Baltic Marine Environment Protection Commission

Working Group on the State of the Environment and Nature Conservation

Tallinn, Estonia, 7-11 November, 2016

STATE & CONSERVATION 5-2016

Document title	Cyanobacterial Bloom Index (CyaBI) – core indicator proposal
Code	4J-5
Category	DEC
Agenda Item	4J – HELCOM indicators and assessments
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Submitted by	Finland, as proposed by HELCOM IN-Eutrophication

Background

The EUTRO-OPER project proposed an indicator on cyanobacterial blooms to be included to the core set of eutrophication indicators (see HELCOM EUTRO-OPER project report). STATE & CONSERVATION 2-2015 agreed on pre-core status for the indicator, and requested the following improvements to be considered (4J-15):

- cyanobacteria biomass shall be included as an additional parameter to the indicator,
- indicator targets should be proposed,
- the role of long-term hydrographical changes to the outcome of the indicator shall be analyzed and taken into account,
- a plan for indicator update and inclusion to the eutrophication information and data flow must be included.

In this document we present an update of the Cyanobacterial Surface Accumulation (CSA) indicator into Cyanobacterial Bloom Index (CyaBI), proposing core indicator status, with the aim of applying the indicator in the HOLAS II process.

The current version of the indicator report is presented in the EUTRO-OPER project report.

Action required

The Meeting is invited to:

- endorse the proposal to shift the status of the pre-core indicator Cyanobacterial Bloom Index (CyaBI) to core indicator,
- consider the preliminary GES boundaries for the indicator,
- agree to endorse the final proposals on GES boundaries intersessionally.

Introduction

The *Cyanobacteria Surface Accumulation (CSA)* indicator was originally developed during the MARMONI -project, and further developed by EUTRO-OPER, with Finland in lead of the work. The original indicator, with status calculated based on remote sensing (satellite) data, had the potential of being broadened to take advantage of data from additional sources.

STATE & CONSERVATION 3-2015 requested the indicator to be improved with information from cyanobacteria biomass data, utilizing the environmental fact sheet developed and updated regularly by the PEG group. The environmental fact sheet provides annually observed and analyzed information on cyanobacteria biomass in the open-sea basins, with time-series extending as far back as the early 1990's (and occasional even older data).

Developing a combined cyanobacteria indicator

The HELCOM pre-core indicator *Cyanobacteria Bloom Index (CyaBI)* is an update of the *Cyanobacterial Surface Accumulation (CSA)* indicator with information from the *Cyanobacteria Biomass* environmental fact sheet (HELCOM PEG). It is based on a multiparametric approach that could be developed even further by including cyanobacteria information collected on different platforms. All added parameters must fulfill the following requirements: each new parameter must 1) describe a relevant aspect of cyanobacteria accumulations not already considered by the other parameters, 2) contain sub-basin specific GES targets and 3) be updatable by status values for the sub-basin division and status period defined for the existing indicator.

The *Cyanobacterial Surface Accumulation* indicator (Anttila et al. *submitted*) consisted of three satellite-based parameters. Each of these parameters described a different aspect of cyanobacterial surface accumulations: the volume, the time-period and the intensity of the blooms (requirement 1). As these parameters rely on the same satellite-based dataset, the target is calculated for them jointly (requirement 2). The status is updated for the 9 major open-sea sub-basins for 2011-2014 using Meris and MODIS observations, and can in the future be updated for using SENTINEL observations (requirement 3). SYKE /Finland is responsible for the regular update of the satellite-based parameters, as well as for reporting them to the HELCOM eutrophication assessment database hosted by ICES.

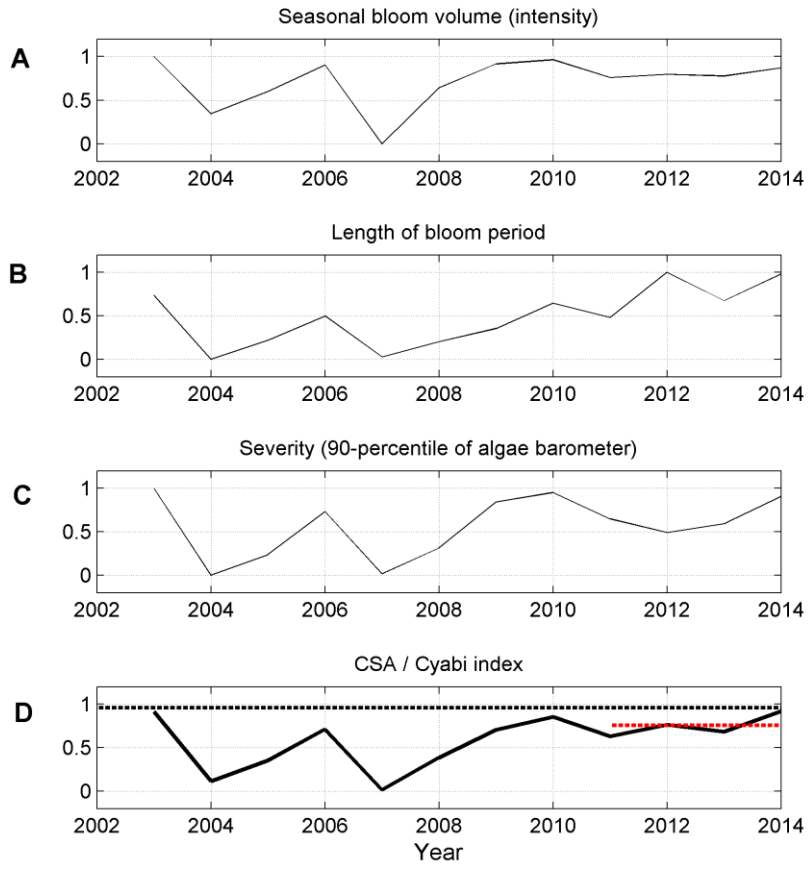

Figure 1. Figure 4. The normalised satellite-based indicative variables and their combination into the Cyanobacterial Surcace Accumulations (CSA) for the Gulf of Finland. Time series from the top are A) seasonal bloom volume (spatial), B) length of the cyanobacterial bloom period (temporal), C) severity of the cyanobacterial bloom period, and D) all of these combined to form the CSA (D). The black dashed line expresses the parameter-specific CSA target and the red dashed line expresses the 2011-2014 CSA average. Note that the parameter group as well as CSA responds negatively to increased anthropogenic pressure, i.e. the lower the CSA value, the more substantial the cyanobacterial blooms are.

The added parameter, *Cyanobacteria Biomass* describes the mean biomass (wet weight, µg/L) of the three bloom-forming cyanobacteria genera in the open Baltic Sea sub-basins during their blooming period. The data is based on monitoring and analysis conducted by the contracting parties, according to the HELCOM COMBINE programme. Cyanobacteria Biomass estimates are updated annually by the HELCOM PEG group (Wasmund et al. 2015).

Cyanobacteria Biomass supplements the existing satellite-based CSA parameter group by providing information of the actual amount of cyanobacteria in the water (requirement 1). Due to less frequent monitoring, neither the status- nor the target estimates have sufficient confidence for it to stand alone as a HELCOM core indicator. However, combined with the *Cyanobacteria Surface Accumulation* parameter group, a more reliable product is developed: an indicator expressing the consequence of increased cyanobacteria, the blooms, with high confidence; yet and indicator related strongly to changes in the actual amount of cyanobacteria, and subsequently, to eutrophication.

The targets for *Cyanobacteria Biomass* are based on the time-series provided by the HELCOM PEG group in their environmental fact sheet (Wasmund et al. 2015), slightly modifying the approach applied for the satellite-based parameters (requirement 2, see next chapter). The *Cyanobacteria biomass* status is updated for 2011-2014

based on the environmental fact sheet (requirement 3). The PEG group has taken responsibility of updating the status as well as the fact sheet regularly.

The new parameter is introduced using the existing indicator approach. The targets and assessment evaluations are calculated for *Cyanobacteria Biomass* separately, and normalized between 1 and 0 (with 1 expressing high status). The status of the proposed core indicator CyaBI is calculated as a weighted average of the CSA and the Cyanobacteria Biomass.

In case of missing data, for any of the indicator parameters, the indicator may still be calculated using a reduced number of parameters (as the targets have been calculated separately). This will however decrease the confidence of the indicator for the sub-basin in question.

Developing targets for cyanobacteria biomass

Cyanobacterial blooms are a natural phenomenon in the Baltic Sea, and the target-setting did not aim at pristine conditions, but a sustainable level of blooms.

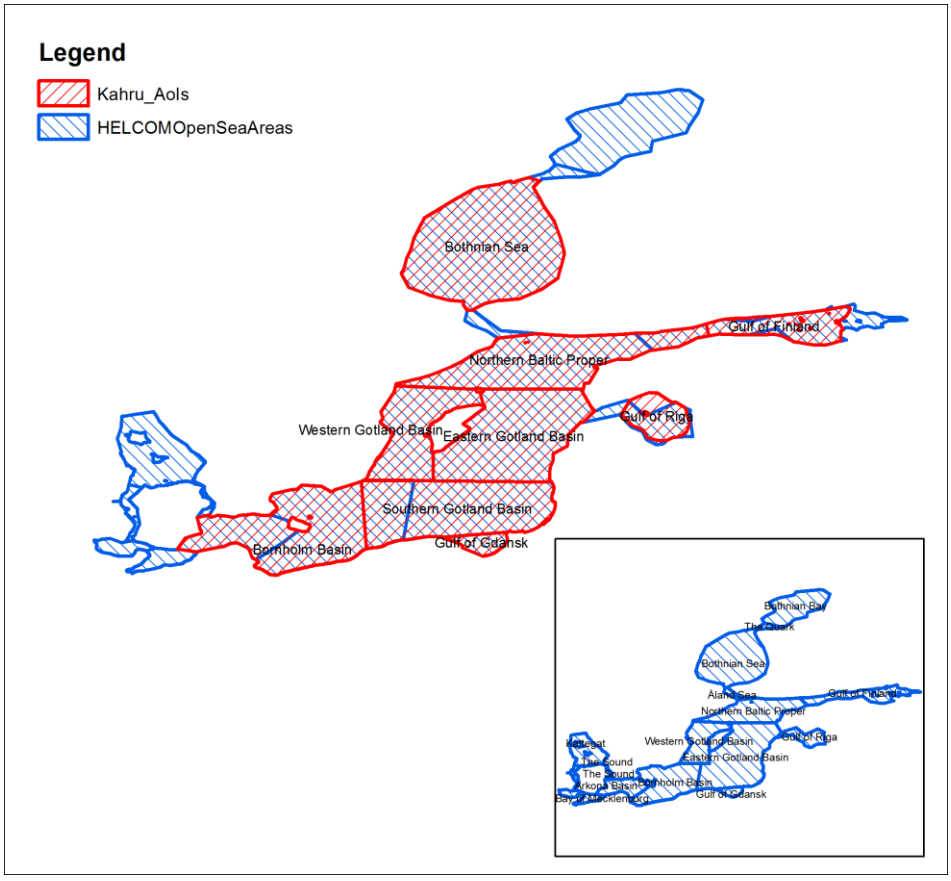

Figure 2. Open sub-basins with sufficient long-term data for calculating the targets for the satellite-based parameters (red dashed areas, from Kahru & Elmgren 2014).

The aim was to apply the same target-setting method for the *Cyanobacteria Biomass* parameter, with minor adjustments due to the shorter time-series (the minimum length between shifts was set at 5 years, instead of seven). However, especially in some of the southern sub-basins, the time-series of *Cyanobacteria Biomass* clearly did not extend far enough back in time to express periods of good status. A secondary approach was thus required in areas where the biomass time-series did not cover the target period identified from satellite data, and appropriate target periods could not be identified with the shift-detection method. In these cases, the best quartile of the data was accepted as a sufficient target.

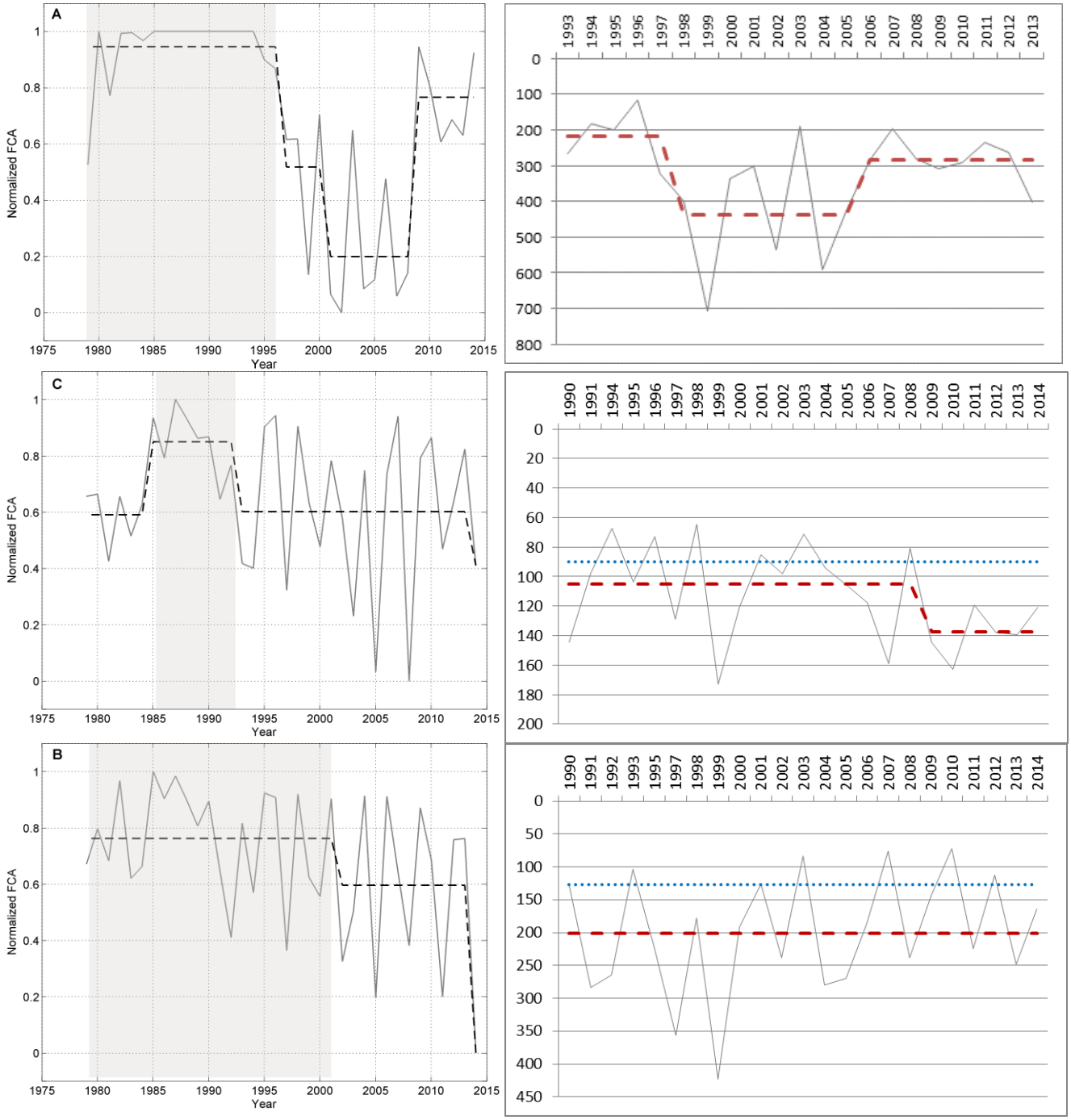

Figure. Detecting the target level for the Gulf of Finland (upper row), Northern Baltic Proper (middle row) and Western Gotland Basin (bottom row). Left: for for the satellite-based bloom indicator, with dashed black line representing the levels distinguished by shift-detection, and the selected target period in gray. Right: for the cyanobacteria biomass (µg/l), with a red dashed line showing the shift-detection levels and a blue dotted line representing the lowest quartile, in the cases where the shift-detection approach was rejected. [THE FIGURE WILL BE UPDATED TO INCLUDE INFORMATION FROM ALLTOGETHER 9 OPEN-SEA SUB-BASINS]

The targets were thus developed separately for the two monitoring platforms. This allows applying the parameters separately also in the future.

The proposal includes both cyanobacterial bloom and biomass targets in seven major sub-basins: the Arkona Sea, Bornholm Sea, Gdansk Basin, Eastern Gotland Basin, Western Gotland Basin, Northern Baltic Proper, Gulf of Riga, Gulf of Finland and Bothnian Sea. In five additional minor sub-basins, the Kiel Bay, Bay of Mecklenburg,

Gdansk Basin, Western Gotland Basin and Åland Basin, targets can be made available for one of the two parameters. The Great Belt and the Sound will remain without targets. The indicator is not relevant in the Kattegat, Quark and Bothnian Bay, due to ecological grounds.

Table. Proposed targets for cyanobacterial blooms and cyanobacteria biomass. THE TABLE WILL BE UPDATED IN THE REVISED DOCUMENT.

HELCOM_ ID	Assessment unit name	Proposed CSA target (normalized between 0-1, with 1 expressing high status)	Proposed cyanobacteria biomass target [µg L^{-1}] (/ normalized target between 0-1, with 1 expressing high status)	Proposed GES boundary for CyaBI [µg L^{-1}] (/ normalized target between 0-1, with 1 expressing high status)
SEA-001	Kattegat	No suitable data currently available	No suitable data currently available	
SEA-002	Great Belt	No suitable data currently available	No suitable data currently available	
SEA-003	The Sound	No suitable data currently available	No suitable data currently available	
SEA-004	Kiel Bay	No suitable data currently available	Developed if needed	
SEA-005	Bay of Mecklenburg	No suitable data currently available	Developed if needed	
SEA-006	Arkona Sea	Under progress	Under progress	
SEA-007	Bornholm Sea	Under progress	Under progress	
SEA-008	Gdansk Basin	Under progress	No suitable data currently available	
SEA-009	Eastern Gotland Basin	0.84	127 / 0.84	
SEA-010	Western Gotland Basin	0.87	No suitable data currently available	
SEA-011	Gulf of Riga	Under progress	Under progress	
SEA-012	Northern Baltic Proper / Landsort deep	0.77	90 / 0.77	
SEA-013	Gulf of Finland	0.96	218 / 0.83	
SEA-014	Åland Sea	Under progress	No suitable data currently available	
SEA-015	Bothnian Sea	Under progress	Under progress	
SEA-016	The Quark	Not relevant for indicator	No suitable data currently available	
SEA-017	Bothnian Bay	Not relevant for indicator	Not relevant for indicator	

Taking into account the role of long-term change in hydrography

Aside form the effect of increased nutrients, especially phosphorus, the increase of cyanobacteria is affected by water temperature. The formation of surface accumulations is affected by other hydrographical parameters as well. It is thus clear, that the indicator is targeted not only by eutrophication-related pressures (in terms of nutrient increase), but also other, even non-anthropogenic pressures.

This is not an uncommon aspect among eutrophication indicators. The aspect is suggested to be taken into account when setting the indicator weights in the eutrophication status assessment produced by HEAT 3.0. HELCOM IN-Eutrophication is responsible for proposing indicator weights, based on scientific information on the ecology of the indicator parameters and the sub-basins.

Indicator update

Satellite-based information will be updated by SYKE, and reported to ICES.

The biomass information will be updated by the PEG-group and updated to ICES. Also a separate environmental fact sheet will be produced.

The information reported to ICES will be included into the EUTRO-OPER information and data flow.

References

Anttila S, Fleming-Lehtinen V, Attila J, Junttila S, Hällfors H, 2016. A novel ecological indicator for cyanobacterial blooms. Manuscript.

Kahru, M. & Elmgren, R. (2014). Satellite detection of multi-decadal time series of cyanobacteria accumulations in the Baltic Sea. Biogeosciences Discussions, 11, 3319-3364.

Wasmund N, Busch S, Göbel J, Gromisz S, Höglander H, Jaanus A, Johansen M, Jurgensone I, Karlsson C, Kownacka J, Kraśniewski W, Lehtinen S, Olenina I, v. Weber M, 2015. Cyanobacteria biomass. HELCOM Baltic Sea Environment Fact Sheet 2015, Published 18 September 2015. http://helcom.fi/baltic-sea-trends/environment-fact-sheets/eutrophication/cyanobacteria-biomass/

Annexes

ANNEX 1. Cyanobacterial surface accumulations; indicator report for HELCOM pre-core indicator.