HELCOM INDICATORS

HELCOM core indicator report
July 2017

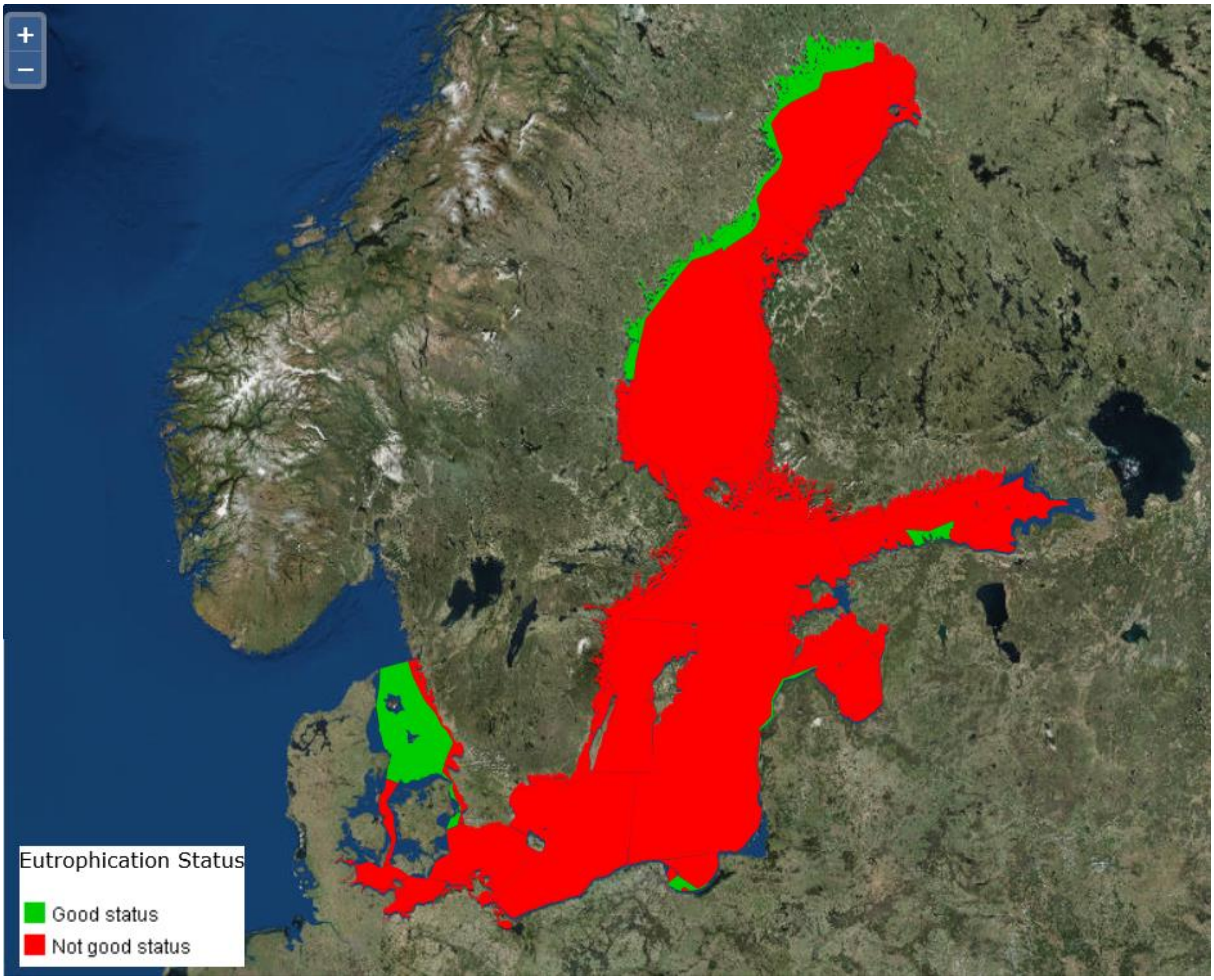
Water clarity

Key Message

The core indicator evaluates water clarity by average Secchi depth during summer (June – September) during 2011-2015.

In open sea areas, good status (Secchi depth above defined threshold value, which reflect good conditions) for water clarity has been achieved in the Kattegat and The Sound. In coastal waters, good status has only been achieved in some water bodies along the coasts of Sweden, Poland, Latvia and Estonia.

During the last century, summer-time water clarity has decreased in all Baltic Sea areas. During the last two decades, water clarity has increased in the southern Baltic Sea sub-basins.



Key message figure 1: Status assessment results based evaluation of the indicator 'Water clarity'. The assessment is carried out using Scale 4 HELCOM assessment units (defined in the HELCOM Monitoring and Assessment Strategy Annex 4).

The confidence of the presented water clarity status estimate was based on the availability of monitoring data and the confidence of the target-setting procedures. The areas of greatest concern are the Quark and Åland Sea, where indicator confidence was determined low. **High** confidence was found in the Bothnian Bay and the Northern Baltic Proper. In the remaining open-sea basins, the indicator confidence was **moderate**.

The indicator is applicable in the waters of all countries bordering the Baltic Sea.

Relevance of the core indicator

Eutrophication is caused by excessive inputs of nutrients (nitrogen and phosphorus) resulting from various human activities. High concentrations of nutrients and their ratios form the preconditions for algal blooms, reduced water clarity and increased oxygen consumption. Water clarity is affected by the light attenuation of the media, caused mainly by water itself, planktonic organisms, especially phytoplankton, suspended particulate matter, colored dissolved organic matter (CDOM) and inorganic compounds. Phytoplankton is the dominating optical constituent in most oceanic waters, whereas in the Baltic Sea, especially the north-eastern parts, a considerable share of the attenuation is caused by CDOM, which is to a large extent not related to increased nutrient loading. Though water clarity responds strongly to eutrophication, it may in some areas express a non-eutrophication-related signal. Long-term nutrient data are key parameters for quantifying the effects of anthropogenic activities and evaluating the success of measures undertaken.

Policy relevance of the core indicator

	BSAP Segment and Objectives	**MSFD Descriptors and Criteria**
Primary link	Baltic Sea unaffected by eutrophication	D5 Human-induced eutrophication - D5C4 The photic limit (transparency) of the water column is not reduced, due to increases in suspended algae, to a level that indicates adverse effects of nutrient enrichment
Secondary link		
Other relevant legislation: EU Water Framework Directive		

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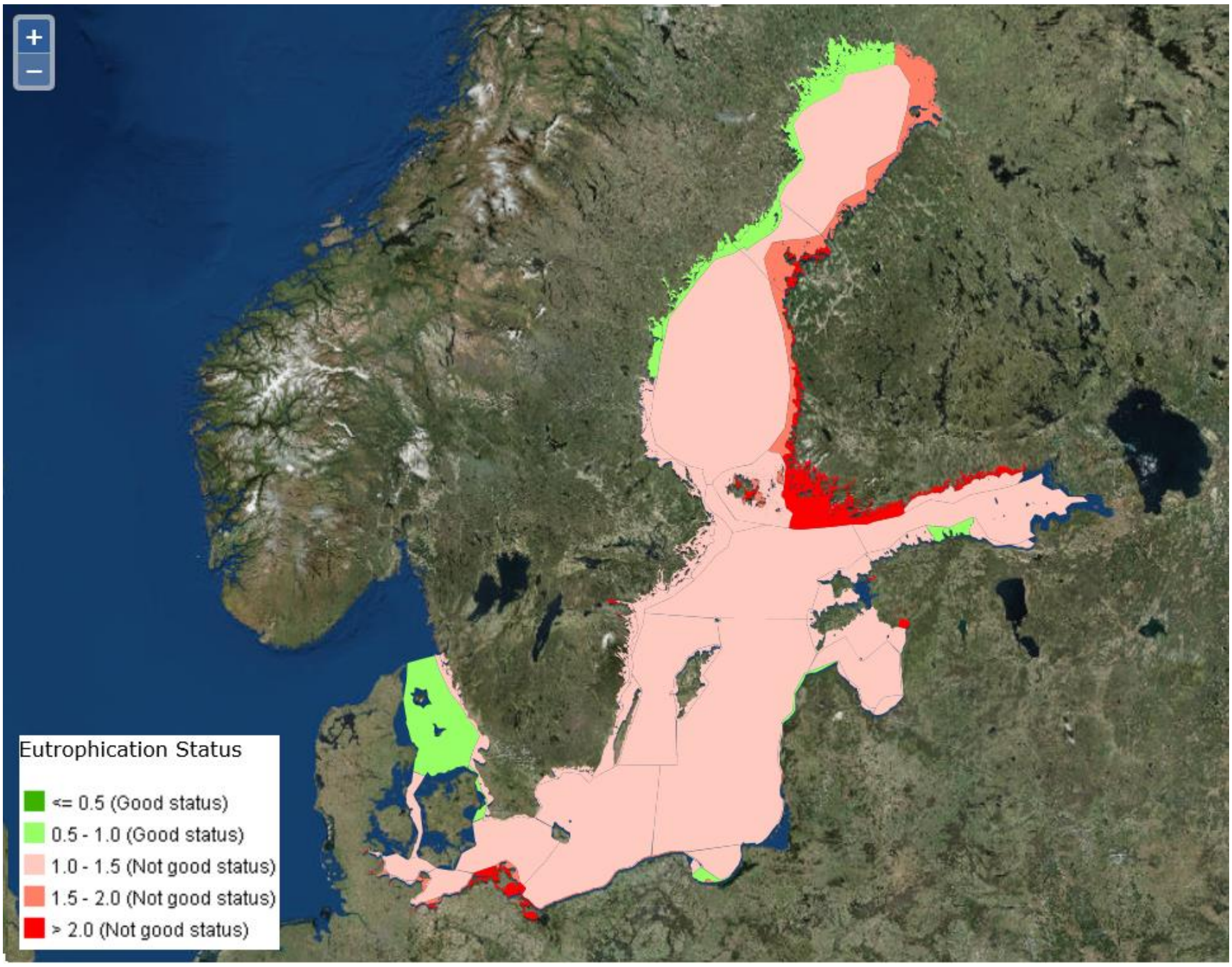
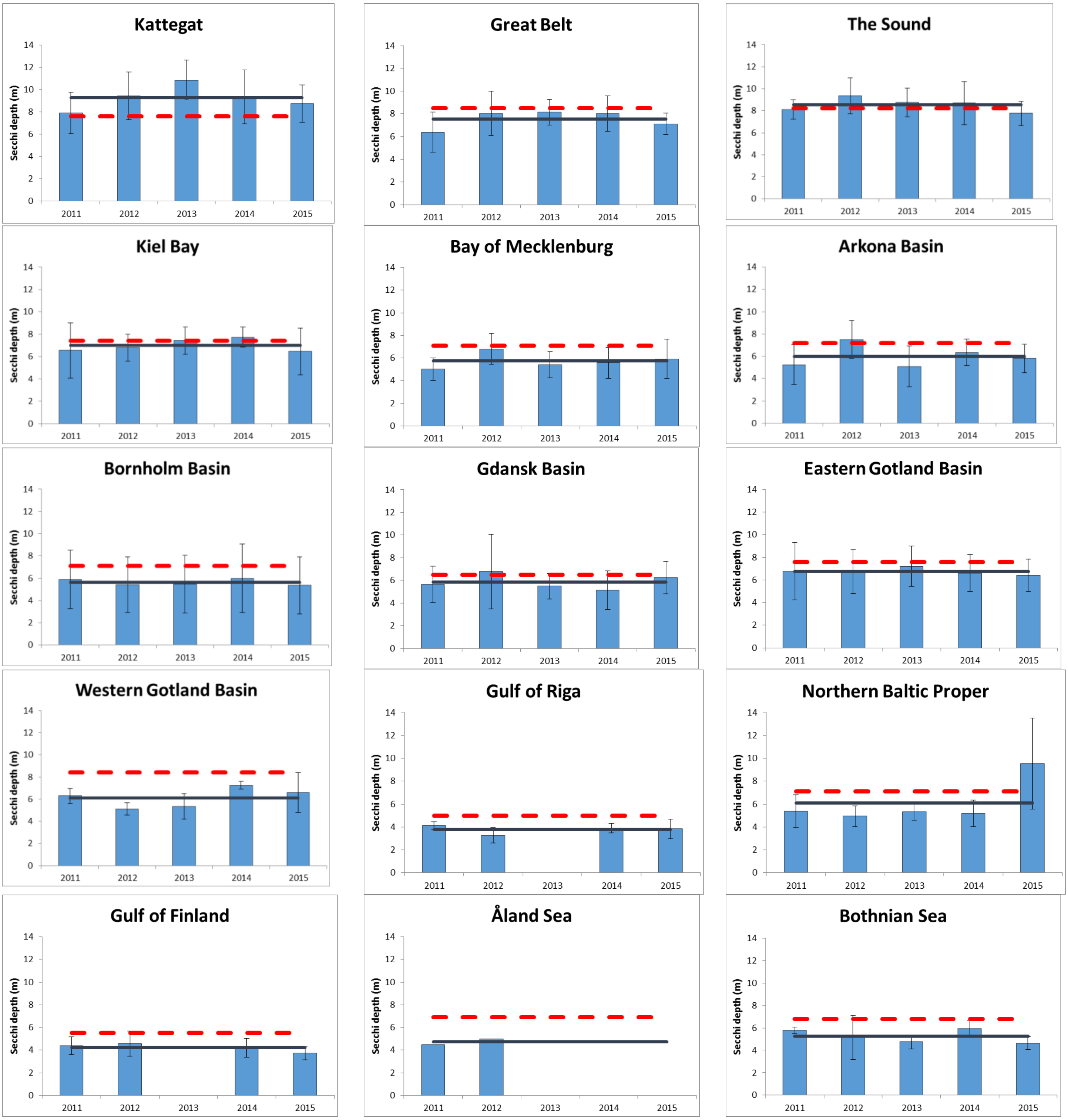
Results and Confidence

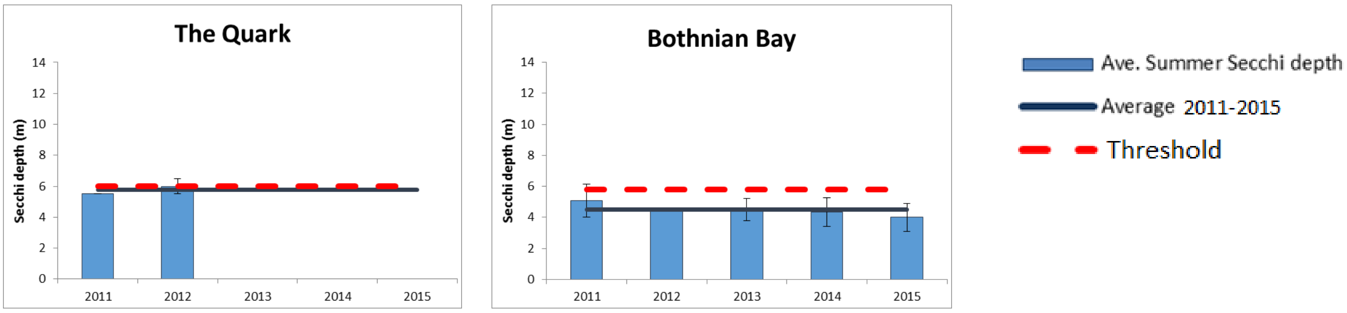
Current status of water clarity

In open sea areas, good status (Secchi depth above defined threshold value, which reflects good conditions) for water clarity has been achieved in the Kattegat and The Sound. In coastal waters, good status has only been achieved in some water bodies along the coasts of Sweden, Poland, Latvia and Estonia.



Results figure 1. Status of the water clarity indicator, presented as eutrophication ratio (ER). ER shows the present water clarity condition in relation to the threshold value, increasing along with increasing eutrophication. The threshold value is ER ≤ 1.00.


Kattegat
Great Belt
The Sound
Kiel Bay
Bay of Mecklenburg
Arkona Basin
Bornholm Basin
Gdansk Basin
Eastern Gotland Basin
Western Gotland Basin
Gulf of Riga
Northern Baltic Proper
Gulf of Finland
Åland Sea
Bothnian Sea
Secchi depth (m)
0
2
4
6
8
10
12
14
2011
2012
2013
2014
2015



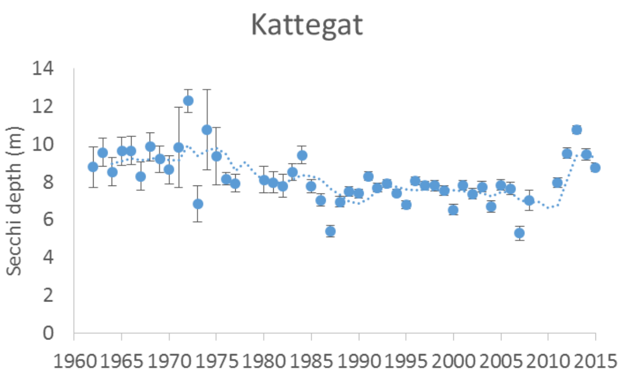
Results figure 2. Summer (June-September) Secchi depth (black line; average for years 2011-2015) and threshold value as agreed by HELCOM HOD 39/2012 (red broken line).

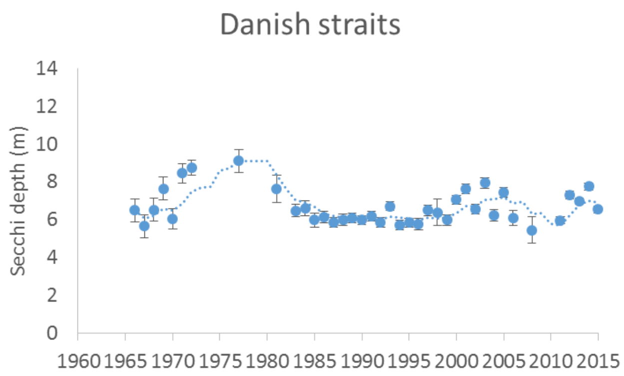
Results table 1. Threshold values, present concentration (as average 2011-2015), eutrophication ratio (ER) and status of Secchi depth in the open-sea basins. ER is a quantitative value for the level of eutrophication, calculated as the ratio between the threshold value and the present concentration – when ER > 1, good status has not been reached.

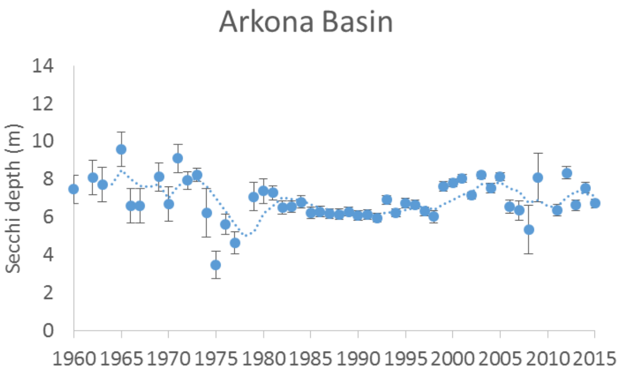
Sub-basin	Target (m)	Average 2011-2015 (m)	Eutrophication ratio, ER	Status (fail/achieve threshold value)
Kattegat	7.60	9.27	0.82	achieve
Great Belt	8.50	7.54	1.13	fail
The Sound	8.20	8.48	0.97	achieve
Kiel Bay	7.40	6.99	1.06	fail
Bay of Mecklenburg	7.10	5.74	1.24	fail
Arkona Basin	7.20	6.00	1.20	fail
Bornholm Basin	7.10	5.63	1.26	fail
Eastern Gotland Basin	7.60	6.71	1.13	fail
Gdansk Basin	6.50	5.85	1.11	fail
Western Gotland Basin	8.40	6.12	1.37	fail
Northern Baltic Proper	7.10	6.08	1.17	fail
Gulf of Riga	5.00	3.79	1.32	fail
Gulf of Finland	5.50	4.21	1.31	fail
Aland Sea	6.90	4.75	1.45	fail
Bothnian Sea	6.80	5.25	1.30	fail
The Quark	6.00	5.75	1.04	fail
Bothnian Bay	5.80	4.48	1.29	fail

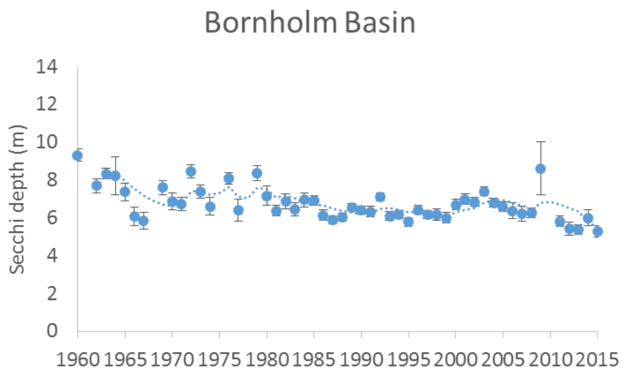
Long-term trends

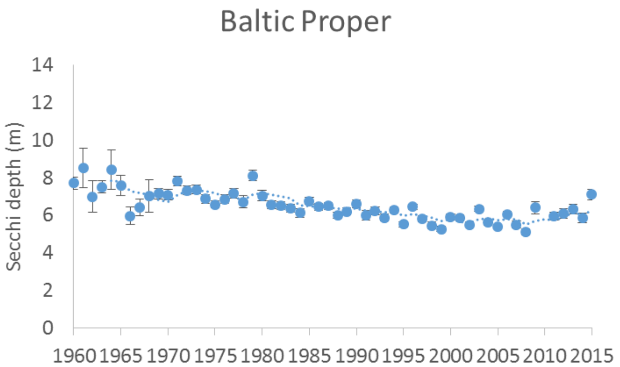
Decrease in summer time water clarity has been observed in all Baltic sub-regions over the last one hundred years. The decrease has been most pronounced in the northern Baltic Proper (from 9 m to 5.5 m) and the Gulf of Finland (from 8 m to 4.8 m). More recent decreases – over the past 25 years – have been most pronounced in the Western Gotland Basin, Northern Baltic Proper, Gulf of Riga and Gulf of Finland. On the other hand, in the Kattegat, Danish Straits, Arkona Basin, Bornholm Basin and Eastern Gotland Basin, the decreasing trend has ceased during the past 20 years and since then the water clarity has remained at about the same level. In the Arkona Sea and Bornholm Sea the water clarity has increased slightly during the last two decades (Figure, BSEP 133, Fleming-Lehtinen et al. 2012).

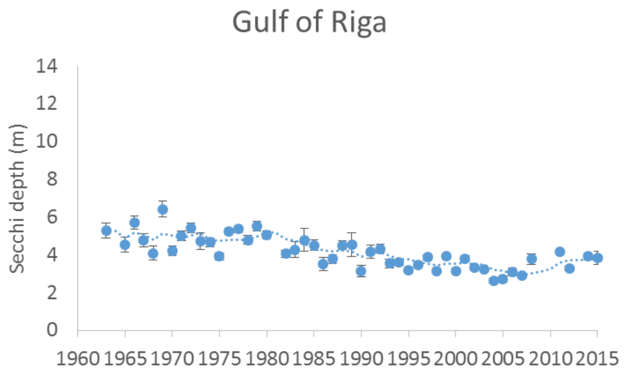

Kattegat
Secchi depth (m)
0 2 4 6 8 10 12 14
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015

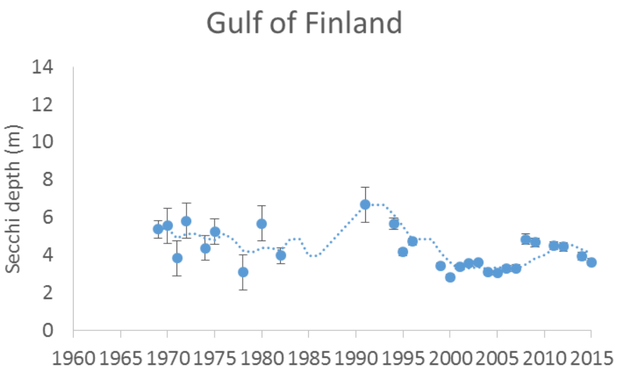

Danish straits
Secchi depth (m)
0 2 4 6 8 10 12 14
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015

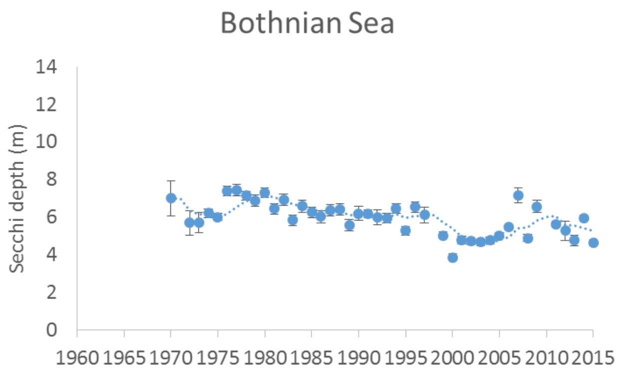

Arkona Basin
Secchi depth (m)
0 2 4 6 8 10 12 14
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015

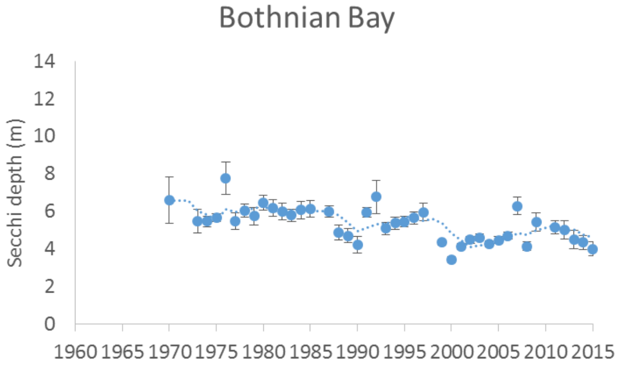

Bornholm Basin
Secchi depth (m)
0 2 4 6 8 10 12 14
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015


Baltic Proper
Secchi depth (m)
0 2 4 6 8 10 12 14
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015


Gulf of Riga
Secchi depth (m)
0 2 4 6 8 10 12 14
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015


Gulf of Finland
Secchi depth (m)
0 2 4 6 8 10 12 14
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015

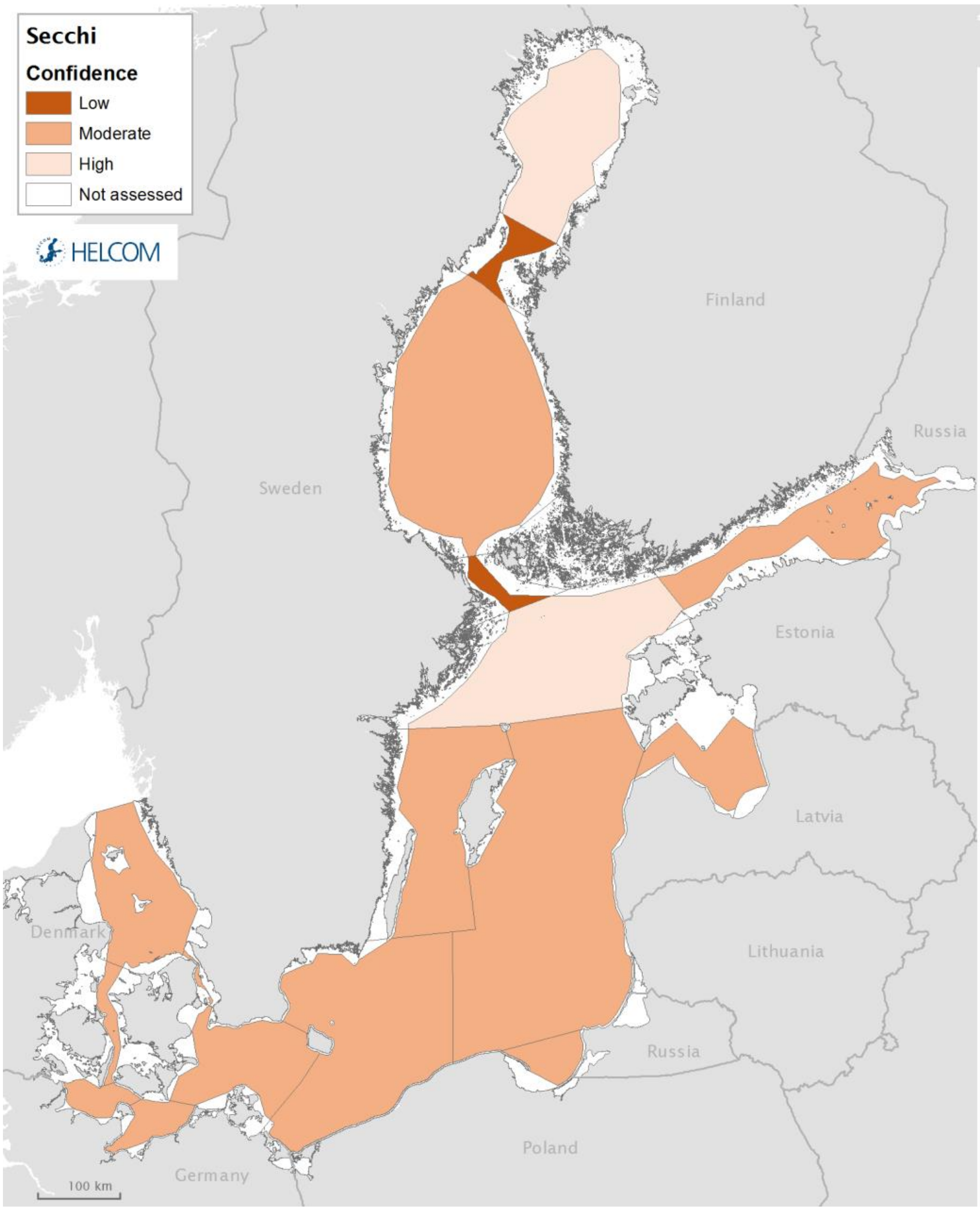

Bothnian Sea
Secchi depth (m)
0 2 4 6 8 10 12 14
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015



Results figure 3. Temporal development of water clarity (Secchi depth) in summer in nine of the sub-basins.

Confidence of the indicator status evaluation

The confidence of the indicator status estimate, based on the spatial and temporal coverage of data as well as the accuracy of the target-setting protocol, was not adequate in all sub-basins. The areas of greatest concern are the Quark and Åland Sea, where indicator confidence was determined *low*. *High* confidence was found in the Bothnian Bay and the Northern Baltic Proper. In the remaining open-sea basins, the indicator confidence was *moderate*.

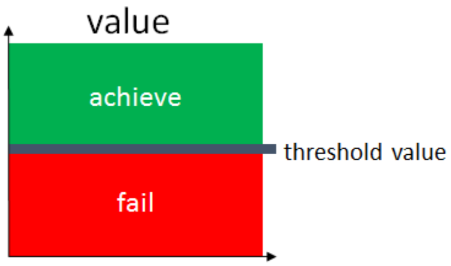


Results figure 4. Indicator confidence, determined combining information on data availability and the accuracy of the target-setting protocol. Low indicator confidence calls for increase in monitoring.

The indicator confidence was estimated through confidence scoring of the target (ET-Score) and the indicator data (ES-Score). The ET-Score was rated based on the uncertainty of the target setting procedure. The ES-Score is based on the number as well as spatial and temporal coverage of the observations for the assessment period 2011-2015. To estimate the overall indicator confidence, the ET- and ES-Scores were combined. See Andersen et al. (2010) and Fleming-Lehtinen et al. (2015) for further details.

Good Environmental Status

Good environmental status is measured in relation to scientifically based and commonly agreed sub-basin-wise threshold value, which defines the concentration that should not be exceeded (Good Environmental Status figure 1).



Good environmental status figure 1. Schematic representation of the threshold value applied in the water clarity core indicator, the threshold values are assessment unit specific (see Good environmental status table 1).

These indicator threshold values were based on the results obtained in the TARGREV project (HELCOM 2013a), taking also advantage of the work carried out during the EUTRO PRO process (HELCOM 2009) and national work for EU WFD. The final threshold values were set through an expert evaluation process done by the intersessional activity on development of core eutrophication indicators (HELCOM CORE EUTRO) and the targets were adopted by the HELCOM Heads of Delegations 39/2012.

Good environmental status table 1. Assessment unit specific threshold values for the water clarity core indicator.

HELCOM_ID	**Assessment unit (open sea)**	**Threshold value Secchi depth, m)**
SEA-001	Kattegat	7.6
SEA-002	Great Belt	8.5
SEA-003	The Sound	8.2
SEA-004	Kiel Bay	7.4
SEA-005	Bay of Mecklenburg	7.1
SEA-006	Arkona Sea	7.2
SEA-007	Bornholm Sea	7.1
SEA-008	Eastern Gotland Basin	7.6
SEA-009	Gdansk Basin	6.5
SEA-010	Western Gotland Basin	8.4
SEA-011	Northern Baltic Proper	7.1
SEA-012	Gulf of Riga	5.0
SEA-013	Gulf of Finland	5.5
SEA-014	Åland Sea	6.9
SEA-015	Bothnian Sea	6.8
SEA-016	The Quark	6.0
SEA-017	Bothnian Bay	5.8

Assessment Protocol

The open-sea core indicators are updated using data reported by Contracting Parties to the HELCOM COMBINE database hosted by ICES, using the algorithms developed for the eutrophication assessment work flow. The oxygen debt indicator is currently an exception to this, and reported as ready indicator products. The values are achieved using indicators specifications shown in Assessment protocol table 1 (see HELCOM Eutrophication assessment manual).

Assessment protocol table 1. Specifications of the core indicator Secchi depth.

Indicator	Secchi depth
Response to eutrophication	negative
Parameters	Secchi depth (m)
Data source	Monitoring data provided by the HELCOM Contracting Parties, and kept in the HELCOM COMBINE database, hosted by ICES (www.ices.dk)
Assessment period	June 2011 – September 2015
Assessment season	Summer = June + July + August + September
Depth	-
Removing outliers	No outliers removed
Removing close observations	No close observations removed
Indicator level	average of yearly average values
Eutrophication ratio (ER)	ER = ET / ES
Status confidence (ES-Score)	LOW (=0%), if no more than 5 annual status observations are found during one or more years. MODERATE (=50%), if more than 5 but no more than 15 status observations are found per year. HIGH (=100%), if more than 15 spatially non-biased [to be specified what this means…] status observations are found each year.
Indicator target confidence (ET-Score)	HIGH
Indicator confidence (I-Score)	Confidence (%) = average of ES-Score and ET-Score

The indicators within the criteria were weighted according to their relevance for eutrophication in each sub-basin. The weight was evenly distributed within the criterion, unless there was a justification to do otherwise. For Secchi depth, the weight was assigned according to the available information on the light absorption by colored dissolved organic matter (CDOM) and the relationship between CDOM absorption and chlorophyll a concentration in the sub-basin (Assessment protocol table 2), respectively. The weight was distributed equally (no weight assigned) for most sub-basins but in the Gulf of Finland and especially in the Gulf of Bothnia Secchi depth received a reduced weight due to increased absorption of light by CDOM. This made Secchi depth a less reliable indicator of eutrophication, and therefore it received a smaller weight in those basins.

Assessment protocol table 2. Secchi depth and chlorophyll a have been weighted according to available information on CDOM absorption of light and the relationship between CDOM light absorption and chlorophyll a (chl-a) concentration in the sub-basin.

Basin	Reduction in Secchi weight	Justification (Ylöstalo et al. in prep., Stedmon et al. 2000)
Kattegat	-	
The Sound	-	Low CDOM absorption [1]
Great Belt	-	Low CDOM absorption [1]
Little Belt	-	Low CDOM absorption [1]
Kiel Bay	-	Assumed similar as in the Belts and Arkona Sea
Mecklenburg Bight	-	Assumed similar as in the Belts and Arkona Sea
Arkona Sea	-	Low CDOM absorption [2], medium in relation to chl-a
Bornholm Sea	-	Low CDOM absorption [2], medium in relation to chl-a
Eastern Gotland Basin	-	Assumed similar as in the Northern Baltic Proper
Western Gotland Basin	-	Low CDOM absorption [2], medium in relation to chl-a
Gdansk Basin	-	No info
Northern Baltic Proper	-	Medium CDOM absorption [2], medium in relation to chl-a
Gulf of Finland	-20 %	High CDOM absorption [2], medium in relation to chl-a
Gulf of Riga	-40 %	Extremely high CDOM absorption [2], high in relation to chl-a.
Åland Sea	-	Interpolated between Bothnian Sea and Northern Baltic Proper
Bothnian Sea	-20 %	Medium CDOM absorption [2], medium-high in relation to chl-a
Quark	-40 %	Interpolated between Bothnian Bay and Bothnian Sea
Bothnian Bay	-60 %	High CDOM absorption [2], extremely high in relation to chl-a.

Assessment units

The core indicator is applicable in the 17 open sea assessment units (from one nautical mile from the baseline seawards)

The assessment units are defined in the HELCOM Monitoring and Assessment Strategy Annex 4.

Relevance of the Indicator

Eutrophication assessment

The status of eutrophication is assessed using several core indicators. Each indicator focuses on one important aspect of the complex issue. In addition to providing an indicator-based evaluation of the water clarity, this indicator will also contribute to the overall eutrophication assessment along with the other eutrophication core indicators.

Policy relevance

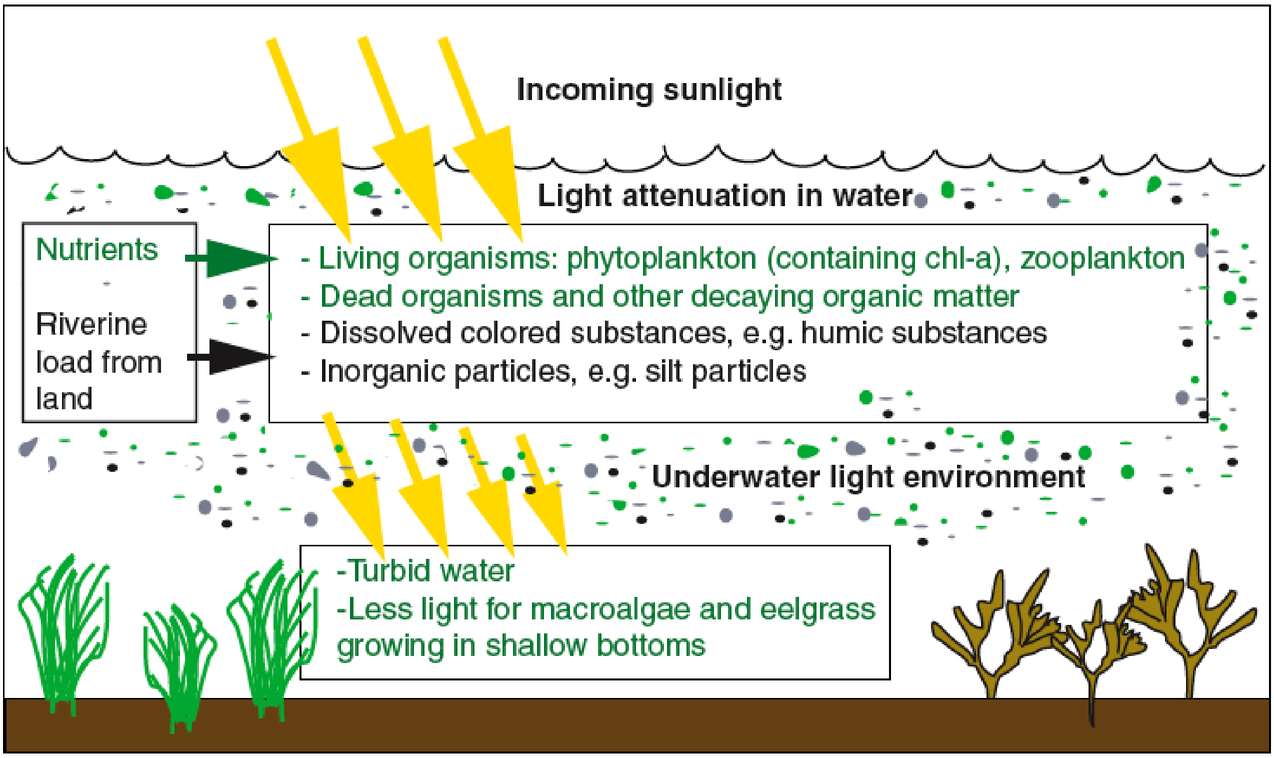
Eutrophication is one of the four thematic segments of the HELCOM Baltic Sea Action Plan (BSAP) with the strategic goal of having a Baltic Sea unaffected by eutrophication (HELCOM 2007). Eutrophication is defined in the BSAP as a condition in an aquatic ecosystem where high nutrient concentrations stimulate the growth of algae which leads to imbalanced functioning of the system. The goal for eutrophication is broken down into five ecological objectives, of which one is “clear water”, possible to assess using Secchi depth as a proxy.

The EU Marine Strategy Framework Directive (Anonymous 2008) requires that “human-induced eutrophication is minimized, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters” (Descriptor 5). ‘Photic limit (transparency) of the water column’ is listed as a criteria element for assessing the secondary criterion D5C4 ‘The photic limit (transparency) of the water column is not reduced, due to increases in suspended algae, to a level that indicates adverse effects of nutrient enrichment’..

The EU Water Framework Directive (Anonymous 2000) requires good ecological status in the European coastal waters. Good ecological status is defined in Annex V of the Water Framework Directive, in terms of the quality of the biological community, the hydromorphological characteristics and the chemical characteristics, including water clarity.

Role of water clarity in the ecosystem

Water clarity is affected mainly by the concentration of particles causing scattering of light therefore enhancing the light absorption. Light absorption is mainly due to water itself, chromophoric dissolved organic matter (CDOM), detritus and to phytoplankton. The concentration of detritus particles and CDOM is the result of organic matter accumulated over time due to high nutrient loadings and particular in the eastern Baltic Sea to a high natural contribution of humic materials from rivers draining peat land and forested areas. Eutrophication increases the attenuation, through nutrients increasing the amount of living organisms. Turbid waters affect the ecosystem through decrease in light availability below the surface.



Relevance figure 1. Simplified conceptual model for water clarity in the Baltic Sea.

Human pressures linked to the indicator

	General	MSFD Annex III, Table 2a
Strong link		Substances, litter and energy - Input of nutrients – diffuse sources, point sources, atmospheric deposition
Weak link		Substances, litter and energy - Input of organic matter – diffuse sources and point sources

Water clarity in the Baltic Sea is affected mainly by the concentration of phytoplankton and chromophorous dissolved organic matter (CDOM). Of these, phytoplankton concentration is directly linked to anthropogenic pressures, ie. nutrient increase.

Monitoring Requirements

Monitoring methodology

Monitoring of water clarity in the Contracting Parties of HELCOM is described on a general level in the **HELCOM Monitoring Manual in the sub-programme Nutrients.**

Monitoring guidelines specifying the sampling strategy are adopted and published.

Current monitoring

The monitoring activities relevant to the indicator that are currently carried out by HELCOM Contracting Parties are described in the HELCOM Monitoring Manual **Sub-programme sub-programme Nutrients:** Monitoring concepts table

Description of optimal monitoring

The regional monitoring effort is considered sufficient to support the indicator evaluation.

Data and updating

Access and use

The data and resulting data products (tables, figures and maps) available on the indicator web page can be used freely given that the source is cited. The indicator should be cited as following:

HELCOM (2017) Water clarity. HELCOM core indicator report. Online. [Date Viewed], [Web link].

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Metadata

Result: Water Clarity

Data source: The average for 2011-2015 was estimated using monitoring data provided by the HELCOM Contracting Parties, and kept in the HELCOM COMBINE database, hosted by ICES (www.ices.dk). Nominated members of HELCOM STATE & CONSERVATION group were given the opportunity to review the data, and to supply any missing monitoring observations, in order to achieve a complete dataset.

Description of data: The data includes secchi depth measurements explained in the HELCOM COMBINE manual.

Geographical coverage: The observations are distributed in the sub-basins according to the HELCOM COMBINE programme, added occasionally with data from research cruises.

Temporal coverage: The raw data includes observations throughout the year, during the assessment period 2011-2015.

Data aggregation: The 2011-2015 averages for each sub-basin were produced as an inter-annual summer (June – September) estimates.

Contributors and references

Contributors

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Archive

This version of the HELCOM core indicator report was published in July 2017:

HOLAS II component - Core indicator report – web-based version July 2017 (pdf)

Older versions of the core indicator report are available:

Core indicator report – June 2017 (pdf)

References

Stedmon, C.A., Markager, S., Kaas, H., 2000. Optical properties and signatures of chromophoric dissolved organic matter (CDOM) in Danish coastal waters. Estuarine, Coastal and Shelf Science 51, 267-278.

Ylöstalo, P., Seppälä, J., Kaitala, S., in prep. Spatial and seasonal variations in CDOM absorption and its relation to dissolved organic carbon and nitrogen concentrations in the Baltic Sea.

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