

Interactive comment on “Heterogeneity of impacts of high CO₂ on the North Western European Shelf” by Y. Artioli et al.

Anonymous Referee #1

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General Comments:

This manuscript used a coupled physical-ecosystem model to predict the impacts of high CO₂ on the future shelf sea ecosystems, including the carbonate chemistry, biological productivity, plankton structure. . . In order to separate and compare the respective effects of climate change and ocean acidification (OA), the model was run with four different scenarios and showed high spatial and seasonal variability in the response of the ecosystem on the North Western European Shelf. While the experiment is well designed and the results are interesting, I found that this manuscript is not well organized and difficult to read. Basic information of the study area was missing and there were no statements of why focused on the North Western European Shelf. The model description of the “climate change” part (both the forcing and the output) was hidden, resulting

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in the discussion on the impacts of changing temperature, mixing and riverine inputs hard to follow. Some major results such as “section 3.3” were only stated with words but not expressed in images. The “Discussion” did not refer to any figure or table. . . In this context, I think this manuscript needs major revisions and significant expansions, making it straightforward for readers, in particular the non-experts in modeling and those not familiar with the area of the North Western European Shelf.

Specific Comments:

Introduction:

The authors gave an extensive review of “OA” and clearly pointed out that because of the complexity of shelf seas regarding “OA”, specialized models are required. But the introduction of the “climate change” was relatively too simple with only a short paragraph. What’s special about the shelf seas under the context of “climate change”? While the “climate change” part should be enriched, I would also suggest some contents of “OA” being removed or refined. For example, it is not necessary to detail the three “general conclusions” (Page 9392 Line 9-20). In addition, the last paragraph as the end of the introduction needs significant improvement. At present it is just descriptive and too general. Which shelf system and what properties/processes of the ecosystem were investigated? What scientific questions or hypotheses were being answered or tested? Please be specific of the study’s motivation.

Material and methods:

Add a section of “study area” with a map marking “German Bight”, “Irish Sea”, “Celtic Sea”....

Precisely define each term/abbreviation of equations (1)-(3). What are “ $p\text{CO}_{2,a}^{\text{Å}}_{2005}$ ”, “ $g\text{PP}$ ”, “asct.resp.”... For scenario 2, what are “the outputs of the . . .” and what is the “IPCC AR4 A1B scenario”? Brief explanations would be helpful to readers.

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Results:

Add illustrations for some results described by only words, e.g., the vertical gradient of pH in section 3.1 (Page 9397 Line 13-15), the changes of Ω and $\text{NH}_4\text{:DIN}$ in section 3.2 (Page 9399 Line 6-10) and the entire section 3.3 (Page 9399 Line 11-23).

In section 3.2, the authors proposed the increase of net PP in the coastal area in summer was associated with riverine discharges (Page 9398 Line 23). But should the riverine discharge, as a driving process of the “climate change”, produce the same impacts between $A1B_{nit,PP}$ and $A1B_{nit}$ scenarios? And the summer zooplankton biomass in the coastal area (e.g., the German Bight) decreased rather than increased, which is obviously not “tightly coupled to the net PP changes” (Page 9398 Line 27-28). Moreover, be cautious to say changes in pH mimic changes in net PP (Page 9399 Line 1-2), as net PP was depth integrated while pH was for the surface waters.

In section 3.3, does “the change of $\text{NH}_4\text{:DIN}$ ratio due to the climate change” refer to the difference between $A1B_{nit}$ and PD scenarios as illustrated by Fig. 3C? But $A1B_{nit}$ predicted not only the impacts of “climate change” but also those of “OA controlled nitrification”.

Discussion:

I found the discussion to be poorly organized and as a result lacked clarity in places. The initial sentence is clear, and the discussion should follow the same logical thread. It would be helpful to split it into several sections with informative titles and a potential plan would be: (1) analyze the heterogeneity induced by OA drivers (PP, nitrification, . . .); (2) analyze the heterogeneity induced by climate change drivers (temperature, riverine input, mixing. . .); (3) compare OA with climate change; (4) upscale based on the this case study. . .

Please do refer to “Figure x/Table x” if necessary, making the discussion easier to follow. Some interpretations and conclusions were speculations which need in-depth

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explanation and/or convincing data support, e.g., “. . . the accumulation of DIC during spring and summer due to community respiration (both pelagic and benthic) . . .” (Page 9400 Line 12-13); “This leads to a larger increase in atmospheric $p\text{CO}_2$ ” (Page 9400 Line 17); “. . . mostly due to decreased nitrate input from the open ocean. . .” (Page 9403 Line 2).

Regarding the “circulation and the freshwater balance” (Page 9400 Line 26), what processes cause the freshening of shelf sea waters? Net precipitation? River input? If river input, what’s the TA concentration of river waters feeding the North Western European Shelf? Elaboration and clarification would be helpful. This should also work for the next paragraph. How did the riverine loadings change? What results could be significantly modified? (Page 9401 Line 9-10)

At last, I still concern with statements related to changes due to “climate change” (e.g., Page 9402 Line 2, Page 9402 Line 28), which were based on the $A1B_{nit}$ simulation involving both climate change and OA. The OA controlled nitrification might not affect the net PP, but it do changed the NH_4 :DIN ratio. As a result, the effect of climate change was not completely separated from those of OA for given diagnostic variables. On the other hand, some statements, similar to “the difference in net PP driven by changes in temperature and physically mediated nutrient availability” (Page 9397 Line 16-17), need further explanation and/or validation. Why temperature and nutrient availability instead of other processes?

Conclusions:

To me, the two paragraphs of this part are implications rather than conclusions. However, the five paragraphs following “some key messages can be drawn from this study” (Page 9401 Line 29) in the “Discussion” read like conclusions. Please reorganize and make the “key messages” easy to get.

Figure captions:

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Fig. 1 - Replace “in” after OA with “on”; remove “on the left” and “on the right”

Fig. 2 - Rewrite for clarity. “Mean values of the monthly mean minimum of...” is unintelligible. Specify it is for warm seasons?

Fig. 3 - Replace “eco system” with “ecosystem”; specify the differences are between A1B_{nit} and PD scenarios.

Minor Points/Technical Corrections:

Page 9391 Line 18-20: This sentence needs rewording for clarity. What is the “...significant seasonal and diurnal variability”? What is the “seasonal temperature signal” and what can it do?

Page 9392 Line 9: “a number of synthesis papers are appearing” should have references

Page 9392 Line 10: “(Riebesell et al., 2010)” was not listed in the “References”

Page 9393 Line 24: Replace “total alkalinity” with “TA”

Page 9394 Line 5-8: Specify “a clear relationship” and “treatment values”; Replace “C_{enh}” with “C_{enh}” (enh subscript)

Page 9394 Line 13: “the first one” means C_{enh}?

Page 9395 Line 11: Replace “ensemble” with “ensemble’s”?

Page 9395 Line 12: “PD_{nit}” or “PD”?

Page 9395 Line 15: Remove “... the for...”

Page 9395 Line 26: Insert “state (Ω)” after “aragonite saturation”

Page 9396 Line 9: Replace “stressor” with “stressors”

Page 9396 Line 23: Remove “but”

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Page 9397 Line 5-6: Perhaps this sentence should read “The shelf-ocean gradient is also evident when looking at the future surface aragonite saturation state.”

Page 9397 Line 6: What are the “two basins”? Shelf and ocean?

Page 9397 Line 12: Perhaps “ $\Omega \sim 0.7$ ” would be better than “ $\Omega \geq 0.7$ ”

Page 9398 Line 1: Remove “in sign”

Page 9398 Line 22: Insert “the increase” after “in summer”

Page 9398 Line 28: Insert “net” before “PP”?

Page 9399 Line 2: Insert “net” before “PP”? Please be clear between net PP (output) and OA enhanced PP (forcing) throughout the text

Page 9399 Line 8: Insert “change” after “climate”

Page 9400 Line 2: Replace “ocean acidification” with “OA”

Page 9401 Line 8-9: Replace “dissolved inorganic carbon and total alkalinity” with “DIC and TA”

Page 9401 Line 12 and 28: Specify the “model uncertainty”

Page 9401 Line 15-27: I didn’t find the context logic of this paragraph

Page 9401 Line 29: Insert “is” before “preliminary”

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