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PHOTO-IDENTIFICATION OF GRAY WHALES (ESCHRICHTIUS ROBUSTUS) OFF THE NORTHEAST COAST OF SAKHALIN ISLAND IN 2018

ФОТОИДЕНТИФИКАЦИЯ СЕРЫХ КИТОВ (ESCHRICHTIUS ROBUSTUS) У СЕВЕРО-ВОСТОЧНОГО ПОБЕРЕЖЬЯ О. САХАЛИН В 2018 ГОДУ

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PHOTO-IDENTIFICATION OF GRAY WHALES (ESCHRICHTIUS ROBUSTUS)

OFF THE NORTHEAST COAST OF SAKHALIN ISLAND

IN 2018

Photo by A.V. Bobkov

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prepared for

Exxon Neftegas Limited

and Sakhalin Energy Investment Company Ltd.

and Gazpromneft-Sakhalin LLC

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FEDERAL PUBLICLY FUNDED RESEARCH INSTITUTION

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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 2018

Project supervisor:

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Vladivostok, 2019

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Report contains 69 pages, 11 figures, 15 tables, and a supplement

REPORT ON RESEARCH WORK - PHOTO-IDENTIFICATION OF GRAY WHALES (ESCHRICHTIUS ROBUSTUS) OFF THE NORTHEAST COAST OF SAKHALIN ISLAND IN 2018

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

Photographic identification surveys have been conducted offshore Northeastern Sakhalin Island since 2002 as part of the comprehensive multi-annual Western gray whale (*Eschrichtius robustus*) monitoring program being implemented on commission from the companies Exxon Neftegas Limited and Sakhalin Energy Investment Company Ltd. In 2018, the company Gazpromneft-Sakhalin LLC joined this project and has been managing surveys in the Offshore feeding area. Excellent management of the operations made it possible to gather a large body of scientific data in the two known feeding areas of these animals (Piltun and Offshore) offshore Sakhalin Island. Surveys conducted in 2018 are described in this report and compared with the findings of previous years. The multi-year studies of gray whales have yielded valuable data on these animals, which use the water area off the northeast coast of Sakhalin as their feeding grounds during the summer/fall period.

From 2002 through 2013, the work on photo- and video-identification of gray whales was conducted by one team based on vessels using launch boats. In 2014–2015, 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 were moving along the coast collecting data on the animals feeding in shallow waters, and the boat-based teams carried out photographic surveys in deeper waters of the Piltun and Offshore feeding areas. In 2017 and 2018, the south and north 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 2018. The efforts of the vessel-based team focused on the Offshore feeding area, where 125 whales (16 of which was also sighted in the Piltun feeding area) were recorded.

In the Piltun area the north vehicle-based team recorded 21 whales. The south vehicle-based teams conducting a photographic survey of the south coast of the Piltun area sighted 45 gray whales. The joint efforts of the two teams in the Piltun area identified 46 individual animals. A total of 155 whales were recorded during the 2018 field work season in the known feeding areas off the coast of Sakhalin Island.

In addition to Sakhalin field group data, photos of gray whales sighted in Olga Bay (Kamchatka Peninsula) in June 2018 were obtained from specialists working outside the joint monitoring program. A total of 31 whales were photographed. Nineteen whales out of the total number of recorded animals were also sighted offshore Sakhalin Island in various years. Five whales that were assigned numbers in the Sakhalin Catalogue were sighted in the Piltun area as the young of the year and were not sighted there subsequently. Of all the whales identified in Olga Bay, fifteen were sighted there for the first time, including four calves. All calves were paired with cows and arrived with them in the Piltun area (Sakhalin Island) at later date.

Annual gray whale records are affected by the scope of work (efforts) and the number of animals present in the study area, which varies from season to season. The vessel crew worked for 16 days in the Offshore area in 2018. The efforts made were much greater than in 2016 and 2017, when the vessel team failed to perform the entire scope of survey planned in the Offshore area due to weather conditions and tight schedule of supply boats operations. Therefore, the number of identified whales in 2018 was significantly higher than in two previous years.

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. The whales photographed from the shore were the same that were photographed by the unmanned drones. Video recording from unmanned drones also helped to obtain new data about the animals feeding and behavior.

Twelve (12) new whales, including ten (10) calves and two (2) adult whales, were identified in the Offshore area during field studies. Currently the Sakhalin gray whale catalogue includes 297 identified individuals.

From 2002 to 2018, 290 whales were sighted in the Piltun area, of which 143 had never been encountered in the Offshore area. This number includes calves and young whales up to 4 years old. Only 4 whales were sighted exclusively in the Offshore area. One whale was photographed north of Cape Elizaveta in 2005 and has not been seen since. In all the years of study, 12 whales have been encountered near Okha (90 km north from 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 and since then have not been encountered anywhere by our teams, but according to Burdin A.M., one of them was encountered in Olga Bay (Kamchatka Peninsula) (Burdin et al. 2017).

Cow-calf pairs were recorded in the Sakhalin offshore area only in the Piltun feeding area. The number of calves varies from year to year. The smallest number observed was 3 calves in 2004, and the largest number was 17 calves in 2011. In 2018, 8 cow-calf pairs and 2 unassociated calves (a total of 10 calves) were recorded off Sakhalin Island. All calves observed in all the study years were in good physical condition.

According to long-term observations, the break-up of cow-calf pairs usually begins in mid-August and continues until mid-September. In 2018, the last pair was sighted on August 4. In the next days of the observations, the calves were sighted only in calf groups. All identified cows relocated to the Offshore Area for feeding. The unmanned drones in the Piltun area helped to definitely identify both cow-calf pairs and calves sighted in calf groups. Photographing from height showed definite difference in the length of calves and grown whales bodies. All identified calves started to procure food independently after the break-up of the pairs.

Observations from 2003 through 2018 show that the physical condition of most of the whales improves over the course of the season.

Based on the determination of reproductive performance, 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.

INTRODUCTION

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 group of gray whales (*Eschrichtius robustus.* Gray whale of the Okhotsk-Korean (Asian) or West-pacific (Western) subpopulation was classified by the International Union for Conservation of Nature (IUCN) as an endangered species, (IUCN, 2018), and was listed as endangered species on the Russian Federation Red Book (Category 1, 2001, 2018). Russian Federation Government Authorities recommended that both Companies should conduct a regular gray whale monitoring. Gazpromneft-Sakhalin, Ayashsky License Area Operator, Sakhalin-3 project operator, joined the program in 2018, which expanded the ability to implement vessel monitoring in the Offshore feeding area.

As part of the Sakhalin group of gray whales (*Eschrichtius robustus*) monitoring program the photo-identification surveys of gray whales started in 2002, and since then have been annually performed in summer/fall feeding period of animals. Multi-year studies have yielded valuable data on these animals, which use the water area of the northeast cost of Sakhalin Island as their feeding grounds in summer. Study of the group condition is also necessary for development of the respective measures to mitigate impact on the western group of gray whales.

From 2002 through 2013, the work on 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 2018, two shore-based teams had an

opportunity to use DJI Phantom 4Pro drones for photo-identification. This allowed not only obtain quality images of whales, but also collect additional data, for example, about cow-calf pairs.

Gray whale photo-identification operations, the results of which are described in this report, were conducted in June-October in accordance with the Gray Whales Monitoring Program off the Northeast Coast of Sakhalin Island in 2018 developed by ENL and Sakhalin Energy and the environmental monitoring program based on the Gazpromneft-Sakhalin LLC (Gazpromneft-Sakhalin) scope of work. The studies were duly endorsed by the federal executive agencies – the Ministry of Natural Resources and Ecology of the Russian Federation (Russian Ministry of Natural Resources), the Federal Service for Natural Resource Use Oversight (Rosprirodnadzor), and Federal Fisheries Agency (Rosrybolovstvo).

The study of individual animals provides information on population trends and demography, social structure, and other aspects of the ecology of this population. In the longer term, it also provides information on population status and health. The photo-identification, as a major monitoring component, substantiates the need for and the setting up of impact 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 Western 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 individual Western Gray Whale (WGW);
2. Assess the body and skin condition of individual animals;
3. Assess affinity of some whale species to the specific feeding areas northeast of Sakhalin;
4. Describe feeding group demographics and structure;
5. Describe habitat use (including seasonal and annual movements of individual gray whales between feeding areas);

6. Assess the number of cow-calf pairs, their body condition, use of habitat, and the annual determination of separation dates of such pairs.

This report provides a brief overview of the results of gray whale photo-ID efforts in 2018. 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; Yakovlev et al, 2007, 2009, 2010, 2011, 2012, 2013, and 2014, 2015, 2016, 2017; Yakovlev et al., 2015).

1. MATERIALS AND METHODS

1.1. Study Area and Field Work Methods

The studies offshore Sakhalin Island basically encompass the two traditional summer-fall whale feeding areas – the Piltun area (52°40' N–53°30' N), stretching 120 km along the shore of Piltun Bay, where the whales feed primarily at depths of less than 20 m, and the Offshore area, located further offshore from Chayvo Bay (51°50' N–52°25' N) with depths of 35–60 m (Maminov and Yakovlev, 2002; Yakovlev et al., 2009). The primary materials for the photo-identification of gray whales were collected from June 2 through October 15, 2018 (Figures A1, A3).

The 2018 materials were collected by three photo-ID teams. One vessel-based team was based on Siem Sapphire vessel (Gazpromneft-Sakhalin, Sakhalin-3 project operator), and two onshore teams were based at camps on the coast. The onshore teams moved along the shore in vehicles taking imagery of the whales they encountered directly from shore.

A photographic survey of gray whales in the Offshore feeding area by the vessel-based team was conducted during the period from August 4 through October 15, 2018. The work was performed from an FRC boat with a water-jet motor, or from the vessel during recording operations and production operation support trips. All photo-ID operations were conducted within the latitudes 52°47' N on the south and 52°17' N on the north and longitudes 143°37' E on the west and 143°59' E on the east (Figure A1). The details of the field studies methodology by the vessel-based photo-ID team are presented in the annual report (Yakovlev et al., 2013a).

The planned onshore vehicle-based photo-identification team work (drone photo-ID) in 2018 were conducted from July 3 through September 29. In addition, a southern team led by Peter Van der Wolf conducted gray whale surveys during early periods of the feeding season during the period from June 2 to June 30.

Onshore vehicle-based drone photo-ID was performed in the southern and northern parts of the Piltun feeding area and covered an area from 52°26' N on the south to 53°20' N on the north and from 143°12´ E on the west to 143°22´ E on the east (Figure A1)[1].

Drone photo-ID missions were conducted in good weather: mandatory condition of over 500 meters visibility and maximum force 5 wind (Beaufort scale). A detailed description of vehicle-based drone photo-ID methods is provided in the 2016 report (Yakovlev et al., 2016).

During the operations, the south shore-based photo-ID team also used the Solmeta GMAX GPS Geotagger attached to the Nikon D810 camera.

Since 2017, the 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 drone operator to find whales far from the coast line. Sometimes, drones were used to record whales at 2.5 km distance from the shore. However, in most cases drones recorded at a distance of about 800 meters from the shore with standard flight height 8 meters.

The high-resolution photographs that were made by photo cameras and drones were saved in JPEG format to 10 Transcend SDXC 128 GB memory cards.

During their work in the field teams used Fujinon 7 x 50 binocular glasses and Celestron 20-60 x 60mm telescopes to scan sea surface and find whales for further recording.

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

[1] Estimated coordinates of the locations of whales within the observation area.

Photographs of gray whales obtained from specialists carrying out similar studies in Olga Bay off the southeastern shore of the Kamchatka Peninsula beyond the joint monitoring program were analyzed in 2018 in addition to the field teams data. Data was obtained from V.V. Vertiankin, who surveyed the animals on June 8, 15, and 17 and from A.M. Burdin, who provided for identification purposes the best photos of the right sides of whales taken on June 26, 27, and 28, but only of those animals that were absent from the Russian project catalogue, which contains only 267 whales (Burdin et al., 2017).

1.2. Laboratory Methods

During lab processing of the photos, each photo obtained during a season is studied for the purpose of identifying 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 the pictures have been identified and supplied with a detailed description of the animal and its catalogue number, the best available photos for each whale that, if possible, best describe the animal, are selected. The whales encountered for the first time are assigned new catalogue numbers, if a high-quality image of the right side of the animal is available. Afterwards all the data are entered into a database, which makes it possible to extract any information on a specific animal, for any observation period, and groups of animals in each of the studied areas. A catalogue of identified individuals is prepared for each study year and is 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 made it necessary to update the catalogue with whale body photographs taken from height, as unique marks of animals known to the experts become hidden under water. Thus, a new fifth aspect appeared in whale catalogue – “Back”. Three experts verified proper whale identification.

2. SURVEY RESULTS

2.1. Field Work Results

The offshore team started taking gray whale photo and video imagery on August 4 and continued through October 15, 2018.

The shore-based vehicle-based teams began work on July 3 and ended work on September 29, 2018. The southern onshore vehicle-based crew conducted photographic surveys during the early period from June 2 to 30. These data were also provided for laboratory processing and analysis. Photo-identification was conducted in part of the northeast Sakhalin Island offshore area adjacent to Piltun Bay.

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 in the Appendix. Depth measurements were conducted while acquiring imagery from a boat at whale sighting locations in the Offshore and Piltun areas.

Table 1. Volume of Photo-ID Work of Vessel-based Team off Sakhalin Island during the 2018 Expedition (Field Data)

Area	Vessel-based team				
	Work days	Number of missions*		Number of pods	Number of whales
		M	M0		
Piltun	0	0	0	0	0
Offshore	16	10	15	221	428
Total	16	25		221	428

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

The duration of the mission, the number of whale sightings during a mission, the number of observed whales in a pod, the duration of each sighting, etc., were recorded in the respective database section. In total, vessel-based teams photographed 428 animals including repeat sightings (field data).

The vehicle-based teams photographed 308 animals, including repeat sightings (field data). The information on the efforts of onshore vehicle-based teams and recorded animals is summarized in Table 2.

Table 2. Scope of Photo-ID Operations Performed off Sakhalin Island in 2018 by Two Vehicle-based Teams (Field Data)

Area	South vehicle-based team				North vehicle-based team			
	Work days	N of missions	N of groups	N of whales	Work days	N of missions	N of groups	N of whales
Piltun	49	53	155	258	23	27	37	50

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

A total of 33,146 photographs were taken by the three teams during the 2018 field season. The total number of whales recorded, including repeat sightings of the same whale during different missions, was 736 (field data)[2].

2.2. Identification of Whales and Number of Individuals

All field materials obtained during the 2018 field season were processed and compared with data from previous years. Of particular interest is not only the information gathered regarding new whales, but also data pertaining to whales that were identified in previous years, since combining these data amasses more extensive and detailed information on the history of observations of individual animals.

Compiling the annual and main gray whale catalogues is one of the tasks of the photo-ID operations. The quality of the gray whale identifications in subsequent encounters is 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 fluke and

[2] The major difference between field and laboratory gray whale recording data can be explained by the fact that the vehicle-based 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.

the ventral 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.

Along with the main catalogues, a record is also kept of whales whose photographs are not definitive enough to assign them a permanent number. This is done, so that they can be entered into the catalogues later, after complete data is obtained on these whales, without losing the information on the histories of encounters with them. After the number of a temporary whale is determined, it is added to the catalogue for the year in which it was first encountered. Information on temporary whales is given in Table A3 in the Appendix. In 2016, the database was completely revised, subsequently temporary whales with poor quality photos were identified based on encounters in the following years. All tables in the report and in the Appendix have been updated with the additional data.

Thanks to drones, we gained the opportunity to add photos of dorsal fluke for young whales, which are encountered only in Piltun bay, into the catalogue. In addition, the images of 41 whales taken from above were added into the 2017 catalogue, as often identification marks known to us are hidden under water. The 2018 catalogue will be supplemented with back images of 10 animals taken from drones. Drone photo-ID improved whales recording capability, as often whales were under water and did not appear on surface. Provided that water was clear, it was possible to identify such animals.

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

Data regarding the number of whales identified offshore northeast Sakhalin Island in 2002-2018 are presented in Figure 1 and Table A2 in the Appendix.

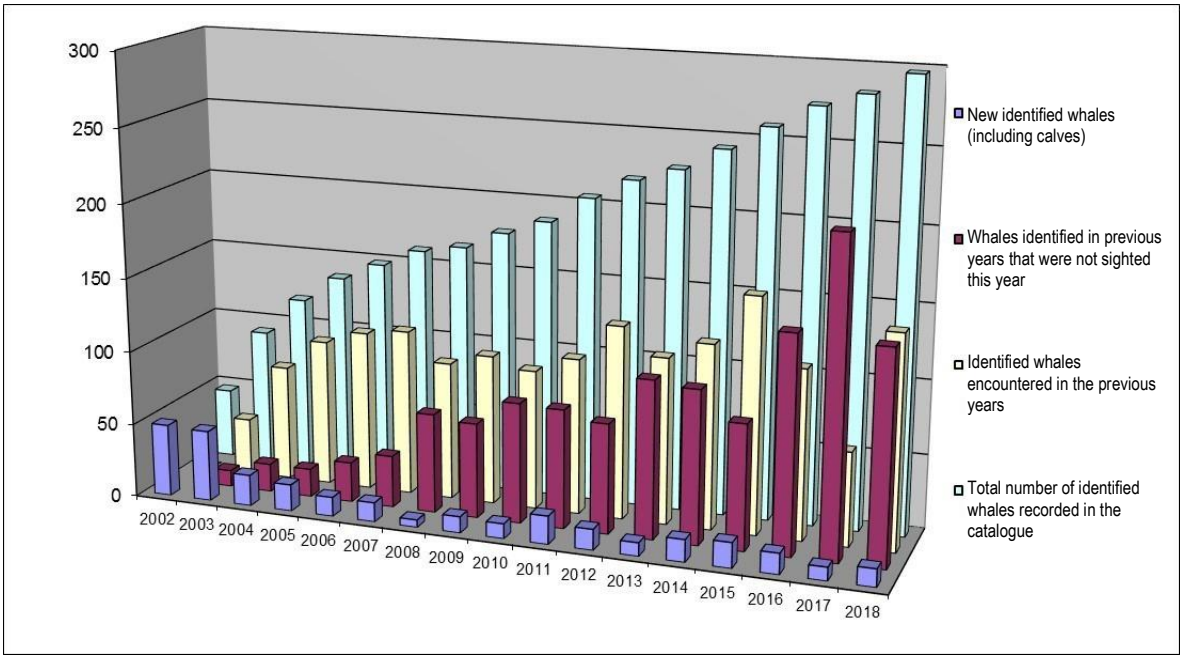


Figure 1. Number of Gray Whales Recorded in the Catalogue and Identified in 2002-2018 off the NE Coast of Sakhalin Island

During the 2018 field season, 155 animals were identified in the Piltun and Offshore feeding areas, including 12 new whales, including 10 calves and 2 adult whales sighted in the Offshore area. Taking into account the new data from all teams, the master catalogue of gray whales recorded off Sakhalin Island contains photos of 297 whales, including the deceased whale KOGW126 (Table A2 in the Appendix). Whale KOGW284 was photographed in 2015 and added to the catalogue in 2018 after the 2015 data update. The left side of whale KOGW285 was photographed in 2007 by the behavior team and was presented for registration in the existing catalogue in 2018. Considering the fact that this whale appears under the number KamGW076 in the Kamchatka catalogue and we know how his right side looks, it was decided to assign a number to this whale in the Sakhalin Catalogue.

2.2.2. Identification of Whales and Number of Animals in Olga Bay Offshore Southeastern Kamchatka Peninsula

In 2018, not only photographs obtained as part of the Western Gray Whale Monitoring Program, but also photographs of gray whales taken by a team of specialists in the Kronotsky Nature Reserve (Olga Bay, Kamchatka) in June, were handed over for laboratory identification.

During three days of surveys between June 8 and 17, 2018, V.V. Vertiankin photographed 27 gray whales (KamGW), including three cow-calf pairs. Of the 27 animals, 16 also had a number in the Sakhalin master catalogue (KOGW), i.e. were also sighted offshore Sakhalin Island in different years of surveys. Fifteen whales were new to the Kamchatka Catalogue, including 3 calves.

According to incomplete data (see the "Methods" section) provided by A.M. Burdin, during the period from June 26 to 28, 2018 a total of 14 animals (KamGW) were identified, including a calf paired with a cow. The photograph of the cow shows only the head with a small front portion of the body. The cow was successfully identified after processing of all data obtained for the 2018 season (see the "Cow-Calf Pairs" section). Of the 14 animals photographed, 8 had a Sakhalin catalogue number (KOGW).

During a comparison of data obtained from the two sources (Vertyankin V.V. and Burdin A.M.) it became clear that 10 animals (KamGW) were registered by both researchers, and 5 of them had a Sakhalin catalogue number (KOGW).

A total of 31 whales were registered (KamGW). Nineteen whales out of the total number of recorded animals were also sighted offshore Sakhalin Island in various years (KOGW). Of all the whales identified in Olga Bay, fifteen were sighted there for the first time, including four calves.

Of the whales included into a Sakhalin catalogue, five were sighted in the Piltun area only as young of the year in different survey years, and have not been sighted in the waters off Sakhalin Island since then:

KOGW142 (KamGW028) – a calf in 2006.

KOGW216 (KamGW162) – a calf in 2012.

KOGW217 (KamGW171) – a calf in 2012.

KOGW236 (KamGW168) – a calf in 2014.

KOGW246 (KamGW163) – a calf in 2015.

The Kamchatka catalogue of gray whales currently includes photos of 174 animals, 95 of which also have a Sakhalin catalogue number (KamGW/KOGW).

The total number of gray whales registered in Sakhalin and Kamchatka water areas and known from the Sakhalin Catalogue and identified in the 2018 season is 162.

2.3. Cow-calf pairs

In 2018, ten calves were recorded, 8 of which were paired with cows.

According to the current practice (Yakovlev et al., 2013), all cows and calves are assigned confidence indices. The results of classification are presented in Table 3.

Table 3. Sighting Frequency of Cow-Calf Pairs and Calves Encountered without Cows Offshore Sakhalin Island in 2018, with the Assigned Confidence Indices*.

Number of calf in main catalogue KOGW###	Number of monitoring days	Calf identification confidence index	Number of cow in main catalogue KOGW###	Number of monitoring days (cow with calf)	Cow identification confidence index
288	22	A	019	3	I
289	12	A	093	7	I
290	8	A	044	4	I
291	18	A	020	12	I
292**	11	A	-		-
293	3	A	115	2	I
294	7	A	107	6	I
295	6	A	103	4	I
296**	3	A	-	-	-
297	4	A	027	2	I

Note:
*See the description of the quantitative indices system in Section 3.5.6, Vol. I, 2013 Report (Yakovlev et al., 2013).
** Whales KOGW292 and KOGW296 were not sighted in pairs with cows; however, photos taken using an unmanned drone show clearly discernible attributes of calves and small body size in contrast with "non-calves".

Six of the identified cows already arrived with sucklings in previous years, while KOGW107 and KOGW115 were sighted for the first time as nursing cows.

The use of drones provided identification both of cow-calf pairs and solitary calves encountered in calf groups. Aerial photographs reliably show the body length difference between the calves and the adults. In addition, we were able to register calves feeding on their own. The first cow-calf pair was sighted on July 3. Calves without cows were encountered on several occasions (Table 6, Table A6), both in the company of other cows and in "calf groups", which is why they could be identified as calves with greater confidence (Table 3). All of the identified calves were able to feed on their own already by early August.

Out of the eight cows identified in 2018 in Sakhalin water area, four (KOGW019, KOGW020, KOGW044, KOGW115) were sighted earlier with calves in June in Olga Bay (Table 4).

Table 4. Intra-Seasonal Migration of Cows that Arrived with Calves in 2018.

Whale number	Date of first sighting in the survey area		
	Olga Bay (Kamchatka)	Piltun area (Sakhalin)	Offshore area (Sakhalin)
KOGW019	June 8	July 14	August 4
KOGW020	June 8	July 14	August 28
KOGW027	-	July 14	August 16
KOGW044	June 8	July 19	September 23
KOGW093	-	July 8	October 10
KOGW103	-	July 24	September 27
KOGW107	-	July 3	August 16
KOGW115	June 28	August 2	September 16

The data from the previous years show that the cow-calf pairs break-up starts approximately in mid-August and continues through mid-September. In 2018 season, some pairs were observed to break up earlier. The last cow-calf pair was sighted on August 4. As can be seen from Table 4, all of the identified nursing cows of the current season were recorded in the Offshore feeding area at a much later time.

According to our research, for cows the interval between births varies from year to year, ranging from two to three or more years. Between 2002 and 2018, 31 cows from the Sakhalin Catalogue, 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 these, 24 cows were sighted with calves on two or more occasions (Table A6 in the Appendix). Because we have regularly observed the young of the year without cows, we obviously cannot account for all females who gave birth to calves in the current year. For example, KOGW047 was sighted with a calf in 2016, while cow KOGW022 came with a suckling in 2014. In 2018, they were sighted near other cow-calf pairs and calf groups throughout the season, but were never recorded in a stable pair with a calf. Cows 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 Offshore Sakhalin Island

Generally, the same individuals come to Sakhalin every year for feeding. Some of these whales are recorded several times during a season and in different years, while others were recorded only once within a long period of time or are new for the catalogue. We suggested that due to the fact, that researchers cannot record all whales that come here for feeding, analyzing the 2002–2018 data on the return of known individual whales, we should consider only those individuals that are recorded at least once every three years as regularly-sighted whales. As a result, we identified a group of 182 whales that regularly come for feeding to the northeast offshore area of Sakhalin Island. Twenty one whales were recorded in this area at intervals greater than three years; this group was classified as rarely-sighted whales (Table A5). Of 73 whales encountered in Sakhalin water area during one season only and not encountered during the following years, 52 animals were identified as calves (Table 6).

In 2018 two mature whales were encountered for the first time in the Offshore area[3]. They were new to our catalogs, and passport numbers were assigned to them.

Whale (KOGW161) was identified during the current season in the Offshore area. It was encountered for the first time as a calf in 2008 in the Piltun area (KOGW161) and had not been sighted offshore Sakhalin Island until 2018.

A total of 545 whales, including repeat sightings (encounters) and 155 individual whales, were identified among the whales photographed by three teams off Sakhalin Island during the 2018 season (Table 5). These data make it possible to determine the whale sighting frequency (SF) rate for the season. Based on SF rate we can make conclusions on the efforts to record the animals, the validity of group stability information, group movements, etc.

Table 5. 2017 Gray Whale Identification off Northeastern Sakhalin by Research Teams in 2018

Area	Vessel-based team	South vehicle-based team	North vehicle-based team	Total

[3] Note: 12 new whales identified in 2018 were not counted as they were sighted only once.

	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	-	-	211	45	40	21	251	64
Offshore	294	125	-	-	-	-	294	125
Total	294	125	211	45	40	21	545	155
SF		**2.35**		**4.69**		**1.90**		**3.52**

The animals were recorded in the Piltun area along the coast at depths of 4 - 14 m (see the area coordinates above) and in the Offshore area at depths of 20–64 m (see the area coordinates above) (Figure A1 in the Appendix).

The low SF rate presented by the northern vehicle-based team suggest that the observers photographed different animals. The team working in the southern part of the Piltun area mostly observed stable groups of young whales and cows with calves.

Table 6. Frequency of Repeat Sightings of Identified Gray Whales (IDW) Photographed by All Teams off Sakhalin Island in 2018

Number of an individual whale sightings (A)	**Number of whales with this number of sightings (B)**	**Total number of whale sightings (AxB) ***
1	**37**	**37**
2	**39**	**78**
3	**39**	**117**
4	**15**	**60**
5	**3**	**15**
6	**2**	**12**
7	**5**	**35**
8	**2**	**16**
9	**2**	**18**
10	**2**	**20**
11	**3**	**33**
14	**1**	**14**
17	**2**	**34**
18	**2**	**36**
20	**1**	**20**
Total	**155**	**545**

Note:*

*The number of whale sightings does not include temporary whales.

The average number of sightings per individual (sighting frequency – SF) for the 2018 season was 3.52 (Table 7).

Table 7. Frequency of Sightings of Gray Whales (IDW)

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Number of whale sightings	66	154	228	384	385	675	275	297	207	248	374	226	682	768	778	374	545
Number of IDWs per year	49	86	99	117	121	125	98	112	104	124	144	121	139	175	128	72	155
Average number of IDW 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

Whale movement patterns between the coastal (Piltun, including Chayvo) and the Offshore feeding areas have been studied based on repeat sightings of identified animals in both areas over the entire survey period of 2002-2018 (Figure 4, Figure A2, Tables A4, A5 in the Appendix).

2.4.1. Offshore Feeding Area

In 2018, weather conditions and the work schedule onboard the support vessel enabled the vessel crew to work for 16 days in the Offshore area. The volume and informative value of the data acquired was the most significant in all of the survey years. In 2018, 294 animals were identified in the Offshore area, taking into account repeat sightings (Table 3, Figure 2, Figure A1 in the Appendix). Surveys conducted onboard the vessel (M0) were highly successful during vessel-based gray whale counts and during vessel movement through the Offshore area to perform operational tasks (Figure 2).

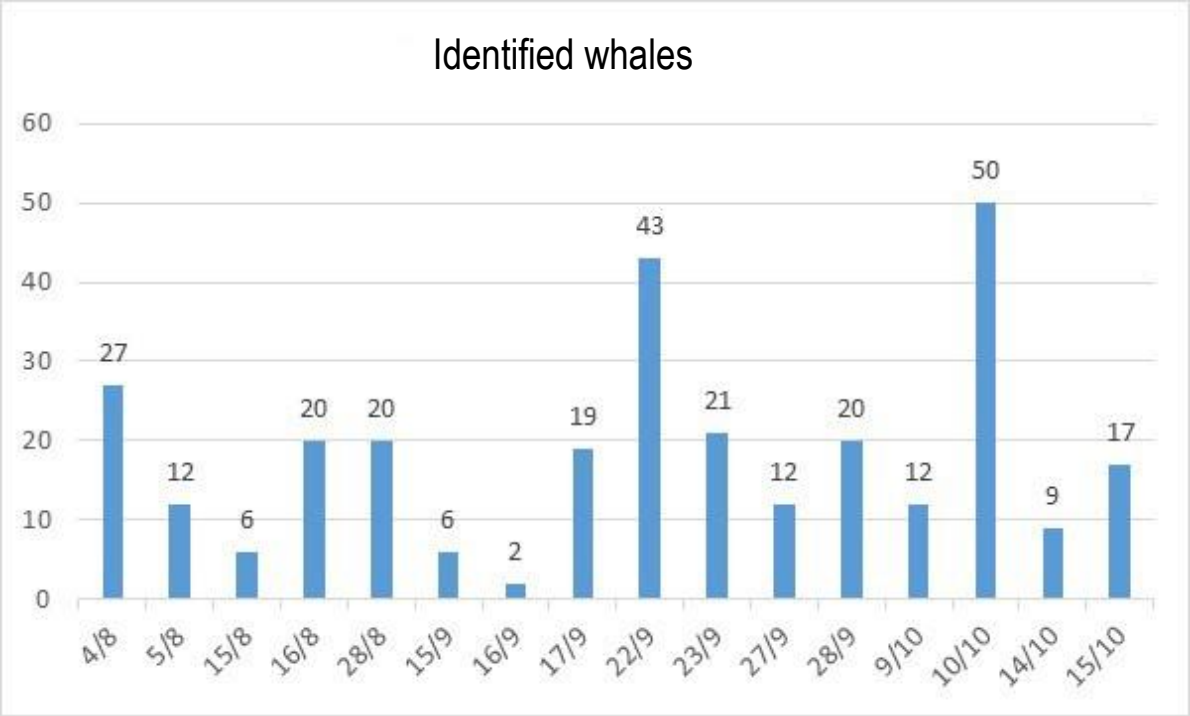


Figure 2. Registrations of Identified Gray Whales in the Offshore Area for Each Day of Photo-ID Surveys as Part of the 2018 Expedition

The efforts made in the 2018 season in the Offshore area were much greater than in 2016 and especially in 2017, 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 distribution surveys in the Offshore area, when from 32 to 70 animals were recorded during a work day. (MAIN REPORT ON THE GRAY WHALES (ESCHRICHTIUS ROBUSTUS) MONITORING PROGRAM OFF THE NORTHEAST COAST OF SAKHALIN ISLAND IN 2017).

A total of 125 whales were identified in the Offshore area during the field season, 15 of which were encountered for the first time in deep waters. Of the total number of animals recorded, 109 were sighted only here (i.e., they were not sighted in the Piltun area in 2018) (Figure 3, Tables A4, A5 in the Appendix).

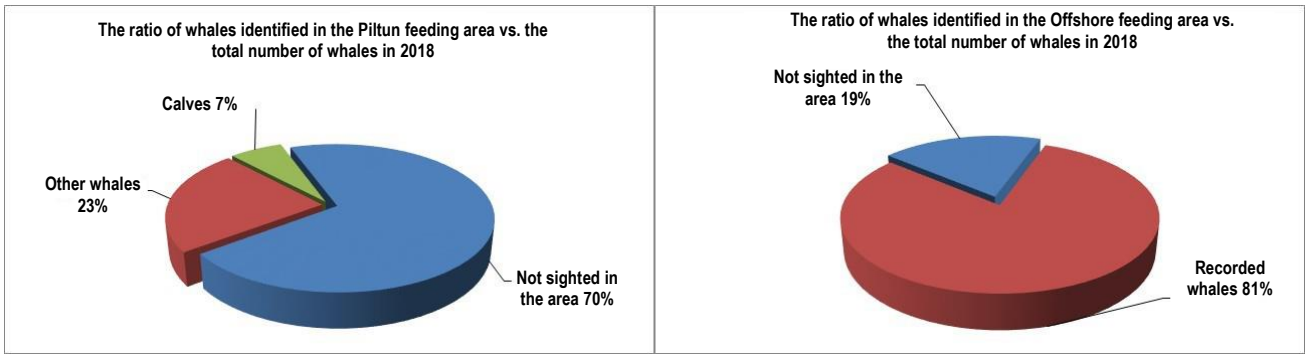
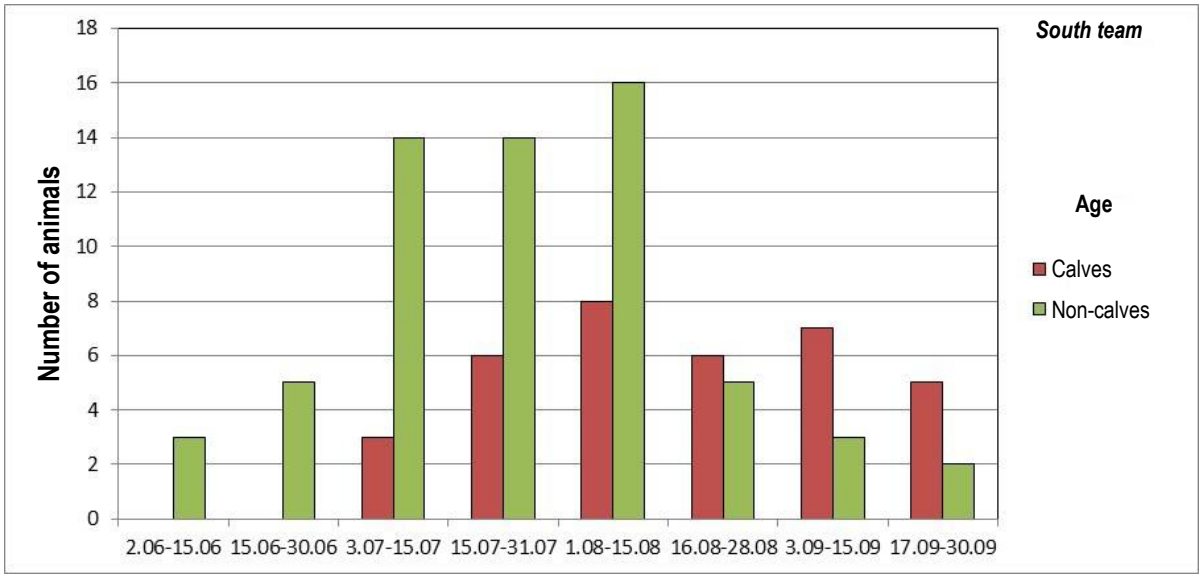


Figure 3. The Ratio of Whales Sighted in the Piltun and Offshore Feeding Areas vs. the Total Number of Identified Whales in 2018.

In 2018, same as in all previous study years, the research teams did not observe any young whales (up to 4 year old), calves, or cow-calf pairs in the Offshore feeding area.

2.4.2. Piltun Feeding Area

251 whales, including repeat sightings, were photographed in the Piltun area in 2018 by two teams.



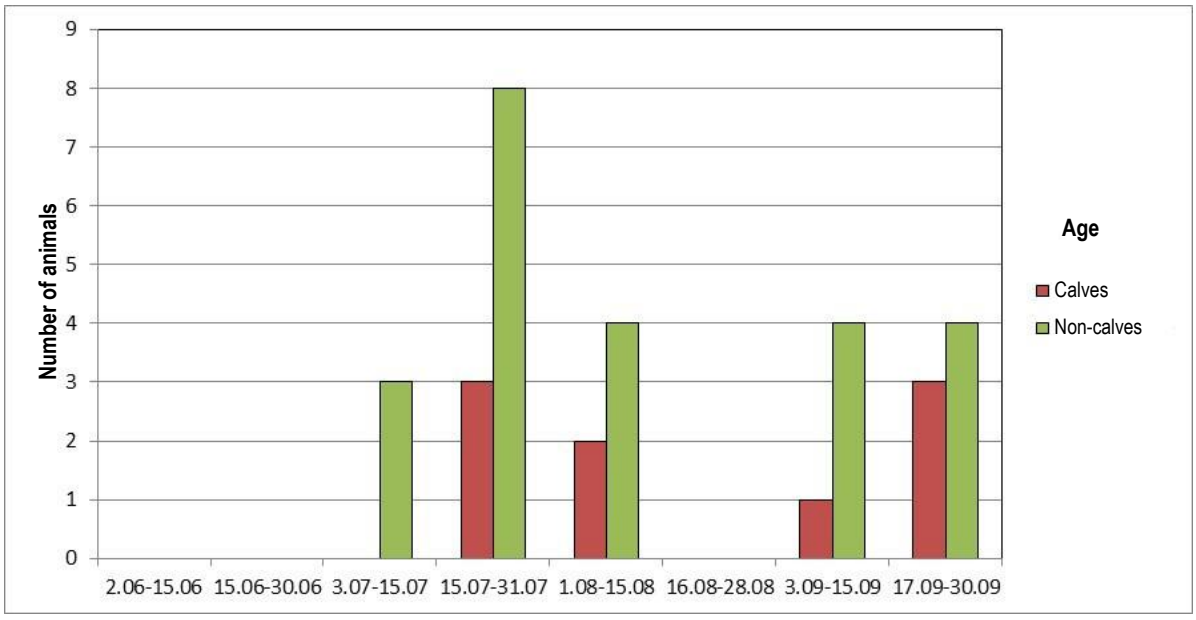


Figure 4. Sightings of Calves and Animals Older than 1 year in the South and North Parts of the Piltun Feeding Area for Each Work Day of the 2018 Field Season

Data shown in Figure 4 indicates a considerable difference between gray whale sightings in the south and north parts of the Piltun feeding area. Most sightings of animals older than 1 year were recorded between early July and mid-August in the south Piltun area, while a sharp decline in the number of non-calves" was recorded here in the second half of August. The number of whale

sightings in the north Piltun area was low, and not a single animal was recorded between mid-August and late August; however, a small number of whales were photographed in the area in September (Figure 3, Figure A1, Table A5 in the Appendix).

A total of 46 animals were sighted in the Piltun feeding area, 30 of which were registered in this area only (Figure 3). Out of the total number of identified whales, 10 animals (7%) were no older than 1 year (Figure 4, Table A4 in the Appendix).

Sixteen whales were identified in the Piltun area and the Offshore area each during the 2018 field season (Figure 5, Table A3 in the Appendix).

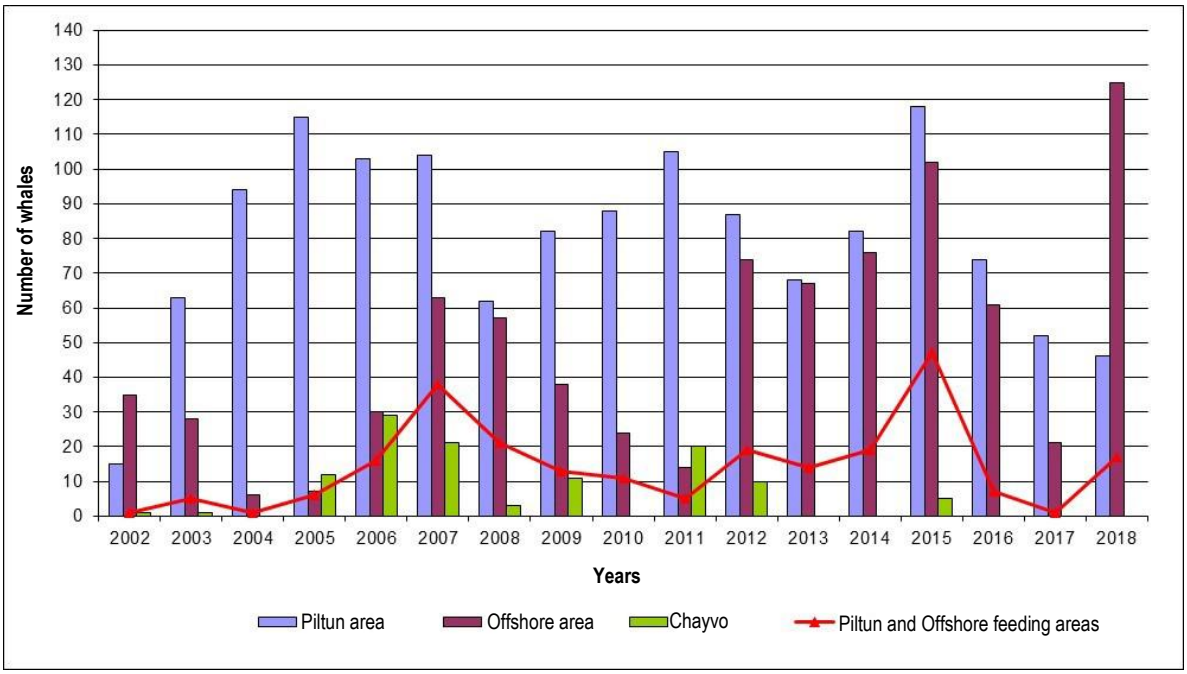


Figure 5. Number of Whales Sighted in the Main Feeding Areas off NE Sakhalin Island from 2002 through 2018

From 2002 to 2018, 290 (98% of all known whales in the catalogue) whales were sighted in the Piltun feeding area, of which 143 had never been recorded in the Offshore feeding area. This quantity includes calves and young whales no older than 4. Only four whales were not sighted anywhere else except the Offshore feeding area, including 2 new whales (Figure 6).

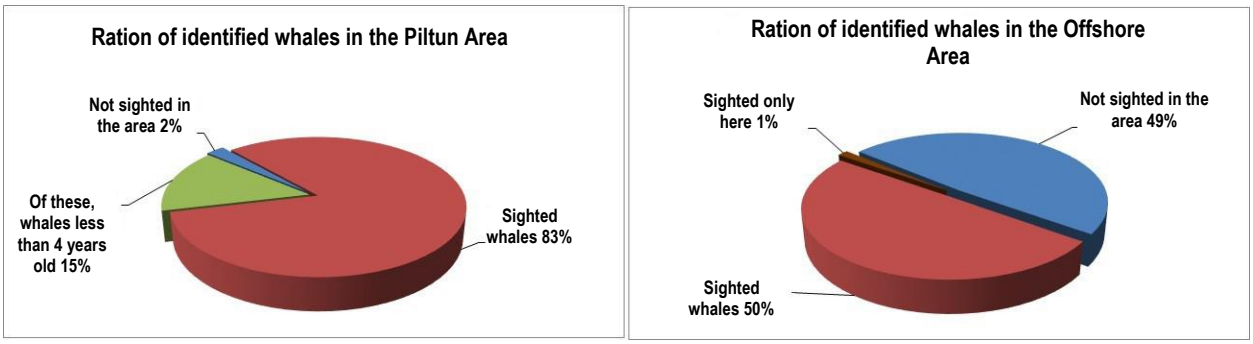


Figure 6. Ratio of Gray Whales Sighted in the Offshore and Piltun Areas throughout All Study Years (2002–2018)

Over the 17 years of monitoring, 44.8% of the known whales were recorded as calves for the first time (Table A6 in the Appendix). Therefore, we know the age of 133 whales described in the Sakhalin Master Catalogue of Whales. Of these, 42 whales (ten calves identified in 2018 are not included in this number) were sighted off Sakhalin Island only once when they were less than 1 year old (Table A5 in the Appendix). We recorded a total of 147 whales that used the Piltun and Offshore feeding areas both during the same season and in different years (Figure 5, Figure 6, Table A5). Twenty-nine whales that were identified in the Piltun area for the first time as young-of-the-year were also sighted in the Offshore area in different years. Three cows that repeatedly brought sucklings to the Piltun area had never been sighted in the Offshore area (Tables A5, A6 in the Appendix).

Calves and young whales apparently cannot feed at great depths and have always been observed only in the nearshore zone at depths of 4 to 15 meters. For this reason, we believe that the 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 anywhere.

2.5. Body Condition

2.5.1. Body Weight

In 2018, 19 whales with poor body condition (BC) were identified, including 8 nursing cows we could identify (Table 8).

Table 8. Body Condition of Gray Whales off Sakhalin Island in 2018.

BC Class	Number of Whales in Each BC Class in 2018	Percentage of Whales in Each BC Class Recorded in 2018
0	**84**	**66.1**
I	**24**	**18.9**
II	**10**	**7.9**
III	**5**	**3.9**
IV	**4**	**3.1**

Notes:
- The body condition of 127 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 BC class during the first encounter, but BC improved during the subsequent sightings, we used the BC data recorded during the last sighting.

This accounts for 14.9% of the total number of animals with a specific body condition (127 animals) recorded in 2018 (Tables 7, 8). Just like in previous years, all calves recorded in 2018 were well-nourished.

Table 9. Number of Whales with Poor Body Condition (BC) Sighted Offshore Sakhalin Island in 2003-2018

Year	Total Identified Whales	Total Whales with Low BC Class	Percentage of Total Recorded Whales with Low BC Class	Number of Nursing Cows 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	16.4%	3
2007	125	13	10.4%	6

Year	Total Identified Whales	Total Whales with Low BC Class	Percentage of Total Recorded Whales with Low BC Class	Number of Nursing Cows Recorded in Given Year
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	30,3%	3
2014	139	20	14.4%	9
2015	175(150*)	29	19.3%	8
2016	128(108*)	23	21.3%	8
2017	72(63*)	21	33.3%	6
2018	155(127*)	19	15.0%	8

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).

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

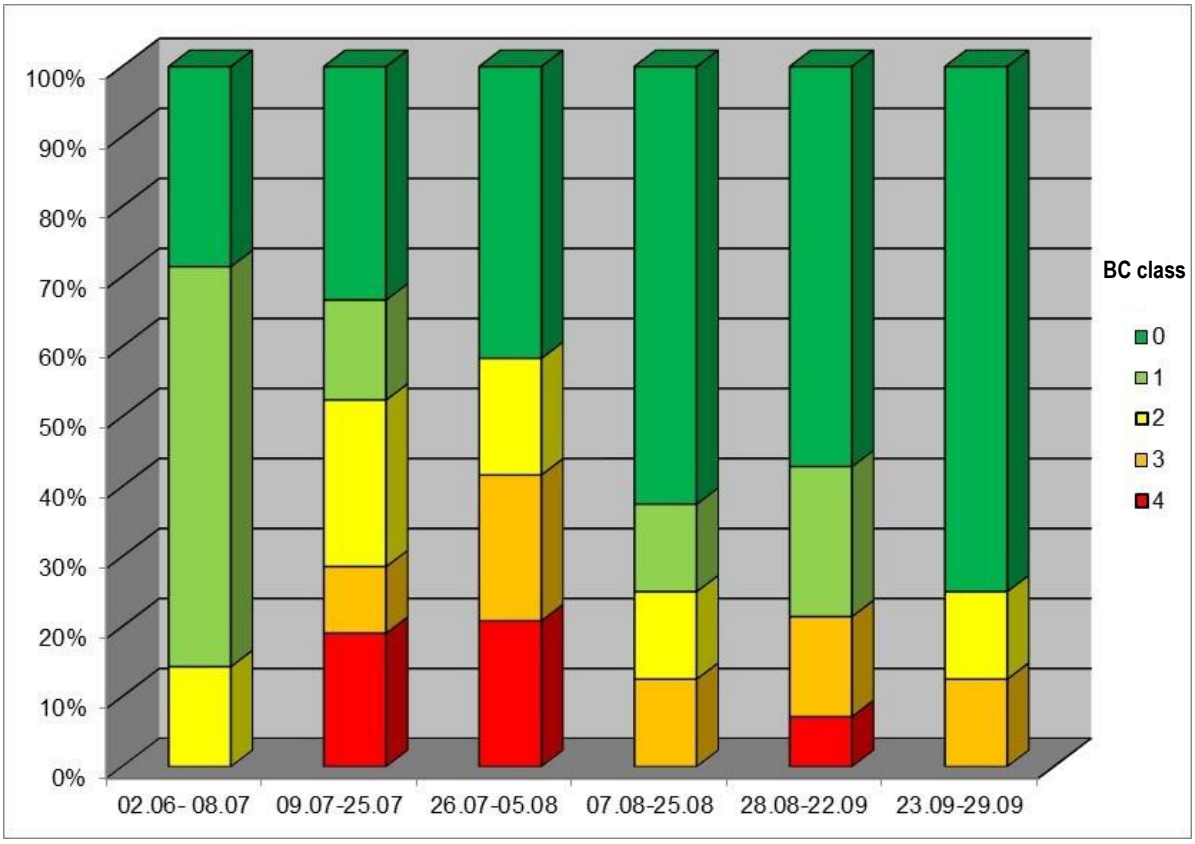


Figure 7. Percentage of Photo-identified Gray Whales within Each Body Condition (BC) Class Relative to the Total Number of Whales Recorded during the 2018 Field Season in the Piltun Area.

In general, the whales identified in the Offshore feeding area had good body condition (Figure 6). The number of whales with BC class 3-4 increased somewhat in the Offshore feeding area in September. These whales have been identified as females who in the current year came to the Piltun area with calves for the first time and later on, after the break-up of the pairs, moved to the Offshore area for feeding.

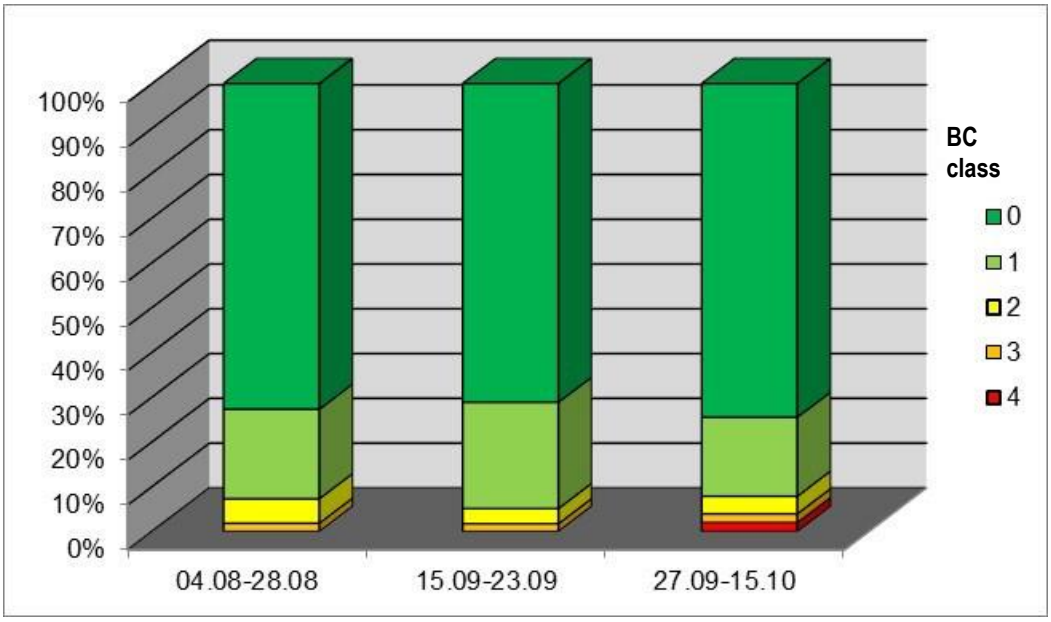


Figure 8. Percentage of Photo-identified Gray Whales within Each Body Condition (BC) Class Relative to the Total Number of Whales Recorded during the 2018 Field Season in the Offshore Area.

Improved BC was noted in 27 whales during the 2018 field season, including identified cows (Figure 9).

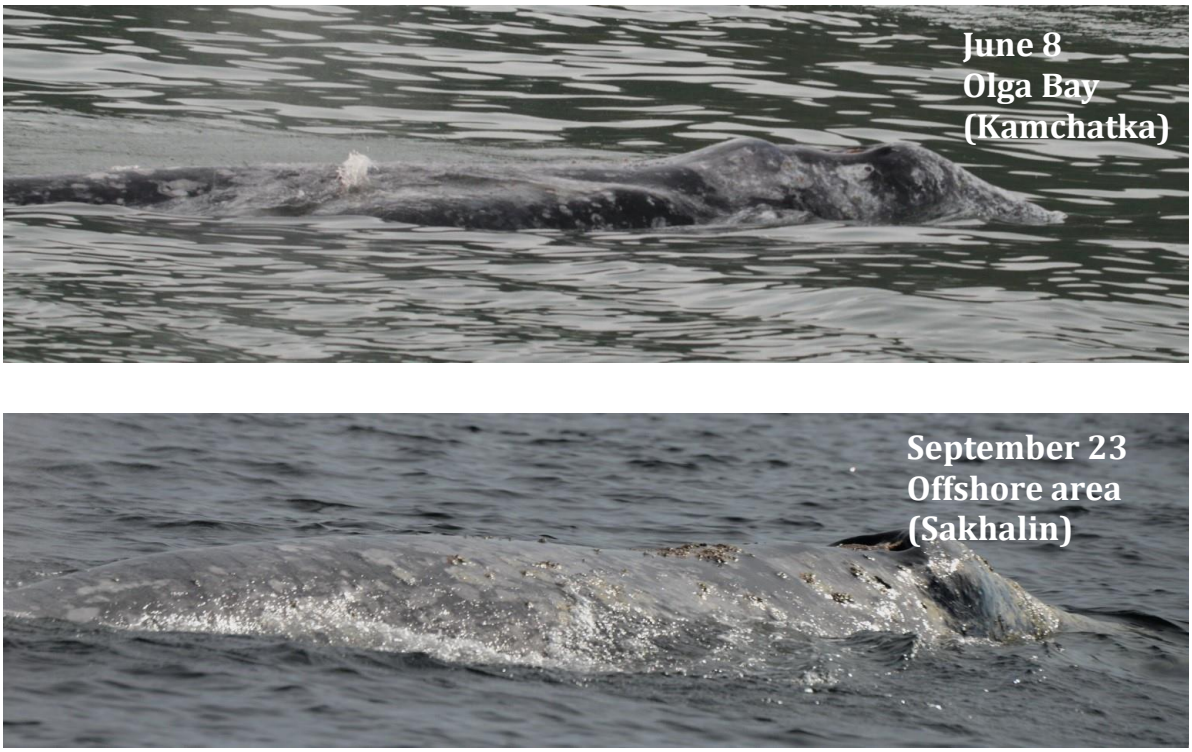


Figure 9. Changes in the Body Condition of Cow KOGW044 that Arrived with a Calf in 2018 during the Feeding Season

In 2018, we were able to track the body condition of animals that were identified in 2017 as cows with calves. Six cows that had been seen with calves in 2017 were sighted in 2018 in the Offshore area. All the cows had improved BC (Table 10).

Table 10. Year-to-Year Comparison of the Body Condition of 2016 Cows and Calves Observed off NE Coast of Sakhalin Island in 2018

	Number of cows with calves in 2017	Number of cows/calves with poor BC in 2017	Number of sighted cows/calves in 2018 from 2017	Changes in BC observed in 2018 vs. 2017	
				Improvement in BC	Worsening of BC
Cows	6	6	6	6	0
Calves	9	0	1	0	0

2.5.2. Skin Condition

One of the WGW health parameters is their skin condition. Over a number of years, we have seen all types of skin problems.

In 2018, the nursing cow KOGW027 had large white stains on the body when encountered on August 2, which vanished by the next time she was sighted on September 23 (Figure 10).

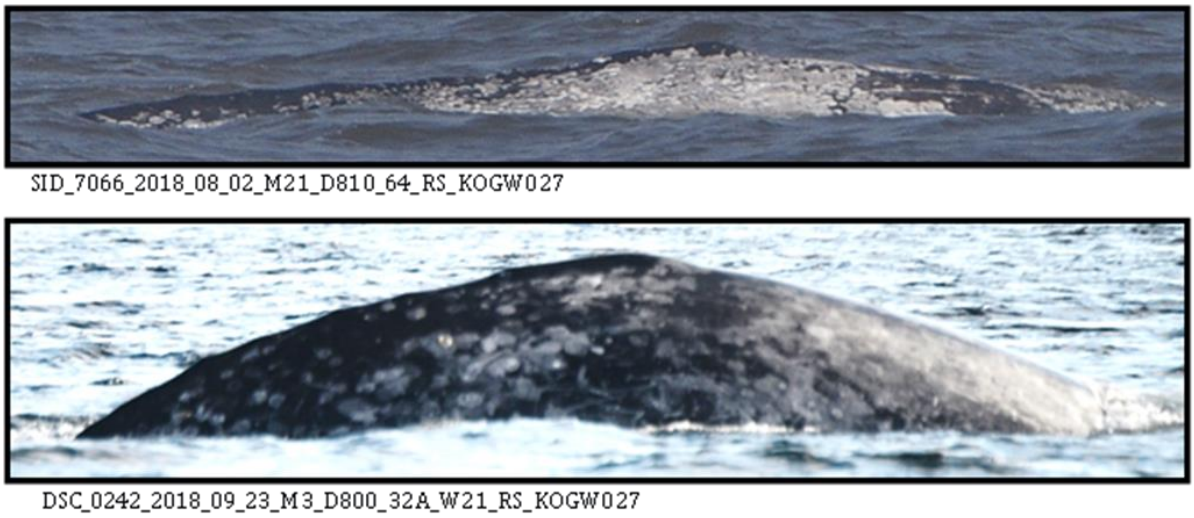


Figure 10. Skin Changes in Cow KOGW027 that Arrived with a Calf in 2018 during the Feeding Season.

3. DISCUSSION

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

Since 2016, onshore photo-ID teams have started to use unmanned aerial vehicles (UAVs) that helped to obtain quality photos of gray whales suitable for identification. This material is an excellent addition to the data collection methods used previously. Aerial photographs allow using new body aspects for subsequent identification and make it possible to identify whales underwater as long as the water is transparent enough. This method of taking photographs makes it possible to identify, very accurately, mother/calf pairs and calves encountered without mothers, since the difference in the size of the animals is clearly visible from the height. Due to UAVs, gray whales can be observed in natural conditions with animal anxiety reduced to a minimum, and tracked to their feeding points throughout the field season; also, reliable data can be obtained on the transition of calves to independent feeding.

Using UAVs can also help monitor potential risks to gray whales, such as abandoned fishing nets.

3.2. Movement of Whales between Sakhalin Feeding Areas

Methods of photo-identification of whale populations are often used to determine their use of habitat areas. Tracking the movements of gray whales during their feeding period can broaden the understanding of their ecology.

The analyses of 2002–2018 photo-ID data collected offshore Sakhalin indicate that inter- and intra-year movements of gray whales occur both within the Piltun and Offshore areas and between these areas.

Of the 290 whales recorded in the Piltun area during the entire period of studies (2002-2018), 143 were never recorded in the Offshore area. This number includes calves and young whales. Only four whales were sighted exclusively in the Offshore area. One whale was photographed north of Cape Elizaveta in 2005 and has not been seen since. In 2015, two whales were sighted in the waters off the Vostochny wildlife refuge and since then have not been recorded

anywhere by our teams, although according to Burdin A.M., one of them was encountered off Kamchatka in Olga Bay (Burdin et al. 2017).

It has been established that whales travel to the north and south of the traditional feeding areas off Sakhalin Island, as well as off Kamchatka (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 geographical movements (Meier et al., 2007; Vladimirov, 2006, 2008). As shown above, information about the whales' movement between areas over the course of a single season can only be provided by repeat sightings with individually-recognized whales in that season. Solitary gray whale sightings in one area during a season with repeat sightings of the same animal in another area in subsequent years provide information about inter-year movements.

The frequency of sightings over the entire survey period is another important factor in studying whale movements between different areas. In 2018, three teams collected a significant volume of materials. The total average sighting frequency (SF) of individual whales was 3.52 as compared to 4.69 for the south team alone, which indicates that the same animals gravitated to this area.

During the 2018 field season, 125 gray whale animals were recorded in the Offshore area, which is the highest number recorded in the Offshore area in all of the years of monitoring. It can be explained on the one hand by greater efforts especially compared to 2016 and 2017) and possibly by the presence of a large number of animals compared to the previous year. Benthic community studies offshore Eastern Sakhalin demonstrate large quantities of biomass suitable for gray whales to feed on. The calculated capacity of the environment for gray whales in the deep water Offshore area allows a larger number of gray whales to feed in this area compared to the shallow nearshore Piltun area (Labai et al., 2018).

Sufficient amount of material collected in the Piltun area, including with the use of drones, enables to assess in more detail the way adults and cow-calf pairs use the feeding grounds. Data on feeding sites received as a result of the aerial photography in shallow waters provided new information about the calves weaning.

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 all whales identified in the surveyed areas offshore SE Kamchatka in 2004 and 2006-2012 and in 2018, about 54.6% (95 out of 174) were also photographed in various areas offshore Sakhalin. In 2018, 12 of 31 whales photographed in Olga Bay (Kamchatka) were sighted offshore Sakhalin Island during the same season. Over all the survey years, 95 gray whales have been identified (32% of all known Sakhalin catalogue whales and 54.6 % of all known Kamchatka catalogue whales) that have visited both the Sakhalin and Kamchatka offshore areas, both in different years and in the same season. This proves 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 (Sakhalin), have not been sighted there for a long time in subsequent years, but have been sighted in Olga Bay (Kamchatka). For example, KOGW161 has not returned to Sakhalin for 10 years, while KOGW142 has been sighted exclusively in the Kamchatka area for 12 years now. Therefore, it is likely that these whales are part of the same feeding aggregation. The question regarding the group affiliation of the other 45.4% (79 animals) sighted offshore Kamchatka remains uncertain.

3.4. Whale Movement between Sakhalin 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, Calambokidis et al., 1989, Calambokidis et al., 1990, Calambokidis and Quan, 1997, Weinrich et al., 1997, Wilson et al., 1997, Forney and Barlow, 1998, 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; Meier, 2003, 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 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), offshore 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 were assigned catalogue ID numbers starting with the NOGW acronym (Vladimirov et al., 2007). In 2007, one of these, whale NOGW003 was sighted in the Piltun area (five sightings) and was given catalogue ID number KOGW160 (Table A5 in the Appendix). In 2011, whale NOGW001/KamGW024, which was recorded for the first time in Kekurny Bay (Sea of Okhotsk) and in subsequent years was encountered in Olga Bay (Kamchatka), was identified offshore Sakhalin Island and was given catalogue ID number KOGW190. Since they were listed in the catalogue, both whales have been regularly sighted in Sakhalin.

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 recorded 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). A comparison of the gray whale catalogues of Sakhalin Island and the catalogues of the west coast of the United States and Mexico also showed that some "Sakhalin" whales visited offshore areas historically occupied by Eastern Gray Whales (Urban et al., 2012, 2013).

In addition, two gray whale cows that had previously been photographed in California, Mexico, were photographed in the Piltun area during the 2015 season (IBM KOGW 108, 23-08-2015 South Piltun – 13-0096-I-LOL-M, Lagoon Ojo de Liebre 2013 and IBM KOGW 114 10-08-2015 South Piltun – 11-0505-I-БИС-M, Lagoon San-Ignacio 2011).

3.5. Cow-Calf Pairs

Our observations indicate that calves are weaned in the period 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 counts conducted in 2005 (Vladimirov et al. 2006) indicated that the separation of cow/and calf pairs had been completed by early September, with the last cow-calf pair observed from the shore on September 11. In 2009, data provided by the vessel-based and shore-based photo identification teams indicated that the last pair recorded offshore Sakhalin Island was encountered on September 19. In 2014, one cow-calf pair was observed until September 30. The last cow-calf pair was sighted on September 7 in 2015. In 2016, the observers noted earlier separation of the cow-calf pairs. The last cow-calf pair was observed on August 21.

In 2018 the first cow-calf pair was identified on July 3, and the cow-calf pair was last recorded on August 4. Subsequently, all earlier identified calves were sighted only in calf groups, and all cows were photographed in the Offshore area later. Two calves were encountered without the cows already in early July. Observations using unmanned drones showed that by that time they were already weaned.

Before 2008, the shallow-water Piltun area on the Sakhalin Island offshore area was considered to be the only feeding ground for the cow-calf pairs. But in 2008, the cow-calf pair was found in Olga Bay on the eastern offshore area of the Kamchatka Peninsula. This cow was recorded with calves offshore Sakhalin Island in previous years (Tyurneva et al., 2010). Research conducted off the Kamchatka Peninsula in 2009-2012 earlier than in previous years demonstrated that cows with calves also used Olga Bay for feeding (Yakovlev et al., 2011). These females identified in Olga Bay included both the individuals recorded in the Sakhalin catalogue, as well as the ones not sighted offshore Sakhalin Island. It was registered that some calves and cow-calf pairs swam from Olga Bay to the Piltun area during one season (Yakovlev et al, 2012; Tyurneva et al, 2012). In 2018, four cow-calf pairs were photographed in Olga Bay. All cows had been previously sighted in Sakhalin and all of them brought calves to the Piltun area later. It is possible that cow-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 cows with calves stay to feed in Olga Bay, while others migrate to the Sakhalin Island shelf and other areas that are unknown to us.

3.6. Body Condition

During migration, gray whales cover great distances and probably exhaust their reserves 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 rich sources of forage (Fadeyev, 2013).

Some whales that showed signs of emaciation in previous years failed to exhibit such signs in subsequent years. This seasonal ability of emaciated whales to regain good physical condition was also observed previously (Yakovlev and Tyurneva 2003 and 2013; Yakovlev et al. 2007; Weller et al. 2004). The biological energy of gray whale foraging in combination with fasting and feeding cycles involving migrating, feeding, and breeding, are a dynamic process. It is known, that not all of the gray whales moving north from the winter breeding areas (Baja California) to feed in the Chukchi, Bering, and Beaufort Seas reach these destinations. Approximately halfway along this migration route, in the Vancouver area (British Columbia, Canada), some whales stop moving north and start feeding on the organisms present in this area (Pike, 1962). Due to the shortening of the migration period by almost two months, the feeding season of these whales is extended accordingly (Darling, 1984).

At this point, the recovery and deterioration of the body condition of both nursing and non-nursing whales still cannot be fully explained based on available data.

Skin sloughing was observed among some of the whales in 2003. Repeated observations of these whales in 2004-2014 based on photographs indicate that skin sloughing observed in 2003 and 2014 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).

The appearance of white patches observed on some gray whales since 2005 has yet to be explained. Continued photo-ID monitoring of these individuals has not resulted in any obvious 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 2002–2018:

1. In 2018, a total of 155 individual gray whales were photo-identified in the known (Piltun and Offshore) feeding areas off the northeast coast of Sakhalin Island.
2. Twelve new whales (including two adults and calves) were recorded and catalogued during the 2018 field season. Currently, the Sakhalin gray whale catalogue includes 297 identified individuals.
3. 46 whales were recorded in the Piltun feeding area, 30 of which were sighted only in that area. 125 whales were recorded in the Offshore feeding area, 109 of which were sighted only in that area. Sixteen individuals used both areas for feeding during the season, including eight females identified as current year cows.
4. Since 2012, there is a steady trend whereby gray whales use the Offshore feeding area intensively. In 2018, the largest number of animals were registered in this area in all of the survey years.
5. From 2002 to 2018, of the 297 whales entered in the Sakhalin catalogue, 143 were recorded only in the Piltun area, and 4 whales were recorded only in the Offshore area (including two new whales). 147 whales use both Piltun and Offshore feeding areas (29 of which were first recorded in the Piltun area as calves and later also sighted in the Offshore area).
6. Between 2002 and 2018, 31 cows listed in the Sakhalin catalogue of the Marine Biology Institute of the Far East Branch of the Russian Academy of Sciences were sighted as they came to the feeding areas with calves offshore Sakhalin and Kamchatka. Of these, 24 cows were sighted with calves on two or more occasions. In 2018, two cows were sighted with sucklings for the first time.
7. The number of sighted calves varies from year to year. From 2002 through 2018 the minimum number of calves – 3 - was observed in 2004, the maximum number – 17 - in 2011 (15 calves in the Piltun area and 2 calves near Kamchatka). In 2018, eight cow-calf

pairs were sighted near Sakhalin, and two calves without cows (10 calves total). The calves without cows were encountered both near identified pairs and in calf groups.

8. The cow-calf pairs were sighted offshore Sakhalin only in the Piltun area, and never in the Offshore area. It was established that at least one other similar area is located in Olga Bay (Kamchatka). In 2018, four cow-calf pairs were identified in Olga Bay in June, and all of them were sighted in the Piltun area later.
9. Gray whales may use the feeding areas near Kamchatka and Sakhalin Island during the same season. The Kamchatka catalogue of gray whales (Khalarkyr Beach, Vestnik Bay, Olga Bay) for 2004, and 2006–2018 currently lists 174 identified individuals, including 95 individuals photographed off Sakhalin Island. Possibly, most of these gray whales belong to the same feeding population. The placement of the other 79 individuals encountered near Kamchatka is still an open question.
10. During the period of the multi-year studies, 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 has not been seen since. In 2015, 2 whales that had not been encountered elsewhere before, were sighted in the water area near the Vostochny wildlife refuge.
11. Every year, primarily the same individual whales return to feed off the Sakhalin coast, demonstrating strong attachment to the feeding areas. A group of 182 whales has been identified that come to the northeast coast of Sakhalin Island for feeding on a regular basis. Twenty one whales were recorded in this area at intervals greater than three years; this group was classified as rarely-sighted whales. A total of 61 individuals have been recorded once in the period from 2002 through 2017 (42 of them were recorded as calves).
12. In 2018, 19 whales (including 8 lactating females) were identified with inadequate body condition (BC), which amounted to 15.0% of the total number of animals whose photographs allowed assessment of body condition (127 whales). Most whales improve

their physical body condition during the feeding season. Good body condition was seen in whales sighted in the Offshore area late during the observation period.

13. The new photo-ID technique using drones provided additional possibilities for obtaining high-quality images of whales, identifying calves and cow-calf pairs, and determining exact dates when the calves begin to feed independently.
14. In 2018, nursing cow KOGW027 during early periods of monitoring exhibited skin changes in the form of white stains covering much of the body. Photos taken at a later time show that the stains vanished and the skin looks healthy.
15. Based on the determination of reproductive success, the number of animals observed, their ability to recover after a period of malnutrition, we can conclude that this feeding population of gray whales is in good condition and its numbers are stable.

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Vessel-based team video camera operator	Arseniy Yuryevich Yakovlev	National Scientific Center of Marine Biology of the Far East Branch of the Russian Academy of Sciences
Vessel-based team scribe	Aleksandr Evgenievich Oskolkov	National Scientific Center of Marine Biology of the Far East Branch of the Russian Academy of Sciences
Vessel-based team boat operator	Nikolay Ivanovich Prokhorov	National Scientific Center of Marine Biology of the Far East Branch of the Russian Academy of Sciences
Photographer, the North vehicle-team leader	Vladimir Vasilyevich Vertyankin	Kronotsky reserve Sakhalin State University
The North vehicle-team team drone operator	Alexander Valentinovich Bobkov	Sakhalin State University
The North vehicle-team team scribe	Alexander Sergeyevich Kvashnin	Sakhalin State University
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The South vehicle-team drone operator The South vehicle-team scribe	Vladimir Vladimirovich Chernitsyn	Sakhalin State University

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APPENDIX

FIGURES

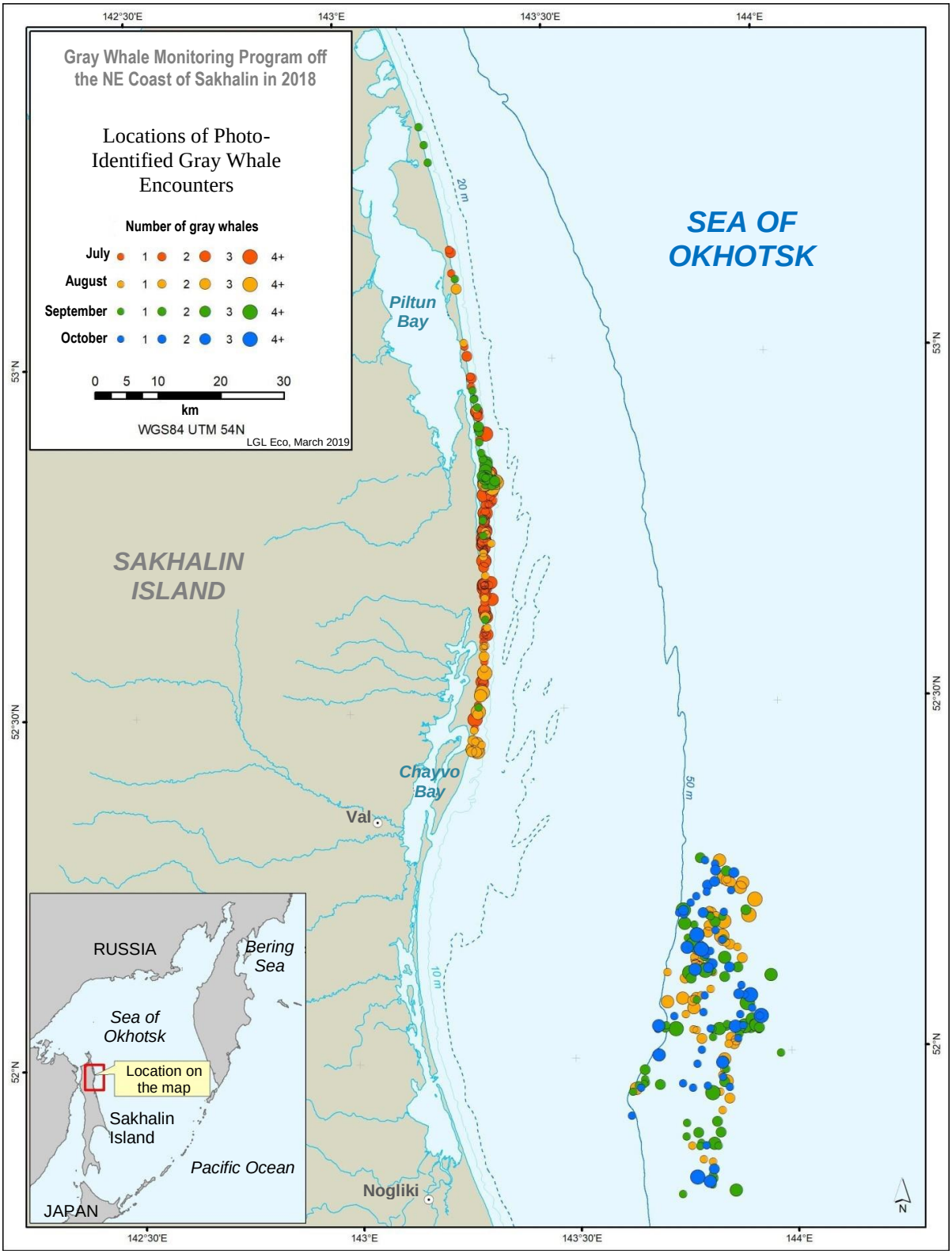

Gray Whale Monitoring Program off the NE Coast of Sakhalin in 2018
Locations of Photo-Identified Gray Whale Encounters
Number of gray whales
July 1 2 3 4+
August 1 2 3 4+
September 1 2 3 4+
October 1 2 3 4+
0 5 10 20 30
km
WGS84 UTM 54N
LGL Eco, March 2019
SEA OF OKHOTSK
SAKHALIN ISLAND
Piltun Bay
Chayvo Bay
Val
Nogliki
20 m
50 m
10 m
142°30'E
143°E
143°30'E
144°E
53°N
52°30'N
52°N
RUSSIA
Bering Sea
Sea of Okhotsk
Location on the map
Sakhalin Island
Pacific Ocean
JAPAN
N

Figure A1. Locations of Photo-Identified Gray Whale Encounters in 2018 Based on Sakhalin Island Photo-ID Teams' Data

TABLES

Table A1. Scope of FRC Boat Photo-Identification Work (Number of Missions) and Average Sea Depth During Each Vessel-Based Mission off Sakhalin Island in 2018 (Vessel-Based Team Data)

Date	Feeding Area	Mission No.	Average depth per mission			Mission time
08/04/2018	Offshore	1	49.7	±	3.3	5:20:00
08/05/2018	Offshore	1	46.3	±	0.5	1:38:00
08/28/2018	Offshore	1	43.5	±	1.0	2:19:00
08/28/2018	Offshore	2	62.7	±	1.1	3:07:00
09/15/2018	Offshore	1	53.1	±	2.6	1:20:00
09/15/2018	Offshore	2	50.0	±	1.1	0:36:00
09/22/2018	Offshore	1	36.8	±	1.5	4:00:00
09/23/2018	Offshore	1	50.5	±	1.0	1:00:00
09/23/2018	Offshore	2	41.8	±	1.2	1:25:00
09/23/2018	Offshore	3	21.7	±	0.9	1:06:00

Table A2. Number of Gray Whales Identified off the Northeast Coast of Sakhalin Island in 2002-2018

Year	Total number of whales per year	Whales this year that were identified in previous years	New whales including calves	New whales excluding calves	Whales observed in past years but not encountered this year	Number of whales in catalogue
2002	49	0	49			**47**
2003	86	38	48	38	11	**92**
2004	99	78	21	18	19	**118**
2005	117	99	18	14	19	**136**
2006	121	108	13	8	27	**148**
2007	125	112	13	4	35	**160**
2008	98	93	5	0	67	**165**
2009	112	101	11	5	64	**177**
2010	104	94	10	6	81	**187**
2011	124	105	19	4	80	**205**
2012	144	130	14	5	74	**219**
2013	121	112	9	3	106	**228**
2014	139	124	15	3	103	**243**
2015	175	158	17	6	84	**259**
2016	128	114	14	0	145	**274**
2017	72	63	9	0	210	**283**
2018	155	143	12	2	142	**297**

Table A3. 2002-2018 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					

Note:

* *The values in parentheses show the number of animals that were recorded only in the specified area and not encountered in other survey areas. Table values can be changed annually based on an*

update to the catalogue, for example, as a result of correlating temporary whales. The numbers include temporary whales.

Table A4. Areas of Identified Gray Whales Encountered off the Northeast Coast of Sakhalin Island

	2002			2003			2004			2005						2006				2007			2008			2009			2010			2011			2012			2013		2014		2015				2016		2017		2018	
ID	P	O	C	P	O	C	P	O	C	P	O	C	Oha	El	P	O	C	Oha	P	O	C	P	O	C	P	O	C	P	O	Oha	P	O	C	P	O	C	P	O	P	O	P	O	C	Vost	P	O	P	O	P	O
001		1						1		1						1				1	1		1	1			1						1			1				1	1	1					1				1
002		1			1		1			1						1	1			1	1	1		1						1			1		1		1			1	1	1								1
003		1																																															
004		1		1																																													
005		1		1			1			1							1			1	1		1			1			1				1	1	1		1		1	1	1			1		1		1	
006		1		1			1			1	1						1			1	1		1			1									1	1				1	1	1			1				1	
007	1			1			1			1					1		1			1	1							1							1					1						1				1	
008		1		1			1			1			1		1	1				1			1			1		1	1	1					1					1					1				1	
009		1					1			1					1					1	1		1			1		1				1			1					1	1								1	
010		1					1			1					1				1	1	1				1			1			1			1			1	1	1	1				1		1			
011		1			1		1			1		1			1				1	1			1			1		1					1	1						1					1				1	
012		1		1	1		1			1		1			1	1			1	1			1	1		1		1				1			1				1		1	1						1	1
013		1			1		1			1					1	1				1			1		1									1	1					1								1	
014		1					1			1					1	1				1			1															1	1		1								
015		1			1					1					1				1	1		1	1					1			1				1		1			1	1								1	
016		1			1		1			1						1			1			1			1						1			1					1						1				1	
017		1			1		1			1					1	1			1	1						1		1	1						1					1										1	
018	1			1			1			1					1														1		1	1		1			1		1					1				1	
019		1			1			1		1	1					1				1						1									1					1	1					1			1	1
020		1			1		1			1		1			1	1	1		1	1		1	1					1			1			1					1		1	1						1	1
021		1			1		1			1					1					1		1	1			1		1	1		1			1					1	1	1			1	1					1
022	1			1			1			1					1		1		1			1					1		1				1	1		1			1					1		1		1	
023	1						1								1		1									1		1						1						1									1	
024	1									1					1		1		1	1			1		1						1			1						1	1	1							1	
025	1	1		1	1		1			1	1					1			1	1						1			1			1			1				1						1					
026	1			1						1		1			1							1			1			1			1			1			1			1					1					1
027	1			1			1										1		1			1						1			1		1	1				1					1		1		1	1
028		1		1			1			1					1				1						1			1			1			1						1						1		1	1
029	1			1			1			1					1				1	1		1	1		1									1			1		1	1					1		1		1	
030	1			1			1			1					1				1	1		1	1		1	1						1			1			1		1					1		1		1	
031	1				1		1								1				1			1			1				1		1			1	1		1													
032		1		1			1			1					1				1	1			1																											
033		1			1		1			1					1				1				1			1			1						1					1					1				1	
034		1					1			1					1				1			1			1																								
035		1		1	1		1			1					1				1	1		1	1		1			1			1			1			1	1		1	1				1				1	
036		1			1		1			1					1	1			1	1			1						1					1				1							1				1	
037		1		1			1			1	1				1				1	1		1	1		1						1			1				1	1	1									1	
038		1		1			1			1		1			1			1	1			1			1			1			1		1						1		1									1	
039		1		1						1					1		1		1	1		1	1		1	1		1																						
040		1		1			1			1										1			1			1		1											1		1	1								1	
041		1		1			1			1						1			1	1		1			1		1				1			1	1			1			1						1				1	
042	1		1				1			1						1			1	1		1				1			1						1					1										
043		1		1	1		1			1		1				1			1				1					1												1	1								1	
044		1		1		1	1			1					1		1		1			1			1		1	1			1			1					1	1								1	
045		1			1			1		1							1			1						1						1			1					1	1								1	
046					1		1			1					1	1			1				1			1						1			1	1					1	1								1	
047				1						1					1				1		1	1			1			1			1			1			1		1		1				1		1		1	
048				1			1			1					1				1	1			1		1			1			1			1			1		1		1				1	1	1			1	
049	1			1			1			1		1	1		1	1			1			1			1						1						1			1							1				
050				1			1			1					1				1			1			1						1			1			1		1		1									
051					1		1			1									1	1			1				1					1									1						1				1	
052				1																																														
053				1						1					1				1						1			1			1			1			1		1		1	1								1	
054					1		1			1						1			1	1		1	1		1			1			1	1		1	1				1		1	1								1	
055				1						1	1				1				1	1		1			1	1		1						1			1				1										
056				1			1			1					1				1			1			1	1		1			1						1	1		1		1								1	
057				1						1					1	1			1	1			1		1	1			1		1			1				1			1									
058				1			1			1		1					1		1		1	1						1	1				1	1	1				1			1				1	1		1		1
059				1	1					1		1			1	1			1	1					1			1			1			1				1	1	1	1	1			1			1		1
060				1			1			1					1					1		1	1		1			1	1		1			1			1	1	1	1	1	1				1					
061				1			1			1							1		1		1	1		1			1	1		1	1			1			1	1		1	1	1					1				1	
062				1				1		1					1	1			1	1			1	1				1			1			1			1	1		1	1						1				1	
063				1			1			1		1			1				1	1					1			1	1		1	1		1						1								1				1	
064				1			1			1		1			1				1		1				1		1	1			1			1						1	1	1						1	1		1	1
065				1																																														
066					1		1			1					1		1		1				1		1			1			1	1						1	1										1	
067				1			1			1					1	1			1												1			1				1	1	1	1	1							1	
068				1			1			1					1				1			1			1			1			1			1						1						1				1	
069				1			1			1					1	1	1		1		1	1	1		1	1									1						1									1	
070					1		1			1					1		1			1			1		1	1		1			1				1		1	1			1	1								1	
071				1			1			1					1				1		1	1			1			1						1	1			1	1		1	1								1	
072				1			1			1					1						1	1	1		1			1	1					1				1		1	1	1							1	
073				1															1						1			1	1		1									1	1								1	
074				1			1			1					1		1		1			1			1			1	1		1			1				1			1	1									

Table A4, continued

	2002			2003			2004			2005					2006				2007			2008			2009			2010			2011			2012			2013		2014		2015				2016		2017		2018	
ID	P	O	C	P	O	C	P	O	C	P	O	C	Oha	El	P	O	C	Oha	P	O	C	P	O	C	P	O	C	P	O	Oha	P	O	C	P	O	C	P	O	P	O	P	O	C	Vost	P	O	P	O	P	O

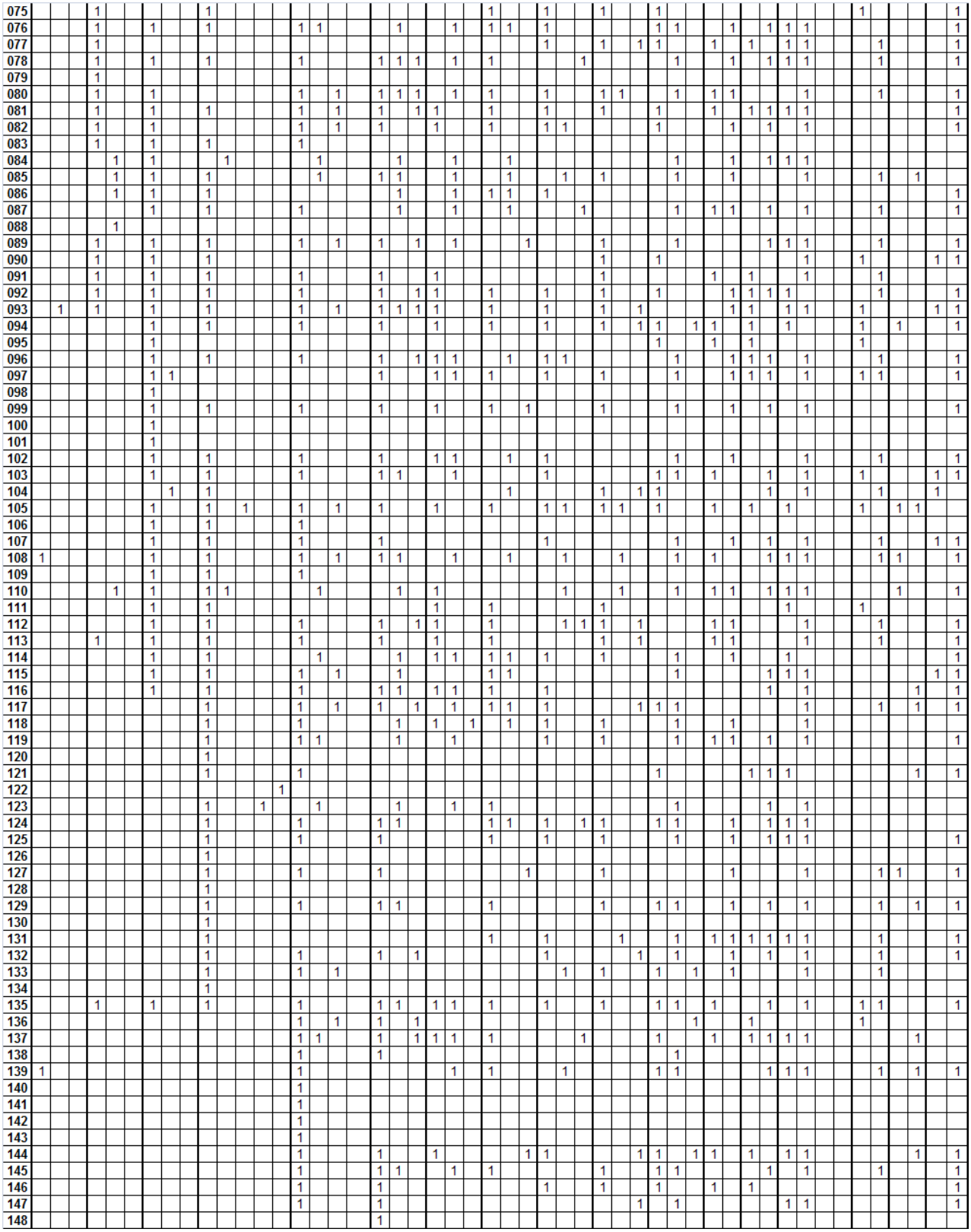


Table A4, continued

	2002			2003			2004			2005					2006				2007			2008			2009			2010			2011			2012			2013		2014		2015				2016		2017		2018	
ID	P	O	C	P	O	C	P	O	C	P	O	C	Oha	El	P	O	C	Oha	P	O	C	P	O	C	P	O	C	P	O	Oha	P	O	C	P	O	C	P	O	P	O	P	O	C	Vost	P	O	P	O	P	O

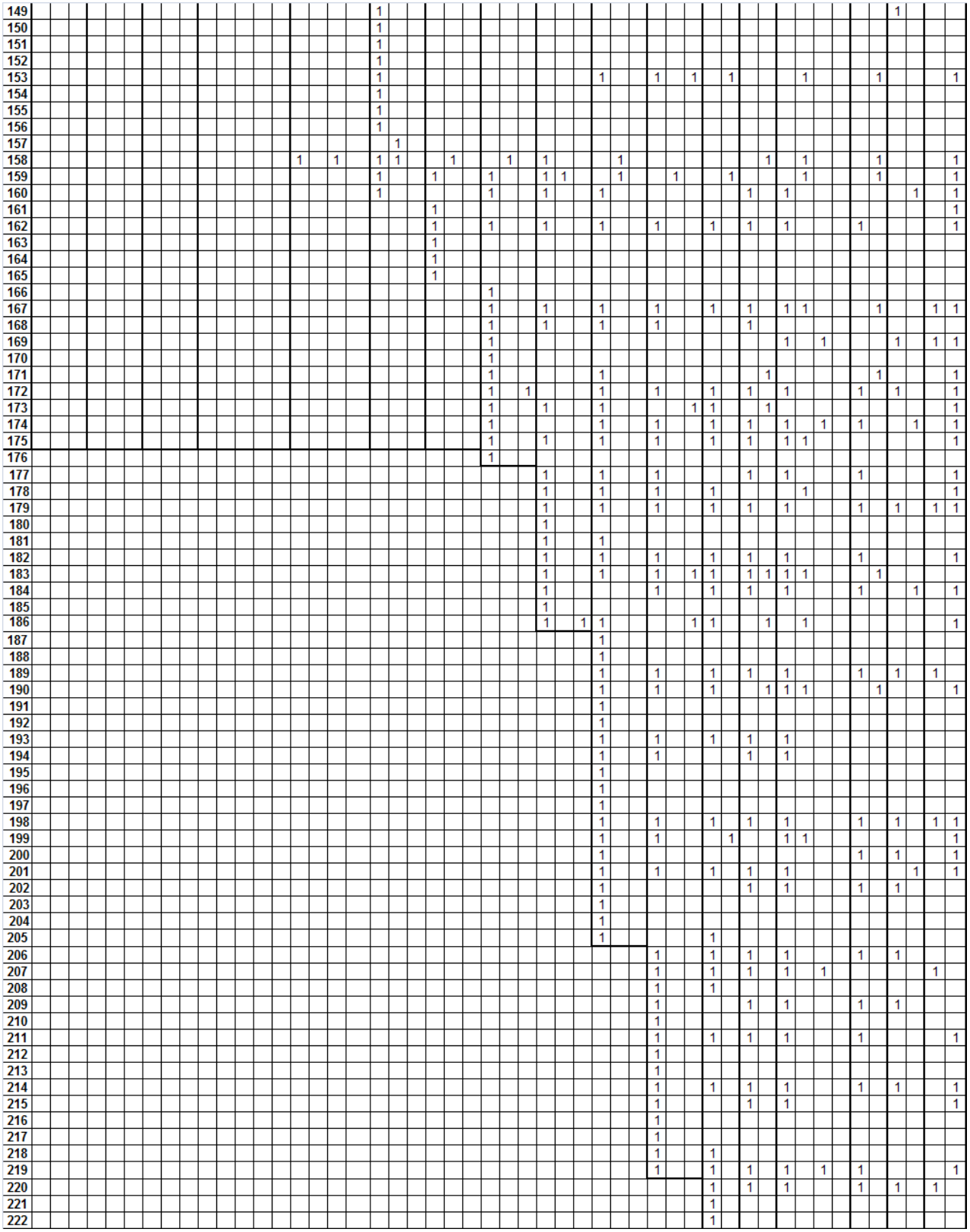
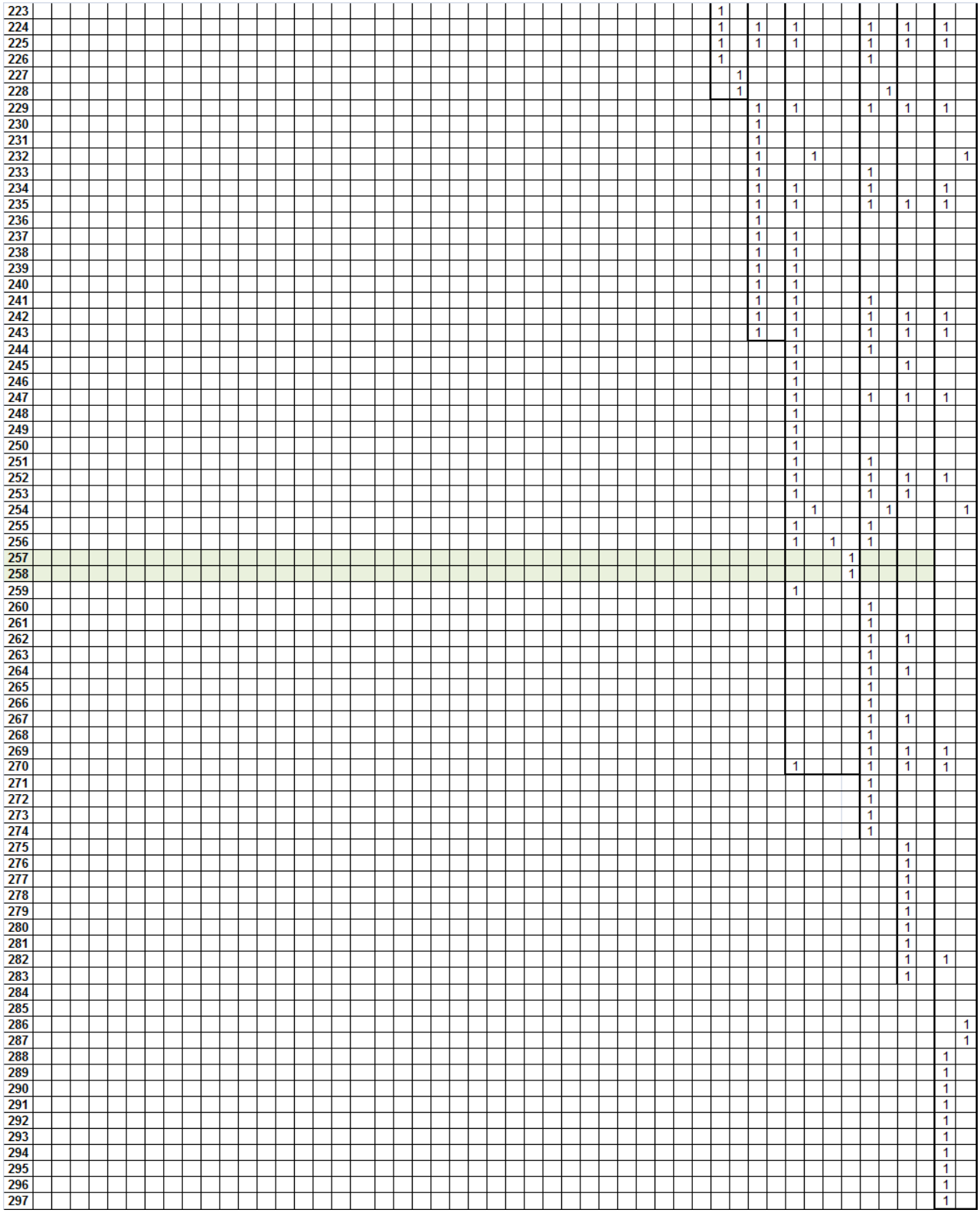


Table A4, continued

	2002			2003			2004			2005					2006				2007			2008			2009			2010			2011			2012			2013		2014		2015				2016		2017		2018	
ID	P	O	C	P	O	C	P	O	C	P	O	C	Oha	El	P	O	C	Oha	P	O	C	P	O	C	P	O	C	P	O	Oha	P	O	C	P	O	C	P	O	P	O	P	O	C	Vost	P	O	P	O	P	O



O – Offshore area
P – Piltun area
C – Chayvo area
Oha – area near Okha
El – area beyond Cape Elizaveta

Table A5. Cow-Calf Pairs and Calves without Identified Mothers Recorded During Surveys in 2003-2018

KOGW/KamGW	2003 Calf No.	2004 Calf No.	2005 Calf No.	2006 Calf No.	2007 Calf No.	2008 Calf No.	2009 Calf No.	2010 Calf No.	2011 Calf No.	2012 Calf No.	2013 Calf No.	2014 Calf No.	2015 Calf No.	2016 Calf No.	2017 Calf No.	2018 Calf No.
005 / 000	077/010		124/035										244/000		279/000	
007 / 000								180/000					253/000		278/000	
015 / temp01					150/074		177/104				225/000		249/000			
018 / 031	083/000					000/066						241/000				
019 / 039								183/133					247/000			288/170
020 / 000							176/000						245/000			291/173
021 / 000				143/000		162/142			188/000			231/000		269/000		
022 / 000												239/000				
027 / 000	078/000		125/103		148/053									264/000		297/000
031 / 000							169/141		196/000							
037 / 000	076/000		126/078						193/000			236/000		260/000		
045 / 068								182/124				234/000				
044 / 000		096/000						184/000				230/000				290/000
047 / 013									191/000			238/000		267/000		
050 / 000		095/008		141/000			173/000		189/000							
062 / 000			127/064		149/048				201/000		220/000					
063 / 000	075/026				154/052			179/000							277/000	
064 / 060		101/000			152/050			181/135		208/000						
090 / 001							000/086									
092 / 038					156/000		167/000						251/000			
093 / 000						161/111		178/000				229/000		271/000		289/000
096 / 000												235/000				
097 / 000					151/056		168/000		192/000					262/000		
103 / 087							174/088							266/000		295/000
107 / 000																294/000
108 / 000													250/000		276/000	
110 / 084							000/085						246/000		280/000	
114 / 000													255/000			
115 000																293/000
127 / 064															275/000	
135 / 000											221/000			273/000		
000 / 057							000/100		000/144							
000 / 085										000/152						
000 / 101							000/102			000/151						
000 / 106							000/105									
неизв / неизв	052/000															
неизв / неизв	069/000															
неизв / неизв	073/077															
неизв / неизв	079/000															
неизв / неизв	082/000															
неизв / неизв				142/028												
неизв / неизв				144/129												
неизв / неизв				146/000												
неизв / неизв					153/054											
неизв / неизв					155/000											
неизв / неизв						163/083										
неизв / неизв						164/080										
неизв / неизв						165/000										
неизв / неизв							175/000									
неизв / неизв																
неизв / неизв									194/000							
неизв / неизв									195/000							
неизв / неизв									197/000							
неизв / неизв									198/000							
неизв / неизв									200/000							
неизв / неизв									202/000							
неизв / неизв									203/000							
неизв / неизв									205/000							
неизв / неизв										206/000						
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неизв / неизв										213/000						
неизв / неизв										214/000						
неизв / неизв										215/000						
неизв / неизв									000/145							
неизв / неизв										000/154						
неизв / неизв											222/000					
неизв / неизв											223/000					
неизв / неизв											224/000					
неизв / неизв												233/000				
неизв / неизв												237/000				
неизв / неизв												240/000				
неизв / неизв													248/000			
неизв / неизв													252/000			
неизв / неизв																
неизв / неизв														261/000		
неизв / неизв														263/000		
неизв / неизв														265/000		
неизв / неизв														268/000		
неизв / неизв														272/000		
неизв / неизв														274/000		
неизв / неизв															281/000	
неизв / неизв															282/001	
неизв / неизв															283/002	
неизв / неизв																292/000
неизв / неизв																296/000

неизв. - Unidentified

- The whale was recorded as a calf or a cow in Kamchatka