Thursday 15 December 2023

Author’s response to the second round of review of the manuscript titled “Building your own mountain: The effects, limits, and drawbacks of cold-water coral ecosystem engineering.”

Dear Peter Landschützer, associate editor with Biogeosciences,

Thank you for the opportunity to resubmit our manuscript after minor revisions.

We addressed the comments from dr. Andres Rüggeberg. Our response is attached at the end of this letter. We think that we addressed all comments sufficiently and that the manuscript improved.

My apologies for the slight delay in the revisions of this manuscript.

Thank you for considering our manuscript for publication in your journal.

With kind regards,
On behalf of all co-authors,

Anna van der Kaaden

Reply to dr. Andres Rüggeberg.

General remarks:

The manuscript went already through a review process with suggested major revisions and the present revised version improved a lot. However, I still have some concerns, which I would like the authors to consider:
- I think the authors should better differentiate between short and long-term processes in their discussion, please see detailed comment for lines 388–398 in the attached pdf;
- The authors could better discuss the relationship of mound height to increasing hydrodynamic variables (see more detailed comment to Lines 181 and 281 in the attached pdf). I miss the discussion on mounds reaching a maximum height at the boundary (perm. thermocline, water mass, density) and their behavior/control at the maximum height, or mounds occurring at much shallower water depths (e.g., Norway);
- Figures and tables could be improved, see comment to Fig. 1, Table 1, Lines 214 and following, Fig. 4 and Fig. 8 in the attached pdf;

In the end, I suggest moderate revisions to address these points, but also to publish this article after revisions, as the data and conclusions bring some new aspects to the general discussion of coral carbonate mounds and environmental drivers.

I hope, these comments help the authors to improve their manuscript.
Kind regards.

Dear dr. Rüggeberg,
Thank you for your careful review and for your helpful suggestions. Indeed, we did not discuss the hypothesis of a maximum mound height and what could happen near the boundaries of water masses etc. We like the suggestion, and we are glad to include it in our discussion. Below is our reply to your detailed comments.
Kind regards,
Anna

Detailed remarks:

Line 56: …develop into mounds, where coral growth and sediment infill… add a "comma" and "where", otherwise the sentence does not make sense.

Yes, thank you.

Fig. 1: The color coding for the transects are not well chosen as they are hardly to be identified. Wouldn't it be better to simply use black and white including numbers? The authors could also zoom into the area as for the side view – then the transects are larger and better visible (see sketch to the right).

Yes, thank you. We added a zoom in on the part of the map with the transects (same as for the side view) and highlighted the transects in black, with a colour-shading. We also numbered the transects, like in the side view and labelled the different sub-figures (a, b, and c). We also increased the size of the legend. We choose to keep the large image of the entire province since it also indicates the encircled cold-water coral mounds that are used in our analysis.

Line 140: space between 140 and m

Yes, thank you.

Table 1: To better structure the table and compare the data, I would recommend to add columns to min, mean, max values instead of separation by comma. For downward velocities, numbers are in opposite order (max, mean, min).
Furthermore, the authors present the hydrodynamic variables for the "mound-and-corals setting" only – however, it would be helpful for the reader to compare the data with the "no-mound setting" of the smoothed seafloor – even, if they had been published earlier. For example, in Lines 176-179, the authors mention "We calculated the coral mound engineering effect by subtracting … (hydrodynamic variables) … of the simulation with smoothed bathymetry (…) from simulations with unmodified bathymetry (…)." or in the caption of Fig.6 – it would be helpful showing these data to better grasp the difference and the impact CWC reefs and mounds do have.

Yes, thank you. We added columns for the min, mean, and max values and changed around the values for the downward velocities. We also added a second table (Table 2) with the min, mean, and max values of the hydrodynamic variables for the unmodified and smoothed bathymetry. These are the values on the locations of the mounds (as in Fig. 1), not from the entire area. We liked the idea of adding these values. Before we simply didn't think of it.

Line 180-181: quite confusing sentence – better rephrase.

We rephrased the sentence to (Line 181):
"We define a coral mound engineering effect as a positive or negative feedback, meaning that the magnitude of the hydrodynamic variables increases or decreases resp. with increasing coral mound height. To investigate which hydrodynamic variables are influenced by the size of a coral mound we calculated…"

Line 181: "hydrodynamic variables will increase if mound height increases" – this is a positive feedback mechanism – just for curiosity, do there also exist negative feedback mechanisms?
What about the situation, if mound height reaches the level of deep thermocline or water mass boundaries or change in density level – then the mounds would grow more towards the sides then further increasing the height of the mounds. In this situation, the mound height would also limit the engineering effect and influence the environmental factors supportive for the corals. It would be nice to see a discussion on this issue as well.

Yes, there can be a negative feedback. Actually, we see that bottom current speeds are decreased at some mound sides and that the absolute effect on bottom current speeds significantly correlates with mound height, suggesting a negative feedback. To make it clearer that both feedbacks are possible, we changed the sentence on line 183: "A significant correlation thus indicates a significant positive or negative effect of coral mound engineering on the hydrodynamic variable."

With regards to the 'maximum mound height': When performing hydrodynamic simulations around two coral mounds of increasing (and decreasing) size, we saw no such limiting effect of hydrodynamic variables on the mounds (van der Kaaden et al., 2021, Deep-Sea Res. I), even though the coral mound heights were increased up until 1.5 times their current size and through the permanent pycnocline. Of course, coral mound formation can be restrained by non-engineered factors, as we discuss in section 4.1. The engineering effects are still interesting to study, even if mounds are constrained by non-engineered processes, and the massenerhebung effect would still apply.

To the discussion on broad-scale environmental control (section 4.1), we added (line 340): "Environmental factors other than the hydrodynamic variables investigated here, might also affect coral reef growth and subsequent cold-water coral mound formation. For example, certain water masses (Schulz et al., 2020), the permanent pycnocline (White and Dorschel, 2010), internal waves (Wang et al., 2019; Wienberg et al., 2020), seawater density (Flögel et al., 2014), and (terrestrial) sediment supply (Pirlet et al., 2011; Vandorpe et al., 2017; Lo Iacono et al., 2014) have been suggested to restrain mound formation. Cold-water coral mounds can become buried following changes to the sedimentary regime (Lo Iacono et al., 2014) and for the Logachev cold-water coral mound province it has been hypothesized that the mounds stopped growing when reaching the permanent pycnocline (White and Dorschel, 2010) or the WTOW upper boundary (Schulz et al., 2020). Van der Kaaden et al. (2021) found no levelling off of the engineering effect of the coral mound on the local hydrodynamics, even when the mound was higher than at present. Such a levelling off is also not apparent in our results (Fig. 6). This underlines that, even though coral mounds engineer their local hydrodynamic environment, coral mound formation could be restricted by non-engineered environmental processes. Still, for cold-water coral mounds that are not buried it can be interesting to investigate the general hydrodynamic regime that arises around cold-water coral mounds and how this regime might explain reef zonation on mounds."

From Line 214 onwards you describe data of RDA Axes 3 and 4, which are not shown. I would recommend to show these data as well in Fig. 4, which could be arranged like this sketch (or put a) and B9 on top and c) and d) at the bottom):

Or dependent on the proportion explained by RDA axis, skip axes 4 and 5 (also in the description, as both have values below 1%) and only show axes 1–3 (also in the figure 4).

We liked your suggestion, so we added the third axis to figure 4 and removed reference to the fourth axis in the text. We added to the results (line 219): "We do not discuss the fourth axis, as it explained <1 % of the variation in benthic cover."

Fig. 7: in a) y-axis: add space between "Absolute" and "bigdelta"

Yes, thank you.

Lines 281–283 (and in general): This conclusion may be true for the investigated Logachev mound province. However, mounds which have reached the permanent thermocline/water mass boundary/density gradient like the upper Belgica Mound chain in the Porcupine Seabight may not provide this supportive, engineering conditions to positively affect coral/mound growth. Here and elsewhere like the Norwegian reefs, the mound height may not directly affect the coral reef growth as at the (bigger) Logachev mounds. I would recommend to tone done conclusion and/or link them to the study site instead of too much generalization.

We added (line 279) "Our results underline that, at the Logachev cold-water coral mound province, conditions for cold-water corals…"
We further do not claim that the mounds positively affect mound growth, but we discuss how the hydrodynamic regime that arises around coral mounds determines the facies/reef zonation on coral mounds (section 4.2). We do think that the 'hydrodynamic regime' is a general feature of coral mounds as its description is based on hydrodynamic theory of waterflow passed an object in combination with observations from several cold-water coral mounds (line 361).

Line 326: add space between 600 and m

Yes, thank you.

Line 351: replace the second "3)" with "5)"

Yes, thank you.

Line 354–356: there exist earlier studies and from different disciplines showing this pattern of coral settlement and sedimentary facies on carbonate mounds, for example:

1. Freiwald, A., Hühnerbach, V., Lindberg, B., Wilson, J. B., and Campbell, J., 2002, The Sula Reef Complex, Norwegian Shelf: Facies, v. 47, p. 179–200.
2. Foubert, A., Beck, T., Wheeler, A. J., Opderbecke, J., Grehan, A., Klages, M., Thiede, J., Henriet, J.-P., and The Polarstern ARK-XIX/3A Shipboard Party, 2005, New view of the Belgica Mounds, Porcupine Seabight, NE Atlantic: preliminary results from the Polarstern ARK-XIX/3a ROV cruise, in: Freiwald, A., and Roberts, J. M. (eds.), Cold-Water Corals and Ecosystems: Springer-Verlag, Berlin, p. 403–415.
3. Dorschel, B., Hebbeln, D., Rüggeberg, A., And Dullo, C., 2007, Carbonate budget of a deep water coral mound: Propeller Mound, Porcupine Seabight: International Journal of Earth Sciences, v. 96, p. 73–83.
4. Mortensen, P. B., Hovland, M. T., Fossa, J. H., and Furevik, D. M., 2001, Distribution, abundance and size of Lophelia pertusa coral-reefs in mid-Norway in relation to seabed characteristics: Journal of the Marine Biological Association of the UK, v. 81, p. 581–597.
5. Wheeler, A. J., Kozachenko, M., Henry, L.-A. Foubert, A., De Haas, H., Huvenne, V. A. I., Masson, D. G., and Olu, K., 2011a, The Moira Mounds, small cold-water coral banks in the Porcupine Seabight, NE Atlantic: Part A—an early stage growth phase for future coral carbonate mounds?: Marine Geology, v. 282, p. 53–64.
6. Foubert, A., Huvenne, V.A.I., Wheeler, A., Kozachenko, M., Opderbecke, J., Henriet, J.P.,

2011. The Moira Mounds, small cold-water coral mounds in the Porcupine Seabight, NE Atlantic: Part B - Evaluating the impact of sediment dynamics through high-re- solution ROV-borne bathymetric mapping. Mar. Geol. 282 (1–2), 65–78.
An overview:
Vertino, A., Spezzaferri, S., Rüggeberg, A., Stalder, C., Wheeler, A., and the EUROFLEETS CWC-MOIRA Cruise Scientific Party (2015) An overview on cold-water coral ecosystems and facies. Cushman Foundation Special Publication No. 44, p. 12–19.

Thank you for the references. Freiwald et al. (2002), Mortensen (2001), Wheeler (2011), and Foubert (2011), address the reefs that are much smaller (i.e., with a height in terms of meters, up to at most 35 m) than the coral mounds that we address (with a height of several tens of meters up to hundreds of meters), therefore we did not add these references. We added the reference to Cold-water corals and ecosystems (2005), Dorschel et al. (2005), and Vertino et al. (2014).

Line 378–380 and line 384: here you should refer to mountain instead of mound. It should read: "These zones vary with relative altitude on the mountain, but not with the absolute height above the ground, because of feedbacks between the size of the mountain and the environment (…)" and "…feedbacks between the mountain and the environment, …".

Thank you. We now wrote 'mountains' when referring to the massenerhebung effect as described for terrestrial mountains and to 'mounds' when referring to cold-water coral mounds (line 390).

Lines 388–390: I think that the authors make it a bit too simple. They should clearly differentiate between the short-term processes related to different times with long-term processes. For example, the deep winter mixing occurs during February, which correlates with the higher downward velocities (indicate in Fig. 8 the timing of the processes, especially in 8b Side view – here it looks like all processes happens at once), while the upward velocities occur during August supporting the nutrient upwelling.
The latter was also reported by Findlay et al. (2014) but only to the depths of the coral mounds. Soetart et al. (2016) then shows that the upwelling occurs also to shallow areas, but together with the February downwelling they are clearly tidally influence with strong velocities (interesting for the engineering process) during spring tides only.
In Lines 393–398 the upwelling processes are related to nutrients transported to the sea surface, where strictly speaking the reference to Findlay et al. (2014) is not supporting this. Further in the text, the authors compare that the primary productivity is stimulated by these upward water motion bringing nutrients to the surface with processes on millennial time scales (glacial-interglacial) and refer to Eisele et al. (2011), which compare coral age data with TOC mass accumulation data from a close-by ODP core offshore Mauritania indicating a possible relationship at millennial time scales, or to Wienberg et al. (2020) and (2022), which do not present any nutrient- or primary productivity-related data to compare (2020), or they compare the western Mediterranean Sea coral mound record with an eastern Mediterranean ODP core showing Monsoon-related variability of Nile river discharge (far away from the coral site) for the former study (2022). I would recommend clear separation of processes on short- and long-term and discuss it properly.

We clarified our reasoning in this paragraph and toned down our discussion on nutrient upwelling (line 407): “These nutrients might be transported by the predominantly upward water motions…”. We clarified our reasoning using millennial time-scale studies (line 409): “This might benefit the coral reefs, as a global review (Maier et al., 2023) and studies on millennial time scales (Eisele et al., 2011; Wienberg et al., 2022) show the benefits of increased primary productivity for coral reef growth.”

Figure 8: in panel (a) we clearly state that these processes happen in February. The engineered hydrodynamics in panel (b) happen regardless of season. In the caption for panel (b) we clarified: “The up- and downward water motions do not necessarily happen simultaneously but can result from (spring-neap) tidal motions.”

In the section (4.3 Ecosystem engineering effects on cold-water corals and climate change) we explicitly discuss the ecosystem engineering effects in relation to climate change and not the non-engineered environmental processes such as deep winter mixing (discussed in section 4.1). From previous studies we know that cold-water coral mounds also influence downward water motions, but within the entire cold-water coral mound province we did not find a correlation between mound height and the absolute effect on downward velocities in February. We find it likely that this is because the signal is obscured by broad-scale environmental processes in February, e.g., deep-winter mixing. We already indicated this at the beginning of section 4.2 but now elaborated to (line 356): “Previous studies (e.g., van der Kaaden et al., 2021; Davies et al., 2009; Findlay et al., 2013; Cyr et al., 2016; Mienis et al., 2007) showed that cold-water coral mounds affect downward water motions. Our results also indicate that coral mounds influence downward velocities in February (Fig. 6). However, the magnitude of this effect does not correlate to mound height, likely because of the prevailing influence of non-engineered broad-scale environmental processes in winter (discussed in section 4.1).”