Harmful Algae News
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An extensive bloom of filamentous cyanobacteria in the Baltic Sea region in summer 2025

An extensive cyanobacteria bloom was observed in the Baltic Sea region in summer 2025. During the same period, cyanotoxins were detected in bivalve shellfish harvested along the Swedish Skagerrak coast. The temporal overlap between the bloom and the toxin detection, with a short delay, suggests that the cyanotoxins in bivalve shellfish may have originated from the Baltic Sea bloom and were likely transported by surface currents into the mussel farming locations within the Skagerrak. Potentially, the cyanobacteria had been growing in the unusually warm waters in the Kattegat. Here we report on this large bloom and ongoing efforts to develop an early warning system for harmful algal blooms (HABs).

The Baltic Sea is a brackish shelf sea connected to the North Sea through narrow straits leading to the Kattegat, a transitional area connecting it to the Skagerrak. The Baltic Sea is divided into different sub-basins, mainly the Baltic Proper, which has surface salinities in the range ~6–10, while the Bothnian Sea and the northernmost Bothnian Bay have salinities of approximately 5 and <3, respectively. Surface temperatures in summer sometimes reach 20°C offshore and may be higher in protected bays and archipelagos. HABs are common in the area and affect tourism and the marine ecosystem [1]. Nitrogen-fixing, filamentous cyanobacteria from the order Nostocales form surface blooms in summer [2–3]. The dominant taxa contributing most of the biomass are *Aphanizomenon flos-aquae, Nodularia spumigena*, and *Dolichospermum* spp. [2, 4]. These cyanobacteria play a key role in the Baltic Sea food web [5–6]. When sinking to the seafloor, their biomass is degraded in a process that consumes oxygen, which can lead to low-oxygen conditions in the deeper parts of the Baltic Sea. The hepatotoxin nodu-

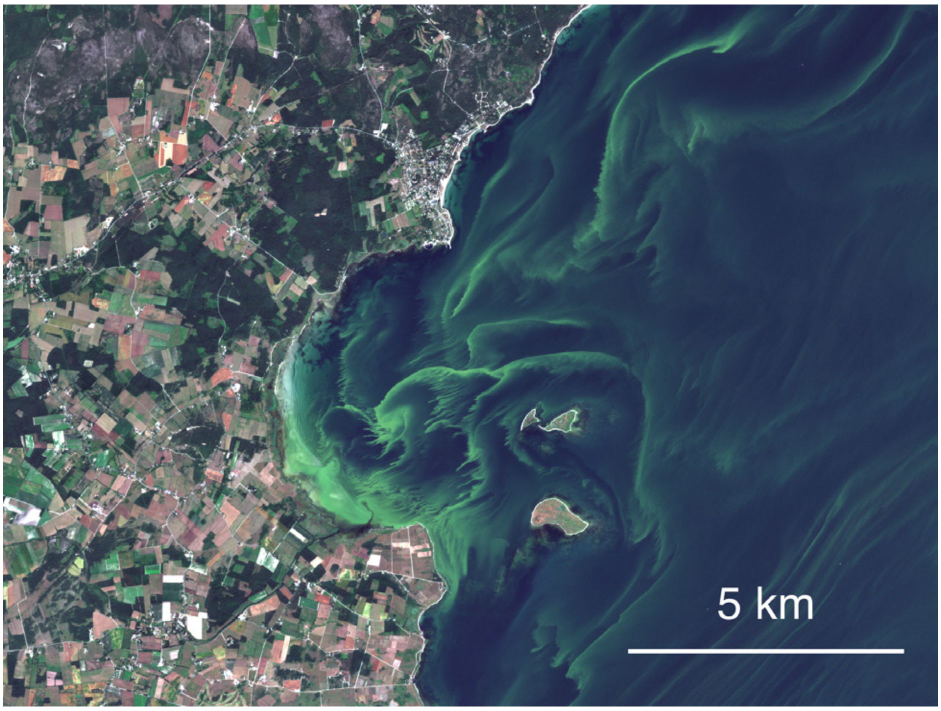

Fig. 1. Satellite image showing the distribution of near-surface cyanobacteria bloom on 20 July 2025 in Lausvik Bay, southeastern Gotland, a large island in the Baltic Proper. ESA-Sentinel 2 processed by SMHI. Quasi true colour RGB.

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Content

larin is produced by *N. spumigena* and has previously been detected in, for example, European flounder (*Platichthys flesus*), blue mussels (*Mytilus edulis*) and common eider ducks (*Somateria mollissima*) in the Baltic Sea [7–8].

A multi-method approach was applied to study the bloom dynamics, including phytoplankton distribution, composition, and biomass. Satellite remote sensing of ocean colour, through the Baltic Algae Watch System, operated by the Swedish Meteorological and Hydrological Institute (SMHI), provided daily updates on the distribution of near-surface cyanobacterial accumulations. Thresholds of reflectance at specific wavelengths were applied to distinguish between bloom or no-bloom conditions [2–3]. To minimize the impact of cloud cover, composite images were generated using observations collected during seven-day periods. *In situ* fluorometers configured with excitation and emission wavelengths specific for phycocyanin [9] – a pigment indicative of filamentous cyanobacteria – were employed to assess the distribution of the cyanobacteria. The fluorometers were mounted on an ocean glider, integrated into depth-profiling instruments, and included in an underway system on R/V Svea. These bio-optical instruments yielded data on both the horizontal and vertical distribution of the cyanobacteria in the water. In addition, the Imaging FlowCytobot (IFCB) [10–12], an imaging flow cytometer integrated in the flow-through system on the research vessel, and manual microscopy of water samples collected at sampling stations, provided detailed information on species composition, abundance and biomass.

The month of June 2025 was characterized by windy conditions, and cyanobacterial surface accumulations were first observed from satellite in early July. However, preliminary analyses of *in situ* phycocyanin fluorescence data from an ocean glider off the west coast of Gotland indicate that the bloom was already ongoing earlier (data not shown). It is likely that wind-driven mixing prevented the formation of surface blooms in June, but that cyanobacteria were proliferating deeper in the water column. In July, near-surface accumulations of cyanobacteria were observed using satellites (see example

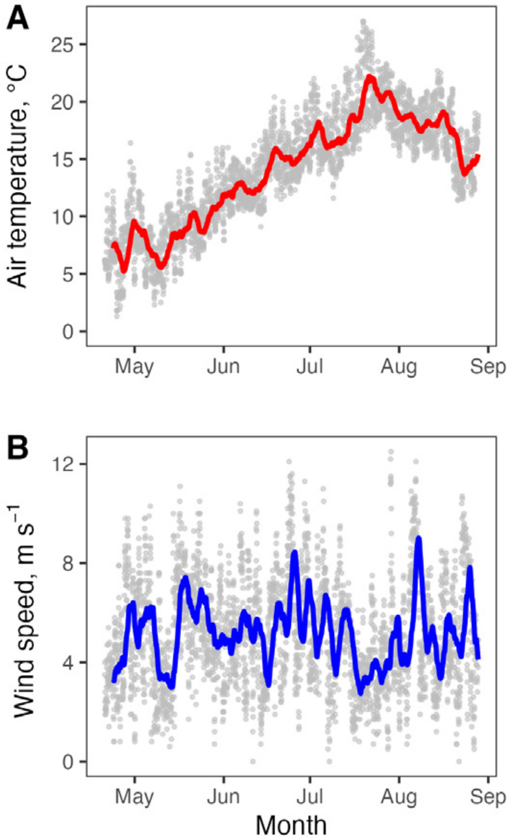

Fig. 2. Air temperature (A) and wind speed (B) on Gotland, summer 2025. Three-day running means with hourly data in the background. Data from station Hoburg A, SMHI.

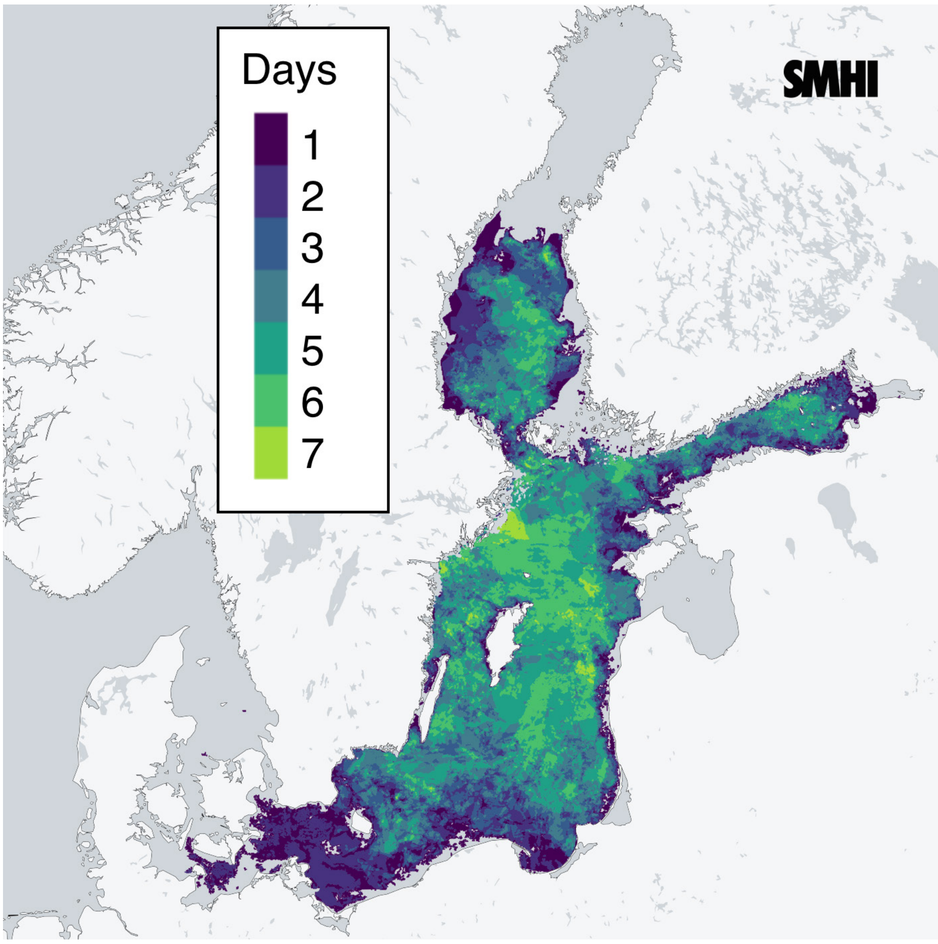

Fig. 3. Map showing the observations of near surface accumulations of cyanobacteria between 14 and 20 July 2025. Colours indicate the number of days when surface accumulations were observed during the seven-day period. Source: SMHI Baltic Algae Watch System.
https://www.smhi.se/data/hav-och-havsmiljo/alger/data-fran-algovervakning

in Fig. 1). A period of high air temperatures and low wind speed (Fig. 2) coincided with daily satellite observations of cyanobacterial blooms, with their maximum extent reached in late July (Fig. 3). The bloom covered most of the Baltic Proper, the Gulf of Finland, and the Bothnian Sea. Blooms in the Bothnian Sea have become more common in recent years [2]. Results from the IFCB, operated during a R/V Svea cruise (14–20 July), show the distribution and biomass of cyanobacteria (Fig. 4). *N. spumigena* and *A. flos-aquae* (Fig. 5) were observed in high amounts along the ship's route in the Baltic Proper, but in much lower amounts in the Kattegat and Skagerrak (Figs. 4A, 4C). During another cruise with the same vessel (9–16 August), the bloom had declined in the Baltic Proper but *N. spumigena* and *A. flos-aquae* were observed in higher amounts in the Kattegat (Figs. 4B, 4D) using IFCB. Results from microscopy (not shown) confirmed the IFCB data. During the same period, several species of bivalve shellfish harvested along the Swedish Skagerrak coast were found to contain varying concentrations of nodularin. Presence of this toxin in bivalves from the same region was reported earlier [13]. As there is currently no established regulatory limit for nodularin in mussel meat, the authorities advised a cautionary principle against all recreational harvesting in both the affected and adjacent coastal areas.

The results presented here show that a major cyanobacterial bloom occurred in the Baltic Sea in summer 2025 and that the bloom extended into the more saline waters of the Kattegat and the Skagerrak. Cyanobacteria observed at these higher salinities appeared healthy when observed in the microscope, suggesting that local populations may contribute to blooms under favourable conditions. Blooms of cyanobacteria in the Kattegat are rare: the last major event was in 2006, when a large bloom was also observed in the Southern Baltic Proper. Salinity has been thought to constrain the growth of *N. spumigena* in the Kattegat, where surface salinities are ~15–20. However, *N. spumigena* has recently been reported in the Great Salt Lake (USA) at salinities up to 45 [14].

Finding cyanotoxins in bivalves indicates a potential risk for human health.

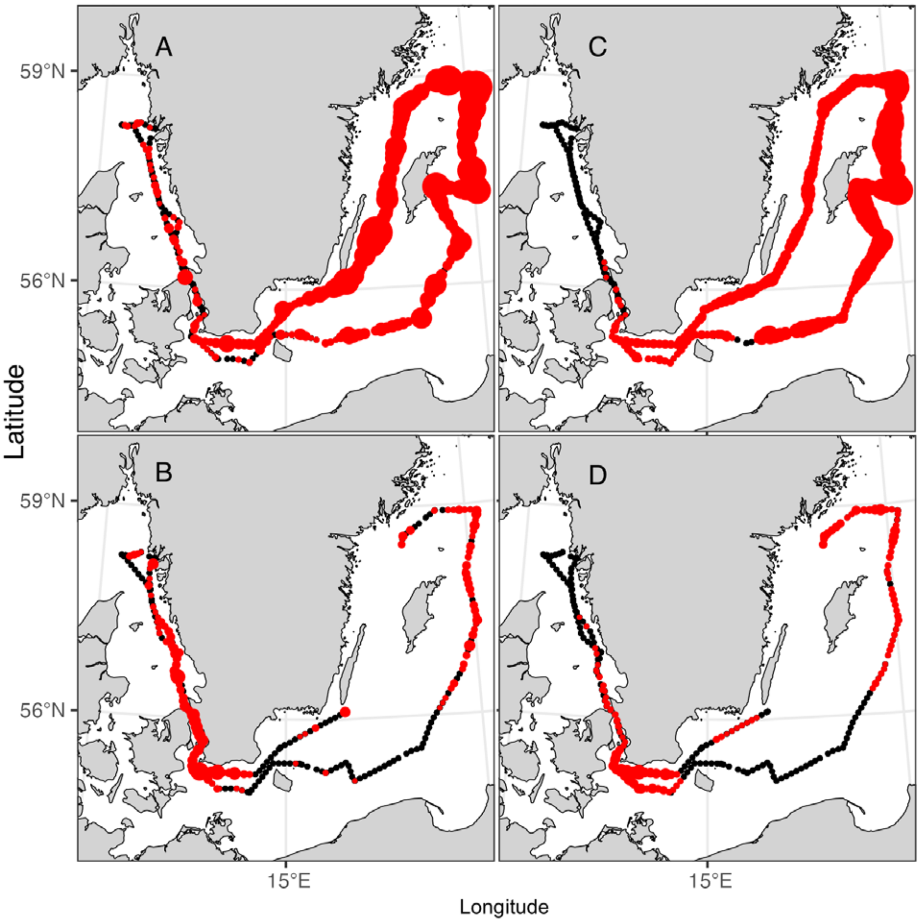

Fig. 4. Map showing the biomass of two cyanobacteria species in summer 2025. (A). N. spumigena *14–20 July. (B).* N. spumigena *9–16 August. (C).* A. flos-aquae *14–20 July. (D).* A. flos-aquae *9–16 August. Results are based on automated plankton analyses using the IFCB operated as part of the flow-through system on R/V Svea. Black points indicate stations where samples were collected but the taxon was not detected.*

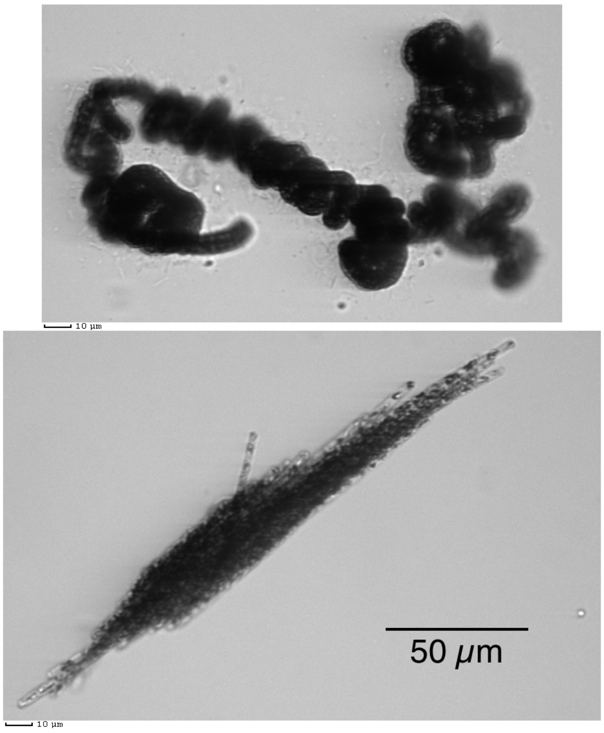

Fig. 5. Nodularia spumigena *and* Aphanizomenon flos-aquae*: examples of images from the IFCB.*

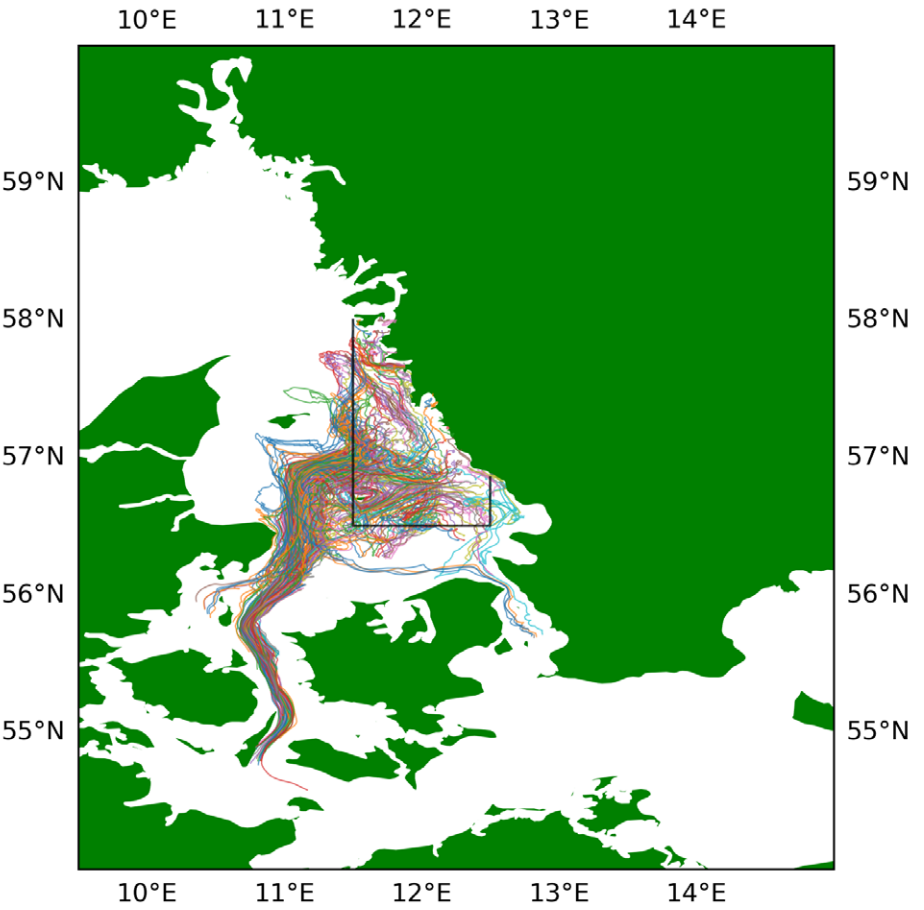

Fig. 6. The map illustrates the advection of neutrally buoyant particles in the surface layer (0–2 m) from 18 July to 1 August 2025. The NEMO-Nordic ocean model was used to backtrack 400 particles distributed within the rectangle in the Kattegat and southern Skagerrak. The colours of lines indicate the modelled paths of individual particles. Particle simulations forced by NEMO-Nordic operational ocean model from the Baltic Marine Forecasting Centre (BAL MFC), run by SMHI and available via Copernicus Marine Services (https://doi.org/10.48670/moi-00010).

Cyanotoxins have previously been observed in harvested molluscs in the Baltic Sea [15], indicating the same risk in this area. Swedish marine monitoring, along with two ongoing research projects, contributed to the results presented here. The aims are to learn more about cyanobacteria and their toxins and to develop an early warning system combining observations and short-term modelling [16], based on SMHI's operational ocean modelling [17], see example in Fig. 6. Tourism and desalination facilities on Gotland are two sectors that may benefit from these results.

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Authors

Bengt Karlson, Lars Arneborg, Lars Axell, Mikael Hedblom, Maria Karlberg & Anders Torstensson, Swedish Meteorological and Hydrological Institute, Oceanography, Sweden

Inga Koszalka, Department of Meteorology, Stockholm University, Sweden

Malin Olofsson, Department of Aquatic Sciences and Assessment, Sweden

Malin Persson & Aida Zuberovic Muratovic, Swedish Food Agency, Sweden

Email corresponding author:
bengt.karlson@smhi.se

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