

## ***Interactive comment on “Modeling dissolved oxygen dynamics and coastal hypoxia: a review” by M. A. Peña et al.***

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### Summary

This paper presents a comprehensive overview of modeling studies of oxygen dynamics in coastal environments. It is clear that much effort has gone into this work for which the authors should be commended. The strength of this paper is that it integrates hypoxia models for benthic and pelagic systems. Overall, however, and in disagreement with the views of Referee #1 who posted before me, I find this paper poorly organized and frustrating to read. The structure is muddled and illogical in places, which detracts from the value of the paper. It is my opinion that a major reorganization is needed if this work is to have an impact on the audience which the quality of the journal demands. I am sorry to be negative because the authors are people whom I respect and who

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usually produce quality science, but I think it's worthwhile to address these issues in detail. Below I have indicated where I think the major problems lie and have provided some (hopefully) constructive recommendations which could help this paper become a widely-cited piece of work. Please do not misinterpret my objections, this has the potential to be a great paper, but the information is just not easily accessible in its present form (in my completely subjective opinion).

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### Organizational issues and recommendations

A major issue I find is the overlap between sections 2 (“Approaches to modeling dissolved oxygen dynamics”) and 3 (“Modeling the effect of oxygen depletion on biogeochemical cycles”). These sections are not clearly defined and neither is their content. At present, I'm not sure where the authors want to go with Sections 2 and 3 (see following paragraphs). It is cumbersome for the reader (or for me at least) to distinguish between the true “approaches” and “effects” in the discussion. It may help to point out that words such as “approaches” and “effects” without supporting adjectives become extremely vague nouns. It is not an easy task, but if the authors can nail this obstacle, i.e. make a clear cut distinction between “approaches” and “effects” and restructure the sections accordingly, then the paper will be much more fluid and easier to digest.

To begin with, Section 2 is vaguely entitled “Approaches to modeling dissolved oxygen dynamics”, and the section subheadings do nothing to add clarification. Isn't the whole paper somehow focusing on approaches to modeling dissolved oxygen dynamics? Why not entitle this section “Major physical and biogeochemical processes” and include “air-sea exchange” etc as sub-subheadings, perhaps also clearly distinguishing between pelagic and benthic? The discussion on advection and dispersion sets the framework for the biogeochemistry and so should precede the biogeochemical information. Incidentally, advection-diffusion processes also apply to sediment dynamics

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and not just those in the water column, and some of the biogeochemical processes discussed under section 2.2 (water column dynamics) also occur in the sediments. Currently, the manuscript implies that they are mutually exclusive which we all know is not the case. A summary figure (replacing Fig. 1 which currently provides nothing new or useful) of processes in the water column and sediments reflecting state-of-the-art biogeochemical advances is urgently needed here to be instructive and helpful to the reader (see Lam et al. 2009 (PNAS v106 p4752-4757) for an example of the contemporary marine N cycle in oxygen depleted waters).

Section 3 is “Modeling the effect of oxygen depletion on biogeochemical cycles”. Again, this section is not well structured and there is a degree of overlap with section 2. For example, subsection 3.1 “Processes in the water column” could easily go into subsection 2.2 since the emphasis is on processes. On the other hand, 3.2.1 “Phosphorus remobilization” and 3.2.2 “Sediment denitrification and ammonium release” could be viewed as biogeochemical responses (effects) of hypoxia. I also think that the title of subsection 3.2 “Combined water column sediment models” is misleading because it implies that all the models cited in 3.2 are coupled in the sense of the Luff and Moll model (2004, cited) which is not the case. I also think that 3.2.3 “Transient adjustment versus steady state” is far too short and important to be dumped at the end of 3.2. In my opinion, it deserves a section in its own right because modern hypoxia is of increasing importance globally. Here is an opportunity for the authors to provide their own thoughts and ideas on one of the hottest topics in contemporary marine science. It would be a shame if this section is not revamped in the revised manuscript.

Section 4 “Nutrient enrichment and hypoxia models”. The introductory paragraph is so long it could be given its own subsection title, “River and estuaries” for example? On the other hand, much of the information is also directed toward the Gulf of Mexico, which is then discussed again separately in the following subsection 4.1. More importantly, what is this section doing here in the middle of the paper? It would be more appropriate to rename it as “Case studies”, or similar, where all the aspects presented

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previously could be discussed in a natural context, and moved to the end of the paper before section 7. I also believe that an important element of hypoxia is missing here – Oxygen Minimum Zones – which would make a much-needed addition to the paper since hypoxia is not restricted to confined water bodies. Again, OMZ research is booming, and its inclusion here would help put this paper in the spotlight. Section 6, climate change effects, mainly deals with OMZs and could be used as a basis for the OMZ “case study”. There is no reason why the discussion of climate effects cannot be included alongside OMZs since the OMZ models are more often than not coupled atmosphere-ocean General Circulation Models.

Section 5 “Modeling the influence of hypoxia on ecosystems”. This section is tentative, and contains little information of value except for subsection 5.3. I would tend to remove Section 5 completely, and incorporate 5.3 into either section 2 or 3 depending on how they are reorganized.

Other important comments

1) Keep the introductory paragraphs at the start of each major section (1,2,3 etc) to a minimum and free of references. Use this short paragraph to properly introduce the following section and guide the reader. Presently, much of the information contained within these paragraphs can be moved to the following subsections (especially true for section 4).

2) This is a long paper and there is little diversion for the reader by way of tables and figures. How about a figure in the introduction showing a map of hypoxic areas where model studies have been carried out to put the paper in some sort of global context? I agree with Referee #1 in that I also don't see clearly on what grounds the other figures have been chosen. Figs 3 and 4 are fine, Fig 1 should be removed/replaced, and Fig 2 is out of context with the modeling theme of the paper. How about something along the lines of Fig 3 but applied to sediments for comparison of processes/scales? Perhaps a figure for each of the “case studies” could also be useful. I would also really like to

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see a synthesis table summarizing the modeling studies that have been done so far, maybe for the systems outlined for example in “case studies”, in terms of whether the study is benthic or pelagic or both, transient versus steady state, O<sub>2</sub> concentrations and uptake rates, main controls on O<sub>2</sub> consumption/sensitivity etc. Please give the reader something quick and easy to access without having to wade through all the text.

3) Finally, my last point is more of a plea to the authors rather than a recommendation for improving the manuscript. I feel that this paper lacks added value, something new. It's a review paper so much repetition of previous studies is to be expected, but this doesn't mean that it should be free of new ideas. Many paragraphs are little more than a listing of the studies one or two sentences of their main findings, which becomes tiresome. On a completely crude and blunt (but realistic) level, what original work is there which would lead people to reference this paper? There is a definite dearth of own discussion by the authors, i.e. their thoughts and opinions and interpretations of existing data/findings. This type of information is what I personally look for in review papers such as this, but I'm sorry to say that it is missing at the moment. The authors should capitalize on their considerable efforts thus far and come up with something tangible or thought provoking – maybe along the lines of (i) time-scales of oxygen depletion, (ii) a table listing specific research areas requiring urgent attention to produce more robust models, (iii) a discussion of what models have done or can do and their future integration with process based studies. I think this information is somehow already contained within Section 7, but can it be transformed smartly into a table or figure?

In conclusion, the authors should consider whether they want to:

1) Reorganize the paper, maybe along the lines of: Processes (physical and biogeochemical and benthic versus pelagic) -> Biogeochemical impacts of hypoxia -> Transient versus steady state dynamics -> Case studies -> Synthesis and recommendations

2) Include OMZs in detail as a case study

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3) Improve the figures and include tables

Minor comment

Given the geographical application of some of the cited studies (Black Sea, OMZs, and Fig. 4), I wonder if the word “coastal” is appropriate for the title of the paper.

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