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Ocean Science Discussions

Interactive comment on "Restoration of the Baltic Proper by decadal oxygenation of the deepwater" *by* Anders Stigebrandt

Anonymous Referee #2

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In this paper, a simple model is used to assess whether artificial oxygenation of the Baltic Sea would lead to a major improvement of water quality. This topic is of great interest and the modeling study thus has great potential.

Unfortunately, however, the paper lacks detailed justification of the assumptions in the model, does not discuss the weaknesses of the model and many statements are made without the inclusion of any references. Furthermore, a direct comparison is made to previous periods of hypoxia but the differences between those periods and the modern period of hypoxia are not discussed. A major assumption is that sediments overlain by oxic bottom waters do not act as an internal source of P. This is not so as is also well-known from lake studies. Finally, the transient aspects of the processes in the Baltic Sea are not included in the model and the consequences of this are not discussed. I recommend major revision of the manuscript and an inclusion of a discussion of all of

these aspects.

Detailed comments.

1. p2. Lines 1-5. There are no references in this paragraph. Relevant references should be added (e.g. Conley et al., 2002 ES&T for the internal P source).

2. p2. Lines 30-34. The Carstensen et al. (2014; PNAS) study shows that enhanced respiration, which is linked to the increased external supply of P, played a key role in the expansion of the hypoxia since 1950. The text here could be modified to make this clearer.

3. P3. Lines 11-16 and further. Here, a steady state model is used whereas the Baltic Sea is in a transient state and the magnitude of the internal P source is a complex function of a large number of factors besides bottom water oxygen, including the previous depositional history of the sediment, the presence of macrofauna, the Fe-chemistry etc. That bottom water oxygenation does not shut-off P fluxes from the sediment as suggested here is well demonstrated in many lake studies (e.g. see for example the work of Katsev and Dittrich, 2013; Ecological Modeling) and also explains why high phosphate fluxes from the sediment to the overlying water are observed in many continental margin systems (see references in Ruttenberg (2003; Treatise of Geochemistry; Elsevier).

4. P4. 16-18. The immediate impact of reoxygenation (time scale of 1-2 years) can be very different from the long-term impact (>2 years to decades) because of recolonization of the sediment by fauna, saturation of the sediment Fe-oxides with P etc. This is relevant when discussing the data for the Bornholm basin and By fjord. Can the author indicate how representative the present-day Bornholm basin is for the Baltic Sea? Is the Bornholm basin recolonized by macrofauna during periods of oxic conditions that are used as a reference here? Can more detailed information on By Fjord be given? How was the P sequestered in these sediments? Was the lack of P released sustained over a period of multiple years to a decade?

5. P6. Lines 1-2. See earlier comment above. There is no evidence that sustained oxygenation will shut off the internal source of P from the sediment completely.

6. P6. Lines 4. There is no evidence that the internal source will vanish, see above.

7. P6. Line 11. The oxygen debt in the sediment (organic carbon, iron-sulfides) is very large. How would the results of the calculations change if this were included?

8. P6. Line 32. The conditions during the two previous hypoxic periods were very different: there was much less phosphate in the system and, during the hypoxic intervals of the HTM, the salinity was much higher. The author should consider these differences in the discussion in this section.

9. P7. Lines 2-4. Given the uncertainties, is it really possible to conclude that this restoration can be achieved in 10 years? The model is simple and does not account for the transient state the Baltic Sea is in and the release of P that occurs from sediments below oxic bottom waters, so is this truly justified? The oxygen debt in the sediment is also not included in the calculations (see comment above).

10. P8. Lines 2-3. See earlier comment. There is no evidence that sediment release of P will stop under oxic conditions.

11. P8. Lines 8-10. No evidence is shown that the trophic state will change from eutrophic to oligotrophic.

12. P8. Lines 28-29. See earlier comment. The modern Baltic Sea contains much more P than it did during past periods of hypoxia. There were also important other differences, such as the difference in salinity during the hypoxic interval of the HTM. They can thus not be compared directly in this manner.

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