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Time traveling with biomarkers: Baltic Sea sediment archives reveal frequency of "blue-green algae" since 1860

Researchers from Warnemünde and La Jolla, California, have succeeded for the first time in reconstructing the history of blue-green algae blooms in the central Baltic Sea over the last 160 years by using biomarkers and a well-dated sediment core. This way, they extended the period, for which information on the frequency of blooms was previously available, well into the past. In the international journal "Biogeosciences" they discuss possible causes for the fluctuations they detected. No clear evidence of a causal link between cyanobacteria abundance and eutrophication of the Baltic Sea was apparent, but they found evidence of a link with increased summer surface water temperatures.

Midsummer is their prime time: Cyanobacteria – colloquially known as blue-green algae – do particularly well in the period July/August, when only few nutrients are left in the surface water after the main growth phase. Their mass occurrence does not only spoil bathing fun by turning water into a yellow-brown broth, but these organisms also damage the ecosystem: When the cyanobacteria die, they sink to the sea floor where oxygen is consumed during their decomposition. The "dead zones" at the bottom of the Baltic Sea basins continue to expand. Marine biologists at the Leibniz Institute for Baltic Sea Research Warnemünde (IOW) have been trying for years to find the causes of the frequent blue-green algae blooms. Now they have received support from their colleagues in the Marine Geology department.

The two biomarkers they applied are almost exclusively produced by the cyanobacteria *Aphanizomenon* sp. and *Nodularia spumigena*, which are the most common ones in the central Baltic Sea. They are called 6- and 7-methylheptadecane (abbreviated: 6+7Me-C17:0). These are hydrocarbons that the cyanobacteria produce from fatty acids. They have the advantageous properties not to decompose even within millennia and can be detected in sediment samples with a reasonable analytical effort. This way, a team led by marine geologist Jérôme Kaiser from the IOW succeeded in detecting cyanobacteria continuously within a sediment core covering the last 160 years, but only at a relatively low frequency until 1920. After that, periods of high and low frequency alternated. They found no significant increase in the 1950s, when the eutrophication of the Baltic Sea accelerated considerably. However, they revealed a parallel to the variations in the summer surface water temperature in the central Baltic Sea. In addition, cyclical circulation fluctuations of ocean currents in the North Atlantic (60-90 years) seem to have an indirect influence.

To shed more light on the relevance of the biomarkers, the geologists from Warnemünde evaluated material from sediment traps in the central Baltic Sea, which had been collected over several months. Sediment traps are large funnel-like devices that are anchored to the seafloor and kept upright in the water by buoyancy bodies. They gather everything that falls into them, separated according to individual weeks, in collecting containers.

The team compared the biomarker data, both from the sediment trap material and from the sediment core, with data on the occurrence of cyanobacteria from monitoring programmes and satellite images taken over the last 35 years. They showed that the biomarkers 6+7Me-C17:0 not only indicate the presence of cyanobacteria in general, but also provide rough information about the amount of organisms that have produced them. This is particularly true for the species *Nodularia spumigena*, the most common cyanobacteria species in the central Baltic Sea.

With these findings, the scientists also ventured to examine a 7,000-year-old sediment core from the Bothnian Sea, a large basin in the north of the Baltic Sea. This period comprises the Middle and Late Holocene, a warm period that began with the end of the last ice age. It is of particular interest for today's climate research because in the climate optimum of the Middle Holocene, the average temperatures in the northern hemisphere were 1-1.5 °C higher than today. In a corresponding section of the Bothnian Sea sediment core, the 6+7Me-C17:0 content was up to 100 times higher than in today's central Baltic Sea. This suggests frequent and strong cyanobacterial blooms - where today the biomass of cyanobacteria blooms is 4 to 5 times lower than in the central Baltic Sea - an enormous change. "The two methyl heptadecan biomarkers can be used for the entire Holocene," said Jérôme Kaiser summarising the results. “They have shown us that cyanobacteria can react drastically to climate anomalies. In view of the continuing global warming, we should keep this in mind.”

The results can be read in detail at: Kaiser, J., N. Wasmund, M. Kahru, A. K. Wittenborn, R. Hansen, K. Häusler, M. Moros, D. Schulz-Bull and H. W. Arz (2020). *Reconstructing N2-fixing cyanobacterial blooms in the Baltic Sea beyond observations using 6- and 7-methylheptadecane in sediments as specific biomarkers. Biogeosciences 17: 2579-2591, doi: 10.5194/bg-17-2579-2020*

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