Conclusions of the HELCOM Workshop on Baltic Sea region climate change and its implications

5-6 February 2013, Warnemünde, Germany

Introduction

HELCOM together with BALTEX organised the Workshop on Baltic Sea region climate change and its implications on 5-6 February 2013 in Warnemünde, Germany, to bring together Baltic Sea region climate change scientists and marine environment-related experts and managers. The aim of the workshop was to present and discuss the current knowledge on climate change in the Baltic Sea region and its implications for the Baltic Sea ecosystem. A specific aim of the Workshop was to begin to specify more stringent actions and supplementary measures, as called for by the HELCOM Ministerial Meetings in 2007 and 2010.

Climate changes and transforms the Baltic Sea

Global change

Atmospheric concentrations of carbon dioxide (CO_2) have increased from below 300 ppm to 400 ppm since 1990. At the same time global mean temperature has increased by 0.8˚C. In 2012, many climate records were broken with different types of weather extremes. July 2012 was the fourth warmest July since record keeping began in 1880. In the Arctic, the September 2012 sea ice extent was the lowest on record. In the summer of 2012, the U.S. Midwest faced the worst drought in 56 years, causing reduced crop yields and sky-rocketing food prices.

Changes in the past in the Baltic Sea region

During the past 12,000 years the Baltic Sea region has experienced substantial changes in air temperatures most likely attributable to orbital forcing at a millennial time scale. The current temperatures are at the lower end of the range. In recent decades the Baltic Sea region has warmed up faster than the global average and the warming continues and is expected to continue throughout the 21st century. The past warming has been greatest in the northern areas and during the spring period. Evidently, there has been a warming trend in the sea water since the 1950s compared with the first half of the 20th century.

Nonetheless, non-natural influences on regional warming have been detected which currently cannot be explained by anything else than increased greenhouse gas concentrations.

The increase of CO_2 concentrations in the atmosphere results in an increased absorption of dissolved CO_2 in sea water and ocean acidification. For the central Baltic Sea, the increase in atmospheric CO_2 since 1750 has had the potential to decrease the Baltic seawater pH by 0.14. Simultaneously, an increase of alkalinity in the central Baltic Sea has taken place, resulting in counteraction of acidification by about 35%.

The rate of decline of deep water oxygen concentrations after an input of high-saline oxygen-containing water from the North Sea to the Baltic Sea has accelerated since the 1960s as a result of eutrophication. The current volume and area of hypoxic water is the largest in measurement records. No association has been established between the lower frequency and strength of saline

water inputs and climate change since the beginning of the 20th century although there seems to be a climatologically induced change.

In the Baltic Sea ecosystem, a decrease of salinity from the 1980s to the late 1990s was associated with a negative anomaly in the abundance of the zooplankton *Pseudocalanus acuspes* which is an important prey for herring. At the same time, herring abundances declined and sprat recruitment increased. Sprat is favoured by warmer temperature and indirectly also by lower salinity. This shift was accompanied by a decline in the cod population. Cod is negatively affected by declining salinity and oxygen levels, as well as the larger number of sprat feeding on cod eggs. In addition, fishing has had a negative impact on the size of the cod stocks. Even small changes, in driving factors, possibly not detectable with certainty, seem to be able to result in abrupt changes in the ecosystem and food webs. These abrupt changes can be expected especially when changes in drivers are accompanied by other drivers and take place within the range of an ecological threshold or a tipping point.

Future changes in the region

Projections of future climate change during the 21st century indicate greater warming for the northern areas than the south and this change particularly concerns the winters. Overall, a decrease of 75% in snowfall and a sea ice decrease of around 50-80% are expected for the next 100 years. More winter precipitation is expected for the southern areas compared to the north. A sea level rise comparable to the global rise is expected for the southern half of the Baltic Sea while in the northern part the isostatic rebound maintains a decrease in sea level.

Changes in precipitation cannot be presented with good certainty and the changes that have already been observed are greater than what scenarios had projected. Run-off is likely to increase by the end of this century but the magnitude of the increase cannot be estimated at the moment.

According to current scenarios, changes in volume-averaged salinity are not expected to be detectable until around 2020 due to the great variability. For the ecosystem, a decrease in salinity would imply a decline in the number of species. For some species groups, the freshening might cause an increase in freshwater species large enough to counteract and even exceed the decline in marine species. Changes in the food webs due to climate change would vary greatly from one sub-basin to another. In the long run, a drastic decline in recruitment can be expected for cod. Overall, the species composition and dominance structure will change.

Chlorophyll a concentrations and cyanobacteria abundance will increase due to climate change by the end of this century. Climate change and biogeochemical cycles act on similar time-scales and responses to nutrient load reductions have been observed at similar time scales as climate change. An impact of climate change is to counteract load reductions. In a future climate, increased loads and temperature-dependent rates of biogeochemical processes may result in an overall intensification of internal nutrient cycling, including substantial increases in both primary production of organic matter and oxygen consumption for its mineralization.

Will the Baltic Sea Action Plan ensure a good environmental status in future climate?

According to scenarios for the western Baltic Sea, reductions of nutrient loads according to the Baltic Sea Action Plan (BSAP) will result in a decrease in chlorophyll a concentrations and cyanobacteria and an increase in water transparency after a lag period. Close to the Oder River, in Ahlbeck, the simulations show that even if the loads are reduced according to BSAP requirements good status cannot be reached. In the Mecklenburg bight the reductions would result in reaching the good status only in 2030-2040. Therefore, a further spatial differentiation of eutrophication targets is important. It is important to focus on climate induced changes in the drainage area because changes in crops, including increases in those used as biofuels, runoff and overall land use will have impacts on coastal areas and the open sea.

Even with the full implementation of the BSAP, it is likely that oxygen levels in the deep main basin will decrease further even though there would be a slight decline in the anoxic and hypoxic area. The oxygen saturation maximum is lower in warmer water and a decrease of oxygen levels has an

impact on other processes as well. Without drastic nutrient load abatements, hypoxic and anoxic areas are projected to increase. The BSAP will not result in a return to the environmental conditions of the pre-1960s.

The BSAP maximum allowable inputs, as currently set, are the same independent of the climate. This means that more stringent measures will likely be required to reach the maximum allowable inputs if, e.g., precipitation, run-off and loads will be higher due to climate change. On the other hand, a maximum allowable input sufficient to reach targets for good environmental status today may not be enough to reach targets in the future climate and nutrient loads will need be reduced further to reach eutrophication status targets that in the past were reached with smaller reductions. This should be taken into account in the review of the nutrient load reduction scheme of the BSAP.

Adaptation, planning and coastal challenges

Coastal areas are vulnerable to floods, storms, droughts and heat waves and the great majority of species and habitats in the coastal zone are impacted. In the Baltic Sea area, all countries except those in the north are vulnerable to coastal erosion.

The EU Integrated Coastal Zone Management (ICZM) Strategy was reviewed in 2011 and a long-term approach and precautionary approach are its major principles. It promotes the development of national strategies and transboundary cooperation.

Maritime Spatial Planning sets out a structured planning process and allows for settling of potential conflicting interests. It is a support tool for integrated decision making process like the ICZM.

The EU Adaptation Strategy which is foreseen to be adopted in 2013 will aim to make Europe more climate resilient, e.g. in the different economic sectors, environmental systems and key spatial dimensions, with the coastal zones included but the marine environment or fisheries not specifically addressed. Increased consistency and comprehensive integration of climate change considerations into policies is one of the aims of the Strategy.

The reviewed EU Strategy for the Baltic Sea region (EUSBSR), to be adopted in February 2013, will include climate change adaptation as a horizontal action.

The Baltic Sea region adaptation strategy developed by the BaltAdapt project (2010-2013) will raise awareness on the need to adapt, provide policy relevant research-based knowledge for adaptation, ensure platforms for policy or stakeholder-science dialogues, review policies and make the Baltic Sea region a model for regional adaptation. An action plan associated to the Strategy will contain actions that ought to be taken to adapt.

Local adaptation strategies may vary considerably depending on the socio-cultural and economic setting. In Germany, neighbouring coastal regions have applied highly varying approaches to coastal defence planning even though the information on future sea level rise available was the same for all. This accentuates the importance of understanding socio-cultural settings. Local actors are crucial for implementing actions.

The role of HELCOM

HELCOM is the organization responsible for coordinating the actions and activities of its Contracting Parties for ensuring the protection of the marine environment of the Baltic Sea. HELCOM implements the Helsinki Convention, the Baltic Sea Action Plan and HELCOM Recommendations. In addition, Declarations of the meetings of HELCOM ministers and high-level representatives are being put into action.

Adaptation to climate change is a central question for HELCOM. From HELCOM's perspective, adaptation means adjustment of the measures to protect the Baltic Sea marine environment so as to allow for reaching the vision of a healthy Baltic Sea even in a changing climate.

The ecological targets for the marine environment which have been set by HELCOM should not be compromised in the face of a changing climate. Instead, the impacts of climate change should be counteracted whenever there is a need to do so. In 2007 and 2010, HELCOM ministerial meetings noted that climate change will have impacts and this should ultimately be reflected in HELCOM policies. In the 2007 Baltic Sea Action Plan, the text reads: "We are… fully aware that climate change will have a significant impact on the Baltic Sea ecosystem requiring even ***more stringent actions*** in the future", while the 2010 HELCOM Moscow Ministerial Meeting Declaration reads: "We agree… on the need for ***supplementary actions*** and admit that climate change may have profound consequences both for the environmental status of the Baltic Sea as well as for the scope of the measures adopted by the Contracting Parties until now."

Specifying these more stringent and supplementary actions requires scientific knowledge as its basis.

Precautionary approach

Uncertainty is an inherent part of climate scenarios. Uncertainty increases when scaling up from greenhouse gas emissions, to projecting global and regional warming and further up to presenting scenarios on ecosystem changes of the Baltic Sea. Variability and uncertainty in climate projections are greater for smaller geographical scales and hence the simulations for the Baltic Sea region have poorer certainty than those for the global level.

It is however important to note that the precautionary principle is an essential part of the Helsinki Convention and action should be taken by the Contracting Parties even in the presence of uncertainty.

The Helsinki Convention's Article 3 on Fundamental principles and obligations states that the Contracting Parties shall apply the precautionary principle, i.e., to take preventive measures when there is reason to assume that substances or energy introduced, directly or indirectly, into the marine environment may create hazards to human health, harm living resources and marine ecosystems, damage amenities or interfere with other legitimate uses of the sea even when there is no conclusive evidence of a causal relationship between inputs and their alleged effects.

Current level of knowledge

Scientific efforts undertaken to understand past changes in the climate of the Baltic Sea region have progressed especially in the past two decades. Future changes and effects of the change have also been intensely addressed recently. Increasing effort is being expended to detecting changes that go beyond natural variability, although the attribution to causes is still in its infancy.

Current level of knowledge and understanding are rather good with regard to the physical aspect of climate change, and scenarios of regional change are routinely constructed. The largest short-comings in scientific understanding are in relation to biological effects and socio-economic impacts from climate change.

It is still a challenge to discriminate impacts from the various human pressures from impacts resulting from climate change impacts still poses a challenge. In many cases this may not be possible, as climate change is an overall stressor.

More results are expected from systems analyses in the future for example related to regime shifts, tipping points and resilience science.

In 2008, the BALTEX community published the first Assessment of Climate Change for the Baltic Sea Region (BACC I). A second BACC report (BACC II) is expected to be released in late 2013/early 2014 and based on the material of this book, HELCOM will publish a thematic assessment of climate change in 2013.

Proposals from the Workshop

Climate change impacts should be included into the Baltic Sea Action Plan load reduction scheme review

In their 2013 meeting, the HELCOM ministers and high-level representatives should aim at acknowledging that changes which are due to the warming of the climate risk to undermine efforts that are being taken to combat eutrophication and contamination, including hazardous substances. Warmer water will undisputedly lead to higher prevalence of hypoxia and anoxia, shifting the oxygen targets further away from being reached. Climate change will challenge the reduction of eutrophication in the Baltic Sea, requiring possibly additional measures to reach agreed environmental targets and emphasizing the need to ensure that the BSAP nutrient load reductions will be fully implemented. HELCOM should include climate change considerations already into its review of the Baltic Sea Action Plan nutrient reduction scheme in 2013, as far as possible, although it is apparent that it will not be possible to produce quantitative information on these aspects. Ensemble modelling and hierarchical modelling is needed in the future work of HELCOM, especially on the nutrient load reduction scheme revisions.

Impacts of climate change in the catchment should be better accounted for when planning nutrient reduction measures, e.g., changes in land use and agricultural practices.

Inclusion of atmospheric deposition of nutrients on the Baltic Sea Action Plan is expected to improve with the BSAP revision. In the future, deposition of nitrogen in the Baltic Sea may change due to climate change but this is a less well known issue and more information on it is needed.

Other human pressures should be decreased to mitigate the climate impacts on biodiversity

Human pressures are prevalent in all areas of the Baltic Sea, as has been demonstrated, e.g., by the HELCOM Initial Holistic Assessment. Climate change acts on the ecosystem structure and function in multiple different ways changing it.

With the warming and shortening of the ice period, ranges and distribution of cold-adapted species diminish and move towards the north. Populations of ice-breeding seals, particularly ringed seal, will have slower population recovery, which together with other prevalent pressures may endanger the viability of the population.

In order to counterbalance the impacts from the climate change, HELCOM Contracting Parties should take action to decrease inputs of nutrients, organic matter and pollutants, hunting pressure, habitat disturbance, noise, fishing, by-catch of marine mammals and seabirds, as well as physical disruption of the coastal zone. Reduction of eutrophication should be in the focus as it will lead to a diminished pressure on biodiversity and increase the resilience of the ecosystem to the effects of climate change.

Fishing practices should be adjusted to take into account the additional pressure of climate change, e.g. maximum sustainable yields need to be adjusted to take into account the weakened condition of fish stocks.

Communities should take into account the additional pressure of climate change when carrying out environmental impact assessments of coastal development and offshore installations. For this, also communication with stakeholders and a good knowledge-base is necessary for cost-efficient and informed decision making.

Better knowledge of the occurrence and status of many of the species, distribution of habitats and species, characteristics and sensitivities of habitats and understanding of the biology (growth and mortality) of many species and their reaction to threats, as well as better understanding of the food web and ecosystem functions of different species (especially phyto- and zooplankton species) is still needed.

Ecologically coherent network of protected areas is essential to ensure a safe space for species and habitats

There should be a strong and ecologically coherent network of protected areas where species and habitats can develop undisturbed by effects from other anthropogenic impacts. In the future it may be necessary to assess the boundaries of marine protected areas (MPAs) to take into account possible changes in the distribution of species and habitats caused by changes in temperature and salinity. The network of protected areas should be evaluated at regular intervals as it may need to be adjusted to better support species and habitats with special needs. Management of MPAs should take into account potential impacts of climate change, including the need to possibly protect species that are not already included in the HELCOM Red List. Future analyses of the necessity to complement the network of protected areas, e.g. with MARXAN analyses, should take climate change into account.

Non-indigenous species may increase and cause an additional pressure

Warming and longer growth period opens up new ecological niches for non-indigenous invading species. Introduction of non-indigenous species can add pressure to Baltic species and habitats which are already living under stressful conditions.

Monitoring programmes should also accommodate for early warning – e.g. detecting non-indigenous species. Port monitoring of non-indigenous species should include improved monitoring of plankton species. There is a need to maintain a database on non-indigenous species, and this should include also plankton.

Shipping and aquaculture should take effective measures to minimize the risk of introduction of alien species.

Balancing acts are necessary to decrease the effects of toxic pollutants when climate change puts an additional physiological pressure on the organisms

Pollution by certain hazardous substances is an additional anthropogenic pressure. The changing properties of the marine environment, like declining salinity and pH, will cause an extra pressure on the Baltic Sea organisms, the majority of which are already living at the margins of their physiological adaptation capacity. The cumulative impacts of climatic and pollution stressors are projected to increase with the climate change. In order to reduce pressures from toxic pollutants, balancing actions in the future in the form of stricter measures against widespread PBT substances, pesticides and pharmaceuticals are recommended. Use of such compounds is likely to increase due to climate change and this poses a risk to the marine environment that should be addressed.

Acidification requires attention

The global ocean takes up about one fourth of the anthropogenic CO_2 emitted to the atmosphere, causing acidification of the marine environment. This has been noted in the international arena as the Ocean Acidification International Coordination Centre (OA-ICC) was established at the Environment Laboratories of the International Atomic Energy Agency (IAEA) in July 2012. Although current knowledge points to that acidification has not progressed alarmingly in the Baltic Sea, acidification and its effects on biota of the Baltic Sea are still poorly understood and further observations, as well as research are needed to better understand e.g. the process of acidification and its possible linkages to other acidifying substances in the Baltic Sea. Particularly the effects of acidification on the Baltic biota need more attention in the future.

Climate risks and vulnerability

Climate change increases the risk for potentially dangerous phenomena such as flooding, strong storms and associated sea level rise and coastal erosion in the coastal zone. Better preparation is needed and HELCOM groups such as MARITIME, Nature protection and biodiversity (HABITAT)

group and Land-based pollution group (LAND) should consider these risks and vulnerabilities and how to address them in their work.

Develop and maintain marine monitoring and data assimilation

Ongoing economic hardships put a pressure on and risk decreasing ongoing monitoring and observation activities of the marine environment. At the same time, the changing climate and ecosystem make long-term observations more valuable than ever before. Long temporal time series of observations are essential for detecting changes in the environment and for validating mathematical models.

Mathematical models enable creating future scenarios along with hindcasts of past events and better understanding the functioning of the marine ecosystem. In addition, data assimilation to operational models is still an area that needs to be further developed. To enable basin wide analysis and verification of climate change effects on the marine ecosystem, availability and easy access to data from national monitoring programmes and other relevant research should be facilitated by HELCOM. Ensemble modeling and hierarchical model approaches (incorporating models that address different spatial and temporal scales of complexity) should be an aim.

There is a need to be able to monitor climate induced changes in the ecosystem and therefore develop indicators for monitoring change and drivers of change. Better and sufficient monitoring to capture impacts of climate change should be ensured. Increased use of novel observation tools as well as mobile monitoring stations should be encouraged. The HELCOM monitoring and assessment programme should be able to answer the questions: is there a change and what is causing the change? Developing a methodology to assess the confidence of attributing the contribution of different drivers to the change, should also be a priority to support HELCOM monitoring and assessment activities.

Apply a multiple-stressor and holistic approach

HELCOM should increasingly aim at employing models which capture the multiple-stressor holistic approach in order to address various types of pressures which may act synergistically or antagonistically. These models should also be used to review and further develop targets for good environmental status in such a way that climate change and its impacts are taken into account. In some occasions it is possible that current targets cannot be reached due to climate change.

Research needs

Nutrient retention in the coastal zone is poorly understood. Bioavailability of nutrients varies between models. Sensitivities of the different models vary in their response to changing nutrient loads. Global climate models cannot be used to force scenarios. Further study of bioavailability of nutrients in a warmer climate is important.

The new IPCC assessment should be used for new scenario simulations. Salt water inflows should be addressed in more detail to resolve why there is a decrease in inflows in present climate and to better account for the smaller inflows in the models. Climate to land use to socio-economy interaction and feedbacks should be further studied. More cost-effective implementation of the BSAP could be done by optimizing nutrient ratios at a smaller scale. More plausible nutrient load scenarios consistent with large-scale socioeconomic developments are needed. Further knowledge of changes in the catchments is needed in order to enable efficient action in the catchment.

Impacts of climate change, especially changes in temperature, salinity, acidification etc. on underwater habitats and species, e.g. on their reproduction success needs to be investigated.

So far many climate related aspect have been identified at a qualitative level and there is a need to strive for research that enables quantification as far as possible.

Research on the impacts that climate change causes on hazardous substances and their effects should be paid more attention in the future.

Overall, HELCOM should encourage applied research.

It would be helpful to assess (1) the confidence of the likelihood that the ecosystem change will take place as a result of climate change; (2) the severity of the impact to the ecosystem and (3) the severity of the impact to man.

Communicate uncertainties

There is a general need to better communicate uncertainties related to scientific findings, especially when communicating with the decision-makers and media. This should be done with the view that displaying error bars will also enable implementation of the precautionary approach.

Improve the communication between science and policy

Communication is dependent on the cultural framework and this should be taken into account in the Baltic Sea context. Communication should not be primarily top-down, from experts to laymen and natural scientists should increasingly learn from social scientists how to be in dialogue with stakeholders. Positive developments should also be high-lighted.

Education of young people on the topics of climate change and marine environment is important.

Science should be communicated at an early stage and accompanied with uncertainties, ranges of knowledge and knowledge gaps. For decision-makers an early dialogue allows for timely consideration of feasibility of scientific findings and inclusion of stakeholders to the considerations. Cross-sectorial communication with the aim to ensure better cross-sectorial integration is needed.

Scientific advisors to political processes evaluate and digest scientific information and for this it is crucial to have high-quality science with complete background information and transparent presentation of modeling processes. Protocols for scenario simulations and assessments developed by independent review groups are needed and this type of activity could be incorporated into the HELCOM activities in the future.

Visualisation, including films, is a powerful tool and should be increasingly used to communicate climate change, impacts and adaptation needs.

HELCOM could consider creating a concept for briefing of journalists which could be implemented by the Contracting States.

Knowledge on climate change and Baltic Sea impacts should be reviewed at regular intervals

The activities of the workshop were found helpful. The Workshop was of the opinion that assessment of knowledge on climate change and its effects on the Baltic Sea should be done at regular intervals within HELCOM. Following the adaptive management approach any changes in this knowledge should be communicated to the decision makers to enable possible changes to the policies. HELCOM could consider including this activity into its six-year assessment cycle and work towards further strengthening the cooperation with BALTEX in such a way that the knowledge assessment activities could be carried out in collaboration with BALTEX also in the future.

This regular activity should also aim at contributing to the harmonisation of HELCOM, WFD and MSFD assessments, targets, approaches and regional differentiations, one holistic view is the goal.