frontiers | Frontiers in Marine Science

TYPE Editorial
PUBLISHED 29 August 2024
DOI 10.3389/fmars.2024.1470915

OPEN ACCESS

EDITED AND REVIEWED BY
Stelios Katsanevakis,
University of the Aegean, Greece

*CORRESPONDENCE
Irini Tsikopoulou
itsikopoulou@hcmr.gr

RECEIVED 26 July 2024
ACCEPTED 12 August 2024
PUBLISHED 29 August 2024

CITATION
Tsikopoulou I, Nasi F and Bremner J (2024) Editorial: The importance of understanding benthic ecosystem functioning.
Front. Mar. Sci. 11:1470915.
doi: 10.3389/fmars.2024.1470915

Editorial: The importance of understanding benthic ecosystem functioning

Irini Tsikopoulou[1]*, Federica Nasi[2] and Julie Bremner[3]

[1]Institute of Marine Biological Resources and Inland Waters, Hellenic Centre for Marine Research (HCMR), Heraklion, Greece, [2]Section of Oceanography, National Institute of Oceanography and Applied Geophysics, Trieste, Italy, [3]Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Lowestoft, United Kingdom

KEYWORDS

functional diversity, biological traits, ecosystem functioning, ecosystem services, human impacts

Editorial on the Research Topic
The importance of understanding benthic ecosystem functioning

Introduction

Benthic habitats constitute the largest single ecosystem on earth and provide important and valuable ecosystem services (Thrush et al., 2021). Benthic organisms help stabilize sediments, preventing erosion and maintaining seabed structure. They provide a food source for commercially important fish and invertebrates, and through bioturbation and bioirrigation processes, play a crucial role in nutrient cycling.

However, the climate crisis and other human activities threaten the functioning and services of benthic ecosystems (Solan et al., 2004). Biological traits analysis has led to a better understanding of the role of species within a community, the relationship between ecological functions, spatial distribution, and environmental characteristics (de Juan et al., 2022), and how these are altered by humans.

Biological traits approaches are based on the idea that ecosystem functions have well-established relationships with species traits. While this is commonly investigated for individual species in experiments, there still needs to be more clarity on how species traits at a community scale are related to ecosystem functioning. This linkage of biological traits with ecosystem functions may be more complex at a large scale since it may be affected by environmental variability, species interactions, and human-induced disturbances.

The purpose of this Research Topic is to compile studies investigating the links between biodiversity and the functioning of benthic ecosystems across a broad spatial scale. This Research Topic - four original research articles, a meta-analysis, and an opinion article - addresses three major themes related to the biological traits approach:

1. Functional diversity in the era of global changes and the significance of the a priori selection of traits
2. Effects of species interactions on ecosystem functioning
3. Human-induced changes and ecosystem processes

The significance of *a priori* trait selection

Lelievreet al. investigated the diversity and composition of benthic communities in the sub-Antarctic, providing a critical baseline for future conservation efforts. They examined the taxonomic and functional diversity of the subtidal benthic communities in both natural and artificial substrates at Crozet Archipelago, revealing that benthic communities are highly vulnerable to environmental changes due to low functional richness, evenness, and redundancy. The authors point out the importance of trait selection, in particular, in terms of the response and effect traits dichotomy. This dichotomy was examined in greater depth in Beauchard's opinion paper. Beauchard emphasized that functional diversity (FD) assessments have been conducted in various contexts with mixed types of traits, often without specifying the theoretical links between traits and FD, which brings the meaning of FD into debate. To avoid misleading results related to FD and ecosystem resilience/resistance, the author argues, it is important to distinguish what the species *are* (e.g. life strategies, response traits) and what the species *do* (ecosystem functions, effect traits).

Effects of species interactions on ecosystem functioning

Gusmaoet al. conducted a mesocosm experiment on the effects of four habitat-forming species, the lugworm *Arenicola marina*, the eelgrass *Zostera marina*, the mussel *Mytilus* spp. and the clam *Macoma balthica*, on invertebrate colonization in the Baltic Sea. Their key finding was that the combined effect of multiple ecosystem engineers differs from their individual effects, suggesting potential synergistic or antagonistic interactions of their effects on the benthic system. The role of species and their traits in structuring ecosystem interactions was further investigated by Ming Khanet al., who used Bayesian network modelling to explore epibenthic food-webs in the challenging environment of the deep Antarctic. While they discovered a well-connected web of deposit, filter, and suspension feeders, they found little evidence of a strong role for predators in the food-web function of the deepwater communities, contrasting with the role of predators in shallow Antarctic communities and potentially making these deeper communities vulnerable to invasive predators as Antarctic waters continue to warm.

Human-induced changes and ecosystem processes

Beauchardet al.'s meta-analysis of the impact of bottom trawling on benthic ecosystems across 13 European marine environments found that it selectively alters benthic effect trait compositions, with tube-dwelling species thriving at low trawling frequencies and deep burrowing species at higher frequencies. A key finding was that although trawling significantly effects benthic ecosystem functions, the effect trait pattern along the trawling gradient was never related to life span, a key response trait generally assumed to express recoverability following disturbance. The findings highlighted the complexity of trawling impacts and the importance of considering both response and effect traits. Goedefrooet al., studied the impact of sand extraction on biological traits and functional indices, finding that macrobenthic secondary production decreased following a high yearly extraction intensity, whereas a high cumulative (10-year period) extraction intensity resulted in slightly increased secondary production. These high cumulative extraction volumes increased the abundance of opportunistic species, which could have contributed to the higher secondary production. Response traits were positively influenced by a long-term disturbance, indicating a more disturbance-tolerant community. For effect traits, both short- and long-term extraction favoured deposit feeders, which can structure organic matter distribution and thus indirectly influence nutrient and oxygen fluxes.

Future perspectives and needs

Given the abundance of research now available on benthic traits, there is a need for systematic reviews and meta-analyses in the manner of Beauchardet al., that consolidate existing studies to address uncertainty on the mechanistic links between traits and function. This would help identify patterns and gaps, piecing together the puzzle of how traits influence ecosystem functioning and how the relationships are impacted by environmental change. It is clear from Beauchardet al.'s and Goedefooet al.'s studies that human activities can produce unexpected and sometimes counterintuitive effects on traits - suggesting similar effects on function - so there is space for more studies to elucidate the impacts of individual human activities and, crucially for our growing blue economy, on multiple uses of the seas. Lelievreet al. and Beauchardet al. show us that different traits may tell us different things, and Gusmaoet al. and Ming Khanet al.'s studies illustrate the complex and geographically-dependent relationships among traits, meaning such studies must take care to consider both which biological traits they select and how they generalise their results.

Author contributions

IT: Writing – original draft, Writing – review & editing, Conceptualization. FN: Conceptualization, Writing – original draft, Writing – review & editing. JB: Conceptualization, Writing – original draft, Writing – review & editing.

Acknowledgments

We thank all the authors who submitted their work on the Research Topic and all the reviewers for their constructive

comments and suggestions that improve the quality of this Research Topic.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

de Juan, S., Bremner, J., Hewitt, J., Törnroos, A., Mangano, M. C., Thrush, S., et al. (2022). Biological traits approaches in benthic marine ecology: Dead ends and new paths. *Ecol. Evol.* 12, 1–11. doi: 10.1002/ece3.9001

Solan, M., Cardinale, B. J., Downing, A. L., Engelhardt, K. A. M., Ruesink, J. L., and Srivastava, D. S. (2004). Extinction and ecosystem function in the marine benthos. *Sci. (80-.).* 306, 1177–1180. doi: 10.1126/science.1103960

Thrush, S., Hewitt, J., Pilditch, C., and Norkko, A. (2021). *Ecology of Coastal Marine Sediments* (New York: Oxford University Press). doi: 10.1093/oso/9780198804765.001.0001