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O.V. Titova, O.A. Filatova, I.D. Fedutin, E.N. Ovsyanikova, Haruna Okabe, Nozomi Kobayashi, Jo Marie Acebes, A.M. Burdin, E. Hoyt

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Marine Mammal Science (in review)

Photo-identification matches of humpback whales (*Megaptera novaeangliae*) from feeding areas in Russian Far East Seas and breeding grounds in the North Pacific

O.V. Titova [1], O.A. Filatova [2], I.D. Fedutin [1, 2], E.N. Ovsyanikova[3], Haruna Okabe [4],Nozomi Kobayashi [4], Jo Marie Acebes [5], A.M. Burdin [1], E. Hoyt [6]

[1] Kamchatka Branch of Pacific Institute of Geography FED RAS, Petropavlovsk-Kamchatsky, Russia

[2] Departmeni of Vertebrate Zoology, Faculty of Biology, Moscow State University, Moscow, Russia

[3] Cetacean Ecology and Acoustics Laboratory, School of Veterinary Science, University of Queensland Gatton Campus, QLD 4343, Australia

[4] Okinawa Churashima Foundation, Japan

[5] BALYENA.ORG, Paseo del Mar, Barangay Pangdan, Jagna, Bohol 6308, Philippines

[6] Whale and Dolphin Conservation, UK

ABSTRACT

The Russian Far East is one of the summer feeding regions for humpback whales in the North Pacific. Since the collaborative project SPLASH (Structure of Populations, Levels of Abundance, and Status of Humpback whales), the number of identified whales in this region has increased from 222 in 2009 to 1459 individuals in 2014. We have compared the latest Russian Far East catalog with catalogs from wintering areas collected by SPLASH in 2004-2005 and with two regional catalogs from Okinawa from 1989-2006 and the Philippines from 2000-2006, which has provided new insights into the migratory pathways of the humpback whales found in the Russian Far East. We found a total of 152 matches: 106 with Asian breeding grounds, 35 with Hawaiian and 11 with Mexican waters. No matches were found with Central American breeding ground. In concordance with SPLASH results, we found that the overall match rate was higher in the mainland Kamchatkan sites (Karaginsky Gulf, Eastern Kamchatka and Koryak coast) (32%) and consisted mostly of whales from the Asian breeding ground. In the Commander Islands, the amount of overall matches was lower (8,2%). Besides, in contrast to SPLASH results that found the equal proportion of migrants from the Asian, Hawaiian and Mexican breeding grounds, in our study the proportion of whales from Asia was twice higher than from Hawaii and six times higher than from Mexico. About 30 percent of whales matched with breeding grounds were registered near the Commander Islands in more than one year. The average number of years sighted varied from 2.5 (max 6) for the whales from Asia to 1.5 (max 4) from Mexico. These results indicate substantial regularity of feeding trips between the Commander Islands and these three breeding grounds.

In general, our results support the conclusions made previously by the SPLASH study: the wintering place of the majority of whales that feed in the Russian Far East is still unknown. This supports the hypothesis of the existence of some undescribed breeding location for humpback whales in the North Pacific.

INTRODUCTION

Many baleen whales are known to make long distance seasonal migrations. Investigating their migration contributes to understanding the population structure of the species and enables the definition of population units for management and conservation purposes.

Migratory paths of humpback whales (*Megaptera novaeangliae*) have been found to be complex (Kennedy *et al*. 2014, Wenzel et al. 2009, Zerbini *et al*. 2006, 2011). Most humpback whale populations migrate between high-latitude productive areas where they feed in summer and low-latitude waters where they breed in winter.

Initially, all humpback whales in the North Pacific were considered as one stock or population (Donovan 1991). 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. Based on photographic matches between breeding and feeding areas, North Pacific humpback whales were divided into two groupings: the central stock, which breeds off Hawaii and migrates to feed in Alaskan waters; and the American stock, which winters off Mexico and feeds along the California coast (Baker *et al*. 1986, Darling and McSweeney 1985). The Asian stock, which is smaller in abundance, was thought to breed off southern Japan and travel north to feeding areas in the Sea of Okhotsk and around Kamchatka peninsula, based on observations from early whalers (Kellogg 1929).

Later as a result of a series of collaborative projects, the structure of migration routes in the North Pacific was found to be much more complicated with cases of interchange both between breeding and feeding grounds (Calambokidis et al. 1997, 2001, Urban *et al*. 2000). Also, a small low-density isolated grouping was identified off Central America. These whales migrate exclusively to areas off California (Steiger et al. 1991, Calambokidis et al. 2000).

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 Mexican breeding ground, which includes coastal waters of mainland Mexico, Baja California and Revillagigedo archipelago and Central American breeding ground in waters from south Mexico to Costa Rica. 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 north-east 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 (Calambokidis *et al.* 2008, Symposium, 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 2004-2005, 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, 2009) was the first substantial review in which information about humpback whales in the Russian Far East was presented. In this study three main regions of humpback whale concentration in the Russian waters were reported: Karaginsky Gulf (northeastern Kamchatka), Gulf of Anadyr (southern Chukotka Peninsula) and the Commander Islands. 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, on 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 (Calambokidis et al. 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. In 2010-2014

we catalogued 1229 individual humpback whales: 1193 off the Commander Islands and 12 off different regions of Kamchatka coast. Also 24 individual photographs humpback whales were obtained during Heritage Expedition cruises in the Chukchi Sea in 2013.

The purpose of the present study was to analyze in greater detail the connections between the explored feeding grounds with wintering places using approximately six times more data than previously available. The study utilized an additional seven years of annual observations in the Commander Islands to evaluate the consistency of these migratory connections.

METHODS

Study areas

In this study we used all photographs of humpback whales included in the latest version of the Russian Far East catalog (Burdin et al. 2014). The catalog includes photographs collected in multiple areas both during SPLASH project and other projects (Table 1).

During the SPLASH surveys in 2004 and 2005 photographs of humpback whales were collected in Anadyr Gulf of Chukotka Peninsula, along the Koryak Coast of Kamchatka, in Karaginsky Gulf of Kamchatka, along the eastern Kamchatka Coast and off the Commander Islands (Figure 1). 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 the Commander Islands. Data collected during this period were summarized at the final SPLASH symposium in Quebec in 2009 (Symposium, 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 2013 additional set of photographs from the Chukchi sea was kindly provided by Heritage Expeditions, expedition cruise company that does regular trips in the Russian Far East. In August 2014 we obtained some photographs during a yacht survey to the western Kamchatka Coast and northern Kuril Islands.

Photo identification

The main array of photographs obtained off the Commander Islands and in Karaginsky Gulf was taken from small boats (4.5 m inflatable in 2008-2010 and 7.6 fiberglass boat in 2010-2014). Survey in 2014 was conducted using 10m fiberglass sailing yacht; to approach whales we used 4.5 m inflatable boat.

To take photographs we used digital cameras with 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. 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. 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 whale, the best quality photo from all seasons was chosen for further matching with catalogs from the various breeding grounds. 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.

Comparison of catalogs

Three sources were used to compare the whales from the Russian Far East catalog (Burdin et al. 2014) with sightings on the breeding grounds. The first and the largest was the SPLASH catalog of 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 (Symposium, 2010).

Whales from two other catalogs belong 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 where 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.

Match index

To compare the probability of interchange between Russian Far East feeding ground and Asian, Hawaiian and Mexican breeding grounds we calculated the Match Index for each pair of regions. Match Index or Interchange Index is a modification of Lincoln-Peterson estimation for population size, which has been used by many authors to examine interchange of humpback whales both among areas and years (Baker et al. 1985, Calambokidis 1997, Urban et al. 2000).

$$I_{i->j} = [m_{i->j} /(a_i n_j)]x\ 1000$$

Where:

a_i - Whales, identified on the breeding ground

n_j –whales, identified on the feeding ground

$m_{i->j}$ – number of matches between feeding and breeding ground

The value of the Match Index is directly proportional to the movement probability. Higher value of the index corresponds to a higher probability of moving whales from the given breeding ground (Calambokidis et al. 2001).

Site fidelity analysis

Of all the sampled sites, photo-identification efforts were conducted regularly only off the Commander Islands. There we were able to re-sight individuals from year to year over the period of seven years. For the whales identified around the Commander Islands and matched with different

breeding grounds we calculated the number of years sighted and number of encounters per year. This enabled us to evaluate the site fidelity to the Commander Islands of the whales from each breeding ground. Site fidelity is the tendency to return to a previously occupied location. Here we define site fidelity as a tendency of the whales to return to the same feeding ground from year to year. We estimated site fidelity in order to evaluate whether the whales from Asian, Hawaiian and Mexican breeding grounds are regular seasonal residents or accidental visitors in the waters of the Commander Islands. To compare site fidelity across the whales from different breeding grounds, we calculated the average and maximum number of years sighted, percent of whales sighted more than one year and average number of sighting per year. We compared the number of years sighted and the number of encounters per year across the whales from different breeding grounds using the nonparametric Mann-Whitney test.

RESULTS

Sample size and overall matches

A total of 4414 sightings were documented in the Russian Far East feeding sites during 233 days of effort in 2004-2014 years, representing 1459 individual humpback whales. Number of whales identified in each of the study regions is presented in Table 1. The number of identifications of new whales in the Russian Far East steadily increased over the course of the study, except for an abrupt rapid increase in July 2010 (Figure 2).

We compared all the identified whales with 4525 individuals identified from the breeding grounds. Among these whales 152 matches were found, which comprise 10 percent of all humpbacks in the current Russian Far East catalog.

Interchange with breeding grounds

The highest number of matches – 106 individuals – was found with the whales from Asian breeding ground (match index 0.066), 35 whales were matched to Hawaiian waters (match index 0.011) and 11 to Mexican waters (match index 0.004) (Table 2).

The overall match rate was higher in the mainland Kamchatkan sites. In Karaginsky Gulf we found 43.48 percent of whales, matched with any of the breeding grounds, off Eastern Kamchatka Coast it was 18.52 percent. The same proportions for more offshore and northern sites were substantially lower. Off the Commander Islands it consist 8.23 percent, in the Gulf of Anadyr - 14.81 percent and in the Chukchi Sea – 4.17 percent, which is 9.07 percent on average. We do not consider the Western Kamchatka, the Kuril Islands and the Koryak Coast here due to the small sample sizes (Table 3).

The whales from the various breeding grounds were distributed differently across the sampled regions. The proportion of whales matched with Asian breeding ground was higher in Kamchatkan coastal sites. In Karaginsky Gulf whales were matched exclusively with Asia, off Eastern Kamchatka Coast the proportion of Asian whales was 80 percent of all matched individuals. The proportion of Asian whales for the Commander Islands and Gulf of Anadyr was lower: 60.7 and 25 percent of all matched individuals respectively. Off the Commander Islands, in Anadyr Gulf and off the western Kamchatka Coast we also found whales migrating from Hawaiian and Mexican breeding grounds (Figure 1). In Chukchi Sea we matched only one individual and this match was found in Asian breeding ground catalog.

For one whale (10RUCO234) newly matched between the Commander Islands and Okinawa, Japan, there was an additional re-sighting off the Western Aleutians found in the SPLASH database.

Site fidelity

During seven years of annual efforts on the Commander Islands we encountered 28.9 percent of individuals in more than one year. For the whales matched with different breeding grounds, this percentage was 24.6 percent for the Asian breeding ground, 43.8 percent for Hawaiian, and 30 percent for Mexican (Table 4).

There was no significant difference in the number of years present as well as in the number of encounters per year for the whales matched with different breeding grounds (Mann-Whitney test $p > 0.6$ for all comparisons).

DISCUSSION

We present results for the updated dataset which includes data previously obtained by SPLASH study and findings for six additional years of work on photo-identification of humpback whales in the Russian Far East. In general, our results confirm the previously obtained by SPLASH.

Of 1459 individual humpback whales identified in Russian Far East waters over the 11-year period (2004-2014), only 10 percent were matched with breeding grounds. Most of these matches were found with the Asian breeding ground, fewer with the Hawaiian and the fewest with the Mexican breeding grounds. The proportion of the whales from different breeding grounds varied across the sampled regions. For example, for the whales identified off Karaginsky Gulf in northeastern Kamchatka, all the matches were with the Asian breeding ground, supporting the results previously

obtained by SPLASH. Among individuals matched off the Commander Islands, Asian whales comprised about 60 percent. In contrast to SPLASH results that found the equal proportion of migrants from the Asian, Hawaiian and Mexican breeding grounds in the Commander Islands, in our study the proportion of whales from Asia in the Commander Islands was twice higher than from Hawaii and six times higher than from Mexico.

In spite of the increased number of identified humpback whales, their match rate with breeding grounds was low: about 10 percent in our study, even lower than the 30 percent reported earlier by SPLASH (Calambokidis et al. 2010). The time lag of five or more years between catalogs from 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. This could also explain the low match rate and destination diversity in the Chukchi Sea, sampled only in 2013.

The general distribution pattern of humpback whales migrating from the various breeding grounds to feeding areas is also similar to the SPLASH findings. Including all the North Pacific feeding grounds sampled by SPLASH, the proportion of humpback whales migrating from the Asian breeding ground increased from east to west: 14 percent of all whales matched with any breeding ground at the Aleutians and 6 percent in the offshore regions of the Bering Sea, whereas in Alaska and British Columbia it was less than 1 percent. In our study, the matched sample from the Commander Islands shows 63 percent from Asian breeding ground; for Karaginsky Gulf, Asia is the only destination ascertained. In contrast, the proportion of whales from the Hawaiian breeding ground matched to feeding grounds decreased from east to west and comprised more than 70 percent on the northwest coast of North America, 50-55 percent in Aleutians and Bering Sea, 30 percent in the Commander Islands and only sporadic whales along the Russian mainland coast. Mexican whales were found in small numbers in all feeding grounds. Thus, most whales adhere to the same migration destinations for their stock (central, American or Asian), but some whales travel to other destinations thereby forming areas of overlap from the various breeding grounds. The presence of Hawaiian and Mexican whales off the Commander Islands and in Chukotka waters illustrates this overlap. The sighting of the Hawaiian whale off the Eastern Kamchatka coast provides a new link with feeding grounds for the central humpback whales stock.

In the SPLASH sample, no matches were found between Russian sites and the Aleutians or other places in the eastern Bering Sea. The absence of interchange between Russian sites and the Aleutians could be explained by the relatively small sample size collected on the Russian sites. Despite the fact that we did not specifically compare the Russian catalog with other feeding grounds, in our results the connection between the western Aleutians in U.S. waters and the Russian Far East was revealed. One individual (10RUCO234), first photo-Identified in 2004 off Okinawa, was re-sighted first in 2004

in the western Aleutians (SPLASH database). In 2010, this individual was photographed off the Commander Islands. Further study will be needed to determine if connections can be made between the humpback whales from the Russian sites and the feeding grounds in the Eastern North Pacific off the North American continent.

The annual long-term research conducted off the Commander Islands shows high site fidelity for returning humpback whales, similar to the fidelity of whales returning to known breeding grounds. On average, about 30 percent of 107 matched whales were encountered in more than one year. This result is close to that calculated for Southeast Alaska, where it was 48 percent of 464 individuals identified (Perry et al. 1990). Maximum number of interannual re-sightings for whales matched with all three breeding grounds is more than half of the span of whole study conducted off the Commander Islands. This indicates substantial regularity in feeding trips between the Commander Islands and Asian, Hawaiian and Mexican regions and confirms the importance of Commander Islands waters for the whales from most of the North Pacific breeding grounds.

The waters of the Russian Far East have been assumed to be one of the migration destinations for humpback whales breeding on the Revillagigedo archipelago, situated 500 km from the Mexican coast and considered separate from the American stock based on genetic data and migration observations (Urbán et al. 2000). In the SPLASH report (Calambokidis *et al.* 2008), this assumption was supported by only one match between the Revillagigedo archipelago and Commander Islands. Now we can confirm that six of the ten whales found migrating from the Mexican breeding ground came from Revillagigedo and some were encountered off the Commander Islands over two or more years. This fact reveals that the whales even from such a remote destination as Revillagigedo are not casual visitors to the Commander Islands, but regularly come here to feed in summer time.

Our results confirm the complexity of migratory connections between the breeding and feeding grounds of humpback whales in the North Pacific. It also supports the conclusions made previously by the SPLASH study: the wintering place of the majority of whales that feed in the Russian Far East is still unknown. This supports the hypothesis of the existence of some undescribed breeding place for humpback whales in the North Pacific.

Although the whales from different breeding grounds can mix on the feeding grounds, they form distinct local groupings (Baker *et al.* 2013), which depend year after year on the resources of the same region and the health of its ecosystem. Healthy ecosystems need not only to deliver sufficient prey but should also be protected from known threats to feeding humpbacks such as entanglement in fishing gear and ship strikes. Thus, these various feeding regions for humpbacks should be considered as different units for management, monitoring and conservation purposes based on ecosystem management principles (Hoyt 2011).

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LITERATURE CITED

Baker, C. S., Herman l. M., Perry A., Lawton, W.S., Straley, J.M., Straley J. H. 1985. Population characteristics and migration of summer and late- season humpback whales (*Megaptera novaeangliae*) in southeastern Alaska. Marine Mammal Science 1 :304-323

Baker, C.S., Herman L. M., L.M., Perry A., Lawton, W.S., Straley, J.M., Wolman, A.A., Kaufman, G.D., Winn, H.E., Hall, J.D., Reinke, J.M., Ostman, J. 1986. Migratory movement and population structure of humpback whales *(Megaptera novaeangliae)* in the central and eastern North Pacific. Mar Ecol Prog Ser 31:105-119.

Baker, C., Steel, D., Calambokidis, J., Falcone, E., González-Peral, U., Barlow, J., Burdin, A., Clapham, P., Ford, J., Gabriele, C., Mattila, D., Rojas-Bracho, L., Straley, J., Taylor, B., Urbán, J., Wade, P., Weller, D., Witteveen, B., Yamaguchi, M. 2013. Strong maternal fidelity and natal philopatry shape genetic structure in North Pacific humpback whales. Mar Ecol Prog Ser 494:291–306.

Barendse, J., Best, P.B., Thornton, M., Elwen, S.H., Rosenbaum, H.C., Carvalho, I., Pomilla, C.,Collins, T.J.Q., Meyer, M., Leeney, R.H. 2011. Transit station or destination? Attendance patterns, movements, and abundance estimate of humpback whales off west South Africa from photographic and genotypic matching. S Afr J Mar Sci 33: 353–373

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 John Calambokidis.

Burdin, A.,M., Titova O.,V., Hoyt E. 2014. Humpback Whales of Russian Far East Seas. Photo-ID Catalog 2004-2014. Russian Geographical Society, Moscow, 149pp. Available on https://www.researchgate.net/publication/272493253_Humpback_Whales_of_Russian_Far_East_Seas_Photo-ID_Catalog_2004-2014

Calambokidis, J. Steiger, G.H., Straley, J.M., Quinn, T., Herman, L.M., Cerchio, S., Salden, D.R., Yamaguchi, M., Sato, F., Urbán, J.R., Jacobsen, J., Von Zeigesar, O., Balcomb, K.C., Gabriele, C.M., Dahlheim, M.E., Higashi, N., Uchida, S., Ford, J.K.B., Miyamura, Y., Ladron, P. de Guevara, Mizroch, S.A., Schlender, L., Rasmussen, K. 1997. Abundance and population structure of humpback whales in the North Pacific basin. Final Contract Report 50ABNF500113 to Southwest Fisheries Science Center, P.O. Box 271, La Jolla, CA 92038 72pp.

Calambokidis, J., Steiger, G.H., Rasmussen, K., Urbán, J.R., Balcomb, K.C., Ladrón, P. de Guevara, Salinas, M.Z., Jacobsen, J. K., Baker, C. S., Herman, L. M., Cerchio, S., Darling J. D. 2000. Migratory destinations of humpback whales from the California, Oregon and Washington feeding ground. Mar Ecol Prog Ser 192:295-304.

Calambokidis, J., Steiger, G.H., Straley, J.M., Herman, L.M., Cerchio, S., Salden, D.R., Urbán, J.R., Jacobsen, J.K., Von Ziegesar, O., Balcomb, K.C., Gabriele, C.M., Dahlheim, M.E., Uchida, S., Ellis, G., Miyamura, Y., Ladrón, P. de Guevara, Yamaguchi, M., Sato, F., Mizroch, S.A., Schlender, L., Rasmussen, K., Barlow, J., Quinn II, T. J. 2001. Movements and population structure of humpback whales in the North Pacific. Mar Mamm Sci 17:769-794.

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.

Darling, J. D., Calambokidis, J., Balcomb, K. C., Bloedel, P., Flynn, K., Mochizuki, K., Mori, K., Sato, F., Suganuma, H., Yamaguchi, M. 2006. Movement of a humpback whale (*Megaptera novaeangliae*) from Japan and British Columbia and return. Mar Mamm Sci 12:281-287.

Dawbin, W. H. 1966. The seasonal migratory cycle of humpback whales. In : S. Norris (ed) Whales, dolphins and porpoises. University of California Press, Inc., Berkeley, California, USA, 145–70.

Doroshenko N. V. 2000. Soviet humpback (Megaptera novaengliae) whailing in North Pacific 1961 - 1979. Materialy Sovetskogo kitoboinogo promisla (1949-1979), pp. 96-103. M.: Centr ecologicheskoi politiki Rossii.

Franklin, W., Franklin, T., Brooks, L., Gibbs, N., Childerhouse, S., Smith, F., Burns, D., Paton, D., Garrigue, C., Constantine, R., Poole, M. M., Hauser, N., Donoghue, M., Russell, K., Mattila, D. K., Robbins, J., Oosterman, A., Leaper, R., Harrison, P., Baker, S., Clapham, P. 2012. Antarctic waters (Area V) near the Balleny Islands are a summer feeding area for some eastern Australian Breeding Stock E(i) Humpback Whales (*Megaptera novaeangliae*). J Cetacean Res Manage 12(3): 321–327.

Gill, P. C., Burton, C. L. K., Bannister, J. 2006. Photographic resight of a humpback whale between Western Australia and Antarctic Area IV. Mar Mamm Sci 11(1):96-100.

Hoyt, E. 2011. Marine Protected Areas for Whales, Dolphins and Porpoises: A World Handbook for Cetacean Habitat Conservation and Planning. Earthscan/Routledge and Taylor & Francis, London and New York, pp9-10, 73-79.

Jann, B., Allen, J., Carrillo, M., Hanquet, S., Katona, S. K., Martin, A. R., Reeves, R. R., Seton, R., Stevick, P. T., Wenzel, F.W. 2003. Migration of a humpback whale between the Cape Verde Islands and Iceland. J Cetacean Res Manage 5(2), 125-129.

Katona, S.K., Beard, J.A. 1990. Population size, migrations and feeding aggregations of the humpback whale (*Megaptera novaeangliae*) in the western North Atlantic Ocean, In Individual recognition of cetaceans: use of photoidentification and other techniques to estimate population parameters. Edited by P.S. Hammond, S.A. Mizroch, and G.P. Donovan. Cambridge University Press, Cambridge, England, pp295–305.

Kellogg, R. 1929. What is known of the migration of some of the whalebone whales. Smithsonian Institution Annual Report 1928:467-494, +2 plates.

Kennedy, A.S., Zerbini, A.N., Vásquez, O.V., Gandilhon, N., Clapham, P.J., Adam, O. 2014. Local and migratory movements of humpback whales (*Megaptera novaeangliae*) satellite-tracked in the North Atlantic Ocean. Can J Zool 92(1):9-18.

Mackintosh, N.A. 1942. The southern stocks of whalebone whales. Discov Rep 22:197–300.

Mackintosh, N.A. 1965. The stocks of whales. Fishing News Books, London.

Norris, K.S. 1967. Some observations on the migration and orientation of marine mammals. *In* R. M. Storm, ed. Animal orientation and migration. Oregon State University Press, Corvallis, OR, pp101-125.

Olavarría, C., Baker, C.S., Garrigue, C., Poole, M., Hauser, N., Caballero, S., Flórez-González, L., Brasseur, M., Bannister, J., Capella, J., Clapham, P., Dodemont, R., Donoghue, M., Jenner, C., Jenner, M.N., Moro, D., Oremus, M., Paton, D., Rosenbaum, H., Russell, K. 2007. Population structure of South Pacific humpback whales and the origin of the eastern Polynesian breeding grounds. Mar Ecol Prog Ser 330: 257–268, 2007

Perry, A., Baker, C.S., Herman, L.M. 1990. Population characteristic s of individually identified humpback whales in the central and eastern North Pacific: A summary and critique. Report of the international Whaling commission (Special Issue 12): 307 – 317.

Rock, J., Pastene, L.A., Kaufman, G., Forestell, P., Matsuoka, K., Allen, J. 2006. A note on East Australia Group V Stock humpback whale movement between feeding and breeding areas based on photo-identification. J Cetacean Res Manage 8(3):301–305.

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.

Smith, T.D., Allen, J., Clapham, P.J., Hammond, P.S., Katona, S., Larsen, F., Lien, J., Mattila, D.K., Palsbøll, P.J., Sigurjonsson, J., Stevick, P.T., Øien, N. 1999. An ocean-basin-wide mark–recapture study of the North Atlantic humpback whale (Megaptera novaeangliae). Mar Mamm Sci 15(1): 1–32.

Stevick, P.T., Aguayo, A., Allen, J., Avila, I.C., Capella, J., Castro, C., Chater, K., Dalla, R. L., Engel, M.H., Felix, F., Florez-Gonzalez, L., Freitas, A., Haase, B., Llano, M., Lodi, L., Munoz, E., Olavarrıa, C.,

Secchi, E.R., Scheidat, M., Siciliano, S. 2004. Migrations of individually identified humpback whales between the Antarctic Peninsula and South America. J Cetacean Res Manage 6, 109 113.

Symposium on the results of the SPLASH humpback whale study. Final Report and Recommendations. 11 October 2009, Quebec City, Canada. Compiled by John Calambokidis. Available on www.cascadiaresearch.org

Urbán, R. J., Jaramillo, L. A., Aguayo, L. A., Ladrón de Guevara, P. P., Salinas, Z. M., Alvarez, F. C., Medrano, G. L., Jacobsen, J.K., Balcomb, K.C., Claridge, D.E., Calambokidis, J., Steiger, G.H., Straley, J.M., Von Ziegesar, O., Waite, J.M., Mizroch, S., Dahlheim, M.E., Darling, J.D., Baker, C.S. 2000. Migratory destinations of humpback whales wintering in the Mexican Pacific. J Cetacean Res Manage 2(2):101-110.

Wenzel, F. W., Allen, J., Berrow, S., Hazevoet, C., Jann, B., Seton, R., Steiner, L., Stevick, P., López-Suárez, P., Whooley, P. 2009. Current Knowledge on the Distribution and Relative Abundance of Humpback Whales (Megaptera novaeangliae) off the Cape Verde Islands, Eastern North Atlantic. Aquatic Mammals 35(4), 502-510.

Zerbini, A.N., Andriolo, A., Heide-Jorgensen, M.P., Pizzorno, J.L., Maia, Y.G., VanBlaricom, G.R., DeMaster, D.P., Simoes-Lopes, P.C., Moreira, S., Bethlem, C. 2006. Satellite-monitored movements of humpback whales, Megaptera novaeangliae, in the south-west Atlantic Ocean. Mar Ecol Prog Ser 313, 295–304.

Zerbini, A. N., Andriolo, A., Heide-Jørgensen, M. P., Moreira, S.C., Pizzorno, J.L., Maia, Ygor G., Vanblaricom, G.R., Demaster, D.P. 2011. Migration and summer destinations of humpback whales (Megaptera novaeangliae) in the western South Atlantic Ocean. J Cetacean Res Manage (Special Issue) 3, 113–118.

Figure 1. Locations of photographic efforts conducted during the study period and the number of whales from different feeding areas in the Russian Far East matched to three breeding grounds. Numbers on the map: 1 – Gulf of Anadyr, 2 – Koryak Coast, 3 – Karaginsky Gulf, 4 – eastern Kamchatka Coast, 5 – Commander Islands, 6 – northern Kuril Islands, 7 – western Kamchatka Coast, 8 – Chukchi Sea.

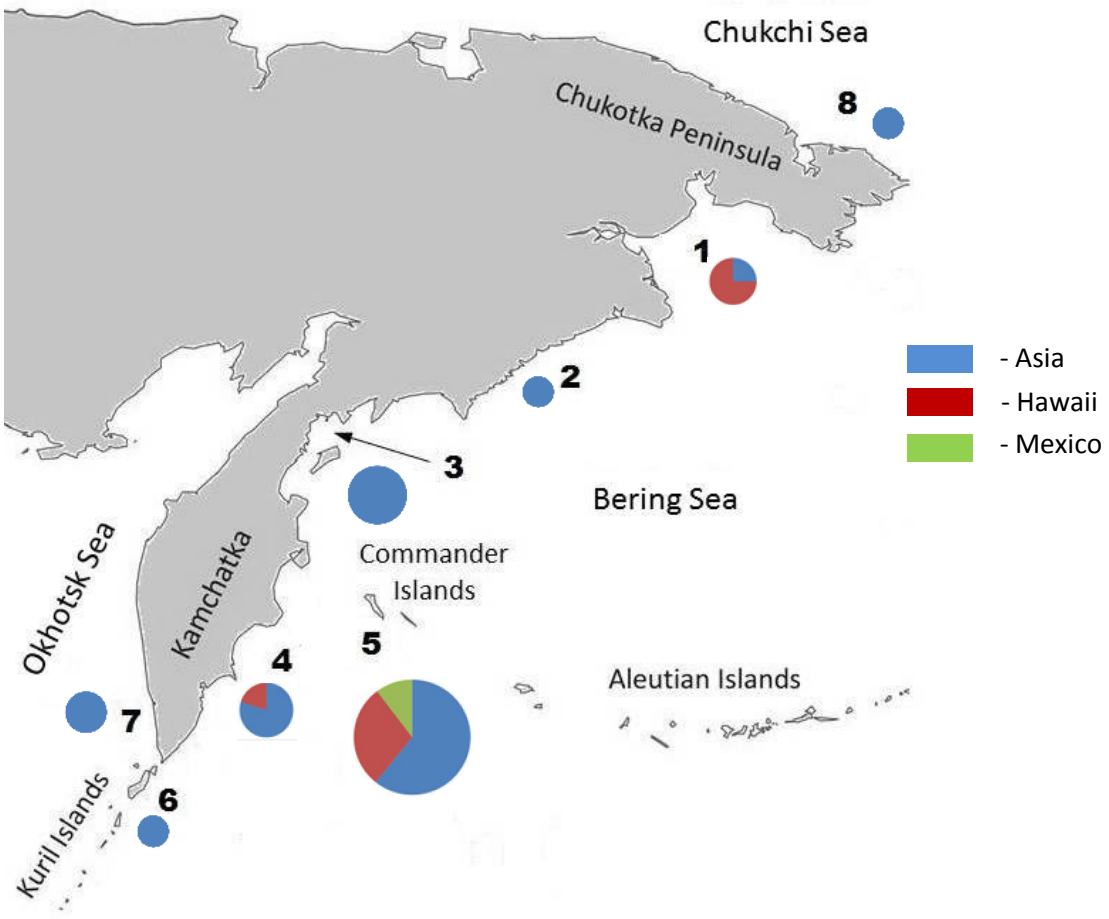

Figure 2. Cumulative identification of humpback whales in the Russian Far East in 2004-2014

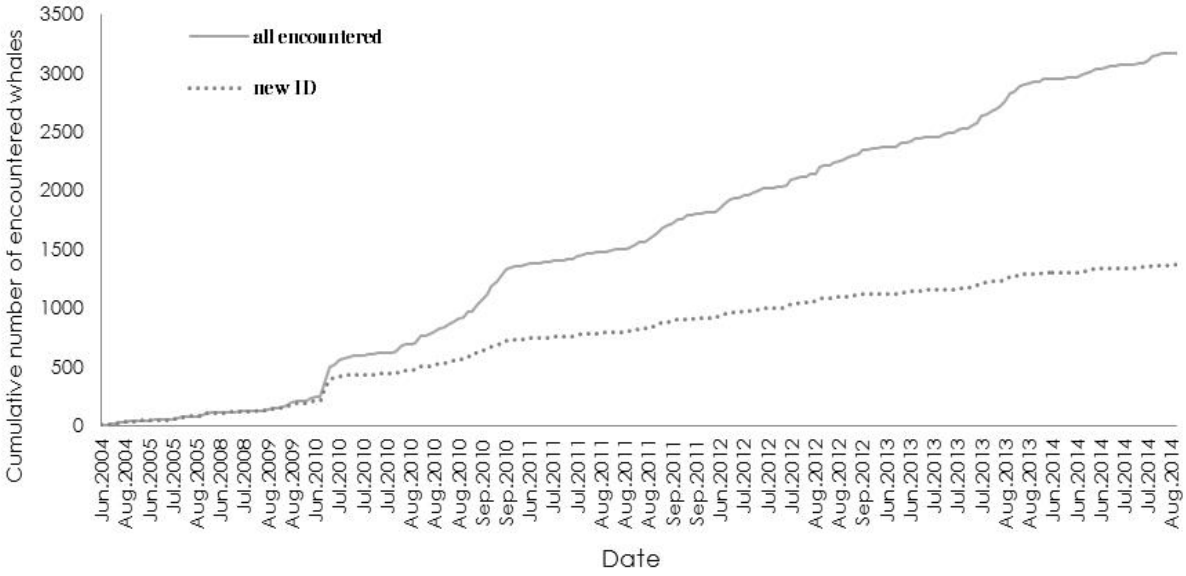

Table 1. Number of individual whales identified in the different regions of the Russian Far East.

Data source	SPLASH survey, occasional photographs	SPLASH survey, occasional photographs	FEROP	Occasional photographs	FEROP, RCHP	FEROP, RCHP	FEROP, RCHP	FEROP, RCHP	FEROP, RCHP	FEROP, RCHP Heritage Expeditions	FEROP, RCHP	
Years / Study region	2004	2005	2006	2007	2008	2009	2010*	2011*	2012 *	2013 *	2014 *	**total**
Gulf of Anadyr (1)		27										27
Koryak Coast (2)		4										4
Karaginsky Gulf (3)	32	24		2	7	7						72
Eastern Kamchatka Coast (4)		1			2	15			3		6	27
Commander Islands (5)	18	9	3	3	12	59	545	190	201	196	61	1297
Kuril Islands (6)	1										1	2
Western Kamchatka Coast (7)	2	2									2	6
Chukchi Sea (8)										24		24
total	53	67	3	5	21	81	545	190	204	220	70	1459
Effort (days with whales)	12	15	2	2	5	13	46	37	36	38	29	233

* new unpublished data

Table 2. Number of matches and interchange index of humpback whales from different breeding grounds and the Russian Far East.

	Matches	Total number in the catalog	Match Index
Asia	106	1099	0.066
Hawaii	35	2008	0.011
Mexico	11	1418	0.004
Total	**152**	**4525**	**0.022**

Table 3. Summary of matches made between Russian Far East sampling sites 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**		
Kamchatkan coastal	Koryak Coast*	4	2			**2**											2	50
	Karaginsky Gulf	69	21	5	10	**30**											30	43.48
	Eastern Kamchatka Coast	27	4			**4**		1	1			**1**					5	18.52
	Western Kamchatka Coast*	6			2	**2**											2	33.33
northern and offshore	Commander Islands	1300	43	20	15	**65**	4	23	2	1	1	**31**	2	3	6	**11**	107	8.23
	Gulf of Anadyr	27	1			**1**		3				**3**					4	14.81
	Chukchi Sea	24	1			**1**											1	4.17
	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
	Interchange within the breeding grounds					**17**						**1**				**0**	18	

* - small sample size

Table 4. Multi-year presence of individual humpback whales from different breeding grounds during long-term efforts off the Commander Islands, Russia.

	Matches with breeding grounds			Whales encountered off Commander Islands
	Asia	Hawaii	Mexico	
Individuals	**65**	**31**	**11**	**1300**
Average years	2.5	1.6	1.5	1.4
Maximum years	6	4	4	7
Encountered in more than 1 year	24.60%	43.80%	30%	29%
Average encounters/year	1.6	1.6	1.7	1.6