HELCOM INDICATORS

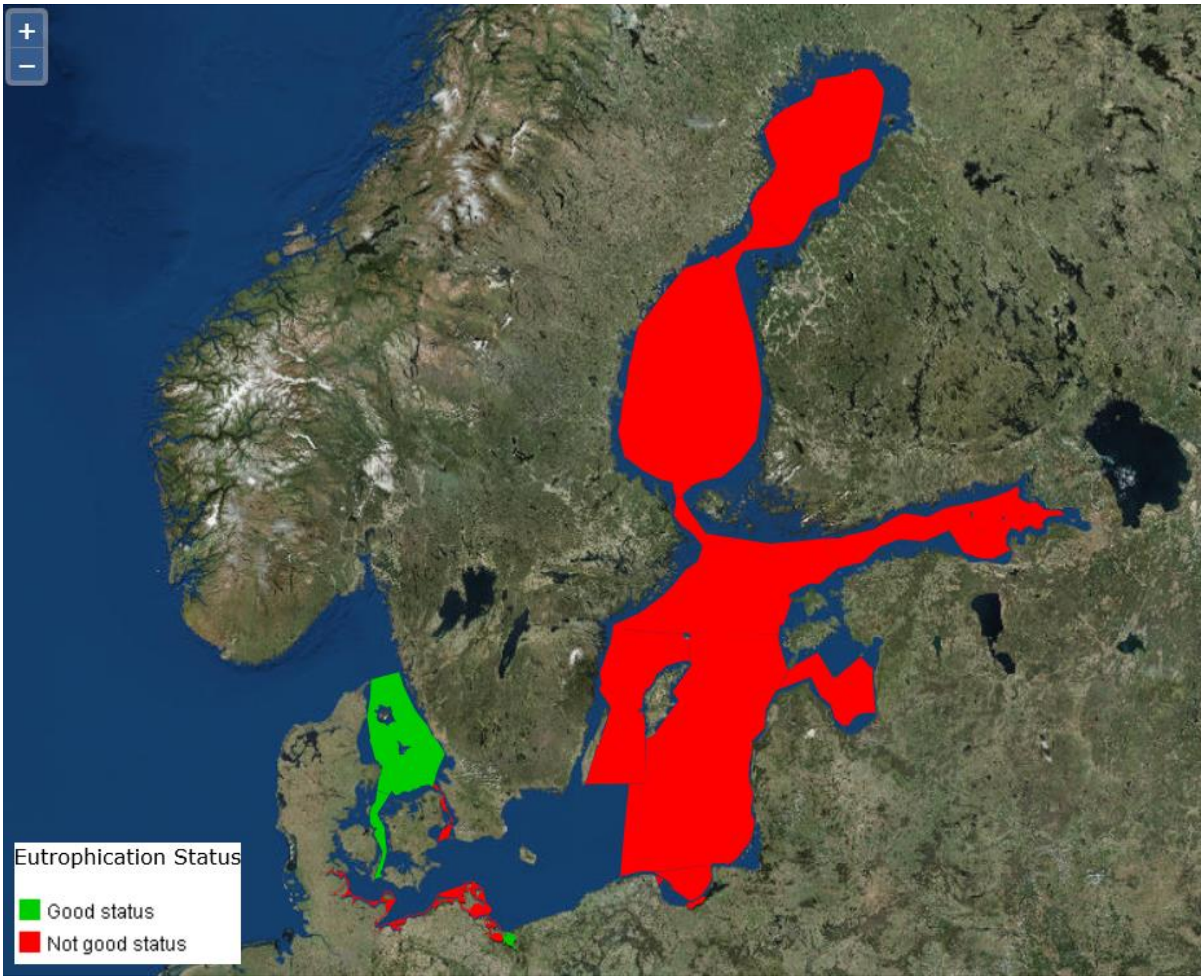
HELCOM core indicator report
July 2017

Total nitrogen

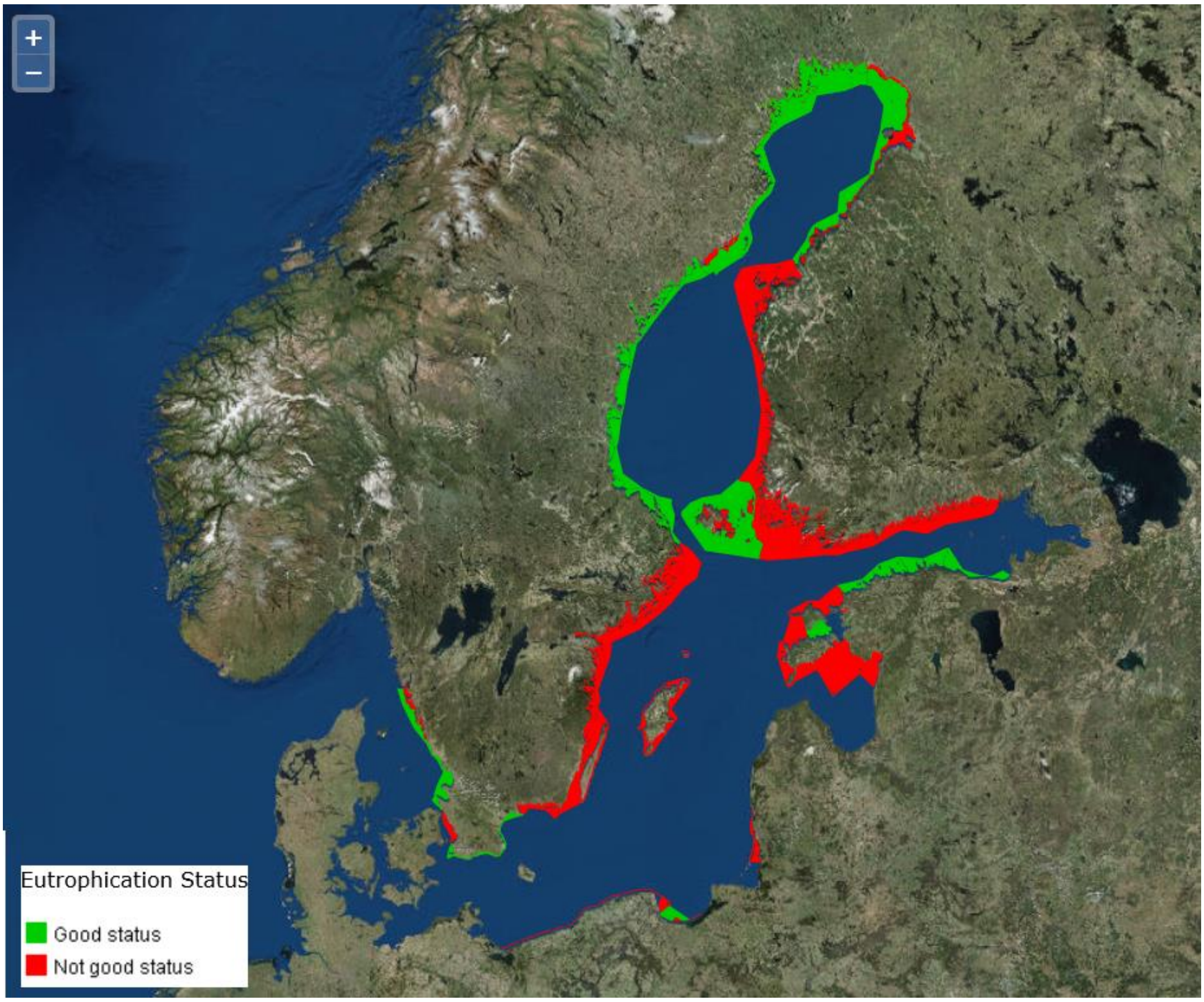
Key Message

For Total nitrogen, 13 open-sea assessment units were evaluated for the period 2011-2015, of which good status has been achieved only in Kattegat and Great Belt (total nitrogen concentration below defined threshold value).

In the majority of coastal water assessment units, the threshold values set for Total nitrogen were failed.



Key message figure 1: Status assessment results based on evaluation of the indicator 'Total nitrogen'. The assessment is carried out using Scale 4 HELCOM assessment units (defined in the HELCOM Monitoring and Assessment Strategy Annex 4). Please note that for some sub-basins threshold values are still under discussion and that only those coastal areas are shown in which the assessment is based on annual data (same as in the open-sea assessment). See key message figure 2 for other coastal areas.



Key message figure 2: Status assessment results based on evaluation of the indicator 'Total nitrogen' for coastal areas in which the summer concentrations (June-September) were used for assessment. The assessment is carried out using Scale 4 HELCOM assessment units (defined in the HELCOM Monitoring and Assessment Strategy Annex 4).

The indicator is applicable in all coastal and open sea assessment units. The indicator period and method of calculation varies between open-sea and coastal areas, and thus the threshold- or assessment concentrations are not directly comparable between the open-sea and coast, nor between all coastal assessment units where nationally binding threshold values may have been set.

The indicator is applicable in the waters of all countries bordering the Baltic Sea, though not operational in all assessment units yet as for some open-sea areas threshold values still need to be agreed upon.

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 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	A Baltic Sea unaffected by eutrophication	D5 Human-induced eutrophication - D5C1 Nutrient concentrations are not at levels that indicate adverse eutrophication effects
Secondary link	A favourable conservation status of Baltic Sea biodiversity	D1 Biological diversity of species and habitats Theme: Pelagic habitats -D1C6 The condition of the habitat type, including its biotic and abiotic structure and its functions, is not adversely affected due to anthropogenic pressures. Theme: Benthic habitats -D6C5 The extent of adverse effects from anthropogenic pressures on the condition of the habitat type, including alteration to its biotic and abiotic structure and its functions, does not exceed a specified proportion of the natural extent of the benthic habitat type in the assessment area.
Other relevant legislation: Water Framework Directive, ecological status, QE4		

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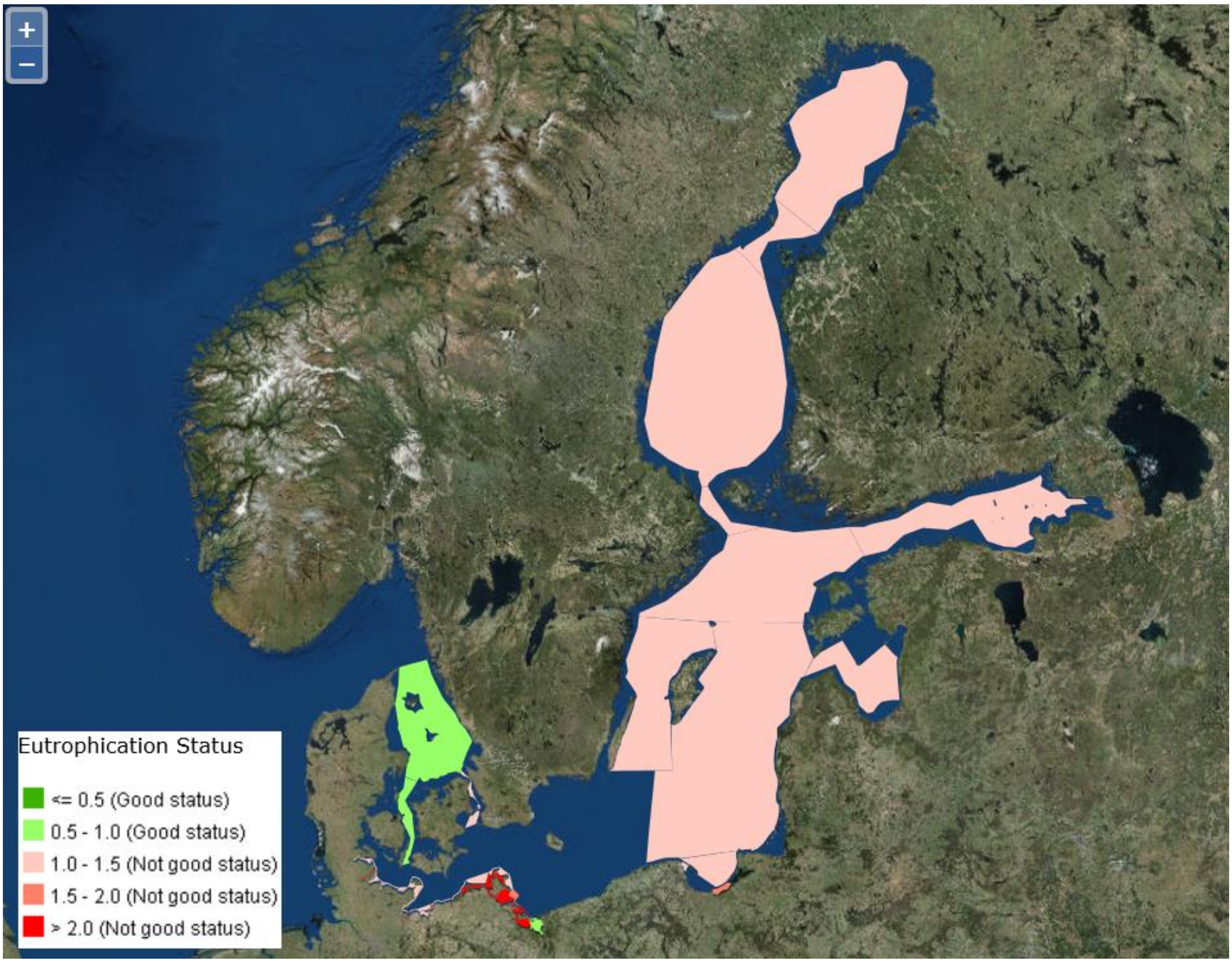
Results and Confidence

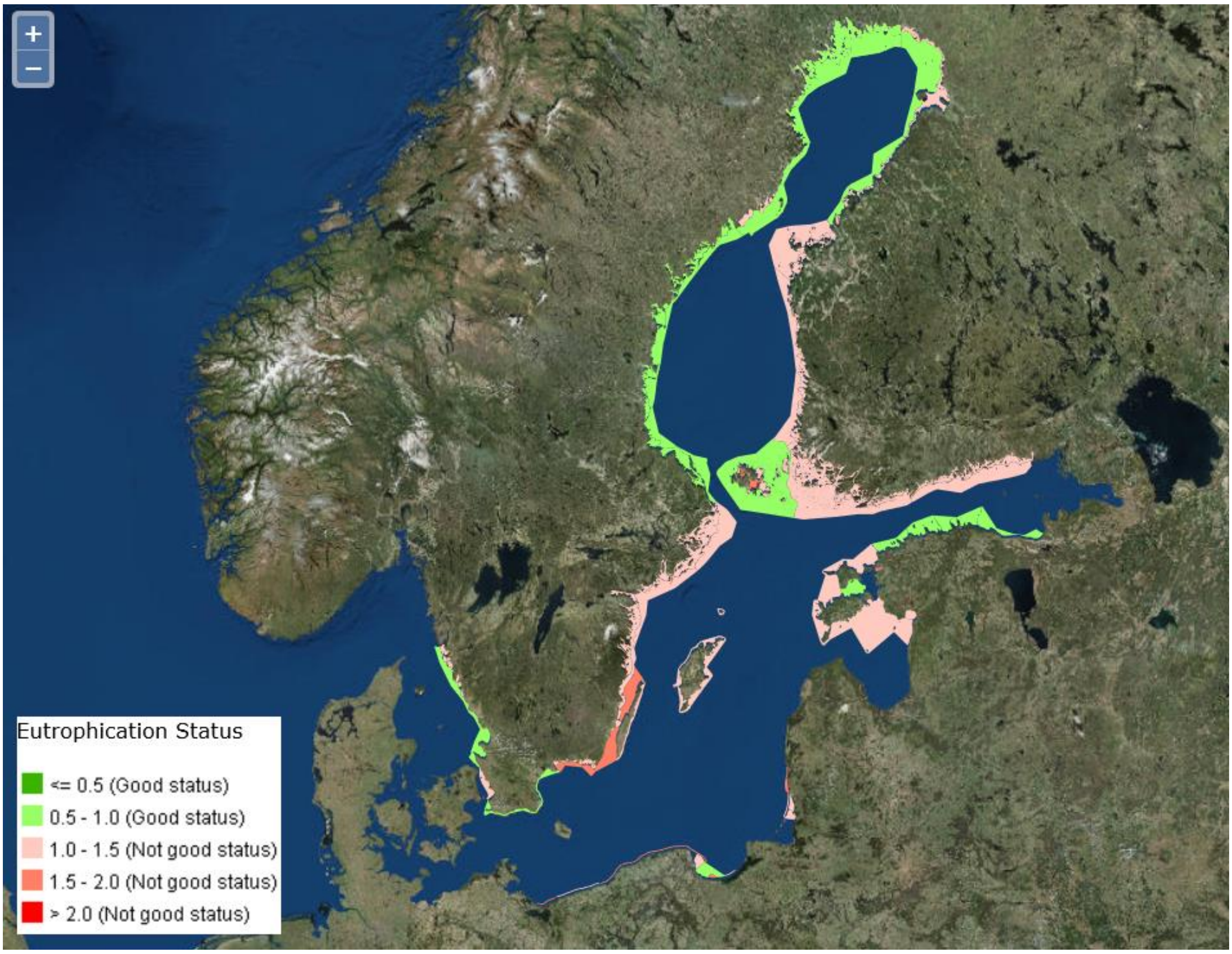
The evaluation of total nitrogen in the open-sea areas is made as the average of total nitrogen concentration in the upper (0-10 m) water layer throughout the year. Two out of 13 sub-basins assessed were found in good status (below threshold value) during the assessment period 2011-2015: The Kattegat and Great Belt. The remaining sub-basins were above threshold value, with a number of sub-basins being near to the threshold, or could not be assessed as threshold values still need to be agreed upon at HELCOM-wide level (Results figures 1 and 3, table 1).

As some Contracting Parties favoured the use of seasonal instead of annual means when developing the indicator, a comparison was made between both methods. In most of the basins, the annual and summer concentrations were at a relatively equal level when measured annually or for summer months only (difference 0-1.5 µM/l). Annual concentrations were clearly higher than summer values in the Gulf of Riga (difference 6.2 µM/l), and slightly higher in the Great Belt and the Quark (difference 2-3 µM/l). In consequence, the annual average was used for the indicator in open-sea areas.

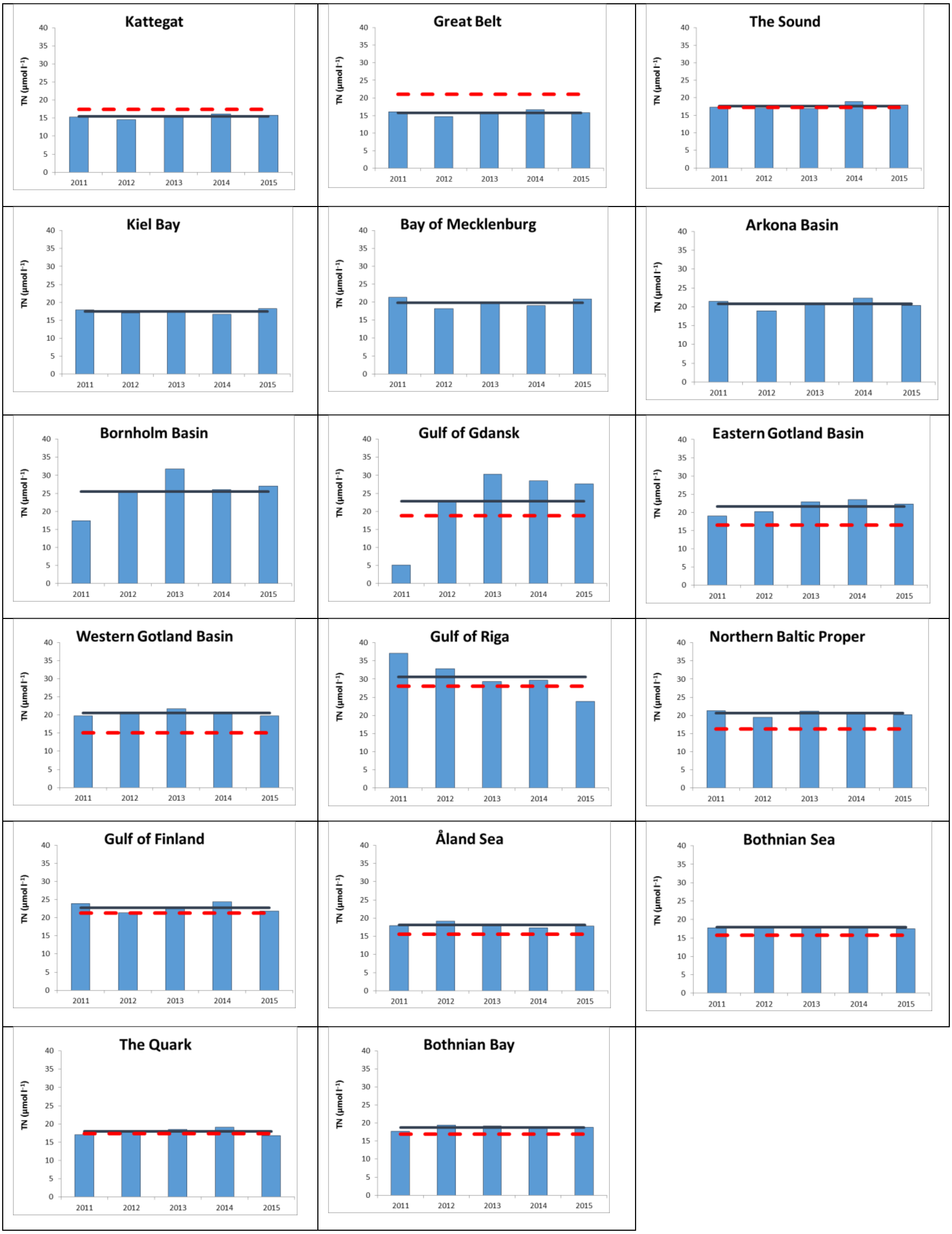


Results figure 1. Detailed eutrophication assessment with the Eutrophication ratio (ER) of total nitrogen being split into 5 classes to show a more differentiated picture than the 2-class division used in the key message figures. ER is calculated as the ratio of the average concentration during assessment period and the threshold value (Fleming-Lehtinen et al. 2015). Please note that for some sub-basins threshold values are still under discussion and that only those coastal areas are shown in which the assessment is based on annual data (same as in the open-sea assessment). See figure 2 for other coastal areas.

As becomes obvious from Results figure 1, some coastal areas in the southwestern Baltic are highly eutrophied. In the remaining coastal areas, seasonal instead of annual averages were used for assessment. Based on mean summer concentrations (June-September), some areas along the coasts of Sweden, Finland and Estonia were classified as achieving good status (Results figure 2).



Results figure 2. Detailed Eutrophication status assessment with the Eutrophication ratio (ER) of total nitrogen in coastal areas being split up into 5 classes to show a more differentiated picture than the 2-class division used in the key message figures. In coastal areas, the assessment is based on summer values (June-September). ER is calculated as the ratio of the average concentration during assessment period and the threshold value (Fleming-Lehtinen et al. 2015).



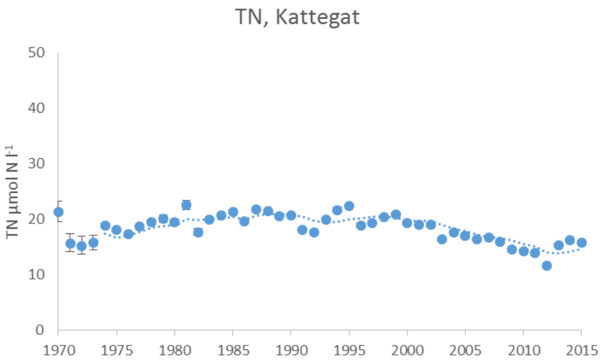
Results figure 3. Average annual surface total nitrogen concentrations (black line; average for 2011-2015). The red dash line represents threshold values. For Kiel Bay, Bay of Mecklenburg, Arkona and Bornholm Basin threshold values are still under discussion. Therefore, no dashed red line is shown in these cases, and these basins occur as “not assessed” in the maps above. The low concentration value in Gulf of Gdansk in 2011 are due to data handling problems. The issue is being investigated and is planned to be rectified for the next update of this indicator report.

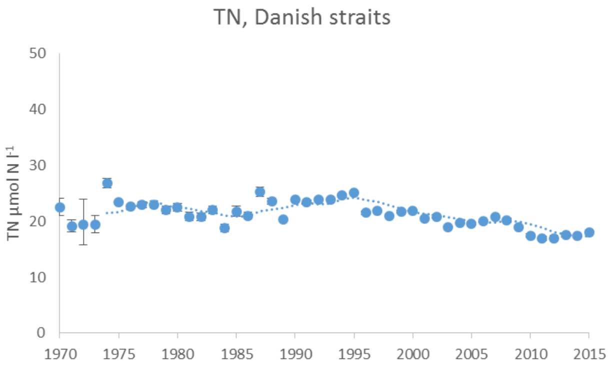
Results table 1. Threshold values, present concentration (as average 2011-2015), eutrophication ratio (ER) and status of total nitrogen in the open-sea basins. ER is a quantitative value for the level of eutrophication, calculated as the ratio between the threshold value and the present concentration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

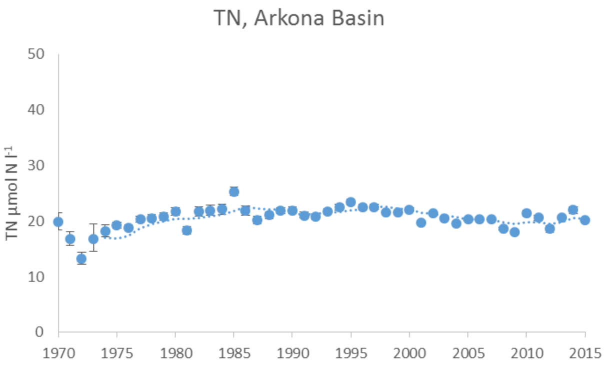
HELCOM ID	Assessment unit (open-sea)	Threshold value (µmol l^{-1})	Average 2011-2015 (µmol l^{-1})	ER	Status (fail/achieve threshold value)
SEA-001	Kattegat	17.4	15.2	0.87	Achieve
SEA-002	Great Belt	21	15.7	0.75	Achieve
SEA-003	The Sound	17.3	17.4	1.01	Fail
SEA-004	Kiel Bay		17.4		Not assessed
SEA-005	Bay of Mecklenburg		19.8		Not assessed
SEA-006	Arkona Sea		20.8		Not assessed
SEA-007	Bornholm Sea		25.5		Not assessed
SEA-008	Gdansk Basin	18.8	22.8	1.21	Fail
SEA-009	Eastern Gotland Basin	16.5	21.9	1.33	Fail
SEA-010	Western Gotland Basin	15.1	20.6	1.36	Fail
SEA-011	Gulf of Riga	28	30.6	1.09	Fail
SEA-012	Northern Baltic Proper	16.2	20.5	1.27	Fail
SEA-013	Gulf of Finland	21.3	22.6	1.06	Fail
SEA-014	Åland Sea	15.6	18.1	1.16	Fail
SEA-015	Bothnian Sea	15.7	17.9	1.14	Fail
SEA-016	The Quark	17.3	17.9	1.03	Fail
SEA-017	Bothnian Bay	16.9	18.8	1.11	Fail

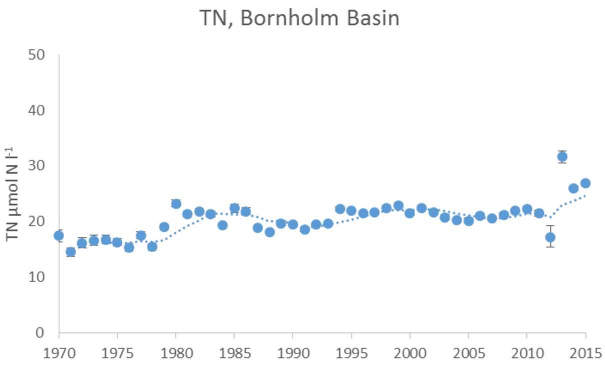
Additional information on temporal trends

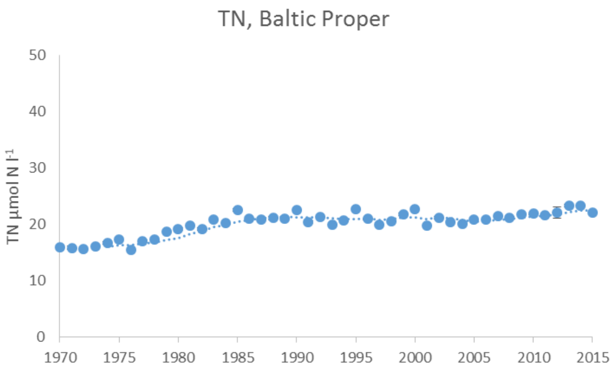
Temporal trends provide additional information on the total nutrients in the Baltic Sea that supports the interpretation of the indicator results (Results figure 4). It should be noted that the temporal trends do not affect the indicator result, which is a status assessment where a concentration is compared to a threshold value. It should be further noted that the long-term temporal trends are not presented for the HELCOM assessment units, but are calculated for the BALTSEM basins.

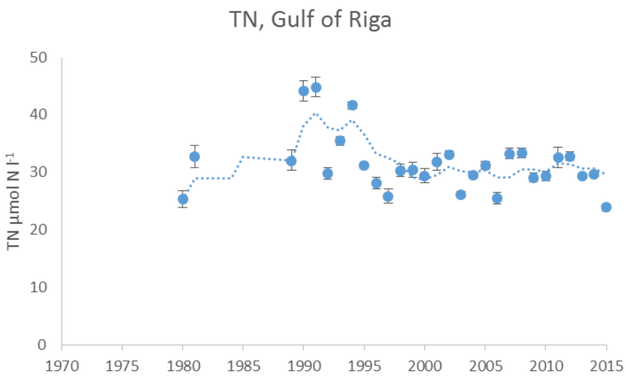

TN, Kattegat
TN µmol N l-1
0 10 20 30 40 50
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015

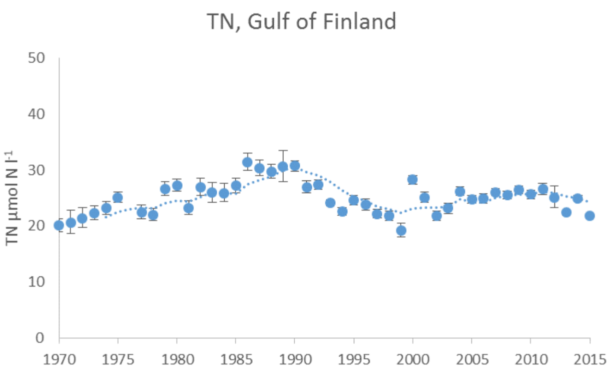

TN, Danish straits
TN µmol N l-1
0 10 20 30 40 50
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015

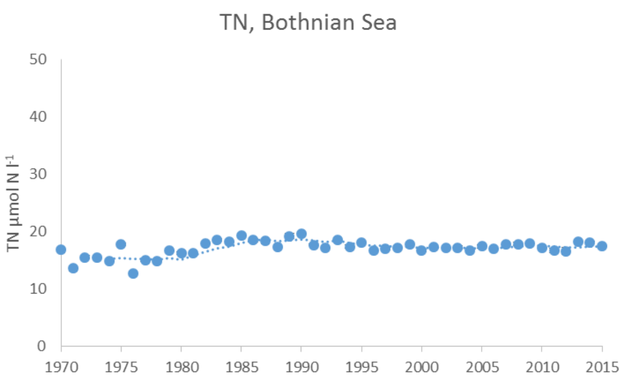

TN, Arkona Basin
TN µmol N l-1
0 10 20 30 40 50
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015

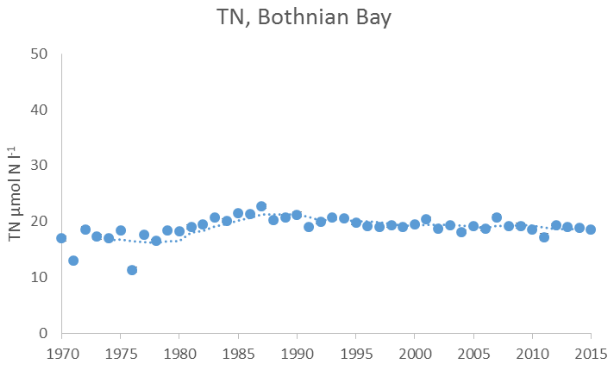

TN, Bornholm Basin
TN µmol N l-1
0 10 20 30 40 50
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015


TN, Baltic Proper
TN µmol N l-1
0 10 20 30 40 50
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015


TN, Gulf of Riga
TN µmol N l-1
0 10 20 30 40 50
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015


TN, Gulf of Finland
TN µmol N l-1
0 10 20 30 40 50
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015

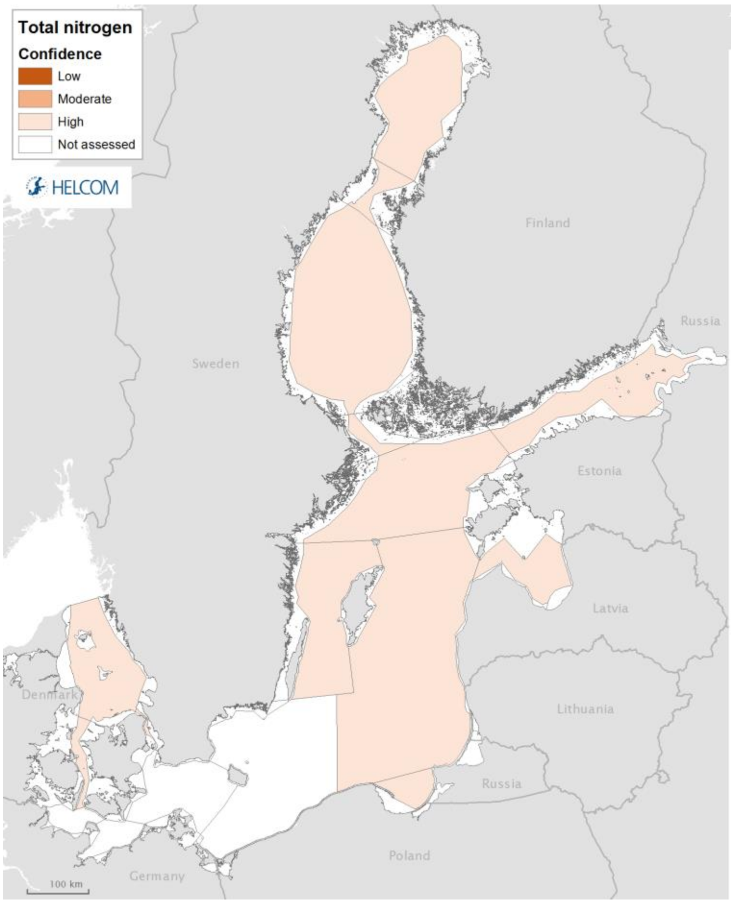

TN, Bothnian Sea
TN µmol N l-1
0 10 20 30 40 50
1970 1975 1980 1985 1990 1995 2000 2005 2010 2015



Results figure 4. Long-term trends in annual surface TN concentrations in the BALTSEM basins (see HELCOM 2013) for 1970-2015. The data until 2012 is from TARGREV project. The spatial and seasonal patterns of historical data are separated across the years, using a GLM-GAM model according to Carstensen et al. 2006. Data for 2013-2015 is based on data extraction from the HELCOM eutrophication assessment database and shows annual average concentrations for each sub-basin. Dashed lines indicate the 5-year moving average (starting from 1970) and error bars represent standard errors (SE).

Confidence of the indicator status evaluation

The data confidence of the presented total nitrogen status evaluation for the open sea areas (Results figure 5) is high in all assessed sub-basins. It should be noted that the confidence is only based on data, not the target confidence since target confidence was not available for the indicator calculation.



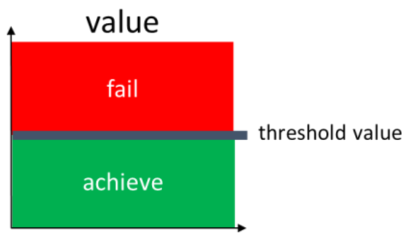
Results figure 5. Indicator data confidence, determined combining information on data availability for the indicator when using observations from all months of the year. Low indicator confidence calls for increase in monitoring.

The indicator confidence was estimated only for the indicator data (ES-Score) due to absence of ET-Score, which describes the uncertainty of the threshold value 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-score should be defined and ET- and ES-Scores combined. See Andersen et al. 2010 and Fleming-Lehtinen et al. 2015 for further details.

As the indicator period and method of calculation varies between open-sea and coastal areas, and thus the threshold- or assessment concentrations are not directly comparable between the open-sea and coast, nor between all coastal assessment units where nationally binding threshold values may have been set, only the confidence for the open-sea areas are shown in Results figure 5.

Good Environmental Status

The threshold value of the 'Total nitrogen' indicator is an assessment unit specific concentration which is not to be exceeded in order for an assessment unit to be evaluated as having achieved the threshold value indicating good status (Good environmental status figure 1).



Good environmental status figure 1. Schematic representation of the threshold value for the core indictor 'Total nitrogen'. Assessment unit specific threshold value are used (see Good environmental status table 1).

Threshold values for the open sea assessment units have been derived in HELCOM (Good environmental status table 1). For coastal assessment units, national boundaries used for estimating Good Environmental Status under WFD may be used.

Good environmental status table 1. Assessment unit specific threshold values for total nitrogen.

HELCOM_ID	**Assessment unit (open sea)**	**Threshold value [µmol l^{-1}]**	**Reference**	**Comments**
SEA-001	Kattegat	17.4	HELCOM 38-2017	TARGREV value applied
SEA-002	Great Belt	21.0	HELCOM 38-2017	TARGREV value applied
SEA-003	The Sound	17.3	HELCOM 38-2017	TARGREV value applied
SEA-004	Kiel Bay			
SEA-005	Bay of Mecklenburg			
SEA-006	Arkona Basin			
SEA-007	Bornholm Basin			
SEA-008	Gdansk Basin	18.8	HELCOM 38-2017	New value (expert judgement)
SEA-009	Eastern Gotland Basin			
SEA-010	Western Gotland Basin	15.1	HELCOM 38-2017	TARGREV value applied
SEA-011	Gulf of Riga	28.0	HELCOM 38-2017	New value (expert judgement)
SEA-012	Northern Baltic Proper	16.2	HELCOM 38-2017	TARGREV value applied
SEA-013	Gulf of Finland	21.3	HELCOM 38-2017	TARGREV value applied
SEA-014	Åland Sea	15.6	HELCOM 38-2017	TARGREV value applied
SEA-015	Bothnian Sea	15.7	HELCOM 38-2017	TARGREV value applied
SEA-016	The Quark	17.3	HELCOM 38-2017	TARGREV value applied
SEA-017	Bothnian Bay	16.9	HELCOM 38-2017	TARGREV value applied

Some of the open-sea indicator threshold values were based on the results obtained in the TARGREV project (HELCOM 2013), taking also advantage of the work carried out during the EUTRO PRO process (HELCOM 2009) and national work for EU WFD implementation. The TARGREV values were derived as geometrical means, thus bearing close resemblance to median values (J. Carstensen, pers. comm.).

However, as Total nitrogen (TN) was not simulated in the TARGREV modeling exercise, only upper limits of annual means of TN derived from estimates of the mean level during 1970-1975 are used as threshold values (see TARGREV report pages 84 and 134). These upper levels might already represent a eutrophied Baltic Sea in the early 1970s, and thus not be in agreement with the threshold value of the other eutrophication indicators with modelled threshold values (e.g. DIN, DIP) or threshold values based on extensive monitoring (e.g. Secchi depth). They are however expected to be in agreement with threshold values based on shorter term monitoring data (e.g. chlorophyll-*a*).

A new modeling approach has recently provided revised concentrations for German national threshold values of total nutrients in the Kiel Bay, Mecklenburg Bay, Arkona Basin and Bornholm Basin (Hirt et al. 2013; Schernewski et al. 2014; BLANO 2014), taking into account HELCOM, MSFD and WFD requirements for good status. The finally agreed BLANO threshold values represent median values and are included in the Federal Surface Water Ordinance (2016).

Break-point analysis was applied for setting Polish national threshold value in the Gdansk Basin. The results of these exercises were used as additional input in the threshold setting.

Assessment Protocol

The assessment of total nitrogen in open-sea areas is made as the average of total nitrogen concentration in the upper (0-10 m) water layer throughout the year. In some coastal areas, annual averages are used as well (Key message figure 1), while in Sweden, Finland, Estonia, Lithuania and Poland the summer average is used to assess total nitrogen in coastal areas (Key message figure 2).

Assessment protocol table 1. Specifications of the indicator Total nitrogen.

Indicator	Total nitrogen
Response to eutrophication	positive
Parameters	Total nitrogen concentration (µmol l^{-1})
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	2011-2015
Assessment season	Annual / Summer (June-September)
Depth	Surface = average in the 0-10 m layer
Removing outliers	No outliers removed
Removing close observations	No close observations removed, but Station 431 (Ven station) in The Sound has been included in the open-sea area of The Sound, despite that it is located within the WFD baseline of the Ven island. However, due to the strong currents in The Sound this station is representative for the open waters in this assessment unit. Including this station will result in a much improved assessment for this assessment unit.
Indicator level (ES)	Average of annual/seasonal average values (mostly average = arithmetic mean, in some Contracting Parties the median is used instead to assess status versus threshold)
Indicator target (ET)	Agreed threshold values are mainly derived from TARGREV values as agreed by HOD 39-2012 with additions as agreed by HELCOM 38-2017. For some basins discussions on threshold values are still ongoing.
Eutrophication ratio (ER)	ER = ES/ET
Status confidence (ES-Score)	HIGH (=100%), if more than 15 spatially non-biased status observations are found each year. MODERATE (=50%), if more than 5 but no more than 15 status observations are found per year. LOW (=0%), if no more than 5 annual status observations are found during one or more years.
Indicator target confidence (ET-Score)	HIGH, if the target was based on numerous observations made earlier than the 1950's, possibly in combination with hindcast modelling. MODERATE, if the target was based on observations made earlier than the 1980's and/or hindcast modelling. LOW, if the target was set through expert judgement and/or information from reference sites and/or observations made during or after the 1980's.
Indicator confidence (I-Score)	Confidence (%) = average of ES-Score and ET-Score

Assessment unit

The indicator is assessed within the geographical HELCOM assessment unit scale 4: open sea sub-basin areas and coastal waters WFD coastal types and bodies.

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 total nitrogen, this indicator also contributes to the overall eutrophication assessment along with the other biodiversity 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". Increase in nutrient concentrations can be assessed using measurements of all suspended and dissolved nutrients.

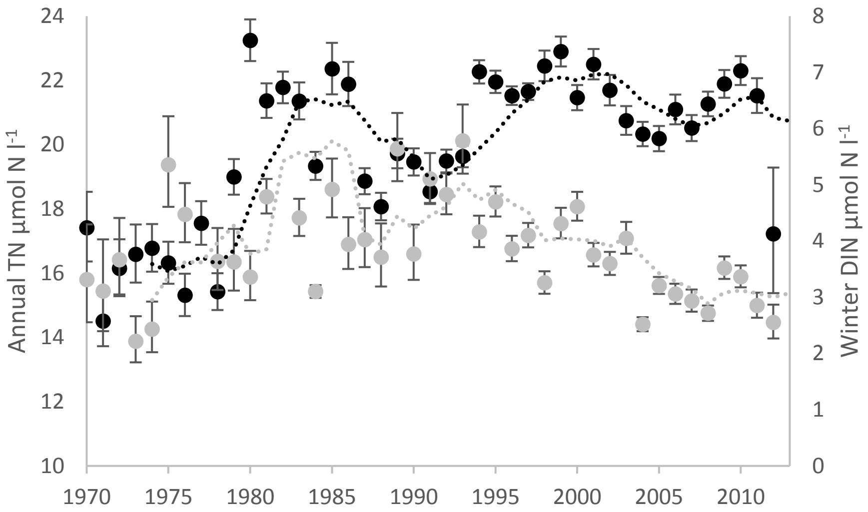
The EU Marine Strategy Framework Directive (Anonymous 2008) requires that "human-induced eutrophication is minimized, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters" (Descriptor 5). 'Total Nitrogen (TN)' is identified as a criteria element to be assessed using the criterion D5C1 'Nutrient concentrations are not at levels that indicate adverse eutrophication effects' in the Commission Decision on criteria and methodological standards on good environmental status of marine waters (Anonymous 2017).

The EU Water Framework Directive (Anonymous 2000) requires good ecological and chemical 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 including phytoplankton biomass (usually measured as chlorophyll-*a)*, the hydromorphological/hydrological characteristics and the chemical characteristics. Nutrient concentrations, measured as total or inorganic nutrients, is one of the indicators listed in Annex V.

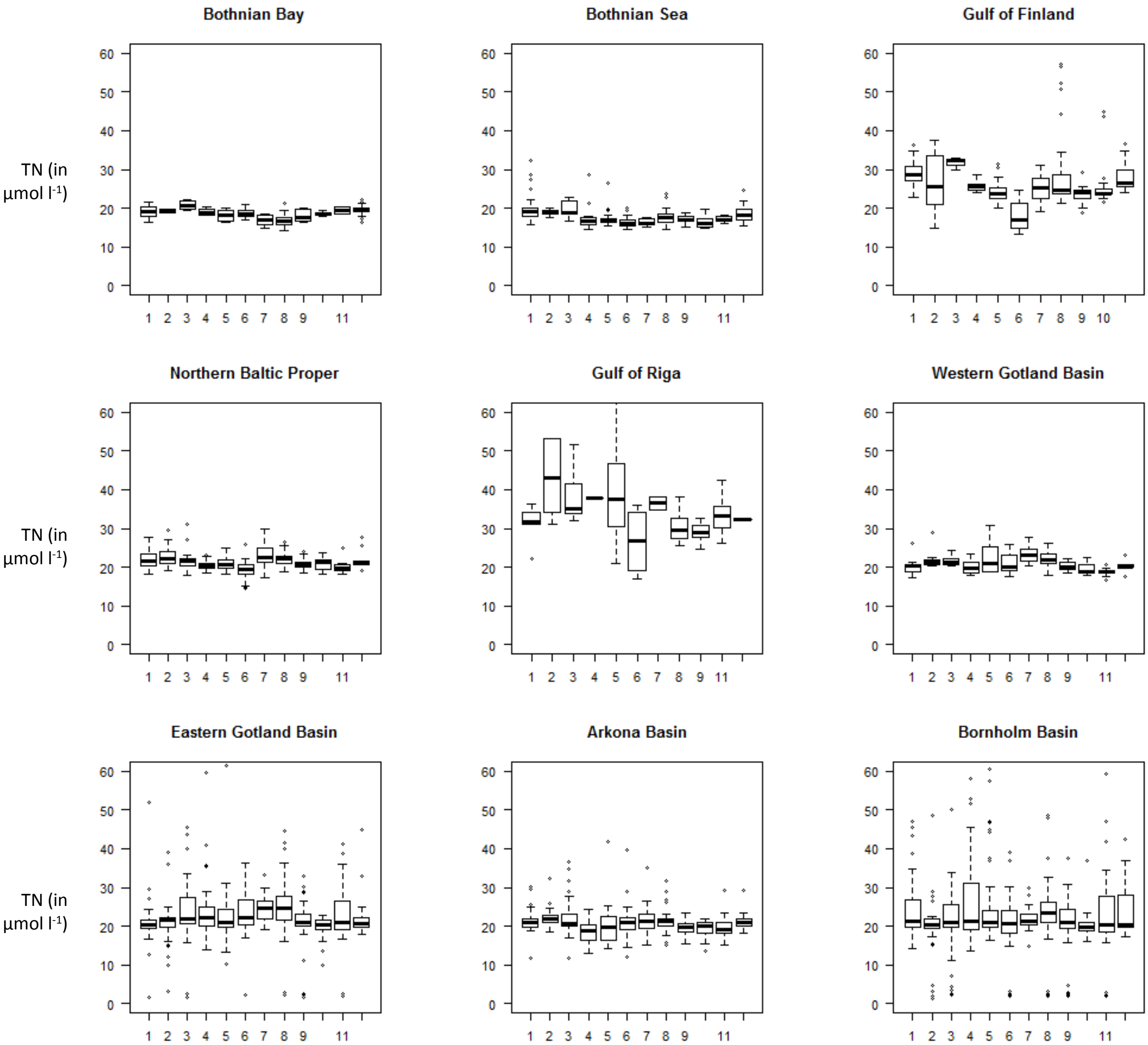
Role of total nitrogen in the ecosystem

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

Adding total nutrients alongside inorganic nutrients as core indicators strengthens the link from nutrient concentrations in the sea to nutrient enrichment. In particular these parameters allow to take account of climate change in the eutrophication assessment since higher temperatures will lead to year-round phytoplankton proliferation and / or possible changes in zooplankton communities. To illustrate this point, the concentration of the total and the dissolved inorganic fractions of nutrients have been compared, and diverging trends have been observed in some sub-basins. For example, a decrease in winter DIN concentrations has been identified in the Bornholm Basin since the 1990's, but TN concentrations have remained high (see figure below). A possible reason for this observation could be that in winter more nutrients are bound in the phytoplankton due to the higher water temperatures. In such a situation, assessing only dissolved inorganic concentrations gives the wrong impression that nutrient concentrations seem to be declining, while, in fact, they are stable or increasing as can be seen when also assessing total concentrations. In conclusion, to get a good understanding of the trend in nutrient concentrations in the marine environment monitoring and assessing both, total and dissolved nutrients, is important.



Relevance figure 1. Time series of annual TN (black line and dots) and winter DIN (gray line and dots) in the Bornholm Basin. The decrease in winter DIN since the 1990's is not expressed by annual TN. The figure is modified from BSEP 133.



Relevance figure 2. Monthly values of total nitrogen concentration (in µmol l^{-1}) in the surface layer (0- 10m) during 2007-2011.

Human pressures linked to the indicator

	General	MSFD Annex III, Table 2a
Strong link	Nutrient concentrations in the water column are affected by anthropogenic nutrient loads, both water- and airborne.	Substances, litter and energy - Input of nutrients – diffuse sources, point sources, atmospheric deposition - Input of organic matter – diffuse sources and point sources
Weak link		

Monitoring Requirements

Monitoring methodology

Monitoring of total nitrogen 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: **Nutrients**.

Total nitrogen is monitored year-round. Furthermore, TN is already widely assessed by Contracting Parties: according to the questionnaire sent to contracting parties via EUTRO-OPER, total nutrients in open-sea areas are monitored and reported by Denmark, Estonia, Finland, Germany, Germany, Germany, Latvia, Lithuania, Poland, the Russian Federation and Sweden. Guidelines for monitoring these indicators exist in the HELCOM Monitoring Manual. Concentrations of total nutrients are total nutrients measured *in situ*, both from fixed stations using traditional sampling and with Ferrybox flow-through sampling.

Description of optimal monitoring

For assessment purposes, at least 15 status observations should be conducted annually during the period January to December in each open-sea assessment unit. The compilation of observations is expected to be distributed spatially within the assessment unit in a non-biased way. In coastal areas, at least monthly sampling of representative stations is desirable.

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) Total nitrogen. HELCOM core indicator report. Online. [Date Viewed], [Web link].

ISSN 2343-2543

Metadata

Result: Total Nitrogen (TN)

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 total nitrogen observations, determined as explained in the HELCOM COMBINE manual. Measurements made at the depth of 0 – 10 m from the surface were used in the assessment.

Temporal coverage: The raw data includes observations throughout the year, during the assessment period 2011-2015. For the summer average, observations taken during June-September were included only.

Data aggregation: The 2011-2015 averages for each sub-basin were produced as an inter-annual estimates using observations from all months / June-September.

Contributors and references

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With contributions from other participants of HELCOM EUTRO-OPER and HELCOM IN-Eutrophication

Archive

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

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