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PREFACE

I am very glad to introduce you to the fourth volume of the *Cetacean Population Studies (CPOPS)*. The publication of this CPOPS Vol. 4 turned out to be a long and difficult process. This may be in part because we expended much of our energy in editing the previous CPOPS Vol. 3, Dr. Seiji Ohsumi Memorial Volume, but mainly because I, as Editor-in-Chief, had to temporarily leave the editorial front for health reasons.

I understand that the burden of the CPOPS editorial board and the secretariat members, especially Dr. Gabriel Gomez Diaz, who filled the void, was not negligible. In a nutshell, the publication of this volume owes much to their efforts.

This is how CPOPS Vol. 4 came out to light. Although we were unable to cover all the papers submitted, we would like to make a fresh start for the next volume while taking advantage of the unique characteristics of our journal.

August 1, 2023

Hidehiro Kato, Ph. D.
Chairman
Publication Committee for the Cetacean Population Studies

Foreword*

Remarkable evolution in cetacean studies in recent decades owes much to major journals that have made significant contribution to the development of modern cetology: Discovery Reports, published by the National Institute of Oceanography in the United Kingdom, and Norwegian Whaling Gazette in Norway, as well as The Scientific Reports of the Whales Research Institute in Japan.

The Scientific Reports of the Whales Research Institute was first published in 1948, a year after the Whales Research Institute was established. Aiming to share valuable research findings and scientific knowledge worldwide, the publication was formatted in English since its beginning, quite an ambitious attempt in Japan still recovering from the devastation of World War II.

Since its first publication, a total of 246 scientists contributed 419 scientific papers to The Scientific Reports of the Whales Research Institute. It is widely acknowledged and appreciated that these scientific papers were the foundation for the development of cetacean studies worldwide, and in today's terms, it was a research journal that had a significant impact factor, or high number of citations. Regrettably, however, The Scientific Reports of the Whales Research Institute was discontinued in 1988 with the 39th volume after the institute was reorganized into the Institute of Cetacean Research.

In the 30 years since then, various types of journals on cetacean studies have been published globally, each offering different perspectives on scientific research outcomes. As for Japan, no research journal matching The Scientific Reports of the Whales Research Institute in its quality has been published. It is probably because many domestic cetologists have sought to publish their papers in international research journals based outside Japan.

As the global environment surrounding the issue of whaling became increasingly complex, we have observed a shift in publishing policies among these journals, rejecting papers whose findings are based on specific research methods such as lethal sampling. Because of this, no small numbers of papers submitted by biological scientists using samples collected through lethal surveys, even just for some parts, have been denied proper reviews. While we agree that animal ethics should be given high priority when writing a research paper, if a paper, the research method of which is allowed under domestic and international rules, is rejected, it is a decision made beyond scientific judgment.

Our new journal for cetacean population studies intends to follow the scientific policy of The Scientific Reports of the Whales Research Institute, that is, to contribute to global development of cetacean studies. As long as submitted papers conform to scientifically-accepted animal ethics, we do not make distinctions based on research methods. At the same time, to maintain the journal's neutrality in the complex global environment surrounding whaling issues, the journal will be published from a newly organized committee, rather than as a bulletin type scientific report from a specific research institute. The title of the new journal will be Cetacean Population Studies to be abbreviated CPOPS, and we aim to keep our door wide-open for researchers worldwide, contribute to the scientific development of resource studies for marine mammals especially focusing on cetaceans, and nurture many aspiring scientists.

Seiji Ohsumi

Seiji Ohsumi[†], Ph. D.
Chairman
Publication Committee for the Cetacean Population Studies

December 31, 2018

*Introductory declaration by the former Chairman of the Cetacean Population Studies Publication Committee on the occasion of the launching of this journal.

Full Paper

A blue whale just after blowing, Antarctic.

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EFFECT OF SEA SURFACE TEMPERATURE ON THE DISTRIBUTION OF COMMON MINKE WHALES OFF SOUTHEASTERN HOKKAIDO, JAPAN, BETWEEN 2002 AND 2006, WITH NOTES ON THE FORMATION OF PACIFIC SAURY FISHING GROUNDS

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Abstract

The relationships between oceanographic conditions and the distribution of common minke whales off southeastern Hokkaido was investigated in this study. Sighting surveys of common minke whales in this region were conducted in September, in 2002 and from 2004 to 2006. The density index (DI, the number of schools per 100 n.miles) of the whales decreased from 5.6 schools in 2002 to 1.2 schools in 2006. During the 4 years in which surveys were conducted, the monthly mean sea surface temperature (SST) in the survey area increased from 16.6°C in 2002 to 19.5°C in 2006, while the mean SST recorded at sighting locations was 15.5°C. The proportions of surveyed areas with a monthly mean SST ≤16°C in 2002 and 2004 were 46.5% and 17.0% respectively, whereas in 2005 and 2006, none of these areas had a monthly mean SST of less than 16°C. Pacific saury are among the major prey items of the minke whales in this region, and the number of the fishing boats was used as an indicator of the presence of the species in the surveyed area. The 4 year mean SST at the locations of the boats was 15.1°C. A reduction in the local abundance of the saury from 2002 to 2006 was inferred from the number of the boats operating in the region. These findings suggested that the apparent decline in the abundance of whales in the study area was associated with changes in SST and the availability of Pacific saury.

Key words: *Balaenoptera acutorostrata*, *Cololabis saira*, habitat, North Pacific, Oyashio, spatial distribution.

Introduction

The common minke whale (*Balaenoptera acutorostrata*, hereafter minke whale) is a small species of baleen whale with body length of approximately 8 m at physical maturity (Kato, 1992), and has been reported to live to ages of up to 49 years (Maeda *et al*., 2017). Records of past commercial catches indicate that the waters off southeastern Hokkaido (also known as the Doto region), Japan, are among the most important summer feeding areas for the Okhotsk Sea–West Pacific Stock (O Stock) of the species, particularly for immature individuals and mature males (Hatanaka and Miyashita, 1997; Kasamatsu and Tanaka, 1992). The results of the Japanese Whale Research Program under Special Permit in the western North Pacific (JARPN) and its Phase II (JARPN II) between 1994 and 2016 showed that they fed on a variety of prey species, such as krill, Japanese common squid (*Todarodes pacificus*), Japanese anchovy (*Engraulis japonicus*), Pacific saury (*Cololabis saira*, hereafter saury) and walleye pollock (*Gadus chalcogrammus*) in the western North Pacific (Konishi *et al.*, 2009; Murase *et al.*, 2007; Tamura *et al.*, 2009). It has been suggested that the spatial distribution of minke whales off southwestern Hokkaido during September could be associated with the distribution of saury (Tamura and Fujise, 2002). Nevertheless, despite this conjecture, it has yet to be sufficiently established whether changes in the minke whale spatial distribution are associated with the distribution of saury and/or oceanographic conditions (e.g., sea surface temperature, SST).

The saury, along with other small pelagic fishes, such as Japanese sardine (*Sardinops melanostictus*), Japanese anchovy, and chub mackerel (*Scomber japonicus*), is regarded as an economically important species in Japan (Watari *et al.*, 2019). Since the 1900s, the commercial catches and biomass of these small pelagic fish have fluctuated, reflecting decadal changes in species composition (i.e., species replacement) (Yatsu, 2019). Fluctuations in the populations of small pelagic fish detected during the 20th century have been linked to cold and warm water temperature regimes, as indicated by the Pacific Decadal Oscillation (PDO) index. However, the regime around Japan from the 2000s to 2010s was now defined as an unconventional regime as the relationship did not follow previous ones (Kuroda *et al.*, 2020). It should be noted that the biomass of saury was high in the 2000s in the time series between 1980 and 2018 (4th Meeting of the Technical Working Group on Pacific Saury Stock Assessment, 2019).

Saury generally (1) spawn during the winter months in the Kuroshio (the subtropical western boundary current with warm high-salinity water) waters off the southern coastline of Japan, (2) migrate to the North Pacific subarctic–subtropical transition zone during summer to feed and (3) commence their southbound return migration to the spawning grounds (Fuji *et al.*, 2020; Fukushima, 1979; Kosaka, 2000; Watanabe and Lo, 1989). It is in September during this southbound migration that the saury is commercially fished in grounds off the southeastern coast of Hokkaido. With the transition of the seasons from summer to autumn, the first branch of the Oyashio (the subarctic western boundary current with cold low-salinity water) extends southward along the coast of Hokkaido and Honshu, showing annual variation in both pattern and extent. The location of these saury fishing grounds off Hokkaido is determined by the location of the Oyashio front (the 5°C water temperature isotherm at a depth of 100 m), and accordingly shifts from year to year, tracking the variable pattern of the Oyashio front (Yasuda and Kitagawa, 1996). The primary indicator determining the location of the saury fishing grounds is SST, and it has been reported that the mode of SST at the fishing grounds in this area is 15°C (Tseng *et al.*, 2011; Watanabe *et al.*, 2006). It can thus be speculated that the spatial distribution of minke whales off southeastern Hokkaido in September is associated with the seasonal extent of the Oyashio current and/or the southbound saury migration.

The findings of previous studies have provided evidence indicating that the spatial distribution of minke whales worldwide is associated with a diverse range of biotic and abiotic factors, including bottom depth, topography, seafloor substrate, oceanographic conditions (e.g., SST); and the distribution of prey species (Chavez-Rosales *et al.*, 2019; Doniol-Valcroze *et al.*, 2007; Hamazaki, 2002; Hooker *et al.*, 1999; Ingram *et al.*, 2007; Macleod *et al.*, 2004; Naud *et al.*, 2003; Skern-Mauritzen *et al.*, 2011; Tetley *et al.*, 2008; Waggitt *et al.*, 2020; Zerbini *et al.*, 2016). However, given that these associations tend to differ depending on location and season, it has hitherto not been possible to draw any general conclusions. Consequently, to gain a better understanding of minke whale ecology, the location and season-specific effects of biotic and abiotic factors on the spatial distribution of these whales warrant further investigation.

In this study, it was sought to determine the associations among oceanographic conditions, and the distribution of saury and minke whales off southeastern Hokkaido in September. Specifically, the aims were to investigate (1) whether the distribution of minke whales in this area in September is related to SST, and (2) whether the spatial distribution of minke whales is related to the presence of saury. An earlier version of this paper was submitted to the International Whaling Commission's Scientific Committee as Appendix 4 of paper SC/59/O7 in 2006.

Materials and Methods

Sighting surveys of minke whales were conducted off the coast of southeastern Hokkaido, Japan, in 2002, 2004, 2005, and 2006, as a part of the coastal component of JARPN II (Hakamada *et al.*, 2009). The longitudinal boundaries of the survey area were set at 143°15′E and 146°00′E, whereas the latitudinal boundaries were set at the 50 m isobath and 41°N (Fig. 1). Surveys were conducted during the month of September in the aforementioned years (Fig. 2). The survey area between 143°15′E and 146°00′E was stratified into the following four strata: an Offshore (O) stratum and three coastal strata [coastal-Center (C), coastal-East (E), and coastal-West (W)], with the boundary between the offshore and coastal strata being set at a distance of 60 n.miles from the Hokkaido coastline. In 2005 and 2006, an additional stratum (H) was surveyed off Hidaka sub-prefecture (between 142°30′E and 143°15′E).

Sighting surveys were conducted from onboard the survey vessel (SV) *Kyoshin-Maru No. 2* (372 GT; Kyodo Senpaku Co., Ltd). Primary observers were allocated to the top barrel (3 observers) and the upper bridge (2 observers). Zigzag tracklines with randomly selected starting points were constructed in the survey area. The sighting survey (i.e., on-effort) was conducted during daylight hours from 1 hour after sunrise to 1 hour before sunset under acceptable weather conditions (i.e., the visibility was 2.0 nautical miles or more, the wind speed was 20 knots or less, and the Beaufort wind force scale was less than 6), and the nominal steaming speed along the tracklines was 10 knots. Sightings during the on-effort were treated as primary sightings.

There were two survey modes: Closing Mode and Passing Mode. Closing Mode was applied in 2002 and 2004 while Passing Mode was applied in 2005 and 2006 to increase survey coverages. When the sightings during Closing Mode (primary sightings) were likely to be minke whales, the SV approached them to confirm species and individuals within the schools. Sightings during the approaches to primary sightings were secondary sightings and were not included in the analysis. During Passing Mode, no approach was made to sightings. All sightings made in the Passing Mode were treated as

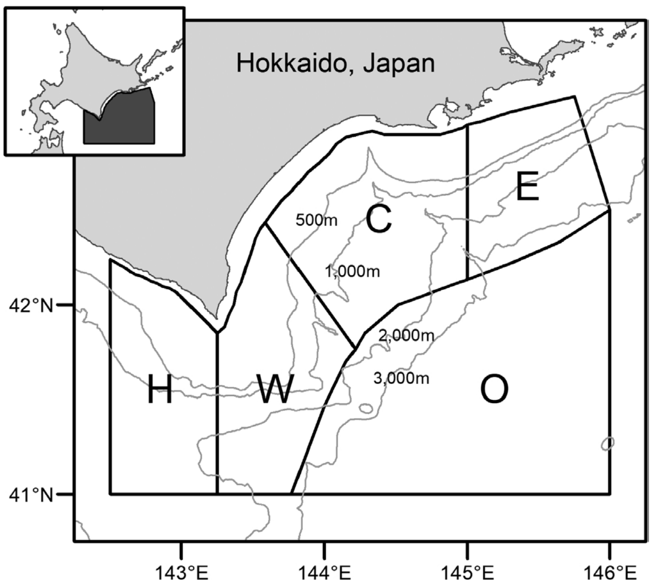

Fig. 1. Surveyed strata off the coast of southeastern Hokkaido, Japan [coastal-Center (C), coastal-East (E), coastal-West (W), Offshore (O)] and off Hidaka sub-prefecture (H). Black lines represent the boundaries between strata, and thin gray lines indicate isobaths.

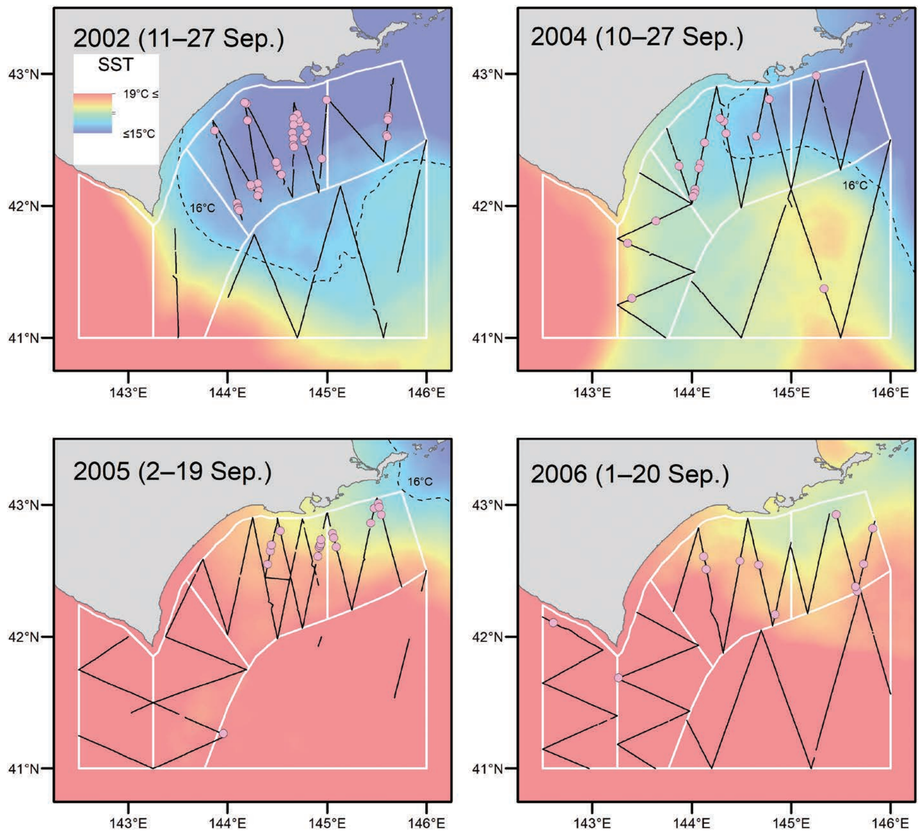

Fig. 2. Surveyed tracklines (black lines) and positions of common minke whale sightings (pink circles) off the coast of southeastern Hokkaido, Japan, in September 2002, 2004, 2005, and 2006. The monthly mean sea surface temperatures (SSTs) derived from GHRSST are also shown. Dashed black lines represent the 16°C isotherms, and white lines indicate the boundaries between strata.

primary sightings. However, if the identity of the species sighted was uncertain, abeam closing was conducted during Passing Mode. Given that the minke whales observed during the survey tended to occur individually rather than in schools, application of the Passing Mode is deemed adequate.

Density indices of schools and individuals (DI, the number of schools and individuals sighted per 100 n.miles) were calculated for each stratum in each survey year to show relative abundance of minke whales. Mean values of the SSTs recorded at the time of each sighting were obtained for each stratum in each of the survey years. Estimated abundance of minke whales based on the line transect sampling (Hakamada *et al.*, 2009) and amount of saury consumed by the whales (Tamura *et al.*, 2009) at the time of surveys were also used in this study.

As an indicator of the presence of saury, numbers of commercial saury fishing boats were summarized by each stratum in each survey year. Mean of SST recorded by the fishing boats was also summarized by each stratum in each survey year. The data of fishing positions of the boats and SST were provided by the Japan Fisheries Information Service Center (JAFIC).

SST data, A Group for High Resolution Sea Surface Temperature (GHRSST) Level 4 sea surface temperature analysis (JPL MUR MEaSUREs Project, 2010), were used to characterize oceanographic conditions at the time of the surveys. Monthly mean September SST data corresponding to the survey periods with a global 0.01 degrees grid spatial resolution were extracted using Marine Geospatial Ecology Tools 0.8a73 (Roberts *et al.*, 2010). Data pertaining to sightings, fishing boat locations, and SST were overlaid on maps using a geographic information system (GIS), ArcGIS Desktop 10.7 (ESRI, US). The area of sea surface classified by 1°C SST increments was also calculated using the GIS. ETOPO1 global relief model (Amante and Eakins, 2009) and A Global Self-consistent, Hierarchical, High-resolution Geography Database (GSHHG) (Wessel and Smith, 1996) data were also used in the maps. The UTM zone 55N projection was used for the mapping.

Results

All strata

The surveyed tracklines and the sighting positions of minke whales were overlaid on the SST maps (Fig. 2), as were the positions of the saury fishing boats (Fig. 3). These maps indicated an increase in the overall SST in the survey area during the course of the survey period from 2002 to 2006. Mean SST was found to have risen from 16.6°C in 2002 to 19.5°C in 2006 (Table 1). The frequency of the number of minke whale sightings with respect to SST (1°C increments) is shown in Fig. 4. During the four survey years, the mean SST at sightings positions was 15.5°C (CV=12.4%, n=87), whereas that in the years 2002, 2004, 2005, and 2006 was 14.3°C (CV=8.0%, n=38), 15.4°C (CV=4.5%, n=17), 15.6°C (CV=8.4%, n=20), 19.1°C (CV=6.0%, n=12), respectively (Table 1). Correspondingly reductions in the DIs, abundance, and saury consumption of minke whales were detected from 2002 to 2006. The frequency of the number of saury fishing boats with respect to SST (1°C increments) is shown in Fig. 5. Mean SST at the fishing positions of saury fishing boats over the four survey years was 15.1°C (CV=10.2%, n=2,646), whereas that in 2006 was 16.4°C (CV=10.3%, n=450) (Table 1). Notably, there were fewer boats fishing for saury in 2006. The frequency of area (n.mile^2) of SST ≤16°C and >16°C in all survey strata in September 2002, 2004, 2005, and 2006 is summarized in Table 1. Given that over the four survey years, the mean SST at the sighing positions of minke whales was 15.5°C, a temperature of 16°C was set as a cutoff point. From 2002 to 2006, a contraction

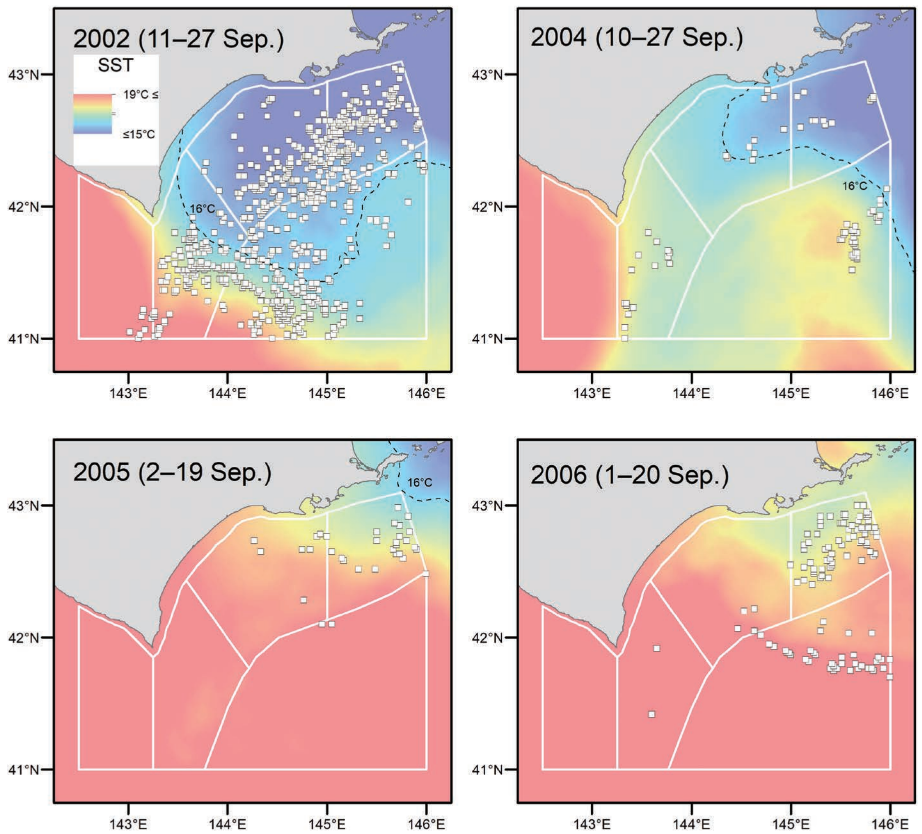

Fig. 3. The fishing positions of commercial Pacific saury fishing boats (open squares) off the coast of southeastern Hokkaido, Japan, in September 2002, 2004, 2005, and 2006. The monthly mean sea surface temperatures (SSTs) derived from GHRSST are also shown. Dashed black lines represent the 16°C isotherms, and white lines indicate the boundaries between strata.

Table 1. Summary of the September sightings and Pacific saury consumption of common minke whales, sea surface temperatures (SST) derived from GHRSST, and commercial Pacific saury fishing boats in the survey area. The density index (DI) indicates the number of schools/individuals per 100 n.miles. Values for the abundance and Pacific saury consumption of minke whales were obtained from Hakamada *et al.* (2009) and Tamura *et al.* (2009). Note that data for Pacific saury consumption are only available for "All strata".

Year	Common minke whale sightings & saury consumption									SST in survey blocks (GHRSST)				Commercial Pacific saury boats	
	Effort (n.miles)	Sch.	Ind.	Mean SST (°C)	DI (Sch.)	DI (Ind.)	Abundance Ind.	Abundance CV	Saury consumption (mt)	Mean °C	Mean CV	Area ≤16°C (%)	Area 16°C< (%)	Number of boats	Mean SST (°C)
All strata															
2002	681.5	38	40	14.3	5.6	5.9	601	0.4	861	16.6	9.8	46.5	53.5	1,815	14.8
2004	809.4	17	18	15.4	2.1	2.2	368	0.4	1,075	17.1	6.6	17.0	83.0	256	14.9
2005	827.1	20	21	15.6	2.4	2.5	316	0.4	39	19.1	4.6	0.0	100.0	125	15.5
2006	994.0	12	12	19.1	1.2	1.2	241	0.4	153	19.5	5.8	0.0	100.0	450	16.4
C stratum															
2002	272.6	33	34	14.4	12.1	12.5	323	0.2	—	15.1	2.3	100.0	0.0	403	14.6
2004	238.7	12	13	15.5	5.0	5.4	175	0.4	—	16.2	2.6	30.2	69.8	36	15.0
2005	365.3	10	11	15.4	2.7	3.0	81	0.7	—	18.5	2.0	0.0	100.0	47	15.0
2006	247.4	5	5	18.7	2.0	2.0	75	0.4	—	18.6	4.1	0.0	100.0	25	15.7
E stratum															
2002	73.5	5	6	13.8	6.8	8.2	117	1.1	—	15.0	3.4	100.0	0.0	431	14.2
2004	140.6	1	1	15.1	0.7	0.7	16	1.1	—	15.4	3.9	83.9	16.1	56	15.0
2005	127.7	9	9	15.3	7.0	7.0	135	0.3	—	17.8	4.3	0.0	100.0	81	15.5
2006	145.0	5	5	18.9	3.4	3.4	65	0.7	—	17.8	2.7	0.0	100.0	324	16.5
W stratum															
2002	48.2	0	0	—	0.0	0.0	0	0.0	—	17.1	7.1	28.2	71.8	305	15.2
2004	164.9	3	3	14.9	1.8	1.8	52	0.4	—	17.1	2.2	0.0	100.0	59	15.6
2005	180.3	1	1	20.7	0.6	0.6	15	1.1	—	19.1	1.5	0.0	100.0	0	—
2006	161.9	1	1	20.0	0.6	0.6	19	0.9	—	19.7	1.5	0.0	100.0	4	16.7
O stratum															
2002	287.2	0	0	—	0.0	0.0	0	0.0	—	16.5	4.7	29.2	70.8	664	15.0
2004	265.2	1	1	17.4	0.4	0.4	27	1.0	—	17.2	3.1	3.9	96.1	105	14.5
2005	41.7	0	0	—	0.0	0.0	0	0.0	—	19.3	1.1	0.0	100.0	7	18.1
2006	285.3	0	0	—	0.0	0.0	0	0.0	—	20.1	4.4	0.0	100.0	98	16.2
H stratum															
2002	—	—	—	—	—	—	—	—	—	19.6	3.2	0.0	100.0	17	16.9
2004	—	—	—	—	—	—	—	—	—	19.1	2.1	0.0	100.0	0	—
2005	112.1	0	0	—	0.0	0.0	0	0.0	—	20.7	2.1	0.0	100.0	0	—
2006	154.4	1	1	21.3	0.6	0.6	18	1.0	—	20.4	2.0	0.0	100.0	0	—

in the size of the area with an SST ≤16°C was recorded, with none of the areas having an SST of less 16°C in 2005 and 2006.

Coastal-Center (C) stratum

Overall patterns of SST distribution, sightings of minke whales, and the positions of saury fishing boats in the C stratum were similar to those characterizing the entire survey area (Table 1). Most of sightings during surveys were found in this stratum. Over the four survey years, the mean SST recorded at the positions of minke whale sightings in this stratum was 15.1°C (CV=10.1%, n=60), whereas in 2006 it was 18.7°C (CV=3.9%, n=5). Comparatively, the mean SST at the fishing positions of commercial saury boats during these 4 years was 14.7°C (CV=7.4%, n=511), and that in 2006 was 15.7°C (CV=0.8%, n=25). The location of the 16.0°C isotherm SST front indicated that SST in the entire stratum was lower than 16.0°C in 2002, whereas in 2004, the temperature in only a small portion of the eastern part of the stratum was lower than this value (Fig. 2). Contrastingly, in 2005 and

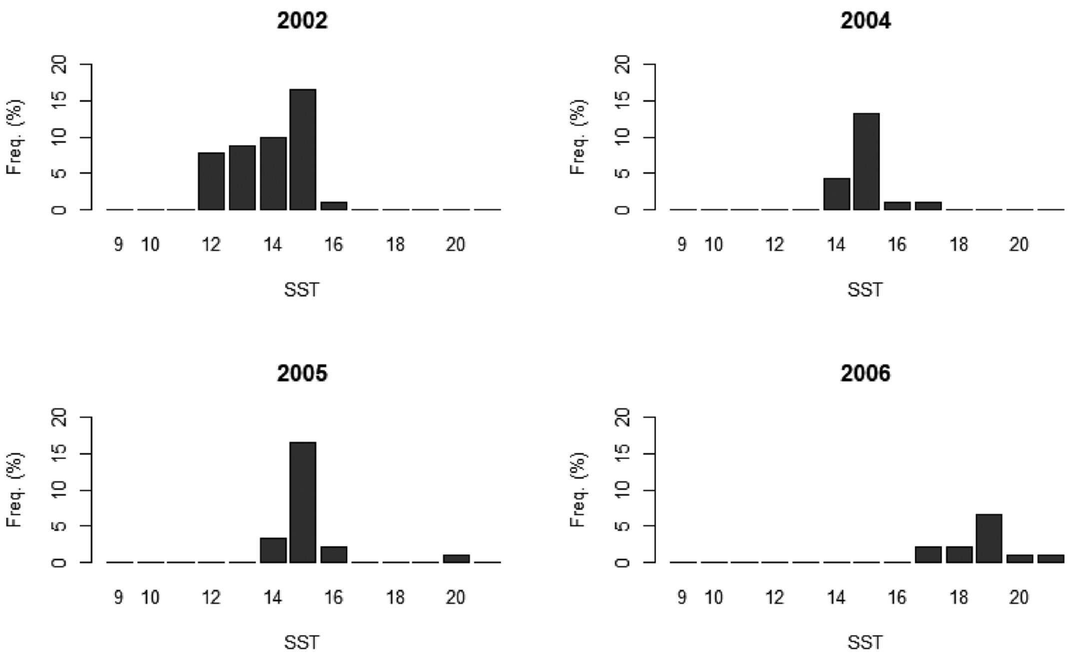

Fig. 4. Frequency of the number of common minke whale sightings according to sea surface temperature (SST: 1°C increments) in all surveyed strata off the coast of southeastern Hokkaido, Japan, in September 2002, 2004, 2005, and 2006. Data from all the years are pooled to calculate the frequency. SSTs recorded at sighting positions were used.

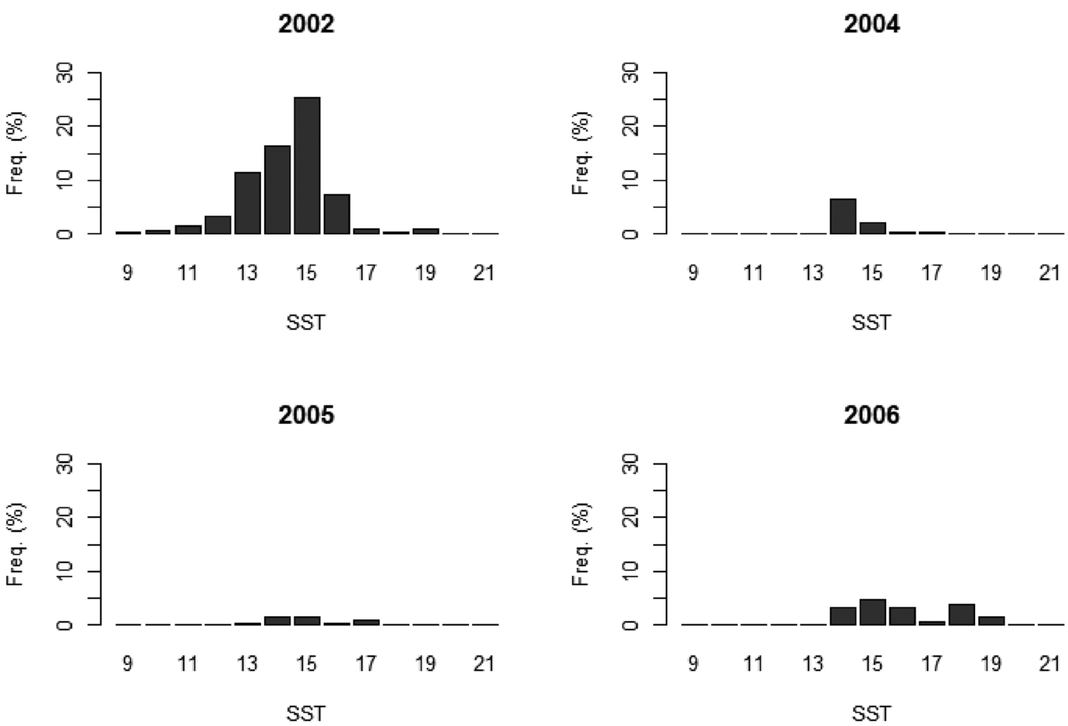

Fig. 5. Frequency of the number of commercial Pacific saury boats according to sea surface temperature (SST: 1°C increments) in all surveyed strata off the coast of southeastern Hokkaido, Japan, in September 2002, 2004, 2005, and 2006. Data from all the years are pooled to calculate the frequency. SSTs recorded at the positions of boats were used.

2006, no evidence of a 16.0°C isotherm SST front in this stratum was detected. Corresponding to an increase in the mean SST of this stratum from 2002 to 2006, a reduction in DI values was detected, and similarly a reduction in the frequency of SST ≤16°C during this period was recorded (Table 1).

Strata other than the C stratum

Compared with the C stratum, fewer sightings were made in the O and H strata, where mean SSTs were high regardless of the year of survey (Table 1). In the W stratum, the DIs and abundance were highest in 2004, coinciding with a period during which an area of relatively low SST extended over the stratum (Fig. 2), giving rise to the lowest (Table 1) and spatially homogeneous (Fig. 2) SST. Contrastingly, in the E stratum, DIs and abundance were the lowest in 2004. With respect to other survey years, the W stratum was found to be characterized by homogeneously high SSTs in 2005 and 2006 and a marked 16.0°C isotherm SST front in 2002, whereas in 2005 and 2006, DIs and abundance in the E stratum were higher than those in the C stratum.

Discussion

The mean SST (15.1°C) recorded at the positions of minke whale sightings in the C stratum lies within the range of 7 to 17°C that has previously been reported for sightings of this species in the western North Pacific (Matsuoka *et al.*, 2000). Notably, relatively few minke whales were sighted in the C stratum when the SST was higher than 16.0°C, and thus it is conceivable that the distribution of minke whales is limited to within the SST range reported by Matsuoka *et al.* (2000). Consistent with findings in the present study, Watanabe *et al.* (2006) have reported that mode SST at the saury fishing boat positions was 15.0°C. Consequently, it would appear that minke and saury have a similar suitable range of SSTs. In this regard, it has been reported that the timing and route of the saury migration from northern waters to those off the southeastern coast of Hokkaido show considerable changes coinciding with annual fluctuation in oceanographic conditions (Fukushima, 1979; Yasuda and Kitagawa, 1996; Yasuda and Watanabe, 1994).

Historical commercial catch data indicate that the migration and spatial distribution of minke whales in the western North Pacific differ with respect to sex and maturation stage (Hatanaka and Miyashita, 1997; Ohsumi, 1983; Omura and Sakiura, 1956; Wada, 1989). The findings of JARPN II in the C stratum have revealed that immature individuals are generally distributed in coastal waters whereas mature males tend to be found at both coastal and offshore waters (Kishiro *et al.*, 2009). In this regard, it has been suggested that mature minke whale males showed prey preference for saury over other species, such as krill and walleye pollock (Kishiro *et al.*, 2009). The number of mature males in the C stratum during the period of the JARPN II survey declined from 2002 to 2006 (Kishiro *et al.*, 2009), coinciding with the decline of DIs and abundance reported in this study.

At least two different stocks of minke whales have been identified in the waters around Japan, namely the J and O stocks (Goto and Pastene, 1997; Kato, 1992; Ohsumi, 1977; Omura and Sakiura, 1956; Pastene *et al.*, 2007; Wada and Numachi, 1991). Of these, O stock is mainly distributed in the waters of the western North Pacific, whereas J stock is mainly distributed in the Sea of Japan, although it has been reported that a small proportion of this stock mixed with O stock off the southeastern coast of Hokkaido (Pastene *et al.*, 2016). Although the exact route whereby mature O stock males migrate is still under investigation, it is evident that during the summer months, at least a proportion of these individuals migrates northward in offshore regions of the western North Pacific (e.g., east of 150°E) (Zenitani *et al.*, 2000). Moreover, it seems probable that during autumn, they migrate southward along the coastal region of Japan, including waters off the southeastern coast of Hokkaido in autumn. The migration timing and route of mature male minke whales would thus appear to be similar to that of the saury, and indeed, these whales are known to feed on saury in both offshore regions and the waters off southeastern coast of Hokkaido (Lindstrøm *et al.*, 1998; Tamura *et al.*, 1998).

Findings in the present study provide evidence in support of the hypothesis that the migration route of mature male minke whales coincides with a suitable SST (approximately 15°C) and the migration of their primary prey species, the saury. In the C stratum, these mature males could make a high contribution to the observed changes in DIs and abundance. For example, in response to a suitable SST and an abundance of saury (as in 2002), many mature males could migrate into the stratum, whereas in contrast, when SSTs exceed a suitable level, and the availability of saury is low (as in 2006), there would be relatively few migrants in this stratum.

Collectively, the findings of this study indicate that the abundance of minke whales in a particular area is influenced to varying extents by changes in oceanographic conditions and the availability of prey. In this regard, abrupt changes in the abundance of minke whales have been reported in other regions of the world. For example, changes in abundance of this species in Icelandic waters have been linked to changes in oceanographic conditions and the patterns of prey species distribution (Víkingsson *et al.*, 2015). Consequently, to gain a reasonably clear understanding of the factors underlying such changes, analyses of whale sighting data should simultaneously take into consideration data obtained for a range of environmental variables, thereby enabling us to distinguish between apparent and absolute changes in abundance.

A stock assessment for a time series between 1980 and 2018, revealed that the overall abundance of saury was generally high during the period covered by the present study (2002–2006) (4th Meeting of the Technical Working Group on Pacific Saury Stock Assessment, 2019). Furthermore, the findings of a population dynamics study appear to indicate no abrupt change in abundance of the O stock of minke whales during the period between the 1990s and 2010s (Kitakado and Maeda, 2016). On the basis of these findings, it can be concluded that observed changes in the abundance of minke whales in waters off the southeastern coast of Hokkaido between 2002 and 2006 were apparent rather than actual changes, attributable to annual variations in oceanographic conditions. These variations similarly influence the route and timing of saury migrations. It seems probable that the apparent change in the abundance of minke whales coincided with changes in local oceanographic conditions and the availability of saury. It was reported that contractions in the size of potential saury fishing grounds off southeastern Hokkaido were associated with increases of SST and sea level anomaly, a reduction in chlorophyll concentration, an increase in the frequency of clockwise eddies, and a reduction in Oyashio transport (Kuroda and Yokouchi, 2017). It should be noted that the abundance index of saury in the present study area in August and September was high in 2002, although low between 2004 and 2006 in response to the environmental conditions (Kuroda and Yokouchi, 2017).

Nevertheless, given that minke whales also consume other prey items, such as Japanese anchovy, walleye pollock, and Japanese common squid (Tamura *et al.*, 2009), the interrelationships among minke whales, their prey, and oceanographic conditions in this region might be more complex than hitherto assumed. In this context, minke whales in the surveyed region have in the past fed on Japanese sardine and mackerel when the abundances of these prey were high (Kasamatsu and Tanaka, 1992). However, it has yet to be ascertained how the minke whale distribution changes in response to the replacement of pelagic fish species, along with changes in oceanographic conditions. Accordingly, long-term monitoring of both the whales and their prey, together with oceanographic conditions, will be necessary to gain a realistic insight into the factors underlying changes in the distribution of minke whales in the waters off southeastern Hokkaido.

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Short note

Surface feeding of a sei whale, North Pacific.

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PRELIMINARY REPORT ON THE CRANIAL MEASUREMENTS OF A BRYDE'S WHALE STRANDED IN FAILAKA ISLAND, KUWAIT IN 2014

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Abstract

On 28 February 2014, a dead baleen whale was stranded and found by residents on the east coast of Failaka Island, Kuwait. The specimen was a female with a total length of 14 m. After muscle and internal organ removal and sample collection, the remains of this animal were buried *in situ*. The Japanese authors of this paper visited Failaka Island to check the condition of the skeleton after about nine months since the stranding event. A total of 44 measurements, including condylobasal length, were made from the dorsal side of the skull. Skull length was 3.222 m, which represented 26.85% of the body length. The skull of the specimen possesses diagnostic characteristics of Bryde's whale, such as the outer edge of the rostrum being rounded and flattened in dorsal and lateral views, respectively. The number of ribs were 13 on the left, and 12 on the right side. The skeleton was reburied to allow natural decomposition of the remaining soft tissue. As of 2022 we have not been able to excavate this skeleton, but we hope to do so in the near future and hope the specimen will be properly catalogued and permanently stored at some museum or institution in Kuwait.

Key words: Skeletal measurement, Balaenopteridae, Bryde's whale, *Balaenoptera edeni* morphometric, large whale.

The Bryde's whale *Balaenoptera edeni* Anderson, 1879, is a medium-sized balaenopterid with a total length of about 13 to 15 meters. While most baleen whales have a clear seasonal migration and antitropical distribution, the Bryde's whale inhabits tropical and warm temperate waters of the Indian, Pacific, and Atlantic Oceans of 40°N to 40°S with a circannual water temperature of 16.3°C or warmer (Kato and Perrin, 2018).

Two genetically and morphologically distinct populations exist within this species, namely *B. edeni brydei* (Olsen, 1913) and *B. edeni edeni* (Committee on Taxonomy, 2022). *Balaenoptera e. brydei* is larger and inhabits offshore waters, whereas *B. e. edeni* is smaller and found closer to shore (Wada *et al.*, 2003; Sasaki *et al.*, 2006; Kanda *et al.*, 2007; Kato and Perrin, 2018; Committee on Taxonomy, 2022). In recent years, some scientists have suggested that these two populations should be separated at the species level and named as *B. brydei* and *B. edeni*, but no agreement has been reached yet (Rosel *et al.*, 2021). In 2021 Bryde's-like whales from the northern Gulf of Mexico were described as a new species, *B. ricei* (Rosel *et al.*, 2021).

Morphological information, such as external and skeletal characteristics, is one of the essential taxonomical traits along with genetics to determine cetacean species. However, for large whales such as

Bryde's whales, the number of available skeletal specimens is small and makes a significant challenge for taxonomic studies. Although several sightings and strandings of Bryde's whale have been reported from the Arabian Sea and adjacent waters, the number of skeletal specimens of this species is limited. Only five skeletal remains of Bryde's whale have been reported from the Iranian coast of the Arabian (Persian) Gulf and the Gulf of Oman since 1971 (Braulik *et al.*, 2010). Some of the other Bryde's whales strandings from the Arabian (Persian) Gulf include the following: (1) a 12.5 m male stranded at Qasr, Iraq on 5 February 1967 (Al-Robaae, 1967, Mahdi, 1967), (2) a 14.5 m individual stranded near the ARAMCO causeway at Abu Ali Island, Saudi Arabia in March 1995 (Robineau and Fiquet, 1996), and (3) a dead specimen stranded in May 1995 at the Saudi Arabia-Bahrain causeway (Robineau and Fiquet, 1996).

Stranding events are the only way of obtaining skeletal specimens of large whales in areas where whaling is not conducted. However, especially in the case of large whales, they are not always collected from all stranded animals due to the high cost of cleaning, preparing and maintaining such skeletal specimens and the problem of securing storage space. Therefore, the number of scientifically valuable skeletal specimens available for academic research is limited.

In early 2014, a baleen whale was stranded on Failaka Island in Kuwait. This animal was buried after being examined by local scientists. About nine months later, following the request of a Kuwait scientific institute to make a skeletal specimen, the whale carcass was temporarily dug out to verify its conditions and to conduct preliminary research on skeletal measurements by Japanese researchers. As of 2022, the skeleton has not yet been excavated for various reasons. However, the data obtained from our brief examination are valuable to further understand the ecology of the Bryde's whale. Therefore, they are provided in this preliminary report.

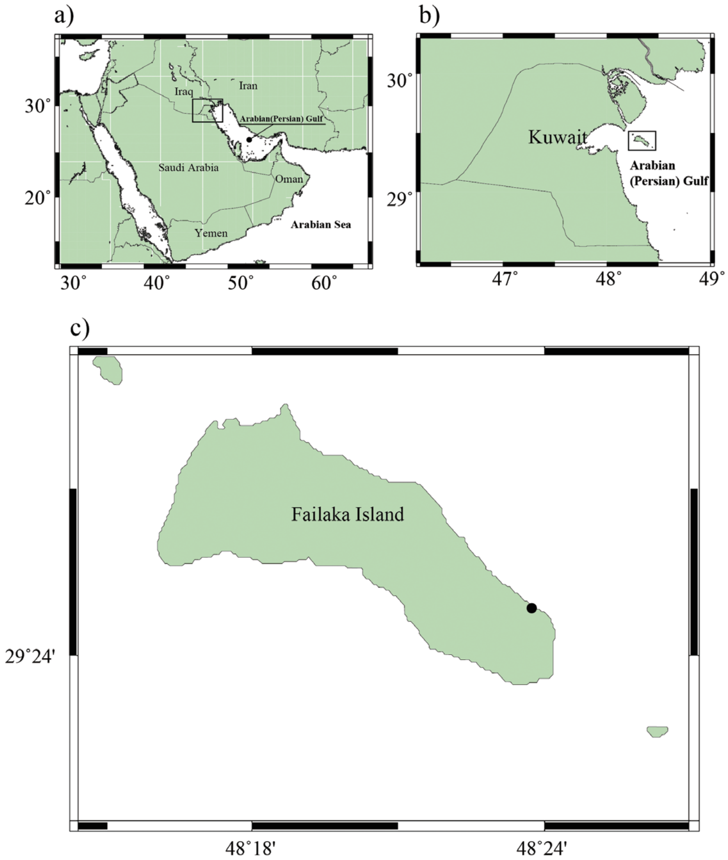

Fig. 1. Location of the Bryde's whale that stranded in 28th February, 2014. a) Wider area map, around the Arabian (Persian) Gulf. b) Map showing the position of Kuwait and Failaka Island. c) Failaka Island map. The black circle indicates the Bryde's whale stranding location.

Fig. 2. December 2014 excavation of the Bryde's whale to check the skeletal conditions and to conduct scientific observations.

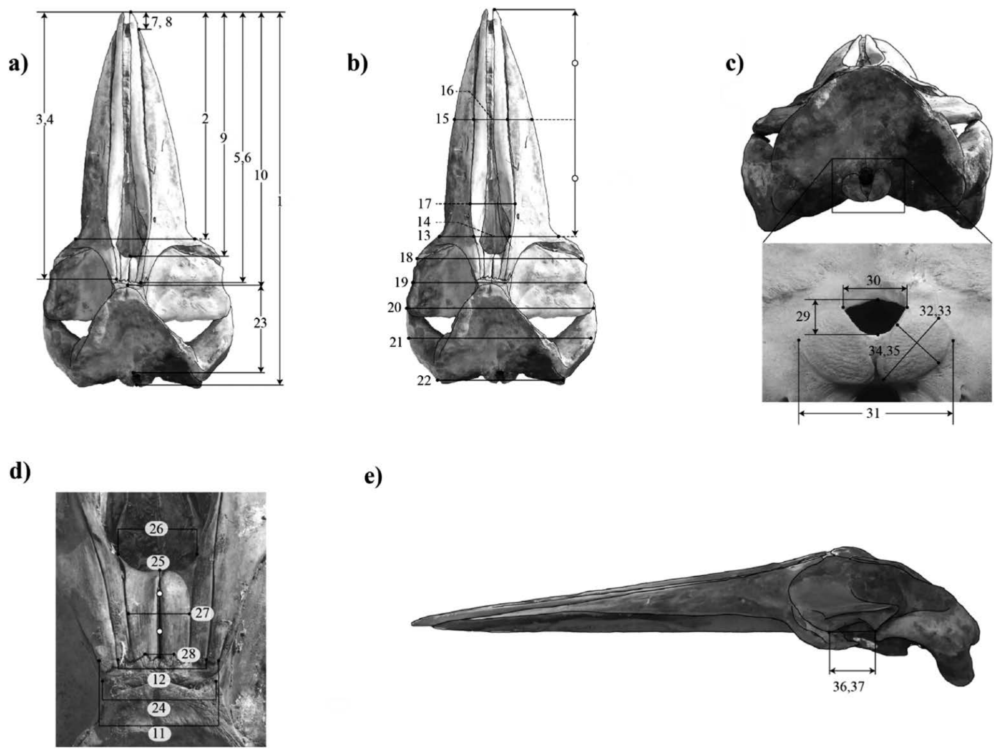

Fig. 3. Cranial measurement points and values of the Bryde's whale stranded in Failaka Island, Kuwait, in February 2014. a) and b) dorsal view, c) caudal view, d) dorsal view of the vertex, and e) lateral view of the skull. For measurement point explanation and values, see Table 1.

On 28 February 2014, a dead baleen whale was found stranded by residents on the east coast of Failaka Island (29°24′50.9″N, 48°23′44.86″E), Kuwait. This island is located about 20 km off the coast of Kuwait City, in the northern part of the Arabian (Persian) Gulf (Fig. 1). In response to the stranding report, on 1 March 2014 Kuwaiti researchers visited the site to examine the carcass and to make an assessment on the possible causes of the whale's death. After their conducting external measurements followed by autopsy and examination of the internal organs, this animal was initially identified as a fin whale having a body length of 14 m (Khalaf, 2014). After sample collection and removal of muscles

Table 1. Cranium measurements of the Bryde's whale stranded in Failaka Island, Kuwait, in 2014.

No.	Measurement points	cm
1.	Condylobasal length	322.2
2.	Length of rostrum	209.1
3.	Length of premaxillary (L)	245.7
4.	Length of premaxillary (R)	246.7
5.	Length of maxillary (L)	227.5
6.	Length of maxillary (R)	227.5
7.	Tip of premaxillary to tip of maxillary (L)	20.0
8.	Tip of premaxillary to tip of maxillary (R)	19.7
9.	Tip of premaxillary to nares, anterior	224.2
10.	Tip of premaxillary to vertex	248.7
11.	Breadth of maxillary, posterior edge	23.6
12.	Breadth of premaxillary, posterior edge	17.4
13.	Breadth of rostrum at base	90.5
14.	Breadth of premaxillary at base	29.3
15.	Breadth of rostrum at middle	63.3
16.	Breadth of premaxillary at middle	28.8
17.	Greatest breadth of premaxillary	34.2
18.	Breadth of cranium, maxillary	135.6
19.	Breadth of cranium, middle of orbital foramen	134.8
20.	Breadth of cranium, anterior edge of zygomatic process	146.6
21.	Breadth of cranium, middle of zygomatic process	145.6
22.	Breadth of occipital bone	97.0
23.	Length from upper ridge of foramen magnum to superior part of occipital bone	71.4
24.	Minimum breadth of parietal bone	23.4
25.	Length of nasals	22.2
26.	Breadth of nasals, anterior	17.6
27.	Breadth of nasals at middle	13.1
28.	Breadth of nasals, posterior	5.8
29.	Height of foramen magnum	10.0
30.	Breadth of foramen magnum	7.3
31.	Breadth across occipital condyles	25.6
32.	Breadth of occipital condyle (L)	11.3
33.	Breadth of occipital condyle (R)	11.4
34.	Height of occipital condyle (L)	17.4
35.	Height of occipital condyle (R)	18.2
36.	Breadth of orbit (L)	24.0
37.	Breadth of orbit (R)	23.3

and internal organs, the remaining parts of the animal were placed in a pit four to six meters deep and buried in the sand.

From 20 to 22 December 2014, the authors of this paper visited Failaka Island to unbury and check the skeleton's condition and to obtain photographic and measurement records (Fig. 2). The left flipper was first excavated. The orientation of finger bones was photographed and traced with a clear plastic sheet. The soft tissue was almost decomposed and liquefied but still remained within the finger bones. As regards the rest of the skeleton, the residual muscle and fatty tissue had not completely decomposed and were still remaining, especially at the underside of the bones. Ribs, cervical, and dorsal ver-

Fig. 4. Dorsal (a) and lateral (b) view of the skull. Note that ventral part of the skull is filled with sand. The scale bar indicates 1 meter.

tebral bones were assigned numbers and labeled with plastic tags. The remnant bones (right flipper's, vertebrae, ribs, and chevrons) were also collected. Measurements and photographic records were taken of the skull for the purpose of academic use before burying them again. Except for the pelvic bones and some (maybe three to five) tips of the right finger bones and the left tympanic bulla, all skeletal parts have been collected. About 17 neural spines of the dorsal and lumbar vertebras were broken. This would probably have been caused by the following reasons: first, that the spines were also decaying within the flesh, which was not removed completely. And a second reason may be the neural spines' position, which stayed level and under pressure from the above sand.

A total of 44 measurements, including skull length, were taken from the dorsal side of the cranium. The skull length (condylobasal length) was 3.222 m, which represented 26.85% of the specimen's body length (Fig. 3, Table 1). Omura (1959) compared the osteological characteristics of Bryde's and sei (*B. borealis*) whales. The skull shape of the animal possesses diagnostic characteristics of Bryde's whale, such as the outer edge of the rostrum being rounded and flattened in dorsal and lateral view, respectively, which was reported by Omura (1959) (Fig. 4). Numbers of ribs were 13 and 12 in left and right, respectively. The 13th left rib was separated into two pieces (not broken). The vertebral formula was as follows:

$$\mathrm{C7}+\mathrm{D13}+\mathrm{L13}+\mathrm{Ca17}+\alpha.$$

After measuring and photographing the skull, the skeletal pieces were transported from Failaka Island to a protected area on mainland Kuwait and buried again. This will allow the remaining soft tissues still attached to the bones to decompose so that a skeletal specimen of this animal may be prepared later on. We hope to do so in the near future so that this scientifically valuable specimen may be permanently stored in a museum or another appropriate institution in Kuwait.

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DWARF MINKE WHALE (*BALAENOPTERA ACUTOROSTRATA* SUBSP.) INTERACTIONS WITH VESSELS OFF THE COAST OF BRAZIL

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Abstract

The dwarf minke whale (*Balaenoptera acutorostrata* subsp.) is a hard to detect small baleen whale whose behavior towards vessels and man-made structures in South Atlantic waters is still not well characterized. This study compiles records on the behavior of this species in Brazil, employing citizen science reports and data from ship and sailboat surveys. A total of 16 records were obtained from 2001 to 2021. The data indicate a consistently curious approach toward boats (81.25% of all identified behaviors). Other identified behaviors included traveling/fleeing (6.25%), and breaching (6.25%). These assessments comprise valuable tools for field identification of this species, as color patterns may become exposed during different aerial displays. This is the first approach to understand the ephemeral behavior of the dwarf minke whale along the southeastern coast of Brazil.

Key words: Mysticetes, dwarf minke whale, *Balaenoptera acutorostrata* subsp., anthropogenic activities, behavioral responses.

Nine baleen whale species comprise the *Balaenoptera* genus, including the common minke whale (*B. acutorostrata*) (Wada *et al*., 2003; Rosel *et al*., 2021), the smallest of all (Stewart *et al*., 2002). This species is further categorized into three subspecies, the North Atlantic common minke whale (*B. acutorostrata acutorostrata*), the North Pacific common minke whale (*B. acutorostrata scammoni*), and a Southern Hemisphere, still unnamed subspecies generally referred to as the dwarf minke whale (*B. acutorostrata* subsp., Best, 1985), whose geographical distribution encompasses tropical, temperate, and polar waters of the South Atlantic, South Pacific, and Indian Oceans (NOAA Fisheries, 2022).

A clear taxonomical separation between the dwarf minke whale and the Antarctic minke whale (*B. bonaerensis*) is noted, as well as differences in size and coloration (Best, 1985; Arnold *et al.*, 1987). Furthermore, genetic evidence suggests a separation between the Western South Atlantic and Western South Pacific dwarf minke whale populations (Pastene *et al.*, 2010; Milmann *et al.*, 2021). However, both species can reach similar sizes, depending on their age class, exhibiting certain common morphological traits, such as a third white shoulder patch near the fluke insertion (da Rocha and Braga, 1982; Secchi *et al.*, 2009; Milmann *et al.*, 2018) that hinder their field identification in geographical areas where they can be sympatric. This is of significant interest, as the International Union for Conservation of Nature categorization of “Least Concern” refers to all *B. acutorostrata* subspecies, with no specific separate category assigned to dwarf minke whales, and is based on estimates from parts of the species range in the Northern Hemisphere only (The Minke Whale Project, 2022). The species, however, is at risk for several threats common to other whale species, comprising entanglement in fishing gear, ocean noise, vessel strikes and climate change effects (NOAA Fisheries, 2022).

Concerning behavior, common minke whales have been known to swim close to ships (Leatherwood *et al.*, 1976), while dwarf minke whales have been known to voluntarily approach dive tourism vessels and passengers and maintain contact for prolonged periods off Australia’s Great Barrier Reef, in the Western South Pacific (Arnold *et al.*, 1987; Mangott *et al.*, 2011). Very limited information on this species behavior and reactions to vessels and man-made structures is, however, available, especially for Western South Atlantic waters.

In this regard, dwarf minke whales appear in most lists and reviews concerning stranded or opportunistically sighted cetaceans off the coast of Brazil (Geise and Borobia, 1988; Simões-Lopes and Ximénez, 1993; Magalhães *et al.*, 2008; Zerbini *et al.* 1996, 1997; Santos *et al.*, 2010; Costa *et al.*, 2017; Mayorga *et al.*, 2020), and dedicated surveys on land, oil platforms and at sea, have proven invaluable in detecting this species off the coasts of the states of Rio de Janeiro (Hassel *et al.*, 2003), Santa Catarina (Cremer *et al.*, 2009), São Paulo (Santos *et al.*, 2019; Figueiredo *et al.*, 2020) and in Northeastern Brazil (Zerbini and da Rocha, 1999). Incidental dwarf minke whale entanglements in fishing gear have also been reported in the state of Rio Grande do Sul, Southern Brazil (Secchi *et al.*, 2003). See Milmann *et al.* (2020) for a recent compilation on minke whale stranding records off the coast of Brazil.

Concerning general dwarf minke whale behavior, it has been reported interacting with other species, such as humpback whales (*Megaptera novaeangliae*) and small odontocetes like bottlenose dolphins (*Tursiops truncatus*) and rough-toothed dolphins (*Steno bredanensis*) off the state of Bahia, Northeastern Brazil (Rossi-Santos *et al.*, 2006). Data on reactions to anthropogenic activities for this species off the coast of Brazil, however, are sorely lacking. In this regard, one of the few studies available indicates that dwarf minke whales can swim close to offshore structures, as reported by Cremer *et al.* (2009) for Southern Brazil, as well as near tourist and fishing boats, during feeding in the summer in coastal waters off Arraial do Cabo, in Southeastern Brazil (Hassel *et al.*, 2003). Another, ethnobiological approach study conducted off the central Bahia coast, in Northeastern Brazil, described dwarf minke whale (locally known as “*tauaçu*”) interactions with fisheries activities, noting that fishers there believe that the minke whale attacks people, mainly due to its vessel-approaching behavior, and, in this regard, they may have negative attitudes reflected in behaviors that can harm these animals (Seminara *et al.*, 2019).

In this context, it is relevant to report unpublished records concerning dwarf minke whale approaches to vessels and interactions with other man-made structures off the coast of Brazil. This study, therefore, compiles unpublished records from multiple sources on dwarf minke whale reactions to human activities along the SE and NE Brazilian coastlines. The categorized reactions motivated by human activities follow Watkins (1986) for four baleen whales (common minke whale, fin whale *B. physalus*, northern right whale *Eubalaena glacialis* and humpback whale *M. novaeangliae*), defined as Positive (P), Uninterested (U) and Negative (N). "Positive" reactions include apparent curiosity to the presence of the vessel, "Uninterested" reactions comprise events in which stimuli were apparently ignored, and the whales continued their activities uninterruptedly, and "Negative" reactions include sudden changes in behavior (*e.g.*, activity to inactivity, inactivity to activity, or changes in activity). Behaviors that were not clearly identified as P, U, or N, or that could not be identified due to lack of information, were classified as Undetermined (Und).

A total of 16 dwarf minke whale records concerning reactions to anthropogenic activities were obtained for Brazil, comprising 13 positives (boat attraction), two negatives (traveling/fleeing and intensive breaching), and one undetermined. These behaviors were identified by both research (n=9; platform D) and platform of opportunity vessels (n=5; platform C), as well as literature reports (n=2; platform L). Geo-referenced available records are listed in Table 1 and depicted in Fig. 1. Sightings from dedicated surveys were performed by experienced observers when the boats were in motion, while "platform C" refers to opportunistic sightings with or without the boat in motion. Remarkably, the only two cases of negative behavior were recorded from opportunistic platforms, which could be related to a sudden movement of the boat towards the animal or even a sudden stop from the boat for observation.

Dwarf minke whales off the coast of Brazil are seemingly very inquisitive, similar to behavior observed in Australia, where whales voluntarily approach dive tourism vessels and passengers and maintain contact for prolonged periods of time (Mangott *et al.*, 2011). This behavior was detected in two areas in Brazil, along the Northeastern coast for both Antarctic and dwarf minke whales, and in Campos Basin, in Southeastern Brazil, where whales approached vessels curiously after perceiving them and remained immobile while the vessels passed by. This curious approach towards vessels may comprise a valuable tool to detect and identify dwarf minke whales in the field, considering their lower detectability when compared to other baleen whales (Zerbini *et al.*, 2006; Martin *et al.*, 2013) due to their smaller size and almost undetectable respiratory blow in tropical areas.

The traveling/fleeing behavior reported herein has been described as depending on the number of whales in the group and type of group (Argüelles *et al.*, 2022). This behavior has been noted for other whale species, such as blue whales (*B. musculus*) (McKenna *et al.*, 2015), and southern right whale mother-calf pairs or solitary individuals (Argüelles *et al.*, 2022), where whales dive to deeper depths when at the surface or delay their surfacing following a diving period when near ships. However, avoidance behavior seems to be species-specific to a certain extent (Argüelles *et al.*, 2022), and the low number of records reported herein for this category may seem to indicate low dwarf minke whale sensitivity to vessels, potentially increasing vessel collision events and comprising a threat to the species.

Finally, the breaching behavior is more frequent in certain species, such as humpback and right whales (Segre *et al.*, 2020), and rarer in others, like fin whales (Aguilar and García-Vernet, 2018). Dwarf minke whales do not usually exhibit this behavior, although some records are available in the literature (Arnold and Birtles, 1999; Segre *et al.*, 2020). Concerning the present study, breaching was observed for one dwarf minke whale individual, which breached 17 times in a period of 15 minutes (13 h35 to 13 h50) on 1 May 2020 off Ilha de São Sebastião, in SE Brazil (Fig. 2). This high number of breaches in such a small period of time is likely to add up to a significant amount of spent energy, as breaching comprises a high energy expenditure in whales (Segre *et al.*, 2020), potentially associated with vessel proximity. However, ultimately, the reasons for this behavior are still unknown, although some hypotheses have been put forth, such as courtship, parasite dislodgement, communication, and reactions to nearby activities, including the presence of vessels, noise, and others (Werth and Lemon, 2020). Thus, breaching behavior when noted in association with nearby vessels should be interpreted cautiously. Further, this behavior may comprise a valuable tool for dwarf minke whale identifi-

Table 1. Records from multiple sources on the 'reaction' behavior of dwarf minke whales (*Balaenoptera acutorostrata* subsp.) to anthropogenic activities. Abbreviations: Positive (P), Uninterested (U), Negative (N), Undetermined (Und), Rio de Janeiro State (RJ), São Paulo State (SP), Northeastern (NE), Bahia State (BA). Platform: C=citizen report, D=direct observation, L=literature.

Location	Platform	Date/Period	No. sightings	Behavior	Source	Latitude	Longitude
Pontal do Atalaia, Arraial do Cabo, RJ	L	2001	22	P	Hassel et al. (2003)	—	—
NE Brazil continental shelf	L	1998–2001	1	P	Zerbini and da Rocha (1999)	—	—
Campos Basin, RJ	D	13-April-2008	1	P	This study	—	—
Campos Basin, RJ	D	10-May-2008	1	P	This study	—	—
Campos Basin, RJ	D	23-May-2008	1	P	This study	—	—
Campos Basin, RJ	D	28-May-2008	1	P	This study	—	—
Campos Basin, RJ	C	23-Sep-2014	1	P	This study	—	—
Santos Basin, RJ	D	10-Mar-2020	1	P	This study	−25.72809	−46.03487
36 nm off S. Sebastião, Ilhabela, SP	C	28-April-2020	1	Und	This study	−24.39166	−45.47201
ca. Parcel da Itapecirica, S. Ilhabela, SP	C	01-May-2020	1	N	This study	−23.91270	−45.07871
8 nm off Ilhéus, BA	C	04-Jun-2020	1	P	This study	—	—
Ilha de Búzios, Ilhabela, SP	D	23-Jun-2020	1	P	This study	−23.77620	−45.07871
São Sebastião, Ilhabela, SP	C	09-Jul-2020	1	N	This study	−23.82055	−45.38898
28 nm off São Sebastião, Ilhabela, SP	D	20-Jan-2021	1	P	This study	−24.18333	−44.90000
SE offshore area, RJ	D	27-May-2021	1	P	This study	−23.65395	−40.98630
70 nm off Ilhabela. São Sebastião, SP	D	21-Nov-2021	1	P	This study	−24.56666	−44.55933

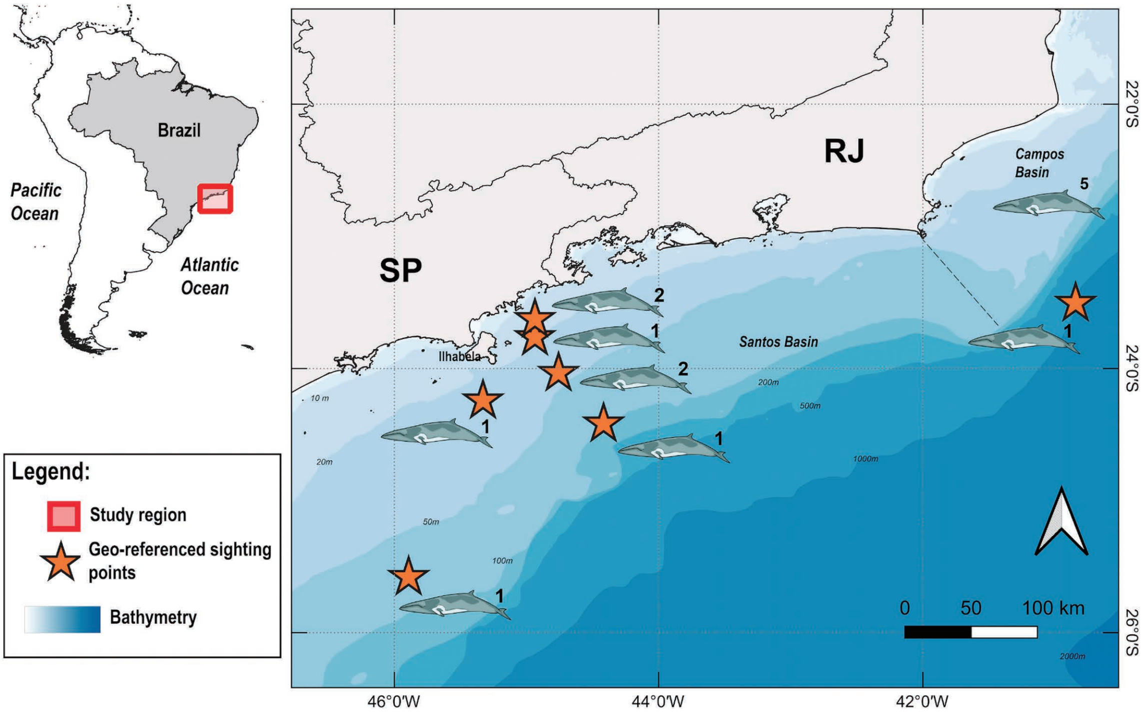

Fig. 1. Locations of the southeastern Brazil dwarf minke whale (*Balaenoptera acutorostrata* subsp.) records concerning reactions to anthropogenic activities reported in this study. The digits indicate number of records at each position. Five records at Santos Basin are not indicated by a star because location was derived from a description of the locale instead of geographic coordinates. Abbreviations: Rio de Janeiro State (RJ), São Paulo State (SP).

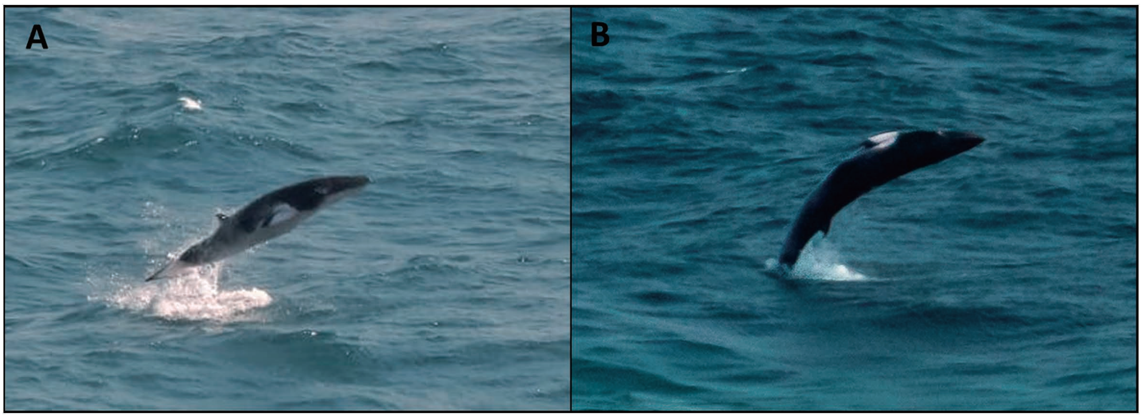

Fig. 2. Breaching behavior of a dwarf minke whale (*Balaenoptera acutorostrata* subsp.) off Ilha de São Sebastião, SE Brazil, May 2020. Photos: (A) Jurandir Paulo and (B) Frank Santos.

cation in the field, as the white patches present above the pectoral fin in this subspecies become visible during different aerial displays (see Fig. 2).

Changes in dwarf minke whale reactions to stimuli from anthropogenic activities are gradual and vary with increasing exposure periods (Mangott *et al.*, 2011). Therefore, the descriptions concerning dwarf minke whale behaviors reported herein comprise a starting point to detect potential changes over time through continuous monitoring efforts. Furthermore, it seems that dwarf minke whales display slightly more diverse behavior while in the tropics than previously described, seemingly engaging in more positive behaviors while off the Brazilian coastline, exhibiting interest in boats and potentially comprising an attraction for the whale watching industry. In addition, breaching behavior is noted as a potentially valuable tool for dwarf whale minke field identification.

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OBSERVATION OF FIN WHALE (*BALAENOPTERA PHYSALUS*) FEEDING BEHAVIOR IN THE AUSTRAL SUMMER SOUTHERN HEMISPHERE MID-LATITUDES

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Abstract

In the Southern Hemisphere, fin whales (*Balaenoptera physalus*) feed mainly in the latitudinal range between 50°S and 60°S during the austral summer. In February 2021, five fin whales were sighted about 1,000 km south of the Cape of Good Hope, South Africa at position 43°49′S, 19°12′E. Feeding behavior was evident as the whales were lunging laterally into surrounding red patches with their mouth open. Examination of sampled red patches revealed that the fin whales were feeding on either *Calanus australis* or *C. agulhensis*. This is the first report of fin whales preying on *Calanus spp.* in this sea area and time of the year.

Key words: *Balaenoptera physalus*, Southern Hemisphere, fin whale, distribution, feeding behavior.

In austral summer, fin whales (*Balaenoptera physalus*) mainly distribute in the latitudinal range between 50°S–60°S for feeding (Mackintosh, 1966; Miyashita *et al.*, 1995; Edwards *et al.*, 2015; Aguilar and Garcia-Vernet, 2018). They prey on krill, mostly *Euphausia valentini* and *E. superba*, and rarely on copepods and amphipods in the Southern Hemisphere (Kawamura, 1980). In recent years, fin whales have been reported to feed on krill between 29°S and 43°S, along the coast of Chile (Perez *et al.*, 2006; Toro *et al.*, 2016; Buchan *et al.*, 2021).

On 13 February, 2021, one school of five fin whales was first sighted at position 43°49′S, 19°12′E, approximately 1,000 km south of the Cape of Good Hope, South Africa by the captain (Nobuo Abe) on board the *Yushin Maru No.2* (747GT), a research vessel engaged in the 2020/21 austral summer survey of the Japanese Abundance and Stock-structure Surveys in the Antarctic (JASS-A; Isoda *et al.*, 2021) program. The sighting was made during the vessel's transit between the Antarctic and the home port in Shiogama, Japan.

At the time of the observations, visibility was 5 n. miles, and the wind speed was 14 knots in direction southeast. Air and sea surface temperatures were 9.9°C and 10.9°C, respectively. Each of the five whales was swimming in separate directions about 200 m apart. The behavior of two of them (designated as Whale-A and Whale-B) was observed from the upper deck of the vessel and aerial video footage was recorded using an unmanned aerial vehicle (UAV; Phantom Pro4 Ver2.0, DJI, China). The body lengths of the two whales recorded in the UAV footage were visually estimated by an experienced observer onboard: 19.7 m (Whale-A) and 19.3 m (Whale-B). The other three individuals were estimated to be 20.3 m, 18.5 m and 17.2 m, but were not videotaped because they were too spread apart to be spotted by the UAV monitor.

According to UAV observation, multiple reddish patches approximately 20–50 m long scattered on

Fig. 1. Lateral lunge feeding of a fin whale (Whale-A) with its right jaw down. A detailed behavior sequence and the shape of prey patches are shown in the supplement video.

Fig. 2. Lunge feeding of Whale-A without turning the body sideways.

the sea surface around the whales. Both whales A and B were feeding on the sea surface and no deep diving was observed. The swimming direction of Whale-B was not constant, and the feeding was made in circular movements. When the patch formed longitudinally on the sea surface, the whales were either lunging parallel to it or passing through when they were intersecting perpendicular to the patch. The change in the direction of lunging relative to the patch could be for increasing prey capture efficiency. More detailed observation of the feeding behavior indicated the whales were lunging laterally with their right jaw down (Fig. 1). A total of four blows and six lateral lunge feedings were observed in Whale-A during a period of 225 seconds for a distance of about 620 m (distance calculated from the UAV flight log). Most of the time, lunge feeding was carried out laterally, however, non-lateral lunge feeding was observed twice on Whale-A (Fig. 2). Whale-B made lateral lunge feedings three times and blew twice during a period of 143 seconds for a distance of approximately 280 m with no display of non-lateral lunge feeding.

Samples of sea surface red patch at the location of the sighting were collected using 10 L buckets. Identification of the prey species in the red patches was subsequently conducted in the laboratory through morphological examination. The result suggested the occurrence of either *Calanus australis* or *C. agulhensis* at its stage C5 (Fig. 3). The identification was based on the characteristics of the prosome, which was rounded in the posterior end and measured 2.65–2.70 mm. According to Brad-

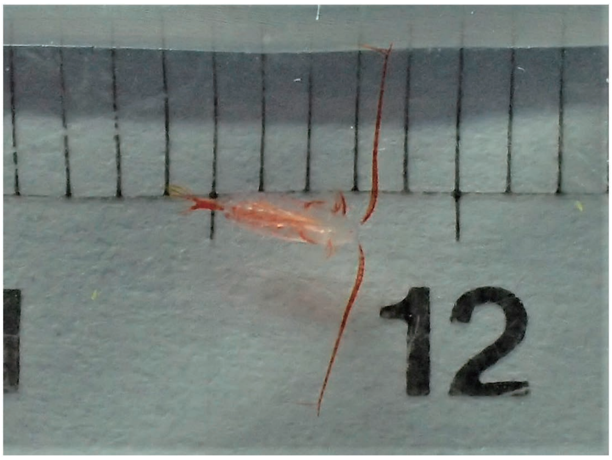

Fig. 3. Copepod sampled at 43°47′S, 19°14′E on 13 February, 2021, and identified as either *Calanus australis* or *C. agulhensis*.

ford-Grieve *et al.* (1999), the candidate species that fit the prosome length in stage C5 are *C. australis* and *C. agulhensis*. Effort was made to discern between the two species by examining the fifth swimming leg and the arrangement of the inner spines, but results were not conclusive. Therefore, it was not possible to discern between these two species using morphology, confirming the difficulty mentioned by Bradford-Grieve (1994) for the identification of *C. australis* from *C. agulhensis*. Furthermore, the location of the sampling corresponded to the distribution areas of both species. The copepod species that have been reported as prey of fin whales include *C. tonsus* (*Neocalanus tonsus*) in the Southern Ocean and off South Africa (Kawamura, 1980) and *Calanoides carinatus* and *Nannocalanus minor* off South Africa (32°40′S–36°30′S) (Best, 1967), and *C. chilensis* off northern Chile (43°S) (Buchan *et al.*, 2021). According to Best (1967), 94.1% of fin whales caught off South Africa fed on krill, 3.8% on copepods, and 2.0% on amphipods. Kawamura (1980) discussed that rorquals off South Africa have a highly variable species composition because of their feeding grounds were concentrated in small areas. The location where fin whales were sighted in this study is within a narrow and productive area due to the Agulhas Current System (Fig. 4). It is considered that fin whales in this area feed not only on krill but also several available species, including copepods as a secondary prey source. However, recent information on the prey species of fin whales in the Southern Hemisphere is limited, and their diet may have changed from the time when the previous studies had been conducted. In the Northern Hemisphere, Jory *et al.* (2021) reported an expanded dietary niche for fin whales in the St. Lawrence Estuary due to changes in the marine environment caused by climate change in the 2000s. On the other hand, the major whaling grounds of fin whales in the past were reported on the coast of South Africa and south of 50°S (Mackintosh, 1966). The small catches of fin whales around 45°S might have made it unknown that copepods possibly are major prey items for fin whales in the Southern Hemisphere mid-latitudes.

Fin whale feeding behavior in non-Antarctic Ocean waters in austral summer was reported for a near-shore productive zone in the Humboldt Current System off Chile (Perez *et al.*, 2006; Toro *et al.*, 2016; Buchan *et al.*, 2021).

Chlorophyll-*a* (Chl-*a*) concentration at the sighting position of fin whales in this study (43°49′S, 19°12′E) was relatively high. The monthly average Chl-*a* concentration in February 2021 observed by MODIS-Aqua at the location of the fin whale sighting is shown in Fig. 4. The Chl-*a* concentration missing values were complemented using the fill no data feature with default values in QGIS (Version 3.16.13-Hannover). The concentration of Chl-*a* at the sighting position was 0.35 mg/m^3. The Chl-*a* concentration in the latitudinal range between 40°S–45°S is relatively higher than that outside of this range (Fig. 4). In the latitudinal range between 40°S–44°S between South Africa and Antarctica, the

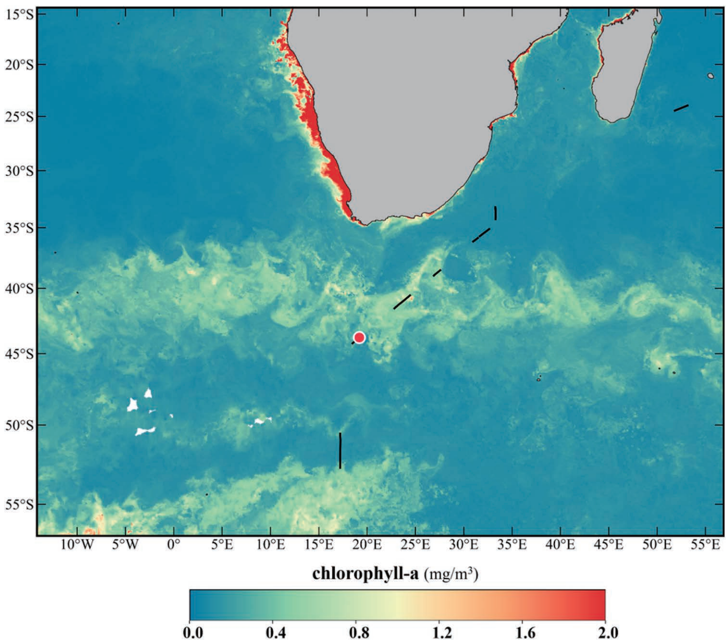

Fig. 4. The sighting location of a five-fin whale school (red circle) on 13 February, 2021 with searching tracks (black lines) of the survey vessel. Monthly average chlorophyll-a concentration for February 2021 is also shown (Original data: Ocean color web, from https://oceancolor.gsfc.nasa.gov/ (Accessed 2022-7-8)).

eddies that separated from the Agulhas Current System transported nutrient-rich water southward and mixed with the surrounding water in a shallow depth (the mixed layer was formed at 35 m depth, on average) resulting in the high concentration of Chl-*a* (Luis and Lotlicar, 2021). Read *et al.* (2000) reported high concentrations of surface Chl-*a* (in the range 0.5–0.8 mg/m^3) between 41°S–44°S and 35°E–45°E where different currents converge. These studies have shown that offshore waters of South African middle latitudes are highly productive and are likely an important feeding area for fin whales.

Venkataramana *et al.* (2020) investigated the community of zooplankton using the horizontal towing bongo net (200 μm mesh) and the multiple plankton sampler (upper 1000 m) between 40°S–56°S and 47°E–57°E from January to February and reported copepods were the dominant group across the entire region. In addition, past commercial catches and post-whaling sighting information have also shown that fin whales distribute offshore South Africa, around 45°S, from December to February (Miyashita *et al.*, 1995; Matsuoka *et al.*, 2006; Edwards *et al.*, 2015). These results suggested that fin whales may be using copepods as prey in this area, as reported in this study. Fin whales in the Northern Hemisphere have been associated with copepod concentrations (Nemoto, 1963; Flinn *et al.*, 2002; Baraff, 2006), and copepods are considered the second most abundant prey after krill (Flinn *et al.*, 2002; Baraff, 2006; García-Vernet *et al.*, 2021), or the primary prey for fin whales (Witteveen and Wynne, 2016).

The offshore waters of South Africa are possibly an important feeding area for fin whales. However, few survey efforts have been made in this area; most sighting surveys after the late 1970s were conducted south of 60°S (Branch and Butterworth, 2001; Matsuoka and Hakamada, 2014) targeting mainly Antarctic minke whales (*B. bonaerensis*). Additional sighting survey effort in mid-latitude waters (i.e., 35°S–50°S) would warrant further understanding the feeding ecology of fin whales in the Southern Hemisphere.

Supplement

Video footage of the feeding observations of whales A and B is available at: https://cpops.jp/archive/2022S003Whale-A.mp4 and https://cpops.jp/archive/2022S003Whale-B.mp4.

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Others

Snouting of an old Bryde’s whale, North Pacific.

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Short Communication

SECOND OCCURRENCE OF A DOLPHIN WITH FIN-SHAPED HIND APPENDAGES FROM WATERS OFF TAIJI, THE PACIFIC COAST OF JAPAN

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Key words: hind appendages, *Tursiops truncatus*, *Stenella coeruleoalba*, striped dolphin, Taiji.

Ohsumi and Kato (2008) reported on a very unique bottlenose dolphin (*Tursiops truncatus*) having fin-shaped hind appendages, captured from waters off Taiji (33°35′N, 135°57′E), Wakayama Prefecture, Japan in 2006. We have currently confirmed the finding of another such animal with hind appendages occurring from waters off Taiji.

The recently discovered dolphin was found among dolphin fisheries harvest in Taiji. The animal was from a striped dolphin (*Stenella coeruleoalba*) school which consisted of 20 individuals seen on January 5th, 2023, 7 nautical miles off Taiji. The Taiji Whale Museum staffs successfully confirmed the dolphin among the 16 dolphins that were visually examined on their ventral surfaces for sex determination.

Fig. 1. Lateral view of the striped dolphin with fin-shaped hind appendages just after an initial dissection (upper), magnified lateral view (left bottom) and ventral view of the appendages (right bottom).

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The dolphin (Taiji Whale Museum serial specimen ID 230105) was a male, 182 cm long; sex was confirmed by the external shape of genitalia. The hind appendages arose obliquely at both front sides of the anus slit and were ventrally located about 56 cm (left side, 30.8% of body length) anterior to the notch of the tail flukes (Fig. 1). They were of similar size and shape, 4.3 cm (left side) to 5.8 cm (right side) in straight length, with the right one being slightly larger. The shape was similar to that of the pectoral flippers but more sticklike exterior (Fig. 1; left bottom). The ventral aspect of the left side appendage was the same color as the dorsal appearance of the left side fin, while coloration of the right-side one was a lighter shade of gray. Also, we note the white line surrounding the base of both hind appendages, like in the previous animal having such appendages documented in Ohsumi and Kato (2008). Further details will be followed in later reports.

Body trunk parts including the hind appendages are kept in lab freezer conditions, and lots of tissue samples, including blood and serum samples are kept frozen and fixed in formalin or ethanol solutions. These are expected to be used in future studies.

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Short Communication

DEVELOPMENT PROGRESS OF A LONG-RANGE VERTICAL TAKEOFF AND LANDING UAV FOR THE IMPROVEMENT OF SHIP-BASED CETACEAN SIGHTING SURVEYS

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Key words: aerial survey, cetacean, drone, unmanned aircraft systems, unmanned aerial vehicle, VTOL-UAV/ASUKA.

Estimating the abundance of cetaceans is critical to the conservation and management of those species concerned. Abundance estimates are based primarily on sighting data collected during shipboard sighting surveys. However, these useful and standardized survey methods have their limitations. In some cases, surveys may not be able to entirely cover the cetacean distribution areas, such as coastal areas with high density of fishing gear, or pack ice areas in polar regions. To improve the abundance estimates in such undersurveyed areas, in 2019 we started developing an unmanned aerial vehicle (UAV) which was subsequently given the name of ASUKA (Matsuoka and Yoshida, 2021). The new aircraft would have to combine the following four characteristics. First, be able to takeoff and land vertically, allowing deployement from and to confined spaces on the research ship's deck. Second, be able of long flight time required to cover large survey areas. Third, be able to carry sufficient payload for installing a camera or cameras, which can capture a wide range with a high resolution to detect and identify cetacean species. The final point is the UAV's resistance to windy conditions. Because cetacean sighting surveys are conducted offshore, an aircraft that can operate in windy conditions is required.

After repeated trials with flight tests at sea in 2019 and 2020, the ASUKA Mk 4 was completed in 2021. In March 2021, ASUKA Mk 4 achieved an autonomous flight distance of 51 km from a research vessel in the North Pacific. Then, in March 2022, it autonomously flew 104 km in 1 hour and 20 minutes at an altitude of approximately 110 m, setting a new Japanese record for distance traveled in a single flight by a small UAV (Fig. 1). In addition, a preliminary fin whale (*Balaenoptera physalus*) field survey off Abashiri, Hokkaido (Fig. 2) and another for finless porpoise (*Neophocaena sunameri*) in Mikawa Bay, Aichi, were conducted. Equipped with a Sony DSC-RX0M2 camera, ASUKA Mk 4 successfully detected both target species. In the near future, the ASUKA Mk 5 (Fig. 3 and Table 1), developed as a commercial model, will be used in actual whale research in the Antarctic Ocean to conduct aerial visual surveys in areas of pack ice where vessels cannot navigate.

UAVs are increasingly being used to observe and study marine mammals, including cetaceans. A Google Scholar search (https://scholar.google.com) on the number of articles containing "UAVs" and "marine mammals" showed that it quadrupled from 2012 to 2021. In addition to visual surveys of marine mammals, UAVs have been used for photogrammetry, photo ID, and tagging (Leslie *et al.*, 2020; Ryan *et al.*, 2022; Murakami *et al.*, 2021). This suggests that UAVs are replacing helicopters and small aircraft that require airfields for takeoff and landing, and that UAVs are becoming a necessary survey tool. Cetacean research using UAVs has already begun (e.g., Hodgson *et al.*, 2017), and they are being used for various observational purposes in polar regions (e.g., Funaki *et al.*, 2014; Angliss *et*

Fig. 1. VTOL-ASUKA (Mk 4 Type 2) during vertical take-off from the research vessel in Mikawa Bay on 27 March 2022.

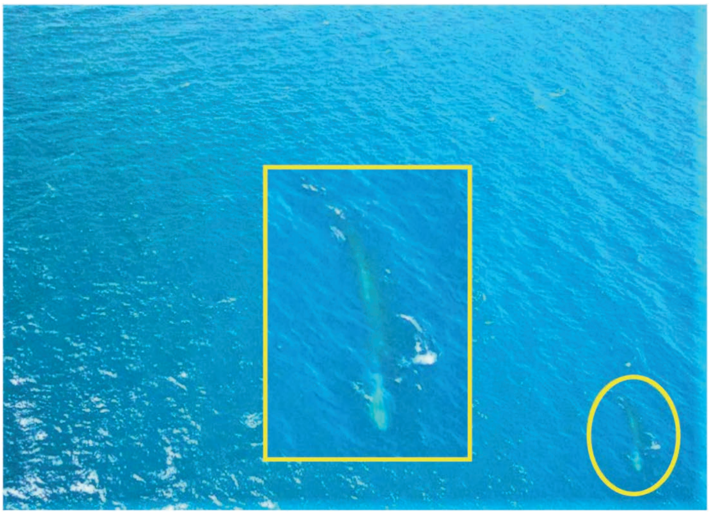

Fig. 2. An underwater fin whale photograph taken by ASUKA (Mk 4 Type 2) off Abashiri, Hokkaido, on 27 May 2022. The approximate flying altitude was 80 m.

Fig. 3. The latest VTOL-UAV aircraft (ASUKA Mk 5) developed in 2022.

Table 1. Specification of the newly-developed VTOL-UAV in 2022.

Item	ASUKA Mk 5*
Overall length	1,904 mm
Wingspan	3,335 mm
Overall height	843 mm
Body weight	22.9 kg
Cruising range	Over 100 km
Maximum speed	160 km/h (Long-range flight cruising speed 80 km/h)
Payload	5 kg maximum (104 km range achieved with a 2 kg payload)
Seaworthiness	Regular operation at 25-knot wind speed Level flight maintained at 40-knot wind speed

*The acronym 'Mk' and 'Type' followed by a number indicate the UAV prototype series identifier.

al., 2018). In addition, in anticipation of the widespread use of UAVs, methods have been developed for abundance estimation using digital data captured by cameras (Borchers *et al.*, 2020). Given the above, it is highly probable that abundance estimation of marine mammals using data obtained with UAVs will become more widespread. Accordingly, we anticipate that ASUKA, which can take off from and land on a ship and has a long-range, and sufficient payload capacity, will be used in visual and various other surveys.

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