J-STAGE Advance published date: November 8, 2021

EVIDENCE OF WINTER MIGRATION OF HUMPBACK WHALES TO THE HACHIJO ISLAND, IZU ARCHIPELAGO OFF THE SOUTHERN COAST OF TOKYO, JAPAN

Taiki KATSUMATA[1, 2]*, Ayumi HIROSE[1], Ken NAKAJO[1], Chieri SHIBATA[1], Haruna MURATA[1], Tadashi YAMAKOSHI[3], Gen NAKAMURA[1] and Hidehiro KATO[1, 2]

[1] *Tokyo University of Marine Science and Technology, 4–5–7 Konan, Minato-ku, Tokyo 108–8477, Japan*
[2] *Institute of Cetacean Research, 4–5 Toyomi-cho, Chuo-ku, Tokyo 104–0055, Japan*
[3] *Hachijo Town Office, 2551–2, Oogago, Hachijo Town, Tokyo, 100–1401, Japan*
* *Corresponding author: katsumata@cetacean.jp*

Abstract

In the western North Pacific Ocean, humpback whales (*Megaptera novaeangliae*) migrate to the Okinawa (26°13′N, 127°41′E) and Ogasawara (27°04′N, 142°13′E) islands of Japan for breeding. The Hachijo Island (33°06′N, 139°47′E) is located in the Izu Archipelago —further north from known wintering grounds of those whales. In the 2015–16 winter, humpback whales were sighted around the Hachijo Island in significant numbers. This led to a monitoring project of whales around the island that was initiated from the 2016–17 winter to elucidate their migration. Here, we report the results of monitoring over two subsequent winter seasons (2016–17 and 2017–18). A survey was conducted within 5 nautical miles of the coast of the island using a dedicated vessel (12GT) for respectively 32 and 34 days in the first and second season from November to April. Humpback whales were sighted from November to March in the first season and from November to April in the second season, and a total of sightings of respectively 205 and 397 whales were recorded in the 2016–17 and 2017–18 seasons. Characteristic behaviors in the wintering grounds, such as singing and forming competitive groups, were confirmed in both seasons. Moreover, around 15% of the whales were repeatedly sighted during the same season, and six individuals observed in the first season were resighted in the second season. These results suggest that waters around the Hachijo Island are part of the winter migration grounds of humpback whales, and their migration to waters off the Hachijo area is expected to continue in the future. Long-term monitoring focusing on the social composition of groups is necessary, and additional photo-identification and genetic data should be collected to shed light on the habitat use and causes of sudden occurrence of humpback whales around this island.

Key words: Hachijo Island, humpback whale, wintering ground, Photo-ID, residency, site fidelity.

Introduction

Humpback whales (*Megaptera novaeangliae*) belong to the family Balaenopteridae of the suborder Mysticeti (Fig. 1). They undergo seasonal migration, staying in highly productive feeding grounds at high latitudes during the summer and autumn and migrating to breeding grounds at temperate low latitudes in winter (Dawbin, 1966; Baker *et al.*, 1986; Clapham, 2000). In the North Pacific Ocean,

Fig 1. Humpback whale. This Photo was taken in 22 January, 2017 at Hachijo Island.

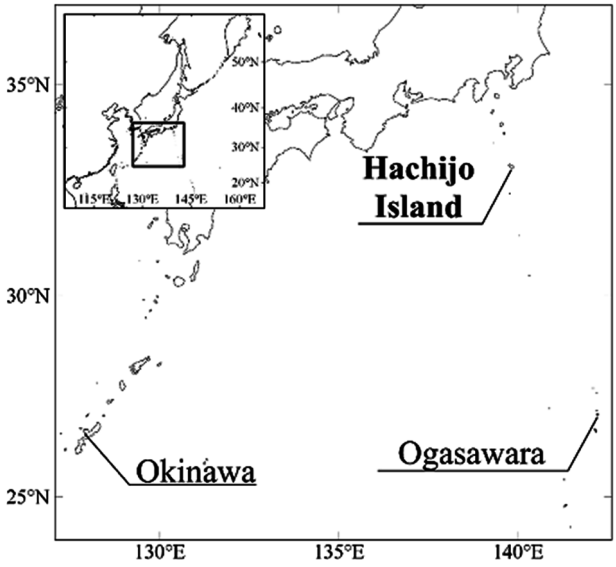

Fig. 2. Map of Hachijo Island and two other major wintering grounds of humpback whales known in Japan.

some wintering grounds have been reported, namely the coasts of Mexico, Revillagigedo Archipelago (Urbán and Aguayo, 1987), Hawaii (Baker and Herman, 1981), the Philippines (Acebes *et al.*, 2007), Ogasawara Islands (Darling and Mori, 1993), Okinawa (Nishiwaki, 1959; Kobayashi *et al.*, 2016), and Mariana Archipelago (Hill *et al.*, 2020). The occurrence peak of humpback whales in the wintering ground of the North Pacific Ocean generally lasts from February to March (Urbán and Aguayo, 1987; Mobley *et al.*, 1999; Kobayashi *et al.*, 2016). In the wintering grounds, some behaviors related to the mating of humpback whales were observed. Male humpback whales sing long complex songs (Payne and McVay, 1971; Baker and Herman, 1984), and males compete physically among multiple male whales for mating opportunities with females (Tyack and Whitehead, 1983; Baker and Herman, 1984; Clapham, 2000).

In November 2015, we received a report from diving companies that an unusually large number of humpback whales appeared around the Hachijo Island (Kono E. and Yamakoshi, pers. comm.). The Hachijo Island is located south of Tokyo in the southern part of the Izu Archipelago (33°06′N, 139°47′E), approximately 700 km north of the Ogasawara Islands, which is one of the known primary wintering grounds of humpback whales in Japan (Fig. 2). According to Uda (1954), the waters around

the Hachijo Island have not been previously reported as the whaling grounds of humpback whales. Furthermore, there has been no scientific monitoring of large whales in this region. Therefore, there are not any previous formal records which mention whether humpback whales migrated to this region seasonally or not. Before this sudden migration in 2015, only five sporadic sightings of humpback whales around this island were reported, including once each in April 2005 and May 2010 and thrice in March 2013 (Tokyo Metropolitan Government Park Association Hachijo Visitor Center, pers. comm.).

Therefore, on December 23, 2015, the Japan Broadcasting Corporation (NHK) and the Laboratory of Cetacean Biology, Tokyo University of Marine Science and Technology (TUMSAT) collaborated to visually survey the coastal area of Hachijo Island. In this preliminary survey, 37.4 nautical miles were searched along the coast of the island and at least 10 humpback whales belonging to five social groups were sighted in the southwest part of the island in water depths less than 200 m. Moreover, a song was confirmed and recorded.

To examine whether the migration of a significant number of whales around the Hachijo Island is temporary and to collect photo-identification data for investigating the migratory connections to other areas, a shipboard survey has been conducted around the island by the local government and TUMSAT throughout the breeding season (November to April) since 2016. The present study reports the results of monitoring over two subsequent seasons (2016–17 and 2017–18) and explores the importance of waters around the Hachijo Island as wintering grounds of western North Pacific humpback whales based on occurrence, behavior, and photo-identification data.

Materials and Methods

Field Survey

We conducted surveys within five nautical miles of the coast of the Hachijo Island, departing from and arriving at the Yaene Port (33°06′N, 139°46′E). In the field the *Aki-Maru*, a small dedicated research vessel of 12 GT (length, aprox. 15 m; width, 2.5 m) with a single inboard diesel-powered engine was used. Three researchers on board visually searched for whales with the naked eye from the observation platform (3 m above sea level). The survey was conducted from 9:00 to 15:00, and the search speed of the vessel was set at 8–9 knots. When whales were sighted, one researcher recorded the time and position of the vessel (latitude and longitude) using a global positioning system (Garmin eTrex10J). When the vessel reached the estimated location at which the whales were spotted, one researcher recorded the time, position, and sea surface temperature (SST), and two other researchers attempted to take photographs for identification. In addition, the behavior and group size of the whales were observed and recorded. The researchers lowered a hydrophone (OKI Whalephone II) at least once per day to evaluate whether the whales were singing.

Photo-identification

Humpback whales can be identified based on the pattern of pigmentation on the ventral fluke and the shape of its edge (Katona and Whitehead, 1981). When humpback whales were sighted, the vessel immediately followed the target group, and the researchers took photographs for identification using a NIKON D7000 camera with a 55–300 mm lens (AF-S DX NIKKOR 55–300 mm f/4.5–5.6 GED) and a NIKON D7500 camera with a 19–300 mm lens (AF-S DX NIKKOR 18–300 mm f/3.5–5.6 GED). Two types of surveys were conducted—one was circling around the island, and the other was staying in the waters where sightings were expected. In both types of surveys, we attempted to take as many photographs as possible.

After the surveys were completed in each season, the resightings were compiled to assess the residency around the island during a season. In the present study, the good-quality photographs that were in focus and clearly showing the pattern of pigmentations on the ventral fluke and the shape of its

edge were used. We printed the photographs obtained during each season and sequentially compared them by visual examination to identify the individuals. Each of the three researchers performed the above steps, and the final identification results were compiled as resightings. The individuals re-photographed at intervals of 1 or more days within the same season were considered resightings. Moreover, photographs were compared between the 2016–17 and 2017–18 seasons to assess whether the same individuals migrated to areas around the Hachijo Island in the following season.

Results and Discussion

Survey effort and sightings

Table 1 summarizes the results of the survey effort and sightings during the 2016–17 and 2017–18 seasons. The survey was conducted for respectively 32 and 34 days from November to April in the 2016–17 and 2017–18 seasons. Table 2 summarizes the monthly survey effort for each season. In both seasons, a large amount of effort was devoted to February and March when the occurrences of whales were generally expected to be high in order to obtain more Photo-ID (Urbán and Aguayo, 1987; Mori *et al.*, 1998; Mobley *et al.*, 1999; Kobayashi *et al.*, 2016). The survey area and track lines during each season are illustrated in Fig. 3. In the 2016–17 season, we covered 986.0 nautical miles in total, and the first sighting of a humpback whale in the season was recorded on November 20, 2016. From that day until March 19, 2017, 205 whales belonging to 136 social groups were sighted. In the 2017–18 season, we covered 835.6 nautical miles in total and sighted 397 whales belonging to 232 social groups from November 28, 2017, to April 9, 2018. The mean sighting rate in the 2017–18 season (11.7 whales per day) was approximately two times the rate in the 2016–17 season (6.4 whales per day). Fig. 4 presents the monthly changes in sighting per unit effort (SPUE; number of whales sighted per day) in both seasons. The temporal trend of occurrences in a season is one of the critical indicators to clarify the habitat use of humpback whales during the winter. In Okinawa (Kobayashi *et al.*, 2016) and Ogasawara (Mori *et al.*, 1998), the period of the most frequent occurrence of whales was from February to March, with a single peak. The trend observed in eastern Australia, which is considered a migration corridor, frequently occurs in the early stages of the season; this is followed by a decline and then an increase in number of whales at the end of the season (Burns, 2010).

Table 1. Survey period, survey effort (number of days surveyed and total search distance in nautical miles), total number of sightings, and sightings per unit effort (SPUE) in each winter season.

Season	Start survey (yyyy/mm/dd)	Finish survey (yyyy/mm/dd)	Survey effort (days)	Survey effort (nautical miles)	Sightings (groups/whales)	SPUE (whales/days)
2016/17	2016/11/18	2017/04/24	32	986.0	136/205	6.4
2017/18	2017/11/28	2018/04/23	34	835.6	232/397	11.7

Table 2. The number of survey days and searching distance per month in each season. The study was designed to increase survey efforts in February and March as the frequency of humpback whale occurrence in the wintering ground was expected to be high.

Season	Survey effort							
	Unit	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
2016/17	Days	3	5	4	7	9	4	32
	Nautical miles	134.4	169.5	103.1	182.3	233.5	163.2	986.0
2017/18	Days	2	6	5	9	8	4	34
	Nautical miles	61.5	137.3	127.3	214.3	192.1	103.2	835.6

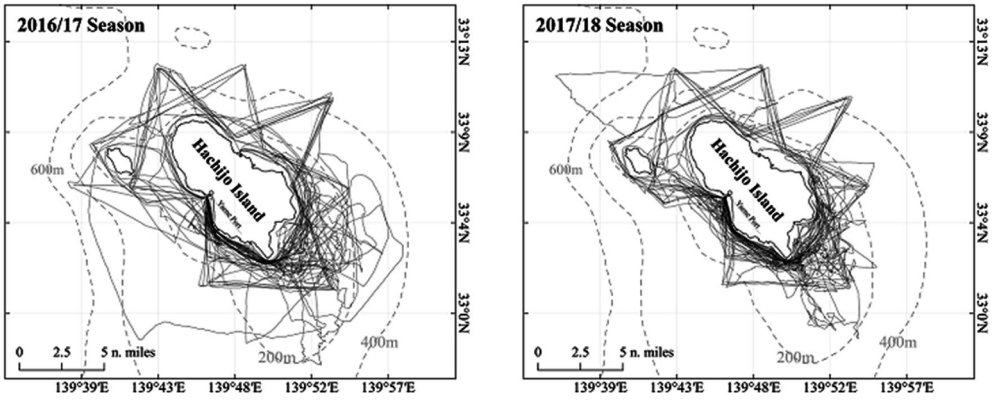

Fig. 3. Survey track lines in the 2016–17 (left) and 2017–18 (right) winter seasons. The survey was conducted within 5 nautical miles from the coast of Hachijo Island in both seasons.

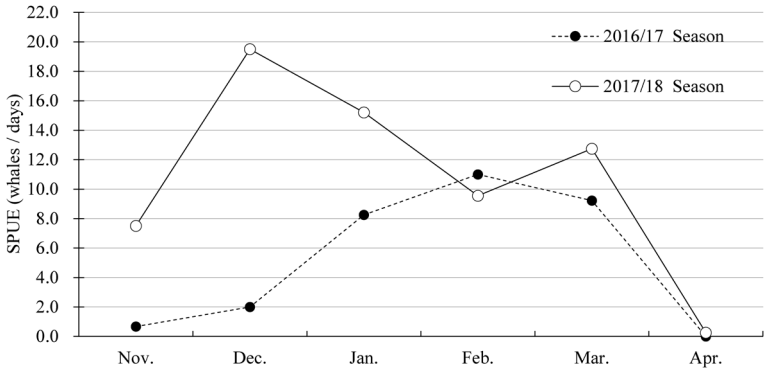

Fig. 4. Monthly sightings per day from November to April in the 2016–17 and 2017–18 seasons. SPUE: Sightings per unit of effort.

In the first season, a single peak of occurrences around the Hachijo Island was recorded in February; however, in the second season, SPUE decreased after a peak in December and then increased in March. The Kuroshio Current path is one of the possible reasons for these differences in the temporal trends of whale occurrence between the two seasons. The Kuroshio large meander was underway since August 2017, and the current path around the Hachijo Island (around 140°E) significantly differed between the first and second seasons (Qiu, 2019). In the Southern Hemisphere Madagascar wintering grounds in, humpback whales swim along strong currents during non-migratory offshore movements (e.g., travel between breeding sites or short-term offshore travel) (Trudelle *et al.*, 2016). Assuming that humpback whales behave in the same manner around the Hachijo Island, they might swim near the island or offshore depending on the Kuroshio Current path. This may have also affected the number of annual sightings in the survey area. However, detailed investigation to elucidate the above is not possible with data collected for only 2 winter season surveys. In addition, the unevenness in the amount of effort in each month of the season raises the possibility that the SPUE of some months does not adequately reflect the relative abundance of whales. Based on the above, the present study results do not allow us to determine when the peak in the number of migrating whales to Hachijo Island occurs, and it is not possible to conclude whether the use of the area by humpback whales is similar to that of Okinawa and Ogasawara. Therefore, continuous field surveys and long-term monitoring of individuals through satellite telemetry are necessary to understand the trend of occurrence of humpback whales around Hachijo Island. However, as humpback whales were continuously sighted around Hachijo Island from November to March for the two consecutive seasons, it is reasonable to assume that this species uses this area for winter migration.

Characteristic behaviors

Humpback whale singing behavior was confirmed from mid-January to late March in 2016–17 and from late November to late March in 2017–18. Singing behavior is considered to play specific roles; as such, songs serve as an acoustic display to attract females, a threat behavior during intrasexual competition, and a spacing function among males (Clapham, 2000). Furthermore, on March 5, 2017, a group of four whales and another group of two whales merged to form a six-whale group. The whales of this group swam violently. For instance, one individual hit its head on the water surface, while another pushed other whales with its head. These behaviors were consistent with the competitive behaviors reported in the wintering grounds by Tyack and Whitehead (1983) as well as by Baker and Herman (1984). Such competitive behaviors were observed respectively two and three times in the 2016–17 and 2017–18 seasons. Based on the observations of singing and competitive behaviors, humpback whales likely use the areas around the Hachijo Island as a mating ground.

Photo-identification

A total of 203 individuals were identified during both seasons. Respectively 58 and 151 individuals were identified in the 2016–17 and 2017–18 seasons, and six individuals were identified in both seasons. Table 3 summarizes the results of photo-identification in the same season, and Tables 4a and 4b summarize the survey dates and the dates when individuals were resighted for each season. In the 2016–17 season, 10 of the 58 individuals (17.2%) were resighted within the same season. Nine of ten individuals were resighted once, while one individual was resighted twice, and the period between the first and the last sighting (or occupancy) ranged from 1 to 40 days (mean: 9.5 days; SD: 13.7 days). In the 2017–18 season, 21 of the 151 individuals (13.9%) were resighted within the same season. Thirteen of the 21individuals were resighted once, six were resighted twice, and one individual was resighted each three and four times, respectively; and the occupancy ranged from 1 to 52 days (mean: 10.6 days; SD: 15.4 days). Thus, in both seasons, most of the individuals were not resighted and around 15% were resighted within the same season.

The proportion of individuals resighted during a season provides basic information on the residency of humpback whales. For instance, a high proportion indicates that individuals are likely to be resighted in a certain area and tend to stay there for a long period, whereas a low proportion indicates that individuals are less likely to be sighted in a certain area and tend to move around instead of staying. The frequency of resighting in the Hawaiian waters (off Kauai) was 5%–14% (Cerchio, 1998), and similar values have also been reported in Silver Bank (9.1%) (Mattila *et al.*, 1989), Samana Bay (15.8%) (Mattila *et al.*, 1994), Ecuador (12.9%) (Scheidat *et al.*, 2000), and Abrolhos Bank (13%) (Wedekin *et al.*, 2010). Values of approximately 10%–15% indicate that individuals do not stay in the same area for a long period and tend to move widely within each wintering ground. This observation is also supported by the reports using satellite telemetry of extensive local movements in Hawaii (Mate *et al.*, 1998), Silver Bank (Kennedy *et al.*, 2014), and Ecuador (Guzmán and Félix, 2017). In contrast, the frequency of resighting in the feeding grounds has been reported to be as high as 77.3% in the Gulf of Maine (Clapham *et al.*, 1993) and as low as 2.1% along the east coast of Australia, which is believed to be a migration corridor (Burns, 2010). Of note, these proportions depend on the survey

Table 3. Number of individuals photo-identified and resighted in each season, and the minimum and maximum period between the first and last sighting of the resighted individuals in the same season.

	Number of Photo-IDs	Number of individuals resighted (%)	The minimum period between first and last sighting (days)	The maximum period between first and last sighting (days)
2016/17	58	10 (17.2%)	1	40
2017/18	151	21 (13.9%)	1	52

Table 4a. The survey dates and dates when individuals were resighted in the 2016–17 season. Black circle indicates the date an individual was sighted.

ID #	Month	Nov.			Dec.					Jan.				Feb.						Mar.								Apr.				Number of resighting
	Day	18	20	29	3	12	13	25	26	17	18	20	22	4	5	8	25	26	27	4	5	8	9	17	18	19	20	23	5	6	23	24	
IH-004								●	●																							1
IH-007										●	●							●														2
IH-008										●	●																					1
IH-025															●						●											1
IH-029															●		●															1
IH-037																	●	●														1
IH-039																	●	●														1
IH-043																	●	●														1
IH-059																				●	●											1
IH-061																				●	●											1

Table 4b. The survey dates and the dates when individuals were resighted in the 2017–18 season.

ID #	Month	Nov.		Dec.						Jan.					Feb.									Mar.								Apr.				Number of resightings
	Day	28	29	9	10	18	20	21	23	7	8	20	21	22	8	9	10	17	18	19	20	21	22	3	4	13	14	15	26	27	28	9	10	22	23	
IH-108				●	●								●																							2
IH-101				●			●																													1
IH-049				●									●	●																						2
IH-117					●			●																												1
IH-127						●	●		●																											2
IH-159										●	●																									1
IH-166												●				●	●				●					●										4
IH-169												●		●																						1
IH-176													●	●																						1
IH-200															●		●																			1
IH-201															●		●																			1
IH-203																●							●													1
IH-207																●	●						●													2
IH-212																●	●																			1
IH-237																					●		●													1
IH-265																										●	●	●								2
IH-276																											●	●								1
IH-279																											●	●								1
IH-281																											●	●		●						2
IH-282																											●	●	●		●					3
IH-303																													●	●						1

effort and population size. In the present study, since 80% of the resighted individuals were sighted within three days of their first sighting, the proportion of resighting may have been underestimated due to 1–2 weeks interval between the survey dates. However, considering the short gap between resighting and the rare sighting of individuals, such as IH-166, for two months, possibly few individuals remain in the vicinity of Hachijo Island for an extended period, suggesting that the residency of humpback whales around Hachijo Island is comparable to that in other wintering grounds.

Interestingly, 6 of the 58 individuals identified in the first season returned to the waters around the Hachijo Island in the subsequent season (Fig. 5). According to Calambokidis *et al.* (2001), few individuals migrate to different wintering grounds every year, and each population has a specific wintering ground.

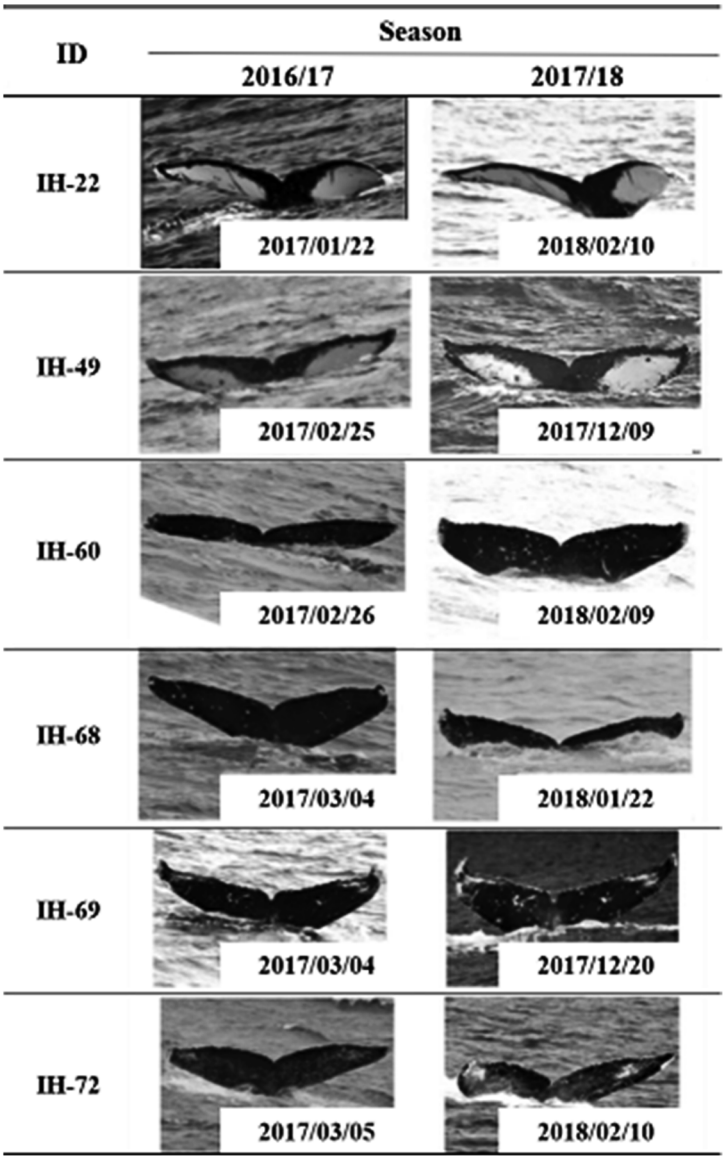

Fig. 5. Tail photographs of whales that were observed around the Hachijo Island in two consecutive seasons. Dates indicate the day on which each individual was photographed in each season (all copyrights are reserved to TUMSAT).

Calambokidis *et al.* (2001) assessed the site fidelity for North Pacific wintering grounds using the Match index (Equation 1), which reflects the size of the overall population sampled and the degree of site fidelity.

The Match index is expressed by the following:

$$I_{i\to j} = [m_i / (a_i n_j)] \times 1{,}000 \quad (1)$$

where,

a_i = number of marked releases at time 1 in region i (i=1, …, R)
n_j = number examined for marks at time 2 in region j
m_i = marked recaptures in region j, originally marked in region i

The frequency of identification of the same individual in different wintering grounds during different years was low, and the Match index was 0.015 between Mexico and Hawaii, 0.010 between Hawaii and Japan (Okinawa and Ogasawara), and 0.000 between Mexico and Japan; however, frequency

of reidentification of the same individual in the same wintering grounds but during different years was relatively high, and the Match index was 0.257 for Hawaii, 0.518 for Mexico, and 2.365 for Japan (Calambokidis *et al.*, 2001). Around the Hachijo Island, 58 individuals were marked in the first season (a_i), 151 individuals were examined for marks in the subsequent season (n_j), and 6 individuals were recaptured (m_i). Based on these counts, the Match index was 0.685, indicating that site fidelity for the Hachijo Island is similar to that reported for Hawaii and Mexico.

Considering that the residency and site fidelity for the Hachijo Island were comparable to those for the other wintering grounds, the same population likely migrates to the areas around the island annually and uses it as some parts of their wintering grounds. In other words, this area is as important as other wintering grounds for the migration of humpback whales, and migration to waters off the Hachijo area is expected to continue in the future.

Absence of mother–calf pairs

Newborn calves (typically approximately 4 m long) were not sighted in both seasons. In Okinawa and Ogasawara, mother–calf pairs have been observed during winter (Darling and Mori, 1993; Kobayashi *et al.*, 2016). Generally, the SST at the wintering grounds of humpback whales is above 21.0°C (Rasmussen *et al.*, 2007). However, according to daily measurements near the Yaene Port (33°06′N, 139°50′E) by the Tokyo Metropolitan Islands Area Research and Development Center for Agriculture, Forestry and Fisheries, the mean SST from November to April was 19.0°C (SD: 3.1°C; range: 13.6–25.8°C) in the 2016–17 season and 19.9°C (SD: 1.9°C; range: 15.4–24.1°C) in the 2017–18 season. This relatively low SST may be unsuitable for nursing. However, based on a personal communication (Kato, H., Akama, N. and Kono, E., pers. comm.) a mother-calf pair was observed in the southeastern part of the island in March 2016, which may have been missed in our survey.

The results of the present study provide novel insights into the annual migration of humpback whales to the waters around the Hachijo Island and their distinct breeding behavior in winter. However, we cannot conclude whether the waters around the Hachijo Island indeed serve as a breeding ground for these whales, similar to Okinawa and Ogasawara, given the absence of newborn calves. The objective of migration to the areas around the Hachijo Island remains debatable, and several hypotheses have been put forth, such as these areas being part of a migration corridor or this being a temporary migration. If the waters around the Hachijo Island are established as a breeding ground in the future, mother–calf pairs should be sighted frequently around the island. Therefore, long-term monitoring focusing on the composition of the social groups should be conducted to reveal the habitat use. Moreover, in humpback whales, the timing of migration to wintering ground varies depending on the sex and reproductive status (Dawbin, 1966; Brown *et al.*, 1995) of individuals. Therefore, the sex and sexual maturity of whales sighted around the Hachijo Islands should be determined and compared with those of whales reported in other wintering grounds to clarify the habitat use of the waters around this island.

Causes of sudden appearance

The abundance of humpback whales in the North Pacific Ocean declined from approximately 15,000 in 1905 to 1,000 in 1965 because of catch in commercial whaling (Johnson and Wolman, 1984). Following the prohibition of commercial whaling of this species in 1966 by the International Whaling Commission, the number of humpback whales increased. More recently, the abundance of humpback whales in the North Pacific Ocean was estimated to be 21,063, which is greater than the estimates of pre-whaling abundance (Barlow *et al.*, 2011). This explosive increase in the number of humpback whales in the North Pacific Ocean may be one of the reasons for the sudden appearance of these whales around the Hachijo Island in winter. In fact, the expansion of the wintering grounds of humpback whales with the recovery of their population in the Hawaiian waters has been reported (Mobley *et al.*, 1999). Similarly, expansion of the wintering grounds was confirmed near

Peru (Guidino *et al.*, 2014). However, there are no data on the abundance of humpback whales in the western North Pacific Ocean after the "Structure of Populations, Levels of Abundance, and Status of Humpbacks" (SPLASH) study (Barlow *et al.*, 2011). Further, the population dynamics around 2015, when humpback whales appeared around Hachijo Island, must be clarified to prove this hypothesis. Currently, the stock structure of the population migrating to the Hachijo Island remains unclear. Therefore, the migratory connections between the Hachijo Island and other wintering grounds in the North Pacific Ocean and feeding grounds at high latitudes must be established based on photo-identification and genetic data. To clarify the cause of the sudden appearance of humpback whales around the Hachijo Island, continuous monitoring at a local scale around the island, and at a broader scale, is imperative.

Acknowledgements

The field survey was financially supported by the Hachijo Town Office. The authors express their deep gratitude to Hachijo Town government. We would like to thank the citizens and tourists of Hachijo Island and Hachijo Branch, Tokyo Metropolitan Islands Area Research and Development Center of Agriculture, Forestry and Fisheries for providing helpful sighting information and the Hachijojima Tourist Information Center for summarizing the sighting information. The authors thank Y. Yamamoto and E. Kono of Japan Broadcasting Corporation (NHK) for enabling the first investigation on the Hachijo Island. The authors would like to thank the Captain of the research vessel, N. Akama. The authors are also grateful to M. Yamaguchi, Y. Kim, and all other researchers of Tokyo University of Marine Science and Technology for their assistance with the present surveys. Finally, we would like to express our sincere thanks to the anonymous reviewers.

References

Acebes, J. V., Darling, J. D. and Yamaguchi, M. 2007. Status and distribution of humpback whales (*Megaptera novaeangliae*) in northern Luzon, Philippines. *J. Cetacean Res. Manage*. 9: 37–43.

Baker, C. S. and Herman, L. M. 1981. Migration and local movement of humpback whales (*Megaptera novaeangliae*) through Hawaiian waters. *Can. J. Zool*. 59: 460–469. doi: 10.1139/z81-067.

Baker, C. S. and Herman, L. M. 1984. Aggressive behavior between humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters. *Can. J. Zool.* 62: 1922–1937. doi: 10.1139/z84-282.

Baker, C. S., Herman, 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. and Östman, 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. doi: 10.3354/meps031105.

Barlow, J., Calambokidis, J., Falcone, E. A., Baker, C. S., Burdin, M. A., Clapham, P. J., Ford, J. K. B. and Gabriele, C. M., Le Duc, R., Mattila, D. K., Quin II T. J., Rojas-Bracho, L., Straley, J. M., Taylor, B. L., Urbán, R. J., Wade, Weller, D., Witteveen, B. H. and Yamaguchi, M. 2011. Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. *Mar. Mamm. Sci.* 27: 793–818. doi: 10.1111/j.1748-7692.2010.00444.x.

Brown, M. R., Corkeron, P. J., Hale, P. T., Schultz, K. W. and Bryden, M. M. 1995. Evidence for a sex-segregated migration in the humpback whale (*Megaptera novaeangliae*). *Proc. R. Soc. B. Biol. Sci*. 259: 229–234. doi: 10.1098/rspb.1995.0034.

Burns, D. 2010. Population characteristics and migratory movements of humpback whales (*Megaptera novaeangliae*) identified on their southern migration past Ballina, eastern Australia. PhD thesis, Southern Cross University, Lismore, NSW. 248 pp.

Calambokidis, J., Steiger, G. H., Straley, J. M., Herman, L. M., Cerchio, S., Salden, D. R., Urbán, R, J., Jacobsen, J. K., von Ziegesar, O., Balcomb, K. C., Gabriele, C. M., Dahlheim, M. E., Uchida, S., Ellis, G., Miyamura, Y., Ladrón de Guevara, P., Yamaguchi, M., Sato, F., Mizroch, S. A., Schlender, L., Rasmussen, K., Barlow, J. and Quinn, T. J. 2001. Movements and population structure of humpback whales in the North Pacific. *Mar. Mamm. Sci*. 17: 769–794. doi: 10.1111/j.1748-7692.2001.tb01298.x.

Cerchio, S. 1998. Estimates of humpback whale abundance off Kauai, 1989 to 1993: evaluating biases associated with sampling the Hawaiian Islands breeding assemblage. *Mar. Ecol. Prog. Ser*. 175: 23–34. doi:10.3354/meps175023.

Clapham, P. J. 2000. The humpback whale: Seasonal feeding and breeding in a baleen whale. pp. 173–196. *In:* Mann, J., Tyack, P. L., Connor, R. and Whitehead, H. (eds.) *Cetacean Societies: Field Studies of Dolphins and Whales*. University of Chicago Press, Chicago, 433 pp.

Clapham, P. J., Baraff, L. S., Carlson, C. A., Christian, M. A., Mattila, D. K., Mayo, C. A., Murphy, M. A. and Pittman, S. 1993. Seasonal occurrence and annual return of humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. *Can. J. Zool*. 71: 440–443. doi: 10.1139/z93-063.

Darling, J. D. and Mori, K. 1993. Recent observations of humpback whales (*Megaptera novaeangliae*) in Japanese waters off

Ogasawara and Okinawa. *Can. J. Zool*. 71: 325–333. doi: 10.1139/z93-045.
Dawbin, W. H. 1966. The seasonal migratory cycle of humpback whales. pp. 145–170. *In:* Norris, K. S. (ed.) *Whales, Dolphins, and Porpoises.* University of California Press, Berkeley, 789 pp.
Guidino, C., Llapapasca, M. A., Silva, S., Alcorta, B. and Pacheco, A. S. 2014. Patterns of spatial and temporal distribution of humpback whales at the southern limit of the Southeast Pacific breeding area. *PLoS ONE*. 9(11): e112627. doi: 10.1371/journal.pone.0112627.
Guzmán, H. M., and Félix, F. 2017. Movements and habitat use by southeast Pacific humpback whales (*Megaptera novaeangliae*) satellite tracked at two breeding sites. *Aquat. Mamm*. 43: 139–155. doi: 10.1578/AM.43.2.2017.139.
Hill, M. C., Bradford, A. L., Steel, D., Baker, C. S., Ligon, A. D., Ü, A. C., Acebes, J. M. V., Filatova, O. A., Hakala, S., Kobayashi, N., Morimoto, Y., Okabe, H., Okamoto, R., Rivers, J., Sato, T., Titova, O. V., Uyeyama, R. K. and Oleson, E. M. 2020. Found: a missing breeding ground for endangered western North Pacific humpback whales in the Mariana Archipelago. *Endang. Species Res.* 41: 91–103. doi: 10.3354/esr01010.
Johnson, J. H. and Wolman, A. A. 1984. The humpback whale, *Megaptera novaeangliae*. *Mar. Fish. Rev*. 46: 30–37.
Katona, S. K. and Whitehead, H. P. 1981. Identifying humpback whales using their natural markings. *Polar Rec.* 20: 439–444. doi: 10.1017/S003224740000365X.
Kennedy, A. S., Zerbini, A. N., Vásquez, O. V., Gandilhon, N., Clapham, P. J. and Adam, O. 2014. Local and migratory movements of humpback whales (*Megaptera novaeangliae*) satellite-tracked in the North Atlantic Ocean. *Can. J. Zool*. 92: 9–18. doi: 10.1139/cjz-2013-0161.
Kobayashi, N., Okabe, H., Kawazu, I., Higashi, N., Miyahara, H., Kato, H. and Uchida, S. 2016. Peak mating and breeding period of the humpback whale (*Megaptera novaeangliae*) in Okinawa Island, Japan. *Open J. Anim. Sci.* 6: 169–179. doi: 10.4236/ojas.2016.63022.
Mate, B. R., Gisiner, R. and Mobley, J. 1998. Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. *Can. J. Zool*. 76: 863–868. doi: 10.1139/z98-008.
Mattila, D. K., Clapham, P. J., Katona, S. K. and Stone, G. S. 1989. Population composition of humpback whales, *Megaptera novaeangliae*, on Silver Bank, 1984. *Can. J. Zool*. 67: 281–285. doi: doi.org/10.1139/z89-041.
Mattila, D. K., Clapham, P. J., Vásquez, O. and Bowman, R.S. 1994. Occurrence, population composition, and habitat use of humpback whales in Samana Bay, Dominican Republic. *Can. J. Zool*. 72: 1898–1907. doi: 10.1139/z94-258.
Mobley, J. R., Bauer, G. B. and Herman, L. M. 1999. Changes over a ten-year interval in the distribution and relative abundance of humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters. *Aquat. Mamm*. 25: 63–72.
Mori, K., Sato, F., Yamaguchi, M., Suganuma, H. and Ueyanagi, S. 1998. Distribution, migration and local movements of humpback whale (*Megaptera novaeangliae*) in the adjacent waters of the Ogasawara (Bonin) Islands, Japan. *Tokai University Bulletin*. 45: 197–213.
Nishiwaki, M. 1959. Humpback whales in Ryukyuan waters. *Sci. Rep. Whales Res. Inst.* 14: 49–87.
Payne, R. S. and McVay, S. 1971. Songs of humpback whales. *Science*. 173: 585–597. doi: 10.1126/science.173.3997.585.
Qiu, B. 2019. Kuroshio and Oyashio Currents. pp. 384–394. *In*: Cochran, J. K., Bokuniewicz, H. and Yager, P. (eds.) *Encyclopedia of Ocean Sciences (3rd Edition)*. Academic Press, Amsterdam, 4306 pp.
Rasmussen, K., Palacios, D. M., Calambokidis, J., Saborío, M. T., Dalla Rosa, L. D., Secchi, E. R., Steiger, G. H., Allen, J. M. and Stone, G. S. 2007. Southern Hemisphere humpback whales wintering off Central America: insights from water temperature into the longest mammalian migration. *Biol. Lett.* 3: 302–305. doi: 10.1098/rsbl.2007.0067.
Scheidat, M., Castro, C., Denkinger, J., González, J. and Adelung, D. 2000. A breeding area for humpback whales (*Megaptera novaeangliae*) off Ecuador. *J. Cetacean Res. Manage.* 2: 165–171.
Trudelle, L., Cerchio, S., Zerbini, A. N., Geyer, Y., Mayer, F., Jung, J. L., Hervé, M. R. and Adam, O. 2016. Influence of environmental parameters on movements and habitat utilization of humpback whales in the Madagascar breeding ground. *R. Soc. Open Sci.* 3(12):160616. doi: 10.1098/rsos.160616 .
Tyack, P. and Whitehead, H. 1983. Male competition in large groups of wintering humpback whales. *Behaviour*. 83: 132–154. doi: 10.1163/156853982X00067.
Uda, M. 1954. Studies of the relation between the whaling grounds and the hydrographical conditions. *Sci. Rep. Whales Res. Inst.* 9: 179–187.
Urbán, R. J. and Aguayo, L. A. 1987. Spatial and seasonal distribution of the humpback whale, *Megaptera novaeangliae*, in the Mexican Pacific. *Mar. Mamm. Sci*. 3: 333–344. doi: 10.1111/j.1748-7692.1987.tb00320.x.
Wedekin, L. L., Neves, M. C., Marcondes, M. C. C., Baracho, C., Rossi-Santos, M. R., Engel, M. H. and Simões-Lopes, P. C. 2010. Site fidelity and movements of humpback whales (*Megaptera novaeangliae*) on the Brazilian breeding ground, southwestern Atlantic. *Mar. Mamm. Sci*. 26: 787–802. doi: 10.1111/j.1748-7692.2010.00387.x.

Received: January 26, 2021
Accepted: July 7, 2021
Published online: November 8, 2021