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Effect of major Baltic inflows on the vertical distribution of hydrophysical parameters, oxygen and inorganic nutrients in the Baltic Proper and the Gulf of Finland: a numerical modelling experiment

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Certain meteorological and oceanographic conditions cause episodic inflows of highly saline and usually oxygen-rich water into the Baltic Sea termed major Baltic inflows (MBI). These events ventilate the deep water of the Central Baltic Sea, but also increase stratification stability and suppress vertical mixing. During stagnation periods the deep water oxygen pool is exhausted and salinity is decreasing due to mixing processes.
While the effect of MBIs on the deep area of the Central Baltic received much attention in the recent years, less is known about their influence on hydrophysical and ecological conditions in the Baltic sub-basins. It is a fact, that despite a reduction in nutrient discharge to the Baltic Sea from agricultural runoff and industrial production in the beginning of 1990s, in the Gulf of Finland (GoF) near-bottom oxygen conditions became worse and phosphate concentrations have even increased during the recent decade. This is raising the question of the role that MBIs play in the exchange of water and material between Baltic Proper and the GoF.
To improve our understanding of the effects of MBIs on the interaction of the Gulf of Finland and the Baltic Proper, the hydrodynamic model GETM coupled with the ecosystem model ERGOM was applied to the Baltic Sea area for the period 1991-2009. Model performance was validated and showed good agreement with the available measurement data at HELCOM monitoring stations BY15, LL17, LL12, LL7 and LL3A, which represent a transition from the Gotland Deep to the eastern GoF. To exclude the effect of MBIs, an experimental model run without imposed sea-level variations at the open boundary in Kattegat was performed, thus excluding one of the major factors driving the barotropic inflows to the Baltic Sea.
Model results have shown that in no-inflow situations, surface salinity is lower by about 1 PSU and near-bottom salinity by about 2 PSU in the Baltic Proper, while in the GoF the difference is about 0.5 and 1.5 PSU, respectively. There is no significant difference in surface temperature values, but in the absence of inflows near-bottom temperature is in general lower. In the case without inflows, near-bottom oxygen content in the GoF is higher and phosphate concentration is lower, while in the Baltic Proper the situation is opposite. Nitrate is either absent or very low in the Baltic Proper, while in the GoF its concentration is higher than in the "default" case. Comparison of model results has shown that variability of stratification clearly influenced vertical distributions of all the parameters.
Our results confirm that MBIs have played a distinct role in shaping the status of the GoF ecosystem during recent decades and emphasize the fact that the exchange between Baltic Proper and the GoF should receive proper attention in the process of the Baltic Sea ecosystem management.