# Reply to reviewer 1:

De Froe and co-workers use a predictive mechanistic model to estimate cold- water coral biomass distribution and respiration. Their model successfully reproduces observed reef biomass and respiration patterns. The advantage of this approach can be used to obtain the effect of changing environmental conditions such as ocean temperature, export production or ocean currents.

The study presents a first mechanistic model predicting cold-water coral biomass distribution based on organic matter transport and hydrodynamics. The authors set up the model by cleverly coupling three models, offering a new perspective on the mechanisms driving coral distribution. They demonstrate that coupling organic mater uptake with the cold-water coral model is key to predicting the spatial distribution of these corals.

The authors clearly identify existing gaps in the field and present a study that brings new knowledge and tools that can be applied in future research.

**Scientific quality:** yes, excellent.

**Presentation quality:** The manuscript is clearly written and well-structured. The number of figures, conceptual diagrams, and tables is appropriate, and they are of high quality. The supplemental material is warranted and adds value. The authors also discuss the limitations of their work, and the conclusions are well-supported and justified.

I am very positive towards the study, as the findings are important.

Dear reviewer,

Thank you for having taken the time to review our manuscript and your kind words. Below you can find a reply to each of your specific comments:

**Specific comments and detail points**:

Line 87 : “This feedback between organisms and their environment can greatly affect how they respond to environmental changes: by modifying their own environment, organisms can rearrange their spatial patterns in response to climate change thereby avoiding a tipping point towards extinction (Rietkerk et al., 2021)” could be reworded. The temporal aspects are not fully resolved within the time scale of the study. Also add a reference relevant to corals.

Thank you for this comment. Indeed, the changing spatial patterns are not resolved by our model. This would require a dynamic seabed in our model domain. We here introduce the idea that spatial-self organization can accommodate negative effects of climate change in general (Rietkerk et al.) and that CWC reefs show signs of spatial self-organization (vd Kaaden et al.). We rephrased the sentence to clarify this. ##

References in introduction and discussion : Consider reducing to 3-4, as some currently contain five. This will improve readability and focus.

Thank you. We think it is important to acknowledge research where appropriate. Some sentences indeed have five references, but they are only limited. We suggest leaving these few (extra) references in the manuscript.

Line 163: replace " numerous associated animals" with "numerous associated organisms".

Done.

Lines 508-510: The authors could be more specific in this section to enhance clarity and strengthen the argument.

We interpret this comment as the reviewer would like a more explicit link between depletion of POC in the bottom water, negative scale-dependent feedback, and spatial self-organization. A bit more context is indeed useful to add, we adapted this paragraph as:

Our model results are in line with previous work which shows that CWCs are self-organizing ecosystems engineers and reefs form self-organized regular patterns (van der Kaaden et al., 2023). Self-organization is the process where organisms form regular patterns in ecosystems due to local-scale interactions between organisms and their environment (Camazine et al., 2001). These interactions can either be positive, whereby organisms enhance local resources by modifying their environment (i.e., ecosystem engineers), or negative, whereby organisms deplete resources, which leads to competition (Rietkerk and van de Koppel, 2008). If feedback mechanisms operate at different spatial scales, it is referred to a as scale-dependent feedback, which is a central principle in the theory of self-organization (Rietkerk and van de Koppel, 2008). The results of our modelling study also indicate the presence of scale-dependent feedback in CWC mounds in our study area. CWC mounds enhance food availability on a very local scale (summit and the upper flank of the mounds) which is a positive scale-dependent feedback and leads to high CWC biomass in these areas. Depletion of POC in the bottom water by CWCs in our model decreased the quantity of available food for CWCs on a wider spatial scale located downstream of the areas with high CWC biomass (Figure 10B). This can be seen as a negative scale-dependent feedback (van der Kaaden et al., 2020), and leads to lower CWC biomass in the areas downstream of the upper flank and summits of the CWC mounds. This depletion of resources by CWC in the water column due to filtering activity has also been observed in the field (Lavaleye et al., 2009; Wagner et al., 2011). Our model successfully simulates this process, providing further evidence that CWC reefs are self-organizing ecosystems, and therefore might show resilience to environmental change (van der Kaaden et al., 2023; Rietkerk et al., 2021).

Lines 581 to 585: This section needs to be better explained, particularly the last sentence. I recommend splitting it into two sentences for improved clarity and flow.

Thank you, changed these lines to the following:

The presented mechanistic modelling framework could be used to study the effect of changing temperatures, currents, pH, and nutrients on the spatial distribution of CWCs in the deep sea. CWCs could be severely affected by rising global temperatures and ocean acidification (Chapron et al., 2021; Gómez et al., 2018, 2022; Gori et al., 2016; Guinotte et al., 2006; Lunden et al., 2013; Orr et al., 2005). This modelling framework could be used to study these effects by, for example, coupling CWC respiration to water temperature or mathematically simulating the higher cost of calcification under ocean acidification by increasing basal CWC respiration (Dodds et al., 2007; Gori et al., 2016; McCulloch et al., 2012).

References : There are some inconsistencies in formatting within the reference list. Please revise to ensure uniform style throughout.

We revised the reference list and removed any errors (as the reference to Guinotte et al., 2006 for instance).