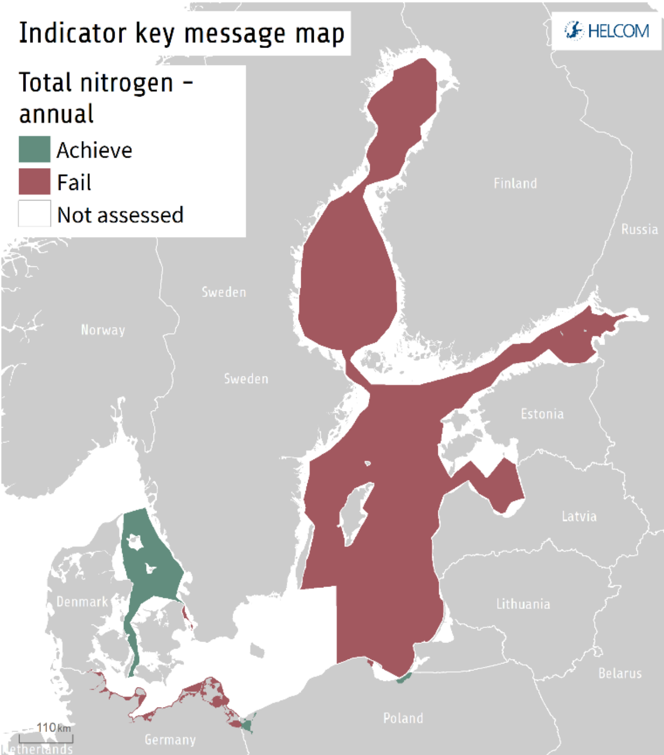
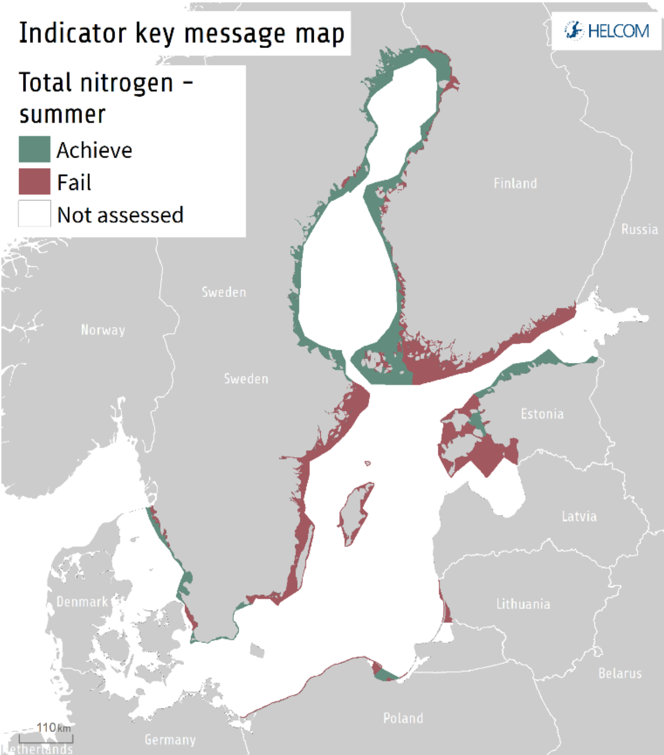
HELCOM core indicator report
July 2018

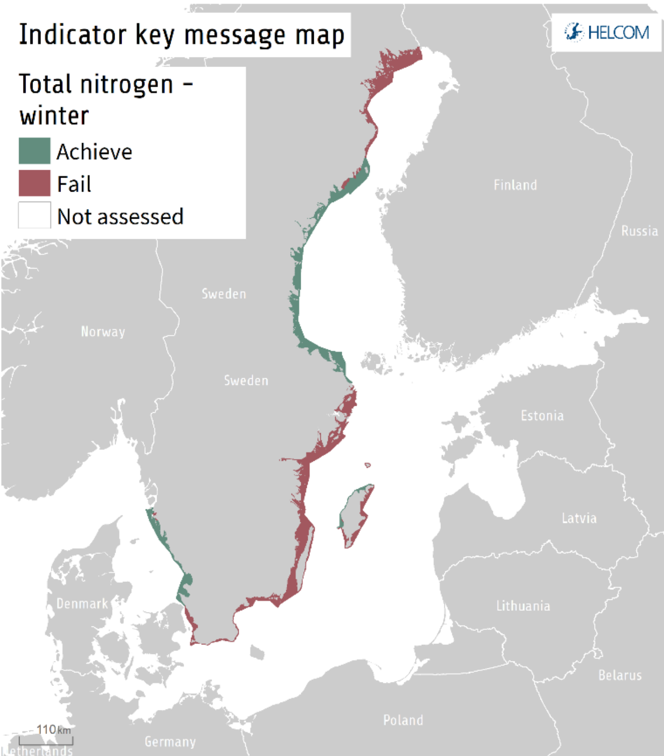
# Total nitrogen

## Key Message

For total nitrogen, 13 open-sea assessment units were evaluated for the period 2011-2016, of which good status was achieved only in Kattegat and Great Belt (total nitrogen concentrations below a defined threshold value). In coastal water assessment units, the threshold values set for total nitrogen were commonly failed, though some Swedish, Finnish, Estonian and Polish coastal areas achieved the threshold values and good status (Key message figure 1).






**Key message figure 1.** Status assessment evaluation of the indicator 'Total nitrogen' - 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 sub-basins threshold values are still 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. See Results section below for details. **Click here to access interactive maps at the HELCOM Map and Data Service: Total nitrogen**.

The confidence in the presented total nitrogen status evaluation for the open sea areas is **high** in most of the assessed sub-basins. The data confidence was **moderate** in the Quark and **low** in 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 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 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<br>- 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<br>Theme: Pelagic habitats<br>-D1C6 The condition of the habitat type, including its biotic and abiotic structure and its functions, is not adversely affected due to anthropogenic pressures.<br>Theme: Benthic habitats<br>-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 | | |

## Cite this indicator

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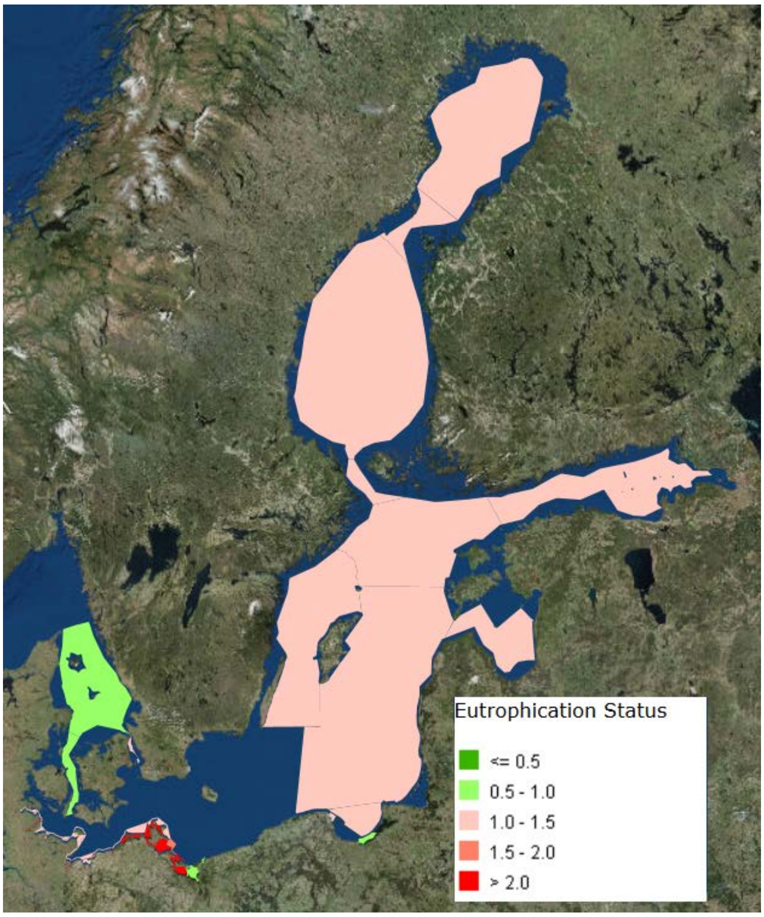
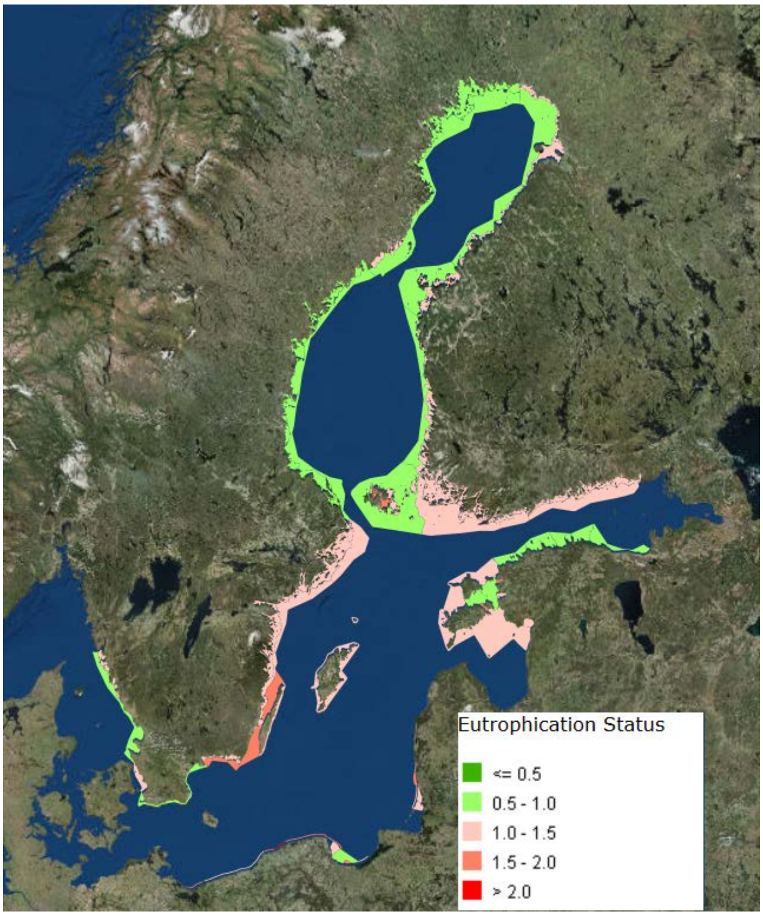
# Results and Confidence

The evaluation of total nitrogen in the open-sea areas is made as the average of total nitrogen concentrations in the upper (0-10 m) water layer throughout the year (annual). Out of the 13 sub-basins assessed, two were found to be in good status (below threshold value) during their assessment period 2011-2016: The Kattegat and Great Belt. The remaining assessed sub-basins were above the threshold values, with a number of sub-basins being near to the threshold (Results figures 1 and Results table 1). Some assessment open sea units could not be assessed as threshold values still need to be agreed upon at the HELCOM-wide level.

As some Contracting Parties favoured the use of seasonal (i.e. summer) instead of annual mean values when developing the indicator, a comparison was made between both methods. In most of the open sea basins, the annual and summer concentrations were at a relatively equal levels when measured annually or for summer months only (difference 0-1.5 µmol $l^{-1}$). Annual concentrations were clearly higher than summer values in the Gulf of Riga (difference 6.2 µmol $l^{-1}$), and slightly higher in the Great Belt and the Quark (difference 2-3 µmol $l^{-1}$). As a consequence of this study, the annual average was used for the indicator in open-sea areas.

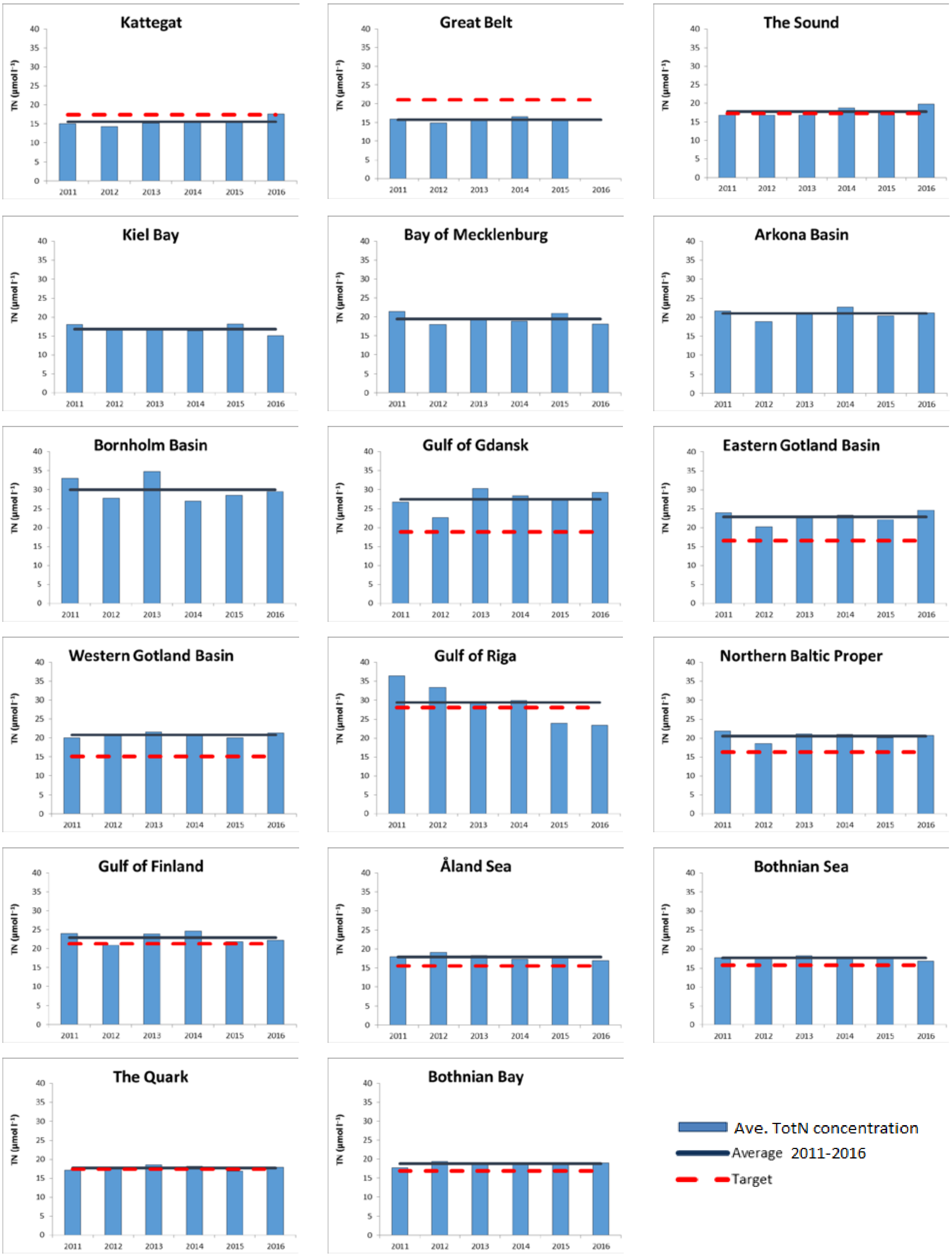
In general concentrations during the current assessment period for open sea assessment units remained relatively stable, though there were some fluctuations and an apparent decrease observed in the Gulf of Riga (Results figure 2).






**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 coastal areas shown are from national reporting and can reflect annual or summer data (see Results table 2 fro 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 coast of Sweden, Finland, Estonia, and Poland were classified as achieving good status (Results figure 1 and Results table 2).




**Results figure 2.** Average annual surface total nitrogen concentrations (black line; average for 2011-2016). The red dashed line represents the 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.

**Results table 1.** Threshold values, present concentration (as average 2011-2016), 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 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 $l^{-1}$) | Eutrophication ratio (ER) | Status (fail/achieve threshold value) |
|---|---|---|---|---|---|
| **SEA-001** | Kattegat* | 17.4 | 15.59 | 0.90 | Achieve |
| **SEA-002** | Great Belt* | 21.0 | 15.72 | 0.75 | Achieve |
| **SEA-003** | The Sound* | 17.3 | 17.77 | 1.03 | Fail |
| **SEA-004** | Kiel Bay* | | | | Not assessed |
| **SEA-005** | Bay of Mecklenburg* | | | | Not assessed |
| **SEA-006** | Arkona Sea* | | | | Not assessed |
| **SEA-007** | Bornholm Sea | | | | Not assessed |
| **SEA-008** | Gdansk Basin | 18.8 | 27.44 | 1.46 | Fail |
| **SEA-009** | Eastern Gotland Basin | 16.5 | 22.85 | 1.38 | Fail |
| **SEA-010** | Western Gotland | 15.1 | 20.81 | 1.38 | Fail |
| **SEA-011** | Gulf of Riga | 28.0 | 29.36 | 1.05 | Fail |
| **SEA-012** | Northern Baltic Proper | 16.2 | 20.51 | 1.27 | Fail |
| **SEA-013** | Gulf of Finland | 21.3 | 22.92 | 1.08 | Fail |
| **SEA-014** | Åland Sea | 15.6 | 17.88 | 1.15 | Fail |
| **SEA-015** | Bothnian Sea | 15.7 | 17.68 | 1.13 | Fail |
| **SEA-016** | The Quark | 17.3 | 17.74 | 1.03 | Fail |
| **SEA-017** | Bothnian Bay | 16.9 | 18.83 | 1.11 | 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.

Coastal area assessment results are based mostly on summer and annual average total nitrogen values, and in some cases (in Sweden) also winter averages are used (Results table 2). In Estonian coastal waters, the threshold value has been achieved in 7 waterbodies out of 16 and in Finland in 4 out of 14, based on summer estimates. In the coastal areas of Germany, the threshold value has been achieved in one waterbody out of 45, based on annual values. In Lithuania none of the 6 coastal areas achieved the threshold value. 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 1 of them achieving the threshold value. In Sweden both summer and winter averages were used in assessing coastal areas. Concerning summer values, the threshold value was achieved in 10 areas out of 24, and using winter values in 9 areas out of 22. Concerning the percentage of total assessed area to achieve the threshold value (i.e. good status) per country (if the threshold value was achieved in some basins), over half of the area is in good status in Poland, Sweden (summer values) and Finland; 56%, 52% and 51%, respectively. According to winter values in Sweden, 38% of the assessed area is in good status. Estonia has 32% of the area in good status and Germany <1%.

**Results table 2.** Results for national coastal total nitrogen indicators by coastal WFD water type/water body. The table includes information on the assessment unit (CODE, defined in the HELCOM Monitoring and Assessment Strategy Annex 4), assessment period (start year and end year), average concentration during assessment period, threshold values, units, and Eutrophication Ratio (ER). The ER is colored red or green to denote if the status evaluation has been failed or achieved, respectively. Data and status evaluations were reported by Contracting Parties for different seasons, indicated by * = annual, ** = winter, and no symbol = summer. - indicates only status provided and not raw result value.

| CODE | Period | Average | Threshold value | Units | Eutrophication ratio (ER) |
|---|---|---|---|---|---|
| EST-001 | 2011-2016 | 23.30 | 26.80 | µmol $l^{-1}$ | 0.87 |
| EST-002 | 2016 | 20.82 | 26.80 | µmol $l^{-1}$ | 0.78 |
| EST-003 | 2014 | 21.26 | 22.80 | µmol $l^{-1}$ | 0.93 |
| EST-004 | 2011-2016 | 19.71 | 22.80 | µmol $l^{-1}$ | 0.86 |
| EST-005 | 2011-2016 | 20.65 | 22.80 | µmol $l^{-1}$ | 0.91 |
| EST-006 | 2011-2016 | 19.67 | 22.80 | µmol $l^{-1}$ | 0.86 |
| EST-007 | 2011-2013 | 19.94 | 18.30 | µmol $l^{-1}$ | 1.09 |
| EST-008 | 2011-2015 | 35.65 | 21.00 | µmol $l^{-1}$ | 1.70 |
| EST-009 | 2015 | 26.46 | 21.00 | µmol $l^{-1}$ | 1.26 |
| EST-010 | 2012-2016 | 23.90 | 18.30 | µmol $l^{-1}$ | 1.31 |
| EST-011 | 2012 | 23.31 | 18.30 | µmol $l^{-1}$ | 1.27 |
| EST-012 | 2011-2016 | 26.62 | 23.70 | µmol $l^{-1}$ | 1.12 |
| EST-013 | 2011-2016 | 32.32 | 29.20 | µmol $l^{-1}$ | 1.11 |
| EST-014 | 2016 | 21.52 | 21.00 | µmol $l^{-1}$ | 1.02 |
| EST-015 | 2013 | 35.40 | 21.00 | µmol $l^{-1}$ | 1.69 |
| EST-016 | 2011-2016 | 19.99 | 21.00 | µmol $l^{-1}$ | 0.95 |
| FIN-001 | 2007-2012 | 437.00 | 325.00 | µg $l^{-1}$ | 1.34 |
| FIN-002 | 2007-2012 | 350.00 | 290.00 | µg $l^{-1}$ | 1.21 |
| FIN-003 | 2007-2012 | 418.00 | 350.00 | µg $l^{-1}$ | 1.19 |
| FIN-004 | 2007-2012 | 348.00 | 325.00 | µg $l^{-1}$ | 1.07 |
| FIN-005 | 2007-2012 | 364.00 | 310.00 | µg $l^{-1}$ | 1.17 |
| FIN-006 | 2007-2012 | 466.00 | 325.00 | µg $l^{-1}$ | 1.43 |
| FIN-007 | 2007-2012 | 268.00 | 280.00 | µg $l^{-1}$ | 0.96 |
| FIN-008 | 2007-2012 | 383.00 | 275.00 | µg $l^{-1}$ | 1.39 |
| FIN-009 | 2007-2012 | 268.00 | 315.00 | µg $l^{-1}$ | 0.85 |
| FIN-010 | 2007-2012 | 375.00 | 340.00 | µg $l^{-1}$ | 1.10 |
| FIN-011 | 2007-2012 | 309.00 | 315.00 | µg $l^{-1}$ | 0.98 |
| FIN-012 | 2007-2012 | 512.00 | 333.00 | µg $l^{-1}$ | 1.54 |
| FIN-013 | 2007-2012 | 326.00 | 319.00 | µg $l^{-1}$ | 1.02 |
| FIN-014 | 2007-2012 | 311.00 | 312.00 | µg $l^{-1}$ | 1.00 |
| GER-001* | 2007-2012 | 24.09 | 22.50 | µmol $l^{-1}$ | 1.07 |
| GER-002* | 2007-2012 | 24.09 | 22.50 | µmol $l^{-1}$ | 1.07 |
| GER-003* | 2007-2012 | 41.49 | 22.50 | µmol $l^{-1}$ | 1.84 |
| GER-004* | 2007-2012 | 19.84 | 19.50 | µmol $l^{-1}$ | 1.02 |

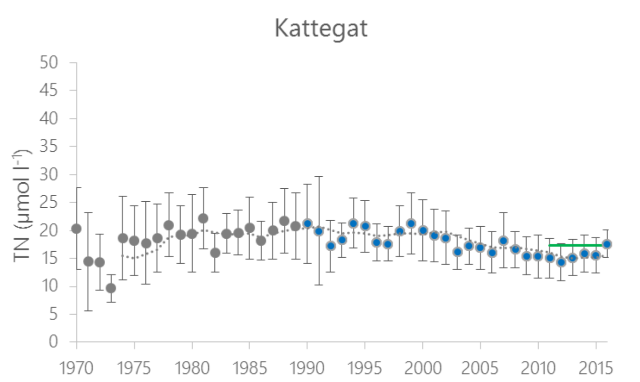
| | | | | | |
|---|---|---|---|---|---|
| GER-005* | 2007-2012 | 45.77 | 17.70 | µmol l-1 | 2.59 |
| GER-006* | 2007-2012 | 20.32 | 19.50 | µmol l-1 | 1.04 |
| GER-007* | 2007-2012 | 185.50 | 38.10 | µmol l-1 | 4.87 |
| GER-008* | 2007-2012 | 143.90 | 38.10 | µmol l-1 | 3.78 |
| GER-009* | 2007-2012 | 96.33 | 17.70 | µmol l-1 | 5.44 |
| GER-010* | 2007-2012 | 20.76 | 18.00 | µmol l-1 | 1.15 |
| GER-011* | 2007-2012 | 40.48 | 17.70 | µmol l-1 | 2.29 |
| GER-012* | 2007-2012 | 47.76 | 17.70 | µmol l-1 | 2.70 |
| GER-013* | 2007-2012 | 42.75 | 17.70 | µmol l-1 | 2.42 |
| GER-014* | 2007-2012 | 125.00 | 17.70 | µmol l-1 | 7.06 |
| GER-015* | 2007-2012 | 20.24 | 18.00 | µmol l-1 | 1.12 |
| GER-016* | 2007-2012 | 110.45 | 38.10 | µmol l-1 | 2.90 |
| GER-017* | 2007-2012 | 114.50 | 38.10 | µmol l-1 | 3.01 |
| GER-018* | 2007-2012 | 29.09 | 18.00 | µmol l-1 | 1.62 |
| GER-019* | 2007-2012 | 59.81 | 18.00 | µmol l-1 | 3.32 |
| GER-020* | 2007-2012 | 105.00 | 38.10 | µmol l-1 | 2.76 |
| GER-021* | 2007-2012 | 22.27 | 19.70 | µmol l-1 | 1.13 |
| GER-022* | 2007-2012 | 17.09 | 14.28 | µmol l-1 | 1.20 |
| GER-023* | 2007-2012 | 17.09 | 14.99 | µmol l-1 | 1.14 |
| GER-024* | 2007-2012 | 16.29 | 14.28 | µmol l-1 | 1.14 |
| GER-025* | 2007-2012 | 76.59 | 19.70 | µmol l-1 | 3.89 |
| GER-026* | 2007-2012 | 121.31 | 37.12 | µmol l-1 | 3.27 |
| GER-027* | 2007-2012 | 121.31 | 37.12 | µmol l-1 | 3.27 |
| GER-028* | 2011-2016 | 16.29 | 14.28 | µmol l-1 | 1.14 |
| GER-029* | 2016 | 16.82 | 14.99 | µmol l-1 | 1.12 |
| GER-030* | 2014 | 15.57 | 14.28 | µmol l-1 | 1.09 |
| GER-031* | 2011-2016 | 17.00 | 14.99 | µmol l-1 | 1.13 |
| GER-032* | 2011-2016 | 27.71 | 19.70 | µmol l-1 | 1.41 |
| GER-033* | 2011-2016 | 15.57 | 14.28 | µmol l-1 | 1.09 |
| GER-034* | 2011-2013 | 15.57 | 14.28 | µmol l-1 | 1.09 |
| GER-035* | 2011-2015 | 15.57 | 14.99 | µmol l-1 | 1.04 |
| GER-036* | 2015 | 17.26 | 14.28 | µmol l-1 | 1.21 |
| GER-037* | 2012-2016 | 17.18 | 19.70 | µmol l-1 | 0.87 |
| GER-038* | 2012 | 17.57 | 14.28 | µmol l-1 | 1.23 |
| GER-039* | 2011-2016 | 17.26 | 14.99 | µmol l-1 | 1.15 |
| GER-040* | 2011-2016 | 17.85 | 14.28 | µmol l-1 | 1.25 |
| GER-041* | 2016 | 19.98 | 14.28 | µmol l-1 | 1.40 |
| GER-042* | 2013 | 100.76 | 19.70 | µmol l-1 | 5.11 |
| GER-043* | 2011-2016 | 142.31 | 37.12 | µmol l-1 | 3.83 |
| GER-044* | 2011-2016 | 149.99 | 37.12 | µmol l-1 | 4.04 |
| GER-111* | 2011-2016 | 49.94 | 17.60 | µmol l-1 | 2.84 |
| LIT-001 | 2011-2016 | 1.07 | 0.67 | mg l-1 | 1.60 |
| LIT-002 | 2011-2016 | 0.36 | 0.25 | mg l-1 | 1.44 |

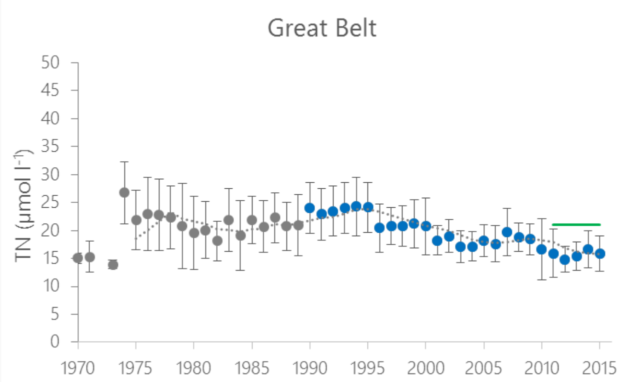
| | | | | | |
|---|---|---|---|---|---|
| LIT-003 | 2011-2016 | 0.44 | 0.25 | mg $l^{-1}$ | 1.76 |
| LIT-004 | 2011-2016 | 1.39 | 1.07 | mg $l^{-1}$ | 1.30 |
| LIT-005 | 2011-2016 | 1.24 | 1.08 | mg $l^{-1}$ | 1.15 |
| LIT-006 | 2011-2016 | 0.50 | 0.25 | mg $l^{-1}$ | 2.00 |
| POL-001* | 2011-2016 | 1.53 | 1.90 | mg $l^{-1}$ | 0.81 |
| POL-002* | 2011-2016 | 1.66 | 1.90 | mg $l^{-1}$ | 0.87 |
| POL-003* | 2011-2016 | 0.90 | 0.98 | mg $l^{-1}$ | 0.92 |
| POL-004* | 2011-2016 | 0.41 | 0.30 | mg $l^{-1}$ | 1.37 |
| POL-005 | 2011-2016 | 0.49 | 0.40 | mg $l^{-1}$ | 1.22 |
| POL-006 | 2011-2016 | 0.35 | 0.40 | mg $l^{-1}$ | 0.88 |
| POL-007 | 2011-2016 | 0.77 | 0.27 | mg $l^{-1}$ | 2.86 |
| POL-008 | 2011-2016 | 0.65 | 0.40 | mg $l^{-1}$ | 1.62 |
| POL-009 | 2011-2016 | 0.83 | 0.53 | mg $l^{-1}$ | 1.58 |
| POL-010 | 2011-2016 | 0.49 | 0.30 | mg $l^{-1}$ | 1.64 |
| POL-011 | 2011-2016 | 0.45 | 0.40 | mg $l^{-1}$ | 1.12 |
| POL-012 | 2011-2016 | 0.52 | 0.30 | mg $l^{-1}$ | 1.75 |
| POL-013 | 2011-2016 | 0.37 | 0.30 | mg $l^{-1}$ | 1.22 |
| POL-014 | 2011-2016 | 0.53 | 0.30 | mg $l^{-1}$ | 1.76 |
| POL-015 | 2011-2016 | 0.82 | 0.30 | mg $l^{-1}$ | 2.74 |
| POL-016 | 2011-2016 | 0.54 | 0.30 | mg $l^{-1}$ | 1.78 |
| POL-017 | 2011-2016 | 0.50 | 0.30 | mg $l^{-1}$ | 1.68 |
| POL-018 | 2011-2016 | 0.70 | 0.40 | mg $l^{-1}$ | 1.74 |
| POL-019 | 2011-2016 | 0.34 | 0.30 | mg $l^{-1}$ | 1.13 |
| SWE-001** | 2011-2016 | -- | 0.79 | EQR | 0.95 |
| SWE-001 | 2011-2016 | -- | 0.77 | EQR | 1.09 |
| SWE-003** | 2011-2016 | -- | 0.79 | EQR | 0.84 |
| SWE-003 | 2011-2016 | -- | 0.77 | EQR | 0.94 |
| SWE-004** | 2011-2016 | -- | 0.77 | EQR | 0.81 |
| SWE-004 | 2011-2016 | -- | 0.77 | EQR | 0.97 |
| SWE-005** | 2011-2016 | -- | 0.77 | EQR | 1.07 |
| SWE-005 | 2011-2016 | -- | 0.77 | EQR | 1.15 |
| SWE-006** | 2011-2016 | -- | 0.84 | EQR | 1.04 |
| SWE-006 | 2011-2016 | -- | 0.77 | EQR | 0.98 |
| SWE-007** | 2011-2016 | -- | 0.84 | EQR | 1.04 |
| SWE-007 | 2011-2016 | -- | 0.77 | EQR | 1.14 |
| SWE-008** | 2011-2016 | -- | 0.84 | EQR | 1.67 |
| SWE-008 | 2011-2016 | -- | 0.77 | EQR | 1.81 |
| SWE-009** | 2011-2016 | -- | 0.85 | EQR | 1.02 |
| SWE-009 | 2011-2016 | -- | 0.79 | EQR | 1.23 |
| SWE-010** | 2011-2016 | -- | 0.85 | EQR | 0.98 |
| SWE-010 | 2011-2016 | -- | 0.79 | EQR | 1.17 |
| SWE-011** | 2011-2016 | -- | 0.85 | EQR | 1.11 |
| SWE-011 | 2011-2016 | -- | 0.78 | EQR | 1.17 |

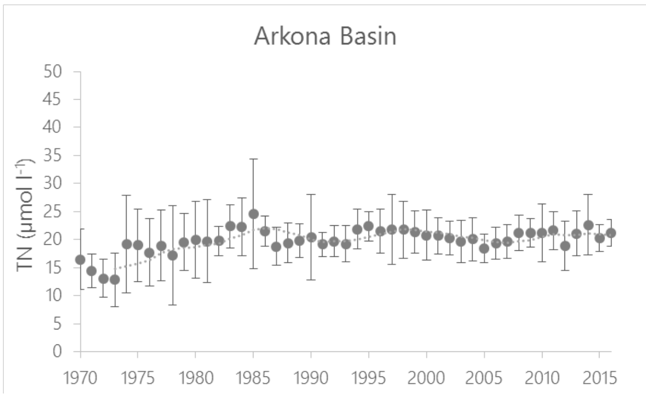
| | | | | | |
|---|---|---|---|---|---|
| SWE-012** | 2011-2016 | -- | 0.83 | EQR | 1.16 |
| SWE-012 | 2011-2016 | -- | 0.78 | EQR | 1.20 |
| SWE-013** | 2011-2016 | -- | 0.83 | EQR | 1.43 |
| SWE-013 | 2011-2016 | -- | 0.78 | EQR | 1.26 |
| SWE-014** | 2011-2016 | -- | 0.83 | EQR | 1.11 |
| SWE-014 | 2011-2016 | -- | 0.78 | EQR | 1.16 |
| SWE-015 | 2011-2016 | -- | 0.78 | EQR | 1.15 |
| SWE-016** | 2011-2016 | -- | 0.85 | EQR | 0.97 |
| SWE-016 | 2011-2016 | -- | 0.76 | EQR | 0.98 |
| SWE-017** | 2011-2016 | -- | 0.85 | EQR | 0.88 |
| SWE-017 | 2011-2016 | -- | 0.76 | EQR | 0.88 |
| SWE-018** | 2011-2016 | -- | 0.83 | EQR | 0.92 |
| SWE-018 | 2011-2016 | -- | 0.75 | EQR | 0.84 |
| SWE-019** | 2011-2016 | -- | 0.83 | EQR | 0.90 |
| SWE-019 | 2011-2016 | -- | 0.75 | EQR | 0.81 |
| SWE-020** | 2011-2016 | -- | 0.83 | EQR | 1.18 |
| SWE-020 | 2011-2015 | -- | 0.78 | EQR | 1.05 |
| SWE-021** | 2011-2015 | -- | 0.83 | EQR | 0.91 |
| SWE-021 | 2011-2015 | -- | 0.78 | EQR | 0.83 |
| SWE-022** | 2011-2015 | -- | 0.85 | EQR | 1.01 |
| SWE-022 | 2011-2015 | -- | 0.76 | EQR | 0.91 |
| SWE-023** | 2011-2015 | -- | 0.85 | EQR | 3.33 |
| SWE-023 | 2011-2015 | -- | 0.76 | EQR | 0.82 |
| SWE-024 | 2011-2015 | -- | 0.78 | EQR | 1.22 |
| SWE-025** | 2011-2015 | -- | 0.79 | EQR | 1.14 |
| SWE-025 | 2011-2016 | -- | 0.77 | EQR | 1.15 |

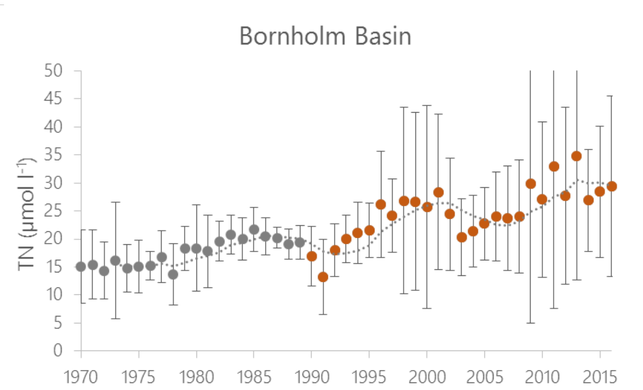
## Additional information on temporal trends

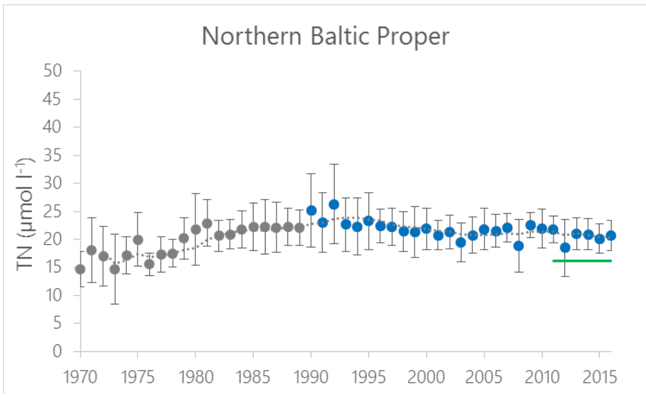
Temporal trends provide additional information on the total nutrients in the Baltic Sea that supports the interpretation of the indicator results. Data for this extended time period indicate that decreasing concentrations are found in several open sea assessment units, though an increasing trend is recorded in the Bornholm Basin (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.

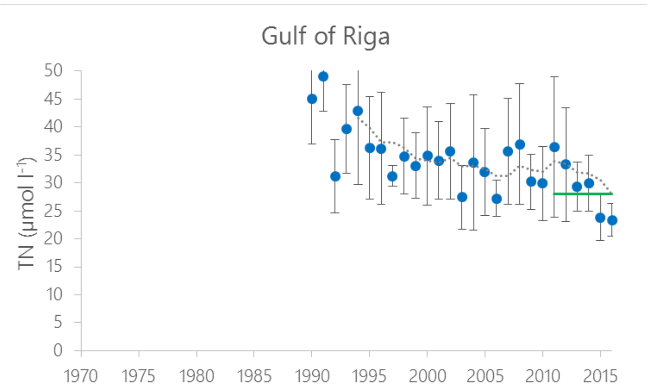

Kattegat
TN (µmol l⁻¹)

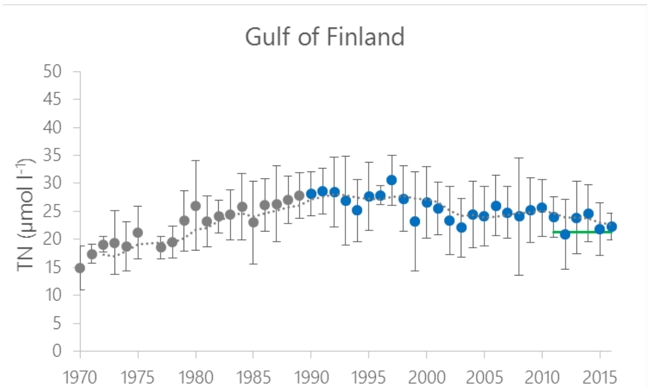

Great Belt
TN (µmol l⁻¹)

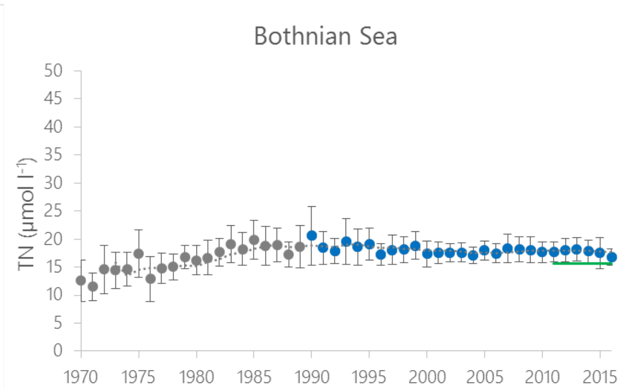

Arkona Basin
TN (µmol l⁻¹)

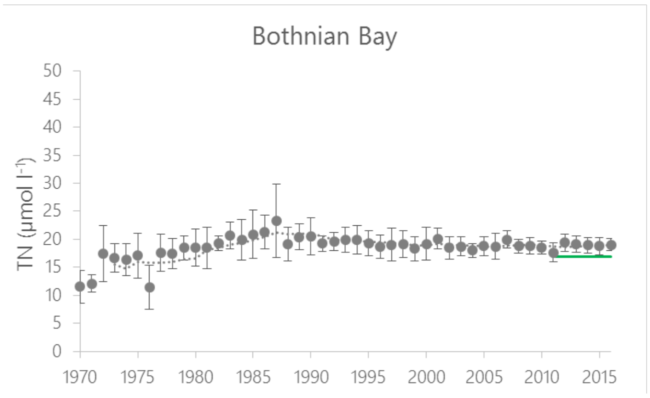

Bornholm Basin
TN (µmol l⁻¹)


Northern Baltic Proper
TN (µmol l⁻¹)


Gulf of Riga
TN (µmol l⁻¹)


Gulf of Finland
TN (µmol l⁻¹)

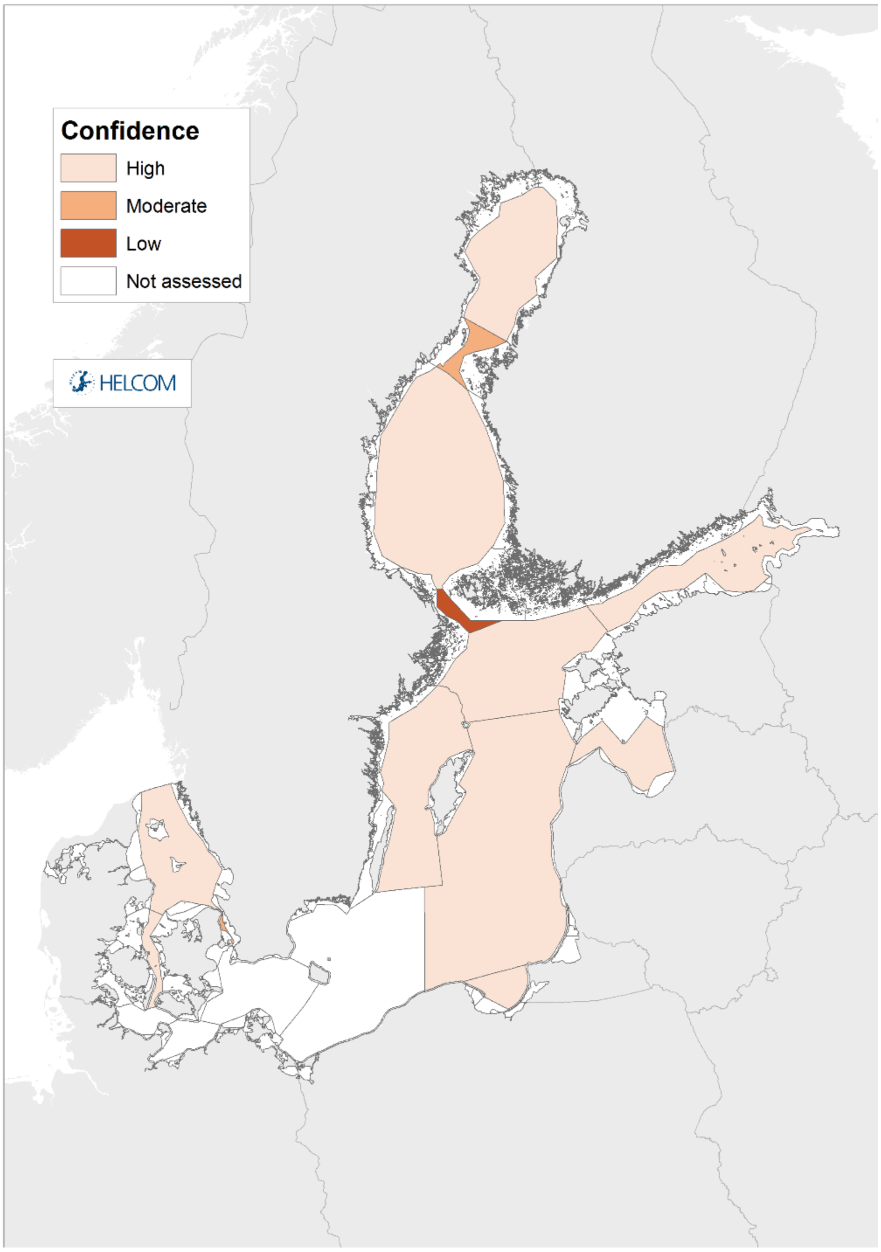

Bothnian Sea
TN (µmol l⁻¹)




**Results figure 4.** Temporal development of total nitrogen (TN) concentrations in the open-sea assessment units in 1970-2016. 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 in the presented total nitrogen status evaluation for the open sea areas (Results figure 5) is **high** in most of the assessed sub-basins. The data 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.



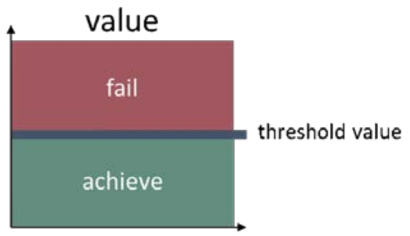

**Results figure 5.** Indicator data confidence, determined combining information on data availability for the indicator when using observations from all months of the year. Low indicator confidence calls for increase in monitoring.

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 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 (Thresholds and Status evaluation figure 1).




**Thresholds and Status evaluation figure 1**. Schematic representation of the threshold value for the core indictor 'Total nitrogen'. 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 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 | 16.5 | HELCOM 38-2017 | TARGREV value applied |
| **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), 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, as Total nitrogen (TN) was not simulated in the TARGREV modelling 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 modelling 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. 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 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** | 2011-2016 |
| **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.<br>MODERATE (=50%), if more than 5 but no more than 15 status observations are found per year.<br>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.<br>MODERATE, if the threshold was based on observations made earlier than the 1980's and/or hindcast modelling.<br>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 total nitrogen, 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.

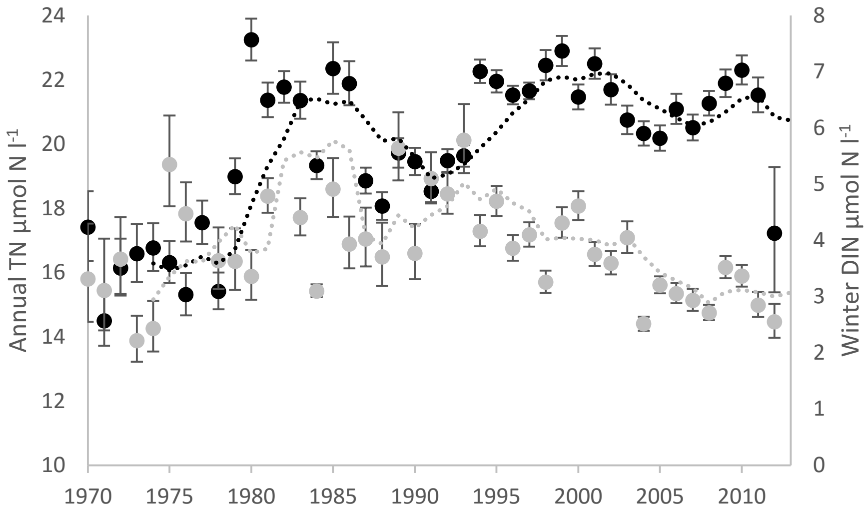
The EU Marine Strategy Framework Directive (Anonymous 2008) requires that "human-induced eutrophication is minimized, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters" (Descriptor 5). 'Total Nitrogen (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.

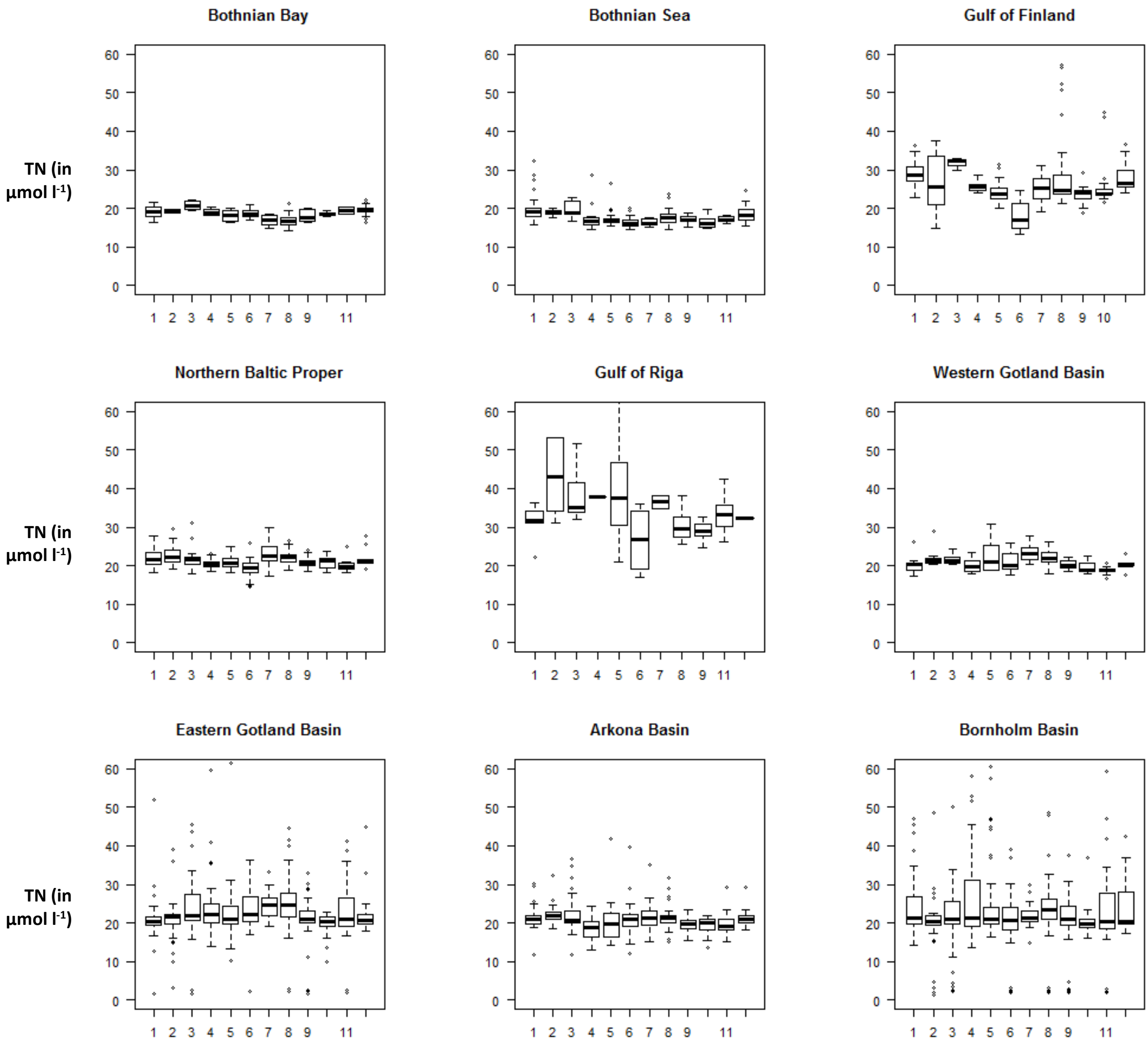
## Role of total nitrogen in the ecosystem

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 (Relevance figure 1). 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 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<br>- Input of nutrients – diffuse sources, point sources, atmospheric deposition<br>- 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 (2018) Total nitrogen. HELCOM core indicator report. Online. [Date Viewed], [Web link].

ISSN 2343-2543

## Metadata

Result: Total Nitrogen (TN)

**Data source**: The average for 2011-2016 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 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 2011-2016. 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.

# Contributors and references

## Contributors

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## Archive

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

**Total nitrogen 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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