balt adapt

Baltic Sea Region
Climate Change Adaptation Strategy

Climate Change in the Baltic Sea Region: Eutrophication

BALTADAPT CLIMATE INFO # 13

Eutrophication in the Baltic Sea

The future ecological conditions in the Baltic Sea are not only determined by possible reductions in the nutrient loads but also by changes in temperature, salinity and oxygen caused by a changing climate. This means that a reduction performed in today´s climate may not be as effective in a future climate.

Current situation

Nutrient concentrations increased in the Baltic Sea up to the 1980s, but decreased in many areas during the past two decades due to reduced nutrient loads from the catchment area. Chlorophyll-a concentrations had also increased and water transparency decreased and only recently, improvements are visible due to the reduced nutrient concentrations. However, according to a HELCOM assessment (2009), only the Bothnian Bay and the Swedish parts of the north-eastern Kattegat are not affected by eutrophication today. The open waters of all other basins and also most coastal waters are still classified as areas affected by eutrophication. Oxygen depletion and hypoxia (low oxygen conditions) are direct effects of eutrophication and still a major problem in many parts of the Baltic Sea (cf. Baltadapt Climate Info #5: Oxygen and Baltadapt Climate Info #12: Nutrient Loads).

Climate change impacts

Results from scenario simulations (Meier et al., 2011) of surface (upper 10 m) nitrate and phosphate concentration changes between the periods 2070–2099 and 1969–1998 are presented in a set of maps. 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, or other models, may give different results.)

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

Part-financed by the European Union
(European Regional Development Fund)

Baltic Sea Region
Programme 2007–2013

CBSS-Baltic 21 Lighthouse Project

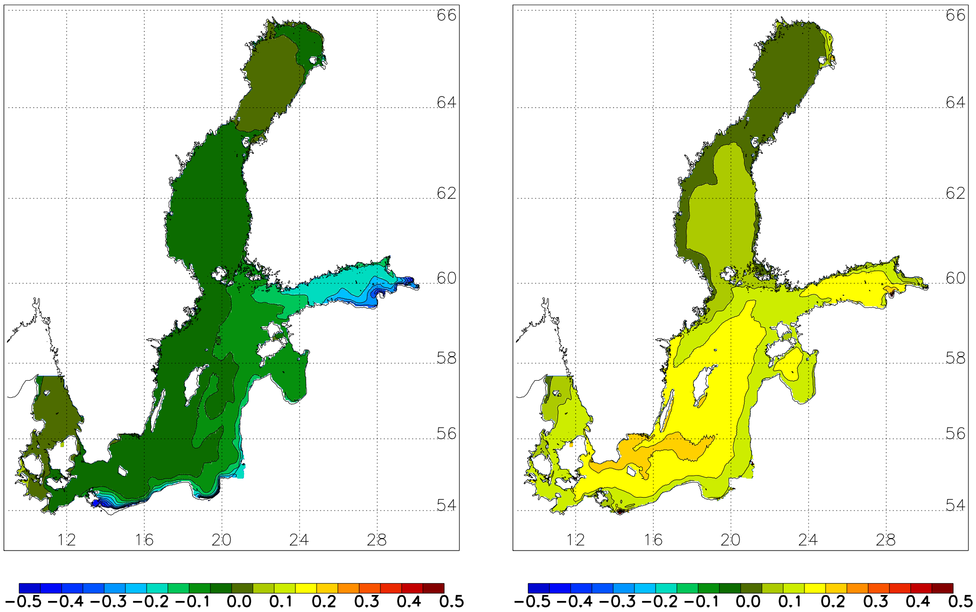

Figure 1:

Left panel: The mean change in the annual surface phosphate concentrations (mmolP/m³) between 2070–2099 and 1969–1998. The nutrient load scenario is BSAP.
Right panel: The range of the changes. (From Meier et al., 2011)

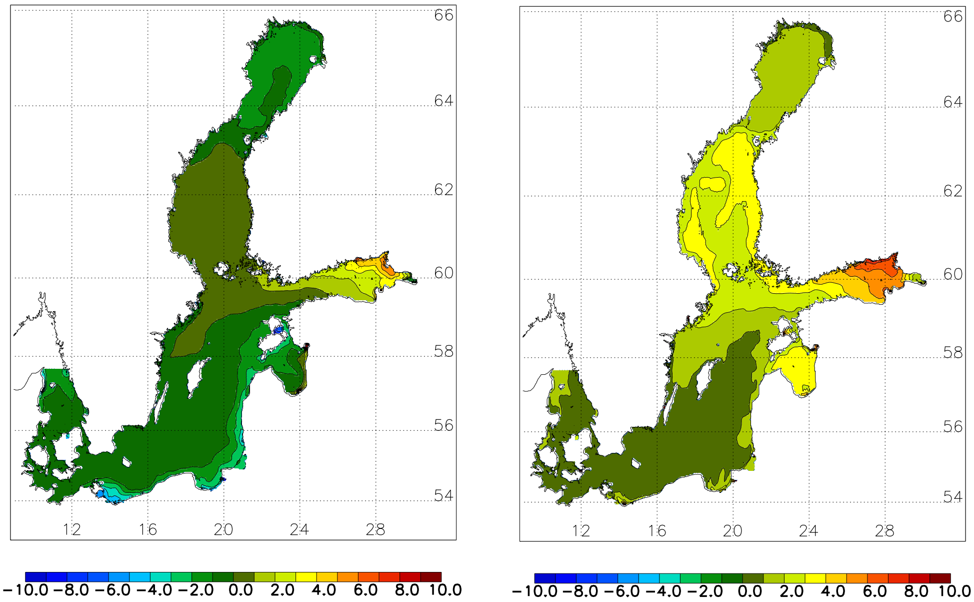

Figure 2:

Left panel: The mean change in the annual surface nitrate concentrations (mmolN/m³) between 2070–2099 and 1969–1998. The nutrient load scenario is BSAP.
Right panel: The range of the changes. (From Meier et al., 2011)

- In Figures 1 and 2 the results are shown for the nutrient load scenario following the Baltic Sea Action Plan (BSAP) under climate change conditions.
- The changes (decrease) in surface phosphate concentrations are generally small except in the Gulf of Finland and in the south of the Arkona Basin. The largest range is found in the Gulf of Finland and in the Baltic Proper.
- A decrease in surface nitrate concentrations is found in the Baltic Proper and in the Bothnian Bay. In the Gulf of Finland there is instead an increase but this is also the area where the largest spread of the simulations is found (cf. right panel in Figure 2)
- The largest reductions, but also the largest spread, are found in winter and spring for phosphate. For nitrate the reductions are higher during spring.
- The second set of maps, presented in Figures 3 and 4, show the corresponding changes in the surface concentrations of phosphate and nitrate for a reference (REF) nutrient load scenario under climate change conditions.
- The surface phosphate concentrations increase in the Baltic Proper especially in the southern parts. The Gulf of Bothnia is mostly unaffected. The largest spread of the simulations is found in the Gulf of Finland and along the southern part of Arkona.

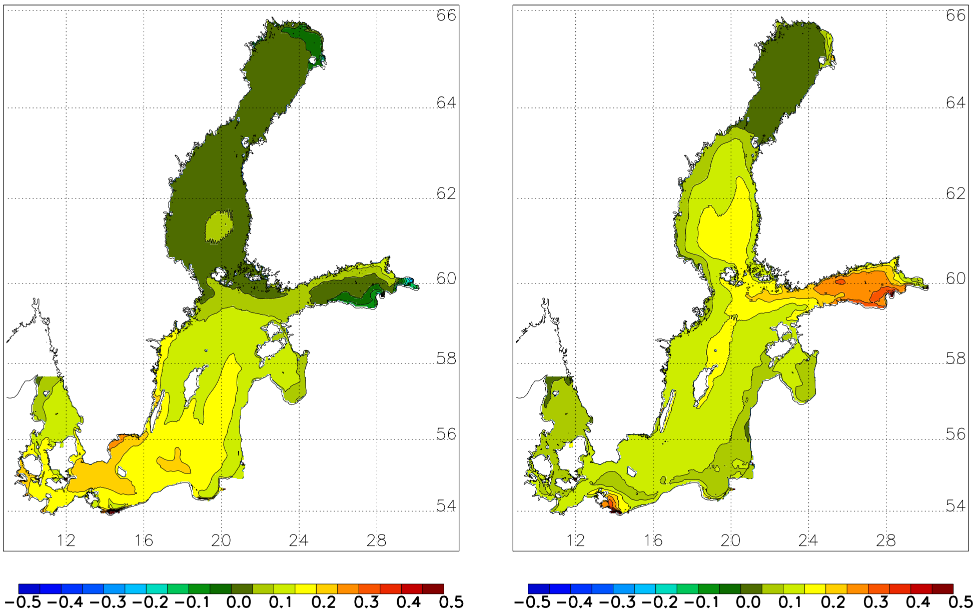

Figure 3:

Left panel: The mean change in the annual surface phosphate concentrations (mmolP/m³) between 2070–2099 and 1969–1998. The nutrient load scenario is REF.
Right panel: The range of the changes. (From Meier et al., 2011)

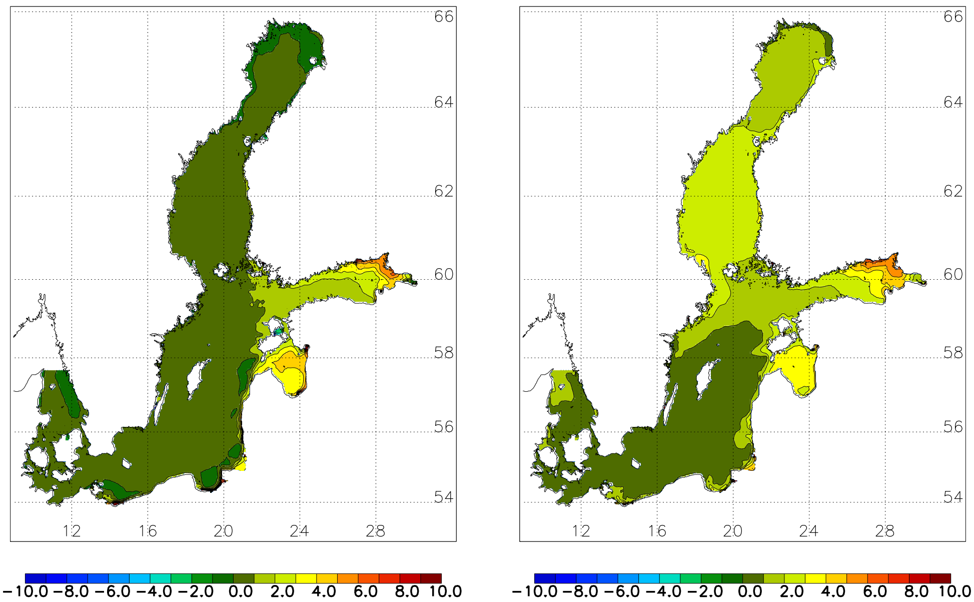

Figure 4:

Left panel: The mean change in the annual surface nitrate concentrations (mmolN/m³) between 2070–2099 and 1969–1998. The nutrient load scenario is REF.
Right panel: The range of the changes. (From Meier et al., 2011)

› The surface nitrate concentrations remain the same except for the Gulf of Finland and the Gulf of Riga, where also the largest spread of the simulations are found.

› It is mainly the winter season that displays a substantial increase in the surface phosphate concentrations while the largest spread of the simulations is found in spring. For surface nitrate a slight increase in winter in the Baltic Proper is followed by a slight decrease in spring, leaving the annual mean unchanged in this area. The increase in Gulf of Finland and Gulf of Riga is largest in winter while the spread has the highest values in summer and fall.

Conclusion

The applied model suggests that if the nutrient loads remain at the same level as today the future water quality may decline due to changing climate. An increase in runoff and a reduction of oxygen rich inflows may increase the areas with hypoxic (oxygen concentrations < 2 ml/l) conditions. Surface nutrient and phytoplankton concentrations may increase and the water transparency may be reduced in the Baltic Proper. If the BSAP is applied the water quality may be improved but not as much as it would in today´s climate.

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 more in 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 and further reading

HELCOM, 2007. Toward a Baltic Sea unaffected by eutrophication. Background document to Helcom Ministerial Meeting, Krakow, Poland, Tech. rep., Helsinki Commission, Helsinki, Finland.

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Editing and layout:

Project Coordination Office
s.Pro – sustainable projects GmbH
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balt adapt
www.baltadapt.eu

1st edition – November 2011

The Baltadapt project in a nutshell

The Baltic Sea and its coastlines face challenges due to climate change. The projected increase in precipitation amounts and temperature will jeopardize the integrity of the ecosystem and increase risks caused by natural disasters. Adaptation strategies are needed to cope with the inevitable consequences of climate change. Baltadapt is developing a transnational climate change adaptation strategy for the Baltic Sea Region. This will help decision makers allover the 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.