

Evidences of tropicalization of infralittoral communities in the Balearic Islands

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INTRODUCTION

The increase in seawater temperature affects marine ecosystems causing marine species to change their distribution and abundance [1]. An exceptionally severe and long-lasting Marine Heatwave (MHW) affected the Mediterranean Sea between 2022 and the end of 2023, mainly in the western basin [2]. Such a temperature increase may lead to rising proportions of thermophilic biota of temperate region marine habitats.

The arrival and establishment of tropical and subtropical species, a phenomenon known as **Tropicalization**, has been reported in many areas in the Mediterranean Sea, as global warming intensifies [3].

As part of the Marine Strategy Framework Directive (MSFD) (2008/56/EC), the infralittoral rocky bottoms of Balearic Archipelago (Western Mediterranean) was surveyed in 2022. Same sampling has been repeated in 2025 paying special attention to the frequency and abundance of warm-affinity species.

METHODS

Infralittoral rocky bottoms were sampled through underwater visual censuses (UVC) conducted by 6 scuba divers in 24 stations of the Balearic Archipelago (Fig 1A). The study was restricted to depths between 5-18 m. A total of 200 m, distributed in 4 transects of 50 m, were surveyed in each station.

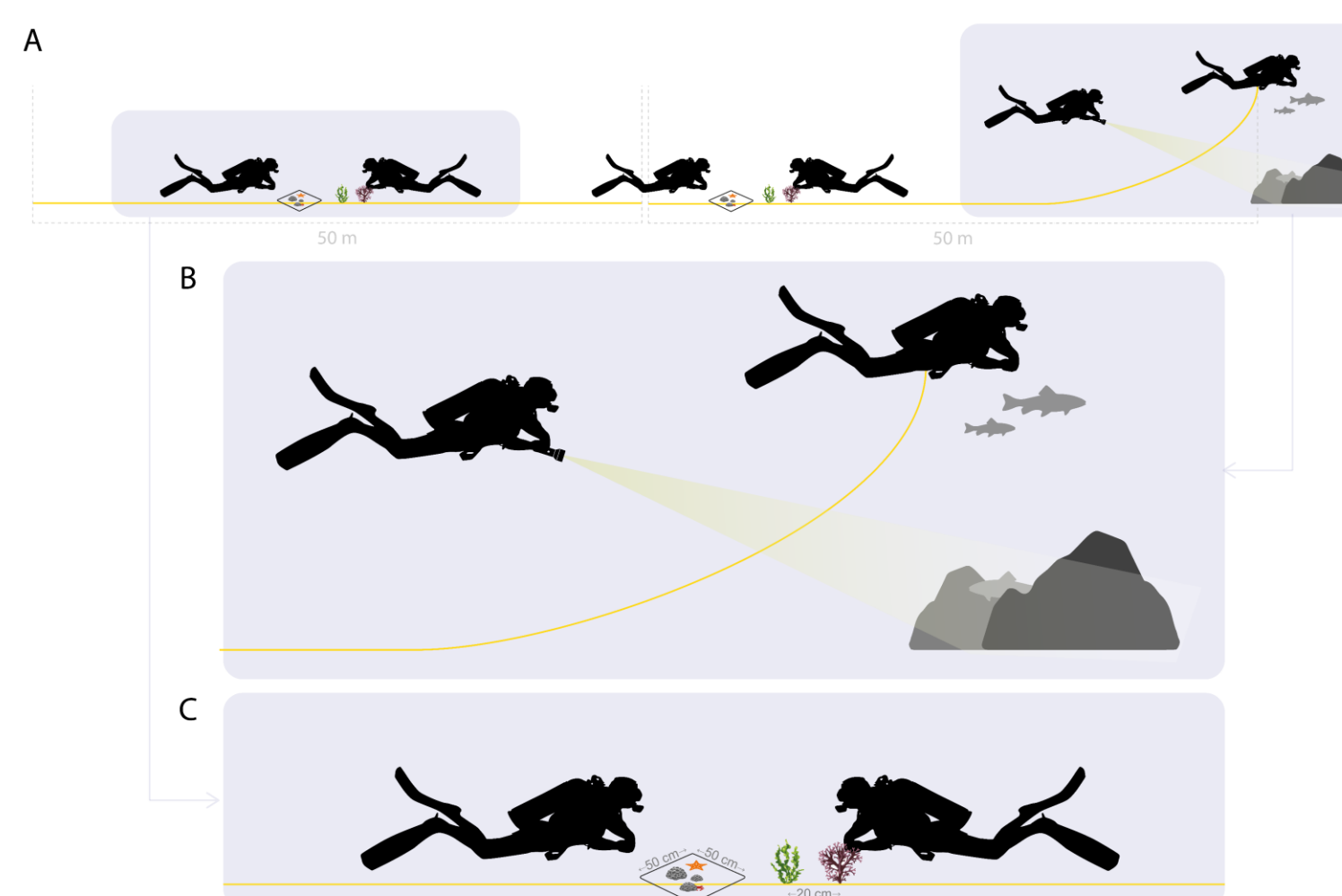


Figure 1: Schematic representation of sampling design (A), fish survey (B) and benthic survey (C).

Station surveys were carried out in 2022 and repeated in 2025. Along each transect the following features were registered:

- **Fish:** species, abundance and size were recorded within 50x5 m belt transect (Fig. 1B).
- **Macroinvertebrates:** species and abundances were recorded using 50x50 cm quadrats placed every 2 m (Fig. 1C, Diver Left).
- **Macroalgae:** contact point methodology recorded every 20 cm (Fig. 1C, Diver Right).

RESULTS & DISCUSSION

Comparisons between data collected in 2022 and 2025 reveal an increase in the frequency of warm-affinity biota sightings in Balearic Islands (Fig. 2). These results emphasize the idea that while seawater warming cause severe impact on marine ecosystems, it can benefit some species [4].

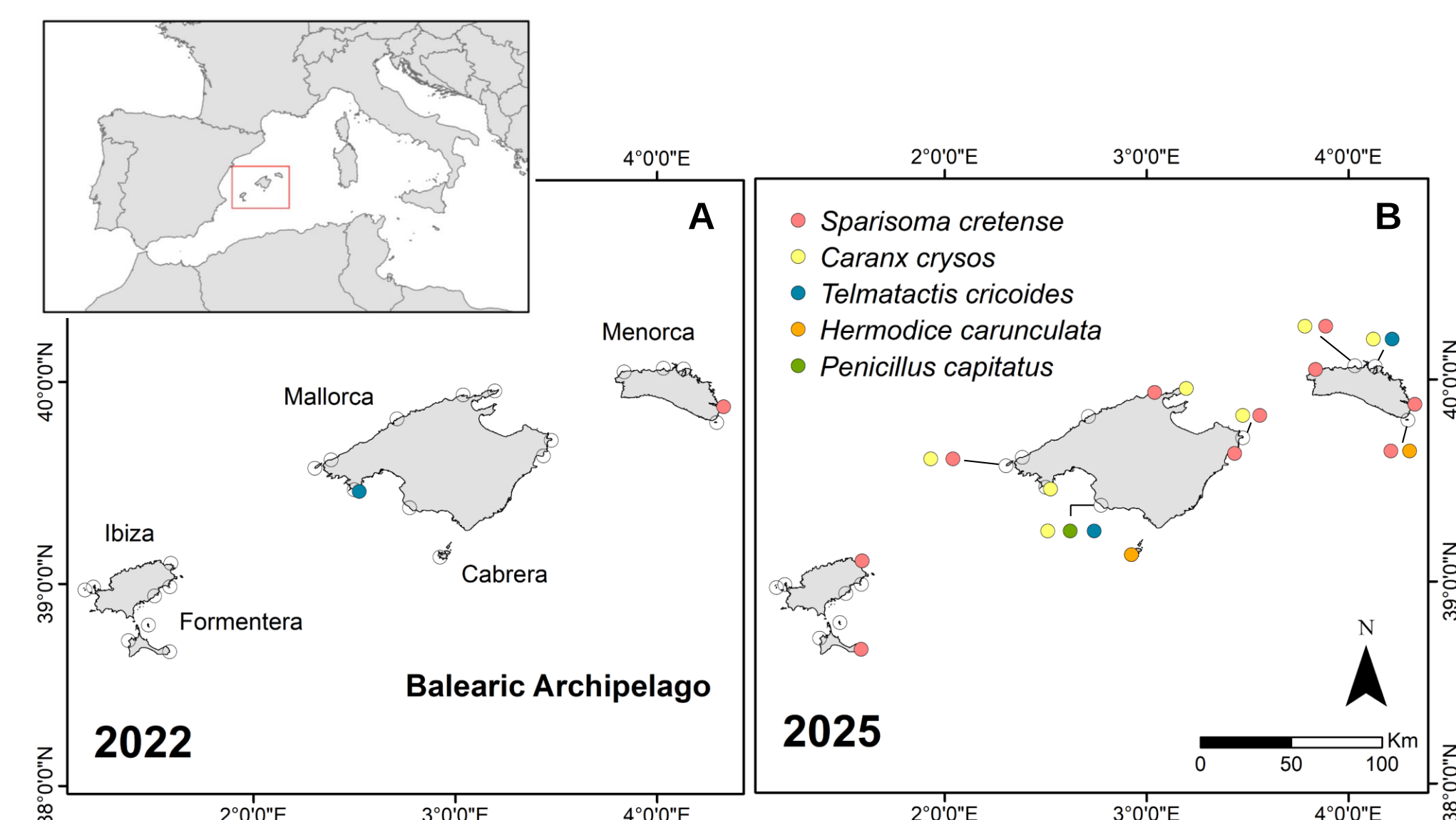


Figure 2: Distribution of sampling stations (empty circles) in Balearic Archipelago (Mediterranean Sea) in 2022 (A) and in 2025 (B). Colour-filled circles indicate sightings of thermophilic biota; each colour represents a different species (as indicated in the legend). Colour code on the maps matches the species in the plot (Fig. 3).

We observed fish *Sparisoma cretense* (Teleostea, Scaridae) and *Caranx crysos* (Teleostea, Carangidae) as the species with the greatest increase in abundance when comparing the two survey periods (Fig. 3), probably linked to its greater mobility in comparison with the other thermophilic species registered.

The invertebrates *Hermodice carunculata* (Annelida, Polychaeta, Amphinomidae) and *Telmatactis cricoides* (Cnidaria, Anthozoa, Actiniaria) and the algae *Penicillus capitatus* (Chlorophyta, Halimedaceae) have also been registered more frequently in 2025 than in 2022 (Fig. 2-3).

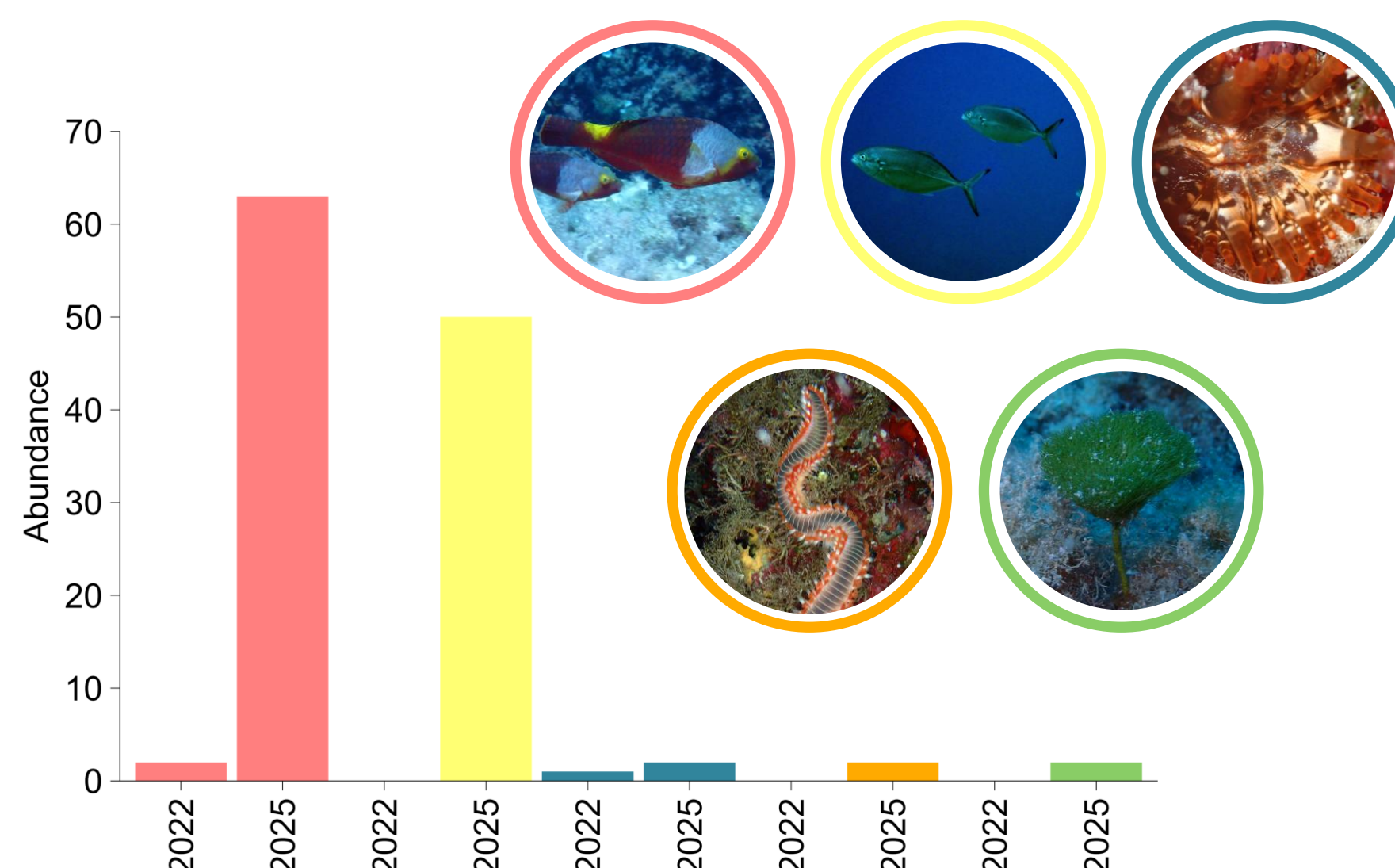


Figure 3: Bar plot showing the abundance of each species each year surveyed. The colour code on the maps (Fig. 2) matches the species in the plot.

All these species are present in the Mediterranean Sea, however, our results suggest that they are expanding their distribution, probably as a consequence of increasingly frequent and prolonged marine heatwaves. Therefore, it is important to stay alert of any changes in the frequency of these thermophilic species, as they can be possible indicators of climate warming [5].

CONCLUSION / FUTURE WORK

Our findings highlight the importance of monitoring programs as essential tools to detect environmental changes –such as tropicalization– that might influence benthic communities. The methodology applied appears to be suitable to provide timely information to respond to a rapidly changing marine ecosystem. Thus, we propose a continuous monitoring methodology of the infralittoral domain to detect shifts on species range distribution and to evaluate consequences on local biodiversity. Such monitoring could be even more useful if adopted by other EU countries in order to evaluate effects of tropicalization on a large-scale.

REFERENCES/ACKNOWLEDGEMENT

- [1] Poloczanska E. S. *et al.*, “Responses of marine organisms to climate change across oceans,” *Front. Mar. Sci.*, 2016.
- [2] Marullo S. *et al.*, “Record-breaking persistence of the 2022/23 marine heatwave in the Mediterranean Sea,” *Environ. Res. Lett.*, 2023.
- [3] Bianchi N. *et al.*, “Global sea warming and ‘tropicalization’ of the Mediterranean Sea: biogeographic and ecological aspects,” *Biogeogr. J. Integr. Biogeogr.*, 2003.
- [4] Boudouresque C. F. *et al.*, “The Heatwave of Summer 2022 in the North-Western Mediterranean Sea: Some Species Were Winners,” *Water*, 2024.
- [5] Pagana I., *et al.*, “Is the typical stage of *Penicillus capitatus* Lamarck (Bryopsidales, Halimedaceae) a possible indicator of climate warming?,” *Mediterr. Mar. Sci.*, vol. 25, 2024.

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