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Ocean Science
Discussions

Interactive comment on "Consequences of artificial deepwater ventilation in the Bornholm Basin for oxygen conditions, cod reproduction and benthic biomass – a model study" *by* A. Stigebrandt et al.

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The authors thank referee #2 for the overall positive general comments, and the useful corrections brought about by the referee's minor comments, in particular the suggestion to add a schematic image of the model.

Below we respond to comments and suggestions by the referee and we also present changes in our manuscript brought about by the comments. Comments by the reviewer are marked by R, authors' responses are marked by A and changes in manuscript are

marked by M.

R P C890 L21-24: "The discussion is rather speculative, particularly concerning the potential impacts on benthic communities and cod reproduction of ventilating the bottom water, although the authors are clearly trying to base their arguments on accepted, published science."

A: In response to similar critique by referee #1 we will make the following changes in the manuscript.

M: On P 1805 L1 we add: "The bottoms deeper than 75 m, with an area of about 5000 km2, will be habitable for benthic biomass as further discussed in Section 4.6". On P.1808 below L2 we add: "The oxygenation of the deepwater in the Bornholm Basin may only marginally change the supply of organic matter and the oxygen consumption in the basin water beneath the sill depth as explained above*. The changes in hydrography and oxygen conditions induced by pumping will therefore be lost when the pumps are turned off for a longer period or permanently." On P1813 L27 we add: "The increase of biological production since the 1950s is the main reason for present day hypoxia and anoxia. Oxygenation of the Bornholm Basin cannot change this but can be used to improve the oxygen conditions in the deep part of the basin and thereby also make the deepest parts habitable. However, as long as the biological production is not reduced, the oxygen conditions in the Bornholm Basin will return to present time conditions if the pumping is shut off. A reduction of the large-scale eutrophication might possibly be achieved by restoration of the Baltic Proper which would require oxygenation of all anoxic bottoms in the Baltic Proper. This will be discussed in a forthcoming paper."

*refers to a new paragraph on P 1806 below L 24, part of the response to referee #1, shown below.

M: On P 1806 below L 24 we add a new paragraph: "The changes in salinity due to pumping can easily be seen in Fig. 6 in Stigebrandt and Kalén (2012), which shows

that the pumped winter water, of salinity about 8, is interleaved in the lower part of the halocline, well below 60 m depth, due to strong mixing with the ambient deepwater. When interleaved, the volume flow of the pumped plumes has increased by a factor of 20 to 30. Equally strong mixing of the pumped flow was observed in the By Fjord experiment where the volume flow of pumped plumes increased by a factor of 30 before they were interleaved (Stigebrandt et al., 2014). Because the pumped water is interleaved in the lower part of the halocline, the dynamics of the surface layer, including the local supply of nutrients and the production of organic matter, should be negligibly influenced by the pumping. However, since the oxygenation reduces the leakage of phosphorus into the deep-water of the Bornholm Basin (Stigebrandt et al. 2013), this water will carry less phosphorus with it when it is flushed and further transported into the basins east of the Bornholm Basin. Consequently there will be a decreased upwelling of P in the basins east of Bornholm Basin. The effect of decreased P-loading of the Baltic Proper will eventually also be felt in the surface layer of the Bornholm Basin, as an indirect effect of the pumping, and lead to a decreased production of organic matter sinking down into the deep basin. This will be beneficiary to cod recruitment since the oxygen consumption decreases in the deep-water. The benthic biomass will get less feed falling down from the surface layers."

R P C891 L1-2: "A schematic of the various exchange flows between basins would be useful to help visualize the relationships between model terms.

A: We agree and we will add the suggested figure, here denoted Figure B, which is attached as a separate pdf-file.

M: On P 1789 L7 we will add the sentence "A schematic image of the model flows (further described below) is shown in Figure B."

M: Figure caption, to be placed where appropriate. "Figure B. Schematic image of model flows. Grey is used to indicate salinity, with the saltiest water darkest. Dense bottom currents in the Arkona and Bornholm Basins are shown by their vertical compo-

nents. These flows increase with depth due to entrainment of ambient water. Pumping in the Bornholm Basin is shown by a vertical pipe transporting winter water into the deepwater. The pump-induced flow increases due initial mixing at the pipe outlet and thereafter by plume mixing while rising. The flows are further described in section 2.1."

R P C891 L3: "Figures 2 and 3: Are the figure legends the wrong way round?"

A: Yes, the figure captions for Figures 2 and 3 have accidently been switched.

M: The order of the figure captions will be corrected in the manuscript.

R P C891 L4: " P 1803, L23. "why" should be "where"?

A: As suggested by both referees #1 and #2, this sentence does not read well and will be rewritten.

M: The sentence, and the following sentence, changed to: "This layer has lower oxygen concentration than the surrounding water, why oxygen efficiently will diffuse into the layer from both above and below. Hereby the oxygen content is expected to increase already before the water in this layer exits through the Bornholm Channel."

Interactive comment on Ocean Sci. Discuss., 11, 1783, 2014.

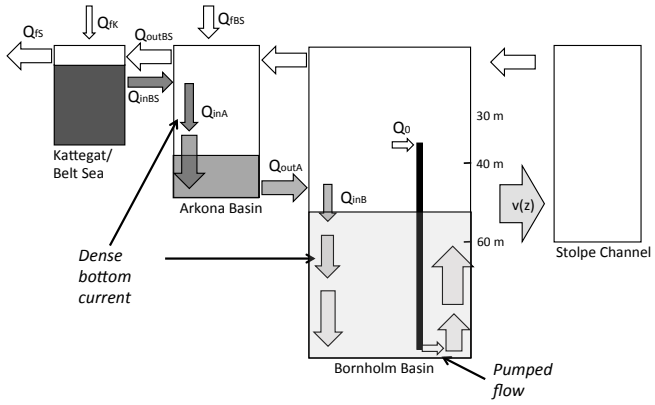

Fig. 1. Figure B. Schematic image of model flows.