INTERNATIONAL EVALUATION OF THE SCIENTIFIC AND LEGAL BASIS FOR NITROGEN REDUCTIONS IN THE 3RD DANISH RIVER BASIN MANAGEMENT PLAN

Peter Hermann

Alice Newton

Bo Gustafsson

Henrik Josefsson

Robert Krüger

Revised Report

12th October, 2023

CONTENT

Cover photo

The Panel wishes to thank Peter Bondo Christensen for allowing us to use the cover photograph of healthy eelgrass in Danish coastal waters.

Commonly used Acronyms

Art.	Article
AU	Aarhus University
BC	Baltic Countries
BQE	Biological Quality Element
Chl-a	Chlorophyll-*a*
CIS	Common Implementation Strategy
DCE	Danish Centre for Environment and Energy
DHI	Danish Hydraulic Institute
DTU	Danish Technical University
ECOSTAT	Ecological Status
EQR	Ecological Quality Ratio
GIG	Geographical Intercalibration Group
G/M	Good/Moderate (class boundary)
HELCOM	Helsinki Commission (The Baltic Marine Environment Protection Commission)
H/G	High/Good (class boundary)
IC	Intercalibration
Kd	Diffuse light attenuation coefficient
MAI	Maximum Allowed Inputs
MECH	Mechanistic (model)
MSFD	Marine Strategy Framework Directive
N	Nitrogen
NEA	North East Atlantic
OSPAR	Oslo-Paris convention, the regional authority for the North Sea
P	Phosphorus
RBMP	River Basin Management Plan
RBMP2:	2^{nd} River Basin Management Plan
RBMP3:	3^{rd} River Basin Management Plan
STAT	Statistical (model)
WFD	Water Framework Directive

GENERAL INTRODUCTION

Background on the "second opinion" on the scientific basis for calculated need for nitrogen reduction.

In the Agreement on Green Transition of the Agriculture Sector (October 2021), the second opinion is described as follows:

> *"The parties to the Parliament agreement agree on having carried out an independent assessment of the scientific basis for the calculated need for reduction of nitrogen ("second opinion") with the involvement of international experts. A second opinion will include an assessment of the scientific basis for the calculated need for reduction of nitrogen with a focus on exploring whether assumptions, preconditions or choices have been made that could lead to adjustments of the estimated need for reduction of the nitrogen load on coastal waters within the legal and scientific framework of the Water Framework Directive."*

As described in the terms of references for the second opinion, it is divided into three phases. The involvement of international experts that constitutes the basis for this report takes place in phase two out of three.

- The first phase of the second opinion consists of 1) a review of current scientific and legal basis for the calculated need for Nitrogen reduction and 2) an analysis of the legal and scientific room for manoeuvring within the Water Framework Directive. This analysis was provided by COWI and NIRAS and included remarks from stakeholders. It forms a basis for the international evaluation in phase two.
- In phase two, the main task for the panel of experts was to evaluate the Danish management approach from both a scientific and legal perspective and to evaluate, whether there are other potential approaches within the scientific and legal boundaries of the Water Framework Directive.
- The international evaluation and its recommendations should provide basis for implementation in the third phase, where a revised assessment of the remaining need for action will be conducted to conclude the second opinion.

The results of the preliminary analysis in phase I, including comments from stakeholders, were presented to the political parties behind the *Agreement on Green Transition of the Agriculture Sector* of 2021.

The terms of reference for the phase II international evaluation state that the second opinion should be carried out with regards to both a legal evaluation of the Danish implementation of the EU Water Framework Directive (WFD) and a scientific evaluation of the basis for the calculation of the need for reduction of nitrogen load.

The Ministry of Finance, The Ministry of Food, Agriculture and Fisheries, and The Ministry of Environment (hereafter the Ministries) has provided the panel with technical support as part of preparations for the evaluation.

Composition of the Panel

The international Panel was composed of the following members:

- Peter Herman, Deltares, The Netherlands (chairman) – marine ecologist and modeller
- Bo Gustafsson, Stockholm University, Sweden – marine ecological modeller, expert in HELCOM
- Alice Newton, University of Algarve, Portugal – oceanographer and expert in WFD implementation
- Robert Krüger, Geiersberger Glas & Partner, Germany – legal expert in environmental law
- Henrik Josefsson, Uppsala University, Sweden – legal expert in environmental law

Overview of activities of the Panel:

The Panel first met on 29th of March 2023 and received material to analyse, in particular the Phase I report by COWI and NIRAS as well as the stakeholder comments. There followed discussion meetings on the 16th of May, the 27th of June, and the 5th of September. In the latter meeting, there was also a presentation by representatives of the phase III pilot projects undertaken by four coast water councils (*kystvandråd)*.

There was also dedicated meetings with Ministries' legal experts, scientists, and Phase III participants during which the Panel requested additional material and discussed selected materials: June 13th interview with modelling group, June 26th interview with phase III experts, June 29th interview with legal advisors.

The Panel met in person with the Ministries, the stakeholders and some of the participants of Phase III on the 11th of September. Prior to this meeting, the Panel invited the stakeholders to highlight which comments they considered most important as well as to express what solutions they considered to be viable to solve the issue. During the following days the Panel discussed and made a first draft of the present report. The draft report was made available to the stakeholders on the 21th of September.

Stakeholder comments to draft report and replies from the Panel in Annex

After receiving the draft report, the stakeholders had until 2nd October to submit their comments to the draft report. The Panel has carefully read these comments and taken them into account in revising and supplementing certain sections in the draft report and transformed them into the present revised evaluation report.

In addition, the Panel has also provided direct responses to some of the stakeholder comments on topics where the Panel found it necessary to reply directly and clarify its position on the selected topics. These replies are inserted in a table in the separate Annex 1 to the evaluation report. Hence, the table in Annex 1 contains: (1) replies where the Panel explains its position without this has given rise to changes in the report, and (2) replies where the Panel indicates that changes were made relating to the comment (with references to the report sections where the changes occur). In total the evaluation report therefore consists of:

- Revised evaluation report (present document)
- Annex 1 with replies from the Panel to selected stakeholder comments to the draft report
- Annex 2 with the compiled stakeholder comments to the draft report

Aims and limitations of the evaluation report

In the terms of reference for the Panel, the Ministries raised a number of topics that deserved the attention of the Panel. These topics covered most of the points of criticism and appraisal raised by the COWI and NIRAS report, as well as the remarks made by the stakeholders. The Panel independently verified the completeness and the relevance of these points, based on the respective reports. The Panel further consulted the large number of reports and publications documenting the modelling and analysis underlying the RBMP3, as well as the reports and analyses provided by stakeholders. The underlying information on the modelling is rather scattered. The Panel received technical support from the Ministries to retrieve all relevant information, and further looked up details in publicly available publications and reports. In addition, the opportunity to discuss with researchers, legal experts and agents involved in local/regional analyses, has supplemented the information provided.

The Panel acknowledges its limited knowledge of local situations and has refrained from commenting on aspects that heavily depend on these local settings. In using the remarks and suggestions provided by the stakeholders, the Panel has taken great care not to overlook the essence of the formulated criticism. However, the sheer volume of questions and remarks makes it impossible to formulate a detailed response to each of them.

The aim of the Panel's analysis is to give a general overview and appraisal of the models, arguments and analyses performed by the different actors in the process of building the RBMP3 and the second opinion. The main questions addressed are reflected in the headings of the different chapters, although some topics come back in several chapters. The Panel refrained from commenting on details of the modelling and analyses where it was estimated that these details, although potentially important for precise quantitative estimates, would not change the overall outcomes in a fundamental way. In doing so, the Panel concentrated on the way forward rather than on a precise critique of the work accomplished.

The Panel assessed whether the modelling and analysis was fit for purpose, i.e. formed a sufficiently robust basis for concrete implementation of measures and significant steps forward on the way to achieving the goals of the WFD. Also, in recommendations on future work, the Panel emphasised gaps in knowledge for these future steps, rather than successive refinements of modelling tools that had already proven their value as a sufficient basis for action.

A central theme of the questions posed by the Ministries is whether and where room for manoeuvring for the political process can be found. The Panel investigated whether any such room could be found in how targets have been defined, what assumptions had been made underlying the models, what alternative approaches apart from Nitrogen load reduction could be used, and what room for exemptions is available in the legal framework of the WFD. In the cases where such room for manoeuvring was detected, the Panel concluded that concrete proposals for policy options will be dependent on the political process and on advanced knowledge of the local conditions that goes beyond the Panel's expertise.

It will be left to the political system to make concrete propositions within the room provided by the WFD. Therefore, the conclusions and recommendations formulated by the Panel should not be viewed as an alternative proposal for the RBMP3, but as a starting point for the political decision-making process leading to the final version of this plan.

CHAPTER 1: REFERENCE CONDITIONS, G/M BOUNDARY TARGET, AND INTERCALIBRATION

1.1 Introduction to the theme

The modelling behind RBMP3 is an extensive set of scientific work. Mechanistic and statistical models have been made, calibrated and validated using long-term extensive data bases. In addition, modelling approaches needed to estimate reference conditions and calculate MAI for nitrogen to the different water bodies. Some additional model applications have explored other aspects that will be discussed in other chapters. The Panel will not introduce this modelling work in the present report. An introductory text has been prepared by the researchers that have performed the analyses (Erichsen et al., 2023).[1] More details can be found in reports on different aspects, to which the introductory text gives a guidance.

'Reference conditions' play an essential role in the application of the WFD. Reference conditions are specific for certain water body types. Reference conditions are represented by the state of the biological quality indicator when a water body in the type is characterised by values of the physico-chemical and hydromorphological quality elements that have no, or only very minor, anthropogenic alterations. Reference conditions may be determined by observation of undisturbed water bodies of a similar type, derived from historical observations, or – when observations are unavailable – by modelling. Expert judgment may be used when neither of these approaches are feasible. For the Danish water bodies, reference conditions for Chl-a have been calculated using the models developed within the River Basin Management Plans and using nutrient input values at nearly pristine levels.

In comparison to the Danish RBMP2, reference conditions have been recalculated in the Danish RBMP3.[1] The following important differences are to be noted:

- A new typology has been implemented, following criticism on the rather crude typology used in RBMP2. This typology, however, plays a less decisive role in RBMP3 than in RBMP2, because for most water bodies, reference conditions have now been calculated in a water-body specific way. Typology still plays a role in the statistical models, and to a limited extent also for extrapolating to the few water bodies for which no model is available. Some water bodies that were used in the intercalibrations with neighbouring countries, and that all belonged to the same water body type at the time of the intercalibration, are now classified in different types. This poses the question of how to relate them to the intercalibration results.
- The mechanistic modelling has now been extended to (almost) all water bodies. Statistical models are restricted to water bodies with sufficiently long data series, but a representative set of water bodies is covered by both model approaches. The methodology of statistical modelling has been revised, compared to RBMP2. A regression approach was used to derive Chl-a reference conditions for (almost) all water bodies based on estimates from the statistical and mechanistic model. In RBMP2, an ensemble modelling approach and a type-based approach was used instead of a regression approach.
- Reference conditions which used to be projected onto the year 1900 in RBMP1 and RBMP2, are now no longer associated to that year in RBMP3. Calculation of Chl-a reference values follow similar procedures in RBMP2 as used in RBMP3, however. It has been argued that nutrient loading in 1900 was already elevated relative to pristine conditions[2]. This does not pose a problem for the definition of reference conditions for Chl-a, however it does pose a problem for the consistency between reference conditions for Chl-a and eelgrass depth limits, as will be explained below.
- The total nitrogen load used to calculate reference conditions for Chl-a (BQE of phytoplankton) is lower in RBMP3 than in RBMP2, but the difference is small: 16.000 tonnes N instead of 17.000 tonnes N on a national basis. This difference contributes little to the differences in calculated Chl-a reference conditions used in RBMP2 and RBMP3. More important is that in RBMP3, the models have been forced by boundary and initial conditions, as well as nutrient stocks in the sediments, that were close to a pristine state of the entire Baltic Sea. This aspect has been worked out more meticulously in RBMP3 and RBMP2, and it has given rise to differences in the calculated reference conditions.
- G/M boundary concentrations of Chl-a, and boundary value for Kd, have been calculated by applying the EQR values derived from the existing intercalibrations, to the recalculated reference values. This has generally resulted in stricter boundary values for Chl-a in open waters, and more lenient boundary values in enclosed water bodies.

---

[1] Anders C. Erichsen, Karen Timmermann and Jesper P. A. Christensen. 2023. Second opinion readers guide to RBMP 3 models and scenarios in Denmark. Aarhus University, DCE – Danish Centre for Environment and Energy, 31 pp. Technical Report No. 268 http://dce2.au.dk/pub/TR268.pdf

[2] Jung-Madsen, S. and Bach H. (red.) 2022. Transport of nitrogen and phosphorus from land to sea around year 1900. Aarhus University, DCE – Danish Centre for Environment and Energy, 192 pp. Scientific Report No. 498 http://dce2.au.dk/pub/SR498.pdf

- Reference conditions for eelgrass depth limit have been expanded to 'rooted marine vegetation depth limit', which was formally approved by the European Commission[3]. The revised method includes documentation on other types of "rooted marine vegetation" but does not change the target values nor the use of eelgrass depth limits as an indicator. Reference conditions are derived from the same historical data base that was also used in RBMP2 for the (then) indicator 'eelgrass depth limit'. In RBMP3, a regression approach and, to a limited extent, type-based approach was used to derive reference conditions in water bodies lacking historical observations. No regression approach was used in RBMP2 and depth limits where extrapolated only based on the water body type.

1.2 Results from Phase I

1.2.1 Central findings by COWI and NIRAS

COWI and NIRAS assessed that Denmark has established reference conditions in accordance with the WFD by using either predictive models or hindcasting methods based on historical paleo-ecological and other available data. It is further assessed that the established reference conditions are based on robust methodologies, but that there is room for improving quality assurance of the applied methodology, thereby, ensuring improved compliance with the provisions of the directive.

COWI and NIRAS assessed that the revised Danish typology for the River Basin Management Plan 3 (RBMP3) is an improvement, as it allows for a better differentiation of coastal water types that reflects the diversity of Danish coastal waters compared to previous RBMPs. However, COWI and NIRAS found that the revised typology is more complex and requires transparent documentation for establishing reference conditions and translating ecological status class boundaries into national types. COWI and NIRAS further found that there is a need to establish clear links between individual coastal waters and common IC types to comply with the WFD and that the revised typology requires changes to established reference conditions and ecological status class boundaries, which should be presented and discussed in the CIS ECOSTAT working group. It is suggested that an analysis and demonstration of the new typology's sensitivity to eutrophication pressure could be a test of its capability to group water bodies in this respect, particularly for fjords and enclosed water bodies.

Regarding Chl-a references, COWI and NIRAS assessed that the Danish Marine Model Complex has developed mechanistic and statistical models using revised typology descriptor values, considering non-Danish transboundary nutrient input to Danish marine waters, enabling the derivation of reference values for Chl-a in individual water bodies. The MECH model is assessed to be applied consistently across all individual water bodies/coastal water types, qualifying for the translation of intercalibrated ecological status class boundaries for common IC types into national types. The RBMP3 Chl-a reference condition values for open waters show lower (more stringent) values than the RBMP2 reference conditions values, which could have implications for the intercalibrated G/M class boundaries.

Regarding references for eelgrass depth limit, COWI and NIRAS assessed that the revised reference conditions generally show a good agreement between the RBMP2 and RBMP3 sets of reference condition values, including in water bodies, where only type-specific reference values were established in RBMP2. A comparison indicates lower depth limits (less stringent) for type-specific reference condition values for open coastal waters, and higher depth limits (more stringent) for type-specific reference values for water bodies with natural lower depth distribution (e.g. enclosed fjords). COWI and NIRAS further assessed that the model for deriving eelgrass depth distribution reference values is only applicable for deriving reference values in a historical regime, where eutrophication and eutrophication-induced light attenuation and limitation have no influence on the eelgrass distribution. COWI and NIRAS suggested that establishing pressure-impact-gradients could provide a basis for compliance with the CIS guidelines and procedures for deriving reference conditions.

Regarding supporting quality elements, COWI and NIRAS assessed that reference conditions have not been established for physico-chemical quality elements or hydromorphological quality elements, and that the European Commission notes that more focus needs to be given to eutrophication-related supporting quality elements such as nitrogen and phosphorus concentrations as well as 'light availability'. COWI and NIRAS therefore suggested that supporting quality elements should be used in comparison of reference conditions and class boundaries for biological quality elements, thereby providing a higher level of confidence.

In task 10 on room for manoeuvring for reference conditions, COWI and NIRAS assessed that the established reference conditions are based on robust methodologies and that there is little room for manoeuvring. However, they evaluated that there is a room for improving quality assurance of the applied methodology. COWI and NIRAS suggested supplementing the current method with alternative methods, such as developing pressure-impact

[3] https://circabc.europa.eu/ui/group/9ab5926d-bed4-4322-9aa7-9964bbe8312d/library/0142894f-56bd-46ee-8ee7-236775509d57/details

gradients for nutrient concentration/Chl-a relationship and identifying common ecological response characteristics. It is proposed to 'supplement' (not necessarily replace) the one-step relation between nutrient loading and biological quality elements (Chl-a, eelgrass depth limit) by a two-step approach, consisting of a relation between nutrient loading and nutrient concentrations, followed by a relation between nutrient concentrations and biological quality elements. COWI and NIRAS acknowledged that this will likely increase the uncertainty of the loading-quality relationship and that including these elements may not reduce the need for reduction of nitrogen load. Yet, they evaluated that it will increase transparency and confidence in model results and ensure compliance with WFD normative definitions.

Regarding consistency between reference conditions, COWI and NIRAS further stated that reference conditions must be in the "High condition range" including "background loads" (e.g. used for Chl-a reference conditions), and that this range might also include nutrient loads around year 1900. However, COWI and NIRAS also stated that eelgrass depths around year 1900 might have exposed a 'discontinued' response due to resilience to the increased nutrient load, indicating that the period around 1900 could be considered a 'transition period', where the 'true' long term relation between nutrients and eelgrass depths in a reference condition cannot be inferred.

1.2.2 Central Remarks by stakeholders regarding confidence in reference conditions

Several stakeholders note that it is not clear from the phase I report, if the current modelling approach for reference conditions is in compliance with the WFD.

- Some stakeholders note that the level of uncertainty in estimates and the changes in reference conditions and ecological class boundaries between RBMP2 and RBMP3 does not add to the confidence in estimates. The stakeholders both criticise uncertainty of references for eelgrass depth limit and the precision of these estimates in calculations, and how the revised Chl-a references might have impacted the current ecological status-class for a large number of water bodies.
- One stakeholder further notes that the current model-based approaches might not be suited for certain types of water bodies (e.g. water bodies with high resuspension).
- Some stakeholders also criticise that the report does not reflect on whether there is an issue with "angiosperms" being measured by "eelgrass depth limit" in a Danish context and thereby ignoring "abundance" ("eelgrass cover"), as described in the WFD.
- One stakeholder finds that the discussion on typology in the phase I report is incoherent and that a deeper investigation is needed concerning the real demand regarding the WFD and what makes sense to get the best knowledge and to make to best planning.
- Some stakeholders argue that there is an inconsistency between the reference conditions for eelgrass and Chl-a, as eelgrass references refer to the year 1900, while Chl-a references uses background N-loads, which some stakeholders describe to be from a time period more than 1000 years ago "before the Viking age".

It should be noted that the "model group" behind the model development and estimation of reference conditions also have submitted a few remarks on the conclusions from COWI and NIRAS.

- The stakeholder, DCE from Aarhus University, who is responsible for estimation of the reference nitrogen loads in RBMP3 shared in their remarks to the report by COWI and NIRAS, that the method used for estimating reference nitrogen loads has been shown to underestimate the concentration of total nitrogen with an average of 13.5 per cent.

1.3. Selected focus by the panel in the evaluation of the theme

In this chapter, the Panel briefly comments on typology and the inclusion of supporting physico-chemical elements into the modelling and management cycle of the RBMP. Most emphasis, however, is placed on the reference conditions, how these have affected the G/M boundary values, and how that relates to the intercalibration results that have previously been decided upon by the European Commission. Details of model approaches are not discussed in this chapter; relevant aspects will be covered in Chapter 2.

1.4. Discussion of issues within the evaluation theme

1.4.1 Typology

The panel agrees with the assessment by COWI and NIRAS that the new typology is an improvement compared to the previous one. At the same time, the panel notes that the role played by the typology in RBMP3 is more limited than in RBMP2, as almost all relevant parameters (reference conditions, MAI, need for N-reduction) are calculated as water-body specific values. Typology only plays a role in smoothing reference values, and as a basis for extrapolation to a few water bodies where no MECH model is available. In the regression models for reference conditions, only parameters used to define the typology of water bodies have been applied when e.g. extrapolating reference conditions for either Chl-a concentration or Eelgrass depth limits. However, most calculations are water body specific and do not force equal results across all water bodies belonging to a specific type. The new typology is fit for purpose in these contexts. The panel estimates that further elaboration of the typology is not necessary.

With respect to the comparison between the newly calculated reference and G/M boundary values with those stemming from the intercalibration, the panel takes note that the water bodies used in the intercalibrations (which were all of the same type at the time of the IC) can now belong to different types. However, this does not change the water bodies themselves, nor the variability within the set of water bodies used for the intercalibration. It remains fully possible to compare the new reference and G/M boundary values with the values obtained from the intercalibration. There is, therefore, not a problem of compatibility with the WFD guidelines.

1.4.2 Supporting quality elements and pressure-impact-response relationships

The panel is of the opinion that establishment of the environmental targets cannot be challenged with the argument that Denmark has not set reference conditions for the nutrient conditions as part of the chemical and physico-chemical elements supporting the biological elements[4]. As supporting quality element, the nutrient conditions help the indication of water bodies having a good or high ecological status. The CIS Guidance Document No. 20[5] explains this function of the supporting physico-chemical elements:

> "*The ranges and levels established for the general physico-chemical quality elements must support the achievement of the values required for the biological quality elements at good status or good potential, as relevant.*" (pg. 13)

In 1.3 (i) Annex V the WFD obliges the Member States to set water body type-specific physicochemical conditions that represent the physicochemical quality elements specified – *inter alia* the nutrient conditions – at a high ecological status. When establishing the reference conditions for the eelgrass depth limit, nitrogen concentrations were used.[6] They were found at 230 µg/l (inner waters) and 200 µg/l (outer waters). However, Denmark has not yet developed targets for concentrations of nitrogen in coastal waters as supporting quality elements. Several research projects have been performed on this issue in recent years, but there are still some unresolved issues related to boundary setting and the use of nutrient concentrations as supporting elements.

The Panel is of the opinion that it would be good to have clear boundary concentrations of nutrients, if it is feasible to validate the approach with the extensive available data base (considering nutrients have been monitored in many water bodies since many years). However, it anticipates many difficulties, as the relation is expected to depend on characteristics of the water bodies, as well as on specificities of the seasonal cycle and the correlation between nitrogen and phosphorus concentrations, light, oxygen conditions and possibly other factors. A more direct approach would be to use nitrogen and phosphorus *loading* to the systems as a specification of the 'nutrient conditions'. Extensive knowledge has been collected on the relation of this variable with the biological quality indicators in the modelling already performed. G/M and H/G boundaries can be derived from the models for nutrient loading. In addition, nutrient loading is regularly monitored for the water bodies, and the monitoring data can be used as an independent check on the (also monitored) field data of the biological quality elements. Thus a check on consistency between physico-chemical conditions and biological quality indicators is possible, fulfilling the basic requirements of the WFD.

As for developing the pressure-impact-response two-steps model between nutrient loading, nutrient concentration and biological quality elements (Chl-a and Kd), the panel notes that COWI and NIRAS themselves acknowledged that single-step relations keep uncertainty low (and are therefore advised for calculation of MAI) and that it is unlikely to change the calculated need for reduction of nitrogen load. However, COWI-NIRAS recommend a two-step approach for setting reference conditions because it will increase transparency and the level of confidence in the model results. The Panel disagrees with this view. Transparency and confidence are not increased by using different approaches for calculating MAI and reference values or by alternative methods that increase uncertainty. The Panel also fails to see what valuable additional information could be brought by the two-step approach. It would require an extensive amount of work to be established, calibrated, and validated, but is very unlikely to significantly change the required nitrogen reductions, or improve the precision of the estimate of these required reductions. The panel is of the opinion that other topics for research, in particular the portfolio of possible reduction measures and implementation details, are much more in need of research support and consequently advise against developing more research along this line.

[4] See Nr. 1.1.4 Annex V WFD.

[5] See also CIS Guidance Document No. 23, pg. 37: "*For a water body to be at good status there must be a negligible probability of such disturbances to the balance of organisms being present.*"

[6] See COWI and NIRAS, pg. 91.

1.4.3 Change of reference conditions with respect to RBMP2

A major change has been the calculation of water body specific, instead of type specific, reference conditions in RBMP3. This recalculation has confirmed that the typology used in RBMP2 to derive reference conditions was generally valid, but far off in some cases. Such misclassifications are much less probable in RBMP3. Hence, the change of strategy has been an improvement. Stakeholders questioning the validity of the modelling, based on the large differences in reference conditions in some systems, misinterpret the results. Where these large differences occur, they were mainly (or only) due to a misclassification of the water body into an unfit type, rather than to a drastic change in the model results. Note that reference conditions in RBMP2 were set at the average value of the type, not at the value calculated for the water body. The panel endorses the strategy of calculating water body specific reference and target conditions.

Across all water bodies, our own analysis does not show a systematic difference between the reference values of the water bodies in RBMP2 and in RBMP3 (Figure 1.1). The geometric-mean regression line between these values is RBMP3 = 1.36 * RBMP2 – 0.59. This regression line shows that the new estimates of reference conditions for Chl-a tend to be lower than the old ones for the open waters with low reference values, and higher for more enclosed water bodies with high reference values. Note that here and in the subsequent text, the term ‘open waters’ is used in a relative sense. Danish water bodies have a varying degree of ‘openness’, i.e. influence from Baltic waters and the nutrients contained in these waters. With ‘open waters’ those water bodies with a significant Baltic influence are denoted.

.

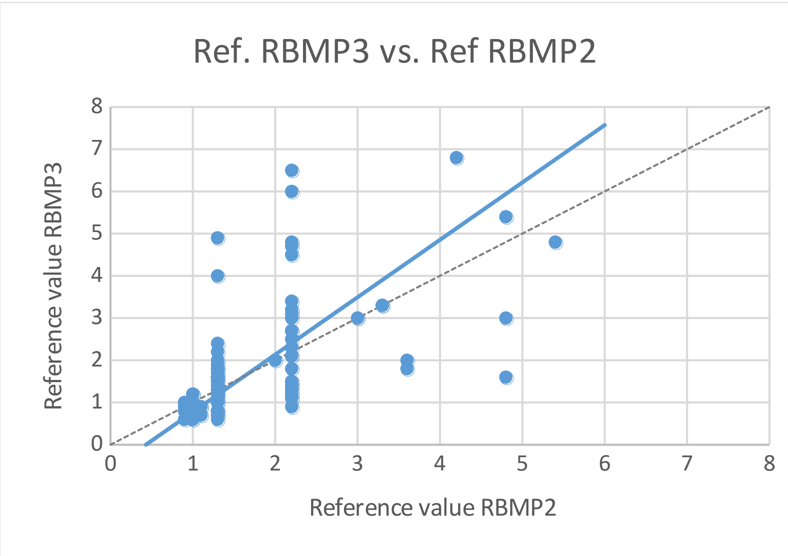

Figure 1.1 Relation between reference values for Chl-a in RBMP3 (y-axes) and reference values in RBMP2 (x-axis). Blue line: Geometric Mean Regression line between the two variables. Grey dotted line: 1:1 line. Sources: RBMP2 references: https://www.retsinformation.dk/eli/lta/2016/1001, RBMP3 references: https://www.retsinformation.dk/eli/lta/2023/792

The comparison confirms the statement by COWI that reference conditions for open waters are lower in RBMP3 than in RBMP2. However, it also shows that by taking into account the specific hydrographical conditions of the water bodies, reference values for many enclosed waters are now higher than they used to be. This trend is also confirmed in a map of differences in reference conditions, prepared by the Ministries (see Figure 1.2 next page).

A noteworthy exception to this general picture is Limfjorden and adjacent waters. In RBMP2, the reference and boundary values in these systems were estimated based on type-specific values, whereas they have been modelled in RBMP3. New water bodies have been introduced in Limfjorden for RBMP3, whereas they were pooled in RBMP2. It is also noteworthy that the blue coloured water bodies, where conditions in RBMP3 are significantly less stringent than in RBMP2, are difficult to see on the map. These are relatively small, confined water bodies with limited exchange and dilution with sea waters. The fact that estimated references are much higher in the present calculations than before, lends credibility to the new estimates, as their enclosed and low-dilution status was insufficiently resolved in the previous typology.

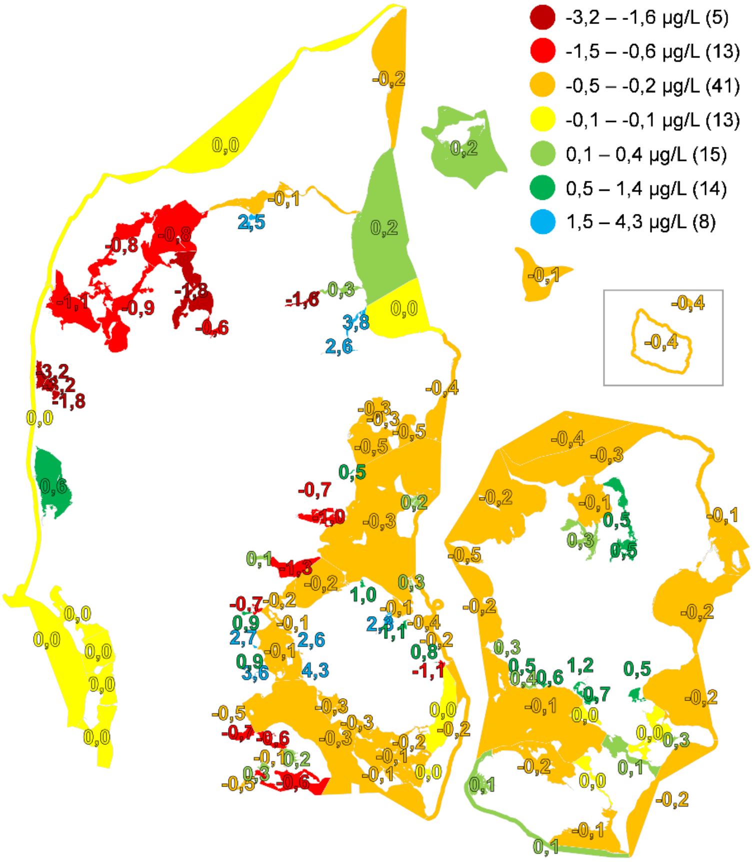

Figure 1.2. Numerical differences between the reference values for Chla between RBMP3 and RBMP2. Red colors indicate decreased reference values (more stringent), green to blue colors increased values (less stringent objectives).Sources as in Figure 1.1. Note that some water bodies are new in RBMP3, including several water bodies in Limfjorden.

1.4.4 Validity of the new reference conditions

The difference in reference conditions, especially for the open waters, cannot be explained by the update of the estimated nutrient loads for undisturbed conditions, previously projected in 1900 but now well before. Apart from the time projection, the pristine nutrient load estimates were roughly the same between the two estimates (17,000 tonnes in RBMP2 and 16,000 tonnes in RBMP3 for Danish land-based N-loads). This cannot fully explain the difference in reference conditions. The major difference in the modelling in RBMP3, compared to RBMP2, is that boundary conditions (i.e. concentration of nutrients in Baltic waters and nutrient/organic matter stocks stored in the sediments) have been adjusted to a situation where significant anthropogenic nutrient additions had not yet occurred. In consequence of these changes, fewer nutrients were advected into Danish waters and less nutrient replenishment of the water column from the sediments occurred. These changes explain the differences in Chl-a and water transparency in the open coastal waters. They had very little consequences for the enclosed water bodies, where the influence of land-based sources was dominant over that of offshore waters, even in pristine conditions.

Apart from this difference in initial and boundary conditions, the inclusion of Limfjorden and surroundings is also a difference between the two models.

1.4.5 Consistency between the new reference conditions and the Intercalibration

In what follows the Panel concentrates on changes in the reference conditions for Chl-a. Reference conditions for eelgrass depth limit have changed between RBPM2 and RBMP3 due to a change from a type-based to a regression-based approach, but in both cases the same historical observations were at the basis. For the water bodies where intercalibration was performed, only limited changes are observed between the two plans (see Table 1.1).

The lowering of the reference conditions for open waters poses a problem of compatibility with the intercalibrated boundary values in the European Commission´s intercalibration decision from 2018.[7] The procedure by which the RBMP3 boundary values for the G/M boundary were set was to keep the EQR from the intercalibration and apply

[7] Commission Decision (EU) 2018/229 (ABl. L 47/1).

it to the revised reference conditions. These were, in general, lower than the reference conditions used during the intercalibration. Table 1.1 below compares the RBMP3 G/M boundaries, calculated as the average value over the water bodies that had been used in the intercalibration. This comparison shows no differences for the North Sea water bodies, where the models have not changed between the two RBMPs, but a significant lowering of the boundary values in the Baltic open waters. No intercalibration has taken place for inner fjords and waters with higher G/M boundaries, as none of these are of types are shared with another country. However, it is not expected that the model changes have impacted the G/M boundaries of these enclosed waters.

Table 1.1 Overview of intercalibration GIGs and G/M-boundaries and corresponding EQR-values in parenthesis, shown for the Danish RBMP2 and 3 and for Commission Decision from 2018, and compared to relevant HELCOM targets for neighbouring open waters.

Intercalibration GIG	Description (And number of RBMP3 water bodies included in calculated average G/M boundary, based on table 1)	HELCOM targets	RBMP2 (2015-2021): applied avg. numeric G/M-boundary in IC water bodies (G/M EQR value)	Commission Decision on IC from 2018 (G/M EQR value)	RBMP3 (2021-2027) applied avg. numeric G/M-boundary in IC water bodies (G/M EQR value)
Chlorophyll-a concentration					
NEA8b (Sweden, Kattegat, Great Belt) (IC from 2016) average May-Sep	Inner Danish waters (Number of WB in IC: 7)	Kattegat **1.5 µg/l** Great Belt **1.7µg/l**	**1.6 µg/L** (0.6)	**1.58 µg/L** (0.64)	**1.31 µg/L** (0.64)
BC8 (Germany) (Baltic IC from 2013) average May-Sep	Belt Sea, south part of Funen (Number of WB in IC: 6)	Mecklenburg Bay **1.8 µg/l** Kiel Bight **2.0 µg/l**	**1.5 µg/L** (0.6)	**1.9 µg/l*** (0.60)	**1.38 µg/L** (0.60)
BC6 (Sweden) (IC from 2016) average May-Sep	Baltic Sea area west of Zealand (Number of WB in IC: 4)	Arkona Basin **1.8 µg/l** Bornholm Basin **1.6 µg/l**	**1.7 µg/L** (0.6)	**1.72 µg/L** (0.62)	**1.23 µg/L** (0.62)
NEA1/26c (Germany) (North Sea IC from 2013) 90 percentile March-Sep	The Wadden Sea (Number of WB in IC: 4)		**7.5 µg/L** (0.44)	**7.5 µg/L** (0.44)	**7.5 µg/L** (0.44)
NEA8b (Sweden, The Sound) (IC from 2016) average May-Sep	The Sound (Number of WB in IC: 1)	The Sound **1.2 µg/l**	**1.7 µg/L** (0.6)	**1.63 µg/L** (0.59)	**1.5 µg/L** (0.59)
NEA1/26d (Denmark) (North Sea IC from 2013) 90 percentile March-Sep	Skagerak (Number of WB in IC: 1)		**4.0 µg/L** (0.50)	**4.0 µg/L**** (0.50)	**4.0 µg/L** (0.50)
Macroalgae and angiosperms (Eelgrass depth limit)					
NEA8b (No source)	Inner Danish waters (Number of WB in IC: 7)		**9.0 m** (0.74)	- (0.74)	**8.19 m** (0.74)
BC8 (Germany) (Baltic IC from 2013)	Belt Sea, South part of Funen (Number of WB in IC: 8)		**7.0 m** (0.74)	**7.0 m** (0.74)	**7.45 m** (0.74)
BC6 (Sweden) (No source)	Baltic Sea area west of Zealand (Number of WB in IC: 4)		**8.1 m** (0.74)	- (0.74)	**7.13 m** (0.74)

Note: *According to the BC8 IC-document from 2013, the G/M-boundary was set to 1.9 µg/L for the Common Metric used for the intercalibration for BC8. This value was not presented in the Commission Decisions from 2013 and 2018. Only the corresponding EQR-value of 0.6 to the G/M-boundary is presented in the Commission Decisions.
**Skagerak was intercalibrated in 2013, but did not appear in the Commission decision from 2013.
Source: Individual intercalibration reports are shown with hyperlinks in the leftmost column.
Phase II (2013) intercalibration: decision: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013D0480&from=DA.
Phase III (2018) intercalibration decision: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018D0229&from=DA.
DK decision on class boundaries for RBMP2 2015-2021: https://www.retsinformation.dk/eli/lta/2014/1399
DK decision on class boundaries for RBMP2 2021-2027: https://www.retsinformation.dk/eli/lta/2023/792
HELCOM targets are for offshore sub-basins that are not exactly mapping to the intercalibration regions. That is why there are two basins in some cases. Formal reference to the HELCOM decision is HELCOM Head of delegation meeting 39-2012, document 2/7/rev.1. Values can also be found in: HELCOM Chlorophyll core indicator report, 2023, https://indicators.helcom.fi/indicator/chlorophyll/

Although the difference between the new and the intercalibrated G/M boundary values seem small in absolute values, the importance of these differences should not be underestimated. In open coastal water bodies, the water quality is to a large extent determined by the quality of the offshore water because of large coast-offshore exchange. In these cases, if offshore concentrations are above the G/M target values, there is no way to reach the Good Ecological Status by changing Danish land-based inputs into the coastal water body.

The ecological status of coastal water bodies – and thereby the status of biological quality elements (BQEs) – is to be expressed as ecological quality ratios (EQRs).[8] The WFD requires the Member States to establish the boundaries between the high/good status and between the good/moderate statuses in an intercalibration exercise.[9] The results of the intercalibration exercise and the values established for the Member State monitoring system classifications are to be adopted using a Commission decision.[10] The boundaries for the EQRs included in the Commission Decision 2018/229 are to be applied by the Member States when classifying the ecological status of water bodies:

> "*For the purposes of Section 1.4.1(iii) of Annex V to Directive 2000/60/EC, Member States shall use in their monitoring systems classification the values of the boundaries between classes that are set out in Part 1 of the Annex to this Decision.*" (Art. 4 par. 1 EC Decision 2018/229)"

By that provision the European Commission binds the Member States to the boundaries set in the intercalibration process. Therefore, the Member States cannot change the scientific basics that have an influence on the intercalibrated boundaries between the high/good status and between the good/moderate status. Such changes – and in result the changed boundaries – can only be implemented by the Member States if the European Commission amends the Decision 2018/229 accordingly.

It was argued by the researchers behind the revised RBMP3 in their contact with the Panel, that not the boundary values, but the EQR values, are the most important numbers fixed by the intercalibration decision. In that case, when reference conditions are recalculated, G/M boundary values would automatically be adjusted while EQR values remain constant. The Panel disagrees with this view, because the numeric G/M boundary values for the BQE-indicators are crucial as a basis for the systems classification. The Panel 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.

In any case, the reference conditions for the Biological Quality Elements eelgrass depth limit and Chl-a concentration are basics that have an influence on boundaries between the high/good status and between the good/moderate status. With the dependency of the intercalibration process on the used reference conditions, it cannot be ruled out that changes on the foundation will lead to different status boundaries values as stated in the European Commission Decision 2018/229. Thus, due to the binding effect of the boundaries between the high/good status and between the good/moderate status set in the European Commission Decision 2018/229 for the quality elements Phytoplanktion (Chl-a) and Macroalgae and Angiosperms (depth limit of eelgrass), Denmark has to ensure that a change of reference conditions in RBMP3 is coherent with the provisions on intercalibration in WFD and CIS.[11]

The normative definitions of the High, Good, Moderate and other quality classes have been phrased in terms of the deviation from the reference conditions, with qualitative descriptions like 'deviate only slightly' etc.[12] It can be argued that by improving the estimation of the reference conditions and adjusting them to generally lower concentrations, the new research has shown that the intercalibrated G/M boundary concentrations in actual fact differ more, and probably too much, from the reference conditions and should therefore be adjusted. However, as the normative definitions are put in qualitative terms only (what is exactly a 'slight deviation' is not quantified), it can equally be argued that the new research has shown that conditions, previously estimated to represent good to moderate ecological conditions, deviate slightly more from reference conditions than previously thought. The new research therefore has shed more light on what a 'slight deviation' means in quantitative terms.

This argument is strengthened by the observation that the modelling studies for RBMP3 do not provide a single argument why the G/M boundary values as used in RBMP2 and as settled in the intercalibration, would be inappropriate. The lowering was a rather technical exercise and not the result of new considerations concerning the good/moderate transition boundary. This boundary was originally based on expert judgment that assessed that concentrations in the mid of the twentieth century were still representative of acceptable ecological conditions.[13]

---

[8] See 1.4 (ii) Annex V WFD.

[9] See 1.4 (iii) Annex V.

[10] See 1.4 (ix) Annex V.

[11] 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).

[12] See 1.2 Annex V WFD.

[13] Carstensen, J. and P. Henriksen, 2009. Phytoplankton biomass response to nitrogen inputs: a method for WFD boundary setting applied to Danish coastal waters. Hydrobiologia 633:137–149. DOI 10.1007/s10750-009-9867-9. We refer here to a published, source which was not available at the time of the intercalibration. The intercalibration refers to Carstensen et al. (2008) http://www.dmu.dk/Pub/FR683.pdf - but the values used are the same.

The Panel is of the opinion that this judgment is still valid, and moreover is supported by many similar judgments in the RBMPs of neighbouring countries as well as in estimations by HELCOM. Therefore, the Panel concludes that the new research on reference conditions has improved our quantitative insight in what constitutes an acceptable deviation between reference conditions and G/M boundary conditions, but should not lead to a re-estimation of the Chl-a concentrations at the G/M boundary.

Given the narrow range between the intercalibrated G/M boundary values and (current and foreseen) concentrations of Chl-a in open Baltic waters, the Panel is of the opinion that lowering the G/M boundary below the intercalibrated value is creating disproportionate problems and too many situations where land-based measures are not capable of reaching Good Ecological Status. Therefore, the Panel advises to recalibrate the G/M boundary values for Chl-a concentrations to the level established during the intercalibration. Such recalibration is needed for the open water bodies with low G/M boundary values, but should taper out for the inner water bodies, for which no intercalibrated results are available but also no need is apparent for changing the G/M boundary values calculated in RBMP3.

More detailed analysis is needed of an appropriate method to rescale the reference conditions to the values from the intercalibration. The Panel refrains from prescribing details about the approach. The problem is complicated by the fact that intercalibrated boundary values are only available for a subset of water bodies, and not for all relevant water bodies in open waters, whereas appropriate and consistent G/M boundary values are needed for all these water bodies. A first rough estimate is that an increase by approximately 50-70 per cent is needed for the lowest estimated G/M boundaries of approximately 1 µg/l, decreasing to zero increase from a G/M boundary of 2-2.5 µg/l onwards. Such a rescaling would satisfy the condition of correspondence with the intercalibration. It would raise the G/M boundary for Chl-a concentration in Bornholm from an unattainable 1 µg/l to a value in the range of 1.6-1.7 µg/l, which corresponds to the HELCOM goals for the Bornholm Basin in the Baltic (Table 1.1), but is still below the current value of 2.2 µg/l. It can be seen in Table 1.1 that the intercalibrated G/M boundary value is similar to the value for adjacent HELCOM open waters. This may still be problematic, as it leaves little room for addition of nutrients from the coast, but it is far less problematic than a G/M boundary value significantly below the HELCOM target, as was proposed in RBMP3.

The Panel notes that the proposed adjustments, which are concentrated on open water because it is there that changes in boundary and initial conditions affect the revision of reference conditions, would result in slightly different EQR values between inner and open waters. This is not a problem in itself, as EQRs must be constant within water body types, but should not necessarily be the same across all water bodies in a country.

1.4.6 Technical remarks on reference nutrient loads

In a reaction to the COWI/NIRAS report, DCE/AU remarked that the TN concentrations in ‘pristine’ rivers had been underestimated due to an analytical error in concentration determinations. The underestimation is 13.5 per cent, as published by Larsen et al. (2020)[14]. Possible consequences of this change in estimated nutrient loads to the calculation of reference conditions were discussed in a note of the DTU/AU/DHI researchers to the Ministry of Environment in 2023.[15] In this note, the researchers do not dispute the technical arguments leading to the update. They evaluate in general terms the possible effects on calculated need for reduction of N-loads. They point out that the difference between current loads and reference loads is large (on average a difference between 5.5 mg/l N and 1 mg/l N) and that consequently a change of 10 per cent in the lower number (1 mg/l N) does not change this difference very much when expressed as a difference relative to the current load (from 82 per cent of the current load to 79 per cent of the current load). They further point out that the change does not affect other sources of nitrogen in the reference situation, such as atmospheric load and load from external waters. Overall, they conclude that the effects on the estimation of the need for reduction of nitrogen loads will be small, in the order of a few per cent.

The Panel notes that the scientific knowledge on the revised estimates became available only after the extensive work in calculating reference conditions, scenarios, MAIs etc. was finished. Updating these calculations would require big investments in money and time. They should only be performed if the flaw is expected to have significant effects on the result. While some effects are expected, these are too small to warrant the efforts and especially the delay that would entail.

The Panel advises to incorporate all new scientific insights and close scrutiny of data into updates of the plans in later phases, but to do that in an ordered way. Building consensus on the quality and consistency of the data bases underlying such new calculations is an important prerequisite that should receive sufficient attention before any

[14] Larsen, SE, Tornbjerg, H. & Kronvang, B. 2022. Development of a correction formula for nitrogen concentrations analyzed in natural streams in the period 2009-2015. Aarhus University, DCE – National Center for Environment and Energy, 19 pp. – Academic note no. 2022|64

[15] Aarhus University, note of 14. april 2023 - Konsekvensvurdering af korrigerede TN-målinger i naturvandløb https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Notater_2023/N2023_17.pdf. The Panel used a Google translated version of this file

revision of calculations and conclusions are prepared in such a next phase. Once the data base is established, it should remain fixed for the duration of the RBMP phase – any new insights being accumulated into a next revision.

1.4.7 The year 1900 discussion and consistency between reference conditions

It was stated before that the reference conditions used in RBMP3 were calculated using approximately the same nutrient loading as the calculations in RBMP2. However, whereas these calculations in RBMP2 were projected onto the year 1900, this is no longer the case. Updated estimates of the nitrogen load in 1900 suggest that it was much higher than pristine conditions[2], although it appeared from interviews by the Panel that this estimate is not supported by all scientists active in the area. This is another example illustrating the need for consensus building on underlying data and models before performing extensive calculations on scenarios.

In any case, the updated estimate raises a problem of consistency between reference values for Chl-a (situated well before 1900) and for Kd/eelgrass depth limit, derived from observations around 1900. The question arises whether the reference values, derived from the observations of eelgrass depth limit, are sufficiently close to the almost-undisturbed conditions that define a reference condition. It has been argued by the researchers that this is the case.

The evidence is based on two lines of reasoning. One is based on model results. It is shown that the predicted eelgrass depth limits based on light conditions from modelling of Chl-a references is quite close to the observed depth limits in the 1900 eelgrass data base. This correspondence is illustrated in Figure 1.3 provided by DTU/AU/DHI researchers at the request of the Panel.

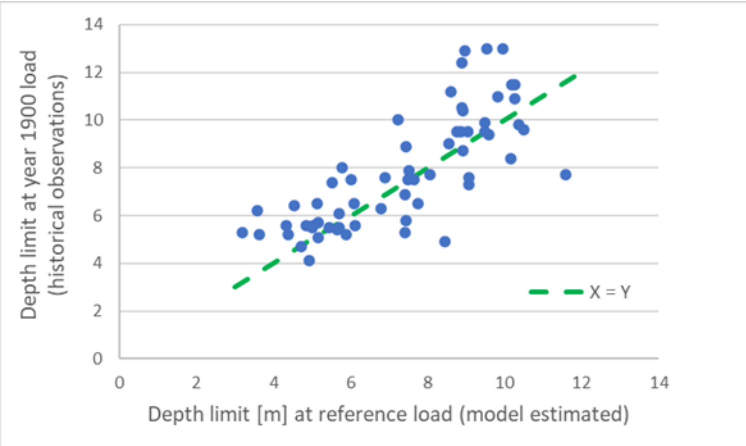

Figure 1.3. Comparison between historical observed depth limit of eelgrass (y-axis) and model-calculated depth limit of eelgrass at reference N load (x-axis). The green line is the 1:1 line.

From this calculation it can be concluded that, if eelgrass reference conditions would have been calculated from the model in the same way as for Chl-a, these reference conditions would have been of a similar value than the observed values in the years 1900. There may be some circularity in this reasoning, if the modellers would have used these same observations to tune their parameters. The Panel was told that this was not the case, as calibration has only been made on recent data, in the same way as for Chl-a.

One could have chosen to calculate reference conditions for eelgrass depth limit in exactly the same way as was done for Chl-a, for reasons of consistency in the procedure as a whole. The comparison in Figure 1.3 shows that in that case, the model-based reference conditions would not have been very different from the ones observed around 1900 and used in the current procedure. This demonstrates to the Panel that the reference conditions used in RBMP3 are mutually consistent. One can wonder why, in this condition, the choice has been made to use the observed values. However, in comparison to model-based estimates observed values have lower uncertainty, better representation of non-modelled water body specific factors and higher credibility. Because of these additional advantages, and because it has been demonstrated that the general level of the depth limit is consistent with a model-based estimation, the Panel endorses the use of historical observations.

It cannot be left unmentioned, however, that a scientific problem still remains. If nitrogen loading in 1900, at the time of the eelgrass observations, was indeed as high as currently estimated, why did the eelgrass not show a response in its depth distribution? There seem to be two possible solutions. Either the real nitrogen loading was lower than the estimate and closer to the reference conditions, or eelgrass has shown considerable resilience against this initial increase of nitrogen loading.

The Panel has insufficient information to enter into a discussion on the 1900 nitrogen loading estimate, but it can comment on eelgrass resilience. It is well known that eelgrass has a retarded reaction to environmental conditions. Eelgrass meadows, once established, exert a profound influence on the environment. The eelgrass fixes fine sediment and prevents its resuspension. It blocks bioturbating animals, e.g. lugworms, from developing and destabilising sediments (see Maxwell et al., 2017[16] for an extensive scientific review). Seagrass meadows also take up large amounts of nutrients and store them into organic matter with a long residence time in the system, thus preventing the fast nutrient recycling typical of phytoplankton-dominated systems. At least qualitatively, all these observations lead to the conclusion that it is likely that seagrass meadow extent did not react rapidly to increasing eutrophication. However, the validity of this argument depends on how long the reconstructed 1900 conditions for nitrogen loading had already been in place before the year 1900. Eutrophication effects tend to accumulate in time and there is a limit to the resilience of eelgrass meadows to these accumulating effects.

The flip side of the reasoning on eelgrass resilience is that it cannot be expected that eelgrass depth limit will rapidly increase when nutrient loading decreases. Due to the positive feedbacks between eelgrass presence and environmental conditions favouring eelgrass, establishing new meadows at larger depth is a slow and difficult process. Time lags are caused by the factors mentioned above: the presence of large pools of resuspendible sediment, presence of bioturbating organisms, rapid turnover of nutrients and uptake of all nutrients by phytoplankton. Delays in this biological indicator are therefore expected. This is a disadvantage because it will probably not confirm immediately that conditions of nutrient loading have improved. However, it is an advantage in the sense that it is a longer-term indicator of improvement that is partially independent from the (more rapidly adjusting) Chl-a indicator.

In conclusion, the Panel does not expect that the historical observations of eelgrass depth limit were strongly biased relative to Chl-a reference conditions. The advantage of using historical observations is that the reference conditions are independent of the models used, which lends strength to these values. To the degree that conditions around 1900 were already deteriorated for eelgrass, the reference conditions based on the observations could be slightly more lenient than the reference conditions for Chl-a. However, it will take longer for eelgrass depth limit to adjust to improved eutrophication conditions, which makes the eelgrass depth limit a more stringent indicator than Chl-a. The delayed response of eelgrass depth limit therefore works in both directions, but it is clear that inclusion of eelgrass depth limit, besides summer Chl-a, is a valuable addition to the estimation of ecological status in Danish coastal waters.

At a more general level, the Panel reiterates that building consensus estimates on such important variables as historical nitrogen loading, as well as data quality and representativeness, has to be explicitly incorporated into the workflow when a revision of the River Basin Management Plan is considered.

1.4.8. Validity of keeping two Biological Quality Element indicators

The international panel evaluation of RBMP2 in 2017 made a number of critical remarks concerning the use of eelgrass depth limit as an indicator. The criticism was mostly based on the retarded reaction of this indicator to changes in water quality. It was recommended to critically re-appraise this indicator.

In RBMP3, the indicator has been extended to include more species. This solves problems where, e.g., *Ruppia* rather than *Zostera* is the dominant angiosperm. Also, the use of this (extended) indicator has been formally approved by the European Commission. This approval confirms that the use of the depth limit is assumed to implicitly represent angiosperm biomass density or cover sufficiently well to serve as an indicator. The Panel endorses that view.

Scientifically, the Panel has been convinced of the added value of the rooted angiosperm depth limit on several grounds. The indicator has been shown to react to eutrophication. The response may show delays that explain poor dose-response relations at the short time scales, but there is added value in an indicator that summarises accumulating effects of eutrophication. Furthermore, it has been pointed out that the summer Chl-a indicator may not capture changes earlier in the season equally well as rooted angiosperm depth limit, as the latter integrates responses over the entire season. This indicator may also be sensitive to changes in epiphytes and *Ulva*, which may proliferate if top-down control by benthic grazers (e.g. mussels or clams) suppress Chl-a in the water column.

Reviewing these scientific arguments, the Panel endorses the use of both Chl-a and rooted angiosperm depth limit as indicators of eutrophication.

[16] *Biol. Rev.* (2017), 92, pp. 1521–1538. doi: 10.1111/brv.12294

1.5 Conclusions and recommendations

In this chapter, the Panel concluded that:

- The new typology in RBMP3 is fit for purpose. Further refining or calibrating this typology is not deemed to be of high priority, also in view of the limited role left for typology in the present implementation of the WFD.
- Development of pressure-impact-response models, consisting of two steps (loading-nutrient concentration and concentration-effect on BQE) would constitute a considerable amount of scientific work, is unlikely to change conclusions with respect to nitrogen reduction, will increase uncertainty, and risks leading to contradictory results with the present plan. The Panel does not see the need for such a development.
- 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. In general, reference conditions have been lowered in open water, 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 been lowered significantly 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. Hence, 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.
- No signs of large inconsistency can be found between the time frame for reference conditions of Chl-a (undetermined) and Eelgrass (1900, based on observations). Eelgrass reference conditions would have been similar to historical observations if they would have been model-derived as was the case for Chl-a. Eelgrass reacts slowly to environmental changes and can be expected to have been in reasonably undisturbed state at the time of the observations. Nevertheless, a scientific problem remains with the interpretation of reconstructed nitrogen loading in 1900.
- The Panel detects several examples where scientific discussion on data quality and reconstruction of historical conditions has remained unsolved. A recent revision of the nitrogen concentration in pristine rivers is not expected to be so important as to warrant recalculation of all model results. However, in a future revision or update of the RBMP, building scientific consensus on all underlying data is recommended to be explicitly incorporated into the workflow.

This gives rise to the following recommendations:

- Further elaborate on the development of boundary values for nutrient concentrations, in order to be fully compliant with instructions on physico-chemical supporting quality elements for nutrient concentrations. However, in the meantime, rely on nutrient loading as a supportive element that sufficiently supports conclusions from the biological indicators. In terms of regulation of nutrients, the panel endorses the focus on annual N-loads as a basis for calculation of MAI and thus as a foundation of the management. Efforts to also develop boundary values for nutrient concentrations should not replace the currently applied methodology for MAI estimation.
- Do not further elaborate the models on the nutrient loading – indicator response. These models are deemed fit for purpose (see also Ch. 2).
- Recalibrate the G/M boundary values for Chl-a to the intercalibrated values as well as possible. In particular, undo the lowering of the G/M boundary values in the Danish open waters.
- Do not further elaborate models and approaches on reference conditions, both for Chl-a (model-based) and eelgrass (observation-based), as the two sets can be considered to be sufficiently consistent for application.
- In future updates or revisions of the RBMPs, pay sufficient attention to building scientific consensus on the quality and meaning of all underlying data and models.

CHAPTER 2: MARINE MODELS AND THEIR USE IN SETTING MAXIMUM ALLOWABLE INPUT

2.1 Introduction to the theme

This chapter assesses the modelling and calculations that relate the ecological status of a water body, specified by the indicators summer Chl-a and Kd (as proxy for eelgrass depth limit), to the magnitude of nutrient inputs. The model results and certain subsequent adjustment are used to determine maximum allowable inputs (MAI) to reach Good Ecological Status. A comprehensive documentation on the models and the methodology used to determine MAIs and the improvements since RBMP2 is available[17]. The model calculations involve a number of steps:

- In (almost) every water body, the ecological indicators (i.e. Chl-a and Kd as a proxy for eelgrass) and their relation to nutrient loads (so called slopes) are modelled with a mechanistic model and in some water bodies also with a statistical model.
- With the mechanistic model, additional relations (slopes) between the ecological indicators (Chl-a and Kd, respectively) in the water bodies and changes in nitrogen or phosphorus loads from other sources are explored further (e.g. one slope is derived for Chl-a's response to change of the atmospheric nitrogen deposition, another for Chl-a's response to change of the nitrogen load from other countries than Denmark, and another for the Kd's response to change phosphorus load from other countries than Denmark and so on).
- An algebraic "surrogate" model is developed that combines the derived slopes into a single equation so that the indicator value can be computed directly from a set of loads in the categories: Danish N-loads, Danish P-loads, atmospheric deposition of N, other countries' N-loads and other countries' P-loads. The equation can also be inverted to calculate the Danish N-loads for a given indicator value, and combination of other loads. Inserting the Good/moderate (G/M) ecological status boundary value for the indicator provides the N-MAI for a given set of other loads (management scenario).
- There can be at most four N-MAIs for a given management scenario and water body, i.e., one for Chl-a and Kd, respectively, for each of the statistic (STAT) and mechanistic (MECH) model estimates of the Danish N-load slope. Final N-MAI is computed as the average of the model-specific N-MAIs available for each water body.
- Finally, the need for reduction of nitrogen (NFR) is calculated as the difference between Baseline 2027 loads and N-MAI. Also, an averaging procedure is applied in chained water bodies that obviously to a large extent experience similar pressure from the local loads, and the NFR is distributed equally per area of agricultural land in the combined catchment of the chained water bodies.

For certain water bodies subsequent ad-hoc adjustments of MAIs from the management scenarios are needed to correct the scenario to be in line with assumptions in the RBMPs (e.g. including correction of catchment specific phosphorus load and reductions from the baseline effect in the MAIs) or correcting for Danish N-MAI which are considered too close to background levels.

The methodology to calculate N-MAI has evolved substantially between RBMP2 and RBMP3. The main changes are:

- Improved methodology in the STAT model
- STAT model evaluation on individual water body level
- MECH model implementations cover (almost) all water bodies and are extensively validated in all water bodies with available observations
- N-MAI are now computed directly for all water bodies which makes the use of typology for extrapolation obsolete
- The surrogate model for N-MAI allows to readily evaluate scenarios that also include P reductions from both Danish and other countries' sources
- A wide range of elaborate management scenarios has been applied that provides the impact on N-MAI of different regional and EU policies
- The previously existing averaging of MECH and STAT results at intermediate steps is removed. Averaging is now performed at the very last stage, i.e., a final average N-MAI is computed only when the specific N-MAIs have been computed for the two indicators with slopes from both MECH and STAT models

[17] Erichsen, A.C., Timmermann, K. & Christensen, J.P.A. 2023. Second opinion readers guide to RBMP 3 models and scenarios in Denmark. Aarhus University, DCE – Danish Centre for Environment and Energy, 31 pp. Technical Report No. 268 http://dce2.au.dk/pub/TR268.pdf

2.2 Results from Phase I

2.2.1 Central findings by COWI and NIRAS concerning the models and their application.

In their thorough review of the marine models, COWI and NIRAS conclude that the MECH model performance is satisfactory, and implementation is state-of-the-art, while they had a number of critical remarks on the STAT model. From that evaluation, it was judged that the MECH model is of higher scientific credibility than the STAT model. This conclusion is primarily based on the conclusion that the STAT model includes less information and less knowledge of the functionality or causal relations of the ecosystem than the MECH model. Based on these observations, COWI and NIRAS suggest that the STAT model should be applied only as supporting tool to the MECH model.

COWI and NIRAS suggest further improvement of the STAT model while they argue that the MECH model is probably close to its optimal intrinsic complexity and therefore additional processes may even reduce accuracy.

The suggestions by COWI and NIRAS on improvement of the STAT model are related to a wish to include more explicit causal relations by adding or removing some of the driving parameters. The primary causalities or processes that are suggested to potentially include are a representation of internal sources and sinks of N and P and a representation of exchange with adjacent water bodies. Of these two, it is argued that water exchange, and its related nutrient transport from adjacent water bodies, is of particular importance. Therefore, some explicit formulation that quantifies nutrient import should be included, e.g. using Knudsen relations or residence times. Having no parameters in the STAT model representing nutrient imports from adjacent water bodies may lead to major overestimation of the importance of land-based loads.

COWI and NIRAS observe that there are large differences in pressure-impact relationships (slopes) for specific water bodies between the MECH and STAT models. Their interpretation is that STAT underestimates slopes in some water bodies with high local load impact and overestimate slopes in water bodies with small local impact. They suggest that a possible reason is that STAT model is only calibrated to local loads and other changes (loads elsewhere) covarying with local loads will be interpreted as local load influence by the statistics. COWI and NIRAS advice to carry out deeper analysis into cases with large differences to avoid averaging good and bad results.

COWI and NIRAS welcome the improvements in the methodology to calculate N-MAI. For example, also effects from reductions of P-loads are explicitly included and long-term positive effects are managed in the refined approach. Overall, it is assessed that the methodology is scientifically valid and represents an optimal concept on the existing basis.

Despite this conclusion, COWI and NIRAS criticise the averaging procedure of the MAIs: “all four basic values are included at an equal level is not a ‘safe way’ of action”, primarily because it is not demonstrated that the models are of equal quality. However, it is noted that averaging MAIs does not violate the one-out-all-out principle since that principle applies only to the actual Good Ecological Status evaluation based on marine monitoring of status indicators. In addition, it was concluded that targeting the G/M boundary, when estimating the need for reduction of nitrogen, implies that 50% of coastal waters will not reach Good Ecological Status due to statistical uncertainty in calculations.

2.2.2 Central remarks by stakeholders concerning the models and their application

Several stakeholders question the quality and usefulness of the marine models. Concerning the MECH model, the stakeholders are primarily concerned with the low Spearman rank correlation between observations and simulations of Chl-a and Kd. For the STAT model, concerns are primary focused on whether the correlation between N-load and Chl-a/Kd is representative of the real impact from local load, or if, at least in some cases, the true impact originates from loads from larger regions/other countries.

Stakeholders ask in general for the Panel’s opinion on the usefulness of the models in the current application, if they are the best available, and about the potential of making even better models. More specifically, whether the models have sufficiently high accuracy and precision to be used to calculate N-MAI for regulation or if they rather should be used to provide supportive and indicative information.

Stakeholders are concerned with the differences in the pressure-impact relationships between MECH and STAT models presented in COWI and NIRAS, and the potential impact of these differences on the final results.

A series of concerns are expressed on the level of uncertainty in N-MAI and related to that, whether and to what degree N-MAI represents the loads that will ensure Good Ecological Status or if it only ensures that the G/M boundary is reached on average. In addition, what does it imply that the N-MAI places the goal centred on G/M boundary.

2.3 Selected focus by the panel in the evaluation of the theme

We highlight here the quality assurance aspects of the marine models as their results constitute the foundation of the N-MAI calculation scheme. Model performance has been a major concern both in COWI and NIRAS and among stakeholders. We cover further each individual step of calculations until the final 'need for reduction of nitrogen' product, with some focus on the methodology to calculate N-MAI under given scenarios of loads from other countries with what we call the surrogate mode. We evaluate the choice to use averaging to aggregate the N-MAI for the two indicators and the two models. We pay significant attention to cases where the N-MAI calculations, for one reason or another, fails to provide a useful result for a water body.

2.4 Discussion of issues within the evaluation theme

2.4.1 General modelling strategy

The Panel is impressed by the progress made in developing the modelling scheme that produced a country-wide distribution of water body specific need for reduction of nitrogen (NFR) that represents the minimal effort required to achieve Good Ecological Status across Danish coastal waters. The evolution from the previous management cycle is remarkable. The extrapolation across water bodies in RBMP2 using a coarse typology caused inconsistencies in nutrient reduction demand for especially fjords and enclosed water bodies, and we can now see that the huge investment in time and effort to make the N-MAI calculation framework water body specific has paid off in RBMP3. Resulting demands with respect to need for reduction (NFR) of nitrogen (see Figure 2.1 below) appears to be qualitatively and quantitatively consistent with the spatial distributions of both eutrophication problems as well as catchments with high proportion of anthropogenic nutrient inputs.

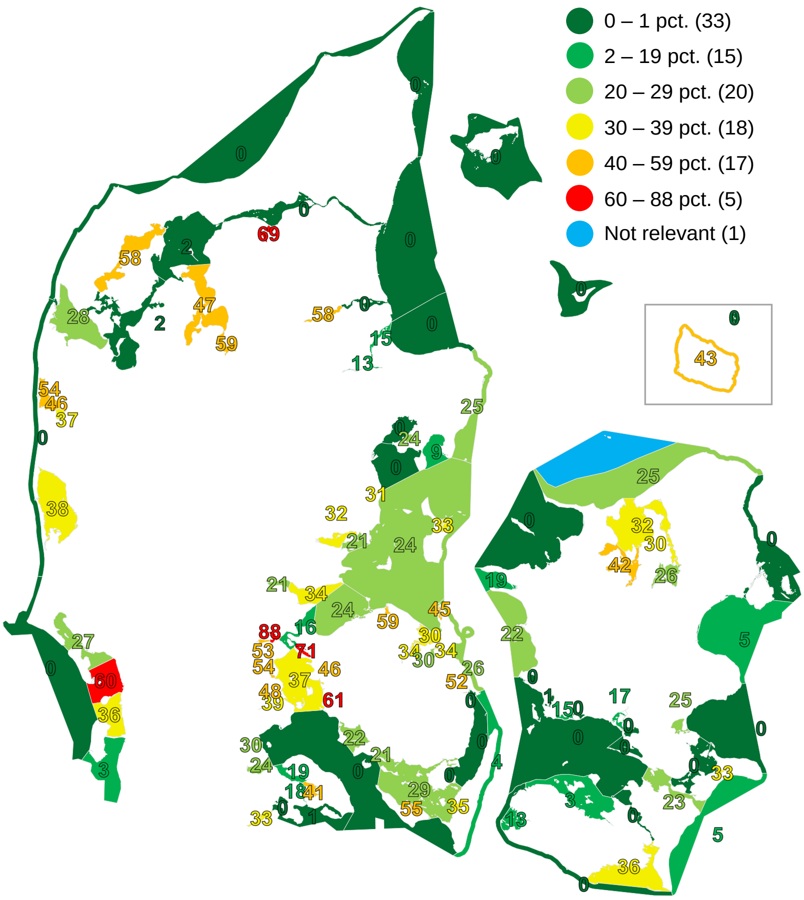

Figure 2.1: The final product of the computations is the distributed need for reduction of nitrogen (NFR) per water body[18]. The colour scheme and numbers in the map illustrates the magnitude of NFR expressed in per cent of Baseline 2027 loads, i.e. the figure shows the remaining reduction requirement that needs to be addressed with new measures. Note that the blue area represents the water body (ID205) that surrounds the small island Hesselø which is not included in the calculations of the need for reduction in RBMP3.

[18] Calculations based on data in: Miljøministeriet (2023). Vandområdeplanerne 2021-2027 (3rd RBMP). https://mim.dk/media/235166/vandomraadeplanerne-2021-2027-5-7-2023.pdf

The water body specific approach also simplifies identification, and subsequent complementary analysis, of cases where the N-MAI general calculation approach fails and an alternate approach needs to be taken to establish the scale of necessary measures to implement.

Several other aspects have also been successfully developed and implemented. The STAT modelling approach has been revised and is now solidly based on a coherent Bayesian approach. The models have been further refined and several regional applications of the MECH model were implemented. Explicit inclusion of methodology to handle phosphorus load reductions is also an important development.

In summary, the current approach to estimate and distribute the effort required to reach Good Ecological Status in coastal waters is now quite mature and provides decision support on a level of detail and quality that, to our knowledge, is not available in any other country.

2.4.2 The models' reliability and quality

The mechanistic modelling is performed using the mature DHI modelling system built from well-proven formulations and parametrisations that are used in models worldwide. The mechanistic model results are extensively and quantitatively validated against all available water column time-series in the Danish monitoring program as described in a series of reports by DHI[19]. The performance of the hydrodynamic model is classified as very good to excellent according to the statistical validation metrics, and even in complex areas like for example Limfjorden both mean spatial distributions as well as temporal variations at single stations of salinity and temperature are very well captured. Therefore, it can be trusted that the hydrodynamic model provides an accurate physical environment for the biogeochemical sub model. Spatial variations of nutrient concentrations and, in most cases also, temporal variability at single stations is also well captured but not to the same degree as salinity and temperature.

Single station time-series comparisons of the indicator variables, Chl-a and Kd, show qualitatively that seasonality is reasonably well captured, but correlation statistics of time-series are in general indicating poor performance. The reason for this is that a large part of the variability of e.g. Chl-a in nature (and hence in observations) is not resolved by the spatiotemporal resolution or by the simplified process representation in the model. However, the levels of the Chl-a concentrations and Kd across all modelled systems of quite variable degree of eutrophication are very well captured. At the seasonal scale, where the indicators are used (the Chl-a indicator is a summer average, and so is Kd) correspondence with data is much better than at the instantaneous scale. Finally, we have assessed that the model parameterisations are sound and since hydrodynamics and hydrochemistry perform well on all scales, it is reasonable to expect that the response of the Chl-a and Kd to changes in nutrient loading are relatively accurate.

It is well documented in the scientific literature that there are good arguments for a link between nutrient inputs and Chl-a/Kd, both in general and specifically in Danish waters[20]. Summer Chl-a and Kd are dependent on a number of other factors as well[21]. These factors are well covered by the selected parameters, representing other external forces, such as irradiance and mixing wind etc., that are tested for in the Chl-a and Kd statistical models[22]. COWI and NIRAS suggest including nutrient concentrations as intermediate step. This would, however, only lead to introduction of additional errors to the model. Neither is there any point to introduce simple water exchange parameters, as suggested by COWI and NIRAS, because in almost all cases riverine nitrogen concentrations are so much higher than in the offshore that for water exchange to be the dominant supply of nutrients, the salinity difference will be very small and the uncertainty of a water exchange estimation, using conservation of salt and water as sketched out by COWI and NIRAS, very large.

The fact that two models provide quantitatively different indicator responses to load change is not surprising and the uncertainties causing the deviations are the main reason for using the two-model approach, even though the MECH model results are now available for all water bodies. The scientists that developed the STAT models (AU) have confirmed in their stakeholder comments to COWI and NIRAS report that for a few water bodies detailed

[19] See reports under subsection 3.5 at https://mst.dk/erhverv/rig-natur/naturindsatser/vandomraadeplaner/vandomraadeplanerne-2021-2027/supplerende-oplysninger

[20] See, for example, including references therein: Riemann, B., Carstensen, J., Dahl, K., Fossing, H., Hansen, J. W., Jakobsen, H. H., et al. (2015). Recovery of Danish Coastal Ecosystems After Reductions in Nutrient Loading: A Holistic Ecosystem Approach. *Estuaries and Coasts*, *39*(1), 82–97. https://doi.org/10.1007/s12237-015-9980-0

[21] See for example: Conley, D.J., et al. (2007) Long-term changes and impacts of hypoxia in Danish coastal waters. Ecological Applications 17: S165-S184.

Krause-Jensen, D., Duarte, C.M., Sand-Jensen, K., Carstensen, J. (2021) Century-long records reveal shifting challenges to seagrass recovery. Global Change Biology 27: 563-575. DOI: 10.1111/gcb.15440

[22] Christensen, J.P.A., Shetty, N., Andersen, N.R., Damgaard, C. & Timmermann, K. 2021. Modelling light conditions in Danish coastal waters using a Bayesian modelling approach. Model documentation. Aarhus University, DCE – Danish Centre for Environment and Energy, 48 pp. Scientific Report No. 422 http://dce2.au.dk/pub/SR422.pdf

Shetty N, Christensen JPA, Damgaard C & Timmermann K. 2021. Modelling chlorophyll-a concentrations in Danish coastal waters using a Bayesian modelling approach. Documentation report. Aarhus University, DCE – Danish Centre for Environment and Energy, 62 pp. Scientific Report No. 469. http://dce2.au.dk/pub/SR469.pdf inspection did show that STAT model results were not trustworthy and that in management scenarios, STAT model results were excluded from the estimate of N-MAI for these water bodies.

2.4.3 Methodology to calculate N-MAI

The surrogate model produces the N-MAIs based on the indicator response to load change calculated by the MECH and STAT models. It further takes into account MECH model calculated indicator responses to Danish P-loads, atmospheric N deposition, and N and P-loads from other countries[23]. The documentation and justification of this model is rather poor. Compared to the huge effort invested in developing the STAT- and MECH-models, refining typology, and setting reference conditions, it is surprising how little attention has been paid to this important sub-model. Even the documentation is misleading in the way that the reader is told that the net change of the indicator value is the sum of change due to each of the load sources while, in fact, the equations describe a multiplicative approach, i.e., the total indicator value is the product of the values obtained from each of the factors. A compensatory 'system factor' is introduced partly to compensate for the bias introduced by the multiplicative approach and partly to adjust the surrogate model so that for reference loads it will exactly reproduce indicator reference values.

Although there are obvious possibilities for improvement to this model, it is probable that in most practical cases the surrogate model is describing the combined effect of different load sources reasonably well. In water bodies with dominating influence of Danish N-loads, the surrogate model will reduce to basically the original linear relationship described by the MECH or STAT model. Based on these last remarks, we conclude that the surrogate model provides results of sufficient quality to be fit-for-purpose. However, we cannot help to reflect that it would have been comforting to confirm the final N-MAI results by investigating the resulting eutrophication state from a simulation with the MECH model forced by N-MAI and other loads as in the chosen management scenario.

N-MAIs are calculated for a large number of management scenarios describing nutrient loads under different policy options from atmospheric deposition and other countries[24]. Quantitatively, the scenarios range from current loads to most optimistic thinkable in terms of nutrient load reductions. The most optimistic scenario, denoted scenario 2e, implies full implementation of regional and EU policies in adjacent countries. The consequence of using that scenario is that it is assumed that, in principle and in due course, the open waters surrounding Denmark will reach Good Ecological Status, inferring that any deterioration in Danish water would be due to Danish sources. Hence, this scenario leaves no room for manoeuvring in estimating the needed Danish nutrient load reduction. To the degree that other countries do not live up to their promises, more effort may be required in Danish waters to reach Good Ecological Status. We refer to Chapter 4 on Burden Distribution for a detailed discussion.

There are eleven water bodies that are shallower than the eelgrass depth limit G/M boundary, and 17 that are shallower than the reference depth limit[25]. Considerable debate has arisen about how to assess and model the ecological status in these cases. It was not easy for the Panel to find a reliable description of the exact procedures. According to an answer to a public hearing question from SEGES, it was stated that in cases where G/M boundary values are deeper than the maximum depth of the water body, eelgrass depth limit in assessment of ecological status, was considered unavailable or unusable when there was >10 per cent cover at maximum depth of the water body. In those cases, observations of Kd are used as proxy for the rooted angiosperm maximum depth limit. Also in the modelling, the required Kd at G/M boundary in a water body is not truncated by the actual water body depth. The justification for this approach is that in order to have a thriving well-developed eelgrass meadow at the deepest depth of a shallow water body, it is not sufficient to have water clarity just sufficient for 10 per cent cover. In addition, when two water bodies are very similar, but one happens to have a single deep pit and the other not, different water clarity requirements would be needed for these two water bodies.

The Panel sees the scientific logic of this argument, but notes a lack of rigour in its application. It is not formally defined what a 'thriving meadow' is, or how much more light it needs than a 10 per cent cover meadow. In addition, the adopted approach turns Kd into the real indicator – at least for the shallow systems – and observed eelgrass distribution into its proxy. That is a reversal of the priority, compared to the WFD requirements. It also results, as is shown by repeated contributions by stakeholders, in requirements that are difficult to communicate and explain. The Panel believes that this choice creates unnecessary complications and in practice changes N-MAI in only a

[23] Erichsen A.C., Timmerman, K.,Larsen, T.C., Markager, S. & Christensen, J. 2021: Application of the Danish EPA's Marine Model Complex and Development of a Method Applicable for the River Basin Management Plans 2021-2027 - Conceptual Method for Estimating Maximum Allowable Inputs. Report from DHI, DTU, AU and DCE. Available from https://mst.dk/erhverv/rig-natur/naturindsatser/vandomraadeplaner/vandomraadeplanerne-2021-2027/supplerende-oplysninger

[24] For all scenario calculations, see subsection 3.6 at https://mst.dk/erhverv/rig-natur/naturindsatser/vandomraadeplaner/vandomraadeplanerne-2021-2027/supplerende-oplysninger

[25] Timmermann K, Christensen JPA, & Erichsen A. 2020. Referenceværdier og grænseværdier for ålegræsdybdegrænser til brug for vandområdeplanerne. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 28 s. - Videnskabelig rapport nr. 390. http://dce2.au.dk/pub/SR390.pdf

few very shallow water bodies.[26] Hence, we advise to use G/M boundary depth limits for rooted angiosperms that are truncated at maximum depth, both in the environmental status assessment and in the model calculations of N-MAI.

The model calculations result in one N-MAI per indicator for each of the models. The approach taken is to make an average of these N-MAIs. This has given rise to discussions on the question to what degree Good Ecological Status will be reached and whether it is appropriate to average results from the two models with equal weight. The current procedure is to first average N-MAI for the two indicators for STAT and MECH models separately, and thereafter average these two. The choice to average N-MAI for the two indicators Chl-a and Kd, leads to the theoretically obvious conclusion that only one of the indicators will achieve the Good Ecological Status classification. However, in light of the relatively large uncertainties in both the G/M boundary values of the indicators and in model calculations, we encourage to average N-MAI for the two indicators since it is a robust methodology that reduces some of the uncertainties. Using an average N-MAI implies that there is no room for manoeuvring to choose an even higher N-MAI since already the uncertainty is in a sense centred around the G/M boundary. If for some reason, a higher degree of certainty to reach Good Ecological Status would be required, it is straightforward to perform N-MAI calculation requiring indicators to reach to mid-point between Good and High status. Examples of scenarios like this are available and the impact on N-MAI from different assumptions can be analysed based on these.

To our knowledge there is no objective way to quantify that the results from one model are more credible than the other, hence, a simple approach of averaging N-MAIs computed with results from the different models should provide the most robust result. One could possibly only use N-MAI from the MECH model, but at least according to COWI and NIRAS that would lead to generally lower N-MAI. In the present RBMP, we still advice to use both models, because despite various limitation the STAT model is still built upon the observed “real” relationships. In addition, a statistical analysis of the sensitivity of the N-MAI calculation to uncertainty reveals relatively small differences in most water bodies between N-MAI determined from STAT and MECH models[27].

The averaging approach is not that straightforward to argue for in the case when N-MAI are available for one indicator from both models, but the N-MAI for the other indicator only is available from one model. In this case, there will be additional weight on the N-MAI for the indicator available from both models. Inspecting the individual results for N-MAI in the few cases where available for both indicators from both models, we get the impression (without proper statistical analysis) that N-MAI varies more in-between indicators than between models which implies that averaging induces unnecessary bias in this respect. A simple way to make an unbiased estimate in terms of indicators, that will be more accurate if the observation on the variation of N-MAI is larger between indicators than models, could be to put double the weight on the N-MAI for the indicator only available from one model, in other words, assume that the single available N-MAI is valid for both models. However, this is not critical for the overall calculations, since it only would change N-MAI for some 9 water bodies[28] and in these the changes are probably within the uncertainty of N-MAI.

Initially, need for reduction is computed as the simple difference between the baseline load and N-MAI for each water body. For chains of connected water bodies, the need for reduction is accumulated downstream with the presumption that the reduction is effective also downstream. The methodology will lead to slightly less total reduction demand. The total need for reduction for the chain of the water bodies is at the last stage distributed evenly across the catchments according to their agricultural areas. The scheme to calculate the need for reduction of nitrogen is simple and seems reasonable, and results in easily communicable reduction demands. The scheme alleviates some of the total reduction burden compared to not applying the distribution across chains of connected water bodies, but we find that justifiable from a scientific point of view.

2.4.4 Cases of catchments with MAI near to, or even below background levels.

In the remarks by stakeholders, considerable attention has been paid to cases of catchments where it would not be possible, or at least extremely difficult, to reach the G/M boundary by reducing the Danish land-based N-load. In some of these cases the calculated N-MAI is even below the background level. The cases have been used to question the general validity of the models and are therefore of high importance in the public discussion and the policy-making.

---

26 In the results from scenario 2e we identify 6 water bodies where eelgrass depth limit G/M boundary is larger than the maximum depth and where Kd gives lower N-MAI than Chl-a, with only marginal difference in two of them.

27 Larsen, T., Christensen, J., Kloppenborg Møller, J., Erichsen, A.E. & Timmermann, K. 2021 Application of the Danish EPA's Marine Model Complex and Development of a Method Applicable for the River Basin Management Plans 2021-2027 - Estimating Confidence Intervals for Maximum Allowable Inputs (MAI) Report from DHI, DTU, AU and DCE. Available from https://mst.dk/erhverv/rig-natur/naturindsatser/vandomraadeplaner/vandomraadeplanerne-2021-2027/supplerende-oplysninger

28 Preliminary calculation using results from scenario 2e show that here are 15 water bodies where STAT N-MAI results are missing for one indicator and of these the revised average N-MAI would be 10 – 36 % higher for 7 water bodies and 20-25% lower for 2 water bodies. For the remaining 6 water bodies, the difference would be less than 4%.

The Panel has considered three type examples of these cases, but with the caveat that the Panel does not have detailed local knowledge on the natural history and ecology of these systems. General trends, rather than system-specific details, have been the main focus of this analysis.

The cases considered exemplify three different situations:

a) the Bornholm type. Even reduction of land-based N-load to zero (which is theoretically impossible) is not sufficient to reach G/M boundary conditions.

b) the Lillebælt 217 Bredningen type. Reaching G/M boundary conditions by lowering Danish land-based sources is theoretically possible, but MAI is very close to background and drastic reductions of activities would be needed

c) the Limfjorden – Halkær Bredning type. This is a heavily eutrophied water body where currently Chl-a concentrations are 5-7 times as high as the target value. Inorganic N and P concentrations are among the highest that the Panel members have ever seen for brackish water systems[29]. The model-derived slope for Chl-a reduction is 0.4 per cent Chl-a reduction per 1 per cent N-load reduction. Extrapolating this slope shows that with a 100 per cent N-load reduction, not more than 40 per cent Chl-a reduction could be reached, whereas a Chl-a decrease of at least 80 per cent would be needed. Thus, although the model shows considerable sensitivity of Chl-a to nutrient input, it also suggests that reaching the Good Ecological Status would not be possible with this slope.

Cases (a) and (b) have in common that the ability to reach G/M boundary values in the indicator, is heavily dependent on the quality of water flowing in from outside, i.e. from the Baltic at large. It is impossible to reach Good Ecological Status at Bornholm, not only at the present-day concentrations of nutrients in the Baltic, but even at concentrations conforming to the most ambitious HELCOM plans for improvements. Clearly then, this is a consequence of incompatibility of target values. It has been argued in Chapter 1 that the reference conditions and G/M boundary values for open waters are lower in RBMP3 compared to the intercalibrated values. The cases discussed here illustrate the type of problems that can be caused by this lowering of the target concentrations. Readjusting the boundary values to the intercalibration results (see Chapter 1 for details), may partly decrease the gap between the current boundaries and the best attainable conditions, but the Panel can presently not control if this will solve the entire problem.

It is discussed in Chapter 8 that this case could require the use of exemptions, due to the inflow of pollution that comes from external sources outside of the jurisdiction of the Member State. In any case, although Bornholm clearly represents a difficult case demanding special action, the fact that it is impossible to reach Good Ecological Status by reducing land-based N-loads does not invalidate the models used but can be attributed to a combination of inflow of external waters and the target values used. Case (b) is similar to the Bornholm case, but presents the additional difficulty that here it cannot be argued that reaching Good Ecological Status is completely impossible. However, it would require very high costs, which may be disproportionate. Again, this is a case where exemptions could apply (see Chapter 8).

In case (c), the situation is entirely different from that in cases (a) and (b). This catchment is heavily eutrophied, to the degree that the ecological functioning has crossed some critical transition points and the system as a whole cannot be expected to react approximately linearly between the current situation and the situation of Good Ecological Status. It can be seen in the graphs of inorganic nitrogen and phosphorus concentration in this system and some of the other very heavily eutrophied Danish water bodies[29] (see also graph in Chapter 6 for another example), that neither of the two nutrients reaches limiting concentrations during the growing season. This means that other factors (most probably light, but possibly also dilution) regulate the Chl-a concentration, and that the system will be relatively insensitive to marginal reductions of nutrient loading at this level of eutrophication. Sensitivity will increase from the point onwards where one nutrient (P) becomes limiting in spring. Once in the regime where nutrient limitation starts to play a significant role, the system's sensitivity to nutrient load reduction increases. At first, this will be sensitivity to P-loading only, followed by a phase where both P and N-loading are important. Eventually, close to background loading a phase may be reached where the system again becomes less sensitive to variations in land-based loading, but this is a rather theoretical consideration in the case of Halkær Bredning.

[29] Gertz F, Thostrup L K, Møller K D, 2022. Nutrient limitation in Danish Coastal Waters. Report from SEGES Innovation. Available from: https://www.landbrugsinfo.dk/-/media/landbrugsinfo/public/6/B/D/cowi_report_nutrient_limitation_in_danish coastal_waters

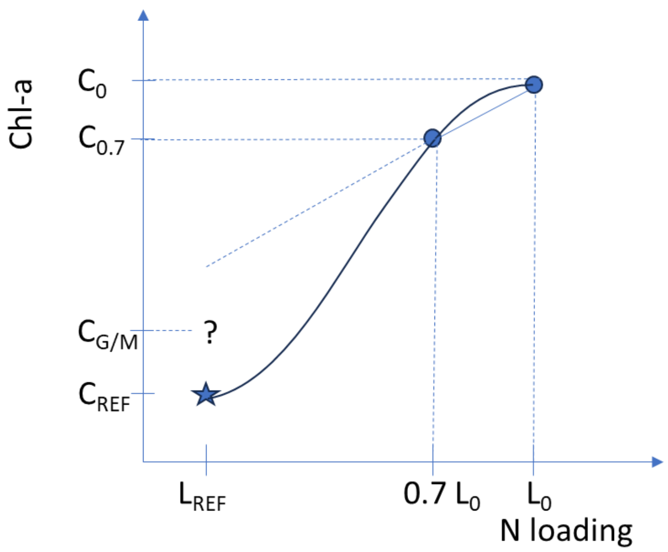

Figure 2.2. Conceptual illustration of the non-linear sensitivity of a water body to nutrient loading, leading to an overestimation of the amount of nutrient load reduction required. The black curve expresses that at current nutrient loading (L_0) the system is relatively insensitive to nutrient reduction, causing the relation between Chl-a and N-loading to be flat. At lower levels of nutrient loading, this relation steepens as the system becomes more sensitive to nutrient load reduction. Sensitivity may again flatten out close to the background loading L_{REF}. In determining MAI, a model scenario at 70 per cent of current loading (0.7 L_0) is used, and the slope is interpolated linearly. When this slope is extrapolated to lower loading, it does never reach the G/M target Chl-a concentration for any loading above zero.

Figure 2.2 illustrates how such a variation in sensitivity to nutrient loading affects the estimation of the MAI. The slope of the response curve between Chl-a and nutrient loading is estimated from a scenario run with a 30 per cent reduction in N-loading. If most of that reduction takes place in the regime where the system is too over-eutrophied to be very sensitive to nutrient reductions, extrapolation of the slope from the present situation will overshoot the Good Ecological Status condition and suggest that this is not attainable with local nutrient reductions. This is not a sign of a dysfunctional model, nor a wrong interpretation of the results, but in the first place a sign of extreme overloading of the system in the current situation.

The management implications of this interpretation are relatively straightforward. Very eutrophic water bodies such as Halkær Bredning, with Chl-a more than 5 times above Good Ecological Status, are so far from target that it is no longer possible to exactly estimate what will have to be done in terms of load reduction. However, at the same time it is beyond doubt what direction management should take: reduce the eutrophication substantially at short notice. Only after the situation has improved sufficiently, will it become possible to make more accurate estimates of the total effort needed. It is discussed in Chapter 8 that such situation calls for adaptive management and possibly the use of exemptions.

2.5 Conclusion and recommendations

- Substantial improvements have been made to all components of the N-MAI calculations since RBMP 2 and the quality of the results has improved. The N-MAIs computed by the models are of sufficient quality to be used within RBMP 3 without further improvements.
- There is no room for manoeuvring in the sense of increased N-MAIs, since the most optimistic scenario is chosen concerning water quality improvement due to other countries' efforts in reducing nutrient inputs.
- Calculating N-MAI by averaging results for the two indicators and from the two models is advisable, despite the implication that G/M boundary is reached on average and, theoretically, not all BQEs will then fulfil the requirements. However, considering uncertainties, this procedure should provide the most robust result adequate for RBMP3. Obviously, progress needs to be monitored closely to make potential adjustment in future RBMP cycles if Good Ecological Status is not reached. In view of the sometimes extremely large leaps needed (in some water bodies Chl-a has to be decreased by over 80 per cent) it cannot reasonably be estimated if one will end at the right side of the G/M boundary line.
- The Panel advises to truncate assessments and model calculations of depth limit of rooted angiosperms to the maximum depth of the water bodies concerned. In practice it will make a difference only for a few water bodies, while it is easier to explain and gives due precedence to observed plant depth limit over its proxy (Kd).

- There are no indications that further model development or improvements would lead to N-MAIs at a significantly different level than the ones derived. It would be interesting to investigate a predictive simulation with the MECH model with respect to how close the final set of N-MAIs will get the water bodies in relation to Good Ecological Status.
- In future RBMP cycles, it may be advisable to focus on the mechanistic modelling since explicit consistent future projection simulations of the state development in response to N-MAIs in the different management scenarios can be performed and used to demonstrate the consistency of the overall policy. However, still some surrogate model would be needed to back-calculate MAI from indicator values. Since in the coming period extensive monitoring data will be collected on many water bodies that moreover will be subject to nutrient load reduction measures, the statistical expertise may be used to demonstrate and quantify the effects of these measures, test and validate the MECH model results and refine and validate estimates of future needs of measures for nutrient reduction.

CHAPTER 3: STATUS LOAD, BASELINE, AND EFFECTIVENESS OF MEASURES

3.1 Introduction to the theme

Chapter 3 addresses issues fundamental for the calculation of the nitrogen status load and modelling the baseline forecast. It also addresses the effectiveness of the measures.

The status load: The definition of the status load is fundamental because the status load for each catchment is the basis for the 'need for reduction' (NFR) to reach the target in 2027, and hence the severity of measures. In RBMP3, the status load is defined as "the load in 2018 calculated as the average flow-normalised loads during the last three years (2016-2018), which is done to correct for variation in climate and some interannual variability. The status load is comprised of loads from the various sources of N: diffuse (90 per cent) and point sources (10 per cent). The diffuse sources include the inputs from cultivated and uncultivated land, including the discharges of wastewater from scattered settlements without a public sewer system. The main point sources are the effluent from urban wastewater treatment plants and storm water flows via the sewage system.

The status load is compiled from a combination of, on the one hand, monitored concentration and flows and, on the other hand, modelled concentration and flows (in the unmonitored parts of the catchment areas). The sampling stations, which are geographically distributed across the country, cover approx. 60 % of the country's catchment transport of nutrients to coastal waters. The unmonitored catchments are handled by catchment models developed by Aarhus University, Danish Centre for Environment and Energy (DCE). The status loads are computed with a very high spatial resolution in order to obtain accurate estimates of loads to each coastal water body. To obtain a stable and representative status load, so-called *flow normalisation* was performed to reduce interannual variability in the loads due to wet and dry years as far as possible. Currently, the status loads are being updated to reflect the loads in 2021.

The *2027 baseline*. The 2027 baseline is the projected N-loads in 2027 assuming reductions from already implemented or planned initiatives and general development, which together form the baseline effect. The difference between the need for reduction of nitrogen (NFR) derived from MAI and the baseline effect determines the additional load reduction requirements which need to be address by new measures in RBMP3 in order to reach Good Ecological Status. The *baseline effect* is derived from data from a variety of sources such as the Danish environment and agriculture authorities, contributions from municipalities, utility providers, and companies. These consider a forecast of agriculture production, the effect of livestock distribution, the effect of crop distribution and nitrate leaching. In total, the baseline effect is just below 5.000 tonnes/year of nitrogen and 45 tonnes/year of phosphorus[30]. As part of second opinion, phase III, the baseline effect will be updated based on data up to 2021. Hence the approximately 5000 tonnes will probably be revised.

The effectiveness of measures: The models and data analysis underlying the calculation of MAI thoroughly document the relation between the N-loading of coastal water bodies on the one hand, and the development of Biological Quality Elements (Chl-a, eelgrass depth limit) on the other hand. Details of the dose-response relationship and the time lags and complexities involved are discussed elsewhere in this report. In the present chapter, we briefly discuss the steps between management decisions on measures to curb eutrophication, and the actual decrease of N-loading to the coastal water bodies. Field measures that can be taken, and have been taken in the last years, are of diverse nature. Aarhus University[31] has documented the N reducing effect of more than 40 different measures as well as the side effects on P and climate. These range from on-field-measures to collective measures in the recipient water. This catalogue of N reducing measures is in Danish, so difficult for the Panel to understand. The measures can either limit the total influx (e.g. control the total amount of nitrogen applied to the field as either artificial fertiliser, manure or resulting from N fixation, control the total area of land used by agriculture in a watershed), control the fate of nitrogen sources applied to the field (e.g. control the way manure is applied, the season of fertilisation etc.) or control the retention in the field and the landscape (e.g. use catch crops to avoid winter leaching, develop wetlands to remove N by denitrification).

It is clear that measures in agriculture and wastewater treatment taken during the 1980s, 1990s and into the first decade of the 20th Century caused major reductions in nutrient loads, and subsequent considerable improvement in the coastal ecosystems.[32] However, no or very minor reductions in nutrient loads have been observed during the

[30] Blicher-Mathiesen, G., Olesen, J.E. & Jung-Madsen, S. (red). 2020. Opdatering af baseline 2021. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 140 s. - Teknisk rapport nr. 162 http://dce2.au.dk/pub/TR162.pdf, and

Blicher-Mathiesen, G. & Sørensen, P. (red). 2020. Baseline 2027 for udvalgte elementer. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 120 s. - Teknisk rapport nr. 184 http://dce2.au.dk/pub/TR184.pdf

[31] Eriksen, J., Thomsen, I. K., Hoffmann, C. C., Hasler, B., Jacobsen, B. H. 2020. Virkemidler til reduktion af kvælstofbelastningen af vandmiljøet. Aarhus Universitet. DCA – Nationalt Center for Fødevarer og Jordbrug. 452 s. – DCA rapport nr. 174 https://dcapub.au.dk/djfpdf/DCArapport174.pdf

[32] Riemann, B., Carstensen, J., Dahl, K., Fossing, H., Hansen, J. W., Jakobsen, H. H., et al. (2015). Recovery of Danish Coastal Ecosystems After Reductions in Nutrient Loading: A Holistic Ecosystem Approach. Estuaries and Coasts, 39(1), 82–97. https://doi.org/10.1007/s12237-015-9980-0

past decade.[33] This gives rise to concerns regarding the prospects of achieving improved environmental status in the coastal water bodies. As this concern has also been raised by some stakeholders, the issue on the so far adopted measures and their effectiveness is shortly discussed in this chapter.

3.2 Results from Phase I

3.2.1 Central findings by COWI and NIRAS

The Status Load: A new method had to be introduced in RBMP3 to correct for laboratory errors in the analysis of total N in water samples in the period 2009-2015 in order to use for full data set from 1990 to 2018. The final status loads were calculated by averaging the flow-normalised loads over the last 3 years (2016-18) to eliminate some additional interannual variability. COWI and NIRAS assess that averaging of 3 years data instead of the 5 years used in RBMP2 will not affect the status load significantly. Further it is acknowledged that, although climate normalisation was carried out to reduce inter-annual variation due to rainfall, it does not remove other effects such as years with poor harvests, lack of sowing or poor growth of, e.g., subsequent crops.

The normalisation method has been updated and gives a smaller relative model error, when estimating current loads. Nevertheless, there is a small difference compared to the previous method at the national level.

COWI and NIRAS conclude that the methodology improved since RBMP2. The major improvement is that status load is now calculated for the runoff to each catchment area to the coastal water bodies.

The 2027 Baseline: COWI and NIRAS found that the N-model had been updated in RBMP3 and changes had been made to parts of the model concept, based on experience. These included changes to the sub-models and to the catchment boundaries. The updated model is considered to provide an improved description of N-transport. The update also ensures a higher degree of consistency between models used in the N-model and other models used during the preparations of RBMP3. COWI and NIRAS further stress that the full effect of measures taken during RBMP2, is not expected to be realised by 2027. Considerable uncertainty remains as to the final effect of these measures, and this does not allow for a reduction in MAI in the meantime.

The effectiveness of measures: COWI and NIRAS conclude that on a national scale there was no difference in the baseline loads between RBMP2 and RBMP3, so that the measures implemented have been largely ineffective yet, although there are some differences at the local scale and a large uncertainty. There are expected decreases in atmospheric deposition, cultivated area and afforestation.

3.2.2 Central Remarks by stakeholders regarding status load, baseline and measures

Urgency: Several stakeholders expressed their frustration at the lack of implementation of measures, delayed by discussions and the urgent need to act in view of the enormous effort that is necessary. One stakeholder commented that despite all efforts, no reduction has been realised in the last 15 years.

The 2027 baseline: one stakeholder urged for a critical analysis of the 2027 baseline. They expressed frustration that the measured load of N over many years is very difficult to find, which shrouds the methodology.

Updated time series for status load: One stakeholder is particularly concerned with the scientific basis for the nutrient load calculation, questioning whether it is scientifically acceptable to define the nutrient load in tonnes related to an undefined volume in the free water masses in a catchment.

Range of years selected: The same stakeholder expressed concern that the data for 2019-2022 was not included, questioning whether the MAI would be significantly affected if the status load time series was extended to include more years and whether extreme years, in terms of nitrogen load, should be included when determining status load. This stakeholder was also concerned that Denmark's nutrient loads is calculated in a different way than neighbouring countries.

Effectiveness of Measures: One stakeholder expressed frustration as to why the different and very expensive measures for reductions of TN from cultivated land do not have any effect on the total runoff since the beginning of the millennium. The same stakeholder commented that the mandatory area of specified catch crops has apparently led to increased leaching of TN in the spring. The stakeholder expressed frustration that measures were implemented without considering if they will actually work and questioned how such actions are evaluated.

[33] Thodsen, H., Tornbjerg, H., Rolighed, J., Kjær, C., Larsen, S.E., Ovesen, N.B. & Blicher- Mathiesen, G. 2023. Vandløb 2021. -Kemisk vandkvalitet, stoftransport og miljøfarlige forurenende stoffer. NOVANA. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 90 s. - Videnskabelig rapport nr. 527 http://dce2.au.dk/pub/SR527.pdf

3.3. Selected focus by the panel in the evaluation of the theme

The Panel has focused on the status load, which is fundamental to the whole process and a major concern for the stakeholders. It shortly discusses the baseline load and finishes with some remarks on the effectiveness of measures.

3.4. Discussion of issues within the evaluation theme

3.4.1 Status load

In the status load, the actual load to the sea is calculated from observations of concentrations and flow in the streams complemented by modelling for catchment areas not covered by observations. However, there is an added element of source attribution to evaluate the effects on the load from measures in different regions and sectors. Atmospheric deposition is accounted for in the loads from the land classes. Nitrogen fixation on agricultural land is not specifically included but accounted for in the cultivated land loads.

The Panel agrees with COWI and NIRAS that the methodology for calculating the status load has improved and is of high quality. Important quality elements for the method to update the status load is that it can easily incorporate the latest consolidated data, is sufficiently robust to dampen the effect of unusual years (that may occur more frequently due to climate variability), and that updates of the status load should result in smooth changes. These requirements are fulfilled by the methods currently used or proposed. The Panel remarks that in Phase III of the second opinion, significant improvements of the methodology are to be implemented (see below), and also that the latest available data are being incorporated into the status load. The Panel is of the opinion that this update and the methodology used are sufficient to accommodate the concerns raised by some stakeholders that the most recent data should be used.

Stakeholders have claimed that in some individual water bodies, errors have been made in the calculations. They have used this to argue that the status load is not of general high quality. The Panel has not been able to recalculate or check all numbers on all water systems. It appears that there have been and perhaps still are some errors at the local level in specific water bodies (e.g. Nakskov Fjord and Rødsand/Bredningen). This may be addressed through an efficient correction procedure. Errors can, unfortunately, never be excluded. A solid hearing process is necessary to properly treat such cases, but these exceptions should not be generalised as a source of distrust in the modelling approach as a whole.

The Panel was asked to give advice whether to continue to use the three-year average methodology or implement more refined methods, e.g. piece-wise linear regression, to estimate the 2021 status loads. The statistical analysis leading to the piece-wise linear regression approach result cannot be evaluated, but there is also no reason for the Panel to doubt it. Even more important than finding an optimal statistical measure of the status loads is whether it is fit-for-purpose. The piecewise linear regression method proposed seems to be quite similar to the methodology used in the HELCOM assessments of fulfilment of Maximum Allowable Inputs and Nutrient Input Ceilings. The experience from HELCOM shows that this method delivers quite robust estimates of current (last year loads). An additional year of data only occasionally causes large changes in the estimate in subsequent assessments. There is an added advantage to this methodology because it delivers trend information. Trend information is quite important for the HELCOM assessment, and the piece-wise linear approach directly provides clear information of the current trends, or absence of trends, over the time-period. In addition, the trend estimate for recent years becomes quite independent on data quality in the earlier part of the time-series, which is a major concern with many HELCOM load data sets.

According to the experience from the HELCOM methodology there are two disadvantages to piece-wise linear regression methodology:

- It is difficult to communicate and explain the methodology and its advantages as it is technically more complicated than simply using an average over subsequent years
- The methodology is difficult to fully automate and does therefore require quite some manual work

The three-year average method is indeed more sensitive to interannual variability in the years that are averaged, and status load may therefore be subject to larger differences when new data are introduced. In addition, in cases where there is a trend, the status load will be under- or overestimated, depending on the direction of the trend, although with only three-year averages this effect is not expected to be large.

The Panel is of the opinion that both methods (three-year average or the newly proposed piece-wise linear regression) are expected to generate acceptable status load estimates. However, the piece-wise linear regression has some statistical advantages, and especially if it can be made fully consistent with approaches used in HELCOM, also offers the advantage of compatibility between Danish and international estimations.

3.4.2 The 2027 baseline

The Panel agrees with the methodology for setting the 2027 baseline. The 2027 baseline was established from the status load in 2018. It is calculated as the status load minus the baseline effects from implemented or planned initiatives and general development of the effects from these measures by 2027.

The N-model (national N-model, NKM, also called retention model) has been developed to translate measures in the field into rates of nitrogen loading of the coastal waters. The N-model represents the important processes taking place between the moment of application of fertiliser or manure in the field, and the moment N leaches to the coastal waters. This includes leaching in soils and N-retention in the landscape and reflects local conditions and catchment characteristics. Some complicated aspects of this modelling could be better explained and communicated. These include: the changes in the catchment boundaries; further adjustments for measures that may be necessary; long-time lags. Nevertheless, the RBMP3 baseline 2027 is calculated using state-of-the-art modelling, and we have confidence in that the best available knowledge to estimate effects from the baseline measures are used. However, as also noted by COWI and NIRAS, some uncertainty in results of these calculations is to be expected and is acceptable within the overall uncertainty of all calculations.

The Panel encourages the planned updates to the N-model and sub-models. Compared to the models linking N-load to the coastal waters to the Biological Quality Elements, the models linking measures in the field to N-loading of the coastal waters have a smaller underlying data base and less empirical foundation. It is to be expected that, when more measures are taken or taken at larger scale, this empirical basis for modelling the effectiveness of measures will improve. The Panel is of the opinion that this constitutes one of the priority knowledge gaps in the programme as a whole.

3.4.3 The effectiveness of measures

The Panel has noted with worry the lack of significant reduction of nitrogen concentrations in rivers within the agricultural landscapes during the past decade.[34] Consequently, also nitrogen loads to the coastal water bodies have not significantly changed in this period. The large decrease in nitrogen loads that occurred up to around 2010 appears to be quite consistent with a continuous reduction of the net supply of N to the fields in that period. The lack of further decrease of the nitrogen loading to the coastal waters could have two different reasons: either too few measures have been taken to expect a measurable effect at national scale, or the measures taken are ineffective and do not result in the expected decrease in N-loading. Stakeholders from agriculture allude to the latter possibility and use it as a basis for questioning the application of further measures.

From information summarised by the Ministries, it appears that the application of measures during the first and second RBMP's was changed and delayed due to several reasons. Some measures taken during RBMP1, e.g. buffer land between fields and water courses, were stopped and reversed in the Food and Agriculture Package of 2015. This Package also phased out the general lowered N-fertilisation standards, leading to an effective increase in the total national N-fertilisation after 2015. As a measure to prevent deterioration, a catch crop program was initiated in 2017 to replace the effect of the reduced N fertilisation norms. This targeted catch crop scheme was not purely voluntary, as catch crop requirements were obligatory in catchments where there was an insufficient take up of the voluntary (compensated) scheme. However, the scheme was in the very first years limited to an effect equivalent to secure non-deterioration after the removal of the reduction of general N fertilisation norms. Hence, one cannot expect an actual improvement in the coastal waters. Later on, the scheme was replaced by the targeted regulation, where efforts were increased stepwise in order to achieve an actual improvement in the respective coastal water bodies.

Substantial reductions in nitrogen leaching can be achieved through permanent and efficient measures such as e.g. wetlands and rewetting of peatlands, which also deliver on biodiversity and climate gas emission goals. Mini-wetland construction was part of the, mainly voluntary, collective measures. There have been earlier rounds of larger wetlands construction. The wetland measures are all voluntary and based on subsidies and/or the state offering exchange of lands (jordfordeling) for the farmers. Yet, the potential for converting lowlying lands into wetlands by shutting off drains is still far from exhausted. Moreover, only a small portion of the recently agreed projects have been realised, but the number of new projects is quite large and suggests (but cannot yet assure) that more success will be achieved in the coming years.

In the meantime, and as a measure to prevent further deterioration, a rather extensive catch crop program was initiated in 2017. The effect of catch crops is rather dependent on which part of the system one looks at. Effects in the root zone (water) are rather immediate. However, depending on hydrological pathways and transport times

[34] Thodsen, H., Tornbjerg, H., Rolighed, J., Kjær, C., Larsen, S.E., Ovesen, N.B. & Blicher- Mathiesen, G. 2023. Vandløb 2021. -Kemisk vandkvalitet, stoftransport og miljøfarlige forurenende stoffer. NOVANA. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 90 s. - Videnskabelig rapport nr. 527 http://dce2.au.dk/pub/SR527.pdf

towards the recipient coastal water bodies, a considerable delay in effect can occur. The efforts in the consecutive scheme of “targeted regulation” increased stepwise since 2019 and aim at specific reductions of nutrient loads to the respective recipient coastal waters. However, effectiveness cannot fully be evaluated yet, as national monitoring data is only available up to 2021 at the current stage. The program aims at more than just securing non-deterioration, i.e. actual concrete improvements and catchment-specific nutrient load reductions.

Overall, then, it appears to the Panel that political uncertainty about the way forward and the measures to take, has slowed down the effective and consistent implementation of nutrient load reducing measures in the 2010’s, explaining that a full decade was virtually lost for lowering nutrient loads to coastal water bodies. This has raised the impression with stakeholders that many efforts have been discussed and sometimes also (briefly) applied, without much effect. The Panel sees no reason, however, to doubt that measures can be found that have the potential to be effective, if applied at scale, and therefore does not express doubt as to the *technical possibility* of achieving the RBMP3 goals with appropriate measures. It can be deplored that valuable time has been lost in the 2010s, but this is balanced by the observation that the past experiences have been built into the more ambitious plans for measures in RBMP3. The real vulnerability is in the *political possibility* to implement and sustain these measures. The Panel can only hope that sufficient political support for a sustained and coherent implementation of measures will be provided within RBMP3. Many measures take time to be effective, and there is no room for changing policy too often. For the people affected, mostly in the farming community, predictability of the future policy is also of utmost importance.

In view of the late implementation of measures, including more wetlands and catch crops, experience from the field on the effectiveness of these measures under different conditions remains limited. The Panel advises to closely monitor the realised projects and quickly expand the empirical basis for further development of nitrogen reduction strategies and measures. It is also important to study regional differences in the effectiveness of different measures,and involve local communities in the evaluation and further elaboration of the measures.

As argued in Ch. 7, some coastal waters may not be able to reach Good Ecological Status within a reasonable time frame through nitrogen reductions alone. The restoration of the marine environment through measures such as sand capping or active eelgrass replanting may reduce the expected time delay to reach Good Ecological Status, when combined with sufficient measures to reduce nutrient load from land. Therefore, in addition to nutrient load, other stressors will have to be considered, to reach Good Ecological Status. Some of these stressors, e.g. chemical pollution or bottom disturbance, could and should be addressed at the same time as nutrient load. However, other measures such as sand capping, may not be effective while eutrophication is still going on and remains a factor disturbing the sediment quality. Care should also be taken not to rely too heavily on symptom reducing methods. Mussel culture, as an example, may reduce Chl-a levels due to filtration but simultaneously lead to accumulation of (pseudo)faeces at the sediment, with high oxygen demand and ensuing water quality problems.

3.5 Conclusions and recommendations

- *Status Load*: Overall, the Panel found the methodology to be sound. Temporal aspects such as time-lags, inter-annual climate variability and longer-term climate change continue to be sources of uncertainty. The proposed piece-wise regression method has advantages compared to the presently used three-year average. However, changing methodology is not expected to cause much quantitative change to the status loads. The Panel approves the Phase III effort to update status loads to the latest consolidated data, as this may avoid difficult discussions.
- *2027 Baseline*: The Panel found that the methodology and the models are fit for purpose, but even so there are considerable uncertainties, in particular regarding when measures have effect on nitrogen loads. The N-model is adequate to determine the extent, type and prioritisation of measures.
- *Effectiveness of measures*: The Panel expresses concern that during the last decade, little or no reduction of N-load to coastal waters has taken place. In analysing different possible causes for this halting of progress, the Panel concludes that it is not due to inherent ineffectiveness of the measures, but to political changes in the 2010s that have led to delay in implementation. Therefore, there is still hope for further N-load reduction in RBMP2 and RBMP3, but this will require steadfast and ambitious policy decisions and sustained implementation. The Panel advises to closely monitor the measures that are currently being implemented, in order to further enhance the empirical basis needed for further development of reduction programmes.

CHAPTER 4: BURDEN DISTRIBUTION

4.1 Introduction to the theme

The Danish water bodies feature a range of exposure to the open sea conditions, which is very important for their sensitivity to nutrient loading from land-based sources. In coastal water bodies that are more open towards the sea, dilution will work stronger on nutrient and Chl-a concentrations, and the concentrations in the coastal water body will be closer to the open-water concentrations. On the one hand, this enhanced importance of dilution leads to lower sensitivity to land-based nutrient loads to the water body. Concentrations in the water body will only raise significantly when the influence of loading overrides that of dilution. On the other hand, these open coastal water systems are very vulnerable to the nutrient and Chl-a concentrations in the open sea waters. As an extreme case, if the water that enters from the open sea does not conform to the criteria for Good Ecological Status, then this state can never be reached, irrespective of whether additional nutrient loading is taking place to the water body or not. Many practical cases are less extreme. Concentrations of Chl-a in the water body does depend on local nutrient sources, but also to a large extent (often more than 50 per cent) on nutrients imported from open sea waters.

Where an impaired eutrophication status in the open sea hinders achievement of Good Ecological Status by reduction of local loads, a logical step is to improve the eutrophication status of the open sea. This is an international endeavour, which is being done through international treaties within HELCOM for the Baltic Sea and OSPAR for the North Sea. However, improving water quality of the Baltic or North Seas is a long-term effort that will not contribute much to achieving Good Ecological Status in Danish coastal waters by 2027.

This chapter explores if solutions can be found to these problems that allow for trustworthy RBMPs, while taking into account the realities of eutrophication abatement at the scale of regional seas.

4.2 Results from Phase I

4.2.1 Central findings by COWI and NIRAS

The second opinion report by COWI and NIRAS from phase I, covers burden distribution as “the effect of nitrogen loads from neighbouring countries (via atmosphere and waters) and their effect on the condition in Denmark compared to the nitrogen load from Denmark”.

COWI and NIRAS have assessed that “Establishing additional management scenarios (i.e. assessing the burden distribution between Denmark and its neighbouring countries) may strengthen the managerial basis for establishing measures”. According to the consultants, “this may leave room for manoeuvring in specific water bodies, e.g. Wadden Sea, Flensburg Fjord and Bornholm”, while it was emphasised that “such additional scenario modelling shall not, however, delay the implementation of measures to reduce nutrient loads”.

COWI and NIRAS concluded that “the N contribution from neighbouring countries (from atmosphere and adjacent water areas) is secondary to the N-load to Danish waters in general and particularly to the inner fjords. Land-based N-load from Denmark is the dominating pressure.” Further, it is argued that the Danish nitrogen loads have a much higher share of bioavailable nitrogen promoting larger algae growth per nitrogen unit than the long-transported nitrogen from other countries around the Baltic Sea.

In RMBP3, the chosen scenario entails that land-based nutrient discharge from other countries are calculated based on foreign RBMPs and fulfilment of international treaties (the updated BSAP in 2021 (HELCOM) and OSPAR, implementation of RBMP 2015-2021 (RBMP2) in all relevant EU countries, full implementation of the NEC-directive with respect to atmospheric N-deposition, and an additional Wadden Sea P-reduction of 30 per cent). Hence, it is assumed that other countries realise nutrient reductions corresponding to all their currently formulated promises in the framework of the WFD, MSFD (through HELCOM) and NEC-directive, after which Denmark must carry out the remaining nutrient reductions necessary to achieve Good Ecological Status.

4.2.2 Central Remarks by stakeholders regarding burden distribution

Following up on the results in COWI and NIRAS report, several stakeholders find that there is a need for further analysis and recommendations from the panel on possibilities for establishing a revised burden distribution, which is – legally and scientifically – consistent with the WFD.

Some stakeholders are especially criticising the assessment by COWI and NIRAS that “N-contribution from neighbouring countries” being “secondary to the N-load to Danish waters in general”. They claimed that most Danish waters (except closed, inner fjords) are strongly affected by nutrient emissions from other countries (both air- and waterborne).

Moreover, a couple of stakeholders have raised concerns regarding other countries application of exemptions, and their insufficient measures by 2017 for achieving Good Ecological Status, which can lead to higher reduction needs from Danish sources, as efforts are based on (partly insufficient) measures in other countries. In this connection, one of the stakeholders also calls for an analysis of the applicability of WFD article 12 and its potential role in relation to burden distribution.

One stakeholder has also requested to include a scenario, which is based on an assumption that all other countries comply with the WFD obligation to implement measures by 2027, which support reaching Good Ecological Status and hence calculate the residual need for reductions from Danish sources.

One of the stakeholders is also appealing to the panel for clarifying the role of the EU Commission with respect to burden distribution.

4.3. Selected focus by the panel in the evaluation of the theme

Both the COWI and NIRAS report and various stakeholders address whether the obligations in the RBMP3 to reduce nitrate inputs to coastal waters are justified, considering that a large part of the nitrate pollution, especially in open coastal waters, is (co-)caused by other Member States of the European Union. This aspect of the RBMP3 is addressed under the heading of Burden Distribution.[35]

In fact, the discussion is only relevant for water bodies where eutrophication and the associated failure to achieve Good Ecological Status are significantly due to inputs from other Member States. These are the 'open coastal waters', where the degree of openness can vary but significant Baltic influence can be detected. For these waters, the exact level of the targeted G/M boundary value, in comparison to present-day values as well as HELCOM and OSPAR targets, are very relevant.

COWI and NIRAS and the stakeholders discuss several different scenarios of burden distribution, where different divisions between countries are proposed. However, there are no legal mechanisms to implement any of these scenarios, which reduces them to rather academic exercises. The discussion on burden distribution has no impact *a priori* on Denmark's obligations to improve ecological status in the sense of the WFD by significantly reducing nitrate inputs to water bodies. This remains true, even if load reductions from Denmark down to reference loads will not lead to achieve Good Ecological Status. However, high loading from open waters where the source of pollution is not under Danish jurisdiction, as well as disproportionate costs to achieve Good Ecological Status, may be used as a reason to make use of exemption schemes. This will be further discussed.

4.4. Discussion of issues within the evaluation theme

4.4.1 The importance of reference and G/M boundary target values

In the framework of a discussion on Burden distribution, the comparison of Danish G/M boundary target values with HELCOM target values for Chl-a becomes extremely relevant. In open Danish waters, there is a significant degree of dilution with water coming from the open Baltic Sea. At some time in the future, it is hoped and expected that this water will conform to the HELCOM target concentration of Chl-a. However, it seems rather unlikely that it will ever go much below these target values. It can be argued that WFD targets are more stringent than HELCOM targets, and that Baltic waters would therefore be of better quality than HELCOM targets if all countries would fully comply with WFD. However, not all sources of nutrients to the Baltic are regulated by the WFD, and moreover some major sources of nutrients to the Baltic have no G/M boundaries for nutrients under the WFD that further restrict their current nutrient inputs. In a recent report from HELCOM.[36] it was indeed shown that HELCOM BSAP goals will not be achieved by compliance to G/M boundary nutrient concentrations in rivers for all countries. It was even noted that G/M boundaries for river nutrient concentrations are allowing for even higher total loads to the Baltic Proper than observed 20 years ago. HELCOM targets can therefore be considered as 'less than optimal, but politically negotiated and relatively realistic', even if less ambitious than the WFD targets of some countries, such as Denmark, Sweden or Germany.

It follows that, if the Danish G/M boundary target for a water body receiving Baltic open water is significantly below the HELCOM target value for the open Baltic water, then it can be expected for the coming decade or longer that any water flowing into the Danish coastal water body is, relatively speaking, over-enriched in Chl-a and probably

[35] Under the topic burden distribution, a number of other aspects regarding the responsibility of reducing future nitrogen loads in the coastal waters can be addressed. For example, the question of Danish farmers carrying the main load of achieving the Good Ecological Status in Danish coastal waters with regard to other pressure on its ecology. However, the panel´s task is limited to evaluate the burden distribution as discussed in the COWI AND NIRAS report.

[36] HELCOM (2021) Compatibility of targets under different marine policies - Sufficiency of the EU WFD targets for individual rivers basins to achieve the BSAP goals. HELCOM Baltic Sea Environment Proceedings n°183, HELCOM, Helsinki, 35pp. available from https://helcom.fi

also in nutrients. Expectations are that the Danish coastal water body, in this case, will never go down in Chl-a concentration to the Danish G/M boundary.

In Chapter 1, it was argued that the revision of reference conditions, and (tied to that) G/M boundary values, in RBMP3 has led to significant lowering of target values in open coastal waters. Current target values are well below the intercalibrated target values. It is also shown that the intercalibrated target values corresponded rather well to the HELCOM targets for adjacent open Baltic waters. This is no longer the case after the lowering of these target values in RBMP3. The Panel advised in Chapter 1 to somehow rescale the G/M boundary values to the values decided upon in the intercalibration. Doing so would also alleviate the most difficult problems in burden distribution, as it would at least in principle create situations where Danish water bodies of the open coastal type would be able to achieve G/M boundary values in the future, provided international Baltic waters do not deviate from the planned course.

With respect to burden distribution, the Panel realises that adjustment of G/M boundaries to the intercalibrated values will not solve all problems, but is a necessary step to take in order to make the problem manageable. It remains rather optimistic to have G/M boundary values for coastal water bodies that are not higher than the target values for open waters adjacent to the coast. As there is inevitably some nutrient input at the coast, a scientifically consistent solution would require coastal G/M boundary values to be at least slightly higher than the values for open waters. To the degree that HELCOM targets are currently less stringent than WFD targets, full consistency could obviously also be reached by making the HELCOM targets more stringent. In any case, the Panel identifies consistency between MSFD and WFD targets as a point of concern and a subject for further international action in the coming years.

With respect to international diplomatic action, Denmark has weakened its position by lowering unilaterally the G/M boundary values that had previously been agreed upon in intercalibration exercises. If Danish waters cannot reach a target value that lies significantly below the concentrations of inflowing open sea water, chances are high that this will be considered by other countries as a self-inflicted problem. It is highly unlikely that other countries would engage in achieving a water quality better than their own intercalibrated quality goals, just because Denmark has later revised its calculation and deviated from the intercalibrated (i.e. internationally agreed) goals.

4.4.2 Scenarios used for calculating burden distribution

The discussion on burden distribution is founded on a large number of scenarios run with the models. Eventually, for RBMP3 scenario 2e has been chosen, supplemented with some additional measures for P-reduction in the international Wadden Sea. This combination of scenarios is rather optimistic. Judging from the way neighbouring countries implement their RBMP3, including the use of exemptions, the Panel estimates a rather low probability that all promises summarised in these scenarios will be fulfilled. Consequently, no room for manoeuvring is seen in further pushing hopes in scenarios. On the contrary, a realistic provision for not reaching all projected hopes in the chosen scenario should be made. The Panel notes that the diversity of scenarios calculated provides sufficient information to do so if the need for it would become clear.

4.4.3 Legal evaluation

The Panel concludes that Denmark has to fulfil its WFD obligations for the achievement of Good Ecological Status in coastal waters. There is no legal evidence for arguing that the influence of transboundary pollution on achieving the Good Ecological Status results in decreased obligations under WFD. On the other hand, the Panel also concludes that the influence of transboundary pollution on the achievement of Good Ecological Status is an essential element in the decision-making process on the utilisation of exemptions. The Panel discusses the framework for the use of exemptions in detail in Chapter 8.

The European Union obliges its Member States to cooperate loyally (see Art. 4 (3) TEU). The Panel stresses that Denmark is obliged by – *inter alia* – the principle of loyal cooperation of the Member States under European law to assume, when determining the necessary nutrient reductions, that the other Member States in their RBMPs comply with and will comply with their obligations under WFD. This means: The Danish determination of the required nutrient reductions is linked to the use of the exemptions from the management objectives for coastal waters in the RBMP3 in Sweden and Germany and the resulting reduction measures there. An exception to this principle can only be considered if it has been established with certainty that another Member State is in breach of mandatory provisions of WFD, e.g. if a decision of the European Court of Justice (CJEU) contains corresponding findings.

Following this main European principle, the Member States are obliged to implement all measures necessary to comply with the obligations arising from the legal acts of the institutions of the European Union. This obligation is concretised with regard to the management of coastal waters by the legal acts of WFD and MSFD (see Art. 288 TFEU). From a legal point of view, an exception to this basic obligation only exists if a legal act explicitly provides for it (see Art. 192 par. 5 TFEU)[37]. The WFD contains exemption provisions regarding the achievement of Good Ecological Status in coastal waters in Art. 4.4 to Art 4.7 WFD. The permissible use of these exemptions must be examined and assessed at the water body level (see chapter 8). In doing so, the influences of transboundary pollution on the possibility of achieving Good Ecological Status (in time) in a water body can be taken into account.

It is of importance that addressing the influence of transboundary pollution on the achievement of Good Ecological Status in Danish coastal waters in the context of eutrophication with other Member States is not a justification for not identifying the required Danish nutrient reductions and/or not selecting the measures necessary for implementation. WFD contains no indication that – on an abstract level – the obligations of the WFD are not to be fulfilled, because the achievement of Good Ecological Status is largely dependent on influences that cannot be changed by a reduction of nitrogen loads in Denmark. In this context, the Panel emphasises that only in the open coastal waters, e.g. around Bornholm, transboundary pollution constitutes a decisive influence that prevents the achievement of the WFD objectives. Contrary to what some stakeholders suggest, transboundary pollution is by no means an influence that equally prevents the achievement of ecological status in all coastal waters.

In this context, the Panel refers to chapter 8 and its findings on implementing the necessary measures to achieve WFD's aims while using an exemption. Regarding the implementation of effective measures to reduce transboundary pollution, the CIS Guidance Document No. 23 refers the Member States to the international actions within the Regional Sea Conventions, e.g. OSPAR and HELCOM:

> *"Where coastal eutrophication is an international problem, it needs to be tackled by co-ordinated national and international efforts. This reality is at the origin of the Regional Seas Conventions, which have started strategies to combat eutrophication already in the late eighties recognising the need for a harmonised way of assessing the eutrophication status of the nations 'common' waters. For more detailed information on the work on eutrophication by the regional sea conventions see Annex I Section 2 of this guidance."*[38]

Furthermore, Art. 5 in MSFD provides a framework for the cooperation of Member States which is applicable on challenges coming from transboundary pollution for achieving the Good Ecological Status in coastal waters. The Member States are obliged to cooperate on finding the measures necessary to address the objectives in MSFD, including the demand for decreasing the effects of eutrophication (See also chapter 8):

> *"Member States sharing a marine region [the Baltic Sea] shall cooperate to ensure that, within each marine region […], the measures required to achieve the objectives of this Directive, in particular the different elements of the marine strategies […], are coherent and coordinated across the marine region […] concerned […]"*

Art. 5.2 (b) MSFD includes the requirements for Member States to cooperate in the establishment of programmes of measures to achieve Good Ecological Status in marine waters. In this way, the European Union is creating a framework in which Denmark, together with the other Member States responsible for transboundary pollution in Danish coastal waters, can take the necessary measures to achieve the WFD targets for ecological status.

For the findings, the Panel has considered the stakeholder´s statements on the COWI and NIRAS report. The Panel addresses the included criticism provided by Landbrug & Fødevarer briefly in the following:

- The references by Suykens/van Calster to the planned amendment of the WFD are irrelevant to the Panel´s evaluation.[39] The Panel is obviously bound to the applicable law for evaluating the RBMP3. A future amendment to upgrade certain WFD regulations for the management of transboundary pollutions has no relevance for the determination of the reduction of nitrate inputs from Denmark in RBMP3.
- In addition, it is uncertain whether the additions to Art. 12 WFD will actually provide the member states with an effective instrument to address the transboundary nitrogen loads vis-à-vis the other member states. And even then, it is the Panel's recommendation to use a revised Art. 12 WFD in addition to the existing possibilities to reduce nitrate pollution in the Baltic Sea together with the other Member States in such a way that the nitrate situation in the Danish open water bodies improves considerably in the sense of the WFD. The Panel strongly advises against waiting until a revised Art. 12 WFD is implemented in all Member States to implement the necessary measures for reducing transboundary nitrogen loads on an international level.
- It is irrelevant whether it is true that the determination of the reduction of nitrogen loads did not take into account the exemptions claimed in Germany and Sweden.[40] This argument is based on a

[37] Art. 192 (5) TFEU: „Without prejudice to the polluter pays principle, where a measure referred to in [a legal act on environment] involves disproportionate costs for the authorities of a Member State, it shall include appropriate provisions in the following form: […] temporary derogations."

[38] CIS Guidance Document No. 23, pg. 54.

[39] See Suykens/van Calster, High level review of COWI ´Second opinion on the need for reduction of nitrogen in the third RBMP for 2021-2017, Phase I´, pg. 9.

[40] See Suykens/van Calster, pg. 10.

misunderstanding of WFD´s exemption scheme. A legitimate use of the exemptions, e.g. the time extensions for coastal waters in German RBMPs until 2039 or 2045, requires that all measures necessary to achieve Good Ecological Status are implemented. These measures must be planned, financed and started in implementation to significantly reduce nitrate loads by 2027 in order for Germany to meet its obligations to achieve Good Ecological Status in coastal waters - despite the use of the deadline extension.

4.5 Conclusions and recommendations

Denmark should use the existing legal framework to minimise the effects of transboundary pollution as quickly as possible together with the other states cooperating in the Regional Sea Conventions OSPAR and HELCOM. Denmark should invite the other Member States to intensify cooperation in the preparation of the programmes of measures under MSFD, and in coming years aim at improving consistency as much as possible between the WFD requirements for Good Ecological Status with complementary requirements of the MSFD.

The discussion on the influence of transboundary pollution on the achievement of Good Ecological Status in coastal waters should not distract from the necessity of Denmark fulfilling its obligations to achieve the objectives of the WFD in coastal waters. However, the influence of transboundary pollution should be considered at the level of the application of the exemptions (see Chapter 8).

It is recommended to update the identification of reductions in nutrient inputs from other Member States based on their RBMP3 in the further course of the Danish RBMP3. This will ensure that the current efforts of the other Member States are determined.

CHAPTER 5: SEASONALITY

5.1 Introduction

The discussion on 'seasonality' is based on early model results that have shown that, by selectively reducing nutrient loads in the summer season, the annual load reduction of nutrients to some water bodies could be reduced.[41] Since nitrogen in general is the limiting nutrient in summer months, summer season nutrient load reductions would affect the biological quality indicators more directly than reductions in winter and fall.

However, this discussion has been confounded from an early stage onwards by a second discussion on the importance of point source loading in summer. It has been argued by stakeholders that nutrient leaching from fields is minimal in summer, and that therefore point sources are disproportionately important in summer season and major determinants of the quality indicators. Both questions are therefore linked, but it adds confusion to the debate if questions shift from the balance between point and diffuse source measures, to the balance between year-round and growth-season measures for diffuse sources, and back. Moreover, further complication is added because questions regarding the seasonal reduction of N-load are mixed with questions regarding the reduction of P-load. In what follows, the Panel will try and keep these discussions as separate as possible. Note that questions regarding reduction of P-load are discussed in chapter 6.

5.2 Results from Phase I

5.2.1 Central findings by COWI and NIRAS concerning seasonality

Overall, COWI and NIRAS have assessed that "N-load reduction during the summer season (seasonality) may give room for manoeuvring for specific water bodies".

Seasonality is assessed in more detail in task 7 in the phase I report by COWI and NIRAS, which to some extent is based on assessment of Erichsen et al., 2021[42]. In task 7, COWI and NIRAS conclude that while N-loads during the growth season may have a higher impact on the biological indicators and it may be possible to optimise the effect of "per tonnes load reduction" on biological indicators, this optimised reduction will be at a local level, that will not change the overall need for reduction at a national level. COWI and NIRAS also assess that it will require a comprehensive and site-specific documentation on sources and measures to assess alternative potential effects of summer measures on MAIs. It is also assessed, that introducing summer measures will add considerable uncertainty to the model results, and that it will be relevant to include phosphorus in the analysis, because phosphorus is often the limiting factor for Chl-a growth during spring, while N-concentrations are often limiting during the summer:

> *"Seasonal subdivision of the N-load is calculated on small data sets in the present study. However, the method seems applicable to indicate how the choice of measures will affect the N-load during the summer months. But because of the uncertainty of the effect of the targeted measures, it is difficult to assess the effect on the summer discharge of N. However, 18 out of 109 water bodies have a large or medium potential for N-MAI modification through reduced summer load. The effect of increased reduction of summer load on N-MAI is modelled for each water area. Locally, there can be an effect. At a national level, the effect is insignificant. In most of the designated water bodies, the diffuse N-load is still the largest. It is less than 75 per cent of the summer load in just four out of the 18 water areas. This diffuse discharge of N during the summer is likely not to be reduced by measures including the cultivation surface, while in some catchment areas the targeted effect may be achieved through drainage measures.*
>
> *Assessing the potential effect of summer measures, and hence the MAI modification, requires comprehensive and site-specific investigations/documentation. The limited experience from summer measures introduces considerable uncertainty to the model results, and nutrient load reductions on annual scale is therefore still most effective. It will also be relevant to include P in the analysis of the effects of seasonal variation as P concentration often is the limiting factor for the phytoplankton growth during spring, while N concentrations often is limiting during summer."*

5.2.2 Central remarks by stakeholders concerning seasonality

Among the stakeholders who have commented on seasonal variation in the modelling work, the comments in general highlight the importance of point sources during summer when N output from agriculture is low, and that

[41] DHI (2017) Optimisation of the Nitrogen Loadings to Karrebæk Fjord - Seasonal Effects from Nitrogen Reductions. Report prepared for SEGES, 89pp.

[42] Erichsen, A. C., Nielsen, S. E. B., Timmermann, K., Højberg, A. L., Eriksen, J., & Pedersen, B. F. (2021). Muligheder for optimeret regulering af N- og P-tilførslen til kystvandene med fokus på tilførslen i sommerhalvåret - Analyse og kvantificering. DHI. https://pure.au.dk/portal/files/228142340/Muligheder_for_optimeret_regulering_af_N_og_P_tilf_rslen_til_kystvandene_med_fokus_p_tilf_rslen_i_sommerhalv_ret.pdf [In Danish, accessed through Google translate]

this has not been assessed by COWI and NIRAS. They also point to the importance of stormwater overflow, which are active sources year-round, but with a relatively higher importance in summer.

Some stakeholders comment on the conclusion from COWI and NIRAS on seasonality being “insignificant” at the national level. The stakeholders state that in water bodies with fast water exchange, nitrogen loads from fall/winter will be gone before algal spring bloom starts, and that this applies to most Danish fjords and all open waters. They highlight that seasonal variation potentially can have a very significant impact on N-MAI, and that the importance of water exchange on the timing of when N becomes the limiting factor is not investigated sufficiently in Erichsen et al., 2021[42], or in the report by COWI and NIRAS. One stakeholder also stresses the link between seasonality and strategies to reduce P-load.

5.3. Selected focus by the panel in the evaluation of the theme

For this chapter, the Panel identified two core discussions. One is on the question whether to focus on point or on diffuse sources of nitrogen to the coastal waters. The other is on the practical feasibility of applying seasonal nutrient load control. Both questions are also subject to further investigation within Phase III of the second opinion, therefore this ongoing work is shortly mentioned even though final products were not available to the Panel to comment on.

5.4. Discussion of issues within the evaluation theme

5.4.1 Phase III project on seasonality and other matters

In Phase III of the second opinion process, models will be developed to investigate the possibilities and costs of refined measures to reduce N-loading during the summer growth season, balance reduction measures between N- and P-loading, balance reduction measures between point and diffuse sources, and calculate the cost-effectiveness of the different scenarios. The research focuses on those watersheds that have been shown to be sensitive to seasonally managed N-inputs and/or to combined N-P reduction measures.

Results of this study were not available at the time of writing this report. The Panel’s evaluation therefore applies to the state of affairs prior to finalising the Phase III research. However, the Panel takes note of the fact that some of the concerns expressed in the present evaluation will be addressed in that Phase III research. It is therefore proposed by the Panel that the researchers in Phase III explicitly evaluate to what extent they have been able to address the questions and remarks formulated in the present report of the Panel.

5.4.2 Evaluation of ‘point versus diffuse sources’ discussion

Point sources of nutrient loading are primarily related to wastewater treatment plants. Over the past decades, Danish water authorities have made a huge investment in wastewater purification systems, and there is continued spending on the running costs of purification. These efforts have strongly reduced the nutrient load from point sources to Danish water bodies. Between 1990 and 2021, the nitrogen load from point sources has decreased with approximately 80 per cent, from approximately 25.400 tonnes N/year in 1990 to approximately 5.800 tonnes N/year in 2021[43]. That was realised despite a significant increase of total population number. The decrease in diffuse source loadings have been much lower, 35 per cent over the same period[44]. Hence, the contribution of point sources to the total load has decreased from approximately 25 per cent of total loadings in 1990 to approximately 11 per cent in 2021.[44] Also at the level of individual water bodies, diffuse sources currently dominate over point sources in most catchments. That is true even when we focus on summer loads. Only in three out of 18 investigated water bodies, the diffuse loading is less than 70 per cent of the total summer loading (table 6-2 in Erichsen et al. 2021).[42] Addressing point sources may therefore only make sense in a few well-selected water bodies.

A notable exception to this tendency is the contribution by stormwater overflow, which became a more important part of the total point source loadings as the sewage water treatment was improved. The N-load from stormwater/rain related point sources (*regnbetingede udledninger*) rose from approximately 3 per cent to 17 per cent of total N-load from point sources between 1990 and 2021, corresponding to approximately 1.3 per cent of total land-based N-load.[45] Simultaneously, the P-load from stormwater/rain related point sources rose from 4 to 24 per cent of total P-load from point sources, corresponding to approximately 7.4 per cent of the total land-based P-load.[45] Although stormwater overflow is not, in general, the quantitatively largest source of eutrophication, it is the component of point sources that has received almost no attention and that has actually increased in absolute magnitude while wastewater sources have plummeted. Apart from being a source of nutrients, stormwater overflow

[43] Miljøstyrelsen, 2023. Punktkilder 2021 – NOVANA punktkilder, 82pp. https://www2.mst.dk/Udgiv/publikationer/2023/03/978-87-7038-492-6.pdf

[44] Thodsen, H., Tornbjerg, H., Rolighed, J., Kjær, C., Larsen, S.E., Ovesen, N.B. & Blicher- Mathiesen, G. 2023. Vandløb 2021. - Kemisk vandkvalitet, stoftransport og miljøfarlige forurenende stoffer. NOVANA. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 90 s. - Videnskabelig rapport nr. 527 http://dce2.au.dk/pub/SR527.pdf

[45] See RBMP3, table 3.28 on p60, https://mim.dk/media/235166/vandomraadeplanerne-2021-2027-5-7-2023.pdf

may locally also be a major source of pollution by other contaminants and faecal bacteria. As such, there are good reasons for concentrating more on this source. Treating stormwater overflows is not easy and may require landscape intervention, e.g. for buffering. Synergy with landscape retention measures useful for diffuse sources may become possible in the future. Ideally, such measures should focus on the role of stormwater overflow in P-loading rather than in N-loading, which is a technical challenge as retaining P is more difficult than retaining N.

The discussion on the reduction of summer loads by further purifying point sources versus taking measures in agricultural fields, also has two components. One discussion is on the technical feasibility and cost of measures. The other discussion is on diversion of costs from agriculture to the wastewater sector. Enhanced efforts on point sources will probably be financed mainly by utilities (and hence the water and wastewater customers), whereas the cost of measures in agriculture will be at the expense of the agricultural sector. The panel will not comment on this political question of cost distribution but emphasises the urgency to deal with it.

Cost-effectiveness of different measures, including a weighting of the cost of reducing point sources and diffuse sources, is subject of extended studies in Phase III. Without having access to these results, the Panel expects that the law of diminishing returns will apply, since further N- and P-reductions at the wastewater treatment plants over and above the 80 respectively 92 per cent reductions which have been achieved between 1990 to 2021 will imply relatively high marginal costs. Provided new technological approaches and solutions can be found, this law of diminishing returns may not apply to stormwater overflows, which until now remain largely untreated and thus offer some opportunities for first measures to be cost-effective.

5.4.3 Technical feasibility of seasonally adjusted nutrient load reductions in agriculture

In discussing the feasibility of seasonally adjusted nutrient load reduction in agriculture, it has been argued that such measures would be called for in catchments of water bodies with a short residence time of the water. In these water bodies, flushing would eliminate all winter/spring nutrient loading before the summer season starts.

However, for this discussion it is important to note that the residence time of the water in a water body is only one of a whole series of relevant time scales for the dynamics of nutrient loading and its impact. Much longer time scales are involved with the residence time of nutrients in the field. Further, nutrients in the coastal water bodies are taken up by phytoplankton in spring and retained in benthic detritus pools, even when the water is flushed and renewed. This may lead to prolonged residence times of nutrients, compared to water, in the water bodies. The mechanistic modelling represents this process, but the model outputs have not been specifically inspected to quantify its importance. Finally, residence time of the nutrients in the total body of coastal waters may be much longer than residence time in the headwater fjord if the latter is rapidly flushed. Downstream effects are therefore likely if winter loading is not restricted.

The current explorations have not investigated these effects, but they are almost inevitable. Erichsen et al. 2021[42] concluded that significant extension of the present modelling tools would be needed to evaluate the full possibilities, including downstream and catchment effects, for all water bodies that have some potential for seasonal regulation. This aspect will be taken up in Phase III research, but currently no results are available. At this moment, it is a major source of uncertainty.

Erichsen et al. (2021)[42] also made an inventory of possible measures to control the seasonality of nutrient loading from the fields. With the exception of constructed wetlands (see below), the number of other possibilities is very limited. The management of drainage systems is a possible seasonal measure in some watersheds, but it is a distributed measure which is extremely difficult to monitor and control. In order to arrive at practical guidance for the implementation of 'seasonality' measures, the Phase III research should not only include technical possibilities, but also consider actual implementation and compliance control aspects. With the presently available information, the Panel does not see any real opportunity besides wetland construction.

Construction of artificial wetlands to enhance nitrogen retention in the field, can either be considered a year-round measure (wetlands obviously exist year-round), or a seasonal measure as the processes in these wetlands are faster and removal of nitrogen is more intense in summer. Depending on the further accumulation of knowledge and data about the functioning of these wetlands as they are implemented in practice, there should be room for consideration of their contribution in a seasonal context. If constructed wetlands have more beneficial effect in summer than in winter, this could be reason to weight their contribution to total nitrogen retention with a 'seasonality equivalence' that expresses how 1 kg N removed in the growing season is equivalent to x kg N retention if it were retained year-round. The models developed in Phase III can likely provide a basis for such estimation, under the condition that they correctly incorporate downstream effects. The Panel estimates that such seasonality factors will be strongly water-body specific, as they depend on retention times in both soils and water bodies.

5.4.4 Local Community-Based Management

According to the documentation by the Ministries, local/regional analysis initiatives have been made possible in four selected areas covering nine coastal water bodies. These initiatives should lead to well-based alternative plans to be incorporated into the Second Opinion. The initiatives have been presented to the Panel. Subjects of analysis and pilot testing are wide-ranging, but few final results are currently available. Seasonality of nutrient input is one of the subjects explored in these initiatives, as is more emphasis on P, marine measures etc. The Panel was impressed by the broadness of the local participation and of the local/regional knowledge collected in these initiatives. This mobilisation of local knowledge offers advantages for problem ownership, creativity in solutions and flexibility in adjusting solutions to local conditions. The Panel noted a certain ambiguity with respect to the aims of the local initiatives. Where they focus on re-analysing the causes and possible remediations of eutrophication, this seems to be a duplication of the entire RBMP process and an unattainable goal within the given time frame. One should not lose more valuable time in prolonged studies and discussions, especially because it is highly unlikely to find significant alternatives to a strategy of decreasing diffuse loading. It would also be very counterproductive if every region could modify the aims of the river basin management plans.

The Panel is convinced that maximal effectivity of these local initiatives can be obtained if they can concentrate on the planning and execution of concrete measures within clearly defined, and well monitored objectives to be reached in fixed time periods. For this to be the case, the establishment of year-round MAIs per water body is necessary. However, the strategy may include, as noted above with respect to wetlands and also noted in Chapter 6 with respect to phosphorus measures, that there could be equivalence relations, expressing how a measure with seasonal influence or with influence on P, 'trades' for a measure that results in year-round N-retention. In contrast to P, where in most systems 1 per cent P-retention will value less than 1 per cent N-retention (see Ch. 6), an amount of N retained in summer will value more than the same amount in winter.

5.5 Conclusion and recommendations

With respect to managing point sources rather than diffuse sources, the panel concludes that this only seems to make sense in those few water bodies where point sources make up a significant part of the total summer load. Even in these water bodies, it should be carefully considered what the year-round expected effects are (including also downstream effects), what the relative costs of point vs. diffuse source control are, and who is going to cover these costs. Within point sources, a relatively underexplored possibility is the solution of problems caused by stormwater overflows, for which possibilities may arise in conjunction with landscape measures.

With respect to seasonal strategies on agricultural diffuse sources, careful consideration should be made of the likelihood of downstream effects, the complicated nature of catchment retention effects and the uncertainty that would be added when addressing seasonal strategies. Given these factors – and with the caveat that unexpected new insights may be provided by the Phase III research – the Panel agrees with the conclusion of COWI and NIRAS that seasonal strategies are unlikely to change national efforts, and that they will not play a main role in fulfilling the Danish obligations from the WFD.

However, in as far as the construction of wetlands is considered to be a seasonal measure, this option provides a clear exception. It is known that N removal processes in wetlands are more effective in summer than in winter. By using appropriate 'seasonality equivalences', one could focus on such systems with a correct estimate of their beneficial effects on eutrophication.

In order to obtain a coherent and convincing national strategy to address the WFD challenges in a reasonably short time span, the Panel is convinced that it is necessary to establish year-round MAIs for every water body. Only within such an overall strategy, would it be possible to open options for an adjusted local/regional strategy. Such a strategy should primarily aim at incorporating valuable local knowledge in the design and implementation of locally adapted measures and could include 'seasonality equivalence' factors that would broaden the scope for measures and adjust them to local conditions.

CHAPTER 6: PHOSPHORUS EFFORTS

6.1 Introduction

In the development of the different river basin management plans, most emphasis has been placed on the reduction of the nitrogen load to the coastal water bodies. The reason is that nitrogen (N) is the nutrient that is most often regulating phytoplankton development in most Danish systems. By further reducing the N-load, phytoplankton can be kept in check.

However, phytoplankton needs more than only nitrogen to grow. Phosphorus (P) is another macronutrient that may be in short supply and therefore limiting. Stakeholders have long argued that there is an over-emphasis on N, mostly emitted in large quantities from agriculture, compared to the importance of P, which is emitted in large quantities from both the agriculture and wastewater sectors.

In the models developed for RBMP3, more attention has been paid to possible effects of P-load reduction as a means of reducing eutrophication. Therefore, it is now possible to discuss whether there is room for manoeuvring by focusing not only on N-load reduction but also on P-load reduction.

6.2 Results from Phase I

6.2.1 Central findings by COWI and NIRAS concerning phosphorus efforts

Overall, COWI and NIRAS have assessed that there may be water bodies where N-MAI can be modified by exchanging a part of the nitrogen reduction requirements for a reduction of P-loads, but that such modifications would require more detailed studies of each individual water body. In addition, they find that water body-specific cost efficiency of relevant measures should be studied.

COWI and NIRAS acknowledge that the effect of Danish P-load reductions has been modelled for all management scenarios, allowing for examination of the effect of phosphorus reduction on indicator values at a water body-specific level. However, COWI and NIRAS observe that the period for which the Chl-a indicator is defined (i.e. summer) and the period when phosphorus is considered limiting for phytoplankton growth (i.e. spring) do not overlap. On this basis, they conclude that the effect of P-reductions is underestimated. Using a spring Chl-a indicator, in addition to the summer Chl-a indicator, would be more adequate to observe the effect from P-reductions. However, COWI and NIRAS conclude that introducing a spring Chl-a indicator is not practically feasible, due to the difficulty of obtaining representative Chl-a observations during the short spring bloom. They also recognise that it is unrealistic to include a new indicator into the WFD implementation.

At the national level, only a limited increase in N-MAI can be obtained by substituting with P-load reductions. For a 10 per cent P-load reduction at national level, the trade-off is only a 2 per cent increase in N-MAI, corresponding to approx. 1,000 t N/year.

6.2.2 Central remarks by stakeholders concerning phosphorus efforts

Many stakeholders suggest further investigations on the role of P in the eutrophication process, and especially the effect of reducing P. Furthermore, some stakeholders highlight the need for more knowledge in general and consider that too little investigation/focus was documented in phase I. In particular, the comments highlight the importance of understanding the timing of when N and P are considered the limiting factors during the growth season. Stakeholders comment that the effect of P on eutrophication is underestimated by the indicators (primarily Chl-a) measured during the summer period.

Several stakeholders highlight the role of the nutrient legacy (especially the P-legacy) on the current eutrophication, both at the large scale of the Baltic Sea system, and in the Danish fjord systems. This results from historically high P-loads. Some stakeholder remarks and opinions are very well informed with respect to sediment P-pools, sediment-water exchange dynamics, delays, and seasonal dynamics. There is less emphasis on the storage of P in soil and the sources from agricultural practices.

Most stakeholders encourage the use of P-reductions to a larger degree, as an alternative to N-reductions. They point out that in the past, eutrophication has responded fast and reliably to reductions in P-load from wastewaters. They state that the currently used indicators (summer Chl-a and eelgrass depth limit) focus on seasons outside the period of P-limitation and may therefore mask the important role of P in the ecosystem, as well as the possibilities offered by further P-reduction.

6.3. Selected focus by the panel in the evaluation of the theme

For the implementation of the WFD, the most important question is whether reduction of P-load can, to a certain extent, replace N-load reduction, which would provide room for manoeuvring in the management. To evaluate this, possible influences in the effectiveness of P-reduction would have to be taken into account. Recently compiled data is used to illustrate the intricate relation between N- and P-loading. The suggestion to introduce a new indicator that is more sensitive to phytoplankton dynamics in the (often P-limited) spring season is also addressed.

6.4. Discussion of issues within the evaluation theme

6.4.1 Room for manoeuvre by implementation of phosphorus reduction measures

The sensitivity simulations performed with the mechanistic model demonstrate some effect on the Chl-a and Kd/eelgrass indicators from phosphorus load reductions in some water bodies[46]. The sensitivity was explored by imposing a 30 per cent reduction of phosphorus load while all other loads were kept at present day condition. Subsequently, the N-MAI for each water body was computed by combining all responses in management scenario 2e with the effect for selected levels of P reduction in Denmark. Thereby, an N-MAI for each water body for each level of P-reduction is available. This information allows for a calculation of a water body-specific equivalent N-reduction for a given P-reduction. This could form the basis of a simple accounting scheme where, for example, measures that will result in both N- and P-reductions can be transformed into an equivalent (higher) N-reduction. Similar to what has been stated with respect to seasonality in Chapter 5, the Panel believes that such accounting system would, in practice, broaden the scope for local implementation schemes that maximise all possibilities for nutrient reduction. Where the aims of improving water quality can be reached more efficiently by (also) reducing P load, it would be deplorable not to use these opportunities. With the use of equivalence ratios, part of the need for N reduction following from the national RBMP, could locally be 'traded' for an equivalent P reduction.

The Panel warns that it follows from the model results[46] that the room for manoeuvring by shifting N-reductions to P-reductions is in practice rather small, both on a national level and in most water bodies[46]. However, as most measures on diffuse sources will have an effect on both N and P, a certain room for manoeuvring may exist.

COWI and NIRAS claim that additional water body-specific investigations would be necessary before N-MAI could be modified by P-reductions. The Panel sees no scientific arguments that the modelling of the effectiveness of Danish P-reductions should be of lower quality or accuracy than those for N-reductions. Therefore, there are no objective reasons for not using the available information when planning and implementing measures in the current RBMP. The Panel estimates that no further research on this topic is needed, as the current information is already available at the scale of individual water bodies and in a form that allows for an accounting exchange with N-load reduction.

6.4.2 Limitations of effectiveness of phosphorus load reductions

In a recent report[47], the nutrient limitation regimes were documented for a large number of water bodies. Seasonal cycles of surface inorganic nutrient and Chl-a concentration data were computed and displayed for monitoring stations, showing that, in several cases, inorganic phosphorus (DIP) is depleted before inorganic nitrogen (DIN), as illustrated in Figure 6.1-6.3 on the next page.

It is evident that the spring depletion of DIP is due to the very high winter DIN compared to DIP, as in the example in Figure 6.1-6.3 when the current winter DIN:DIP molar ratio is close to 80:1, which greatly exceeds the Redfield ratio for phytoplankton (16:1). The actual winter concentration levels show that there is a strong excess of DIN due to unproportionally higher anthropogenic nitrogen loads than anthropogenic phosphorus loads. In the absence of this large excess of N-loading, which is the case in some (open) water bodies, N and P decrease simultaneously in spring and both are depleted around the same time. Consequently, it is expected that the onset of N-limitation will shift to earlier in the season (early summer or even spring) as the severity of N eutrophication decreases.

Typically for shallow systems, there is a strong benthic-pelagic coupling where planktonic material sinks to the sediment and remineralises on the sea floor, causing a reflux of inorganic nutrients. Typically, about 50 per cent of the nitrogen is lost through denitrification during each cycle, while virtually all phosphorus is returned to the water column. In cases with seasonal oxygen depletion, phosphorus bound to iron oxides at the sediment surface will be released, adding to the reflux of phosphate.

In most of the Danish fjords, the stronger refluxes of phosphorus in relation to nitrogen during the summer-autumn manifests in loss of phosphorus limitation and increasing DIP concentrations.

---

[46] Overview and links to detailed reports are available in: Erichsen, A.C., Timmermann, K. & Christensen, J.P.A. 2023. Second opinion readers guide to RBMP 3 models and scenarios in Denmark. Aarhus University, DCE – Danish Centre for Environment and Energy, 31 pp. Technical Report No. 268 http://dce2.au.dk/pub/TR268.pdf

[47] Gertz F, Thostrup L K, Møller K D, 2022. Nutrient limitation in Danish Coastal Waters. Report from SEGES Innovation Link: https://www.landbrugsinfo.dk/-/media/landbrugsinfo/public/6/B/D/cowi_report_nutrient_limitation_in_danish_coastal_waters

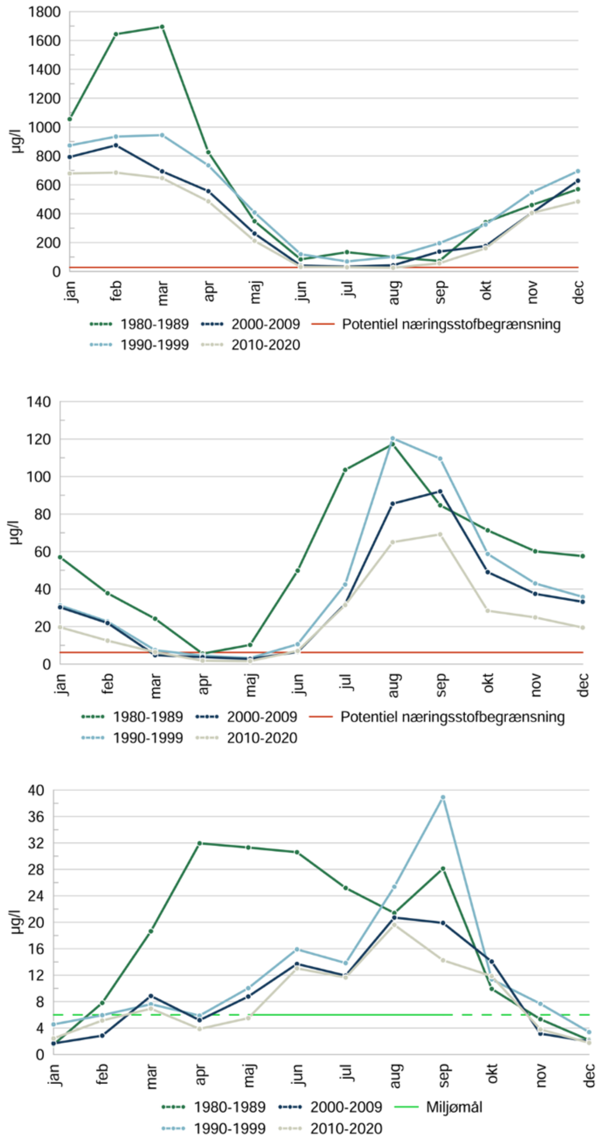

Figure 6.1-6.3. Monthly average concentrations of DIN (top panel), DIP (middle panel) and Chl-a (bottom panel) in the surface layer of Skive Fjord. The red lines in the DIN and DIP figures indicate approximate levels where the nutrient becomes limiting. DIP concentrations have since the 1990s been depleted during spring, while DIN concentrations still are quite high, indicating a clear case of phosphorus limitation in spring. Only in June are DIN concentrations low enough to cause nitrogen limitation. The reason for spring DIP limitation is primarily the excess of DIN during winter, and DIN only becomes limiting when DIP increases during summer due to intense reflux from sediments. Figures are obtained from Gertz et al., 2022.[47]

A conclusion from these observations and interpretations for eutrophication abatement is that the effectiveness of P-load reductions is not independent of N-loading. When nitrogen inputs are curbed and winter DIN concentrations are reduced, N and P will become co-limiting earlier in the season, and specific phosphorus reductions will have less controlling effect on the early summer productivity and consequently on the indicators. Whether or not this can evolve in enclosed fjords to a co-limitation of N and P from the early spring onwards, as is seen in open coastal waters, is unsure. However, the forward shifting of the co-limitation implies that a re-evaluation of the dose-response relationships for P may be needed when effects from measures are evident and N-limitation gains in importance.

6.4.3 New indicator being sensitive to ecosystem dynamics in spring

Stakeholders have suggested adding an additional indicator that is more sensitive to ecosystem dynamics in spring, and thus to the potential effect of P-reduction. COWI and NIRAS have rejected the idea based on time and effort considerations, and on the lack of suitable data for the short and very variable spring season. The Panel endorses these arguments and also rejects the idea of extending the set of indicators. It is clear, and illustrated by the discussion above, that the biogeochemical cycles of N and P are intricately linked, but largely dominated by the N-load in most Danish systems. Thus, while not rejecting any practical opportunities to reduce eutrophication by (also) reducing P-load, the Panel is convinced that the focus of the implementation of the WFD should remain on N-loads as the main factor responsible for eutrophication of the coastal waters.

6.5 Conclusions and recommendations

- Modelling results can provide the basis for converting P reductions in equivalent N reductions, thus opening possibilities for combined N-P load reductions in planning and implementing measures in the current RMBP. N-equivalence of P-reductions, based on the available models, could be used in an accounting system that rewards measures that (also) aim at P-reduction.
- The model results show that this can only be a profitable strategy in a limited set of water bodies and will not replace most of the necessary N-reduction. However, measures that reduce N- and P-load simultaneously, will be more effective than purely N-reduction in at least part of the systems.
- A re-evaluation of the effectiveness of P-reduction on eutrophication indicators should be performed as the nutrient limitation regime will change when nitrogen concentrations decrease in the water body.
- Development of an additional indicator for spring phytoplankton (Chl-a) is difficult and neither useful nor necessary.

CHAPTER 7: PRESSURES AND STRESSORS OTHER THAN NITROGEN

7.1 Introduction to the theme

The objective of Chapter 7 is to review the importance of the impact of other pressures than nitrogen load, that may be of significance for achieving the objectives of the Water Framework Directive (WFD). The Phosphorus load has been treated in Chapter 6. In this chapter, the impact of eight further pressures is discussed. They are a mixture of physical, chemical and biological pressures and stressors: sand extraction; dumping and dredging; physical structures; hazardous substances; plastic; ship traffic; invasive species; fishery.

7.2 Results from Phase I

7.2.1 Central findings by COWI and NIRAS

In their evaluation, COWI and NIRAS assessed which factors can be modelled to a sufficient degree to estimate how they could impact MAI, and further evaluated how large this impact can be expected to be. The pressures from sand extraction, dumping, dredging, physical structures and hazardous substances on the biological quality elements (Chl-a and eelgrass) can be modelled to a relatively high degree with existing tools. It is found that the impacts of these pressures are mostly limited in mass, space and time and that their impacts are therefore of smaller scale than the impacts of N- and P-load as long as the impacts are within the orders of magnitude that have been experienced until now. It is considered unlikely that these pressures have potentially significant impacts at water body level. No impact-response relations were found for fishery, ship traffic, plastic and invasive species, so these pressures were not modelled but evaluated based on expert judgement. The most important of the pressures was physical disturbance from fishery. Nevertheless, the pressure from fishery is secondary compared to nutrient load, although fishery cannot be modelled to the degree of validity of the N- and P-models. Furthermore, fishery has mainly a local impact, especially on eelgrass.

Overall, COWI and NIRAS concluded that “it is expected that measures towards other press factors will not lead to changes in MAI. This does not mean that other pressures are not relevant. For instance, it could be considered to have a more systematic approach regarding other pressures to support achieving Good Ecological Status”.

7.2.2 Central Remarks by stakeholders in relation to other pressures

The Focus on nitrogen: Several stakeholders expressed their frustration with respect to the focus on the nitrogen pressure for establishing the Reference condition and Good Ecological Status. One stakeholder points to the role of organic matter in wastewater as an important source of pollution. Several stakeholders acknowledge the central role of nutrients in the ecological status, but argue that other stressors also negatively affect the ecological status; reducing these may thus decrease the need for limiting nutrient input.

One stakeholder discusses the effect of other stressors on light conditions for eelgrass. Reference is made to recent literature showing that fisheries’ disturbance may significantly affect light climate, and that, moreover, eelgrass has difficulty recovering once it has disappeared, because other organisms affect the stability of the sediment and indirectly the light climate. It is argued that such effects can be modelled. Stakeholders also put forward that disturbance of sediments by fisheries can affect release of chemicals, including phosphorus, and can lead to smothering of eelgrass beds.

7.2.3 Other relevant information

A project investigating other pressures was performed by DTU Aqua. Results were summarised in one overall report.[48] From this report we note the following general conclusions in the English Summary:

> *“Overall, the screening of the scientific research literature and the performed data analyses that have been possible show that primarily fishing and secondary – and to a much lesser extent – invasive species are currently the most significant other pressure factors on the WFD quality elements in the WFD water bodies besides nutrient loading and climate change. However, for some of the pressure factors, this conclusion is based on a deficient data base. […]*
>
> *With regard to fisheries, use of bottom affecting gear like bottom trawl, mussel dredge etc. take place in almost half of the WFD water bodies. In the vast majority (68%) of the fisheries affected areas, the cumulative impact over 5 years constitutes <10% of the total area of the water body (some of which may be repeated impacts of the same area), but for some areas it is a very massive fishing impact. This applies in particular to the areas along Jutland's west coast, but there is also a significant area impact in several areas in and around the Kattegat. It can be readily assumed that fishing with bottom trawls can have a very*

[48] J.K. Petersen. 2021. *Andre presfaktorer end næringsstoffer og klimaforandringer – sammenfatning*. DTU Aqua-rapport nr. 381-2021

significant effect on eelgrass, not least because the expected regeneration time for eelgrass is very long, whereas it was not possible to detect effects on benthic infauna using the WFD indicator DKI. A model study on impact of mussel dredging on Chlorophyll a concentrations did not reveal effects. A literature review of cascade effects of finfish fishing on the quality element phytoplankton likewise could not demonstrate expected significant effects in Danish WFD water bodies."

7.3. Selected focus by the panel in the evaluation of the theme

In the discussion below, the Panel focuses on three main questions. First, it is discussed which other pressures are regulated by the WFD, and which are primarily taken care of by other directives.. Next, the Panel distinguishes between two clearly different aspects of the influence of other stressors: (i) can alleviating other stressors lead to less need for reduction of nutrient inputs? and/or (ii) will other stressors mask the positive effects of nutrient load reductions? Our discussion focuses on relatively large-scale impacts that could have effects on the scale of WFD water bodies. This rather formal approach is necessary from the legal point of view. However, all the relevant pressures must be considered, as well as the legal aspects.

For these discussions, the Panel leans on the inventories and studies made previously and cited above.

7.4. Discussion of issues within the evaluation theme

7.4.1 Relevance of the various pressures to the WFD

Not all the 8 pressures are of equal relevance to the WFD; some of them are more relevant to other Directives. For example, contaminants, fisheries, marine constructions, marine noise are dealt with in the MSFD, rather than the WFD. The contaminants are now in the Environmental Quality Standards directive[49] rather than Annex VIII and X of the WFD.

The following assessment is based on the defined Quality Elements of the WFD. Physical pressures from sand extraction, dumping and dredging, physical structures, and to a lesser extent disturbance of sediment by ship traffic, are relevant to the Structure and Substrate Hydro-morphological Quality Element of the WFD. Chemical pressures from hazardous substances are relevant to the WFD. Some are under the Annex VIII, Indicative list of main pollutants, which includes biotin compounds and biocides. They are also relevant to Annex X of the WFD and therefore to the Environmental Quality Standards Directive. Ship traffic is both a physical and chemical pressure. Invasive species are Descriptor 2 of the Marine Strategy Framework Directive. The MSFD explicitly requires fishing activity to be managed so that conservation objectives for the broader marine ecosystem might also be achieved. Plastics are Descriptor 10 of the Marine Strategy Framework Directive. Ship emissions will be included in the EU Emissions Trading System (ETS) as from January 2024, whereas energy and noise from ships are under descriptor 11 of the MSFD. It means that these pressures from shipping are more relevant to other policies than to the WFD.

It is well known that in coastal waters the Good Ecological Status, aimed at in the WFD, can also be threatened by some of the stressors primarily regulated through other directives. Fisheries pressure on sediments may be a good example of these. While primarily regulated through MSFD, it remains a factor of importance for reaching Good Ecological Status. Policies within WFD to reach GES must therefore co-ordinate with policies within other framework directives, in order to reach common goals.

7.4.2 Can the need for nutrient input reduction be alleviated by reducing other stressors?

More stakeholders assert that the lack of attention to other stressors may lead to higher-than-necessary reductions of nutrient load. This argument implicitly assumes that several stressors in ecosystems are additive and therefore can, to a certain extent, be exchanged for one another. If this assumption can be confirmed, it would offer a certain room for manoeuvring where one could, for example, trade off reduction of fisheries effort against reduction of agriculture-derived nutrient load.

With respect to Chl-a, the Panel is not aware of any evidence brought forward in favour of such an interpretation. Although a study performed by NIVA [50]is argued by one of the stakeholders to prove the point, in actual fact it is very useful as an inventory and ranking of many different stressors to Danish marine waters, but not a study showing that alleviating one stressor can be traded for another. Also, examples brough forward by the stakeholders and the studies of DTU Aqua mostly concern effects of other stressors on eelgrass rather than Chl-a. It should be noted that the models used to calculate MAI do not include any stress from other factors and therefore can be considered to model MAI already assuming that other factors will not interfere significantly with the result. In other words, the models assume that other stressors are managed to be maintained at an acceptable level to assure

[49] Directive 2013/39/EU

[50] Andersen et al. 2017. Under the surface: A gradient study of human impacts in Danish marine waters https://niva.brage.unit.no/niva-xmlui/bitstream/handle/11250/2452464/7128-2017.pdf?sequence=1&isAllowed=y

good functioning of the ecosystem. The Panel further notes that with respect to fisheries, the stirring up of sediments could lead to less light availability in the water column, less primary production and therefore less ability for the phytoplankton to fully take up the available nutrients. Alleviating stress from fisheries could, at least theoretically, therefore lead to an increase, rather than a decrease, of Chl-a for an equal load of nutrients. However, examination of possible effects by DTU-Aqua has found none from fisheries and this neutral interpretation is also followed by the Panel.

The situation is not as clear-cut with respect to the eelgrass depth limit. Other stressors can interfere with the development of eelgrass in different ways. Fisheries and other mechanical bottom disturbance, such as sand dredging and dumping, can directly and mechanically interfere with the integrity of eelgrass meadows by uprooting or burying existing plants. These activities can directly raise the suspended sediment load in the water column. They may also change the structure of the sediment so that it will resuspend at lower current or wave stirring, which can lead indirectly to an increase in suspended sediment in the water. Research by DTU Aqua has shown that sand dredging and dumping are localised activities with little importance at the scale of water bodies, but fisheries is quite significant in several water bodies.

The dependence of the eelgrass depth limit on eutrophication is through the transparency of the water column, expressed as K_d, the light extinction coefficient. The processes underlying these relationships are not entirely clear. Eutrophication-induced production leads to more ‘fluffy’ detritus on the sediment surface, that can easily resuspend. Further, the increased eutrophication-induced production may lead to more coloured substances in the water, to direct light extinction by increasing the Chl-a in phytoplankton and stimulate the growth of epiphytes on the eelgrass. Addition of suspended sediment due to fisheries activities would add to this light extinction and is, in that sense, additive. However, also here the models used to calculate MAI do not incorporate any fisheries or other activities, and solely concentrate on the eutrophication effects. Therefore, they should primarily be interpreted as estimating what should be done from the point of view of eutrophication to bring eelgrass depth limits back to acceptable levels. No arguments show that these stressors could be alleviated *instead of* the nutrient load. It could be argued that the model parameters *implicitly* contain effects of other stressors. However, especially for the mechanistic model, this is unlikely. The parameters have fixed values, at least across different water bodies covered by the domain of a model implementation, and strong fisheries effects are limited to only a few water body types.

The Panel therefore agrees with COWI and NIRAS that no evidence has been found or brought forward showing that the need for nutrient reduction is dependent on the level of other stressors. Therefore, no change in the priority scheme is required. Necessary measures for the reduction of nutrient input are required, as good nutrient conditions are a prerequisite for Good Ecological Status that cannot be replaced or compensated by measures taken on other stressors.

7.4.3 Can other stressors inhibit reaching GES, once nutrient conditions are sufficiently improved?

In general, it can be stated that good nutrient conditions do not guarantee the realisation of Good Ecological Status, if other stressors would be such that they inhibit the realisation of the ecological potential. For example, recovery of eelgrass is not possible in areas that are intensively dredged for mussels, even if nutrient conditions would allow for eelgrass development. In as far as beam trawling takes place within the eelgrass habitat, this may also be limiting. These examples show that reaching Good Ecological Status cannot solely depend on improving eutrophication in the different water bodies. As eutrophication problems come under control, more attention will be needed for other stressors. However, although locally strong effects by other stressors have been documented, no evidence is presented that these effects are equally strong everywhere. Also, the stressors mentioned and studied can, in principle, be kept under control or be alleviated.

Relatively little attention has been paid to chemical stressors, in particular herbicides and organotin compounds, that have been documented to have detrimental effects on the development of eelgrass at relatively low concentrations. Especially in catchments that are under strong agricultural pressure, good control for herbicides and their potential effect on reaching Good Ecological Status is important.

In addition, we draw attention to the effects of aquaculture. Fish cages are important sources of organic matter and nutrients, that have become relatively important in coastal waters. Other forms of aquaculture, e.g. mussel culture, constitute a net sink for nutrients, but may enhance the transfer of organic matter to the sediment in the form of faecal pellets, leading to longer residence times of nutrients in the enclosed water bodies.

Of special importance are also legacy effects of eutrophication. Most Danish water bodies have been subject to eutrophication over a prolonged period, and in some water bodies this eutrophication was very intense, including anoxia and all concomitant biogeochemical consequences. It has been argued by some researchers and stakeholders, that this legacy may have translated into a structural change in the sediments. Large accumulations of organic-rich, light and ‘fluffy’ material that is very easily resuspended, may be responsible for prolonged reductions of light transparency in the water column even after reducing eutrophication effects. Therefore, when evaluating eelgrass depth limits, in the context of measures taken to reduce eutrophication, allowance will have to be made for time lags in the response. It is currently very difficult to precisely estimate the duration of these time lags. Additional restoration measures for eelgrass could be considered, but these may be limited in geographical scope and should be very carefully planned and evaluated through a series of pilot experiments.

With respect to timing and priority setting compared to N-reduction measures, some stressors should be taken away as fast as possible. There is no reason to wait with measures addressing chemical pollution, as an example. Other stressors, however, can only be meaningfully addressed after the main cause of deterioration (eutrophication) has been sufficiently controlled. Restoring sediments, e.g. by sandcapping, is an expensive and energy-intensive measure that one would not deploy if afterwards a new eutrophication-generated layer of organic fluff will form again. Trawling effects on sediments can prevent eelgrass development and should be addressed once water clarity has sufficiently been restored. When funding and resources are in short supply, the Panel advises to give priority to measures that address eutrophication simultaneously with restoring landscapes, such as wetland construction, over too-early marine restoration projects. Local knowledge and experience should be mobilised when making such choices.

Concluding, the Panel is aware that other stressors may need to be alleviated *in addition* to nutrient stress. From inventories made by DTU Aqua, fisheries seem to be the most prominent factor to be considered in this respect. The Panel also points out possible legacy effects of eutrophication, which could lead to time lags in the ecological response of the water bodies to improvements in nutrient loading. Restoration measures can be needed to speed up ecosystem recovery, but these make little sense if eutrophication effects have not been properly addressed first.

7.5 Conclusions and recommendations

The Panel concludes that:

- Very few impacts of other pressures on phytoplankton Chl-a have been documented by the DTU Aqua studies, the COWI and NIRAS report, or the stakeholders. This BQE seems relatively insensitive to other pressures than eutrophication.
- Inventories in Danish waters found many other stressors to be of minor or only local impact. For some pressures, COWI and NIRAS found that impact-response relations could be reasonably well modelled and that these models showed no wide impact. For other stressors, notably also fisheries, such modelling is not possible and expert judgment was used. Fisheries, affecting directly or indirectly the depth limit of eelgrass, stands out as potentially the most important other stressor. Invasive species are insufficiently documented but could also be important in some cases.
- To this list of potentially important other stressors, the Panel points to chemical stressors are also important for the implementation of not only the WFD (Chemical Status) but also for other directives (e.g. EQD). In particular, herbicides and organotin compounds have been shown to be significant inhibitors of eelgrass development. Measures addressing chemical pollution should be taken timely, as they may require sufficient time to have effect.
- No convincing evidence shows that alleviating other pressures can be considered *instead of* nutrient load reductions. The nutrient load reductions calculated by the models and reflected in the MAIs have been calculated without taking account of other stressors. The Panel agrees with COWI and NIRAS that consideration of other stressors does not change the top priority attached to reducing N-loads.
- There is convincing evidence, however, that other stressors will have to be considered *in addition to* nutrient loads, in order to reach Good Ecological Status. In addition, legacy effects of long eutrophication on sediment structure and other ecosystem characteristics, may also demand restoration solutions, that should be applied after the eutrophication status has come within bounds required to reach Good Ecological Status.

CHAPTER 8: POSSIBILITIES FOR FURTHER USE OF EXEMPTIONS

8.1 Introduction

One of the legal questions that the panel was given is to analyse whether there is further room for manoeuvring regarding the exemptions found in WFD Art. 4.4 (extension of timeframe) and Art. 4.5 (less stringent objective). In phase I COWI and NIRAS (see section 8.2) came to the conclusion that there was no such room, while a review of the report by van Calster and Suykens provided as stakeholder input from Landbrug & Fødevarer (see section 8.3) came to the conclusion that the interpretation by COWI and NIRAS was not always correct and of a conservative nature. Stakeholders have also raised the question whether the COWI and NIRAS report is correct in its conclusions on the room for manoeuvring (see section 8.4). The panel is assigned to give a second opinion on the conclusion in phase I and also analyse the critique raised against the report.

The focus in this chapter is therefore to analyse whether the panel sees further room for manoeuvring in the legal application of the exemption scheme in Art. 4.4 and 4.5 WFD. Any room for manoeuvring identified by the panel, will be supported by recommendations on the applicability of the respective provisions.

In the COWI and NIRAS report, it is mentioned that Germany and Sweden interpret Art. 4.4 and 4.5 in a different manner compared to Denmark. In their report, COWI and NIRAS included examples of the respective interpretation. However, it was not analysed if it would be reasonable for Denmark to interpret the exemption scheme in a similar manner as Germany and Sweden. Since the use of exemptions in Germany and Sweden likely affects the future status of some Danish coastal water bodies, the panel is asked to analyse the German and Swedish use of exemptions with the intention to discuss if this gives room for manoeuvring for Denmark when it comes to other countries' emissions and whether their use of exemptions could serve as a reference for the application.

The background of the panel´s assessment on exemptions is that Danish coastal water bodies receive eutrophic substances from both internal sources and other countries, these substances come to Denmark through water and air (see chapter 4 for an assessment of burden distribution). The use of exemptions must therefore be understood in this context. In addition, the panel has been asked to look at the interaction between the WFD exemptions and the Nitrates and Habitats Directives.

Section 8.2 will start with a description of the legal context of Art. 4.4 and 4.5, then a short summary with only the most important aspects of the COWI and NIRAS report, followed by a summary of the comments by the stakeholders and the review carried out by van Calster and Suykens. After that discussion and conclusion on room for manoeuvring will end this section. The panel focuses on the room for manoeuvring. The question whether the report and review provide a correct interpretation of the WFD in general is not addressed.

8.2 Legal analysis of the Water Framework Directive

This section provides a legal oversight and analysis of WFD´s exemption scheme. It focuses on Art. 4.4 and 4.5 and the context of these exemptions. Thus, this section does not include a narrative of the whole WFD, nor the implementation of the Water Framework Directive in Denmark.

8.2.1 Main objectives

The objectives under the WFD are for surface water in accordance with Art. 4.1 (a) (i-ii):

- Member States shall implement the necessary measures to prevent deterioration of the status of all bodies (prohibition of non-deterioration), and
- Member States shall protect, enhance and restore all bodies of surface water to a good ecological and chemical status (improvement requirement).

Also, in accordance with Art. 4.1 (c) WFD, protected areas, Member States shall achieve compliance with any standards and objectives at the latest 15 years after the date of entry into force of this Directive, unless otherwise specified in the Community legislation under which the individual protected areas have been established. These areas are specified in Art. 6.2 and Annex IV and include nutrient-sensitive areas such as vulnerable areas under the Nitrates Directive. Furthermore, this provision applies to the Natura-2000 sites under the Habitats Directive.

According to Art. 4.2, when more than one of the objectives mentioned under Art. 4.1 relates to a given body of water, the most stringent shall apply.

The objectives to achieve good ecological and good chemical status under Art. 4.1 are so-called *objectives of results*. That means: The European Union obliges the Member States to reach the status by a certain time. The

Member States have discretion regarding the question on how to reach the respective status – inter alia on the measures to be implemented to fulfil WFD´s obligations. It is important to stress that an objective of results in general includes an exemption scheme. Such exemption scheme is necessary to prevent disproportionate obligations for Member States. Furthermore, the Panel points out that the precautionary principle of water law, as also reflected in the WFD, is limited by the correct application of the exemption provisions. In other words, the lawful use of an exemption is compatible with the precautionary principle of water law.

Regarding the prohibition of non-deterioration, the Panel notes that ECJ is clear that a degradation in principle is unacceptable on the level of each quality element´s status level. Thus, the degradation of the status of a quality element from moderate to poor is an infringement of the prohibition of non-deterioration. However, if the quality element is already classified in the lowest class any deterioration of that element constitutes a "deterioration of the status" of a body of water.[51] It is unclear what quality a deterioration in this constellation must have in order to be considered a violation. As far as the Panel understands, a deterioration in the lowest class can only occur if there is a measurable impact on the ecological status or if measurable increases occur of the substance's quantity in a water body.[52] This understanding is supported by the ECJ judgement stating that only impacts which by their nature appear to have a minor effect on the status of the affected water body are acceptable with regard to the prohibition of non-deterioration.[53]

There is some difference when it comes to Art. 4.5 WFD specifying that e.g., the best possible ecological status should be ensured (see below). Here the Member State must show that they have implemented best environmental practises and best available techniques in accordance with Art. 10.2, 10.3 and 11.3 WFD.

8.2.2 Article 4.4

According to Art. 4.4 WFD Member States can extend the deadline for achieving the objectives laid down in Art. 4.1 for a water body, if a number of requirements are met. The requirements for extended timeframe are that:

- no further deterioration occurs in the status of the affected water body,
- extension of the deadline, and the reasons for it, are specifically set out and explained in the river basin management plan,
- a summary of the measures which are necessary to bring the water body progressively to the required status (see Art. 11) and the reasons for any significant delay in making these measures operational are provided.

In the COWI and NIRAS report the question is raised whether such extension can be implemented beyond the year 2027. According to the WFD, the extension of the time for reaching a good status in a water body beyond 2027 can only be implemented in cases where the natural conditions are such that they do not allow timely improvement in the status of the body of water until 2027:

> *"Extensions shall be limited to a maximum of two further updates of the river basin management plan except in cases where the natural conditions are such that the objectives cannot be achieved within this period." (Art. 4.4 c WFD)*

In the CIS Guidance Document No. 20 on WFD´s exemption scheme, the interpretation is that if it would be disproportionately expensive to complete the additional improvements in time to achieve good status by 2027, or as soon after 2027 as the natural conditions allow for, a time extension is possible for both – the measures and the objective. Taking into account Art. 4.4 (c) WFD and the CIS Guidance Document No. 20, the decisive question, whether time extensions beyond 2027 can be implemented, is on natural conditions preventing a timely achievement of the good ecological or chemical status. In this context, it is accepted that the time lag in water bodies to achieve good ecological or chemical status caused due to an embedded deterioration of the natural ecological conditions caused by adding polluting substances to the water body from historic sources.[54] In essence, Art. 4.4 WFD recognises that after sometimes decades of unsustainable practices, some water bodies may take long periods of time to recover after the necessary corrective measures have been taken.[55]

The application of Art. 4.4 WFD does not require that pressures are removed completely if there is evidence that the achievement of the objectives will require more time due to natural conditions.[56] What is necessary is that the RBMP3 includes the measures deemed necessary to achieve good status by 2027 (see Art. 4.4 (d) WFD). The

[51] Case c-461/13 70.

[52] Case c-535/18 119.

[53] Case c-525/20 45.

[54] CIS Guidance Document, Clarification on the application of WFD Article 4(4) time extensions in the 2021 RBMPs and practical considerations regarding the 2027 deadline, (2017), p. 9.

[55] CIS Guidance Document, Clarification on the application of WFD Article 4(4) time extensions in the 2021 RBMPs and practical considerations regarding the 2027 deadline, (2017), p. 6.

[56] CIS Guidance Document, Natural Conditions in relation to WFD Exemptions, (2017), p. 7.

CIS Guidance mentions that the provision assumes that measures have been taken by 2027 at the latest in order to allow extension of the timeframe for achieving a status beyond 2027.[57] However, the guidance also states that if time extensions are applied, the Member States must provide a record of measures to be put in place, so that any gaps in the required actions can be identified.[58] The Commission Staff working document includes a somewhat similar wording in relation to the WFD fitness check. Here the Commission states that time extensions under Article 4.4 can only be authorised in cases where all the measures have been put in place but the natural conditions are such that the objectives cannot be achieved by 2027.[59]

Still, it remains unclear, what is meant in the documents, when stipulating that the measures are to be taken by 2027. It is arguable that for the application of a time extension it is not necessary that all measures are implemented in the sense that the planned actions are completed. The panel assesses that, in the light of the reviewed documents, planning, financing and starting to realise the necessary measures to reach the good status of water body is sufficient for legally utilising a time extension. The wording in Art. 4.4 (d) WFD supports this understanding that the implementation of the measures to develop the status of the water body into a good status is not required. According to the wording of the provision, a summary of the measures, which are envisaged as necessary to bring the bodies of water progressively to the required status by the extended deadline, is sufficient. However, a time extension beyond 2027 cannot be applied if the measures implemented are a priori ineffective for reaching the environmental objectives in time (until 2027). In addition, given that it is difficult to fully predict how ecosystems will respond to measures, an interpretation, which states that no measures beyond 2027 are allowed, seems contradictive to the idea of taking natural conditions into account.

Adding to this, in the CIS Guidance Document it is also mentioned that pollution that affects water bodies but is beyond the control of Member State to address is a potential candidate for Art. 4.4 and 4.5 if the achievement of good status would be infeasible or disproportionately expensive.[60] Even if the WFD mainly focuses on international river basin water districts (see Art. 3.5 WFD) the CIS Guidance Document No. 20 states that countries receiving transboundary pollution via marine currents or by atmospheric deposition are also considered downstream (or affected) countries in the manner of Art. 3.3 and 3.5.[61] Member States must demonstrate that the reasons for not achieving the environmental objectives are outside their jurisdiction and competence.[62] It is also likely that Member States need to show that they have taken all reasonable actions to fulfil their part in achieving good status in the water body affected by transboundary pollution.[63] The key issue in applying exemptions regarding transboundary pressures is the provision of evidence that the relevant Member States have taken all reasonable actions to fulfil the legal obligations and that the application of exemptions does not permanently exclude or compromise the achievement of the objectives in other water bodies within the same river basin district.[64]

8.2.3 Article 4.5

According to Art. 4.5 WFD, Member States may set less stringent objectives if the necessary requirements are fulfilled. The water body must be affected by human activity, or their natural condition is such that the achievement of the WFD objectives – set in Art. 4.1 – would be infeasible or disproportionately expensive. Also, the following requirements for utilising this exemption provision are specified:

- the environmental and socioeconomic needs served by such human activity cannot be achieved by other means, which are a significantly better environmental option not entailing disproportionate costs (see Art. 4.5 (a) WFD),
- for surface water, Member States must ensure, that the highest ecological and chemical status possible is achieved, given impacts that could not reasonably have been avoided due to the nature of the human activity or pollution (see Art. 4.5 (b) WFD),
- no further deterioration occurs in the status of the affected body of water (see Art. 4.5 (c) WFD), and

[57] See CIS Guidance Natural Conditions in relation to WFD Exemptions (2017), p. 13; CIS Guidance Clarification on the application of WFD Article 4(4) time extensions in the 2021 RBMPs and practical considerations regarding the 2027 deadline (2017), p. 6.

[58] CIS Guidance Document, Natural Conditions in relation to WFD Exemptions (2017), p. 11.

[59] Commission Staff Working Document Fitness Check of the Water Framework Directive, Groundwater Directive, Environmental Quality Standards Directive and Floods Directive {SEC(2019) 438 final} - {SWD(2019) 440 final}, p. 119.

[60] CIS Guidance Document No. 20 (2009), p. 35; CIS Guidance Document, Natural Conditions in relation to WFD Exemptions, (2017), p. 5, 13: "*Exemptions can also apply in a transboundary context in cases where pressures affecting water bodies are outside the competence and jurisdiction of the Member State.*"

[61] CIS Guidance Document No. 20 (2009), p. 35.

[62] CIS Guidance Document No. 20 (2009), p. 35.

[63] CIS Guidance Document No. 20 (2009), p. 15.

[64] CIS Guidance Document, Natural Conditions in relation to WFD Exemptions, (2017), p. 5.

- the establishment of less stringent environmental objectives, and the reasons for it, are specifically mentioned in the river basin management plan and those objectives are reviewed every six years (see Art. 4.5 (d) WFD).

Due to the last two requirements, the overall objective of achieving the water body´s good status remains binding. The same applies to WFD´s non-deterioration objective.

The relevant requirements are that the water body must be affected by human activity or that its natural conditions make the achievement of the WFD objectives infeasible or disproportionately expensive. Furthermore, the environmental and socioeconomic needs served by such human activity should not be achievable by other means that constitute significantly better environmental options not entailing disproportionate costs. In Guidance Document No. 20 for fulfilling this requirement, the Member States need to answer the following question: Could the environmental and socioeconomic needs served by the human activity leading to not obtaining the good status be achieved by other means that are a significantly better environmental option not entailing disproportionate costs.[65] If the human activity in question is agriculture, it has to be asked, if this agricultural activity can be achieved by other means not entailing disproportionate costs.

In principle, this means that a less stringent objective should be defined based on the condition expected in the water body once all measures that are feasible and not disproportionately expensive have been taken.[66] An assessment of disproportionate costs therefore only makes sense after a combination of the most cost-effective solutions has been identified. This means that all measures that can be taken without involving disproportionate costs should still be implemented to reach the best status possible (see Art. 4.5 (b) WFD).[67] 'Disproportionality', is referred to in Guidance Document No. 1 as a political judgement informed by economic information, and an analysis of the costs and benefits of measures is necessary to enable a judgement to be made on exemptions and especially environmental and socioeconomic needs.[68]

When there is no activity to pinpoint and e.g., the pollution comes from a transboundary context, it may be difficult to apply Art. 4.5 WFD since the exemption requires a certain human activity fulfilling environmental and socioeconomic needs.[69] It appears that the European Union has not included such constellation in WFD, but instead – at least with regard to the Baltic Sea – provided the Member States with the stipulations in MSFD as the main tool to move marine areas away from a diffuse situation of pollution e.g., eutrophication (see also chapter 4 on Burden Sharing).[70] Adding to this, Guidance Document No. 20 includes a rather pragmatic approach and states that the requirement in Art. 4.5 (a) does not apply in case of transboundary pollution or transboundary ecological impacts:

> *“In case of transboundary effects, there is no human activity within the Member States' competence that can be compared with another. The human activity causing the pollution or the ecological impacts is outside the jurisdiction of the Member State. Thus, this condition does not apply in case of transboundary pollution or transboundary ecological impacts.”* [71]

It should be noted that in this type of situations where the Guidance Documents provide a principal statement that not only explain how a provision should be implemented, but actually provide normative interpretations, has on a few occasions been tried by the ECJ and the Court has dismissed these interpretations.[72] Such dismissal is arguable, if the interpretation of Art. 4.5 WFD regarding transboundary pollutions is contrary to the general scheme of that directive and the objectives pursued by it.

The last requirement in Art. 4.5 (a) WFD is interlinked with the question of what measures are feasible and not disproportionately expensive. Based on this assessment the Member State utilising less stringent objectives have

[65] CIS Guidance Document No. 20 (2009), p. 21.

[66] CIS Guidance Document No. 20 (2009), p. 21.

[67] CIS Guidance Document No. 20 (2009), p. 13.

[68] CIS Guidance Document No. 1, p. 189-209; CIS Guidance Document No. 20 (2009), p. 36.

[69] It should be noted that Art. 6 EQS-Directive holds a specific provision on transboundary pollution, which complements Art. 4.5 WFD. A Member State does not breach its obligations as a result of the exceedance of an environmental quality standard, if it can demonstrate that the exceedance was due to a source of pollution outside its national jurisdiction; it was unable as a result of such transboundary pollution to take effective measures to comply with the relevant standard; and has applied the coordination mechanisms (see Art. 3 WFD) and, as appropriate, taken advantage of the provisions of e.g. Art. 4.4 and Art. 4.5 WFD for those water bodies affected by transboundary pollution. In the revision of the EQS-Directive it is suggested that River Basin Specific Pollutants should be moved from “ecological status” and WFD into “chemical status” in the EQS-Directive. This will result in that nitrates and phosphates will be regulated under the EQS-Directive and the exemption in Art. 6 applicable for e.g., transboundary nitrates emissions and the Commission will be able to where necessary provide EU-wide environmental quality standards for nitrates. Member States still need to implement measures to show that they are trying to reduce their impact on water body when this is necessary. This is clear from revision of Art. 4 WFD as it is amended to include an explicit obligation for Member States to progressively reduce pollution from river basin specific pollutants, not just from priority substances.

[70] The EU is also part of the OSPAR Convention (just as Denmark), however, it’s not an EU legal act as the MSFD.

[71] CIS Guidance Document No. 20 (2009), p. 36.

[72] See Case C-525/20 30-31.

to ensure that the highest possible ecological and chemical status is achieved considering the impacts that could not reasonably have been avoided due to the nature of the human activity or pollution. However, concerning Art. 4.5 WFD there is no exemption besides time extension, for a less stringent objective. Since Art. 4.5 obliges Member States to implement measures to ensure a non-defined status (highest status possible), the objective is different from Good Ecological Status, good ecological potential and good chemical status that to a certain extent have definitions in the WFD, e.g., in Annex V, on what the objective entails and shall be achieved.

There is also the possibility to use Art. 4.5 WFD with regard to natural conditions. It is however reasonable to understand the requirement of natural conditions in a different manner in Art. 4.4 and 4.5 WFD. Regarding the extension in timeframe, the idea is to allow for measures in e.g., other parts of the marine waters of the Baltic Sea than the coastal waters to have an effect while also taking into account the difficulty to assess on what timeframe measures will have effect on open coastal water bodies. It is possible that less stringent objectives will be necessary to open costal water bodies due to natural conditions, but it is too early to come to this conclusion as there are too many uncertain parameters as regards their ecological recovery. Which means that for using less stringent objectives due to natural conditions different requirements are to be fulfilled compared to the time extension under Art. 4.4 WFD.

8.2.4 Interaction between WFD Exemptions and other European legislation

According to Art. 4.9 WFD the utilisation of an exemption has to be in line with requirements set forth by the European Union in other legislation:

> *"Member States have to ensure that the application of the new provisions, including the application [Art. 4.4 and 4.5], guarantees at least the same level of protection as the existing Community legislation."*

Hence, utilising the exemption scheme in the Danish RBMP3 it must be ensured that other European environmental objectives can still be achieved. With regards to Art. 4.9 WFD and exemptions for coastal water bodies, the interaction between WFD and the Nitrates Directive and the Habitats Directive is of importance.

8.2.5 Nitrates Directive

The WFD and Nitrates Directive have a formal relationship through Art. 11.3 (a) WFD. Under this provision the measures performed by the Member States under the Nitrates Directive are deemed as basic measures within WFD´s scope for – *inter alia* – achieving good status.

However, the WFD and Nitrates Directive have different approaches for enhancing the water quality. The WFD sets out general water quality objectives while the Nitrates Directive provides a regulative approach for diffuse emissions in areas where the Nitrates Action Programme applies (i.e. in designated vulnerable zones or throughout the national territory as it is the case for Denmark), with the goal to reduce water pollution caused or induced by nitrates from agricultural sources and preventing further pollution (see Art. 1 Nitrates Directive). A vulnerable zone is a protected area under Art. 4.1 (c) WFD, which for Denmark – as for Germany – includes the entire country.[73] Together, both Directives aim to decrease eutrophication as they assume that such action leads to negative impact on species, habitats and the water environment in general.

Regarding point and diffuse sources, the WFD aims to harmonise the objectives under Art. 4.1 through Art. 10 (the combined approach). Art. 10.3 WFD provides a regulation of source-related emission and calls on the Member States to implement the most far-reaching requirements regarding point and diffuse sources. Stricter requirements must be imposed when requirements (e.g. emission limits based on Best Available Techniques (BAT) for point sources and best environmental practice for diffuse sources) are not enough to achieve the European quality objectives or quality standards (see Art. 10.2 and 10.3 WFD). The commission has emphasised the importance of the combined approach as a prerequisite for achieving the WFD objectives and a coherent approach.[74]

In the early days of the WFD, the commission concluded that the more general conditions of the WFD objectives were more far-reaching than sectors Directives. The ECJ decisions show that if more than one Directive applies, the Directives' content determines which objectives apply, i.e. that content takes precedence over general criteria such as *lex specialis*.[75] The ECJ has stated that consideration should be given to the content and objectives of a Directive. Considering this, the more specific objective should not outweigh the more general provision.[76] The generality and the binding effects of Art. 4 WFD indicate that it holds a content that together with its binding

---

[73] The reason for this is that according to the article 3.5 Nitrates Directive: "*Member States shall be exempt from the obligation to identify specific vulnerable zones, if they establish and apply action programmes referred to in Article 5 in accordance with this Directive throughout their national territory.*" The reason to implement an action programme for the entire country is based on assumption that the entire country is in need of the measures provided by programme and therefore a nutrient-sensitive area.

[74] C-648/13, Commission v. Poland [2016] 125

[75] Directive 91/676/EEC.

[76] C-9/04, Geharo [2005] 26-29.

character is more far-reaching than the Nitrates Directive. This argument is supported by Art. 11.3 (a) WFD stating that the measures under the Nitrates Directive are one of several basic measures implemented to achieve WFD´s Art. 4 objectives. Still, both Directives aim for a status where the effects of nitrates do not result in negative effects on the water environment.

It makes sense that the Nitrates Directives assessment of eutrophic waters is complemented by the WFD's more advanced water quality assessment.[77] The ECJ case law strengthens this notion and that the WFD objectives are more stringent than the Nitrates Directives which means that, it in principle, it is possible to use the WFD exemptions and not infringing the obligations in Art. 4.8 and 4.9 WFD.[78]

8.2.6 Interaction between WFD Exemptions and Habitats Directive

The EU enacted the Habitats Directive to meet obligations under both the Bern Convention and Convention on Biological Diversity. The Habitats Directive obliges for Member States to implement measures to protect both natural habitats and species. The Directive´s recital states that its main aim is to promote the maintenance of biodiversity by ensuring that species and habitats in the European Union that need conservation measures achieve a favourable status (see Art. 2.1 and 2.2 HD).

Conservation is defined in the Habitats Directive as a series of measures required for maintaining or restoring habitats and species to a favourable status (Art. 1 (a) HD). The conservation status of a species is defined as the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations (Art. 1 (i) HD). The conservation status is favourable when a species is able to maintain itself long-term as a viable part of its natural habitats; the natural range of the species neither being reduced nor likely to be reduced in the near future, and where there is, and will continue to be, a sufficiently large habitat to maintain its populations over the long-term. Thus, the sum of the influences acting on the ability of a species to maintain itself and persist within its natural range, which demands a sufficiently large habitat, must not result in a situation where the species concerned cannot maintain itself over the long-term. To achieve this, the Habitat Directive prescribes a strict protection of these species (see Art. 12-16 HD).

The aim of the Habitat Directive for natural habitats and the habitats of species is their conservation through the establishment of the Natura 2000 network (Art. 3-10 HD). The main measures for preserving habitats are the establishment of Natura 2000 sites. These sites shall be established to preserve the habitats of European importance that are listed in the Directive´s Annex I and the habitats that are linked to Annex II species in need of conservation measures (Art. 3.1 HD). In the Directive, the conservation status of a habitat (habitats found in Annex I) is 'favourable' when the natural range and areas are stable or improving, where the specific structure and functions that are necessary to its long-term maintenance exist and are likely to continue to exist in the near future, and where the conservation status of the habitat's typical species is favourable (Art. 1 (e) HD). The aim is for these habitats to be maintained or restored to a 'favourable conservation status' (Art. 3.1 HD). The natural range of these habitats, when identified, must be stable or improving, and the Natura 2000 network is a coherent network, which means that these habitats provide the spatial baseline for what is needed to achieve a 'favourable conservation status' (also see Art. 6.4 HD).

Under the Habitats Directive, this means that species and habitats achieve favourable conservation status (and do not become extinct), while the WFD objectives aim to secure a general ecological status with functioning ecosystems focusing on water. Even if overlaps exist between the WFD and Habitats Directive, there is a difference, as the Habitats Directive focuses on the population and the WFD focuses on the composition and abundance of type-specific communities and disturbance-sensitive taxa[79] restricted to waters. However, both Directives include similar approaches to achieve its goals.

The broad ecological nature of the WFD objectives indicate that its approach provides the most stringent one in a general sense. At the same time, it is difficult to generally define which is the most stringent in relation to Art. 4.2 WFD without place-specific assessments that take into account the species and habitat that a Natura 2000 site is intended to conserve. In conclusion, utilising an exemption under WFD does not infringe with the Habitats Directive a priori. Thus, an interpretation falls short of the Directives´ relationship that excludes the use of the WFD exemption scheme in water bodies that include Natura 2000 sites. It has to be assessed on a local level whether the protected species demands in a Natura 2000 site preclude an exemption because this would hinder the achievement of the conservation status required under the Habitats Directive.

[77] See also CIS guidance No 23 Eutrophication.

[78] C-237/12, Commission v. France [2014]. Here it is important to see the difference between the best legal assessment system and the best ecological/biological assessment system.

[79] Group of living beings that can be described by common characteristics and distinguished from other groups.

8.2.7 Marine Strategy Framework Directive

The Marine Strategy Framework Directive (MSFD) obliges Member States to prevent, maintain and, where appropriate, improve the environmental status of their marine waters so that the environmental status of marine waters is good by 31.12.2020 (see Art. 1 MSFD). So far, the Commission has not initiated infringement procedures against Member States for failing to achieve good environmental status by 2021. Marine waters within the meaning of the Directive include coastal waters designated as water bodies under the WFD. For an assessment of environmental status based on the descriptors and indicators, Member States may use the designations made under the WFD for coastal waters under Commission Decision EC/2017/848, where relevant.[80] In other words: If the WFD requirements for Good Ecological Status and good chemical status are met in a coastal water, the marine water is in good environmental status in that area.[81] The MSFD contains a comprehensive exemption regime (see Art. 14 MSFD). Member States may make use of exemptions from the obligation to achieve good environmental status of a marine water if e.g. natural conditions do not allow timely improvement in the status of the marine waters concerned (see Art. 14.1 (a) MSFD).

In consideration of the above, it can be argued that an exemption utilised for a water body under Art. 4.4 or 4.5 WFD (because natural conditions prevent an improvement in ecological status) is not contrary to the objectives of the MSFD. It is even conceivable that such an exemption would at the same time meet the requirements to be classified as an exemption under the MSFD.[82] This is further suggested by the MSFD making the preservation of the status quo in marine waters and the achievement of good environmental status in coastal waters dependent on the fulfilment of the applicable WFD requirements specifying – *inter alia* – Good Ecological Status.[83]

In conclusion, MSFD and WFD are interlinked with the effect that management decisions, such as applying the WFD`s exemption scheme in a water body, is coherent with MSFD´s objectives by default.

8.2.8 A note on Case Law

There is a lot of case law on the Nitrates and Habitats Directive. On WFD´s objectives a significantly smaller number of court decisions by the ECJ exist.[84] Furthermore, there is no specific case law from the ECJ on the application of Art. 4.4. and 4.5. In one judgement the Court rules on the utilisation of Art. 4.7 WFD. In this decision, the Court of emphasises Member State discretion for applying WFD´s exemption scheme. With regard to an individual project – not the RMBP – it states that Member States must be allowed a certain margin of discretion for determining whether an overriding public interest exists in the view of Art. 4.7 WFD.[85]

The Court also generally emphasises that the WFD, which was adopted on the basis of Art. 175 (1) EC (now Art. 192 (1) TFEU), establishes common principles and an overall framework for action in relation to water protection and coordinates, integrates, and – in a longer perspective – develops the overall principles and the structures for protection and sustainable use of water in the European Union. Those principles and that framework are to be developed subsequently by the Member States by means of the adoption of individual measures. Thus, the directive does not seek to achieve complete harmonisation of the rules of the Member States concerning water.[86]

8.2.9 The Case of Sweden – Art. 4.4 and 4.5

Despite implemented measures to reduce the leakage of nutrients from agricultural land, eutrophication problems remain for many of Sweden's lakes, rivers and coastal waters. The Water Authority has assessed that even if measures have been implemented there are potential for further measures to reduce the negative impact from agriculture. Not all of the measures are judged to be possible to implement in full by 2027, but they need to be divided into two periods based on cost effectiveness. The first part is to be implemented during the period December 2022–2027 and part two during 2027–2033. Depending on the circumstance around the eutrophication and whether there are time lags in the implementation of measures this deadline may need to be extended to 2039.[87]

---

[80] Example: The Descriptor 5 (Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters) in coastal waters has to be assessed utilising – inter alia – the Chl-a concentrations set in accordance with Directive 2000/60/EC.

[81] It should be noted that MSFD´s environmental targets comprise aspects not covered by WFD, such as invasive species (Descriptor 2), marine litter (Descriptor 10) and introduction of energy (Descriptor 11). Apparently, obtaining the Good Ecological Status under WFD does not include meeting MSFD´s requirements for achieving a good environmental status in the marine waters regarding these assessment components.

[82] The panel acknowledges – agreeing with COWI and NIRAS (see pg. 48) – that for such conclusion the other requirements for an exemption under MSFD have to be fulfilled set out in Art. 14 (2) MSFD. However, COWI and NIRAS do not address the relationship of WFD and MSFD with respect to WFD´s exemption scheme.

[83] See C-346/14 70 and the cited case law. Regarding the Nitrates Directive, CJEU has come to a similar conclusion. The Nitrates Directive should not be interpreted as aiming at harmonising the Member States' implementation but rather that the Member States have a broad discretionary field within which to implement the obligations following from the Nitrates Directive (C-293/97, p. 37, 39).

[84] See Case C-346/14.

[85] See Case C-346/14 70.

[86] See Case C-461/13 34.

[87] Förvaltningsplan södra östersjön 191.

The extension of the timeframe to 2039 can be seen in coastal areas around the west and east cost of Sweden and also around the large islands of Öland and Gotland where the objective for nutrients and phytoplankton are assumed to be achieved by 2039 due to the effects from marine areas.

Exemptions in the form of less stringent objectives is used for agriculture operations that are located at water bodies in the coastal area and the emissions mainly run into an inland water body (stream or lake) and not coastal water body. The exemption is used when its infeasible or disproportionately expensive to achieve a Good Ecological Status for the agriculture activity. The need for improvement is thus significantly greater than what is possible to achieve based on the measures that the Water Authorities has deemed possible. The Authorities do not use the terminology of the WFD, but likely the measures are what the Authorities deem best environmental practices (see Art. 10.2 WFD). On these occasions, the environmental objective has then been set a status class higher than what is expected when these measures have been implemented, i.e., if the expected status corresponds to poor status, the environmental objective is set to moderate status. The reason for this is uncertainties in both the basis for these assumptions, the effect that measures will result in, and the estimates of the scope for measures. In other words, that there are uncertainties in the assessment of the extent to which it is infeasible or disproportionately expensive to achieve Good Ecological Status. In addition, the measure analysis for agriculture includes only a subset of all possible measures to reduce the impact of nutrients. For agriculture, possible measures that are not deemed unfeasible or disproportionally are protection zones[88], adapted protection zones[89], wetlands and structural liming[90]. The Water Authority intends to work further with the issue of possible measures and develop the methodology for less stringent objectives and agriculture during the coming management cycle.[91]

Less stringent environmental objective regarding nutrients, eutrophication and coastal area has been applied along the Swedish west coast, which are opposite to Denmark, for the e.g., the water bodies Gisselöån, Skivarpsån and Jonsbergsån. Note that the use of less stringent objectives for agriculture is applied only when it is clear that agriculture is solely or mainly responsible for emitting the nutrients to the water body. In a situation where there are several activities that emit nutrient there is a reluctance to use the exemption as the question of disproportionality is difficult to assess in relation to several activities such as urban wastewater treatment facilities versus a range of agricultural operations.

Sweden do not use less stringent objectives for coastal waters with respect to agriculture operations draining directly into coastal waters. It is assumed that the load in coastal water is too complex compared to inland waters and the impact of emissions from marine areas are difficult to assess. There is also a lack of knowledge about the load situation which makes it difficult to clearly distinguish the load and the impact on the status from Swedish agriculture operations.[92]

The overarching problem in Sweden is, however, not agricultural emissions, but hydro power activities in relation to which measures to improve the status of water bodies have not been implemented since the WFD came into force. Most hydro power permits are from a time before permits included environmental considerations. Many permits can be about 100 years old or older. Since it was clear beyond any doubt that Sweden would not fulfil its obligation under the WFD regarding the hydro power impacts, the Commissions put Sweden under pressure which resulted in a national plan to review the entire hydro power sector. The purpose of the national plan is that the reassessments should lead to both the greatest possible benefit for the water environment and an effective national access to hydroelectricity. To ensure that this is done, strict legal requirements has been implemented in the Environmental Code. Moreover, a Hydroelectric Environmental Fund has been established to cover about 85 per cent of the costs associated with the review for the operators. The fund will cover the costs of an environmental investigation, examination of the environmental measures in court and the actual implementation of the measures decided by the court, and also compensate for any production losses. The fund is established by the largest hydro power owners in Sweden (due to state aid), and in return they got a tax reduction which is larger than the capital moved into the fund, about 10 billion Swedish kroner.

COWI and NIRAS mention that there are less stringent objectives for coastal water, which is mainly for harbours. These costal water bodies have previously been classified as heavily modified bodies of water, but where then re-classified into an Art. 4.5 exemption. This was due to a lack of monitoring data to set the Good Ecological Potential objective and the Water Authorities also state that the guidance from Marine and Water Authorities are not

A protection zone against a water area is a zone overgrown with forage grass or forage grass mixed with forage legumes along a water area. A water area is an area covered by water at the highest foreseeable water level. It could be, for example, a ditch that carries water for some part of the year, a lake or a pond. The protection zone must be located on arable land directly adjacent to the water area. There must not be too many trees and bushes between the protection zone and the water area. Scattered trees and bushes are allowed, but it must not be forest or similarly dense tree areas.

An adapted protection zone is a zone overgrown with forage grass or forage grass mixed with forage legumes that must be located on erosion-prone land that is subject to surface runoff. It can be, for example, land adjacent to surface water wells or in depressions on arable land.

[90] Structure liming is a method to stabilise clay aggregates and thereby reduce the risk of phosphorus losses.

[91] Förvaltningsplan södra östersjön 191–192.

[92] Förvaltningsplan södra östersjön 187, 194.

developed to help them with setting the objectives for heavily modified bodies of water for harbours. This is not a question that are of relevance regard eutrophication and objective setting for costal water. Furthermore, in principle it is wrong to set an Art. 4.5 exemptions for a heavily modified harbour.

8.2.10 The Case of Germany

The respective German authorities – River Basin Communities (Flussgebietsgemeinschaften) – have included time extensions (see Art. 4.4 WFD) in the RBMP3 for all German coastal water bodies in the Baltic Sea. For example: In the River Basin District Warnow/Peene for all present 20 coastal water bodies a time extension was issued regarding the objective to reach a Good Ecological Status by 2027. The RBMP3 states that the Good Ecological Status shall be achieved in some coastal waters by 2039 and by 2045 in other coastal water bodies.[93] The reasoning for the time extension is disproportionate cost (1 water body) and/or natural conditions (20 water bodies). Apparently, in some water bodies more than one of the reasons in Art. 4.4 WFD for extending the time frame to achieve a Good Ecological Status is applied.

The River Basin Communities provide the following reasons for *disproportionate costs*:

- excessive demands on non-governmental cost bearers, such as water works or private landowners, necessary stretching of cost distribution over time,
- excessive demands on state cost bearers, necessary stretching of cost distribution over time, and
- constitutionally defined, democratically conditioned financial autonomy of measure bearers.

The River Basin Communities provide the following reasons for *natural conditions*:

- temporal effect of measures already initiated or planned,
- duration of self-dynamic development, and
- necessary coordination of measures whose implementation is necessary to reduce pollution in the respective water body; not in the water body itself, but in one or more upstream and/or downstream water bodies. For example, reduction of pollution with a substance that is discharged via one or more upstream water body or the establishment of continuity in one or more downstream water bodies to enable connection to the upstream.

Furthermore, the River Basin Communities explain that the implemented measures only address one of many pressures relevant for the ecological status of water bodies:

> *„A large number of extensions of deadlines are at a large extent due to the fact that an extension is already necessary if, despite extensive measures, only one of often several types of pressures cannot be sufficiently reduced. This obscures the parallel, often successful reductions of other pressures. The fact that "good" status must be measurably demonstrated in the water body in order to achieve the target also has a significant impact. However, many measures require such a long time for appropriate planning, approval and implementation that the remaining time periods are not sufficient to demonstrate the achievement of "good" status, even if the measures are implemented. Examples are, in particular, hydromorphological measures, which often require long periods of time until they take full effect, as well as the slow biological recolonisation of water bodies with animals and plants."* [94]

Besides the time extensions (see Art. 4.4 WFD) Germany has not utilised the other parts of the exemption scheme in Art. 4.5 WFD (less stringent environmental objectives) or in Art. 4.7 WFD (exemption from reaching a e.g. Good Ecological Status).

8.3 Central remarks on exemptions by stakeholders regarding Phase I

There are some comments on the COWI and NIRAS report from the stakeholders. Below the stakeholder's main remarks on legal aspects relating to exemptions in the WFD are summarised:

- COWI dismisses the possibility of referring to transboundary sources of pollution as reason for exemption possibilities. However, according to one of the stakeholders, CIS guideline No 20, Annex II clearly states that Member States may rely on exemptions when the reasons for not achieving environmental objectives are situated outside their jurisdictional control. Thus, the expert panel should consider both options, fair burden sharing and exemptions, when analysing solutions for handling non-Danish stressors.

[93] The same applies to the RBMP3 in other River Basin Communities, such as Schlei/Trave.

[94] River Basin Community (FGE) Warnow/Peene, Aktualisierung des Bewirtschaftungsplans nach § 83 WHG bzw. Artikel 13 der Richtlinie 2000/60/EG für die Flussgebietseinheit Warnow/Peene für den Zeitraum von 2022 bis 2027, 2021, pg. 90. (download: https://www.wrrl-mv.de/static/WRRL/Dateien/Dokumente/WRRL/BMU/bwz3/WarnowPeene/WP_BZR3_BP_Text_red_Anderungen_2023.pdf).

- In the same line of reasoning another stakeholder emphasises that CIS guideline No 20, Annex II clearly states that Member States may rely on exemptions when the reasons for not achieving environmental objectives are situated outside their jurisdictional control. This is because it is not possible for Denmark to take measures to compensate for nutrient load from other countries or international water bodies.
- With regard to Art. 4.4, extension of time, COWI states that measures should be in place before 2027 (legally binding and financially funded). According to one stakeholder, this is one perspective, well in line with the precautionary principle. However, measures need to be proportionate and appropriate to achieving Good Ecological Status, which may not be the case if focus is put exclusively on Danish nitrogen load reductions.
- Considering Art. 4.5, less stringent objectives, COWI states that Denmark has not used this exemption in previous RBMP cycles. This is true but having applied for an exemption previously is not a prerequisite for doing it now, in the third cycle, according to the stakeholder.
- In discussing the exemptions of Art. 4.4 and 4.5, COWI refers to Art. 4.8 in the WFD and links it to especially the Nitrates Directive and the Habitats Directive to imply that less stringent objectives would result in non-compliance with these directives. With regard to the Nitrates Directive, one stakeholder makes the following comment: in 2021 the European Commission came to the following conclusion in the assessment of Denmark's Programme of Measures for the 2nd cycle RBMPs: "For nitrates, rules are in line with the fulfilment of the Nitrates Directive across all river basin districts".[95] Thus, we do not consider there to be any legal nor scientific basis to imply non-compliance with the Nitrates Directive.

8.4 Summary of Remarks by van Calster and Suykens on phase I

Besides the Panels Second Opinion there has been a legal evaluation of the COWI and NIRAS report by van Calster and Suykens and what the panel consider to be their main critique and comments on the report is summarised below. The evaluation by van Calster and Suykens was provided to the panel as stakeholder input from Landbrug & Fødevarer.

The authors mention that Recital 12 emphasises, a balanced socioeconomic development of the EU and its regions, on the basis of cost-benefit analysis, is equal part of the EU's environmental agenda. The Directive shows a lot of understanding for the difficulties, including socioeconomic difficulties, which the Member States may have in reaching the WFD objectives.

Regarding the implementation of the Nitrates Directive the authors state that in 2021 the European Commission came to the following conclusion in the assessment of Denmark's Programme of Measures for the 2nd cycle RBMPs: "For nitrates, rules are in line with the fulfilment of the Nitrates Directive across all RDBs". They therefore do not consider that there is either a legal or a scientific basis for the reference or implication of non-compliance with the Nitrates Directive, throughout the Report.

The authors also (just as Stakeholder see above) find that it is unclear how COWI and NIRAS came to the conclusion to dismiss the possibility of referring to transboundary sources of pollution in exemption possibilities in correspondence with CIS guideline No. 20. The authors note that the CIS Guideline No. 20 leaves room for exactly this situation and that exemptions may be applied in cases where a certain Member State cannot resolve the reasons for not achieving the environmental objectives because they lay outside the competence and jurisdiction of the Member State. The authors state that in case of transboundary pollution being the (main) cause, it is to be assessed whether it is infeasible to implement any additional improvements to the status of the water body.

One of their conclusions is that it could be envisaged that a less stringent objective would apply proportionate to the amount of pollution stemming from areas which are beyond the jurisdiction and competence of Denmark. Likewise, the transboundary pollution aspect could be factored into the arguments for obtaining more time beyond the 2027 deadline, to allow neighbouring countries to reduce their impact on Danish waters.

8.5 Discussion of issues within the evaluation theme

COWI and NIRAS reach the conclusion that there is very little room for manoeuvring in the legal application of WFD´s exemptions for achieving a Good Ecological Status in Denmark's coastal water bodies in 2027. The conclusions are based on an interpretation of the provisions found in Art. 4.8 and 4.9, which states that a possible extended deadline must not lead to non-compliance with the WFD objectives in other water bodies and guaranteeing the same level of protection as the existing Community legislation such as the Nitrates Directive and the Habitat Directive. Furthermore, COWI and NIRAS argues that the exemption scheme in Art. 4.4 and 4.5 can

[95] Assessment of Member States' progress in Programmes of Measures during the second planning cycle of the Water Framework Directive, Denmark, December 2021.

only be applied when – by 2027 – all necessary measures to achieve a Good Ecological Status in coastal waters are implemented – meaning that the action have been performed and/or completed.

The panel reviewed COWI and NIRAS´ opinion on the utilisation of WFD´s exemption scheme considering the legal interpretation for applying Art. 4.4 and/or Art. 4.5 WFD as well as the provision in Art. 4.9 WFD (see above). The panel´s review leads to the following discussion of the COWI and NIRAS statements.

8.5.1 Time extension under Article 4.4 WFD

COWI and NIRAS' approach to the issue is based on the assumption that it is only considered possible to extend the deadline for achieving a good ecological and chemical status after 2027, when all necessary reduction measures have been implemented in the sense of realised and/or completed by 2027.

In the RBMPs up to 2021, but not beyond, nitrogen pressures in coastal waters from other countries have been used as reason for time extensions. It has been done under the presumption that other countries reduce nitrogen according to their river basin management plans, MSFD and international treaties in HELCOM/OSPAR. This is not the case after 2027 as it assumed that the other countries affecting Danish coastal waters will implement all necessary measures by 2027 which together with Danish measures will eventually result in the achievement of Good Ecological Status when biological response time to these measures catch up with the lessened nitrogen input. However, time extension beyond 2027 are set for 104 coastal water bodies due to natural conditions based on the argument that these conditions affect the effectiveness of measures.[96] The reasons for the extensions are explained in the RBMP3 (p. 130) stating that the effects of measures will not fully be achieved by 2027. The deadlines are set in appendix 1-4 to the statutory order on environmental objectives. Time lags between implementation of measures and result is without doubt what is considered a natural condition.

As the panel shows in section 8.2 it can be argued that the strict interpretation of Art. 4.4 is not of an absolute nature. There are legal and scientific arguments supporting the panel´s position: neither WFD nor the CIS Guidance Documents argue that all measures and actions necessary to achieve a Good Ecological Status have to be realised and/or completed by 2027 in order to utilise a time extension beyond the 3rd RBMP cycle. Rather, it can be argued that such measures must be planned, financed and implementation under way by 2027 to meet the requirements in Art. 4.4 WFD. This interpretation is also supported by the way the provision on the time extension is applied by Sweden and Germany in their current RBMP´s (see above section 8.2). The panel has no information that the EU Commission has assessed these time extensions as being incompatible with European Law.

It is possible that natural conditions affect the possibility to implement necessary measures over a short period of time and therefore a step-by-step approach may be necessary. However, WFD´s idea is that the three management cycles should have provided the Member States with an opportunity to see which measures are effective in order to achieve the good status by 2027. Still, it cannot be ruled out that natural conditions also after 2027 infringe the effectiveness of measures and, by that, limit the potential of the implemented measures. COWI and NIRAS´ position therefore of a very conservative nature, and that position does not have a robust legal foundation. Furthermore, such interpretation does not recognise the potential of Art. 4.4 WFD. Also, the panel points to the fact that Sweden and Germany have applied time exemptions extensively for open coastal waters and the MSFD objectives are at the same time not achieved for eutrophication in the Baltic Sea. Taking that into account, Denmark cannot expect for the transboundary pollution a decrease to a level that its coastal water bodies will have a Good Ecological Status by 2027 even if the implemented Danish measures are realised and/or completed by then.

It is obvious – and repeatedly stated in the CIS Guidance Documents – that utilising time extensions do not allow to fall short on Denmark´s obligations to start implementation of necessary measures for achieving the Good Ecological Status by 2027 or later. An approach that aims to implement insufficient measures assuming that an applied time extension results in a lower ecological objective is not compliant with WFD. However, it´s the panel´s interpretation that Denmark is allowed to enact further measures in the course of RBMP3 and during future RBMP if an evaluation shows that the measures implemented initially will not lead to a Good Ecological Status in a water body.

8.5.2 Less stringent objectives under Article 4.5 (a) WFD

Denmark does not plan to apply less stringent environmental objectives under Art. 4.5 in the RBMP3 with regard to nitrate emissions from ongoing Danish agricultural activities which contribute to eutrophication of Danish coastal waters. This opinion is based on an interpretation of the provisions in Art. 4.5 (a) WFD that ongoing agricultural

[96] See p. 101 in RBMP3 (https://mim.dk/media/235166/vandomraadeplanerne-2021-2027-5-7-2023.pdf) or Tabel 3.1 in appendix 1-4 in Statutory order no. 819 of 15th of June 2023 on environmental objectives, (https://www.retsinformation.dk/eli/lta/2023/819), water bodies: Smålandsfarvandet, syd (34), Avnø Fjord (37), Kattegat, Nordsjælland >20 m (205), Anholt (139), and Skagerrak (221).

activities do not serve environmental needs (see Art. 4.5 (a) WFD: "[…] *the environmental and socioeconomic needs served by such human activity* […]"). This interpretation is supported by COWI and NIRAS.

There is no legal basis to understand the requirement in Art. 4.5 (a) WFD as meaning that human activity is only covered by the requirement if it addresses *both* environmental and socio-economic needs. The context of the provision shows that the European Union's aim with this provision is to consider both needs – environmental and socio-economic – when assessing whether alternative measures exist for the respective human activity.[97] Thus, if an assessed human activity does not serve environmental needs, then no other activity must be found that meets environmental concerns without having a comparably significant impact on the ecological status in order to utilise the exemption provision. Furthermore, stating that there are no environmental needs attached to agriculture that fulfil the requirements of implementing what constitutes e.g. best environmental practices is a far-reaching interpretation.[98] Accordingly, it does not seem justifiable to exclude the use of Art. 4.5 (a) WFD from the outset.

However, taking into consideration the Guidance Document No. 20 (see above), it seems unlikely that applying Art. 4.5 WFD is legally secure for open coastal water bodies. According to COWI and NIRAS in these water bodies the achievement of a Good Ecological Status is dependent on a number of pressures that are both transboundary and not dependent of a specific Danish activity.

For inner coastal waters where water bodies receive nutrients mainly from internal Danish sources, it's not unreasonable to conclude that less stringent objectives in the sense of Art. 4.5 (a) WFD can be utilised. If these types of coastal water bodies, or adjacent water bodies, where the measures to achieve a Good Ecological Status will result in disproportionate costs or are infeasible – and there is no other relevant direct sources of nutrient to this water body – the panel interprets Art. 4.5 WFD of being generally applicable. Such applicability of the exemption provision is possible regardless of COWI and NIRAS´ interpretation. They state: *"Thus, a Member State cannot establish less stringent environmental objectives in Denmark to avoid an increase in pollution elsewhere in the world in case production is outsourced."*[99] The panel finds this conclusion to be unexpected as it is rather common to use less stringent objectives for agriculture in other Member States. Neither WFD nor the CIS Guidance Documents give a hint that such interpretation of the exemption scheme is legally founded. This finding is supported by Member States and academic literature. For example, in Sweden Art. 4.5 is used when there are no proportional measures to be implemented and, hence, a Good Ecological Status cannot be achieved in the respective water body.

The panel stresses the point that it is outside the scope of its evaluation task to assess, if and to what extent there are disproportionate alternative measures to agriculture and its utilisation of fertiliser and manure in Denmark. In fact, in the CIS Guidance Documents concepts such as "need" and "disproportionality" are to be assessed from a national perspective. It seems obvious that these legal terms are not subject to a harmonisation within the European Union. The Member States reasonably have a large degree of discretion when assessing these requirements.

At the same time, Art. 4.5 WFD is – similar to Art. 4.4 WFD – clear in requiring measures to be implemented to reduce the negative impact on the aquatic environment from the pressures of the human activity as a condition for utilising the less stringent objective. Applying less stringent objectives does not result in lowering the overall aim – in this case the best achievable ecological status (see above). Under this consideration, all the necessary measures for achieving such status are to be implemented, recorded and evaluated with regard to its effectiveness. Taking into account WFD´s main purpose of improving the status of the aquatic ecosystems, the panel finds it very unlikely that the ECJ will accept an approach of applying less stringent objectives without a profound set of measures being implemented.

8.5.3 Exemption scheme and achieving the aims of the Nitrates and Habitats Directive

The following section discusses the influence of the Nitrates and Habitats Directive on the applicability of WFD´s exemption scheme. For notes on the legal relationship between WFD and MSFD, see section 8.2.

The protection of surface water and groundwater according to the Nitrates Directive is – according to the Danish Government and COWI and NIRAS – another important issue in assessing the use of WFD´s exemption scheme in regard to agriculture activities. The Nitrates Directive does not include any provision with exemptions on the obligation to decrease the eutrophication and pollution of waters. Thus, COWI and NIRAS assumes that utilising an exemption under Art. 4.5 WFD would infringe the Nitrates Directive objectives due to unacceptably sustaining the nitrogen pollution from agricultural activities. Denmark has made the choice to apply the Danish Nitrates Action Programme to its whole territory and, hence, according to Nitrates Directive Article 3.5, is exempt from the obligation to designate vulnerable zones on a regional or local level. In accordance with Art. 4.1 (c) WFD, Denmark (as a

[97] The panel´s interpretation is backed by the perception in the German legal commentary.

[98] It is known to the panel that some Natura 2000 sites actually mandate agriculture using fertiliser, f. ex. growing summer crops, in order to provide sufficient foraging habitats for certain bird species, such as the mew gull.

[99] COWI and NIRAS, p. 211.

whole) is therefore a protected area. For such areas Member States shall achieve compliance with any standards and objectives no later than 15 years after the date of entry into force of this Directive, unless otherwise specified in the Community legislation under which the individual protected areas have been established.

COWI and NIRAS seems to have a similar approach in assessing WFD exemptions with regards to the Habitats Directive. Adding to this, the RBMPs are the main instrument in Denmark to improve the general condition of the aquatic nature types in the Natura 2000 sites. Thus, more specific measures under the Habitats Directives are needed such as additional species protection measure or measures for enhancement of habitats for specific species.[100] Furthermore, the Habitats Directive has an exemption scheme that differs significantly from WFD´s respective provisions.

However, the Nitrates and Habitats Directive both lack a timeframe explicitly stating when its objectives are to be achieved. The idea in these two Directives is that Member States continuously implement measures to achieve a state where eutrophication does not disrupt the balance of aquatic organisms and decrease the quality of the water nor affect the possibility to achieve a favourable conservation status. It could be argued then that since it is not specified in neither of the two Directives that the European Union binds the achievement of its objectives to the WFD and its exemption scheme. Thus, for all aspects regarding the ecological status of coastal waters within the scope of the Nitrates Directive and the Habitats Directive, applying an exemption for a water body is in principle compliant with these Directives. On the other hand, it is arguable that both Directives specify that their objectives do not have a timeframe and therefore the second part of the sentence of Art. 4.1 (c) WFD is therefore fulfilled. It is reasonable that the European Union did not introduce a timeframe into the Nitrates Directive or the Habitats Directive by installing Art. 4.1 (c) WFD. Another interpretation would be in contrast to the decision to not include a timeframe in these two Directives.

Furthermore, based on the legal analysis in section 8.2, it is without doubt that the WFD provides the most stringent objective in relation to the Nitrates Directive. For the Habitats Directive this is not so sure and as the Danish implementation indicates other more species or habitat precise measure are likely needed in most Natura 2000 areas. However, in a general sense, the WFD objectives are by default stringent, but Natura 2000 site assessments are needed to see if additional measures are needed.

Regarding Art. 4.5 WFD, for a water body that also falls under the Nitrates Directive, the use of the exemption must be consistent with the implementation of the Directive and guarantee at least the same level of protection as the existing Community legislation. Considering the above statements regarding exemptions Art. 4.9 WFD has the function of ensuring that the requirements of the Nitrates and Habitats Directive are taken into account when a Member State examines the requirements of Art. 4.4 and/or Art. 4.5 WFD. If such an assessment comes to the conclusion that applying an exemption under WFD will result in a breach of the obligation to decrease the nitrogen situation in waters, it cannot be legally implemented. However, in such cases it seems feasible to address the obligations of the Nitrates Directives by the measures that are to be implemented mandatorily when applying a WFD exemption (see above). For that the Nitrates Directives´ (and Habitats Directive) targets are to be considered as part of the WFD basic measures (see Art. 11.3 (a)).

The overarching aim of the Nitrates Directive is to decrease the negative effects that follow from eutrophication. This aim is achievable under WFD. This Directive´s idea is to primarily secure the fundamental obligation of non-deterioration, which also are specified as a requirement in Art. 4.5 (c) WFD, and then aim for a better status, which as a starting point is good status. The requirement in Art. 4.5 (b) WFD is that the highest ecological and chemical status possible should be ensured. The only situation where an increase in eutrophication could be approvable is under Art. 4.7 being, however, unlikely since its limited to new modifications to the physical characteristics of a surface water body or alterations to the level of bodies of groundwater. The WFD shows no indication supporting the idea that the use of exemptions would lead to an infringement of the Nitrates Directive objective of reducing water pollution caused or induced by nitrogen from agricultural sources. Also, Art. 5.4-5 Nitrates Directives specifies that a few basic measures shall be implemented and additional measures if the basic ones are not effective. Under Art. 4.5 (b) WFD it is required that the highest ecological and chemical status possible is achieved. To adhere to this requirement Member States must make certain that they have implemented all possible measures that are not of a disproportionate economical nature (see above). In conclusion, it is not justifiable to generally argue that utilising an exemption under Art. 4.5 WFD would (automatically) infringe the requirements of the Nitrates Directive specified in Art. 5.5. With this result, the panel is aware that the ECJ has stated that additional measures under the Nitrates Directive must be implemented as soon as the Member State observes that there is a need for them and not later.[101]

[100] LOV nr 1150 af 17/12/2003: Lov om miljømål m.v. for vandforekomster og internationale naturbeskyttelsesområder (miljømålsloven), https://www.retsinformation.dk/eli/lta/2003/1150

[101] Case c-322/00 166.

It can be argued that the situation for protected areas under the Habitats Directive differs to some degree. Applying less stringent objectives for water bodies within Natura 2000 sites apparently requires more consideration. However, it cannot be excluded to derive less stringent objectives that do not affect the requirement to increase the favourable conservation status in these sites. A site-specific assessment can secure that the implementation of measures to achieve the highest ecological and chemical status applying Art. 4.5 WFD does not jeopardise to achieve a favourable conservation status. Such measures should preferably support the effort to preserve or reach the favourable conservation status – in order to be the best effort possible.

Lastly, setting less stringent environmental objectives in a water body do not infringe the Nitrates or the Habitats Directive's objectives, if the implemented measures turn out to be disproportionately expensive. Although it is thinkable that the remaining measures implemented to achieve the less stringent ecological status will result in an infringement within the scope of the Nitrates and the Habitats Directive. However, Art. 4.5 (c) WFD ensures that, while using the exemption, no further deterioration occurs in the status of the respective water body. Hence, Art. 4.5 is a tool to manage a theoretical individual conflict situation. The panel stresses once again that less stringent objectives under Art. 4.5 (c) WFD cannot be applied for a water body, if the assessment shows that the obligations of the Nitrates Directive and the Habitats Directive are infringed. The exemption includes provisions which – if applied properly – ensure that the two Directives objectives are to be considered in the individual assessment.

8.5.4 Examples for the Application of WFD´s exemption Scheme in Article 4.4 and 4.5

In chapter 2 three examples are used to demonstrate three different situations with particular challenges when it comes to achieving Good Ecological Status. The Panel here discusses on a general level if it may be reasonable to apply the exemptions in Art. 4.4 and 4.5 in these situations. The Panel notes that the following section's purpose is to give information on certain aspects when assessing the possibility of applying the exemption scheme. This information does not replace the need for a specific examination using all available data.

The Bornholm example: Around the island of Bornholm, the reduction of land-based N-load to zero (which is theoretically impossible) is not sufficient to reach G/M boundary conditions in the coastal water bodies since the main pressure comes from the marine waters in the Baltic Sea (transboundary pollution).

In this situation, the extension of timeframe is possible to allow for a phased achievement of the objectives for water bodies under Art. 4.4 WFD. For this finding, we refer to the Panel´s legal analysis which shows that natural conditions due to transboundary pollution can be viewed as natural conditions. The requirements for a time extension under Art. 4.4 WFD are:

- No further deterioration occurs in the status of the affected body of water,
- Extension of the deadline, and the reasons for it, are specifically set out and explained in the river basin management plan,
- A summary of the measures required under Art. 11 which are envisaged as necessary to bring the bodies of water progressively to the required status by the extended deadline, the reasons for any significant delay in making these measures operational, and the expected timetable for their implementation are set out in the river basin management plan. A review of the implementation of these measures and a summary of any additional measures shall be included in updates of the river basin management plan.

Under Art. 4.4 WFD, even if a time extension is implemented, all measures must be implemented based on an assessment of what constitutes best environmental practise and/or best available technique. This also means that Denmark together with other Baltic Sea Member States that also are faced with the challenge of transboundary pollution must take the necessary measures within the Regional Sea Conventions and/or MSFD (see chapter 4) to secure that the coastal waters around Bornholm achieve a Good Ecological Status when the time extensions run out.

In the Guidance Document No. 20, it is stated that transboundary pollution that cannot be managed through international water district RBMP[102] can be understood as a natural condition which hampers the possibility to achieve Good Ecological Status. At the same time for transboundary pollution, it is impossible to determine which human activity is responsible for the emissions which makes it difficult to apply Art. 4.5. Neither can the requirement in Art. 4.5 regarding natural conditions be fulfilled, as for Art. 4.4, since most of the nutrients come from the Baltic Sea it cannot be ruled out that the pollution of the water bodies around Bornholm can be decreased through measures under MSFD. Art. 4.5 is therefore not applicable before measures under the MSFD has been fully implemented.

The Limfjorden – Halkær Bredning example. This is a heavily eutrophied catchment where the current level of loading is so high that the system is insensitive to marginal load decrease and it is, hence, not possible to determine

[102] It has to be noted that WFD does not include international water districts for coastal waters.

at what loading it may reach Good Ecological Status. This is a clear example with a need for adaptive catchment management. As the Panel explains in chapter 2, it is necessary to implement measures (load reductions) which ensure that the water bodies becomes responsive to reductions in land-based N-loadings. Then, it may be possible to devise a management plan that could move the catchment towards Good Ecological Status.

Limfjorden – Halkær Bredning could serve as an example where it may be possible to apply both Art. 4.4 and 4.5 WFD and set a less stringent objective for affected water bodies with a management timeframe beyond 2027.

The reasoning for utilising Art. 4.4 WFD differs from the one in the Bornholm case. But, in essence the time extension is implemented to allow for a phased achievement of Good Ecological Status in the water bodies since it is impossible at this moment to know the extent of load reduction needed to bring such a polluted area to Good Ecological Status. An adaptive management approach may be devised, which the WFD allows as long as the measures necessary to elevate the water body progressively to a Good Ecological Status by the extended deadline are implemented and evaluated.

A decision on applying Art. 4.5 WFD, however, requires that it is possible to pinpoint the human activities responsible for the emissions – and also that it is possible to assess the question on proportionality for implementing more than best environmental practise and/or best available technique, which is the baseline of action.

In the assessment below, the Panel assumes that agriculture activities are the main human activity affecting the nutrient situation in Limfjorden. The Panel finds that some requirements must be fulfilled when applicating less stringent objectives under Art. 4.5 WFD to the Limfjorden case type:

- Under Art. 4.5 WFD it has to be identified what human activity affects Limfjorden in a way that the achievement of a Good Ecological Status regarding the nitrogen load would be infeasible or disproportionately expensive. Fulfilling this stipulation needs research on the cost of stopping the respective human activity – most likely on the level of the catchment area. The researched cost must be weighed against the achievement of the objective of Good Ecological Status of the water body.
- Art. 4.5 (a) WFD requires that the environmental and socioeconomic needs served by the human activity – agriculture – cannot be achieved by other means, which are a significantly better environmental option not entailing disproportionate costs.
- The panel cannot determine whether there are other means possible that serve the same environmental and socioeconomic needs as the specific agricultural activities in the catchment area Limfjorden. In a first step, such research needs to include whether the products produced, the income generated for agriculture and the region, as well as the tax revenue, can be generated elsewhere.
- It has to be ensured that the highest ecological and chemical status possible is achieved (Art. 4.5 (b) WFD). Since the catchment is so heavily polluted, it could be impossible to determine the highest ecological and chemical status of the water body which is possible to achieve. Therefore, it is logical that the ecological status to achieve will need to be defined by measures that are implemented in a step-by-step manner. The first step is to determine the status the water body can achieve under the implementation of all reasonable measures. With the evaluation of the measures´ performance the next set of possible and proportionate measures can be identified that would elevate the water body into a higher ecological status. Meanwhile the respective highest ecological status must be fulfilled with the implemented measures and a catchment-specific plan.
- Furthermore, it has to be determined what impacts that could not reasonably have been avoided due to the nature of the human activity (see Art. 4.5 (b) WFD). Apparently, WFD obliges Member States to determine the impacts by the human activity in question – agriculture – that could not have been reasonably prevented. Arguably, the part of the impact on the aquatic environment that requires the use of the exemption should be identified. The investigation should also ensure that all other impacts – which could reasonably be prevented – are addressed by the measures taken to achieve the target status. The "relief" for the management of the catchment area is intended to cover only those impacts of human activity that would have been impossible or disproportionate to prevent.
- Setting a less stringent ecological status, no further deterioration must occur in the status of the affected body of water (see Art. 4.5 (c) WFD).
- The establishment of less stringent environmental objectives, and the reasons for it, must be specifically mentioned in the river basin management plan and those objectives must be reviewed every six years (see Art. 4.5 (d) WFD). This requirement leads to the conclusion that good status is always the first alternative and when the evaluation of measures is evaluated the question if the water bodies can achieve good status should always be considered.

The Lillebælt 217 Bredningen example. This example has similarities with the Bornholm and Limfjorden examples. Yet, while it was not possible to reach G/M boundary conditions in Limfjorden and Bornholm through measures directed towards Danish sources, this seems possible in the Lillebælt example. However, since the main pressure seem to be from water flowing in from outside, i.e., from the Baltic at large, the use of time extension based on the arguments for the Bornholm example should be applicable. If it eventually becomes clear that it is not enough to implement measures through MSFD (see above) together with national measures to reduce the nitrogen load it may be possible to use less stringent objectives for this type of water body. For the application of a time extension and/or less stringent environmental objectives, the Panel refers to the other examples in this section.

At last, the Panel points out that it should be permissible to introduce or modify exemptions from the environmental objectives for water bodies in the course of RBMP3. It is not apparent that the WFD requires the establishment of exemptions at the time of the adoption of RBMP. Also, even if previous RBMP´s have been unsuccessful in achieving a Good Ecological Status WFD´s legal provisions do not exclude the utilisation of further exemptions during RBMP3 per se. The panel notes that all Member States provide the EU Commission with information on their RBMP (Art. 15 WFD). To the knowledge of the Panel, the EU Commission has not claimed that the utilisation of exemptions in past RBMP´s was not in line with the WFD provisions. This assessment is supported by the fact that in the past the EU Commission has not claimed a WFD infringement case against Denmark regarding the exemption scheme in past RBMP´s. However, for using exemptions in RBMP3, especially beyond 2027, Denmark has to ensure that all requirements are fulfilled for each water body that are exempted.

8.6 Conclusions and Recommendations

The panel concludes that there is further legal room for manoeuvring than concluded by COWI and NIRAS and there is also indication that the current Danish approach in the third RBMP could include more exemptions:

- In the context with WFD´s exemption scheme the panel gives the following recommendations: For the further application of the WFD in the RBMP3 and beyond, it is advisable to examine the applicability of the exemptions at the level of the specific water bodies. An examination with the content of whether the application of exemptions could be excluded a priori is not advisable in view of the water body-specific requirements for the use of an exemption. The Panel makes this recommendation against the background that Denmark is in breach of its obligations under WFD if Good Ecological Status is not achieved in a water body by 2027 without an exemption having been claimed.
- For the utilisation of exemptions, the introduction of effective measures to achieve WFD´s ecological objectives are mandatory. The use of the exemption does not entitle Denmark to manage a water body merely to maintain the status quo. WFD´s objectives are to enhance the status of the water bodies and the measures required to achieve this continue to apply, only with modified temporal or qualitative requirements.
- The use of exemptions does not mean that good status no longer has to be achieved in the water bodies concerned. If a deadline extension is used, the good status in the water body has to be achieved later, i.e., after the regular deadline in 2027 has expired. And if less stringent environmental objectives are set, a review may conclude that the achievement of a good status in the respective water body is possible. In such a case, this objective has to be activated (again).
- The time required to consider the use of exemptions shall not result in the non-implementation of measures necessary to achieve an improvement in water body status. The effectiveness of these measures must be regularly reviewed with the aim of assessing whether they enable the achievement of the objectives applicable to the water body. Even if WFD requires a water body approach, this does not mean that measures must be implemented based on such as a scale. A cost-effective measure can be removing an activity and restore the area in one place and implement mitigation measures in another.
- To this end, Denmark must maintain a monitoring network that allows to collect the necessary data in the quantities and cycles required by Nr. 1.3 Annex V WFD. If during the RBMP3 it becomes apparent that the measures taken are not sufficient to achieve the Good Ecological Status applicable in a water body, further measures must be set into action within the framework of the WFD requirements.
- It is likely to be harmless if exemptions are added during the period of validity of the RBMP3, e.g., because an assessment of the effectiveness of the measures shows that less stringent environmental objectives need to be set in a water body so that Denmark does not violate the WFD. The WFD allows RBMPs to be amended and supplemented even after they have been (initially) prepared.

CHAPTER 9: GENERAL CONCLUSIONS

Between RBMP2 and RBMP3, considerable effort has been devoted to improving the quality and the spatial resolution of the modelling underlying the plans. The Panel estimates that the current state of the models has resulted in tools for estimating MAI that are not only fit for purpose, but that are exemplary in the way they reflect the specificities of the different water bodies while maintaining coherence and consistency across the land- and seascape. For that reason, the Panel is of the opinion that, overall, a robust basis for estimating required reductions of nutrient inputs into the different water bodies has been realised and no further improvement of these models is needed.

In future studies, focus should therefore shift to investigating and expanding the portfolio of possible measures to cost-effectively reduce the nitrogen loading into coastal water bodies, while preserving, as well as possible, agricultural activities. Emphasis should also be placed on the monitoring and evaluation of the effectiveness of these measures in reducing nutrient load to the water bodies under consideration of WFD´s respective requirements.

The Panel supports the averaging of N-MAIs between mechanistic and statistical models as performed in this model cycle. However, it advises that, in the future, the mechanistic model could be used for MAI-setting, offering the advantage that a run with all loadings set at MAI could be used as a verification tool. Statistical expertise will increasingly be needed to support the monitoring of many water bodies and investigating whether the effects on nutrient loads and the biological quality indicators follow predictions.

The Panel is of the opinion that the recalculation of the reference conditions, which can be considered an improvement from a scientific point of view, has led to inconsistencies between the newly derived G/M boundary values, and the intercalibrated G/M boundary values that are included in the European Commission Decision 2018/229. The Panel advises to ensure that these boundary values in open coastal waters are still in line with the European Commission Decision considering the procedure in CIS Guidance Document No. 30. The argument for performing this return to the intercalibrated values is that the intercalibration decision is binding for classifying water bodies in different quality classes, hence the importance of the boundary values.

Re-adjusting the G/M boundary values to the intercalibrated G/M boundary values will resolve some of the problems of burden distribution, as the current Danish boundary values are too low to allow for realisation of the Good Ecological Status in some water bodies even when all Danish land-based loads would be removed completely. In addition to coherence with the intercalibrated G/M boundary values, coherence with the HELCOM target values should also be aimed at as far as possible. The intercalibrated values are much more coherent with HELCOM target values than the currently recalculated ones.

The Panel approves using reference values for eelgrass depth limit based on observations from around the year 1900, even if reference conditions for Chl-a are derived with nutrient loads from well before that period. Observations on the slow response of eelgrass to nutrient conditions, and calculations of eelgrass depth limit for the reference conditions, both support the notion that essentially the two sets of reference conditions are consistent. The Panel advises to truncate values for the depth limit of rooted angiosperm vegetation to the maximum depth of the water bodies. Although valid arguments can be brought forward for the current practice, where Kd replaces the depth limit in shallow systems, precedence should be given to the biological quality indicator over its supporting physico-chemical variable. The Panel further advises to build scientific consensus on the quality of data bases and measurements before a next update of the models, but does not estimate that currently further adjustments are needed.

The Panel is aware that other stressors, apart from nutrient loading, affect the ecological status of Danish coastal waters. However, little or no evidence shows that reducing these stressors can be done *instead of* reducing nutrient loads. The calculated reduced nutrient load is necessary for reaching Good Ecological Status, even if other stressors are reduced. However, there is sufficient evidence to state that, especially for stress stemming from fisheries (affecting the sediment stability, as well as exerting direct mechanical damage to eelgrass), reducing the other stressor *in addition to* reducing nutrient loading may be needed to reach Good Ecological Status. The Panel estimates that restoration measures can be very useful. However, they should not be started before eutrophication has been brought under control.

The Panel sees limited perspective in replacing annual-based MAIs with MAIs for the summer season. Although it is true that nitrogen limitation mostly takes place in summer, possibilities to reduce N load in summer *only* are extremely limited. However, some landscape measures, in particular wetland construction, are more effective in summer than in other seasons. Within clear objectives of annual load reduction, room can be created to weight such measures more heavily than measures uniformly reducing nutrient load year-round.

To the Panel, the discussion on including phosphorus measures alongside nitrogen measures is a mixture of two different discussions. One discussion is on emphasising point sources rather than diffuse agricultural sources in designing measures. Given the high degree of purification of point sources in Denmark, there will be diminishing marginal N- and P-effects from further treatment of wastewater from point sources. A notable exception could apply to stormwater overflows, which may be addressed with interventions in the landscape that offer synergy with measures addressing diffuse sources.

The other discussion on phosphorus measures concerns the question whether some of the required N-load reduction measures may be replaced by P-load reduction measures. The models offer sufficient information to recalculate P-interventions in terms of equivalent N-interventions. In general, these calculations show that the trade-off potential is limited, but locally some options, especially for joint N/P reductions, may be present and relevant to pursue further.

The Panel acknowledges that forthcoming results of Phase III projects may affect the conclusions on, *inter alia*, seasonality and phosphorus efforts. With respect to local/regional studies examining the implementation options for specific water body systems, the Panel endorses the incorporation of as much local knowledge as possible. However, the Panel stresses that the local knowledge should be incorporated within firm, nationally consistent, constraints and reduction targets to be effective.

The Panel endorses the approach taken to estimate the baseline load in 2027. The developments of statistical methods and models for N-retention in the landscape are robust and reliable. The Panel stresses the need for careful monitoring of measures once these are implemented at scale. This will improve the knowledge base on these measures and form a solid basis for further planning and evaluation. It should be the prime focus of knowledge development in the coming years. The Panel observes with concern, that during the 2010s almost a decade has been lost, in which little N-load reduction has been realised. However, the Panel remains convinced that the types of measures proposed have an inherent potential to lead to reduced N-input into coastal systems. The Panel can only express hope that during the coming years of the RBMP3 period, a steadfast and sustained political environment will implement the necessary measures to realise the ambitious goals of the WFD.

Based on a thorough legal analysis of the Water Framework Directive, as well as its relation to other Directives (e.g. Nitrates Directive, Habitats Directive and Marine Strategy Framework Directive), the Panel concludes that COWI and NIRAS' assessment that there is virtually no room for making use of exemptions in the WFD, is too strict. Exemptions based on Article 4.4 (time exemptions) and 4.5 (setting less stringent objectives) are generally possible but bound to well-defined requirements. The Panel emphasises that the use of exemptions can in no way lead to the abandonment of well-defined plans with goals and time schedules to significantly improve the water quality in Danish waters. Exemptions can only be formulated for a specific water body and thus require extensive knowledge and data on that water body. That includes making use of socio-economic information to prevent that the applied measures lead to 'disproportionate cost'. The Panel foresees that achieving Good Ecological Status in all Danish waters by 2027 will not be possible, and it advises to use exemptions wisely as part of a strategy to achieve the environmental goals in an orderly and socially acceptable way.

With respect to the central question of room for manoeuvring, the Panel is of the opinion that the assumptions and scenarios used in the modelling leave no additional room for manoeuvring, as all the room has already been taken up in the present modelling strategies. There is, however, room for manoeuvring in setting the targets for the open waters, as this will have to be considered anyway to correspond with the intercalibration but at the same time may lead to a higher probability of reaching the adjusted G/M boundaries. The Panel finally sees room for manoeuvring in the use of exemptions, which offer more flexibility than previously estimated. However, a structured scheme and process must be followed to implement exemptions, such as less stringent objectives, in a legally acceptable way.