Document title	New indicator ”nutrient ratios”
Code	5-4
Category	CMNT
Agenda Item	5 – Further development of HELCOM eutrophication assessment methodology
Submission date	5.2.2015
Submitted by	Germany
Reference	EUTRO-OPER 1-2014

Background

One task of the EUTRO OPER project is to develop new core eutrophication indicators. EUTRO OPER 1/2014 has decided that indicators for nutrient ratios should be further developed. The document provides an overview of the indicator rationale and some considerations based on analyzing nutrient ratio data in the Baltic Sea.

This work is produced under subtask 3b.i in the EUTRO-OPER roadmap.

Action required

The Meeting is invited to take note of the considerations and to discuss and agree on next steps.

Indicator rationale for nutrient ratios

Eutrophication often leads to changes in the ratio of dissolved inorganic nitrogen and dissolved inorganic phosphorus. For phytoplankton growth a ratio of C:N:P = 106:16:1 is considered optimal (Redfield Ratio, Redfield et al. 1963). An N:P ratio much lower than 16:1 indicates a possible nitrogen limitation while a much higher ratio indicates a possible phosphorus limitation of phytoplankton growth. Nitrogen limitation provides an advantage for cyanobacteria. Deviations from the Redfield Ratio therefore can influence primary production, species composition, abundance and biomass of phytoplankton and via these the whole marine food web. Hence nutrient ratios are suggested as an important indicator to be assessed for descriptor 5 of the MSFD (see Commission Decision indicator 5.1.2.). Under OSPAR, nutrient ratios are assessed in the OSPAR Common Procedure as a causal effect parameter.

The added value of assessing nutrient ratios alongside nutrient concentrations is that this indicator could inform managers on how the ratios are influenced by nutrient reduction efforts. However, such information requires a sound judgment on what ratios represent a "good status".

Monitoring requirements for nutrient ratios

Availability of monitoring data is not an issue for this indicator, since the indicator is calculated by dividing DIN concentrations by DIP concentrations.

Monitoring results and GES targets

In the OSPAR Common Procedure an assessment level of +/-50% from the Redfield ratio is proposed for the indicator nutrient ratios. It is doubtful that such an assessment level can also be applied in the Baltic Sea, since nutrient ratios in the Baltic Sea show large diversions from the Redfield ratio. For example, in the Arkona Basin, Bornholm Basin and Gotland Basin the winter N/P ratio in the surface water is about 7-9:1 (Nausch et al. 2008). By contrast, in the Western Baltic Sea the N/P ratio is only slightly below 16 (Wasmund & Siegel 2008). In the large estuaries and in the Bothnian Sea ratios are much larger than 16 (Wasmund & Siegel 2008). For the central Baltic Sea N:P ratios were at the end of the 1950ties between 7 and 10 and have not changed much since then due to the stable hydrographic conditions (stable stratification with denitrification in oxygen -low or oxygen-free waters below the halocline and resulting loss of nitrogen through transformation to atmospheric N). Based on sediment core investigations in the Central Baltic Sea it is however evident that before 1850 the hydrographic regime was different, which implies that also nutrient ratios were different as well. These observations indicate that changes in the N/P ratios in the deep basins due to eutrophication are buffered by transformation processes triggered by the prevailing hydrodynamic conditions (denitrification and release of phosphorus from the anoxic sediments). For a nutrient ratio indicator it means that natural processes cannot be separated from anthropogenic eutrophication effects, making the indicator less useful for management purposes.

Table 1 shows nutrient ratios for a transect in the German Baltic Sea. It is evident that ratios show a wide range – from potential phosphor limitation to potential nitrogen limitation. The strong phosphorus limitation at Ahlbeck is caused by the influence of the Odra river discharging a high nitrogen load.

Table 1 Nutrient ratios in the German Baltic Sea between 2001-2011 (media of February DIN and DIP and resulting N/P ratios). Highlighted in red is potential phosphorus limitation and highlighted in blue is potential nitrogen limitation.

Station		2001-2011, February DIN [µmol/l]	DIP [µmol/l]	N:P	Number of measurements
225003	Flensburger Außenförde	10,2	0,59	17,3	8
225007	Eckernförder Bucht, Bookniseck	4,0	0,58	6,9	4
225006	Kieler Bucht	4,9	0,58	8,4	17
225082	Lübecker Bucht, vor Grömitz	9,1	0,61	15,1	3
O22	Lübecker Bucht Boltenhagen	6,4	0,62	10,4	15
O12	Mecklenburger Bucht	4,9	0,64	7,7	18
O4	Buk	7,5	0,53	14,2	9
O5	Warnemünde	6,3	0,73	8,7	9
O6	Fischland	8,2	0,66	12,4	8
O7	Darsser Ort	6,1	0,61	9,9	8
O9	Hiddensee	5,5	0,63	8,7	9
113	Arkonasee	3,3	0,56	5,9	11
O10	Kap Arkona	4,8	0,66	7,3	10
O11	Sassnitz	5,3	0,59	9,0	9
O133	Greifswalder Oie	12,6	0,71	17,9	10
O14	Zinnowitz	12,4	0,73	17,0	9
OB4	Ahlbeck	17,4	0,77	22,6	9

Figure 1 shows nutrient ratios along a transect from the river mouth of the rivers Schwentine, Trave and Warnow to the open Baltic Sea. In the rivers a phosphorus limitation is observed which is typical for limnic waters while in the open sea nitrogen limitation occurs. The processes that lead to such gradients are not yet fully understood. One reason could be that nitrogen originates mainly from diffuse sources whereas phosphorus came in the past to a considerable amount from point sources where it can be reduced much easier.

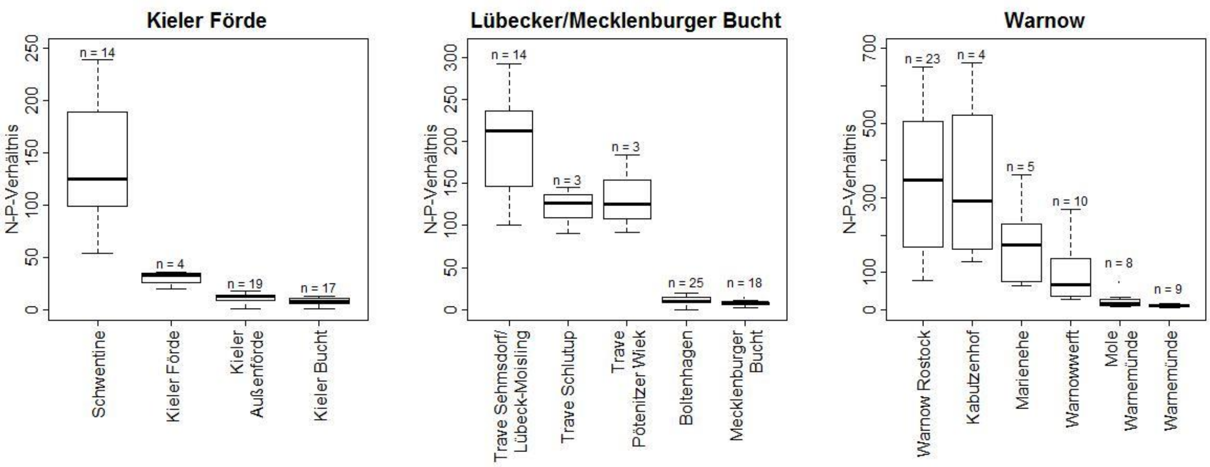

Fig.1 Mean nutrient ratios for 2001-2011 along a transect from the river mouth to the open Baltic Sea for Schwentine and Kieler Förde, Trave and Lübecker Bucht and Warnow and Mecklenburger Bucht. Shown are the February measurements (BLANO 2015).

Figure 2 shows the location of the monitoring stations in table 1 and the transects in figure 1.

Fig. 2 Map of stations in the German Baltic Sea where nutrient ratios were analysed.

In conclusion, it can be demonstrated that for coastal waters as well as the open sea nutrient ratios are often far away from the Redfield Ratio and that this divergence cannot be explained with eutrophiation processes alone but is strongly influenced by hydrodynamic processes. Hence it is difficult to derive a reasonable GES-boundary for nutrient ratios in the Baltic Sea.

We therefore propose that the indicator is less suitable to be integrated into the HEAT assessment. Nevertheless, nutrient ratios should be assessed as explanatory variables (without GES boundaries) to gain information on potential nutrient limitations.

References

Nausch, G., Nehring, D. & Nagel, K. (2008): Nutrient concentrations, trends and their relation to eutrophication. In: Feistel, R., Nausch, G. & Wasmund, N. (Hrsg.): State and Evolution of the Baltic Sea, 1952-2005. John Wiley & Sons, Inc., Hoboken, New Jersey, 337-366.

Redfield, A. C., Ketchum, B. H. & Richards, F. A. (1963): The influence of organisms on the composition of seawater. In: Hill, M. N. (Hrsg.): The Sea, Vol. 2. Wiley, New York, 26-77.

v. Weber, M., Carstens, M., Bachor, A., Petenati, T., Knefelkamp, B., Leujak, W., Schernewski, G., Friedland, R., Nausch, G. (2014) Harmonisierte Hintergrund- und Orientierungswerte für Nährstoffe und Chlorophyll-a in den deutschen Küstengewässern der Ostsee sowie Zielfrachten und Zielkonzentrationen für die Einträge über die Gewässer. – ad-hoc-Arbeitsgruppe „Nährstoffreduktionsziele und Eutrophierung der Ostsee“– www.meereschutz.info/index.php/sonstige-berichte.html

Wasmund, N. & Siegel, H. (2008): Phytoplankton. In: Feistel, R., Nausch, G. & Wasmund, N. (Hrsg.): State and Evolution of the Baltic Sea, 1952-2005. John Wiley & Sons, Inc., Hoboken, New Jersey, 441-481.