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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.

L. Levin

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Final Author Response: Biogeosciences Discuss. 2009-9 Biogeosciences Discuss., 6, 3563, 2009

Response to Anonymous Referee#1 (RC C383)

The primary comment of this reviewer was a request that the article recognize that the facilitative benefits to animals of detoxification of sulfide by bacterial mats is still a hypothesis. We have modified the abstract and text accordingly to emphasize this point. We hope that this article might stimulate some further research on the topic.

The abstract now says: Under suboxic conditions, large mats of filamentous sulfide oxidizing bacteria cover the seabed and consume sulfide. They are hypothesized to

provide a detoxified microhabitat for eukaryotic benthic communities.

Main Text now reads: Many protozoans and metazoan animals live in association with mats of mega- and macro-bacteria, including some eukaryotes with symbiotic bacteria (Bernhard et al., 2000; Gallardo and Espinoza, 2007). An active hypothesis is that large mat-forming, sulfide- oxidizing bacteria detoxify sediment by removing sulfide, and thus facilitate metazoan habitation. In this regard, a positive correlation between Thioploca and meiofaunal biomass was observed on the central Chile shelf during non-El Nino conditions when Thioploca was abundant; after El Nino, when Thioploca declined, no relationship was found. Although this evidence does not verify a detoxification role for Thioploca mats, Thioploca presence is thought to have had a positive influence on meiofauna (Neira et al. 2001b). Different bacterial taxa exhibit differences in their sulfide removal capacity (Bruchert et al., 2006), but the extent to which these differences control animal distributions, and whether they are related to the source of hypoxic conditions, requires further study.

Response to Interactive Comment by R . Diaz

Biogeosciences Discuss 6, Page 3563 (SC C 139) This reviewer requests that we mention diel cycling as a key form of hypoxia in shallow tributaries in estuaries. We have added the text: In shallow, well-mixed settings subject to nutrient loading, hypoxia may occur over diel cycles, with supersaturation resulting from primary production in daylight hours and anoxia resulting from heterotrophic respiration at night (Verity et al. 2006; Tyler et al. 2009).

We acknowledge the excellent figure (Fig. 1) provided by this reviewer that illustrates the rapid increase in human-induced hypoxia in the coastal zone, and its causes.

Response to comments by D. Breitburg, (RC C 774)

This reviewer also requests mention of diel cycling. We include mention that hypoxia associated with diel cycling may be less effectively avoided by fish and could provide chronic exposure that affects reproduction.

The text has been changed to clarify the point that improvements in the Black Sea occurred only on the shallow shelf, and that the deeper regions are most likely naturally hypoxia (and remain so).

We have clarified percentages of Chesapeake Bay that become hypoxic and that the Patuxent R. is a deeper tributary.

We have modified text to indicate that oyster declines in Chesapeake Bay are a combined result of overfishing, disease and hypoxia.

We have added the point that sperm activation in Baltic cod requires minimum salinity.

We have added subheadings to the final section of the paper, and modified the section title

We have added the reviewer's idea that upwelling conditions could dissipate excess phytoplankton production and that seasonal upwelling-induced hypoxia might select for short life spans and mobile taxa as in eutrophic areas.

All minor changes requested by the reviewer ('details') have been made, including addition of spatial scale to meiofaunal recovery paragraphs.

Additional Modifications: -Change Middelburg in address to: - Faculty of Geosciences, Utrecht University, POBox 80021, 3508 TA Utrecht, Netherlands -We mention 2 newly published articles by Alteiri (on fisheries shellfish species that benefit from hypoxia) and Zettler. (on Namibian fauna).

New References added or updated.

Altieri, A. H.: Dead zones enhance key fisheries species by providing predation refuge, Ecology, 89, 2808-2818, 2008

Tyler, R. M., Brady, D. C. and Targett, T. E.: Temporal and spatial dynamics of diel-

cycling hypoxia in estuarine tributaries, Estuaries and Coasts, 32, 123-145, 2009.

Tuzzolino, D.: Examining the prey resource value of diel-cycling hypoxia impacted benthic habitat for juvenile weakfish (Cynoscion regalis) and summer flounder (Paralichthys dentatus) in an estuarine tributary. Masters Thesis in marine Biosciences. University of Delaware, Lewes, Delawar, 2008.

Van Colen, C., Monserrat, F., Verbist, K., Vincx, M., Steyaert, M., Vanaverbeke, J., Herman, P.M.J., Degraer, S., and Ysebaert, T.: Tidal flat nematode responses to hypoxia and subsequent macrofauna-mediated alterations of sediment properties, Mar. Ecol. Progr. Ser., 381, 189-197, 2009.

Van Colen, C., Monserrat, F., Vincx, M., Herman, P.M.J., Ysebaert, T., and Degraer, S.: Macrobenthic recovery from hypoxia in an estuarine tidal mudflat, Mar. Ecol. Progr. Ser., 372, 31-42, 2008.

Verity, P. G., Alber, M. and Bricker, S. B.: Development of hypoxia in well-mixed subtropical estuaries in the southeastern USA, Estuaries and coasts, 29, 665-673, 2006.

Zettler, M.L., R. Bochert and F. Pollehne. 2009. Macrozoobenthos diversity in an oxygen minimum zone off northern Namibia. Mar. Biol. DOI 10.10007/s00227-009-1227-9.

Text edits page 3571 line 13 and page 3572 line 3 change Vaquer to Vaquer-Sonyer Page 3585 line 24 California Cooperative Fisheries Investigation (CalCOFI) Page 3615 line 23 Changed Black Sea to Baltic Sea.

Interactive comment on Biogeosciences Discuss., 6, 3563, 2009.