

***Interactive comment on* “Effects of spatial variability on the exposure of fish to hypoxia: a modeling analysis for the Gulf of Mexico” by Elizabeth D. LaBone et al.**

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We want to thank the reviewer for their helpful comments. Our responses are below on how we propose to revise the manuscript to address these comments; specific revisions are shown in italics.

Choice of Spatial Maps

The reviewer suggests that using controlled and manipulated spatial maps would enable a clearer analysis of the effects spatial variability. While this always true, the downside is that any artificial manipulation of the spatial maps of dissolved oxygen

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(DO) would be criticized for lacking realism. Model generated maps (and field data) show the spatial patterns in DO to vary greatly on multiple spatial and temporal scales and to depend on the DO concentration. And this becomes further complicated by a 3-D view. We opted to use the FVCOM-WASP model to generate realistic and complex spatial patterns for this analysis and then mine the maps to quantify their differences in spatial variability of low moderate and high DO. There are features and variability of the hypoxic region that would be lost if contrived test maps were used. We did a careful selection of maps from FVCOM-WASP to provide some degree of contrast. Also, we used multiple snapshots of similar area and spatial variability, as well dynamic versions of the maps for the same area and time period, to provide a way to understand variability of model results for similar conditions of spatial variability and to help interpret differences in predictions across levels of variability.

In our revision, we will expand on our rationale for using FVCOM-WASP output briefly (new text) in the Introduction and especially (1-2 paragraphs) in the Discussion. The paragraphs added to the Discussion will compare (advantages and disadvantages) of our approach with the alternative approach suggested by the reviewer. We will also add to the Supplement a few extracts (zoomed views) from the spatial maps used to better illustrate the spatial patterns in hypoxic and sub-lethal DO.

Movement rules

The reviewer notes that the analysis used a specific set of movement rules and questioned how did this affect the results and also our ability to generalize the results. Our movement rules are representative of a commonly used class of algorithms (random-walk) and thus our results should apply to other systems (with similar hypoxia dynamics) and alternative movement rules. For example, in a previous analysis, we found only small differences in hypoxia exposure between Random Walk and Cauchy Correlated Random Walk (LaBone et al., 2017). Furthermore, Neighborhood Search is a particularly effective avoidance algorithm and would generate similar results as other algorithms that were also effective. Finally, we included two levels of avoidance com-

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petency to investigate how that affected hypoxia and sublethal exposure. Adding low and high noise to the algorithm also provides a partial broadening of the generality of the results as we can assess how effectiveness of the algorithms influence the model responses. An aspect to our movement rules in the same context as the reviewer's comment is our default rule was not based on reacting to environmental variables, such as temperature or salinity, or to hunting prey or predator avoidance that could position the fish differently when low DO behaviors are triggered.

We will add a paragraph or two to the Discussion about the generality of our results – aspects that support generality and aspects that limit generality. This will include a brief discussion of how our movement rules fall into a broader class of rules that are commonly used. We will also explain how our previous exploration of movement rules in earlier papers lead us to this set we used in this analysis; we had generality in mind. This will also serve to better show the relationship among the earlier papers and this analysis. The new text will also discuss some details of the movement rules, such as the threshold trigger (either avoidance or not) of 2 mg/L and our use of two levels of competency, and how they affect generality.

Presentation

The reviewer commented on that the descriptions of several aspects of the analysis would benefit from more clarity. *We will modify the Abstract, add explanation (Section 2.4) of the interpretation of Ripley's K, add additional text to sections 2.2.1 to 2.2.6 to make sure the movement rules are clear and insert examples to illustrate the general algorithms, and clearly state (Section 2.5) how fish were started on the grid for simulations.*

Interpretation/Novelty

The reviewer commented on how more information is needed on how this analysis relates to the earlier papers, the Discussion lacked sufficient placement of this analysis into the broader context, limitations by not using controlled maps, and generality of

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movement rules. *All of these will be addressed by revisions proposed in response to earlier comments. In addition, we will include a discussion of how our methods and results relate to other such analyses reported in the literature, and, when appropriate, link these other analyses to the existing discussion of our results (paragraphs 2-6 of the Discussion).*

In summary, we will make the following changes (see details above) in a revised version of this manuscript:

1. Expand on the rationale of an analysis in the Methods and Discussion, and illustrate the spatial patterns in hypoxic and sub-lethal DO using zoomed-in images from the spatial maps. This will include adding text in the Discussion that describes the alternative approach (manipulated spatial maps so variability is controlled) suggested by the reviewer and the advantages and disadvantages of both approaches.
2. Add new paragraphs to the Discussion about the generality of our results. This will include: how our movement rules fall into a broader class of rules, how our earlier papers lead us to movement rules used here, the relationship among the earlier papers and this analysis, the influence on generality of some of the methodological details (threshold for avoidance, competency), and how our methods and results relate to other such analyses reported in the literature.
3. Modify the Abstract, add an explanation of the interpretation of Ripley's K, better illustrate the movement rules, and state how fish were started on the grid.

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