

***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.**

Anonymous Referee #2

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In several systems, it is now clear that low oxygen conditions are highly variable in space and time. This creates variable hypoxic edges and as fish move to avoid hypoxic conditions this has implications for their subsequent exposure to low oxygen conditions. This premise of this paper is to contribute to understanding of how spatially variable oxygen conditions affect exposure to sub-lethal low oxygen conditions (defined by authors as 2-4 or 2-3/3-4 mg/l) and to a lesser extent hypoxic conditions (<2 mg/l). The authors used output from hydrodynamic/biogeochemical model and aspects of previously published agent-based model (LaBone et al. 2017,2019) to evaluate potential low oxygen exposure under different spatial distributions of low oxygen. They found differences in low oxygen exposure among scenarios with different spatial distributions

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of low oxygen and different movement rule assumptions.

I found the paper interesting, but I have questions/criticisms related to three main themes: 1) appropriateness and consequences of various modeling and analytical decisions and assumptions, 2) issues with presentations of the study and 3) questions related to the novelty and potential broader generalizations that may emanate from the study.

1) Assumptions/Decisions: a) Spatial Maps: The authors set out to “quantify fish exposure to hypoxia and sublethal DO concentrations under different levels of spatial variability in DO static maps.” This proposition is based on being able to compare results across different maps. The authors selected snapshot maps from a 10 day FVCOM-WASP model. These snapshots included different % coverage of hypoxia and sublethal low DO and they included different levels of spatial variability of sub-lethal DO levels. A limitation with this approach is that it is impossible to really interpret the effect of spatial variability vs areal coverage because they both varied (and co-varied) across maps. It would have been more direct to generate maps with equal areal coverage and different spatial variability (or vice versa). This would have allowed for more controlled creation of modelled environments and analyses across maps which differ for only a single spatial feature as opposed to multiple. The approach the authors used to select maps limits the ability to interpret differences in simulated exposure across maps. While the authors acknowledge this in the Discussion, I think this acknowledgement could be more apparent and the authors could better justify their approach for map selection. Given the goal of the study as described by the authors, why did they not generate maps in a more standard manner allowing for more direct comparison?

b) Movement rules: My understanding is that the authors used similar movement rules as past modeling papers. While I found the description of these algorithms and utility functions to be somewhat difficult to follow, they seem reasonable. However, the specific movement rules are bound to influence the time simulated individuals remain in hypoxia and sub-lethal low oxygen conditions. With this in mind, how generalizable

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are these results? Are they at all meaningful if other movement assumptions are applied? c) Static maps: The authors used static maps in several cases, even though they acknowledge that oxygen levels (especially along the edges) are likely to be highly variable. Similar to question regarding movement rules: How generalizable are results? They did include one case with temporal variation, but they may have considered other temporally variable cases. d) Avoidance of >2 mg/l DO: Is it reasonable that fish move if DO is below 2 mg/l, but do not move at all in response to any level above 2 mg/l? If so, can the authors provide a reference? If fish do move in response to oxygen levels between 2-4 mg/l, how generalizable are results?

Presentation and descriptions: a) Abstract: I found the Abstract not very compelling and somewhat difficult to follow. I think the authors have conducted interesting analyses and I think they can do a better job of attracting potential readers of this paper by presenting a more clear and compelling abstract. b) Spatial variation and Ripley's K: I think this description could use a reference, and it should be clear that Ripley's K is generated by enumerating sublethal DO cells in the vicinity of other sublethal DO cells (i.e., not sublethal DO cells in the vicinity of randomly selected cells) c) Movement Rule and algorithm: Again, I urge the authors to review these descriptions and see if they can be presented in a more clear manner. d) How initially placed?: I was unclear how exactly the initial placement of individuals was determined. Please provide more details regarding this aspect.

Interpretation/Novelty: a) Relation to past publications: Analyses build on past modeling analyses and the fish movement was the same used in previous studies (LaBone et al. 2017, 2019). Can the authors more clearly differentiate this current study from these past studies? b) Discussion: The Discussion largely focused on restating and interpreting results. There was very limited effort to relate the study to past studies and other modeling approaches. (Paragraphs 2-6 of the Discussion do not have a single citation). The citations that are cited in the Discussion do not really address the issues of environmental spatial variation, movement modeling and exposure. To a large extent

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this is a methods paper and model development paper, but the Discussion does not connect to other studies with similar foci. This limits the potential utility of the study. c) Confounded by spatial maps used: As described above, I believe the interpretation and potential conclusions that can be reached from the study are confounded by the spatial maps used (i.e., not generated in a manner to allow for direct evaluation of singular spatial effects). d) Generality of Movement Rules: As described above, the generality of the study is confounded by the specific movement rules applied. Are the findings at all applicable to studies using different movement rules? e) Clarify unique contribution: I think it is important that the authors clarify and emphasize what they see as the unique contribution made by this study and ideally communicate the generality of this contribution.

Thanks for the opportunity to review. I think the authors are conducting important/interesting analyses.

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