Baltic Marine Environment Protection Commission

Working Group on the State of the Environment and Nature Conservation

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STATE & CONSERVATION 15-2021

Document title	Shallow-water near-bottom oxygen indicator – pre-core indicator to be tested in HOLAS III
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Submitted by	Co-lead countries Germany, Finland, Denmark

Background

An indicator for near-bottom oxygen in shallow waters is among the priority topics where development is to be carried out for HOLAS III, as agreed by HOD 57-2019. Different proposals have been further developed including test assessments and provisional thresholds, which were discussed at several IN-EUTROPHICATION meetings and two dedicated oxygen indicator workshops. At IN-EUTROPHICATION meeting 21-2021, a concept for the shallow-water near-bottom oxygen indicator based on two main approaches was agreed. It was further agreed to submit the indicator template to STATE & CONSERVATION 15-2021 to include the pre-core indicator in HOLAS III.

Action requested

The Meeting is invited to consider and endorse the pre-core indicator on shallow-water near-bottom oxygen to be tested in the HOLAS III assessment.

Shallow-water near-bottom oxygen indicator – pre-core indicator for the Western Baltic Sea, the Gulf of Riga and the Northern Baltic Sea

Indicator name
Pre-core indicator: shallow-water near-bottom oxygen
Scale of assessment for HOLAS III and rational
Shallow-water oxygen was not assessed in HOLAS II due to the lack of an agreed indicator concept. Therefore, the scale of assessment described below is new and aims to complement the areas where the oxygen debt indicator is not applicable in order to achieve an adequate oxygen assessment in all areas of the Baltic Sea. The scale of assessment for the shallow-water near-bottom oxygen indicator is HELCOM scale 4 to be consistent with other eutrophication indicators, in particular with the oxygen debt indicator using open-sea areas of HELCOM scale 4 assessment units. All shared/offshore basins without a strong permanent halocline where the oxygen debt indicator cannot be applied should be assessed with the shallow-water near-bottom oxygen indicator. Based on the splitting of the Bornholm Basin into Pomeranian Bay and the remaining part of Bornholm Basin as well as sub-division of the Gulf of Finland into a western and eastern part, assessments with the shallow-water near-bottom oxygen indicator will be applied in the Pomeranian Bay and the Gulf of Finland Eastern (SEA-13b).
Spatial coverage of the indicator for HOLAS III
The spatial coverage of the indicator will increase in HOLAS III as this is a new indicator that was not previously assessed in the areas listed below. Spatial coverage of the indicator is foreseen for the following sub-basins: - Kattegat (SEA-001) - Great Belt (SEA-002) - The Sound (SEA-003) - Kiel Bay (SEA-004) - Bay of Mecklenburg (SEA-005) - Arkona Basin (SEA-006) - Pomeranian Bay (SEA-007B) - Gulf of Riga (SEA-011) - Gulf of Finland Eastern (SEA-013B) - Bothnian Sea (SEA-015) - The Quark (SEA-016) - Bothnian Bay (SEA-017)
Methodology to be applied for HOLAS III and rational
Different oxygen indicator proposals (based on national assessment concepts) and further developments were discussed at several IN-EUTROPHICATION meetings and specific oxygen indicator workshops. Based on latest agreements of IN-EUTROPHICATION 21-2021, a combined oxygen indicator concept is proposed to include an oxygen minima-based approach as well as an approach where the number of days with volume and areas below certain thresholds is calculated. Both methods can be applied both individually and jointly, depending on suitability and specific conditions in the different sub-basins.

The general concept of the oxygen minima approach considers seasonal oxygen minima concentrations, which are subsequently aggregated using the median of seasonal minima for the assessment period. The deepest sample from each measurement (generally 1m above or closer to the seafloor) is used in the assessment to determine near-bottom oxygen concentrations. A station-based approach is used, where the results of individual stations are subsequently aggregated to the overall result for the assessment area. To account for climate change factors such as rising temperatures, oxygen saturation should be included in the assessment of near-bottom oxygen concentration.

The area/volume-based approach estimates the extent of oxygen depletion below a certain oxygen concentration on both temporal and spatial scales to provide an indicator to describe the duration and extent of oxygen depletion. The area of hypoxia is calculated using an interpolation model based on the determined depth per station where oxygen concentrations fall below defined thresholds. Thresholds of 2, 4 and 6 mg/L are suggested. This approach requires high-resolution data (CTD profiles and high-frequency data) and the support of modelled data, particularly for setting thresholds. The maximum acceptable extent of oxygen depletion in the area/volume-based approach needs to be defined not only spatially in terms of the area or water volume below certain oxygen concentrations, but also on temporal scales related to the number of days with hypoxia/anoxia each year. Model results to support this process are described in document 2-1 of IN-EUTROPHICATION 21-2021.

The general methodology of the shallow-water near-bottom oxygen indicator will include a decision tree-like assessment structure to identify the optimal assessment procedure in terms of using a single or combined approach in the different assessment areas based on data availability, oxygen conditions and area-specific characteristics related to the respective reference periods and threshold values established. The trend-based approach for near-bottom oxygen concentrations is expected to be applied in the northern Baltic Sea, while in the western Baltic Sea and the Gulf of Riga the area/volume-based approach and the oxygen minima-based approach are assumed to be used.

Since this indicator was not applied in HOLAS II, the use of indicator results for the category of indirect effects may lead to changes in the overall eutrophication assessment result in the respective sub-basins where this indicator is applied, provided that the test indicator would be integrated into HEAT.

Threshold value setting logic and rational

Sufficient oxygen levels are important to ensure vital benthic communities and scientific literature exists that reports on such levels for different taxonomic groups. However, the difficulty in threshold value setting for the Baltic Sea basins is that oxygen deficiency is partly also a naturally occurring phenomenon and this needs to be considered for setting realistic threshold values. Basis and logic of the threshold setting approach is specific to the different approaches used for this indicator. For the oxygen minima approach, which is predominantly based on measurements, two different threshold setting procedures can be applied. One is related to near-bottom oxygen concentrations below a specific threshold (possibly differentiated for seasonally-stratified areas and well-mixed conditions). The second method, applied in areas where oxygen depletion has not yet occurred and oxygen concentrations are well above the thresholds but declining, is based on trend assessments of near-bottom oxygen concentrations. In general, it is proposed that the threshold for the near-bottom oxygen concentration should not be set lower than 4 mg/L for the critical oxygen assessment season between July and November to ensure that the benthic community is not severely affected by oxygen depletion. Threshold values for the trend assessment in the Northern Baltic Sea are established based on reference data of the 1960s (or earlier data dependent on available oxygen measurements in the different sub-basins) and the

reference period determined for the oxygen debt indicator using break-point analysis during the TARGREV process separating non-eutrophic from eutrophic conditions. The precautionary approach is used for threshold setting in both procedures.

For the area/volume-based approach, a limit of oxygen-deficient or low-oxygen water volume needs to be set at a sub-basin specific level related to conditions in the 1950s that are considered to be only slightly affected by human activities. To establish the maximum acceptable extent (on spatial and temporal scale) modelled data are used in addition to available measurements. Analysis of recent model runs in the western Baltic Sea provides the basis for determining the sub-basin specific percentage of area with oxygen depletion and the number of days with hypoxia/anoxia in this region in relation to reference periods and acceptable deviations from these.

References:

Kuosa, H., Fleming-Lehtinen, V., Lehtinen, S., Lehtiniemi, M., Nygård, H., Raateoja, M, Raitaniemi, J., Tuimala, J., Uusitalo, L., Suikkanen, S. (2017): A retrospective view of the development of the Gulf of Bothnia ecosystem. Journal of Marine Systems 167: 78–92

Vaquer-Sunyer, R. & Duarte, C. M. (2008): Thresholds of hypoxia for marine biodiversity. PNAS 105, 40, 0803833105, 6pp. https://doi.org/10.1073/pnas.0803833105

Villnäs, A., J. Norkko, K. Lukkari, J. Hewitt, A. Norko (2012): Consequences of increasing hypoxic disturbance on benthic communities and ecosystem functioning. PLOS ONE, 7, 10, e44920, 12pp.

Threshold value(s)

Based on existing provisional threshold values in some areas and needed sub-basin specific adaptations, developments will take place in the near-future until mid-November/end of 2021 to address setting of thresholds per sub-basin, after prior determination of the sub-basin specific procedure to be applied (oxygen minima approach/trend in oxygen concentration, area/volume-based approach as a single or combined method). This remaining work is anticipated before HOLAS III, but specific thresholds are currently not available and are therefore indicated as 'possible-underway'.

Other significant issues that need to be addressed or presented to State and Conservation

Given that oxygen is a primary criterion for the MSFD assessment, there is an urgent need to address the existing gap caused by the lack of oxygen assessment results in shallow-waters that cannot be fully captured by including assessment results of benthic indicators which are not necessarily linked to eutrophication.

Latest indicator report or (for new indicators) initially completed indicator template

Not applicable, this indicator is currently under development and the first version of the report will be prepared for HOLAS III. Further background can be found in the following meeting documents:

Documents of Oxygen indicator workshop IN-EUTROPHICATION 19A-2021 (2-3 rev.1, 2-1, 2-5)
Document 2-1 and outcome of IN-EUTROPHICATION 21-2021