Is the Baltic Sea at a crossroads? Future scenarios for the combined effect of climate change and nutrient load

Can effective marine management mitigate climate change impacts so that the Baltic Sea regains a good environmental status? Can record blue-green algae blooms and other extreme events with an impact on future tourism be averted? A team led by Markus Meier from the Leibniz Institute for Baltic Sea Research Warnemünde (IOW) now presents a study, in which various greenhouse gas and nutrient pollution scenarios are modelled up to the year 2100. Only in the most optimistic scenario – nutrient reduction according to a perfect implementation of the Baltic Sea Action Plan – a good environmental status is achievable and extreme algae blooms can be avoided despite increasingly frequent heat spells.

Excessive nutrient loads are a major ecological problem for the Baltic Sea. The result: excessive phytoplankton growth – especially blue-green algae blooms in summer. Dying and decaying algae blooms in turn promote oxygen deficiency in deeper water, where then only specialised bacteria can survive, but no higher organisms such as mussels or fish. Although all the Baltic Sea riparian states agreed on clearly defined nutrient reduction targets within the framework of the Baltic Sea Action Plan (BSAP) more than 10 years ago, implementation is slow and the "Good Environmental Status" of the Baltic Sea as defined in the BSAP will not be achieved by 2021 as planned. In addition, more and more studies indicate that climate change will exacerbate the problem of eutrophication.

An important reason for aiming to achieve a good environmental status is the high recreational value of the Baltic Sea – not least because tourism is of great importance for the economy of the entire Baltic Sea region. Whether or not tourists find their visit to the sea attractive, however, is usually not determined by average temperatures or by the general state of the Baltic Sea ecosystem (as reflected by BSAP indicators). It is rather extreme events, such as long lasting extreme heat spells or extensive blankets of poisonous or smelly algae close to the beach that make a lasting impression. "To date, such extreme events have not been taken into account in analyses of future climate change impacts on the Baltic Sea," says Markus Meier, climate expert at the IOW and in charge of the study, which has now been published in the renowned journal *Ambio*. "Our modelling up to the end of the 21st century therefore focused on the following questions: Can the Baltic Sea still achieve a good environmental status at all? If so, when and under what conditions? And for the first time we investigated, how the probability of extreme events relevant to the recreation and tourism sector will change," adds Meier.

The research team simulated various future scenarios, in which they coupled three nutrient pollution scenarios (1. perfect implementation of the BSAP targets, 2. continuation of the current situation, 3. worst-case scenario with increasing pollution due to growing population numbers) each with one of two greenhouse gas pollution scenarios (medium and high pollution). The development of classical BSAP indicators such as Secchi depth, nutrient concentrations and oxygen deficiency in deep water was analysed. Indicators for extreme events included the occurrence of summer heat waves (expressed as the number of successive "tropical nights" warmer than 20 °C) as well as permanently high sea surface temperatures (above 18 °C) and record blue-green algae blooms (number of bloom days per year, which must be higher than all previously observed). The simulation period covered the years 1975 to 2100 in order to evaluate the predictive value of the modelling results on the basis of already measured data.

“According to our scenario calculations, the Baltic Sea region will change significantly due to climate change,” Markus Meier comments on the results. “Depending on which climate scenario we base our calculations on, it will become 2 – 4 °C warmer in midsummer. Between 2070 and 2100, high greenhouse gas concentrations will lead to summer heat waves with tropical nights in almost the entire Baltic Sea region that on average last 2 – 3 weeks and in extreme cases up to two months non-stop. These changes are also reflected in the water temperatures, Meier continues. By the end of the century, the surface temperature of the Baltic Sea on average will be 2 – 3 °C warmer, and summer sea surface temperatures above 18 °C might last up to a month longer than today. “Taking Warnemünde as an example, the models show that, compared to today’s climate, record sea surface temperatures will occur much more frequently in the near future up until 2050: Depending on the scenario, this will happen 200 – 400 % more frequently than expected,” emphasises the marine physicist.

What at first glance looks like a plus for visitors to the Baltic Sea – numerous ‘tropical nights’, high swimming temperatures over many weeks –belongs, however, to the kind of extreme events that make negative impacts on tourism increasingly more likely. For one thing, such conditions generally promote the development of blue-green algae blooms. Markus Meier: “According to our calculations, record blue-green algae blooms temporarily will become rarer after 2025 in all scenarios, but only if a reduction of nutrients is implemented strictly according to BSAP, they will stay away permanently.” And only then will the environmental goals set by the BSAP – e.g. with regard to Secchi depth and oxygen deficiency in deep water – be achieved before 2100 for all parts of the Baltic Sea, Meier says.

“If, instead, we continue as before or if the nutrient load even increases at high greenhouse gas concentrations, the likelihood of extreme blue algae blooms to occurr is 10 times higher at the end of the century than in today’s climate. And if we do not achieve the BSAP environmental goals, we will have to face numerous other negative consequences for the Baltic Sea ecosystem,” stresses Meier. Furthermore, it is known from studies in other temperate regions that extreme heat events and frequent heat waves significantly increase health and mortality risks. “Here in the Baltic Sea, for example, this could mean that infections with the life-threatening, sepsis-causing Vibrio bacteria occur more frequently,” explains Markus Meier.

“The Baltic Sea is at a crossroads. This is critical, but it also means that we still have it in our hands where it is heading. We can keep the Baltic Sea attractive as an environment and a tourist destination in the long term through rigorous marine management based on the clear BSAP regulations and – even if this is more difficult – through increased climate protection efforts,” Markus Meier concludes on the study results.

More information:

H.E. Markus Meier, Christian Dieterich, Kari Eilola, Matthias Gröger, Anders Höglund, Hagen Radtke, Sofia Saraiva, Iréne Wåhlström (2019). *Future projections of record-breaking sea surface temperature and cyanobacteria bloom events in the Baltic Sea*. Ambio, https://doi.org/10.1007/s13280-019-01235-5

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