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Biogeosciences Discussions

Interactive comment on "Effects of natural and human-induced hypoxia on coastal benthos" *by* L. A. Levin et al.

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Review of Levin et al.

The paper by Levin et al is an impressive and valuable synthesis of information from a much broader range of systems than usually included in a single paper. I have no question that it will be a much-cited classic and contribute to understanding and progress in this important area. The inclusion of natural and human-induced hypoxia and the broad taxonomic and geographic scope are notable. The writing is clear and, with the exception of the last section of the paper (see comment below), well organized. I strongly recommend publication with minor revision.

Specific comments are below.

Major issues:

1) P3572-3 and elsewhere– I would add diel cycling hypoxia to the list of kinds/durations of hypoxia that occur in estuaries. There is a growing body of work by Tim Targett's lab, Peter Thomas and Ann Cheek (and others) suggesting that this sort of low oxygen is less effectively avoided by fishes and that chronic exposure may significantly affect reproduction of species otherwise considered quite tolerant of exposure to hypoxia. The link between hypoxia and seagrass mortality discussed on pp 3601-2 is another example of why explicitly considering diel cycling hypoxia is important.

2) P3570 & elsewhere. Using the example of the improvements in Black Sea hypoxia as a result of nutrient reductions in the context of enclosed seas with the massive hypoxic basins of enclosed seas seems out of place without a qualifier. The unique feature of enclosed seas is the formation of hypoxic basins that last years – millennia. The improvement in the Black Sea was on the shallower shelf – a habitat more similar to that found in shallower estuaries. It is important throughout the text when discussing the Black Sea to distinguish between the deep, persistant (and presumably natural) hypoxic basin, and the locations and type of hypoxia related to high nutrient loads (and changes in those loads).

3) Chesapeake Bay issues: P3573- The Patuxent is the deepest of the Chesapeake Bay tributaries, so the wording is a bit misleading (as phrased, it sounds like you're pointing to is as being a shallow trib instead of just shallower than the mainstem) P3574 -I believe the 25% number is for the mainstem Bay. This qualifier should be added since part of the discussion is about Chesapeake Bay tributaries. The number provided to me by the Chesapeake Bay Program modeling group, including mesohaline tributaries is 18% P3574, lines 16-26. The ordering of statements in this paragraph makes it sound like hypoxia has been a major cause of the decline of oysters in Chesapeake Bay. This is not the case. The major causes are over a century of overfishing followed by more recent epizootics of Dermo (Perkinsus marinus) and MSX (Haplosporidium

nelsoni). That's not to imply that no oysters die from hypoxia – it just is not thought to be a major cause of the decline. P 3574. The statement: 'Near total faunal depletion in summer has been recorded for over 30 years in the Patuxent estuary' is not correct. Only portions of the Patuxent have severe hypoxia, and in those areas, only the bottom exposed to subpycnocline waters is defaunated by low-oxygen exposure. The statement could be made correct by referring to 'parts of the Patuxent estuary'.

4) P3617: The minimum salinity (11) for baltic cod reproduction is required for sperm activation (Nissling & Westin, MEPS 1997) – not egg buoyancy. Also – bay anchovy eggs sink into hypoxic bottom waters in weakly stratified tributaries, but not in the strongly stratified areas of the mainstem Bay.

5) The last section of the paper is an important one, but I would suggest rewriting it so that the conclusions are clearer. The question posed in the section heading is "Do benthic responses differ under human-caused vs natural coastal hypoxia?", but most of the text deals with whether the location and characteristics of hypoxia differ for human-induced and natural hypoxia. Separating sections on differences in the location and characteristics of human-induced and natural hypoxia from sections on differences in biological responses would help (there are probably other solutions that would also work). It might also make more sense to use a separate subheading for the discussion of climate change. Or, perhaps changing the title of the current section heading would be best. I would also recommend that clear support for ideas in this section be provided. For example on p3617, the possibility that long-term exposure to natural upwelling generates resistance to hypoxia is suggested. How could pre-exposure to upwelling prevent oxygen depletion? A better explanation of a mechanism should be provided with this idea. A logical possibility – that the conditions that lead to or accompany upwelling tend to dissipate excess primary production – is not considered. Similarly, it is not clear why seasonal upwelling of oxygen depleted waters should not select for 'infaunal species with annual (or shorter) life spans or mobile taxa able to migrate away from hypoxic areas' just as the authors suggest seasonal oxygen depletion

due to eutrophication does. In some cases, it is not clear whether the authors are really talking about anthropogenic nutrient enrichment or its consequence – eutrophication.

Details: Abstract – A variety of authors have either used different cut-offs for hypoxia or argued that a single cut-off is inappropriate. At the same time, providing a definition makes a paper clearer. I would suggest changing the 2mg/l as 'defined here as' instead of 'defined as'. The more nuanced explanation on pp 3570-3571 is much better

P 3567-organic matter often settles below the pycnocline, not just to the pycnocline The following two sentences seem to contradict each other –rewording would make meaning clearer : 'In regions and at water depths where well-oxygenated currents prevail, hypoxia is rare. The interaction of such currents (e.g., the California Current,The Humboldt Current, the Benguela Current) with strong upwelling and high primary production creates sharp natural oxygen gradients along the coast and continental margin'

P3571- hogchoker, not hogchoaker

Paragraph spanning p 3609-10- The authors correctly point out the importance of spatial scale to recolonization. It is important to provide at least a qualitative indication of the size of affected areas in the recolonization section for each of the examples

P 3615 lines 2-3. Seasonal hypoxia does often last for months, so this distinction is not clear.

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