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ANNUAL SUMMARY REPORT

Satellite-tagging and tracking of sperm whales in the South China Sea: Insights into distribution, movement, and habitat characteristics

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Sperm whales (*Physeter macrocephalus* Linnaeus, 1758) are widely distributed in the deep sea all over the world, but the occurrence and ecological information of this species in the South China Sea (SCS) has not been well documented. To address this knowledge gap, we aim to employ the satellite-tagging approach to track sperm whales in the SCS, thus to provide a preliminary understanding of the sperm whale occurrence and distribution in this region.

From 2019 to 2023, we encountered 15 groups of sperm whales during our field surveys in the SCS (Table 1). Furthermore, during the field surveys, we tagged and tracked a total of six sperm whale individuals (all adults) in this region (Table 2). Nursery groups are quite common in the SCS (Figure 1). Based on historical whaling information, several sperm whaling areas were identified in the SCS and its adjacent waters, including the Luzon Strait, southern SCS, eastern Philippines, Sulu Sea, and Sulawesi Sea. We also collated 26 strandings, one bycatch, and 24 opportunistic sightings of sperm whale in this region. All relevant sites and tracks were shown together in Figure 2. Some preliminary results also can be seen in Lin et al. (2021). See more results about sperm whales in details from Liu et al. (2023, 2022).

In conclusion, Xisha waters have been identified to potentially serve as a critical nursing ground for sperm whales, with evidence that frequent female nursery groups involving immature individuals, e.g., juveniles or calves, could be observed during dedicated boat-based surveys. Owing to a lack of investigation, these regions have never been identified as sperm whale habitats during past centuries. Although our survey effort and field data are still insufficient, sperm whale groups in the northwestern and central SCS were observed across five different survey months (i.e., April, May, July, August, and September). In addition, opportunistic sightings

also support the occurrence of sperm whales in Xisha waters across three different months (i.e., April, May, and July). Satellite tracking data have shown that sperm whales in the SCS display both fine-scale and long-distance movements across Xisha, Zhongsha, and Nansha waters.

We believe that deep waters in the SCS and their adjacent waters may include important habitats preferred by sperm whales, likely for nursing and feeding. As such, further research is necessary, especially regarding habitat suitability, regional-scale movement, and potential long-distance migration, to investigate sperm whales in the region. We recommend integrative approaches, including ship-based surveys, acoustic monitoring, biologging, and genetics be employed in future research.

Table 1. Sighting records of sperm whales in the South China Sea (2019-2023)

Date	Observation period	Group size*	Presence of calves/juveniles (No. of calves/juveniles)	Association with Fraser's dolphins (group size)	Water depth (m)#	Distance to 1000-m isobath (km)
May 1, 2019	08:20-12:09	4/4/4	Yes (1)	No	1423	10.2
May 6, 2019	13:04-18:23	3/6/8	Yes (1)	No	1526	20.4
July 24, 2020	11:37-16:17	7/8/10	Yes (2)	No	1665	11.7
July 24, 2020	16:55-17:58	3/3/3	Yes (1)	No	1679	18.7
July 31, 2021	12:06-12:33	3/4/5	No	No	1200	18.9
July 31, 2021	14:39-17:10	5/7/10	Yes (2)	Yes (20-30)	1336	31.2
August 7, 2021	15:48-17:28	2/3/3	Yes (1)	Yes (50-100)	992	1.2
August 8, 2021	08:28-10:09	3/3/3	No	No	1120	3.4
September 2, 2021	12:32-16:41	6/8/10	Yes (2)	No	1205	23.7
April 25, 2022	10:36-	4/4/4	Probably 1	No	NA	NA
April 25, 2022	14:19-	4/4/4	No	No	NA	NA
April 26, 2022	13:01	8/9/10	Likely 2-3	No	NA	NA
June 27, 2023	13:50	3/3/3	No	No	NA	NA
June 30, 2023	14:01	4/4/4	Yes (2)	No	NA	NA
July 14, 2023	15:21	3/3/3	No	No	NA	NA
Total	25.3 hs	62/73/84	15-16	-	-	-
Mean ± SD	2.8 ± 1.6 hs	5.1 ± 2.3*	-	-	1350 ± 242	15.5 ± 9.7

Table 2. Summary of four satellite-tagged sperm whales in the South China Sea

Whale_ID	Whale_1	Whale_2	Whale_3	Whale_4	Whale_5	Whale_6	Mean \pm SD
Start	July 24, 2020, 11:50:22	July 24, 2020, 12:24:08	July 24, 2020, 13:58:50	April 26, 2022, 14:32	July 14, 2023, 16:31	July 14, 2023, 18:13	-
End	August 1, 2020, 05:31:19	July 27, 2020, 08:57:59	July 28, 2020, 17:39:47	May 8, 2022, 21:40	July 23, 2023, 11:36	July 21, 2023, 09:55	-
No. of tracked days	9	4	5	13	10	8	8.2 \pm 3.3
No. of Argos transmitted locations	149	45	134	279	191	50	141 \pm 88.5
No. of filtered locations	40	17	22	88	51	26	41 \pm 26.3
No. of filtered locations per day	4.4	4.3	4.4	NA	NA	NA	4.4 \pm 0.1
Travel distance of each tagged animal (km)	351.4	326.2	289.5	NA	NA	NA	322.4 \pm 31.1
Core area based on 50% kernel density estimation (km ²)	835.7	2110.4	688.3	NA	NA	NA	1211.5 \pm 782.0
Water depth at filtered locations (m)	1776 \pm 352	1545 \pm 563	1282 \pm 392	NA	NA	NA	1494 \pm 445
Distance to 1000-m isobath (km)	11.6 \pm 10.7	11.9 \pm 8.4	12.8 \pm 9.3	NA	NA	NA	12.0 \pm 9.9
Distance to 3000-m isobath (km)	140.0 \pm 14.8	159.9 \pm 24.5	138.6 \pm 11.5	NA	NA	NA	143.9 \pm 18.6
Distance to Hainan Island (km)	186.3 \pm 14.9	166.2 \pm 24.2	187.6 \pm 10.9	NA	NA	NA	182.3 \pm 18.5
Distance to Yongxing Island (km)	172.1 \pm 12.0	183.6 \pm 16.7	170.6 \pm 9.9	NA	NA	NA	174.2 \pm 13.6

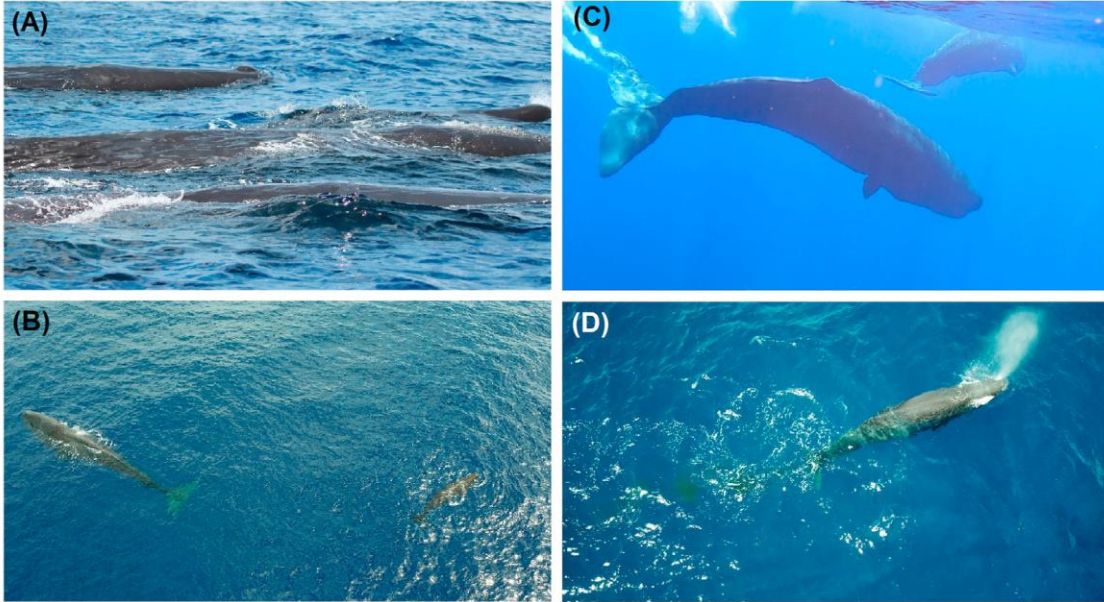


Figure 1. Photographic examples of sperm whales encountered in Xisha and Nansha waters, China. (A) A group of individuals with various age classes; (B–C) Mother-calf pairs; and (D) A adult excretes feces on the sea surface.

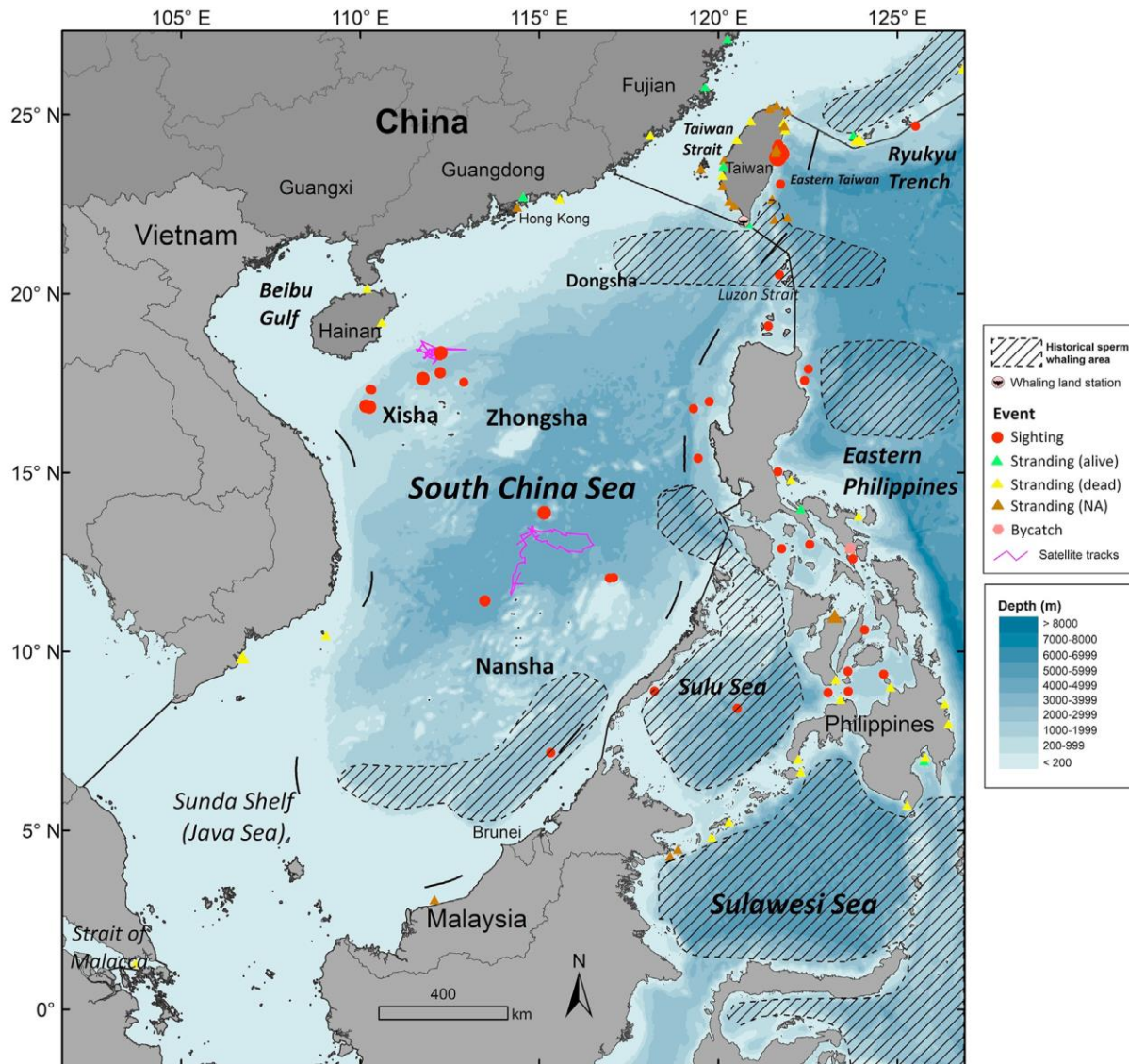


Figure 2. Records of sperm whales in the South China Sea and adjacent waters. Red dots: sperm whale field sightings; Purple curves: movement tracks of satellite-tagged sperm whales.

Relevant publications

- Liu, M., Lin, M., & Li, S. (2023). Sperm whales in the waters off China: A glimpse of the past and present. *Water Biology and Security*, 2(3), 100133. <https://doi.org/10.1016/j.watbs.2022.100133>
- Liu, M., Lin, W., Lin, M., Caruso, F., Rosso, M., Zhang, P., ... & Li, S. (2022). Sperm whales (*Physeter macrocephalus*) in the northern South China Sea: Evidence of a nursing ground?. *Deep Sea Research Part I: Oceanographic Research Papers*, 184, 103767. <https://doi.org/10.1016/j.dsr.2022.103767>
- Lin, M., Liu, M., Caruso, F., Rosso, M., Tang, X., Dong, L., ... & Li, S. (2021). A pioneering survey of deep-diving and off-shore cetaceans in the northern South China Sea. *Integrative Zoology*, 16(4), 440-450. <https://doi.org/10.1111/1749-4877.12508>