	6
2008	98	20	20.4%	3
2009	112	19	17.0%	3
2010	104	12	11.5%	5
2011	124	23	18.5%	7
2012	144	14	9.7%	1
2013	121	25	20.7%	3
2014	139	20	14.4%	9
2015	150* (175)	29	19.3%	8
2016	108* (128)	23	21.3%	8
2017	63* (72)	21	33.3%	6
2018	127* (155)	19	15.0%	8
2019	136* (193)	40	29.4%	18
2020	108*(175)	28	25.9%	7

Note:
* Total number of whales with recorded BC. (Only data for whales with photographs that allowed assessment of the body condition were used in the table).

In the Offshore area, mothers who came to the area for feeding after the pair breakup started being observed in August-September. At the same time, it was not possible to fully monitor the dynamics of the BC restoration in all these mothers, due to the low rate of their re-sighting in the Offshore area.

During the first sighting in the Offshore area after the separation from the calves in August, two mothers, whose nutritional status we were able to determine, had BC Class 3 (KOGW168, KOGW019). By September 26, KOGW168 improved her body condition to class 1, and KOGW019 - to class 2. Mother KOGW027, sighted on August 26, had a pronounced thinness of class 4; she could not be photographed in September. We were able to track the BC changes for two mothers only at the end of September, they both improved their physical condition (KOGW107 - class 1, KOGW097 - class 2) compared to the [condition] observations in the Piltun area. We could not determine BC for KOGW005 encountered in the Offshore area on September 9 from the photographs taken.

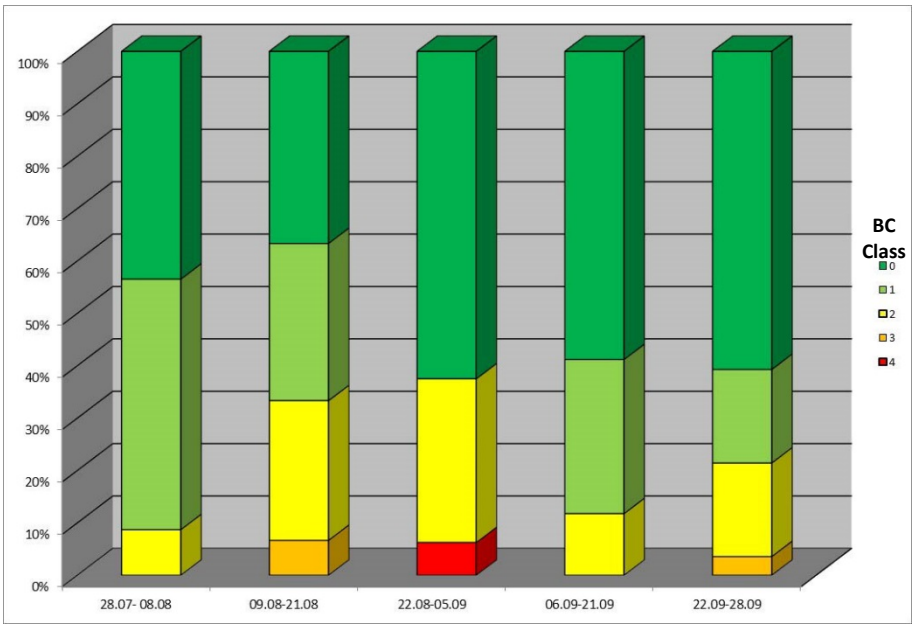


Figure 8. Percentage of Photo-identified Gray Whales within Each Body Condition (BC) Class Relative to the Total Number of Whales Recorded during the 2020 Field Season in the Offshore Area.

As Figure 8 shows, the number of sightings of whales with poor BC decreases by the end of the observation season. Improved BC was also noted in identified mothers.

In 2020, we were able to track the body condition of animals that were identified in 2019 as mothers with calves. Eighteen mothers who were observed with calves in 2019 were sighted in 2020 in the Offshore area. It was possible to determine body condition of ten animals. All the mothers had improved their BC (Table 10).

Table 10. Year-to-Year Comparison of the Body Condition of 2019 Mothers and Calves Observed off NE Coast of Sakhalin Island in 2020

	Number of mothers/calves in 2019	**Number of mothers/calves with poor BC in 2019**	**Number of sighted mothers/calves in 2020 from 2019**	**Changes in BC observed in 2020 vs. 2019**	
				Improvement in BC	**Worsening of BC**
Mothers	19	19	18	10	0
Calves	22	0	7	1	6

2.5.2. Skin Condition

One of the gray whale health parameters is their skin condition. Over a number of years, we have seen many types of skin conditions.

No skin abnormality was found in 2020.

3. DISCUSSION

3.1. Use of Unmanned Drones for Gray Whales Photo-ID in the Piltun Area

In 2020, the north and south onshore teams used unmanned aerial vehicles (UAVs or drones) to supplement the data obtained from shore-based photography. Since 2017, onshore photo-ID teams used UAVs to obtain photos of gray whales suitable for identification. The use of UAVs allows shore-based groups to obtain photos closer to the whale's location, while shore-based photography is limited to animals approaching the shoreline. Photographic quality diminishes as individuals are farther from shore. Aerial photographs also provide an additional identification aspect for subsequent identification and make it possible to identify whales underwater as long as the water clarity is sufficient. (Tyurneva et al., 2019a). This method of taking photographs enhances the ability to identify mother/calf pairs and calves encountered without mothers, since the difference in the size of the animals is clearly visible from the height. UAVs are also relatively non-invasive that allows us to observe gray whales in their natural conditions with minimal disturbance, as well as to document observed behavior within the limits set by the UAV flight duration.

In addition, using UAVs also allows to identify potential risks to gray whales, such as abandoned fishing nets (Tyurneva et al., 2019a).

3.2. Movement of Whales between Sakhalin Feeding Areas

Photo-identification methods can help understand gray whale habitat use off Sakhalin. Tracking the movements of gray whales during their feeding period can broaden the understanding of their spatial ecology.

Individual whale movement patterns between different feeding areas during a single season can be assessed through repeated sightings of individuals during a feeding season. The observation of individual whales in a single area and a repeated sighting of the same whale in another area in subsequent years gives evidence of its seasonal and inter-seasonal movements.

The multi-year studies of gray whales of a very small population by the photo-ID method allowed to determine the important parameters of their behavior in the feeding areas offshore Sakhalin Island. Regular return of the registered animals to the feeding areas in the summer-fall period is described, as well as their movements between the areas that allow to use food resources

more efficiently. Processing of the multi-year data collected by the photo-ID method from the shore, vessels, boats and drones about the endangered gray whales in the environment of oil and gas development of the Sea of Okhotsk shelf allowed to determine annual and year-to-year affinity of animals for their feeding areas during the seasonal migrations. Population growth rates and return of animals in the following years (with a small immigration) suggest that this population is demographically self-sufficient and that the nearshore Piltun and Offshore feeding areas are critically important sources of food (Bröker et al., 2020). Information on individual whale movements between the feeding areas during a single season can be analyzed based on repeated sightings of specific whales during a feeding season. The observation of individual whales in one area and a repeated sighting of the same whale in another area in subsequent years gives evidence of its seasonal and interseasonal movements. Frequency of repeated encounters between these areas show a continuous exchange of whales.

As of 2020, a group of 182 whales is identified which regularly comes to the Sakhalin shelf in the summer-fall period. Of all known whales included in the Master Catalogue, 104 animals were encountered on the Sakhalin shelf only during one season, and they were not sighted in the following years. Of which 77 animals were recorded as the young of the year. (Nine calves and 2 adult whales identified in 2020 are not factored in the calculations, as there are no inter-annual observation data.). Some of the 104 whales were encountered at Kamchatka Peninsula in different years (Tyurneva et al., 2015).

The 2002–2020 photo-ID data collected off Sakhalin indicate that inter- and intra-year movements of gray whales occur both within and between the Piltun and Offshore areas.

Of the 320 whales identified in the Piltun area during the entire period of studies (2002-2020), 145 were never sighted in the Offshore area. This number includes calves and young whales. Only nine whales were observed exclusively in the Offshore area. Outside of the two traditional areas, gray whale occurrence was more sporadic albeit less effort was conducted in these areas. One whale was photographed north of Cape Elizaveta in 2005 and never seen since. Two whales were sighted off the Vostochny wildlife refuge in 2015, and have not been re-sighted anywhere by our teams. However, Burdin et al. (2017) encountered one of the individuals in Olga Bay, Kamchatka in 2017.

Whale occurrence off Sakhalin outside of the traditional feeding areas, as well as occurrence of whales from the Sakhalin group off Kamchatka Peninsula suggests they are broader

dispersed in the western part of the Pacific Ocean than it was believed during the early years of studies (Yakovlev and Tyurneva, 2008; Tyurneva et al., 2010; Tyurneva et al., 2010, 2011; Yakovlev et al., 2012). Continuous long-term monitoring is needed to identify these spatial movements (Meier et al., 2007; Vladimirov, 2006, 2008).

During the 2020 field season, 149 gray whales were identified in the Offshore area, which is the highest number recorded in the Offshore area in all of the years of monitoring (Table A3). The previous best years were 2019 with 147 whales, 2018 with 125 whales, and 2015 with 102 whales. In all three of these years, the research teams regularly had access to vessels for photo-ID surveys as part of more extensive studies conducted within the framework of the monitoring program by one of the Companies. The increased number of whales identified in the Offshore area for the last three years can be explained both by greater effort, especially compared to 2016 and 2017, and by the growing number of whales feeding in the Offshore area. Another contributing factor is the high quantities of gray whale prey biomass in the sediments of the Offshore feeding area. The calculated capacity of the environment for gray whales in the Offshore area allowed a larger number of gray whales to feed in this area than in the shallow Piltun area (Labay et al., 2018).

In 2020, 6 whales, all mothers of the year, travelled from the Piltun to the Offshore area to feed (Table A3). This indicator of the number of whales sighted in both feeding areas during one season differs significantly from the data collected in 2015 (47 whales) and in 2019 (46 whales). The above results were driven by the reduced timeframe of monitoring work in both feeding areas compared with the two said years. The 2020 survey began when most of the adult whales were already in the Offshore area.

The benefit of a long-term monitoring program is that a longer study period results in more sighting data on the same individuals, allowing more robust analyses of patterns regarding whale movement and feeding area utilization.

3.3. Whale Movement between Southeast Kamchatka and Sakhalin Island

Of the whales identified in the surveyed areas off southeast Kamchatka in 2004, 2006-2012 and 2019, 55% (101 out of 184) were also photographed in various areas off Sakhalin. In 2019, 11 of 25 whales photographed in Olga Bay (Kamchatka) were sighted off Sakhalin during the same season, allowing to suggest they were migrating through the area. They included four mother-calf

pairs and one motherless calf. Whale KOGW142 (a calf in 2006), which was not sighted off Sakhalin in 13 years, came to the Piltun area from Olga Bay in 2019.Over all the survey years, 101 gray whales have been identified (31.5% of all known Sakhalin whales) that have visited both the Sakhalin and Kamchatka areas, both in different years and in the same season. It suggests that gray whales relocate between NE Sakhalin and Kamchatka both within the same feeding season and between seasons. Some of the whales that were first identified as calves in the Piltun area, were not sighted there for a long time in subsequent years, but were sighted in Olga Bay. For example, KOGW161 was only observed as a calf in the Piltun area in 2008 and in Olga Bay in 2009. It had not been sighted off Sakhalin for 10 years until it was photographed in the Offshore area in 2018. This whale was also seen in the Offshore area in 2019 and 2020. The group affiliation of the other 45.1% (83 animals) sighted off Kamchatka remains uncertain.

3.4. Whale Movement between Sakhalin Island and Other Areas

Seasonal changes in whale distribution have been described in numerous studies and are considered a reaction to seasonal variations in habitat and the movement of whale prey (Payne et al., 1986, Karczmarski et al., 1999). For example, Eastern (Chukotka-California) Gray Whales feeding along the west coast of Vancouver Island, Canada, rotate feeding grounds and prey types both within and between the summer feeding seasons based on the distribution and abundance of their prey (Bass, 2000; Dunham and Duffus, 2001, 2002; Nelson et al., 2008). The distribution of Eastern Gray Whales along the west coast of North America is variable both within and between years, with whales using areas from northern California to the Beaufort Sea from spring to autumn, involving significant interchange of animals between areas with varying efficiency of biotopes utilization within and between years (Calambokidis et al. 2002). In recent years, gray whales have begun to be sighted more frequently in the Beaufort Sea, where encounters were rare as recently as 30 years ago (Stafford et al., 2007).

According to historical records, the feeding area of the Western Gray Whale population in the Sea of Okhotsk included Sakhalin Bay (west of the northwestern tip of the island), the Akademiya and Tugursk Bays south of the Shantar Islands (at the far west end of the Sea of Okhotsk, west of the northwest coast of Sakhalin Island), northeast Sakhalin, Shelikhov Bay, the Gizhiga Gulf, and Penzhina Gulf in the southeast corner of the sea, as well as waters offshore western Kamchatka (Sleptsov, 1955; Krupnik, 1984; Reeves et al., 2008; Yablokov and Bogoslovskaya, 1984).

In 2006, in Kekurny Bay and Babushkin Bay in the northern part of the Sea of Okhotsk, three gray whales were identified and assigned catalogue ID numbers starting with the NOGW acronym (Vertyankin et al., 2007). In 2007, one whale NOGW003 (KOGW160) was recorded within the Piltun area (five sightings) (Table A4). In 2011, whale NOGW001 (KOGW190) was identified in the Piltun area. It was subsequently encountered a year later in Olga Bay (KamGW024). Both whales have been regularly sighted in Sakhalin since.

In 2008, in Zakatny Bay offshore Shiashkotan Island, located near the center of the Kuril Islands, a joint survey between the Pacific Institute of Bioorganic Chemistry (PIBC FEB RAS) and Institute of Marine Biology of the Far East Branch of the Russian Academy of Sciences produced photographs of one whale that had been recorded in 2007 in Olga Bay off Kamchatka. It was subsequently encountered in Olga Bay during the same season in 2008. One gray whale that was recorded earlier in Olga Bay and off the coast of Sakhalin Island in 2007 was identified in the vicinity of Medny Island (Komandor Islands).

From 2008 through 2012, additional photo-ID surveys were conducted in Kamchatka (in addition to Sakhalin) as part of the monitoring program, making it possible to obtain data on the movements of gray whales between these two water areas. During this period, whales were annually observed as visiting both the Sakhalin and Kamchatka areas during the same season and/or during previous seasons (Yakovlev et al., 2011).

Satellite tagging of whales performed by a team of Russian and foreign scientists in the Piltun area showed the fall migration of whales with satellite tags toward the west coast of North America (Rozhnov et al., 2011; Mate et al., 2015). Comparison of the gray whale catalogues of Sakhalin and the catalogues of the west coast of the United States and Mexico also showed that some Sakhalin whales visited areas historically occupied by Eastern Gray Whales (Urbán et al., 2012, 2013, 2019).

Additional information on whale movements between the Pacific coasts of Asia and North America were obtained over the period up to 2019 (Urbán et al., 2019). The comparison on 379 gray whales from the summer feeding areas of Sakhalin Island (316 whales) and southeastern coastal waters of the Kamchatka peninsula (150 whales) was conducted with 10,685 images of whales taken near the North American shores. 43 whales were identified to visit the coast of both sides of the Pacific. These included 25 whales that were sighted off Sakhalin Island and Mexico, 14

whales - off Sakhalin, Kamchatka, and Mexico, and 4 - off Kamchatka and Mexico. If we assume that 11 instances of overlaps (redundant whale images) were discovered in the catalogues, then 54 whales visited the shores of Russia and the eastern side of the North Pacific. It was discovered that from 1994 through 2016, the number of whales that traveled between the opposing shores of the Pacific Ocean made 14.2% of 379 whales of the Sakhalin and Kamchatka catalogues, and that from 1998 through 2019, 0.5% of the whales from the catalogues of identified gray whales of North America (a total of 10,685 individuals) were sighted in Russian waters (Urbán et al, 2019).

3.5. Mother-Calf Pairs

Our observations indicate that calves were weaned from July through September. According to the data obtained by Bogoslovskaya (1966), for gray whales in the offshore waters of the Chukotka Peninsula, demographic grouping starts in July and August, when calves leave their mothers and gather in groups in the shallowest waters that are rich in prey. Shore-based vehicle groups in 2005 (Vladimirov et al. 2006) indicated that the separation of mother/calf pairs had been completed by early September. However, the timeline of pair separation may vary from year to year.

It was established based on the past years data, that the breakup of the identified mother-calf pairs usually begins approximately from mid-August and continues until mid-September, but regularly encountered calves not associated with mother indicate an earlier timing of pair separations. For example, in 2019, when the expedition season was the longest, three calves met without mothers at the early stages of observations were already weaned, as was shown by the observations using drones, and the recorded pairs began separating starting on 18 July, and the last sighting of a mother-calf pair was on 7 September. Subsequently, all earlier identified calves were sighted as individuals or in other groups, and 16 out of 19 mothers were photographed in the Offshore area later.

In 2020, the first pairs were recorded on 28 July (first work day of the field season). The last time a mother-calf pair was recorded on 9 September. Mothers with the young of the year were recorded in three pairs only till late July. Most likely, we are unable to always track early-separating pairs, and the calves unaccompanied by mothers are encountered annually.

Before 2008, the shallow-water Piltun area was considered to be the only feeding ground for the mother-calf pairs. But in 2008, a mother-calf pair was found in Olga Bay off the eastern

shoreline of the Kamchatka Peninsula. This mother was recorded with calves off Sakhalin in previous years (Tyurneva et al., 2010). Research conducted off the Kamchatka Peninsula in 2009-2012 earlier than in previous years demonstrated that mothers with calves also used Olga Bay for feeding (Yakovlev et al., 2011). These females identified in Olga Bay included both individuals recorded in the Sakhalin catalogue, as well as the ones not sighted off Sakhalin. It was registered that some calves and mother-calf pairs swam from Olga Bay to the Piltun area during one season (Yakovlev et al, 2012; Tyurneva et al, 2012). In 2019, four mother-calf pairs were photographed in Olga Bay. All mothers had been previously sighted in Sakhalin and all of them brought calves to the Piltun area later. It is possible that mother-calf pairs use the Kamchatka shelf area early in the season, when the main feeding areas are not accessible due to ice conditions. It is still unclear why some mothers with calves stay to feed in Olga Bay, while others migrate to the Sakhalin Island shelf and other areas that are unknown to us. No 2020 survey data are available for Olga Bay.

3.6. Reproductive Females

According to studies, the interval between births for reproductive females ranges from two to three years. Between 2002 and 2020, there were 41 reproductive females paired with a calf in the feeding areas of Sakhalin and Kamchatka (Yakovlev et al., 2008, 2009, 2010, 2011, 2012; Tyurneva et al., 2009, 2010, 2011, 2012). Of these, 28 mothers with calves were sighted on two or more occasions (Table A5). Given the regular observations of yearlings, it is not possible to account for all the females that gave birth to calves in the current year. For example, mother KOGW047 was spotted with a calf in 2016. During the 2018 and 2019 seasons, she was observed near other mother-calf pairs and calf groups, but was never recorded in a stable pair with a calf. Mother KOGW095 (a 2004 calf) was also observed along pairs and calves during almost the entire field season (Table A5). As in the case of other mothers with calves, the body condition of these mothers was assessed as “unsatisfactory” (Class 4). This BC indicator could be explained by the loss of the calf as a result of a predator attack before arrival in Sakhalin area or weaning of an unidentified calf before it was observed by the field teams.

Whale KOGW168 joined the list of reproductive females of known age when she arrived with a calf for the first time to the Sakhalin coast in 2020. She was born in 2009 (11 years old). Table 11 provides a list of the five mothers who were first recorded as calves off Sakhalin.

Table 11. Mothers of known age

Mother	Year when recorded as a calf	Year when first recorded in a pair with calf	Age at the time of the first recording in a pair
KOGW075	2002	2019	17
KOGW096	2004	2014	10
KOGW127	2005	2017	12
KOGW168	2009	2020	11
KOGW178	2010	2019	9

3.7. Body Condition

Every field season since 2003, we have recorded whales with the body condition different from the standard. In 2002 the survey began in September, and there were no encounters with emaciated whales. However, when surveys begin early, the percentage of whales with a poor body conditions is always high (Table 9). During migration, gray whales cover great distances and use a substantial amount of energy by the end of the spring migration, which might partially explain the presence of emaciated whales, especially at the beginning of the season. Studies of the food supply of the gray whales that feed off the coast of Sakhalin Island revealed that the Piltun area and, in particular, the Offshore feeding area are characterized by high biomass density that can provide for the life-sustaining activity of the whale population (Fadeyev, 2013).

Some whales that showed signs of emaciation in previous years did not exhibit such signs in subsequent years. The ability of emaciated whales to regain good physical condition within one season was also observed previously (Yakovlev and Tyurneva, 2003-2013; Yakovlev et al. 2007; Weller et al. 2004). The annual cycle of gray whale foraging during the summer and fall seasons and periods of fasting during the winter and spring seasons represents a perpetual process. When studying the movement of identified whales in search for food, their body condition and its change in the summer-fall period were also determined. The number of feeding mothers with calves coming to Sakhalin from the breeding grounds was also determined for the 2002-2017 period. Intervals between births were also determined. It was found that when enough food was available, significant variations of factors that affected the population health and grown rates were observed. Analysis of the effect of environmental factors, from man-made to natural, showed that duration of the feeding season dependent on the ice condition in the area has a very strong impact on the population growth rates. In case of long migrations when the whales do not feed, a short feeding period negatively affects animals with high energy consumption, such as mothers with a 13-month

pregnancy. Their calves born the following year are less likely to survive than those of mothers having a longer feeding season while pregnant (Gailey et al., 2020). It is known that not all of the gray whales moving north from the winter breeding areas (Baja California) feed in the feeding areas of the Chukchi, Bering, and Beaufort Seas. Approximately halfway along their migration route, in the Vancouver area (British Columbia, Canada), some whales stop moving north and start feeding in this area (Pike, 1962). Due to the shortening of the migration period by almost two months, the feeding season of these whales was extended accordingly (Darling, 1984). Annual study of the profile of seasonal variations of this whale species' body condition is very important for monitoring, because it is known that an elevated death rate is observed among the eastern population in some years that results from extreme emaciation of some animals, and the reasons for emaciation are not studied well enough yet (Stimmelmayr and Gulland, 2020; Christiansen et al., 2021).

Skin sloughing was observed among some of the whales in 2003. Repeated photographic observations of these whales in the years since indicate that skin sloughing does not seem to have any noticeable long-term effect on the external body condition of the whales' skin. So far, the phenomenon of skin sloughing remains unexplained, but it may be a result of several factors, such as poor immunoresistance, diseases caused by bacteria, viruses, fungi (Gaydos et al., 2004), internal or external parasites (Dailey et al. 2000), pollution, or excessive exposure to fresh water. The documented examples of skin sloughing showed that the skin recovers quickly after sloughing, and no subsequent pathological consequences were observed on the surface of the whales' skin (Yakovlev et al., 2005; Tombach Wright et al. 2007).

No cases of skin abnormality were observed in 2020. In 2018, whale KOGW027 was photographed in the Piltun area with extensive white patches on her body, but after two weeks they disappeared and the skin pattern became conspicuous. In 2019, whale KOGW123 was sighted in the Offshore area. White patches completely covered the visible part of the body, hiding the natural pattern of this whale's skin. The identification was done based on the fluke, which was unaffected by the white patches. The appearance of white patches observed on gray whales since 2005 has yet to be explained. Continued photo-ID monitoring of these individuals has not resulted in any conclusions about the effect of white skin patches on gray whales. To date, no obvious health effects have been documented, but as this phenomenon is poorly understood, it is essential to continue observation of all known individuals afflicted with these white patches.

CONCLUSIONS

The following conclusions can be drawn based on the results of photo-identification operations conducted in 2002–2020:

1. In 2020, a total of 175 individual gray whales were photo-identified in the Piltun and Offshore feeding areas off the northeast coast of Sakhalin Island. Eleven new whales (including 9 calves) and 2 new adult whales were registered.
2. Currently, the Sakhalin gray whale catalogue includes 332 identified individuals.
3. 32 whales were recorded in the Piltun feeding area, of which 26 were sighted in that area only. A total of 149 whales were registered in the Offshore feeding area, 143 of which were sighted only in that area. Six individuals that were identified as current year mothers used both areas for feeding during the season.
4. Since 2012, there has been a steady trend of gray whales increasing their utilization of the Offshore feeding area. In 2020, the largest number of individuals were sighted in this area in comparison with the previous years.
5. From 2002 to 2020, 145 whales were observed to only utilize the Piltun feeding area, and only 9 whales were observed exclusively in the Offshore feeding area. A total of 175 whales were recorded in two feeding areas (52 were first recorded in the Piltun area as calves and in later years also sighted in the Offshore area).
6. Between 2002 and 2020, 41 reproductive females with calves were recorded within the feeding areas off Sakhalin and Kamchatka. Of those, 26 mothers were recorded with calves on two or more occasions. In 2020, one eleven-year old female was sighted with a calf for the first time.
7. The number of calves varies annually. The minimum number of calves recorded was 3 in 2004), and the maximum number was 22 in 2019.
8. Seven mother-calf pairs and two calves, whose mothers were not identified, were sighted off Sakhalin in 2020.
9. Gray whales may use the feeding areas near Kamchatka and Sakhalin during the same season. The Kamchatka catalogue totaled 184 individuals, of which 101 individuals were also identified off Sakhalin. The relationship of the other 83 individuals encountered off the Kamchatka Peninsula with the Sakhalin feeding group is still unclear.

10. During the period of the multi-year study, gray whales were also sighted outside of the main feeding areas. In all survey years, 12 individual whales were encountered near Okha, and all of them were also seen in other areas. One whale was sighted north of Cape Elizaveta in 2005, and we have not observed the individual since. In 2015, two whales were sighted near the Vostochny wildlife refuge, but these whales were not observed in other study areas.
11. Gray whales sighted off Sakhalin every year demonstrate strong affinity for the Piltun and Offshore feeding areas. As of 2020, 182 whales arrive to the northeast coast of Sakhalin for feeding on a consistent basis. Thirty-four whales were sighted in this area at intervals greater than three years; this group was classified as rarely sighted whales. A total of 104 individuals have been sighted once in the period from 2002 through 2020 (77 of them were recorded as calves). Whale KOGW126 was found dead in 2009. Nine calves of the current season and two adult whales identified in 2020 are not factored in this count.
12. In 2020, 28 whales (including 7 mothers) were identified with inadequate body condition (BC), which amounted to 25.9% of the total number of animals whose photographs allowed assessment of body condition (108 whales). Most whales improved their physical body condition during the feeding season. Good body condition was observed in whales sighted in the Offshore area late in the feeding season.
13. In 2020, no whales exhibited skin changes in the form of sloughing or white patches covering much of the body.
14. Based on the reproduction dynamics, the number of animals observed, their ability to recover after a period of malnutrition, we conclude that this feeding population of gray whales is in good condition and its numbers are increasing.

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South vehicle-based team	Peter van der Wolf, photographer, team lead; Vladimir Vladimirovich Chernitsyn, unmanned drone operator, data registrar; Aleksander Sergeevich Kvashnin, drone operator, data registrar Mikhail Aleksandrovich Pushilin, data registrar Aleksei Viktorovich Bezrukov, data registrar	Geocon Sakhalin State University
North vehicle-based team	Aleksandre Valentinovich Bobkov, unmanned drone operator, team lead; Sergey Yurievich Ivanenko, photographer; Petr Alekseevich Permyakov, data registrar Dmitriy Olegovich Nam, data registrar	Sakhalin State University

Project Areas	Participants	Place of Work
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Technical Support	Sergey Alekseyevich Tyurin	LGL Eco LLC
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Report review	Sergey Alexandrovich Vinogradov Vladimir Victorovich Efremov	Sakhalin Energy Investment Company Ltd. Exxon Neftegas Limited

APPENDIX

FIGURES

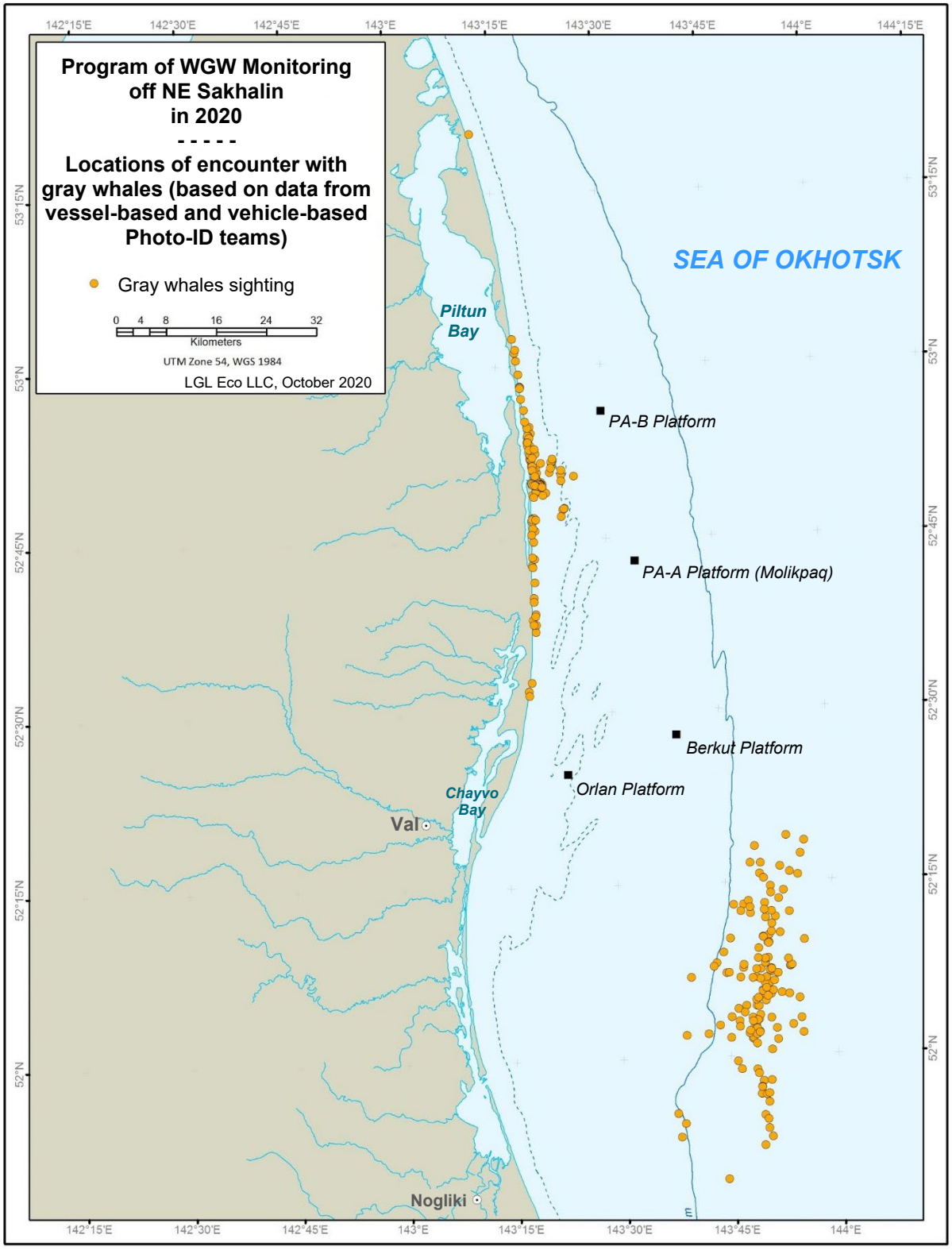

Figure A1. Locations of Encounters of Gray Whales in 2020 near the Sakhalin Island Based on the Photo-ID Teams' Data

TABLES

Table A1. Scope of FRC Boat and Vessel-Based Photo-Identification Work (Number of Missions) and Average Sea Depth During Each Vessel-Based Mission off Sakhalin Island in 2020 (Vessel-Based Team Data)

Date	Feeding Area	Mission Number	Average Depth per Mission		Mission Time
02.08.2020	Offshore	0	59.0	±2.0	3:41:00
04.08.2020	Piltun	1	20.3	±0.5	1:30:00
07.08.2020	Offshore	0	49.0	±2.0	5:36:00
07.08.2020	Offshore	1	53.3	±3.8	
07.08.2020	Piltun	0	53.3	±5.3	
10.08.2020	Piltun	0	60.7	±1.7	5:45:00
13.08.2020	Offshore	1	14.8	±0.5	1:19:00
14.08.2020	Offshore	0	57.5	±4.9	2:00:00
17.08.2020	Offshore	0	58.3	±1.5	3:00:00
26.08.2020	Offshore	0	21.7	±1.7	2:04:00
27.08.2020	Offshore	0	20.7	±1.3	3:30:00
28.08.2020	Offshore	0	59.5	±1.0	2:00:00
31.08.2020	Offshore	0	63.5	±2.9	6:34:00
09.09.2020	Offshore	0	57.7	±2.4	5:00:00
09.09.2020	Offshore	1	58.5	±2.9	
09.09.2020	Offshore	0	59.0	±2.0	
09.09.2020	Offshore	0	58.5	±2.9	
26.09.2020	Offshore	0	52.0	±3.9	4:32:00
26.09.2020	Offshore	0	60.5	±4.1	11:40:00

Table A2. Number of Gray Whales Identified off the Northeast Coast of Sakhalin Island in 2002-2020

Year	Total number of whales per year	Including whales that were identified in previous years	New calves	New whales excluding calves		Whales observed in past years but not encountered this year	Number of whales in catalogue
				Catalogue No. assigned in current year	Catalogue No. assigned in other years		
	A (=B+C+D+E)	B	C	D	E	F	G (=B+C+D+F)
2002	49	0	0	45	4	0	**45**
2003	86	35	10	38	3	10	**93**
2004	99	75	3	20	1	18	**116**
2005	117	98	4	15	0	18	**135**
2006	122	108	5	7	2	27	**147**
2007	125	112	9	4	0	35	**160**
2008	98	93	5	0	0	67	**165**
2009	112	101	8	3	0	64	**176**
2010	104	94	7	3	0	82	**186**
2011	123	104	15	4	0	82	**205**
2012	144	130	10	4	0	75	**219**
2013	121	112	6	3	0	107	**228**
2014	139	124	12	3	0	104	**243**
2015	175	158	11	5	1	85	**259**
2016	128	113	14	1	0	146	**274**
2017	72	63	9	0	0	211	**283+2***
2018	156	144	10	2	0	141	**297**
2019	193	169	22	2	0	128	**321**
2020	175	164	9	2	0	157	**332**

* - Two whales from other sources were added to the catalogue.

Table A3. 2002-2020 Movement of Whales between Known Feeding Areas off the Northeast Coast of Sakhalin Island*.

Year	Number of whales identified in the Piltun area	Number of whales identified in the Piltun area only	Number of whales identified in the Offshore area	Number of whales identified in the Offshore area only	Number of whales identified in the Offshore and Piltun area	Number of whales identified in the Chayvo area	Number of whales identified in the Chayvo+Piltun / Chayvo+Offshore areas	Number of whales identified in the Chayvo+Piltun+Offshore areas	Number of whales identified near Okha	Number of whales identified in other areas
2002	15	13	35	34	1	1	1/0			
2003	63	57	28	23	5	1	1/0			
2004	94	93	6	5	1					
2005	115	95	7	1	6	12	12/0		3	1
2006	103	63	30	12	16	29(6)	21/0	2	1	
2007	104	46	63	20	38	21(1)	15/0	5		
2008	62	39	57	35	21	3	2/1			
2009	82	64	38	24	13	11(5)	5/1			
2010	88	73	24	11	11				9(4)	
2011	105	90	14	9	5	20(10)	10/0			
2012	87	61	74	54	19	10(3)	6/0	1		
2013	68	54	67	53	14					
2014	82	63	76	57	19					
2015	118	66	102	55	47	5	5/0			2
2016	74	67	61	54	7					
2017	52	51	21	20	1					
2018	46	30	125	109	16					
2019	92	46	147	101	46					
2020	32	26	149	143	6					

Note:

* *The values in parentheses show the number of animals that were registered only in the specified area and not encountered in other survey areas. Table values can be changed annually based on updates to the catalogue, for example, as a result of correlating temporary whales. The numbers include temporary whales.*