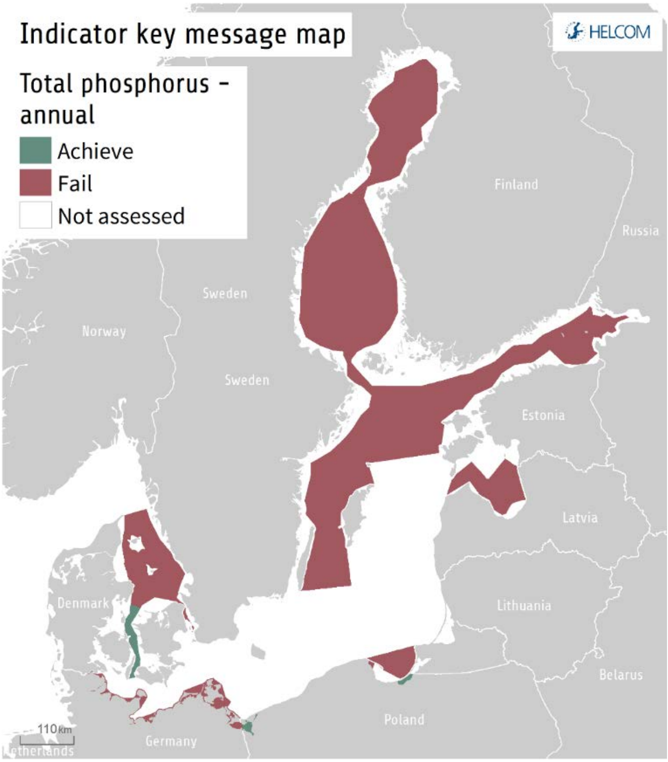
HELCOM core indicator report
July 2018

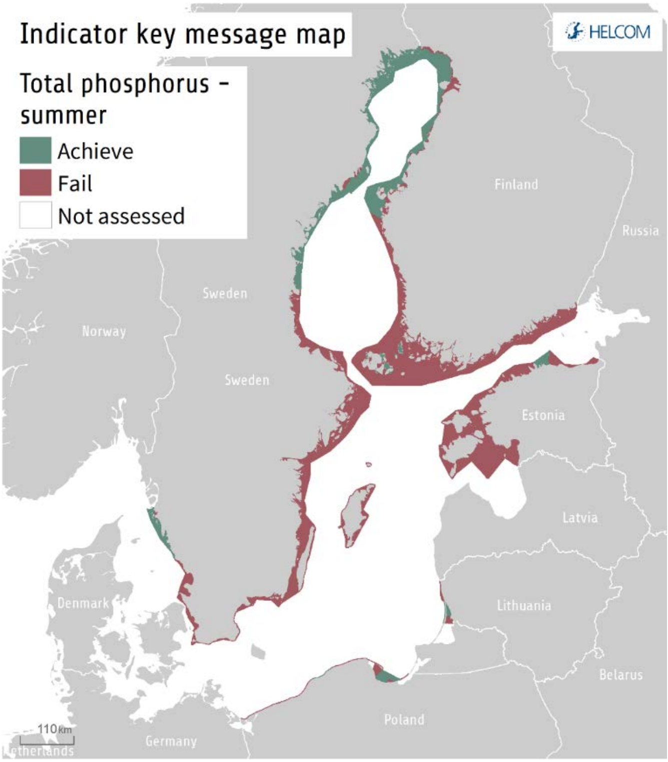
Total phosphorus

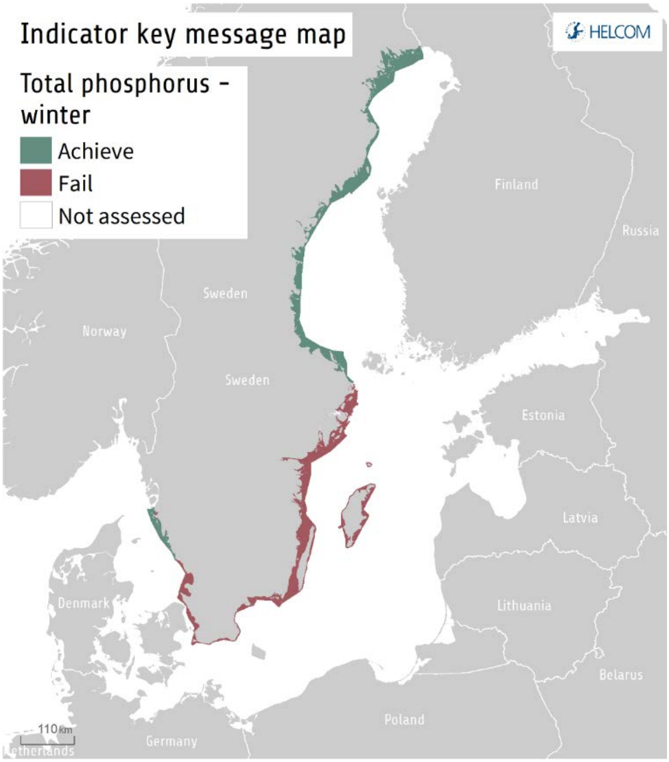
Key Message

Total phosphorus (TP) is assessed in 12 open sea assessment units for the period 2011-2016, of which good status (total phosphorus concentration below defined threshold value) was achieved only in the Great Belt. In the Kattegat, Gdansk Bay and Bothnian Bay the concentrations were only slightly above the threshold value (Key message figure 1 and Results table 1).

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







Key message figure 1. Status assessment evaluation of the indicator 'Total phosphorus' - annual monitoring (top), summer (middle) and winter (bottom). 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 open sea areas threshold values still are under discussion, and that in coastal areas the assessment is based on annual data, summer data and winter data, as reported by HELCOM Contracting Parties, and these details are defined in Results table 2. Map 1 represents annual values, map 2 the values for summer and map 3 the values for winter. See Results section below for details. **Click here to access interactive maps at the HELCOM Map and Data Service**: **Total phosphorus**.

The confidence of the total phosphorus indicator status evaluation for the open sea areas is **high** in most of the assessed sub-basins. The confidence was **moderate** in the Quark and **low** in the Åland Sea. It should be noted that the confidence is only based on data availability, not the threshold confidence since the latter was not available for the indicator calculation.

The indicator is applicable in all coastal and open sea areas. The indicator period and method of calculation varies between open sea and coastal areas, and thus the threshold value- 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 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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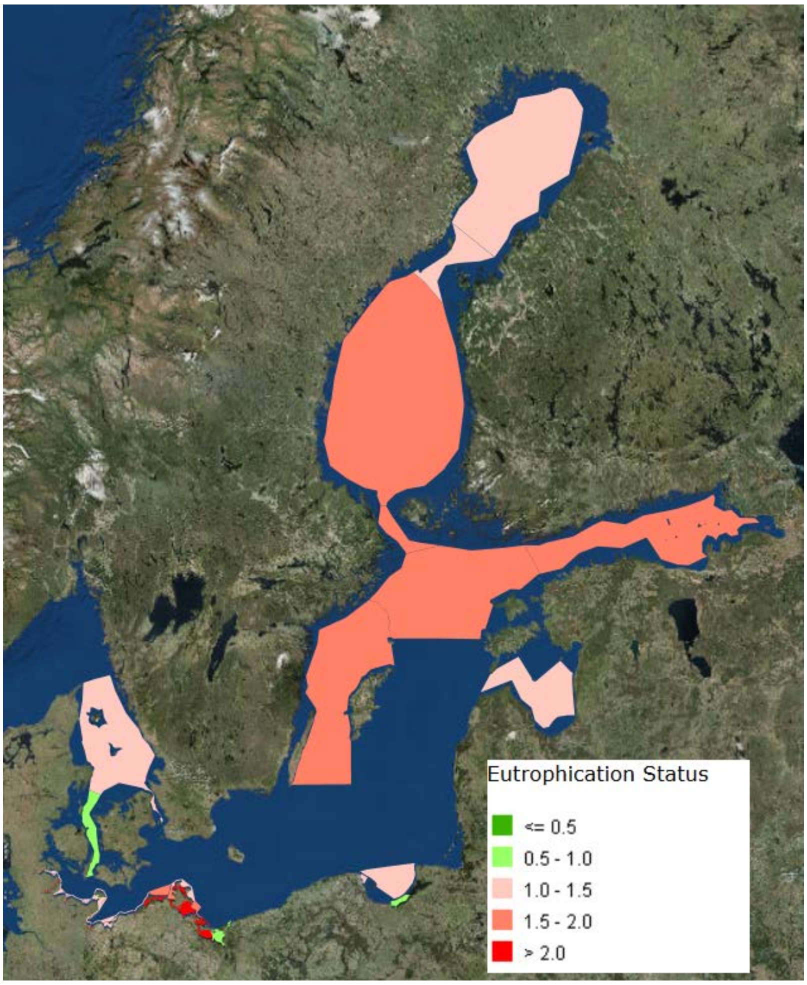
Total phosphorous HELCOM core indicator 2018 (pdf)

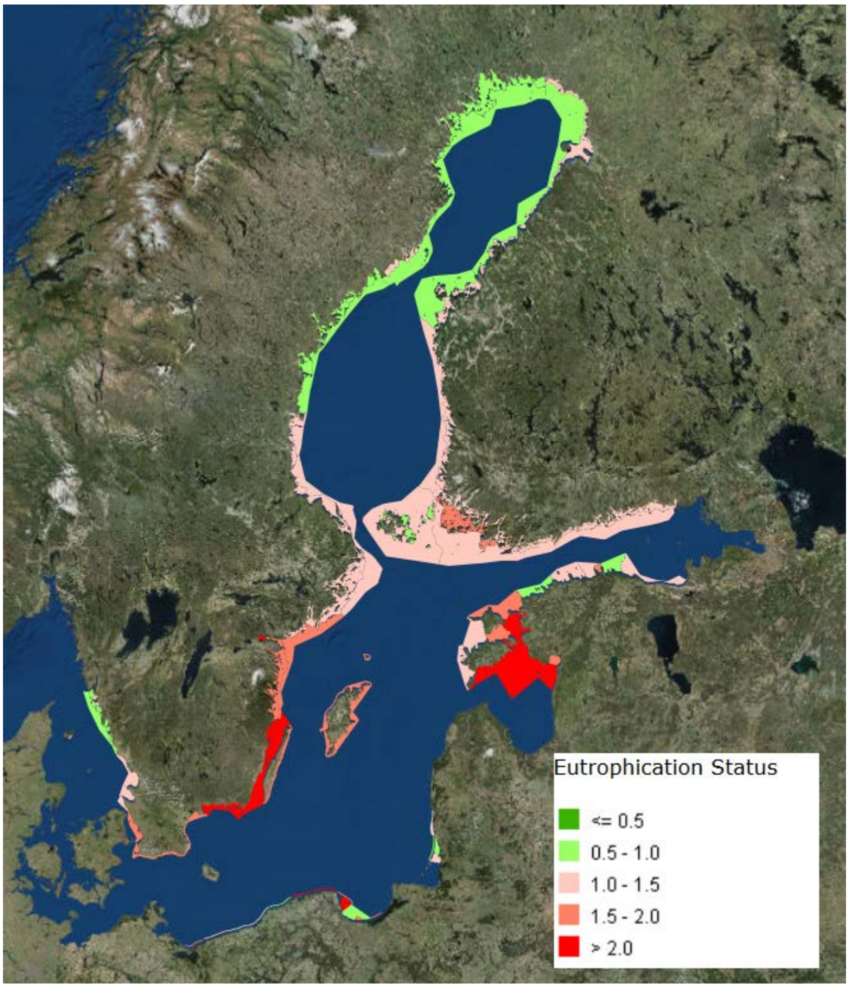
Results and Confidence

The assessment of total phosphorus in the open sea areas is made as the average of total phosphorus concentration in the upper (0-10 m) water layer throughout the year.

One assessment unit, namely the Great Belt, was found to achieve the threshold value during the assessment period 2011-2016. The remaining sub-basins were assessed as failing the threshold value or could not be assessed as threshold values still need to be agreed upon at HELCOM-wide level (Results figures 1 and Results table 1). In the Kattegat, Gdansk Basin and Bothnian Bay the concentrations were only slightly above the threshold value (Results table 1).

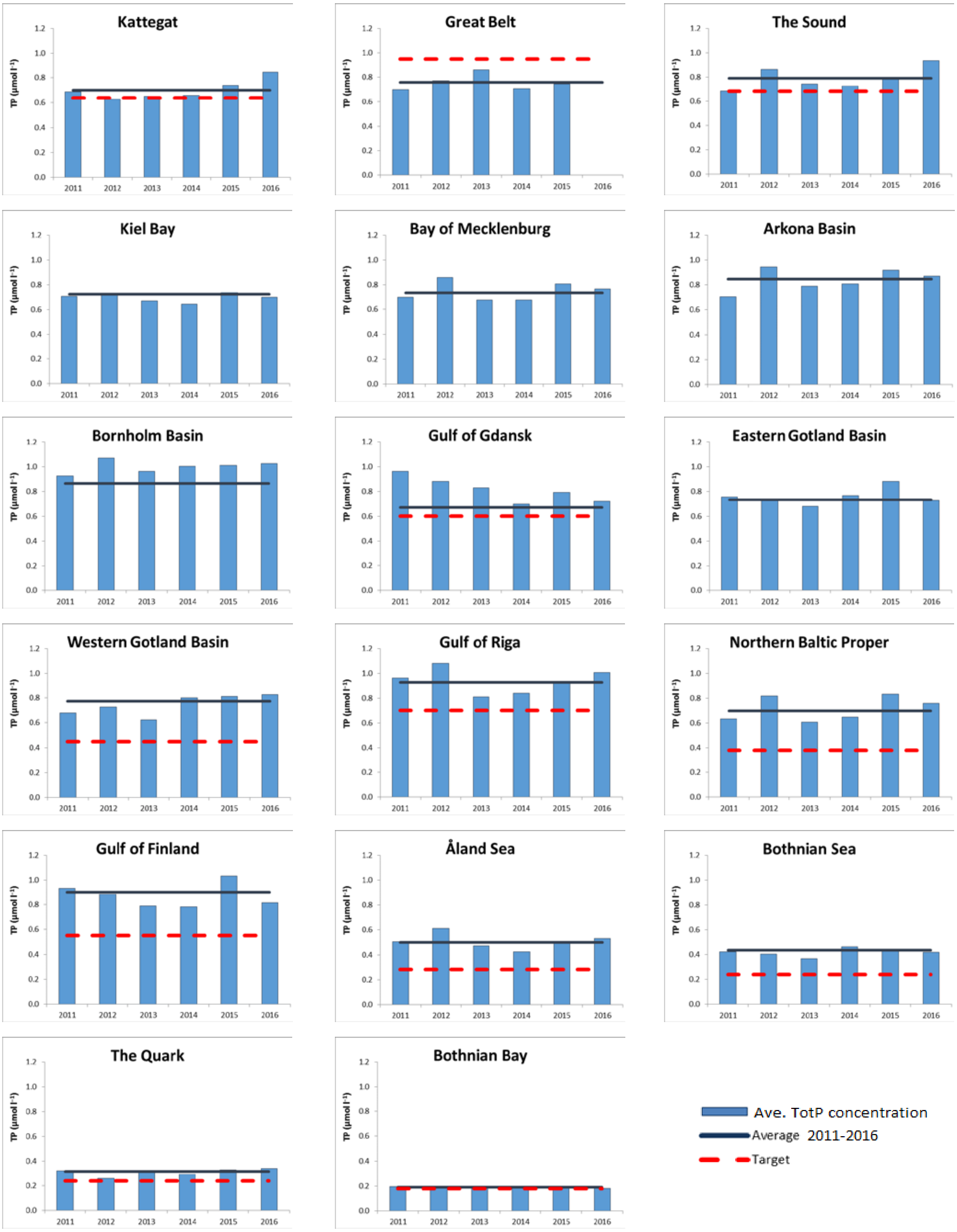
Although some fluctuation was apparent during the current assessment period the levels of total phosphorus remained relatively unchanged (Results figure 2).





Results figure 1. Detailed eutrophication status assessment with the Eutrophication ratio (ER) of total phosphorus split into 5 classes. 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 open sea areas threshold values still are under discussion, and that only those coastal areas are assessed differently by the Contracting Parties reporting coastal data and evaluations (see Results table 2 for details).

Some coastal areas in the south-western Baltic are highly eutrophied. In the remaining coastal areas, seasonal instead of annual averages were used for assessment. Based on mean summer concentrations (June-August / June-September), some areas along the coasts of Sweden, Finland, Estonia and Poland are classified as achieving good status (Results figure 1), but highly eutrophied areas are found as well. If compared with the total nitrogen assessment, these coastal areas are somewhat more strongly affected by phosphorus than nitrogen.



Results figure 2. Average annual surface total phosphorus concentrations (black line; average for 2011-2016) in open sea assessment units. The dashed red line displays the threshold value. For Kiel Bay, Bay of Mecklenburg, Arkona Basin, Bornholm Basin and Eastern

Gotland 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.

Results table 1. Threshold values, present concentration (as average 2011-2016), eutrophication ratio (ER) and status of total phosphorus in the open sea basins. ER is a quantitative value for the level of eutrophication, calculated as the ratio between the present concentration and the threshold value – when ER >1, threshold value has not been reached.

HELCOM ID	Assessment unit (open sea)	Threshold value (µmol l-1)	Average 2011-2016 (µmol -1)	Eutrophication ratio (ER)	Status (achieve/fail threshold value)
SEA-001	Kattegat*	0.64	0.70	1.10	Fail
SEA-002	Great Belt*	0.95	0.76	0.80	Achieve
SEA-003	The Sound*	0.68	0.79	1.16	fail
SEA-004	Kiel Bay*				Not assessed
SEA-005	Bay of Mecklenburg*				Not assessed
SEA-006	Arkona Basin*				Not assessed
SEA-007	Bornholm Basin				Not assessed
SEA-008	Gulf of Gdansk	0.60	0.81	1.35	Fail
SEA-009	Eastern Gotland Basin				Not assessed
SEA-010	Western Gotland Basin	0.45	0.75	1.66	Fail
SEA-011	Gulf of Riga	0.70	0.94	1.34	Fail
SEA-012	Northern Baltic Proper**	0.38	0.72	1.88	Fail
SEA-013	Gulf of Finland**	0.55	0.87	1.59	Fail
SEA-014	Åland Sea**	0.28	0.51	1.81	Fail
SEA-015	Bothnian Sea**	0.24	0.42	1.75	Fail
SEA-016	The Quark**	0.24	0.31	1.30	Fail
SEA-017	Bothnian Bay**	0.18	0.19	1.05	Fail

*NOTE: Danish measurements presented in this report are underestimated. This might affect content and conclusions in this report in regard to the status assessment and assessment of nutrient inputs to Danish waters.

**NOTE: Finnish monitoring open-sea estimates of phosphate and total phosphorus in 2011-2014 are in general 10 % lower than in 2015-2017 due to the changes in instrumentation and accompanying methodology. This might affect the indicator values in these assessment units.

Coastal area assessment results are based mostly on summer and annual average TP values, and in some cases (in Sweden) also winter averages are used (Results table 2). In Estonian coastal waters, the threshold value was achieved in 1 waterbody out of 16 and in Finland in 3 out of 14, based on summer estimates. In the coastal areas of Germany, the threshold value was achieved in one waterbody out of 45, based on annual values. In Lithuania, the threshold value was achieved in 2 of the 6 coastal areas. In Poland, 4 coastal areas were assessed using annual values, and in 3 waterbodies the threshold value was achieved. For the remaining 15 areas summer averages were used, with 3 of them achieving the threshold value. In Sweden, both summer and winter averages were used when assessing coastal areas. Concerning summer values, the threshold value was achieved in 7 areas out of 24, and using winter values in 10 areas out 22. The percentage of total assessed area achieving the threshold value, i.e. in good status, per country (if good status was achieved in some basins) represents over half of the assessed area in Poland and Sweden (winter values), 60% and 52%, respectively. Lithuania has 41% of the coastal area in good status. According to summer values in Sweden, 35% of the assessed area is in good status. Finland, Estonia and Germany have 23%, 4% and <1% of the area in good status, respectively.

Results table 2. Threshold values, present concentration (as average 2011-2016), eutrophication ratio (ER) and status of total phosphorus in the coastal-sea basins. ER is a quantitative value for the level of eutrophication, calculated as the ratio between the present concentration and the threshold value – when ER >1, threshold value has not been reached. Note that the used units can be either µmol l^{-1} or µg l^{-1} depending on Contracting Party. The majority of data is from the summer season, though differences in sampling season also occur between countries, indicated in the table as follows: no symbol = summer, * = annual sampling, and ** = winter sampling.

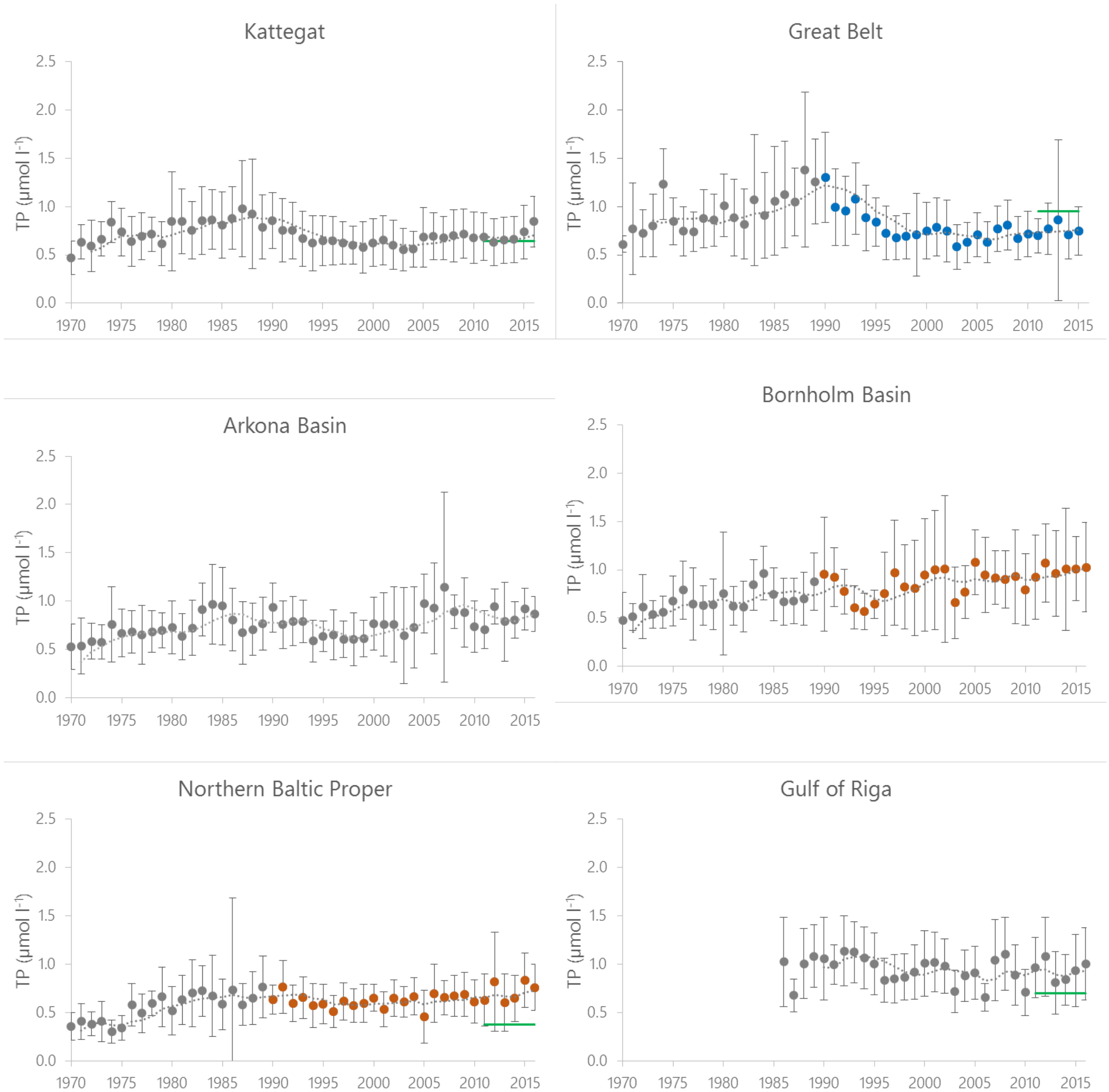
CODE	Period	Average	Threshold value	Unit	Eutrophication ratio (ER)
EST-001	2011-2016	0.92	0.84	µmol l^{-1}	1.10
EST-002	2011-2015	0.52	0.84	µmol l^{-1}	0.62
EST-003	2011-2016	1.16	0.72	µmol l^{-1}	1.61
EST-004	2011-2016	0.91	0.72	µmol l^{-1}	1.26
EST-005	2011-2016	0.90	0.72	µmol l^{-1}	1.25
EST-006	2011-2016	0.80	0.72	µmol l^{-1}	1.11
EST-007	2011-2016	0.80	0.42	µmol l^{-1}	1.90
EST-008	2011-2016	1.57	0.30	µmol l^{-1}	5.23
EST-009	2011-2016	0.65	0.30	µmol l^{-1}	2.17
EST-010	2011-2016	0.57	0.42	µmol l^{-1}	1.36
EST-011	2011-2016	0.61	0.42	µmol l^{-1}	1.45
EST-012	2007-2012	0.94	0.50	µmol l^{-1}	1.88
EST-013	2007-2012	1.12	0.67	µmol l^{-1}	1.67
EST-014	2007-2012	0.45	0.30	µmol l^{-1}	1.50
EST-015	2007-2012	1.29	0.30	µmol l^{-1}	4.30
EST-016	2007-2012	0.82	0.30	µmol l^{-1}	2.73
FIN-001	2007-2012	32.90	23.00	µg l^{-1}	1.43
FIN-002	2007-2012	22.20	18.00	µg l^{-1}	1.23
FIN-003	2007-2012	30.00	24.00	µg l^{-1}	1.25
FIN-004	2007-2012	21.40	20.00	µg l^{-1}	1.07
FIN-005	2007-2012	32.90	20.00	µg l^{-1}	1.65
FIN-006	2007-2012	21.90	17.00	µg l^{-1}	1.29
FIN-007	2007-2012	12.40	13.00	µg l^{-1}	0.95
FIN-008	2007-2012	21.20	20.00	µg l^{-1}	1.06
FIN-009	2007-2012	15.80	14.00	µg l^{-1}	1.13
FIN-010	2007-2012	17.50	14.00	µg l^{-1}	1.25
FIN-011	2007-2012	10.40	11.00	µg l^{-1}	0.95
FIN-012	2007-2012	30.00	22.00	µg l^{-1}	1.36
FIN-013	2007-2012	18.00	18.00	µg l^{-1}	1.00
FIN-014	2007-2012	16.00	15.00	µg l^{-1}	1.07
GER-001*	2007-2012	0.99	0.73	µmol l^{-1}	1.36
GER-002*	2007-2012	0.99	0.73	µmol l^{-1}	1.36
GER-003*	2007-2012	0.98	0.73	µmol l^{-1}	1.34

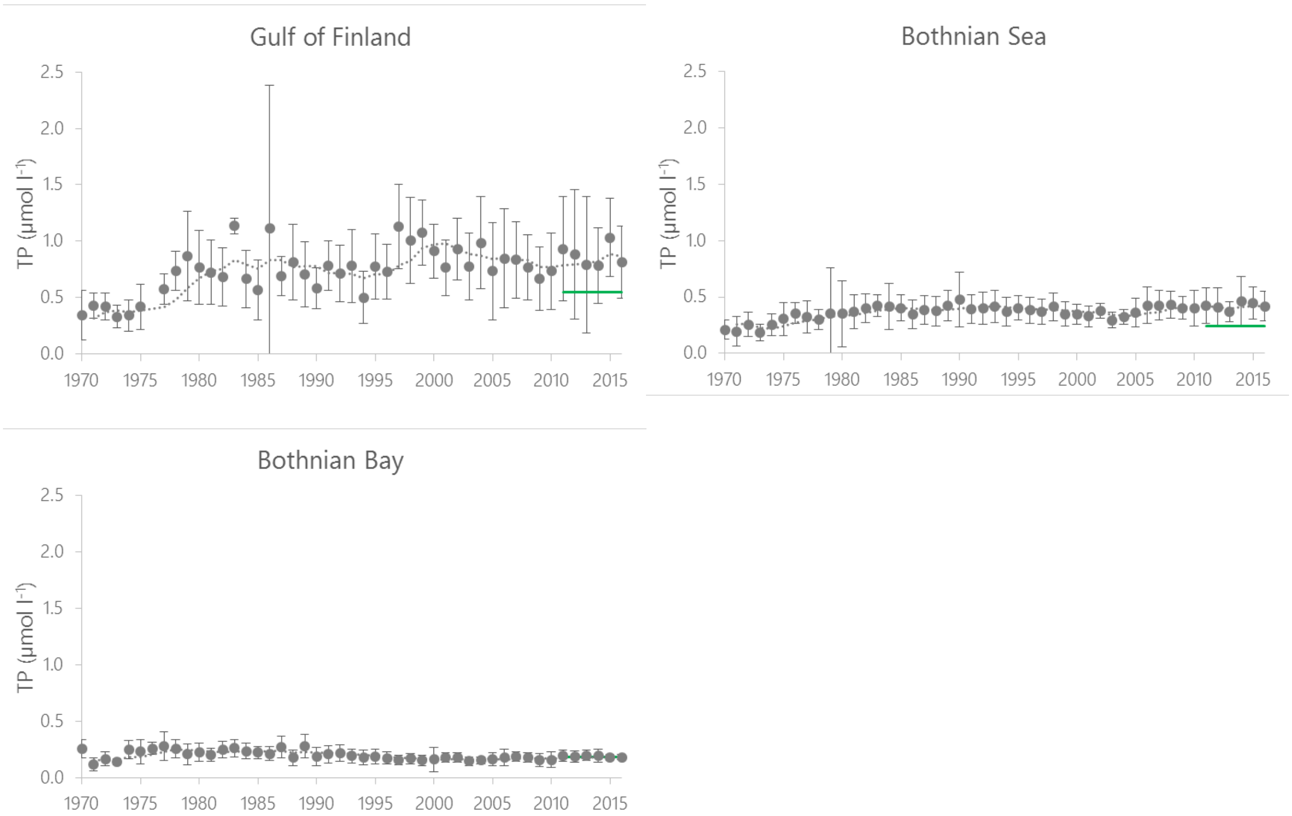
GER-004*	2007-2012	0.83	0.65	µmol l-1	1.28
GER-005*	2007-2012	1.56	0.59	µmol l-1	2.64
GER-006*	2007-2012	0.86	0.65	µmol l-1	1.32
GER-007*	2007-2012	3.88	1.42	µmol l-1	2.73
GER-008*	2007-2012	3.38	1.42	µmol l-1	2.38
GER-009*	2007-2012	2.35	0.59	µmol l-1	3.98
GER-010*	2007-2012	1.00	0.62	µmol l-1	1.61
GER-011*	2007-2012	1.11	0.59	µmol l-1	1.88
GER-012*	2007-2012	1.36	0.59	µmol l-1	2.31
GER-013*	2007-2012	1.45	0.59	µmol l-1	2.46
GER-014*	2007-2012	3.70	0.59	µmol l-1	6.27
GER-015*	2007-2012	0.89	0.62	µmol l-1	1.44
GER-016*	2007-2012	2.87	1.42	µmol l-1	2.02
GER-017*	2007-2012	3.33	1.42	µmol l-1	2.35
GER-018*	2007-2012	1.07	0.62	µmol l-1	1.73
GER-019*	2007-2012	1.45	0.62	µmol l-1	2.34
GER-020*	2007-2012	3.68	1.42	µmol l-1	2.59
GER-021*	2007-2012	0.96	0.52	µmol l-1	1.86
GER-022*	2007-2012	0.61	0.44	µmol l-1	1.39
GER-023*	2007-2012	0.61	0.50	µmol l-1	1.22
GER-024*	2007-2012	0.54	0.44	µmol l-1	1.23
GER-025*	2007-2012	1.76	0.52	µmol l-1	3.41
GER-026*	2007-2012	3.85	1.10	µmol l-1	3.51
GER-027*	2011-2016	3.85	1.10	µmol l-1	3.51
GER-028*	2016	0.54	0.44	µmol l-1	1.23
GER-029*	2014	0.59	0.50	µmol l-1	1.18
GER-030*	2011-2016	0.54	0.44	µmol l-1	1.23
GER-031*	2011-2016	0.60	0.50	µmol l-1	1.20
GER-032*	2011-2016	0.88	0.52	µmol l-1	1.70
GER-033*	2011-2013	0.54	0.44	µmol l-1	1.23
GER-034*	2011-2015	0.54	0.44	µmol l-1	1.23
GER-035*	2015	0.54	0.50	µmol l-1	1.08
GER-036*	2012-2016	0.60	0.44	µmol l-1	1.37
GER-037*	2012	0.51	0.52	µmol l-1	0.99
GER-038*	2011-2016	0.61	0.44	µmol l-1	1.39
GER-039*	2011-2016	0.61	0.50	µmol l-1	1.22
GER-040*	2016	0.58	0.44	µmol l-1	1.32
GER-041*	2013	0.60	0.44	µmol l-1	1.37
GER-042*	2011-2016	2.10	0.52	µmol l-1	4.07
GER-043*	2011-2016	2.49	1.10	µmol l-1	2.27
GER-044*	2011-2016	2.83	1.10	µmol l-1	2.58
GER-111*	2011-2016	1.58	0.59	µmol l-1	2.68
LIT-001	2011-2016	0.06	0.05	mg l-1	1.13
LIT-002	2011-2016	0.02	0.03	mg l-1	0.77
LIT-003	2011-2016	0.03	0.03	mg l-1	1.15
LIT-004	2011-2016	0.09	0.08	mg l-1	1.14
LIT-005	2011-2016	0.07	0.08	mg l-1	0.88
LIT-006	2011-2016	0.03	0.03	mg l-1	1.15
POL-001*	2011-2016	0.13	0.15	mg l-1	0.85
POL-002*	2011-2016	0.14	0.15	mg l-1	0.91
POL-003*	2011-2016	0.06	0.12	mg l-1	0.52
POL-004*	2011-2016	0.03	0.03	mg l-1	1.10
POL-005	2011-2016	0.08	0.04	mg l-1	2.29
POL-006	2011-2016	0.03	0.04	mg l-1	0.97
POL-007	2011-2016	0.06	0.04	mg l-1	1.48
POL-008	2011-2016	0.09	0.05	mg l-1	2.00
POL-009	2011-2016	0.07	0.05	mg l-1	1.64
POL-010	2011-2016	0.05	0.03	mg l-1	1.80

POL-011	2011-2016	0.06	0.03	mg l-1	1.97
POL-012	2011-2016	0.08	0.03	mg l-1	2.60
POL-013	2011-2016	0.04	0.03	mg l-1	1.30
POL-014	2011-2016	0.03	0.03	mg l-1	0.97
POL-015	2011-2016	0.02	0.03	mg l-1	0.73
POL-016	2011-2016	0.07	0.03	mg l-1	2.27
POL-017	2011-2016	0.08	0.03	mg l-1	2.60
POL-018	2011-2016	0.04	0.02	mg l-1	1.83
POL-019	2011-2016	0.04	0.03	mg l-1	1.23
SWE-001**	2011-2016	-	0.78	EQR	0.95
SWE-001	2011-2016	-	0.71	EQR	0.97
SWE-003**	2011-2016	-	0.78	EQR	0.95
SWE-003	2011-2016	-	0.71	EQR	0.92
SWE-004**	2011-2016	-	0.78	EQR	1.10
SWE-004	2011-2016	-	0.71	EQR	1.01
SWE-005**	2011-2016	-	0.78	EQR	1.26
SWE-005	2011-2016	-	0.71	EQR	1.71
SWE-006**	2011-2016	-	0.69	EQR	1.19
SWE-006	2011-2016	-	0.74	EQR	1.66
SWE-007**	2011-2016	-	0.69	EQR	1.37
SWE-007	2011-2016	-	0.74	EQR	2.76
SWE-008**	2011-2016	-	0.69	EQR	1.19
SWE-008	2011-2016	-	0.74	EQR	2.37
SWE-009**	2011-2016	-	0.68	EQR	1.20
SWE-009	2011-2016	-	0.73	EQR	1.69
SWE-010**	2011-2016	-	0.68	EQR	1.20
SWE-010	2011-2016	-	0.73	EQR	1.62
SWE-011**	2011-2016	-	0.66	EQR	1.86
SWE-011	2011-2016	-	0.74	EQR	1.35
SWE-012**	2011-2016	-	0.66	EQR	1.93
SWE-012	2011-2016	-	0.74	EQR	1.95
SWE-013**	2011-2016	-	0.66	EQR	2.19
SWE-013	2011-2016	-	0.74	EQR	3.46
SWE-014**	2011-2016	-	0.66	EQR	1.86
SWE-014	2011-2016	-	0.74	EQR	1.55
SWE-015	2011-2016	-	0.74	EQR	1.14
SWE-016**	2011-2016	-	0.71	EQR	0.94
SWE-016	2011-2016	-	0.72	EQR	1.22
SWE-017**	2011-2016	-	0.71	EQR	0.85
SWE-017	2011-2016	-	0.72	EQR	1.02
SWE-018**	2011-2016	-	0.71	EQR	0.84
SWE-018	2011-2016	-	0.70	EQR	0.86
SWE-019**	2011-2016	-	0.71	EQR	0.90
SWE-019	2011-2016	-	0.70	EQR	0.85
SWE-020**	2011-2016	-	0.64	EQR	0.86
SWE-020	2011-2015	-	0.69	EQR	1.28
SWE-021**	2011-2015	-	0.64	EQR	0.72
SWE-021	2011-2015	-	0.69	EQR	0.83
SWE-022**	2011-2015	-	0.64	EQR	0.79
SWE-022	2011-2015	-	0.69	EQR	0.87
SWE-023**	2011-2015	-	0.64	EQR	0.72
SWE-023	2011-2015	-	0.69	EQR	0.84
SWE-024	2011-2015	-	0.74	EQR	1.30
SWE-025**	2011-2015	-	0.78	EQR	1.15
SWE-025	2011-2016	-	0.71	EQR	1.17

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.

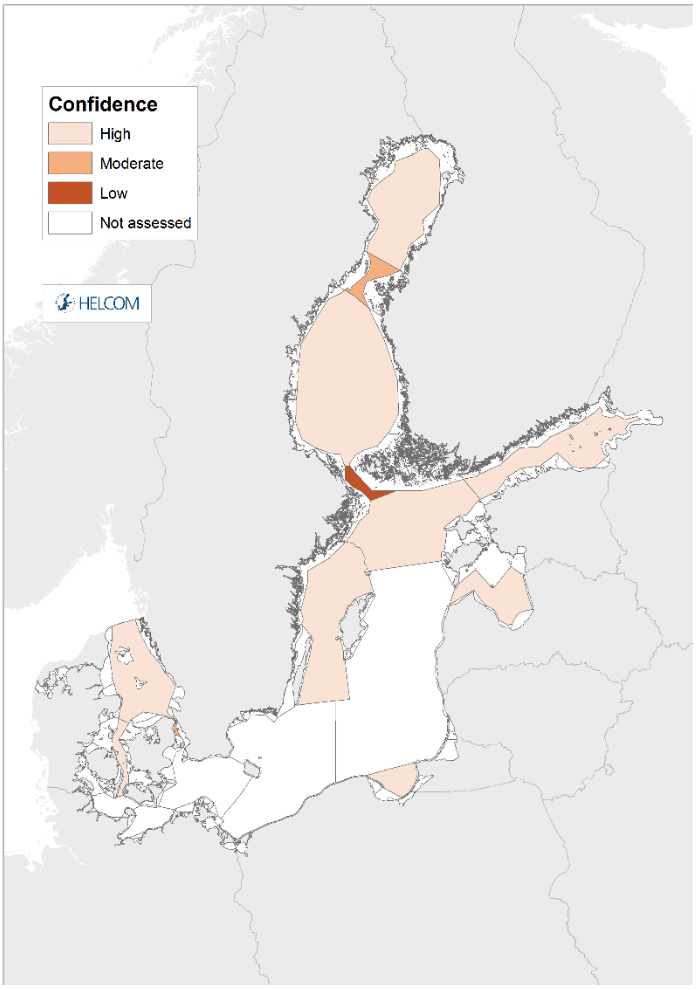




Results figure 4. Temporal development of total phosphorus (TP) concentrations in the open-sea assessment units from 1970s to 2016. Dashed lines show the five-year moving averages and error bars the standard deviation. Green lines denote the indicator threshold. Significance of trends was assessed with Mann-Kendall non-parametric tests for period from 1990-2016. Significant ($p<0.05$) improving trends are indicated with blue and deteriorating trends with orange data points.

Confidence of the indicator status evaluation

The confidence of the total phosphorus indicator status evaluation for the open sea areas (Results figure 5) is **high** in most of the assessed sub-basins. The confidence was **moderate** in the Quark and **low** in the Åland Sea. It should be noted that the confidence is only based on data availability, not the threshold confidence since the latter was not available for the indicator calculation.



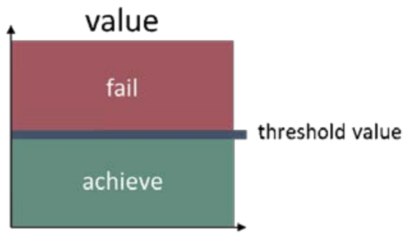
Results figure 5. Indicator data confidence, determined combining information on data availability for the indicator when using observations from all months of the year. Low indicator confidence calls for increase in monitoring.

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 2011-2016. 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.

Thresholds and Status evaluation

The threshold value of the 'Total phosphorus' core 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 (Thresholds and Status evaluation figure 1).



Thresholds and Status evaluation figure 1. Schematic representation of the threshold value for the core indictor 'Total phosphorus'. Assessment unit-specific threshold values are used (see Thresholds and Status evaluation table 1).

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

Thresholds and Status evaluation table 1. Assessment unit-specific threshold values for total phosphorus.

HELCOM_ID	Assessment unit (open sea)	Threshold value [µmol l^{-1}]	Reference	Comments
SEA-001	Kattegat	0.64	HELCOM 38-2017	TARGREV value applied
SEA-002	Great Belt	0.95	HELCOM 38-2017	TARGREV value applied
SEA-003	The Sound	0.68	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	0.60	HELCOM 38-2017	
SEA-009	Eastern Gotland Basin			
SEA-010	Western Gotland Basin	0.45	HELCOM 38-2017	TARGREV value applied
SEA-011	Gulf of Riga	0.70	HELCOM 38-2017	New value (expert judgement)
SEA-012	Northern Baltic Proper	0.38	HELCOM 38-2017	TARGREV value applied
SEA-013	Gulf of Finland	0.55	HELCOM 38-2017	TARGREV value applied
SEA-014	Åland Sea	0.28	HELCOM 38-2017	TARGREV value applied
SEA-015	Bothnian Sea	0.24	HELCOM 38-2017	TARGREV value applied
SEA-016	The Quark	0.24	HELCOM 38-2017	TARGREV value applied
SEA-017	Bothnian Bay	0.18	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), also taking 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, total phosphorus (TP) was not simulated in the TARGREV modelling exercise, only upper limits of annual means of TP 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 modelling approach has recently provided revised concentrations for German national threshold value of total nutrients in the Kiel Bay, Mecklenburg Bay, Arkona Basin and Bornholm Basin (Hirt et al. 2013; Schernewski et al. 2015; 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 phosphorus in open sea areas is made as the average of total phosphorus 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 phosphorus in coastal areas (as in Key message figure 1).

Assessment protocol table 1. Specifications of the indicator 'Total phosphorus'.

Indicator	**Total phosphorus**
Response to eutrophication	positive
Parameters	Total phosphorus 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	2011-2016
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 threshold (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 threshold confidence (ET-Score)	HIGH, if the threshold was based on numerous observations made earlier than the 1950's, possibly in combination with hindcast modelling. MODERATE, if the threshold was based on observations made earlier than the 1980's and/or hindcast modelling. LOW, if the threshold 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 the total nutrients, this indicator also contributes to the overall eutrophication assessment along with the other 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 Phosphorus (TP)' 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).

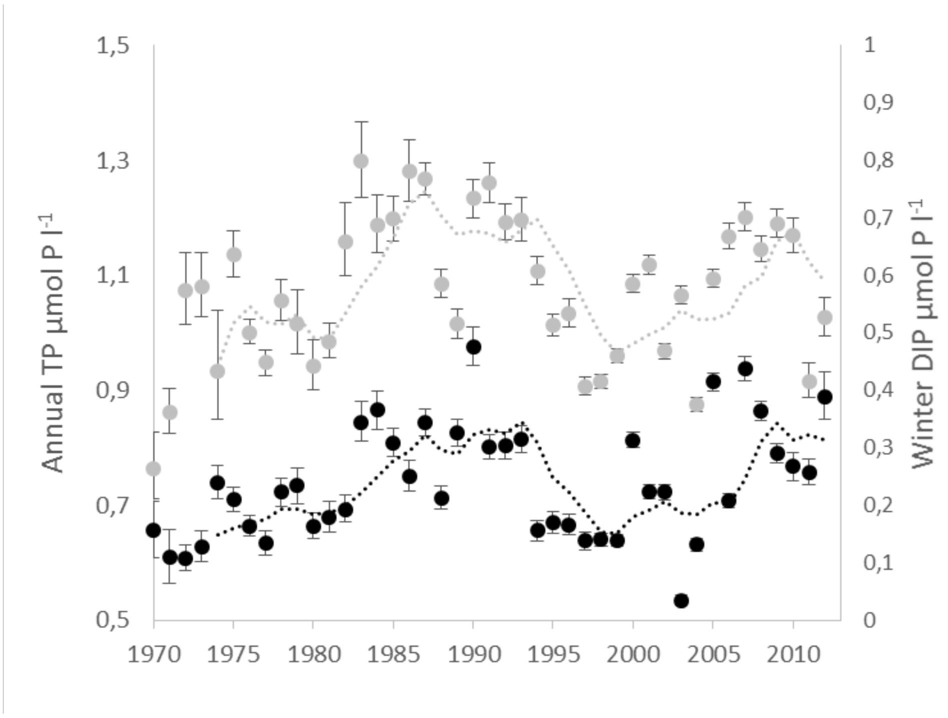
The EU Water Framework Directive (Anonymous 2000) requires good ecological and chemical status in the European coastal waters. Good ecological status is defined in Annex V of the Water Framework Directive, in terms of the quality of the biological community including phytoplankton biomass (usually measured 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 phosphorus in the ecosystem

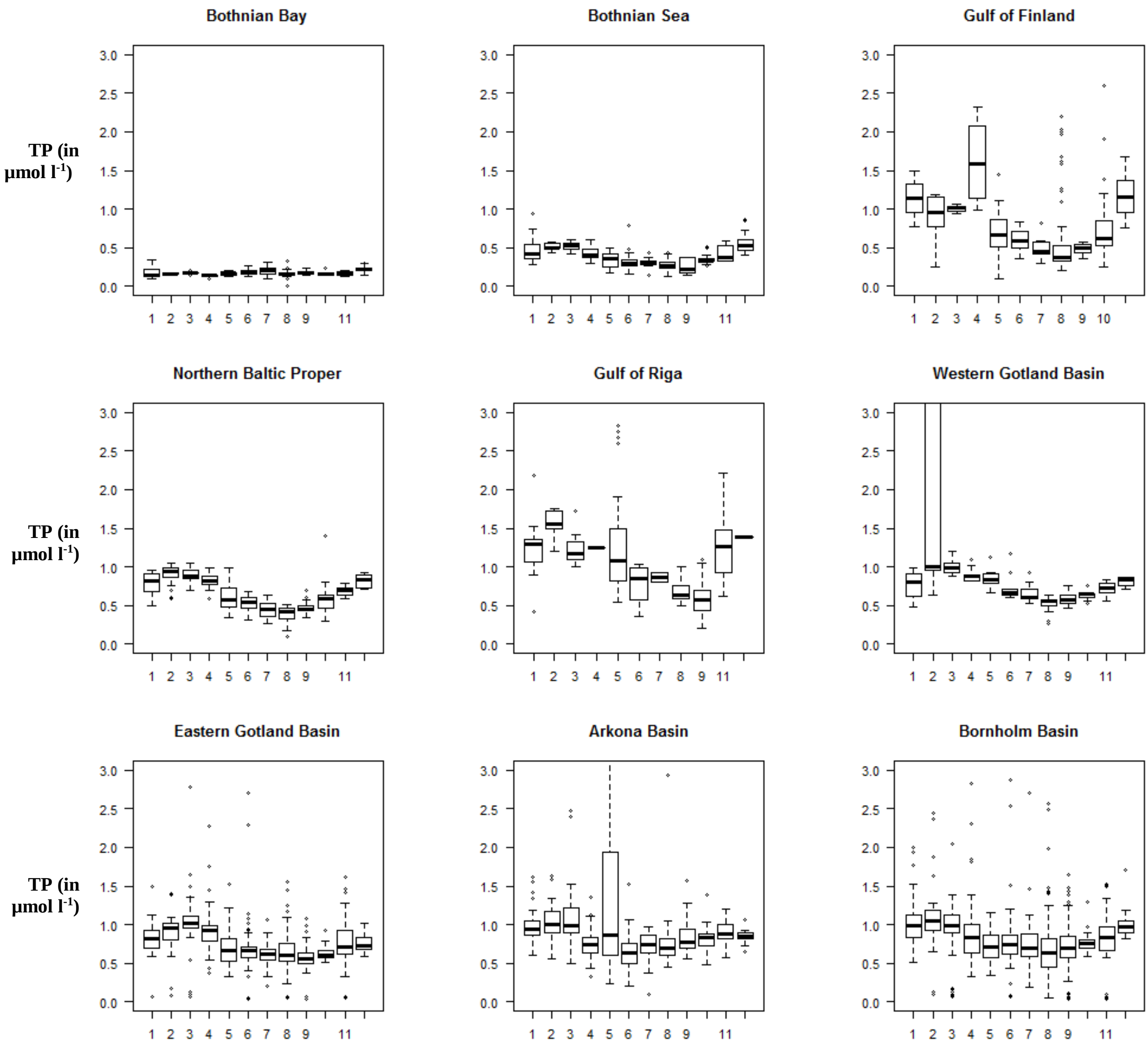
Marine eutrophication is mainly caused by nutrient enrichment leading to increased production of organic matter in the Baltic Sea with subsequent effects on water transparency, phytoplankton communities, benthic fauna and vegetation as well as oxygen conditions. Phytoplankton and benthic vegetation need 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, an indication of decrease in winter

DIP concentrations has been identified in the Arkona Basin during the last five years, but TP concentrations have remained somewhat unchanged (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 (Relevance figure 2). 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 TP (black line and dots) and winter DIP (gray line and dots) in the Arkona Basin. The late (since 2008) decrease in winter DIP is not expressed by annual TP. The figure is modified from HELCOM 2013.



Relevance figure 2. Monthly values of total phosphorus concentration (as 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 phosphorus 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.**

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 (2018) Total phosphorus. HELCOM core indicator report. Online. [Date Viewed], [Web link].

ISSN 2343-2543

Metadata

Result: Total phosphorus

Data source: The average for 2011-2016 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 phosphorus 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 2011-2016. For the summer average, observations taken during June-September were included only.

Data aggregation: The 2011-2016 averages for each sub-basin were produced as an inter-annual estimates using observations from all months / June-September.

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Archive

This version of the HELCOM core indicator report was published in July 2018:

Total phosphorous HELCOM core indicator 2018 (pdf)

Earlier versions of the core indicator report include:

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

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