Cyanobacteria blooms in the Baltic Sea

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Key Message

In 2017, extensive surface blooms of cyanobacteria were observed chiefly from the second week of July through mid-August. The first indications of subsurface blooms were noted exceptionally early on May 18, but windy and chilly conditions in June delayed the major bloom until July. The sea area most affected by surface blooms was the Northern Baltic Proper.

In comparison with previous years, the indexes of normalized intensity and normalized extent were lower than average for the 2017 bloom, the normalized duration was about average. However, the indexes recorded from 2010 onwards should not be directly compared with the 1997 to 2009 values, as an improved detection method is now used.

Satellite data from the MODIS sensor on EOS-Aqua and the VIIRS sensor on Suomi-NPP were used in the summer of 2017.

Results and Assessment

Relevance of the BSEFS for describing developments in the environment

Nitrogen fixation by cyanobacteria is a significant source of nitrate to the Baltic Sea. The amount of available phosphate in the surface water, the water temperature and weather conditions during the summer are important factors regulating the intensity of cyanobacteria bloom in the Baltic Sea. The surface water phosphate concentrations in the Baltic Proper were about average in May, but consumed during the rest of the summer. (See SMHI, https://www.smhi.se/en/publications/cruise-reports-from-the-marine-monitoring).

Assessment

An unusually warm second half of May set off the cyanobacteria bloom already on the 18th in the southernmost part of the Eastern Gotland Basin. As persistent winds continuously mixed the water in June, surface blooms were more or less absent in large parts of the Baltic Proper until the beginning of July.

As ample amounts of cyanobacteria were present in the water, surface blooms increased rapidly as the winds ceased in July. The peak was noted on July 22, when about 109 000 km^2 of cyanobacteria blooms were recorded from satellite data. A transit into windier August conditions meant a decline of the cyanobacteria bloom, which from mid-August was almost over in the Baltic Proper.

Surface blooms of cyanobacteria were present in the southern Bothnian Sea mainly from the last week of July, and peaked in mid-August. Although the open sea blooms were over by the start of September, local coastal blooms were reported until the end of the month.

During the bloom season from mid-May through August, SMHI undertook three monitoring cruises in on the Finnish Environment Institute's research vessel R/V Aranda. The cruise tracks mainly went through the Baltic Proper, but the western part of the Gulf of Finland was also covered. See detailed reports on https://www.smhi.se/publikationer/2.1054, nos. 5-7 2017. Grains or aggregates of cyanobacteria were found in the water samples on all cruises, with *Aphanizomenon flos-aquae* being the most abundant species in May, and *Nodularia spumigena* dominating in June. The July cruise featured medium to high amounts of *Dolichospermum* sp., *Aphanizomenon flos-aquae* and *Nodularia spumigena* in the water

samples. Surface blooms were only observed in the July cruise, chiefly in the Eastern and Western Gotland basins, and in the Northern Baltic Proper.

To be able to compare blooms between different years, the definitions of bloom normalized **duration (T), extent (A)** and **intensity (I)** have been developed. Based on the annual summaries (see example in Figure 1) where the area (a_i) is equal to the extent that is covered by surface accumulations of blooms during (i) number of days, the normalized duration and extent is given, with (i) ranging from 1 to the maximum number of days with bloom observations during the current year. The intensity is given in "extent days" or km^2 days. (Hansson, 2006 & Hansson & Håkansson, 2007)

$$\text{Duration, T} = \frac{\sum a_i * i}{\sum a_i} \quad [days]$$

$$\text{Area, A} = \frac{\sum a_i * i}{\sum i} \quad [km^2]$$

$$\text{Intensity,} \quad I = A * T \quad [km^2\ days]$$

The total time series of satellite image analysis of cyanobacteria blooms in the Baltic Sea region is presented in the last two figures, where the current analysis method has been used since 2010 (Figure 3). Although no comparison with the years 1997-2009 (Figure 4) should be made since the detection procedure has changed and the time series have not been corrected, the normalized bloom intensity was 15 679 km^{2}days and duration 4.8 days, whereas the normalized extent was 3278 km^2. The maximum area covered by cyanobacteria blooms (~109 000 km^2) was observed on July 22. In all, the cyanobacteria bloom of 2017 bloom can be considered to be below average.

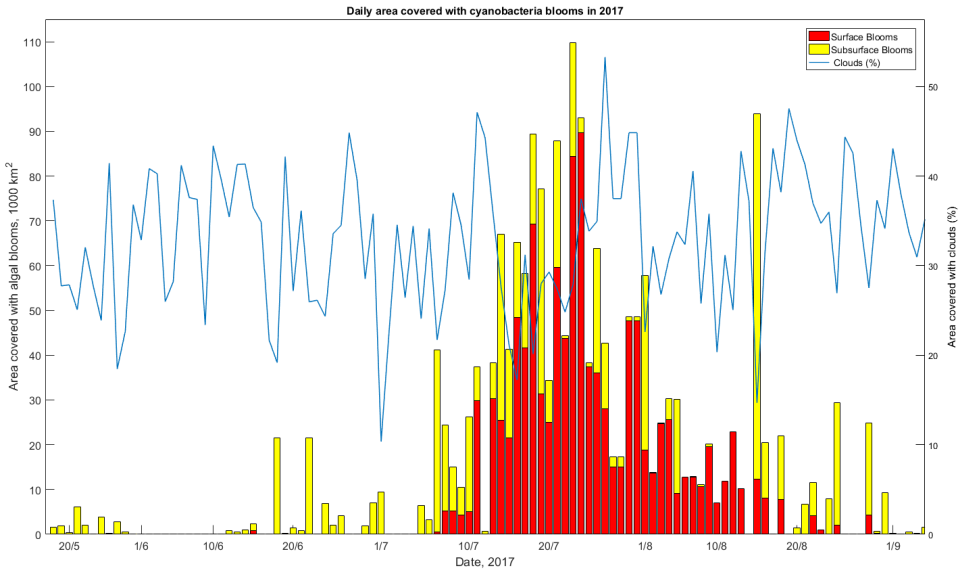

Figure 1. Daily extent of cyanobacteria blooms in the Baltic Sea during 2017, detected by MODIS and VIIRS satellite imagery. Red bars correspond to surface bloom and yellow bars indicate subsurface bloom. The blue line represents the integrated cloud cover (in percent of the total area) over the whole analysed area.

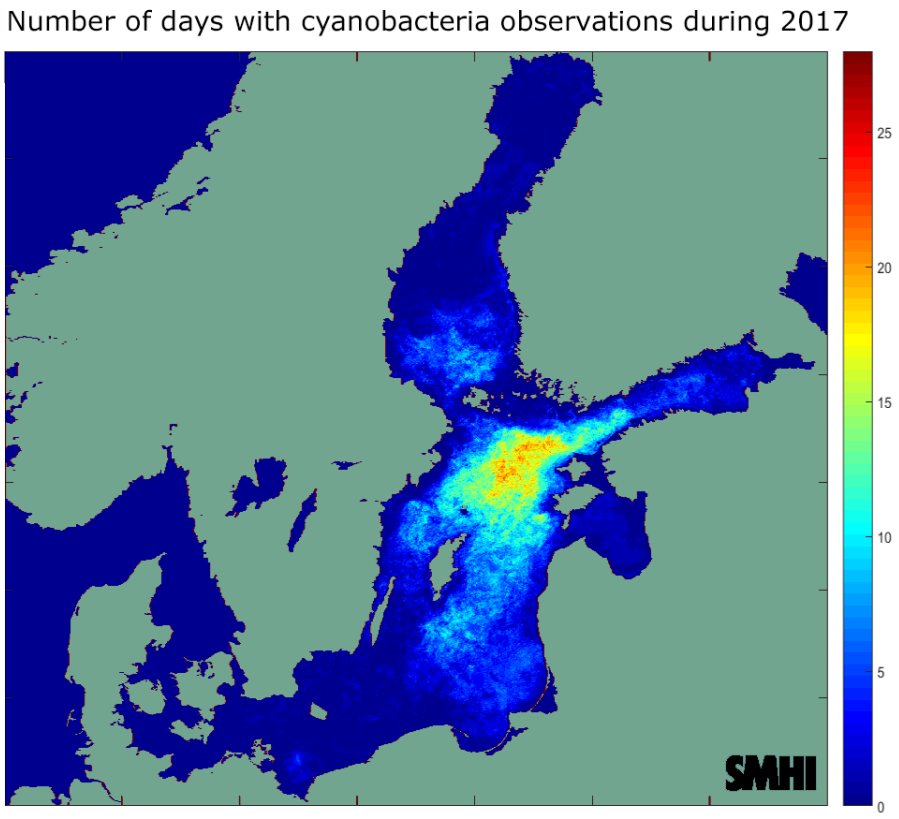

Figure 2. Number of days during 2017 with surface blooms of cyanobacteria observed in each pixel based on MODIS and VIIRS satellite data.

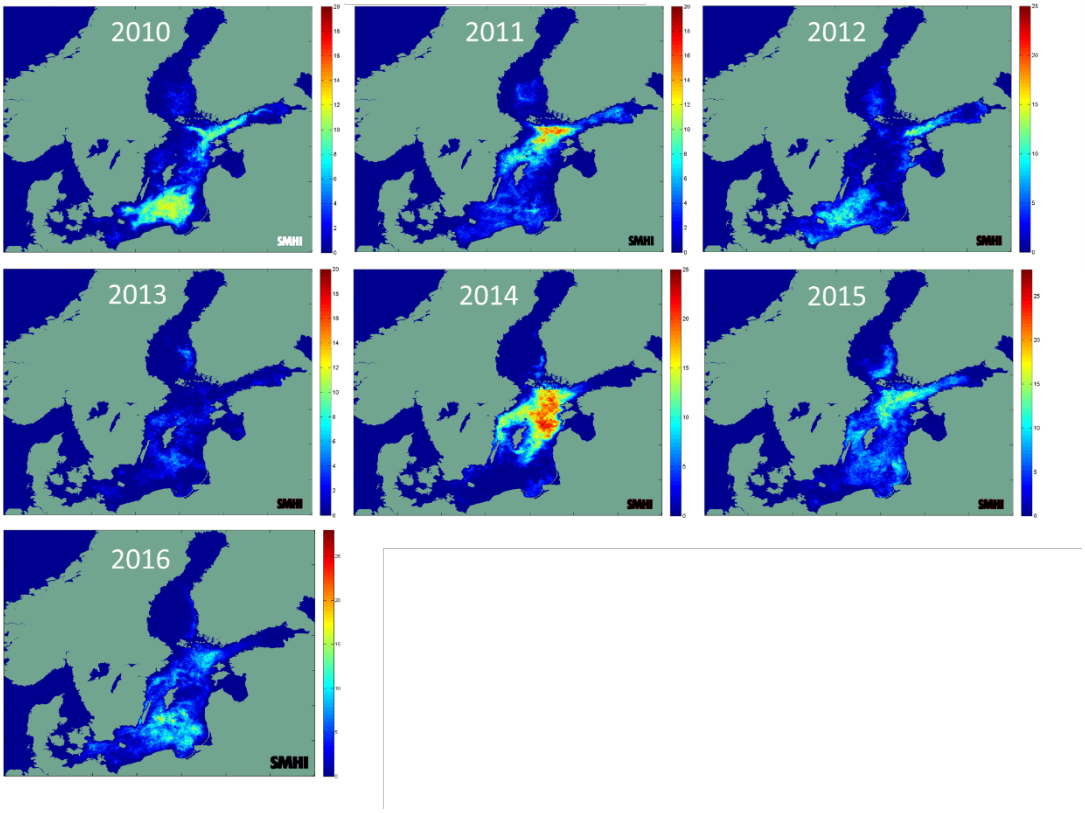

Figure 3. Summary of number of days with cyanobacterial blooms observed in each pixel during the period 2010-2016. Note that comparison between these results and results from the period 1997-2009 should not be made since the detection method is different.

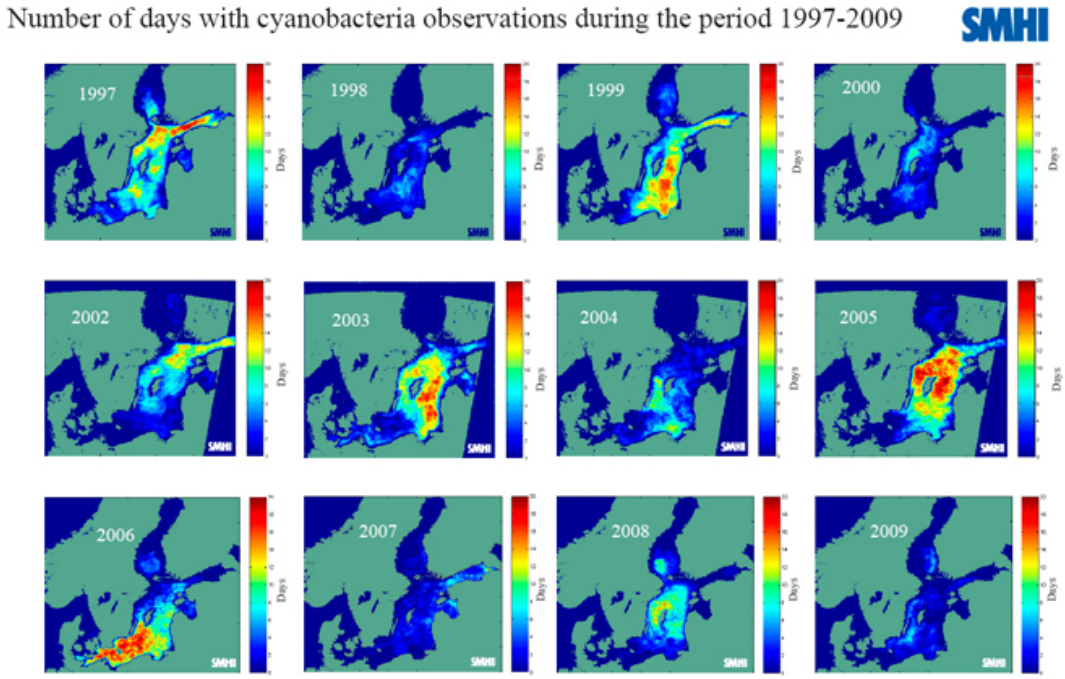

Figure 4. Summary of number of days with cyanobacterial observed in each pixel during the period 1997-2009, based on NOAA-AVHRR satellite imagery. Year 2001 is missing. Note that comparison of the results from 2010-2016 with previous years should not be made since the detection method is different.

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Data

All available and current MODIS and VIIRS L2 data covering the Baltic region were collected via FTP-boxes (Near Real-Time service at OceanColorWeb, NASA) to SMHI. Analysed satellite images showing the extent of surface and subsurface bloom in the Baltic Sea is presented at

the following website. The images are updated on a daily basis during June-August, or longer if the bloom continues into September.

www.smhi.se/en/Weather/Sweden-weather/the-algae-situation-1.11631

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