Query Details

Back to Main Page

1. Please note, the title and ref. 2 have been adjusted to match Ingels et al.

fine to us

2. Please check your article carefully, coordinate with any co-authors and enter all final edits clearly in the eproof, remembering to save frequently. Once corrections are submitted, we cannot routinely make further changes to the article.

ok thanks

3. Note that the eproof should be amended in only one browser window at any one time; otherwise changes will be overwritten.

ok

4. Author surnames have been highlighted. Please check these carefully and adjust if the first name or surname is marked up incorrectly. Note that changes here will affect indexing of your article in public repositories such as PubMed. Also, carefully check the spelling and numbering of all author names and affiliations, and the corresponding email address(es).

ok cheching i ongoing

5. Please note, the sentence beginning 'To our knowledge, the 112' was edited to address the claim of priority for style. 'conducted to date' was removed from the end as this is clear from the rest of the sentence.

ok

6. Please add both EU Directives mentioned in the sentence beginning 'The reference to the' to the reference list, providing the full details. Ingels et al. do not mention an EU Water Framework Directive (they cite Marine Strategy Framework Directive 2008/56/EC), so please amend here as needed.

the initially cited the EU Water Framework directive, then likely they corrected the final text after our reply, we need to change the ref accordingly, but need first to know what they referred in the final version
If Ingels removed the reference to WFD we need to change the text accordingly

7. In the Acknowledgements, does 'GA N.' mean 'grant number'? If so, it will be adjusted, but if not please write in full.

GA N is from grant agreement number, could be corrected as G.A. n.

8. As per style, please provide the data availability statement.

No additional data are provided in the Reply

9. Please note, the competing interests statement has been edited for style.

ok

Matters Arising

Reply to: Ecological variables for deep-ocean monitoring must include microbiota and meiofauna for effective conservation

Roberto Danovaro, [1✉,2]

Email r.danovaro@univpm.it

Emanuela Fanelli, [1,2]

Jacopo Aguzzi, [2,3]

David Billett, [4]

Laura Carugati, [1]

Cinzia Corinaldesi, [5]

Antonio Dell'Anno, [1]

Kristina Gjerde, [6]

Alan J. Jamieson, [7]

Salit Kark, [8]

Craig McClain, [9]

Lisa Levin, [10]

Noam Levin, [11,12]

Eva Ramirez-Llodra, [13]

Henry Ruhl, [4,14]

Craig R. Smith, [15]

Paul V. R. Snelgrove, [16]

Laurenz Thomsen, [17]

Cindy L. Van Dover, [18]

Moriaki Yasuhara, [19,20]

[1] Department of Life and Environmental Sciences, Polytechnic University of Marche, Ancona, Italy

[2] Stazione Zoologica Anton Dohrn, Naples, Italy

[3] Instituto de Ciencias del Mar (ICM-CSIC), Barcelona, Spain

[4] National Oceanography Centre, Southampton, UK

[5] Department of Sciences and Engineering of Materials, Environment and Urban Planning (SIMAU), Polytechnic University of Marche, Ancona, Italy

[6] IUCN Global Marine and Polar Programme, Cambridge, MA, USA

[7] School of Natural and Environmental Sciences, Newcastle University, Newcastle upon Tyne, UK

[8] The Biodiversity Research Group, The School of Biological Sciences, Centre for Biodiversity and Conservation Science, The University of Queensland, Brisbane, Queensland, Australia

[9] Louisiana Universities Marine Consortium, Chauvin, LA, USA

[10] Center for Marine Biodiversity and Conservation and Integrative Oceanography Division, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA, USA

[11] Department of Geography, The Hebrew University of Jerusalem, Jerusalem, Israel

[12] Remote Sensing Research Centre, School of Earth and Environmental Sciences, University of Queensland, Brisbane, Queensland, Australia

[13] Norwegian Institute for Water Research, Oslo, Norway

[14] Monterey Bay Aquarium Research Institute, Moss Landing, CA, USA

[15] Department of Oceanography, University of Hawaii at Mano'a, Honolulu, HI, USA

[16] Departments of Ocean Sciences and Biology, Memorial University of Newfoundland, St. John's, Newfoundland, Canada

[17] Jacobs University, Bremen, Germany

[18] Division of Marine Science and Conservation, Nicholas School of the Environment, Duke University, Durham, NC, USA

[19] School of Biological Sciences and Swire Institute of Marine Science, The University of Hong Kong, Hong Kong SAR, China

[20] State Key Laboratory of Marine Pollution, City University of Hong Kong, Hong Kong SAR, China

Received: 8 May 2020 / Accepted: 23 September 2020

REPLYING TO J. Ingels et al. *Nature Ecology & Evolution* https://doi.org/10.1038/s41559-020-01335-6 (2020).

Meiofauna and microbes are key components of deep-sea ecosystem assessments and were included among the list of essential variables in our recent comprehensive assessment and prioritization of global deep-ocean monitoring and conservation strategy[1]. Meiofauna ranked in the top three variables, whereas microbes (bacteria, and archaea) were reported as key variables for some aspects of monitoring the deep sea. However, larger components of the deep-sea fauna (such as macro- and megafauna) received the highest priority.

AQ1

AQ2

AQ3

AQ4

In their Matters Arising, Ingels and co-workers[2] criticized the ranking because, in their opinion, macro- and megafaunal components cannot be considered higher-priority variables than microbes and meiofauna. They concluded that this result reflects an unequal distribution of the competence of the authors and of the respondents to the elicitation survey. However, their criticisms are unjustified for conceptual, methodological and operational reasons.

On semantic and theoretical grounds, Ingels et al. confused the concept of priority with that of relevance/importance. Ingels et al. seem also to confound the concept of monitoring and protecting with the importance of research for advancing scientific knowledge; these are two partly related, but distinct, objectives. Indeed, recognizing the ecological importance of one biological component is one thing, but identifying the monitoring variables where capacity to deliver for conservation management globally is well established, is quite another. We cannot apply the same monitoring and conservation approach to all biological components because small organisms, such as prokaryotes, protists and meiofauna encompass massive numbers of undescribed species with largely unknown ecologies[3, 4] and shorter turnover times, which may make them more resilient to disturbance than larger biota.

Even an ocean completely depleted of large fauna, sharks and all predators would remain flush with meiofauna and microbes. Yet, a deep-sea system with abundant meiofauna and prokaryotes would almost certainly function poorly without higher trophic levels. This well-known ecological principle is certainly one of the reasons there was a wide consensus among the 112 experts (including the microbiologists and meiofauna experts who participated in the expert elicitation) on censusing larger species to protect vulnerable habitats they inhabit or create. The much more limited evidence for microbial and meiofaunal endemicity, the great proportion of unidentified species and the lack of life-history information greatly compromise any proposal to use these components as proxies for monitoring and mapping conservation areas. Thus, the results of the expert elicitation, on the one hand, reflect the maturity of the disciplines and the capability to deliver indicator information and, on the other hand, recognize the role of larger organisms in current conservation priorities, while acknowledging fundamental roles of all groups.

Another important aspect overlooked by Ingels et al. is that deep-sea biodiversity was only one of the five main research areas addressed by the study. In the second research area we considered, which was dedicated to ecosystem functions, benthic faunal biomass and benthic faunal production were ranked as top variables (see table 1 in Danovaro et al.[1]). Because meiofauna and microbes typically dominate benthic faunal biomass at abyssal depths[5, 6], we took care to emphasize the functional role of microbial components: “microbes (primarily bacteria followed by archaea) largely dominate overall biomass and production. These microscopic components, essential for deep-sea ecosystem functions … we stress microbial heterotrophic and chemoautotrophic C production as two essential ecological variables needed for understanding the

key processes sustaining the functioning of deep-sea food webs and biogeochemical cycles".

We also strongly disagree with the methodological criticisms of Ingels et al. As scientists, we endeavour to remove all potential sources of bias in the framework of standard good practices for data evaluation. Our study is based on expert elicitation, which is a procedure to find consensus on priorities, not an experiment with treatments and controls; thus, standard deviations cannot be treated as in ecological experimental designs. Our Perspective describes how we endeavoured to achieve an objective methodology (that is, coverage of different research fields and knowledge for each of the five main themes, scientists covered a broad range of geographic regions, different taxonomic expertise, academic qualifications and years of experience). These aspects, including statistical treatment, were discussed in detail using multiple rounds of enquiries, following rigorous procedures[7], and were presented transparently in the supplementary information of our paper[1]. To our knowledge, the 112 scientists participating in this elicitation make this study the widest deep-sea community ever to participate in defining priorities based on standardized questions.

AQ5

Ingels et al. assumed that microbial and meiofaunal components were not prioritized because most of the respondents were macrofaunal or megafaunal experts. However, this is not evident in our data, because a large fraction of respondents covered multiple fields of expertise (note that the supplementary information[1] reported only one main topic per scientist). Their criticism suggests that deep-sea scientists are divided into two groups: micro- meiofaunal experts competing against macro- megafaunal experts, fighting to prioritize their own work, rather than a community working together towards a common objective. Obtaining expert opinions for comprehensive deep-sea management, as we did, requires the involvement of scientists working in different sectors (such as deep-sea technologies, conservation biology, biological oceanography, biogeochemistry, policy and management), thus participants cannot simply be classified as experts by faunal size category. The fact that many scientists, in responding to the questionnaire, did not automatically prioritize their own research specialty for deep-ocean monitoring, conservation and impact assessment suggests that this is a false and non-productive dichotomy. Accordingly, we reaffirm that the expert elicitation reported in Danovaro et al. [1] is robust, accurate and balanced, and simply reflects the prioritization of the groups of organisms/habitats and associated variables to monitor in light of anthropogenic impacts, conservation needs and currently available technology, feasibility and knowledge.

In operational terms, environmental monitoring, especially in the deep sea, requires ready-to-use technologies and methods that are employable, which greatly influences the choice of monitoring priorities and rankings of the consulted experts. Our paper innovatively coupled this need with the technology readiness levels of the described technologies. We agree that the scientific community should do more to document the importance of small organisms, to establish and disseminate the best standardized practices for collecting such observations and to increase our knowledge of undescribed species and their ecological roles to use them more effectively in future monitoring plans, particularly in light of the ongoing effects of global change[8, 9, 10].

At the same time, no marine protected area (in both shallow waters and in the open ocean) or other conservation initiative anywhere targets the loss of meiofaunal or microbial diversity. The reference to the biological quality elements of the EU Water Framework Directive (2000) made by Ingels et al.[2] does not support their positions, as it refers only to rivers and lakes, transitional and coastal waters, and was completely replaced, in 2008, by the Marine Strategy Framework Directive (2008/56/EC), designed to address the Good Environmental Status of marine ecosystems (including the deep sea). None of these directives prioritize meiofauna or microbes. Moreover, to the best of our knowledge, there is no single ongoing, nor planned, monitoring strategy of a national agency based on or prioritizing microbial or meiofaunal diversity in their standard protocols. Further efforts are thus necessary to better integrate microbes and meiofauna in future monitoring and conservation programmes. To do this, the global deep-sea community must encourage joint efforts, share common goals and use standardized tools.

AQ6

Acknowledgements

This work was supported by the H2020 projects MERCES (GA N. 689518), and IDEM (GA N. 11.0661/2017/750680/SUB/EN V.C2.), by the Norwegian Institute for Water Research, by the NSERC Canadian Healthy Oceans Network and CFREF Ocean Frontier Institute, by JPI Oceans2 and ONC, by ARIM (MartTERA ERA-Net Cofound), by NSF grant OCE 1634172, by DOOS from the Consortium for Ocean Leadership, by the EMSO-Link EU project (Grant agreement ID: 731036) and by the Faculty of Science RAE Improvement Fund of The University of Hong Kong.

AQ7

Author contributions

R.D., E.F., J.A., D.B., L.C., C.C., A.D., K.G., A.J.J., S.K., C.M., L.L., N.L., E.R-L., H.R., C.R.S., P.V.R.S., L.T., C.L.V.D. and M.Y. equally contributed to the work, critically revised the final version and gave approval for publication.

Data availabillity

xxx

AQ8

Competing interests The authors declare no competing interests.

AQ9

References

1. Danovaro, R. et al. Ecological variables for developing a global deep-ocean monitoring and conservation strategy. *Nat. Ecol. Evol.* **4**, 181–192 (2020).

2. Ingels, J. et al. Ecological variables for deep-ocean monitoring must include microbiota and meiofauna for effective conservation. *Nat. Ecol. Evol.* https://doi.org/10.1038/s41559-020-01335-6 (2020).

3. Dell'Anno, A., Carugati, L., Corinaldesi, C., Riccioni, G. & Danovaro, R. Unveiling the biodiversity of deep-sea nematodes through metabarcoding: are we ready to bypass the classical taxonomy? *PLoS ONE* **10**, e0144928 (2015).

4. Leray, M. & Knowlton, N. DNA barcoding and metabarcoding of standardized samples reveal patterns of marine benthic diversity. *Proc. Natl Acad. Sci. USA* **112**, 2076–2081 (2015).

5. Wei, C.-L. et al. Global patterns and predictions of seafloor biomass using random forests. *PLoS ONE* **5**, e15323 (2010).

6. Marchais, C. L., Bett, B. J., Paterson, G. L. J., Smith, K. L. Jr. & Ruhl, H. A. Using metabolic theory to assess structure and function in the deep-sea benthos, including microbial and metazoan dominance. *Deep Sea Res. Pt II* **173**, 104762 (2020).

7. Morgan, M. G. Use (and abuse) of expert elicitation in supportof decision making for public policy. *Proc. Natl Acad. Sci. USA* **111**, 7176–7184 (2014).

8. Danovaro, R., Molari, M., Corinaldesi, C. & Dell'Anno, A. Macroecological drivers of archaea and bacteria in benthic deep-sea ecosystems. *Sci. Adv.* **2**, e1500961 (2016).

9. Cavicchioli, R. et al. Scientists' warning to humanity: microorganisms and climate change. *Nat. Rev. Microbiol.* **17**, 569–586 (2019).

10. Chiu, W. T. R. et al. Marine latitudinal diversity gradients, niche conservatism and out of the tropics and Arctic: Climatic sensitivity of small organisms. *J. Biogeogr.* **47**, 817–828 (2020).