Cyanobacteria blooms in the Baltic Sea

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Key Message

In 2014, surface blooms of cyanobacteria were observed uninterruptedly for over five weeks, from July 4 to August 10. Although the major bloom started comparably late and had a lesser than average spatial extent, the northern part of the Eastern Gotland Basin and the adjacent Northern Baltic Proper had intensive blooms in the entire period above.

In all, this year's bloom was about average in an initial comparison with previous years. The normalized duration of the bloom was among the highest recorded but the normalized extent among the lowest. However, the normalized bloom intensity, extent and duration should not yet be compared with the blooms from 1997 to 2009, as an improved detection method is used since 2010.

Satellite data from the MODIS sensor on EOS-Aqua were used in the summer of 2014.

Results and Assessment

Relevance of the indicator for describing developments in the environment

Nitrogen fixation by cyanobacteria is a significant source of nitrogen 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 2014 phosphate concentrations in the Baltic Proper were about average for the season. (See SMHI, www.smhi.se/en/cruise-reports).

Assessment

The Baltic Sea
The warm and sunny weather in July was benign for the formation of surface blooms in the Baltic Sea region. However, the blooms started late and lasted only until early August. In all, the densest blooms were observed west to northwest of the islands Saaremaa and Hiumaa.

The sea surface temperature in the southern Baltic Proper had risen to about 15 °C in mid-June. The first subsurface blooms of cyanobacteria were observed in the Bornholm Basin already around June 10, which meant a very early start of the bloom. Persistent winds for the next two weeks however meant that surface blooms did not form until early July. The blooms in the southern half of the Baltic Proper were not long-lived, instead one week into July dense blooms formed in the eastern part of the Northern Baltic Proper and the northern half of the Eastern Gotland Basin.

Although minor blooms continued in the south, it was the northern half of the Baltic Proper that housed the major part of the cyanobacteria blooms for the rest of the summer. Into August, the blooms were concentrated to the eastern part of the Northern Baltic Proper with little left in other areas. On August 11, the summer warmth gave way for a cooler, low-

pressure dominated weather period continuing towards the end of the month. This ended the cyanobacteria bloom season of 2014 in the Baltic Sea.

In situ observations

SMHI undertook three cruises in June-August with the Finnish Environment Institute's research vessel R/V Aranda. The cruises covered various parts of the Arkona and Bornholm Basins as well as the Eastern and Western Gotland Basins. Detailed reports (in English) can be found at www.smhi.se/publications/algal-situation-reports-2-1056. In the mid-June cruise, the species *Aphanizomenon flos-aqua* was very common at most sampling stations. The mid-July cruise showed ample amounts of the toxic species *Nodularia spumigena* as well as *Aphanizomenon flos-aqua* to be present both as surface accumulations and in surface layer samples from all stations. The observations from the August cruise, undertaken in the first week of the month, showed large patches with surface accumulations in the eastern part of the Northern Baltic Proper containing equal quantities of *Aphanizomenon flos-aqua* and *Nodularia spumigena*.

Normalized indexes

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)

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

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

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

Although no comparison with the years 1997-2009 should be made since the detection procedure has changed and the time series have not been corrected, the normalized bloom intensity was 26293 km^2days and duration 7.8 days, while the normalized extent was 3337 km^2. The maximum area of surface blooms (~83 000 km^2) was observed on July 24. Overall the intensity of the 2014 bloom can be considered to be slightly above normal.

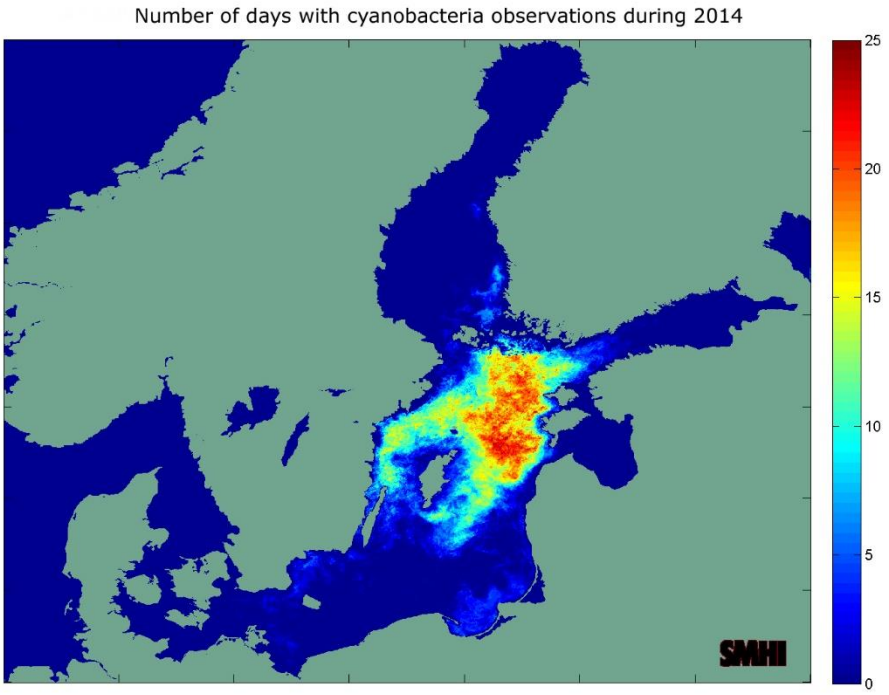

Figure 1. Number of days during 2014 with surface blooms of cyanobacteria observed in each pixel based on MODIS satellite data.

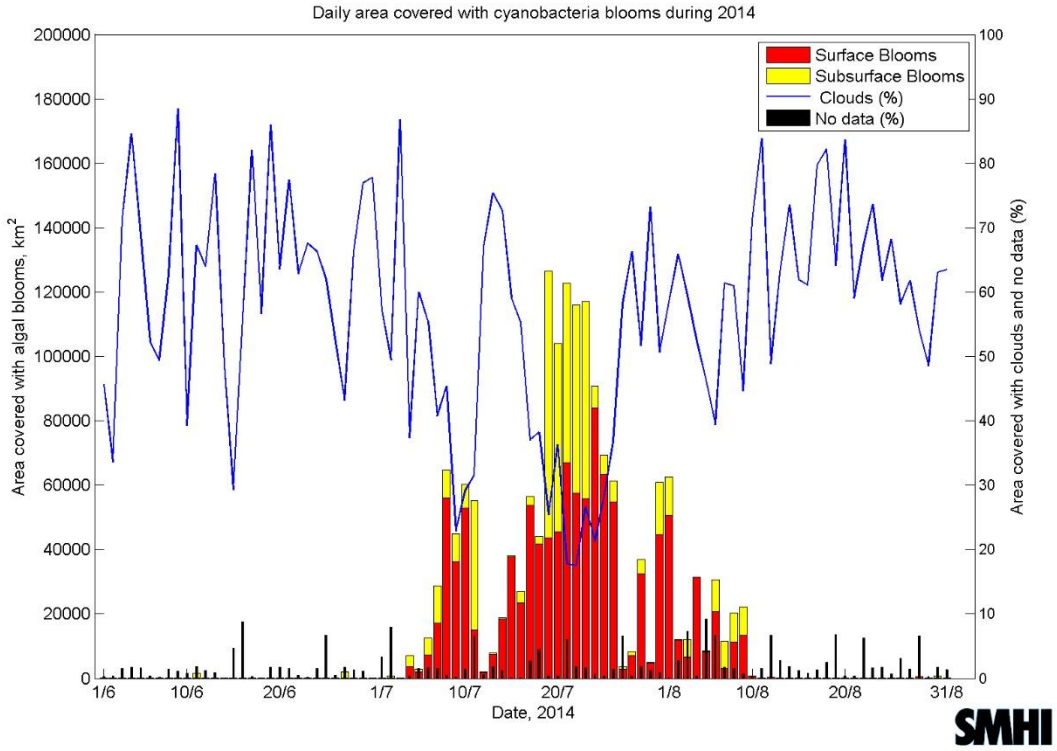

Figure 2. Daily extent of cyanobacteria blooms in the Baltic Sea during 2014, detected by MODIS satellite imagery. Red bars correspond to surface bloom and yellow bars indicate subsurface bloom. The blue line represents the integrated cloud cover (in percent of the total area) over the whole analysed area, the black line no data.

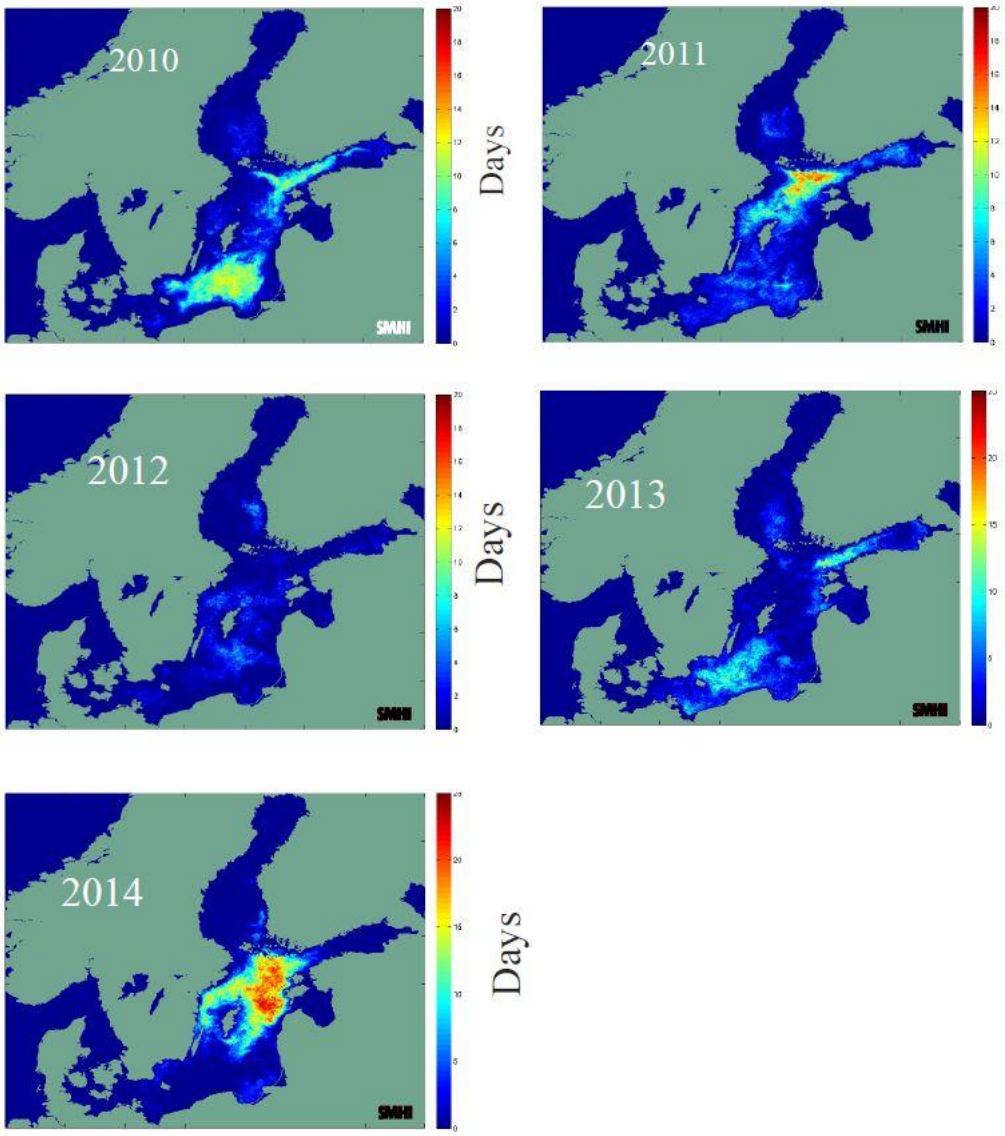

Figure 3. Summary of number of days with cyanobacterial blooms observed in each pixel during the period 2010-2014. Note that comparison between these results and results from the period 1997-2009 should not be made since the detection method is different.

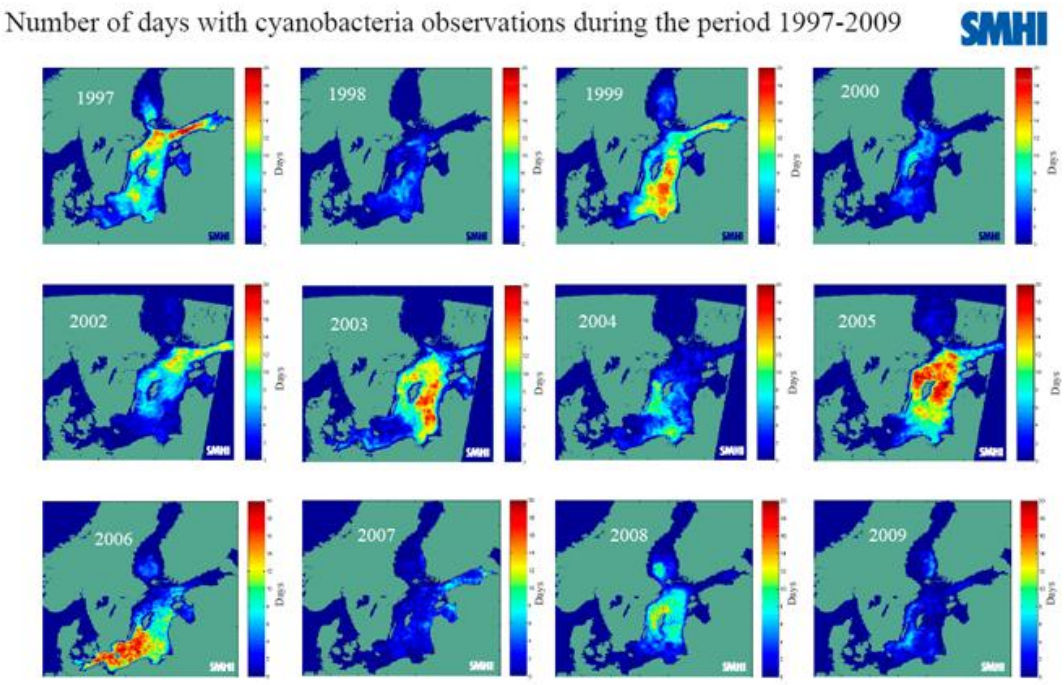

Figure 4. Summary of number of days with cyanobacterial observed in each pixel during the period 1997-2009, based on NOAA-AVHRR satellite imagery. Year 2001 is missing. Note that comparison of the results from 2010-2014 with previous years should not be made since the detection method is different.

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www.smhi.se/oceanografi/oce_info_data/reports/havmiljoarkiv/oce_reportarchive12.html

Data

All MODIS L2 data covering the Baltic region that were available from the previous day area were automatically collected via FTP-boxes (Near Real-Time service at OceanColorWeb, NASA) to SMHI. Data from the previous day is convenient to use, since a new bloom map can be made available directly around 09:00 local time and the public and environmental managers can then get updated information about the algal situation early in the morning. It is also practical for the operator who does not need to wait for late arrival of satellite data which can delay the production of bloom maps. 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.

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