Number 10, October 2011

BONUS briefing

SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

ECOSUPPORT

Advanced tool for scenarios of the Baltic Sea ECOsystem to SUPPORT decision making

ECOSUPPORT model projections of the Baltic Sea show that changes will occur in the marine environment in a future climate: water temperature will increase and (eventually) salinity will decrease. Warmer water changes the oxygen saturation concentrations and turnover rates of biogeochemical processes, enhancing eutrophication. Therefore, nutrient load reductions to the Baltic Sea are of even higher importance in a warmer climate. To keep water quality targets set in the HELCOM Baltic Sea Action Plan in the future, the results indicate that even further load reductions are necessary.

OVERVIEW

The Baltic Sea suffers from severe problems due to eutrophication, for example large cyanobacterial blooms (Figure 1) and bottoms with very low oxygen concentrations. To overcome these problems it is of vital importance to reduce nutrient loads from atmosphere, point sources and rivers with international policies. It is here that the Baltic Sea Action Plan is a unique and necessary collaboration for a healthy Baltic Sea with a water quality of good status.

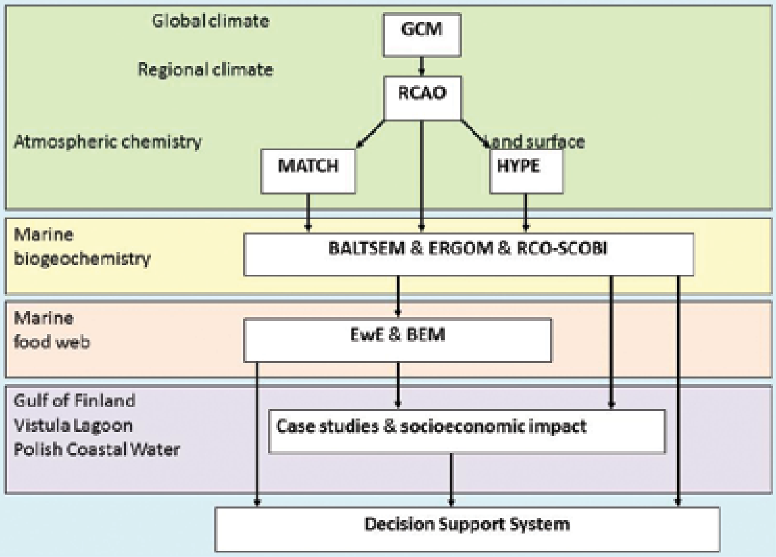
ECOSUPPORT plays a role in the process where we can supply decision makers with sound, scientific knowledge of results of actions on water and on land, in present and future climate. It is necessary to understand what effect different cost-consuming measures, or the lack of them, will have on the marine environment and the ecosystem. Hence, models are needed to assess complex interactions between atmosphere, land and sea in order to make projections of the future.

The response of the marine ecosystem during the 21st century depends on several, partly competing drivers, like changing phosphorus and nitrogen loads, increased water temperatures, and reduced salinities. Thus, presently discussed targets for nutrient load reductions to improve the ecological status might have a different outcome in future climate conditions.

The main aim of ECOSUPPORT is to provide a multi-model system tool to support decision makers to assess the human -induced impact of the state of the Baltic Sea environment. The advanced modelling tool produces scenario simulations of the whole marine ecosystem that can underpin and inform design strategies to ensure water quality standards, biodiversity and fish stocks (Figure 2). The model system includes data from global General Circulation Models (GCMs), a regional climate model for the Baltic Sea catchment area, two hydrological models to calculate river flow and nutrient loadings, an atmospheric chemistry and transport model system, three marine physical-biogeochemical models of differing complexity for the Baltic Sea, food web and statistical fish population models, regional case studies and socio-economic impact studies.

An ensemble of model simulations for the period 1850-2099 has been performed. Four climate change scenarios using regionalised

Figure 1. Cyanobacterial bloom in the Baltic Sea during 2005 visualised with the satellite sensor MODIS (Moderate Resolution Imaging Spectroradiometer) (source: SMHI Oceanographic Unit)



data from two General Circulation Models (GCMs) and two greenhouse gas emission scenarios (A2, A1B) have been used to force three state-of-the-art coupled physical-biogeochemical models (for details see Figure 2). Four nutrient load scenarios, ranging from a pessimistic business-as-usual to a more optimistic case, have been investigated with the models: a reference with a continuation of present loads, current legislation, implementation of abatements according to the Baltic Sea Action Plan and "business as usual" with increasing loads due to increased use of fertilisers in transitional Baltic Sea countries.

OUTLINE OF KEY RESULTS

A LARGE DATABASE WAS GENERATED IN ORDER TO ASSESS THE ENVIRONMENTAL STATUS AND THE FORCING PARAMETERS IN THE BALTIC SEA

A large, publicly available database of climate and environmental model data and observations was built that describe past and future climates of the Baltic Sea region. These data were generated with an advanced modeling tool for scenarios of the Baltic Sea as a result of an intensive international collaboration (Figure 2). The database contains scenario simulations of various differing models allowing a quantification of agreement and disagreement of future projections. For research purposes larger amounts of data from model simulations are available via ftp server at the Swedish Meteorological and Hydrological Institute (SMHI).

The database comprises also of analysis results of the multi-model ensemble simulations combining climate change and nutrient load reduction scenarios. To identify and quantify the impact of nutrient load reductions on the eutrophication status in future climate we used ecological quality indicators suggested by HELCOM, e.g. winter surface nutrient concentrations, summer average Secchi depths, chlorophyll-a concentrations, and extension and duration of hypoxic areas. In addition, we quantified changes of extension and duration of anoxic areas, extension of areas covered with cyanobacteria, cyanobacteria concentrations, plankton biomass, primary production, nitrogen fixation, denitrification, and permanent burial of phosphorus and sediment concentrations.

CLIMATE CHANGE WILL HAVE CONSIDERABLE IMPACT ON THE MARINE ENVIRONMENT WITH SOCIO-ECONOMIC IMPLICATIONS

All investigated climate projects based upon the emission scenarios A1B and A2 suggest warmer air temperatures in the future, with an annual mean increase in the range of 2.7 - 3.8 K for 2070-2099 relative to 1969-1998 in the Baltic Sea region. Precipitation also shows an increase and the projections range between 12 and 18 %. Depending on the scenario simulation river runoff to the Baltic basin will increase in the range between 4 and 22%, with largest increase in the northern parts of the region.

As a consequence of changing atmospheric and hydrological conditions the overall water temperature is projected to increase and salinity to decrease (Figure 3). Such changes together with present loads will very likely affect the marine environment inter alia with enhanced eutrophication, increased bottom areas with missing higher forms of life, so-called hypoxic areas (Figure 3), reduced biodiversity and increased risk for acidification.

The food web model used in ECOSUPPORT shows that due to the changing hydrological conditions, where the cod reproductive habitat based on oxygen concentration and salinity (the cod reproductive volume) decreases, also the total cod biomass will decrease. However, in the Baltic Sea cod dynamics are controlled by several factors, including exploitation, climate variability and predation by seals. ECOSUPPORT has simulated how the combined effects of these variables might affect cod abundance in the 21st century. The results show that under a sustainable exploitation level, there could be modest to high abundances of cod, even if salinity decreases by 15% and if seal abundance and predation increases to levels similar to those seen in the early 1900s. These results will support ecosystem-based approaches to fisheries management and biodiversity conservation in the Baltic Sea.

Climate change will also have other socio-economic implications. Biological valorisation at local focus study sites at the Polish coastal waters shows that the most valuable area here is the Puck Bay. Interestingly, although it is a hot spot for marine biodiversity, it is also the most degraded part of the Polish Exclusive Economic Zone (EEZ).

Figure 2. The ECOSUPPORT decision support system is based on information from scenario simulations. The scheme is highly simplified, neglecting complex interactions (e.g. fish predation pressure on zooplankton, socio-political changes that will affect climate and nutrient load scenarios). Further information is available on the ECOSUPPORT website.

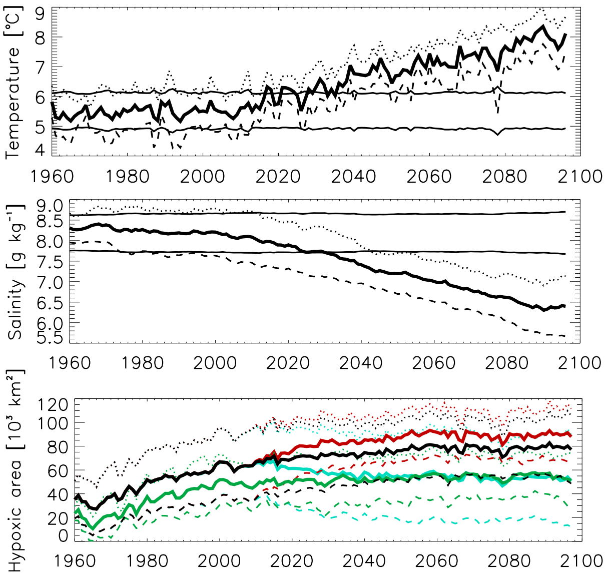


Figure 3. Volume integrated water temperature and salinity and hypoxic area (with bottom oxygen concentrations below 2 ml/l) in the Baltic Sea (solid lines). The ranges of plus/minus one standard deviation around the ensemble means are depicted by dotted and dashed lines, respectively. Straight lines indicate the 99% confidence interval for significant changes from present climate variability during 1978-2007. The various nutrient load scenarios are denoted with colored lines: reference (black), current legislation (green), BSAP (blue) and business-as-usual (red).

The Bay is the largest recreation centre in Poland, key national site for windsurfing and quite important site for local fishery. It is also the place of strong conflicts between nature conservation, recreation and fishery. The conflicts will probably become more intense because of the global warming. Both the conflicts and the climate change will influence the provision of ecosystem services, among which recreation, fishery, seaways and marine aerosols are mostly recognised by the local municipalities. Apart from the biggest cities, the economy of the Polish coast is strongly dependent on the marine resources and the health of the environment. The Puck Bay is not currently a spatially managed area and this study supports need for more transparent, science-based and participatory decision making.

NUTRIENT LOAD REDUCTIONS ARE EVEN MORE IMPORTANT IN FUTURE CLIMATE THAN IN PRESENT CLIMATE

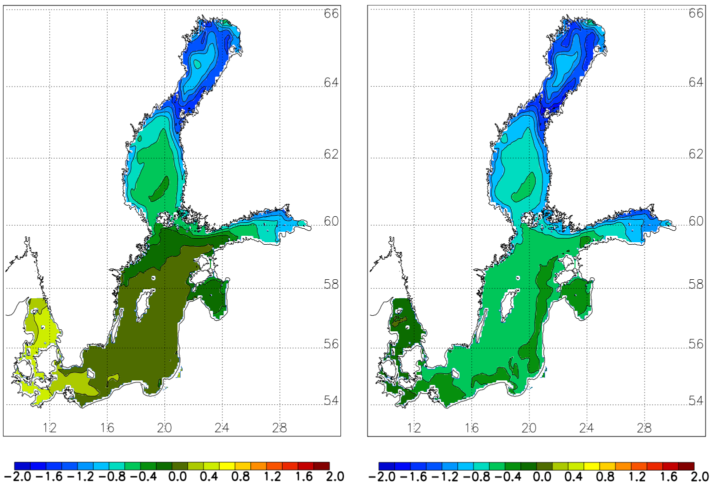
Assuming even the most optimistic nutrient load scenario following the BSAP, hypoxic areas will still exist at the end of this century exceeding the levels of the 1960s (Figure 3). The models suggest that due to increased water temperatures oxygen saturation concentrations will decrease and turnover rates of biogeochemical processes will increase. Hence, internal nutrient cycling is intensified and permanent removal of nutrients from the sediments is reduced. In addition, due to increased river flows eventually larger amounts of nutrients might be flushed out from land. Thus, nutrient load reductions are less effective for the marine environment in future compared to present climate. For instance, under the Baltic Sea Action Plan scenario, the future water transparency will not increase significantly and will even be reduced assuming present loads (Figure 4). Hence, Baltic Sea management has to consider the impact of climate change in addition to eutrophication and other human induced threats. Nutrient load reductions are even more important in future climate than in present climate.

Figure 4. Changes of the water transparency (expressed by the Secchi depth in meter) in future (2070-2099) relative to present climate (1978-2007): reductions according to BSAP (left panel) and present nutrient loads (right panels).

NEXT STEPS

The outcome of ECOSUPPORT will continuously be communicated to relevant policy makers; one form of communication being the platform "Baltic Vision". Here we aim to bridge the communication gap between scientific disciplines, decision makers and practitioners by creating a platform for dialogues on climate change in the Baltic regions, with an emphasis on the sea and the coastal zone. The scientifically produced knowledge and information is projected in a visual form accessible to a wide public audience by an existing digitalised visualisation platform displayed in a portable, inflatable dome (Figure 5). The specific goal is to provide a platform for collaboration between environmental scientists, decision-makers, and local, regional and transnational stakeholders representing different sectors. The interactive visualisation presentations aim to increase the knowledge among a wide group of stakeholders and interest groups. They promote discussions on these issues and can also feed ideas of relevant developments of the visualisation material for coming projects.

The outcome of ECOSUPPORT will also be found in a Decision Support System at the project webpage, www.baltex-research.eu/ecosupport. This will consist of a large database displaying the scenarios for the Baltic Sea under the combined effect of climate change and nutrient loading.



IN BRIEF

ECOSUPPORT
Advanced tool for scenarios of the Baltic Sea ECOsystem to SUPPORT decision making

KEY RESULTS

- ECOSUPPORT has developed a multi-model system tool to assess the combined effect of climate change and nutrient loads to the Baltic Sea.

- The tool demonstrates that as a consequence of changing atmospheric and hydrological conditions the overall water temperature is projected to increase and salinity to decrease. Such changes together with present loads will very likely lead to enhanced eutrophication, increased bottom areas with missing higher forms of life, so-called hypoxic areas, reduced biodiversity and increased risk for acidification.

- To reach HELCOM targets for a Baltic Sea unaffected by eutrophication, nutrient load reductions are even more important in a future climate. For instance, under the Baltic Sea Action Plan scenario the future water transparency will not increase significantly and will even be reduced assuming present loads (Figure 3).

WHO NEEDS THE INFORMATION

ECOSUPPORT information will be made ready available for all policy makers concerned with a Baltic Sea unaffected by eutrophication and the adaptation to climate change.

Figure 5. Baltic Vision: visualizations in a GeoDome as a support to decision makers.

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www.baltex-research.eu/ecosupport
www.bonusportal.org/ecosupport

Photos: iStock.com; ECOSUPPORT

BONUS is supported by the national research funding institutions in the eight EU member states around the Baltic Sea and the EU Commission's Research Framework Programme

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