Document title	Pre-core indicator on total nutrients – proposal to shift status to core indicator
Code	4J-38
Category	DEC (LATE)
Agenda Item	4J – HELCOM indicators and assessments
Submission date	20.10.2016
Submitted by	Lead Country Germany and EUTRO-OPER EXTENDED, as proposed by IN-Eutrophication

Note that this document was submitted after the established deadline.
It will be decided by the Meeting whether the document can be discussed or is postponed to the next meeting.

Background

At present, the core indicators for nutrients in the water are dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP), both measured during the winter months December – February. The HELCOM EUTRO-OPER project tested and proposed additional indicators of total nutrients, and these were accepted as pre-core indicators by STATE & CONSERVATION 3-2015.

In the following paper, indicator GES-boundaries are proposed, and the indicator concept is defined further, with the aim of giving the indicator core status and applying it in HOLAS II.

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

Action required

The Meeting is invited to:

- endorse the shift of the indicator status to core indicator,
- endorse the assessment protocol,
- consider the preliminary GES boundaries for the indicator and agree to endorse the final proposals on GES boundaries intersessionally.

Indicator concept

Adding total nutrients alongside inorganic nutrients as core indicators strengthens the link from nutrient concentrations in the sea to nutrient enrichment. As opposed to the present nutrient core indicators, nutrient loads are measured as the total fraction of nutrients entering the sea annually. In addition, total nutrients allow taking into account effects of climate change in the eutrophication assessment: higher temperatures are expected to 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 during winter, more nutrients are bound to phytoplankton than previously, due to increased water temperatures. In such a situation, dissolved inorganic nutrients might give an impression of declining nutrient concentrations while, in fact, total nutrient concentration is stable or increasing. 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.

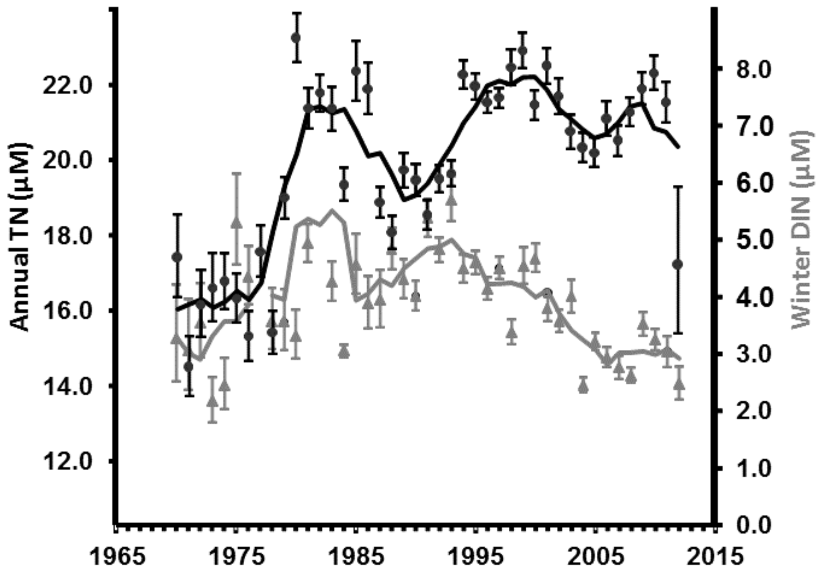
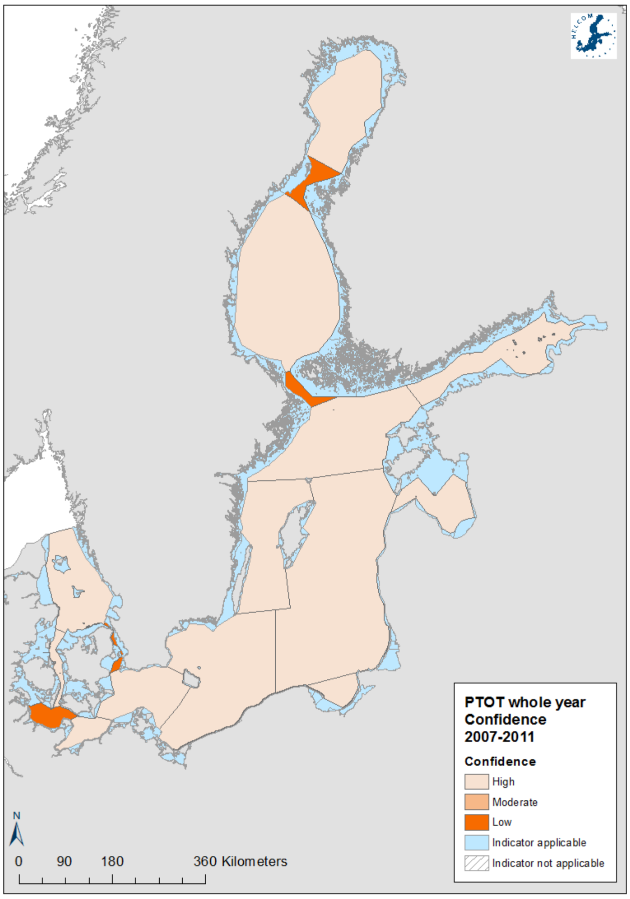


Figure 1. Time series of annual TN (black line and dots) and winter DIN (gray line and dots) in the Bornholm Basin. The decrease in winter DIN since the 1990's is not expressed by annual TN. The figure is modified from BSEP 133.

The EUTRO-OPER project proposed two alternative indicator concepts for total nutrients: 1) annual and 2) summer period June-September. Both approaches were tested and compared. The difference between annual and summer nutrient concentrations is not extreme (ANNEX 1), and only the annual option is supported by sufficient data (see figure below). At this point, GES boundaries can be achieved only for annual nutrients. Hence, the annual approach is proposed to be used.



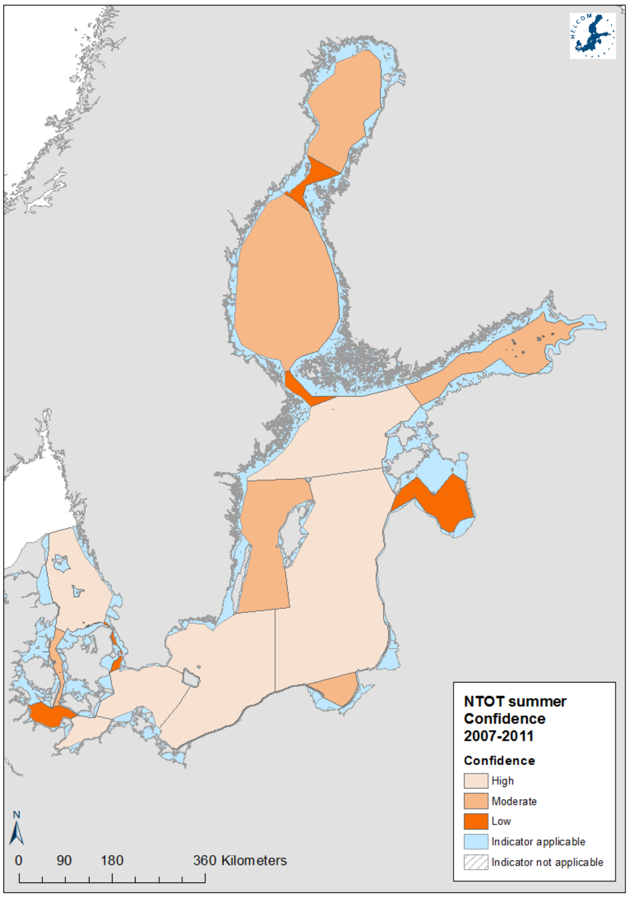


Figure 2. Indicator status confidence, determined combining information on data availability for the indicator when using observations from all months of the year (left) and from summer months June-September only (right). A clear difference in the indicator confidence was observed between the annual and summer total nitrogen indicators, due to lower number of observations in the latter. When using annual values for the indicator, status confidence was high for 14 out of the 17 sub-basins. When only information from the summer months was used, the status confidence decreased from high to moderate in 6 sub-basins and to low in two additional sub-basins.

Proposing GES boundaries

Target estimations for annual total nutrients have been calculated by the TARGREV project (HELCOM 2013), applying a GAM/GLM normalizing approach on long-term data dating back to the early 1970's. The data-based targets, nowadays referred to as GES boundaries, were not coupled to model results. The GES boundary estimations do not date back to a pre-eutrophied time (1940), but do describe a time prior to the period of heavy eutrophication. Thus they (similarly as the chlorophyll-a GES boundary estimations) should be regarded as the highest possible target level.

In the southern open-sea areas of the Baltic Sea, national GES boundaries for annual total nutrients have been taken into account for Poland and Germany. The estimations from Germany are based on modelling historical nutrient inputs. The Polish target values are based on an ECOSTAT project.

Annual total nitrogen and total phosphorus GES boundary proposals can be derived from these projects (see tables).

Table. Total nitrogen GES boundary proposals (µmol l^{-1}), derived from earlier estimations: the values calculated during the TARGREV project (data mining) and the modelling results achieved from the ECOSTAT project (Poland) or a national approach (Germany). Items left for discussion are highlighted in yellow.

HELCOM sub-basin	Sub-basin name	TARGREV target/GES (<)	Variation of medians	National GES	Reference	Proposed GES	Comments
SEA-001	Kattegat	17.4	15 - 21			17.4	
SEA-002	Great Belt	17.3				17.3	
SEA-003	The Sound	21.0				21.0	
SEA-004	Kiel Bay	22.3[1]		16.4[2]	GER	16.4	Choose national
SEA-005	Bay of Mecklenburg	21.8		16.7	GER	16.7	Choose national
SEA-006	Arkona Basin	17.3	13 - 20	19.5	GER	19.5	Choose national
SEA-007	Bornholm Basin	16.1	15 - 17	18.0 / 14.4	GER / POL	14.4	Choose lowest national
SEA-008	Eastern Gotland Basin	16.5		15.5	POL	15.5	Choose national
SEA-009	Gdansk Basin	17.3		17.3	POL	17.3	
SEA-010	Western Gotland Basin	15.1				15.1	
SEA-011	Northern Baltic Proper	16.2	16 - 16			16.2	
SEA-012	Gulf of Riga	37.5	23 - 33			28.0	TARGREV overestimate[3]
SEA-013	Gulf of Finland	21.3	20 - 22			21.3	
SEA-014	Åland Sea	15.6				15.6	
SEA-015	Bothnian Sea	15.7	13 - 17			15.7	
SEA-016	The Quark	17.3				17.3	
SEA-017	Bothnian Bay	16.9	17 - 19			16.9	

[1] The TARGREV-targets for Kiel Bay, Bay of Mecklenburg, Arkona Basin and Bornholm Basin for TN and TP are taken from HELCOM CORE EUTRO 7/2012 Document 3/9/Add.1. The targets from the original TARGREV report were revised due to the inclusion of German data in the 1-12nm zone. Note that these "targets" are now referred to as GES boundaries.

[2] Note that the German national GES boundaries provided for Kiel Bay, Bay of Mecklenburg, Arkona Basin and Bornholm Basin for TN and TP relate to the median of monitoring data and not to the mean. If the mean will be used it might be necessary to adjust these boundaries.

[3] The estimate made by the TARGREV project describes the situation in the early nineties, when average levels had already increased considerably (HELCOM 2013, p 103 Fig. B.1). The variation of the early years was high, and a value at the middle of this variation is proposed instead.

Table. Total phosphorus GES boundary proposals (µmol l^{-1}), derived from earlier estimations: the values calculated during the TARGREV project (data mining) and the modelling results achieved from the ECOSTAT project (Poland) or a national approach (Germany).. Items left for discussion are highlighted in yellow.

HELCOM sub-basin	Sub-basin name	TARGREV target/GES (<)	Variation	National GES	Reference	Proposed GES	Comments
SEA-001	Kattegat	0.64	0.49 - 0.65			0.57	TARGREV target/GES overestimate[4]
SEA-002	Great Belt	0.68				0.68	
SEA-003	The Sound	0.95				0.95	
SEA-004	Kiel Bay	0.91		0.41	GER	0.41	Choose national
SEA-005	Bay of Mecklenburg	0.89		0.45	GER	0.45	Choose national
SEA-006	Arkona Basin	0.66	0.61 - 0.65	0.48	GER	0.48	Choose national
SEA-007	Bornholm Basin	0.5	0.49 - 0.60	0.59	GER / POL	0.59	Choose national
SEA-008	Eastern Gotland Basin	0.45		0.68	POL	0.68	Choose national
SEA-009	Gdansk Basin	0.55		0.60	POL	0.60	Choose national
SEA-010	Western Gotland Basin	0.45				0.45	
SEA-011	Northern Baltic Proper	0.38	0.37 - 0.49			0.38	
SEA-012	Gulf of Riga	0.70	0.51 - 0.79			0.70	
SEA-013	Gulf of Finland	0.55	0.45 - 0.70			0.55	
SEA-014	Åland Sea	0.28				0.28	
SEA-015	Bothnian Sea	0.24	0.20 - 0.26			0.24	
SEA-016	The Quark	0.24				0.24	
SEA-017	Bothnian Bay	0.18	0.12 - 0.23			0.18	

Indicator status

When applying the indicator concept presented in this document, eutrophication ratio (ER, the ratio of monitored concentration and GES boundary) varied within 0.93 - 1.5 for TN and 0.8 – 2.5 for TP (when GES = 1.0, see tables below). The indicator was classified below GES in most of the open-sea sub-basins. For TN, GES was reached only in the Kattegat (SEA-001) and Sound (SEA-003), and for TP, GES was reached in the Sound (SEA-003), Gulf of Riga (SEA-012) and Bothnian Bay (SEA-017).

[4] The estimate made by the TARGREV project describes a situation where the levels were already increasing rapidly (HELCOM 2013, p 107 Fig. B.5). The variation of the early years was high, and a value at the middle of this variation is proposed instead of the average.

Table. Total nitrogen and phosphorus concentrations, proposed GES boundaries, eutrophication ratios (ER) and status classifications for the assessment period 2007-2011, applying the indicator concept presented above.

HELCOM ID	Basin	TN conc.	TN GES	TN ER	TN status	TP conc.	TP GES	TP ER	TP status
SEA-001	Kattegat	16.19	17.4	0.93	GES	0.70	0.57	1.23	sub-GES
SEA-002	Great Belt	17.84	17.3	1.03	sub-GES	0.73	0.68	1.07	sub-GES
SEA-003	The Sound	20.93	21.0	1.00	GES	0.78	0.95	0.82	GES
SEA-004	Kiel Bay	18.36	16.4	1.12	sub-GES	0.69	0.41	1.69	sub-GES
SEA-005	Bay of Mecklenburg	19.92	16.7	1.19	sub-GES	0.83	0.45	1.84	sub-GES
SEA-006	Arkona Basin	20.82	19.5	1.07	sub-GES	0.88	0.48	1.83	sub-GES
SEA-007	Bornholm Basin	24.80	14.4	1.72	sub-GES	0.82	0.59	1.39	sub-GES
SEA-008	Eastern Gotland Basin	22.30	15.5	1.44	sub-GES	0.75	0.68	1.10	sub-GES
SEA-009	Gdansk Basin	20.89	17.3	1.21	sub-GES	0.67	0.60	1.12	sub-GES
SEA-010	Western Gotland Basin	20.67	15.1	1.37	sub-GES	0.75	0.45	1.66	sub-GES
SEA-011	Northern Baltic Proper	21.44	16.2	1.32	sub-GES	0.96	0.38	2.53	sub-GES
SEA-012	Gulf of Riga	35.44	28.0	1.27	sub-GES	0.64	0.70	0.92	GES
SEA-013	Gulf of Finland	25.94	21.3	1.22	sub-GES	0.75	0.55	1.36	sub-GES
SEA-014	Åland Sea	18.32	15.6	1.17	sub-GES	0.48	0.28	1.72	sub-GES
SEA-015	Bothnian Sea	18.02	15.7	1.15	sub-GES	0.42	0.24	1.74	sub-GES
SEA-016	The Quark	18.76	17.3	1.08	sub-GES	0.37	0.24	1.55	sub-GES
SEA-017	Bothnian Bay	18.75	16.9	1.09	sub-GES	0.17	0.18	0.97	GES

In the south-western sub-basins (Kattegat, Great Belt, the Sound, Kiel bay) and the northern sub-basins (the Gulf of Finland, Bothnian Bay, Quark, Bothnian Sea), the eutrophication ratio was clearly lower, and hence the status classification better, for TN than DIN (HELCOM 2014). In the Bornholm Basin and Gulf of Riga, on the contrary, the status was estimated to be worse for TN than DIN (see Figure below). This would be expected in a situation, where a large part of the nutrients is bound in particular matter even during the winter period.

In the Sound, Bornholm Basin and Gdansk Basin, DIP status was better than TP, as would have been expected. On the other hand, DIP status was clearly worse than TP status in the Bothnian Bay – Quark – Bothnian Sea area, the Gulf of Riga and the Mecklenburg – Kiel bay area, even though the German modeled GES-boundaries were applied in these areas instead of the less strict TARGREV estimates.

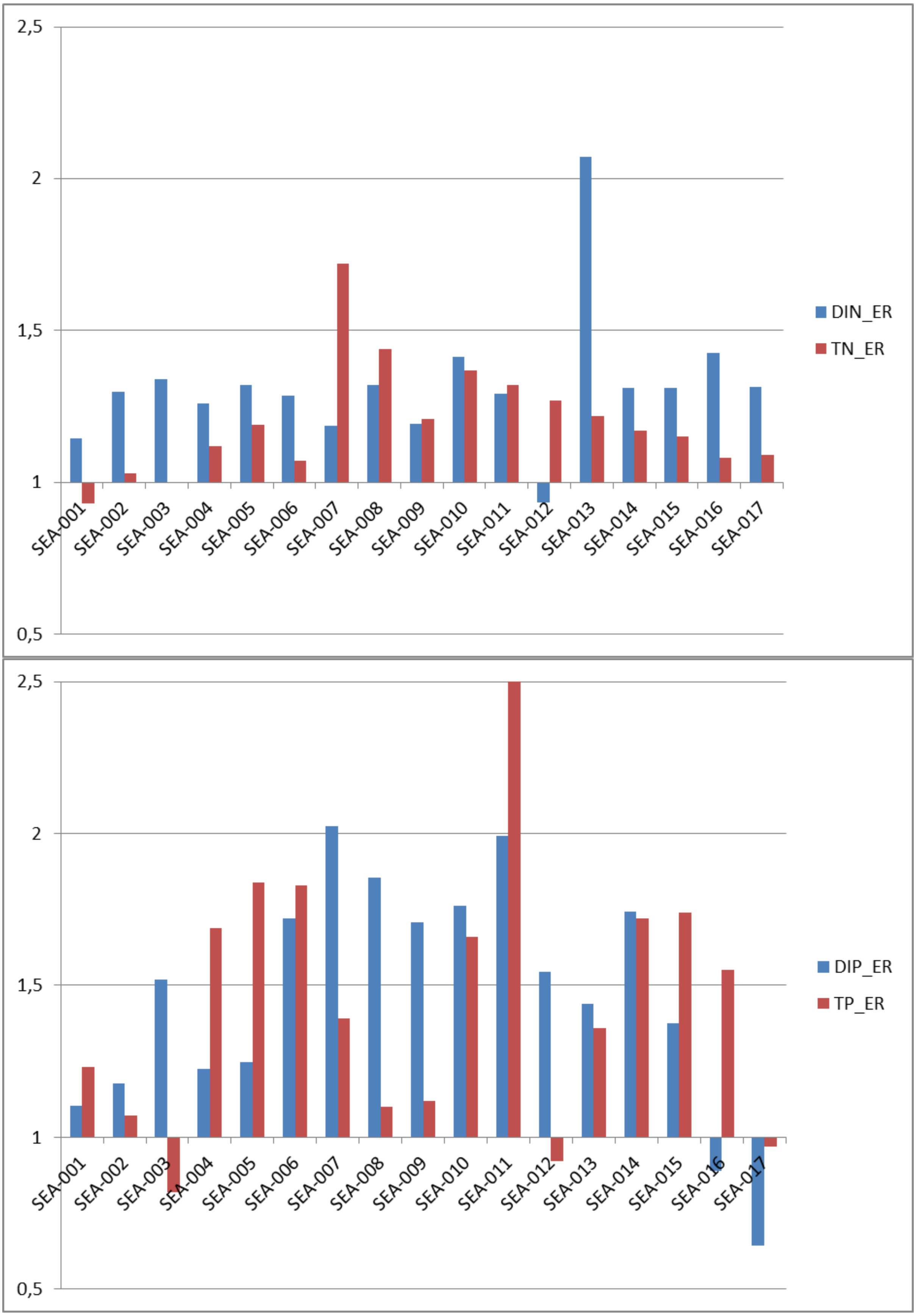


Figure 3. Comparing the eutrophication ratio (ER) of dissolved inorganic nutrients (DIN, DIP) and total nutrients (TN, TP). Above: nitrogen, below: phosphorus.

-

References

HELCOM 2013. Approaches and methods for eutrophication target setting in the Baltic Sea region. BSEP 133.

HELCOM 2014 (Pyhälä M, Fleming-Lehtinen V, Laamanen M, Łysiak-Pastuszak E, Carstens M, Leppänen J-M, Leujak W, Nausch G, 2014). Nitrogen status - HELCOM Core Indicator Report. Online. [Viewed 12.10.2016], http://helcom.fi/baltic-sea-trends/eutrophication/indicators/DIN

HELCOM 2014 (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. [Viewed 12.10.2016], http://helcom.fi/baltic-sea-trends/eutrophication/indicators/DIP

Schernewski, G., Friedland, R., Carstens, M., Hirt, U., Leujak, W., Nausch, G., Neumann, T., Petenati, T., Sagert, S., Wasmund, N., von Weber, W, 2014, 'Implementation of European marine policy: new water quality targets for German Baltic Waters', Marine Policy 51: 305-321.

ANNEX 1. Indicator report for total N and total P from EUTRO-OPER final report (will be updated)