Adjustment of chlorophyll-a targets in open intercalibrated water bodies

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Preface

This report constitutes a follow-up to the International Evaluation of the Scientific and Legal Basis for Nitrogen Reduction in the 3rd Danish River Basin Management Plan, which was finalised in October 2023. One of the issues identified by the international evaluation panel was the discrepancy between the intercalibrated chlorophyll-a (Chl-a) good-moderate target values and the good-moderate target values used in the 3rd Danish River Basin Management Plan (RBMP3), in open intercalibrated water bodies. In this report we explore several methods aimed at aligning the intercalibrated Chl-a values and the results from RBMP3. Furthermore, we present recommendations for adjusted Chl-a target values that can be used in an update of the RBMP3 that will be compiled in 2024. These proposed targets should be considered intermediate, until a more durable solution is found involving Sweden and Germany. This report is financially supported by the Danish Environmental Protection Agency (DEPA) under the project “Second opinion”. While DEPA has commented a previous draft of the report, the content and recommendations are the sole responsibility of the authors.

Content

1. Introduction

Between 2016 and 2020, collaborative efforts by Aarhus University (AU), Technical University of Denmark (DTU), and DHI A/S resulted in the development of models and methodologies used for determining the maximum nitrogen inputs allowing Danish coastal waters to achieve "good ecological status", as mandated by the Water Framework Directive (WFD). These models and methods form a pivotal component of the scientific foundation for the 3rd Danish River Basin Management Plan for coastal water bodies (RBMP3), scheduled for implementation between 2021 and 2027.

As part of the agreement on the “Agriculture Package,” adopted in October 2021, it was decided to conduct an international evaluation of the models and methods underpinning the River Basin Management Plan. This evaluation, which was conducted by five internationally recognized experts from different research institutions, sought to scrutinize assumptions, prerequisites, or choices that could impact the calculation of remaining nitrogen effort within the legal and scientific framework of the Water Framework Directive. The outcomes of this evaluation, completed in October 2023, hold potential significance for the revisit of the Agricultural Package scheduled for 2024 (Hermann et al. 2023).

The international evaluation panel finalized their evaluation report in October 2023. One of the key issues identified by the panel was a discrepancy between the Chl-a good-moderate (G/M) boundary values used in the 3rd Danish River Basin Management Plan (RBMP3) and the intercalibrated Chl-a G/M boundary values in the Western Baltic Sea. More specifically, the panel states that “…G/M boundaries for the intercalibrated water bodies in the Baltic realm have been lowered significantly compared to the Commission approved intercalibration results” and the panel recommends “to ensure that the comparability with the intercalibrated standards is not affected…”

One of the major changes from RBMP2 and RBMP3 involved the transition from type-specific reference values used in RBMP2 to water body specific reference values, based on typology parameters used in RBMP3 as well as an improved model reference scenario set-up for establishing individual reference conditions in all Danish marine water bodies. These changes have led to overall higher Chl-a reference conditions in the estuaries and an overall lowering of the reference condition in open waters. While the international panel endorse this strategy (Hermann et al. (2023), p.11) and the chl-a reference values calculated with the new methods for RBMP3 are considered an improvement from a scientific point of view (Hermann et al. (2023), p. 66), they flagged the potential compatibility issue with the intercalibrated Chl-a boundary values in the European Commission´s intercalibration decision from 2018 (Hermann et al. (2023), p. 12).

The intercalibrated Chl-a G/M boundaries stipulated in the commission decision from 2018 are based on type-specific reference values calculated in RBMP2. For open waters, the RBMP2 reference conditions were overall higher than the RBMP3. As the RBMP3 Chl-a G/M boundaries are calculated from the intercalibrated ecological quality ratio (EQR) boundaries and revised reference conditions, the overall lower and water body specific reference conditions estimated in RBMP3 compared to the reference values used during the intercalibration process result in a situation where EQR boundaries are consistent between RBMP3 and the intercalibration process, but the Chl-a G/M boundaries (Chl-a concentration) are different.

To address the panel's recommendation, this report aims to explore methods aligning intercalibrated Chl-a G/M boundaries and the RBMP3 Chl-a G/M boundaries in open intercalibrated water bodies.

The scientifically optimal solution requires a re-intercalibration using the best available scientific knowledge on reference values and thus establishes an improved and updated common basis for determining EQR boundaries and a re-calculation of Chl-a boundaries. However, as the intercalibration process is slow and will induce substantial delay in the update of the RBMP3, a temporary alternative solution satisfying the recommendation from the panel is required while the re-intercalibration is in process. Alternative solutions may introduce inconsistencies, as the alignment between RMBP3 results and intercalibrated boundaries involves a mixture of two different approaches for calculating reference conditions.

The analysis will be confined to intercalibrated open waters in the Inner Danish waters (east of Skagen), as the reference conditions for the water bodies at the west coast of Jutland have not been revised in RBMP3. Consequently, for these water bodies, the intercalibrated Chl-a G/M boundaries and the G/M boundaries applied in RBMP3 are identical. However, as the OSPAR boundaries have recently been updated and the Chl-a indicator used for water bodies at the west coast of Jutland differs from other Danish coastal waters, it could be reasonable to re-intercalibrate the Chl-a indicator for coastal waters surrounding the North Sea.

2. Comment from the International evaluation panel

The panel has identified a discrepancy between intercalibrated Chl-a G/M boundary values and Chl-a G/M boundary values for intercalibrated open waters, whereas there is no difference between the intercalibrated EQR boundaries and the EQR boundaries applied in RBMP3.

The panel (Hermann et al. (2023), p.18) concludes that:
Estimates of reference conditions have been changed in RBMP3 compared to RBMP2. Scientifically, this constitutes an improvement in the consistency and extent of the modelling and is aligned with the recommendation from an international evaluation carried out as part of RBMP2. In general, reference conditions have been lowered in open waters, and increased in closed water bodies. By keeping EQR at the same value as in the intercalibration results while reference values have been lowered, G/M boundaries for the intercalibrated water bodies in the Baltic realm have generally been lowered compared to the Commission-approved intercalibration results. The Panel estimates that this is not according to instructions, especially since the net effect of the changes are G/M boundary values that are (almost) unattainable by land-based nutrient reduction measures.

And the panel (Hermann et al. (2023), p.18) recommends that:
For the revised reference conditions to be in line with WFD, the Panel advises to ensure that the comparability with the intercalibrated standards is not affected considering the stipulation in CIS Guidance Document No. 30[1].

The panel argues that the intercalibrated Chl-a boundary values and not the intercalibrated EQR boundary values are the most important numbers determined in the intercalibration decision, because the numeric G/M boundary values for the BQE indicators are crucial as a basis for the systems classification (Hermann et al. (2023), p. 14). The Panel further notes that "the Commission Decision explicitly mentions, for the boundary values of Chl a concentration, not only the EQR but also the concentration in µg/l. Since both numbers are published, and they are only related to one another through the reference conditions, it can be argued that, implicitly, the Commission has also decided on the reference concentrations" (p.14). As a consequence, Denmark has to ensure that a change of reference conditions in RBMP3 is coherent with the provisions on intercalibration in WFD and CIS #30[1].

The panel points out that the intercalibrated Chl-a boundary values, which are those used in RBMP2, were originally established by "expert judgement" (Henriksen, pers. comm.) and supported by many similar judgments in the RBMPs of neighboring countries as well as in estimations by HELCOM (pg.15).

3. Response from the model group

The Chl-a G/M boundary values used for RBMP3 is based on improved and water body specific reference values and intercalibrated EQR G/M boundary values. In our opinion the EQR boundaries are the fundamental results of the intercalibration process, and these are determined independently of the reference conditions. According to Annex V, the EQR based classification system is to be used by Member States for ecological status classification and to ensure comparability of biological monitoring results (Annex V, 1.4) and it is the numerical values of the EQR boundaries that should be established through the intercalibration process. This is stated in Annex V, 1.4.1 8 iii:

Each Member State shall divide the ecological quality ratio [EQR] scale for their monitoring system for each surface water category into five classes ranging from high to bad ecological status, as defined in Section 1.2, by assigning a numerical value to each of the boundaries between the classes. The value for the boundary between the classes of high and good status, and the value

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[1] Taking into account CIS Guidance Document No. 30, the change in reference conditions would lead to Denmark using a ´revised national classification method´ (CIS Guidance Document No. 30, pg. 11). In such a case, the comparability of the intercalibrated standards may be affected. CIS Guidance Document No. 30 therefore provides for a specific procedure to adjust the intercalibrated values to the revised classification method. If at the end of this procedure it is determined that the new limits are lower than the old limits, the comparability with the intercalibrated standard must be checked, as the criteria for boundary bias may no longer be met. In these cases, the procedure for fitting new classification methods must be followed (CIS Guidance Document No. 30, pg. 11).

for the boundary between good and moderate status shall be established through the intercalibration exercise described below.

The numerical EQR boundaries are the quantitative translation of the normative definition of status classes stated in the Directive. The intercalibation aims at harmonizing the EQR boundaries, and once intercalibrated EQR boundaries have been established the Chl-a boundaries are determined from combining these with reference conditions. Hence, Chl-a boundaries can be derived from the main results of the intercalibration process. This further supports the EQR boundaries and not the Chl-a boundaries as being the main result from the intercalibration process.

If this is the case, the approach used in RBMP3 is in accordance with the intercalibration results and the EU commission decision from 2018.

We do, however, acknowledge that the international panel disagrees with this view, and we agree with the panel, that in situations where not only the EQR boundaries but also the Chl-a boundaries have been intercalibrated, any revision of reference conditions by one Member State might induce the need for a re-intercalibration. For the Danish inner waters, intercalibration with Sweden (but not Germany) involves intercalibration of the Chl-a boundaries. Given that the cardinal point for establishing an intercalibration with Sweden is agreement on the Reference Condition rather than the G/M-boundaries for Chl-a (Carstensen 2016), a revision of the current intercalibration results with Sweden will allow for an update of the reference conditions for intercalibrated water bodies using improved models and methods and ensure consensus on the scientific foundation underpinning the intercalibration process. An update should include more focus on the natural variety of water bodies belonging to the same intercalibration type. The Swedish Reference Conditions for Chl-a have been based on log-log relationships between Chl-a and Secchi depth, where historical observations of Secchi depths are used to predict the reference condition for Chl-a. This approach was pursued in Denmark in the early stages of the WFD implementation but soon abandoned due to the poor relationships between Chl-a and Secchi depth for the open waters, where light conditions are primarily determined by the amount of dissolved organic matter (Henriksen & Carstensen 2009). However, as the intercalibration process is slow and will extend beyond the update of the RBMP3 in 2024, we will investigate if there are temporary alternative solutions, including the re-fitting approach suggested in CIS #30 to align with the intercalibration results while the re-intercalibrations is in process.

In the next sections we provide an overview of the intercalibration results and other Chl-a target values relevant for Danish waters and explore methods to align RBMP3 results with the intercalibrated boundaries. Recommendations for short-term and long-term approaches to update RBMP3 following the international evaluation will be provided in section 3.4.

3.1 Overview of current intercalibration results and target values

According to the Commision decision from 2018 (L_2018047EN.01000101.xml (europa.eu)) Denmark has three intercalibration types in inner Danish waters (BC6, BC8 and NEA8b) and share these intercalibration types with two other countries: Sweden and Germany

Type BC6: Sweden, Denmark
Type BC8: Germany, Denmark
Type NEA8b: Denmark, Sweden

BC6 and BC8 are located within the Baltic Geographical Intercalibration Group, whereas NEA8bis located in the Northeast Atlantic Geographical Intercalibration Group.

Denmark also shares types in the North Sea with Germany (intercalibration type NEA1/26c). However, neither EQRs nor reference values have been updated as part of RBMP3 why water bodies belonging to NEA1/26c will not be assessed in the present report.

As part of the intercalibration process including Denmark, Sweden and Norway (Carstensen 2016) both EQR – and Chl-a boundaries were intercalibrated for the two types: BC6 and NEA8b (including the Sound). However, the last intercalibration type Denmark shares with Germany in the Baltic Sea (BC8), only includes intercalibration of EQR boundaries (also according to Comission decision from 2018). The various intercalibrated EQRs and boundaries are included in Table 3-1.

Table 3.1 Intercalibrated EQRs and boundaries as reported in Commission decision from 2018 (EU Comm 2018)

Country and Type	Ecological Quality Ratios		Values (µg/l)	
	High-good boundary	Good-moderate boundary	High-good boundary	Good-moderate boundary
BC6				
Denmark	0.78	0.62	1.36	1.72
Sweden	0.79	0.64	1.44	1.78
NEA8b (the Sound)				
Denmark	0.79	0.59	1.22	1.63
Sweden	0.80	0.60	1.18	1.56
NEA 8b (The Kattegat and Great Belt)				
Denmark	0.83	0.64	1.22	1.58
Sweden	0.84	0.65	1.18	1.52
BC8				
Denmark	0.8	0.6	-	-
Germany	0.8	0.6	-	-

The various Danish water bodies, that were part of the different intercalibration processes for BC6 and NEA8b are highlighted in Figure 3.1 and Table 3.2. With respect to BC8, we have searched for the Danish water bodies that is included in the intercalibration. However, we have not been able to find a clear water body definition. According to COWI (2023) the BC8 intercalibration water bodies are similar to the OW3a water body types (VP1 and VP2 typology), which is also the general opinion of the Danish EPA. However, no intercalibration documents supports this definition. The OW3a water bodies, BC6, NEA8b and NEA1/26c are included in Figure 3.1.

In Henriksen et al. (2014) several benchmark water bodies are mentioned for BC8. These benchmark water bodies includes both estuaries and 12 nm water bodies, as well as open waters like OW3a. In a background report for the intercalibration process for BC8 (Henriksen et al. 2013) there is a figure illustrating the water bodies being intercalibrated, including many – but not all – of the benchmark water bodies in Henriksen et al. (2014), and including the 12 nm water body at Bornholm. Also, Henriksen et al. (2014) mention Falster as a water body in BC6 and Falster has never been a designated Danish water body. Furthermore, 12 nm water bodies are not really to have GM boundaries for biological quality elements and corresponding indicators. The water bodies included in BC8 could be a mix of Henriksen et al. (2013) and Henriksen et al. (2014) as illustrated in Figure 3.2.

Hence, based on the various documents we have discovered, no clear conclusions can be made regarding BC8, and we conclude that the present intercalibration has targeted the EQR alone, and no nominal summer Chl-a value exists in BC8.

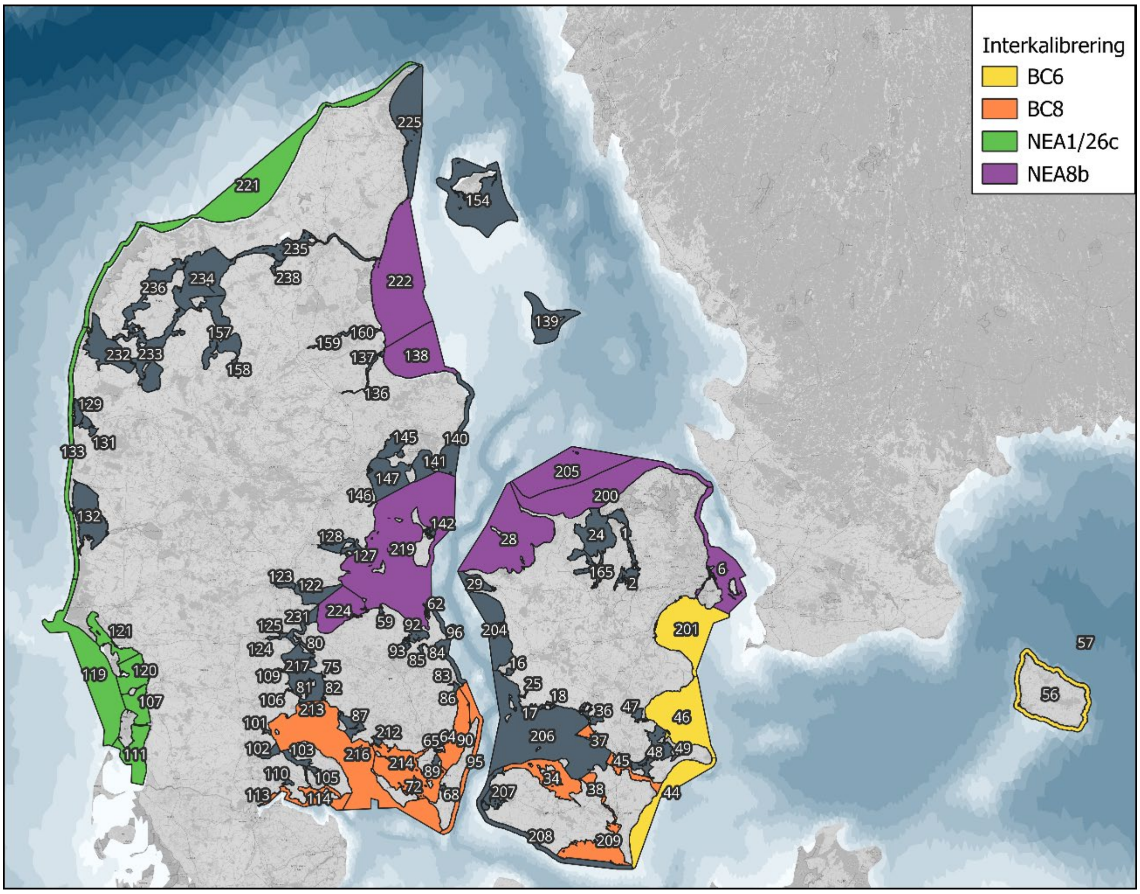

Figure 3.1 The location of Danish water bodies included in the intercalibration exercise with Sweden (BC6, NEA8b) (Carstensen 2016), and Germany (BC8, NEA1/26c). Water bodies in BC8 are here defined as OW3a water bodies. Water bodies not included in the intercalibration are shown in grey.

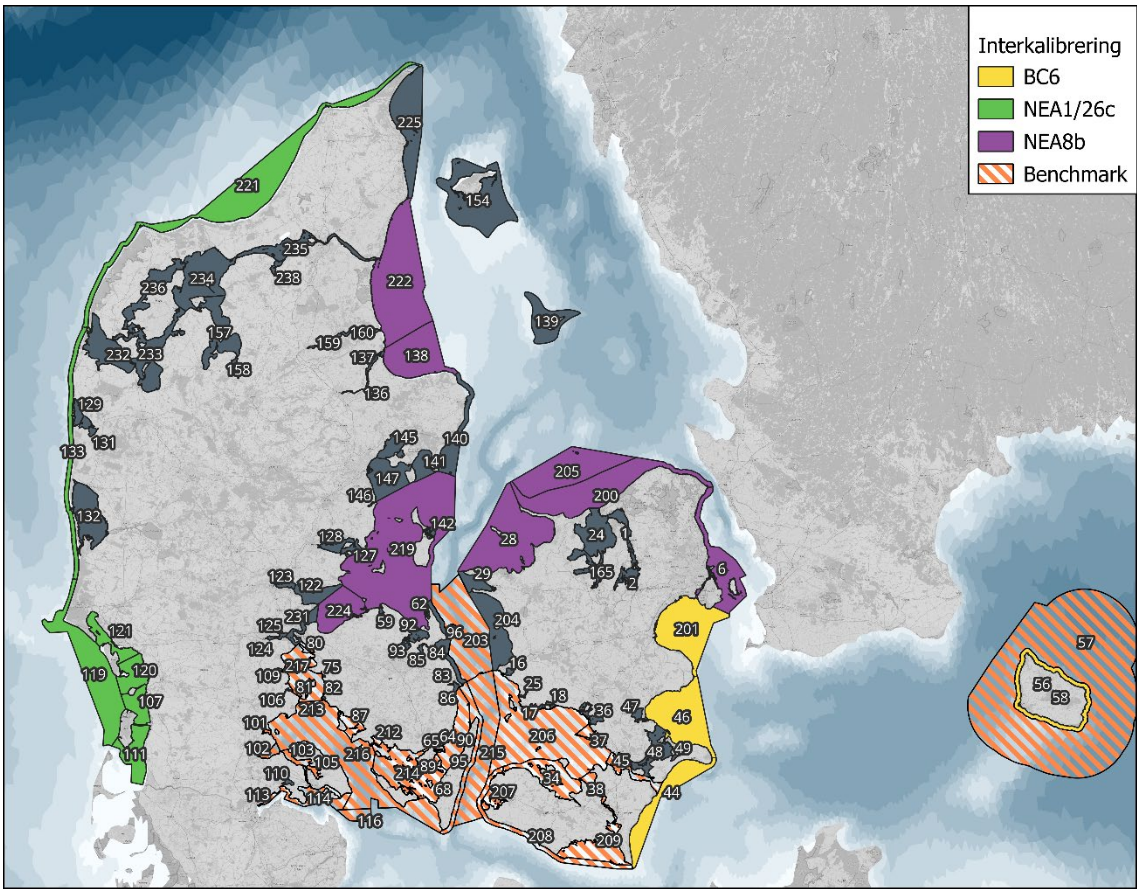

Figure 3.2 The location of Danish water bodies included in the intercalibration exercise with Sweden (BC6, NEA8b) (Carstensen 2016), and Germany (BC8, NEA1/26c). Water bodies in BC8 are here defined as a mix between Henriksen et al. (2013) and Henriksen et al. (2014) and designated "Benchmark areas". Water bodies not included in the intercalibration are shown in grey.

Table 3.2 The Danish water bodies (RBMP3) that are located within one of the four relevant intercalibration areas.

Water body no.	Water body name	GIG Intercalibration	BC8 (OW3a)	BC8 (benchmark)
44	Hjelm Bugt	BC6		
46	Fakse Bugt	BC6		
56	Østersøen, Bornholm	BC6		
201	Køge Bugt	BC6		
34	Smålands-farvandet, syd			BC8
37	Avnø Fjord			BC8[b]
38	Guldborgsund			BC8
45	Grønsund		BC8	BC8[b]
68	Lindelse Nor			BC8
87	Helnæs Bugt			BC8
90	Langelandssund		BC8	BC8

95	Storebælt, SV		BC8	
96	Storebælt, NV			BC8 [b]
102	Åbenrå Fjord			BC8
103	Als Fjord			BC8
104	Als Sund			BC8
105	Augustenborg Fjord			BC8
113	Flensborg Fjord, indre			BC8
114	Flensborg Fjord, ydre			BC8
206	Smålands-farvandet, åbne del		BC8	BC8
207	Nakskov Fjord			BC8
208	Femerbælt		BC8	BC8
209	Rødsand og Bredningen			BC8
214	Det sydfynske Øhav		BC8	BC8
216	Lillebælt, syd		BC8	BC8
217	Lillebælt, Bred-ningen [a]		BC8	BC8
??	Storebælt, SV, 12 nm			BC8 [b]
??	Storebælt, NV, 12 nm			BC8 [b]
??	Østersøen, Bornholm, 12 nm			BC8
107	Juvre Dyb	NEA1/26c		
111	Lister Dyb	NEA1/26c		
119	Vesterhavet, syd	NEA1/26c		
120	Knudedyb	NEA1/26c		
121	Grådyb	NEA1/26c		
133	Vesterhavet, nord	NEA1/26c		
221	Skagerrak	NEA1/26c		
28	Sejerø Bugt	NEA8b		
96	Storebælt, NV	NEA8b [c]		
138	Hevring Bugt	NEA8b		
140	Djursland Øst	NEA8b [c]		
200	Kattegat, Nordsjælland	NEA8b		

205	Kattegat, Nordsjælland >20 m	NEA8b		
219	Aarhus Bugt syd, Samsø og Nordlige Bælthav	NEA8b		
222	Kattegat, Aalborg Bugt	NEA8b		
224	Nordlige Lillebælt	NEA8b		
225	Nordlige Kattegat, Ålbæk Bugt	NEA8b[c]		
6	Nordlige Øresund	NEA8b (The Sound)		
231[d]	Lillebælt, Snævringen			

[a] Not included in Danish contribution to the EU Water Framework Directive intercalibration phase 2 (au.dk)

[b] Not included in Henriksen et al. (2013)

[C] Not included in the intercalibration of NEA8b areas (Carstensen 2016)

[d] Water body 231 Snævringen, was not a separate water body in RBMP2/last intercalibration but part of water body 217 and 224.

3.2 Potential approaches to refitting

The CIS guidance document #30 (European Commission 2015) has outlined a methodology for revising intercalibrated assessment methods, i.e. when a member state who participated in a completed intercalibration exercise now wishes to revise its intercalibrated method. According to the guidance document, this methodology applies to assessment methods with changes in 1) data acquisition (e.g. changing the Chl-a extraction method from acetone to ethanol), 2) numerical evaluation (e.g. changing the seasonal window from May-September to annual mean (January-December), and 3) classification (e.g. reference conditions, boundaries). Since reference conditions were changed from RBMP2 to RBMP3, going from type-specific to waterbody-specific values, the guidance document should, according to its objectives, apply. However, we have identified implementation problems with this approach and will therefore investigate other potential approaches for refitting intercalibrated values. Below, we will present four different approaches, including the approach from the guidance document, and discuss the underlying assumptions and applicability of these.

1. Refitting EQR boundaries from a qualified national dataset (approach from CIS #30)
2. Refitting EQR boundaries while keeping Chl-a boundaries from RBMP2/intercalibration
3. Refitting Chl-a boundaries while keeping EQR boundaries from RBMP2/intercalibration
4. Retaining Chl-a boundaries from RBMP2/intercalibration and rescaling EQR boundaries for open coastal water bodies

The first approach (CIS #30) uses data from the intercalibration exercise of Chl-a with Sweden (shared types BC6 and NEA8b), whereas the three other approaches are based on boundary values from RBMP2 and RBMP3. In this section, the relevant intercalibration boundaries for Chl-a are termed HG and GM, whereas boundaries on the EQR scale are referred to as EQR_HG and EQR_GM. For RBMP2, the intercalibrated boundaries for NEA8b and BC6 are used for open waters (OW types), as opposed to the original boundaries used in RBMP2 (see Bekendtgørelse #1399) that were used as input to the intercalibration (Carstensen 2016).

3.2.1 Refitting EQR boundaries from a qualified national dataset

This approach follows the steps outlined in CIS guidance document #30 (using the same numbering of steps).

1. The Danish contribution to the dataset used for the intercalibration exercise with Sweden qualifies for the exercise (Carstensen 2016). This dataset includes 6-year means (May-September; 1991-1996, 1997-2002, 2003-2008, and 2009-2014) of for water bodies within BC6 (n=14) and NEA8b (n=101), including both open coasts and estuaries. EQR status values were calculated using reference conditions from RBMP2 and RBMP3, which were related by linear regression (Figure 3.2). Relationships established for the two intercalibration regions had R^2 values both above and below 0.80. For R^2<0.80, CIS #30 stipulates that intercalibration feasibility should be checked by relating the EQR status of the new method to the EQR status of the common metric used in the intercalibration exercise. Since the Danish assessment method was used as the common metric in the intercalibration exercise, the relationships of this intercalibration feasibility exercise are identical to Figure 3.1. Hence, the IC feasibility check 1 & 2 from CIS guidance document #14 are valid.
2. The EQR boundaries (EQR_HG and EQR_GM) of the old method (RBMP2) can be translated into EQR boundaries for the new method using the established relationships (Figure 3.2).
3. In BC6, EQR_HG is translated from 0.78 to 0.63 and EQR_GM is translated from 0.62 to 0.49. In NEA8b, EQR_HG is translated from 0.83 to 0.70 and EQR_GM is translated from 0.64 to 0.58 (Figure 3.1).
4. The EQR boundaries of the new method (RBMP3) are not more precautionary (i.e. higher), so the criterion for this step is not met and step 5 should be considered.
5. All EQR boundaries are lower with the new method and hence, the procedure for fitting new classification methods must be followed (cf. Chapter 5 in CIS #30).

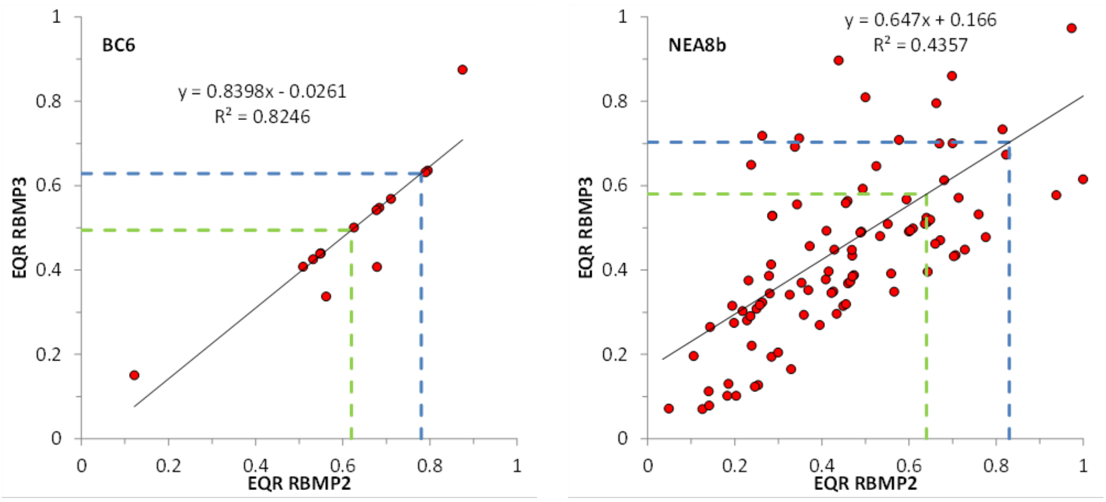

Figure 3.3: Relationships between EQR values for Chl-a based on reference conditions from RBMP2 versus RBMP3.

According to Chapter 5 Case B1[1] (pseudo-common metrics (option 3) using reference/benchmark sites), the refitting can be carried out based on national data only by comparing the new national metric with the pseudo-common metric. However, since the Danish metric (mean Chl from May to September) was used as pseudo-common metric, and since the assessment method has not changed (i.e. only reference conditions have changed), there is no need for refitting the national metric. In fact, the procedure outlined in Chapter 5 (CIS #30) is only relevant for changes in 1) data acquisition or 2) numerical evaluation, which affects the assessment metric. This highlights the inadequacy of CIS #30 when reference conditions or boundaries are changed. From careful reading of CIS #30, the outlined procedures were most likely developed with changes in data acquisition or numerical evaluation in mind, and the case of changing reference conditions was erroneously included under the same procedure.

Importantly, the refitting procedure is based on the implicit assumption that metrics calculated with the new and old method from the national dataset represent the same status. Whereas this assumption is reasonable when changing data acquisition or numerical evaluation, corresponding to a calibration exercise of one assessment method versus another, then that assumption does not hold in the case of changing reference conditions. Changing reference conditions imply that EQR status values with the old method do not represent the same status as EQR values obtained with the new method. The consequence is that the relationship between new EQR and old EQR status values violates the underlying implicit assumption for a refitting regression and hence, **the approach for refitting EQR status values (cf. CIS #30) in the case of revising reference conditions is flawed**.

[1] Note that in CIS #30, this option is labeled as A2 in Figure 1 and as B1 in Chapter 5.

3.2.2. Refitting EQR boundaries while keeping HG and GM from RBMP2

This approach is similar to that in the previous subsection, except that the relationships are based on EQR boundaries (EQR_HG and EQR_GM) instead of EQR status values. <u>It does not comply with the CIS guidance document #30 and is presented here as a theoretical possible method for refitting</u>. The new EQR boundaries have been calculated using Chl-a reference conditions from RBMP3 and the HG and GM boundaries from RBMP2 (e.g. EQR_GM(new)=RefCond(RBMP3)/GM(RBMP2)). In other words, it is assumed that HG and GM boundaries are maintained from RBMP2 to RBMP3 (Table 3.1). **One remark: This assumption is questionable, given that revised reference conditions would also change our perception of what characterizes HG and GM boundaries under RBMP3.** Since there is little variation in the EQR_HG and EQR_GM for RBMP2, the refitting of EQR boundaries from RBMP2 to RBMP3 by linear regression will be uncertain (Figure 3.3) and the variation in water body specific reference conditions calculated in RBMP3 is transformed into variation in the new EQR values without any scientific justification. Moreover, this approach is less meaningful as it reduces the resolution of waterbody-specific boundaries in RBMP3 to type-specific boundaries as employed in RBMP2 (three levels for BC6 and eight levels for NEA8b). Hence, in this case **it is better to keep the EQR boundaries for RBMP3 without employing a refitting to EQR boundaries for RBMP2**.

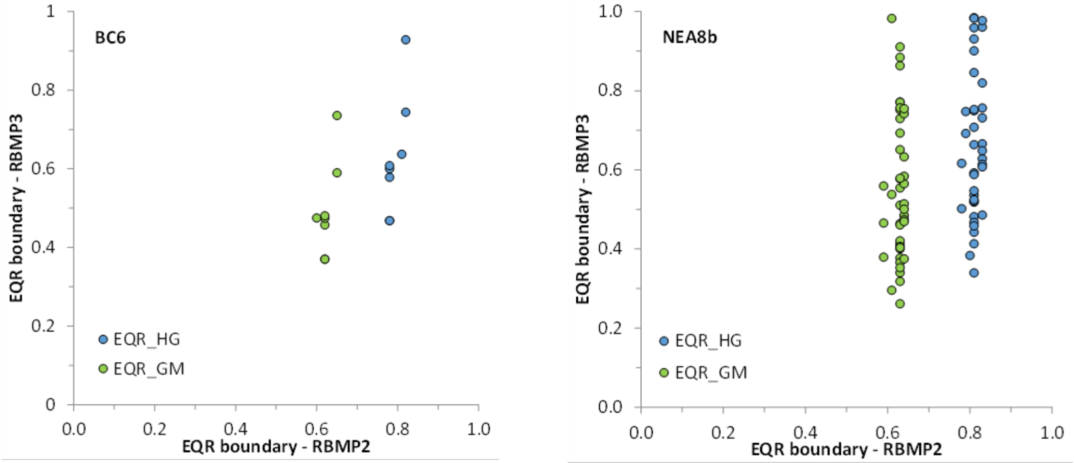

Figure 3.4: Relationships between EQR boundaries for Chl-a based on Chl-a reference conditions from RBMP2 versus RBMP3, with Chl-a GM and HG boundaries from RBMP2 in both cases. Observations are boundaries from all Danish water bodies in the two intercalibration areas, i.e. both coastal waters and estuaries.

3.2.3 Refitting GM boundaries while keeping EQR boundaries from RBMP2

This approach is based on a refitting of Chl-a boundaries rather than EQR boundaries. It does not comply with the CIS guidance document #30 and is presented here as a theoretical possible method for refitting. The underlying assumption of this approach is that the EQR boundaries from RBMP2 are also used for RBMP3, which seems to be a reasonable assumption given that this corresponds to the overall WFD approach to ecological status assessment and intercalibration, i.e. that relative deviations from the reference conditions are harmonized between and within countries. The HG and GM boundaries for RBMP3 are calculated from the revised reference conditions and the EQR boundaries from RBMP2 (e.g. GM(RBMP3)=RefCond(RBMP3)/EQR_GM(RBMP2)). This calculation corresponds to the original suggestion for RBMP3 boundaries (Timmermann et al., 2021). It is possible to derive reasonable relationships between boundaries from RBMP2 and RBMP3 due to the larger spread of HG and GM boundaries under RBMP2. However, it makes little sense to use a regression for recalculating already established HG and GM boundaries under RBMP3, providing high spatial resolution and acknowledging the diversity of different water bodies, to the reduced set of boundaries established under RBMP2. This regression assumes that there should be a linear relationship between Chl-a boundaries from RBMP2 to RBMP3, and that any deviation from this regression is due to uncertainty. However, this assumption does not seem appropriate as deviations are due to waterbody-specific variability and not randomness. Hence, in this case **it is better to keep the calculated HG and GM Chl-a boundaries under RBMP3 without employing a refitting to the coarser set of boundaries established for RBMP2**.

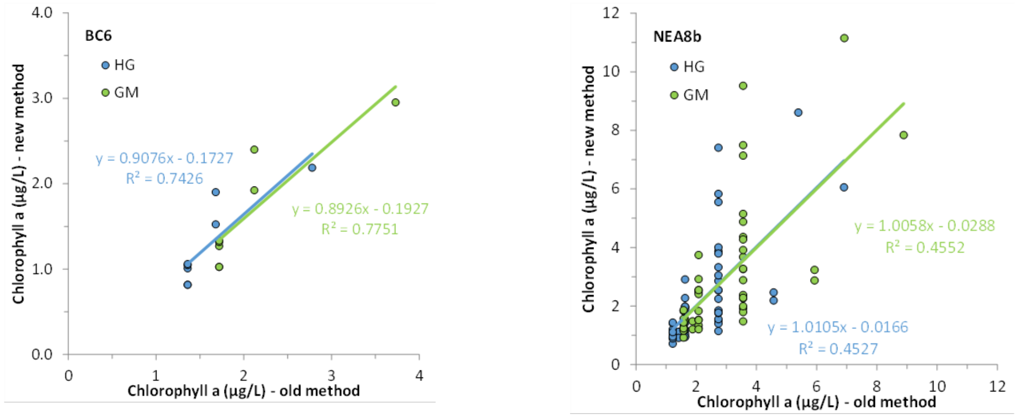

Figure 3.5: Relationships between HG and GM boundaries for Chl based on reference conditions from RBMP2 versus RBMP3. Observations are boundaries from all Danish water bodies in the two intercalibration areas, i.e. both coastal waters and estuaries.

3.2.4 Retaining intercalibrated Chl-a boundaries for open coastal waters

This pragmatic approach is a compromise between the RBMP3 Chl-a boundaries and the request by the expert panel in Second Opinion to keep the intercalibrated Chl-a boundaries for types shared with other countries. For BC6 and NEA8b, Chl-a values for the “good-moderate” and “high-good” boundaries has been intercalibrated with Sweden (Carstensen 2016) and stated in the current EU decision on intercalibration results (EU Comm 2018). According to Carstensen (2016), 12 water bodies have been intercalibrated with Sweden and these are marked in yellow and purple in figure 3.1. The intercalibration results on Chl-a boundaries for BC6 and NEA8b are based on- and largely similar to -the Chl-a reference and boundary values established as part of RBMP2. For BC8, only EQR boundaries and not Chl-a boundaries have been intercalibrated and stated in the current EU decision on intercalibration results (EU Comm 2018). New reference conditions have been calculated for all water bodies under RBMP3, including those in open and intercalibrated coastal waters. For these intercalibrated open coastal water bodies, the reference conditions, Chl-a boundaries (HG and GM) and EQR boundaries (EQR_HG and EQR_GM) from the EU intercalibration decision are used for RBMP3, acknowledging that this should be considered a temporary solution until new boundaries, based on the improved scientific basis of RBMP3 while satisfying the harmonization of boundaries with neighboring countries sharing the same types.

It should be stressed that using Chl-a boundary setting from the intercalibration decision/RBMP2 for open coastal waters and changing the boundary setting for water bodies that were not included in the intercalibration could lead to spatial inconsistencies. For example, Sejerø Bugt was included in the intercalibration (GM(RBMP2)=1.58 µg/l), whereas the neighboring Kalundborg Fjord was not, yielding GM(RBMP3)=1.23 µg/l when employing the revised reference condition of RBMP3. Similar discrepancy is observed across intercalibration types, such as GM(RBMP2)=1.72 µg/l for Hjelm Bugt and Fakse Bugt (both in BC6) and GM(RBMP3)=1.6 µg/l for neighboring Grønsund.

3.2.5 summary

In this section, four different approaches to refitting boundaries for Chl-a, either on EQR- or indicator-scale, are presented. These four approaches represent possible ways to address the inconsistencies experienced when redefining reference conditions from RBMP2 to RBMP3. All four approaches have deficiencies that make them unsuitable for refitting boundaries. Hence, to obtain EQR boundaries satisfying the requirements of the intercalibration process, it is recommended to maintain the boundaries and reference values from RBMP2 for the specific open coastal water bodies that were part of the intercalibration as a temporary solution (cf. section 3.2.4) and in the longer term, initiate a new harmonisation exercise with Germany and Sweden.

3.3 Potential application of revised boundaries

According to the international panel, the proposed adjustment of RMBP3 Chl-a boundaries to the intercalibrated Chl-a boundaries should be applied for open (intercalibrated) waters and not extend into the estuaries (pg. 15). In this context “open intercalibrated waters” refers to selected water bodies in NEA8b and BC6 as these water bodies have intercalibrated Chl-a targets. The remaining intercalibrated water bodies (BC8) only have intercalibrated EQR- but not Chl-a boundaries, and hence, no discrepancy exists between the intercalibration descission and RBMP3. Suggested EQR boundaries as well as Chl-a boundaries for BC8 appear in a background report (Henriksen et al., 2013) underpinning the EU Commission decision. The Chl-a reference, G/M and H/G boundaries in the background report are, however, in conflict with the intercalibrated values stated in the EU Commission decision (EU Comm 2018). Aligning Chl-a G/M boundaries in RBMP3 with the Chl-a G/M boundary suggested in the background report would thus conflict with the intercalibration results stipulated in the EU commission decision (EU Comm 2018).

If adjustments are made for water bodies in BC6 and NEA8b it will affect the boundary setting for water bodies marked in yellow and purple in figure 3.1 compared to RBMP3.

As only a subset of open water bodies has been intercalibrated, there will be a shift in targets between adjacent open intercalibrated water bodies based on RBMP2 type specific boundaries and reference values and non-intercalibrated water bodies based on RBMP3 water body specific boundaries values. However, spatial inconsistencies are unavoidable when two different approaches for boundary setting are applied.

3.4 Recommendations

Due to the redefining of reference conditions from RBMP2 to RBMP3 inconsistencies between RBMP3 Chl-a boundaries and intercalibrated Chla-boundaries in NEA8b and BC6 have emerged. For BC8, no inconsistencies between RBMP3 and the latest intercalibration decision have been detected as only EQR boundaries and not Chl-a boundaries are included in the EU Commission decision (EU Comm 2018). For all common water body types (NEA1/26c, NEA8b, BC6 and BC8), intercalibrated EQR boundaries stated in the EU Commission decision are used in RBMP3. The international panel evaluating the Danish RBMP3 has recommended to align RBMP3 and intercalibrated Chl-a boundaries for open intercalibrated water bodies. According to the Directive annex V, EQR boundaries are the main result of the intercalibration process, however, in situations where the indicator boundaries are also stated in the EU decision any revision of reference conditions by one Member State might induce the need for a re-intercalibration. In order to align with the suggestions from the panel, we recommend the following approach for a potential revision of the RBMP3.

- Initiate a re-intercalibration process with Sweden (NEA8b, BC6) and Germany (BC8) to establish an improved and updated common basis for determining reference conditions, EQR boundaries and Chl-a boundaries for the common water body types. As the status of open Danish coastal waters to some extend depends on the status of incoming Baltic or North Sea water an alignment with the reference conditions and Chl-a targets and not only EQR boundaries for coastal waters could be beneficial. For status classification and extrapolation of the intercalibration results to all Danish water bodies, the EQR boundaries (and not Chl-a boundaries) are, however, the important intercalibration result. A re-intercalibration process, aiming at harmonizing reference conditions and EQR boundaries, is the scientifically optimal solution and the only solution where inconsistencies can be avoided or at least reduced to a minimum. It is, however, not possible to complete an intercalibration exercise within the time frame of RBMP2021-2027.
- As a temporary solution to accommodate the recommendation from the international panel, it is suggested to use EQR boundaries and Chl-a boundaries from the EU intercalibration decision (EU Comm 2018) for open coastal water bodies that were part of the intercalibration with Sweden (NEA8b, BC6, se fig. 3.1). This solution ensures that RBMP3 is in accordance with all intercalibration results stated in the latest EU commission Decision (2018). However, the intercalibrated Chl-a boundaries are based on type-specific and less valid reference conditions from RBMP2, which do not necessarily reflect the characteristics of the different water bodies. Furthermore, there will be (spatial) inconsistencies between boundaries for adjacent water bodies using either RBMP2 or RBMP3 estimations of reference conditions. It is not possible to use the re-fitting approach described in CIS #30 in situations where reference conditions have been updated, as the underlying assumption for the re-fitting regression is violated. Other re-fitting procedures result in highly variable and unjustified EQR boundaries not complying with the intercalibration results, and similar EQR boundaries reported from other member states.
- For BC8, RMPB3 is fully aligned with the intercalibration results stated in the EU commission decision (EU Comm 2018) and there is no justification for modifying Chl-a boundaries in a revision of RBMP3. Any potential future change of Chl-a boundaries for BC8 water bodies should await a re-intercalibration with Germany.

- It is recommended to limit any changes in RBMP3 boundaries to water bodies in NEA8b and BC6 to minimize unavoidable (spatial) inconsistencies and maintain a high spatial differentiation allowing reference values to reflect the different hydrodynamic conditions in open water bodies.

Reference

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