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Science for Environment Policy

New insights into multi-century phytoplankton decline in North Atlantic predict further decline under climate change

Phytoplankton are essential to marine food webs and fisheries. However, a new study indicates that their levels have declined in the North Atlantic since the beginning of the 19th century. This coincides with weakening ocean-circulation patterns, partly caused by melting ice caps. If the melting continues, the study warns of a dramatic fall in North Atlantic plankton levels that could have cascading effects across marine food webs, reducing the ocean's ability to absorb carbon and threatening the supply of seafood for humans.

Phytoplankton form the foundation of marine ecosystems. These microscopic, mostly single-celled organisms absorb carbon dioxide from the surface of the ocean and convert it into organic carbon. Larger organisms on the next rung of the food chain, such as zooplankton, then consume this organic carbon as a source of energy.

The process of synthesising organic carbon, which may then be passed up through the food chain, is referred to as 'primary production'. Any drop in plankton levels will thus limit oceanic primary production and cause repercussive effects that are felt throughout the marine food chain, including in fisheries. Phytoplankton's ability to absorb carbon means they also play a key role in mitigating climate change. However, this new study suggests that climate change itself is a threat to the future survival of phytoplankton.

The study explored historical levels of phytoplankton by analysing 12 columns of ice, each around 100–200 metres long, extracted from across the Greenland Ice Sheet. These ice cores comprise layers of annually-deposited snow and ice that have been preserved for centuries. Each layer provides clues to past levels of phytoplankton in the North Atlantic at the time of original snow deposition, in the form of methanesulfonic acid (MSA). MSA is a chemical breakdown product of an aerosol released by microbes when phytoplankton expand into large blooms. Winds deposit MSA onto the sea or land, where it can subsequently become trapped in ice. Phytoplankton are the only source of MSA, and it is associated with the species groups dinoflagellates, haptophytes (including coccolithophores) and, to a lesser extent, diatoms, chrysophytes and prasinophytes.

The researchers used measurements of MSA from the ice columns as an indicator of productivity, which, in turn, roughly represent levels of phytoplankton themselves. They analysed MSA levels in ice samples covering the period 1767–2013, and found that levels started to drop from the mid-19th century onwards. This coincides with the start of the industrial era and the large-scale release of greenhouse gases. Overall, the results indicate that phytoplankton productivity, and thus phytoplankton levels, have fallen in the North Atlantic since the mid-19th century. There is some uncertainty as to the level of decline, but the results suggest it could be by around 10%.

The researchers believe that the decline may be driven by changes to the Atlantic Thermocline Overturning Circulation (AMOC), a large-scale ocean-circulation pattern that mixes up layers of seawater, distributing nutrients to phytoplankton in the process. Since the start of the industrial era, the AMOC is believed to have weakened by around 15%. Scientists are still exploring reasons for this weakening, but there is evidence that it is partly caused by melting ice caps and Arctic sea ice releasing huge amounts of freshwater into the sea, given that it slowed down markedly in the 1980s and 1990s. This period follows a massive accumulation of freshwater in the subarctic Atlantic during 1965–1990.

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The researchers compared their results with 20th–21st century data from studies that measured phytoplankton levels more directly by analysing seawater or satellite images of the sea. Their results matched up well, suggesting that MSA is a reliable proxy for phytoplankton levels, and also indicated that the decline has been going on for much longer than prior studies have been able to reveal.

Ice caps are continuing to melt, with further slowing of AMOC expected. The study speculates, therefore, that phytoplankton levels in the North Atlantic will decline further in coming decades. These results may support predictions[1] of a collapse in North Atlantic plankton levels by more than half — something with major implications for the climate, ecosystems and fisheries.

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1. Schmittner, A. (2005). 'Decline of the marine ecosystem caused by a reduction in the Atlantic overturning circulation'. *Nature*. 434 (7033): 628–633. DOI: 10.1038/nature03476.