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Policy Brief

Baltic Sea Centre
Stockholm University

Emerging ocean acidification threatens Baltic Sea ecosystems

More jellyfish but fewer mussels – the expected spread of ocean acidification can have major effects on species composition in the Baltic Sea. It may also make the water slimier and less attractive for swimming. To protect unique ecosystems and future food production, carbon dioxide emissions must be dramatically reduced and measures must be taken against eutrophication, overfishing and releases of hazardous substances.

The blue mussel is one of the Baltic Sea species threatened by the expected ocean acidification.

Photo: Jerker Lokrantz/Azote

It is now well known that the world's large-scale emissions of greenhouse gases are leading to climate change and global warming. However, there is less awareness of what has been called "the other carbon dioxide problem" – ocean acidification.

In the 1980s, acidification of soil, watercourses and lakes was one of the environmental problems attracting most attention. Emissions of sulphur and nitrogen oxides from combustion processes (e.g. in motor vehicles and power and heating plants) was giving rise to precipitation of sulphuric and nitric acids. This was popularly called "acid rain" and had major effects on lake and forest ecosystems. However, in the 1980s and 1990s, a combination of greatly improved emission control and the liming of lakes and waterways resulted in decreased acidification in the Baltic Sea area.

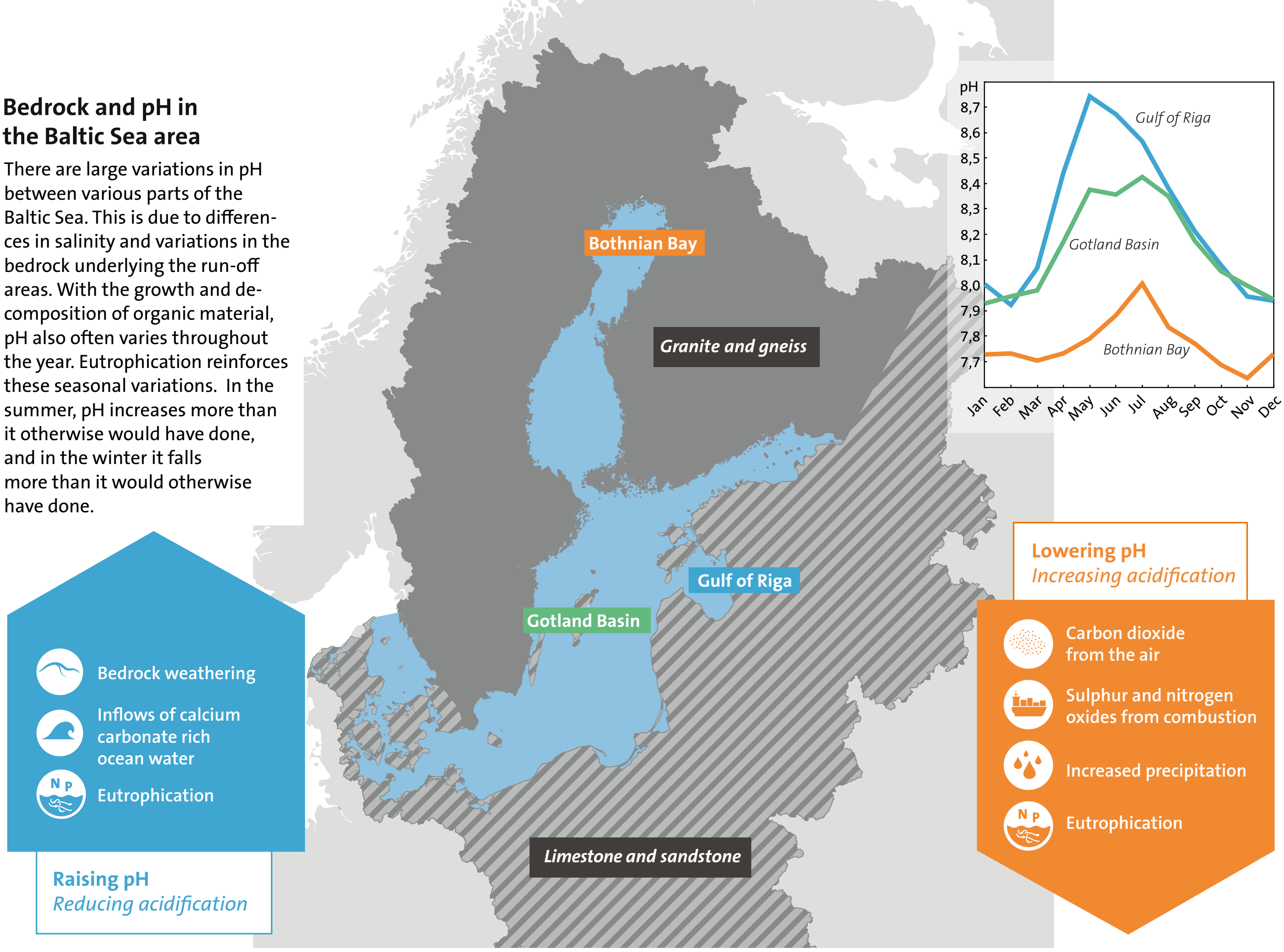
In its stead, another type of acidification has attracted attention in recent years – global ocean acidification. This is caused by massive emissions of carbon dioxide and cannot be solved by liming. Up until now, the changes have not been large in the Baltic Sea. However, in the long run, this acidification will have effects here too and, eventually, threaten the sea's ecosystems.

RECOMMENDATIONS

- To minimise the consequences of ocean acidification, work towards implementing more stringent carbon dioxide emission goals (as per Sustainable Development Goal 14.3).
- Expand the acidification measurement programmes to include both open sea and coastal waters. High-quality and cohesively longer time series for all parts of the year and in all parts of the Baltic Sea will give a more comprehensive basis for deciding on measures.
- Accelerate measures against problems such as eutrophication, overfishing and emissions of hazardous substances. Many species can tolerate water that is more acidic. However, their resistance and resilience to stress is diminishing.
- Coordinate controls and measures against the above-mentioned problems. To strengthen the Baltic Sea's resistance to future acidification, a marine environment perspective needs to be integrated into land management measures.
- To promote the development of low-sulphur fuels, investigate a prohibition on emitting scrubber system water from vessels.
- Widen the support for research into how acidification is affecting ecosystems in the Baltic Sea.

Bedrock and pH in the Baltic Sea area

There are large variations in pH between various parts of the Baltic Sea. This is due to differences in salinity and variations in the bedrock underlying the run-off areas. With the growth and decomposition of organic material, pH also often varies throughout the year. Eutrophication reinforces these seasonal variations. In the summer, pH increases more than it otherwise would have done, and in the winter it falls more than it would otherwise have done.



Changed species composition in the long term

Under current conditions no major problems are being linked to ocean acidification of the Baltic Sea. In the long term, acidification might however lead to an altered species composition, unless carbon dioxide emissions are reduced.

Ocean acidification favours some organisms while others are negatively affected. The major losers in a more acidic environment are the calcifying organisms such as corals and mussels. This is because shell and skeleton formation is more difficult in these conditions. In their larval stage, fish such as herring, halibut and cod are also particularly sensitive to acidification.

Other organisms such as jellyfish and certain types of algae generally benefit from acidification. Eutrophication and the rise of ocean temperatures also favour them. Consequently, the overall development of sea environments has been described as "the rise of slime". Strong growth of these favoured species leads to water that is more turbid and slimier, and not as friendly for humans and other animals.

This changed species composition far down in the food web also affects organisms higher up that no longer have the same access to food. Examples are fish, birds and seals. Thus, in the long run, acidification is threatening all the Baltic Sea's ecosystems and, thereby, the marine industries that currently depend on them.

Ocean acidification can contribute to the "rise of slime", a phenomenon resulting from the favouring of jellyfish and certain algae.

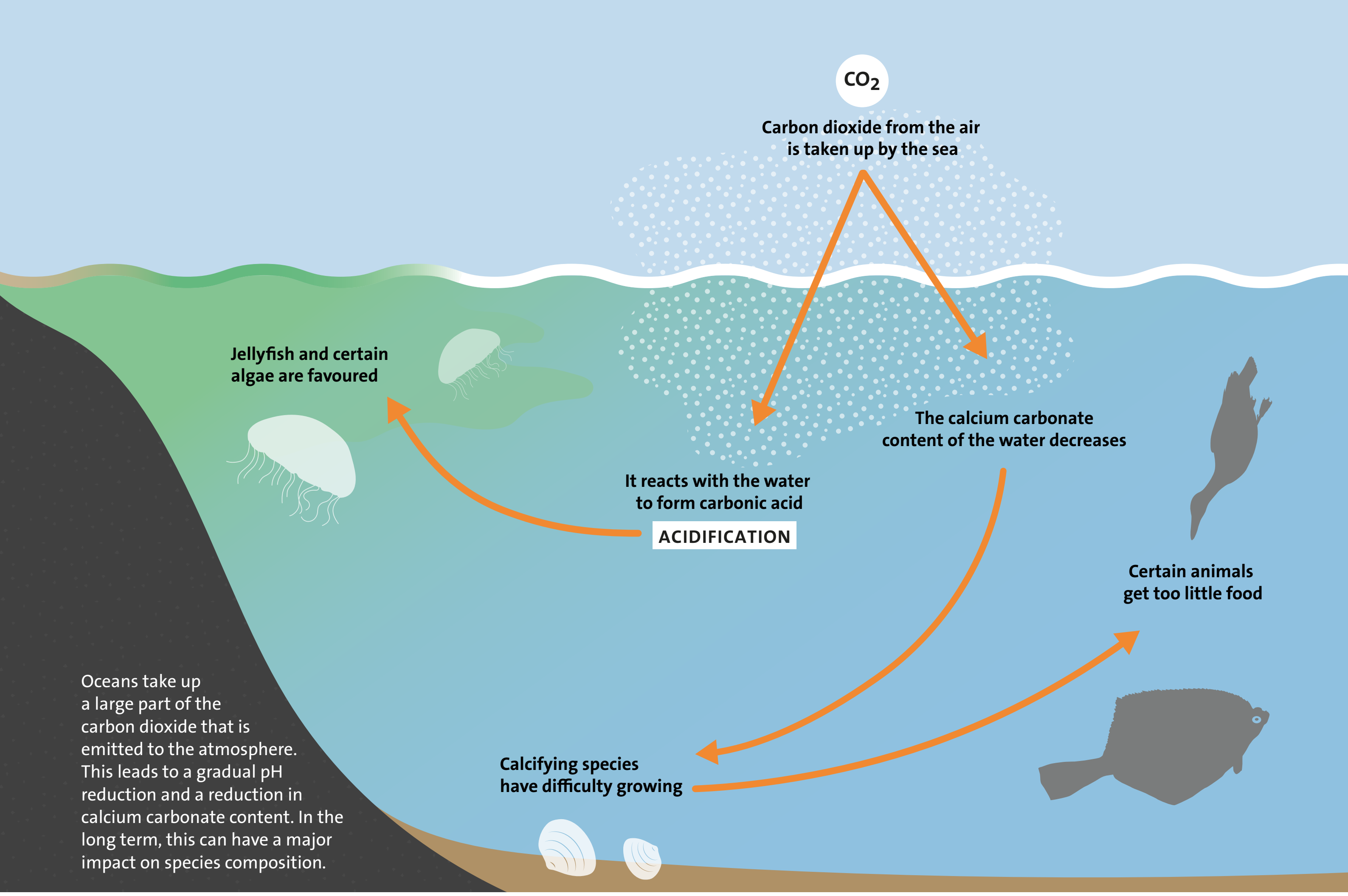
Photo: Johanna Källstrom/Mostphotos

Oceans dampen the greenhouse effect

Since the start of the industrial age, the atmosphere's carbon dioxide content has increased drastically. Analyses of air trapped in Antarctic ice show that, in the past 800,000 years the carbon dioxide content has varied from about 180 ppm (parts per million) in glacial periods to approximately 280 ppm in interglacial periods. However, over the past two hundred years, atmospheric carbon dioxide has risen to today's value of around 410 ppm.

Currently, about 42.5 billion tonnes of carbon dioxide are released annually into the air as a result of, amongst other things, the burning of fossil fuels, cement production and changed land use. Just under half (45 per cent) of the emissions accumulate in the atmosphere. Some 30 per cent is taken up by terrestrial ecosystems and 25 per cent by the world's oceans. Thus, the oceans contribute to dampening the increase of carbon dioxide in the atmosphere and, thereby, the greenhouse effect. Consequently, oceans have long been primarily regarded as carbon dioxide sinks.

However, it has now become clear that the oceans' uptake of carbon dioxide is not exclusively positive. It is also gradually leading to the acidification of not only the oceans, but also of all the world's water areas.



Illustrations: Elsa Wikander/Azote

Carbon dioxide is acidifying the oceans

When carbon dioxide is taken up by ocean water, it reacts with water to form carbonic acid. This is leading to a gradual fall in the oceans' pH.

Currently, the pH of the oceans' surface waters is dropping by around 0.002 pH units a year. Since the start of the industrial age, the pH has dropped by more than 0.1 pH units in total. This may sound small but, as the pH scale is logarithmic, it means a change of more than 30 per cent. Under the various emission scenarios of the Intergovernmental Panel on Climate Change (IPCC), atmospheric carbon dioxide is expected to rise further and may reach 950 ppm by 2100. In turn, this is expected to lead to average global warming of up to three degrees Celsius and, simultaneously, a reduction of a further 0.3 pH units of the oceans' surface waters.

This can have serious consequences for marine life, partly because some species cannot tolerate the more acidic environment and partly because the calcium carbonate level in the oceans is dropping. The latter is attributable to carbon dioxide in the water reacting with, and reducing the level of, carbonate in the oceans. This makes it difficult for calcifying species to form skeletons and shells. Globally, this has been predominantly seen as a problem for sensitive coral reefs. However, even in the Baltic Sea, there are important calcifiers such as the blue mussel, a key species for the ecosystems.

Certain areas of the Baltic Sea more sensitive than others

The degree of pH reduction in relation to atmospheric increases in carbon dioxide is regarded as predictable in the open oceans' surface waters. However, prediction is far more complicated in coastal seas such as the Baltic Sea. This is because the pH here is relatively more affected by other factors.

Geographically, there are large salinity differences in the brackish Baltic Sea. Similarly, there are marked differences in pH between the various basins and between coastal and open water. This is partly due to differences in the fresh and salt water mixes in the various basins. Ocean water rich in salt and carbonate often has a higher pH than freshwater. However, pH is also influenced by the characteristics of the catchment area. In the south-eastern Baltic Sea, the bedrock is typically dominated by limestone and sandstone. River water here has a considerably higher concentration of dissolved carbonate (which makes water alkaline) than it does in northern parts of the Baltic Sea where the bedrock is largely granite and gneiss. Thus, for example, the water of the Gulf of Riga has a higher pH than that of the Bothnian Bay. Consequently, the former is less sensitive to future ocean acidification than is the latter.

Nonetheless, it is not only the geographic differences that are important for the Baltic Sea. Emissions of sulphur and nitrogen oxides from vessels can have a considerable effect on pH locally in highly trafficked sea lanes and harbours, even if the overall effect is low compared to that of carbon dioxide emissions. New, stronger, global rules are now limiting sulphur emissions to air. Unfortunately, one consequence of this has been greatly increased use of so-called scrubber technology. This flue gas cleaning method is primarily used to wash sulphur dioxides out of vessel exhaust fumes. The process holds the sulphur content in the fumes below the set limit. However, with a pH of around 3, the scrubber water released into the sea is highly acidic.

In parts of the Baltic Sea (e.g. the Baltic Proper), acidification has been less marked than in the world's oceans. In other parts (e.g. some of the Danish fjords), pH has fallen faster than in the oceans. If atmospheric carbon dioxide continues to increase, it is likely that acidification of the Baltic Sea can not be counteracted by other processes. Instead, this acidification will, in the long term, be noticeable throughout the Baltic Sea.

Eutrophication reinforces natural pH variations

The connection between eutrophication and acidification is complex. Owing to carbon dioxide being bound in plants and animals and then released when these decompose, seawater pH varies naturally across each year. High influxes of phosphorus and nitrogen from fertilisers in river water often give rise to major algal blooms. These latter bind a great deal of carbon dioxide. Thus, there is a large, acidification-counteracting pH increase in spring and summer when the light conditions are favourable for photosynthesis.

Conversely, bound carbon dioxide is released back into the water when the organic material decomposes. The larger the quantity of organic material that decomposes, the larger the release of carbon dioxide. In waters with large influxes of nutrients and considerable plant growth, the pH increase in the summer is higher than in nutrient-poor water. However, at the same time, the pH reduction in the winter is also more marked in the nutrient-rich waters.

On average, across a full year, high influxes of nitrogen and phosphorus, with their resultant major algal blooms, are giving the Baltic Sea a slightly higher pH than it would otherwise have had. However, the seasonal variations are becoming larger and this can be a problem for ecosystems. Nonetheless, the negative consequences that decreased eutrophication would have for future acidification should be regarded as marginal compared with the other positive effects that can be linked to reduced eutrophication.

During plankton blooms, surface water pH can increase by more than 0.5 points in the course of a month and then fall just as much in the winter when the carbon dioxide is released by decomposition processes. These are far larger changes than the carbon dioxide driven pH reduction that is currently around 0.002 points per year. As the seasonal pH variations in the Baltic Sea are so large, it can be difficult to distinguish and quantify a slow, gradual, overall drop in pH. Thus, to quantify long-term pH changes with any certainty, high-quality measurements are necessary. Parts of the Baltic Sea do not presently have this.

Another consequence of the considerable seasonal variations in the Baltic Sea is that the organisms that live here have adapted to large, short-term pH changes. This may indicate that a number of species also have a good ability to adapt to future ocean acidification.

Combined effects can hit hard

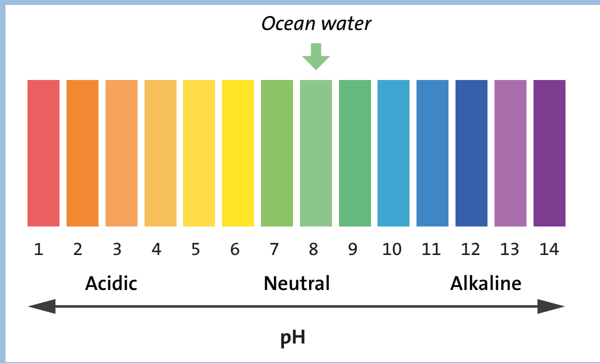
Parallell to ocean acidification, other processes linked to climate change are also taking place in the Baltic Sea. One of these is increasing water temperature. According to calculations made using climate models, it is predicted that precipitation will generally increase in the Baltic Sea area. This will gradually reduce the salinity. In itself, reduced salinity may, in the future, have major consequences for species that are already held back by the Baltic Sea's low salinity. It is probably more difficult to adapt to the combination of falling salinity and acidification than it is to adapt to either of these two phenomena individually.

Furthermore, the Baltic Sea's ecosystems are already subject to stress from overfishing, emissions of hazardous substances and environmental impact related to nutrient loads (i.e. eutrophication and the associated plankton blooms and increased expansion of oxygen depleted deep water areas).

There is a great need for knowledge regarding how the combination of ocean acidification and other processes will affect the Baltic Sea's ecosystems in the future. With respect to future global climate changes it is also important to reduce the regional problems in the Baltic Sea (i.e. eutrophication, overfishing and emissions of hazardous substances). Nevertheless, to prevent large-scale ocean acidification, the only realistic measure it to severely limit future carbon dioxide emissions.

Facts about pH

- pH is used to describe how acidic or basic (alkaline) a liquid is, the pH value is a measure of the concentration of hydrogen ions.
- At room temperature (25°C), pure water is neither acidic nor basic and has a pH value of 7. This is designated as neutral.
- A lower pH means that a liquid is acidic, and a higher that it is basic.
- Seawater contains, amongst other things, dissolved calcium carbonate and, consequently, is usually slightly basic (pH ≈ 8 on average). However, both geographically and seasonally, there are large variations.



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