Biogeosciences Discussions

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Comment on bg-2020-482

Anonymous Referee #1

Referee comment on "Toward a global calibration for quantifying past oxygenation in oxygen minimum zones using benthic Foraminifera" by Martin Tetard et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2020-482-RC2, 2021

The authors explore the relationships between various morphological characteristics of benthic foraminiferal tests (porosity, size distribution, circularity) and the ambient bottom-water oxygen concentration. In this context, the authors established calibration data sets for OMZ samples mainly from the Pacific Ocean and successfully applied the new method to a paleo-record from the eastern Pacific Ocean. Oxygen plays a crucial role in shaping the ecosystem diversity and species composition of marine environments and oxygen changes are tightly linked to climate variability and marine biogeochemical cycles. Recent studies have documented an extension of dysoxic zones in modern ocean environments due to the effects of global warming. In order to assess the potential future impacts of ocean deoxygenation, it is very important to better understand how ocean environments and marine ecosystems responded to climate-related oxygen changes in the past. The present manuscript addresses this important and up-to-date topic and since oxygen is tightly linked to nitrogen and carbon cycling, this issue is very well suited for the journal "Biogeosciences". Although the easy-to-apply morphological approach is very promising and thus highlights the significance of this study, the manuscript will profit from minor revision concerning the evaluation and presentation of the results.

General comments:

1) The authors demonstrate the successful application of the different morphological approaches particularly to the Pacific OMZ and future application to other OMZ appears promising. Nevertheless, at this point, a "global" calibration (as promised in the title) should be based on a much higher number from all major OMZs. Therefore, a more specific title would provide a more honest reflection of the content of the manuscript.

2) Different OMZs of the global ocean have existed over various time intervals, leading also to the evolution and establishment of new, and partly endemic, taxa. In this context,

some taxa have developed and adapted to extremely low oxygen values, which do not share the expected typical morphological features usually observed in low-oxygen faunas. Just to mention some examples: In the Arabian Sea, the rounded *Rotaliatinopsis semiinvoluta* can occur at considerable numbers at very low oxygen concentrations (e.g., Jannink et al., 1998; DSR I 45, 1483-1513). Similarly, the round *Epistominella smithi* apears co-occurs with elongated taxa in the OMZ off SW-Africa (e.g., Schmiedl et al., 1997; MarMic 32, 249-287). This potential bias should be addressed in the discussion chapter.

3) The number of elongated tests can also significantly increase in well-oxygenated environments which experience enhanced organic matter fluxes. There are many examples from shelf and slope environments (e.g. in the Mediterranean Sea and Atlantic Ocean), where the proportion of elongated shallow infaunal taxa (e.g. certain uvigerinids, buliminids and bolivinids) increase in abundance under constantly high oxygen levels. Although this potential bias has been shortly addressed in the discussion chapter it would deserve a bit more attention since it may also play a role at the upper and lower margins of OMZs.

4) The significance and applicability of your calibration data set for the new morphometric index (MARIN) is hampered by the under-representation of calibration points above oxygen concentrations of 0.3 mL L-1 (Values above ~0.3 mL L-1 are represented only by one data point). Please address this issue more elaborately in the revised manuscript. In addition, you should provide the standard deviations and associated errors of your estimates for better assessment of the uncertainty of the different transfer functions.

Specific comments:

Abstract

- Lines 2-5: The first three sentences have an introductory character and may be deleted from the abstract.
- Lines 13-14: It would be useful to add information on the standard deviations and thus uncertainty of the transfer functions.

1 Introduction

- Page 2, line 2: provide reference for the defined oxygen value of 0.5 mL L-1
- Page 2, lines 25-30: you should add one or two sentences that despite the common preference of specific morphologies in low-oxygen environments there are various exceptions (see general comment above).

- Page 3, lines 1-2: The statement "When oxic conditions prevail, the benthic fauna is dominated by epibenthic species" is not correct. In many oxic environments, the proportion of shallow-infaunal taxa can be quite high relative to the amount of available food. A good example is the present Mediterranean deep sea, where oxygen concentrations are high but where a W-E food gradient is reflected by the proportion of shallow infaunal taxa (e.g., De Rijk et al. 1999, JFR 29, 93-103; De Rijk et al. 2000, MarMic 40, 151-166).

2 Material and methods

- General remark: Concentration on the size fraction >150 µm appears useful, since this fraction is widely used in foraminiferal studies. Nevertheless, you should add, that in future studies, the calibration should be also tested on the smaller size fraction (63-150µm) since low-oxygen environments often contain a high number of small-sized taxa and individuals.
- Page 4, line 21: "...available in their..."
- Page 5, line 3: "...disaggregate..."
- Page 5, line 11: Provide information if specimens have been picked from splits or from the entire residue?
- Page 6, lines 2-3: provide a concise summary of the method (no details but just on the general method)

3 Results

- Pages 8-10: as mentioned already above, please add the standard deviation to each determination coefficient in the text and in Fig. 3, and errors to estimated values in Table 2 for better assessment of the uncertainties of your transfer functions.

4 Discussion

- Figures 4 and 5: The graphical design of these figures should be revised. I recommend to simplify the figure by deleting the background coloration and enhancing the contrast of displayed foraminifera.
- Page 12, lines 1-6: Please discuss the potential bias of food flux changes in highly oxygenated environments. Elevated numbers of elongated infaunal taxa (e.g. certain *Uvigerina* species etc.) may occur under similar oxygen concentrations but different food availability. This also illustrates the limitation of your approach in suboxic to oxic environments. You should clearly emphasize this in the revised version.
- Page 13: You should create a new figure presenting the down-core records and oxygen reconstructions of core MD02-2508. This would further illustrate the general applicability of your new method.

- Page 13, line 13: "...by the fact that..."