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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-

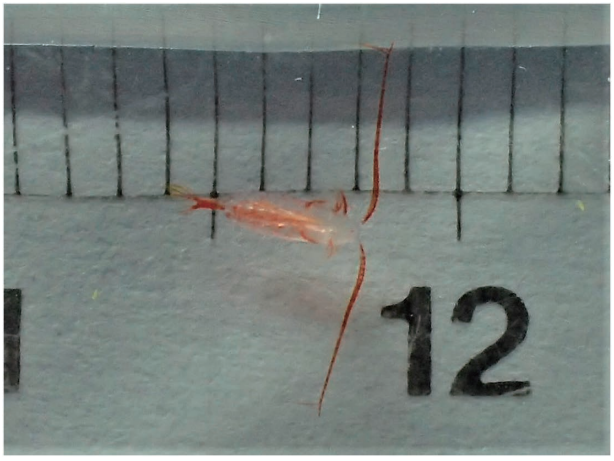

Fig. 3. Copepod sampled at 43°47′S, 19°14′E on 13 February, 2021, and identified as either *Calanus australis* or *C. agulhensis*.

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

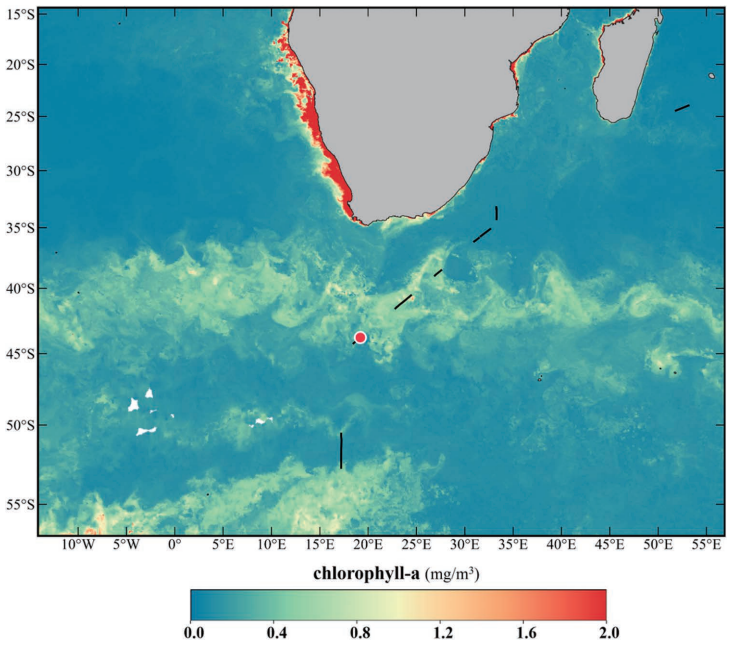

Fig. 4. The sighting location of a five-fin whale school (red circle) on 13 February, 2021 with searching tracks (black lines) of the survey vessel. Monthly average chlorophyll-a concentration for February 2021 is also shown (Original data: Ocean color web, from https://oceancolor.gsfc.nasa.gov/ (Accessed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

Aguilar, A. and García-Vernet, R. 2018. Fin whale: *Balaenoptera physalus*. pp. 368–371. *In*: Würsig, B., Thewissen, J. G. M. and Kovacs, K. M. (eds.) *Encyclopedia of Marine Mammals* (Third Edition). Academic Press, London. 1157 pp.

Baraff, L. S. 2006. Summer Distribution and Habitat Characteristics of Fin Whales (*Balaenoptera physalus*) and Humpback Whales (*Megaptera novaeangliae*) off Northeast Kodiak Island, Alaska. M.S. Thesis, University of Alaska Fairbanks, Fairbanks, AK. 173 pp.

Best, P. B. 1967. Distribution and feeding habits of baleen whales off the Cape Province. *Invest. Rep. Div. Sea Fish. S. Afr.* 57: 1–44.

Bradford-Grieve, J. M., Markhaseva, E., Rocha, C. E. F. and Abiahy, B. B. 1999. Copepoda. *In*: Boltovskoy, D. (ed.). *South Atlantic Zooplankton*. Backhuys Publishers, Leiden, The Netherlands. 2: pp. 869–1098.

Bradford-Grieve, J. M. 1994. The marine fauna of New Zealand: Pelagic Calanoid Copepoda: Megacalanidae, Calanidae, Paracalanidae, Mecynoceridae, Eucalanidae, Spinocalanidae, Clausocalanidae. *Mem. New Zealand Oceanogr. Inst.* 102: 1–160.

Branch, T. and Butterworth, D. 2001. Estimates of abundance south of 60°S for cetacean species sighted frequently on the 1978/79 to 1997/98 IWC/IDCR-SOWER sighting surveys. *J. Cetacean Res. Manage.* 3(3): 251–270.

Buchan, S. J., Vásquez, P., Olavarría, C. and Castro, L. R. 2021. Prey items of baleen whale species off the coast of Chile from fecal plume analysis. *Mar. Mamm. Sci.* 37(3): 1116–1127. doi: 10.1111/mms.12782.

Edwards, E. F., Hall, C., Moore, T. J., Sheredy, C. and Redfern, J. V. 2015. Global distribution of fin whales *Balaenoptera physalus* in the post-whaling era (1980–2012). *Mamm. Rev.* 45(4): 197–214. doi: 10.1111/mam.12048.

Flinn, R. D., Trites, A. W., Gregr, E. J. and Perry, R. I. 2002. Diets of fin, sei, and sperm whales in British Columbia: An analysis of commercial whaling records, 1963–1967. *Mar. Mamm. Sci.* 18(3): 663–679. doi: 10.1111/j.1748-7692.2002.tb01065.x.

García-Vernet, R., Borrell, A., Víkingsson, G., Halldórsson, S. D. and Aguilar, A. 2021. Ecological niche partitioning between baleen whales inhabiting Icelandic waters. *Prog. Oceanogr.* 199(465): 102690. doi: 10.1016/j.pocean.2021.102690.

Isoda, T., Katsumata, T. and Matsuoka, K. 2021. Results of the dedicated sighting survey under the Japanese Abundance and Stock structure Surveys in the Antarctic (JASS-A) in the western part of Area III in the 2020/21 austral summer season. *Technical Reports of the Institute of Cetacean Research (TEREP-ICR)* No. 5: 7–15.

Jory, C., Lesage, V., Leclerc, A., Giard, J., Iverson, S., Bérubé, M., Michaud, R. and Nozais, C. 2021. Individual and population dietary specialization decline in fin whales during a period of ecosystem shift. *Scientific Reports* 11(1): 17181. doi:10.1038/s41598-021-96283-x.

Kawamura, A. 1980. A review of food of balaenopterid whales. *Sci. Rep. Whales Res. Inst.* 32 : 1 55–197.

Luis, A. J. and Lotlikar, V. R. 2021. Hydrographic characteristics along two XCTD sections between Africa and Antarctica during austral summer 2018. *Polar Science* 30(1): 100705. doi: 10.1016/j.polar.2021/100705.

Mackintosh, N. A. 1966. Distribution of southern blue and fin whales. pp. 125–144. *In*: K. S. Norris (ed.) *Whales, Dolphins, and Porpoises*. University of California Press, Berkeley, CA. 789 pp.

Matsuoka, K., Hakamada, T., Kiwada, H., Murase, H. and Nishiwaki, S. 2006. Distributions and standardized abundance estimates for humpback, fin and blue whales in the Antarctic Areas IIIE, IV, V and VIW (35°E–145°W), south of 60°S. Paper SC/D06/J7 presented to the Intersessional Workshop to Review Data and Results from Special Permit Research on Minke Whales in the Antarctic, December 2006 (unpublished). 33 pp. [Paper available from the Office of the IWC].

Matsuoka, K. and Hakamada, T. 2014. Estimates of abundance and abundance trend of the blue, fin and southern right whales in Areas IIIE–VIW, south of 60°S, based on JARPA and JARPAII sighting data (1989/90–2008/09). Paper SC/F14/J5 presented to the IWC/SC Review Workshop of the Japanese Whale Research Program under Special Permit in the Antarctic-Phase II (JARPAII), February 2014 (unpublished). 27 pp. [Paper available from the Office of the IWC].

Miyashita, T., Kato, H. and Kasuya, T. 1995. Worldwide Map of Cetacean Distribution based on Japanese Sighting Data (Volume 1). National Research Institute of Far Seas Fisheries, Shimizu, Shizuoka, Japan. 140 pp.

Nemoto, T. 1963. Some aspects of the distribution of *Calanus cristatus* and *C. plumchrus* in the Bering and its neighbouring

waters, with reference to the feeding of baleen whales. *Sci. Rep. Whales Res. Inst.* 17: 157–170.

Pérez, M. J., Thomas, F., Uribe, F., Sepúlveda, M., Flores, M. and Moraga, R. 2006. Fin whales (*Balaenoptera physalus*) feeding on *Euphausia mucronata* in nearshore waters off north-central Chile. *Aquat. Mamm.* 32(1): 109–113. doi: 10.1578/AM.32.1.2006.109.

Read, J. F., Lucas, M. I., Holley, S. E. and Pollard, R. T. 2000. Phytoplankton, nutrients and hydrography in the frontal zone between the Southwest Indian Subtropical Gyre and the Southern Ocean. *Deep-Sea Research Part I: Oceanographic Research Papers* 47(12): 2341–2367. doi: 10.1016/S0967-0637(00)00021-2.

Toro, F., Vilina, Y. A., Capella, J. J. and Gibbons, J. 2016. Novel coastal feeding area for Eastern South Pacific fin whales (*Balaenoptera physalus*) in mid-latitude Humboldt Current waters off Chile. *Aquat. Mamm.* 42(1): 47–55. doi: 10.1578/AM.42.1.2016.47.

Venkataramana, V., Anilkumar, N., Swadling, K., Mishra, R. K., Tripathy, S. C., Sarkar, A., Soares Melena Augusta, Sabu, P. and Honey U. K. Pillai. 2020. Distribution of zooplankton in the Indian sector of the Southern Ocean. *Antarct. Sci.* 32(3): 168–179. doi: 10.1017/S0954102019000579.

Witteveen, B. H. and Wynne, K. M. 2016. Trophic niche partitioning and diet composition of sympatric fin (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae*) in the Gulf of Alaska revealed through stable isotope analysis. *Mar. Mamm. Sci.* 32(4): 1319–1339. doi: 10.1111/mms.12333.

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