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# Improving the evaluation of marine ecosystems environmental status

Assessments of the environmental status of marine ecosystems are increasingly needed to inform management decisions, regulate human pressures and meet policy objectives. Ecosystem assessments however have a number of methodological challenges including the selection of appropriate indicators and definition of reference conditions corresponding to "good" or "bad" status of the ecosystem. Furthermore, the combination of individual indicators to an overall ecosystem status involves a number of methodological choices.

Currently ecosystem assessments usually focus on the outcome of the evaluation and corresponding management actions, with less attention paid to the evaluation procedure itself. However, the methodological choices made during the evaluation process can, in some cases, be highly influential to the overall result of the evaluation. Here the case study of the Baltic Sea is used to address some of these methodological challenges in order to improve the transparency of the assessment procedure and help to set priorities for future work.

## Methods of environmental assessments

In 2008 the Marine Strategy Framework Directive (MSFD) was adopted across Europe aimed at achieving good environmental status (GES). In the Baltic Sea the objectives of GES focus mainly on biodiversity (B), eutrophication (E) and hazardous substances (HS). To evaluate the current status of the central Baltic Sea, the reference values for indicators related to B, E, and HS were defined. In a second step, different options were applied to combine individual indicators to an overall status. The options differed in terms of i) the hierarchical structure of indicators, i.e. the indicators associated with a particular objective were combined either all at a same level, or involving multiple steps with prior grouping of related indicators and ii) the arithmetic rules applied in combining individual indicators. The aggregation rules applied were a) average, b) median, and c) conservative fuzzy AND rule (close to "one out-all out" principle).

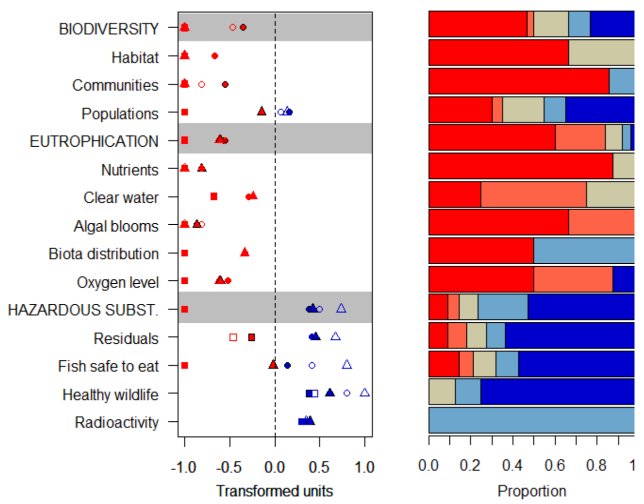


Figure 1. Current status of the central Baltic Sea by ecological objectives, obtained applying different options for aggregating individual indicators (left panel). The values above and below zero (marked in blue and red) indicate a positive and a negative evaluation, respectively. The right panel shows the status of individual indicators within a given ecological objective. The states are shown as a proportional distribution of indicators among five categories, varying from highly negative (red) to highly positive (blue) states.

This resulted in six different evaluations of the current status of B, E and HS in the Baltic Sea, obtained by applying the three different aggregation rules both for the hierarchical and non-hierarchical structure of indicators (results compared in Fig.1). The assessment results were generally not sensitive to the structure of indicator aggregation.

In contrast, the choice of indicator aggregation rule did appear, in some cases, to be of major importance for the assessment. This is most obvious in the case of HS, where both a very positive and a totally negative evaluation could be obtained, depending on the indicator aggregation rules applied (Fig. 1). Even though most of the indicators related to HS showed a positive status, an overall negative evaluation could be obtained when applying a conservative "one out-all out" principle. Negative performance clearly dominated among indicators related to E (Fig. 1). As a result, a negative overall evaluation for E was found, regardless of the aggregation rule applied. Due to variable performance of indicators, the results for B were inconclusive for some objectives (populations) and both negative and positive evaluation could be obtained, depending on the indicator aggregation method selected (Fig. 1).

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## Importance of sensitivity analysis of the assessments

Ecosystem assessments can be highly sensitive to the choice of indicators and the procedures applied in combining individual indicators to an overall ecosystem status. It is important that greater attention is paid to the sensitivity of assessment results to methodological choices so as to ensure the transparency of the assessment procedure and identify the ecological objectives where the status is most uncertain. This can help to set the priorities where more effort is needed to improve the current assessments.

Among the three focus areas for the Baltic Sea (biodiversity, eutrophication and hazardous substances), most uncertain is the assessment for biodiversity. Biodiversity is influenced by a variety of human activities on both land and at sea, as well as by climate change, ecological interactions and conservation measures. Consequently, biodiversity status is associated with a broader spectrum of indicators, which may show mixed performance.


Algal blooms in the Baltic, the impact of eutrophication.
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Recreational use of the Baltic Sea beach of Warnemuende, northern Germany.
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In such situations, the selection of indicators is crucial because the inclusion or exclusion of a certain indicator series may lead to a different evaluation of the overall status. Therefore, in the future more emphasis should be given to biodiversity assessments, compared to eutrophication or hazardous substances where different indicators generally show more consistent performance.

Further, trend-based analysis would be a good supplement to verify the results of assessments based on reference values. In some cases, knowledge of the direction of trends in the indicators can be sufficient to support the management decision-making process. An advantage of a trend-based approach is that it provides a purely observation-based perspective on the performance of indicators, as it is not influenced by potentially subjective or policy-driven definitions of reference values, as well as choices of indicator aggregation methods. However, trend-based analysis needs long-term consistent time-series of indicator data.

## Future action

Out of the three overarching strategic goals for the Baltic Sea, potentially the largest uncertainty is around in evaluation of the current status of biodiversity. Thus, more consideration should be given in the near future to biodiversity assessments. In all cases, the assessment results are sensitive to the reference level set and to indicator aggregation rules. Trend-based assessment is therefore recommended as a supplement to reference-based evaluation. **To facilitate the analysis of trends, long time-series of consistent monitoring data are needed. Continuation of the existing long time-series and potentially establishing new time series of relevant indicator measurements should be considered a priority.**

## Further information

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