

Interactive comment on “Uptake of phytodetritus by benthic foraminifera under oxygen depletion at the Indian Margin (Arabian Sea)” by A. J. Enge et al.

Anonymous Referee #3

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The authors describe a foraminifera community from a push core collected in the center of an OMZ along the Indian margin, and assess the uptake of fresh labeled algae into foraminifera cytoplasm. This kind of work is very interesting from a C-cycling and N-cycling point of view, but not necessarily that novel in the sense that similar studies along the Pakistan margin, and studies on the role of metazoan macrofauna in C and N-cycling in this area have already been carried out.

- Reply: We agree that several studies exist that deal with carbon and nitrogen cycling in the Pakistan margin) and studies on metazoan macrofauna (e.g. Levin et al., 1999, Witte et al., 2003, Woulds et al., 2007, Andersson et al., 2008, ...). But we disagree that the presented study does not present new information that has not been given so far.
- (1) This is the first experiment on foraminifera under such low oxygen concentrations. Even the OMZ studies in the Pakistan margin were performed under higher oxygen concentrations.
 - (2) We successfully tested a new tracer (^{15}N) for future experiments and give information for other studies on how many foraminifera are required as it is different to the commonly used tracer ^{13}C
 - (3) We provide data on single foraminiferal species that have never before studied in other feeding experiments (*U. schwageri*, *B. aculeata*, ...) on biomass, their abundance on the Indian margin and about their specific uptake of phytodetritus. These information are important for ecological studies and for paleo-reconstruction.
 - (4) Different demands in carbon and nitrogen were obtain for different species by the use of two tracers. This information provides more information about the metabolic demands on foraminifera and how this is related to feeding and preferences for specific food types. Such information cannot be provided by the analysis of foraminifera as a group, but only if work is performed on species level

While this is not necessarily a reason for rejecting the paper, I feel that the study is very limited in that only a single 7cm core was collected and all of the results come from a 1 cm slice from this core.

- Reply: We agree with the reviewer that our data set is little and can give only a first insight into the role of foraminifera in C and N cycling on the Indian margin. Yet, it provides first information. Limitation depends on what information you want to gain. For example, we concentrated on the > 125 μm fraction and provide information for one core but with an extremely high number of foraminifera to assure accurate isotope analysis and be able to give uptake rates for 9 single species instead of one rate for the entire community. Other studies such as Woulds et al. (2007) may have provided data on 2 cores but only included foraminifera > 300 μm . But literature on benthic foraminifera shows that the majority of foraminifera is smaller than 300 μm and hence this study might have a better replication but important information on the study object itself is lost.

For comparison with other in situ feeding experiments including foraminifera:

Woulds et al. 2007: 2 replicate
Moodley et al., 2002: 1 replicate
Levin et al. 1999: 2-5 replicates
Nomaki et al. 2006: 1 replicate
Nomaki et al. 2005: 1-2 replicates
Jeffreys et al. 2013: >3 replicates
Witte et al. 2003: 1 replicate

The concentration of the upper 1 cm is based on earlier observations (as stated in the text) that foraminifera in OMZ sediments are almost only found in the upper sediment layer.

For this reason, and the fact that I think the authors have over interpreted most of the findings and made large generalizations from this single core (e.g., first line of the conclusions paragraph), I cannot accept this paper in its present form.

- Reply: We agree with the reviewer that findings were over interpreted and generalizations were made that cannot be based on our findings. Hence the manuscript was revised and shortened. We focused on our observations and on the topic of this manuscript: providing ecological information on single foraminifera and how they react under almost anoxic conditions to a food pulse.

I commend the authors for attempting this type of study as deep-sea experiments are notoriously difficult to carry out, and the amount of work that has gone into sorting and identifying the foraminifera is admirable. However, I would have liked to see at least all 3 of the cores sampled and processed, with maybe less impetus placed on identifying every single protist.

- Reply: Again here we have to state that the focus of the study was on single species and not the assemblage itself. Hence we had to place impetus on the identification of species as this was the aim. We agree that results from three cores would be more accurate and reliable but this is just not possible. Because we are aware of the problem, the picked number of specimens allowed us to measure some species in replicates which showed high similarities to one and another.

I think that one way to overcome the enormous limitation of the experimental design would be to start putting the experiment into context. You have an n of 1 and this 1 sample was only sampled to 1cm depth. This must first be acknowledged and the authors should discuss the pitfalls and limitations of this. In no way should the authors start making generalizations that these results show that foraminifera are strongly involved in the cycling of C in the core of the Indian margin OMZ. While I agree that this may be the case, the results only suggest this (at best).

- Reply: We agree with the reviewer that the data set does not allow generalizations to be made. Hence tried to eliminate them and focused on our results and what they meant in the context of the study.

I found it strange that no mention was made of the potential artifacts that can result when fresh algal material is added. Would it not have been better to have added material that was aged in some way? I completely understand that OMZ's are carbon maximum zones and the seafloor will be receiving less degraded material than seafloor environments under oxygenated water bodies, but what they do receive will be aged to some extent. This may be a cause behind some of the strange responses exhibited by some of the forams with a high biomass (e.g., *Bolivina aff. B dilatata*) that appeared to not play a dominant role in C-uptake.

- Reply: We are aware of the problem and also assume that in OMZ sediments degraded algal material could represent a food source for foraminifera as well. So far and to our knowledge only "fresh" material has been used so far in feeding experiments. This is a limitation of this kind of experiments. The algal material is labeled with a defined amount of tracer (^{13}C , ^{15}N). If algal material would be allowed to decay, this ratio might be changed and then the calculation of uptake would be difficult.

The authors state often that "relaxed predation pressure and food competition through the absence of macrofauna, as well as metabolic adaptations to anoxia allow foraminiferal species to take up fresh phytodetritus in amounts larger than at the Pakistan margin OMZ sites". I found these statements difficult to follow as none of the experiments carried out in this study showed relaxed predation pressure and food competition ultimately results in more uptake of material.

If the authors really want to show and discuss the above, I would collect all of the available data from foraminifera C-cycling experiments and run a meta-analysis using macrofauna biomass and bottom O₂ concentration as dependent factors to test this. Without this and with the limited sample size reported here, this can only be hypothesized.

- Reply: We agree with the reviewer that none of the discussed explanations for the high uptake was investigated in the study. Hence this passage of the manuscript has been deleted

One other thing in the paper that confused me was the repetition in the discussion. I think much of this could be removed, which would ultimately lead to a shorter paper. I believe this would be more appropriate for the type of data presented.

- Reply: We agree with the reviewer that the discussion part showed several repetitions. Revising the manuscript, we tried to avoid them and shortened the discussion part significantly.

In conclusion, I cannot accept this paper in its present form. To be able to accept the paper I would like to see that authors run a meta-analysis using their data and that of others to show how the role of foraminifera in nutrient cycling changes as a function of faunal biomass and O₂ concentration. I really believe that this would strengthen the paper significantly.

- Reply: We understand the point of the reviewer. By revising the manuscript, we changed the focus towards the reaction of single species of foraminifera to a food pulse and away from their role in carbon cycling in an anoxic environment. As the reviewer has stated our data set is limited and insufficient to make generalizations on the role of foraminifera in carbon cycling. Hence comparing our results to data from entire foraminiferal assemblages (e.g. Woulds et al. 2007) would not fit. Also the methods used in the different studies are very different (mesh size, identification level, water depth, type of experiment, ...) which would make a meta-analysis difficult.

Moreover, the limitations of the data should be highlighted and all generalizations that cannot be made with the resulting dataset should be removed.

- Reply: We agree with the reviewer on these points. We tried to eliminate all generalizations in the manuscript. If required from the reviewer to accept this manuscript, an additional paragraph in the discussion part will be provided on the limitation of our study.