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Biogeosciences Discussions

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. We have extracted the comments provided on the PDF manuscript and respond (in italics) on how we will revise the manuscript to address them below.

1. "...such temporal variations have also been documented for other coastal systems." Also in Lake Erie: see Kraus et al. 2015, CJFAS 2015, 72(6): 797-806, (p2 line 49). Response: We will add the suggested reference as well as others we find.

2. Also see Limburg and Casini 2018, Frontiers in Marine Science, for growth impacts;

and Limburg and Casini 2019, Biology Letters, for effects on fish condition. (p3 line 61). Response: We will add the suggested citation.

3. Would it be difficult to include another panel in the figure, showing the sigma layers? (p4 line 103). Response: Sigma layers are commonly used so we will not add a figure but we will expand the textual description.

4. How many fish in total were modeled per simulated map? (p4 line 110). Response: We described this in the methods but it is not clear enough, so we will add further description of the number and locations of starting fish and why the number was selected and also mention it where the reviewer asked about it.

5. Please italicize the variables even here in the text, so it's easier to see them. (p5 line 124). Response: We will italicize variables in the text using the style in accordance with the journal.

6. What about total volume (in reference to our use of hypoxic area)? (p8 line 226). Response: We will mention that others have used hypoxic volume as an indicator of severity and in our case, area and volume are related. Area is better for the 2-D analysis represented; we will briefly discuss how volume is also of interest, such as with the 3-D analysis in the Supplemental.

7. "The Ripley's K statistic measures..." Is "counts" a better word for "measures?" (p8 line 230). Response: We will expand and explain how Ripley's K works and how to interpret it.

8. Is this a radius? (p8 line 230). Response: As part of our response to (7), we will expand and explain how Ripley's K works and how to interpret it.

9. "... we used the area under the curve (AUC) relating Ripley's K to r for each time steps." This is a little hard to visualize. Could you please draw a schematic, and insert it in the supplemental information, perhaps just prior to Figure S5? Response: We will add an explanation on how the AUC was calculated and how to interpret it to main text

(briefly) and some combination of additional explanation, an example, or a schematic to the Supplemental.

10. I (the reviewer) don't see how the AUC units in Table 1 relate to the units of K(r)/r in Figure 2. (p8 line 235). Response: see response to (9).

11. This (referring to the 913 fish) would be good to mention earlier...and how did you come up with 913 fish? (p9 line 249). Response: see response to (4).

12. You don't actually come out and say anywhere in the methods that 2 mg/L is a cutoff between lethal and non-lethal conditions. Do fish in your model always die if they stay in DO < 2 mg/L? And if so, how long must they stay there in order to die? (p10 line 277). Response: We will clarify that fish do not die in the model and that lethal refers to those simulated fish that are exposed to 2 mg/L or less, which is often considered, with even moderate exposure, to be lethal for many species. We will remove the phrase "lethal" when referring to simulated exposures and simply refer to the "hypoxia" exposure. We will explain our labeling as "hypoxia" and "sublethal."

13. It looks like Sprint was invoked after time step 200, i.e., 2 hours later than the critical 2 days. Why was this? Is it due to randomness in the algorithm? (p10 line 284). Response: We will update figure 4 so that initial positions and conditions are time step 0, which results in time step 200 in the model lining up with time step 200 in the plot.

14. Did you try decreasing the degree of randomness and observe those results? (p11 line 308). Response: We will clarify that we already have the case of reduced randomness by using the results of good avoidance (still has randomness but less than poor avoidance).

15. "There was a weak suggestion that exposure to hypoxia decreased with increasing variability with the high sublethal area maps but increased with increasing variability for moderate sublethal area maps." This is a little vague here, but I guess OK. (p11 line 318). Response: We will try to reword or add a sentence to make it more specific as a

lead-in to the next sentence that refers to the figure.

16. Visually, it appears that fish with ID numbers > 750 tended to experience more cumulative days of sublethal exposure. Any idea why? (p11 line 326). Response: We will note that the fish with ID numbers > 750 start in or near the hypoxic zone, so will have more lethal and sublethal exposure than fish that start elsewhere.

17. What opportunities were available to the fish to experience normoxia? That could be discussed a bit. (p13 line 395). Response: We will add the patterns in normoxia to the description of the spatial maps (using Figure 3) and also some summary information about the percent and locations of the map that is normoxic as supporting information to the new text to Table 1.

18. One thing that occurs to me is that fish exposed to hypoxia, or even 2-3 mg/L DO, might become considerably more sluggish as time goes on. I'm not sure that this is programmed into your algorithms, but could be explored. In other words, do your fish encounter a reinforcing feedback and become trapped in this poor oxygen zone? This is something we wonder about Baltic Sea cod. (p13 line 400). Response: We will add to the Discussion where we discussed assumptions that fish swimming speed was not affected by hypoxia exposure, and suggest ways this feedback could be added in future analyses.

19. Is there any way to portray the clustering on the maps? It seems like this should be feasible, since you have all the calculations. (p14 line 411). Response: We will add to the Supplemental a few zoomed in views of spatial maps to illustrate the "clustering" aspect of the patchiness indicated by Ripley's K values.

20. Some more detail on the availability of normoxic cells would be helpful. (P14 line 426). Response: see response to (17).

21. Wording and editorial suggestions throughout. Response: All suggested wording and editorial changes will be incorporated.