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THE PROJECT KNOWHALE: IMPROVING KNOWLEDGE ON FIN WHALE ACOUSTIC OCCURRENCE AND BEHAVIOUR IN THE CENTRAL MEDITERRANEAN SEA.

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ABSTRACT

The scarce information available on fin whales (*Balaenoptera physalus*) in the Central Mediterranean Sea limits the understanding of key bio-ecological activities of the endangered Mediterranean population. This work is part of a collaborative effort within the project “KNOWhale” and aims to expand knowledge about the species’ acoustic behavior and seasonal distribution. Acoustic data were collected from three different recording areas. Site-1, located in the Ionian Sea: OBS/H, 2065 m depth, 100 Hz sampling frequency (fs), operating continuously between May 2017 - January 2018; Site-2, South Adriatic Sea (EMSO-ERIC regional facility): Silence-LP recorder, 700 m depth, 64 kHz fs, 50% duty cycle, November 2022 – June 2023; Site-3, Sicily Channel: SoundTrap ST600 recorder, 157 m depth, 192 kHz fs, 50% duty cycle, February - April 2022. Fin whales 20Hz calls were detected at all sites using custom automatic detector, with calls occurring in 17, 122 and 16.54 hours respectively in Site-1 (0,29% detection rate), Site-2 (4,35% detection rate), and Site-3 (2.14% detection rate). Our results show for the first time the acoustic presence of fin whales in the Adriatic Sea over several months and attest to their monthly occurrence in data-deficient regions. This work provides essential baseline knowledge for conservation purposes in the Central Mediterranean Sea.

Keywords: *fin whale; passive acoustic monitoring; conservation; Mediterranean Sea*

1. INTRODUCTION

The fin whale (*Balaenoptera physalus*) is the only resident mysticete species in the Mediterranean Sea [1]. Although its presence has been known since antiquity [2], knowledge of the presence and seasonal movements of this large whale is still limited and not well understood due to its elusive nature, predominantly pelagic distribution and inconsistent data collection. In fact, while some studies seem to support the hypothesis of movements from the northwestern Mediterranean region, in late spring/summer [3–5], to the southern area occupied in late autumn/winter [6]; other studies confirm the presence of the species in the different basins throughout the entire year [1,7,8]; thus contributing to making the fin whale's movement patterns not so predictable and still a matter of debate. Nevertheless, the density and continuity of available information seem to be greater in the northwestern Mediterranean compared to the central-eastern area [2,9,10], where, for zones such as the Adriatic Sea, there is no information regarding its presence. The Mediterranean subpopulation is known to emit two types of calls: a downswung call from 23 to 17 Hz, lasting

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approximately 1 s, and the back-beat signal at 18–20 Hz, lasting about 0.8–1 s [8,11,12]. Acoustic long-term data can be a valuable cost-effective technique to monitor the presence of the species [7].

To fill the current knowledge gaps, the KNOWhale project aims to increase knowledge about the presence and seasonal movements of fin whales in the Central Mediterranean Sea, specifically focusing on the Ionian Sea, the Strait of Sicily and, for the first time, the Adriatic Sea, using passive acoustic monitoring.

2. MATERIALS AND METHODS

2.1 Acoustic data collection

Three areas were selected to comprehensively examine data collection deficiencies across the Central Mediterranean Sea. Specifically, Site-1 is located in the Ionian Sea and represents the largest monitored area, encompassing three recorders distanced 30 km from each other; The Site-1 dataset is comprehensive of acoustic files recorded through 3 synchronized Ocean Bottom Seismometers (OBS) [13,14], equipped with a hydrophone and saving continuously at 100 Hz sampling frequency (sf), from May 2017 to May 2018. Site-2 is in South Adriatic Sea (EMSO-ERIC regional facility E2M3A mooring); at this site, acoustic files were obtained through a Silence-LP recorder, which sampled, at 64 kHz fs (50% duty cycle), from November 2022 to June 2023. Site-3 is located in the Sicily Channel: here data were acquired through a SoundTrap ST600 recorder, at 192 kHz fs (50% duty cycle), from February 2022 to April 2022. Sites locations and depths are shown in Figure 1.

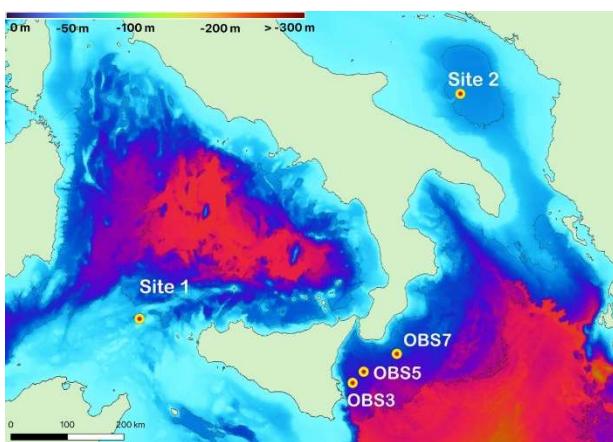


Figure 1. Representation of the three acoustic monitoring sites. Site-1, Ionian Sea: constituted by

three OBS (3, 5 and 6); Site-2, Adriatic Sea; Site-3, Sicily Channel.

2.2 Acoustic occurrence of 20 Hz calls

Firstly, the collected data were organized in MATLAB to facilitate subsequent fin whale detection analysis. Specifically, 1-hour long files from the Site-1 were converted from .SAC to .WAV; files from the Site-2 and -3 were subsampled at 2 kHz. For consistency across all datasets, processed files included accurate timestamps in their filenames and were stored in folders organized by month. Subsequently, the automatic MATLAB detector of FW 20-Hz calls 'SAW' [7] was run, returning a matrix containing information about detected fin whale vocalizations, and a figure (.PNG) showing each 10-min long spectrograms (8192 FFT points, 4096 Hann Win, 98% Overlap) and related detections in time (s).

An operator validated the results of the SAW code by manually visualizing the spectrograms. Only files with more than 4 detected pulses were utilized for the analysis.

Finally, the detection rate (dr) was calculated as the ratio between hours with FW 20-Hz calls and total hours, and expressed as a percentage.

3. RESULTS

Detection rates and temporal patterns of 20 Hz calls varied significantly across locations. Specifically, in Site-1, calls were detected at all the 3 OBS locations, without temporal overlapping among them, for 17 hours (0.29% dr), between late October and early December 2017; in Site-2 calls were detected for 122 hours (4.35% dr) in November 2022 and between February and March 2023; in Site-3, calls were found in 16.54 hours (2.14% dr) during February, March and April 2022 (see Table 1).

Table 1. Fin whale occurrence and detection rate among monitored sites.

	Site-1	Site-2	Site-3
Location	Ionian	Adriatic	Sicily Channel
Years	2017-18	2022-23	2022
Recording months	05 – 01	11 – 05	02 – 04
Duty cycle	100%	50%	50%
Total hours recorded	5862	2804	773





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FW occurrence (months)	10, 11, 12	11, 02, 03	02, 03, 04
FW occurrence (hours)	17	122	16.54
Detection Rate	0.29%	4.35%	2.14%

4. DISCUSSION

In Site-1, the continuous acoustic survey enabled us to assess the occurrence of fin whale calls in autumn/early winter, from October to December 2017. This result adds new information to what was reported in Sciacca et al. [7], where the authors, analyzing continuous acoustic data from July 2012 to May 2013, described fin whale occurrence in all months except in November, December and January. This result may support that fin whale seasonal movements, involve intricate patterns [15] that may don't affect the entire population simultaneously [1,8,16].

Considering Site-2, here acoustic occurrence of fin whales was reported, for the first time, in an area lacking information about this mysticete. The result enhances our knowledge of the spatial distribution of fin whales, documenting their presence in the Adriatic Sea basin during autumn/winter seasons, specifically in November 2022 and from February to March 2023. Future analysis can be directed toward the ecological role of this site, examining if it is used for foraging or breeding purposes by fin whales.

In Site-3, fin whale calls were detected in all recorded months, from February to April 2022. This finding aligns with previous studies which described an increase in fin whale presence during late winter and spring in the Sicily Channel [6,16]. These results support the hypothesis that this area plays an important role in whale seasonal movements [2,16,17,18], particularly toward winter feeding grounds such as Lampedusa [6]. However, our results on this site are based on only three months of acoustic surveys, so additional data spanning an entire year are needed to substantiate this hypothesis.

5. CONCLUSIONS

This short paper underscores the significance of passive acoustic monitoring in studying elusive species like the fin whale, revealing its acoustic presence throughout the Central Mediterranean Sea basin. The acoustic detection in the

Adriatic Sea, reported here for the first time, emphasizes how our understanding of fin whale annual movements remains limited and requires increasing monitoring efforts across both temporal and spatial dimensions. This perspective is particularly important given the fin whale's status on the IUCN Red List; as a keystone species, its presence helps to maintain ecological balance [19], which is increasingly threatened by human impacts, including noise pollution [20]. Notably, Sciacca et al. (2015) documented alarming high levels (98-116 dB re 1 μ Pa) of anthropogenic noise around 20 Hz, emphasizing the need for further investigation into how ambient noise affects fin whale communication in the Central Mediterranean Sea. Our findings therefore establish a baseline for future research on the relationship between noise levels and whale acoustic behavior across reported sites.

6. ACKNOWLEDGMENTS

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