Dissolved inorganic phosphorus (DIP)

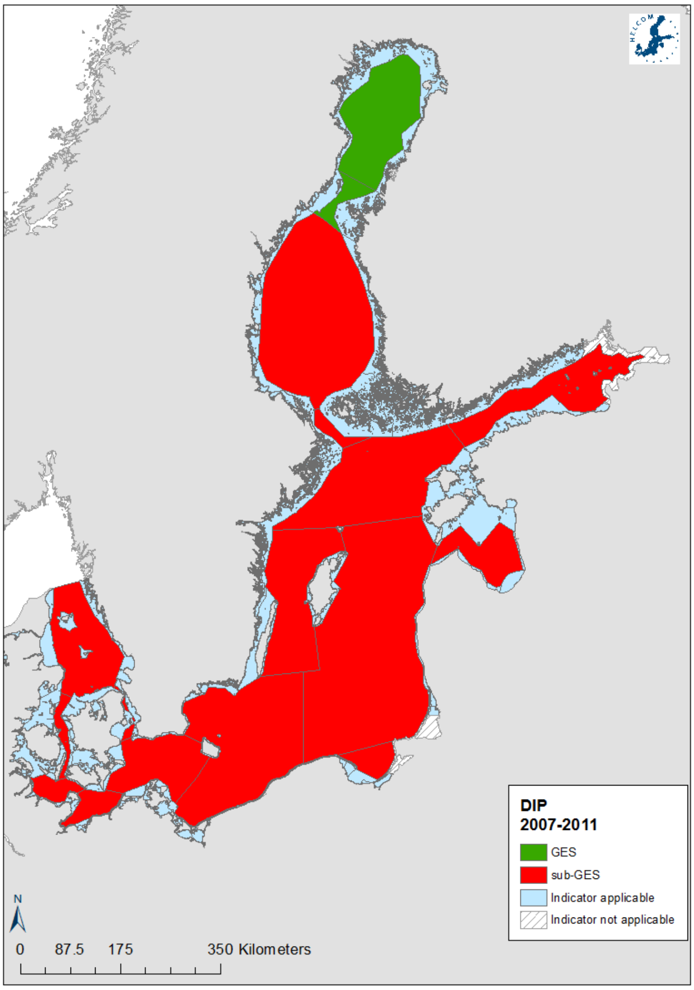
Key Message

Of 17 open-sea sub-basins, good environmental status (GES) for DIP has been achieved only in the Bothnian Bay and Quark.

Of the remaining 15 sub-basins, in the Kattegat, Danish Straits, Bothnian Sea, Bothnian Bay and Gulf of Riga, winter time turned to decrease since the 1980's or 1990's. In the Arkona Basin, Bornholm Basin and Gulf of Finland, DIP has continued to increase.

The confidence of the presented DIP status estimate is high in all 17 open sub-basins.

Average DIP concentration in the surface (0 – 10 m) during winter (December – February) (Open dynamic map viewer in new tab)



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 huge algal blooms, reduced water clarity and increased oxygen consumption. Long term nutrient data are key parameters for quantifying the effects of human activities and evaluating the success of measures undertaken. This core indicator focuses on one important aspect of the complex phenomenon, but does not alone assess the eutrophication status.

Policy relevance of the core indicator

	Primary importance	**Secondary importance**
BSAP segment and objective	A Baltic Sea unaffected by eutrophication	
MSFD descriptor and criteria	5.1. Nutrient levels	
Other relevant legislation	Water Framework Directive	

Cite this indicator

Pyhälä M, Fleming-Lehtinen V, Laamanen M, Łysiak-Pastuszak E, Carstens M, Leppänen J-M, Leujak W, Nausch G, 2014. Phosphorus status - HELCOM Core Indicator Report. Online. [Date Viewed], http://www.helcom.fi/baltic-sea-trends/indicators/phosphorus-dip

ISSN 2343-2543

Download full indicator report

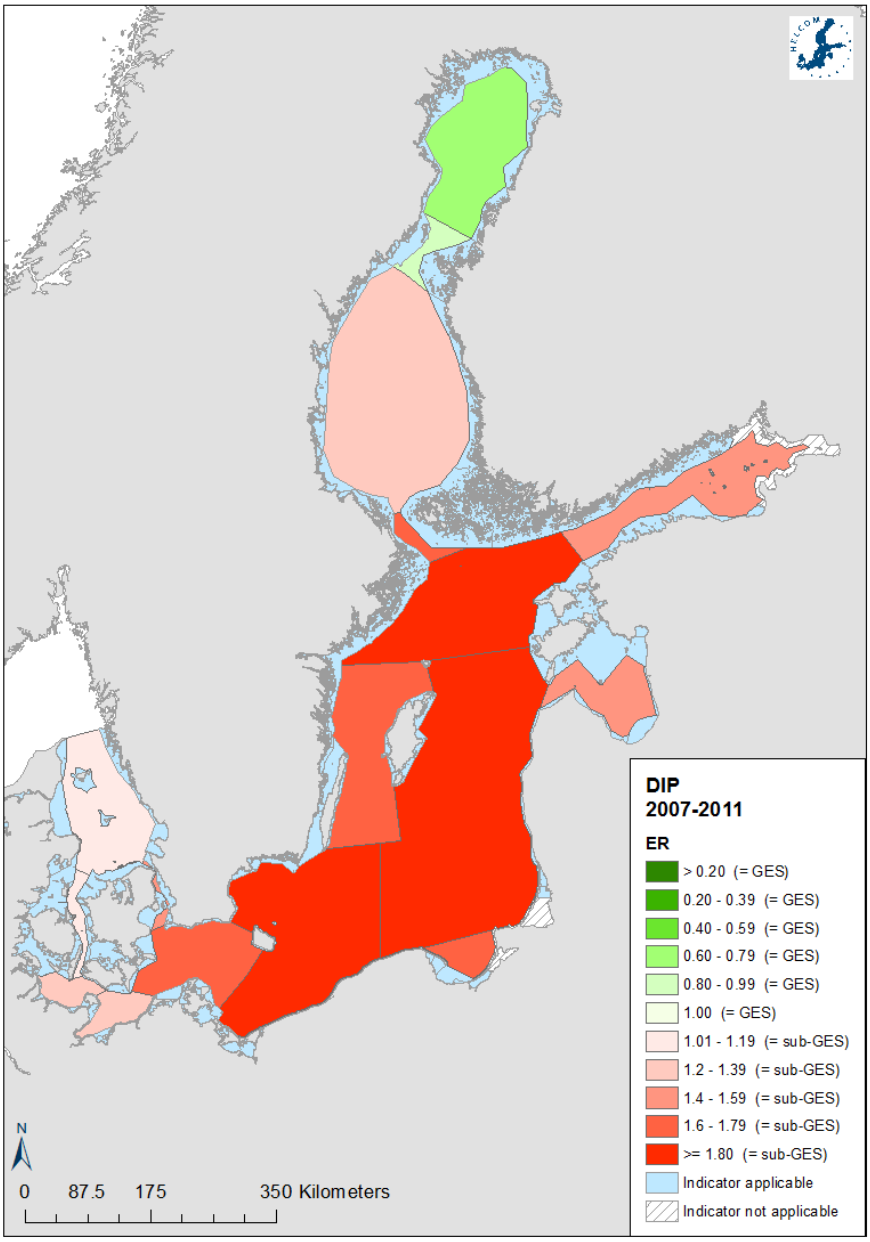
Core indicator – web version 2015 (pdf)

Results and Confidence

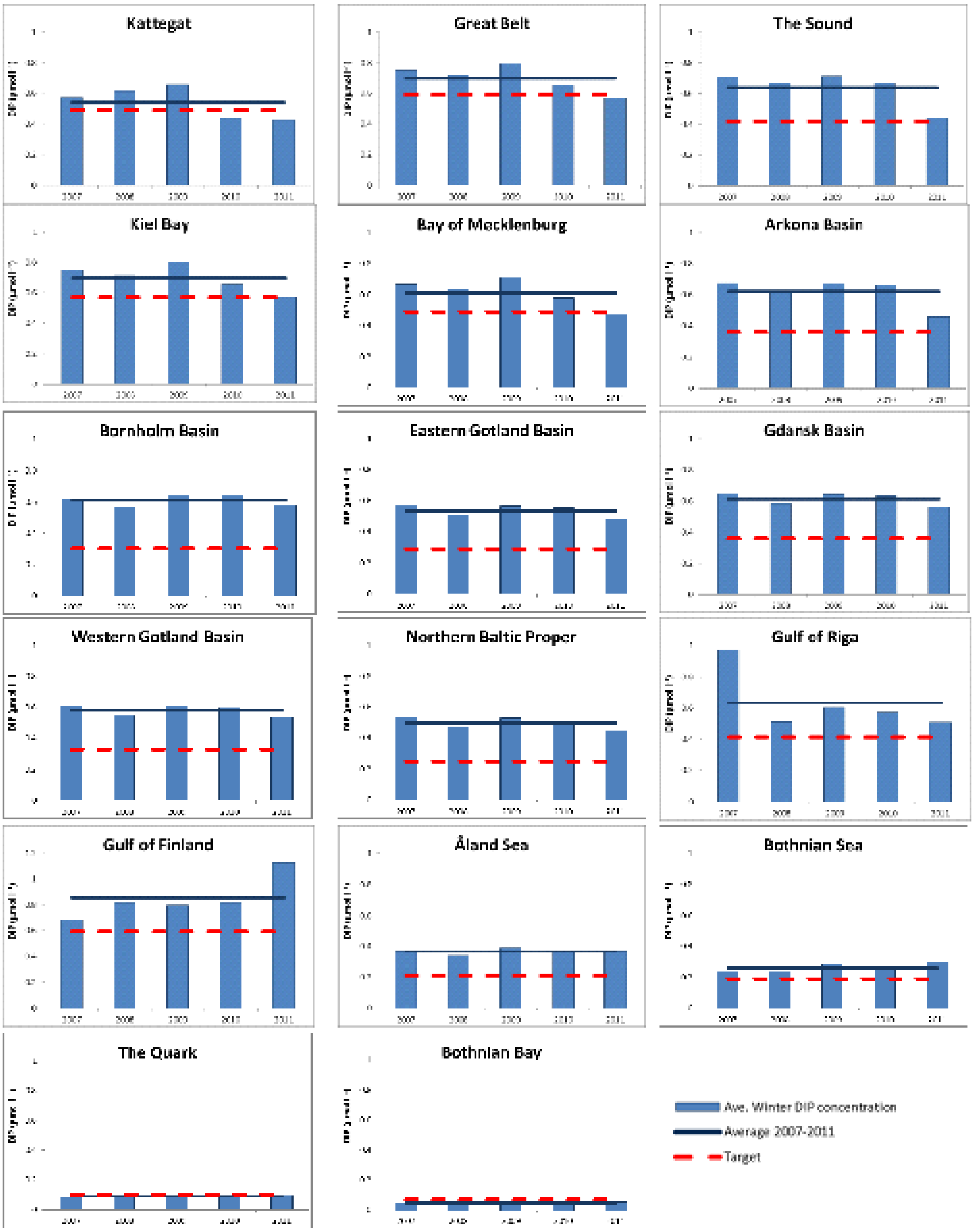
Current status of DIP

Of 17 open-sea sub-basins, good environmental status (GES) for phosphorus (DIP) has been achieved only in the Bothnian Bay and Quark.

The sub-basins causing greatest concern regarding phosphorus status are the Northern Baltic Proper, Eastern Gotland Basin and Arkona Basin. The status of Kattegat and Great Belt are only slightly below GES.



Results figure 1: Status of the phosphorus indicator, presented as eutrophication ratio (ER). ER shows the present concentration in relation to the GES boundary, increasing along with increasing eutrophication. The GES-boundary has been reached when ER ≤ 1.00.



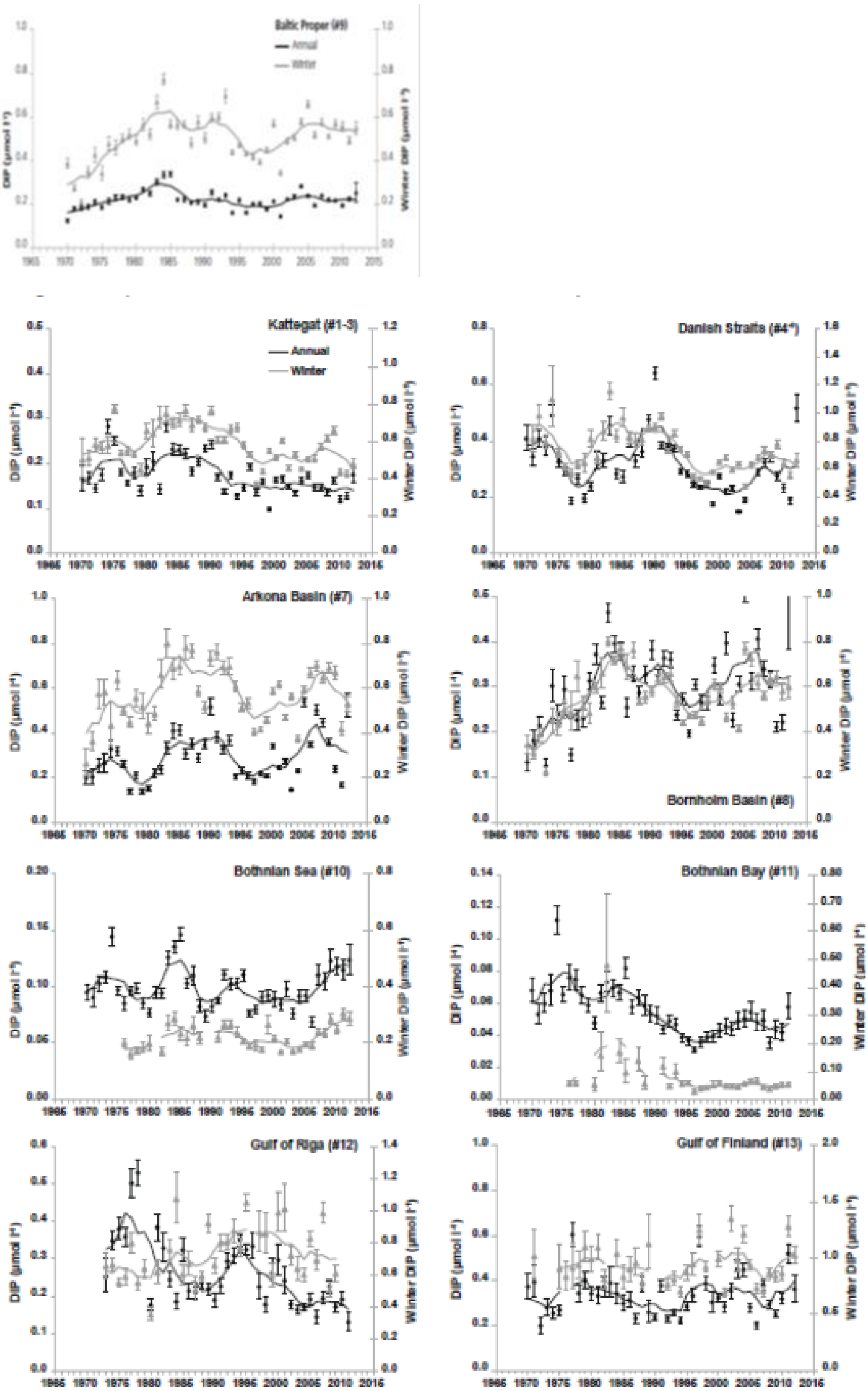
Results figure 2: Winter DIP concentrations (black line; average for 2007-2011) and target levels as agreed by HELCOM HOD 39/2012 (red broken line). Note the different scale in the graph for the Gulf of Finland.

Results Table 1: GES targets, present concentration (as average 2007-2011), eutrophication ratio (ER) and status of DIP in the open-sea basins. ER is a quantitative value for the level of eutrophication, calculated as the ratio between the GES target and the present concentration – when ER > 1, GES has not been reached.

Sub-basin	Target (µmol l^{-1})	Average 2007-2011 (µmol l^{-1})	Eutrophication ratio, ER	STATUS
Kattegat	0.49	0.54	1.104	SubGES
Great Belt	0.59	0.70	1.178	SubGES
The Sound	0.42	0.64	1.519	SubGES
Kiel Bay	0.57	0.70	1.226	SubGES
Bay of Mecklenburg	0.49	0.61	1.247	SubGES
Arkona Basin	0.36	0.62	1.719	SubGES
Bornholm Basin	0.30	0.61	2.023	SubGES
Eastern Gotland Basin	0.29	0.54	1.855	SubGES
Gdansk Basin	0.36	0.61	1.706	SubGES
Western Gotland Basin	0.33	0.58	1.761	SubGES
Northern Baltic Proper	0.25	0.50	1.992	SubGES
Gulf of Riga	0.41	0.63	1.544	SubGES
Gulf of Finland	0.59	0.85	1.439	SubGES
Aland Sea	0.21	0.37	1.743	SubGES
Bothnian Sea	0.19	0.26	1.374	SubGES
The Quark	0.10	0.09	0.890	GES
Bothnian Bay	0.07	0.05	0.643	GES

Long-term trends

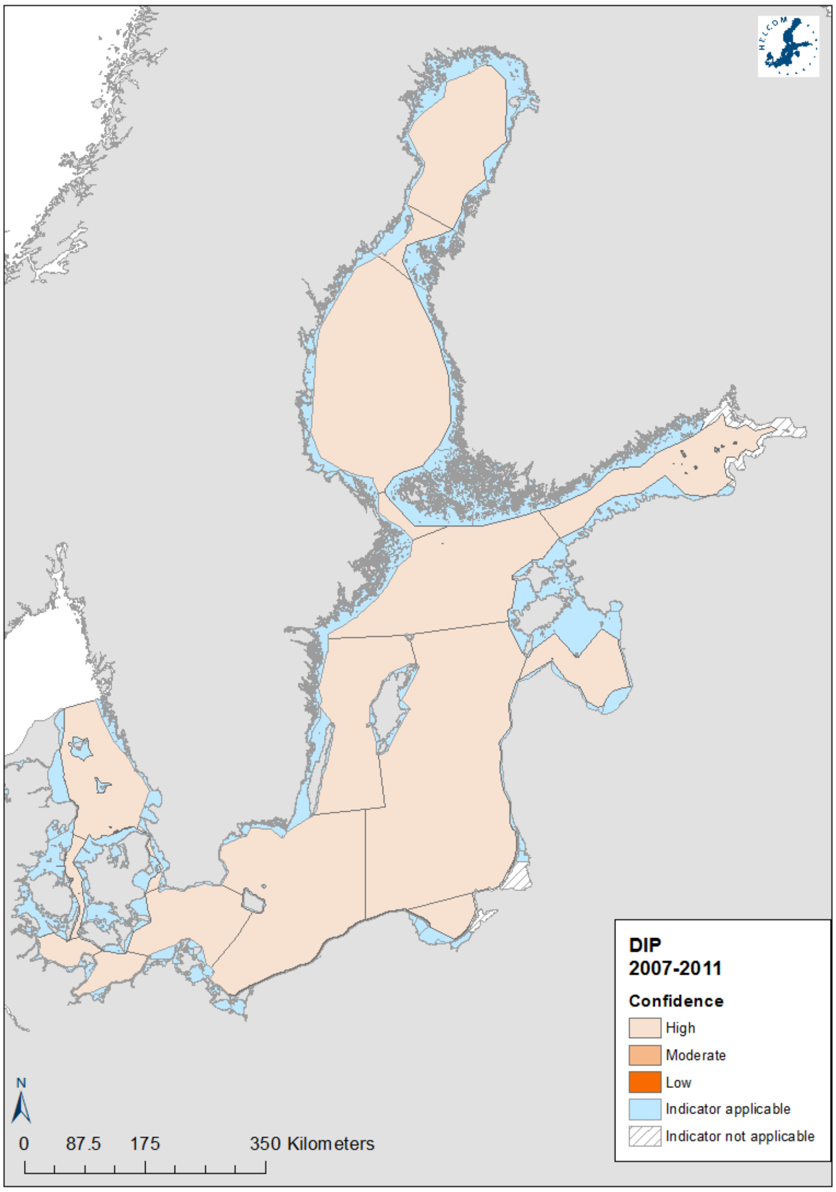
For the eastern Gotland Basin, measurements reach back to the 1950s. Phosphate concentrations of around 0.20-0.25 µmol/l as found in this period are assumed to represent a period relatively unimpacted by anthropogenic activities disturbing the ecological balance of the open Baltic Sea. After the remarkable increase of phosphate in the 1960's and 1970's, concentrations of this nutrient remained on a high level with strong fluctuations as a result of mainly internal processes. Major Baltic Inflows (MBIs) are of great importance in this respect. After the MBIs of 1975/76, 1983 and 1993 lower phosphate concentrations in the subsequent years were measured whereas a comparable decrease after the MBI of 2003 could not be observed, indicating that the vertical transport through the permanent halocline is not sufficiently understood. The historicity of the inflow events and the seasons of MBIs as well as the intensity and depth of vertical mixing must be considered (Nausch et al. 2008; Reissmann et al. 2009).



Results figure 3: Long-term trend in annual (black) and winter (grey) DIP in the sub-basins (from BSEP 133). The spatial and seasonal patterns are separated across the years, using a GLM-GAM model according to Carstensen et al. 2006. Lines indicate the five-year moving average and error bars represent 95% confidence limits of the means.

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 *high* in all sub-basins.



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 2007-2011. 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 target levels.

These GES boundaries 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 WFD. The final targets 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.

HELCOM_ID	**Basin**	**Target (µmol l−1)**
SEA-001	Kattegat	0.49
SEA-002	Great Belt	0.59
SEA-003	The Sound	0.42
SEA-004	Kiel Bay	0.57
SEA-005	Bay of Mecklenburg	0.49
SEA-006	Arkona Sea	0.36
SEA-007	Bornholm Sea	0.30
SEA-008	Eastern Gotland Basin	0.29
SEA-009	Gdansk Basin	0.36
SEA-010	Western Gotland Basin	0.33
SEA-011	Northern Baltic Proper	0.25
SEA-012	Gulf of Riga	0.41
SEA-013	Gulf of Finland	0.59
SEA-014	Åland Sea	0.21
SEA-015	Bothnian Sea	0.19
SEA-016	The Quark	0.10
SEA-017	Bothnian Bay	0.07

Assessment Protocol

Eighteen open sea area sub-basins (at least one nautical mile seawards from the baseline) were assessed using the HEAT 3.0 tool according to the HELCOM division of the Baltic Sea. The assessment units for the indicator are the open Baltic Sea sub-basins (HELCOM 2013b).

The assessments of the open sea areas were based on an integration of state data from core set indicators on winter inorganic nitrogen (DIN) and phosphorus (DIP) concentrations, chlorophyll *a* concentrations, water transparency (Secchi depth) and oxygen conditions below halocline (oxygen debt, only for Bornholm Basin and Baltic Proper ["TARGREV data" distributed over the following sub-basins: Western and Eastern Gotland Basin, Gdansk Basin, Northern Baltic Proper and Gulf of Finland]).

The indicators were grouped under the following three "criteria" as described in the Commission Decision (2010/477/EU): 1. Nutrient levels, 2. Direct Effects, 3. Indirect Effects. The DIPN indicator is listed under Criteria 1: Nutrient levels.

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. In the Bothnian Bay and the Gulf of Riga, where phosphorus is clearly the limiting element for phytoplankton production, DIN and DIP were weighted to increase the effect of the phosphorus using the same proportional weight (33.3% and 66.7%, respectively) as in the previous thematic assessment of eutrophication (HELCOM 2009).

Relevance of the Indicator

Eutrophication assessment

The status of eutrophication is assessed using five core indicators. Each indicator focuses on one important aspect of the complex phenomenon. In addition to providing an indicator evaluation of the levels of inorganic phosphorus, this indicator will also contribute to the next overall eutrophication assessment to be completed in 2018 along with the other eutrophication core indicators.

Policy relevance

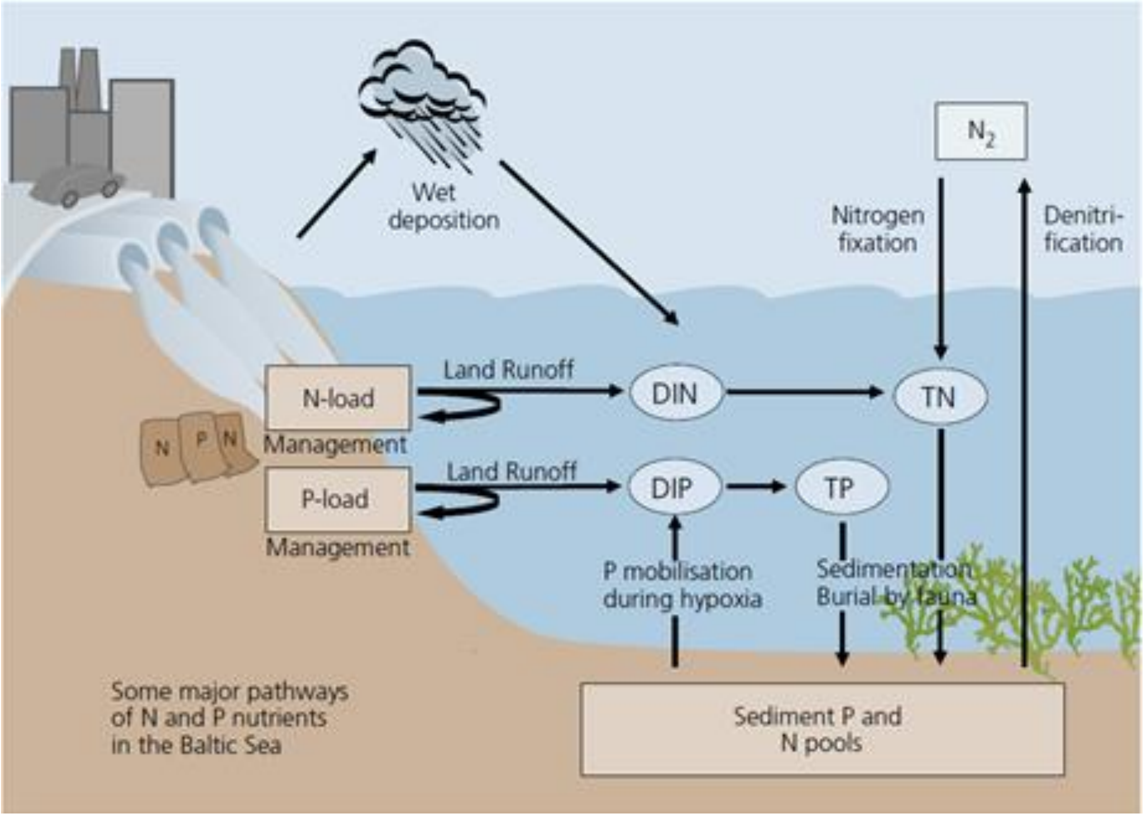
Eutrophication is one of the four thematic segments of the HELCOM Baltic Sea Action Plan (BSAP) with the strategic goal of having a Baltic Sea unaffected by eutrophication (HELCOM 2007). Eutrophication is defined in the BSAP as a condition in an aquatic ecosystem where high nutrient concentrations stimulate 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 "concentrations of nutrients close to natural levels".

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). "Nutrient levels" are determined as one of the three criteria for assessing eutrophication (criterium 5.1), and "nutrient concentration in the water column" is listed as an indicator for assessing the criterium.

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 Proposal, in terms of the quality of the biological community, the hydrological characteristics and the chemical characteristics, including nitrogen concentration.

Role of DIP in the ecosystem

Marine eutrophication is mainly caused by nutrient enrichment leading to increased production of organic matter supplied to the Baltic Sea with subsequent effects on water transparency, phytoplankton communities, benthic fauna and vegetation as well as oxygen conditions. Phytoplankton need nutrients, mainly nitrogen and phosphorus, for growth.



Relevance figure 1. Simplified conceptual model for N and P nutrients in the Baltic Sea, where DIN = Dissolved inorganic nitrogen, TN = Total nitrogen, DIP = Dissolved inorganic phosphorus and TP = Total phosphorus. Flows along arrows into the blue sea area tend to increase concentrations, and flows along arrows out from the sea act in the opposite direction. Management refers to nutrient load reductions.

Human pressures linked to the indicator

Nutrient concentrations in the water column are affected by increased anthropogenic nutrient loads from land and air.

Monitoring Requirements

Monitoring requirements

For assessment purposes, at least 15 observations should be conducted during the period December-February made every winter in each assessment unit. The compilation of observations is expected to be distributed spatially within the assessment unit in a non-biased way.

Gap in monitoring

Existing coordinated monitoring programme (HELCOM COMBINE manual) does not provide sufficient temporal coverage to achieve high confidence in the core indicator status estimate (BSEP143) during the assessment season.

HELCOM Monitoring manual

In the **HELCOM monitoring manual**, under **Hydrochemistry >> Sub-programme Nutrients**, see further information on:

Regional coordination

Purpose of monitoring

Monitoring concepts table

Assessment requirements

Data providers and access

References

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 (2015) Dissolved inorganic phosphorus (DIP). HELCOM core indicator report. Online. [Date Viewed], [Web link].

ISSN 2343-2543

Metadata

Data source: The average for 2007-2011 was estimated using monitoring data provided by the HELCOM Contracting Parties, and kept in the HELCOM COMBINE database, hosted by ICES (www.ices.dk), added with data from the Baltic Encironment Database, hosted by the Baltic Nest Institute (http://www.balticnest.org). Representatives of the Contracting Parties 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 the sum of *in-situ* PO_4 samples, determined using colorimetric methods, as explained in the HELCOM COMBINE manual. Measurements made at the depth of 0 – 10 m from the surface were used in the assessment.

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 they year, during the assessment period 2007-2011.

Data aggregation: The 2007-2011 averages for each sub-basin were produced as an inter-annual winter (December-February) estimates. These annual winter estimates determined from year-round data, using a GLM-GAM procedure to exclude spatio-temporal bias.

Arrangements for updating the indicator

For the 2007-2011 assessment, the data was collated during the HELCOM TARGREV project, reviewed by the HELCOM CORE EUTRO inter-sessional group and processed by Jacob Carstensen, BNI.

For update of future eutrophication assessments, the HELCOM EUTRO-OPER is concentrating in streamlining the process from data reporting to indicator and assessment update.

View data

View assessment data: assessment_data_2007-2011_DIP.xlsx

For raw data, contact ICES.

Contributors and references

Contributors

Vivi Fleming-Lehtinen and Minna Pyhälä, Secretariat of the Helsinki Commission

Maria Laamanen, Ministry of the Environment, Finland

Elżbieta Łysiak-Pastuszak, Institute of Meteorology and Water Management, National Research Institute, Poland

Marina Carstens, State Agency for Environment, Nature Protection and Geology Mecklenburg-Vorpommern, Germany

Juha-Markku Leppänen, Finnish Environment Institute, SYKE, Finland

Wera Leujak, German Federal Environment Agency, Germany

Günther Nausch, Leibniz Institute for Baltic Sea Research Warnemünde (IOW), Germany

Archive

This version of the HELCOM core indicator report was published in June 2015:

Core indicator – web version 2015 (pdf)

Older versions of the core indicator report are available:

Core indicator report – status 2003-2007 (pdf)

Additional relevant publications

Eutrophication status of the Baltic Sea 2007-2011 - A concise thematic assessment (2014)

Approaches and methods for eutrophication target setting in the Baltic Sea region (2013)

HELCOM core indicators. Final report of the HELCOM CORESET project (2013)

Eutrophication in the Baltic Sea. An integrated thematic assesment of the effects of nutrient enrichment in the Baltic Sea region (2009)

Development of tools for assessment of eutrophication in the Baltic Sea (2006)

HELCOM core indicator report,
ISSN 2343-2543