Cyanobacteria blooms in the Baltic Sea

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Key Message

In 2016, surface blooms of cyanobacteria were observed almost uninterruptedly for three months, from June 20 to September *21*. The first indications arrived unusually early on June 2, the major bloom however started three weeks later. The sea areas most affected by intensive blooms were the Eastern and Western Gotland Basins.

In all, this year's bloom was lower than average in comparison with previous years, with the three indexes of normalized duration on medium level, but extent and intensity were lower than average. However, the indexes recorded since 2010 should not be directly compared with the blooms from 1997 to 2009, 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 2016.

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. During the summer of 2016 phosphate concentrations in the Baltic Proper were mostly about average. (See SMHI, www.smhi.se/en/cruise-reports).

Assessment

An unusually warm May laid the foundation for an early onset of the cyanobacteria bloom in early June in the southernmost part of the Eastern Gotland Basin. From June 20, surface blooms were established in large parts of the Baltic Proper, but started to decrease one week into July.

The third week of July was unusually warm. The blooms increased again to peak on July 25, when about 86 000 km^2 of cyanobacteria blooms were recorded from satellite data. A cool and windy transition into August meant a decline of the cyanobacteria bloom, which by mid-August seemed to be over.

However, an upwelling event on August 17 replenished nutrients to the surface waters of the Arkona, Bornholm and Western Gotland basins. The warm and calm weather also returned which meant an unusually late bloom in these basins. As the summer continued, this bloom lasted three weeks into September whereas the blooms were finished in other areas of the Baltic Sea.

From mid-July to mid-September, low to mid-intensity blooms were intermittently observed along the Finnish coast of the Bothnian Sea, but these blooms were less prominent than usual. In all, the cyanobacteria blooms of 2016 continued for an exceptionally long time.

During the bloom season from June through September, SMHI undertook four 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 http://www.smhi.se/publikationer/2.1054, nos. 6-8 2016.

Grains or aggregates of cyanobacteria were found in the water samples on all cruises, with *Aphanizomenon flos-aquae* being the most abundant species in June, and *Nodularia spumigena* dominating from July onwards. Several other species, e.g. *Dolichospermum* sp., *Snowella* and *Aphanothece* were observed. Surface blooms were observed in the three July through September cruises, chiefly in the Eastern and Western Gotland basins, the Bornholm Basin as well as the Arkona Basin.

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 12082 km^2days and duration 4.5 days, while the normalized extent was 2707 km^2. The maximum area covered by cyanobacteria blooms (~86 000 km^2) was observed on July 25. In all, the intensity of the 2016 bloom can be considered to be below average.

Figure 1. Daily extent of cyanobacteria blooms in the Baltic Sea during 2016, 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 2016 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 2010-2015. 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 Spetember.

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

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