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Interactive comment on "Zooplankton mortality effects on the plankton community of the Northern Humboldt Current System: Sensitivity of a regional biogeochemical model" *by* Mariana Hill Cruz et al.

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Comment:

Dear authors,

General comments

The manuscript describes the responses of the ETSP region in terms of model experiments by changing mortality rates of the two zooplankton compartments that the model includes. It is an interesting study and it is related to the scope of the journal.

Overall, I find the model does not match very well the observations at surface level (approx. 20m depth. This is indeed discussed in the manuscript and special attention should be put in these differences, more details should be provided about the sources for these differences. The main strength of this manuscript is represented by the analysis of the experimental design and the responses of the different compartments in the model and how they relate to the region chosen in the domain. I think this manuscript is within the standards of excellence of this journal in terms of scientific quality and significance.

Response:

Dear referee,

The authors thank you for your useful comments and support for this paper. We will put more emphasis on the sources of differences between the model and observations in Sect. 4.1.

We note that in the analysis of scenarios A, which serve as complement for experiments B, there was a mistake in the weighting of the time steps when calculating the annual average of the concentrations. This has now been corrected and affects slightly Fig. 4 and Fig. 10 of the paper (see Figures 1 and 2 in this response). For Fig. 4 in the paper we now only present the surface concentrations of organic compartments, to follow the suggestion by referee three (presented here as Figure 3). These changes do not change any of our conclusions.

Comment:

Abstract

My main comment from the abstract and throughout the manuscript is to be consistent with the names you use for the compartments of the model: either use ‘large’ and ‘small’ zooplankton or use ‘meso’ and ‘micro’ zooplankton. The same comment goes for the compartments of phytoplankton: nano- and micro-phytoplankton or large and small phytoplankton. If they do not mean the same, you should state this, but if they do, you must be consistent with the use of those names.

Response:

We will standardise the language and refer to modelled plankton only as "large" and "small" while keeping the term "mesozooplankton" when referring to observations. This will be explained in the introduction of the revised manuscript.

Comment:

Introduction

L29 'presumably due to sensitivity to environmental variability' – can you specify what environmental variability you refer to?

L32-38 This paragraph should be rephrased or use a connector when you explain the two species.

L50-51 The last sentence in the paragraph should be rephrased for better clarity as it is difficult to understand.

L58 Can you specify what is the definition of linear and quadratic mortality?

Response:

In line 29 we mean the cessation of upwelling caused by El Niño, and will rephrase the sentence accordingly. We will also rephrase lines 32-38 and 50-51, and explain linear and mortalities including their mathematical expressions in the revised manuscript.

Comment:

Methods

Figure 1 – in the introduction you mention that anchovy spans from northern Peru to Talcahuano. Can you add landmarks in the map to show where is Peru and Chile? And

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why did you choose that domain for each region (O, C, F)?

Response:

Politic divisions will be added on Fig. 1 of the paper (see Figure 4).

The full domain was chosen to have an overview on the whole model response. C and O where picked to examine differences in a region with high and low nutrients. The coastal upwelling region was chosen in an area of high nutrient concentrations. Since the upwelling system of Peru is quite heterogenous with lots of mesoscale processes, we restricted our high nutrient region to the very coastal upwelling area where the concentration of large phytoplankton is high. The oligotrophic region was picked as far as possible from the nutrient rich areas along the Equator and along the coast, but apart from the domain boundary to avoid boundary effects. We will extend the description of these regions, and extended the explanation why we picked them at the end of section 2.5.

Comment:

L108 – 126 When you define the compartments for phytoplankton and zooplankton, it would be good to give a quantitative definition for each compartment. For example, in terms of size class: does microzooplankton include all species that are <200 μm? And the same for the other compartments.

Response:

The model does not have a size parameter in the strict sense (as, for example, size-dependent allometric rates) but instead it tries to replicate groups that occupy niches of the large and small communities by simulating the nitrogen fluxes going in and out of each compartment. Therefore, the small zooplankton compartment represents the whole zooplankton community smaller than about 200 μm and large zooplankton the community larger than that. Similarly, large and small phytoplankton aim at representing communities larger and smaller than about 20 μm. We will clarify this in Sect.

2.2.

Comment:

L139 – 146 Do you consider temperature dependence in zooplankton processes? How can this affect your results if you would include it? Or justify/discuss why not having it and the effect this could have in your results if it is relevant.

Response:

The BioEBUS model in its standard configuration does not include any temperature-dependent zooplankton rates. We expect, that if temperature-dependent grazing of zooplankton was implemented, the loophole for phytoplankton growth in the cold waters of the coastal upwelling region (on which we comment in Sects. 3.1 and 4.2) would be even widened, amplifying the "spatial succession" we observed. However, temperature might also affect zooplankton metabolism, with colder temperatures decreasing, for example, its excretion rates, which could mute these effects again. We will comment on this in Sect. 4.2.

Comment:

L205 It might be worth briefly describing the way the model calculates the nitrogen and state variables fluxes or at least reference a paper that describes those processes.

Response:

The model considers several nitrogen processes including anammox, denitrification and nitrification. Because we did not focus on these processes in the study, we kept their explanation to the minimum. The processes are described in detail in the paper by Gutknecht et al. (2013) which is based on the formulation by Yakushev et al. (2007). We will expand in the revised version of the paper.

Comment:

L258-259 P_S shows an important difference in deep water for the A_high and B_low experiments, are those differences negligible? It might be good to at least mention or have a brief explanation about those differences.

Response:

The absolute differences are negligible (0.00004 and 0.00001 in O, 0.00004 and -0.00004 in F, and -0.00019 and -0.00034 mmol N m^{-2} for A_high and B_low respectively). Based on the suggestions made by reviewer 3 we now decided to remove the deep layer (100 to 1000 m) from Fig. 4 of the paper (see Fig. 3) because this is not an important component of the paper and complicates the figure.

Comment:

L321 Please give some examples about the non-linear processes you refer to in this sentence.

Response:

For example, a quadratic zooplankton mortality exacerbates the reduction in zooplankton biomass when concentrations are very high, and prevents its extinction at very low concentrations. In addition, the multiple resources form of the Holling type II grazing function allows the predator to modify its grazing preference towards the most abundant prey (Fasham et al., 1999). Finally, Lima et al. (2002) noted that coupled physical and food web models can transition from equilibrium to chaotic states under even small changes in their parameters. We will mention this in Sect. 4.1.

Comment:

L333-334 Consider not only sampling issues in the differences in Figure 2. What about assumptions in the model? Or bad parameterisation (not only in terms of zooplankton mortality)? Also, you should mention if using a quadratic mortality rate instead of a linear one could produce differences in your results.

Response:

For this study we changed the quadratic mortality term of our model. Systems with a non-density dependant, or línear, mortality rate, respond to perturbations in a "reactive" way, as defined by Neubert et al. (2004), drifting away from equilibrium. We might have expected a stronger impact if we had manipulated the linear mortality due to the lack of the buffer by the density dependency of the quadratic term. We will mention this in section 4.1.

We recall that the observations are likely biased low since they do not include the whole taxonomic range, but mainly crustaceans. However, indeed it is very likely that the model could be improved by a tuning or calibration exercise that targets at a good match between observed and simulated zooplankton concentrations. Despite the complexity of the model, the considerable uncertainty of model parameters, and the sparsity of observations that can constrain these parameters, this is a complex task (see, e.g., Kriest et al., 2017). Therefore, we have refrained from this effort for the present, but aim at provide a better calibrated model in the future. We will add some comments on this in the discussion section.

Comment:

L340 It is not clear to me if you just assumed the values given by Hirst & Kiorboe (2002) for you experimental design. Could the values given by Hirst and Kiorboe (2002) be affected by temperature? Is 25degC a realistic value for your domains (see Fig.1). How much change could be expected in terms of zooplankton mortality rates for 2degC difference? Or is that negligible ?

Response:

We did not assume Hirst and Kiørboe (2002) values on our experimental design, but only use these values for comparison. The values provided by Hirst and Kiørboe (2002) are indeed affected by temperature. At 5° C, a mortality of 0.065 d^{-1}, which is closer to our reference simulation estimate, was reported on the same paper. We will compare against this value in the discussion section. Our modelled region is indeed slightly colder than 25° C (see Figure 1). However, the zooplankton metabolic processes, including mortality, are not affected by temperature in our model so a 2° C change would not have any impact on zooplankton mortality.

Comment:

Conclusions

L497 You mention some effects from ENSO but there is not much discussion associated to this in section 4.

Response:

The ROMS setup presented here is climatological and does not include ENSO and its effects. Because in this study we are mainly interested on the potential effects small pelagic fish may have on the plankton community, rather than the cause for their fluctuations, we will skip the mention of ENSO in a revised version of the paper.

Comment:

Technical corrections

L28 The name of that city is Talcahuano, not Telcahuano.

L119 correct 'dissolved'

L130 correct the symbol for the exudation fraction for eqs. 2, 3 as they do not match both equations.

L157 – 158 correct the typo of the terms PmathrmS, PmathrmL.

L167 missing a parenthesis ending after Gorsky et al. 2010.

Response:

All technical corrections will be implemented.

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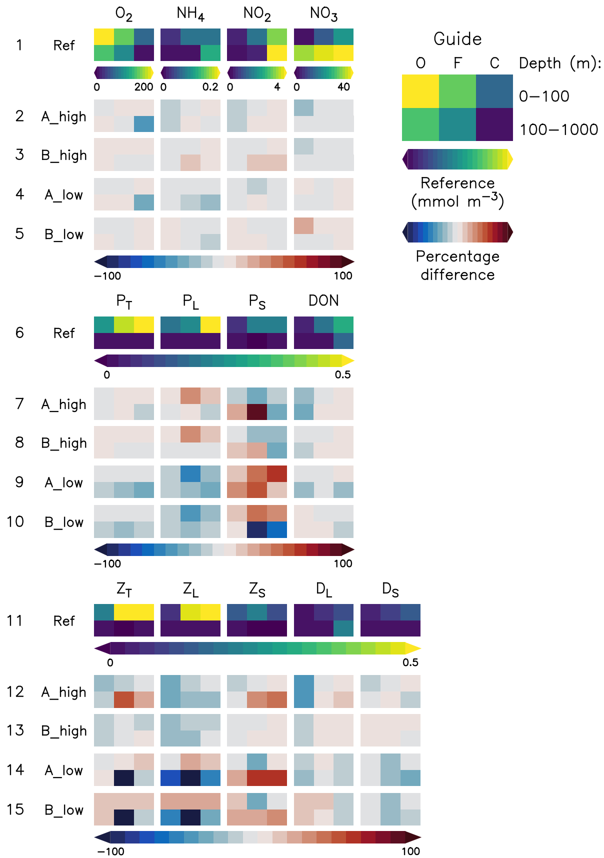

Fig. 1. Same as Fig. 4 of the paper after correcting the averaging weights in experiments A.

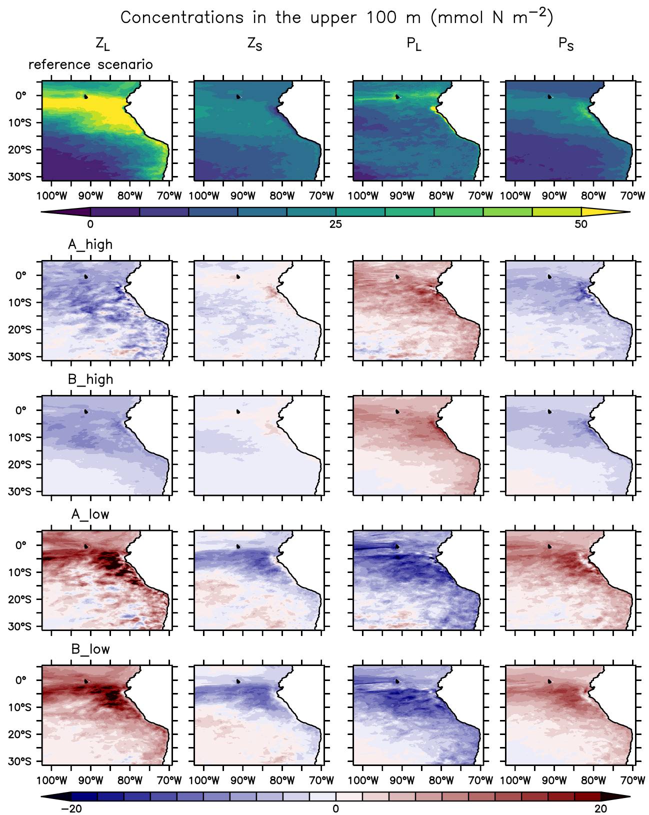

Fig. 2. Same as Fig. D1 of the paper after correcting the averaging weights in experiments A.

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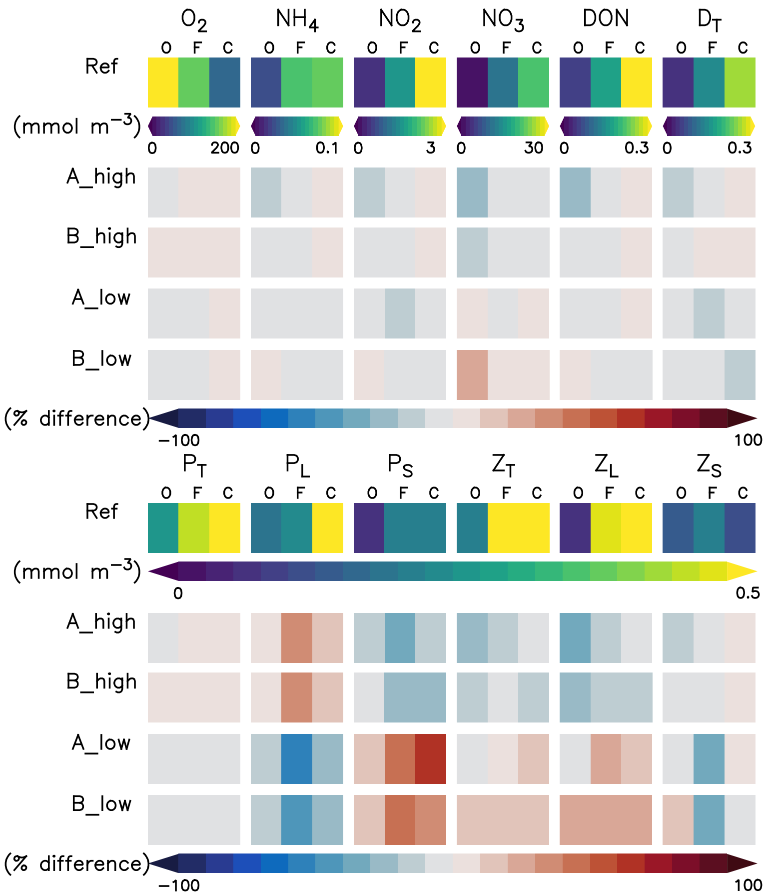

Fig. 3. Same as Fig. 4 of the paper after correcting the averaging weights in experiments A and removing the deep water (100 to 1000 m) layer.

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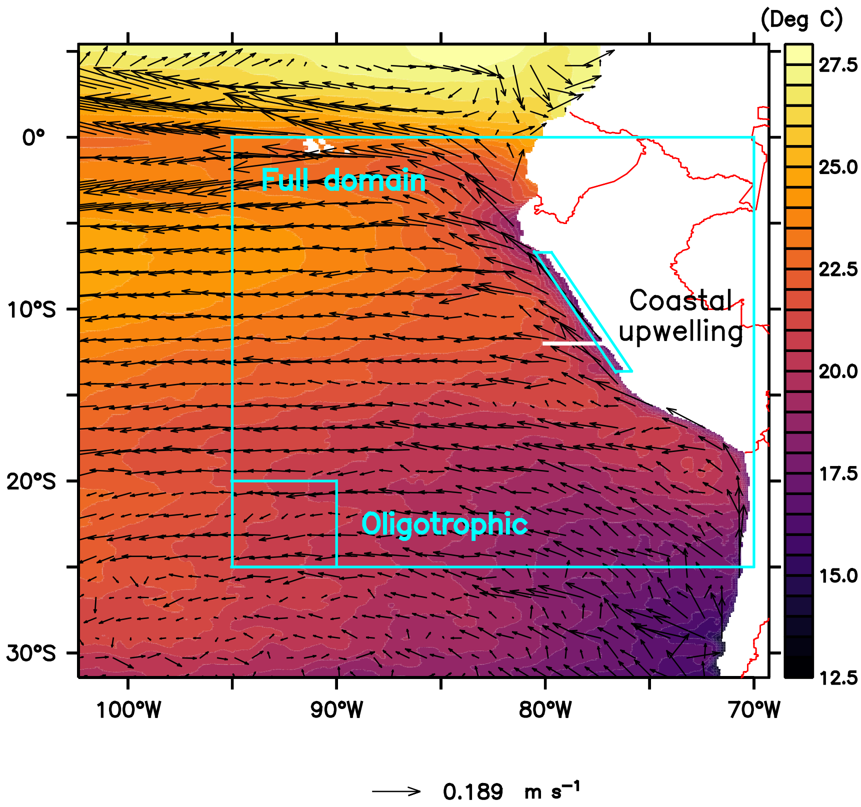

Fig. 4. Same as Fig. 1 of the paper including political division.