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ABSTRACT

From 2004-2006, the SPLASH (Structure of Populations, Levels of Abundance and Status of Humpback whales) project explored humpback whale population structure in the North Pacific, summarizing efforts of more than 50 research groups. At that time, despite significant survey efforts, only 102 whales had been identified in Russia with 30 matches to breeding grounds. After the SPLASH project was completed, photo-identification of humpback whales in Russia continued mainly off the Commander Islands with some effort in locations off Kamchatka and other regions.

In the current study we summarize the results of humpback whale research efforts in the Russian Pacific in 2004-2015 and analyze the connections across different summering areas and wintering places. We found that the number of identified whales was much higher in the Commander Islands than in other areas. Apparently, to some extent this difference was due to variation in efforts. However, despite the lower numbers of identified whales, the recapture rate was higher in Karaginsky than in the Commander Islands. This suggests higher abundance and/or presence of the large number of transient whales in the Commander Islands. Mark-recapture estimate of humpback whale abundance was more than 10 times higher in the Commander Islands than in Karaginsky Gulf. We have less data from other areas, but boat-based surveys confirm that the Commander Islands and Karaginsky Gulf are the main places of humpback whale summer aggregation in Kamchatka and adjacent waters. We have much fewer data from the areas further north around Chukotka; reports from the staff of cruise ships and local researchers suggest that the abundance of summering humpback whales is relatively high in this area.

In spite of the increased number of identified humpback whales, their match rate with breeding grounds was low: about 10% in our study, even lower than the 30% reported earlier by SPLASH. In concordance with SPLASH results, we found that the overall match rate was higher in the mainland Kamchatkan sites and consisted mostly of whales from the Asian breeding ground. In the Commander Islands, the amount of overall matches was lower and the proportion of whales matched with Asia was twice higher than matched with Hawaii and six times higher than with Mexico.

INTRODUCTION

Initially, all humpback whales in the North Pacific were considered as one stock or population. Later, the knowledge about migratory connections between breeding and feeding grounds in the North Pacific was developed through re-sightings of individual whales identified by natural markings. Currently, humpback whales in the North Pacific are considered to have nine geographically distinct breeding sites, which can be grouped into five winter breeding grounds (Calambokidis et al. 2008). Eastern part of the North Pacific population of humpbacks breeds in Central American breeding ground in waters from south Mexico to Costa Rica and in Mexican breeding ground, which includes coastal waters of mainland Mexico, Baja California and Revillagigedo archipelago. Central part of the population breeds in waters around main Hawaiian Islands, which is Hawaiian breeding ground. Western part of the population breeds mainly in Asian breeding ground, which consists of waters off the Philippines, Okinawa and Ogasawara Islands of Japan. Also for the Western North Pacific the second distinct population unit is proposed that mixes with whales migrating through Ogasawara waters, but its location is currently uncertain (Bettridge et al. 2015). Feeding grounds in the North Pacific are represented by numerous distinct regions along the west coast of North America, Aleutian Islands and northeastern coast of Russia.

Movements between feeding and breeding areas are complex and varied. Humpbacks breeding off Revillagigedo Archipelago and Hawaii Islands migrate to feed in more central and high latitude areas like Aleutian Islands, Chukotka Peninsula and Commander Islands. Whales from the breeding grounds of both eastern and western North Pacific migrate to feed in relatively lower latitudes and more coastal areas on each side of the Pacific Ocean, such as California and Kamchatka, Russia (Burdin, Yamaguchi 2004; Calambokidis et al. 2008; Burdin 2010). Strong site fidelity has been observed both to feeding and breeding regions. However, sporadic cases of interchange between different breeding areas suggests some plasticity in the movements of humpback whales (Salden et al. 1999).

From 2004-2006, the SPLASH (Structure of Populations, Levels of Abundance and Status of Humpback whales) project explored humpback whale population structure in the North Pacific, summarizing efforts of more than 50 research groups. The SPLASH report (Calambokidis et al. 2008; Burdin 2010) was the first substantial review in which information about humpback whales in the Russian Far East was presented. In that study three main regions of humpback whale concentration in the Russian waters were reported: Karaginsky Gulf (northeastern Kamchatka), Commander Islands and Gulf of Anadyr (southern Chukotka Peninsula). Among the whales identified in these regions, matches with all except the Central American breeding ground were found. Most of the migratory connections were reported with the Asian breeding ground. Substantially fewer matches were found with Hawaii and only one whale was matched with Revillagigedo in the Mexican breeding ground. In contrast to other feeding grounds, described by SPLASH, whales from Russian waters were not well represented at any of the sampled wintering grounds, suggesting the existence of missing wintering area that has not been previously described (Calambokidis et al. 2008).

At the time of the SPLASH study (2004-2005), despite of significant survey efforts, only 102 whales had been identified in Russia with 30 matches to breeding grounds (Calambokidis et al. 2008). In 2008-2009, 120 more individuals were identified in Russia and 10 matches were found with the Okinawa Churaumi Aquarium catalog, Okinawa Churashima Foundation (Burdin 2010). Four more matches were found later between the Commander Islands and the Babuyan Islands in the northern Philippines (Silberg et al. 2013).

After the SPLASH project was complete, photo-identification of humpback whales continued mainly off the Commander Islands (Bering Island) with some effort in locations off Kamchatka and other regions.

The purpose of the present study is to summarize the results of humpback whale research efforts in the Russian Pacific in 2004-2015 and to analyze in greater detail the connections between the explored feeding grounds with wintering places using approximately six times more data than previously available.

METHODS

Study areas

During the SPLASH surveys in 2004 and 2005 photographs of humpback whales were collected in Anadyr Gulf of Chukotka Peninsula, off Koryakya Coast, in Karaginsky Gulf of Kamchatka, along the eastern Kamchatka Coast and off the Commander Islands. SPLASH surveys did not extend to the Kuril Islands and western Kamchatka Coast, but some additional photographs from occasional reporters from those regions were included in SPLASH report (Calambokidis et al. 2008).

In 2006-2009 the photo identification of humpback whales was continued by the Far East Russia Orca Project (FEROP) and Russian Cetacean Habitat Project (RCHP) in Karaginsky Gulf, off eastern Kamchatka coast and in the Commander Islands. Data collected during this period were summarized at the final SPLASH symposium in Quebec in 2009 (Burdin 2010).

After 2009 research efforts at the Russian Far East were conducted mainly off the Commander Islands as part of the FEROP and RCHP. In August 2014 we obtained some photographs during a ship-based survey to the western Kamchatka and northern Kuril Islands, and in August 2015 – during a ship-based survey to Karaginsky Gulf and eastern Kamchatka.

Table 1. Effort (days with whales) and data sources of humpback whale photographs for different areas of the Russian Pacific in 2002-2015.

| | | Commander Islands | Karaginsky Gulf | CE Kamchatka | SE Kamchatka | W Kamchatka | N Kuril Islands | Koryakya | Chukotka |
|------|----------------------------|----------------------|--------------------|-----------------|-----------------|----------------|--------------------|----------|----------|
| 2002 | ASLC | | 2 | | | | | | |
| 2003 | occasional | 1 | | | | | | | |
| 2004 | SPLASH, occasional | 5 | 4 | | | 1 | | | |
| 2005 | SPLASH, occasional | 3 | 4 | | | 1 | | 2 | 4 |
| 2006 | SPLASH | 2 | | | | | | | |
| 2007 | occasional | 1 | | | 1 | | | | |
| 2008 | FEROP, RCHP, occasional | 5 | 3 | | 1 | | | | |
| 2009 | FEROP, RCHP, occasional | 9 | 5 | 3 | 3 | | | | |
| 2010 | FEROP, RCHP | 46 | | | 6 | | | | |
| 2011 | FEROP, RCHP | 37 | | | | | | | |
| 2012 | FEROP, RCHP | 35 | | 1 | 1 | | | | |
| 2013 | FEROP, RCHP, occasional | 38 | | | 5 | | | | 3 |
| 2014 | FEROP, RCHP | 25 | | | 4 | 1 | 1 | | |
| 2015 | FEROP, RCHP, occasional | 20 | 9 | 4 | 4 | | 3 | | 5 |

Besides, over the years, many photographs were kindly provided by different people and organizations (see Acknowledgements for details).

Photo identification

The majority of photographs obtained off the Commander Islands and in Karaginsky Gulf were taken from small boats (4.5 m inflatable in 2008-2010 and 7.6 fiberglass boat in 2010-2015). Surveys in 2014

and 2015 was conducted using 10m fiberglass sailing yacht; to approach the whales we used 4.5 m inflatable boat.

To take photographs we used digital cameras with 100-200 or 100-400 mm zoom lenses. Individual images were processed with ACDsee Pro 6 software to correct low exposure and increase the contrast. Corrected images were compared with photographs from other encounters. We used the standard methodology of individual recognition of humpback whales focusing on the pigmentation on the ventral surface of the tail fluke, described by Katona et al (1979).

For each identified animal, we created a unique catalog number, containing the year of the first registration of the whale, the four-letter code of the registration region and the number in the database list. At the end of each field season, the best photos of each individual were added to the catalog, and the supporting information about each encounter (date, duration of encounter, type of activity) was added to the database using Microsoft Access 2010.

For each whale, the best quality photo from all seasons was included in the catalog. If some significant changes in marks or coloration of the same fluke were found, both variants were added to the catalog to get the best chance of matching the fluke to earlier or later sightings in other catalogs.

Mark-recapture analysis

Mark-recapture analysis was performed in R package *rcapture* (Baillargeon and Rivest, 2007) using *openp* function. This function computes various demographic parameters using a loglinear model for open populations in capture-recapture experiments. Only re-sightings between (but not within) the years were considered as recaptures for this analysis.

Comparison with breeding grounds

Three sources were used to compare the whales from the Russian Far East catalog with sightings on the breeding grounds. The first and the largest was the SPLASH catalog from 2004-2005. Photographs from the SPLASH catalog were taken under authorized access from the website managed by Cascadia Research Collective (www.splashcatalog.org). As of 2014, it contained 2008 individuals from the Hawaiian breeding ground, 1418 from the Mexican and 543 from the Asian sites. Humpbacks identified in Okinawa, Ogasawara and the Philippines were considered together as belonging to one Asian stock (Burdin 2010).

Two other catalogs contained only the whales belonging to the Asian stock. The catalog from Okinawa by Okinawa Churashima Foundation contained 614 individual whales. The catalog from the Philippines 2000-2006 contained 138 individuals. As the Asian section of the SPLASH catalog also covered Okinawa and the Philippines, some individuals were represented in more than one catalog. For this reason we have compared them with each other to evaluate the overlap rate before matching them to our catalog. This preliminary comparison revealed 210 cases of overlap (196 individual whales) and they were excluded from further calculations. In total, 1099 individual whales from the Asian breeding ground were used for the analysis.

All comparisons were done manually. To make it feasible to process so many images, the images were split into seven groups by percentage of white pigmentation from 0 percent white to 100 percent. Additionally, in each group 5-7 subclasses were distinguished by type of coloration patterns to minimize the number of pictures being compared in each set. Comparisons were performed first inside the closest subclasses. In case an image might be classified ambiguously, it was compared with all similar subclasses. Once a whale was found in a given breeding ground catalog, it was still compared to all other photos to determine if it could be present in another breeding ground.

RESULTS

Identifications of humpback whales in the Commander Islands

During SPLASH surveys in 2003-2005, a total of 27 humpback whales were identified in the Commander Islands. Six additional whales were identified through opportunistic sightings in 2006-2007. Since 2008, dedicated small-boat surveys have been conducted off southwestern Bering Island. In 2008 and 2009, the increase in the number of identified whales was low (9 whales in 2008 and 78 whales in 2009), but in 2010 the number of whales abruptly increased – a total of 587 (543 new, 44 old) whales were identified during 2010 field season (Fig. 1). This increase was partly due to the increase in efforts (long field season June-September, two boats) and partly due to the real increase in the whale abundance: on some days we observed huge feeding aggregations of several tens (maybe more than hundred) of animals. In 2011-2013 the similar effort yielded about 300 whales per year (299 in 2011, 342 in 2012, 362 in 2013). Since 2014, we worked in the Commander Islands only in June and July, which reduced the number of identified whales: 141 in 2014, 202 in 2015.

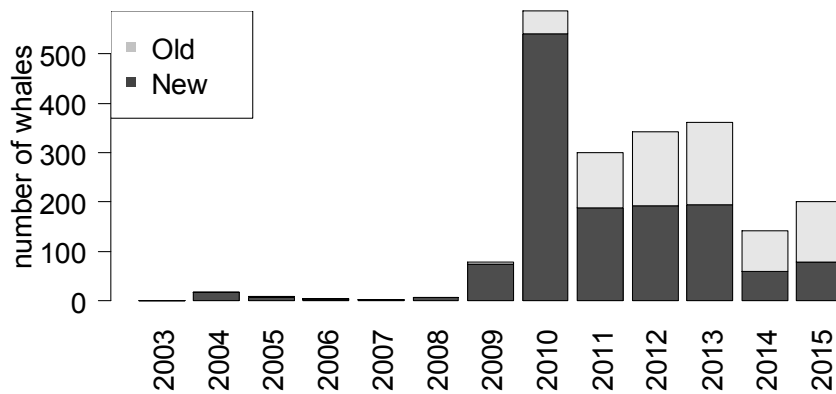


Figure 1. Number of identified and re-sighted whales in the Commander Islands in 2003-2015. New – whales that had not been identified before, Old – re-sighted whales that had been identified in previous years.

Over the years, the ratio of re-sighted whales gradually increased from 4% in 2009 to 61% in 2015. In 2014 and 2015 the number of re-sighted whales exceeded the number of newly identified whales (Fig. 1). However, the identification curve showed no signs of saturation so far (Fig. 2)

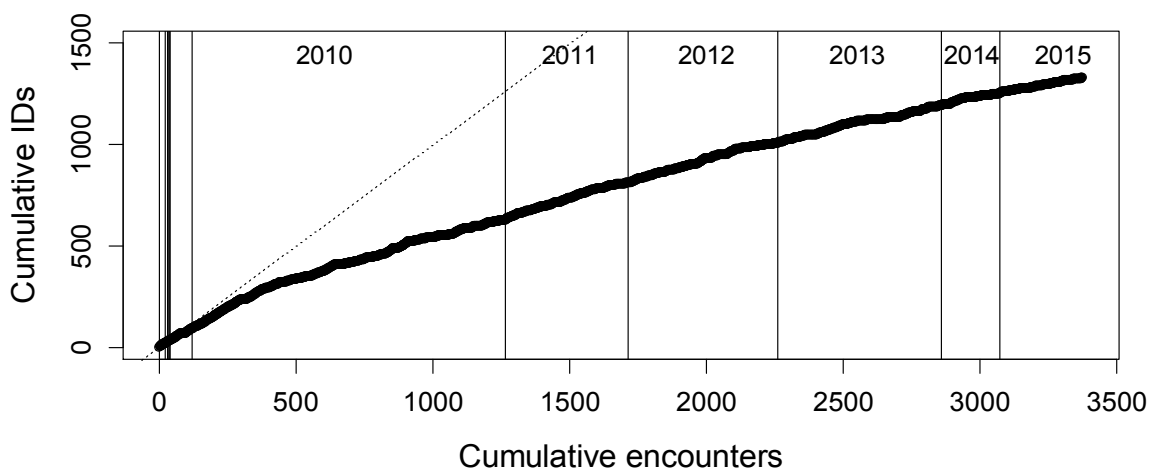


Figure 2. Identification of new whales over the encounters in the Commander Islands in 2003-2015. Dashed line shows the hypothetical curve if all whales were encountered only once. Vertical lines separate different years.

The majority of all whales identified in the Commander Islands were encountered during a single year (Fig. 3).

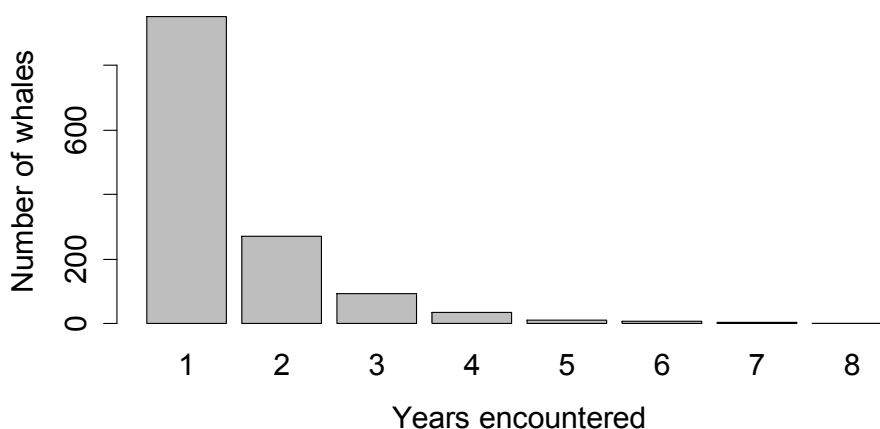


Figure 3. Number of whales encountered during one or more years in the Commander Islands.

The mark-recapture analysis using open population model yielded abundance estimate of whales who inhabited the survey area ($N \pm SE$) 2288 ± 164 . However, Pearson residuals of the model had non-homogenous distribution (residuals for the years 2008-2010 were much higher than for other years), so we tested the model on the whales that were encountered in the Commander Islands during more than one year (424 whales in total). The estimate of the abundance of these whales was 451 ± 7 whales.

The abundance of whales estimated by mark-recapture analysis after SPLASH surveys (in 2008-2015) was 2258 ± 85 individuals. The abundance of whales estimated since the abrupt increase in numbers in 2010 was 1949 ± 64 individuals.

Identifications of humpback whales in Karaginsky Gulf

During SPLASH surveys in 2004-2005, a total of 55 humpback whales were identified in Karaginsky Gulf (NE Kamchatka). Small-boat surveys added to the catalog 6 whales in 2008 and 7 whales in 2009. During vessel-based survey in 2015 we identified 30 new whales in Karaginsky Gulf; eight more whales were encountered for the first time in Karaginsky Gulf but had been registered before in other areas (2 in Avacha Gulf, 6 in the Commander Islands).

Despite the lower numbers of identified whales, the recapture rate was higher in Karaginsky than in the Commander Islands – 29% in 2005, 40% in 2008, 50% in 2009 and 46% in 2015 (Fig. 4). The mark-recapture estimate of the abundance of whales that inhabited the survey area was 164 ± 36 .

Over the years, nine whales were matched between Karaginsky Gulf and the Commander Islands. Two of these whales first identified in Karaginsky Gulf in 2008 were encountered in the Commander Islands in 2010. In 2015, our survey in Karaginsky Gulf revealed seven more whales previously identified in the Commander Islands in 2010-2015. Two of these whales were encountered in both areas during the same 2015 field season (44 and 63 days apart).

Besides, three whales were matched between Karaginsky Gulf and southeastern Kamchatka: one whale encountered in Karaginsky Gulf in 2009 had been identified in southeastern Kamchatka in 2007, and two whales encountered in Karaginsky Gulf in 2015 had been identified in southeastern Kamchatka in 2009 and 2013.

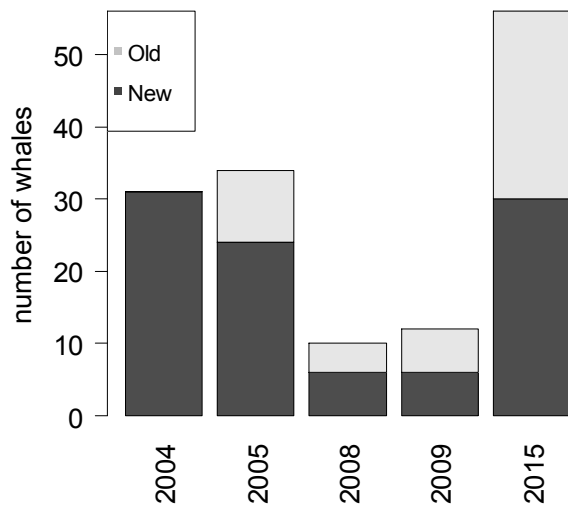


Figure 4. Number of identified and re-sighted whales in Karaginsky Gulf in 2004-2015. New –whales that had not been identified before, Old – re-sighted whales that had been identified in previous years.

Identifications of humpback whales in other areas of the Russian Pacific

Surveys and opportunistic sightings allowed to identify humpback whales in other areas of the Russian Pacific: in different regions of Kamchatka, in the Northern Kuril Islands and Chukotka (Table 2).

Table 2. Number of identified and re-sighted whales in other areas of the Russian Pacific in 2004-2015. New – whales that had not been identified before, Old – re-sighted whales that had been identified in previous years.

| Region | Year | New | Old |
|--------------|------|-----|-----|
| CE Kamchatka | 2009 | 11 | 0 |
| CE Kamchatka | 2012 | 2 | 0 |
| CE Kamchatka | 2015 | 8 | 1 |
| SE Kamchatka | 2007 | 2 | 0 |
| SE Kamchatka | 2008 | 2 | 0 |
| SE Kamchatka | 2009 | 4 | 0 |
| SE Kamchatka | 2010 | 4 | 1 |
| SE Kamchatka | 2012 | 1 | 0 |
| SE Kamchatka | 2013 | 7 | 1 |
| SE Kamchatka | 2014 | 6 | 0 |
| SE Kamchatka | 2015 | 6 | 2 |
| W Kamchatka | 2004 | 2 | 0 |
| W Kamchatka | 2005 | 2 | 0 |
| W Kamchatka | 2014 | 2 | 0 |
| N Kurils | 2014 | 1 | 0 |
| N Kurils | 2015 | 10 | 1 |
| Koryakya | 2005 | 4 | 0 |
| Chukotka | 2005 | 26 | 0 |
| Chukotka | 2013 | 24 | 0 |
| Chukotka | 2015 | 8 | 2 |

In the central eastern Kamchatka (Kronotsky, Kamchatsky and Ozernoy Gulfs) 11 new whales were identified in 2009 and two new whales in 2012. In 2015, eight whales were identified, including seven new whales and one whale previously encountered in the Commander Islands in 2013.

In the southeastern Kamchatka (Avacha Gulf and south to Lopatka Cape) six new whales were identified in 2007-2009. In 2010, five whales were encountered, including one identified in the Commander Islands in the same year. In 2012 and 2014, only new whales were encountered (one in 2012 and six in 2014). In 2013, eight whales were encountered, including one previously identified in the same area (Avacha Gulf) in 2009. This whale was re-sighted in Karaginsky Gulf in 2015. In 2015, eight whales were identified in Avacha Gulf, including one whale identified in Kronotsky Gulf in 2012, and one whale identified in the Commander Islands in 2010.

In the western Kamchatka, two whales were identified in each of 2004, 2005 and 2014. No matches were found either within the region or with other regions of the Russian Pacific.

In the Kuril Islands, one whale was identified in 2014 and 11 whales in 2015, including one whale encountered in the Commander Islands in 2008.

In Koryakya, four whales were encountered in 2005.

In Chukotka, 26 whales were encountered in 2005, 24 in 2013, and ten whales were encountered in 2015 including two whales previously identified in the same region.

Comparing catalogs from different regions of the Russian Pacific revealed matches between different regions of eastern Kamchatka, the Commander Islands and the northern Kuril Islands (Fig. 4).

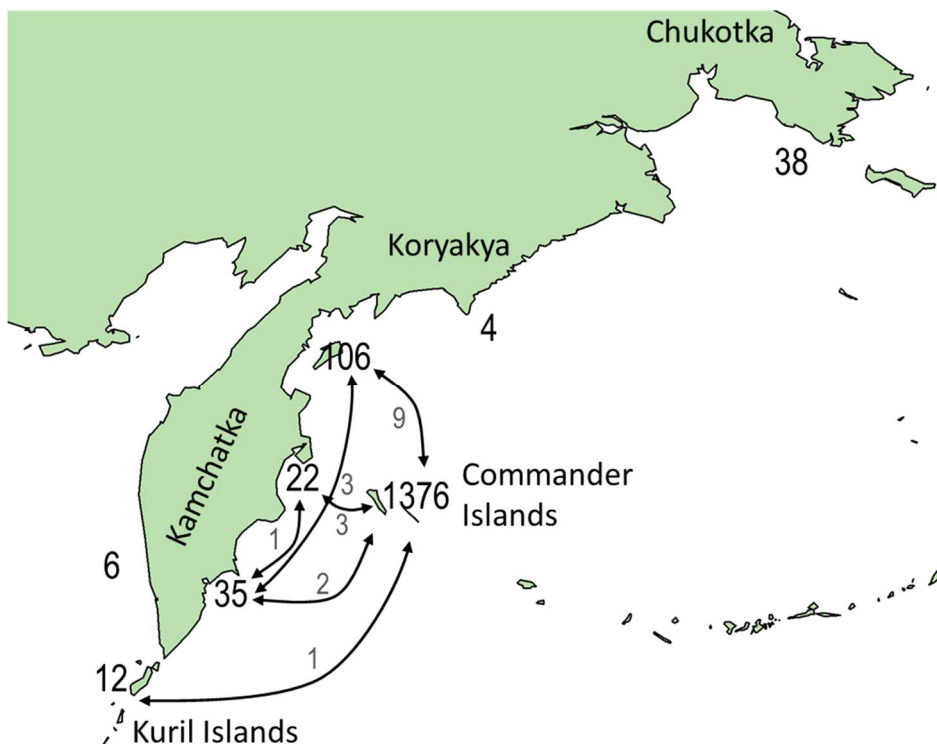


Figure 4. Matches between different areas of the Russian Pacific in 2004-2015. Number of whales identified in each region are shown in large black characters, and number of matches between regions are shown in smaller gray characters next to the arrows.

Matches between the Russian Pacific and breeding grounds in 2008-2014

We compared 1459 whales identified in the Russian Pacific in 2004-2014 with 4525 individuals identified from the breeding grounds (see Titova et al. in rev. for more details). Among these whales 152 matches were found, which comprise 10 percent of all humpbacks identified in the Russian Pacific.

The highest number of matches – 106 individuals – was found with the whales from Asian breeding ground, 35 whales were matched to Hawaiian waters and 11 to Mexican waters (Table 3).

Table 3. Summary of matches between the Russian feeding areas and North Pacific breeding grounds (2004-2014).

| Sampling sites | Identified | Asia | | | | Hawaii | | | | | Mexico | | | | Any breeding ground | Proportion of matches, % | |
|-------------------|-------------|-----------|-----------|-------------|------------|------------|-----------|----------|----------|----------|------------|-----------------|----------|---------------|---------------------|--------------------------|--------------|
| | | Okinawa | Ogasawara | Philippines | All Asia | Big Island | Maui | Molokai | Kauai | Oahu | All Hawaii | Baja California | Mainland | Revillagigedo | | | All Mexico |
| Koryakya | 4 | 2 | | | 2 | | | | | | | | | | 2 | 50 | |
| Karaginsky Gulf | 69 | 21 | 5 | 10 | 30 | | | | | | | | | | 30 | 43.5 | |
| Eastern Kamchatka | 27 | 4 | | | 4 | 1 | 1 | | | 1 | | | | | 5 | 18.5 | |
| Western Kamchatka | 6 | | | 2 | 2 | | | | | | | | | | 2 | 33.3 | |
| Commander Islands | 1300 | 43 | 20 | 15 | 65 | 4 | 23 | 2 | 1 | 1 | 31 | 2 | 3 | 6 | 11 | 107 | 8.2 |
| Anadyr Gulf | 27 | 1 | | | 1 | 3 | | | | | 3 | | | | | 4 | 14.8 |
| Chukchi Sea | 24 | 1 | | | 1 | | | | | | | | | | | 1 | 4.2 |
| Kuril Islands | 2 | | | 1 | 1 | | | | | | | | | | | 1 | 50 |
| Total | 1459 | 69 | 23 | 28 | 106 | 4 | 25 | 3 | 1 | 1 | 35 | 2 | 3 | 6 | 11 | 152 | 10.42 |

The overall match rate was higher in the mainland Kamchatkan sites. In Karaginsky Gulf 43.5% of the whales were matched to any of the breeding grounds, off Eastern Kamchatka 18.5% were matched. The same proportions for more offshore and northern sites were substantially lower. Off the Commander Islands it comprised 8.2%, in the Gulf of Anadyr - 14.8% and in the Chukchi Sea – 4.2%.

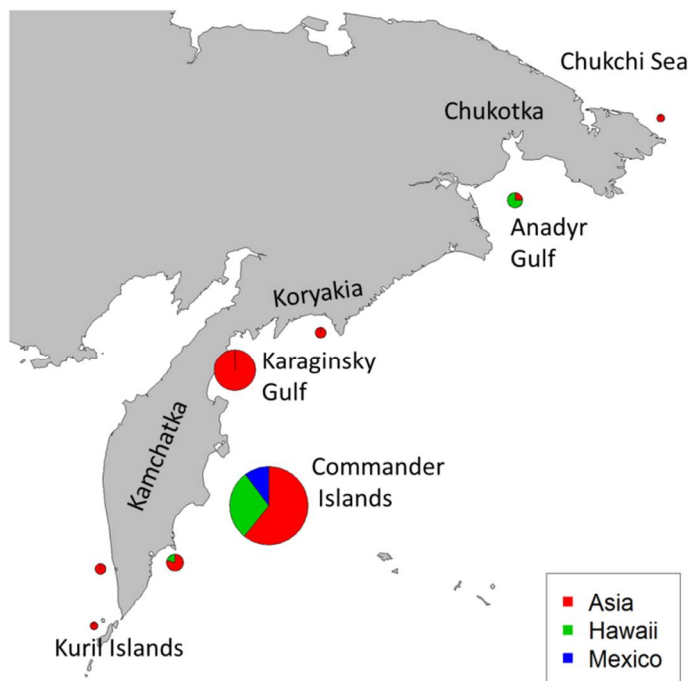


Figure 5. Proportions of whales from different feeding areas in the Russian Pacific matched to three breeding grounds. The area of pie plots is proportional to the number of matched whales.

The whales from the breeding grounds were distributed differently across the sampled regions (Fig. 5). The proportion of whales matched with Asian breeding ground was higher in Kamchatkan coastal sites. In Karaginsky Gulf, whales were matched exclusively with Asia, and off Eastern Kamchatka the proportion of Asian whales was 80% of all matched individuals. The proportion of Asian whales was lower for the Commander Islands and the Anadyr Gulf: 60.7% and 25% of all matched individuals, respectively. In the Commander Islands, in Anadyr Gulf and off Eastern Kamchatka we also found whales migrating from Hawaiian and Mexican breeding grounds (Fig. 5). In Chukchi Sea, only one individual was matched to the Asian breeding ground.

DISCUSSION

The number of identified whales was much higher in the Commander Islands than in other areas – about ten times higher than in Karaginsky Gulf, which has the largest amount of identified whales among other areas. Apparently, to some extent this huge difference was due to variation in efforts – after SPLASH project was finished, we worked in the Commander Islands every summer since 2008, and in Karaginsky Gulf only in 2008-2009 and 2015. However, despite the lower numbers of identified whales, the recapture rate was higher in Karaginsky than in the Commander Islands. This suggests higher abundance and/or presence of the large number of transient whales in the Commander Islands. Mark-recapture estimate of humpback whale abundance was more than 10 times higher for the Commander Islands than for Karaginsky Gulf.

We have less data from other areas, but boat-based surveys confirm that the Commander Islands and Karaginsky Gulf are the main places of humpback whale summer aggregation in Kamchatka and adjacent waters. In other areas of Kamchatka and in the northern Kuril Islands, much smaller and less persistent aggregations or occasional encounters were registered. We have much fewer data from the areas further north around Chukotka (after SPLASH, only occasional photographs were available). Reports from the staff of cruise ships and local researchers suggest that the abundance of summering humpback whales is relatively high in this area.

In spite of the increased number of identified humpback whales in 2008-2014, their match rate with breeding grounds was low: about 10% in our study, even lower than the 30% reported earlier by SPLASH (Burdin 2010). The time lag of five or more years between catalogs from the breeding grounds (1989-2006) and the Russian Far East sampling sites (2004-2014) could reduce the number of potential matches due to natural mortality and recruitment or the attrition of natural markings over time.

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REFERENCES

- Baillargeon, S. and Rivest, L.P. 2007. Rcapture: Loglinear models for capture-recapture in R. *Journal of Statistical Software*, 19(5).
- Bettridge, S., Baker, C. S., Barlow, J., Clapham, P. J., Ford, M., Gouveia, D., ... & Wade, P. R. 2015. Status review of the humpback whale (*Megaptera novaeangliae*) under the Endangered Species Act. NOAA Technical Memorandum NMFS. NOAA-TM-NMFSSWFSC-540. California: US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.
- Burdin A. M., 2010. Humpback whales in summering areas in the Russian Far East. In “Symposium on the results of the SPLASH humpback whale study. Final Report and Recommendations”, 11 October 2009, Quebec City, Canada. Compiled by J. Calambokidis. Available on www.cascadiaresearch.org
- Calambokidis, J., Falcone, E. A., Quinn, T. J., Burdin, A. M., Clapham, J. K., Gabriele, C. M., LeDuc, R., Mattila, D., Rojas-Bracho, L., Janice M., Straley, J., M., Taylor, B., L., Urbán R., J., Weller, D., Witteveen, B., H., Yamaguchi, M., Bendlin, A., Camacho, D., Flynn, K., Havron, A., Jessica Huggins, J., Maloney, N. 2008. SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final report for Contract AB133F-03-RP-00078. For U.S. Dept of Commerce Western Administrative Center Seattle, Washington.
- Katona, S., Baxter, B., Brazier, O., Kraus, S., Perkins, J., & Whitehead, H. 1979. Identification of humpback whales by fluke photographs. In *Behavior of marine animals* (pp. 33-44). Springer US.
- Salden, D. R., Herman, L. M., Yamaguchi, M., & Sato, F. 1999. Multiple visits of individual humpback whales (*Megaptera novaeangliae*) between the Hawaiian and Japanese winter grounds. *Canadian Journal of Zoology*, 77(3), 504-508.

Silberg, J., N., Acebes, J., M., V., Burdin, A., M., Mamaev, E., G., Dolan, K., C., Layusa, C., A., Aca, E., Q. 2013. New insight into migration patterns of western North Pacific humpback whales between the Babuyan Islands, Philippines and the Commander Islands, Russia. *J Cetacean Res Manage* 13(1): 53–57.

Titova O.V., Filatova O.A., Fedutin I.D., Ovsyanikova E.N., Okabe H., Kobayashi N., Acebes J. M., Burdin A.M., Hoyt E. (in rev.) Photo-identification matches of humpback whales (*Megaptera novaeangliae*) from feeding areas in Russian Far East Seas and breeding grounds in the North Pacific. *Marine Mammal Science*.