Cyanobacterial blooms in the Baltic Sea

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Key Message

During 2002 and 2003 major parts of the Baltic Sea were affected by strong surface accumulations of cyanobacteria. Both years had strong blooms but different areas were affected. During 2002 the most intense blooms were observed in the northern Baltic Proper and in the Gulf of Finland. During 2003, blooms were concentrated in the eastern Baltic Proper and the area around Gotland.

Relevance of the indicator for describing developments in the environment

Analysis of sediment cores has indicated that cyanobacterial blooms are as old as the brackish phase of the Baltic Sea, starting 7000 years B.P. (Bianchi 2000). It has also been suggested that cyanobacteria pigments in sediment cores have increased in concentration since the 1960s (Poutanen et al 2001). In recent years there has been a debate on whether there has been an increase of the intensity and areal extent of the cyanobacterial bloom due to eutrophication (Karhu 1994, Finni 2001, Bianchi 2000). Monitoring of the areal extent and the intensity of the surface blooms may give clues about possible human impacts and natural variability.

Assessment

2002

The first cyanobacterial bloom was seen on the 8th of July. The bloom spread around Gotland and the most intense blooms were found in the Northern Baltic Proper and in the Gulf of Finland. The maximal area extent (~110000 km^2) was observed on the 13th of July but due to cloudy weather at the end of July the observed areal extent decreased. The last reliable bloom observation was made on the 16th of August.

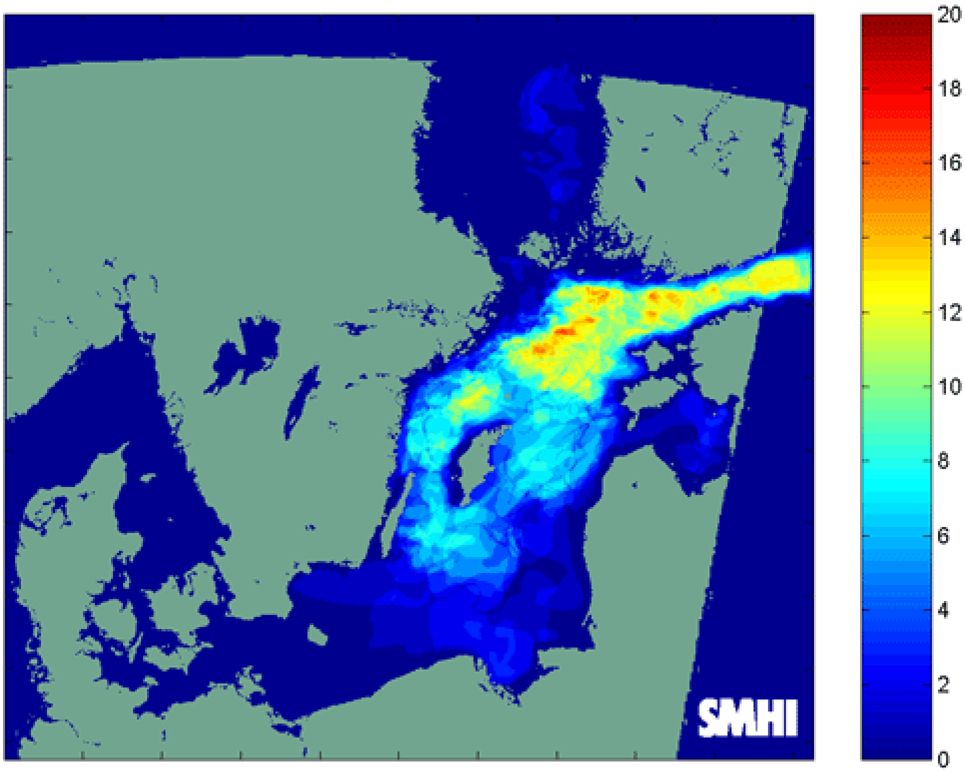

Figure 1. Summary of 2002. Number of days with cyanobacteria observed in each pixel (from NOAA-AVHRR satellite imagery).

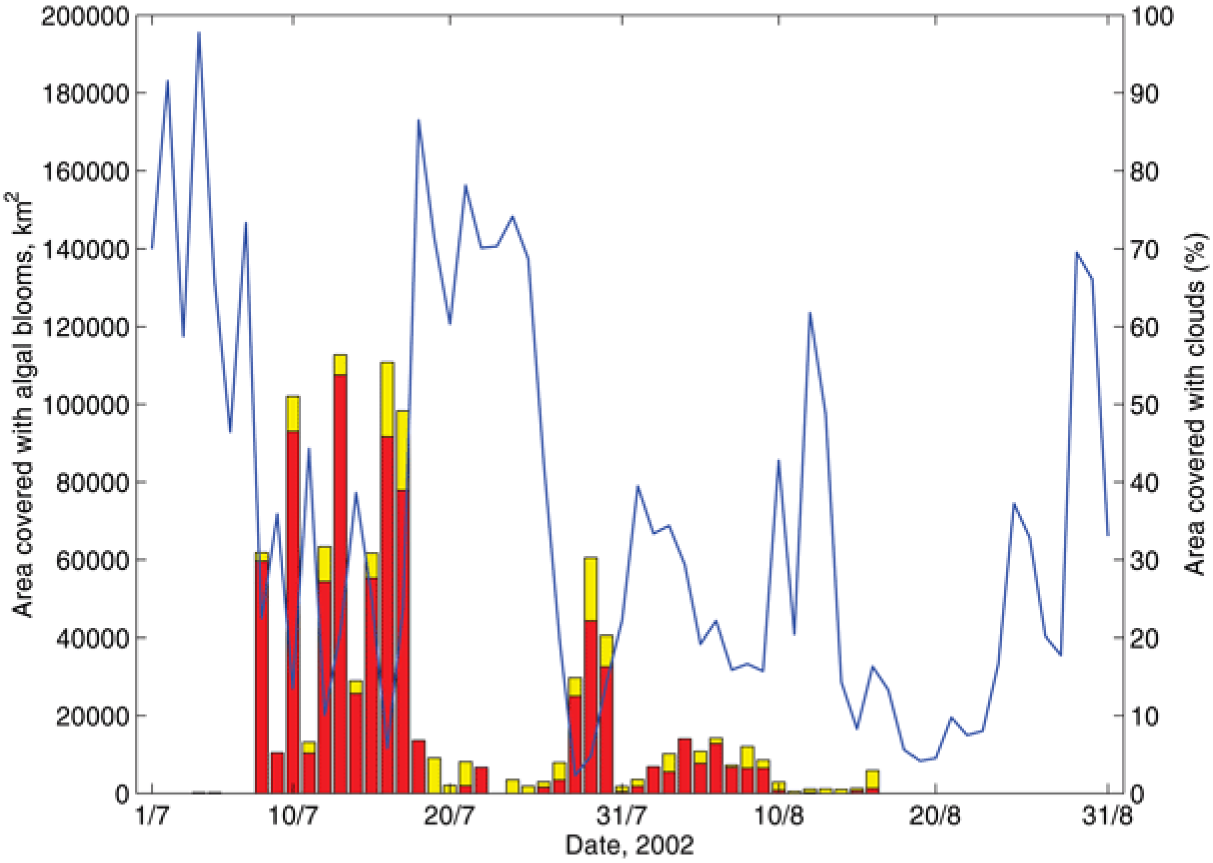

Figure 2. Summary of 2002. Daily areal extent of cyanobacterial blooms in the Baltic Sea. Red bars correspond to certain bloom observations and yellow bars indicate uncertain bloom observations. The blue line represents the integrated cloud cover in percent of the total area over the whole Baltic Sea, excluding the Kattegat, Skagerrak and the Bothnian Bay.

2003

The first observation of surface accumulations of cyanobacteria was made on the 8th of July. Calm, sunny and warm weather conditions, and higher than normal concentrations of phosphorus were favourable for a massive bloom and within a week intense blooms affected a large parts of the Baltic Proper. Maximal areal extent (~110000 km^2) was observed on the 24th and 31st July and most observations were made east and south-east of Gotland. The bloom then spread westwards along the Polish and Swedish coast to the Arkona Basin and Belt Sea. No blooms were observed after the 18th of August.

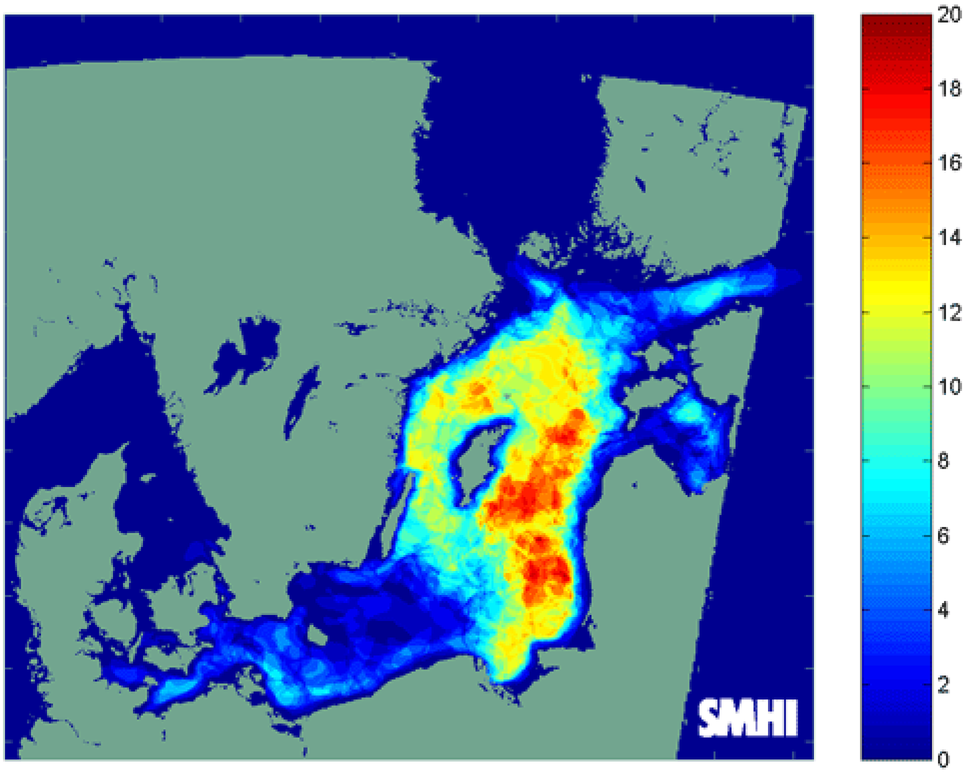

Figure 3. Summary of 2003. Number of days with cyanobacteria observed in each pixel (from NOAA-AVHRR satellite imagery).

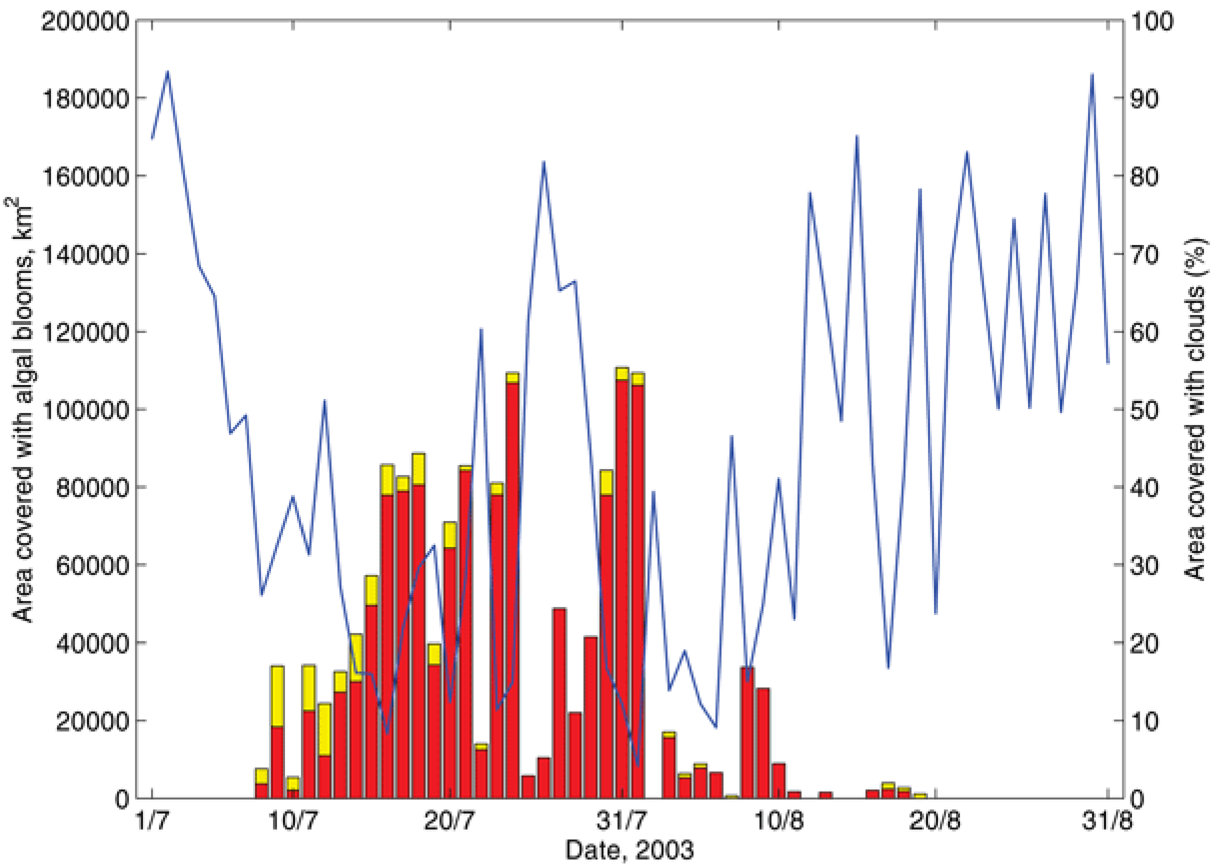

Figure 4. Summary of 2003. Daily areal extent of cyanobacterial blooms in the Baltic Sea. Red bars correspond to certain bloom observations and yellow bars indicate uncertain bloom observations. The blue line represents the integrated cloud cover in percent of the total area over the whole Baltic Sea, excluding the Kattegat, Skagerrak and the Bothnian Bay.

Excess phosphorus after the spring bloom and suitable weather conditions favour cyanobacteria blooms in the Baltic Sea. Stagnation periods in the Baltic Sea Deep Water due to reduced Atlantic water inflow since the late 1970s has increased the phosphorus concentration in the near bottom layers. Weakening stratification in the deeper layers permits vertical transport of phosphorus to the euphotic zone. The intrusion of high salinity water from the Skagerrak and Kattegat can also accelerate the vertical transport since the inflowing water displaces the old bottom water (with high phosphorus concentration) further up the water column making it available for cyanobacteria growth. (See indicator report: Hydrography and Oxygene in the Deep Basins, and Water exchange between the Baltic and the North Sea and conditions in the deep basins)

Both 2002 and 2003 showed similar pattern in affected area extent and the time period of visible surface accumulations of cyanobacteria. However, the area with the most intense blooms was different during the two years.

Reference

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Data

The SMHI satellite receiving station in Norrköping collected the NOAA-AVHRR data.

Technical information

1. Data source: The AVHRR-data from NOAA-satellites was received with the antenna at SMHI headquarters, Norrköping.

2. Description of data: The AVHRR-sensor measures radiation in 5 broad wavelength bands ranging from visible to thermal infrared.

3. Geographical coverage: The satellite monitoring of cyanobacteria has many advantages compared to regular vessel based monitoring. The NOAA-AVHRR has a wide swath width (~2600km), hence most areas of the Baltic Sea is covered. An exception is all near land areas such as archipelagos, which can not be monitored due to the coarse pixel resolution (~1km). The satellite data format excludes the inner parts of the Gulf of Finland.

4. Temporal coverage: Data from the NOAA-AVHRR sensor have been available since the late 1970s. Karhu et al. 1994 and 1997 has produced a compiled time series of satellite data for analysis of cyanobacterial blooms in the Baltic Sea from 1982 to 1994 (Karhu 1997). In 2002, SMHI initiated BAWS (Baltic Algal Watch System) that performs daily interpretations of satellite imagery during the summer. AVHRR data have also been analysed between 1997 and 2000 by SMHI in the EU-project HABES (Harmful Algal Blooms Expert System).

5. Methodology and frequency of data collection: The satellite imagery is analysed using both automatic cloud masks and manual interpretations. NOAA satellites have a repeated cycle of ~0.5 days and since there are several NOAA satellites mounted with the AVHRR sensor there can be ~12 overpasses per day of which between 0-6 overpasses are suitable for further analysis due to low viewing angles, sun glint, clouds or haze. The best viewing conditions are usually encountered during the morning.

6. Methodology of data manipulation: Data were calibrated to albedo for visible and near infrared channels, and to brightness temperature for the thermal channels. Data were also geographically corrected to a Mercator projection.

Quality information

1. Strength and weakness: The obvious strength by using satellite data is the high sampling frequency and the synoptic view. However, monitoring is limited to open sea areas due to the coarse pixel size, and is also limited by cloud cover, since the AVHRR sensors cannot "see" through clouds.

2. Reliability, accuracy, robustness, and uncertainty: The AVHRR satellite can only be used for monitoring of meso-scale, surface accumulations of cyanobacteria. Algae can be found further down the water column. These are impossible to detect with satellite imagery. Hence the satellite data must be complemented by ship borne measurements, for example by data from Algaline. Uncertain bloom observations are always noted and reanalysed when more satellite scenes are available.

3. Satellite data from the high-resolution channels of MODIS (or Moderate Resolution Imaging Spectroradiometer) flown on the TERRA and AQUA satellite were used, when good imagery was available, to re-analyse the algal maps derived from the NOAA-AVHRR data. Manual corrections were performed if needed.

4. Further work required: During 2004 SMHI and BAWS will try to introduce a new area coverage (including the Gulf of Finland) and projection (Albers Equal Area). An algorithm (inspired by Karhu 1997) has also been developed during 2003 to screen clouds and cyanobacterial blooms, the algorithm will make the manual interpretations more uncomplicated and hopefully in use during the summer of 2004.

For reference purposes, please cite this Baltic Sea environment fact sheet as follows:

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