Assessing the need for re-intercalibration of chlorophyll with Sweden and Germany

A suggested roadmap for re-intercalibration

Scientific note from DCE – Danish Centre for Environment and Energy

Date: 3 April 2024 | **19**

AARHUS
UNIVERSITY
DCE – DANISH CENTRE FOR ENVIRONMENT AND ENERGY

Data sheet

Scientific note from DCE – Danish Centre for Environment and Energy

Category: Scientific briefing

Title: Assessing the need for re-intercalibration of chlorophyll with Sweden and Germany
Subtitle: A suggested roadmap for re-intercalibration

Author(s): Jacob Carstensen[1], Jesper P.A. Christensen[1], Anders Erichsen[2], Karen Timmermann[3]
Institution(s): [1]Aarhus University, DCE – Nationalt Center for Miljø og Energi
[2]DHI A/S
[3]DTU Aqua, Technical University of Denmark

Referee(s): Hans Jakobsen
Quality assurance, DCE: Signe Jung Madsen
Linguistic QA: Charlotte Kler

External comment: The Danish Environmental Protection Agency. The comments can be found here: https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Notater_2024/KommentarerN/N2024_19_komm.pdf

Claimant: Miljøstyrelsen

Please cite as: Carstensen J, Christensen JPA, Erichsen A, Timmermann K. 2024. Assessing the need for re-intercalibration of chlorophyll with Sweden and Germany. A suggested roadmap for re-intercalibration. Aarhus University, DCE - Danish Centre for Environment and Energy, 5 s. – Scientific note no. 2024|19

Front page photo: Peter Henriksen

Number of pages: 13

Contents

1 Introduction

This scientific briefing is the third contribution from the modelling group addressing specific questions from the Danish Environmental Protection Agency (Miljøstyrelsen) and the Ministry of Finance (Finansministeriet) following the recommendations from the International Expert Panel evaluation of the third Danish River Basin Management Plan covering 2021-2027 (Hermann et al. 2023).

Denmark has intercalibrated chlorophyll boundaries (May-September) for high-good (HG) and good-moderate (GM) with Sweden (Carstensen 2016, European Commission 2018) and Germany (European Commission 2018) as part of the implementation of the Water Framework Directive (WFD). For the intercalibration with Sweden, EQR boundaries have been provided for the Baltic Sea SW part (BC6: EQR_HG=0.78 and EQR_GM=0.62), Kattegat and Great Belt (NEA8b: EQR_HG=0.83 and EQR_GM=0.64) and the Sound (NEA8b: EQR_HG=0.79 and EQR_GM=0.59) as well as for chlorophyll boundaries for the Baltic Sea SW part (HG=1.22 and GM=1.58 µg/l), Kattegat and Great Belt (HG=1.36 and GM=1.72 µg/l) and the Sound (HG=1.22 and GM=1.63 µg/l). For the intercalibration with Germany (BC8), only the EQR boundaries have been provided (EQR_HG=0.8 and EQR_GM=0.6) in the latest commission decision (European Commission 2018), although boundaries for chlorophyll (HG=1.3 and GM=1.9 µg/l) were proposed in the background material (Baltic GIG 2013). These chlorophyll boundaries are, however, inconsistent with the EQR values of the commission decision. The intercalibrations were based on type-specific reference conditions and boundaries developed under River Basin Management Plan 2015-2021 (RMBP2).

For RBMP 2021-2027 (RBMP3), a new typology, different from the typology used for the intercalibration, was developed and revised chlorophyll reference conditions specific to water bodies were calculated (Timmermann et al. 2021). To calculate HG and GM boundaries for individual water bodies in RBMP3, it was suggested to maintain the intercalibrated EQR boundaries and, consequently, recalculate the chlorophyll boundaries from the revised reference conditions. This improved spatial distribution for reference conditions and resulted in both more and less stringent chlorophyll boundaries for RBMP3 compared to RBMP2, although with a slight tendency towards generally stricter regulation in the coastal water bodies that were included in the intercalibrations. An international evaluation panel assessing the Danish RBMPs highlighted the compatibility issue regarding the intercalibrated chlorophyll boundaries arising from establishing revised reference conditions, i.e. chlorophyll boundaries differ between countries for the open coastal waters. For example, the GM boundaries for the two water bodies north of Zealand are 0.9 and 1.2 µg/l in comparison to the Swedish boundary of 1.52 µg/l (June-August), which corresponds to 1.58 µg/l with the Danish indicator (May-September). It should be noted that the Swedish GM boundary applies to the entire open Kattegat coast, that it compares well with Anholt, Hevring Bugt and Ålbæk Bugt and that it is lower than Ålborg Bugt and Læsø water bodies. This example highlights the problem of having two different spatial resolutions for the intercalibration, i.e. type-specific in Sweden and water body-specific in Denmark.

The International Evaluation panel advised refitting the chlorophyll boundaries in open intercalibrated waterbodies, so that values correspond better to

the intercalibration results. Different approaches for refitting boundaries from RBMP2 to RBMP3 have been investigated, and it was concluded that there is no simple refitting solution (as suggested in European Commission 2015) that secures compatibility with the intercalibrated boundaries (Timmermann et al. 2024). This scientific briefing is a follow-up of this analysis, where the recommendations from Timmermann et al. (2024) are elaborated. These recommendations are assumed to be known to the reader of this scientific briefing.

2 Need for re-intercalibration

The chlorophyll intercalibrations with Germany and Sweden resulted in EQR boundaries that were identical to the national boundaries for BC8 (EQR_HG=0.8 and EQR_GM=0.6) because the national indicators (DK and DE) were identical and only differed slightly for BC6 (EQR_HG~0.78-0.79 and EQR_GM~0.62-0.64) and NEA8b (The Sound: EQR_HG~0.79-0.80 and EQR_GM~0.59-0.60; Kattegat: EQR_HG~0.83-0.84 and EQR_GM~0.64-0.65), because the national indicators (DK and SE) were different. This is an important result, as it signifies an agreement between countries regarding the WFD normative definitions, i.e. the relative deviation from reference conditions to characterize a slight sign of disturbance (EQR_HG) and signs of moderate disturbance (EQR_GM). This agreement on EQR boundaries is important for ensuring the same level of environmental protection for water bodies that otherwise cannot implicitly be compared, e.g. estuaries with different residence times, land connectivity and stratification patterns.

However, open coastal water bodies belonging to the same water body type, i.e. with similar physical-chemical and hydro-morphological characteristics that largely are influenced by the same water mass, should also have comparable reference conditions and chlorophyll boundaries. For example, it seems reasonable that these values should be similar on the Danish and Swedish side of the Sound. The problem is that reference conditions have been established with quite different methods for Denmark, Germany and Sweden. This highlights the need for establishing comparable reference conditions for coastal water bodies with similar characteristics, even when these are located in different countries. The comparability of assessment methods between countries is a general objective of the intercalibration process. However, in the WFD this objective was formulated based on a relatively coarse spatial resolution considering general overarching types. This was the approach taken in RBMP2. With RBMP3, Denmark has adopted a strategy of developing water body-specific reference conditions, as opposed to type-specific reference conditions employed by Germany and Sweden. This means that a single reference condition for a German or Swedish type should match with multiple, and most likely different reference values for multiple water bodies within the same type. This lack of consensus on the appropriate spatial resolution inevitably causes inconsistencies, and it is crucial to reach agreement with Germany and Sweden on this issue before proceeding with any intercalibration process.

Whereas intercalibration within water-body types constitutes the least common spatial denominator, it is possible to compare reference conditions at the higher spatial resolution, i.e. between individual water bodies. This requires the identification of water bodies with matching characteristics within and between countries for comparing reference conditions, if these have been obtained by different methods or, alternatively, using the same methodology for deriving reference conditions across water bodies and countries. In the latter case, a solution is to use the same model or ensemble of models for a larger area to calculate reference conditions for water bodies in the intercalibration types. Such an approach would also ensure consistency across intercalibration types, i.e. comparable reference conditions between NEA8b, BC6 and BC8. A prerequisite for this model approach is the agreement of common forcing data for the models, e.g. agreement on nutrient inputs, meteorological forcing, etc., as well as the conditions defining a reference, e.g. specific period, boundary

conditions, etc. Water bodies possess different characteristics, essentially representing a continuum, and identification of groups with a sufficient number of water bodies possessing similar characteristics for intercalibration poses a grand challenge and, most likely, may involve unsupported approximations and assumptions. Therefore, scientific agreement among countries (DK, DE and SE) on a common approach for determining reference conditions seems most appropriate.

Coupled hydrodynamic-biogeochemical models have developed and become increasingly more reliable in recent years compared to earlier versions that were assessed for determining reference conditions in the early phases of the WFD implementation. The estimation of reference conditions for Danish water bodies as part of RBMP3 has demonstrated the ability of simulation models for this purpose. However, at present there is no single model that covers all water bodies and, typically, models for enclosed water bodies, such as estuaries and embayments, have been developed separately with higher spatial resolution to better describe the more dynamic environment in these water bodies. These water bodies are also not part of shared types with neighboring countries, e.g. only open coastal water bodies have the same typology in the intercalibration between Denmark and Sweden (Carstensen 2016). Therefore, determining reference conditions with the same modelling approach (single or ensemble model) would mainly apply to open coastal water bodies for NEA8b, BC6 and BC8.

Provided that a common approach to estimating reference conditions can be agreed upon, consensus about EQR values for HG and GM boundaries should be determined. The starting points for the national assessment methods in Denmark, Germany and Sweden were EQR_HG=0.8 and EQR_GM=0.6, which were based on expert judgement, as chlorophyll responds almost linearly to the pressure (nutrient input) and, therefore, the pressure-response curve does not include a marked/abrupt change for defining the GM boundary (European Commission 2011). Given that reference conditions are determined with the same approach and that the three countries agree on EQR_HG=0.8 and EQR_GM=0.6, the HG and GM boundaries derived from the reference condition and EQR boundaries will also be consistent. Thus, there will not be a need for an intercalibration exercise as described in European Commission (2015) if reference conditions and EQR boundaries are determined on exactly the same approach.

The use of the same modelling approach for determining reference conditions does not imply that national assessment methods cannot be different. Denmark and Germany use the same assessment method (mean chlorophyll for May-September), whereas Sweden uses a different assessment method (mean EQR observation for chlorophyll for June-August). Employing these two different types of assessment methods to the same model output will inevitably lead to different metrics and, hence, reference conditions, but given that they are calculated from the same model output, they will represent the same reference condition, although assessed by different means. Similarly, the HG and GM boundaries for the national assessment method will be different due to the different metrics employed, but they represent the same relative deviation from the reference condition. However, it would be ideal if the same metric for chlorophyll was employed by all three countries.

A common chlorophyll metric would also allow for comparison of water bodies that are not part of a shared type and, therefore, not part of the intercalibration process. This applies to many of the Danish estuaries, archipelagos along the Swedish Kattegat coast and German coastal lagoons (bodden). Although such different water bodies cannot be compared directly, a relative assessment of their reference conditions, class boundaries and status would still be informative. Moreover, current metrics use a small fraction of the chlorophyll monitoring data collected and, consequently, they are often associated with considerable uncertainty. Carstensen et al. (2015) demonstrated that extending the seasonal window for the chlorophyll metric increases the confidence of the assessment substantially because it is based on more data. Given that the uncertainty of the chlorophyll metrics has not yet been given much attention, it seems timely to also reconsider the most appropriate metric for chlorophyll, preferably as a common metric for all three countries.

3 Roadmap for harmonizing chlorophyll assessment methods between countries

There is a need for re-evaluation of the current national assessment method for chlorophyll in Denmark, mainly driven by the conclusions of the international expert panel, but this re-evaluation will strongly benefit if it also includes the national assessment methods of Germany and Sweden. Revision of the Danish national assessment method will not solve the inconsistencies associated with the intercalibration. Therefore, based on the reasoning outlined above, the following roadmap is proposed:

1. **Common agreement between Denmark, Germany and Sweden on the appropriate spatial resolution** for defining reference conditions and class boundaries. Two different spatial aggregations are currently in use: type-specific (Germany and Sweden) and water body-specific (Denmark). Denmark will need to convince Germany and Sweden about the scientific and management advantages of using a higher spatial resolution. Although the change in Denmark was mainly initiated after the first international evaluation, this process was essentially driven by stakeholders' discontent with broad rules of regulation that did not account for differences in the sensitivity of water bodies. It is possible that similar discontent is found in Germany and Sweden, which could promote the migration towards water body-specific reference conditions and class boundaries. If this is not possible, Denmark will need to revert to RBMP2 values that were intercalibrated for the shared types (NEA8b, BC6 and BC8) or produce type-specific values based on RBMP3 values.

2. **Common agreement between Denmark, Germany and Sweden on modelling approach for reference conditions**. Overall, the scientific basis for the current intercalibrated reference conditions for chlorophyll, some established 20 years ago, is generally weak, poorly documented and needs revision. A common approach between the three countries will facilitate compatibility and enable intercalibration that ensures a similar level of environmental protection between countries. The best state-of-the-art approach for determining reference conditions is using ecological simulation models. Such models are employed in all three countries (DK: DHI; DE: IOW and SE: SMHI), covering the open and coastal waters of NEA8b, BC6 and BC8. Although these models have been calibrated with respect to different focal areas, an ensemble approach, perhaps including area-specific weights for model outputs, seems to be the most optimal solution. This solution respects the overall gradients in chlorophyll concentrations in the open and coastal waters.

3. **Common agreement between Denmark, Germany and Sweden on model set-up and scenarios**. Using the same forcing data, boundary conditions and scenarios will enable comparison of model outputs. This is a prerequisite for the ensemble modelling approach, allowing for simulating an ensemble reference condition scenario that can be used for calculating reference conditions for specific assessment metrics.

4. **Common agreement between Denmark, Germany and Sweden on EQR values of HG and GM boundaries**. All three countries have used EQR_HG=0.8 and EQR_GM=0.6 in their national assessment method. This adoption of these values with revised reference conditions needs to be revisited and confirmed. This agreement, in combination with a common approach to determining reference conditions, fulfils the requirements of the intercalibration process (in the spirit of the WFD implementation).

5. **Revisiting the chlorophyll assessment metric**. Given that a common basis for determining reference conditions is established, it seems appropriate to advocate for a common chlorophyll metric in this region, where phytoplankton dynamics are similar. This will allow for comparability in addition to compatibility. It is suggested to consider the confidence of the chlorophyll metric to make optimal use of monitoring data.

4 Recommendations

The roadmap outlines a 'top-down' approach for developing and harmonizing national assessment methods for chlorophyll, as opposed to the 'bottom-up' approach pursued in the past, which has caused inconsistencies. Reaching an agreement between three national agencies on a common approach might be challenging, but it is the scientifically most optimal, and probably the only, way forward.

Therefore, it is recommended that the Danish Environmental Protection Agency initiates discussions on this issue with relevant authorities in Germany and Sweden.

5 References

Baltic GIG (2013) Intercalibration of biological elements for transitional and coastal water bodies. Coastal waters – phytoplankton. Scientific report from the Baltic Geographical Intercalibration Group.

Carstensen J (2016) Intercalibration of chlorophyll a between Denmark, Norway and Sweden. Western Baltic (BC6), Kattegat (NEA8b) and Skagerrak (NEA8a, NEA9 and NEA10). Aarhus University, DCE – Danish Centre for Environment and Energy, 38 pp. Technical Report from DCE – Danish Centre for Environment and Energy No. 76 https://dce2.au.dk/pub/TR76.pdf

European Commission (2011). Guidance document on the intercalibration process 2008–2011. Guidance Document No. 14. Implementation strategy for the Water Framework Directive (2000/60/EC). Technical report-2011-045. https://op.europa.eu/en/publication-detail/-/publication/3f045e64-c58a-4122-8784-8e2db805cc8e

European Commission (2013) Establishing, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, the values of the Member State monitoring system classifications as a result of the intercalibration exercise and repealing Decision 2008/915/EC. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D0480&from=DA

European Commission (2015). Procedure to fit new or updated classification methods to the results of a completed intercalibration exercise. Guidance Document No. 30. Implementation strategy for the Water Framework Directive (2000/60/EC). Technical report-2015-085. https://op.europa.eu/en/publication-detail/-/publication/43c0f50e-5df6-4c1a-bdba-4a3b7d249799

European Commission (2018) Establishing, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, the values of the Member State monitoring system classifications as a result of the intercalibration exercise and repealing Commission Decision 2013/480/EU. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018D0229&from=DA

Hermann P, Newton A, Gustafsson B, Josefsson H, Krüger R (2023) International evaluation of the scientific and legal basis for nitrogen reductions in the 3rd Danish River Basin Management Plan. Miljø- og fødevareudvalget 2023-2024. MOF Alm.del - Bilag 79.

Timmermann K, Christensen JPA, Erichsen A (2021) Establishing Chlorophyll-a reference conditions and boundary values applicable for the River Basin Management Plans 2021-2027. Aarhus University, DCE – Danish Centre for Environment and Energy, 32 pp. Scientific Report No. 461. https://dce2.au.dk/pub/SR461.pdf

Timmermann K, Erichsen A, Christensen JPA, Carstensen J (2024) Adjustment of chlorophyll-a targets in open intercalibrated water bodies. DTU Aqua report nr. XXX-2024. (INSERT LINK WHEN PUBLIC).