balt adapt

Baltic Sea Region
Climate Change Adaptation Strategy

Climate Change in the Baltic Sea Region: Oxygen

BALTADAPT CLIMATE INFO #5

The Baltic Sea oxygen content

In the Baltic Proper there is a strong permanent halocline (layer where the salinity changes rapidly with depth) at around 60 m depth that inhibits the vertical water exchange. As a consequence the water becomes stagnant in the deeper parts and depleted in oxygen. Inflows of more saline water, with higher oxygen content, will temporarily improve the conditions. In the Gulf of Bothnia the stratification is weaker and winter convection will ventilate the deeper areas. When the oxygen concentration becomes less than 2 ml/l many organisms will have difficulties living in this environment.

Current situation

The oxygen situation in the Baltic Proper may be illustrated by Figure 1 showing areas with seasonal and long-term hypoxia (oxygen concentrations less than 2 ml/l). The figure is based on measurements carried out during the years 2001–2006. More recent (2010) surveys of the Baltic Proper show a similar pattern.

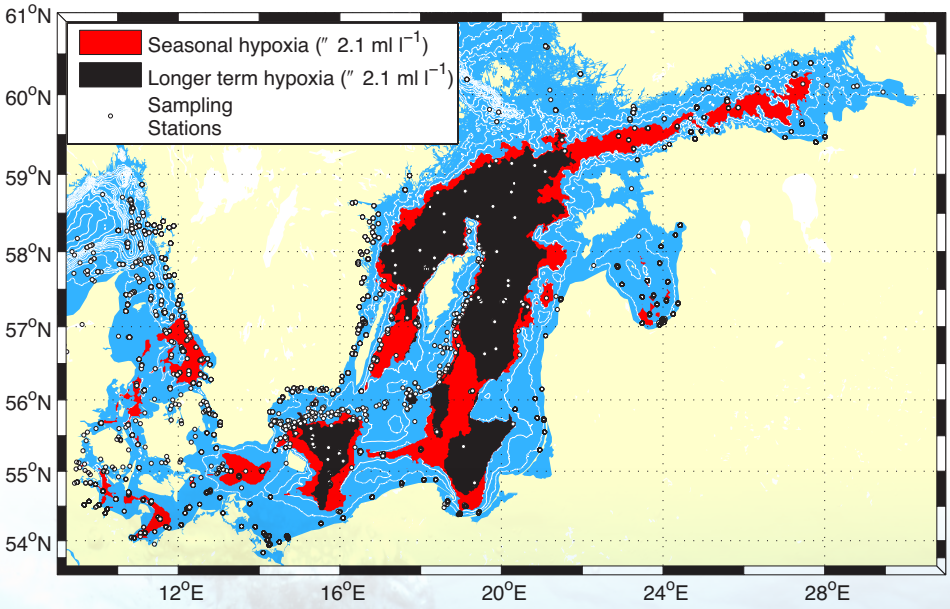

Figure 1: *Extent of seasonal hypoxia (red) and longer-term hypoxia (black) during 2001–2006. Measuring stations are indicated by small dots. (From HELCOM, 2009)*

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Climate change impacts

Results from scenario simulations of bottom oxygen concentration changes between the periods 2070–2099 and 1969–1998 are presented in a set of maps (Figures 2 and 3). Four climate scenarios have been combined with two nutrient load scenarios. For each nutrient load scenario the seasonal and annual means of the simulations have been calculated as well as the difference between the maximum and minimum values obtained among them. This latter quantity, the range, is a measure of the spread of the results from the four simulations where a large value indicates a larger uncertainty. (Note that other climate scenarios and nutrient loads may give different results.)

More information about the scenario simulations is given on the back of this bulletin.

› In the first set of simulations the nutrient load scenario is in accordance with the Baltic Sea Action Plan (BSAP).

› The largest increase in oxygen concentrations is found in the Gulf of Finland, especially in the innermost parts, see Figure 2. Increased values are also evident along the slopes of the Gotland Sea as an effect of a deepening of the halocline (cf. Baltadapt Climate Info #6: Salinity). The more shallow areas show a slight decrease.

› The spread of the scenarios is most prominent along the slopes of the Gotland Sea and in the Gulf of Finland (cf. Figure 2 right panel). The spread is also considerable in the deepest parts of the Bothnian Sea.

› There is no striking seasonality although the changes and the spread is somewhat increased in spring.

› For the reference (REF) scenarios the corresponding changes in the bottom oxygen concentrations are presented in Figure 3.

› All the deeper parts of the Baltic Proper and the Bothnian Sea show a substantial decrease in bottom oxygen concentrations. An increase is found in the innermost part of the Gulf of Finland.

› The spread of the simulations shows a similar pattern as for the BSAP scenario but with somewhat enhanced values along the slopes of the Gotland Sea and in the Gulf of Finland.

› The increase in oxygen, seen in the innermost part of the Gulf of Finland, takes place in winter and spring. The spread of the simulations are largest in spring.

Conclusion

If the nutrient loads remain at the same level as today there may be a decrease in bottom oxygen concentrations in the deeper parts of the Baltic Proper and the Bothnian Sea due to the changing climate. If the BSAP nutrient loads are applied there may instead be an increase of bottom oxygen along the slopes of the Gotland Sea and in the Gulf of Finland. The improvement may, however, not be as large as it would have been in today´s climate. The largest spread of the scenario simulations is coupled to the uncertainties of the future halocline depth.

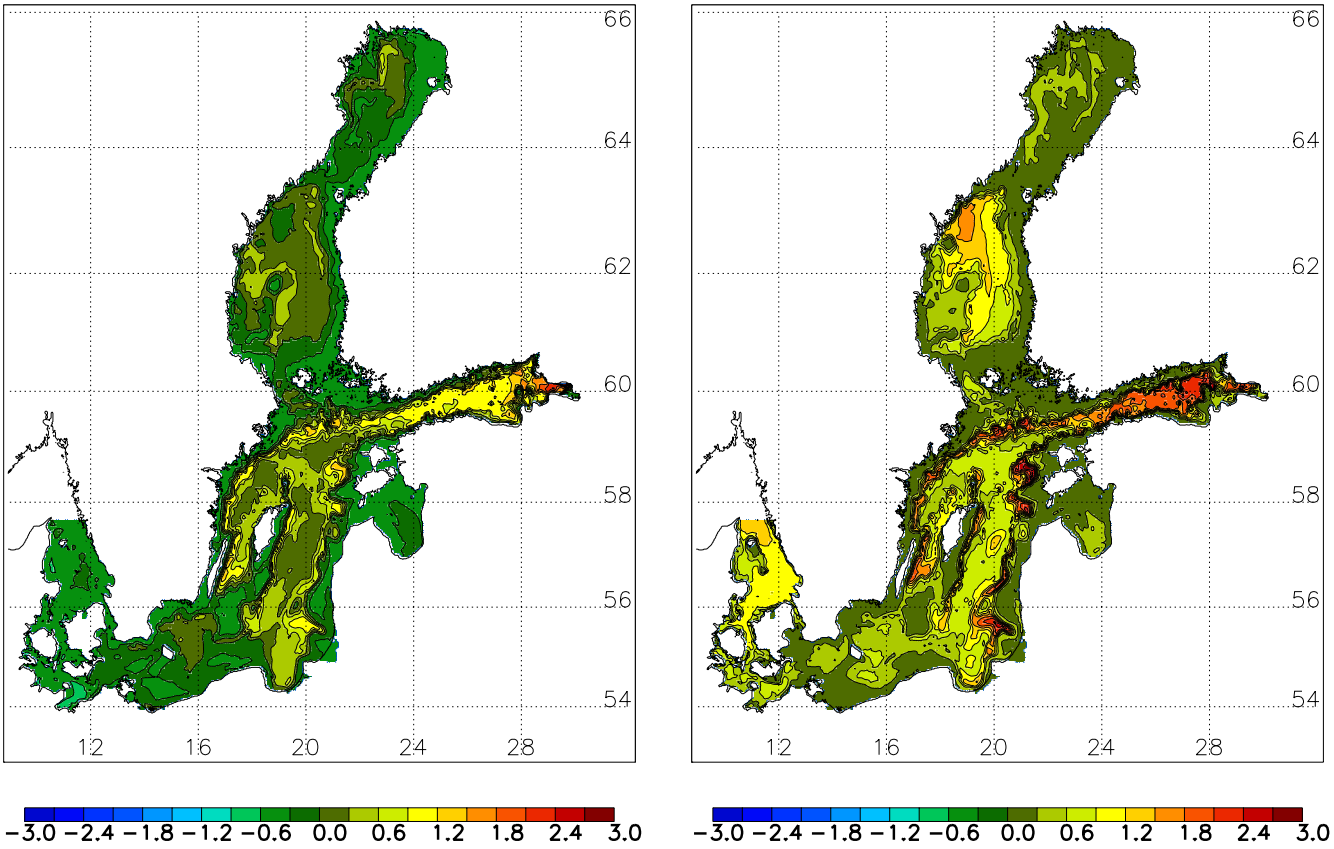

Figure 2: *Left panel: The mean change in the annual bottom oxygen concentrations (ml/l) between 2070–2099 and 1969–1998. The nutrient load scenario is BSAP. Right panel: The range of the changes. (From Meier et al., 2011)*

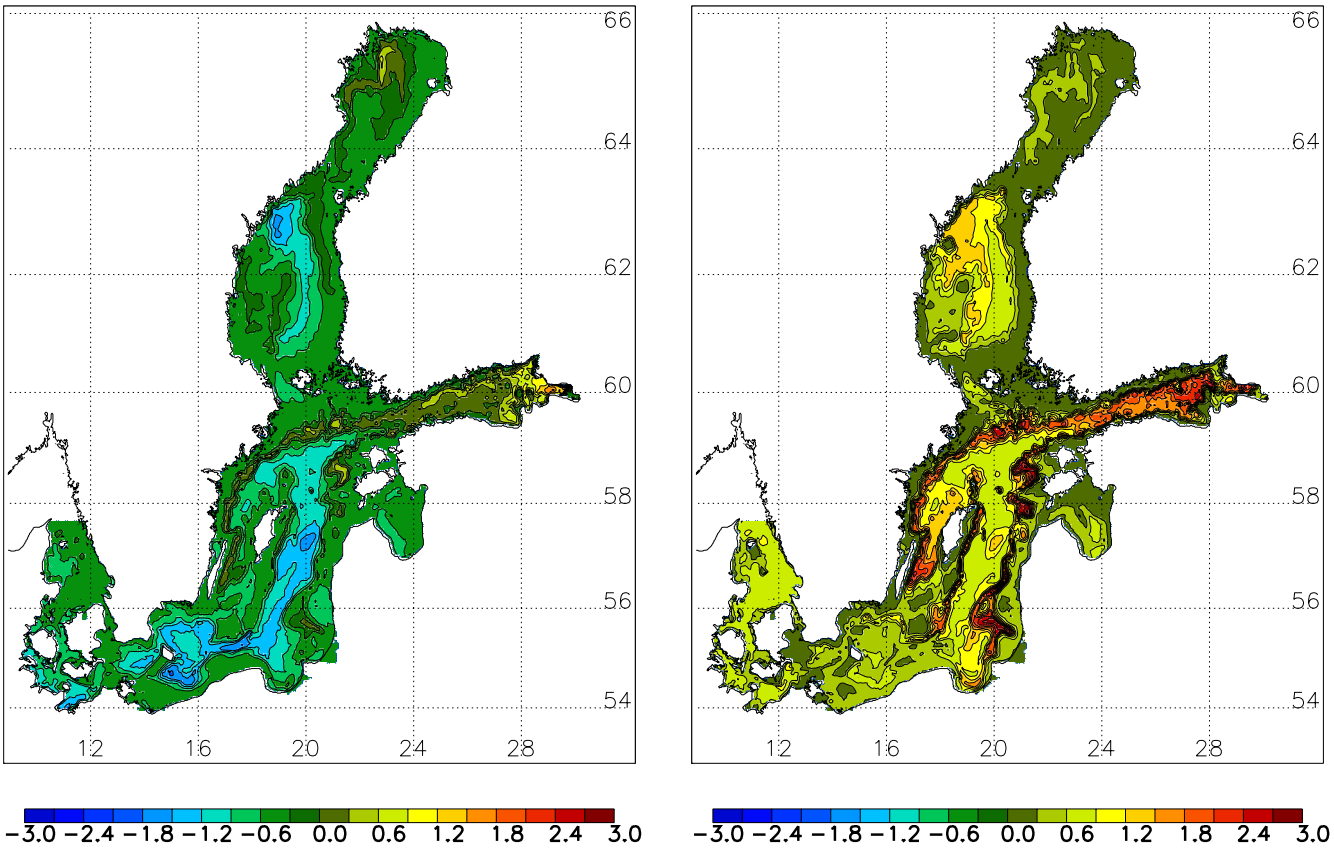

Figure 3: *Left panel: The mean change in the annual bottom oxygen concentrations (ml/l) between 2070–2099 and 1969–1998. The nutrient load scenario is REF. Right panel: The range of the changes. (From Meier et al., 2011)*

Climate scenario data

Four simulations of the changing conditions in the Baltic Sea between the periods 2070–2099 and 1969–1998 have been carried out using a coupled physical-biogeochemical model, RCO-SCOBI (Meier et al., 2011). The scenarios cover the Baltic Sea Region and have a spatial resolution of 3.7 km.

The model is forced by a regional climate model which, in turn, obtains data on its boundaries from a General Circulation Model (GCM), see Baltadapt Climate Info #1. Two different GCMs and two different emission scenarios have been combined to form the four climate simulations.

The emission scenarios chosen for the simulations are A1B and A2 which are characterized by the following storylines:

- A1B: "a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and rapid introduction of new and more efficient technologies with a balance across energy sources".
- A2: "a very heterogeneous world with continuously increasing global population and regionally oriented economic growth that is more fragmented and slower than in other storylines".

The nutrient load scenarios chosen for the simulations are:

- Baltic Sea Action Plan (BSAP): Loads from rivers according to HELCOM (2007) and 50 % reduction of atmospheric deposition.
- Reference (REF): Current loads from rivers and current atmospheric deposition.

One should note that other combinations of GCMs, emission scenarios and nutrient load scenarios, and other models, may give different results.

References

Meier, H.E.M., H. Andersson, C. Dietrich, K. Eilola, B. Gustafsson, A. Höglund, R. Hordoir and S. Schimanke. Transient scenario simulations for the Baltic Sea Region during the 21st century. SMHI, Oceanografi Nr 108, 2011.

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baltadapt

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The Baltadapt project in a nutshell

The Baltic Sea and its coastlines face challenges due to climate change …
Climate change will influence precipitation amounts and patterns, and lead to an increase in terrestrial and sea temperatures and a rise in sea level. The resulting changes will jeopardize the integrity of the ecosystem and increase risks caused by natural disasters.

… it is time to adapt now!
Adaptation strategies are needed to cope with the inevitable consequences of climate change. This is also highlighted in the EU Baltic Sea Region Strategy. Baltadapt is developing a transnational climate change adaptation strategy for the Baltic Sea Region, which focuses on the sea and the coastline.
Baltadapt can't stop climate change but it will help to adapt to its impacts. The project facilitates a knowledge-brokerage process on climate change adaptation between research and policy, thus contributing to improved institutional capacity. This will help decision makers in the Baltic Sea Region to tackle the consequences of climate change.
The project was approved under the Baltic Sea Region Programme 2007–2013 and has a total budget of € 2.86 m. Its partner consortium is led by the Danish Meteorological Institute. Baltadapt is a flagship project under the EU Strategy for the Baltic Sea Region and has been awarded the Baltic 21 Lighthouse Project quality label.

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