Reply to reviewer 2:

General comments

The paper outlines the development of a new mechanistic model predicting coral biomass and respiration rate at Rockall Bank. Model data is compared to observational data and habitat suitability models from Rockall Bank to assess how the new model performs. As someone who is interested in food delivery to deep-water coral habitats I am very excited about the future possibilities of this type of work. I suggest minor revisions, which are outlines below. If this revisions can be addressed, I would happily support this for publication and look forward to seeing what mechanistic modelling of corals can tell us about nutrient cycling.

Specific comments

It would greatly benefit the strength of the paper if the authors could find a way to compare model results to observational data. Maybe an example could involve taking CWC biomass (mmol C/m2) as a ratio of carrying capacity to get a number that is comparable to percentage cover? A few lines of text going over this could replace the section where authors say results are challenging to compare. In doing so, they could elaborate on what type of substrate/conditions/depths the model is most useful for.

The model shows quite good agreement with a published habitat suitability model which is good to see, but more explanation on why the presented model should be chosen over a habitat suitability model moving forward could be explored. An example is given on line 585 where the effect of rising T could be indirectly included in the new model, but presumably T could also be directly updated in a habitat suitability model to predict the effect of warming T? It seems like exploring changes to food availability is a strength of this mechanistic model so expanding on this, or something similar would be very interesting.

Thank you for your review and feedback. To answer your concerns:

1) Comparing model results to observational data.

We see your point. In section 2.5 we elaborate on the data sources that we use to compare our model with observations. We compare our model with coral cover data (the videos, Maier and de Clippele et al.), benthic respiration (the box cores and AEC technique, de Froe et al.), and habitat suitability models (Rengstorf et al.). To use a biomass to carrying capacity ratio could be useful to compare with coral cover, but it is also a bit of a paradox. The carrying capacity was estimated based on pictures from the box cores from de Froe et al., 2019. It is an estimate, and the actual value of this parameter is not well constrained. Coral cover of the video transects is calculated in a different way, as these videos are taken with an ROV. However, from de Froe et al. 2019, we do have biomass estimates from several locations. We will add some sentences that compare our modelled biomass data from these box cores. ##

2) Habitat suitability models vs. mechanistic models: I am not sure if our mechanistic model approach should always be chosen over a habitat suitability model. The two models require different kinds of data as input, which is available/not-available depending on the situation.

Reviewer three also had the following comment on this: Additionally, some key advantages of the approach could be highlighted further. For example, this mechanistic model can estimate parameters that are difficult to obtain with statistical modelling such as species distribution models (e.g., biomass, respiration), especially in data-limited environments such as the deep sea. Statistical models often require extensive datasets and in the case of deep-sea benthic species they are typically limited to presence/absence or abundance data, with very few exceptions, such as the models used for validating the present study. Emphasizing that this model integrates physiological and environmental information without requiring large-scale sampling, except for validation, would strengthen the paper's contribution and practical significance.

To tackle these remarks, we adapted section 3.4 by emphasizing what the advantages are of mechanistic modelling compared to statistical habitat suitability models. For example, in statistical models, temperature could indeed be adjusted as well, but that would be based on a static dataset, where you, for example adjust the mean bottom water temperature over a spatial grid. In mechanistic modelling, you can couple the physiological processes with the water temperature, on a much smaller temporal scale. We emphasize this now in section 3.4. ##

Scientific questions

83 – what is meant by interactions?

Thank you, we mean interactions between cold-water corals and their environment. We added this to the sentence.

85 – enhanced – This word choice makes it sound like corals increase the amount of OM. But I assume it's meant to convey that OM concentrations are higher around the reef relative to nearby sediments because of their ability to retain nutrients? Maybe rephrase as "availability is higher on the reefs related to around them"? Or something like this?

Thank you, we adjust this sentence accordingly. ##

166 – Why is suspended POM selected over sinking POM? Suspended POM is usually more refractory than sinking POC? Sinking POM would presumably have a faster settling rate and so could change model outputs. A line or two on the distinction and the decision for the model would be informative.

Thank you. We mean sinking POM, we will update the MS accordingly. ##

- Suspended and sinking POM are the same, nearly all suspended POM also sinks, depending on the size/shape of the particle (Ivensen et al., 2020).
- We chose a sinking rate of 10 m d-1. Choosing a faster settling rate would increa the passive supply of POM to the seafloor but would lower the concentration of POM in the model. Choosing a slower settling rate would decrease passive supply but increase concentration in the model domain.

In the text, could you expand on any environmental factors that could explain why the model has difficulty matching VT6 in figure 8? Such a large presence of corals from 0-250 m coincides

with very low biomass compared to what is predicted in VT2, VT5. Line 386 says the model agrees with observational data but they don't match that well for some sections. What is it about VT2 that leads to such high values? Some specifics on the sites could be useful beyond mentioned model issues (depth of the model and patchy resolution).

Thank you, there are indeed some transects that match less well with our model than others. We mean that in general, the modelled CWC biomass matches high/low coral or dead framework cover. You can see in the transects, except for VT7, that if high coral cover is recorded in the video, our model shows also a peak on that transect. Therefore, we now start the sentence in 386 with "Generally, ".

But there are indeed some differences between the sites. For VT6, the model predictions are shifted somewhat southward, as with VT1. This is due to the general current direction and velocity in the model domain, and the much lower resolution of the model domain compared to the video transects, and the location of the transects on the mound (i.e., northwestern slope or the northeastern slope). As the general current is in southwest direction, most high CWC biomass is found on the south/southwestern slopes of the mounds. For example, VT6 is located on the northeastern slope of Haas mound, and therefore shows a lower biomass in the model, and VT2 is located on the southern slope, and therefore Coral biomass at VT2 is higher than at VT6. We adapted this section so that we clarify where this difference comes from. ##

Technical revisions

Line 9 – space between 2 and C which other affiliations don't have.

Done.

Line 22 – The distribution of "these"

Done.

Line 25 –30 It's a bit unclear how many different models are used when reading the abstract. Rephrasing this so it's clearer would help the reader.

Thank you, we changed this to the following sentences:

Here, we present the results of a mechanistic process-based model in which coral biomass and respiration are predicted based on hydrodynamics, organic matter transport and coral physiology. The model domain comprises the cold-water coral mounds of the south-east Rockall Bank in the north-east Atlantic Ocean.

Line 30 – available experimental reports - plural.

Done.

Line 32 – occurrences "comply" – Odd word choice?

Done, replaced with agree.

Line 72 – suggest revising sentence. As stated, this is a long sentence and it might be clearer/more accurate to take the latter half "and new tools and models are needed to understand how CWCs will be influenced by a changing marine environment" and rephrase it to say that new tools and models represent a way to offset or supplement, etc. the challenges of physically sampling.

Done.

Very applicable, thank you for pointing that out.

Removed the word soft.

The end of this paragraph provides a bit more information on the relief. We moved the end of the paragraph to the middle and added information on the height of the mounds and ridges. This paragraph now reads as follows:

The study area is situated on the south-eastern (SE) slope of Rockall Bank (north-east Atlantic Ocean; Figure 1A). The substrate in this area is characterized by biogenic sediment at the shallow part of Rockall Bank (300 – 500 m depth), coral capped carbonate mounds and ridges on the slope between 500 – 1000 m depth, and biogenic sediments in between the carbonate mounds and in the deeper part of the Rockall Bank slope (>1000 m depth; Kenyon et al., 2003; Mienis et al., 2006). Numerous CWC ridges and mounds are found along this slope, in an area known as the Logachev mound province (Figure 1B). The CWC ridges differ in height and shape but are mostly elongated perpendicular to the slope. CWC ridges and mounds are generally between 50 – 300 meter in height. The largest CWC mound in the model domain is called "Haas mound" which is around 300 m high, one to two km wide, five km long, and elongated parallel to the Rockall Bank slope (van der Kaaden et al., 2021). For readability, we will refer to the coral mounds and ridges in this area as 'CWC mounds'.

The current direction throughout the water column is predominantly to the southwest, driven by the clockwise gyre circling the Rockall Bank (Hansen and Østerhus, 2000; Holliday et al., 2000; Mienis et al., 2007; Schulz et al., 2020). The area is subject to internal waves with amplitude of several 100s of meters and high bottom current speeds (i.e., >50 cm s^{-1}; Mienis et al., 2007; Mohn et al., 2014). Interaction of tidal currents with mound topography cause breaking of internal waves (Cyr et al., 2016) with subsequent downward transport of organic matter (Duineveld et al., 2007; de Froe et al., 2022; Soetaert et al., 2016).

Thank you, changed the sentence to:

The keystone species *D. pertusum* is used as the model species in this study because it provides habitat to numerous associated organisms (Costello et al., 2005; Freiwald et al., 2002; Husebø et al., 2002; Jensen and Frederiksen, 1992), and contributes substantially to reef metabolism (de Froe et al., 2019).

162 "used as (the?) model species" missing word?

See above.

193 – variably called organic matter transport model, organic matter reactive-transport model, or reactive transport model. Should be consistent throughout.

198 – "/" which should be a "."?

Thank you, corrected.

201 – consider replacing word "representable" with "representative".

Replaced the word.

207 – it would be nice if this formula were in a slightly smaller font and could be on one line.

This should be done in final formatting of the OS editing team I think.

210 – No POCC in formula – is the extra C a type?

Yes, apologies, corrected.

230 – biomass "is" calculated? Typo?

Yes, thank you.

253 – and consists "of" 1.36? typo?

Yes, thank you.

254 – D. pertusum comprises of 2.12 <- should either be "comprises 2.12" or "consists of 2.12".

Corrected.

294 – change in font size

Thank you, adapted.

394 – missing word? Due "to" a patchy distribution

Thank you, corrected.

420 – typo – where framework is "built" up

Thank you, corrected.

426/27 – font change for references

 Thank you, corrected.

Figures

As a general comment for all map figures, it would be informative to have contour interval either on the map or in the caption. Contour lines are labeled in figure 10C but nowhere else I believe.

Thank you, contour lines will be added##

Figure 1

Missing scale bars, contour labels and geographic labels throughout Figure 1. Figure 1A is not useful if the reader is not familiar with the region. Ideally, UK and Ireland could be labeled. B and C – what are the intervals of the contour lines? Either add to figure or in caption. C) Latitude label is mostly covered and if there was meant to be a longitude label it is missing.

It's also a bit confusing that red arrows convey current trajectory and as a label pointing at the mound. Maybe change the colour of one? Or possibly remove the arrowhead from the Haas mound label?

Thank you, I adapted the figure according to your comments. ##

Figure 2

First word should be capitalised.

Done.

Figure 3

Could you provide a scale quantifying the shade of green used? Presumably darker means higher concentration of POC?

Yes, I will adapt this accordingly. ##

Figure 4

I think coral region and coral presence lines are the same? Could you simplify this to one label so the figure and caption are consistent?

Yes, I will adapt this accordingly. ##

Figure 6

Consider replacing this with panel D from Figure 10. It would be more useful to show how the modeled data compares with the habitat suitability model since that is a focus of the paper.

It is the same data, only in figure 10 is the statistical model shown on top of it as red lines. I suggest keeping it this way, as I think the red lines interfere a bit with our results. So, if I replace this figure with 10D, then the distribution of biomass from our CWC model will be unclear. Now you can see nicely that biomass concentrates on the southern slopes of the CWC mounds.

Figure 7

Why does coral presence reach 40-50% in panel A, but corals are nearly absent in Figure 8F? Shouldn't they both come from video 7?

Thank you, no these are not data from the same video. I see that we say in the caption that this is video 7, but it is actually video 1. I changed this to video 1.

Figure 8

The number 1 represent the start of the transect, I replaced it with the "Start", to clarify. ##