Rev. #4 L. Farias

The manuscript entitled: "Dynamics and distribution of natural and human-caused coastal hypoxia" by Nancy Rabalais and co-authors contains an exhaustive revision of hypoxic systems. It covers both oceanic and coastal areas as well as suboxic and even anoxic systems such as the Black Sea and the Cariaco Basin. The ms also discusses the ecological implications of hypoxia and analyzes future scenarios of changes (including local and global scales). Thus, the title does not reflect the content of the ms, nor does the abstract reflect the analysis, interpretation, or comparisons therein. Rather, the latter is a description of two kinds of hypoxic systems (i.e., natural and human-induced hypoxia).

Reply: One thing that is obvious is that we need to do is to emphasize early on about the focus of the SCOR WG being human-caused hypoxia, but that this cannot be taken alone as a subject without comparisons with other areas with low oxygen. The title reflects the focus of the SCOR WG, i.e., coastal hypoxia. However, we could not discuss that focus without placing the human-caused in context of other types of hypoxia. We think that the comparative information in the paper across the categories is a contribution by this ms. We provide a few examples of effects so that the relative differences in the types of hypoxia could be noted, but refer to the other chapters on effects, Levin et al. and Ekau et al. The appropriate word to leave out of the title, even though it was the focus of the SCOR WG, is "coastal," which we will do. "Effects" are excluded from the title, because they are covered in other manuscripts. Future scenarios of change are considered part of the "dynamics" aspect of the ms. The new title will be "Dynamics and distribution of natural and human-caused hypoxia." The abstract will be revised to reflect reviewer's comments.

The authors have not quite succeeded in merging the considerable amount of case studies on natural and human-induced oxygen-deficient waters into a clear structure. It is so long and is not at all easy to treat such a huge and complex data set.

Reply: the case studies were selected to represent the range of hypoxia and its effects on ecosystem functions. A more synthetic approach as recommended by Rev. #2 is accepted and provided in the manuscript.

First of all, I have concerns regarding the use of the term "hypoxia" in this review. The authors defined hypoxia from a physiological point of view, that is, in terms of the effect that oxygen-deficient waters and sediments have on the physiology of organisms (in this case, multicellular eukaryotic organisms). Moreover, the term "normoxic" or "hypoxic" is used to refer to organisms, not the environment. Also, when mentioning a metabolism in relation to oxygen levels, the terms anaerobic (facultative or obligate organisms), aerobic, or micro-aerophilic must be used. However, when describing the environment, the terms oxic, hypoxic, suboxic, and anoxic should be used. It is important that this special volume use a standard definition for the levels of hypoxia in an environment regardless of whether said condition affects an organism, population, community, or ecosystem. This is particularly important for the SCOR working group 128. Personally, I think that since we are dealing with the marine environment, there should be a discussion about this with the SCOR group and the editor.

Reply: The term "hypoxia" was chosen at the initiation of this project in the proposal to SCOR and was approved as such. The series of papers was also a topic of consideration with SCOR oversight and approved. The editors are part of the SCOR WG and agreed (along with the WG) on the definitions and scope of the contributed manuscripts. The ms explains the physiological meaning of hypoxia and makes the case for the use of organismal terminology for environmental conditions. The terms used to describe low oxygen are consistently used in the manuscript and follow the accepted terminology for each of the oceanographic and environmental literature. The ms does not discuss physiology other than the discussion of different oxygen levels having different effects on different organism, life stage, reproductive stage, multiple stressors.

Furthermore, the units of oxygen concentration should be consistent; at present, different units are used throughout the text (e.g., mg L-1, uM). I am not familiar with reporting oxygen concentrations in mg L-1. Consistency is important, and when reporting data from other studies, it is sometimes necessary to transform the units.

Reply: The units for oxygen are varied and reflect the terminology used by various disciplines. We provide a figure that relates units and allows the reader to move from one unit to another. While the ml L^{-1} is provided as an example of use by physical oceanographers, the units used in this ms are mg L^{-1} and μM. While we agree

that switching may be confusing, researchers that focus on OMZs are more comfortable with μM; and those with coastal hypoxia, either mg L^{-1} or ml L^{-1}

Aditionaly, salinity should be given without units. The abbreviation psu means practical salinity scale and is not a unit.
Reply: psu has a definition and has replaced ppt. In 1978, oceanographers redefined salinity as the conductivity ratio of seawater to a standard KCl solution. This ratio has no units as pointed out, but we use psu to indicate the definition of salinity we are using.

In the second place, the authors describe many systems in one ms. Therefore, they address not only coastal systems but also open ocean systems. The paper lacks a narrative thread; it is very difficult to address simultaneously the processes related to the maintenance and dynamics of hypoxia. In the same sense, long-term impacts and consequences are not comparable due to different spatial and temporal scales. No doubt, human-impacted systems are better described than natural systems. Most of the graphs (except Figure 7) present information on human-induced systems. The use of tables could help summarize the information and facilitate comparisons between all the described systems.
Reply: text has be added and reworded to make our narrative clearer, which is that both natural and human-related hypoxia currently are stressing ecosystems and in the future both forms of hypoxia will increase. Several of the case studies were selected to show what efforts are being made to reverse the occurrence of hypoxia, but that information is the focus of Kemp et al. to which we refer. This ms was discussed in length by the SCOR WG and how it could be divided into smaller manuscripts, but the WG agreed that this ms would contain the information that it does with the emphasis to be human-caused with explanation of natural systems to provide context.

Remove section 8.8 "other coastal and oceanic areas". It does not contribute
Reply: the information in this section has been placed elsewhere in the manuscript and is a necessary component in response to Rev. #1.

Regarding the analysis of global climate change (GCC) and future expectations (p. 9403), although mean global ocean temperatures should go up with GCC, in some coastal areas they may drop due to changes in wind patterns (see Bakun). For example, in eastern boundary current systems, the predicted higher temperature gradients between the land and ocean would increase upwelling-favorable winds, promoting an intensification of the coastal upwelling process and, hence, the cooling the coastal ocean. In this scenario, there should be less precipitation and, therefore, less river runoff (dryer conditions on land). However, oxygen levels would still decline due to the increased upwelling of low-oxygen subsurface waters. Thus, the authors should mention that changes in mean global conditions could have different and even opposite local responses depending on the geographic area (see figure 25, wind?, increase or decrease?).
Reply: text was reworded to address this comment. The boxes in this figure were revised to address + or - or mostly + in the headings and make sure that additional opposing aspects are covered in the text. Most of the opposing aspects were already covered. Notably we added the cooling of the coastal ocean where upwelling was affected.

I suggest separating the ms into two: one that describes natural systems and another that deals with human-induced systems. Besides, I propose describing and grouping case studies by similarities. For example, ecosystems could be classified according to their geomorphology.
Reply: our concept was to deal with both natural and human-caused hypoxia as a whole. The traditional dealing with them separately will not work. Our intent was to show how they are connected via ecosystem impacts and GCC. In deference to Rev. #2, we agree that the combination of the two is a contribution to the literature. "*….the range of dominant time scales of variability afforded by physically and biogeochemically divergent systems provide a rich context for understanding hypoxia dynamics currently and into the future……discussion of the dynamics that underlie hypoxia formation across upwelling shelves, enclosed basins, OMZs, and estuaries can alone represent a valuable contribution.*"

Please, include integrated and comparative tables. One table should present the criteria for hypoxia levels (e.g., environmental, biogeochemical, geofacies, etc.) and the corresponding references. Another table should

describe all the case studies presented in the text: location, type of system, biogeochemical and physiological impacts, how they were recorded or observed, if they are undergoing remedial actions, etc., etc.
Reply: A synthetic figure has been added. A table from Tyson and Pearson was considered that recommended terminology for low oxygen and the resulting biofacies in marine environments, but it included more terms than have already been included and would have created more confusion