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Ocean Science
Discussions

Interactive comment on "Estuarine circulation reversals and related rapid changes in winter near-bottom oxygen conditions in the Gulf of Finland, Baltic Sea" *by* T. Liblik et al.

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We thank reviewer for the useful comments and suggestions which improve the manuscript significantly. All of the comments and suggestions were taken into account and respective changes were made in the manuscript.

Regarding the use of English language in the paper, in general the revision by a native English-speaker could be recommended.

Language is now corrected by Elsevier Language Editing.

Page 3, Line 16: "The last remarkable ventilation of the Baltic Proper deep layers was

observed after the major inflow in 1993." This is incorrectly put because the last inflow that has reached the Gotland Deep and caused a rather strong hypoxia in the Gulf of Finland, occurred as late as in 2003" and Line 23: the inflow of 1993 is incorrectly referred to as the latest.

We absolutely agree with the reviewer and corrected this part: Deep layers of the Baltic Proper are supplied with oxygen only during the major inflows, advecting high-saline and oxygen-rich water from the North Sea. Recently such inflow events occurred in 1993 (Matthäus and Lass, 1995) and 2003 (Feistel et al. 2003). A significant ventilation of the Baltic Proper deep layers was observed after the major inflow in 1993, when oxygen concentration in the Gotland deep rose to 90 μmol l–1 (2 ml l–1); however, oxygen again disappeared in 1998 (Fonselius and Valderrama, 2003). Next ventilation event due to major inflow occurred in 2003 when near-bottom oxygen concentration up to 180 μmol l–1 (4 ml l–1) was measured in the Central Gotland Basin. Between the sporadic major inflows, stagnation periods have been observed, when lack of deep advection decreased near-bottom salinity and oxygen concentrations. During 1961–2005, the deep hypoxic zone extended on the average over an area of about 50,000 km2 in the Baltic Sea (Savchuk, 2010), despite of temporary oxygenation during and after the major inflows. However, on intermediate depths (80–120 m) of the water column higher oxygen concentrations have been observed in stagnation periods (Conley et al., 2002).

Page 4, Line 16: '...resulting perhaps also different release rates of phosphorus from sediment'. This assumption needs justification, with relevant references.

We added reference: Viktorsson, L., Almroth-Rosell, E., Tengberg, A., Vankevich, R., Neelov, I., Isaev R., Kravtsov, V. and Hall, P. O. J., Benthic Phosphorus Dynamics in the Gulf of Finland. .Aquat. Geochem., 18, 543–564, doi:10.1007/s10498-011-9155-y, 2012.

Page 18, Line 14: The particular comparison with only the Tokyo Bay circulation effect

is not clear, more explanation is needed. In fact, it is well known that in large tidal estuaries the intrusion of saline waters is often a reason for oxygenation of oxygen-poor bottoms.

We extended this part of discussion: Intensification of estuarine circulation often causes improvement in near bottom oxygen conditions in estuarine environments due to the import of oxygen-rich ocean waters (e.g. Sato et al., 2012). In that respect, the Gulf of Finland is a rather unique marine system, since imported open sea waters are often depleted from oxygen and here the intensification of estuarine circulation leads to an increase of hypoxic water area and volume. A similar estuarine system is found in the Lower St. Lawrence estuary, where bottom water, isolated by permanent halocline from the upper layer, has to travel several years before it arrives at the estuary (Gilbert at al., 2005). Since the hypoxic water origins from the intermediate layer of the Baltic Proper, oxygen conditions there often determine the oxygen conditions in the Gulf of Finland as well. Conley et al. (2012) showed that so called stagnation periods lead to oxygen deficiency in the deep layer of the Baltic Proper while the intermediate layer contains relatively more oxygen during such periods. The last longer stagnation period in 1980s caused weaker halocline (Liblik and Lips 2011) and higher deep layer oxygen concentrations (HELCOM 2009) in the Gulf of Finland while oxygen conditions in the deep layer of Baltic Proper deteriorated during the same period. Thus inflow activity from the North Sea has opposite effect to the oxygen conditions in the deep layer of the Gulf of Finland and the Baltic Proper.

Fig. 3 – very important, but too small, needs to be larger.

The final revised version will have a different format than the discussion paper, i.e. it will be larger. We spread the figure over two columns in revised manuscript.

Interactive comment on Ocean Sci. Discuss., 10, 727, 2013.