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Policy Brief

Baltic Sea Centre

Stockholm University

Measures improve the Baltic Sea environment – even in a changing climate

A changing climate makes it even more important to reduce the nutrient supply to the Baltic Sea. In the coming decades, continued reductions in emissions of nitrogen and phosphorus from land will yield better oxygen conditions and improved water quality - even in the face of major climate change. These measures also make the Baltic Sea ecosystem more resilient to the changing climate.

Scientific studies of the last 100 years indicate that the eutrophication trend in the Baltic Sea has been broken. More nitrogen and phosphorus are disappearing from the sea than are added. The marine ecosystem is slowly recovering and some places are already seeing improvements. However, positive developments risk being slowed down by the next major challenge for the Baltic Sea: climate change.

In the 21st century, the extent of the negative impact of climate effects on the Baltic Sea will largely be determined by two things:

- global climate policy to reduce anthropogenic greenhouse gas emissions.
- society's ability to reduce nutrient inputs to the sea.

Scientific analyses using Baltic Sea-specific climate models show that if nutrient supply continues to decline in the coming decades, it will lead to improved oxygen conditions in the Baltic Sea – even in the most pessimistic climate scenario. At the same time, the ecosystem resilience to negative climate impacts will be strengthened.

Climate can amplify the effects of eutrophication

Ongoing climate change is causing changes in the physical marine environment, such as temperature, oxygen conditions and salinity. These changes have direct impacts on the plants and animals of the Baltic Sea. But there are also indirect impacts. Higher water temperatures and increased precipitation can amplify the effects of eutrophication and thus lead to an even worse oxygen depletion, among other threats.

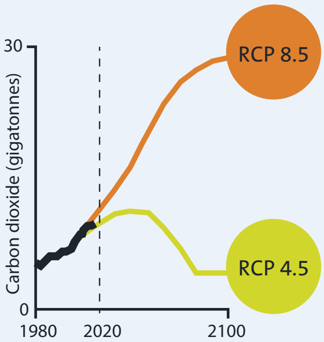
At present, it is difficult to estimate exactly how large these climate effects will be as many parameters are still quite uncertain. However, it is clear that effects from eutrophication and climate change are linked. The greater the eutrophication,

the greater the potential damage of climate change, because eutrophication makes the marine environment more sensitive to other stressors.

Photo: Martin Almqvist/Azote

Reducing nutrient emissions improves the marine environment - even in the event of major climate change

The study of the future for the Baltic Sea is based on regional, detailed projections of two global climate scenarios from two different RCP's – Representation Concentration Pathways – for future atmospheric greenhouse gas concentrations. Research based on the RCP's are part of the UN IPCC assessment



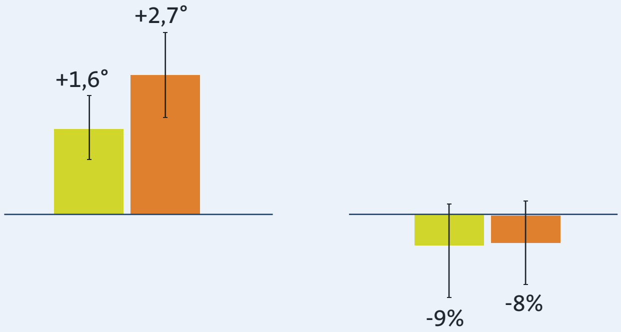
RCP 8.5 – significantly increased greenhouse gas emissions by the year 2100.

RCP 4.5 – significantly reduced greenhouse gas emissions by the year 2100.

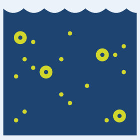
None of the scenarios meet the so-called "two-degree target" of limiting global warming to well below two degrees compared to the pre-industrial levels.

Temperature

Salinity



At all three possible levels of nutrient supply, water temperature and salinity are affected to the same extent.

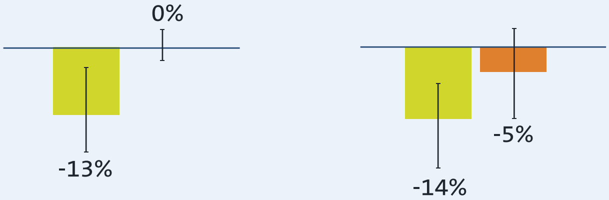


Primary production

Oxygen-deprived bottom environments

The emission scenarios are modelled with three possible levels of nitrogen and phosphorus emissions from land to sea.

BSAP scenario
The supply of phosphorus is continuously adjusted downwards to the levels in the Helcom BSAP (Baltic Sea Action Plan).



Reference
No further measures are taken to reduce emissions from, e.g., agriculture and water treatment.
Climate change gradually increases the supply of nutrients to the sea through more precipitation and increasing inputs from watercourses.

Worst case scenario
The nutrient supply steadily increases and is further strengthened by climate change

Various scenarios for climate and nutrient emissions

In a 2018 study, researchers from the Swedish Meteorological and Hydrological Institute (SMHI) and the Stockholm University Baltic Sea Centre show various possible future scenarios for the Baltic Sea by the year 2100, depending on how much climate change and eutrophication are mitigated.

The study was based on global climate scenarios - based on the emission scenarios (RCPs) for greenhouse gas emissions used in research evaluated by the UN's IPCC climate panel - and scaled them down to a more detailed, regional level for the Baltic Sea:

- RCP 4.5 - significantly reduced greenhouse gas emissions by the year 2100.
- RCP 8.5 - significantly increased greenhouse gas emissions by the year 2100.

None of the scenarios meet the so-called "two-degree target" of limiting global warming to well below two degrees compared to the pre-industrial level.

The emission scenarios are modelled with three possible scenarios for nitrogen and phosphorus emissions from land to sea:

- BSAP - the supply of phosphorus is continuously adjusted downwards to the levels in the Helcom Baltic Sea Action Plan (BSAP).
- Reference scenario - no further measures are taken to reduce emissions from, e.g., agriculture and water treatment. Climate change gradually increases the supply of nutrients to the sea through more precipitation and increasing inputs from watercourses.
- Worst case scenario - the nutrient supply steadily increases and is further strengthened by climate change.

Improved oxygen situation and fewer dead bottoms

The results indicate that the measures currently employed to cut nutrient emissions from land (Reference) are already sufficient to improve the oxygen situation. If nutrient supply is reduced according to the BSAP scenario, the situation will be significantly better in year 2100 compared to what it was in year 2000 - regardless of which of the two climate scenarios is applied.

Even if greenhouse gas emissions increase according to the RCP 8.5 scenario, the situation with oxygen-free bottom environments in the Baltic Sea will gradually improve, as long as the Baltic Sea countries continue – and preferably intensify – efforts to reduce nutrient supply from land.

Only in one of the scenarios does the oxygen situation get worse in the Baltic Sea: continued increasing greenhouse gas emissions (RCP 8.5) combined with an increase in nutrient supply (Worst case scenario). Such a development would lead to an expansion of oxygen depleted (hypoxic) areas in the Baltic Sea.

REDUCING EUTROPHICATION, A SLOW PROCESS

Combating eutrophication in the Baltic Sea is a long-term effort and it takes several decades for implemented measures to have a visible effect on the sea. Despite a large decline in nutrient supply in recent decades, productivity (the growth of organic matter) remains high and oxygen deficiency is widespread. The high productivity is primarily due to the fact that much of the phosphorus added over the last 100 years is still present in the Baltic Sea. The phosphorus is gradually buried in the bottom sediment where it then remains for good or is transported out into the North Sea. But it is a slow process.

Oxygen deprivation is affected partly by productivity, which adds oxygen-consuming organic matter to the deeper parts of the ocean, and partly by substances (such as sulphide) that consume oxygen in the seabed. However, the vast majority of models and studies indicate that the situation will still improve in the long term – as long as the supply of new nutrients from land is kept at low levels.

Strong action increases the resilience of the sea

Over the last 50 years, the Baltic Sea countries have made great efforts to reduce the nutrient supply, especially from sewerage and agriculture. Counteracting eutrophication is a slow process. In most cases, it takes decades for the effects of various measures to become visible in the marine environment. However, thanks to long-term and patient action on land, improvements are now starting to be visible in the Kattegat and in some coastal areas, although they are not yet visible in the extent of hypoxic and anoxic areas in the open Baltic Sea.

According to the researchers, the best measures for the Baltic Sea to combat eutrophication – despite climate impact – is that the Baltic Sea countries achieve and maintain the levels of nutrient supply in the BSAP until the year 2100. In such a case, the climate's impact on the oxygen situation in the sea will be relatively small even in the most pessimistic climate scenario. However, all the Baltic Sea countries still have some way to go before they reach the BSAP targets. At the same time, carbon dioxide emissions are increasing globally from year to year, according to the annual Global Carbon Budget report. This makes it even more important to prioritise regional efforts to reduce the flow of nutrients from land.

With stronger measures such as wastewater treatment, wetland construction and more efficient agricultural practices (e.g. better manure management), the Baltic Sea countries can face the negative impact of climate change together and achieve a better marine environment in the future than today.

Photo: Mickes fotosida/Mostphotos

HOW CLIMATE CHANGE AFFECTS THE BALTIC SEA

Temperature

Depending on the severity of global climate change, the average temperature in the Baltic Sea is expected to increase with about 2–3 degrees Celsius by the year 2100 compared to the end of the 20th century. As the waters warm, many marine species are finding it more difficult to survive. The primary production in the water mass is also increasing, while organic matter on the seabed is decomposing more quickly. In addition, warm water is less able to absorb oxygen than cold water. The result is increased eutrophication and gradually worsening oxygen conditions.

Precipitation

Precipitation is likely to increase as a result of climate change, especially in northern parts of the catchment area. Increased precipitation results in higher riverine flow into the Baltic Sea and, in addition, may result in enhanced leakage of nutrients from surrounding land areas, such as arable land, both potentially increasing nutrient loads. However, there are major uncertainties in the models' calculations of precipitation and other factors that affect runoff, such as evaporation and snow conditions.

Sea level

Climate change is causing increase in global average sea level. In the Baltic Sea, this is most noticeable in the southern parts, while in the north the land uplift is expected to counteract the sea level rise to some extent.

Ice

The winter sea ice extent will diminish significantly, but even in a warmer climate there will still be ice in the northern Baltic Sea.

Salinity

The salinity of the Baltic Sea is affected by runoff from land, precipitation and evaporation, as well as inflows of salt water through the Danish straits (Øresund, Great Belt, and Little Belt). Increased precipitation causes more fresh water to flow into the sea and dilute its salinity. At the same time, rising sea levels in the straits may lead to greater inflows of salt water, thus increasing salinity. The model results indicate a trend towards decreasing salinity levels, but the uncertainty in precipitation and sea level calculations makes it difficult to predict with confidence whether the salinity of the Baltic Sea will increase or decrease.

Completely new conditions

Even if nutrient supply is kept at levels in line with the BSAP, climate change is likely to lead to new and never-before-observed environmental conditions in the Baltic Sea. Some species will benefit from the changed conditions, while others will decline or even completely disappear. This, in turn, will alter food webs and interactions between species. These new and hitherto unknown conditions will demand continued research and the development of knowledge and models to meet the needs of policymakers for input on how the marine environment should be managed.

ABOUT THIS POLICY BRIEF

SMHI

Stockholms universitet

This policy brief is a co-production between the Swedish Meteorological and Hydrological Institute (SMHI) and Stockholm University. It is based on analyses of different Baltic Sea ecosystem models, and in particular the study Baltic Sea ecosystem response to various nutrient load scenarios in present and future climates (2018). The analyses were conducted within the context of the BONUS project BalticApp, by researchers at SMHI and the Stockholm University Baltic Sea Centre. The results are summarised in the Baltic Sea Centre's report series 2/2020, *Framtidens Östersjön – påverkan av övergödning och klimatförändringar*, which was commissioned by the Swedish All Party Committee on Environmental Objectives in 2019/20.

POLICY RECOMMENDATIONS

- **Continue the long-term work** to further reduce the Baltic Sea countries' emissions of nitrogen and phosphorus to the sea. Work actively to reduce greenhouse gas emissions.
- **Clarify and take into account** the existence of synergies between measures to counteract eutrophication and those aimed at reducing greenhouse gas emissions.
- **Continue to develop** simulation models as a decision support in the work to combat both eutrophication and climate change.

TO BRIDGE THE GAP BETWEEN SCIENCE AND POLICY

This policy brief is produced by Stockholm University Baltic Sea Centre.

Scientists, policy and communication experts work together to bridge the gap between science and policy.

We compile, analyse and synthesise scientific research on Baltic Sea related issues and communicate it at the right moment to the right actor in society.

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