MARCH 2023
MINISTRY OF THE ENVIRONMENT AND MINISTRY OF FINANCE

Second opinion on the need for reduction of nitrogen in the third RBMP for 2021-2027, Phase I

FINAL REPORT 25.11.2022 (REV 14.03.2023)

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APPENDICES

List of abbreviations and definitions

Abbreviation	**Meaning**
AAU	Aalborg University
AU	Aarhus University
BC	Baltic Sea coastal water type
BSAP	Baltic Sea Action Plan
BV	Brunt Väisälä
BQE	biological quality element
CD	Commission Decision
Chl-a	chlorophyll-a
CIS	Common Implementation Strategy
COMB	combined
DCE	Nationalt Center for Miljø og Energi
DEPA	Danish Environmental Protection Agency
DIN	dissolved inorganic nitrogen
DIP	dissolved inorganic phosphorus
DPSIR	Drivers, Pressures, State, Impact and Response
EC	European Commission
EDL	eelgrass depth limit
EQR	ecological quality ratio
EU	European Union
EUCJ	European Union Court of Justice
G/M	good/moderate
GD	guidance document
GEUS	The Geological Survey of Denmark and Greenland
GIG	geographical intercalibration groups
H/G	high/good
HELCOM	Helsinki Commission
IC	intercalibration
IDW	Inner Danish Waters
JRC	Joint Research Center
LGM	latent growth modelling
MAI	maximum allowable inputs
MECH	mechanistic

MLR	multiple linear regression
MoE	Ministry of the Environment
MoF	Ministry of Finance
MSMDI	Multi Species Macroalgae Depth Index
MSFD	Marine Strategy Framework Directive
N	Nitrogen
NEA	North East Atlantic coastal water type
NEC	National Emission Ceilings
NERI	National Environmental Research Institute
NLES	nitrogen leaching estimation
NGO	non-governmental organisation
OSPAR	Oslo and Paris Conventions
P	phosphorus
P/B	poor/bad
PLC	pollution load compilation
PLS	partial least squares
QE	quality element
RBMP	river basin management plan
RC	reference conditions
RFM	room for manoeuvring
STAT	statistical
TN	total nitrogen
ToR	terms of reference
TP	total phosphorus
WAIC	widely applicable information criterion
WFD	The Water Framework Directive
WG	working group

DEFINTIONS

Baseline load. Baseline load is the expected load of nitrogen and of phosphorous (tonnes/year) for each water area at the end of the plan period, i. e. 2027.

Burden distribution. Covers 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.

Status load. The nitrogen and the phosphorous load (in tonnes/year) for each water area at the beginning of the plan period, i. e. 2021.

Target load. The load of nitrogen (tonnes/year) that must not be exceeded to obtain a chosen environmental class. It consists of natural background load plus MAI from human sources.

Executive summary

The Water Framework Directive (WFD) aims at restoring 'good ecological status' in surface waters in EU member states.

With a wish to further improve the basis for implementing the third cycle of the WFD (2021-2027), the parties to the Danish Parliament agreement from October 2021 on green transition of Danish agriculture agreed that an assessment (a "second opinion") of the scientific assumptions or choices used for calculating the need for nitrogen reduction should be carried out.

The report constitutes the first phase of the second opinion. It has been undertaken by a cross-disciplinary team of consultants from COWI, NIRAS, Aalborg University and independent consultants. It provides the basis for a subsequent second phase, i. e. an analysis and peer review to be undertaken by international experts. Results from phase I and II provide basis for implementation in the third phase of the second opinion, where a revised assessment of the remaining need for action will be conducted. The combined Second opinion (phase I, II & III) will be the basis for the Parliament's planned future deliberations concerning the Parliamentary agreement on green transition of Danish agriculture made in October, 2021**.**

The report was produced based on the best available scientific and legal knowledge and experience with implementation of the Water Framework Directive in the Danish River Basin Management Plans (RBMP) 2 and 3. COWI and partners are aware that scientific and even legal assessments might be challenged by experts in their respective fields. The basis for the conclusions in the report are fully documented.

Purpose

The purpose of the first phase of the second opinion is to prepare an assessment of the current legal, administrative and scientific basis for the calculation of the need for reduction of the Danish land-based Nitrogen load to Danish coastal waters. The assessment consists of three elements:

› Descriptive assessment (*Redegørelse)* of the legal basis for the calculated need for Nitrogen reduction.

› Descriptive assessment (*Redegørelse)* of the current scientific basis for the calculated need for Nitrogen reduction.

› Analysis of the legal and scientific room for manoeuvring (*handlerum)* within the boundaries of the Water Framework Directive. This includes a specific assessment of whether it is possible to implement/interpret the WFD differently (legally) and if there are options to apply different methods for assessing the necessary Nitrogen reduction.

Findings and conclusions

In what follows, we present overall findings and conclusions under the headings of room for manoeuvring, legal aspects and scientific aspects.

Room for manoeuvring

The 2nd opinion has been charged with investigating whether there is a room for manoeuvring for the Danish politicians and authorities in terms of interpreting and implementing the WFD. The investigation has covered both legal and scientific aspects.

From a legal perspective the 2nd opinion team finds that the room for manoeuvring is very limited. This is based on the following findings:

- The combined legal objectives of the WFD and the Nitrates Directive are clear in scope requiring a constant drive towards preventing and reducing nitrogen pollution (the Nitrates Directive specifically addressing nitrate pollution) of water bodies, regardless the choice of methodology applied related to reference conditions and normative status of water bodies. Therefore, the legal normative wording provides no room for deviating from the overall legal objectives.

- The legal WFD framework provides very little interpretation in detailing boundaries, uncertainties and/or deviations related to reference conditions and normative status of the water body. As such, the implementation of related methodology depends significantly on Common Implementation Strategy (CIS) guidance documents and hence, the rationale and validity of the sound scientific argument.

- As detailed in the scientific sections of this report, the current Danish methodological approach in establishing reference conditions and normative status of water bodies in overall terms is in alignment with the WFD legal framework.

- There is very little room for manoeuvring in the legal application of Article 4.4 (extension in time) or Article 4.5 (less stringent environmental objectives) leading to reduction in measures and actions. This conclusion is based primarily on an analysis of the wording of the provision as interpreted by the European Commission (EUC), the European Union Court of Justice (EUCJ) and in CIS Guidance Documents. It is also based on the strict conditions set out in Article 4.8 and 4.9 ensuring that a possible extended deadline does not lead to the non-achievement of the environmental objective 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.

From a scientific perspective there is limited room for manoeuvring in terms of reducing the measures targeted at nutrient reduction. This conclusion is based on the following main arguments:

- Denmark has established reference conditions for chlorophyll-a and 'eelgrass depth limit' in accordance with the provisions of the WFD. Taking the robustness of the applied methodology for determining the reference conditions the 2nd opinion team assesses that not much room for manoeuvring can be anticipated by alternative assessment methods. However, there is a room for improving quality assurance of the applied methodology, thereby, ensuring improved compliance with the provisions of the directive. Suggested improvements is assessed to have insignificant influence on the already calculated MAIs.

- Even if all currently planned measures would be fully implemented by 2027, the established G/M target implies a situation where only half of the indicators (chlorophyll-a and eelgrass) point to good ecological status. This means that the other half points to moderate or lower ecological status. That would mean that Denmark will not meet the requirements of WFD.

- Eight press factors (additional to N) are studied: Sand extraction, dumping and dredging, physical structures, fishery, ship traffic, plastic, hazardous substances, invasive species. Fishery has the relatively highest impact. None of the factors have, however any significant impact on the nutrient conditions. Meaning that even if the eight press factors are zeroed out completely, the nutrient concentration in Danish waters would remain at too high levels.

- Regarding assessment of status load, the 2nd opinion team assesses that changed technical details of the method will not add significantly to the robustness of the calculated results. The status load may be slightly different, but it is not given that these changes will have significant impact on the already established MAIs.

- N load reduction during the summer season (seasonality) may give room for manoeuvring for specific water bodies.

- It is found that there may be water bodies of interest for modifying N-MAI by reduction of P loads. Such modification requires more detailed studies of each individual water body.

- 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, especially in the more closed marine waters and fjords.

- Establishing additional management scenarios (i. e. assessing the burden distribution between Denmark and its neighbouring countries) may strengthen the managerial basis for establishing measures. This may leave room for manoeuvring in specific water bodies, e. g. Wadden Sea, Flensburg Fjord and Bornholm. Such additional scenario modelling shall not, however, delay the implementation of measures to reduce nutrient loads.

- The intercalibrated EQR-results for chlorophyll-a for Denmark and Germany (from 2013) have not been 'back-transformed' to the 'Danish phytoplankton method' classification system. There is room for manoeuvring in terms of deciding to perform a new back-transformation of intercalibrated EQR-results to the Danish classification system. Adjustments by a correction caused by the lacking back-transformation will most probably result in higher EQR (more stringent) values, thereby, causing lower MAIs.

- The 2nd opinion team has found that it should be investigated whether the new and more detailed objectives of the RBMP3 for coastal waters are in line with the previous conducted intercalibrations or there might be a need for an updated intercalibration of the G/M class boundaries and EQRs especially for the phytoplankton quality sub-element chlorophyll-a. When considering that lower (more stringent) chlorophyll-a G/M class boundaries already have been applied in RBMP3, due to the more stringent reference conditions, and also taking potential improvements of the modelling system and the lacking back-transformation, as described above, into account, the result of a 'fitting' or 'full intercalibration' procedure will most likely result in only minor adjustments of the calculated MAIs, and if any most likely imply increased need for reduction of nutrient loads, and thereby, a reduced room for manoeuvring.

Legal review

The minimum requirements in the Water Framework Directive as concerns set targets and Nitrogen levels have been reviewed from a legal perspective. As concerns Nitrogen loads from agriculture, the review includes an analysis of the WFD legal framework for the establishing of reference conditions and normative status of water bodies relevant for coastal waters, and subsequent an analysis of the options for using the exemptions of the WFDs, i. e. Article 4.4 (extending the time limit until after 2027) and Article 4.5 (lower environmental targets), and to what extent Denmark to date has made use of these.

It is not the mandate of the review to perform a full legal conformity study of the Danish implementation of the WFD. At an overall level, the review has established that the current Danish methodological and scientific approach in establishing reference conditions and normative status of water bodies in overall terms is in alignment with the WFD legal framework.

The legal objectives of WFD are clear in scope requiring a constant drive towards preventing and reducing nitrogen pollution of water bodies, regardless of choice of methodology applied related to reference conditions and normative status of water bodies. This is also supported by both the EU Commission and the case law of the EUCJ. Therefore, the legal normative wording provides no further room for deviating from the overall objective of ensuring a constant drive towards preventing and reducing nitrogen pollution of surface waters. However, the precise definition of the needed measures, and the level hereof, depends on the robustness of the methodology and the basis for establishing the measures.

The WFD itself provides no further detailed legal understanding beyond the wording of the WFD itself regarding the establishment of reference conditions or the ranking of models in WFD, Annex II.1.3. It also does not provide further legal guidance into the normative definition of the difference between "undisturbed conditions" and "slight signs of disturbance" as generally applied by Annex V.1.2.4 for High Ecological Status and Good Ecological Status, respectively. Similarly, it provides no further legal interpretation of the meaning or definition of consistency and validity, and for the use of historical data in Annex II.1.3(v). As such, the determination of border definitions in Annex V.1.2.4, as well as the fulfilment of these conditions in Annex II.1.3(v) shall be met by sound scientific justification and plausible arguments within the scope of the WFD framework and the detailed CIS guidance.

This means that the possible room for uncertainty and/or deviations between reference conditions and normative status of the water body is not further defined by legal terms. The same goes for a definition of the consistency between reference conditions. It also applies for the meaning in Annex II, 1.3 (v) for reference conditions based on modelling, stating that methods shall "provide a sufficient level of confidence about the values for the reference conditions to ensure that the conditions so derived are consistent and valid for each surface water body type". The legal validity of the defined needed "sufficient level" and the fulfilment of being "consistent and valid" depends on the strength of the specific scientific argumentation. The conditions in paragraph (v) are equal in rank and cumulative, which means they all need to be fulfilled.

As presented above, there is no room for further legal application of Article 4.4 leading to a reduced approach in measures and actions. This conclusion is based partly on an analysis of the wording of the provision as interpreted by the EUC, EUCJ and in CIS Guidance Documents and partly on an analysis of the joint conditions in WFD Article 4.8 and 4.9 that applies for both exemptions after WFD Article 4.4 and 4.5.

It is established by both EUC and In CIS Guidance Documents that all relevant measures needed to achieve good status should be taken by 31st of December 2027 at the latest, including sufficient reductions in the nitrogen emissions.

It is noted that the two other EU regions in the scope of this study, Schleswig-Holstein in Germany and Southern Sweden, apply a wide-spread application of article 4.4 based on the reason of "natural conditions". It is also noted for the German and Swedish implementation that measures related to agriculture will not be fully implemented by 2027.

It goes beyond the scope of this study to assess whether the German and Swedish interpretation of the room for manoeuvring when applying Article 4.4. after 2027 is compliant with the WFD. However, the 2nd opinion analysis finds the meaning of "taken by 31st of December 2027" to signify that relevant and sufficient measures should be adopted and legally binding as well as economically funded on the 31st of December 2027 in all Member States.

Thus, only the time lag of the recovery of the water environment to a good status can remain after 2027, for the reason of "natural conditions" to apply. The exact establishment of when the environmental objective shall be obtained, shall be based on a scientific estimation of the time lag for the individual quality elements.

Also, "natural conditions" cannot be considered applicable in a situation where Member States in general need to develop further measures e. g., new technology to achieve the environmental objectives. Such measures are to be based on the precautionary principle and it is underlined that Member States should take decisions based on the best information available at any given moment. As such, Member States cannot delay action simply awaiting full certainty.

Furthermore, the WFD requires detailed information in the RBMP of the reasons for the extension for the individual water body, as the necessary measures required under the WFD Article 11 as well as the expected timetable for their implementation (Article 4.4. b) and d). Thus, the overall assessment and conclusion from the Commission on the Danish implementation of the WFD, going forward, is that the use of exemptions should be documented to a higher degree than was the case with the second RBMPs, i. e. that the relevant criteria for use of the exemptions should be (further) documented.

With regard to Article 4.5, Denmark has not earlier applied Article 4.5 to coastal waters. As such, there is no Danish lessons or experiences on reasons or justifications for applying an exemption for a specific coastal water body in Danish context.

It follows from the country study in the 2nd opinion that only Southern Sweden has made use of Article 4.5 in the 3rd RBMP and only to 3% of its coastal water bodies (8 out of 289). All exemptions are motivated by the hydromorphologic status and the hydrogeographic conditions which only support a 'moderate' environmental objective. All the waterbodies subject to a less stringent environmental objective are adjacent to harbour activities where it has been judged that the harbours fulfil an environmental and socio-economic need that cannot be met in a way that is better for the environment without disproportionate costs. The exemptions are thus motivated by the disproportionate costs required to achieve a 'good' environmental status. It goes beyond the scope of this study to assess whether the Swedish interpretation of Article 4.5 (a) is in line with the WFD. The rationale that port operations fulfil an important and specific socioeconomic need and that a 'good' status would require disproportionate costs (e. g. reconstruction of port infrastructures) are however sound[1]. Furthermore, the use of article 4.5 on such a small number of

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[1] The socioeconomic importance of sea transport is for example presented in the national guidance on socially important activities: MSB (2019), Vägledning för identifiering av samhällsviktig verksamhet, https://www.msb.se/contentassets/d8fca23b124c4686a629970fd2c1aa31/vagledning-for-identifiering-av-samhallsviktig-verksamhet-msb1408---juni-2019.pdf

coastal waters is also in line with the fact that this derogation is meant for specific cases. In continuation of the Swedish example, it is important to stress that both reasons in Article 4.5 (a) should be met and that the exemption can only be applied when the human activity serves both "environmental and socioeconomic" needs.

According to CIS Guidance Document no. 20, page 20, "a 'less stringent objective' does [...] not mean that (a) the other quality elements are permitted to deteriorate to the status dictated by the worst affected quality element or (b) the potential for improvement in the condition of other quality elements can be ignored." On that basis, a less stringent environmental objective is therefore only applicable to the specific quality element in question, and it can therefore not be concluded that the Swedish case can be applied to the Danish context. Even if a waterbody has a derogation for a reduced environmental objective due to e. g. hydromorphology, it would not exempt from the timely implementation of the measures associated with a 'good' status on the remaining quality elements.

The conditions for using Article 4.5 are rather restricted following the recent statement from the European Commission in the 5th Implementation Report. Here, the need for better documentation for the methods used to assess the fulfilment of mandatory criteria when applying exemptions is emphasised. Also, it is argued that the use of the exemption is not intended for general application for the majority of water bodies but shall only be applied in special cases.

In addition, Article 4.5 cannot stand alone. A significant impediment for applying Article 4.5 sits with the obligation of Article 4.9 of the WFD obligating Member States to ensure that other EU-legislation in not compromised when applying exemptions after the WFD. This is furthermore emphasized by the most stringent objective and/or condition shall apply, WFD Article 4.2 and Article 10.3. Article 4.9 establishes that the WFD does not overrule other environmental and nature protection directives and they must all be complied with, regardless of the exemptions regarding extension of deadline or setting less stringent objects are applied within the WFD framework. In this regard, especially the Nitrates Directive obstruct the possible further application of the exemption relating to an extension of the deadline. In this regard it should be noted that the Commission has[2] highlighted Denmark as being among Member States standing out due to a large number of waters that are eutrophic and having recorded bad water quality all around its territory and its systemic problem managing nutrient loss from agriculture.

It follows from the 2nd opinion analysis of the Nitrates Directive that

- If nitrate pollution cannot be seen to be reduced and/or max nitrate levels of 50 mg/l in groundwater cannot be met or risk being exceeded, additional measures must be taken under the Nitrates directive, specifically included in Nitrates Action Programme legislation subject to the Nitrates Directive

[2] The RBMPs further elaborate that in most cases, the function of a port cannot be met in any other way that is significantly better for the environment.

article 5(4) and (5). Similar, it follows that such additional measures also are needed for surface waters, where the nitrate pollution cannot be seen to be reduced by the existing Nitrates Action Programme legislation subject to the Nitrates Directive article 5(4) and (5).

- It is of key importance when assessing potential "room for manoeuvring" within the WFD framework to keep in mind the obligation to implement additional measures/reinforced action to reduce and prevent nitrate pollution from agricultural sources, when contribution from agricultural sources is "significant".

- It is also of key importance to note that the EUCJ has confirmed the importance of the Nitrates Directive Article 5(3) (a) and (b) as requiring member states to base their Nitrates Action Programmes on the *"best available scientific and technical data and the physical, geological and climatic conditions of each region"*.

As such, potentially required additional measures implemented through Nitrates Action Programmes may not be postponed due to on-going scientific discussions and further research on methodology, etc.

Thus, the application of WFD Article 4.4 or 4.5 requires the Member States to meet the objectives set for individual Protected Areas. Also, the EUCJ stated in the Doñana case that Member States can be in breach of their obligations under WFD Article 11 of Directive 2000/60, read in conjunction with Article 4.1I if they do not lay down, in the programme of measures, any measure to prevent disturbance of the protected habitat types. Thus, the ruling does not only confirm the double set of environmental objectives, stated in the WFD Article 4.1I but introduces an obligation on the Member States to actively include in the programmes of measures relevant measures to meet the objectives after other EU-legislation, e. g. the Nitrates Directive and the Habitats Directive.

As regards the Marine Strategy Framework Directive (MSFD), the use of exemptions after WFD Article 4.4. and 4.5 similarly prerequisites an assessment that the WFD extension of the deadline and the setting of less stringent environmental objectives will be consistent with the MSFD. This means that the application of the WFD exemptions within a marine water will not jeopardise the environmental targets or good environmental status after the MSFD, including designated marine protected areas, and that the WFD exemption falls within the area for exemptions defined by MSFD Article 14.

It follows from the above that the application of Article 4.5 from a legal point of view provides no further room for manoeuvring leading to a reduced approach in measures and actions. The application of Article 4.5 depends on the validity of a specific sound argument meeting the strict conditions set out by the legal framework, the EUCJ and the EU Commission.

On a final note, this report presents the argumentation of Germany and Sweden for the use of exemptions subject to WFD Article 4.4 and 4.5[3]. This information may be interesting for comparative reasons but has no impact on the legal analysis presented. The legal analysis is based on review of EU law, the Danish implementation and the Danish dialogue with the EU Commission. The implementation of the WFD as applied by third countries may serve as inspiration, and any preferred approach or lessons observed must in order to obtain legal effect – be endorsed by the CIS and/or be adopted as part of the legal update of the directive. As such, from a legal point of view, the applied implementation by 3rd countries provides no room for manoeuvring in a Danish context.

Scientific review

The Danish Marine Model Complex, developed by DHI/Aarhus University has been used in the revision of existing type-specific reference conditions into water body specific reference conditions for 'chlorophyll-a concentration'. Parameter values of a revised typology and estimated 'reference' nutrient load were used for estimation of chlorophyll-a reference values for individual water bodies. Both statistical and mechanistic models have been used. For 'eelgrass depth limit' historical observations were revisited and applied for individual water bodies, and for water bodies without historical observations reference conditions were established via a regression-based model using historical observations for a description of eelgrass depth distribution in individual water bodies as a function of typology parameters of a revised typology.

It is the 2nd opinion conclusion that the scientific basis for the modelling work of RBMP3 – and developed by DHI and Aarhus University is substantial in content and of high scientific quality. Taking the specific objective into account, the modelling is assessed to be "fit for purpose", meaning that it provides a transparent, consistent and scientifically defendable method for determining target loads and hence of N-MAIs with an acceptable degree of accuracy. Hence, the 2nd opinion team of experts agrees with the conclusion made by the international panel of experts performing an evaluation on the Danish marine models in 2017. The panel concludes:

"In comparison with many other European countries, Denmark has excellent databases, models and scientific expertise as a basis for the implementation of the Water Framework Directive….. The Panel has reviewed the choice of indicators and procedures, in the context of the WFD requirements and specifications, and found that the indicators, the methods to determine reference conditions and the methods to determine required actions were WFD compliant. The Danish implementation is based on either direct historical observation or model determination of reference conditions. Little or no uncontrollable "expert judgement" is involved. In that respect, the Danish models are attaining the highest possible standard of WFD implementation."

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[3] The scope of this study does not include a further legal conformity check of the validity of the Swedish or the German approaches.

(Panel of international experts. *International evaluation of the Danish marine models.* Miljø- og Fødevareministeriet, 10 October, 2017).

The 2nd opinion team also agrees with the international panel in supporting that the two different modelling approaches (mechanistic and statistical) are maintained and further developed.

Whereas the 2nd opinion team assesses the established reference conditions for Chl-a are based on a robust methodology, the results of the statistical models could be improved by focusing on nutrient-load/nutrient-concentration relationships for individual water bodies and on a nutrient/Chl-a concentrations conceptual relationship for development of a generic (empirical) relationship against which outputs from the mechanistic models should be tested. It is the 2nd opinion team's assessment that applying this approach would not imply significant changes in the estimated MAIs.

For eelgrass depth limit the revisiting and re-assessing the historical data set, taking into account the revised typology, have enabled a better differentiation in the setting of reference values for individual water bodies. However, 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. Establishing (nutrient) pressure-impact relationship(s) covering the eelgrass reference conditions could provide a basis for assessment of development of eelgrass depth distribution under such 'high' quality status class conditions and its linkage to more impacted conditions.

The 2nd opinion team finds that the 'K_d-proxy', is a valid parameter to be used as proxy for the 'eelgrass depth limit' G/M class boundaries in model calculations. It is a conclusion, that the result for open coastal waters in the common intercalibration types less affected by Danish N loads shows lower (more stringent) reference values compared to the intercalibrated reference values.

The models developed by DHI/Aarhus University constitute the basis for the current calculation of the need for Nitrogen reduction. The 2nd opinion review describes the key methodological choices which have influenced the calculations. The objective for the modelling work is to estimate the target nutrient loads that will provide a given environmental status.

The target load at the boundary value between Good and Moderate (G/M) status classes gives a 50% probability not to reach the target. Even if the target loads are reached, the environmental status will not be as required in the Water Framework Directive. This also is elaborated upon in the legal chapters of this 2nd review. From a scientific point of view, this represents a logical deficiency.

In addition to the issues regarding the G/M ecological quality class boundary mentioned above, it may be expected that some water bodies may be classified even lower than Moderate Status, even though the median value may fulfil the G/M class boundary requirement.

Furthermore, the 2nd opinion team has identified the following options for improving the models and/or the transparency concerning model results. Such improvements will enhance the credibility, accuracy, and transparency of the modelling. Such improvements will not have any suspending or upholding effect on the measures for reduction of nutrient loads:

- Based on the fundamental differences in the inherent insight into the governing processes between mechanistic and statistical models it may be considered to reduce the use of statistical models to verification purpose only and not to include its results in the quantitative MAI calculation.

- Inclusion of causal relations in the statistical models, i. e. how the parameters (e. g. nutrient loads, nutrient concentrations, chlorophyll-a, …) inter-relate.

- Documentation of the comparison of the pressure-impact-gradient (slopes) of the mechanistic models with those from the statistical models by focusing pressure both on nutrient loads and supporting quality elements (basically, nutrient concentrations, light transparency).

- Extension of the analysis to also comprise the supporting quality elements (N- and P-concentration) and cross-check between the different biological quality elements.

- Finalising and inclusion of the developed macro algae classification method as an additional quality element.

- The 2nd opinion team finds that, there is limited room for manoeuvring in specific and designated, local areas: Estimated Maximum Allowable Inputs (MAIs) of Nutrients (N and P) to coastal waters could possibly be established more accurately through better data from designed pilot projects where all human activity is removed.

Concerning the N-Load determination, the 2nd opinion team finds that the calculation method has been refined since the 2nd plan period, and that it is of high scientific credibility.

Furthermore, the introduced increase of spatial resolution (towards a finer resolution) and the inclusion of phosphorous as nutrient represents an improvement of the N-load calculation.

Different management scenarios are modelled with different nitrogen and phosphorous load conditions. This represents a substantial improvement and illustrates how the different reductions in phosphorus can substitute some of the nitrogen reductions needed to achieve the target values for Chl-a concentration and depth limit for eelgrass. On a national level the effect of a 10% reduction of P-loads leads to a 2% increase in N-MAI. For a few specific fjords, P-load reductions may on local level lead to potentially higher N-MAI increases.

Concerning Baseline Load, the 2nd opinion team finds that the effect of some measures has a longer response time than the plan period. Further, several measures are expected to come into effect after end of[4] the current plan period (2027). It is uncertain to what degree the effect of these measures will materialise within the current plan period.

The 2nd opinion team observes that the effect of future efficiency of increased mitigation measures within agriculture (nutrient uptake, etc.) are included in baseline although the effect of such measures is not yet documented from large scale implementation. This leads to a potentially too low requirement to the need for reductions.

The national inventory between RBMP2 and RBMP3 shows no difference in the baseline loads. The measures implemented during RBMP2 seemed to have had no impact on the loads. This indicates that planned measures had no or delayed effect. Also, the baseline includes potential effects of new N-optimising measures in agriculture (e. g. improved food uptake of stock) during the 3rd RBMP. It is not certain to what extent such future measures will come into effect.

Regarding the effect from neighbouring countries (burden distribution) the following conclusions are made: 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.

Regarding the question of selecting a year (e. g. 1900) for nutrient load as reference condition: The N-load in reference condition must correspond to high ecological status. The WFD defines high ecological status as a status with 'no or very minor evidence of distortion', and corresponding Nitrogen concentrations 'within the range normally associated with undisturbed condition'. Therefore, the year is secondary: it is the high environmental status which is the decisive factor, and the 2nd opinion team finds the nitrogen load level used in the establishment of reference conditions for Chl-a and eelgrass is appropriate as it could represent near undisturbed conditions.

Establishing type-specific biological reference conditions is a WFD key issue and 'anchor' in the classification of water bodies' ecological status. The typology characterises water bodies according to types. It is a tool to assist the process of establishing type-specific reference conditions and setting of ecological quality status class boundaries by enabling comparing 'like with like' (within and across countries). The revised Danish typology for the 3rd RBMP provides general improvement. It enables a differentiation of coastal water types that reflects the diversity of the Danish coastal waters better than the typology of the 1st and 2nd RBMPs. Clear links to the WFD common intercalibration types need to be

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[4] The Danish Environmental Authorities and model developers from Aarhus University and Danish Hydraulic Institute are working on improved modelling of phosphorus as a part of the ongoing second opinion. The project which is a part of the implementation phase of second opinion (phase III), also includes model development regarding seasonality.

established, also showing how the national types are subdivisions of these, and the typology descriptor parameter values need to be included in the RBMP or its associated legislation because their role as hydromorphological supporting quality elements.

1 Introduction

With a wish to further improve the basis for implementing the third cycle of the WFD (2021-2027), the parties to the Danish Parliament agreement from October 2021 on green transition of Danish agriculture agreed that an assessment (a "second opinion") of the scientific assumptions or choices used for calculating the need for nitrogen reduction should be carried out.

The present draft report constitutes the first phase of the second opinion. It has been undertaken by a cross-disciplinary team of consultants from COWI, NIRAS, Aalborg University and independent consultants. It provides the basis for a subsequent second phase, i. e. an analysis and peer review to be undertaken by international experts. Results from phase I and II provide basis for implementation in the third phase of the second opinion, where a revised assessment of the remaining need for action will be conducted. The combined second opinion (phase I, II & III) will be the basis for the Parliament's planned further deliberations concerning the Parliamentary agreement on green transition of Danish agriculture of October, 2021**.**

The report has been produced based on the best available scientific and legal knowledge and experience with implementation of the Water Framework Directive in the Danish RBMP 2 and 3. COWI and partners are aware that scientific and even legal assessments might be challenged by experts in their respective fields. The basis for the conclusions in the report are fully documented.

1.1 Purpose

The purpose of the first phase of the second opinion is to assess the current legal, administrative and scientific basis for the calculation of the need for reduction of the Danish land-based Nitrogen load to Danish coastal waters. The assessment consists of three elements:

- Descriptive assessment (*Redegørelse)* of the legal basis for the calculated need for Nitrogen reduction
- Descriptive assessment (*Redegørelse)* of the current scientific basis for the calculated need for Nitrogen reduction
- Analysis of the legal and scientific room for manoeuvring (*handlerum)* within the boundaries of the Water Framework Directive.

This includes a specific assessment of whether it is possible to implement/interpret the WFD differently (legally) and if there are options to apply different methods for assessing the necessary Nitrogen reduction.

1.2 Approach and method

The assessment is based on desk studies, iterative dialogue with stakeholders and interviews. The desk study includes the relevant EU *Acquis*, including guidance documents such as WFD CIS. It also includes relevant aspects of the Danish legal implementation, including the RBMP 2 and proposed RBMP 3, and it includes relevant background material such as the 2017 international evaluation of the Danish marine models.

The analysis focuses on the WFD and related water *Acquis* addressing the regulation related to nitrogen, as specified by the terms of reference. Three groups of stakeholders have been involved:

- The Steering Group, consisting of Ministry of the Environment (MoE), Ministry of Finance (MoF), and the Consultant.
- The Resource Group consisting of DHI, Nationalt Center for Miljø og Energi (DCE) and Aarhus University (AU).
- The Reference Group consisting of Fair Spildevand, Bæredygtigt Landbrug, Landbrug & Fødevarer, Råd for Grøn Omstilling og Danmarks Naturfredningsforening, Aarhus Universitet, Danmarks Sportsfiskerforbund, DTU Aqua, Limfjordsrådet, SEGES, Syddansk Universitet, Tænketanken Hav og Kommunernes Landsforening. MoE and MoF have been responsible for involving the Reference group.

The time schedule has had the following milestones:

- The project was initiated with the approval of the Consultant's Inception report of 11 May, 2022.
- On 20 May, Ministry of Environment and Ministry of Finance conducted a meeting with the Reference Group.
- The Consultant has had two meetings with the Resource Group (on 8.6 and 12.8). In addition, there has been frequent and numerous bilateral and trilateral meetings with representatives of the Consultant and representatives of the Resource Group, especially with researchers from DHI, DCE, Aarhus University, and representatives of the Environmental Protection Agency, MOE, and MoF.
- The Consultant has had seven status and progress meetings with the Steering Group: on 6.6, 28.6, 26.8, 12.9, 23.9, 30.9 and 5.10.
- On October 14, the draft report was submitted. The final report was submitted on 11 November, upon having received comments to the draft from the MoE and MoF. The Reference Group will comment on the final report. Their written contributions will be included in a revised final report. After this submission, a meeting with the Reference Group is planned for, allowing the consultant to present report conclusions.

The assignment has been covered under three headings: room for manoeuvring, legal aspects and scientific aspects.

1.2.1 Room for manoeuvring

Scientific room for manoeuvring covers four tasks (see Appendix A for details):

- **Task 10: Reference condition:** Assess possible room for manoeuvring in relation to establishing the reference condition and the environmental targets. Description of one to two alternatives for determining the reference condition.

- **Task 11: Revision of scientific basis for EQR:** Assess possible room for manoeuvring in relation to establishing the reference condition and the environmental targets. Options for revising the scientific basis for the EU inter-calibrated EQR values, including the steps necessary for involving other EU Member States and the European Commission in such a process.

- **Task 12: Target load – MAI:** Room for manoeuvring in relation to calculating target load, status and baseline load, model assumptions press factors and P-load reduction.

- **Task 13: Target load – seasonality, neighbouring countries:** Room for manoeuvring in relation to calculating seasonality and effects from neighbouring countries.

1.2.2 Legal aspects

The purpose of the legal review is to describe the legal basis for the calculation of the need for reduction of the Danish land-based Nitrogen load to Danish coastal waters, being the legal basis for the calculated need for Nitrogen reduction based on the framework of the EU Water Framework Directive.

Addressing this purpose, the analysis focuses on the WFD and related water Acquis addressing the minimum requirements related to objective, reference conditions and to the possibilities for extension of deadlines and use of less stringent environmental objectives.

- First part provides a **descriptive study** of the minimum requirements following the WFD.

- Second part is a **specific analysis** addressing the findings and outcome in order to define the WFD legal playing field of the room for manoeuvring with a view to the scientific methods/approaches in establishing reference conditions and normative status of water bodies, and the possible use of exemptions in extending deadlines for obtaining the objectives (WFD Art. 4.4) and in setting less stringent environmental objectives (WFD Art. 4.5).

As such, the review addresses a description of the WFD related legal framework/Acquis, including relevant Court of Justice of the European Union (CJEU) caselaw and CIS guidance documents.

For context, the review provides a shorter descriptive part on the corresponding Danish implementing legal framework. Being descriptive in nature, these presentations will not provide an independent full analysis on the Danish transposition, implementation, or interpretation of the full WFD and related water Acquis. Such analysis will, where relevant and in specific defined areas in both the legal and technical parts, be included in the second part of the legal analysis of the legal playing field/room for manoeuvring.

For comparison and to be further addressed in the analysis of room of manoeuvring, the legal review will present the use/interpretation of the exceptions, including the use of WFD Article 4.4 and 4.5 as applied by the RBMPs in Schleswig-Holstein and Southern part of Sweden.

1.2.3 Scientific aspects

The scientific review has covered a list of nine tasks as per the terms of reference. For each task, the consultant developed a detailed work schedule ensuring a systematic approach to covering the task: purpose, scope, basis, interface, deliverables, team members and deadlines. For a full overview of the tasks and their Objective, Scope and Basis, please be referred to Appendix A.

To manage all tasks, they were structured in three groups: Nitrogen load/discharge, Model calculation (cause-effect relation), and the Environmental Condition. This is illustrated in schematic form in Figure 1-1.

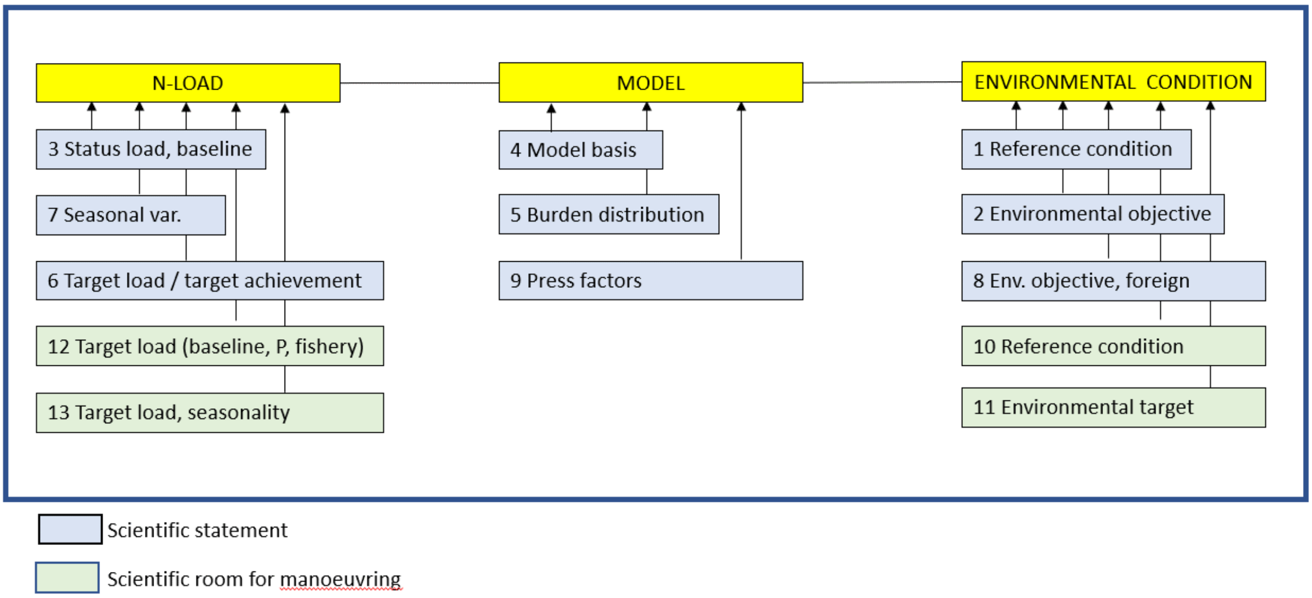

Figure 1-1 Schematic flow diagram for the tasks 1 to 13 of the scientific basis

1.3 Report contents

In addition to the Executive summary and the Introduction, the report has three chapters:

- Chapter 2 Review of the legal basis,
- Chapter 3 Review of the scientific basis, covering tasks 1-9 of the ToR, and
- Chapter 4 Analysis of the legal and scientific room for manoeuvring, covering tasks 10-13 of the ToR.

There are six appendices:

- Appendix A with an overview of tasks and task groups,
- Appendix B with excerpts from the international evaluation from 2017,
- Appendix C presenting the list of references,
- Appendix D presenting the 3rd Danish RBMP,
- Appendix E presenting the status and reasoning for applying extension in time and less stringent environment objectives in 3rd countries, i. e. Schleswig-Holstein and Southern Sweden,
- Appendix F on Reference conditions and environmental objectives, and
- Appendix G with Reference Group comments to the report.

2 Review of the legal basis

The following presents the WFD minimum requirement in objectives and RC, the WFD legal framework related to the extension in time (Article 4.4) and less stringent environment objective (Article 4.5). The chapter also provides the relevant dialogue with the EUC and the relevant caselaw of the EUCJ.

This chapter is supported by Annex D providing a brief insight in the Danish implementation of the WFD by the 3rd RBMP[5]. Annex E also provides a shorter presentation on the content and reasoning by Schleswig-Holstein and Southern Sweden in applying extension in time and less stringent environment objective.

2.1 WFD Minimum Requirements. Objectives and RC

2.1.1 WFD normative legal requirements

This charter presents the overall normative legal framework of the Water Framework Directive 2000/60/EC (WFD) in establishing the relevant environmental objectives and RC related to coastal waters, which falls within surface waters as defined by the WFD6, status classification, analysis of characterisation of river basins, comparability, and presentation of status[7].

The WFD sets in Article 1 the overall purpose/objective in establishing a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater, which prevents further deterioration and protects and enhances the status of aquatic ecosystems (Article 1,a), and aims at enhanced protection and improvement of the aquatic environment (Article 1,c). As such, the overall WFD goal is threefold; a continuously drive towards prevention of deterioration, protection and enhancement of both status and the water environment. In comparison, as it will be presented later in the chapter,

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[5] It is not the mandate of this report to perform a legal conformity study of the Danish implementation of the WFD. As such, Annex D provides a descriptive presentation of the Danish implementation. For further compliance review beyond this study, please refer *inter alias* to recent studies by Elbæk (2020) and Basse (2021).

[6] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ L 327/1 of 22.12.2000, latest revised by Directive 2014/101/EU.

[7] The defined scope of waters for this review, including the defined geographical scope, is coastal waters as defined by the WFD Article 2.7: "*Coastal water means surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters*".

This means that coastal waters are part of surface waters, as defined by the WFD being *"inland waters, except groundwater; transitional waters and coastal waters, except in respect of chemical status for which it shall also include territorial waters*".

the objective of the Nitrates Directive is more specifically in substantial terms to reduce and eliminate nitrate pollution of waters from agricultural activity.

According to the WFD, surface water bodies, including coastal waters, shall be protected, enhanced and restored with the environmental objective of achieving good surface water status, WFD Article 4.1 (a, ii)[8]. For coastal waters, being part of surface waters, the WFD Article 5.1, part 1 and 2 call for an analysis of the characteristics of each river basin district, and a review of the impact of human activity on the status of the surface waters. This is done based on the technical specifications set out in Annex II and involves characterisation of surface water body types (Annex II, 1.1) and the differentiation according to type for coastal waters (Annex II. 1.2.4).

This also includes the establishing of type-specific RC for coastal water (being part of surface water) body types following Annex II, 1.3.(i) with reference to the normative definition of high ecological status classification, Annex V, 1.2.4[9], to the Comparability of biological monitoring results, including IC, Annex V, 1.4.1, and to the classification and presentation of ecological status (Annex V, 1.4.2)[10]. This specifies the QEs for the classification of ecological status, which is set out in Annex V, 1,1.

In this regard it should be noted that the normative framework for biological and physico-chemical quality elements in Annex V, 1.2, as defining descriptors for water status classification are all affected by nutrient enrichment.

Eutrophication therefore becomes a key element in assessing the status of any given waterbody. Eutrophication is not defined in and of itself in the WFD but is defined as a criterion in the Nitrates Directive, Art 2(j). For a further legal discussion of the normative framework between the WFD and the Nitrates Directive follows below in Chapter 4.1.

The topic of modelling interconnectedness between eutrophication and biological and physico-chemical modelling is elaborated on in the description and analysis of reference conditions ("Task 1") below in Section 3.1 and 4.4.

The analysis of the characteristics, together with the review of human impact and the economic analysis required by Article 5.1, shall be reviewed, and if necessary, updated every 6-year, Article 5.2. As such, the result of the review may lead to a reassessment based on the conditions of the water body and the set objective. In specific cases, a possible re-IC may be needed.

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[8] Artificial and heavily modified bodies of water aims at achieving good ecological potential and good surface water chemical status, WFD Article 4.1 (a,iii).

[9] Annex 1.2.4 defines also good and moderate ecological status – as part of Annex V, part 1.2 on the normative definitions of ecological status classifications.

[10] "Ecological status" is an expression of the quality of the structure and functioning of aquatic ecosystems associated with surface waters, classified in accordance with Annex V (as defined by WFD Article 2, para.21).

The minimum requirements of the legal normative framework outlined above, is further underpinned in the scientific analysis, especially Task 1 and 2 describing the related RC and the environmental objectives, together with an analysis of the possible room of manoeuvring (Task 10 and 11).

2.1.2 Legal significance of CIS GDs

The WFD sets out the normative legal framework and overall methodological approach in establishing environmental objectives, RC, status classification, analysis of characterisation, comparability, and presentation of status. The precise outcome for each water body, and thus the implementation of the WFD, is based on sound deliberation by expert judgement, which is significantly guided by the outcome of the on-going transnational expert networking amongst the Member States and the European water directors within the CIS[11].

From the WFD entering into force, CIS has provided a common understanding and reference for the implementation and interpretation of the requirements of WFD. CIS is a result of the decision of the Member States to invoke a *"joint implementation plan"* for the WFD (Krämer 2012, s. 257). CIS is seen as an innovative transnational network-based process amongst participating national states, which approach supplements the traditional regulation (comitology, which also is part of the WFD, Article 21) as applied by EU law, also in the EU environmental legislation prior the WFD[12].

The CIS GDs are not legally binding, which also is stated in the introduction to the CIS Strategic Document p. 2 (see also Grath et all. 2007 and Beijen 2011, s.161). GDs are not EU legal acts included in TFEU 288 but are considered to be supplementing soft law or informal law being part of the *Acquis Communitaire* (Craig & Burca 2015, p.109 and Beijen 2011. s.161)[13]. As such, the CIS GDs can have legal significance in terms of interpretation of the text of the EU directives and therefore, for the correct implementation (see also Sørensen et all. 2014, p. 103s)[14].

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[11] The Strategic Document Common Strategy on the Implementation of the Water Framework Directive, 2 May 2001. A stipulated at p. 2 and Annex V of the Strategic Document, the CIS guidelines for WFD Annex II and V could be adopted under the Committee procedure in WFD art 20.1, 2nd point and art 21.

[12] Comitology can be defined as "*the expression commonly used to denote the relationship between the Commission and the range of committees composed of representatives of national administrations; Committees that the Commission is required to involve in discussing the framing of implementing measures*" (Bergström 2005, 6).

[13] Beijen at p. 161 finds that guidance can have legal binding effect, where such guidelines directly are mandated by an individual EU legal act, e.g. the former IPPC Directive.

[14] See also the case *Alassini,* where also recommendations (non-binding act after TFEU 288, paragraph 5) are considered to have legal effect, in particular where such may cast light on the interpretation of national measures adopted in order to implement them or where they are designed to supplement binding provisions of EU law (see Case C-322/88 *Grimaldi*, paragraphs 7, 16 and 18, and Case C-207/01 *Altair Chimica*, paragraph 41). See

Whether such GDs have decisive legal significance in a particular case depends on the specifics of such case. In terms of the WFD, the legal significance of the CIS GDs may carry such decisive legal weigh considering the well-established CIS practice and process applied for two decades based on the merits of transnational networking, the deliberation and convincing of the better argument, and the broader consensus attributed the relevance and recognition of the GDs as implementation tools for the WFD. In addition, several of the GDs have been applied for many years.

Based on these assumptions, it can be stated that the CIS GDs carry no direct legal binding effect as they are not defined EU legal acts. However, they CIS GDs carry such legal significance that a possible non-complying Member State is in risk of facing legal action by the EU Commission, and related process risk following a subsequent trial at the EUCJ.

2.1.3 WFD Minimum Harmonization

The WFD is based on minimum harmonization following the legal basis of former TEC Article 175 (now TFEU Article 192). As such, and subject to the conditions stipulated by former TEC Article 175 (now TFEU Article 192), Member States shall as a minimum implement the requirements set out in the directive[15]. Also, Member States are allowed to maintain and introduce more protective measures for the environment/water bodies than set by the directive, following the conditions set in TFEU Article 193. The WFD leave no or very limited room for Member State flexibility when it comes to meeting the objectives of the WFD. Flexibility is however, allowed when it comes to implementation approach/methodology of the directive itself (see Voulvoulis et all 2017 with reference to literature, Langlet & Mahmoudi 2011, p.254s and Krämer 2012, p.256ss).

In addition to the minimum requirements, the WFD sets out in Preamble 11 the fundamental precautionary principle, and the principles that preventive action should be taken, environmental damage should, as a priority, be rectified at source and that the polluter should pay, also stated by TFEU Article 191. This indicates that uncertainties following the application of the legal and methodological framework of the WFD cannot lead to a room of manoeuvring allowing a reduction in efforts to prevent and reduce nitrogen pollution of water bodies[16]. Also, it could be argued that the TFEU principle of environmental damage should be rectified at source opposes a possible environmental and socioeconomic argument (e.g. following WFD Article 4.5) for allowing less stringent environmental objectives/room of manoeuvring in Denmark in order to avoid increase in pollution elsewhere in the World in case production is outsourced, see also Chapter 4.3.

Alassini Joined Cases C-317/08, C-318/08, C-319/08 and C-320/08, paragraph 40), and also Sørensen et all. 2014, p. 103s.

[15] Now TFEU Article 192 based on the Lisbon Treaty.

[16] See overall objectives of the WFD, art 1 (in particular a and c) and of the Nitrates Directive, Article 3.1

2.1.4 Framework legislation – protected areas

As a framework directive, the WFD also incorporates the other relevant EU Water *Aquis Communitaire*. As such, together with the other EU water legislation the WFD jointly regulate the protection and use of water resources (see also Basse 2017, p. 90s on framework directives).

For the following, it shall be noted that Denmark is exempt from the obligation to identify specific vulnerable zones as the Nitrates Action Programme is applied throughout the national territory under the Nitrates Directive Art 3.5. As such, the national territory of Denmark constitutes a nutrient-sensitive protected area according to WFD art. 6 and Annex 4, 1. (iv).

First, and with relevance for the regulation of N pollution of water bodies, the WFD addresses environmental objectives for protected areas, Article 4.1.c) by requiring that 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."

Second, it follows from Article 6 that the Member States shall establish a register of protected areas requiring special protection under specific Community legislation, which in accordance with Annex 4 (iv and v) also includes areas designated as vulnerable zones under the Nitrates Directive 91/676/EEC, and areas designated for the protection of habitats, including relevant Natura 2000 sites designated under the Habitat Directive 92/43/EEC and the Bird Directive 79/409/EEC[17].

Third, Article 10 requires that Member States shall ensure that all discharges referred to in Article 10.2 into surface waters are controlled according to the combined approach where Member States shall ensure the establishment and/or implementation of the emission controls, emission limit values, or best environmental practices as set out in relevant community legislation, including the Nitrates Directive.

Fourth, it follows from WFD Article 10.3 that when a quality objective or quality standard, whether established pursuant to the WFD, in the Directives listed in Annex IX, or pursuant to any other Community legislation, requires stricter conditions than those which would result from the application of Article 10.2, more stringent emission controls shall be set accordingly.

Thus, the protected areas are covered by multiple sets of environmental objectives and restrictive measures; as set out for the specific water body after WFD, and as set out by the other relevant EU-regulation. This entails that the environmental objectives of such other legislation must be safeguarded when implementing the WFD in coordinated manners. This also means that the regulatory approach and the implementation of the WFD cannot compromise the

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[17] Now Directive 2009/147/EC Directive 2009/147/EC
The Birds Directive - Environment - European Commission (europa.eu)

set objectives, protection levels and possible need for more stringent measures to fulfil the set goals of these other directives.
In similar terms, the WFD shall include and coordinate the objectives of international agreements, such as the Helsinki Commission (HELCOM) and Oslo and Paris Conventions (OSPAR), Article 1(e) and 4.1.(a), last paragraph.

The implications hereof, and the relevant legal requirements following the Nitrates Directive, the Habitats Directive, and the MSFD, follow in this chapter.

2.2 Exemptions – WFD Articles 4.4. – 4.7

The WFD includes in Article 4.4 – 4.7 a number of exemptions to the general objectives set out in Article 4.1 that allows for less stringent objectives, extension of deadline beyond 2015 or the implementation of new projects. The application of the specific exemptions presupposes that a set of strict conditions are met, and a justification is included in the RBMP[18].

Two general principles set out in Articles 4.8 and 4.9 apply to all exemptions:

- Exemptions to one water body must not permanently exclude or compromise the achievement of the environmental objectives in other water bodies.

- At least the same level of protection must be achieved as provided for by existing Community legislation, including the Nitrates Directive, the Habitats Directive and the MSFD.

2.2.1 WFD Article 4.4. - Extension of deadline

According to Article 4.4. in the WFD the Member States can extend the deadline for achieving the environmental objectives based on af number of cumulative conditions, including the governing condition" that no further deterioration occurs in the status of the affected body of water".

Application of Article 4.4. furthermore, prerequisites application of at least one of the following specific reasons:

i) the scale of improvements required can only be achieved in phases exceeding the timescale, for reasons of technical feasibility;
(ii) completing the improvements within the timescale would be disproportionately expensive;
(iii) natural conditions do not allow timely improvement in the status of the body of water.

[18] CIS Guidance Document 20, para. 2.1.

An extension of the deadline beyond the first two updates of the RBMP can only be made in cases where the natural conditions are such that the objectives cannot be achieved within this period (WFD Article 4.4.c)).

An extension of the deadline, and the reasons for it, are to be specifically set out and explained in the RBMP together with a summary of the measures required under Article 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. (Article 4.4. b) and d).

The conditions for applying Article 4.4 are further analysed in section 4.2, including the field of application for "natural conditions", the requirement to specifically set out and explain reasons for applying Article 4.4, the application of Article 4.4 in 3rd countries, the application of Article 4.8 and 4.9 of the WFD, as well as other relevant obligations relevant for analysing the possible room for manoeuvring.

2.2.2 WFD Article 4.5 - less stringent environmental objectives

Article 4.5 sets out the circumstances under which Member States can set a less stringent environmental objective for a specific water body that is either "so affected by human activity, as determined in accordance with Article 5 (1)", "or their natural conditions is such that the achievement of these objectives would be infeasible or disproportionately expensive".

Furthermore, all the following conditions must be met:

- 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.
- Member States ensure,
  - for surface water, 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,
  - for groundwater, the least possible changes to good groundwater status, given impacts that could not reasonably have been avoided due to the nature of the human activity or pollution,
- no further deterioration occurs in the status of the affected body of water,
- the establishment of less stringent environmental objectives, and the reasons for it, are specifically mentioned in the RBMP required under Article 13 and those objectives are reviewed every six years.

The conditions for applying Article 4.5 are further analysed in section 4.3, including the field of application for Article 4.5 (a) and the test of "other means", the application of Article 4.5 in 3rd countries and the application of Articles 4.5, 4.8 and 4.9.

2.2.3 WFD Article 4.6 – Temporary deterioration

Article 4.6 provides an exemption under certain conditions for temporary deterioration due to natural cause or force majeure of the status of a water body. The provision is limited to circumstances "which are exceptional and could not reasonably have been foreseen".[19]

As the provision in its wording is limited to temporary deterioration due to natural causes the exemption is not likely to be applicable to justify a decrease in the estimated need for reduction of the Danish land-based N load to Danish coastal waters. Thus, this paper will not address the provision further.

2.2.4 WFD Article 4.7. - New modifications or new sustainable human development activities

Article 4.7. sets out the circumstances in which failure to achieve the environmental objectives are permitted.

The provision does not apply to projects in which deterioration is caused by inputs of pollutants from point og diffuse sources that causes the water body to a status below good.[20]

Furthermore Article 4.7 only applies on" new modifications" or "new sustainable human development activities". Thus, the provision applies on new projects and not ongoing activities such as agricultural management. Thus, this paper will not address the provision further.

2.2.5 Relevant CIS-guides on exemptions

A number of CIS guidance's[21] give further guidance on how to interpret the strict conditions for applying the exemptions.

In the following, relevant sections from the CIS guidance concerning the interpretation of Articles 4.4 and 4.5 of the WFD are represented:

WFD Article 4.4.

In 2017 the EU Water Directors endorsed a paper[22], complementing CIS GD No. 20. The paper's purpose is to clarify the use of Article 4(4) time extensions in the 2021 RBMPs on grounds of 'technical feasibility', 'disproportionate costs' and

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[19] CIS Guidance Documents no. 20, para 3.4.

[20] CIS Guidance Documents no. 20.

[21] See CIS Guidance Documents no. 20 and 36 as well as CIS Guidance Documents (without no.) "*Natural Conditions in relation to WFD Exemptions*" and " *Clarification on the application of WFD Article 4(4) time extensions in the 2021 RBMPs and practical considerations regarding the 2027 deadline*"

[22] 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*.

'natural conditions' while addressing some practical considerations with respect to the 2027 deadline.

The GD states on page 5 that:

"The extension of the deadline is therefore limited to two further updates of the RBMPs for reasons of technical feasibility and/or disproportionate costs. No time limitation is specified for the extension of the deadline on grounds of natural conditions*."*

The 2017-paper furthermore states on page 6 that:

"There is nothing that prevents Member States from applying Article 4(4) time extensions in the 2021 RBMPs on grounds of 'technical feasibility' and/or 'disproportionate costs' for the achievement of good status or potential by 2027. 2021 constitutes the deadline for the 2nd update of the RBMPs and is the final possibility for the application of time extensions (except for reasons of natural conditions)*."*

Thus, according to the CIS GD, using the grounds of "technical feasibility" and/or "disproportionate costs" for applying Article 4.4 is a possibility also for the 2021 RBMP (3rd cycle of the RBMPs).

However, it is furthermore underlined in the document, page 7, that:

"The measures required to achieve good status/potential have to be included in the 2021 RBMP. The relevant provisions of the WFD10 require Member States to review the objectives, the exemptions and the measures as part of the preparation of the updated RBMPs in 2027 and beyond. This provides an opportunity for Member States to revise their decisions in light of new evidence and information, including for instance also advanced solutions for mitigation."

The CIS GD on page 7, also deals with the question of the possible lack of information to base action and measures on:

"Based on the precautionary principle*, Member States should take decisions on the basis of the best information available at any given moment. Full certainty is not possible and should not act as a barrier to delay taking action."*

Relationship between Article 4.4 and 4.5 of the WFD

The CIS GD no. 20 describes the relationship between the WFD Article 4.4. and 4.5:

"The conditions for setting less stringent objectives require more information and in-depth assessment of alternatives than those for extending the deadline.

For this reason, there should be a stepwise thinking process for considering what sort of exemption may be most appropriate"[23]

Protected areas

The CIS-guide no. 20 is very clear in its guidance on the conditions for applying exemptions to the fact that application of the exemptions in the WFD cannot be applied to deviate from objectives and obligations in other pieces of EU-legislation:

"*It is generally understood that the exemptions in Article 4.4 and 4.5 and 4.6 are applicable to all environmental objectives in Article 4.1, thus also to Article 4.1(c), which describes the objectives for protected areas. But Article 4.9 is clear in its obligation that when applying the exemptions of Article 4, the same level of protection should be given as in existing Community legislation. This means that exemptions from the WFD environmental objectives cannot be used to deviate from objectives and obligations set by other pieces of EU legislation*."

Clarification of concepts used in WFD Article 4.4. and 4.5.

For the understanding of natural conditions, the CIS GD no. 20 only include limited guidance on how to interpret the concept of "natural conditions" which is the relevant condition for applying Article 4.4 in the 3rd RBMP and a prerequisite for applying Article 4.5 of the WFD. In the Document page 22 it is described that:

"The term 'natural conditions' is used both in Article 4.4 and 4.5 and refers to the conditions which dictate the rate of natural recovery. It recognises that it may take time for the conditions necessary to support good ecological status to be restored and for the plants and animals to recolonise and become established. It also recognises that due to varying natural hydrogeological conditions, groundwater bodies may take time to reach good chemical status. Climate change can also change the natural conditions over time."

A CIS GD from 2017[24] is elaborating on the interpretation of the concept of "Natural Conditions in relation to WFD Exemptions". The document was developed in the context of discussions on the WFD 2027 deadline, which was identified by the Water Directors during discussions in 2016 as needing early attention, specifically in relation to the application of exemptions in the third RBMPs.

The GD establishes on page 7 that:

"Note that the application of Article 4(4) time extensions on grounds of 'natural conditions' does not require that pressures are removed completely but that the 2021 RBMPs include the measures envisaged as necessary to achieve good

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[23] CIS Guidance document no 20, page 18

[24] CIS Guidance Document 2017 (without no). *Natural Conditions in relation to WFD Exemptions* NaturalConditionsinrelationtoWFDexemptions.pdf (europa.eu)

status, and there is evidence that nevertheless the achievement of the objectives will require more time due to natural conditions."

For instance, if measures are taken to stop over-fertilisation of soils used for agricultural purposes, the reduced rate of fertiliser application for crop production, though expected to allow good status to be achieved, may still affect the time scale of the recovery of water bodies (e.g. phosphorus in surface water bodies or nitrates in groundwater bodies)."[25]

The GD also includes a non-exhaustive list of examples and considerations for Article 4.4 time extensions on grounds of 'natural conditions' regarding ecological status surface waters. The list includes "water quality restoration" after pollution with e.g. nutrients or "Recovery of ecological function" following the removal or reduction of pressures.

The GD finally on page 11 is underlining the importance of the information which the Member States provide for in the 3rd RBMP when applying Article 4.4:

"In order to support a coherent and transparent application of Article 4(4) time extensions on grounds of 'natural conditions', information on the measures planned to be put in place by 2027, the expected length of the time extension beyond 2027 and methodological information on the effectiveness of the measures should, where relevant, be provided in the 2021 RBMPs measures and estimating the expected time horizon for reaching good status."

'Natural conditions' in Article 4(5) and difference to Article 4(4)

The CIS GD on natural conditions contains only limited guidance on the interpretation of natural conditions as the concept is used in Article 4.5. On page 11 of the Document the following statement is made:

"*While there is no hierarchical relationship between Article 4(4) and 4(5) and Member States are free to use either as long as the relevant conditions are met, "the conditions for setting less stringent objectives require more information and in-depth assessment of alternatives than those for extending the deadline", meaning that the application of Article 4(5) should be grounded on a particularly solid evidential basis; furthermore the less stringent objectives have to be reviewed every 6 years*."

Thus, further guidance on the concepts of "infeasibility" and "disproportionate costs" would be relevant when applying the exemption in Article 4.5. However, this is currently not offered in the auspices of CIS.

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[25] Please note that the mentioned example in the GD serves as an illustration of the meaning of WFD Article 4.4, namely that the effect (the achievement of good status) of some measures will not enter before after 2021/2027 even after the measures envisaged as necessary to achieve good status are applied. Thus, the example is not giving direction on any thresholds applied, such as percentages of fulfilling the objectives.

Other means

One of the conditions for applying Article 4.5 is that 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 (Article 4.5 (a)).

CIS GD no. 20 includes on page 21 guidance on the interpretation of the concept of other means:

"*Before setting a less stringent objective, Member States must decide whether the environmental and socio-economic needs served by any activity that is preventing the achievement of good status could instead be provided by other means which are a significantly better environmental option not entailing disproportionate costs."*

The Document also offers guidance on the practical aspects on setting a less stringent environmental objective:

"In principle, a less stringent objective should represent the condition expected in the water body once all measures that are feasible and not disproportionately expensive have been taken. For example, this could mean that a less stringent objective is for the majority of the quality elements to be protected at, or restored to, values consistent with good status even though the overall status may be worse than good because of remaining impacts on other quality elements. A 'less stringent objective' does therefore not mean that (a) the other quality elements are permitted to deteriorate to the status dictated by the worst affected quality element or (b) the potential for improvement in the condition of other quality elements can be ignored."

Technical infeasibility (Article 4.4.)

CIS GD no. 20 on page 12 includes guidance on the interpretation of the concept of technical infeasibility which is one of the conditions for applying Article 4.4 (extension of time limit):

"Technical infeasibility is justified if:

- *No technical solution is available,*
- *It takes longer to fix the problem than there is time available,*
- *There is no information on the cause of the problem; hence a solution cannot be identified.*

In practice, the greater the effort expended in trying to overcome practical issues of a technical nature, the greater the likelihood that technically feasible ways of making the improvements will be found. This means that consideration of the costs and benefits will need to be considered alongside technical feasibility."

The GD also offers a limited guidance on the interpretation of the concept of “infeasibility” as applied in Article 4.5:

“Article 4.5 refers to the term 'infeasible', which includes technical infeasibility, but which could also refer to situations where addressing a problem is out of the control of a Member State.”

“It should be noted that the term "infeasible" used in Article 4 (5) is broader than the term "technical feasibility" used in Article 4 (4).

The achievement of a so called “less stringent objective” may require the implementation of measures that are as stringent, if not more so, than the measures that are required for water bodies for which the objective is good status.”

Disproportionate costs

CIS GD no. 20 states on page 13 that “the term disproportionate costs (or disproportionately expensive) is used in Article 4.4, 4.5 and 4.7 of the WFD.

According to the guidance document “'Disproportionality', as referred to in Article 4.4 and 4.5, is 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.”

In the GD it is furthermore stressed on page 13 that:

“Most importantly, for all cases where an exemption is applied, all measures that can be taken without involving disproportionate costs should still be taken to reach the best status possible.”

2.3 Nitrates, Habitat and Marine Strategy Framework Directives

2.3.1 Nitrates Directive

The Nitrates Directive (Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EC)) aims to reduce water pollution from nitrates from agricultural sources and to prevent such pollution in the future.

It follows from the Nitrates Directive that Member States are obligated to set up monitoring programmes to identify waters affected by pollution, or potentially becoming affected by if no action is taken (Article 3.1 and Article 6). Member States are also required to designate vulnerable zones defined as *“(…) all known areas of land in their territories which drain into the waters identified according to* [the monitoring program] *and which contribute to pollution”* (Article 3.2). Denmark is exempt from the obligation to identify specific vulnerable zones as the Nitrates Action Programme is applied throughout the national territory under the Nitrates Directive Art 3.5.

Pollution is in this regard defined as *"(…) the discharge, directly or indirectly, of nitrogen compounds from agricultural sources into the aquatic environment, the results of which are such as to cause hazards to human health, harm to living resources and to aquatic ecosystems, damage to amenities or interference with other legitimate uses of water"* (Article 2(j)).

Further, Member States are required to establish action programmes, whereby specific measures regarding agricultural land use are made to reduce and/or prevent further nitrate pollution (Article 5). It should be noted that Denmark, applying the nitrates action programme throughout the national territory under the Nitrates Directive Art 3.5, is obligated to monitor and report the eutrophic state of water bodies, including surface freshwaters, estuaries and coastal waters every four years (Article 6).

In this regard *"eutrophication"* is defined as meaning *"(…) the enrichment of water by nitrogen compounds, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned"* (Article 2(i)).

The monitoring obligation is a necessary means to fulfil the main objective of the Nitrates Directive to reduce water pollution from nitrates from agricultural sources and to prevent such pollution in the future. Monitoring of eutrophication is, as such, an important indicator to detect N pollution.

Member States are also required to establish so-called codes of good agricultural practice to be implemented by farmers on a voluntary basis with the aim of providing a general level of protection against pollution for all waters (Article 4).

The action programme-obligation carries with it an obligation for Denmark to ensure that a maximum of 170 kg/year of N from manure is distributed per hectare, cf. the Nitrates Directive annex III, section 2.

Pursuant to the directive's Annex III, section 2(b), the Commission has however, for a number of years, derogated from this maximum threshold and allowed Denmark exemptions to this obligation and permitted distribution of higher N quantities per hectares under a number of conditions, including conditions on monitoring of water pollution from nitrate.[26]

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[26] The current and valid exemption valid from July 2000 to July 2024, "Commission Implementing Decision (EU) 2020/1074 of 17 July 2020 granting a derogation requested by Denmark pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources", can be found here: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1601888608600&uri=CELEX:32020D1074

Especially the obligation following from Article 5 to establish action programmes, implemented as legally binding obligations on farmers' use of agricultural land, is of relevance when assessing the RFM within the context of the WFD.

In this regard it is of central importance to note that following the Nitrates Directive Art 3.5, the action programme measures apply to the entire Danish territory.

Further, the above mentioned monitoring and reporting obligations must also be upheld.

Which specific obligations this then entails is analysed in chapter 4 on the room of manoeuvring.

2.3.2 Habitat Directive

Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora aims to ensure the survival of Europe's most endangered and vulnerable species. Together with the Birds Directive 2009/147/EC, the directive sets the standard for nature conservation across the EU. Member States are obligated to designate and manage special protected areas which form the Natura 2000 network with the overall objective to maintaining or restore natural habitats and species of wild fauna and flora of Community interest at favourable conservation status.

Member States are according to Article 6.1 obligated to "establish the necessary conservation measures" e.g. management plans "specifically designed for the sites or integrated into other development plans, and appropriate statutory, administrative or contractual measures."

Member States are furthermore obligated to transmit information on the Natura 2000 network[27] to the EU Commission and to keep the information up to date. The information which shall be transmitted includes information on threats and pressures to the Natura 2000 sites.

According to Article 12 of the Birds Directive and Article 17 of the Habitats Directive Member States are obligated to report on the implementation of the Directives every six years[28]. The reporting obligation involves assessment of conservation status for designated species and natural habitats. The assessment includes an assessment of long-term maintenance of natural habitats and species including main pressures and threats (expected negative impacts in the future) as well as an assessment of whether the established measures can

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[27] Habitats directive, Article 4, 1 (2) and the Commission implementing decision of 11 July 2011 concerning af site information format for Natura 2000 sites
[28] See Reporting under Article 17 of the Habitats Directive, Explanatory Notes and Guidelines and Report Format for the period 2013-2018, Final version – May 2017 and Reporting under Article 12 of the Birds Directive, Explanatory Notes and Guidelines and Report format for the period 2013-2018, Final version – November 2016

prevent negative impact on the designated species and natural habitats. "Natural processes of eutrophication or acidification" is listed as an example of pressures and threats.

In the Report on the status and trends in 2013 - 2018 of species and habitat types protected by the Birds and Habitats Directives[29], based on Member States reporting, it is stated that

- of the nine reported habitat groups, coastal habitats (which include marine habitat types) have the lowest proportion of 'good status' assessments across the Member States[30]
- "the most frequently reported pressures for both habitats and species stem from agriculture, which reflects the relative scale of agricultural land-use and changes in farming practices (intensification and abandonment of extensive agriculture)"[31] and
- "pollution is a key pressure for many habitats and species, and agricultural activities account for almost half (48%) of the pressures relating to pollution."[32]

In the Danish report based on the latest report to the EU Commission according to Article 17 in the Habitats Directive it is recognised that[33]

- the objective of favourable conservation status is not achieved for any of the natural habitats,
- the marine natural habitats are under continuous impact from too big amounts of nutrients from surface waters and from atmospheric fallout,[34]
- thus, 4 out of 8 natural habitats are affected highly by eutrophication, whereas 3 out of 8 natural habitats are affected to a medium degree.[35]

Thus, this indicates that Denmark, in line with many other Member States, has problems in fulfilling the objective of the Habitats Directive to maintain or restore favourable conservation status.

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[29] Report from the Commission to the European Parliament, the Council and the European Economic and Social Committee, The state of nature in the European Union, Brussels, 15.10.2020 COM(2020) 635 final
[30] Ibid. Page 5
[31] Ibid. Page 11
[32] Ibid. Page 12
[33] Bevaringsstatus for naturtyper og arter – 2019, Habitatdirektivets Artikel 17-rapportering, Videnskabelig rapport fra DCE-Nationalt Center for Miljø og Energi, nr. 340, 2019
[34] Ibid. page 13
[35] Ibid. Page 13. The last marine natural habitats, "havgrotte" is due to lack of data assessed as "unknown"

The Habitats and Birds Directives do not – contrary to the WFD – include deadlines for the member states to meet the objectives. Member States are however, as described above, obligated to manage the areas in respect of the directives objective to maintain or restore favourable conservation status both inside and outside the Natura 2000 sites, e. g. through active management of the sites. Also, it shall be noted that the EC on 22nd of June 2022 has adopted a proposal on nature restoration now setting deadlines from 2030 – 2050 to meet targets and requires Member States to restore ecosystems also outside the Natura 2000 network[36].

The proposal complements the WFD by specifying additional restoration requirements for e. g. coastal, marine and agricultural ecosystems.

More specifically the proposal sets out restoration targets for among others coastal and marine ecosystems (which includes other marine areas in addition to those covered by the Habitats Directive). Those targets address restoration and re-establishment of areas, as well as the restoration of habitats of species. Furthermore, the proposal contains an obligation to ensure that the condition of ecosystems does not deteriorate before or after restoration.

Furthermore, the proposal requires Member States to put in place restoration measures necessary to enhance biodiversity in agricultural ecosystems. Thus, Member States shall achieve an increasing trend at national level of each of the 3 indicators in agricultural ecosystems (grassland butterfly index, stock of organic carbon in cropland mineral soils and share of agricultural land with high-diversity landscape features) before 2030. The measures relevant to achieve such an increasing trend may also require reductions in N pollution.

If the proposal on nature restoration is adopted, it must be expected to pose a significant obligation on the Member States to establish the necessary restoration measures to contribute to restoration measures which together shall cover at least 20% of the EU's land and sea areas by 2030 and all ecosystems in need of restoration by 2050. Thus, indirectly a deadline for meeting the objective of the Habitats and Birds Directive will be set if the proposal on nature restoration is adopted. The choice of relevant restoration measures is left to the Member States. It can be expected that some of these nature restauration measures may reduce nitrate pollution.

A central element in the protection and management of Natura 2000 sites today, is the obligation set out in Article 6.3 and 6.4 of the Habitats Directive. Thus, any plan or project likely to damage a Natura 2000 site must be subject to an appropriate assessment within the meaning of Article 6.3 of the Habitats Directive and can only be authorised if it does not affect the integrity of the site, or if it fulfils the conditions for derogations under Article 6.4 of the Habitats Directive[37]. Thus, a derogation prerequisite an argumentation that the plan or project entails "imperative reasons of overriding public interest, including those

[36] COM (2022) 304

[37] CIS GD no 36 for the water framework directive and the floods directive – Exemptions to the environmental objectives according to article 4.7, section 2.8.3.

of a social or economic nature," including that "the Member State shall take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected". Even more strict conditions apply if the Natura 2000 site concerned hosts a priority natural habitat type and / or a priority species.

Such assessments cannot be carried out on a general level but should focus on the individual water body which is subject to the application of the exemptions. As regards the assessment after the Habitats Directive in water bodies that are also designated as Natura 2000-areas, the assessment will need to focus on the relevant species and habitat types for which the areas have been designated. Thus, the assessment of whether the application of the exemptions in WFD Article 4.4 and 4.5 is consistent with the implementation of the Habitats Directive will require a specific and individual assessment for each Natura 2000-site situated in water bodies in question for extension of the deadline or less stringent environmental objectives.

Furthermore, follows a general obligation from the directives Article 6.2 for member status to "take appropriate steps to avoid, in the special areas of conservation, the deterioration of natural habitats and the habitats of species."

The link between the Habitats Directive and the WFD is e. g. established in the WFD Article 4.8.: "*When applying paragraphs 3, 4, 5, 6 and 7, a Member State shall ensure that the application …. is consistent with the implementation of other Community environmental legislation*" and Article 4.9.: "*Steps must be taken to ensure that the application of ….. paragraphs 3, 4, 5, 6 and 7 guarantees at least the same level of protection as the existing Community legislation."* Thus, application of the exemption after the WFD within a Natura 2000 site (or outside a site where the project is likely to affect the basis for designation in a Natura 2000 site) prerequisites that the conditions in Article 6 (3) and (4) are met.

Furthermore, marine Natura 2000-sites constitute "protected areas" in the WFD. The areas are thus also covered by the environmental objectives of Article 4.1.c).

Note should be taken of the fact that the process described above does not entail a possibility to set less stringent environmental objectives in the WFD. The application of Article 4.4 and 4.5 of the WFD prerequisites that the extended deadline og the setting of less stringent environmental objective and related measures do not jeopardize the required scope of Article 6.3 and 6.4 of the Habitats Directive and thus, do not "affect the integrity of the site" (Article 6.3) or that the strict conditions in Article 6.4 are fulfilled including that "the Member State shall take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected".

In the Danish Programmes of measures for the individual Natura 2000-sites it is stated that in general many of the marine natural habitats are affected by nutrients. It is furthermore stated that measures to address this impact are handled in the Danish RBMP's.[38]

Thus, it is the Danish strategy that measures and actions after the WFD shall contribute to meet the objectives also after the Habitats and Birds Directives and thereby ensure Danish compliance with those two directives.

This report is not providing a compliance check of the Danish implementation of these directives. However, it appears from the above description that the aim of achieving the objective of "maintaining or restoring favourable conservation status", also as a precondition for complying with the Habitats and Birds Directive, is not successful. The overall objective of the two directives has not yet been reached and the measures taken in the WFD are so far inadequate to minimise the related threats and pressures from agriculture.

Given the challenges described with regard to the Danish strategy of using WFD measures to ensure compliance with the Habitats Directive, it may prove problematic to extend deadlines or lower targets within the WFD framework.

2.3.3 Marine Strategy Framework Directive (MSFD)

The MSFD 2008/56/EC establishes, according to Article 1, a framework within which Member States shall take the necessary measures to achieve or maintain good environmental status in the marine environment by the year 2020 at the latest.

The MSFD supplements the WFD and covers according to Article 3.1 (b) coastal waters as defined by the WFD but only in so far as particular aspects of the environmental status of the marine environment are not already addressed through the WFD or other Community legislation. It does however, as described below, oblige both the EU and the Member States in their commitments arising from the regional sea conventions (as international legal agreement), i. e. HELCOM and OSPAR.

The MSFD obliges in Article 5 Member States to develop marine strategies for its marine waters. Such strategies shall include among other things an initial assessment of the current environmental status of the waters, a determination of good environmental status, a series of environmental targets and associated indicators and establishment and implementation of a monitoring programme.

The determination of good environmental status is to be carried out according to Article 9 based on a set of qualitative descriptors in Annex 1 to the MSFD. Descriptor 5 is "Human-induced eutrophication is minimised, especially adverse

[38] See eg. Natura 2000 basisanalyse 2022-2027, revideret udgave, Nordre Rønner, Natura 2000-område nr. 20, Habitatområde H 176, Fuglebeskyttelsesområde F 9, November 2021, page 25, and Natura 2000 basisanalyse 2022-2027, revideret udgave, Femern Bælt, Natura 2000-område nr. 251, Habitatområde H 260, November 2021, page 11

effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters."

In CIS GD 23[39] it is furthermore underlined that:

"Further, the Directive Annex III (Table 2 "Pressures and Impacts") includes two pressures (i.e. nutrient and organic enrichment) that need to be considered in the determination of GES and that influence compliance with the eutrophication descriptor."

The MSFD includes an obligation for Member States to implement the MSFD in cooperation with other Member States whom they share marine waters with including the determination of good environmental status and the development of Programmes of measures (Article 4). In Denmark, the marine strategies are coordinated with the countries which we share marine waters within the auspices of the OSPAR Convention and HELCOM.

Member States are according to the MSFD Article 10 further obligated to establish a comprehensive set of environmental targets and associated indicators for each marine region or subregion with the purpose to guide progress towards achieving good environmental status in the marine environment.

Furthermore, Member States shall establish programmes of measures according to MSFD Article 13. According to Article 13.2 Member States shall establishing programme of measures take into account relevant measures required under other Community legislation, in particular the WFD, the urban waste-water treatment directive[40] and the bathing water directive[41] as well as legislation on environmental quality standards in the field of water policy[42] or international agreements. Thus, The MSFD introduces an obligation on Member States to integrate measures after several pieces of Community legislation concerning marine waters. This also includes the objectives of the Nitrates Directive.

In the CIS GD 23 from 2010 it is furthermore stressed that:

"343. The implementation of the MSFD is at a start and one of the main aspects of the work in the first phase will be the development of criteria and methodological standards for the descriptors of GES (July 2010 in accordance with Article 9(3)).

344. It is particularly important that this work consider the links, overlap and synergies with existing policies and Directives. A most important link is expected with the Water Framework Directive (WFD). Indeed the concept of Good Environmental Status in the Marine Directive is very similar to that of the Good Ecological Status in the WFD, and the

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[39] CIS Guidance Document No. 23 on Eurtrophication assessment in the context of European Water Policies, page 106

[40] Council Directive 91/271/EEC of 21 May 1991

[41] Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006

[42] Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008

marine Directive explicitly recognizes the need to develop approaches in accordance with the WFD. This is particularly relevant for the eutrophication."

It should be mentioned that the MSFD obliges Member States to include in their programmes of measures spatial protection measures. The areas are to contribute to coherent and representative networks of marine protected areas. Such areas should according to MSFD Article 13.4 cover special areas of conservation pursuant to the Habitats- and Bird Directives.

In the report from the Commission on implementation of the MSFD from 2020 the EUC gives a summary of the status of the EU's marine environment. In the summary it is concluded that:

- *"46 % of the European Coastal waters is failing to meet good ecological status due to human-induced eutrophication*
- *Nutrient inputs from point sources in the EU have significantly decreased, although inputs from diffuse sources, i.e. losses from agricultural activities, are still too high. Also, there is a long time lag between the actual reduction of nutrient inputs and the reduction of eutrophication effects*
- *Although eutrophication is a relatively well-studied process, the harmonisation of monitoring methods (across countries, between coastal and open sea areas, and between the Marine Strategy Framework Directive and Water Framework Directive approaches) remains an issue in many regions."*[43]

Furthermore, the EC has in its Member State specific recommendations on the MSFD from 2022 given country specific recommendations regarding the obligation to carry out assessment (Article 8), determine good environmental status (Article 9) and the establishment of environmental targets (Article 10).[44]

The recommendation report includes several recommendations to the Danish implementation including the descriptor 5 on eutrophication, e.g. a recommendation to "Develop target(s) which focus on reducing specific pressures and their impacts that are preventing the achievement of GES" [GES being an abbreviation for "good environmental status"].

Thus, it can be concluded that Denmark and the rest of the Member States – like for the WFD – is not currently fulfilling the objective to achieve good environmental status by 2020 at the latest.

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[43] Report from the Commission to the European Parliament and the Council on the implementation of the Marine Strategy Framework Directive (Directive 2008/56/EC), Brussels, 25.6.2020 COM(2020) 259 final, section 4.3.2

[44] Commission staff working document Accompanying the document Communication from the Commission, Commission Notice on recommendations per Member State and region on the 2018 updated reports for Articles 8, 9 and 10 of the Marine Strategy Framework Directive (2008/56/EC), Brussels, 11.3.2022 SWD(2022) 55 final, page 13-15

Likewise, the WFD, also the MSFD in Article 14 includes the possibility for Member States to apply exemptions from the environmental targets or good environmental status in certain circumstances. The reasons for exemptions are among others:

(a) action or inaction for which the Member State concerned is not responsible;
(b) natural causes,
(c) force majeure,
(d) modifications or alterations to the physical characteristics of marine waters brought about by actions taken for reasons of overriding public interest which outweigh the negative impact on the environment, including any transboundary impact,
(e) natural conditions which do not allow timely improvement in the status of the marine waters concerned.

The link between the MSFD and the WFD is – as for the Nitrates Directive and the Habitats Directive - established in the WFD Article 4.8.: "When applying paragraphs 3, 4, 5, 6 and 7, a Member State s*hall ensure that the application …. is consistent with the implementation of other Community environmental legislation*" and Article 4.9.: "Steps must be taken to ensure that the application of ….. paragraphs 3, 4, 5, 6 and 7 *guarantees at least the same level of protection as the existing Community legislation."*

Thus, application of the exemption after the WFD within a costal water body subject to environmental targets of good environmental status set after the MSFD, including designated marine protected areas, prerequisites that the conditions in MSFD Article 14 are met.

In the last Danish Programme of measures from 2017 related to the MSFD it is stated that the exemption in the MSFD Article 14(1)(e) is applied for the Danish parts of Østersøen.[45] The program further expected that the Danish RBMPs towards 2027 will reduce the nutrient loads from land to a level that will sustain the achievement of good ecological status in the coastal waters as well as good environmental status in the open marine waters presupposing that also neighbouring countries implement reductions in their discharges of nutrient[46].

Thus, it is the Danish strategy that measures and actions after the WFD and the Nitrates Directive will contribute to meet the targets also after the MSFD and thereby ensure Danish compliance with the MSFD.

As described above, and according to the EC, the Danish models for assessing necessary criteria and implementation measures to achieve "good environmental

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[45] Danmarks Havstrategi, Indsatsprogram, 10 May 2017, page 57

[46] See the original Danish text, page 87: "For eutrofiering (deskriptor 5) forventes det, at vandområdeplanerne frem mod 2027 vil nedbringe næringsstofbelastningen fra de landbaserede kilder til et niveau som både understøtter, at der på sigt kan opnås god økologisk tilstand i kystvandene og god miljøtilstand i de åbne marine havområder. Dette forudsætter dog, at de omkringliggende lande også gennemfører reduktioner i deres næringsstofudledninger."

status", as a precondition for complying with the MSFD, appear not to be in place. The good environmental status of marine waters has not yet been reached and there are outstanding issues with the model work among other things to reach this point of compliance.

These obligations must be met regardless of how the WFD is implemented. Given the Danish strategy of using WFD measures to ensure compliance with the MSFD and that Denmark is not yet in compliance with MSFD, it may prove problematic to extend deadlines or lower targets within the WFD framework.

It should be noted that no infringement ECJ cases/rulings regarding the MSFD are publicly available as of the drafting of this report.

2.4 Dialogue between Denmark and the EU Commission

2.4.1 Dialogue regarding implementation of WFD

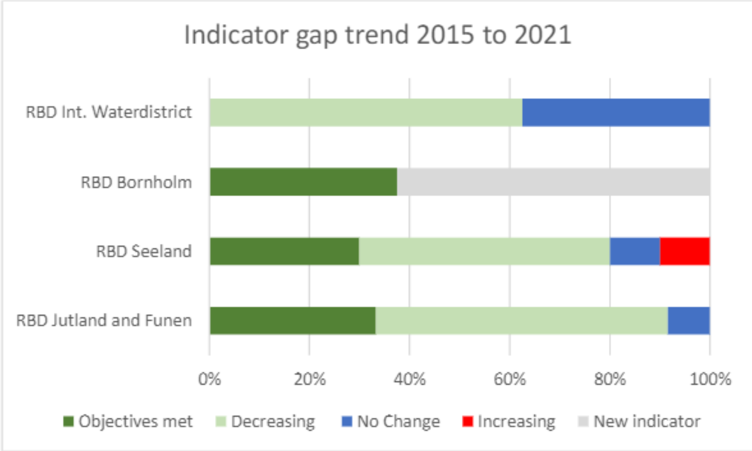
The WFD is subject to a continued review process from the EU Commission, including reviews of whether the WFD should be revised to ensure that the overlying target of *"good status"* for all waterbodies will be obtained.

The reviews also cover country specific reports on the different national implementation strategies and whether the measures taken by Member States fulfil the obligations following from the WFD.

Specifically, the Commission has carried out a "fitness check" in 2021[47]:

- EU and Denmark: General EU standpoint is implementation of RBMP's take place as foreseen but *"the pace is slow(er) and much remains to be implemented"* (6th implementation report, 15/12/2021):

[47] Report from the Commission to the Council and the European Parliament on the implementation of the Water Framework Directive (2000/60/EC), the Environmental Quality Standards Directive (2008/105/EC amended by Directive 2013/39/EU) and the Floods Directive (2007/60/EC), 15 December 2021, available here: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0970



It was furthermore concluded that the Directives are largely fit for purpose. It was however also stressed *"that the fact that the WFD's objectives have not been reached fully yet is largely due to insufficient funding, slow implementation and insufficient integration of environmental objectives in sectoral policies, and not due to a deficiency in the legislation."*

It should be noted that the Commission stressed the fact that

> *"currently more than half of all European water bodies are under exemptions, the challenges for Member States are more than substantial. After 2027, the possibilities for exemptions are reduced, as 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. The Commission will need to continue to work with Member States and help them improve implementation of the Directives at the lowest possible cost, e.g. by sharing best practices on cost recovery, reduction of pollutants at source, green infrastructure and others."*[48]

Namely the country specific 5th implementation report from 2019 (hereafter referred to as the "5th Implementation Report") regarding Denmark's implementation of the WFD in the second RBMPs are of interest, since this report contains specific assessments from the Commission regarding the Danish implementation measures.[49]

Of particular interest is that the EU Commission has found, based on the second Danish RBMPs, that

> *"(…)drivers and pressures leading to exemptions were not reported",*

[48] See Commission staff working document fitness check of the Water Framework Directive, Groundwater Directive, Environmental Quality Standards Directive and Floods Directive, Brussels, 10.12.2019 SWD(2019) 439 final, page iii

[49] Commission Staff Working Document Second River Basin Management Plans - Member State: Denmark, 26 February 2019, available here: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=SWD:2019:38:FIN&qid=1551205988853&from=EN

that

"(...) Article 4(5) was not applied in the first cycle but is now used in the second cycle for surface waters. The information provided is not sufficient to assess whether the application is compliant.",

and further that

"(t)he reasons for exemptions were reported at the water body level. Justifications for exemptions were reported in WISE. However, whether there are clear criteria that have been developed for the application of "technical unfeasibility", "disproportionate costs" and "natural conditions" cannot be assessed due to the lack of reported methodological documents for the application of exemptions in surface and groundwater bodies.[50]

The EU Commission also found that

"Denmark has indicated there may be new physical modifications in forthcoming RBMPs, falling within the scope of Article 4(7). If this is the case, the use of exemptions under Article 4(7) should be based on a thorough assessment of all the steps as requested by the WFD, in particular an assessment of whether the project is of overriding public interest and whether the benefits to society outweigh the environmental degradation, and regarding the absence of alternatives that would be a better environmental option. Furthermore, these projects may only be carried out when all possible measures are taken to mitigate the adverse impact on the status of the water. All conditions for the application of Article 4(7) in individual projects must be included and justified in the RBMPs as early in the project planning as possible."[51]

Finally, the EU Commission also highlighted the following recommendations regarding the Danish implementation of the WFD:

› *"Denmark should further strengthen monitoring of surface waters by covering all relevant biological, physio-chemical and hydromorphological quality elements in all water categories. The proportion of water bodies covered by monitoring for River Basin Specific Pollutants should increase.*

› *Denmark should complete the development of assessment methods for all biological quality elements in all water categories, including methods that are sensitive to nutrients in rivers. Hydromorphological quality elements should be included in the classification of ecological status.*

› *Cost recovery should be applied for water services. Any exemption should be justified using Article 9(4). Denmark should also present in a transparent manner how financial, environmental and resource costs have been calculated and how the adequate contribution of the different users is ensured. The water-pricing policy should be set out in a*

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[50] See the 5th Implementation Report regarding Denmark pages 14-15 and 111-112.

[51] The 5th Implementation Report regarding Denmark pages 111-112.

transparent fashion and a clear overview of estimated investments and investment needs should be provided.

› *Denmark needs to establish objectives for its relevant Protected Areas for surface and groundwater."*[52]

The above cited assessments from the EU Commission have not been touched upon in the 6th implementation report.

What can thus be concluded is that the EU has not yet taken a stance on the compliance of Danish use of exemptions.

The Commissions assessment and recommendation is, however, that going forward the use of exemptions should be documented to a higher degree than was the case with the second RBMPs, i. e. that the relevant criteria for use of the exemptions should be (further) documented.

2.4.2 Dialogue regarding implementation of the Nitrates Directive

The Member States are obliged to report to the Commission on national implementation of the Nitrates Directive. Reports routinely cover four-year implementation periods.

Based on these reports from Member States, the Commission issues reports to the Council and the European Parliament on the status of implementation of the Nitrates Directive.

The latest such report from the Commission to the Council and European Parliament was published on 11 October 2021 (hereafter referred to as the "Nitrates Directive 2021 report").[53]

It is of interest that the Commission refers to global macro level observations and estimations (from the European Environment Agency) that European nitrate and P loss to the environment exceeds "safe planetary boundaries" thresholds by a factor of 3.3 and 2 respectively.[54]

Further, as background for the report, the Commission refers to the implementation of the Nitrates Directive being key in obtaining targets set forth

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[52] The 5th Implementation Report regarding Denmark page 18.

[53] Report from the Commission to the Council and the European Parliament on the implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources based on Member State reports for the period 2016–2019. The report is available here: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2021%3A1000%3AFIN&qid=1633953687154

[54] Nitrates Directive 2021 report, page 1.

in the EU Biodiversity and Farm to Fork strategies of minimum 50% nutrient loss reduction by 2030.[55]

The findings in the report are of interest in the context of assessing WFD implementation measures, given the fact that compliance with the Nitrates Directive is a stand-alone obligation of Denmark. Thus, whatever measures are implemented to comply with the WFD, these measures must also ensure compliance with the Nitrates Directive (and other EU legislation).

In this context the Nitrates Directive 2021 report contains the following high-level findings:

- According to the Commission, Denmark has failed to report information about the contribution of agriculture to N discharge to the aquatic environment.[56]

- When assessing implementation of both the Nitrates Directive and WFD, the Commission recommends assessing trophic status of water bodies using the classification system described in the CIS GD 23 under the WFD regarding eutrophication.[57]

- The Nitrates Directive requires that Member State take preventive action when the quality of water stagnates and does not improve.[58]

  Note: It is assumed this interpretation from the Commission refers to the targets and objectives of the Nitrates Directive, as expressed in Article 1, of *"reducing water pollution caused or induced by nitrates from agricultural sources and preventing further such pollution"*. It is supported by the EUCJ ruling in the case C-197/18 where the EUCJ found that 1) additional measures and reinforced actions to prevent or reduce nitrate pollution must be taken where the contribution of N from agriculture makes a *"significant contribution"* to water pollution and 2) if nitrate pollution of ground water cannot be seen to be reduced and/or max nitrate levels of 50 mg/l cannot be met or risk being exceeded, additional measures must be taken under the Nitrates directive, specifically included

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[55] Nitrates Directive 2021 report, page 1.

[56] Nitrates Directive 2021 report, page 3: "*Regrettably, the information about the contribution of agriculture to nitrogen discharge in the aquatic environment has not been provided by 13 Member States"* mentioning Denmark in footnote 19. This analysis goes no further into the reasoning of this statement. However, please note that in the latest Danish report according to Nitrates Directive Art. 10 of March 2021 the following information can be found: "*Consequently, the share of N discharge to the sea, caused directly by agricultural activities within the country, can be estimated to round about 70% of the total N discharge.*" While the total N discharge is also given. The report is publicly available, see page 59.

[57] Nitrates Directive 2021 report, page 6.

[58] Nitrates Directive 2021 report, page 8.

in Nitrates Action Programme legislation subject to the Nitrates Directive article 5(4) and (5). See section below regarding the EUCJ ruling.

- Denmark is specifically highlighted as being among Member States standing out due to a large number of waters that are eutrophic and having recorded bad water quality all around their territory and a systemic problem to manage nutrient loss from agriculture.[59]

- The above is in line with the Commission finding that *"a very high number of the surface waters are found to be eutrophic"* and that *"(t)he Commission recommends Denmark to further reinforce its action programme to tackle the eutrophication of both inland and marine waters where the agricultural pressure is significant."*[60]

2.5 EU Case law

The EUCJ has had the opportunity to interpret the WFD and related directives a number of times since the WFD and related directives entered into force. This has resulted in a number of rulings central to the understanding of the obligations following from the WFD.

We have identified as central and will in the following subsections in detail account for the following rulings: C-461/13 ("Weser"), C-535/18 ("Land Nordrhein-Westfalen"), C-559/19 ("Doñana"), C-197/18 (Wasserleitungsverband Nördliches Burgenland), C-161/00 (Commission v Germany), C-322/00 (Commission v Netherlands) and C-526/08 (Commission v Luxembourg).

Other preliminary rulings have been handed down but in the following we will focus on the above listed cases since these (preliminary) rulings and the EUCJ's underlying reasoning entail significant obligations for the Member States following from the WFD and related directives.

The cases and rulings are thus of key importance in understanding the obligations following from the WFD and related directives.

We have reviewed and summarized these rulings below in Chapter 4 on the RFM - the background for the cases and key aspects and obligations of relevance which must be complied with when assessing potential RFM when implementing the WFD, also if/when making further use of WFD exemptions.

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[59] Nitrates Directive 2021 report, page 10.

[60] The country specific report regarding Denmark accompanying the Nitrates Directive 2021 report (termed "country fiche" in the Nitrates Directive 2021 report mentioned in note 39 above): *"Commission Staff Working Document accompanying the document Report from the Commission to the Council and The European Parliament on the implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources based on Member State reports for the period 2016–2019 {COM(2021) 1000 final}"* available here: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021SC1001&from=ES

2.5.1 C-461/13 - Weser

The case relates to the German authorities issuing a permit to deepen a waterway in the river Weser, including a permit to dump dug up soil from the riverbed elsewhere in the river (in Danish: "klaptilladelse").

The permit related to three subprojects: One related to deepening of a waterway from the North Sea to Bremerhaven and two related to deepening of waterways upstream from Bremerhaven. All affected areas were protected under the WFD and subject to a German RBMP.

Before issuing the permit, the German authorities had carried out an environmental assessment on the impacts of the project.

This environmental impact assessment showed direct effects related to excavation of the riverbed and dumping of the dug op soil, indirect effects in so far as the deepening of the waterway would entail an increase in waterflow which again entailed an increase in highwater mark at tide and a decrease in the low watermark at ebb and finally changes to salt and sand levels in the river.

The German authorities originally approved the project because the above negative effects did not change the ecological status classification for the Weser river basin as a whole. Two German non-governmental organisations (NGOs), Bund für Umwelt and Naturschutz Deutschland, challenged this approval claiming that the negative effects would lead to deterioration of the Weser river basin, cf. WFD article 4.1(a), and the case was brought before the EUCJ by the German courts.

From the EUCJ's preliminary ruling the following conclusions can be drawn, all of which are of substantial importance regarding obligations following from the WFD and thus must be maintained also when applying WFD exemptions:

- When a RBMP has been adopted for a river basin, the obligation following from WFD Article 4.1(a), to prevent deterioration of the surface water body has direct effect.[61]

- Permits for projects must be subject to a review of whether the project will prevent realisation of the RBMP, specifically whether the project will entail deterioration of water bodies subject to the RBMP and affected by the project.[62]

- Specifically, WFD Article 4.1, does not in itself entail a general prohibition against deterioration but it does entail that all projects that may affect a water body must be made subject to an environmental assessment and that an approval of the project be denied when a) the project will result in

[61] C-461/13, paragraph 43.
[62] C-461/13, paragraph 47-50

deterioration of the water body or b) the project entails a risk that the RBMP aim of *"good status"* for the water body cannot be achieved.[63]

- The assessment of whether a project will result in deterioration of a water body must follow a "one out, all out"-principle.

  Specifically, "deterioration" sets in
  a) *"as soon as the status of at least one of the quality elements, within the meaning of Annex V to the directive, falls by one class, even if that fall does not result in a fall in classification of the body of surface water as a whole."*, or

  b) "However, if the quality element concerned, within the meaning of that annex, is already in the lowest class, any deterioration of that element constitutes a 'deterioration of the status' of a body of surface water, within the meaning of Article 4(1)(a)(i)."[64]

It is also of interest that the EUCJ refers to the possibility of issuing an exemption subject to WFD Article 4.7, in several key paragraphs of the ruling as a possibility for approving individual projects which may otherwise entail a deterioration of a water body.[65]

It should be noted that Article 4.7 is an instrument applicable when assessing whether project-specific approvals should be given to new individual projects, e. g. wastewater discharge permits.

Article 4.7 is not applicable when assessing whether environmental status targets in RMBP's can be lowered and achievement of such targets postponed. It is also not applicable on already approved activities, e. g. already existing and approved agricultural land use.[66]

As such, Article 4.7 cannot be applied for expanding the RFM on a general level, i. e. through RMBP's.

2.5.2 C-535/18 - Land Nordrhein-Westfalen

The case related to the construction of a motorway in Germany. With the preliminary ruling, the EUCJ concluded that:

- The obligation to prevent deterioration also applies to groundwater bodies, cf. WFD article 4(b)(i).[67]

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[63] C-461/13, paragraph 50-51

[64] C-461/13, paragraph 69

[65] C-461/13, paragraph 47, 48 and 50

[66] This is related to the wording of Article 4.7, which only applies to *"(…) new modifications to the physical characteristics of a surface water body(…)"* and *"(…)new sustainable human development activities"*.

[67] C-538/18, paragraph 68-72

- "Deterioration", in this case also following the "one-out, all out-principle, constitutes:

  a) *"(…)failure to observe one of the quality elements referred to in point 2.3.2 of Annex V"*,[68]
  b) *"exceedance, in a body of groundwater, of a single one of the quality standards or threshold values"*[69], or
  c) *"any subsequent increase in the concentration of a pollutant that, with reference to Article 3(1) of Directive 2006/118 (the Groundwater Directive), already exceeds an environmental quality standard or a threshold value set by the Member State"*[70]

- An assessment of the impact from a project regarding deterioration, cf. WFD article 4, must be made prior to the decision to approve or deny the project.[71]

2.5.3 C-559/19 - Doñana

The case related to approval of groundwater abstraction from the protected nature area Doñana in Spain.

From the preliminary ruling, the following conclusions can be drawn:

- The abstraction of groundwater, leading to a decline in the groundwater levels, does not in itself constitute deterioration in the meaning of the WFD article 4.[72]

- Thus, a project resulting in reduction in the amount of abstracted groundwater may actually result in an improvement, rather than a deterioration, of the water body even if there is still abstracted more groundwater than what is naturally formed.[73]

- The assessment of a project, in accordance with the requirements following from the Weser-case, must encompass the project in its entirety.[74]

The ruling also concerned the interpretation of obligations following from WFD Article 4.1(c) and 11 concerning Protected Areas (otherwise protected under the Habitats Directive). On this topic the following conclusions can be drawn:

- When adopting programmes of measures under Article 11 of the WFD, the Member States must not only achieve the environmental objectives

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[68] C-538/18, paragraph 108
[69] C-538/18, paragraph 109
[70] C-538/18, paragraph 110
[71] C-538/19, paragraph 76 and 90
[72] C-559/19, paragraph 49
[73] C-559/19, paragraph 49 and 71
[74] C-559/19, paragraph 169-170

relating to water laid down in that directive but also ensure compliance with the European legislation relating to the protected areas in question. When an area is protected both under the WFD and Habitats Directive, the mechanisms implementing the WFD must therefore also serve as implementation tools regarding the protection of Protected Areas subject to the Habitats Directive.[75]

- When likelihood for significant disturbance to protected habitats of protected areas has been established, that disturbance should therefore have been taken into account in the programme of measures established under Article 11 of the WFD.[76]

- Thus, Member States can be in breach of their obligations under WFD Article 11, read in conjunction with Article 4.1(c) if they do not lay down, in the programme of measures, any measure to prevent disturbance of the protected habitat types.[77]

2.5.4 C-197/18 – Wasserleitungsverband Nördliches Burgenland

The case was based on water in Austrian domestic water wells containing N levels above the maximum target subject to the Nitrates Directive of 50 mg/l.

From the preliminary ruling, the following conclusions can be drawn:

- The Nitrates Directive requires the adoption of action programmes and, if necessary, additional measures and reinforced actions to prevent or reduce nitrate pollution where the contribution of N from agriculture makes a *"significant contribution"* to water pollution.

  The EUCJ did not state when contribution from agricultural sources may be deemed insignificant and thus not resulting in an obligation to take additional measures/reinforced action. The threshold has been tried in one prior case where the EUCJ similarly found that 17% N contribution from agricultural sources was significant. [78]

- Additional measures or reinforced actions are necessary when monitoring programmes and/or the values actually measured in the water or trends that can be identified over time indicate a potential exceedance of the limit value.[79]

- The (risk of) exceedance of the 50 mg/l threshold at one measuring point is sufficient to require action.

  Thus, if nitrate pollution of ground water cannot be seen to be reduced

[75] C-559/19, paragraph 132-135
[76] C-559/19, paragraph 138
[77] C-559/19, paragraph 141
[78] C-197/18, paragraph 50-53 and C-221/03 paragraph 85-93
[79] C-197/18, paragraph 57, 59-63 and 65

> and/or max nitrate levels of 50 mg/l cannot be met or risk being exceeded, additional measures must be taken under the Nitrates Directive, specifically included in Nitrates Action Programme legislation subject to the Nitrates Directive Article 5.4 and 5.5.[80]

It is of key importance when assessing potential RFM within the WFD framework to keep in mind the above obligation to implement additional measures/reinforced action to reduce and prevent nitrate pollution from agricultural sources, when contribution from agricultural sources is *"significant"*.

It is also of key importance to note that the EUCJ has confirmed the importance of the Nitrates Directive Article 5.3(a) and (b) as requiring Member States to base their Nitrates Action Programmes on the *"best available scientific and technical data and the physical, geological and climatic conditions of each region"*.[81]

Thus, potentially required additional measures implemented through Nitrates Action Programmes may not be postponed due to on-going scientific discussions and further research on methodology etc.

Related to this should, however, be noted that the EUCJ has expressed that the Nitrates Directive should not be interpreted as aiming at harmonizing 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.[82]

2.5.5 C-161/00 – Commission v Germany

The case was based on the Commission finding Germany had not adopted national legislation in compliance with the Nitrates Directive.

From the ruling the following conclusions can be drawn that the Nitrate Action Programme Regulation following the Nitrates Directive must contain measures which limit the amount of livestock manure applied to the land each year per hectare. Given both the context and objectives of the directive, the decisive criterion which the directive lays down for limiting pollution by nitrates from agricultural sources is the amount of N applied to the land by spreading on its surface, by injection into the land, by placing below the surface of the land or by mixing with the surface layers of the land, and not the amount of N actually penetrating into the land.[83]

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[80] C-197/18, paragraph 64-68. Based on this case, it follows that such additional measures also are needed for surface waters, where the nitrate pollution cannot be seen to be reduced by the existing Nitrates Action Programme legislation subject to the Nitrates Directive Article 5(4) and (5).

[81] C-197/18, paragraph 58 and C-237/12, paragraph 29.

[82] C-293/97, paragraph 3 and 39 and C-221/03, paragraph 3 and 64-65.

[83] C-161/00, paragraph 36 and 46-47.

2.5.6 C-322/00 – Commission v Netherlands

The case was based on the Commission finding that the Netherlands had not adopted national legislation in compliance with the Nitrates Directive.

From the ruling the following conclusions can be drawn:

- Additional measures subject to the Nitrates Directive article 5(5) must be adopted at the earliest time when Member States become aware that such measures are necessary to achieve the goals of the Nitrates Directive.[84]

- National legislation must contain rules relating to limits on the land application of fertilisers based on a balance between the foreseeable N requirements of crops and the N supply to crops from the soil and from fertilisation, those rules having to take the form of use standards.[85]

2.5.7 C-526/08 – Commission v Luxembourg

The case was based on the Commission finding that the Grand Duchy of Luxembourg had not adopted national measures regarding protection of water from nitrates pollution in compliance with the Nitrates Directive.

From the ruling the following conclusions can be drawn that national legislation must prohibit application of all types of fertilizers, both natural and mineral based, on steeply sloping grounds towards surface waters and in certain periods of the year where application of fertilizers will result in run-off into surface waters (application on snow covered og frozen ground).[86]

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[84] C-322/00, paragraph 166

[85] C-322/00, paragraph 84-85 and 94.

[86] C-526/08, paragraph 54-71.

3 Review of the scientific basis

3.1 Task 1: Reference condition

3.1.1 Objective and approach

Task 1 comprises a review of changes and improvements in RBMP3 in terms of methods, data and calculations for determination of ecological reference condition.

Sub tasks:

- Review of methodological improvements in RBMP3 to determine the ecological reference situation
- Review of improvements in RBMP3 of the applied data basis to determine the ecological reference situation
- Review of improvements in RBMP3 of the calculations carried out to determine the ecological reference situation
- Literature review

(Note: General parts of the WFD regarding reference conditions are not repeated in this chapter unless essential text important for derivation of the reference conditions. The terms and concepts of the directive are considered familiar to the reader. (See Legal Chapter)

Definition of reference conditions

The Water Framework Directive's (WFD) normative definition of ecological status classifications defines reference conditions for surface waters equal to high ecological status by[87]:

"There are no, or only very minor, anthropogenic alterations to the values of the physico-chemical and hydromorphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions.

The values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions and show no or only very minor, evidence of distortion.

These are the type-specific conditions and communities".

The WFD in itself does not specifically define a biological reference condition by other means than "shall be established, representing the values of the biological

[87] WFD, Annex V, 1,2 Normative definitions of ecological status classifications

quality elements … for that surface water body type at high ecological status" (WFD, Annex II, 1,3(i)). Meaning that the whole range of statuses from pristine conditions ('no' disturbance) to the ecological quality class boundary between high and good status ('only very minor' disturbance) is considered reference conditions.

Even if some authors have expressed an understanding that reference conditions should be understood to be the 'pristine conditions' of water bodies' (Nielsen et al, 2003), that understanding **is not** in line with the understanding in the proposal for the WFD Annex II and V, and how it is further developed under the WFD Common Implementation Strategy (CIS). Already in the introduction of the reference conditions concept into the proposal for the WFD, the Explanatory Memorandum of the proposal (EC 1998)[88] recognised: "*zero impact conditions are rare in Europe. For reasons of practicability, therefore, 'high status' was chosen as the reference point, as the state closest to zero impact for which there exist a sufficient number of sites for the practical purposes of providing reference. This first consideration applies whether data for the site concerned are used for the reference, or data from a similar site are used; in each case, the data must correspond to 'high status'.*"

Thus, Guidance Document No. 10 (REFCON) concludes and recommends: "Reference conditions (RC) do not equate necessarily to totally undisturbed, pristine conditions. They include very minor disturbance which means that human pressure is allowed as long as there are no or only very minor ecological effects" (Section 2,1). As a benchmark for very minor disturbances. CIS-GD No. 10 further suggests: High status or reference conditions is a state in the present or in the past corresponding to very low pressure, without the effects of major industrialisation, urbanisation and intensification of agriculture, and with only very minor modification of physicochemistry, hydromorpology and biology.

This implies that there should be no fixed temporal or spatial benchmark, but even if it "raises the problem of not knowing what we are accepting as the degree of change in an anthropogenic pressure that is incorporated into the concept of reference condition", it is proposed "that a flexible temporal benchmark as suggested above best fits the legislative intention".

Reference condition links to typology

Reference condition (high status) is by its definition linked and bound to the water body types and their characteristics. Analysis of the characteristics of water bodies within each river basin district is an essential requirement of the WFD (Art. 5). Furthermore, the WFD stipulates that the analysis must be reviewed and, if necessary, be updated as a basis for every consecutive planning period. Characteristics of surface water bodies (here, coastal water bodies)

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[88] Definition of typology and type-specific reference conditions were also introduced in the proposed amendments (COM (98) 76 final) to the proposal for the WFD of 1997 (COM (97) 49 final), The Explanatory memorandum of (COM(98) 76) describes the use of the typology and type-specific reference conditions as core elements in implementation of the directive (COM(98) 76, Explanatory Memorandum Para 20-30 and proposal for Annex V, Section 1,1,3), With the proposal for amendments (COM (1999) 271 final) the now existing structure and content of the WFD Annex II was introduced.

include characterisation of water body types and establishment of type-specific reference conditions for the water body types.

The WFD, Annex II specifies the methodology for identification and characterisation of water bodies and how to establish type-specific biological reference conditions for surface water body types. For the purpose of this review, two paragraphs of the methodology – one regarding the typology and one regarding reference conditions – are highlighted:

- "*For each surface water category, the relevant surface water bodies within the river basin district shall be differentiated according to type."* (WFD, Annex II, 1.1 (ii))

- "For each surface water body type characterized in accordance with section 1.1, type-specific hydromorphological and physicochemical conditions shall be established, representing the values … at high ecological status.", and "Type-specific biological reference conditions shall be established representing the values of the biological quality elements" … "for that surface water body type at high ecological status" (WFD, Annex II, 1.3 (i)).

Furthermore, a paragraph regarding the comparability of monitoring results is highlighted:

- "…, (classification) ratios shall represent the relationship between the values of the biological parameters observed for a given body of surface water and the values for these parameters in the *reference conditions applicable to that body."* (WFD, Annex V, 1.4.1, (ii))

With these paragraphs cited above, the WFD sets up a strong connection between the characterisation of water bodies according to an ecotype and the establishment of type-specific biological reference conditions. The directive also sets up a strong link between the biological reference conditions to the classification of ecological status and, in turn, focuses on comparability of Member States' assessment methods that must be ensured via the WFD intercalibration (IC) process. The IC process must establish values for the boundary for the High/Good (H/G) and the Good/Moderate (G/M) boundaries for the biological quality elements, which are consistent with the WFD Annex V normative definitions. Selection of a range of sites representing reference conditions and the H/G and G/M class boundaries is an essential part of the IC process[89]. In case that reference sites are not available, agreement between Member States[90] must be met on the criteria for using other information on reference conditions. For ensuring comparability between Member States of environmental status classification the status classification shall be expressed as an ecological quality ratio (EQR). These ratios shall represent the relationship between the values of biological parameters observed for a given water body and the values for these parameters in the reference conditions applicable to

[89] WFD Annex II, 1.3(iv) and Annex V, 1.4.1 (v)

[90] According to the IC procedure prescribed in CIS GD No. 14 (2008-2011 version) it applies to Member States, which share a common intercalibration coastal water type.

that water body. In the framework of the IC exercise compliance of Member States' assessment (classification) methods shall be applied to a common data set representing the selected sites.

For the WFD system to function in a comparable way across Europe there are two key issues: determination of the ecological quality at the reference point (reference conditions) and determination of 'similarity', which essentially involves sorting sites (in water bodies) into classification according to ecotypes or habitat types.

Considering that the WFD is a 'framework' directive, it does not prescribe in detail how the implementation of the WFD and the associated EU Directives should be carried out, it lies down provisions that the Commission may adopt guidelines on the implementation of Annex II and V in accordance with the committee procedures laid down in Article 21. Regarding reference conditions and typology, the Commission has produced several Guidance Documents under the WFD's Common Implementation Strategy (CIS). Relevant for this review of reference conditions and typology are:

- Guidance Document No. 2, "Identification of water bodies" (CIC-GD No. 2) on a WFD common understanding of the definition of waterbodies and suggestions for their identification;
- Guidance Document No. 5, "Transitional and Coastal Waters – Typology, Reference Conditions and Classification Systems" (CIS-GD No.5), which provides a detailed guideline for carrying out a characterization of all coastal and transitional water bodies, referred to as typology;
- Guidance Document No. 10, "River and lakes – Typology, Reference Conditions and Classification Systems" (CIS-GD No. 10), which addresses and elaborates on the understanding of concepts and terms of the directive with regard to reference conditions, typology and classification of ecological status; and in particular
- Guidance Document No. 14. "The Intercalibration Process 2008-2011"[91] (CIS-GD No. 14), which provides guidance for deriving reference conditions and defining alternative benchmarks for intercalibration,

For further description of the WFD intercalibration process and its results, please see Section 3.2.

[91] Two versions exist of Guidance Document No, 14, In this review, reference is only made to the 2008-2011 version, which incorporates experience from the 1st Phase intercalibration and which refers to and includes major parts of the "Guidelines to translate the intercalibration results into the national classification systems and to derive reference conditions" presented together with the Commission Decision CD 2008/915/EC,

3.1.2 Analysis and assessment

Typology – a basis for establishing biological reference conditions

The purpose of assigning water bodies to a ecotype "characterized by parameters with the greatest influence on the ecological characteristics" (EC 1998) is to enable valid comparisons of their ecological status nationally and across Member States. For each type, reference conditions must also be described, as these form the 'anchor' for classification of the water bodies' status or quality. The guidance document highlights that the establishment of reference conditions is the basis for setting class boundaries for assessing the ecological status of water bodies. However, it is important to note that typology in itself is simply a tool to assist this process by comparing like with like.

According to the Explanatory Memorandum of the WFD proposal[92] for the present WFD Annex II the aim of typology is to produce a simple physical typology that is both ecologically relevant and practical to implement, while at the same time providing a benchmark (in terms of discriminatory detail) for a more sophisticated option. To that end Guidance Document No. 5 recognises that a simple typology system needs to be complemented by more complex reference conditions that cover ranges of biological conditions (CIS-GD No. 5, 3,1,4, p, 28).

Consequently, a review of the methodology for establishing type-specific biological reference conditions cannot be made without a review of changes to the typology. In case a review and an update of the typology lead to changes to the type-specific hydromorphological and physiochemical conditions for the various types of water bodies, it could have implications for how the associated values for these factors represent the type-specific biological reference conditions established through the directive's international intercalibration process based on common water body types.

The point of departure is that Danish coastal waters belong to two EU ecoregions: the North East Atlantic (NEA) and the Baltic Sea (BC). Within these ecoregions, Denmark shares common intercalibration types with Germany and Sweden as shown in Table 3-1.

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[92] Two versions exist of Guidance Document No, 14, In this review, reference is only made to the 2008-2011 version, which incorporates experience from the 1st Phase intercalibration and which refers to and includes major parts of the "Guidelines to translate the intercalibration results into the national classification systems and to derive reference conditions" presented together with the Commission Decision CD 2008/915/EC,

Table 3-1: EU common intercalibration types shared with Germany and Sweden

Type	Surface salinity (PSU)	Bottom salinity	Exposure	Ice days	Other characteristics
BC6	8 – 12 Mid mesohaline	8 -12	Sheltered	< 90	Sites along the Western Baltic Sea at the southern Swedish coast and the South Eastern Danish coast
BC8	13 - 18 Upper meso-haline	18 -23	Sheltered	< 90	Danish and German coasts in the Western Baltic Sea
Type	**Salinity (PSU)**	**Tidal Range(m) Depth (m)**	**Current Velocity (knots) Exposure**	**Mixing Residence Time**	**Characterisation**
NEA1/26c	> 30	Microtidal/Mesotidal Range<1–5 Depth<30	Medium 1–3 Exposed or sheltered	Partly stratified Days to weeks	Enclosed seas, enclosed or sheltered, partly stratified, German – Danish Wadden Sea
NE1A/26d	> 30	Microtidal Range<1 Depth<30	Low < 1 Exposed or moderately exposed	Partly stratified Days to weeks	Scandinavian North Sea coast, exposed or sheltered, shallow, Denmark only
NEA8b	Polyhaline 10 – 30	Microtidal Range < 1 Depth < 30	Low < 1 Sheltered to moderately exposed	Partly stratified Days to weeks	Skagerrak, Kattegat and Northern Belt Sea Type, polyhaline, microtidal, moderately sheltered, shallow, Denmark, Sweden

For the purpose of intercalibration of national classification systems, four geographical intercalibration groups (GIGs) were established, two of them being NEA GIG and Baltic GIG. Within these GIGs, EU common coastal intercalibration types were characterised broadly by the descriptors of the WFD System B typology (WFD, Annex II, 1.2.4). The typology for Danish coastal waters was established for the 1st RBMP and RBMP2s based on the EU common intercalibration types within the ecoregions and including a subdivision of 15 different types: five open water types and ten estuary types for fjords and closed coastal waters. Some of these types – in particular, the open water types – are directly associated with the EU common intercalibration types whereas most of the estuary types are considered national types that, on the basis of optional factors, are a subdivision of the common intercalibration type according to the natural hydromorphological variability.

A typology for transitional waters was not applicable for the Danish marine waters. In its assessment report on the second river management plans (EC-

SWD 2019), the Commission accepted the Danish justification for not having designated transitional waters.

System B of the WFD's Annex II was applied in accordance with the CIS guidelines (CIS-GD No. 2 and No. 5) using the obligatory factors 'tidal range' and 'salinity' and optional factors 'exposure' and, in particular for fjords and inlets, 'stratification' (mixing characteristics) and 'sensitivity to land-based input of water' (retention time). The basis for the typology used in both 1st RBMP and RBMP2 and its scientific background was established through the period from 2000 to 2005 and can be found in Nielsen (2001) and Dahl et al, (2005).

The international Panel of expert's findings

In its report "International evaluation of the Danish marine models" (Herman et al. 2017). The Panel of international experts questioned whether the Danish typology of the 1st RBMP and RBMP2 was sufficiently detailed to allow the definition of reliable reference and target values for Chl-a and the other indicators in all coastal waters, in particular the fjords and closed coastal waters. The panel noted that:

- Water bodies with diverse properties were represented by only one common reference value and one target value representing their coastal water type. The Panel found that the Danish typology was too simplified to reflect the specific characteristics and properties of the individual Danish fjords and inner coastal waters.

- Considering the comprehensive Danish monitoring program and that Denmark is one of the few countries in Europe where the necessary data, expertise and models are available, the Panel suggested to subdivide the typology for these systems, taking into account especially water exchange rate and freshwater discharge.

In summary, the Panel concluded that the use of a coarse typology has led to reduction requirements that are not optimal for each of the individual water bodies. The Panel was convinced that the full use of available data and models would *"allow Denmark to forego the typology and develop advanced, specific reduction targets for each water body"*. The Panel recommended focusing on the water body scale of resolution throughout the scientific process.

By addressing The Panel's recommendation it is important to bear in mind that it is made from a scientific point of view and that literally doing as The Panel has stated, i.e. *"to forego the typology"* would not be in compliance with the requirement of the WFD. Focusing only on individual water bodies with no clear link to the typology linked to the common EU intercalibration sites will make it difficult to ensure comparability of the national classification system with other countries. Therefore, focus of this review of the developments and use of the scientific methodology in the RBMP3 will be to assess whether the scientific advice by the panel on focusing on the water body scale is followed, whether the requirements of the Directive are met, whether links to the EU common intercalibration sites are or could be established, and whether it has provided for improvements in RBMP3.

Revision of the Danish typology

Based on the panel's recommendations, the Danish Ministry of the Environment commissioned a report on the review of basis for water body delineation, identification and characterisation and their division into types (typology) (Erichsen et al, 2019).

The main purpose was to review the Danish typology with a view to improving the basis for the RBMP3, e.g., by focusing on individual coastal water bodies, and thereby establishing reference conditions and target values for individual water bodies in order to enable calculation of the nutrient load that better reflects the need for taking measures in individual water bodies.

This review of the Danish typology (Erichsen et al, 2019) undertook a thorough assessment of the existing delineation, including field examination of water bodies. Nine of the WFD System B optional type descriptors, more than used in the existing typology, were included and by use of comprehensive information and physical data and by multi-dimensional scaling and cluster analysis, the review resulted in a new typology assigning 114 water bodies to 39 types. Each type is associated with the descriptors, including the maximum and minimum values for the type.

Basis for revision of the typology

The revised Danish typology is – apart from the new and updated information and quality assurance of the existing information – established in accordance with the guidance of the CIS-GDs. The revised typology enables a differentiation of coastal water types that reflects the diversity of Danish coastal waters, and it has proven useful to the revision of reference conditions and calculation of Maximum Allowable Inputs (MAIs) in particular for fjords and closed coastal waters (see the section below and sections 3.4, 3.6 and 3.7).

Taking a closer look at the typology of the 1st RBMP and RBMP2s, the Scientific Documentation for the 1st RBMP could already indicate that the typology for fjords and closed coastal waters did not reflect sensitivity to pressure (nitrogen input). That appears obvious by associating the RBMP2 types for fjords and closed waters with their level of response (slope) to nitrogen inputs (Carstensen et al, 2008) (See also the section below on Chl-a reference condition). It appears that water bodies belonging to the RBMP2 type do not, according to types, have discrete levels of sensitivity with respect to eutrophication pressure e.g. the nitrogen input pressure (nitrogen input-nitrogen concentration relationship (slope)) Figure 3-1 (see also Figure 3-3). That alone calls for a tool that enables such a differentiation according to pressure-impact sensitivity (See CIS-GD No. 5, 2.2.1, Figure 2.1 and 2.2.10) just as the panel recommends. However, that does not imply that the typology should be detailed to such a level.

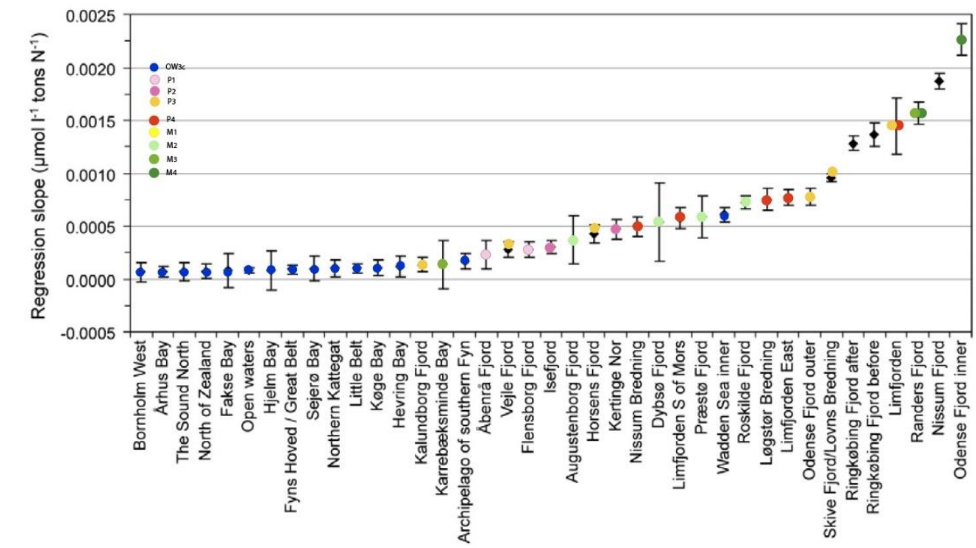

Figure 2.6 Estimated site-specific slopes in TN-nitrogen input relations and 95% confidence intervals for the estimate. Estimates have been sorted by increasing slopes.

Figure 3-1: Water body reaction to nitrogen pressure paired with their type (based on Carstensen et al. 2008)

The new Danish typology does not directly include the most assessment of sensitivity to important pressure factor with regard to eutrophication – reaction to nutrient input. However, by the descriptor 'Fresh water influence', including 'retention time' and 'current velocity', the typology parameter values reflect the sensitive to potential impact caused by nutrient input pressure.

39 types are a high number for a typology as 'simple' as possible. The authors are aware of that but considering the high number of Danish fjords and closed water bodies and vast natural variation in their characteristics, the revised typology is better suited for ensuring a differentiation than the existing typology. Anyway, the high number of types will be a challenge when it comes to translation of intercalibration results of common IC types into national types and comparing 'like with like' on a scale where ecological status classification systems are intercalibrated. For example, the relevant types of the new Danish typology are not (formally) linked to the common EU intercalibration types, and it is not transparent (documented) how the typology will serve in translation of reference conditions and intercalibrated ecological status class boundaries for these types to national types or individual water bodies. As the values for the typology descriptors are used in practise in the preparation of the proposal for the RBMP3, both for deriving biological reference conditions and for calculating the level of pressure reduction (N and P input), these values as well as the link to the common IC types should be accessible in the RBMP or its formal basis. That would ensure compliance with the WFD, Annex II, 1.1 (iv) requirements: *".. the surface water bodies within the river basin district shall be differentiated into types using the values for the obligatory descriptors and such optional descriptors, or combinations of descriptors, as are required to ensure that type specific biological reference conditions can be reliably derived".*

The Commission noted (EC-SWD 2019) in its assessment report on the RBMP2 implementation of the WDF in Denmark that *"several national types for Denmark* *do not appear to have corresponding intercalibration types"*. It was the case for 11 Danish types of coastal water bodies. Member States were also asked to report 'Not applicable' if there was no corresponding intercalibration type for national types. The Commission noted that data from across all the types was used in the intercalibration process, thereby linking also the national coastal water types to the common intercalibration types: *"For the national types that have been linked to common intercalibration types, the Danish classification system has been successfully intercalibrated for all the biological quality elements. This indicates that the Danish typology is biologically relevant for those national types. For the other national types that are not linked to any common type, there is no information available as to whether those types are biologically relevant."* Furthermore, in its previous report on the implementation of the WFD in Denmark (EC-SWD 2012), the Commission recommended that there was a need *"to further develop water typologies which are tested against biological data, and develop and provide further information on reference conditions for all water types."*

This shows that the Commission attaches importance to the link between the individual water bodies and the common intercalibration types and, in turn, the link to the typology.

Furthermore, as the revised typology is used for new estimation of reference conditions for both Chl-a and eelgrass depth limit by other methods than previous estimation of intercalibrated reference conditions, it is to be considered a part of a 'revised national classification method' that could be subject to a new intercalibration as the typology changes may affect the comparability with the intercalibrated standard (CIS-GD No. 30). Therefore, presentation of the typology to the CIS ECOSTAT working group could be appropriate.

Establishing ecological reference conditions – methodology

Guidelines for deriving reference condition

As described above the 'high status' was chosen as the reference point, as the state closest to zero impact. Thus, the whole 'high status' class and not a status at a single point in time is considered to represent reference conditions. Therefore, any point of ecological statuses falling inside the 'high' class between 'no' and 'only very minor' impact can be considered as a benchmark for reference conditions. The WFD, Annex V, 1.2 normative definitions define a link between the status of biological quality elements and supporting physico-chemical quality elements, therefore, the nominal values for biological quality elements and the associated values for the supporting elements together define a reference point (benchmark) when it is inside the 'high status' class. The provisions of Annex II, 1.5 on assessment of impact require assessment of surface water status related to pressures[93], thereby the nominal values of the reference point's biological and supporting quality elements can be associated with a specific pressure. The provisions of WFD Annex V, 1.4 on comparability of

[93] "The direct effects of most pressures are on the supporting elements (i.e. physico-chemical conditions and hydromorphological conditions). The changes in these supporting elements lead to impacts on biological quality elements. Relatively few pressures act directly on the biological quality elements (e. g. fishing)" (CIS GD No. 14, Annex IV).

biological monitoring results require those results to be expressed as ecological ratios (EQR – numerical value between zero and one) representing the relationship between the observed values and the values in reference conditions. The EQR scale shall be divided into the five classes ('high', 'good', 'moderate', 'poor' and 'bad') by assigning a numerical value to each of the boundaries between the five classes. Finally, the values corresponding the 'high-good' (H/G) and the 'good-moderate' (G/M) class boundaries shall be established through an intercalibration exercise. The CIS-GDs No. 5; No. 10; No.13; and in particular No. 14 (2008-2011 version) specify the Commission's understanding of how these provisions should be interpreted scientifically and be practised – see also Section 3.2.

As stated in the introduction to this chapter, establishing type-specific biological reference conditions is a key issue of the directive. The WFD provides four options for establishing type-specific reference conditions, CIS-GD No. 5, Section 4, and in particular CIS-GD No. 10, Section 3, elaborate these options into methods that can be applied for determining reference conditions. And Guidance Document No. 14 (2008-2011 version)94 in particular describes and sets up scientific approaches that should be applied for deriving reference conditions and defining alternative benchmarks for intercalibration and setting boundaries for classification of ecological status. Even if these particular guidelines are included in a guidance document on intercalibration, they were developed based on the experience from the 1st Phase intercalibration to support Member States in their translation of the intercalibration results into their national classification system and to derive reference conditions. The guideline document refers to CIS-GD No. 10's guidance on deriving reference conditions – which is more elaborated than in CIS-GD No. 5 – as a starting point for the document's more specified guidelines for deriving reference condition. As such, the guidance on reference conditions in CIS-GD No. 5 can also be considered extended and the scientific approach of CIS-GD No. 14 can be considered applicable for national coastal water types not covered by the intercalibration. Therefore, this scientific approach forms the basis for the present review together with the fundamental provisions of the WFD on this topic.

Reference conditions may be "either spatially based or based on modelling or may be derived using a combination of these methods. Where it is not possible to use these methods Member States may use expert judgment to establish such conditions" (WFD Annex II, 1.3 (iii)). This provision is interpreted into four options:

- Reference conditions represented by existing undisturbed sites or sites with only very minor disturbance; or

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[94] The "Guidelines to translate the intercalibration results into the national classification systems and to derive reference conditions" (EC 2008b) was issued together with the first Commission Decision on the intercalibration results – CD 2008/915/EC – and the decision referred to the guidelines, For intercalibration purposes most parts of these guidelines, including guidance for deriving reference conditions, are referred to or included in the CIS-GD No, 14, 2008-2011 version, but the guidelines are still existing with regard to reference conditions in national types.

- Temporally based reference conditions using either historical data or paleo reconstruction or a combination of both or
- Reference conditions based on predictive modelling or hind-casting methods.

A combination of the above approaches can be used, and the modelling methods must use historical, palaeological and other available data and must provide a sufficient level of confidence about the values for the reference conditions to ensure that the conditions so derived are consistent and valid for each surface water body type. Where it is not possible to use these methods:

- Reference conditions can be established with expert judgement.

As the reference condition is closely linked to the classification system of ecological quality status and to intercalibration of the good-moderate class boundary values, it is important that reference conditions for the coastal water types being intercalibrated are comparable. If natural or near-natural reference conditions are not available or cannot be derived for a certain type, intercalibration needs to be carried out against an ‘alternative benchmark’. To enhance the transparency of the intercalibration process, defining reference or benchmark conditions must be done using a common data set and must use harmonised criteria independent of national classifications “*(i.e., countries cannot simply nominate the sites they classify as high status as their benchmark sites without further checking)*” (CIS GD No. 14, Annex III). For common IC types – including national types, which do not differ significantly from the characteristics of the common IC types – CIS GD No. 14 prescribes finding reference sites or identification of alternative benchmarks based on actual data sampled at existing sites. The guidance document states that harmonised criteria to define reference condition must be established, and, in case of lacking ‘true’ reference sites, a common dataset for the countries involved must be used, encompassing sampling sites covering the entire gradient of the pressure to be intercalibrated, and hence the complete ecological quality gradient ranging from high to poor ecological status. For the national sites, which differ significantly from the common IC types, a translation of the intercalibration results into these water bodies needs to be undertaken consistent with the relevant descriptions of the ecological status classification set out in WFD Annex V (EC 2008b).

Scientific approach

CIS-GD No. 14, Annex III specifies procedures and a scientific approach for deriving reference conditions for the intercalibration. The guidance document refers to and specifies the guidance given in “Guidelines to translate the intercalibration results into the national classification systems and to derive reference conditions” (EC 2008b), which states that Member States for their national waters “*should use the procedures to set reference conditions agreed in the context in the intercalibration exercise and documented in the intercalibration technical report*” in their translation of intercalibration results into national classification systems. Therefore, the 2nd opinion team has included the scientific approach as specified in CIS-GD No. 14 in our assessment of the revised RBMP3 reference conditions for Chl-a and ‘eelgrass depth limit’.

Furthermore, the 'General conceptual framework to assess eutrophication' of the CIS Guidance Document No. 23 has been applied in the assessment (See also Section 3.4)

A first step in the intercalibration exercise is to identify if reference sites can be identified for each water body type and if no sites are available to specify the relevant criteria for definition of reference values and the H/G class boundary. The guidance document states that a reference benchmark representing 'true' reference conditions must be represented by sufficient sites to enable to confidently estimate reference values, and, in case of lacking 'true' reference sites, it states that alternative benchmark sites representing impacted sites, preferably with status classification close to high status, have to be identified from a common IC type dataset in order to derive either 'true' or 'virtual' reference conditions. The guidance document also states as a precondition to be fulfilled that the pressure-impact relationship must be the same across the dataset used in order to be able to compare the national class boundary settings. CIS-GD No. 14, Annex III includes a specific guidance for deriving reference conditions and defining alternative benchmarks for intercalibration. Depending on the availability of reference sites, a three-tier approach is recommended:

- Tier 1 – 'true' (coastal water) reference sites – sites with no or minimal anthropogenic pressure.
- Tier 2 – 'partial' (coastal water) reference sites – sites subject to greater anthropogenic disturbance, but certain biological quality parameters do not differ from true reference conditions (e.g., 'phytoplankton reference sites' with no or minimal eutrophication pressure, but significant morphological pressure not affecting the phytoplankton community in a significant manner).
- Tier 3 – 'alternative benchmark' (coastal water) sites – sites impacted by similar level of disturbance and exerting similar level of impairment to biology. This approach allows for intercalibration even if reference sites are absent.

It has been concluded in the CIS IC process that all the common IC types, which Denmark shares in the Baltic Sea and North East Atlantic area, are in eutrophic state (as per the WFD understanding) and that no sites can be found in a state of reference conditions with regard to eutrophication (CIS Intercalibration report 2013). That leaves only the above Tier 3 to be applied. Therefore, Tier 1 and 2 will not be further described in this review.

When using alternative benchmark sites, which is the case for Chl-a in Denmark, the preconditions that need to be fulfilled are that a pressure-impact relationships can be established based on observed values for the biological element and the pressure indicator/abiotic supporting quality elements[93], and that it must be the same across the data set used. All relevant pressures need to be accounted for and whether there are multiple pressures. They must be combined in a meaningful way. It is important to identify the position of the alternative benchmark on the pressure-impact gradient (Figure 3-2).

Alternative benchmark sites have to be identified from a common intercalibration data set. That is a data set that includes data representing a common IC type at a broad range of impacted statuses preferably covering most status classes, and with contribution of data from all the Member States sharing the type. It is important to identify the position of the alternative benchmark on the gradient of impact, i.e., to document the deviation of the selected benchmark from reference conditions that would then be considered 'virtual' reference sites as reference sites not existing in reality but conceived as the potential biological components that should be present. Several approaches can be applied for identification of alternative benchmarks, including support by modelling approaches and expert judgement. In the case of Chl-a, the Danish approach has been predicting the reference values based on statistical (multiple regression, Bayesian) analysis. However, alternative benchmark sites and the actual distance from the 'virtual' reference of have not been identified.

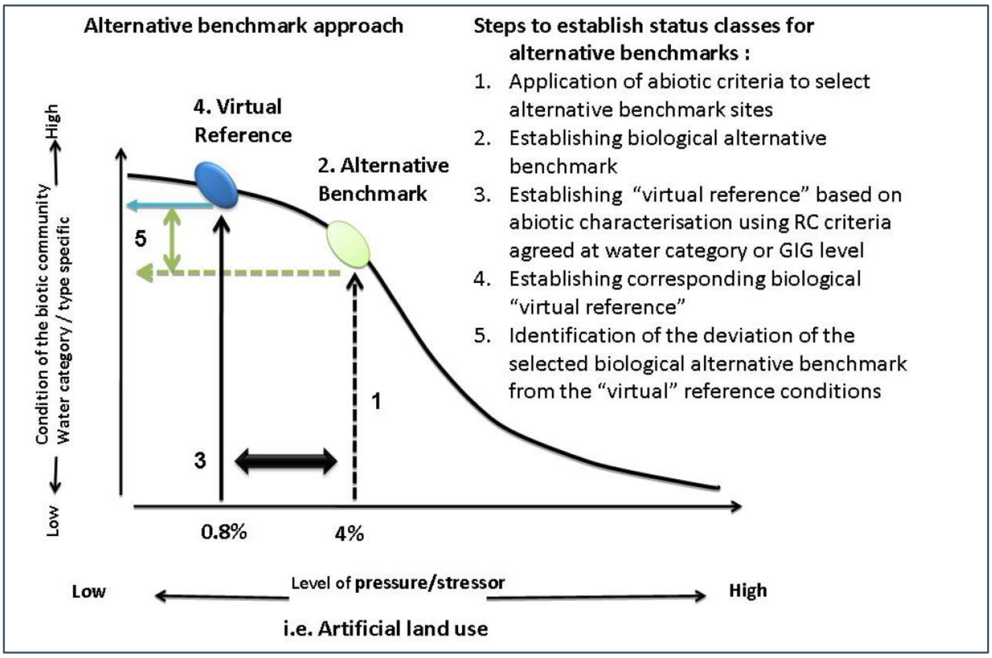

Figure 3-2: Alternative benchmark and reference conditions (From CIS-GD No. 14, Annex III)

Identification and description of the qualifying criteria[95] for type-specific reference conditions are included in the basic step in the intercalibration process. After completion of the intercalibration exercise, it is the obligation of the Member States to translate the results of the intercalibration exercise into their national classification systems in order to set the boundaries between high and good status and between good and moderate status for their national types, which characteristics are significant different from common IC types (CIS-GD No. 14, Para 23). Furthermore, reference conditions are not considered permanent. Climate, land cover and marine ecosystems vary naturally over

[95] Modelling methods; paleolimnological methods, expert judgement etc,

many periods relevant to the WFD. It is accepted that many of these variables are not fully understood in the marine environment and that the development of reference conditions is likely to be an iterative process until adequate data sets are available. However, development of sound predictive models is foreseen to reduce the degree of expert judgement (CIS-GD No. 5, 4.4.2 and 4.9).

It is important to note that the purpose of establishing a pressure-impact relationship (gradient) in the context of reference conditions and setting quality status class boundaries is to describe the link between the biological quality element and the pressure (e.g., represented by nutrient concentration) under steady state conditions. As such it represents the physico-chemical conditions that should be present to support a certain biological status of the water body. Even though it, for some biological elements, would also describe a dynamic reaction to changes in the pressure, this relationship should not be confused with a description of such reaction.

This **review only considers** assessment of two biological quality elements (e.g., Chl-a concentration and eelgrass depth limit) that are relevant and used in relation to the Danish classification of ecological status related to eutrophication and model calculation of MAI. Furthermore, the review focuses on the coastal waters in the inner part of the Danish territories – i.e., the inner Danish territorial waters south of Skagen and the fjords along the North Sea coast. A summary of the documentation on reference conditions, which were established in 1st Phase intercalibration (2008) for application in the RBMP1, has been included in the assessment because they still today are the basis for the intercalibrated H/G and G/M class boundary values and EQRs set in the Commission Decisions on intercalibration results. For Chl-a the 1st Phase intercalibration reference conditions and class boundaries entered the 2nd Phase intercalibration (2013), which results have had further implication on the intercalibrated G/M class boundaries of 3rd Phase intercalibration (2018). Furthermore, the documentation on the 1st Phase intercalibration for Chl-a illustrates use of the scientific approach for deriving reference conditions as set out in CIS-GD No. 14.

Reference conditions – Chl-a

The first reference conditions for the phytoplankton quality element for Danish coastal waters were established during the IC 1st Phase of the EU intercalibration 2004-2006. Chl-a concentration was chosen as an indicator for phytoplankton biomass. This indicator was and still is an often-used indicator by Member States and scientifically – confirmed by the panel – considered a useful intercalibrated indicator of phytoplankton biomass.

In both the Baltic Sea and the Kattegat and Skagerrak parts of the North Sea Atlantic, the average summer Chl-a concentration was chosen as indicator for phytoplankton biomass to be used and intercalibrated. In the Baltic Sea, the average summer concentration (May-September) was chosen as the metric, and in the North Sea (open waters) the 90%ile of the summer concentration (March-October) was chosen as the metric for the intercalibration. For this review, only the metric average summer concentration is relevant as this metric is the only

Chl-a metric used for the MAI calculation. For the EU intercalibration, all countries used the monitoring data available in their national databases to derive the reference conditions for their national types.

In the Baltic Sea area, no reference sites exist (Option 1) and Member States needed to apply another option. Relationships between Secchi depth and Chl-a or nutrient concentration were considered of major importance to define the high status or an alternative benchmark (CIS Intercalibration report 2013, Section 2.3).

RBMP1 Chl-a reference condition

In the 1st Phase intercalibration two methods were assessed for establishing reference conditions for phytoplankton expressed as Chl-a in Danish waters. One method using historical Secchi depth measurements and relationships between Secchi depth and Chl-a obtained from recent monitoring data from Danish coastal waters. Another method using a combination of 1) hind-casted nutrient inputs, 2) characterization of reference loading using the hind-casted estimates, and 3) historical nitrogen inputs projected into total nitrogen (TN) concentration levels and related to Chl-a levels in coastal waters. The latter approach was chosen as it was considered giving more precise and unbiased estimates of reference conditions. The H/G boundary and reference conditions were established by expert judgement based on historical nitrogen loading and corresponding TN-concentration and Chl-a concentration relationships (Figure 3-3). The G/M class boundaries were based on site-dependent (intercept) generic (slope) relationships between total nitrogen and Chl-a concentrations (EC-JRC 2009), thereby, following the CIS GD No. 14 scientific approach. Reference conditions and class boundaries for the TN-concentration and Chl-a were estimated for 39 water bodies and a reference TN-concentration of 15.46 µmol l^{-1} (~220 µg/l) for open coastal waters was estimated (Carstensen et al. 2008). Howev-er, the results were not applied in RBMP1. (See Appendix F for more detailed summary of the methods applied).

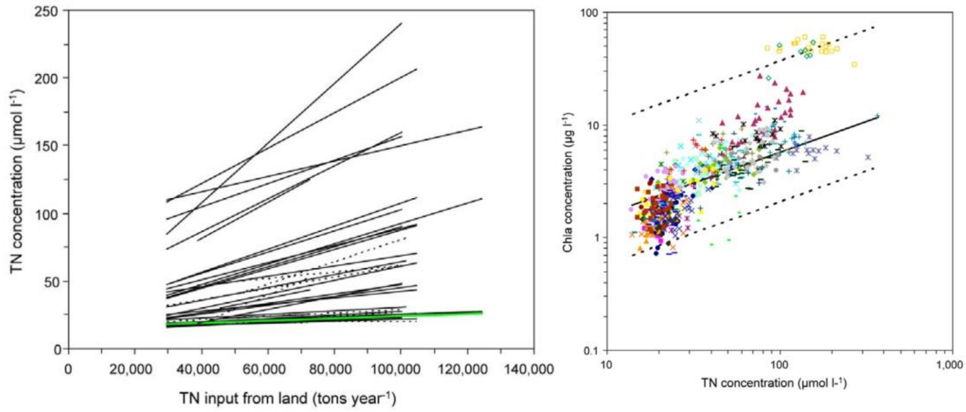

Figure 3-3: Relationship between TN load and TN concentration, and between TN concentration and Chl-a. The regression TN input/TN concentration line (left figure) for open-water stations in the Danish straits is highlighted (bold, green). TN/Chl-a concentration relationships (right) presenting different water body specific relationships (intercept) with a common slope factor were used for setting reference condition values and H/G and G/M boundary values. (Carstensen et al, 2008 and EC-JRC 2009)).

RBMP2 Chl-a reference condition

For the RBMP2, the Scientific Documentation (Erichsen & Timmermann 2017) describes the development of a revised methodology for establishing Chl-a reference conditions and corresponding WFD target values applicable to all Danish WFD water bodies located south of Skagen. The methodology includes model estimation of reference condition values based on both statistical (STAT) and mechanistic (MECH) water body specific models focussing on a relationship directly between nitrogen load and Chl-a concentrations in individual water bodies. In order to obtain robust estimates of the Chl-a reference values, a type-specific approach was used for derivation of reference conditions values. For the estuarine types, an ensemble modelling approach was applied involving results from statistic and mechanistic modelling to further increase the robustness of the estimates and reduce the influence of potential model bias.

Chl–a reference conditions 2021-202

As a follow-up on recommendations by the international evaluation in 2017 (Herman et al. 2017) and commissioned by the Danish Environmental Protection Agency (DEPA), Timmermann et al. (2021) and Erichsen & Timmerman (2022) developed a revised method for establishing Chl-a reference condition values in order to ensure, by as high spatial differentiation as possible, a reflection of the heterogeneity of the Danish water bodies. As no 'true' reference sites exist in the Danish coastal waters and as suitable historical Chl-a data is not available for establishing reference values, a quantitative modelling option (Tier 3) was applied by using water quality models to estimate the reference condition level of Chl-a. A new statistical methodology and the MECH models developed for the RBMP2 for quantification of the maximum allowable nutrient input for obtaining a 'good' ecological status are used, but with focus on individual inner Danish water bodies instead of types as described in Section 3.4.

Basis for intercalibration

The reference conditions for Chl-a derived for the RBMP1 were used as basis for setting H/G and G/M class boundaries in the 1st (2004-2006) and 2nd (2008-2011) Phase intercalibration and the revised reference condition values derived for RBMP2 were basis for 3rd Phase intercalibration (Carstensen 2016).

Nitrogen reference load

The models used in all three RBMPs were forced with nitrogen load data corresponding to a (reference) situation as close to an undisturbed situation as possible. For RBMP1 the nitrogen load around was considered associated with reference conditions status in the Danish coastal waters assuming the human impact was minimal in 'year1900' with a reference load estimated to 14 kton N year^{-1} to the inner Danish marine areas (Carstensen et al. 2008). For RBMP2 and RBMP3 reference TN and TP loadings from Danish catchment areas were estimated from concentrations of TN and TP in streams draining catchment areas with a low (< 10% for TN and < 20% for TP) proportion of agricultural land and no or very few point sources from scattered households and multiplied by the corresponding catchment-specific water flow. In RBMP2 this reference load was referred to as a 'year 1900' load, however this concept was left after the adoption of the RBMP2 and reference TN and TP loadings from Danish catchment areas has since then been referred to as 'background' loads associated with the historical observations of eelgrass depth distribution in the last part 1800th century[96]. The aggregation of annual N loadings in a reference condition used for RBMP2 was calculated at 17 kton N year^{-1} from all Danish catchment areas and 12 kton N year^{-1} when only considering loadings to inner Danish marine waters (Erichsen & Timmermann 2017). The RBMP3 reference load is calculated using the same method as in the RBMP2. In RBMP3, nitrogen reference input is calculated at 16 kton N year^{-1} from all Danish catchments and 11 kton N year-1 from inner Danish waters (Erichsen & Timmermann 2022). Both values are 1 kton N year^{-1} lower than in RBMP2 – see Appendix F.

Modelling ecological reference conditions in RBMP3

The modelling approach in RBMP3 comprises the parallel application of two different model systems – statistical and mechanistic – as described and discussed in Section 3.4. For the purpose of assessing whether the estimated RBMP3 reference condition values for Chl-a for individual water bodies have provided improvements compared to the reference condition type-specific values for RBMP2 the 2nd opinion team finds that a comparison also needs to be made with the reference conditions values estimated for RBMP1 and the 1st Phase intercalibration. The reason is that the RBMP2 and RBMP3 methods are different from the 1st Phase intercalibration method by being based on a relationship directly between 'nitrogen load' and the 'Chl-a concentration' for each individual water body and individual 'slope' factors, whereas the 1st and 2nd Phase intercalibration reference condition values were based on a 'nitrogen concentration'/'Chl-a concentration' relationship with a common 'slope' factor (Carstensen et al. 2008).

RBMP3 model concept

Statistical (STAT) and mechanistic (MECH) models were forced with background (reference) nutrient loads. For the STAT models the background load was restricted to Danish land-based reference loadings, whereas the MECH models also included loadings originated from the atmosphere, the Baltic and North Seas as well as adjustments related to sediments etc. The reference scenario results of the two model types were used to establish a combined model that links reference Chl-a values of the two model types to water body typology parameters. Via a regression analysis (MLR) over a range of physical and hydromorphological typology parameters, water depth and freshwater influence were chosen as the best explanatory variables for the final combined model and they were used to estimate Chl-a reference condition values for all water bodies.

Comparison of reference condition

The two independent water quality model (statistical and mechanistic) systems were forced with the hydromorphological descriptor values for individual water bodies from the revised typology described in the first part of this section and the reference condition values were estimated using a 'background' nitrogen load.

A comparison between the estimated reference values for the 1st Phase intercalibration (NERI Technical Report No. 683 study in 2008, Carstensen et al. 2008) and the established reference values for the RBMP2 shows a decent

[96] Later studies showed that a higher nitrogen load was present in 'year 1900' – se also Section 4.4.

correlation, taking into account that the RBMP2 values represent types and not individual water bodies, Figure 3-4 (Left). It also shows that the simple statistical regression models of the NERI study result in higher reference values than the combined models used for the RBMP2. It was also a finding of the Scientific Documentation, which discussed a tendency for the statistic models to predict elevated reference concentrations compared to the MECH models (Erichsen & Timmermann 2017) (See Section 3.4). However, higher reference values should be expected due to the higher reference load used in RBMP1.

In a comparison between the suggested RBMP3 reference values and the NERI study values it is difficult to see any correlation, see Figure 3-4 (Right).

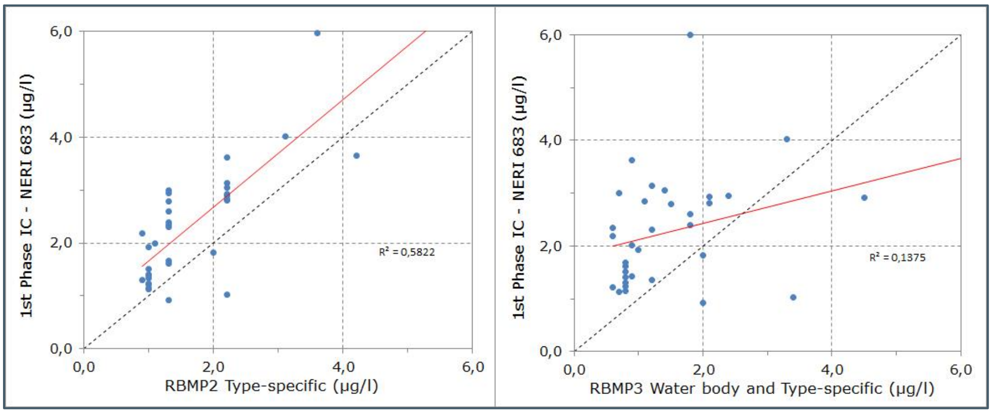

Figure 3-4 Left: Chl-a reference value in RBMP2 (Erichsen & Timmermann 2017) compared with the corresponding values from 1st Phase intercalibration (Carstensen et al. 2008).
Right: Chl-a reference value for RBMP3 compared with the corresponding values from original intercalibration (Carstensen et al. 2008)

Comparing the RBMP2 reference values with the suggested RBMP3 reference values demonstrates the capability of the RBMP3 method to differentiate the RBMP2 type-specific reference values into reference values for individual water bodies, as requested by the WFD planning authorities, Figure 3-5 (left). Comparing the values behind the RBMP2 type-specific reference values for the individual water bodies with the RBMP3 reference values (combined model results) indicates that the values of the RBMP3 on average are slightly lower than the corresponding values in RBMP2. On average, the difference of eight to nine per cent can be considered small and not significant. However, for the water bodies covered by the common IC types, the tendency is more pronounced in Figure 3-5 (right).

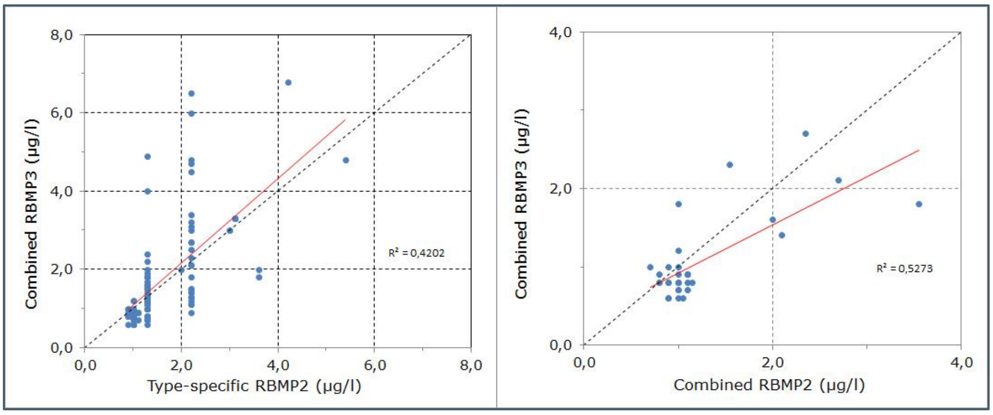

Figure 3-5 Chl-a type-specific reference condition values of the RBMP2 compared with the suggested reference values of the RBMP3 (left). Reference condition values for individual water bodies– compared to 3rd RMBP (Erichsen & Timmermann 2017, Table 8.3-8.6).

The estimated reference values of the Scientific Documentation (combined RBMP2 in the figure) for individual water bodies were included in the 2015 intercalibration data set that formed the basis for deriving the RBMP2 type-specific reference values. For the water body sites that were intercalibrated, Figure 3-6 shows a comparison of both the RBMP2 and the RBMP3 values (combined model results) with the intercalibration results. The slight deviation from the intercalibration shown for the RBMP2 values reflects the minor adjustment of the reference values resulting from the intercalibration between Denmark and Sweden (Carstensen 2016). The RBMP3 values are lower than the values of the intercalibration, on average, around 20 per cent lower than the intercalibration results. It shall be taken into account that the values are for open waters and therefore represent relatively low values (see also Section 3.2)

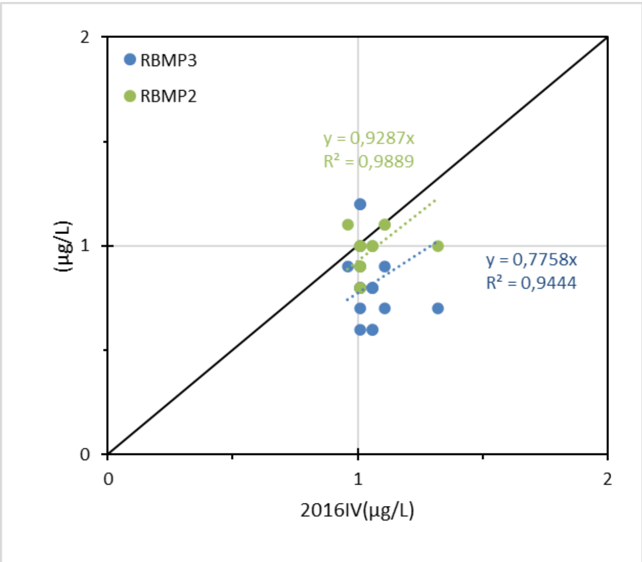

Figure 3-6: Comparison of Chl-a reference values of RBMP2s (Erichsen & Timmermann 2017) and RBMP3s with the 2015 intercalibration results (Carstensen 2016).

Effect of MECH and STAT models on combined reference value

The effect of the STAT and the MECH model on the final set of reference values, called the 'combined method', is illustrated in Figure 3-7 below. The left figure illustrates that the STAT model on average provides values that are about 26 per cent higher than the values determined by the combined method. Accordingly, the correlation between the results of the combined method and the MECH model in the figure (right) illustrates that the MECH model on average provides values that are about 20 per cent lower than the values determined by the combined method, it has to be noted that more values from the MECH model are available than for the STAT model.

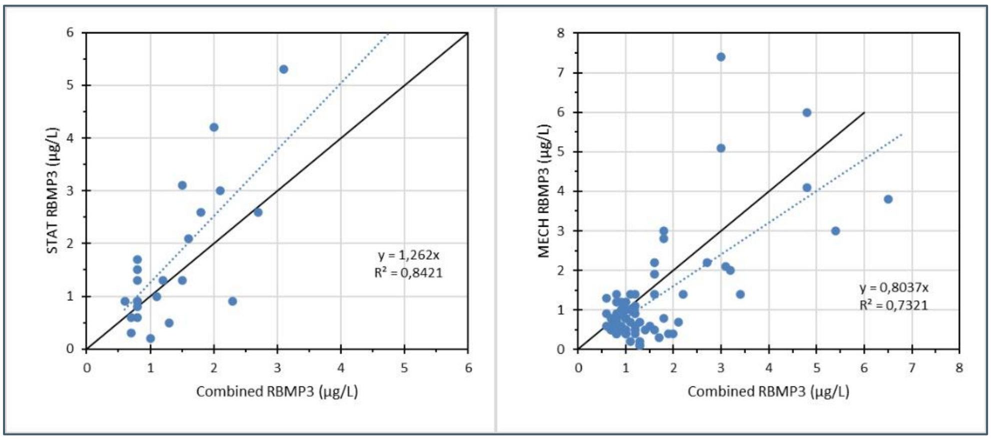

Figure 3-7: *Left: Illustration of the Chl-a reference values determined by the combined method (x-axis) and the reference values determined by the STAT model (y-axis,).*
Right: Illustration of the Chl-a reference values determined by the combined method (x-axis) and the reference values determined by the MECH model (y-axis).

This indicates that the results of the combined method are expected to be somewhere in-between the results of the two methods. At least for open water stations where the freshwater impact and the water depth have relatively less effect. By inspecting the model results for each water area, a different relation between the model results and the values finally selected appears, as illustrated in Figure 3-8.

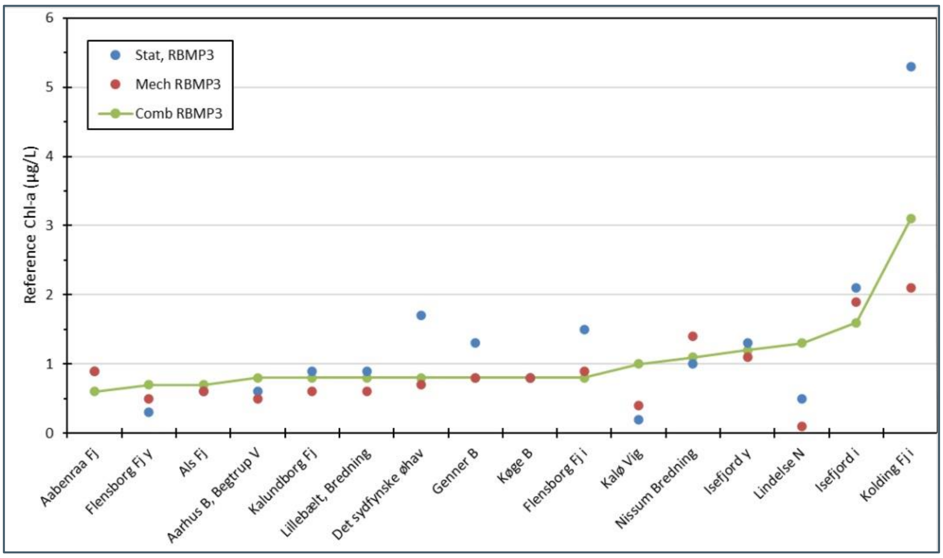

Figure 3-8 Comparison of the Chl-a reference values determined in MECH and the STAT model as well as the combined method per water body. The water bodies are sorted according to the magnitude of the reference values of the combined method. The values for the combined method are connected by lines for optical reasons only. The figure only comprises water bodies where results for MECH, STAT and COMB are presented in (Timmermann, et al. 2021)

It is seen that the combined value often is, respectively, higher and lower than both the STAT and the MECH value. How and to what extent the results of the STAT and MECH models come into play is neither clear nor transparent.

Assessment and discussion

Lacking 'true' reference sites, reference conditions for Chl-a are established according to Tier 3 in the guidelines for deriving reference conditions. Under the 1st Phase intercalibration, statistical regression models based on pressure-impact relationships were developed for estimation of Chl-a reference conditions, and pressure-impact-gradients were demonstrated for a range of pressure (nitrogen concentration) including reference situations. For the RBMP2, the model approach was developed, including development of MECH models for some individual coastal waters. And for the RBMP3, this approach was further developed by developing MECH models for nearly all coastal water and the revised typology Chl-a reference for individual coastal waters was established.

STAT models for both RBMP2 and RBMP3 apply a different approach than what was applied for the 1st Phase intercalibration by not including the statistical analysis with a well-known conceptual model for the scientific pressure-impact relationship between nutrient concentration and Chl-a. Here it should be noted that any reference to the guidance of CIS-GD No. 14 for deriving reference conditions is neither found in the RBMP2 nor the RBMP3 documentation on establishing Chl-a reference conditions.

STAT model

The RBMP3 STAT (Bayesian) model provides a tool for deriving reference conditions for more coastal waters than the STAT models used in the RBMP2. The STAT model analysis sets up a relationship directly between the load and the Chl-a by developing a grouped-station model covering 39 water bodies and single-station models for 43 water bodies (Shetty et a. 2021). The authors concluded that "the model performance statistics and evaluation plots indicate that most of the models can be used for scenario run, at least when the scenarios are within or not too far from the model calibration area. As for all types of models, the uncertainty will increase when moving away from the calibration area". Whereas several of the single-station models showed nearly 1:1 correlation between observed and predicted Chl-a concentrations most models appear to overestimate Chl-a concentrations at the lowest concentration levels as shown in Figure 3-9. The models were calibrated on data from the Danish national monitoring programme only covering a period with elevated eutrophic statuses in coastal waters. For estimation of reference condition values, the models were forced with the 'background' load described in this section, thereby estimating values well outside the calibration area with a risk of overestimating the values for some waterbodies.

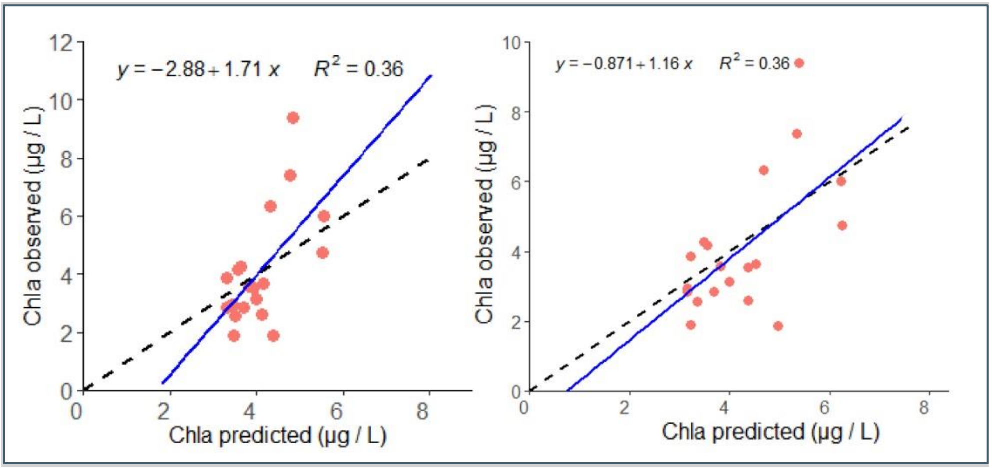

Figure 3-9 Examples of STAT model performance for Als Fjord. Left: Grouped-station model. Right: Single-station model. (From Shetty et al. 2021)

A visual inspection of the performance of the STAT models applied in the RBMP2 indicates a better agreement in general with the 1:1 correspondence line for the RBMP2 statistical regression models than for the RBMP3 Bayesian model.

MECH model

The MECH model builds intrinsically on conceptual models describing the relationship between nutrient load and nutrient concentration, and between nutrient concentration and Chl-a concentration. However, only relationships between nutrient load and nutrient concentration, and between nutrient load and Chl-a concentration are presented/demonstrated (Erichsen & Timmermann 2017) and only for the calibration ranges. Furthermore, it has not been demonstrated if the model is capable of reproducing a pressure range that covers reference conditions. Regarding the relationship between the nutrient concentrations and the Chl-a concentrations the same considerations apply as for the STAT models.

Both models

Even if the MECH model internally manages the relationship between nutrient concentration and Chl-a concentrations, the estimations of reference conditions for Chl-a by both the STAT and the MECH models do not consider the nutrient concentration, which is an important intermediate pressure factor between nutrient load and Chl-a concentration. Thereby, the found relations between nutrient loads and Chl-a concentrations mix up the different water bodies' (types') nutrient concentration reaction to load with the different water bodies' variability in the relationship between the nutrient concentration and Chl-a concentration that was developed in the scientific basis for the RBMP1 and described in the previous section. Thereby, the models lack the options for distinguishing between these two relationships, and the opportunity for testing the results against general conceptual relationship between nutrient concentration and Chl-a concentration is missed. The option for determining values for the supporting nutrient quality element associated with the Chl-a concentrations, as required by the WFD normative definitions, is also missed. Furthermore, the option is missed for providing a basis for determining ecological status class boundaries based on the pressure-impact-gradient as prescribed by CIS GD No. 14 - see Section 3.2.Alternative benchmarks based on monitoring data – ref Figure 3-2 – are not established, thereby not making it transparent how the relationships are used for 'extrapolation' from measured data to the established 'virtual reference' points describing the reference conditions. Demonstrating the conceptual model on the relationship between nutrient concentration and the Chl-a concentration and showing the alternative benchmarks on the pressure-impact-gradient would also provide a basis for more transparency in the translation of intercalibration results to national water bodies, which characteristics are significant different from common IC types. Furthermore, testing the 'virtual reference' point by forcing models with 'zero' nutrient input as done in the NERI Technical Report No. 683 (Carstensen et al. 2008) could contribute to an assessment of 'background' nutrient concentrations in open marine waters.

Anyway, both the RBMP2 and RBMP3 model complexes are capable of reflecting pressure-impact relationship regarding eutrophication and have proven useful as tools for derivation of Chl-a reference condition values for individual water bodies. But the introduction of the Bayesian statistics and its specific application, without considering the conceptual relationship, does not show significant improvement in establishing reference conditions for Chl-a,

The RBMP3 method for deriving reference conditions gives different results (lower values) than reference condition values for the sites in common IC types that were used in the intercalibration. The main reason could be ascribed to a further development of the model and revised typology parameter values (Erichsen pers. Communication). In the understanding of the directive and CIS-GD No. 30, the different reference condition values would be considered a revised national classification method that could require a new intercalibration (see Section 3.2).

Reference conditions – Angiosperms (Eelgrass)

Seagrasses are widely spread in all shallow coastal waters in the whole northern temperate zone. Eelgrass, *Zostera marina*, is an important element in a major part of the Danish coastal ecosystems, in particular in the coastal waters inside Skagen (Kattegat and the Baltic Sea) where the hydromorphological conditions in most coastal waters provides naturally good growth conditions. It is generally recognised that the metric 'Eelgrass depth limit' reacts to eutrophication pressure and is affected by nutrient concentration and water transparency, showing reduced depth distribution with increasing eutrophication pressure. Therefore, monitoring 'eelgrass depth limit' – as an easy indicator to measure – has been a part of the Danish marine monitoring programmes (since the 1980s) and, consequently, the metric entered as an indicator under the biological quality element 'Macroalgae and angiosperms' under the WFD.

Today, no Danish coastal water is in a condition of 'high ecological status' and, consequently, no sites can be identified to be 'true' reference sites for establishing biological reference conditions as required by the WFD. In that case, reference conditions must be established, either by modelling or by use of historical data. A generic model on the relationship between nitrogen concentration and eelgrass depth limit (Nielsen et al, 2001) was used to hind-cast reference depth limits based on (virtual) reference TN concentration levels, but only for the open coastal waters.

Historical observations

Fortunately, an extensive historical data set exists, comprising data on eelgrass depth distribution in Danish coastal waters from the period 1880-1930 and a few decades onwards (Krause-Jensen & Rasmussen 2009). This data suggested a difference in reference depth limits between various coastal waters/estuaries. So, for the 1st Phase intercalibration, it was assessed to be an advantage to use historical information on reference depth limits or to use area-specific values of reference TN to model reference depth limits. The historical data was also found to be adequate for defining reference conditions as the eutrophication pressure at that time was assessed to be at or near-natural (except for locations near major towns or settlements).

Defining reference for eelgrass depth limit

Based on the historical data material, a statistical basis was provided for establishing reference conditions for the main distribution of eelgrass population for a number of specific coastal waters or coastal water types (Krause-Jensen & Rasmussen 2009). The reference depth limit for eelgrass was defined as the values >90%ile of the historical maximum values, representing a depth limit with >10% cover. Furthermore, it was assumed that the depth limit represents the eelgrass main distribution rather than the maximum depth limit. As such, the defined reference depth limit was defined as equalling the high-good boundary, representing 90 per cent of the historical maximum. This definition thus assumed that values above 90 per cent of the historical maximum represent a high ecological status/reference situation. It was observed that, for the reference conditions, there is a reasonable compliance between the historically based and the modelled values, but the modelled values tended to be a bit lower than the data based on historical observations (EC-JRC 2009).

Intercalibrated eelgrass depth limit

In the Baltic Sea GIG, angiosperms were only intercalibrated between Denmark and Germany for their common IC type (BC 8) (See Section 3.8). A comparison of the German definition of reference conditions of the eelgrass depth limit with an application of the Danish 90-per-cent rule to historical data showed a good fit with the Danish values. Angiosperms are not intercalibrated in the other common IC types that Denmark shares in the Baltic GIG, partly because the vegetation is scarce, and the eelgrass distribution is scattered in other Member States coastal waters. The reference values for BC 8 were included in the 1st

Commission Decision on intercalibration results and as no further intercalibration has taken place, they are now included in the latest Commission Decision in force (EC CD 2018 /229/EU).

RBMP1 and RBMP2 reference condition

In RBMP1, the different levels of eelgrass depth limit reference condition values were in general set for the different coastal water types based on a statistical and scientific analysis of the historical data. Two different hierarchical models using typological characteristics were used (Carstensen & Krause-Jensen 2009). For coastal water bodies where high-quality historical data existed, reference condition values were set based on the historical data, and for coastal waters where no data or insufficient data was available, type-specific reference conditions were applied according to a ministerial guideline (MOE-NST 2012), and for the RMBP2, the values were included in a statutory order (Naturstyrelsen 2014, BEK nr. 1399 historical).

RBMP3 reference condition

As a part of the project on the RBMP3 revision of the typology for the Danish coastal waters (See section above on typology), the existing reference condition values for 'eelgrass depth limit' were revisited. First of all, with the purpose of establishing more differentiated reference values for coastal water bodies where no sufficient historical data exists, for which reason they were associated with common type-specific reference values in previous RBMPs. Furthermore, the revised typology also made changes to the delineation of coastal water bodies – separating some and merging others (Timmermann et al. 2020). For this purpose, the historical data set was used to construct a regression-based model, describing eelgrass depth distribution in individual water bodies as a function of three hydromorphological descriptors: average water depth, stratification and water exchange.

The result of the regression showed that it was feasible to use the model for estimation of a 'virtual' reference value for water bodies where values for the physical descriptors are known (Fig 2.2 from Timmermann et al. 2020). For 48 out of 109 coastal water bodies, water body-specific reference values were established based on historical observations. For the remaining water bodies, the regression model forced with the hydromorphological characteristics for each water body was used to estimate water body-specific reference conditions for eelgrass depth limit. For water bodies where either historical data or necessary information on the hydromorphological values was insufficient as input to the regression model, type-specific reference condition values were used.

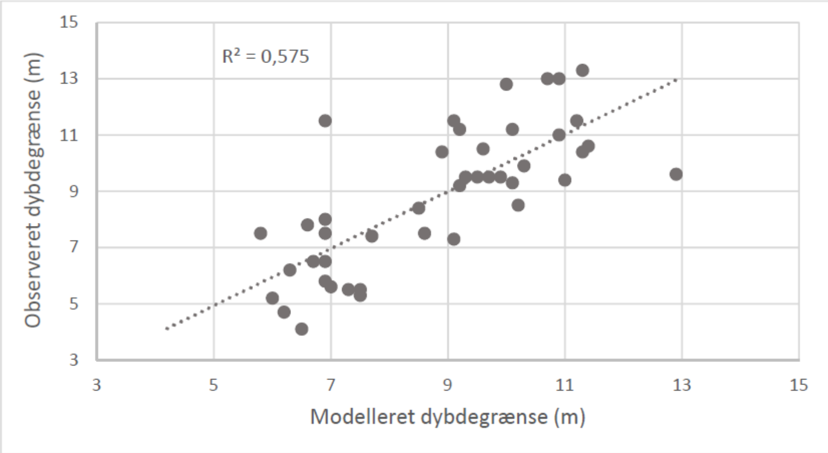

Figure 3-10: *Scatterplot af observed of modelled historical depth limits for eelgrass' main distribution in 44 water bodies with at least one historical eelgrass observation, (Erichsen et al. 2019),*

Assessment and discussion

In general, the same principles for setting values for reference conditions for 'eelgrass depth limit' are used in the preparation of RBMP2 and RMBP3. In both cases, the methods used for establishing reference conditions for the indicator 'eelgrass depth limit' not only provide means for establishing reference values for common IC types to be used for intercalibration: They also establish a method for translation of reference conditions into national types and water bodies. The added value of the regression method used for the RMBP3 is the possibility to differentiate for several more water bodies that were previously associated with type-specific values.

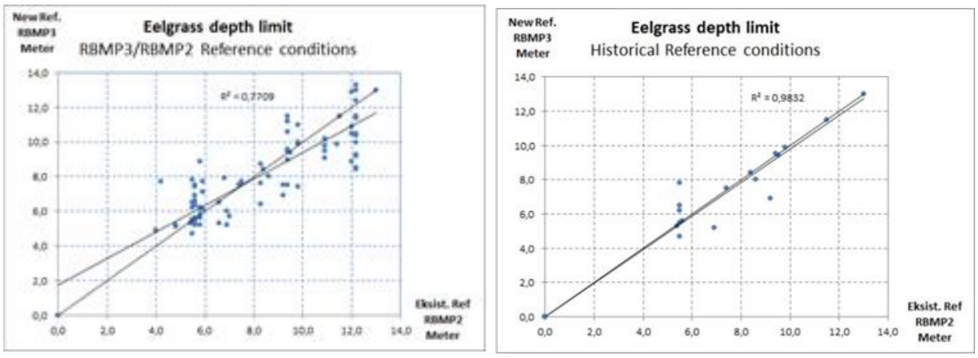

Figure 3-11 *Comparison of 'Eelgrass depth limit' reference conditions between RBMP2 and RBMP3, (Naturstyrelsen 2014, Naturstyrelsen 2021)Left: All water bodies. Right: Water bodies with historical observations*

A comparison between the RBMP2 reference condition values and the revised values used in preparation of the proposal for the RMBP3 the reference conditions based on historical data shows a good agreement between the two sets of values, with a nearly equal deviation on both sides of the 1:1 line. A general differentiation of type-specific reference condition values is obtained (spreading on the RBMP3 axis) although, the RBMP3 high end eelgrass depth limits values tend to be lower than the RBMP2 values and the low-end values of

RBMP3 tend to be higher than the RBMP2 values (Figure 3-11– left). A more detailed assessment follows below.

Revisiting historical observation and revised typology

For water bodies where historical data is used in both RMBP2 and the RMBP3, there is a nearly 1:1 agreement in most cases (Figure 3-11, right). The outliers (all with 5.5-meter RBMP2 axis value) represent mostly water bodies in Limfjorden that, in the new typology, have been separated and subdivided from a single water body that previously had a common reference value. The historical data comprises enough observations for that area, and they have a sufficient level of confidence that, together with the revised typology, warrants and enables the setting of individual water body specific reference values for the subdivided water bodies. For the two other 'outliers' (Smålandsfarvandet and Indre Isefjord), the RBMP3 values are a result of revisiting the data material. For Smålandsfarvandet, the authors give a qualified explanatory note. For Isefjord, the revised value has exactly the same value that was included in the original documentation on historical distribution of eelgrass in Danish coastal waters (Krause-Jensen & Rasmussen 2009) different from the value in RBMP2. As such this revised value can be considered a correction. In conclusion, and except for the two cases explained above, there is no difference between the revised and the original assessment of the historical data set.

For water bodies where reference condition values were set as type-specific values in the RBMP2, revisiting the historical data set has enabled setting water body-specific reference values. A comparison between the type-specific values of the RBMP2 with the RBMP3 values shows that using of this historical data enables establishing reference values for more individual waterbodies (Figure 3-12 left). For the remaining water bodies, the RBMP3 type-specific reference conditions also show significant correlation with the RBMP2 type-specific reference condition values, however, with tendency of higher values for water bodies with the lowest values in the RBMP2.

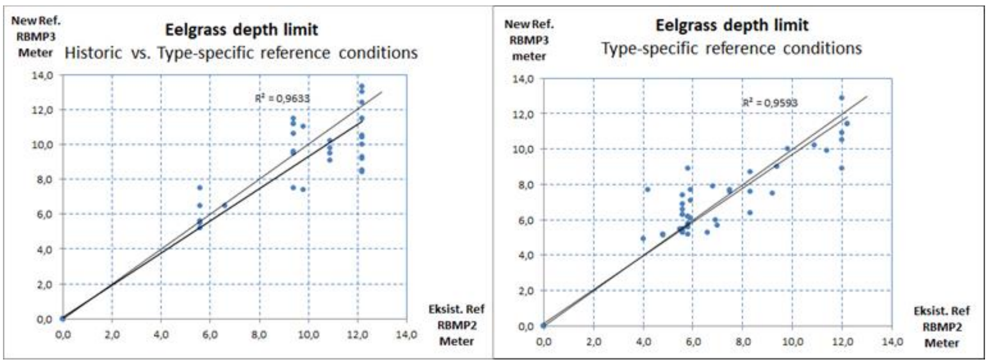

Figure 3-12 Comparison of 'Eelgrass depth limit' reference conditions between 2nd and 3rd RBMPs. Left: RBMP2 type-specific values replaced by historical observations in RBMP3, Right: RBMP2 type-specific values vs, RBMP3 type-specific values. (Naturstyrelsen 2014, Miljøstyrelsen 2021)

The regression model used for RMBP3 can only be used for establishing reference eelgrass depth limits in a historic regime where eutrophication and, in particular anthropogenic eutrophication-induced light limitation is not important to the eelgrass depth distribution, but where the eelgrass depth limits are primarily determined by the water bodies' hydromorphological characteristics. As such the eelgrass depth limit reference values represent a eutrophication level and nutrient load that existed in the time period 1880-1900. As no sufficient monitoring data on supporting quality elements (nitrogen concentrations) exist from that period, and because the number of the historical observations are limited the eelgrass depth limit reference condition values cannot be linked to a pressure-impact-gradient for that period. Neither is it demonstrated if the model is capable of reproducing a pressure-impact relationship covering the eutrophication pressure range including both reference conditions and elevated eutrophic status. Therefore, it is difficult to assess whether the eelgrass depth distribution can be considered stable or expose a development. This issue is discussed further in Section 3.2 and 4.4. Anyway, the establishment of the reference conditions for RMBP3 follows the same principles as for RMBP1, where a pressure-impact-gradient (TN-concentration/eelgrass depth limit) was established based on present time data and was associated with the reference condition values without considering if the development of the eelgrass depth distribution may have exposed a 'discontinuity' during the 1880-1900 period. (Carstensen & Krause-Jensen 2009), (MOF 2020).

Revised classification method for angiosperms

Denmark has submitted a report on a modified classification method on macroalgae and angiosperms into the CIS intercalibration process. The method for the angiosperm indicator implies the existing method on 'Depth distribution of eelgrass (*Zostera marina*)' is expanded in terms of number of species and total amount of data included but the class boundaries remains the same. The revision of the angiosperm indicator will therefore only lead to minor adjustments of environmental status assessments in Danish WFD water bodies. The revision is nevertheless relevant, as the inclusion of data for angiosperms other than *Z. marina* facilitates more robust environmental status assessments in several water bodies. The report states that the modified indicator does not imply adjustments of the reference conditions or class boundaries. After discussion with the ECOSTAT review panel the conclusion was to report the angiosperms separately and after preparation of the IC Protocol on the revised assessment method of angiosperm the revision was approved by ECOSTAT (ECOSTAT 2022). For further detail and finalising the modified angiosperm indicator see Section 3.2

Other biological indicators and assessment tools

Denmark has developed other indicators and assessment methods for phytoplankton, macroalgae and benthic fauna (Carstensen et al. 2014). Phytoplankton biomass and macroalgae indicators are directly associated with eutrophication pressure. As described in Section 3.2 assessment methods for other biological quality elements can be useful in the setting of class boundaries, thereby increasing the reliability of the boundaries.

Supporting quality elements

The WFD, Annex V's normative definitions establish a link between the status of the biological quality elements and the associated status of the supporting hydromorphological and physico-chemical quality elements. Achieving Good Ecological Status implies that various physico-chemical quality elements including transparency *"do not reach levels outside the range established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements"* and *"nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified for the biological quality elements"* (WFD Annex V, Section 1.2). Thereby, the WFD requires that values of the physico-chemical quality elements must be taken into account when assigning water bodies to the high and good ecological status classes (CIS-GD No. 13), implying that class boundary values for the relevant physico-chemical quality elements associated with biological quality elements must be established as a part of the setting of class boundaries for the biological quality elements.

The Commission notes in its assessment reports on the RBMP1 and RBMP2s (EC-SWD 2012. EC-SWD 2019) that classification systems and *"Type-specific reference conditions have not been established for physico-chemical quality elements or hydromorphological quality elements."* Neither does the Danish RBMP3 nor the proposals for the associated legislation include such reference conditions[97].

Hydromorphological quality element

For the hydromorphological quality elements, the revised typology has established parameter values associated with types and individual water bodies. These values can be considered reference condition values as well as supporting conditions throughout the whole classification range.

Physico-chemical quality element

For the physico-chemical quality elements, it is a common scientific understanding that nutrient enrichment of coastal waters enhances the growth of phytoplankton, which increases the light attenuation, thereby affecting the depth distribution of both macroalgae and angiosperms. Thus, there is a causal link between nutrient inputs, phytoplankton biomass and the depth distribution that makes both transparency (also expressed by light attenuation) and nutrient concentrations important supporting quality elements associated with eutrophication. Therefore, values for these elements must be associated with reference conditions and class boundaries for both Chl-a and eelgrass depth limit.

In some cases (e.g., oxygen conditions), there may be an indirect (and therefore weaker) relationship with the BQE, yet this indicates important secondary effects and may also increase in significance as global warming raises water temperatures. These and other supporting elements, such as transparency, may complement information on nutrients and thereby contribute to the decision-making process.

Nutrients

In the Danish contribution to the 1st Phase intercalibration, reference conditions and class boundaries for nitrogen concentrations were estimated related to both Chl-a and eelgrass depth limit. For the reference conditions, the nitrogen

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[97] A report including suggestions on chemical reference concentrations is in preparation (Timmermann – personal communication)

concentrations for the two biological quality sub-elements were at the same level, thereby contributing to the level of confidence of the methods used.

These background concentrations were not referred to in the 1st RBMP, and in the 2nd and RBMP3s, focus has not been on assessing and associating reference nutrient concentrations to the biological reference conditions, as required by the WDF procedure on the establishment of reference conditions and the normative definitions (WFD Annex II 1.3 (i) and Annex V 1.2.4) Se also section below on supporting quality elements under Concluding remarks.

Nitrogen concentration in reference condition

In the Danish contribution to the 1st Phase intercalibration reference conditions for the total nitrogen (TN) concentration associated with the Chl-a reference condition values were predicted from a developed regression model. Based on a reference 'year 1900' TN load, and using the a found reference condition concentration at 15,46 µmol l^{-1} (~220 µg/l) for open-water stations TN reference condition concentrations were predicted for 39 different water bodies ranging from a little above the found open water concentration for open coastal waters to twice as high for inner fjords and closed coastal waters. (Carstensen et al. 2008)

TN concentrations associated with eelgrass depth limit reference conditions for a number of Danish coastal waters were estimated based on an empirical relationship between eelgrass depth limit and TN concentrations (Nielsen et al. 2002). Reference condition TN concentration were found at 16.6 µmol/l (~230 µg/l) (Fakse & Hjelm Bay) and 14 µmol/l (~200 µg/l) (open Danish coasts), and corresponding eelgrass reference depth limit (m) modelled based on a TN concentration at 8.3 m (Fakse & Hjelm Bay) and 7.7 m (open Danish coasts) (EC-JRC 2009).

Phosphorus concentration in reference conditions

The 2nd opinion team is not aware of international studies regarding eutrophication of marine waters where phosphorus has had the same focus as nitrogen under reference conditions. However, in the light of more focus has been attached to seasonal variability of the nitrogen load and to the role of phosphorus in substituting some of the nitrogen load reduction needed to achieve the environmental objectives, and because of the model's complexity allows estimation of environmental interaction caused by both nitrogen and phosphorus more focus should be attached to establishing reference values for phosphorus.

No other supporting quality elements are linked to the biological quality elements in the 2nd and 3rd RBMP.

3.1.3 Concluding remarks

Based on the analysis and assessments of the RBMP3 methodologies for deriving reference conditions, the following can be concluded.

Typology

Establishing type-specific biological reference conditions is a WFD key issue and 'anchor' in the classification of water bodies' (here, coastal waters) ecological status. For this purpose, the typology involving characterisation of water bodies according to types is in itself simply a tool to assist the process of establishing type-specific reference conditions and setting of ecological status class boundaries by enabling comparing 'like with like'. The aim of the typology is to produce as simple a physical typology as possible that is both ecologically relevant and practical to implement. Development of a national typology into a more complex system is recognised under the provisions of the WFD. However, it should be kept in mind: *"The Directive only requires sub-divisions of surface water that are necessary for the clear, consistent and effective application of its objectives. Sub-divisions of coastal and transitional waters into smaller and smaller water bodies that do not support this purpose should be avoided".*

Conclusions on the typology

The revised Danish typology for the RBMP3 provides general improvement. The revised typology enables a differentiation of coastal water types that reflects the diversity of the Danish coastal waters better than the typology of the 1st and RBMP2s. However, it is more complex and consequently calls for transparent documentation of how the typology is going to be used for establishing reference conditions and translating ecological status class boundaries into national types.

Focusing on individual coastal waters with no clear link to the common IC types would not be in compliance with the WFD. As the proposal for the RBMP3 or its associated legislation does not include such links, and in order to keep the typology as a simple tool, there is a need to establish a clear overview, including grouping of types with a clear link or information on how they correspond to the EU common intercalibration types. This overview should include the typology descriptors and their values (intervals).

Furthermore, an analysis and demonstration of whether the new typology reflects different sensitivity with regard to eutrophication pressure (impact from nutrient input) could be a test of the typology's capability to group water bodies in this respect – in particular, for the fjords and closed water bodies.

Finally, the revised typology has been changed to such an extent that implies changes to both established reference conditions and ecological status class boundaries, calling for a presentation and discussion of the typology in the CIS ECOSTAT working group.

Nutrient load in reference conditions

The nutrient load in reference conditions in in RBMP3 is estimated based on measured concentrations of TN and TP in streams draining Danish catchment areas with low proportion of agricultural land-use and no or very few point sources from scattered households. The concept 'year 1900' reference load of the previous RBMPs has been replaced by a 'background' load because newer studies have shown that the load in 1900 must have been significantly increased compared to 'background' loads, which are considered to have been associated with the historical observations of eelgrass depth distribution in the last part 1800th century. For further discussion on this issue see Section 4.4.2.

Chl-a reference conditions

The developed mechanistic and statistical models (Danish Marine Model Complex), using descriptor values of the revised typology, and considering non-Danish transboundary nutrient input to Danish marine waters enable derivation of reference values for Chl-a in individual water bodies. The MECH model is applied with the same approach for all individual water bodies/coastal water types, thereby qualifying for consistent translation of intercalibrated ecological status class boundaries for common IC types into national types.

The developed statistical Bayesian model for the RBMP3 has resulted in statistical reference condition values for three times as many fjords and closed waters than the STAT models for the RBMP2. Whereas the RBMP2 reference conditions showed a fair correlation with reference conditions derived for the 1st Phase intercalibration, which were derived based on conceptual nitrogen/Chl-a concentration relationship, the RBMP3 reference condition values appear more scattered and spread out. Some of the differences can be explained by the focus that has been on deriving reference conditions for individual water bodies instead of type-specific reference condition values. However, considering the tendency of the STAT model to overestimate values at low Chl-a concentrations and putting aside the higher number of water bodies covered by the RBMP3 STAT model, it cannot be concluded that the application of this model has provided more certainty in the established RBMP3 reference condition values.

The RBMP3 Chl-a reference condition values for open waters are basically estimated by the MECH model and show different (lower) values than the RBMP2 reference conditions values. The main reason could be ascribed to a further development of the model and that a higher number of more local models is used and with the revised typology parameter values. Anyway, several of the RBMP3 values for Chl-a in common IC types are significantly lower than the values that formed the basis for the intercalibration of the G/M class boundaries. The difference could have implications for the intercalibrated G/M class boundaries – see section 3.2 and 4.5.

For fjords and closed coastal waters, the models are capable of differentiating reference conditions for individual water bodies where the reference conditions in the previous RBMP2 were established based on type-specific reference conditions. The variation goes both ways with a non-significant tendency of lower values for the RBMP3 and with the biggest differences found in the inner fjords and closed coastal waters.

In the lack of ‘true’ reference sites or historical observations, deriving reference conditions for Chl-a Member States must apply the approach of using existing monitoring data representing elevated nutrient concentration levels, which is in accordance with the provisions of the WFD and its guidance documents. For Chl-a the process of establishing reference conditions prescribes determination of an ‘alternative benchmark’ and a pressure-impact relationship (gradient) based on monitoring data including values for biological quality elements and the associated supporting quality elements (here nutrients concentrations). The data should include ecological quality status classifications across a pressure range that covers sites representing status close to reference conditions and sites representing elevated pressure conditions, and, for shared common IC types, data from relevant other Member States.

Both the RBMP2 and the RBMP3 STAT models/methods for Chl-a include nutrient input-pressure/Chl-a relationship, and the MECH models intrinsically use such conceptual relationships. Both model systems demonstrate relationships between nutrient input and Chl-a concentration. However, in their analysis, neither the RBMP2 nor the RBMP3 STAT models/methods for Chl-a include or test essential conceptual models on the relationship between nutrient (nitrogen) concentration (pressure) and Chl-a concentration (impact) [98]. Neither do they establish 'alternative benchmarks' in derivation of reference conditions. Furthermore, both the mechanistic and the STAT model are used outside their calibration area and reproduction of full range pressure-impact-gradients is not demonstrated.

The documentation on establishment of reference conditions for neither the RBMP2 nor the RBMP3 includes references to CIS-GD No. 14 (2008-2011 version), which includes specific guidelines for deriving reference conditions, nor does the documentation reflect use of these guidelines.

Whereas the models focus on direct coupling between the pressure (nutrient load) and the status of the biological elements (Chl-a concentration and 'K^d proxy' is valid and preferable for calculations of MAIs, thereby keeping uncertainty low by not introducing too many steps in the calculations, it misses essential elements regarding the establishment of reference conditions and the option of checking the models against generic conceptual relationships by not considering the intermediate generic relationship between the nutrient concentration and the Chl-a concentration. Furthermore, the option of determining values for the supporting quality elements (here nutrient concentrations), including determination of status class boundary associated values, is missed.

The results of STAT models (both the 2nd and the RBMP3) could be improved by distinguishing between nutrient-load/nutrient-concentration and nutrient/Chl-a concentrations and by forcing the STAT model by the conceptual relationship and using it to generate generic relationships. Output from the MECH model should be capable of demonstrating the same relationships that could be tested against the generic relationship generated by the STAT model. Testing and demonstrating scientific conceptual (empirical) models for both the mechanistic and the statistic models could provide a basis for establishing compliance with the CIS guidelines and procedures for deriving reference conditions and it could contribute to the level of confidence in the derived reference conditions. It is the 2nd opinion team's assessment that applying this approach would not imply significant changes in the estimated MAIs.

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[98] "The main purpose of the regression models is not to test the hypothesis that for instance chlorophyll-a concentration is dependent on the nutrient loadings but to quantify the relationship between the responding variable and the predictor variables especially the nutrient loading which can be managed" (Erichsen & Timmermann 2017, p. 29).

Eelgrass depth limit

Reference conditions for eelgrass depth limit were established in the 1st Phase intercalibration process, based on historical observations in accordance with the provisions of the WFD and its guidelines. For the RBMP3, revisiting and re-assessing the historical data set, taking into account the revised typology, have enabled a better differentiation in the setting of reference values for individual water bodies. For water bodies with no historical observations and data, a statistical regression model based on the descriptors 'average depth', 'stratification frequency' and 'water exchange' is developed for setting reference condition values, and the descriptor parameter values of the revised typology were used for deriving reference values for water bodies with no historical data.

The revised reference conditions generally show a good agreement between the 2nd (1st) RBMP and the RBMP3 sets of reference condition values, and reference conditions are established for individual water bodies where only type-specific reference values were established in the RBMP2. A comparison indicates a decrease in depth limit for type-specific reference condition values for open coastal waters, and an increase in depth limit for type-specific reference values for water bodies with natural lower depth distribution (e.g., closed fjords). However, a simple check of consistency between reference conditions for Chl-a and eelgrass depth limit based on historical observations shows a general good correlation - see Section 4.4.2.

The model for deriving 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. As such the reference conditions are not linked to (nutrient) pressure-impact relationship(s). Establishing such pressure-impact-gradient could provide a basis for compliance with the CIS guidelines and procedures for deriving reference conditions, in particular, regarding assessment of development of eelgrass depth distribution under 'high' status class conditions and its linkage to more impacted conditions as discussed in Section 4.4.2.

Supporting quality elements

The WFD normative definitions couples the status of the biological quality elements with the status of the hydromorphological and physico-chemical supporting quality elements. The normative definitions (WFD, Annex V, 1.2) set up this linkage by defining general reference conditions for the physico-chemical element as *"elements correspond totally or near totally to undisturbed conditions"* and in the section on establishment of type-specific reference conditions it is required that *"physico-chemical conditions shall be established"* for water body types at high ecological status (WFD, Annex II, 1.3(i)). Therefore, reference condition values must be established for both type-specific and local reference conditions of water bodies.

The European Commission notes in its assessment reports on RBMP1 and RBMP2 that the Danish classification systems and type-specific reference conditions have not been established for physico-chemical quality elements or hydromorphological quality elements (EC SWD 2012 & EC SWD 2019).

For hydromorphological quality elements the type-specific parameter values/intervals, which are established by the revised typology in the RBMP3, should be sufficient as values for the hydromorphological quality element in reference conditions. Type-specific reference condition values for the physico-chemical quality elements were estimated for nitrogen concentration related to both Chl-a and eelgrass depth limit in the 1st Phase intercalibration. Compared with each other they were assessed to be at the same concentration level (200 – 230 µg TN/l), thereby indicating consistency between the values established for the two biological quality elements. These concentration values must be considered representing impacted (increased) background concentrations because they are predicted by regression models based on present time monitoring data representing elevated eutrophic states the marine open waters and because the transboundary influence on the open water eutrophication cannot be accounted for. Therefore, nitrogen concentrations reference conditions for the open waters should be considered being at lower level.

Anyway, the predicted reference conditions were not reported in the RBMP1, and the focus in RBMP2 and RBMP3s has been on the nutrient input relation directly to eutrophication factors (Chl-a concentration and transparency). Consequently, reference condition concentrations for the nutrient supporting quality element are not derived.

The Commissions 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' (e.g., K_d or SD). Furthermore, the 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. The Commission – Joint Research Center further brings into attention for nutrients, it is important to bring the attention to the fact that standards currently in force around Europe are not tailored to the needs of the WFD, but are rather historic standards set to fulfil requirements of earlier directives. For example, the standards for nitrates in freshwaters, where one could be tempted to use values derived from the Nitrates Directive (91/676/EEC) as a standard associated with the G/M boundary. In that case, there is a need to revisit these standards with the particular requirements of the WFD in mind, to ensure that they are also compatible with good ecological status (EC-JRC 2022).

Supporting the work on establishing nutrient supporting element reference conditions and boundary values could, among others, be the following documents: The JRC Technical Reports: "The use of pressure-response relationships between nutrients and biological quality elements: A method for establishing nutrient supporting element boundary values for the Water Framework Directive" (JRC 2018a); and "Physico-chemical supporting elements in coastal waters" (Herrero 2022); and the CIS document: "Best practice for establishing nutrient concentrations to support good ecological status" referring to the JRC Science for Policy Report with the same title (EC-JRC 2018) The CIS document include annexes on 'Statistical tool kit to assist with the development of nutrient concentrations".

Transparency

Water transparency is a supporting quality element, which can be expressed in several ways (e.g., 'light attenuation', Secchi depth, 'light penetration depth' or

K_d). Light is attenuated down through the water column by various substances. Particulate organic matter, mostly phytoplankton, absorb and scatter light, whereas dissolved organic matter absorbs light, particulate matter scatter light, and water absorb light, K_d is a measure of attenuation, hence an indirect measure of growth conditions for benthic plants and algae. Thus, not to be confused with the K_d proxy (indicator) for eelgrass depth limit, K_d is here a factor describing the light conditions for the depth distribution of eelgrass.

A supporting quality element for light conditions is included in the Danish classification system defined as a light requirement for the growth of angiosperms (rooted plants), corresponding to at least 16% light at the seabed (expressed as a mean for the period March – October). This requirement must be met at the water depth to which angiosperms must be able to grow for a good environmental status can be achieved (G/M boundary) (Miljøministeriet 2021d).

3.2 Task 2: Environmental objective

3.2.1 Objective and approach

Review of environmental objectives for coastal waters. Basis for determination of environmental target (EU's EQR)

Sub tasks:

- Review of the scientific basis for methodological improvements introduced in RBMP3 to determine the environmental objectives (good ecological status). Could Denmark have reported other data for intercalibration, and would it give other objectives?
- The review shall include a description of basis used for establishing the environmental target, i.e. the basis used for establishing the EU inter-calibrated EQR (i.e. the factor used for defining the difference between 'good condition' and the reference value).
- The review shall include an overall assessment of the applicability of the analyses for determining the ecological objective as well of its limitations.

The European Water Framework Directive (WFD) requires national WFD assessment methods for classifications of good ecological status to be harmonised through an intercalibration exercise[99]. As this task asks for a review of the Danish classification methods and their intercalibration, it is important to have in mind the EU WFD common understanding of how class boundaries should be set and what an intercalibration exercise comprises. This WFD common understanding is expressed in various guidance documents. For the purpose of this review, this section highlights a few key principles and a brief overview of the principles and steps of setting ecological class boundaries; of the intercalibration process; of how the scientific background available for the process play a role, and how the scientific exercise should be carried out see Appendix F. Focus of the section is on the practical and scientific parts that are relevant for this review regarding the quality elements *phytoplankton* (here, Chl-a) and *angiosperms* (here, eelgrass). Specific references to the WFD associated with these parts can be found in the guidance documents and are thus not repeated here.

This review takes its point of departure in the fact that Chl-a is a generally accepted and intercalibrated indicator of phytoplankton, which also was a

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[99] The WFD describes intercalibration in Annex V, 1,4,1, using the term 'to ensure the comparability of monitoring system' – where 'monitoring system' in WFD Annex V, 1,4,1, should be interpreted to mean only biological assessment, applied as a classification tool, the results of which can be expressed as EQR (ecological quality ratio), In this review as in the CIC-GD No, 14, the term 'WFD assessment method' is used instead of 'monitoring system',

conclusion of the "International evaluation of the Danish marine models" (Herman et al. 2017).

3.2.2 Analysis and assessment

Determination of class boundaries

Member States must establish assessment methods for the purpose of estimating the values of the biological quality elements. For the purpose of assessing the status of coastal waters, the WFD, Annex V, 1.2, sets up a classification system where the environmental objective of good ecological status is generally defined by the normative definitions: *"The values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions"*. How the term *slightly* should be understood is not defined; however, it should be understood together with the definition of the moderate ecological status where *moderate* signs of disturbance from human activities are accepted with *"significant more disturbance than under conditions of good status".*

Determination of high/good (H/G) and good/moderate (G/M) class boundaries is part of the intercalibration process, and guidelines prescribing procedures and requirements for the scientific process are specified in CIS-GD No. 14.

A key step in the intercalibration exercise is description of how the biological quality element is expected to change as the impact of pressure or pressures on supporting elements increase and relate to the WFD normative definitions, to identify any discontinuity in the relationship between the parameter used for the biological quality element and the pressure-impact-gradient represented by the data set and, if so, if the discontinuity relates to a class boundary or class center. Another step is to assess whether class centres or class boundaries can be located using paired parameters related to the same pressure.

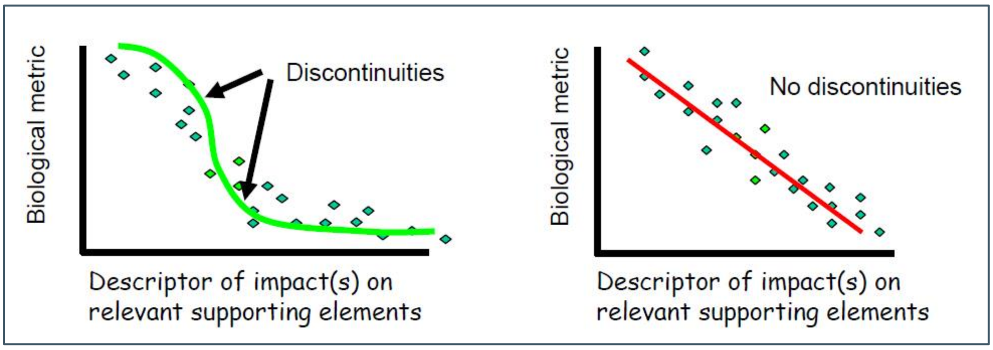

Figure 3-13: Determination of pressure-impact-gradient (CIS-GD No. 14)

Whereas the pressure (N-concentration)-impact-gradient Chl-a in general has been documented to be continuous, discontinuity could be expected to have been the case for the eelgrass distribution in the last part of the 1800, even if the nutrient load increased during that period. From a general understanding of ecosystems some biological elements expose resilience against changes in the ecological status, when put on pressure in an undisturbed (steady state) condition. This could be the case for eelgrass' reaction to an increase in the nutrient load late part of 1800 as described by Timmermann (2020) and in Aarhus University's note annexed to the answer to the Parliament Committee on Environment and Food[100]. The relevance of this phenomenon to determination of a reference nutrient load is addressed in Section 4.4 in more detail. However, even if the lack of historical data on the pressure descriptor makes it difficult to establish the gradient covering reference conditions, the use of defining alternative benchmarks for both Chl-a and 'eelgrass depth limit' as described in Section 3.1 has proven possible. In cases where two or more biological elements responds to the same pressure it is recommended to pair their pressure-impact gradients in order to determine whether their class centres or class boundaries corresponds.

Ecological quality ratio (EQR)

In order to ensure comparability between Member States, the results of their national assessment methods must be expressed as ecological quality ratios (EQR), and for the purposes of classification of ecological status, the EQR must be expressed as a numerical value between zero and one, with high ecological status represented by values close to one and bad ecological status by values close to zero (WFD, Annex V, 1.4).

Here, it is important to understand that an EQR is **not** an expression of the deviation from reference conditions expressed in the definition of ecological status classes. Hence, an EQR for the class boundary between good and moderate status **cannot**, at face value, be understood as a factor defining the difference between good ecological status and reference conditions. The EQR is included in the WFD for comparability reasons only. Instead, the nominal value for the status of a biological quality element at the good/moderate (G/M) class boundary compared with the reference conditions values is, together with the approach of the specific assessment method that must be used for the assessment of whether a value for the (G/M), an expression of a slight deviation from reference conditions.

EU intercalibration process

The European Commission has facilitated three phases of the intercalibration (IC) through the Joint Research Center (JRC), and for many biological quality elements (BQE), this intercalibration exercise has been completed. The results of the exercises are laid down in a Commission Decision (Commission Decision (EU), 2018-229)[101] and the scientific background for the results is documented in technical reports from the EC-JRC. Since the results included in the Commission Decision are consistent with the normative definitions set out in the WFD, Annex V, 1.2, the respective boundary values should be used in the Member States' monitoring systems classifications. Consequently, the same values should be used in calculations that form a basis for adoption of measures required in order to achieve the environmental objectives. A summary of the

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[100] Note included in the Danish Ministry of Environment and Food's answer to the question MOF alm. del 681 of 24. March 2020.

[101] 2018/229/EC - the latest of three decisions – the first (2008/915/EC) and the second (2013/480/EC) are repealed

intercalibration process and the scientific exercise can be found in Appendix F. See also Section 4.4 and 4.5.

Danish participation in intercalibration process

For the intercalibration of ecological status boundaries for coastal waters, Denmark belongs to two intercalibration groups. One for the Baltic Sea (Baltic GIG) and another for the North East Atlantic (NEA GIG). Within these intercalibration groups, Denmark shares common intercalibration types with Sweden (BC6 and NEA 8b) and with Germany (BC8 and NEA 26c). One intercalibration type (NEA 26d) is not shared with other countries (see Section 3.1).

The first intercalibration phase took place from 2004 to 2007, the second intercalibration phase from 2008 to 2012, and the third intercalibration phase started in 2013 and was planned to continue until 2016. The aim of the 3rd Phase intercalibration phase was to intercalibrate BQEs that were not covered in phases 1 and 2.

For the biological elements *phytoplankton* and *macroalgae and angiosperms,* Denmark participated in the intercalibration 1st Phase with the descriptors Chl-a and the depth limit of eelgrass (*Zostera marina*). The results of the 1st Phase intercalibration were considered provisional for Chl-a.

Chl-a class boundaries

Class boundaries for Chl-a are in both the RBMP2 and the RBMP3 set for individual coastal water bodies/types, based on the established reference conditions and simply applying the intercalibrated EQR values. For the 2nd only, one EQR value for the inner Danish coastal waters was applied, and for the RBMP3, specific EQR values for the three relevant common IC types were applied.

Denmark participated in the 1st Phase (2003-2008) WFD CIS intercalibration of the phytoplankton quality element. The NEA and Baltic GIGs intercalibrated single metrics based on Chl-a concentration. For Baltic IC types, average summer (May/June-September) Chl-a concentration was chosen. For the North East Atlantic IC types, the 90 percentile of spring-summer (March-September) Chl-a concentration was chosen. In the following, only ecological quality status class boundaries and EQR based the average summer Chl-a concentrations will be discussed as that is the metric that is used in the models for calculation of MAI to the inner Danish coastal waters.

RBMP1 1st Phase intercalibration

The 1st intercalibration resulted in intercalibrated reference values and values for the H/G and the G/M class boundaries and the associated EQRs for the Danish open water types. However, the results of the 1st intercalibration exercise were incomplete – for all countries – and were included in the IC decision on a provisional basis, with the understanding that further results would be included when the relevant information would have been provided by the Member States. For Denmark, the 2nd IC decision, which formed the basis for the RBMP2, included only the BC 8 type with revised H/G and G/M EQRs and the NEA1/26c type with the same H/G and G/M values and EQRs as in the 1st IC decision.

Scientific background

The Danish scientific basis for establishing reference conditions and setting class boundaries for the phytoplankton BQE was initiated during the first years of the WFD implementation. As described in Section 3.1, the sub-element Chl-a concentration was chosen by the Member States as a metric for the intercalibration of phytoplankton element.

Two different approaches were used to set the Chl-a boundaries between good and moderate ecological status for the selected Danish intercalibration sites (Carstensen et al. 2008):

1. Historical Secchi depth observations are compared to Chl-a Secchi depth relationships established from recent data (as described above). Boundaries between good and moderate status for Chl-a are then defined as reference conditions plus 50 per cent in accordance with the HELCOM Eutro approach.

2. Relationships between nitrogen loading and TN as well as between TN and Chl-a are established using recent monitoring data. Site-specific boundaries for TN and Chl-a were predicted from modelled time series of nutrient inputs to the Danish straits. The boundary values of nutrient inputs for different time periods were selected using expert judgement.

As described for the derivation of reference conditions, the latter approach was chosen and boundaries between ecological status classes were found from a generic relation between Chl-a and TN. Annual values of summer Chl-a (May-September) were related to winter TN (January-June) by means of the functional relationship (Figure 3-3). The appropriateness of the function was investigated and confirmed, and the TN concentration's representativeness for the bio-available nitrogen fraction was concluded by a proportional relationship in agreement with the conceptual theory. Site-specific factors for different coastal waters were estimated and the limitation of the models applicability was identified.

Boundaries between status classes for TN concentrations were calculated based on the established nitrogen input-TN-concentration relationship for estuarine and coastal waters (Figure 3-3– described in Section 3.1). Different ecological status classes were characterised by the nitrogen input of different periods in time since, what at that time was considered to be the reference situation (around 1900). For the inner Danish coastal waters, a basis for determination where the class boundaries should be set took a point of departure in the HELCOM Eutro recommending of 50 per cent deviation from the reference conditions. The H/G and the G/M class boundaries were suggested in combination with an assumption that the status in most open coastal waters in period up to 1950 was considered being at high ecological status, corresponding to a nitrogen input to the inner coastal waters of about 22 kton N year^{-1}, and that the ecological status in the 1950s and 1960s was considered to be good, corresponding to a nitrogen load of about 32 kton N year^{-1} (including 37% increased retention for both periods. Moderate/poor and poor/bad class boundaries were suggested based on the eutrophication status in the late 1960s and the 1970s, which with the high increase in nitrogen input, was considered to be moderate, corresponding an average nitrogen input of about 73 kton N year^{-}

[1]. In the 1980s, the conditions were considered really poor, with an average input of 91 kton N year^{-1}, and in certain years, the status may have been considered bad (an average of 110 kton N year^{-1} for the three worst years) (Carstensen et al. 2008). To these considerations it needs to be noted that later studies based on more data and information have established basis for correction of the nitrogen load associated with the time periods mentioned above.

RBMP1 - 1st Phase intercalibration result

For 39 different water bodies, class boundary values for TN concentrations were estimated and these values were used for estimation of class boundary values for Chl-a by the established functional relationship between TN concentration and the Chl-a concentration – see Section 3.1. Based on these results and taking the HELCOM Eutro 50 per cent approach into account, Chl-a boundaries shown in Table 3-2 were recommended for the Danish intercalibration sites in the Baltic Sea (EC-JRC 2009) and boundaries were included in the 1st Commission Decision (CD 2008/915/EC) on intercalibration results.

Table 3-2: Recommended and 1st Phase IC decided class boundaries and related EQRs for the IC type BC 8.
**: Reference value intrinsically determined by the nominal class boundaries and the respective EQRs*

Intercalibration sites	Reference conditions	High/good boundary		Good/moderate boundary	
		µg/l	EQR	µg/l	EQR (avg)
Bornholm west	1.2	1.3	0.92	1.5-1.9	0.71
IC BC 8 Bornholm west	(1.2)	1.3	0.92	1.9	0.63

As highlighted above, it is important to bear in mind that the EQR – in particular for Chl-a – in itself does not express a 'deviation' from reference conditions. As the range of values representing high status to bad status varies from low to high values, the EQR is calculated in inverse mode: the lowest value divided by the highest value. For example, the HELCOM Eutro approach on 50 per cent deviation from reference conditions equals an EQR value of 0.67. Consequently, an EQR value of 0.63 equals a deviation of 59 per cent from reference conditions.

At the time of the 1st Phase intercalibration, there was no sufficient data for an intercalibration of Chl-a for other IC types covering the inner Danish coastal waters. Furthermore, in the IC 1st phase, no common approach/benchmarking was applied among GIGs or Member States for how to fix reference conditions and no common database was built to verify and validate the high status, the H/G or the G/M boundary in relation to an abiotic characterisation at the scale of the common intercalibration type, which was a clear requirement of the updated IC guidance for the 2nd Phase intercalibration. Furthermore, it was concluded that the relationship between hind-casted estimates of nitrogen inputs (TN) and Chl-a should be a wider applied approach in the future, also trying to make the link to reference nutrient concentrations in rivers and the Marine Strategy Framework Directive (EC-JRC 2011).

Taking into account that the scientific basis for the 1st Phase intercalibration did not cover the full phytoplankton quality element and that differences in sampling and analytical methods between Member States did not allow for conducting full intercalibration, the results of the 1st Phase intercalibration were included in the first Commission Decision (CD 2008/915/EC) on the intercalibration results on a provisional basis. However, due to the availability of data and assessment methods, the values of, e.g., Chl-a were considered directly comparable across Member States, provided the differences in methods were taken into account. For these reasons, in addition to the EQRs, values for the H/G and the G/M boundary were included in the decision. Consequently, the results of the 1st Phase intercalibration were not applied in the RBMP1.

RBMP2 – 2nd Phase intercalibration

The results of 1st Phase intercalibration were considered provisional, leading to a 2nd Phase intercalibration between Denmark and Germany for the IC type BC 8. This intercalibration was carried out based on the information from the 1st Phase intercalibration, extended with further data sets from both countries, and following the CIS intercalibration protocol by addressing and comparing the pressure-impact relationship between nitrogen concentration and Chl-a concentration (see Section 3.8). The boundary values of the 1st Phase intercalibration (Table 3-2) entered the intercalibration exercise and were confirmed at the same nominal values. Only EQRs are included in the 2nd Phase Commission Decision (CD 2013/480/EU) on intercalibration results with the values 0.8 for the H/G class boundary and 0.6 for the G/M boundary to be applied for the Danish coastal phytoplankton method.

As described in Section 3.1, revised type-specific and site-specific reference values were estimated for several coastal waters. For the preparation of the RBMP2, type-specific and site-specific class boundaries between all ecological status classes were found for all Danish coastal waters based on these reference values and using the Commission Decision intercalibrated EQR H/G and G/M values for the BC 8 IC-type. An intercalibration with Sweden of these reference conditions took place in 2015, applying the nominal values of the H/G and G/M class boundaries and their EQRs for the shared common IC types BC 6 and NEA 8b, and resulted in only minor adjustments in both the values and the EQRs (see Sections 3.1 and 3.8). The result was included in the 3rd phase Commission Decision (CD 2018/229/EU) on intercalibration results and forms the basis for preparation of the RBMP3. For all the IC types – except for NEA 1/26d – all steps of the intercalibration process set out in the guidance documents have been fully completed for Chl-a. For NEA 1/26d, it has not been technically feasible to complete the comparability assessment because the type is not shared with other countries.

Assessment of the result of 2nd Phase BC 8 intercalibration

The result of 2nd Phase intercalibration (2009-2011) between Denmark and Germany for the common CI type BC 8 that was applied for preparation of the RBMP2 was included in the EC decision 2013/480/EC with the EQRs (0.8 and 0.6) to be applied with the Danish coastal phytoplankton method. The EQR value of 0.6 represents a deviation from reference conditions of 67 per cent – which differs from the 50 per cent deviation agreed by the Baltic Sea states in the HELCOM Eutro approach, which both Germany and initially Denmark follow in the G/M class boundary setting (corresponding to an EQR of 0.67). However, this difference can be explained by the fact that the intercalibration is according to the assessment method, which is a phytoplankton index in Germany, and not the chlorophyll-a parameter. The nominal values that entered the intercalibration for both countries are confirmed in the IC report for both Denmark and Germany. Using the two intercalibrated EQRs (0.8 and 0.6) with the Danish nominal values results in two different reference condition values ($1.04_{H/G}/1.14_{G/M}$ versus 1.2) that should not be the case and the result differs also from the reference value that entered the intercalibration (Table 3-3).

The intercalibration process – summarised in Section 3.8 – is carried out according to option 3b of the intercalibration protocol (CIS-GD No. 14, Annex V). That option uses a direct comparison; however, by a transformation of the national EQR into a common normalised scale (EQR-ICM) with all classes equal to 0.2 (H/G boundary corresponding to 0.8, G/M boundary to 0.6), thus defining different transformation formulae for each country. Adjustment of the national class boundaries – if necessary – to match these normalised EQR values was made by an iterative process. The German setting of G/M class boundaries is done that way by using an EQR value of 0.67 for Chla-a for all their coastal waters, but because the Germany classification method for coastal waters operates with a phytoplankton index the EQR for Chl-a is transformed to the normalised EQR scale where an EQR of 0.6 corresponds an EQR of 0.67 for Chl-a. . The resulting normalised EQR values (0,6 and 0,8) are included in the Commission Decision without back transformation but with the notion that they for Denmark are to be applied by "*Danish coastal phytoplankton method*". Thus, the intercalibrated EQR values of the Commission Decisions (both CD 2013/480/EU and CD 2018/229/EU) must be transformed back to the Danish EQR scale before being applied in setting G/M class boundaries for the Danish BC 8 coastal waters.

Table 3-3: Illustration of changes in reference conditions and H/G and G/M boundaries in the 2nd and RBMP3s compared with the intercalibrated values.
[1)] Reference values resulting from calculation using IC EQRs with the intercalibrated nominal class boundary values of the CD 2018/229/EU.
[2)] Resulting EQRs as they will be based on the revised reference values and respecting the intercalibrated nominal class boundaries values of the CD 2018/229/EU.

Intercalibration sites	Reference conditions	High/good boundary		Good/moderate boundary	
	µg/l	µg/l	EQR	µg/l	EQR (avg)
Baltic Sea	BC 8				
1st Phase IC	1.2	1.3	0.92	1.5 – 1.9	0.63
2nd Phase IC	(1.2)	1.3	0.92	1.9	0.63
2nd Phase IC EQR	$1.04_{H/G}^{1}/1.14_{G/M}^{1}$	1.3	0.8	1.9	0.6
RBMP2	1.0	1.3	0.8/0.77[2]	1.7/1.9[2]	0.6/0.52[2]
RBMP3	0.6	0.8/1.3	0.8/0.46[2]	1.3/1.9[2]	0.6/0.32[2]
Baltic Sea SW	BC 6				
RBMP2	1.0	1.3	0.8	1.7	0.6
3rd Phase IC	1.06	1.36	0.78	1.72	0.62
RBMP3	0.8	1.0/1.36	0.78/0.59[2]	1.3/1.72	0.62/0.47[2]
Øresund N,	NEA 8b				
RBMP2	1.0	1.3	0.8	1.7	0.6
3rd Phase IC	0.96	1.22	0.79	1.63	0.59
RBMP3	0.9	1.2/1.22	0.79/0.74[2]	1.5/1.63	0.59/0.55[2]

The implication of a lacking back-transformation of the EQRs of the Commission Decisions indicates that too lenient objectives for Chl-a have been applied to the Danish coastal waters. The BC 8 EQRs are used for setting class boundaries for BC 6 and NEA 8 as well, thereby introducing the same risk of setting incorrect boundary values for most Danish coastal waters. That could also have had an implication for the results of the intercalibration with Sweden for BC 6 and NEA 8 by an incorrect adjustment of the class boundaries in the process. It is difficult to assess the effect of a lacking back-transformation since precise technical information is not available about how the intercalibration with Germany for BC 8 was carried out technically. However, Sweden has not applied the results of the 3rd Phase intercalibration and the Commission Decision but uses the EQR values, which it entered into the intercalibration and which in most cases are more stringent. Based on the findings above and the experience from the various intercalibrations carried out, a correction of the Danish EQRs caused by the lack of back transformation would probably be that the Danish EQR values should be adjusted to more stringent values with the G/M boundary within the range of 0.63-0.67. For further details of the Danish-German and the Danish-Swedish intercalibration, see Section 3.8.

RBMP3 – 3rd Phase intercalibration 2015

In 2015, the established Chl-a reference condition values and class boundaries of the RBMP2 were taken through a more comprehensive intercalibration of Chl-a in coastal waters. It took place between Denmark, Norway and Sweden, addressing five different coastal types in the Baltic Sea (BC) GIG and the North East Atlantic (NEA) GIG (Carstensen 2016). The intercalibration was carried out strictly according to the CIS guidelines (CIS-GD No. 14). A large data set with monitoring data from all three countries was combined, and the three different national metrics were calculated for all water bodies and different assessment periods. There was a strong significant correlation between the national metrics, which allowed for translating reference values and class boundaries at the national scales to a common metric scale[102]. And it was agreed to use the Danish metric as the common metric, since it included a larger seasonal window than the Swedish metric, and because it was considered more robust and precise than the Norwegian metric. For Denmark, the reference values and class boundaries derived for the RBMP2 were used.

The two common EU intercalibration water body types BC6 and NEA 8a, shared between Sweden and Denmark, were addressed. After comparing values for reference conditions and class boundaries for H/G and G/M ecological status on the common scale, intercalibrated values were decided (in most cases by averaging) and translated back to the national scales.

For Denmark, the (back) translated reference and class boundary values were indeed close to the initial values. Differences in the values between Denmark and Sweden were generally small, and the comparison resulted in only minor adjustments of values for reference condition, EQR and H/G and G/M boundaries. For Denmark, the intercalibrated values were slightly higher than the existing values (one to six per cent). These tendencies – slightly lowered values for Sweden and slightly higher values for Denmark – were also seen in the values for the national types not included directly in the intercalibration.

For national water body types not included in the intercalibration, reference conditions and class boundaries were suggested by scaling the intercalibration results for the specific type.

For the EU common IC sites, the adjusted values are included in the latest EC decision (EU) 2018/229/EU[103] on the values of the Member State monitoring system classifications as a result of the intercalibration exercise. However, apart from the Carstensen 2016 report to ECOSTAT on how the intercalibration

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[102] Denmark, Norway and Sweden use different metrics – calculation methods for classification of ecological status, Therefore, the countries' reference condition values and EQR class boundary values cannot be compared directly,

[103] An observation on the Commission Decision 2018/229/EU that needs to be addressed is that in the NEA section on Phytoplankton chlorophyll-a, the Danish EQRs and class boundaries for NEA 8b are included in a table that, according to the heading of the section, represents "Parameter values are expressed in µg/l as the 90 %ile value", Considering that the Danish values in fact represent average values and that the values have been used in that way in the preparation of the RBMP, the Decision's notion on the Danish values should be amended in order to avoid future misunderstanding,

procedure has been followed, a specific IC protocol of the CIS-GD No. 14 cannot be identified.

Only the EQRs and the nominal values for the class boundaries are included in the EC decision. However, the EQR values and nominal class boundaries together intrinsically define the intercalibrated value for reference conditions. Thereby, the Commission Decision upholds the directive's main principle of using that reference condition as 'anchor' for the classification.

Different class boundaries in RBMP2 and RBMP3

With the revision of the Chl-a reference condition for each of the consecutive RBMPs (see Section 3.1) and application of the approach of applying the intercalibrated EQR values in setting G/M boundary values for coastal water types and individual water bodies, the boundary values are changed from the RBMP2 to the RBMP3, regardless of the intercalibrated boundary values – illustrated in Table 3-3 – that are considered as fixed as the EQRs.

Such a change would be considered a revision of the classification system, which would require that it can be shown that the revised classification is compliant with the WFD normative definitions and that the class boundaries are in line with the results of an (earlier) completed intercalibration exercise. A 'revised national classification method' is a method that was already intercalibrated for a certain common intercalibration types, but has since been modified with regard to: data acquisition (e.g., sampling design, sample treatment); numerical evaluation (e.g., metric selection, indicator scores, combination rules); or classification (e.g., reference definition, boundary setting). Changes to any of these components may affect the comparability with the intercalibrated standard. And in particular: If the new boundaries are lower (i,e, more stringent) than the old boundaries, the comparability with the intercalibrated standard needs to be checked since the criteria for boundary bias might no longer be satisfied. In these cases, the procedure for fitting new classification methods must be followed (CIS-GD No. 30).

As the changes in reference conditions occur for water bodies in all of the common IC types BC 6, BC 8 and NEA 8, and because the new boundaries of the RBMP3 are lower than in the RBMP2, the changes would imply an obligation to follow the procedure for intercalibrating revised classification methods. A new intercalibration could at the same time eliminate the question raised on the lacking back-transformation of the intercalibration results for BC 8 described above.

A shortcoming of the intercalibration results, regardless of the lacking back-transformation, is that the data used for the intercalibration only represents (for all countries involved) ecological status from moderate to bad – there is not sufficient data covering the full range in nutrient load.

Translation of IC results to national coastal waters

The intercalibration results in the Commission Decision apply to all common IC types and should be applied to national types corresponding to the common IC types as well as to national types whose characteristics do not differ significantly from the characteristics of the common IC types. According to the provisions of the WFD and the guidelines, the intercalibration results must be translated to national types not covered by the intercalibration: *"For those surface water types that are not intercalibrated in the intercalibration exercise, the IC boundaries of high-good and good-moderate status classes need to be translated accordingly. If a significant number of national types do not match the common intercalibration types, then this has to be reported to WG ECOSTAT" (CIS-GD No. 14, para 11), Guidance on this translation is given in "Guidelines to translate the intercalibration results into the national classification systems and to derive reference conditions"* (EC 2008b), prepared by the Commission and referred to in the 1st IC decision. When setting boundaries for such national types whose characteristics differ significantly from the common IC types, Member States should:

(i) consider whether the differences in the characteristics of the water bodies concerned mean that the application of the boundary values specified in the Intercalibration Decision would be inconsistent with the relevant descriptions of the ecological status classifications set out in Annex V,

(ii) when establishing any boundary value which differs from those identified in the Intercalibration Decision, take steps to ensure that this value represents a level of anthropogenic disturbance that is comparable to that represented by the boundaries set for that quality element in the Intercalibration Decision.

In the preparation of the Danish RBMPs, class boundaries are translated into national types that have not been a part of the intercalibration process. For both Chl-a and 'eelgrass depth limit', this is basically made by translating/establishing reference conditions for national types and individual water bodies derived by the Danish Marine Model Complex[104] and statistical analysis as described in Section 3.1. In preparation of the RBMP1, Chl-a was only used in classification of some coastal water bodies, and not in calculation/estimation of nutrient (nitrogen) input targets (MAI). For the RBMP2, the Danish guidelines on preparation of the plans prescribed a translation using reference values for coastal water types or some individual water bodies and by a national-wide application of the intercalibrated EQR of the 2nd IC Decision for the BC 8 common IC type (Miljøministeriet & Naturstyrelsen 2014). The same approach is used in the preparation of the RBMP3; however, by applying intercalibrated EQRs for the BC 6 and NEA 8b.

The characteristics of several Danish coastal waters, in particular of fjords and closed coastal waters, differ significantly from the characteristics of the common IC types. The characteristics differ not only in terms of the hydromorphological parameters, but also the response to eutrophication (nutrient input) and – in particular for Chl-a – different site-specific factors/slopes for the relation between TN load/TN concentration and the Chl-a concentration, as was found by Carstensen et al, (2008) and Erichsen & Timmermann (2017), showing that fjords and closed waters are more sensitive to eutrophication than open waters. To some extent, this difference is addressed by the establishment of reference

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[104] The Danish Marine Model Complex is described in the section on Task 4 and the derivation of reference values is described in Section 3.1,

conditions for individual water bodies. However, just scaling the class boundaries by the EQRs set for the common IC types could have a drastically differently bearing, coming from the boundary values in open waters with low reference values compared to a closed water body with higher reference values. For example, where an EQR of 0.6 for Chl-a – that expresses a deviation of 67 per cent from the reference conditions – which for open waters with a reference value of 1.0 µg/l results in a G/M boundary of 1.5 µg/l with a change in nominal values of 0.5 µg/l, and for closed coastal waters with a reference value of 4.9 µg/l results in a G/M boundary of 8.1 µg/l with a change of 3.2 µg/l. Even considering that closed coastal waters would naturally be at another eutrophication level than open waters, the nominal difference between the reference condition and the G/M boundary in the closed coastal water is of a magnitude that could impair the conditions for other biological quality elements, implying a status not in compliance with the WFD normative definitions of good ecological status. Consequently, the provisions of the WFD would require an assessment of whether the normative definitions of the ecological status classification for all quality elements will be met.

Therefore, the translation of the intercalibration results into setting class boundaries for fjords and closed coastal water types/bodies cannot solely be based on applying an intercalibrated EQR for the common IC types. The provisions of the WFD would require an assessment of whether the nominal boundaries will be in compliance with normative definitions of the WFD, Annex V. For coastal water types whose characteristics differ significantly from the common IC types, developing a type-specific classification method may be needed. Determination of class boundaries could, as prescribed in the Guidance Document No. 14 guidelines, be performed by applying the scientific approach of dividing a type-specific pressure-impact-gradient into the five quality classes.

Such an assessment could include pairing pressure-impact-gradients of the two quality elements – Chl-a and eelgrass depth limit – against a common pressure (supporting QE) as they both respond to eutrophication pressure, and other relevant biological quality elements related to eutrophication pressure could be included.

Angiosperm class boundaries

As for Chl-a, G/M class boundaries for eelgrass depth limit are in both the RBMP2 and the RBMP3 set for individual coastal water bodies/types based on the established reference conditions and by simply applying the intercalibrated EQR values. Only one EQR value has been applied throughout all three RBMPs.

Boundaries for eelgrass depth limit

For the 1st RBMP setting, G/M boundaries were based on two relationships established between nitrogen input and nitrogen concentration (ref. Section 3.1) and a relationship between nitrogen concentration and the depth limit of eelgrass (main distribution) (Carstensen & Krause-Jensen 2009). Several models on the latter were tested, e.g., by taking water body-specific characteristics into account. The assumption of a universal relationship between the main distribution of eelgrass and TN was challenged, as there will often be water body-specific differences in both physical exposure and the composition of TN, which will affect the attenuation of light in the water column.

For the 1st Phase intercalibration, the good-moderate boundary for eelgrass depth limits in Danish coastal waters was calculated in three scenarios representing a 15 per cent, a 20 per cent and a 25 per cent deviation from reference levels (Dahl 2005). To underpin which of the three scenarios describing the G/M boundary was most appropriate, a comparison with a model scenario was carried out. The model scenario entered the total nitrogen concentration, believed to represent the boundary between good and moderate, into the empirical relationship between nutrient concentration and eelgrass depth limit (Nielsen et al, 2002).

In the WFD technical report on intercalibration for coastal waters the Joint Research Centre wrote "Based on expert judgment, the 15 per cent and the 20 per cent deviations were suggested to be the best scenarios to comply with the normative definition of good ecological state (Dahl 2005). This suggestion was supported by observations of populations of eelgrass growing at depths of 4.4-4.0 m in Limfjorden and a population of eelgrass in Kattegat growing at depths of 8.1-7.6 m, and by the fact that these observations were examples of good growing conditions. Accordingly, it was concluded that 25 per cent deviation from the reference condition is not congruent with the definition of "slight changes of disturbance" (EC-JRC 2009)[105].

However, since 1983 until the adoption of the 1st RBMP, the Danish aquatic environment was managed in a regional planning system almost similar to that of the Water Framework Directive, including quality objectives applied for individual water bodies. For coastal waters, the core of the quality objectives was a 'general objective' presupposing, among other things, an "*unaffected or only slightly affected plant and animal life compared with the natural conditions of the individual water body*". Normative definitions provided more details for specific parameters, thus bottom vegetation in soft bottoms should consist of dense populations of eelgrass with good depth range.

The regional planning laid out a major part of coastal waters with 'general objectives', and in this process, some regional authorities set up specific depth limits of eelgrass to be observed in order to achieve the objective. The eelgrass depth limits were set as absolute values based on a technical, scientific and political process in each region. The boundaries set by the regional authorities were analysed and compared with information on historical observations of the depth distribution of eelgrass in Danish marine waters, and the analysis showed that the regional boundaries deviated from the reference conditions in a range from seven to 60 per cent, with an average and a median of 24 per cent.

In lack of specific scientific arguments supporting the expert judgement that a 15 per cent or a 20 per cent deviation from the reference conditions is the best scenario for the good/moderate boundary, an interval of a 25-30 per cent

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[105] The reference, from which JRC has taken the information on the figures mentioned is not available.

deviation from reference conditions was proposed into the intercalibration process, resulting in the value of 26 per cent, equalling an EQR of 0.74. This deviation is also in good agreement with the adopted HELCOM ecological objective: Depth distributions of bladderwrack and eelgrass close to those of undisturbed conditions (maximum – 25 per cent deviation from reference conditions) (referenced in CIS-GD No. 23).

Intercalibration of eelgrass depth limit

The metric 'depth limit of eelgrass' was only intercalibrated between Denmark and Germany in one type BC 8 (see Section 3.8) and the result was included in the 1st Commission Decision (Table 3-4). The metric is not relevant for other countries in the Baltic Sea GIG (see Section 3.8). In the latest, the 3rd, Commission Decision on intercalibration, only the EQRs are included; however, covering all relevant Danish IC types (BC6, BC8 and NEA8).

Table 3-4: Intercalibration result of the 1st Phase intercalibration for the metric 'depth limit of eelgrass'

Intercalibration sites	High/good boundary		Good/moderate boundary	
	metre	EQR	metre	EQR
Western Baltic, Denmark and Germany Open coast	8.5 (8.0-9.0)	0.90	7 (6.6-7.1)	0.74

No further intercalibration has taken place since the 1st Phase intercalibration, and as Germany has developed its assessment method and is not using eelgrass depth limit individually, whereas Denmark only operates with this metric. Therefore, the intercalibration result is included in a Part 2 of the latest Commission Decision (EC 2018 (CD 2018/229/EU)) where the Danish classification method is considered partially intercalibrated so far that it is consistent with the normative definitions set out in WFD, but that it has not been technically feasible to complete the comparability assessment due to different assessment concepts between Denmark and Germany/Sweden. The decision states that the respective boundary values must be used in Member States' monitoring systems classifications.

Danish angiosperm indicator

Recently, a revised classification method on Danish angiosperms has been developed for all Danish coastal waters, with references and class boundaries specified for individual water bodies. The method expands the 'eelgrass depth limit' classification method by addressing 'depth distribution of angiosperms' (angiosperm species in Danish coastal waters mainly belong to the genera *Zostera*, *Ruppia*, *Zannichellia* and *Potamogeton*) but it is based on the same principles as the existing metric 'eelgrass depth limit'. The indicator is related to eutrophication pressure, basically through relationships with the light climate (Secchi depth) and the nitrogen concentrations as is the case for the 'eelgrass depth limit' indicator. The existing method (*Zostera marina* depth limit) has been compared statistically with the revised method (angiosperm depth limit) and showed a nearly 1:1 correlation (R^2= 0.98-0.99) with no further need for translation or fitting of class boundaries. Therefore, the class boundaries remains the same as for the 'eelgrass depth limit' method and the revised angiosperm indicator will only lead to minor adjustments of the environmental status assessments for Danish water bodies. The revision is nevertheless relevant, as the inclusion of data for angiosperms other than *Z. marina* facilitates more robust environmental status assessments in several water bodies.

The revised assessment method has been submitted to the CIS ECOSTAT working group and after discussion with the ECOSTAT review panel an IC Protocol was prepared and scientifically approved by ECOSTAT (ECOSTAT 2022). The further process for finalising and adoption of the modified classification method by the European Commission will be as described in Section 4.5. However, the angiosperm indicator has been included in the Danish classification system to be applied for heavily modified coastal waters with the same EQR values as for the 'eelgrass depth limit' (Miljøministeriet 2021).

3.2.3 Concluding remarks

Based on the analysis and assessments of the RBMP3's application of environmental objectives and how the ecological status class boundaries were determined, the following can be concluded.

Chl-a class boundaries

Class boundaries for Chl-a for individual and coastal water types are in both the RBMP2 and the RBMP3 set for individual coastal water bodies/types, based on the established reference conditions and by simply applying the intercalibrated EQR values. For RBMP2 only one EQR value for the inner Danish coastal waters was applied, and for the RBMP3, specific EQR values for the three relevant common IC types were applied. For both the 2nd and the RBMP3s, Denmark has chosen to use the intercalibrated EQRs together with the derived RC values in setting G/M class boundaries for individual coastal waters.

The model complex translates intercalibrated G/M boundary values into national coastal water types/bodies solely by using the intercalibrated EQR values on the derived reference conditions for Chl-a. However, as several fjords and closed coastal waters have different characteristics and respond differently to eutrophication pressure than the open common IC types, solely applying intercalibrated EQRs may not ensure compliance with the WFD normative definitions. In such cases, the CIS guidelines stipulate an assessment of compliance with the WFD normative definitions and that the results be reported to ECOSTAT WG.

Determination of ecological status class boundaries for Chl-a for Danish coastal waters originate from the 1st Phase intercalibration process. The boundaries were determined by the approach that was later specified by the Commission in a guideline presented together with the adoption of the first Commission Decision on intercalibration. For intercalibration purposes these guidelines were later included in a Commission Guidance Document No. 14 but they are still existing applicable for national coastal waters not a part of the common IC types.

The RBMP2 nominal values and the EQR values for the high/good and the good/moderate ecological status class boundaries are intercalibrated with the countries (Germany 2013 and Sweden 2016) with which Denmark shares common IC types.

Risk of incorrect G/M class boundary values

The result of the intercalibration with Germany for BC 8 was based on the results of the 1st Phase intercalibration where reference condition, H/G and G/M class boundary values and EQRs were set based on relationship (pressure-impact-gradients) between nitrogen concentration and Chl-a concentration. The 2nd Phase intercalibration exercise included a transformation of national data and class boundary EQR values onto a common normalised scale with equidistant EQRs (0.2 – 0.4 – 0.6 – 0.8). Thus, the result of the intercalibration was expressed by these normalised values with $EQR_{H/G}$: 0.8; and $EQR_{G/M}$: 0.6 and included in the Commission Decision as such (CD 2013/480/EU). Therefore, before using the result, the intercalibrated EQR values must be transformed back to the national method. There is a strong evidence of lacking back transformation of intercalibrated EQR result for BC 8 ($EQR_{H/G}$: 0.8; and $EQR_{G/M}$: 0.6) to the Danish classification system, and therefore, as the $EQR_{G/M}$: 0.6 has been used in the RBMP2 for all coastal waters there is a risk that incorrect G/M class boundaries was set for all Danish coastal waters.

The intercalibrated $EQR_{G/M}$ value of 0.6 for BC 8 corresponds to a deviation of the Chl-a concentration of 67 per cent, surprisingly different from the 50 per cent deviation of the HELCOM Eutro approach, which all the Baltic Sea states initially stated as the objective, also for the WFD. Furthermore, Denmark and Germany entered the intercalibration nominal G/M class equal to EQRs between 0.63 and 0.67, and Germany applies an $EQR_{G/M}$ of 0.67 for its national coastal waters. A back-transformation of intercalibrated $EQR_{G/M}$: 0.6 would most likely result in a more stringent Danish EQR value than 0.6.

The intercalibrated $EQR_{G/M}$ value (0.6) for BC 8 was used in the 2nd Phase intercalibration for setting G/M boundaries for the remaining inner Danish coastal waters, thereby forming the basis for the intercalibration with Sweden for BC 6 and NEA 8b. Even if the intercalibration resulted in adjusted EQRs the lack of back-transformation to the Danish national classification method could here have introduced the same incorrect G/M boundaries as for BC 8. As Sweden in their RBMP has applied the EQS it entered into the intercalibration – and not the intercalibrated values, it has no consequences for Sweden. However, for Denmark, correction of the Danish EQRs would probably result in higher EQR values in the range above 0.63 up to 0.67. As these EQR values are higher (more stringent) than the applied values in the RBMP3 the implication for the calculated MAIs would be that they would be lower.

Intercalibration with Sweden

Intercalibration with Sweden on BC 6 and NEA 8b was made using a common metric[106] based on a compiled data set from Denmark, Norway and Sweden. A strong correlation between the Danish and Swedish data sets was shown, implying that the intercalibration result would change insignificantly if another

[106] Translated into a common metric of data from the countries' different methods for measuring and treating monitoring data.

data set representing the same water bodies was used.[107] For Denmark the reference condition values and H/G and G/M class boundaries of RBMP2 entered the intercalibration were confirmed by minor adjustments strengthening most Danish boundaries and loosening most Swedish boundaries. The intercalibration exercise was carried out in accordance with a simplified CIS IC procedure, which can be considered a 'fitting' exercise (see Section 4.5) in which the scientific approach for deriving reference conditions was not discussed.

Inconsistent G/M class boundary values

The revised reference condition values for common IC types in the RBMP3 are lower than those used and confirmed in the intercalibration with Sweden. The intercalibrated reference conditions form together with the nominal values for the intercalibrated H/G and G/M class boundaries the basis for the intercalibrated EQR values. Thus, the intercalibrated EQRs are bound to the intercalibrated reference conditions values and changing method for deriving reference conditions implies an assessment of whether the new derived reference values are consistent with the existing, and whether the intercalibrated EQRs are still valid for application. Just using the intercalibrated EQR on the revised RBMP3 reference condition values result in nominal G/M boundaries that are different and lower (more stringent - up to 25 percent) than the intercalibrated class boundaries, and thereby, inconsistent with the intercalibrated nominal G/M boundary values. This conclusion is drawn for the common IC types, which are represented by the same sites in both RBMP2 and in RBMP3, and a similar conclusion cannot be drawn for other national coastal waters.

The RBMP3 reference conditions for Chl-a are established by applying another and different scientific approach than used in the 1st Phase intercalibration by using a pressure-impact relationship directly between 'nitrogen load' and 'Chl-a concentration' for individual water bodies different from the intercalibration approach, which was based on generic relationships between 'nitrogen load'/'nitrogen concentration' and 'nitrogen concentration'/'Chl-a concentration'.

The inconsistency between the RBMP3 G/M class boundaries and the intercalibrated G/M class boundaries for the common IC types together with the different scientific approach used in RBMP3 leads to a conclusion that the RBMP3 classification method would be considered a revised classification method by the terms of CIS guidance, implying the need for at least a 'fitting' of the revised classification method to established intercalibrated values. However, together with the lacking back-transformation of the intercalibration result of the 2013 intercalibration with Germany a 'full' intercalibration would most likely be needed. Information on which further steps can be taken before initiating another intercalibration process are described in See Section 4.5. and the scientific and technical parts of an intercalibration exercise are summarised in Appendix F.

[107] (The same conclusion could be indicated for the previous intercalibration for BC 8 with Germany; however, the amount of data in that exercise is too small.)

Translation of IC results to national coastal waters

The characteristics of several Danish coastal waters, in particular of fjords and closed coastal waters, differ significantly from the characteristics of the common IC types. The characteristics differ not only in terms of the hydromorphological parameters, but also the response to eutrophication (nutrient load). Therefore, the translation of the intercalibration results into setting class boundaries for fjords and closed coastal water types/bodies cannot solely be based on applying an intercalibrated EQR for the common IC types without an assessment of whether the normative definitions of the ecological status classification for all quality elements will be met.

Eelgrass depth limit class boundaries

Due to lack of sufficient scientific arguments/knowledge, the EQR value of 0.74 (26 per cent deviation from RC) for eelgrass depth distribution, the G/M class boundary was the result of a decision by the Danish Government and the European Commission in the 1st Phase intercalibration process (2006-2008).

Class boundaries for eelgrass depth limit are in both the RBMP2 and the RBMP3 set for individual coastal water bodies/types based on the established reference conditions and by simply applying the intercalibrated EQR values. Only one EQR value has been applied throughout all three RBMPs.

The EQR of 0.74 is decided based on quality criteria for eelgrass depth distribution, which were established in the water quality management plans prepared by the regional authorities before the WFD entered into force.

A full intercalibration of EQR values for eelgrass depth distribution has not been feasible due to different assessment methods and data requirement in the Danish, German and Swedish assessment methods. However, direct comparison of reference values and G/M class boundaries between Denmark and Germany shows equal levels.

G/M boundaries for all Danish water bodies are set based on the RC values for the individual water bodies or types using the common EQR. Until any better scientific basis is provided for setting the boundaries, this method is considered the only feasible method.

Denmark has developed a revised assessment/classification method for depth distribution of angiosperms, which includes all important rooted plants in Danish coastal waters. The method shows a significant 1:1 correlation in the classification of status. The method is scientifically approved by the CIS ECOSTAT working group.

Other quality elements

Both for other biological elements and supporting hydromorphological and physico-chemical elements, see Section 3.1.

3.3 Task 3: Status load, 2027 baseline

3.3.1 Objective

Task 3 comprises a review of methods, data and calculations for determination of status load and 2027 baseline load. It is divided into the following sub tasks:

- Brief description of methods applied for determining the status loads (based on 2016-2018 data) and the preconditions used. Methodological approvements introduced in the RBMP3 plan period.
- Assessment of the impact of the improvements on the accuracy of the load calculation.
- Brief description of method applied for calculation of baseline load (2027) and of the preconditions used.
- Scientific evaluation of the area of applicability of the applied improvements of the methods for load calculation and their limitations.

3.3.2 Analysis and assessment

Status load

The status load for the 3rd RBMP is defined as the load in 2018 corrected for variation in climate during the year and random year-to-year variation. To obtain an estimate as exact as possible of the status load for 2018, the methods for carrying out climate normalisation of the emissions of N are adjusted to reduce variations in the calculations as a result of differences in rainfall between years. The normalised N load is calculated to see the trend of the diffuse N load with a minimal influence of a given year's climate/weather (Larsen et al. 2020).

To correct for the year-to-year variation in the runoff in each catchment area, the calculation of the load has to be water-flow corrected. Wet years with relatively large runoff result in a higher leaching of N than dryer years with less runoff (Thodsen et al. 2019). Thus, the year-to-year variation in runoff gives a substantial variation in the N load. Therefore, it is necessary to normalise data. The normalisation reduces the importance of the freshwater runoff variation. The normalised transport of N illustrates what would have been supplied in the specific year if the water runoff corresponded to average run-off throughout the entire period (1990-2018). The researchers behind the normalisation method point out that the run-off normalisation does not remove other effects such as poor harvests, lack of sowing or poor growth of, e.g., subsequent crops.

In 2018, the runoff of N from the fields to coastal waters varied more than usual, demonstrating a clear geographical pattern. In the past, the pattern has been a larger nutrient loss from catchment areas in the western and northern parts of Jutland and, consequently, less nutrient loss from catchment areas in Eastern Denmark. The reason for this is that the N surplus on the fields in

Eastern Denmark is typically smaller than average, and that water runoff is less to the east than to the west (Windolf et al. 2011). This pattern is in agreement with observations from previous years. Diffuse sources include inputs from cultivated and uncultivated land as well as discharges of wastewater from scattered settlements without a public sewer system. On a national basis, the diffuse supply amounts to approx. 90 per cent, whereas point sources supply ten per cent of the N loads to the coastal waters. This is very similar to the distribution to the coastal water bodies for previous years (2013-2017) (Thodsen et al. 2019).

Tests in Larsen et al. 2020 have shown that the normalised status load calculated with the developed method gives a smaller relative model error, when estimating current loads.

Furthermore, due to laboratory errors in the analysis of N in some water samples in the period 2009-2015, a new method has been introduced to calculate the status load in 3rd RBMP compared to the previous 2rd RBMP (Miljøstyrelsen 2020c). The method has been developed to ensure the calculation of a robust estimate of a 2018 load including confidence interval. The data basis for the status load has been three years (average 2016-2018), rather than directly based on the data set from the period between 2009 and 2015. However, by applying a new partial regression method (piecewise regression), it was possible to include a full data set from 1990 to 2018, including confidence intervals. In the previous 2rd RBMP, the status load was calculated by regression. The applied method by using the approach with average of 3 years data instead of 5 years will not affect the status load significantly. The 2nd opinion team assesses that the status load may be slightly different, but it is not given if these changes will point towards increased or decreased MAIs. It is the understanding of the reviewers that possible effects of changing technical details in the calculations are to be compared with the overall uncertainty of the baseline including the uncertainties of the forecasted effects of planned measures.

The status load is calculated for the runoff in each catchment area to the coastal water bodies using this new approach. Furthermore, the models take the 'hierarchy of runoff' into account when there is a connection to adjacent water bodies situated downstream. The new approach is assessed to give a more precise estimate and an improvement from 2rd RBMP to 3rd RBMP. This is very important as the status load for each catchment area forms the starting point for determining the baseline load and for establishing the 'need for reduction' (in Danish "indsatsbehov") to achieve the target load in 2027.

2027 baseline

The baseline effect or 'baseline' is defined as the effect of already adopted initiatives (measures) as well as developments in the agriculture industry and in the climate which may have an impact on nutrient loss from the cultivated areas in 2027.

The 2027 baseline is established on the basis of status load in 2018. It is calculated as the status load minus baseline effects from already decided measures (actions) and the general development in effects from proposed measures towards 2027. The data foundation for the 2027 baseline is the projected nutrient load reduction (‘earnings’) from the different measures in the catalogue for the period 2021-2027 (Eriksen et al. 2020).

N leached from the root zone in the fields and other areas is transported via groundwater to the surface water system, i. e. streams, lakes and wetlands, from which it flows towards open coasts and fjords. During this transport, from the root zone to the coast, a turnover and N removal take place in the subsoil or in the surface water, which is often referred to as N retention. The N retention depends on the biogeochemical conditions and, thus, varies from place to place.

The effect of baseline elements must, together with the target load and the effect of other measures, form a comprehensive basis for how nitrate and phosphorus discharge is expected to change until 2027. This is important for determining the load reduction requirements and, in turn, the consecutive programmes for measures that ensure the required reduction in the discharge of nutrients, which is necessary for meeting the WFD objective of good ecological condition.

As a basis for a more differentiated regulation of the use of N in agriculture, the national N model was developed (Højberg et al. 2015). It was implemented in RBMP2 and subsequently used in the implementation of the RBMP3, where it was used to assess the extent, type and prioritisation of the measures. The N model consists of existing sub-models from GEUS and Aarhus University (AU). These are linked together to form the national N model, which describes the N transport and turnover from the root zone to coastal waters at a national level.

In the period up to the 3rd RBMP period (2021-2027), the N model was updated, and changes were made to parts of the model concept based on experiences from the existing model. The updated model is considered to be an improved description of N transport compared to earlier (Højberg et al. 2021). The update also ensures that a higher degree of consistency between models used in the N model and other models used during the preparations of 3rd RBMP (Højberg et al. 2021). The most important update is a new method for handling the drain flow, which uses a separate description of the transport via drains in relation to the transport via deeper groundwater. This solution ensures that the N transport via drains is in accordance with the drain flow described with the Danish model. In addition, it provides the opportunity to use a time-varying drain flow, which has been utilised by integrating a monthly mean drainage transport in the model (Højberg et al. 2021).

In addition to the update of the N model itself, sub models have been updated. One of the improvements has been of the NLES model, which provides annual estimates of N leaching that must be subdivided to monthly values, which is the time step used in the N model. In order to meet this need, a new method based on the temporal variations in measured leaching data has been developed, which has improved the monthly dynamics of the calculated leaching data. In the present version of NLES5 model, the N leaching from cultivated areas is calculated based on a significantly larger data set than in previous versions.

Furthermore, the data used reflects the present and specific land use to a greater extent. The NLES5 model has made it possible to use the same model for determining the N leaching for the whole period in 3rd RBMP (Højberg et al. 2021).

Furthermore, the Danish national water resource model, which describes the groundwater flows, has seen improvements. Hydrostratigraphic models for most of Denmark are now incorporated. In addition, the calibration of the Danish model has been adjusted, focusing on nationally consistent detailing and regionalisation of drainage and vegetation parameters. In relation to the description of the turnover in groundwater, the flow paths are combined with a location of the redox boundary. The Danish model has also been updated to describe the transport of organic N in surface water and to describe N turnover in natural wetlands.

For determining the 2027 baseline, the effects are generally distributed based on the same catchment area boundaries as in the 3rd RBMP. A calculation of reference leaching and the effect of decreased cultivated area is carried out in (Blicher-Mathiesen et al. 2020) for adjusted boundaries to illustrate the sensitivity to the choice of catchment boundaries.

The baseline effects included in the 3rd RBMP follows from table 3-5. The total effect in coastal waters is just below 5,000 ton nitrogen and nearly 50 ton phosphorus. The effects are in part based on estimations from Blicher-Mathiesen et al. (2020), estimations from Danish environment and agriculture authorities, and contributions from municipalities, utility providers, and companies.

Table 3-6. Baseline effects for different sources of N and P to coastal areas. The listed effects are based on estimates by
**Blicher-Mathiesen et al., 2020*
*** former Ministry of Food an Environment*
****data from municipalities, utility providers and companies.*

Baseline effect	Reduction in nitrogen to coast (Ton, N)	Reduction in phosphorus to coast (Ton, P)
Areal reduction for agriculture*	1278	23
Wetlands 2021**	977	
Lowland soil extraction*	876	
Increased utilization requirements for Livestock fertiliser*	660	
Atmospheric deposition*	532	
Closed periods for Spreading Manure	445	
Mini-wetlands**	410	
Forest development*	238	0,7
Increased yields*	186	
Revised rules for specific soil types*	287	
Private afforestation, 2021	81	
Point sources **/***	120	42
Aquaculture, 80 ton extra quotas and assigned quotas**	-190	-18
Cessation of targeted catch crops	-986	
Total sum:	4914	47,7

The 2027 baseline includes a forecast of data on agricultural production, on its effect on livestock and on crop distribution in the period from 2018 to 2027. As a central part of the baseline, the forecast of the amount of nitrate leaching is included for the measures estimated by Blicher-Mathiesen et al. (2020). The effects for the remaining baseline elements in the 3rd RBMP baseline in table 3-7 is based on unit numbers provided by AU Blicher-Mathiesen et al. (2020) and estimated by the former Ministry for Food and Environment. Therefore, the 2027 baseline does not provide an overall forecast for all measures in the 3rd RBMP baseline; only for the measures estimated by Blicher-Mathiesen et al. (2020).

The N model describes the development in climate and potential derived effects on nitrate discharge. This includes the potential for N removal by extracting carbon-rich low-lying soils from agricultural cultivation through raised water level etc.

As the effect of measures is a forecast, it can be subject to considerable uncertainty, especially where the effect depends on international economic cycles, and whether other countries comply with adopted conventions. Therefore, the 2027 baseline report (Blicher-Mathiesen et al. 2020) recommends that a mid-term evaluation should be carried out as changes in the development and regulation of agriculture can affect the calculated estimates for nitrate leaching and P discharge.

In order to calculate the baseline effect for each measure, DEPA has made an inventory of baseline effects (Miljøstyrelsen 2021a) for both N (5,000 tonnes) and P (34 tonnes), and on this basis, the 2027 baseline is 51,350 tonnes and 1,800 tonnes, respectively.

The effect of measures initiated and implemented before 2018 is included in the actual measured data behind the status load. The effect of some of these implemented measures has a longer response time, and these effects or future reductions of an already implemented measure are not included in the 2027 baseline but have been accounted for in the 2021 baseline. A significant part of the expected baseline effect will not have full impact in 2027. As illustrated in figure 3-14, the expected impact on nitrate leaching is assessed to appear within a time frame of five to ten years. It should also be added that there will be a certain time delay from the implementation of the measure until an actual effect of the reduction in the leaching from the root zone and to the load to coastal waters. Furthermore, the actual leaching is affected by year-to-year variations in weather conditions (Blicher-Mathiesen 2020).

Furthermore, the researchers behind the '2027 baseline' report point out that there may also be a shadow effect of one measure to another; however, this is not studied in detail.

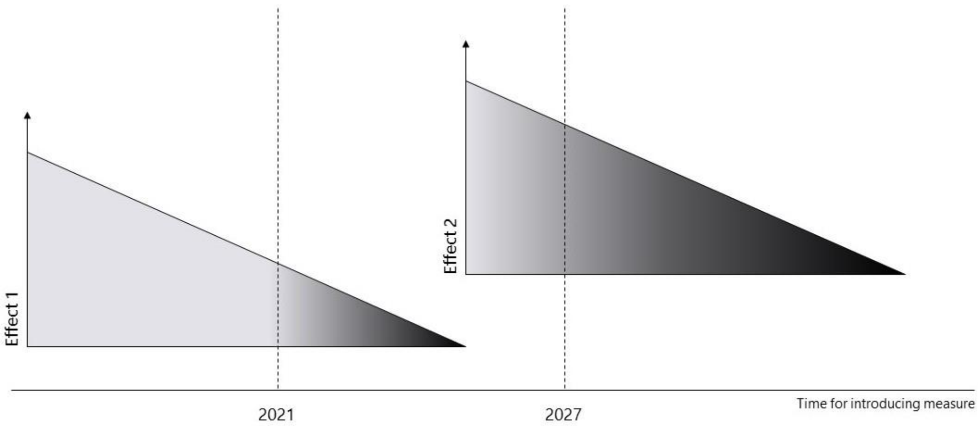

Figure 3-15: Illustration of delayed effects of measures.

A comparison of the national inventory, between RBMP2 (Miljøstyrelsen 2015) and RBMP3 (Miljøstyrelsen 2021c) shows no difference in the baseline load, which indicates that the measures implemented during RBMP2 had no or very little impact at national level. Looking into the inventory on a local scale, there are differences between the baseline load from the two plan periods.

Since the baseline effect has been assessed as a future forecast, there is a certain degree of uncertainty as to whether the actual development will deviate from the projected development. Therefore, AU recommends carrying out follow-up assessments of whether the development follows the expectations

(Blicher-Mathiesen 2020). Furthermore, the report on the 2027 baseline points out that it is also important to look at whether new measures will be introduced to reduce the nitrate and P load, including new measures to meeting Denmark's objective of lower CO_2 emissions. The recommendation from AU is in line with the Ministry of Environment, which is constantly seeking to update and qualify the baseline, and a new report on the baseline has historically (Naturstyrelsen 2011; DCE 2016; DCE 2020) been published every four to five years in order to reflect the development.

The baseline elements presented in the 2027 baseline report (Blicher-Mathiesen 2020) show an expected decrease in nitrate leaching towards 2027 as a result of a decrease in the atmospheric deposition of N, which depends on whether the forecasts for the development of N emissions are correct and on EU countries complying with the emission ceilings for 2027/2030 adopted with the National Emission Ceilings (NEC) directive. In addition, it is especially expected that developments in the ecological area and the decrease in the cultivated area and afforestation will contribute to less leaching towards 2027.

There is considerable uncertainty about the effects of developments in N standards and N yields on nitrate leaching, especially in relation to developments in crop composition (Blicher-Mathiesen 2020). As a derived effect of climate change, increased nitrate leaching is expected due to increased runoff.

The uncertainty in the calculation of the 2027 baseline is mainly due to the uncertainty in the implementation of each measure and possible changes in agriculture, which to a high extent is governed by political decisions. Other factors which can influence the uncertainty of the baseline is the natural delay in the transport of nitrogen from soil to coastal waterbodies and furthermore there is a delay in the effect from measures (e. g. wetlands) established late in the period of the RBMP. Therefore, there may be a risk that the 2027 baseline is overestimated or underestimated and, if overestimated, the need for protective measures will be too low and good ecological status will not be achieved within the plan period.

3.3.3 Concluding remarks

It is our assessment that the methods applied to determine the status loads have been improved and that the influence of errors in measured data has been reduced. The status load is determined on data measured daily and monthly, and the normalisation of data improves the comparison across Denmark and between different years.

Furthermore, the status load is calculated for the runoff in each catchment area to the coastal water bodies using this new approach. The models take the hierarchy of runoff into account when there is a connection to adjacent water bodies situated downstream. It is our assessment that this gives a more precise estimate and that it represents an improvement from the 2rd RBMP to the 3rd RBMP. The 2nd opinion team assesses that changed technical details (e. g.

different averaging period or update of data of status loads up to 2021) not will affect the robustness of the calculated results significantly. The status load may be slightly different, but it is not given if these changes will point towards increased or decreased MAIs.

A significant part of the expected baseline effect will not have full impact in the period prior to 2027. The expected impact on nitrate leaching is assessed to appear within a time frame of five to ten years or longer as there will be a certain time delay from the implementation of the measure until an actual effect of the reduction in the leaching from the root zone and to the load to coastal waters.

A comparison of the national inventory, between the 2rd RBMP and the 3rd RBMP, shows no difference in the baseline load, which indicates that the measures implemented during the 2rd RBMP yet had no or very little impact at national level. However, this is based on measured load until 2018 and a great part of the measures in 2rd RBMP for 2015-2021 had not yet had effect in 2018. It remains to be proven that measures to be implemented within 3rd RBMP have the required effect. From a scientific point of view, it is important to document that the implemented measures have the planned effect. Looking into the inventory on a local scale, differences between the baseline load from the two plan periods are found.

In the period up to the 3rd RBMP period (2021-2027), the N model has been updated as well as the P-model. The phosphorous concentration is often the limited factor for the phytoplankton growth in the spring, while it is nitrogen in the summer. The P-model analyses the connection between the load of nitrogen and phosphorous and the impact of the combined load to the condition of biological parameters. Increased P-load reduction can have a potential N reduction for some specific water bodies and should be investigated in detail specifically for each individual water body. For example, a marine area with high phosphorus limitation can also be sensitive to changes in the nitrogen input. Marine areas exhibiting high levels of phosphorus sensitivity are often characterised by a mainly phosphorus-limited algae growth, and the marine area being influenced by phosphorus input from its catchment area. Similarly, a marine area estimated to have "least" or "low" phosphorus sensitivity can also change environmental state in response to changes in phosphorus inputs. However, major or long-term changes in the phosphorus input would be required to induce a shift in environmental state as either local sources have no significant effect or accumulation of phosphorus in the sediment over time has been so high that many years of low loading are required for a system change to take place. It is therefore assessed that the P-reduction approach is very complex and have to be investigated in more details before full implementation in RBMP. At this point we asses, that the inclusion of estimation of effects from combined N and P reduction modelling can have a negative effect to postpone the actual measures for N-reduction.

With the updated N-model, it is assessed that an improved description of N transport has been achieved. Another improvement is the NLES5 model. In this model, the N leaching from cultivated areas is determined on a significantly larger data set than in previous versions. Furthermore, the data used reflects, at higher accuracy, the conditions of present land use. Another update to the NLES5 model is a new method for handling the drain flow and this solution ensures that the N transport via drains is in accordance with the drain flow described with the Danish national water resource model, which has also been improved (Højbjerg et al., 2021).

Furthermore, the baseline load is calculated based on forecasts of the effect of various forecast measures and efficiency improvements in agriculture. The effects in agriculture, however, have not been fully documented. Although the measures are aimed at the different water bodies and in the summer season (where applicable), it is our assessment that the uncertainty of the effectiveness of such new measures cannot be neglected. If the baseline effects are overestimated, it leads to an underestimation of the need for protective measures. On the other hand, a reduction of protective measures increases the risk of not achieving good ecological status.

3.4 Task 4: Model basis

Models are used to forecast the environmental state in different load conditions for the stationary situation. by 2027. Two different model systems are applied in parallel: STAT models (STAT), and mechanistic (MECH) models.

3.4.1 Objective

The objective of the present task is to review the scientific basis of the modelling approach and its modelling results. The review includes the following:

- Review of the changes and improvements in RBMP3 on the STAT and MECH models with respect to
  - applied methodologies
  - assumptions for the calculations.
- Review of the effects of changes on the applicability of the applied models as well on the introduced limitations.

3.4.2 Analysis and assessment

The modelling aim is to predict changes of the selected environmental components – concentration of chlorophyll-a (Chl-a), and light attenuation coefficient, K_d (as a proxy for eelgrass depth limit) – due to changes in anthropogenic pressures of nutrient loads (nitrogen and phosphorus, N and P).

The following sections describe the overall concept of dealing with two model concepts as well as the two applied model concepts. Furthermore, they describe a comparison of the results of the model concepts among themselves, and the development of the key model parameters from previous to present plan period. The consequences of the applied models for the main result – the maximum allowable input (MAI) of nutrients to achieve the required environmental status – are assessed.

First, however, the use of light as a proxy for eelgrass is presented, as light is used in both model concepts. As mentioned below, light as proxy for eelgrass was discussed earlier by the international evaluation panel (Herman et al, 2017) and Ferriera (2021). Therefore, the following description of light is carried out.

Light attenuation as proxy for eelgrass depth limit

The depth limits for eelgrass/angiosperms respond to changes to the light climate, which is correlated to changes in nutrient levels. Such relationships have been reported in multiple studies based on nationwide Danish data (e.g., Nielsen et al, (2002) and Carstensen & Krause-Jensen (2018)) as shown in Figure 3-16.

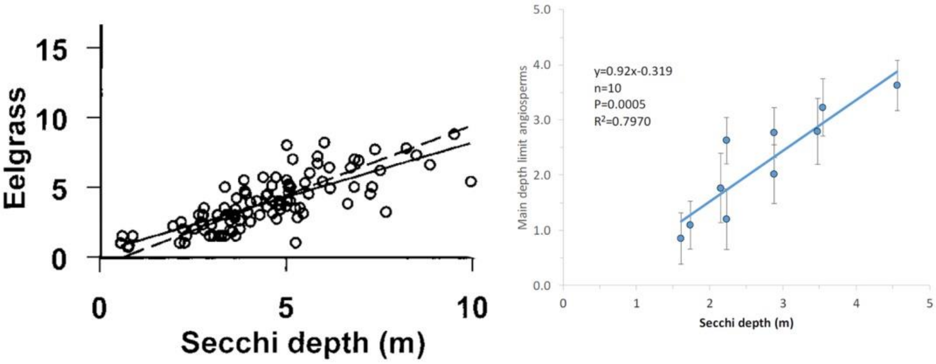

Figure 3-16: Depth limit of eelgrass as a function of Secchi depth (left), and depth limit of angiosperms as a function of Secchi depth (right).

The use of Kd as a proxy[108] for eelgrass depth limit has been subject to critique from the international evaluation panel (Herman et al, 2017) and Ferriera (2021) who both concluded that estimation of the effect of nutrient reduction on Chl-a is more reliable than the estimation of this effect on Kd. Their arguments include various factors such as delay in response and that other supporting conditions need to be met for recovery of eelgrass status to achieve good status. They also point out that the model is not able to reproduce the reference Kd values based on modelled reference load. However, acknowledging that, without at least restoring Kd to the levels needed for meeting the G/M boundary conditions, restoration of eelgrass distribution will not succeed.

Their arguments are valid and appropriate regarding the use of the K_d as an indicator for eelgrass depth limit when it comes to status classification of water bodies based on monitoring results.

Valid is also their notion on the model's lacking ability to reproduce reference values. As stated below, however, the second opinion finds that the 'K_d-proxy', is a valid parameter to be used as proxy for the ecological G/M class boundaries in model calculations.

The 'K_d-proxy' represents light conditions that must be present before eelgrass can be expected to be able to recover to good ecological conditions. The fact that a strong correlated relationship has been documented between the eelgrass depth limits and the transparency allows the 'K_d-proxy' to be compared directly with modelling results of 'K_d'.

Furthermore, the 'K_d-proxy' can easily be translated into a transparency-measure (e. g. Secchi depth), and it can be used to assess whether observed transparencies achieve the supporting transparency conditions for eelgrass recovery. See also the description in Sections 3.2 and 4.4 of the link that is

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[108] It can be confusing that 'K_d' is/has been used as name for both the 'K_d proxy' for eelgrass depth limit and for the 'K_d' parameter for describing the light conditions as they describe different things.

required to be established between the quality elements and the supporting elements.

The light attenuation coefficient K_d and the eelgrass depth limit are interconnected via the light penetration depth and can therefore be a proxy or representative for eelgrass depth limit. The lower eelgrass depth limit is found to correspond to the depth, where approx. 16 per cent of the light (irradiation) at the surface is left (DCE, 2021). Literature also provides other light percentages, e.g., ten per cent (Nielsen et.al, 2013) up to 20 per cent, but here the value only serves to illustrate the relation. The interconnection is described by the equation (EPA, 2000) that describes the light (irradiation) I at a depth z under the water surface:

$$\frac{I(surfavce)}{I(z)} = \exp\left(-K_d \cdot z\right)$$

For a given light attenuation K_d and the 16% (=0.16) light limit, the corresponding depth z is explicitly found:

$$0.16 = \exp\left(-K_d \cdot z\right)$$

The above describes the relation between light attenuation and depth limit, but is stressed that, although light is a necessary precondition for eelgrass, light is not the only precondition for eelgrass. In the model calculations, light is used as a necessary precondition for eelgrass to sustain at certain depths, but not increase biomass nor extend spatially as other pressures to eelgrass are not included in the current marine models.

Modelling environmental status based on nutrient loads

The marine environmental status is a result of a complex network of inter-connected processes that vary in time and space. It is the overarching assumption of the RBMP that the environmental status to a high degree is negatively affected by high nutrient loads – through eutrophication. An illustration of the main processes involved is provided in (EC 2009b), see Figure 3-17.

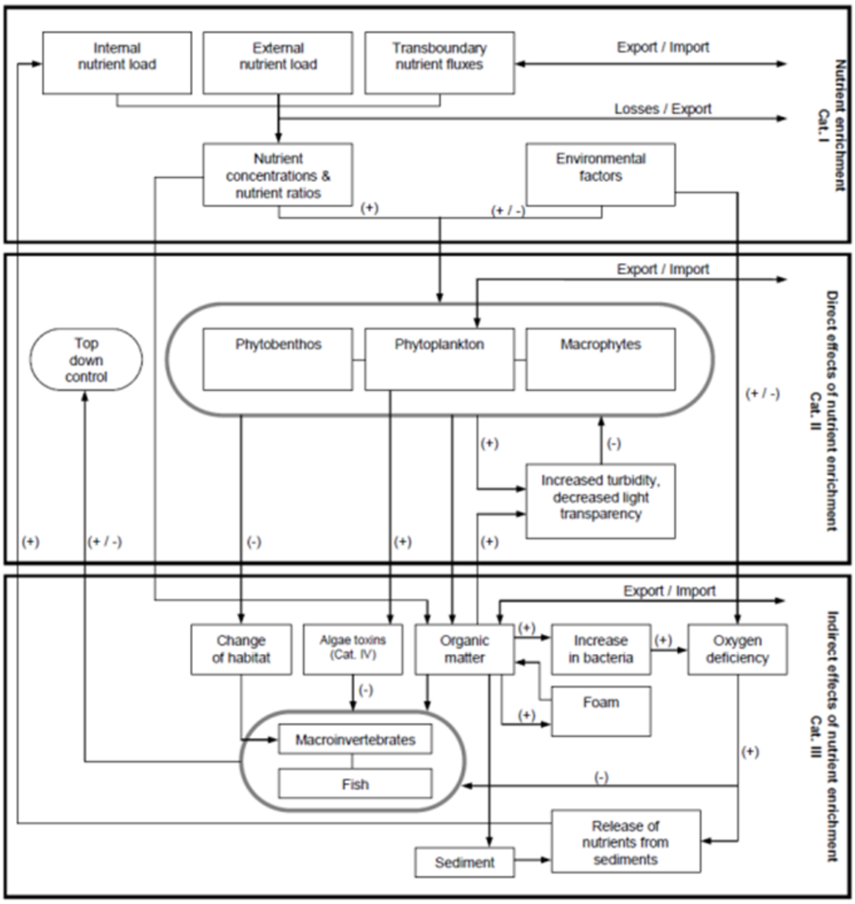

Figure 3-17: General conceptual framework to assess eutrophication in all categories of surface waters. (+) indicates increase; (-) indicates decrease; round boxes indicate biological quality elements of the WFD (EC 2009b).

It is evident, that the modelling task for RBMP3 cannot comprise all processes outlined in Figure 3-17, but that the most important processes are selected to forecast the effect of changed nutrient loads and, hence, identify the loads that will achieve the required environmental status that is defined in terms of specific limit values for the summer Chl-a concentration and the light attenuation coefficient.

An additional input of nutrient to a water body will give rise to an increase of nutrient concentration. The magnitude of the added concentration will be a result of water exchange with neighbouring water bodies, sedimentation, uptake in organisms (algae), and further contribution from sources within the water body (sediments, atmosphere). The biological status is based on Chl-a concentration and light attenuation, which again requires insight into the time-dependent relations between the resulting nutrient concentrations and the biological status elements. As requested by the international expert panel for RBMP2, the number of water bodies covered by the MECH model is extended to 109. This enhanced spatial resolution within the model system provides better possibilities to describe the individual characteristics.

The two-model approach

To model the MAI of nutrients to the different water bodies, the Danish approach applies a two-model approach:

- MECH models applying hydrodynamic and biogeochemical modules
- STAT models applying a Bayesian approach.

Neighbouring countries like Sweden (SMHI, 2020) and Germany (BLANO 2014) have applied only one model system. Denmark has also applied the two-model concept in RMBP2.

The international reviewer of the RBMP2 stated in 2017 that mechanistic models are advanced and comprehensive. They also supported the concept of developing two independent models but questioned the management decision of applying both models for calculating needs for reduction. The present 2. opinion confirms this finding.

An analysis of the performance of the two models with regards to assessment of reference values and to the intercalibration process is carried out in chapter 3.1.2. In present chapter, the assessment is focused on the estimated MAIs.

One of the main reasons for applying both models is that two independent models provide two independent estimates of the MAI required to achieve the required environmental state. Hence, two estimates will enhance the reliability of the results compared to the situation where only one estimate is available, particularly, if the results are within the same range.

The 2nd opinion team finds overall that it is an advantage to continue using a two-model approach, especially when the model results only differ within an acceptable interval, as long as both results can be considered to be of comparable validity. The following should be observed when using a two-model approach in future:

- Using two models may lead to the question of which result to believe, and eventually choose, if the results of the two models differ significantly.

- An argument for applying a two-model concept is that both models are developed to a similar degree of quality and accuracy so that their results can be considered equally valid and that an average value of the two results can be considered a better estimate than selecting one of them.

- Another reason to continue to apply the STAT model is that the intercalibration of the quality classes is carried out by simple statistical relations as outlined in the CIS-GDs (EC 2011). A possible rationale could hence be to apply the same model concept and hence determine consistent pressure-impact relations to achieve the requested status. Such statistical model concepts that are based on pressure-impact relations (causal relations) hence have different concepts and structures than the statistical models applied in RBMP3. It is the assessment of the reviewers that the statistical models applied in RBMP3 do not fully comply with the description of intercalibration in CIS-GDs (EC 2011).

- A STAT model is considered simple and robust since it only relies on actual data.

Concept of the MECH models

The objective of the MECH model is to quantify the relation between nutrient load and chlorophyll-a concentration, depth limit for eelgrass expressed by the light attenuation coefficient (Kd,), total nitrogen concentration (TN) and total Phosphorous concentration (TP). The specific objective of the present model description is to focus on the properties that enables it to forecast the effect of reduced nutrient loads on the chl-a concentration and light attenuation.

The MECH models apply the causal relations for the parameters that must be described. The core of the MECH models is a set of differential equations for conservation of mass and momentum as well as for biological and geochemical processes. The system of causal relations describes how the different parameters depend on each other. It is evident that such equations require insight into the processes that are described (plus significant computer power). The applied MIKE model system, that describes the flow, transport and retention/degradation of nitrogen in the groundwater and surface water, is a widely accepted model system with full scientific documentation. The present model application comprises 11 different model areas (2 sea models, 3 regional models and 6 fjord-models), all models are 3 dimensional and non-stationary, and they describe a long list of parameters for the hydrodynamics (water level, currents, salinity, temperature, density, K_d), water chemistry (TN TP, DIP, DIN, Si), biology (Chl-a, DO) as well as sediment parameters. The model results include 9 parameters that directly can be compared with measure parameters of the national monitoring program.

For further documentation of how the above processes are included in the MIKE model applied in the present case, please refer to the relevant scientific and user manuals.

Each specific application of a model system must be verified to demonstrate that the model is performing. Verification of the MECH model is carried out and illustrated in Figure 3-18. The map of the figure shows that verification is carried out for a large number of monitoring stations. The selected example of Helnæs Bay illustrates the agreement between model and measurement of salinity in the surface layer for a 15-year period. The approx. 180 monitoring stations with nine parameters for upper and lower layer over a 15-year period provides a unique basis for comparing model results with monitoring data. This considerable effort was recommended by the international expert panel in 2017.

Figure 3-18: Example of comparison between model results and data (Station in Helnæs Bay, salinity), (DHI 2022) [*RBMP (dhigroup.com)*](#)

The MECH models include causal relations to the degree that modern science can provide regarding the ecosystem. Since the model is based on the causal relations, it is geared to forecast results to 'what happens if' questions. Furthermore, the MECH models apply basic scientific axioms such as the conservation of volume, mass and momentum. The drawback of MECH models is, however, the relatively large amounts of processes and, in turn, input parameters that must all be calibrated. Although this introduces uncertainties, the calibration and validation processes clearly illustrate to what extent the model is credible.

A large effort has been undertaken to apply several statistical methods (e.g., Spearman Rank, P-bias) for quantifying the reliability of the model results. They all support to a certain degree the validity of the model results. The results of the applied objective methods indicatively support the overall impression of the model validity that is provided by the comparison of model result with measurements. In agreement with many modellers, it is the understanding of the second opinion team that inspection by experts of the time series, where model results are compared with measurements, still represents the best form for model verification. With a so large number of stations and parameters as in the present case, it is not possible to inspect all time series in a systematic way and hence only selected time series were inspected whereas the statistical tests were carried out on all timeseries.

It is also acceptable that for some parameters the agreement between model and measurements is different than for others.

The overall impression of the provided model verification is that the model performs to a satisfying degree and the model hence can be considered fit for purpose.

Although the model is to forecast a state outside its calibration range, the model is based upon processes that are validated. This is the important difference between the MECH and STAT models.

Overall, the MECH model is assessed to be well documented (state-of-the-art). Issues that are not covered in the documentation and that could add to the general understanding of the performance of the model are:

- Comparing modelled and measured depths of the salinity interface
- Comparing modelled and measured strengths of the interface

Concept of the STAT model

As is the case with the MECH model, the objective of the STAT model is to quantify the relation between nutrient loadings (N and P) and Chl-a, Kd, TN and TP. Two statistical models are developed, for Chl-a concentration and for light limitation depth (the K_d proxy for eelgrass depth limit). They are applied for 15 and 22 water bodies for light and Chl-a, respectively. In total, there are 109 water bodies. The specific objective of the present model description is to focus on the properties that enables it to forecast the effect of reduced nutrient loads on the Chl-a concentration and light attenuation.

The STAT model is based on descriptors that are partly recommended by the CIS guidance documents and partly selected by the model developers. The descriptors are, without doubt, relevant for understanding the oceanographic system. The descriptors are:

- Nutrient input
- salinity
- sea surface temperature
- buoyancy frequency
- irradiance
- wind energy.

The present STAT model applies a statistical relation between the target parameter and parameters that are assumed to have an effect on the target parameter. Statistical relations are established by multiple linear regression (MLR) analysis, which assigns high weight to parameters that have high statistical impact on the target parameter and low weight to parameters that have low or no impact on the (normalised) target parameter. The sum of the weighted input parameters describes, to a certain degree, the target parameter.

It was suggested by the expert review of RBMP2 (Herman et al. 2017) to apply advanced Bayesian methods to refine the STAT model. This has been carried out accordingly. However, the selection of basic input parameters for MLR analysis does not include a thorough analysis and documentation of what parameters should be selected from a scientific point of view. It is evident and good scientific practice that the selected parameters comprise the necessary and sufficient information for modelling the requested parameters and their dependency on nutrient inputs.

The calibration of the STAT models indicates that the average levels of Chl-a concentration and light are modelled well. The year-to year dynamics, however, is modelled less well. For the station-specific model, this dynamic seems better. The standard deviation is found to be of the same order of magnitude as the year-to year variations. This is considered a relatively large deviation and a discussion or explanation of these deviations would make the results more understandable.

It is not given that an input of the chosen six parameters (Nutrient input, salinity, temperature, buoyancy frequency, irradiation wind energy) will provide a causal relationship of the parameters included in the multiple regression. Because of this lack of causality, the established statistical relation has significant drawbacks if the relation is applied for forecasting, particularly if the condition of the forecasted scenario is outside the calibration range of the STAT model.

It seems uncertain that modelling at a given location can be performed without taking the surrounding oceanographic conditions into account. The year-to-year persistence of, e.g., phosphorous, is well-known but not included. It is known that phosphorous has a long residence time, and that major phosphorous releases occur during oxygen depletion. Such well-known and important processes are not included in the STAT models. They do therefore not include basic forcing processes. This leaves room for improvement of the STAT models to reach degree of descriptive strength similar to that of the MECH models.

An advanced version of a multiple parameter regression analysis is developed by including Bayesian models to determine their respective weight to the parameters. In 2017, the international expert panel recommended the Bayesian method as a refinement of the STAT model. It replaced the earlier central estimate of the weights with a more qualified estimate, applying information on the distribution of the reference values and slopes in different years and water bodies.

Comments to the relevance of some of the descriptors are given below:

- Nutrient input
  Internal sources and sinks of N and P are not included in STAT. Also, the important exchange with neighbouring water bodies is not included. The STAT models are designed as lake models more so than models for estuaries or coastal areas (e.g., reference is made to a Finnish lake).

- Sea surface temperature (T)
  Sea surface temperature is nor a relevant parameter for Chl-a, since the production of algae does not depend on T, but on light. The same is valid for light (Kd), since turbidity due to other particles is not depending on temperature.

- Buoyance frequency, also called Brunt Väisälä (BV) frequency
  The rationale for including the BV in modelling Chl-a or Kd is unclear and not based on insight into the dominating causal relations. The stratification might have an obvious impact on oxygen depletion, but not on Chl-a or Kd.

- Irradiation has a direct impact on Chl-a production and hence considered of high relevance.

- Wind energy (wind speed to the third power) is usually considered as cause for vertical mixing. This is valid for lakes, but for the Danish coastal waters the stratification strength is more governed by the inflow and outflow events that again are governed by SW-projection of the wind speed to the first power.

When a model of a system is to be established, the descriptors must be connected according to the existing insight into how the system works. If the descriptors are purely connected as a sum of weighted descriptors, as in present case, it is assumed that the dependent variable (e.g., Chl-a) is the result of addition of descriptors that are weighted with their specific weightings. A model that basically consists of the addition of descriptors is not in agreement with current scientific insight into fjord systems.

Example of causal relation

In order to illustrate the importance of including causal relations, a simplified system based on conservation of mass (a basic principle within modelling) is described below to illustrate that addition of descriptors is not a viable concept.

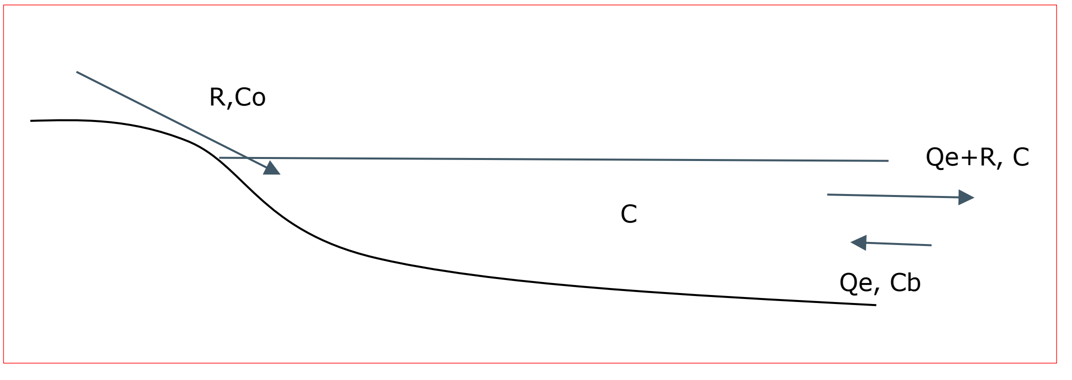

Figure 3-19 Simplified concept of the mass balance indicating the transports necessary for the state of selected variables

Where
C: Concentration (of nutrient proportional to Chl-a) in the fjord
R: River discharge
C_0: River nutrient concentration
Q_e: Exchange discharge over the open boundary
C_b: Nutrient concentration at the open boundary.

The simplified concept illustrates the importance of exchange over open boundaries as well as the boundary concentration. The sketch illustrates the following relation:

$$R \cdot C_0 + Q_e \cdot C_b = (Q_e + R) \cdot C$$

The nutrient load, L, from land is hence

$$L = R \cdot C_0$$

$$C = \frac{L + Q_e \cdot C_b}{(Q_e + R)}$$

Since Qe>>R in almost all marine waters, the formula can be linearised to

$$C = \frac{1}{Q_e} \cdot L + C_b$$

This simple concept indicates that the concentration of nutrient and hence of Chl-a or Kd is described by a linear combination of nutrient load that is divided with the exchange discharge plus the boundary concentration. It is worthwhile noting that neither exchange discharge over the boundary nor the background concentration is included as relevant descriptors in the list given above. Only the nutrient input or nutrient load is included.

Hence, there is a conceptual indication that the parameters Q_e (boundary exchange discharge) and C_b (boundary concentration) can be applied in future statistical approaches. The influence of the other parameters can also be expressed in terms of conceptual relations that can probably be simplified and introduced to the above model of the Chl-a concentration. When the descriptors are included in the model, statistical methods can be applied to determine the respective factors. Also, the concentration at the open boundary as well as the exchange discharge over the open boundary of each fjord could be included in future STAT models as parameters. For future STAT model work, it is suggested to conduct such a parameter analysis and to carry out the MLR analysis with necessary and sufficient parameters. As illustrated in the example outlined above, it can be expected that a statistical method including causal relations will result in model results with less scatter and hence more explanatory power. It is unlikely that the average MAIs will change significantly. MAIs for individual water bodies may, however, be different.

The STAT models are tuned to fit with historical data. When input parameters in modelled scenarios vary within the same range as the parameters have varied during the calibration period, the model may provide results that could be validated from earlier experience. If the parameters vary beyond the range that was included in the calibration, the model is not calibrated. Since the model is to describe a state that is outside the data range used for calibration, the STAT model is not suited to forecast a state outside its calibration range. Forecast outside the calibration range also is a drawback for the MECH models, but the MECH models have the advantage that they include causal relations, and this makes application outside the calibration range less critical.

A significant effort has been carried out to validate the models. An evaluation of the quality and the accuracy of the two models in direct comparison has not been carried out. That is considered a deficiency and could be included in future work. A comparison of the two models regarding reference condition is of general interest.

Water exchange between the different water bodies as well as exchange of nutrients and other state variables are included in the MECH models, not in the STAT models. This has been mentioned by the model developers. It has, however, not been discussed with respect to the resulting effect on the MAIs. Absence of boundary transports may lead to major overinterpretation of the land-based loads, when the condition in the water body is dominated by transports from neighbouring areas – foreign as well as Danish areas. Including the residence time of each specific water body also has an important effect on the concentrations of the input from the specific catchment. Together with the boundary transports, the residence time determines the water exchange of a water body and could be included in future development of STAT models (as it has been in the Swedish model).

The STAT models are only applied for MAI-calculations in a minor part of all water bodies (approx. 15-20 per cent).

Comparison of slopes for pressure-impact relations between MECH and STAT models

Pressure-impact relation means the slope (or inclination) of the line for a quality indicator (e.g., Chl-a concentration og light) (impact) as a function of nutrient load (pressure). The data for the reference values and the slopes (inclinations) are provided by DHI and AU for present second opinion review (DHI/AU, pers. com.). The slopes are given in intervals for each 0.05 %/%, and in the following calculations and graphics, the central value of each interval is applied (e.g., for the interval (0.10-0.15)%/%, the value 0.125%/% is used – for Chl-a).

As illustrated below, many water bodies show identical or similar slopes. For some water bodies, however, significant differences in the modelled slopes (pressure-impact) are found. For each water body, where both models are applied, the slopes (inclinations) are plotted. The water bodies are sorted according to the magnitude of the difference (STAT-MECH).

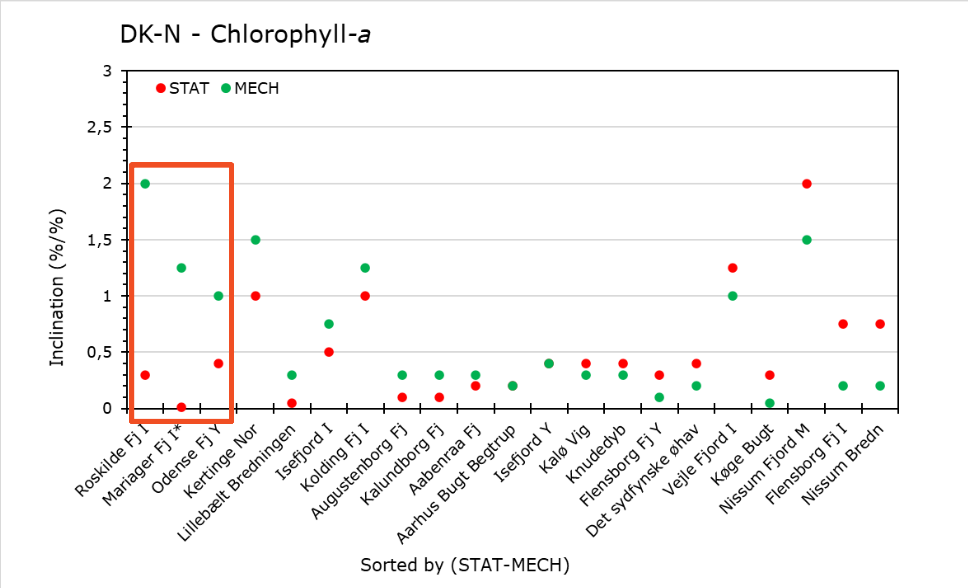

Figure 3-20: The relative deviation between inclinations of Chl-a increases as a function of the Danish N load increase. Inclinations determined by STAT and MECH models are given for each water body. The results are ranked according to the magnitude of the relative difference (smallest to largest). (DHI/AU, pers. com.)

The average slope (inclination) values illustrated in Figure 3-20 for STAT (red dots) and MECH (green dots) is 0.51 %/% and 0.64 %/%, respectively. This looks relative good at a first glance, but the numeric difference between the slopes for each water body varies significantly. The standard deviation of the numeric differences between the slopes for each water body is 0.55 and hence of the same order of magnitude as the slopes. The results of the two models differ in the same order of magnitude as the slopes themselves. This indicates that at least one of the models provides results that are off in the same order of magnitude as the slopes themselves. A discussion of the results and their deviations on fjord level is missing.

Furthermore, it can be seen from Figure 3-20 that the group of water bodies with the largest deviations (STAT-MECH) comprises inner fjords that are highly affected by local loads: Roskilde Fj I, Mariager Fj I, Odense Fjord I (marked with red in Figure 3-20). For these fjords, large slopes are found for the MECH model, indicating that this model requires less load reduction to achieve a certain improvement of the environmental key parameter. The corresponding STAT values indicate smaller or average inclinations compared with the remaining fjords, which contradicts the general understanding that these water bodies are highly affected by local sources. Therefore, the relatively low STAT response hardly seems believable and requires further discussion. Averaging the two significantly different results includes the possibility to introduce bias.

On the other hand, it can be seen from Figure 3-20 that the group of water bodies with positive deviations (MECH<STAT) mainly comprises water bodies that are less affected by local loads from Denmark (Nissum B, Flensburg, Nissum F, Køge B). These areas are represented in the right part of the above diagram. For these water bodies, the STAT model provides inclinations that are

higher than the inclinations determined by the MECH model. These water bodies are highly influenced by foreign loads (neighbouring countries). The STAT model only operated with Danish nutrient loads. For areas that are dominated by foreign nutrient loads, the STAT model explains the effects of foreign loads as a result of the (small) Danish loads and hence result in steeper slopes and indicate an unrealistic high effect of reduced Danish loads.

In the diagrams below, these systematic deviations between the two model results are confirmed by analysing the inclination for light and N load, Chl-a and P load as well as for light and P load. Note that the discretisation of the plots below is a result of the discretisation of the provided data.

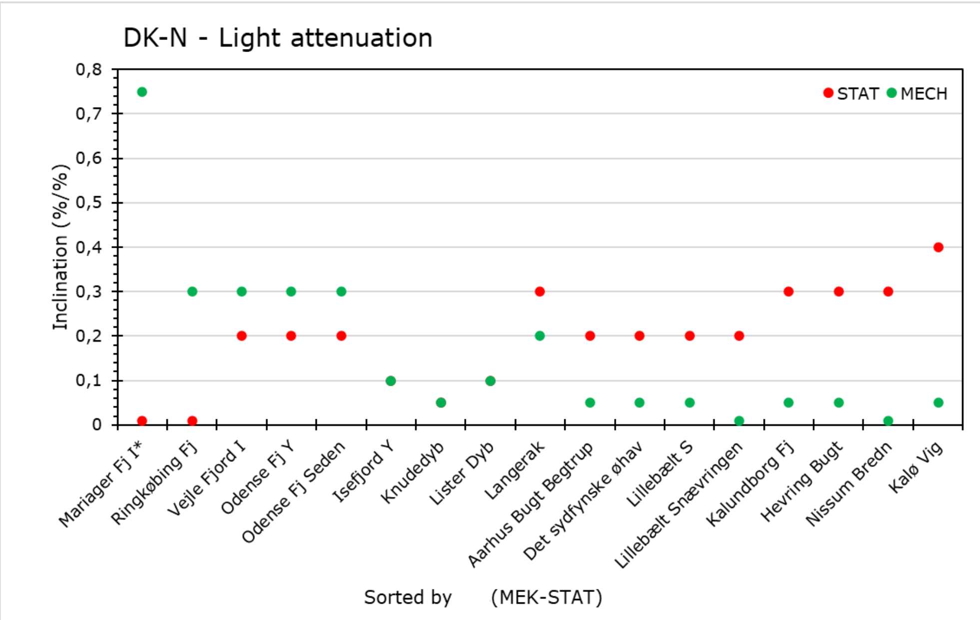

Figure 3-21: *Relative deviation between inclinations of light attenuation increase as a function of Danish N load increase. Inclinations determined by STAT and MECH models are given for each water body. The results are ranked according to the magnitude of the relative difference (large to small). (DHI/AU, pers. com.)*

For the inclination of light attenuation versus N load, the average inclination determined by the STAT and MECH models is 0.19 and 0.16, respectively, whereas the standard deviation of the difference between the two inclinations for each water body is 0.26. This means that the differences between the models are larger than the magnitude of the inclination. This underlines that at least one model is not capable of providing a result in the right order of magnitude. It has been argued that a large difference between the two models may indicate that the models are opposite biased – meaning that if the one is very high, the other is very low and hence the average would be close to correct. Because the two model concepts are independent, there is no reason to assume an in-built 'compensation mechanism'. Such mechanism would require structural and conceptual intercorrelation between the models, and since the models are completely independent, their individual uncertainties also are completely independent. In water bodies, where the two models do not confirm each other, it may be so that both models give misleading results.

Again, the difference shows the same trend where the STAT model provides higher inclinations in fjords with high local load impact and lower inclinations in areas with little local load.

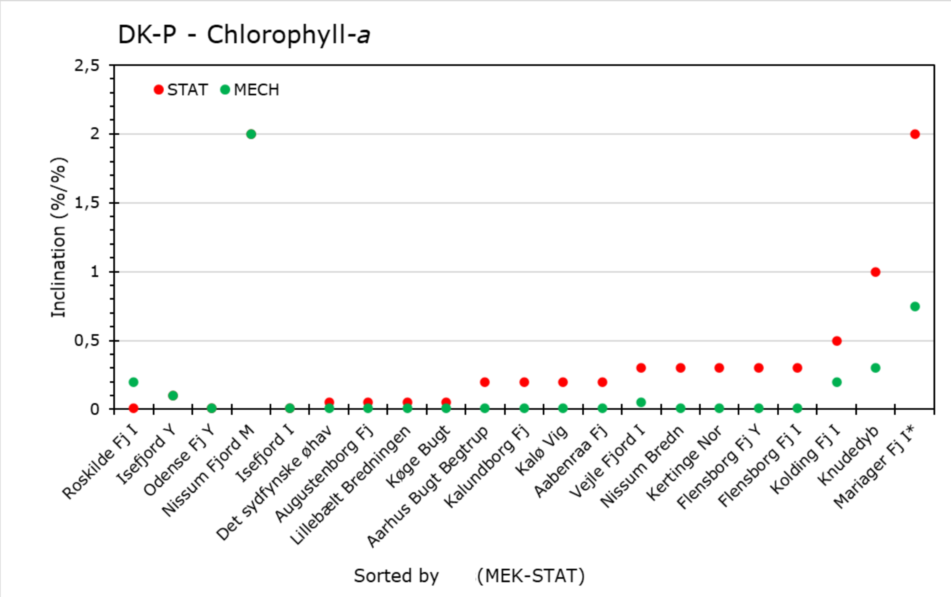

Figure 3-22: Relative deviation between inclinations of Chl-a increase as a function of Danish P load increase. Inclinations determined by STAT and MECH models are given for each water body. The results are ranked according to the magnitude of the relative difference (smallest to largest). (DHI/AU, pers. com.)

For the P dependency of the Chl-a concentration, the above diagram indicates that the STAT model in general gives higher inclinations than the MECH model. A grouping in fjords with high or low local loading is less pronounced for the P dependency.

The average inclination by STAT and MECH is found to be 0.4 and 0.2, respectively, and the standard deviation of the individual differences is 0.3. This underlines the difference in level of model results as well as the difference for each water body.

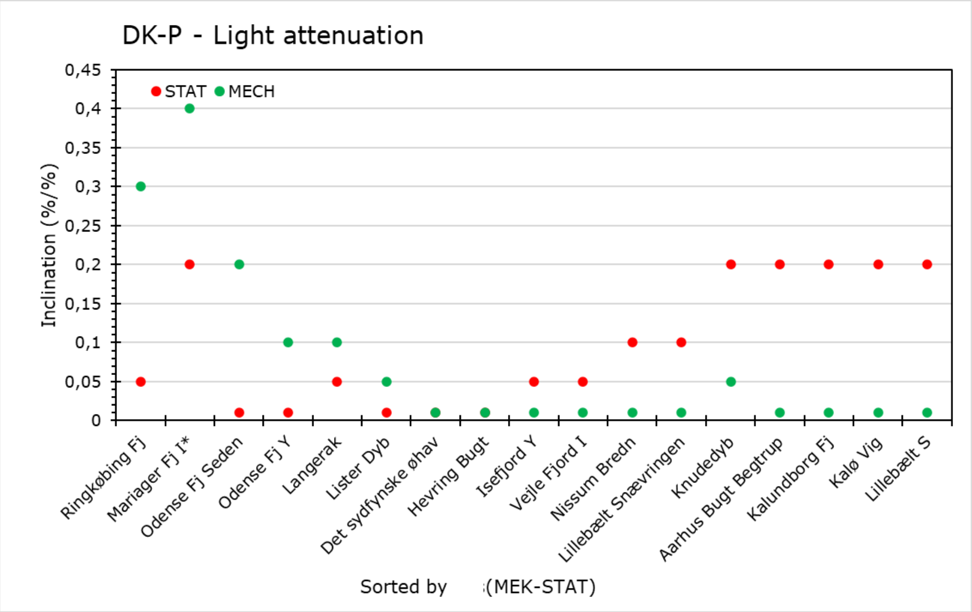

Figure 3-23: Relative deviation between inclinations of light attenuation increase as a function of the Danish P load increase. Inclinations determined by STAT and MECH models are given for each water body. The results are ranked according to the magnitude of the relative difference (smallest to largest). (DHI/AU, pers. com.)

Again, please note that the discretisation of the figure above is a result of the discretisation of the provided input data.

For the P dependency of the light attenuation, the average inclination by STAT and MECH is found to be 0.10 and 0.08, respectively, and the standard deviation of the individual differences is 0.14. This underlines the difference between the model results for each water body.

Systematic deviations between slopes modelled by MECH and STAT

To illustrate the degree of relative agreement between the results of the two models, a relative difference is determined by dividing the absolute difference by the result of the MECH model. The results are illustrated in Figure 3-24 to Figure 3-27.

Since the deviations relative to the MECH results vary significantly, the lines for +50% deviation for –50% deviation are inserted in the figures. This provides a band with for results that only differ with 50% and illustrates parameters where the results differ significantly, such as the plots for DK-N - light, DK-P - chl-a and DK-P – light.

In the following diagrams, the points are grouped within equal values. This is a result of the discretisation of the input data. The diagrams serve to illustrate the order of magnitude of the relative deviation between the results of the different model concepts.

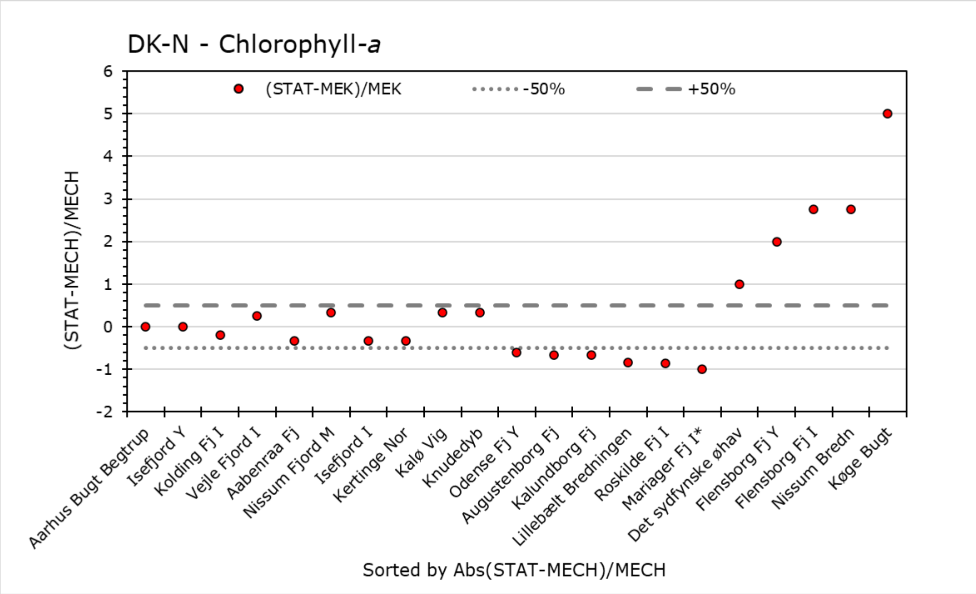

Figure 3-24: DK-N – Chl-a slopes. Relative model differences. A band width of ±50% is indicated by horizontal lines. (DHI/AU, pers. com.)

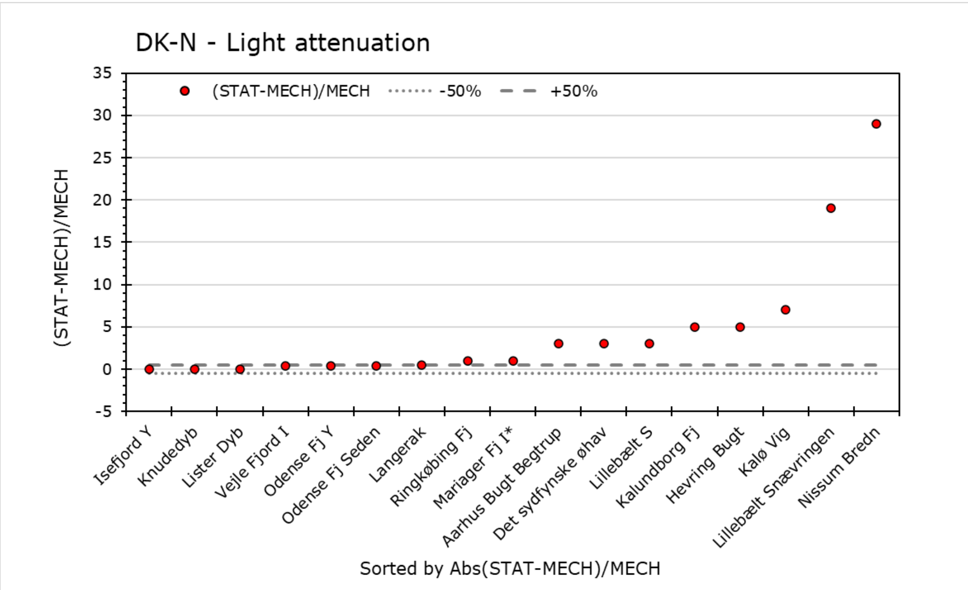

Figure 3-25: DK-N – Light attenuation slopes. Relative model differences. A band width of ±50% is indicated by horizontal lines. (DHI/AU, pers. com.)

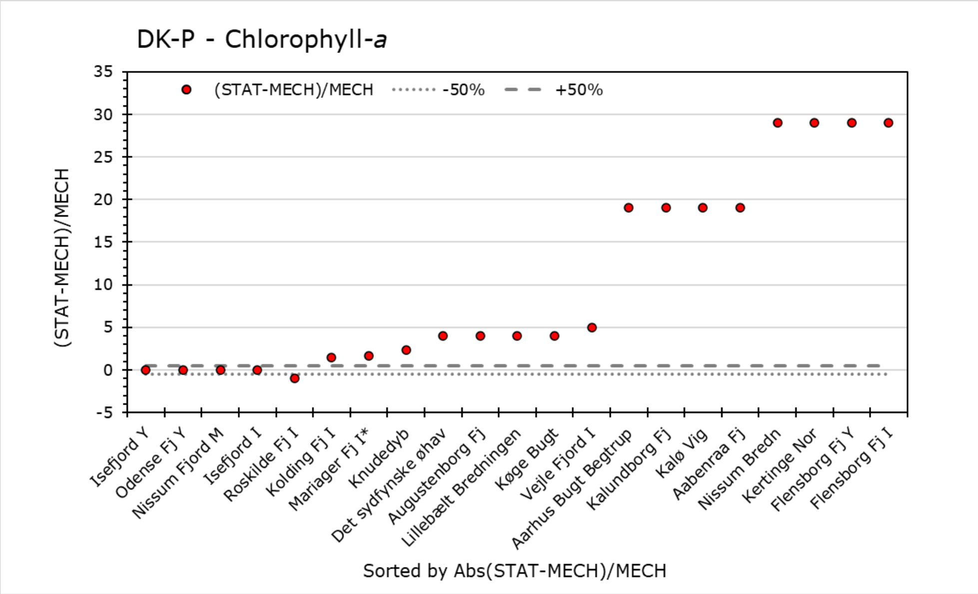

Figure 3-26: DK-P – Chl-a slopes. Relative model differences. A band width of ±50% is indicated by horizontal lines. (DHI/AU, pers. com.)

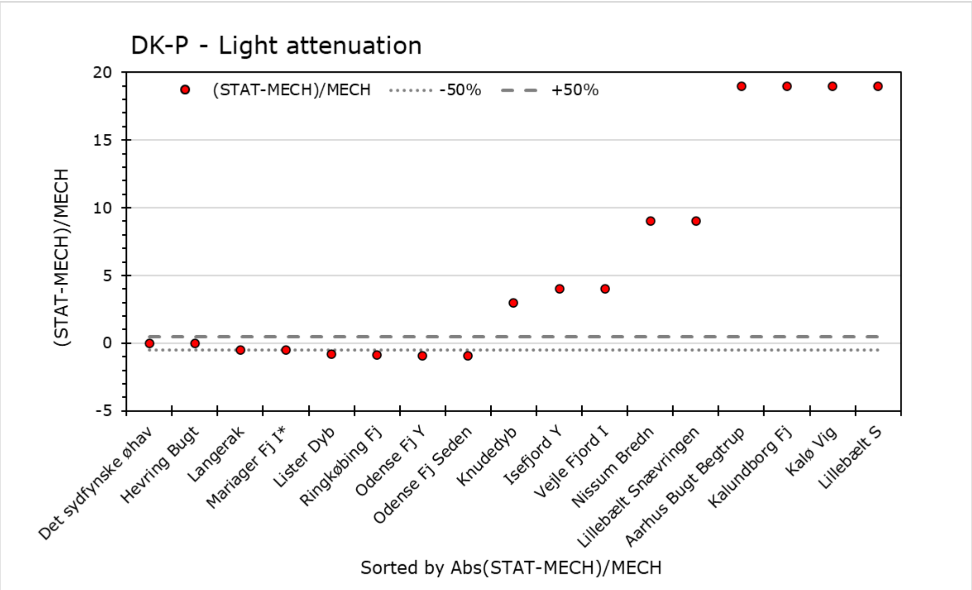

Figure 3-27: DK-P – Light attenuation slopes. Relative model differences. A band width of ±50% is indicated by horizontal lines. (DHI/AU, pers. com.)

The figures illustrate that a high difference between the models corresponds with the STAT model consistently giving higher slopes. If the models were neutral, their differences would randomly be positive and negative. This is the case for water bodies with small differences. For larger differences, however, the models seem to be biased so that either the STAT model gives too large slopes or the MECH too small slopes. Also, both models may not give the correct order magnitude, but this does not mean that an average of two doubtful values would provide a trustworthy estimate.

The fact that the water bodies of concern (Køge Bugt, Nissum Bredning, Flensburg Fjord and Det Sydfynske Øhav) are all areas with relatively small local loads compared to boundary transports, and since these transports are included in the MECH, but not in STAT, indicates that, for some areas, the STAT model is less adequate than the MECH model.

The slopes are, as mentioned above, used with equal weight, and for those water bodies where both models have provided results of acceptable quality, the average of the two inclinations is applied. This requires two preconditions:

- A sorting procedure for results that obviously are not considered suitable.
- An assumption that both models (STAT and MECH) are of equal and comparable quality to be used in the present situation.

In the present situation, it is not enough to describe recent states of the environment, but the results must be used to forecast what will happen if certain measures are taken with regards to load reduction (the management scenarios). It is thus the goal to assess how the system will react to certain measures. Therefore, a full integration of our understanding of the relevant and essential relations must be applied to provide the best basis for decision-making.

The existing knowledge can be incorporated into STAT models as well as into MECH models. It is, however, of paramount importance that as much as possible of the existing knowledge that is of primary relevance for the phenomenon that is to be described is incorporated into the model.

To that end, improvements can be made by:

- describing which objective criteria were applied to carry out the sorting of model results.
- providing the documentation of why both model results are of equal quality. It is not enough that the two methods are independent; they also must be of equal credibility.

Such documentation could be provided by an analysis, illustrating to what degree the models are capable of determining the reference value for Chl-a and Kd when the loading of N and P is reduced to reference level.

Concept of modelling MAI

The concept for calculating MAI is illustrated in the diagram below. It is based on marine monitoring data (measurements) as well as on nutrient loads. The monitoring data is used for calibration for the MECH models and as basis for the Bayesian STAT models (STAT). The two model concepts provide their respective values for the reference concentration (Erichsen et al., 2021b) in the reference situation (almost unaffected situation) as well as the slope for dose-response (pressure-impact) relation. The two sets of reference values are combined into a single reference set. Together with the dose-response slopes and the status condition, the reference values provide the basis for calculating the MAI input of nutrient (MAI). The concept is illustrated in Figure 3-28.

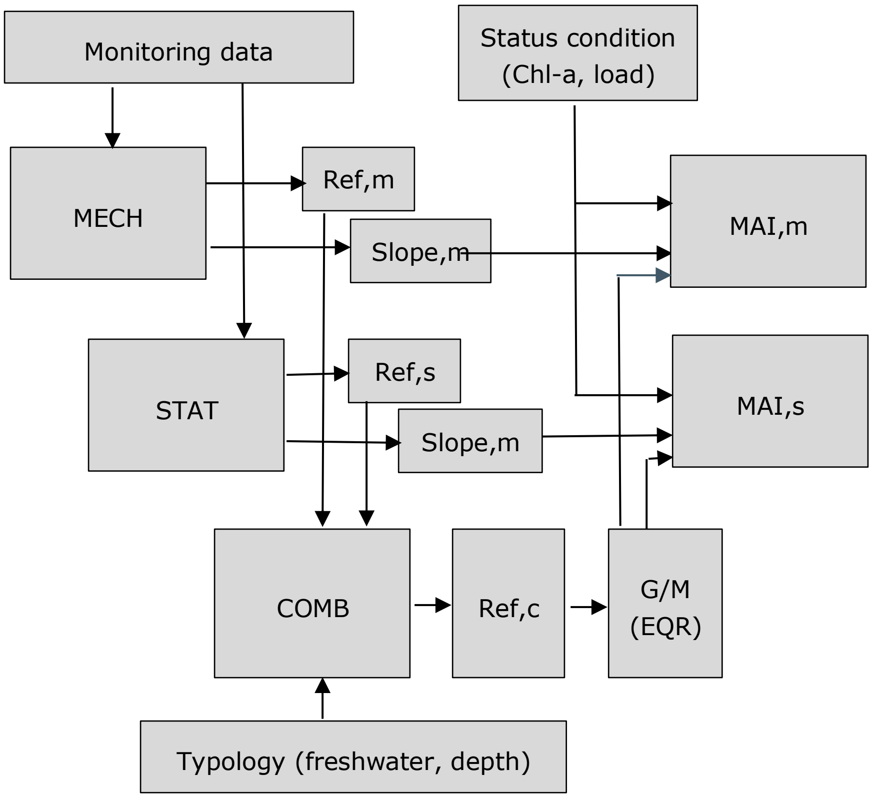

Figure 3-28: Chl-a: Conceptual flow diagram of the modelling process for determining the MAI for Chl-a for a specific management scenario.

The reference values are combined, including selected typology parameters, by means of the combined (COMB) model by means of a multi-variable regression analysis based on the most descriptive parameters: freshwater impact and water depth. The COMB model reduces the two sets of reference values (from MECH and STAT) to a single set of reference values. Applying the EQR values provided from the intercalibration, the limits between G/M condition are determined.

Based on the present status of nutrient load and Chl-a concentration, on the G/M target and on the dose-response slopes from the MECH and the STAT models, MAI values are determined based on MECH and STAT methodology.

The above procedure also is carried out for depth limit of eelgrass, although in a simplified form since the reference condition for depth limit is based on historical data. For eelgrass, historical data from a period close to the reference condition is available and has been applied. Therefore, the modelling procedure is a bit different for light than for Chl-a. The concept is illustrated in Figure 3-29.

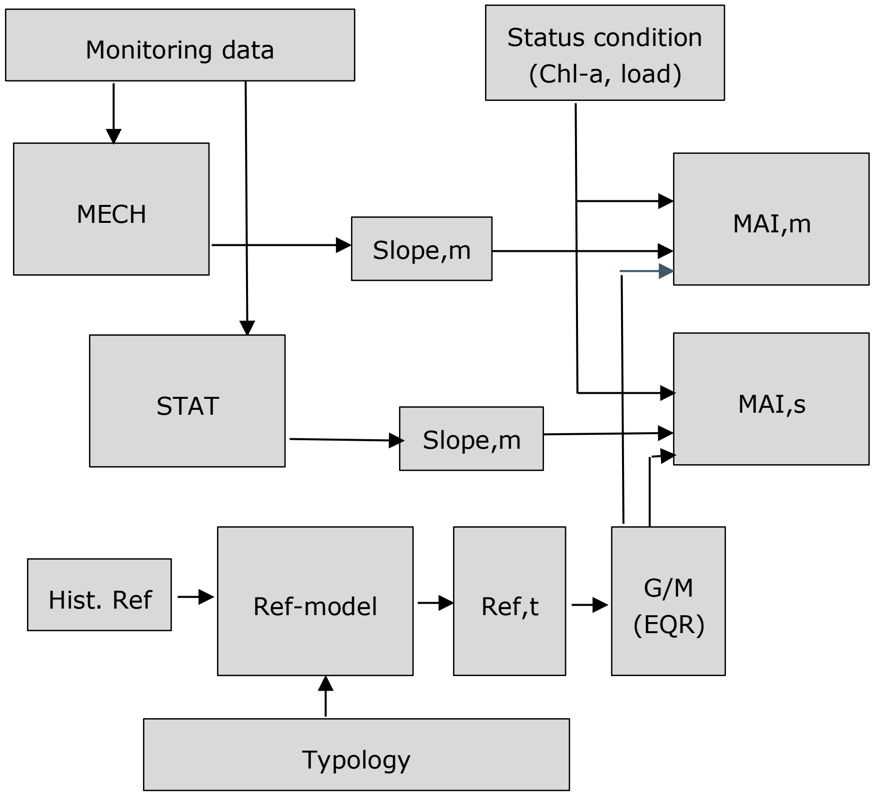

Figure 3-29: Light: Conceptual flow diagram of the modelling process for determining the MAI for eelgrass for a specific management scenario.

It is seen that the reference values for eelgrass depth limit are determined based on historical observations for the water bodies where such observations are available. For the remaining areas, the reference values are determined based on a typology-based model.

The above modelling concept utilises information from the marine monitoring programmes including nutrient load from lands and atmosphere. Furthermore, the concept utilises the historic information on eelgrass depth limits from a time when the condition can be assumed to be close to undisturbed by man-made nutrient loads.

The models are not calibrated against eelgrass depth limits, rather against Kd measurements. To calculate the target light penetration depth in both MECH and STAT, knowledge about relations between light requirements for eelgrass and light availability at different depths is used to convert the eelgrass depth limits at GES to a corresponding light penetration depth, using light attenuation as the relevant indicator.

The process from the four different and partly independent calculations of MAI to a single value is illustrated in the below Figure 3-30.

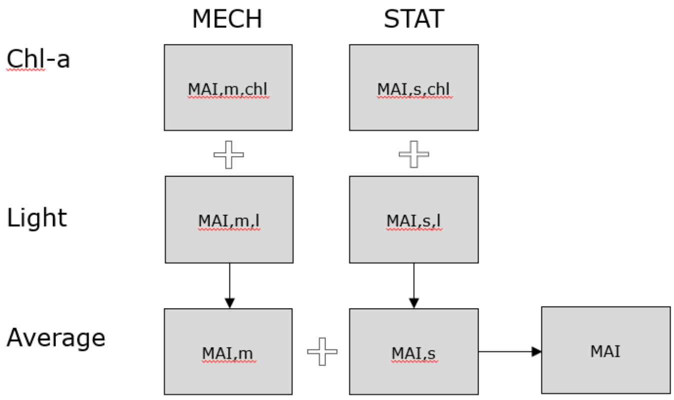

Figure 3-30: Calculating MAI based on averaging results from two models and two parameters.

The two MAI results determined by MECH models for the two quality elements (Chl-a and light) are combined to one MECH-based value, MAI,m.

In parallel, the two MAI results determined by STAT models for the same two quality elements are combined to one STAT-based value, MAI,s.

These two values (MAI,m and MAI,s) are again combined (averaged) to a single resulting MAI.

The process of combining/averaging four modelled values to a single final value, as outlined above, is a process that is not based on an in-depth scientific understanding of credibility, uncertainty, and relevance of the different values. The fact that all four basic values are included at an equal level is not a 'safe way' of action. The applied method taitly assumes that the values are of equal or at least comparable quality. It is the opinion of the reviewer that this assumption is not given and that a scientific selection of the model values is required, because the values often differ significantly. Hence, one or even more values cannot be correct, but as they are included at an equal level, they influence the result.

The chosen averaging sequence also could be carried out alternatively by averaging results for each parameter across the modelling methods first and then averaging across the parameters second. Although different averaging methods will lead to (slightly) different results in areas with three model results, it is assessed that there is no clear indication from a scientific point of view that the one averaging method should be more reliable.

It should be noted that in terms of nutrient loadings supporting GES, target values should in principle be the same across BQEs, as they represent the same ecological status (G/M) and therefore also the same level of human activity, cf. task 1. Therefore, averaging the different MAIs is defendable from a scientific point of view.

It should also be noted that the 'one-out-all-out' principle, stating that all BQEs must achieve GES, is relevant in terms of monitoring conditions and fulfilment of the WFD, but not in relation to calculating the required need for reductions. The applied method for averaging the results with the aim to end up with a single value is hence considered numerical or statistical stable. This method that reduces 4 results to 1 single value requires that the four input values all are of comparable quality. This pre-assumption is not discussed, although relevant to the present reviewer's opinion.

Comparison between MAIs based on MECH and on STAT models

The consequences of the performance difference between STAT and MECH models regarding reference values and dose-response-slopes are also found in the calculations of the MAI, se Figure 3-31. The water bodies where MAIs are calculated for STAT and MECH models (including MAIs determined for the Chl-a as well as for the light parameters) are sorted in relation to the relative MAI difference (MAI calculated with STAT less MAI calculated with STAT, and the difference is divided by the MAI from MECH).

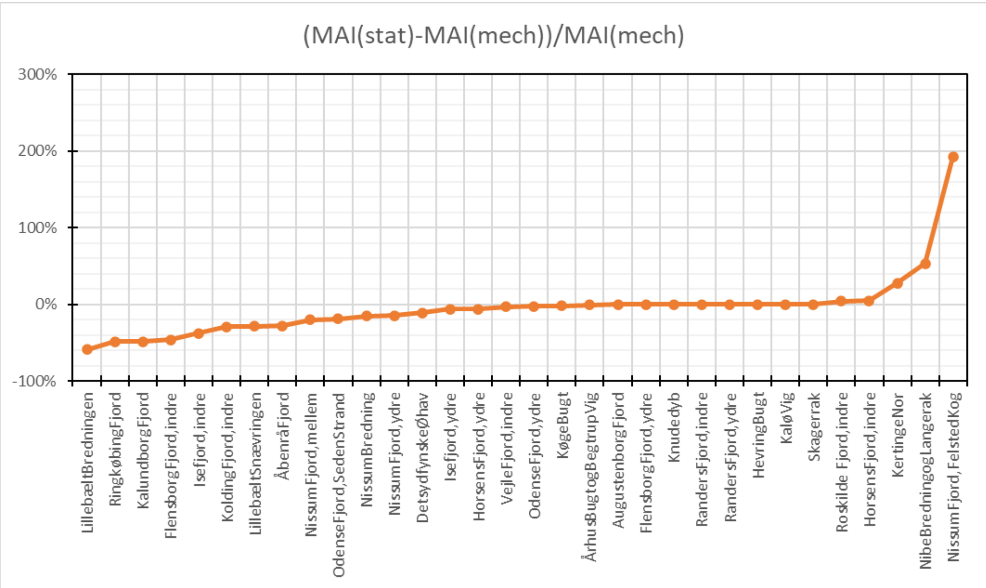

Figure 3-31: Relative difference (%) between the MAIs calculated by STAT and MECH methods divided by MAI calculated by MECH.

It is seen that about eight out of 33 areas have relative differences of less than -20 per cent, and that three have relative differences of more than +20 per cent. For these water bodies, the average MAI is based on significantly differing values. A more thorough analysis and an evaluation of the reason for such differences is lacking. This leads to a request for a scientific recommendation for a reliable and practical MAI for the 8+3=11 water bodies. The fact that 11 out of 33 water bodies require an explanation indicates that also the MAIs of approx. one third of the remaining water bodies may need more interpretation.

Every modelling result requires interpretation of the numerical results. The fact that the results differ in some water bodies is the logic consequence of applying two different modelling approaches. The logic consequence of such findings is to implement the calculated measures to observe and measure the response of the system. When these observations give rise to changed or refined methods, these changes can be adopted.

3.4.3 Concluding remarks

The degree of refinement of the applied models (MECH as well as STAT) is assessed to be remarkably high and reflects the constant development during the past three plan periods. Therefore, it is assessed that further development of the models in terms of inclusion of more processes or further detailing of numerical process description will not add substantially to the accuracy of the model results. On the contrary, it is assessed that increased complexity may add to the uncertainty and reduce transparency of the modelling. This effect is illustrated in a conceptual sketch in Figure 3-32.

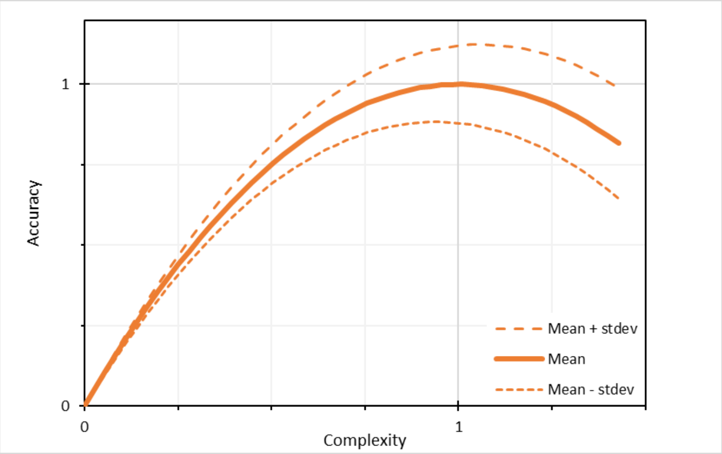

Figure 3-32: Conceptual sketch illustrating the risk of over-developing the complexity of a model system. It will lead to decreasing accuracy and increasing uncertainty.

It is assessed that the developed models can be located close to the value 1 of the x-axis. It is thus concluded that further benefit of the scientific basis of the RMBP3 is to be gained from other activities, such as implementation of pilot projects: To describe recovery processes, pilot projects can be carried out, where measures are enforced, or even over-enforced and N load is reduced significantly. This will provide new data for systems in a low-load-regime. Model improvements might be achieved more efficiently by pilot projects instead of theoretical model refinement.

Although the use of Kd as a proxy for eelgrass depth limit has been subject to critique from the international evaluation panel, the second opinion finds that the 'K_d-proxy', is a valid parameter to be used as proxy for the ecological G/M class boundaries in model calculations.

For the comparison between the modelled impulse-response inclinations to N and P input, the following observation is made: The larger the difference between the MEC and the STAT models, the more often the STAT model provides larger inclinations. The remarks below indicate that the MECH models have a higher scientific credibility than the STAT models.

Higher inclinations mean higher effect of relatively smaller reduction in N and P load. If the STAT inclinations, however, are too high, this implies that the resulting average of MECH and STAT inclinations will be too high also and, hence, the required load reduction too small.

Observation of differences as in Figure 3-31 can, though, not be an excuse for not to reduce the nutrient load and to wait for later clarification. That will only waste time and add to further deterioration of the environmental state.

Based on the assessments in the sections above, the following is concluded:

- Spatial resolution of the models is enhanced compared to the 2nd plan period.

- Reference values for Chl-a (in almost undisturbed conditions) are lower when based on MECH than when based on STAT. This may bias the calculation of MAI when the results of both models are weighted equally in the combined result.

- STAT model

  - By definition, the STAT model includes less information and less knowledge of the functionality or causal relations of the ecosystem than the MECH model.
  - Therefore, the results of the STAT models cannot be compared at an equal level with the results of the MECH results.
  - The results of the STAT model can be applied as a supporting tool for the MECH model. It is noted that Sweden and Germany do not use the same STAT model concept for assessing MAIs as Denmark did in RBMP3.

- The Danish STAT model concept can be improved by adding causal relations between the different key parameters and thereby applying existing understanding of key processes in the marine ecosystem.

- Scientific discussions of the results in general and in particular of obvious discrepancies between MECH and STAT models will help the reader to assess the results in a broader context. This has been carried out in RBMP2 and it can be considered also to prepare a corresponding scientific discussion for RBMP3.

Further model development: The models represent state-of-the-art models that are developed to a high degree of complexity. Adding further complexity to the models and/or their input data implies a risk of adding to the uncertainty without adding to the accuracy and the reliability of the models. A validation campaign documenting a recovery process of a water body seems more appropriate.

3.5 Task 5: Burden distribution

Burden distribution covers 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.

3.5.1 Objective

The applied method as well as its preconditions used for quantifying N contributions from other countries via atmosphere and waters are to be assessed. In particular, the effect of N contributions from other countries is to be compared with the effect of measures in Danish coastal waters.

N loads from other countries comprise loads:

- via atmospheric deposition
- via oceanographic transports.

The methods applied in RBMP3 are compared to the method in RBMP2.

For the analysis of different burden distributions, the results of management scenarios 2a-e, 3a-b (Erichsen et al. 2021c; Erichsen et al. 2021d; Erichsen et al. 2021e; Erichsen et al. 2021f; Erichsen et al. 2021g; Erichsen et al. 2021h; Erichsen et al. 2021i) are applied. The analysis also comprises a description of the limitations of the applied methods.

3.5.2 Analysis and assessment

The consequences of different scenarios for nutrient loads in Denmark and in neighbouring countries are determined by application of the mechanistic model tools. The model tools and the input data hence represent the basic issues that can be assessed in terms of scientific terms.

It is obvious that the influence of the nutrient concentrations from loads from neighbouring countries are different in different water bodies. Water bodies that are highly influenced by nutrient loads from neighbouring countries and only slightly influenced by loads from Denmark (e. g. Wadden Sea, Bornholm) will react different to load reductions from Denmark than water bodies that are dominated by loads from Denmark (e. g. Horsens Fjord, Odense Fjord). For the first type of water bodies, load reductions from Denmark even down to reference loads may not lead to good environmental status in these water bodies. For the second type of water bodies, load reductions in the Danish catchment areas may very well lead to good environmental status.

The formulation of scenarios for various inputs from neighbouring countries can be carried out based on a variety of principles, e.g., ‘most likely’, ‘worst case’ or ‘best case’, and according to existing agreements, etc. Selection of load scenarios serves to set the scene for the range that can be expected for the resulting MAIs. The more scenarios that are investigated the more estimates for possible MAIs will be modelled. This again will provide an expected range for

MAIs necessary to support GES. By choosing enough and relevant scenarios, the managing authority can reduce the risk of overseeing scenarios that result in unexpected high or low MAIs. For the RBMP3, 11 scenarios were investigated, which is considered as sufficient for selecting the most appropriate scenario to determine the MAIs necessary to support GES. Eight of these were scenarios based on different expectations for other countries' contributions. It follows that there is no scientific argument for adding more scenarios.

In the present context the term "burden distribution between countries " describes the extent to which a country must reduce its own nutrient loadings extraordinarily because some countries do not reduce their nutrient discharge enough to achieve GES within their own or common water bodies and hence affect the environmental status negatively in their neighbouring countries via transboundary transports – currents at sea and in the atmosphere. How a country must react to different possible burden distributions is considered a management decision. It is, however, relevant to assess different alternatives to the current strategy. Like all other international agreements, the distribution of burdens between countries can be handled through international cooperation fora (e.g., HELCOM and OSPAR). It is assessed that international agreements on burden distributions will require provision of comprehensive scientific documentation that implemented and/or planned national measures to achieve GES would be sufficient and that transboundary transports from other countries are preventing achievement of GES.

Since the distribution of burdens between countries (i. e. the extent for which a country shall reduce nutrient loadings a little extra because other countries do not reduce their transboundary emissions enough) is mainly a management decision, it can be relevant to assess different alternatives to the current strategy. The distribution of burdens between countries can be handled though international treaties (e. g. HELCOM and OSPAR) or e. g. by providing sufficient scientific documentation to state that national mitigation measures to prevent eutrophication are fair and sufficient but emissions from neighbouring countries are preventing the achievement of GES. Each additional specific scenario implies that evaluation of the results shall be carried out in light of the specific precondition of the chosen scenario.

The investigated scenarios are briefly described below, note that scenario 2e was chosen for RMBP3:

Table 3-8 Management scenarios prepared during RBMP3 (Erichsen, 2021j)

Scenario no.	Sub.no.	Description
Scenario 1 (Regional treaties)	a	Full implementation of the BSAP (HELCOM) and similar reduction targets in the North Sea (OSPAR) Implementation of RBMP 2015-2021 in all relevant EU countries Full implementation of the NEC directive with respect to atmospheric N deposition
Scenario 2 (Full NEC implementation + land-based nutrient)	a	Neighbouring countries are assumed to have had the same percentage of nutrient reduction as Denmark when Danish land-based N-MAIs are reached. The reduction percentage is relative to the basis period 1997-2001.
	b	Neighbouring countries are assumed to have had the same percentage of nutrient reduction as Denmark when Danish land-based N-MAIs are reached. The reduction percentage is relative to the basis period 1997-2001
	c	Loadings from neighbouring countries are unchanged compared to the present-day loadings (2014-2018)
	d	Danish land-based N-MAIs assuming updated BSAP targets. A new set of targets is being developed in HELCOM and will be adopted by the end of 2021.
	e	Scenario '2d' plus additional Wadden Sea P-reductions
Scenario 3 (implementation of BSAP and RBMP2 + Atmosphere N scenarios)	a	Danish land-based N-MAIs correspond to 2027 NEC-prognosis. Both Danish and international N depositions are based on the prognosis of the NEC implementation instead of the full implementation.
	b	Danish land-based N-MAIs assuming synergy impacts from climate actions. As Denmark and other countries work to minimise climate changes, some synergies are expected to impact N depositions as well.
WFD scenarios	a	Increasing the likelihood of achieving GES by changing the indicator target values from the G/M boundary to a target value between good and high status.
	b	One-out-all-out principles. This approach will use average model results per indicator but include the lowest MAI between the two indicators.
	c	MAI calculations are performed without taking the system contribution into account.

With regards to the WFD scenarios, they are included to illustrate the substantial modelling work that is carried out. They are of less relevance to burden distribution.

As stated above, there is no scientific argument for adding more scenarios than the eight regarding contributions from other countries already developed and listed above. Of course, one may decide to add additional scenarios. Additional scenarios can still be important in terms of calculating MAIs which support politically decided levels of measures within the legal boundaries of the WFD, despite not being able to achieve GES through national measures alone. Therefore, we present below three alternative scenarios and their inherent complexity. All three suggest different views on how emissions from other countries could be taken into account in the Danish management approach. It is a precondition that such alternatives fall within the legal boundaries of the WFD, article 12. They all assume that Denmark meets its requirements. For those water bodies where it is not possible for Denmark alone to achieve GES within reasonable ranges of measures, because of large transboundary input of nutrients from other countries, fair solutions are to be found in cooperation with these countries. Such solution entails that Denmark would implement measures that, if neighbouring countries would not implement additional measures, would not be enough to reach GES for these water bodies that are highly impacted by foreign nutrients (e.g., Wadden Sea, Bornholm, Køge Bay and Flensborg Fjord). It is expected that such solutions between countries require scientific documentation from the Danish side to convince the neighbouring countries about their responsibilities.

Alternative I: No distribution of burdens

An alternative scenario which have not previously been reviewed, could be to focus only on Danish anthropogenic contributions when calculating target loads, and calculate the need for reductions independently of the current ecological status of water bodies.

This would imply, for example, that if a water body in GES could handle N-concentration-levels corresponding to 50 tonnes N per year, and Danish loadings only account for four tonnes N per year, then the need for reduction is met with regards to Danish measures. If contributions to the N concentration from other countries correspond to 48 tonnes N per year (measured in Danish loadings), then the necessary reduction (of what corresponds to a Danish load) is two tonnes N per year to meet GES. With the "no distribution of burdens" perspective, the necessary reduction of two tonnes N per year in this example should not be the responsibility of Denmark as Denmark is already way below 50 tonnes N per year. Denmark would in this scenario still undertake the necessary reductions to meet international agreements in HELCOM and OSPAR as well as other relevant EU-directives etc., but with regard to Danish coastal waters, Denmark could make the case, that it cannot regulate foreign emissions. In the context of the Danish marine models, this strategy would imply, that contributions from foreign loads are set to zero (or an equivalent to non-anthropogenic emissions), and that Danish emissions are regulated on this basis.

Such a strategy would presumably require excessive documentation on a water body level, stating Danish contributions versus foreign contributions, as well as the MAI of nutrients regardless of origin, represented in Danish loadings etc.

Alternative II:

Neighbouring countries are assumed to have the same percentage of nutrient reduction as Denmark when Danish land-based N-MAIs are reached. The reduction percentage is relative to the basis period 1997-2001

A strategy where all countries reduce emissions by the same percentage implies, the distribution of burdens (i.e., a country's relative share of impact to a given water body) is constant from a chosen basis period and onwards. The basis period 1997-2001 implies, that the burden distribution from when the WFD entered into force provides the basis for long term burden distribution.

This strategy would imply an increased national need for N reductions of around 600 tonnes (see scenario 2a).

The selected basis period could in principle also be set to other relevant years. If, for example, the basis period is selected at around 1990 when the Nitrate-Directive entered into force and when countries began reducing nitrogen loads, it would mean, that the long term burden distribution is based on the years where nitrogen emissions around Danish waters peaked, and it presumably would reduce the current need for reductions relative to RBMP3, as Danish reductions in the 1990's would be taken into account, and thus imply a higher need for reductions in other countries, since other countries did not reduce emissions to the same extend in that period.

It has not been tested whether a revised basis period would in fact result in a lower need for reductions, nor has it been analysed whether such a strategy could be adopted.

Alternative III:
Neighbouring countries are assumed to have the same area-specific anthropogenic loadings (kg/ha) as Denmark when Danish N-MAIs are reached.

This strategy would imply that loadings per catchment areas should be the same across countries. This would imply a relatively higher need for reductions in Denmark, as the present average emission levels in general are higher in Denmark than in neighbouring countries.

This strategy would imply an increased national need for N reductions of approximately 10,000 tonnes (see scenario 2b).

Model

The applied model (MECH) includes the contribution from neighbouring countries as an intrinsic part of the model set-up.

The model treats the nutrient loads to the marine waters in the neighbouring countries consistently, in the same way as the input to the Danish waters. The applied oceanographic processes for transport, dilution, uptake, sedimentation, mineralisation etc. of nutrients are identical: The only difference is the spatial resolution of the model for the Baltic Sea compared to the model for the IDW and fjords.

Also, the model treats the atmospheric deposition on the surface of the Danish waters from Danish sources and from neighbouring countries equally. The same processes are applied, and the same calculations are carried out.

The description of the bio-geo-chemical processes in the models for the IDW and fjords is developed and refined between RBMP2 and RBMP3.

Boundary data

The input of nutrients from countries around the Baltic Sea and the Wadden Sea (North Sea) is applied to the model the same way as the input from Denmark. The inputs are given as time-dependent fluxes of nutrients at the respective discharge points of the rivers.

Whereas highly detailed input from Denmark is given based on national inventory data, the remaining loadings to the Baltic Sea are obtained from the HELCOM database, which collects a consistent data set of nutrient loads to the Baltic Sea from the Baltic countries. The HELCOM dataset is widely considered to be the most consistent and reliable data available.

Model limitations

The model approach treats nitrogen from all sources equally. This means that nitrogen discharged to the Baltic Proper from, e.g., Poland and nitrogen discharged from the city of Flensburg to the Flensburg Fjord both add to the load of Danish waters. Since the model operated with inorganic and organic nitrogen, it describes most of the bioavailable nitrogen fractions. Also, the most important geo-chemical processes between sediment and water are included in the model.

Nitrogen from Poland (e.g., the Wisla River) stays in the upper layers of the Baltic Sea. The residence time of the upper layer (above 60 m) is often set to approx. 6 to 10 years, contrary to the residence for the entire Baltic Sea of 25-30 years. After being in the upper layers for approx. 6 years, the nitrogen from the rivers and atmosphere has participated in several biological processes and is only bio-available to a minor degree and hence do not have full impact on the environmental status (Markager et.al, 2016). Nitrogen discharged in the vicinity of the Danish waters (e.g., to Flensburg Fjord) reaches the Danish areas within days or weeks and is therefore bioavailable to a higher degree and, in turn, of more relevance for eutrophication.

The sediment-water exchange processes of nitrogen and phosphorous are highly complex. Particularly over long periods small uncertainties in the exchange processes may lead to major uncertainty of the nutrient fluxes.

Hence, the issues of bioavailability and sediment exchange rates for nutrients are processes, where the model may be further developed in future.

3.5.3 Concluding remarks

- The applied models are state-of the-art from a scientific point of view. The applied models in RBMP3 are refined compared to RMBP2 with regards to improved process descriptions.

- Best available data is applied (e.g., HELCOM database).

The effect of the contribution from the atmosphere and adjacent water bodies as well as measures in Denmark are included in the analysis in a consistent and scientifically sound way. The complex effects of bio-available nitrogen contributions from neighbouring countries as well as nutrient exchange between sediment and water column are included in the model.

Eight scenarios have already been developed for how other countries' nutrient emissions affect Danish coastal waters. Together, they provide a sufficient basis for selecting the most appropriate scenario to determine the MAIs necessary for achieving GES based on plausible emission levels from other countries. It may be decided to add additional scenarios to the eight already developed regarding contributions from neighbouring countries. Such additional scenarios would not, however, add scientific clarity to the combined overview, rather explore whether there is a managerial/political RFM in terms of applying calculated need for reductions where MAIs are not based on achieving GES, given significant foreign contributions, but based on politically decided burden distributions within the boundaries of the WFD, where achieving GES might require more foreign reductions than currently taken into account in the RBMP3. Since additional model development will not add scientific clarity, there is no argument for scenario development having an upsetting effect on implementation of measures to reduce nutrient loads.

3.6 Task 6: Target load, target achievement

3.6.1 Objective

The objective of this task is to assess the preconditions for calculation of target N load (MAI) and the certainty for achievement of target N load.

The above main objective is divided into the following sub tasks:

- Brief description of method for determining the target load (2027) that will support achievement of the environmental objectives. Description of methodological approvements introduced in plan period 3 (PP3).
- Model-uncertainty for achievement of target load given the precondition for calculated target loads.
- Assessment of the impacts of the technical data improvements from RBMP2 to RBMP3 on the certainty of the target load calculation.
- Scientific evaluation of the main area of applicability of the methods applied for target load calculation and their limitations.
- Description of all elements that MAI depends on defined RC, environmental target, model preconditions etc.

3.6.2 Analysis and assessment

During the projects 'Application of the Danish EPA's Marine Model Complex' and 'Development of a Method Applicable for the River Basin Management Plans 2021-2027', a number of STAT and MECH models were developed to describe the indicators used for calculating MAI (Erichsen et al. 2021b). Both models were developed based on existing data.

Figure 3-33: Nutrient contributors (from Erichsen et al. 2021b).

As illustrated in Figure 3-33, the nutrient contributors are based on atmospheric deposition, land-based N and P loads from Denmark and contributions from other countries.

In order to evaluate the response of the indicators (Chl-a, eelgrass) to changes in nutrient (pressure) loadings from different nutrient contributors to the various water bodies, the pressure response is assessed in a number of management scenarios carried out with both MECH and STAT models, see the report for the different scenarios (Erichsen et al. 2021b).

A linear relationship is assumed between land-based N loads and changes to the indicator (eelgrass depth or Chl-a). The researchers established this correlation during work carried out for 2rd RBMP in 2015-2021 (Erichsen et al. 2017) and found a good approximation in most water bodies. However, in some water bodies, the nutrient load is not the limiting factor, which is why the approximation is less certain (Erichsen et al. 2021b). The sensitivity of each nutrient contributor is quantified and applied for the calculation of MAI.

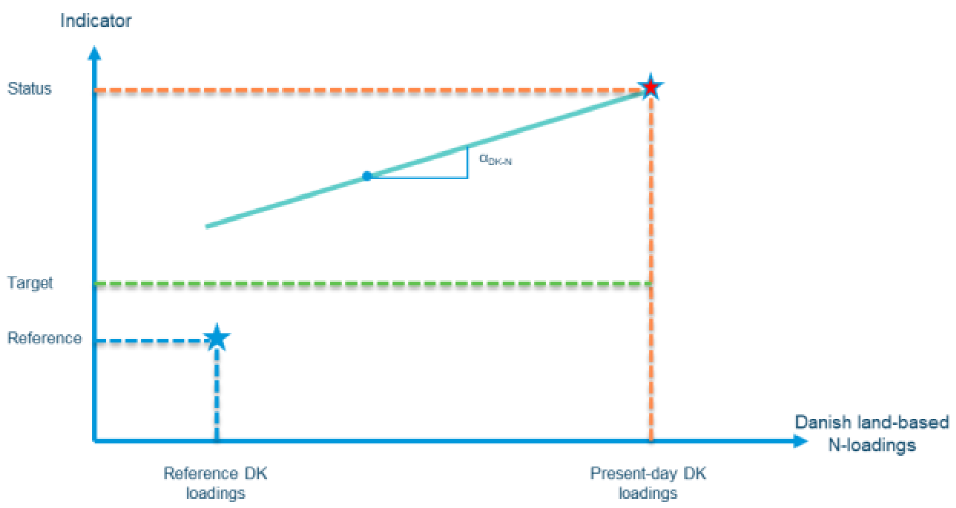

Figure 3-34: Schematic description of the pressure-response of an indicator (x-axis) to N loading, and, in this case, Danish land-based N loadings (Erichsen et al., 2021b). The slope represents the response of the indicator to the pressure of the nutrient load.

As the slope for each nutrient load contribution (see Figure 3-15) is determined separately, the overall effect and collected impact are accounted for by addition of the individual pressure impact plus addition of a system contribution.

The calculation of MAI is based on RCs, the environmental target and defined load conditions that are determined according to the four management scenarios.

The loads of the management scenarios are defined by the researchers to show the effect of the different prerequisites that are decided by the Ministry of Environment and Food.

The administratively decided management prerequisites are:

- As for RMBP2, the aim is to reach the boundary between good ecological status and moderate status (G/M boundary), which implies that 50 per cent of coastal waters will statistically reach target achievement (good ecological status)

- Full implementation of the Baltic Sea Action Plan (HELCOM) and similar reduction targets in the North Sea (OSPAR)

- Implementation of RBMP2 (2015-2021) in all EU countries

- Inclusion of P as a co-limiting factor of N,

The evaluation of 2rd RBMP pointed out that marine coastal waters are not only N-limited, as research has shown that there is a complicated co-limitation pattern and nutrient dynamics (Herman et al. 2017). As studies from Danish waters confirm that N is in general limiting for the algal production during summer and P is the limiting factor during spring (Timmermann et al., 2014; Riemann et al., 2016), the evaluation group suggested that the models took this co-limiting pattern into account. Because field studies suggest that in a number of systems, P load reduction in the spring could be beneficial for the reduction of N (Herman et al. 2017), land-based P loads are introduced in the model as an anthropogenic nutrient contributor (Erichsen et al. 2021b). This is one of the improvements from 2rd RBMP to 3rd RBMP, which in the reviewer's opinion is a positive ongoing work and has improved the calculation of MAI.

As there are no pristine marine areas in Denmark where data for Chl-a and eelgrass can be collected and no historical data before eutrophication took place. The reference conditions (RCs) are based on marine ecosystem modelling (Erichsen & Timmermann 2020). The establishment of reference chlorophyll-a concentrations is based on model scenarios reflecting an undisturbed, or only slightly disturbed, condition. In order to perform such a reference scenario, model-specific forcing data representing an undisturbed/slightly disturbed condition are required. reference TN and TP loadings from Danish catchments are estimated from concentrations of TN and TP in streams draining catchments with a low (< 10% for TN and < 20% for TP) proportion of agricultural land and no or very few point sources from scattered households and multiplied with the corresponding catchment specific water flow (Erichsen & Timmermann 2020). Under reference conditions, eelgrass will likely occupy larger seafloor areas compared to present-day situations. To allow the eelgrass to develop in a reference scenario, eelgrass model variables were initialised based on historical observations and estimates of historical eelgrass depth limits (Timmermann et al. 2019). In task 1 there is a detailed description of reference conditions, and the approach is discussed.

Other improvements from 2rd RBMP to 3rd RBMP include the refinement of the models, as the researchers have followed the recommendation from the evaluation panel and calculated specific MAIs for each water body. The evaluation panel pointed out that it would be possible, as the Danish monitoring programme provides data for each water body or spatially connected water areas (Herman et al. 2017). The reliability of water-body specific MAIs depends on the approach and many factors come into play, as the reliability of the result also depends on other countries reducing their N loads according to international agreements and the introduction of the system contribution.

As the full effect of many measures does not appear until several years or even decades after implementation, the researchers have proposed introducing 'system contribution' as a way of managing long-term positive effects of measures. System contribution is in particular added to water bodies where an expected effect will have an impact on the overall state (Erichsen 2022). The marine ecosystem models will in some water bodies predict that, in addition to the effect of measures, there will be an effect of a delayed return to a stable ecosystem (Miljøstyrelsen 2020b; Erichsen et al. 2021b).

The inclusion of 'system contribution' in the calculation of MAI implies a higher target load, which entails a lower need for protective measures (reduction), and at that time, fewer measures are necessary before the target load is reached.

In order to enhance the certainty for achieving good ecological status by 2027 and reduce uncertainties, two of the assumptions could be adjusted, which is also pointed out in the one of the notes for the steering committee (Miljøstyrelsen 2020a):

- As described earlier, the calculation of target load aims to reach the boundary between good and moderate ecological status. Due to the uncertainties in the calculations, this implies that the calculated target loads statistically support that 50 per cent of the water bodies will be in good condition, and that the rest of the water bodies will only achieve moderate or lower condition. Alternatively, if the aim is set just slightly better than the G/M class boundary, this would imply greater certainty of reaching good environmental status, as the target load determined will thereby statistically ensure that more than 50 per cent of the water bodies are in good ecological status.

- When calculating the target load, system effects (including delayed effects in the ecosystems) are taken into account as these effects are 'taken out of' the calculated target loads. This means that, in some water bodies, when a target load level has been achieved, several years or even decades may pass before the ecosystems have achieved a new equilibrium and good ecological status. To avoid this and to contribute to the sooner return of the ecosystems, the target load could be reduced and/or more measures could be introduced.

To determine the uncertainty of model slope for MAI, a consistent scientific study has been prepared, revealing that the confidence intervals for MAI were $<\pm$ 10% of the median MAI for 93 out of 98 water bodies with MECH models and 22 out of 28 water bodies estimated with STAT models. For water bodies, where the confidence interval exceeded ten per cent, the uncertainty will affect the calculation of MAI (Larsen et al. 2021).

Uncertainty related to the input data on nutrient reductions by neighbouring countries is not evaluated in the study by Larsen et al. (2021).

Target load of RBMP3 and Natura 2000 and WFD

The RBMP is the main instrument for securing and improving the condition of the aquatic nature types in the Natura 2000 sites, where nature types or species based on the designation of a Natura 2000 site depend on the condition of the water body. The bodies are given status as protected through RBMP. The purpose of the RBMP is to improve the condition of the water areas (for all the biological elements) towards a good ecological status, which at the same time provides fundamental improvements to the water quality for the benefit of nature types, birds and species in the Natura 2000 site.

Therefore, the assumption in RBMP3 that the *"50% of the water bodies will have 'good' environmental status, and the remaining 50% will have 'moderate' or lower status"* is not in line with the practice of the impact assessment of marine Natura 2000 areas as Denmark will not reach good environmental status for all Danish waters in 2027 as required in WFD. The Natura 2000 plans cover the period from 2021 to 2026, and it is our assessment that the defined needs for protective actions will not be sufficient to achieve the Natura 2000 objectives.

3.6.3 Concluding remarks

The conceptual model and method for target load and hence MAI calculation is assessed to be a scientifically valid approach, representing an optimal concept on the existing basis.

The state-of-the-art models are developed to a high degree of complexity – and it is our assessment that the model quality has improved as a specific MAI has been derived for each water body and land-based P loads are included in the calculation of MAI. This is an improvement from RBMP2 to RBMP3 and increases the certainty of the target load calculation.

However, the target aims at the boundary value between G/M ecological status. This implies that 50 per cent of the water bodies will have good environmental status, and that the remaining 50 per cent will have moderate or lower status. This means that Denmark will not reach good environmental status for all Danish waters in 2027 as required in WFD.

It is realised that some of the planned measures will not reach their full effect until after several years or decades. Therefore, a 'system contribution' is introduced to include the effect in the current plan period. Consequently, a higher N load is allowed.

It is our assessment that the calculation of MAI is determined with a high degree of certainty and provides an optimal approach to achieving the appointed target.

3.7 Task 7: Seasonal variability

3.7.1 Objective

This task comprises a review of the introduction of seasonal variability of N load. Review of how the impact of the choice of measures with high impact on N load during summer season will affect the N load during the summer months, and of the possibilities for optimising the choice of measures accordingly. The task is divided into the following sub tasks:

- Review of scientific background for the methods applied to assess the effect of seasonal variability of N load on calculation of status load, baseline load and target load (emphasis on effect on summer discharge).
- Scientific evaluation of the main area of applicability of the methods applied for seasonal subdivision of the N load calculation and their limitations.

3.7.2 Analysis and assessment

The report (Erichsen et al. 2021a) identifies 18 water bodies which have a potential for seasonal subdivision of the N load and where it is possible to reach a positive effect on the ecological status in the water bodies. It also includes a review of selected measures (from the report Eriksen et al. (2020)) to reduce the discharge of N to the selected water bodies during the summer season (defined as from May to September). In this period, it is expected to get the highest effect of a reduction in the load of N to the water bodies. Five of the 18 water bodies have been through a more detailed analysis. However, it is not quite clear why these five catchment areas have been chosen. They are quite similar with relatively large overlap between catchment area types (primarily clay and small or no areas with beetroot). So, the question is if this composition of soil is suited as representative for the other 13 water bodies?

The report points out that there may be a need for a more individual analysis of each coastal water area because there are different local conditions to be considered in each catchment area of the water bodies. An example is that knowledge about the precise retention of N in the river system has to be included when the distribution of N sources is determined. Also, there is no known drainage data for any of the 18 catchment areas, so using specific data could have an impact on the calculation of the effect of the measures. Data has been compiled as 'instantly available data'. Does this mean that data can be found at, e.g., HedeDanmark or other similar companies, but that this has not been further investigated or is it an expression of a complete absence of data?

In the report Erichsen et al. (2021a), it is stated that close to 25 per cent of the available data for drainage basins are assessed to have a deviant monthly distribution and are considered as outliners. This seems to be a very high proportion of data in a very limited data set, without further justification of the basis on which the deviation is assessed. In general, the report appears to be based on very small and disjointed data sets, which are again assembled from small data sets where outliers have been sorted out. This may well leave the reader with an uncertainty as to how effective the individual measures are when the results are to cover several catchment areas. The example in Figure 4-5 shows the relative contribution of drainage transport to the total transport of N in the four catchment areas. There is a greater variation between the catchment areas, which may partly be due to variations in the hydrological regime for the four catchment areas and variations in the drainage intensity for the individual months. This is further reinforced by the fact that an average percentage drainage distribution has been used, which does not reflect the actual conditions in all catchment areas equally well. So, the result of a specific draining measure to reduce the discharge of N is subject to an uncertainty regarding its actual effectiveness.

The report of Larsen et al. (2020) includes a new approach to normalisation of N load. The normalised N load is calculated to illustrate the trend of the diffuse N load with a minimal influence of a given year's climate/weather. The evaluation shows that assessments done on monthly or annual data yield different results. Therefore, the entire country approach is used. It is noted in the report that the tested normalisation methods cannot fully take into account all effects of the weather/climate and its effect on the resulting N input to the sea. For example, it is not possible to normalise for the effect of a poor harvest as a result of drought, or for the effect of failure to sow or poor growth of subsequent crops due to a wet period after harvest. There are several factors that cannot be included in the model that can have impact on the runoff from year to year, as well as factors which, all other things being equal, must be expected to occur more frequently in the future due to climate change. This uncertainty increases the risk of underestimating or overestimating the measures to reduce the N load.

In both the above-mentioned studies outliers are removed, or normalised data sets or nationwide data sets are used. There can be many good reasons for this, e.g., a lack of sufficient data to make calculations for the specific water bodies. Specific events may also that can have a major impact on the ecological/biological state of the individual marine catchment areas, e.g., dry years such as this year (2022) and 2018. With the present method, such events will be at risk of being excluded as outliers or equalised by using data that are normalised to a high degree.

Discussion of specific measures to meet the reduction of diffuse N discharge during the summer period.

Specific measures to reduce the N load during the summer season in selected water bodies are evaluated in the report of Erichsen et al. (2021a). Some of them are included in the measures listed in the report of Eriksen (2020). Erichsen et al. (2021a) examines, among other things, the effect of filter matrices in the summer as being effective in removing N, but Eriksen et al. (2020) explains negative effects as the results of increased emissions of greenhouse gases. "*The plant must be closed during the summer months partly to avoid high CH4 emissions and partly to avoid the reduction of sulphate (SO4*

2-) to sulphide (S2-), which smells unpleasant. Sulfide also has the disadvantage that it can block denitrification precisely at the stage where nitrous oxide is reduced to N2, which will lead to the emission of N2O (Sørensen et al., 1980; Tam & Knowles, 1979)". Thus, it is not sufficiently clear whether this tool can actually be used to reduce the N load in the summer season.
Another example is the description of the crop beet as a measure; beets can be used to reduce the diffuse discharge of N on an annual basis, according to Erichsen et al. (2021a). In Eriksen et al. (2020), it is described that crops such as beetroot and maize can cause leaching in the summer season: *"Runoff from the root zone occurs most frequently in autumn and winter, but summer and spring runoff, according to model calculations, can occur approx. 10 out of 20 years in rainfall-rich locations, but only 3 out of 20 years in rainfall-poor locations. Late-sown crops with slow growth and large row spacing (such as beetroot and maize) present a high risk of inorganic nitrogen in the soil. This can cause spring and summer leaching from the root zone on agricultural land where runoff occurs."*

In most of the designated water areas, however, 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. The report concludes that for many of the water bodies there will still be a need, not for seasonal targeted measures, but for measures that reduce the N load on an annual time scale.

In the study of Eriksen et al. (2020), the means of intercropping and paludiculture are mentioned as measures that can reduce N emissions during the summer, but these are not discussed in detail in the report by Erichsen et al. (2021a). Here, it is mentioned that crops such as maize will affect N load during the summer, but this is not included in the study of measures in Eriksen et al. (2020). There is no argumentation for the measures chosen in the study by Erichsen et al. (2021a) and it is not clear if the tested measures should be adapted in the catalogue of measures as presented in report by Erichsen et al. 2021a.

3.7.3 Concluding remarks

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 analyse of the effects of seasonal variation as P concentration often is the limited factor for the phytoplankton growth during spring, while N concentrations often is limiting during summer.

3.8 Task 8: Environmental objective, other countries and areas

3.8.1 Objective

Review of the Danish objectives and the Danish measures compared with those in relevant neighbouring countries/water areas.

Sub tasks:

- Comparison of the Danish objectives and measures to those in relevant neighbouring countries/water areas.
- Evaluation of the scientific basis to conduct such comparisons.
- Review of the applicability of such comparisons of objectives and measures as well as their limitations.

3.8.2 Analysis and assessment of measures

The WFD implementation builds on the DPSIR principle, which is an intervention model following the logic of Drivers, Pressures, State, Impact and Response. According to the WFD, the RBMPs must therefore comprehensively identify the drivers and pressures that have an impact on water bodies. In the context of this study, it is relevant to investigate the pressures with a eutrophication impact, and whether measures are foreseen to address these impacts (CIS-GD No. 23 and see Section 3.4).

The following provides a summary of eutrophication pressures in coastal waters and whether measures are foreseen to mitigate these pressures. The summary is presented for Denmark, Schleswig-Holstein in Germany, and Southern Sweden.

Denmark

A variety of nutrient pressures have a eutrophication impact on Danish coastal waters, and the draft RBMP3s equally seek to address virtually all of these pressures through either basic or supplementary measures (see Table 3-9 below). Agriculture accounts for about 70 per cent of N emissions into water bodies, and diffuse background entries account for about 20 per cent of the emissions (Miljøministeriet, 2021). Agriculture is thus a major source of N emissions.

Table 3-9 Pressures with a eutrophication impact on coastal water bodies in Denmark, and indication of associated measures

		Denmark	Measures planned
Point sources	Industry	Significant	Yes
	Treatment plants	Only upstream	Yes
	Aquaculture	Significant	Yes
	Other point sources	Significant	Yes
Diffuse sources	Scattered settlements	Only upstream	Yes
	Agriculture	Significant	Yes
	Rain-related outlets	Only upstream	Yes
	Airborne deposits	Significant	Not identified
	Other diffuse sources	Significant	Yes
Other	Historic pressures	Not identified	Not identified

Source: Table 3.1 and chapter 7, Miljøministeriet, 2021

Germany

The coastal waters of Schleswig-Holstein are all strongly impacted by nutrient pollution, from particularly diffuse sources. In all three river basin districts of Schleswig-Holstein, about 80 per cent of the N loads entering surface waters originate from drainage or groundwater, leading to a significant nutrient pressure for all coastal waters (see Table 3-10 below)[109]. Other diffuse and point nutrient pressures either apply to a small number of coastal water bodies, or have an impact on upstream water bodies only. Atmospheric deposition and unknown sources are the only two other pressures that significantly impact coastal water bodies. However, these are not categorised to have an impact on eutrophication, but only chemical pollution.

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[109] *RBMP3s*

Table 3-10 Pressures with a eutrophication impact on coastal water bodies in Schleswig-Holstein, and indication of associated measures

		Baltic Sea	North Sea	Measures planned
Point sources	Industry	Not relevant	Not relevant	Yes
	Treatment plants	Only upstream	Only upstream	Yes
	Aquaculture	Not relevant	Not relevant	Not identified
Diffuse sources	Scattered settlements	Only upstream	Only upstream	Not identified
	Agriculture	Significant	Significant	Yes
	Rain-related outlets	Only upstream	Not relevant	Yes
	Airborne deposits	Not relevant	Not relevant	Not identified
	Other diffuse sources	Not relevant	Not relevant	Yes
Other	Historic pressures	Significant	Only upstream	Not identified

Source: RBMP3s, section 2.2; Note: For Germany, a pressure was deemed as significant, if the pressure was significant in at least one River Basin Unit; Draft Programme of Measures, Annex 2

Sweden

Within the study scope of Southern Sweden, consisting of the river basin districts Västerhavet and Södra Östersjön, a comparably wider facet of eutrophication-related pressures in coastal waters can be identified (see Table 3-11 below). In terms of the eutrophication impacts on coastal waters, the waters are primarily impacted by nutrient loads from adjacent coastal waters, accounting for 25 per cent and 40 per cent in, respectively, the Västerhavet and Södra Östersjön RBMPs. Agriculture is, however, the most dominant pressure that can also be identified, accounting for about 20 per cent of the impact on coastal waters. The other pressure factors – such as scattered settlements, wastewater treatment, and forestry – each account for about five to ten per cent of the pollution. It has not been possible to identify the measures foreseen in the adopted versions of the RBMP3s nor the digital information system (VISS). However, based on the draft versions of the RBMPs, it can be identified for a limited number of pressures whether measures are foreseen. The table below shows that measures are foreseen for industry, treatment plants, agriculture and forestry. For the other pressures, it could not be identified whether measures are foreseen.

Table 3-11 Pressures with a eutrophication impact on coastal water bodies in Southern Sweden, and indication of associated measures

		Baltic Sea	North Sea	Measures planned
Point sources	Industry	Significant	Significant	Yes
	Treatment plants	Significant	Significant	Yes
	Aquaculture	Not relevant	Not relevant	Information not available at pressure factor level (n/a)
Diffuse sources	Scattered settlements	Significant	Significant	n/a
	Agriculture	Significant	Significant	Yes
	Forestry	Significant	Significant	Yes
	Rain-related outlets	Not relevant	Not relevant	n/a
	Airborne deposits	Not relevant	Not relevant	n/a
	Other diffuse sources	Significant	Significant	n/a
Other	Historic pressures	Not relevant	Significant	n/a
	Other	Significant	Significant	n/a

Source: VISS (2022), PY02 Påverkan kustvatten cykel 3 2022-09-28 04,38,xlsx; COWI (2021)

The comparison shows that in all three countries, a multitude of eutrophication pressures on coastal waters can be identified. Diffuse sources play a strong role. In Denmark, emissions from agriculture account for more than 70 per cent of N emissions. In Germany, agriculture is a pressure affecting all coastal waters. The role of agriculture is less, but still substantial, in Southern Sweden, where instead the nutrient entries from adjacent waterbodies are the dominant pressure source for coastal waters. As also stated regarding the reference condition for chlorophyll-a below, eutrophication pressures for coastal waters are modelled with the S-HYPE model. All countries implement a variety of measures to address eutrophication. However, in the case of Sweden, it has not been possible to identify all measures. In conclusion, it can be said that agriculture is an important pressure factor, but that measures are also being implemented to address less dominating pressures.

Analysis and assessment of environmental objectives

Most countries collect and assess data with their own methods, and in many cases, the results assessment methods for the same parameter cannot be directly compared. The WFD takes this conundrum into account by its provisions on comparability of biological monitoring results by stating that the values for the class boundaries H/G and G/M must be established through an IC exercise (WFD Annex V, 1.4.1). As addressed in previous Sections 3.1 and 3.2, the EC has facilitated this IC process through the CIS, e.g., by preparation of guidelines and GDs establishing procedures and detailed scientific guidance for the IC process, which enables comparison of a BQE or its parameters between countries that share the same water body types.

The basic principles of the IC process are that reference values and environmental objectives for the same BQE or its parameters can only be directly compared with other countries, if:

- Data represents the same type of water body.
- Data is collected for the same parameter.
- Sampling methods are the same.
- Assessment methods are the same.

In cases where a direct comparison cannot be made, this can be done by following the IC procedure. Therefore, a comparison of the Danish ecological quality objectives with those in relevant neighbouring countries/water areas can only be made conclusively based on IC results.

As done under Task 1 in Section 3.1, the focus of this review lies on relevant environmental objectives and assessment metrics Chl-a and eelgrass depth limit[110], which are the only direct eutrophication-related BQE sub-elements that are intercalibrated so far.

Denmark only shares common IC types with Germany and Sweden. The table below presents an overview of the IC types, and the corresponding national typologies in the three countries. The national typologies provide the basis for identifying the specific environmental objective or assessment metric that is relevant to investigate further.

The typology for the IC types in the Baltic Sea was established for the 1st Phase IC and revised for the 2nd Phase, as the old typology applied wide salinity ranges, which in turn led to a very high number of taxa compositions, and to problems with the comparability of, e.g., benthic fauna with other countries (Berg et al, 2018). Therefore, the typology was revised to create a typology that could be used in the second IC phase. For the Danish coastal water types, only the typology used in the RBMP2 is shown as no information can be found on how the revised typology used in the RBMP3 is linked to the common IC typology (see Chapter on Task 1).

[110] The Danish assessment method for eelgrass has been revised to cover depth limits of other angiosperms/soft bottom vegetation. An IC feasibility check of the revised method demonstrates a one-to-one comparability with the existing ('old') method of *Zostera marina.* The method has been presented to the CIS WG ECOSTAT and is scientifically accepted.

In the following, the extent to which each typology can be compared will be discussed.

Table 3-12: IC typologies, and corresponding national typologies for Denmark, Germany and Sweden, as well as metrics for Chl-a. For the IC types, refer to Table 3-1 in Section 3.1.

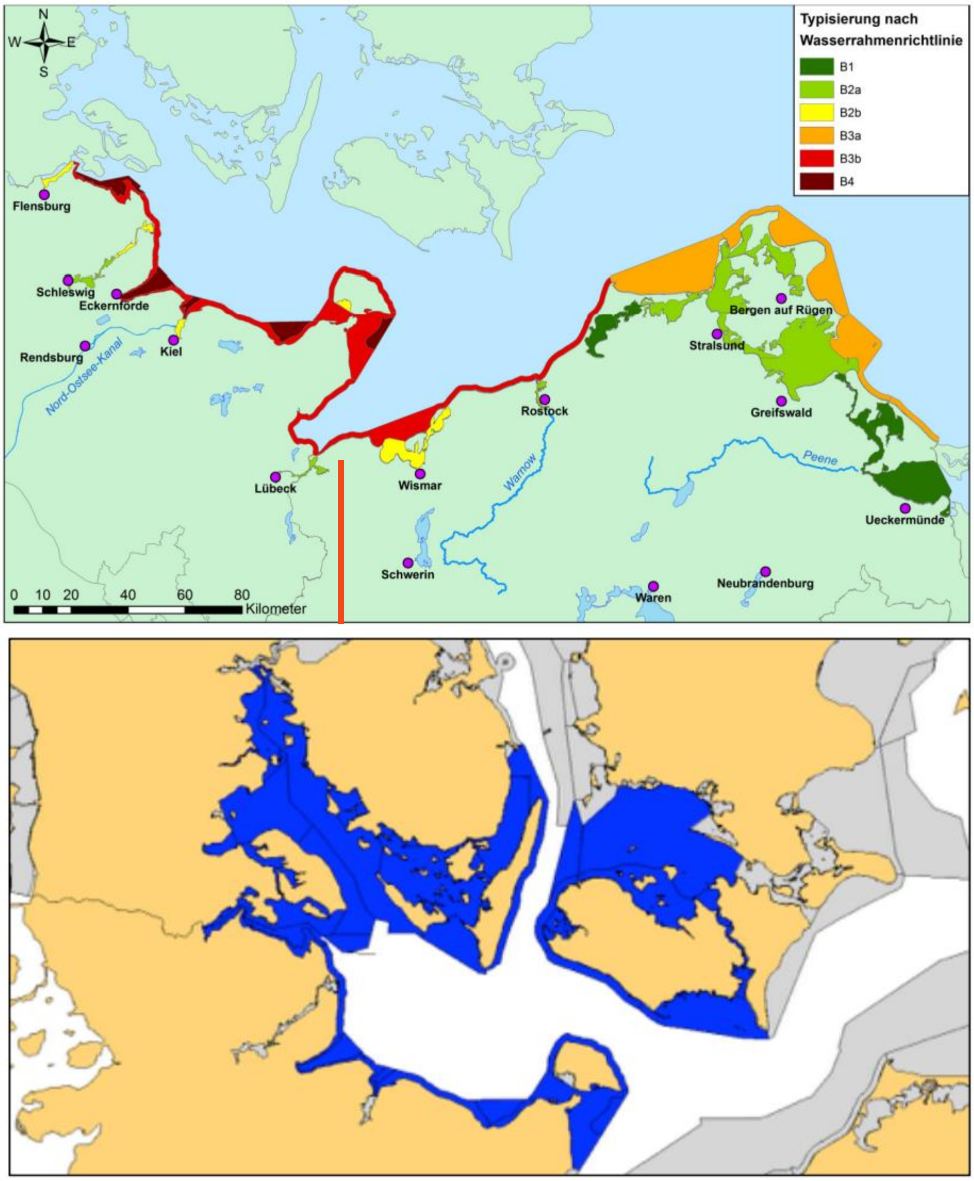
IC Type	Danish typology	German typology	Swedish typology
BC6	OW3b, OW3c, M2*	-	7, 8*, 9
BC8	OW3a, P1*	B3b, B4	-
Metric	May-Sep avg,	May-Sep avg (SH only)	Jun-Aug avg,**

IC Type	Danish typology	German typology	Swedish typology
NEA1/26c	OW5***	N2	-
NE1A/26d	OW4***	-	-
NEA8b	OW2, P2*, P3*, P4*, M1*, M2*, M4*, O3*	-	1s*, 4, 5, 6, 25*
Metric	May-Sep avg,	Mar-Sept 90th perc,	Jun-Aug avg,

*Notes: *: National types not shared between countries and not directly used for IC.*
***: the metric changed to July-August in the RBMP3 (see Table 3-16); reproduced from Table 2.1 in Carstensen (2016), LAWA-AO (2021), Berg et al, (2018) BLMP (2021).*
****: Types not considered in this review.*

For **Germany**, the BC8 typology corresponds to the B3b typology (mesohaline outer coastal waters) and B4 typology (Poly-mesohaline outer coastal waters) in Schleswig-Holstein. Mesohaline inner coastal waters (B2) and (B4) are other typologies applicable to the Baltic Sea, which are found in, respectively, 9 and 5 out of 27 coastal waters. B1, a fourth typology, is only found in the RBMPs of the eastern part of the German Baltic Sea. These RBMPs are administered by the state of Mecklenburg-Vorpommern, which lies outside of the study scope. Figure 3-35 below presents the distribution of coastal waters by typology.

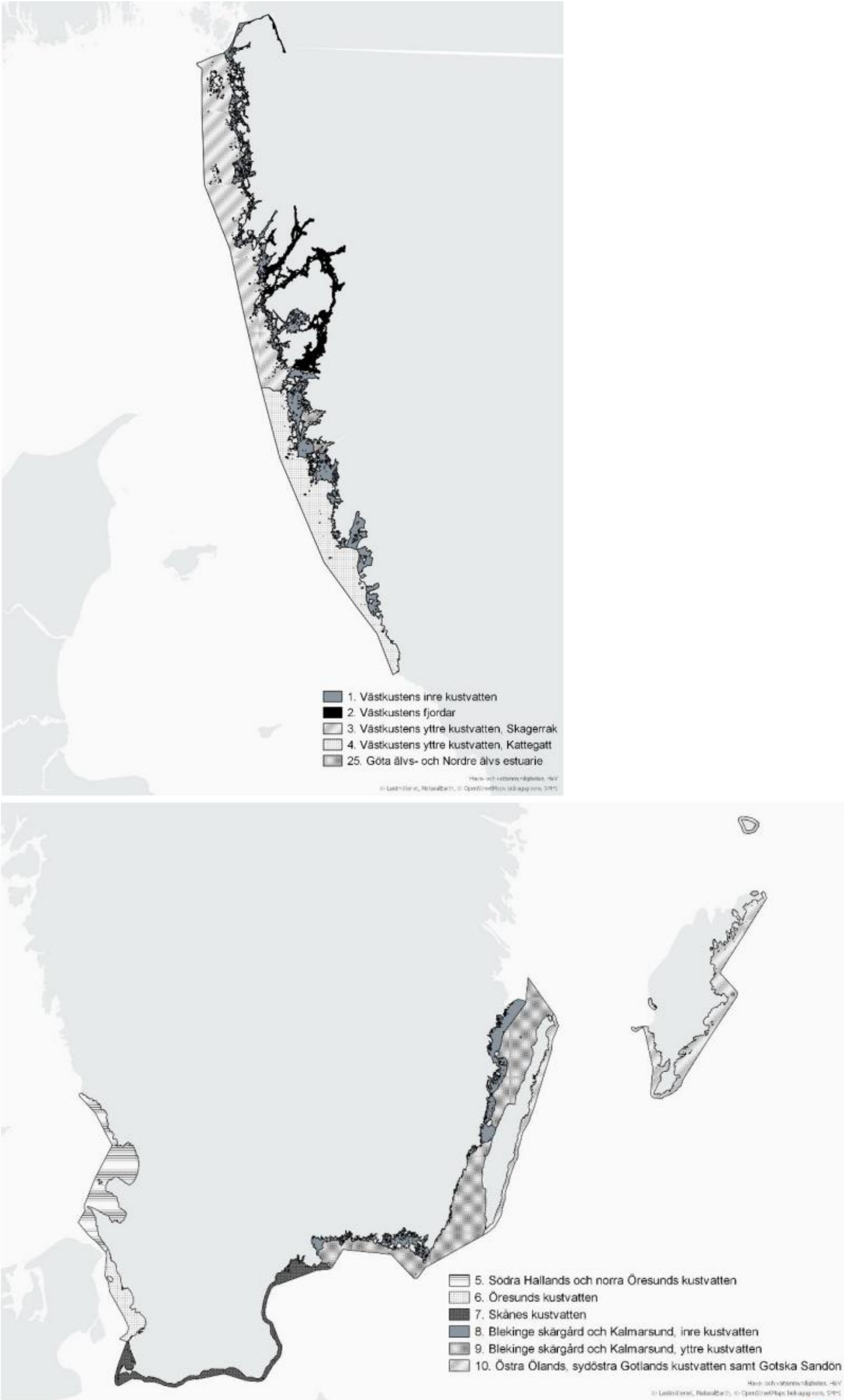
Figure 3-35: (i) German Baltic Sea coastal waters by national typology and (ii) extent of the BC8 IC typology in Denmark and Germany. The waters of Schleswig-Holstein are located to the west of the orange line of the figures. The waters east of the line lie outside the study scope.



Source: (i) BLANO *(2014), p. 8; (ii) Berg et al. (2018), p. 35*

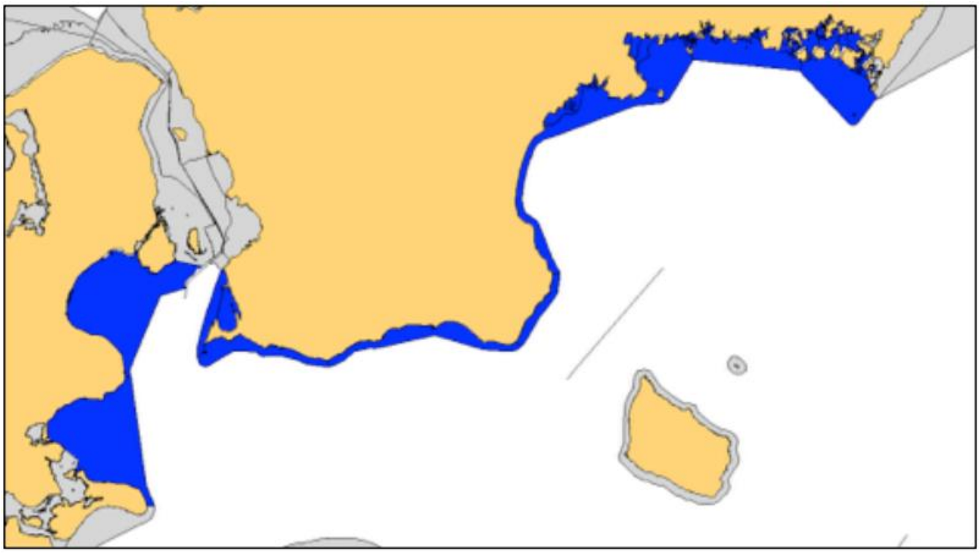
The BC6 typology corresponds to the **Swedish** 7, 8, and 9 typologies, and the NEA 8b typology corresponds to 4 and 5 for the Kattegat and Southern Belt Sea as well as typology 6 for the Sound. Figure 3-36 below presents the distribution of coastal waters by typology. Figure 3-37 presents the extent of the BC6 typology in Denmark and Sweden, which shows that the typology covers the Danish Køge Bay and Faxe Bay and the southern coast of the Swedish Scania. The northern part of the Øresund is covered by the NEA GIG.

Figure 3-36: Distribution of Swedish Baltic and North Sea coastal waters by typology, and in the study scope (Västerhävet and Södra Östersjön)



Source: Havs- och vattenmyndighetens föreskrifter och allmänna råd (HMVFS 2017:20) om kartläggning och analys av ytvatten enligt vattenförvaltningsförordningen (2004:660)

Figure 3-37: Extent of the BC6 IC typology



Source: Berg et al. (2018), p. 35

IC results

In the Baltic Sea, no reference sites exist and the relationship between Secchi depth and Chl-a or nutrient concentration was considered of major importance to define the high status or an alternative benchmark. Denmark and Germany also used hind-casted modelled estimates of Chl-a concentrations.

BC6 & NEA8b – Chl-a

Reference values for TN in Sweden were estimated using historical data on Secchi depth, and using empirical relations between nutrients and Secchi depth based on current data. The modern relationships between nutrients and phytoplankton biovolume and Chl-a were used to estimate RC for these variables. The reference TN concentration value (from 1900-1920) of 15.3 µM and a reference Chl-a concentration value of 1.2 µg/l were estimated for the Baltic open coastal waters. A simple mixing model was used to calculate individual surface water body RC corrected for background concentrations in freshwater TN discharges according to salinity (EC-JRC IC Technical Report 2013).

The Swedish G/M class boundary is calibrated against pre-classified sampling sites. TN in the open coastal areas of the Baltic Sea is assumed to have moderate status, since the Baltic Sea is generally deemed eutrophicated (e.g., by HELCOM). The G/M boundary corresponds to an increase of the bioavailable N during the summer with a factor of 1-1.5 compared to the reference value.

National Swedish Chl-a boundary values cannot directly be compared with the Danish boundary values because they are based on different sampling periods and represent different layers in the water column (Carstensen 2016). Denmark and Sweden thus do not use the same metric for setting boundary values for

Chl-a[111]. However, within the frames of the CIS IC, the values are comparable. The IC was carried out according to Option 3 in the CIS-GD No. 14 (same data acquisition, but different metrics) and showed a strong and significant ($P<0.0001$) correlation between the Swedish metric and the Danish metric in both the shared IC types (BC6 and NEA 8b). The parameters of the regression lines suggested that the Danish metric produced slightly higher values than the Swedish metric, but both regression lines were close to the 1:1 line. The distribution of data points around the regression line suggests that no bias was introduced using different metrics. Furthermore, the national types not included in the IC also appeared to follow the regression line, supporting translation of IC results from the shared types into national types specific to the two countries.

The strong and significant correlation between the national metrics allowed for translating values at the national metric to a common metric for comparison in the IC exercise. Denmark entered the IC with EQR values of 0.8 for the H/G class boundary and 0.6 for the G/M class boundary resulting from the 2nd Phase IC with Germany (see later). Sweden entered the IC with EQR values of 0.8 and 0.67, respectively, where the EQR 0.67 value is strictly in accordance with the HELCOM approach.

Table 3-13 below presents the resulting RC, environmental objectives and EQRs for the intercalibrated water types. Here, it is important to note that even if the values for Denmark and Sweden are different for the same water type, they represent the exact same ecological status assessed by the two countries' assessment methods. For those national waters that were not included in the IC (denoted with '*' in Table 3-12 above), updated values can be found in Carstensen (2016). Overall, it can be said that the updated values for Danish waters only changed within the hundredths of a decimal, and thus very limitedly. For BC6, Kattegat, and Southern Belt Sea, the IC led to an upward and downward adjustment of the Danish and Swedish values, respectively. For the Sound (NEA 8b), the adjustment was the opposite.

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[111] Denmark is using surface chlorophyll a (1 m, mean for May-September). Sweden is using surface chlorophyll a (calculated as mean EQR value for June-August), where surface is integrated from 0-10 m (either hose sample or discrete samples mixed) in deeper water columns (> 12 m) and surface is 0.5 m at shallow stations (< 12 m).

Table 3-13: Intercalibrated Chl-a values of water typologies resulting from the IC. Adjusted values for national types excluded in the IC can be found in Carstensen (2016).

Type	Country	National type	Reference condition (µg/l)	Environmental objective G/M (µg/l)	EQR G/M	Increase/ Decrease
BC6	DK	OW3b, OW3c	1.06	1.72	0.62	Increase
	SE	7, 9	1.14	1.78	0.64	Decrease
Sound (NEA8b)	DK	N Øresund	0.96	1.63	0.59	Decrease
	SE	6	0.94	1.56	0.60	Increase
Kattegat & Southern Belt Sea (NEA 8b)	DK	OW1, OW2	1.01	1.58	0.64	Increase
	SE	4, 5	0.99	1.52	0.65	Decrease

Source: Table 3.5, Carstensen (2016)

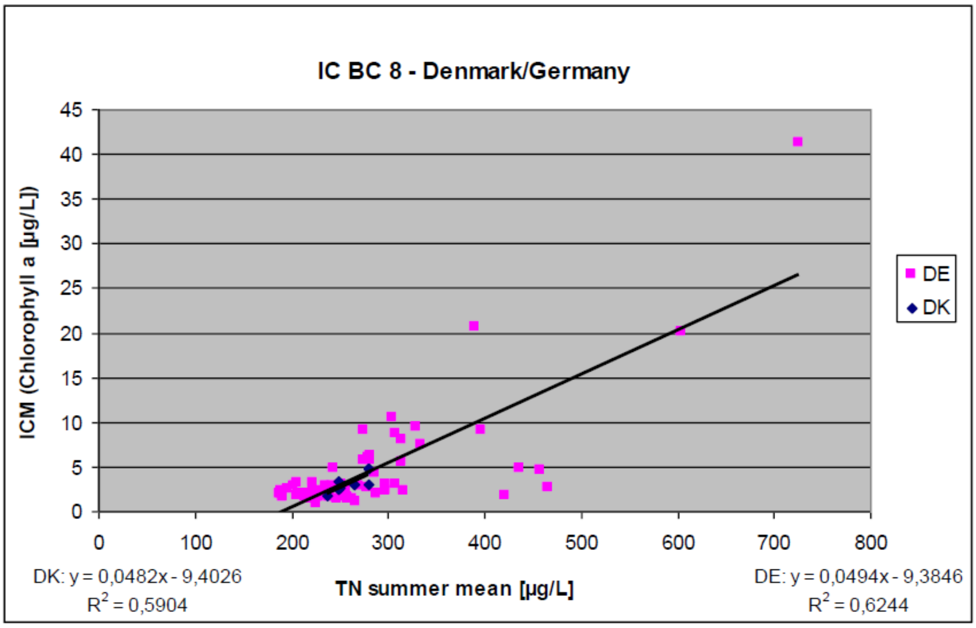
BC6 and NEA8b – Macrophytes

As regards the IC of macroalgae and angiosperms, the intercalibration of the EQRs for the depth limit of *Zostera marina* in Denmark and MSMDI (Multi Species Macroalgae Depth Index) in Sweden has not been feasible. The Swedish monitoring data does not include data on the depth limit of *Zostera marina* at a sufficient level that allows for an IC (Hansen et al, 2016).

BC8 – Chl-a

Germany derived natural background concentrations of Chl-a from modelled pristine concentrations of TN and its recent relations to Chl-a. Assuming a linear relation between salinity and TN in the given salinity range, TN reference values can be calculated for any given salinity. They vary from 12.8 µM for the exposed poly-/mesohaline water bodies to 40 µM TN for the sheltered oligohaline (salinity down to 0.5) parts of the German Baltic Coast. Based on the modelled reference values for TN, reference values for Chl-a can be derived using recent correlations. For this purpose, Chl-a concentrations and Secchi depth are charged against TN concentrations, resulting in significant correlations. The modelled TN concentrations as well as the calculated Chl-a references values could be verified by values deduced from historical macrophyte depth, historical Secchi depth or historical biomass concentrations of phytoplankton found in the literature (see more detailed information in the section on RC below).

The approach for the German G/M class boundary is to set it as a deviation of 50 per cent from the RC, thereby, reflecting the HELCOM Eutro approach (ECOSTAT 2013a).



The pressure/impact relationship did not show a significant difference between Denmark and Germany, so no benchmark standardisation had to be applied. In other words, no translation of the two countries' metrics was needed for and the Chl-a concentration (May-Sep avg,) calculated by both countries was taken as common metric (ICM). Option 2 – indirect comparison (of sites) – was chosen as the two countries' methods differ so much that IC cannot be performed on commonly assessed sites. In the next step, the EQR-ICM was calculated for the Chl-a values, using a uniform ICM reference value (1.3 µg/L) for all data. For both countries, the class boundaries of the 1st Phase IC were adjusted with a change in the EQR values from 0.92 to 0.8 for the H/G class boundary and from 0.63[112] to 0.60 for the G/M class boundary. From the table below, it appears that the two EQRs, together with the normative values for the class boundaries, define different reference values (1.04 µg/L and 1.14 µg/L for Denmark) that also differ from the reference value of 1.2 µg/L, which both countries entered the into the IC (See also Section 3.2) This is due to a normalisation of the EQRs to equidistant EQRs (0.2 – 0.4 – 0.6) applied by Germany. The German assessment method for the coastal waters of the Baltic Sea operates with a phytoplankton index, for which the EQR of the Chl-a concentration must be normalised to equidistant values to enter the index (LAWA-AO, 2021). The CD (2018/229) only presents the intercalibrated EQR values for the classification method and not the Chl-a values. An EQR of 0.67 for Chl-a thus corresponds to an EQR of 0.6 in the German classification method. The EQR of 0.67 for the G/M boundary matches exactly the HELCOM Eutro approach of 50 per cent deviation from RC.

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[112] For the 1st phase intercalibration, Germany as well as Denmark have both considered an approach (HELCOM EUTRO) with the G/M boundary at 50 per cent deviation from the RC that would result in a G/M EQR value of 0.67 – see also Section 3.2.

Table 3-14: Intercalibrated class boundaries for the IC-type BC 8

Type	Country	National type	Env. Objective		EQR	
			H/G (µg/l)	G/M (µg/l)	H/G	G/M
BC8	DK	OW3a	1.3	1.9	0.8	0.6
	DE	B3b, B4	1.3-1.4	1.8-1.95	0.8	0.6

The Chl-a concentrations were intercalibrated in the 1st Phase based on the old typology. For the old B12 typology, a G/M boundary of 1.9 µg/l with an EQR of 0.63 was determined (EC-JRC 2009 IC report). For the H/G boundary, a range of 1.1-1.5 µg/l with a middle value of 1.3 µg/l was determined, owing to different RC of less than 1.1 µg/l in Germany and up to 1.4 µg/l in Denmark.

The 2nd Phase IC attempted to intercalibrate metrics related to phytoplankton taxonomic composition, abundance and algal blooms (Henriksen et al, 2014). The IC of the additional metrics with other countries was, however, unsuccessful.

BC8 – Macrophytes

Germany and Denmark made an IC of the eelgrass depth limit in the 1st Phase IC where Germany, in a similar way as Denmark, used historical records of *Zostera marina* depth limit to define the reference and light modelling to define depth limits for the boundary setting (EC-JRC 2011). In the CD 2008/915/EC, the same reference and EQRs were set for the common type BC8. Germany has since then developed two classification methods: the BALCOSIS index and PHYBIBCO index (formerly ELBO index).

The report Danish contribution to the WFD IC 2nd Phase (Henriksen et al, 2014) refers to an IC exercise between the Danish depth limit of eelgrass indicator and the German BALCOSIS and then-called ELBO indices. The result was that an IC of the whole BALCOSIS index was not feasible, due to insufficient data on usable reference values for the Danish macro algae indicators in open waters, which is the type of waters where BALCOSIS is applied. As stated by the German contribution to the 3rd Phase IC, a low pressure-gradient (e.g., due to lack of sites representing low nutrient pressure) made the IC impossible, as not enough status classes could be covered (Berg et al, 2018)[113]. The EU has accepted this explanation, which leads to the conclusion that no further IC of the BC8 typology regarding macroalgae and angiosperms will be conducted (Berg et al, 2018).

However, an IC by expert judgement of the depth limit for *Zostera marina* was possible in the Phase 1 IC, where a RC of 9.4 metres was derived, with an EQR of 0.74 at the G/M boundary. In both Denmark and Germany, the RC is assumed as the *"genuine historical depth limit of single plants remains unclear since data were obtained with historical techniques"* (Berg et al, 2018, p. 13; EC-JRC 2009).

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[113] The intercalibration would need to use intercalibration Option 2, which requires that the data set covers at least three status classes to provide reliable results (EC, 2010).

As regards, the PHYBIBCO index, its use is limited to inner coastal waters of the BC2 typology, which is an IC typology not shared with other countries. As Germany is the only country with the BC2 typology, no IC was possible (Berg et al, 2018). The index has, however, been validated by the EU to be fully WFD-compliant. The Danish contribution to the 2nd Phase IC states, however, that it was possible to intercalibrate the then-called ELBO index with the Danish depth limit for *Zostera Marina* (Henriksen et al. 2014). The conclusion of the Danish contribution was, though, also that a full IC is not possible.

RC – Chl-a

Based on a previous assessment of the RBMP3s in Schleswig-Holstein (Germany) and Sweden, conducted by COWI for the Danish agriculture and food council, the following method was applied in setting the RC. Schleswig-Holstein has coastal waters in the Baltic Sea and North Sea, with diverging approaches.

Schleswig-Holstein – the Baltic Sea

For the Baltic Sea in Schleswig-Holstein, the only phytoplankton parameter identified is Chl-a concentration.[114]

The RC for Chl-a (and N concentrations as a supporting element parameter) in coastal waters are modelled with support of a river flux model (MONERIS), which is linked to the Baltic Sea flow and ecological model (ERGOM-MOM) (BLANO et al. 2014). The methodology for the RC was revised with the RBMP2 to overcome inconsistencies and flaws identified in the previous approach.

The model uses historic data, using 1880 as reference year – a period without industrialisation and agricultural intensification. The model assumes little influence of anthropogenic activities in that period, as there is strong evidence that water transparency and macrophyte coverage, even in inner coastal waters, were still high. As mentioned above, the MONERIS model is used to calculate riverine nutrient inputs. The remaining nutrient inputs into the Baltic Sea were obtained from a study that reconstructed the historic eutrophication of the Baltic Sea in 1850-2006 (Gustafsson et al, 2012).

The modelling results are subject to large uncertainties but are internally consistent. Therefore, the model calculates the relative difference of Chl-a values between the current and the reference situation. The resulting 'difference-values' are subsequently applied to the recent Chl-a measurements from 2001-2012 for each waterbody type. Subtracting the 'difference values' from the recent measurements leads to the corresponding Chl-a reference values, which lie in the range of 0.87-8.1 µg/l for coastal waters in Schleswig-Holstein, depending on the coastal water typology.

Schleswig-Holstein – the North Sea

Chl-a concentrations are the only (phytoplankton) nutrient-related quality parameter used in setting the RC in the North Sea of Schleswig-Holstein. The reference values are derived from modelled correlations between TN and Chl-a

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[114] Clarification by the German Environmental Agency

concentrations that have been observed in the period from 1980 to 2005, as also further explained below (Gade et al. 2011). [115]

The reference TN concentrations in the coastal waters of the North Sea build on modelled reference nutrient loads in the North Sea (Topuc et al. 2011). These are derived from linear correlations between the weighted means of modelled, riverine, freshwater end-members and recent offshore end-members (Topuc et al. 2011 p. 372).[116] TP is also calculated, but is not used in setting the RC of coastal waters in the context of the WFD.

The values of the riverine, freshwater end-members are modelled with a river flux model (MONERIS). The reference values are established through an assumed reference scenario: The upstream nutrient emissions into water reflect i) an absence of anthropogenic influences, ii) a land cover of only forests and grasslands, and iii) a reduced population. The resulting reference nutrient concentrations are derived from recent measurements of undisturbed reference waters (in, e.g., Northern Sweden) and historic measurements. There is therefore no explicit reference year for the riverine freshwater end-members. Due to highly diverse anthropogenic developments across the regions at the time, a variety of historic measurements construct the reference years. Most measurements date back to before 1880[117]. A clarification by the author of the underlying support study states that due to the diversity of regional developments mentioned above, one must be cautious when referring to a single reference year.

Based on the above reference values and nutrient river loads, the total nutrient export at pristine conditions is calculated for all German rivers with estuaries in the North Sea (i.e. Rhine, Elbe, Weser, Ems and Eider). The reference setting has been validated against domestic and non-domestic rivers that are currently undisturbed, where pristine conditions are modelled, or where historic measurements are available. The reference years for the rivers serving as a validation date as far back as 1850.[118]

For the offshore end-members of the model, the nutrient concentrations are based on measurements in the period of 2000-2005. The motivation to use recent measurements was to ensure the availability of regularly sampled years that comprehensively cover large areas and all seasons.

The natural background nutrient concentrations for the specific coastal waters are determined through a mixing diagram composed of the freshwater and offshore end-members. The offshore end-members used are limited to those that are unaffected by nutrient pollution.

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[115] Clarification by the lead author of Topcu et al, (2011)
[116] The "end-members" refer to the extreme ends of salinity concentrations in, respectively, freshwaters and offshore waters
[117] Clarification by the lead author of Topcu et al, (2011)
[118] Clarification by the lead author of Topcu et al, (2011)

The reference values for Chl-a values that correspond to the modelled TN reference values are subsequently derived from correlations between Chl-a and TN measurements in the German bay in the growing seasons of 1980-2005 (Gade et al. 2011).[119] Correlations were derived for each coastal water typology. The resulting reference values for Chl-a lie in the range of 3.3-6.7 µg/l, depending on the coastal water typology.

Table 3-15 summarises the RC, environmental objective and corresponding EQR value for the BC8 and NEA 1/26c water types that are intercalibrated with Denmark. The adopted values correspond to the intercalibrated values. As also mentioned above, the adopted CD (2018/22) on the third IC presents a normalised EQR value in the case of BC8 (i. e. an EQR of 0.6), representing the German phytoplankton classification method, which corresponds to an EQR of 0.67 in Chl-a values.

Table 3-15: RC, environmental objectives and EQRs adopted in Germany. Values as summer averages for the Baltic Sea and 90th percentile for the North Sea.

IC type	DE Type	Reference condition (µg/l)	Environmental objective (µg/l)	EQR
BC8	B3b	0.87	1.3	0.67
	B4	1.1	1.6	0.67
NEA 1/26c	N2	3.3	7.5	0.44

Source: CD (2018/22), BLANO (2014), OGewV (2016)

Sweden

The RCs for phytoplankton BQEs in Swedish coastal water bodies build on two parameters that are measured and weighted together: phytoplankton biomass and Chl-a. Due to a lack of undisturbed coastal waters, it is not possible to derive RCs from reference sites. The RCs for phytoplankton biomass and Chl-a are therefore based on calculated values. In some cases, these are supported by recent measurements from the specific water body. The calculated RCs are finally corrected for salinity in the different water typologies to adjust for the natural background nutrient-gradient in coastal waters.[120]

In the 1st Phase IC, Sweden estimated reference values for TN based on historical data on Secchi depth and by using empirical relations between nutrients and Secchi depth based on current data. The modern relationships between nutrients and phytoplankton biovolume and Chl-a were used to estimate RC for these variables. From the empirical relationships between Secchi depth and TN, a reference value for TN concentration of 15.3 µM (214 µg/l) was estimated for the open coastal waters of the Baltic proper. Using the TN

[119] Clarification by the lead author of Topcu et al, (2011)

[120] The calculation of reference values for phytoplankton biomass and chlorophyll-a is done with a formula making use of reference values for TN in coastal waters. These reference values are in turn calculated through the relationship between DIN and TN. The reference values for DIN have been adopted from previous research performed within HELCOM and OSPAR. The methods were, however, not fully accepted yet as of the winter of 2021 due to a weak significance in the relationship between the different fractions in some water types. Investigations are ongoing to eliminate the methodological weaknesses.

reference value of 15.3 µM and the empirical relationships found between Chl-a and TN, a reference value for chlorophyll-a of 1.2 µg/l was estimated for the open coastal waters of the Baltic proper (CIS IC report 2009).

The background load of TP and TN in coastal waters resulting from runoff is determined by a hydrological model (S-HYPE) which deducts the anthropogenic load from the runoff. The model uses nutrient load estimations from the Pollution Load Compilation (PLC6) as input values. [121] Based on these reference values, regression analysis is applied to define reference values for Dissolved Inorganic Nitrogen (DIN) and Dissolved Inorganic Phosphorus (DIP) (based on observed relationships between TP and DIP, and TN and DIN. The resulting reference values for nutrients in coastal waters are then defined as fixed values for each coastal water type (25 different types). Background nutrient load in water bodies within the same water type can vary, though.

The reference values adopted for the Swedish coastal water types of the RBMP3 differ from those of the IC (see Table 3-16 below). Whereas the reference values for the Kattegat, the Great Belt and the Sound types (NEA 8b) are nearly identical to the IC results, the corresponding EQR values are slightly lower for the Sound (0.59 instead of 0.60) and higher for the Kattegat (0.67 instead of 0.65). The reference value of the Baltic Sea type (BC6) is notably higher (1.3 instead of 1.14) as well as the EQR (0.67 instead of 0.64).

Table 3-16: RC, environmental objectives and EQRs (i) adopted in Swedish legislation and (ii) according to the IC. Measured as concentrations in July-August averages for the Baltic Sea and June-August average for the North Sea.

IC type	SE Type	Adopted legislation			IC, Decision 2018/229/EU		
		Reference condition (µg/l)	Environmental objective (µg/l)	EQR	Reference condition (µg/l)	Environmental objective (µg/l)	EQR
BC6	7, 9	1.3	1.94	0.67	1.14	1.78	0.64
NEA 8b (Sound)	6	0.94	1.59	0.59	0.94	1.56	0.60
NEA 8b (Kattegat & Belt)	4	1.0	1.49	0.67	0.99	1.52	0.65
NEA 8b (Kattegat & Belt)	5	0.99	1.48	0.67			

Source: Appendix 4.3, Havs- och vattenmyndighetens föreskrifter (2019:25) om klassificering och miljökvalitetsnormer; Commission Decision (EU) 2018/229

RC – Macrophytes

Schleswig-Holstein – Baltic Sea

Table 3-17 below presents an overview of the defining characteristics of the German Baltic coastal water typologies, and the applicable assessment

[121] The PLC6 model is presented here: SMED-Rapport-185-2016_AvrinningPLC6.pdf

procedure for macrophytes. The assessment procedures are further presented below.

Also as stated previously, the status assessment for macrophytes of the BC8 typology (or B3 and B4 according to the German national typology) builds on the BALCOSIS index, which was updated in 2019 (Nickel et al. 2019). BALCOSIS builds on the vegetational stocks of *seagrass*, *fucus*, and *red algae*. For seagrass, which is used for soft bottom biotopes, input parameters are the depth limit of *Zostera marina* and the biomass share of opportunistic algae. The depth limit of *Zostera marina* is weighted twice in the index, as it has a better scientific data basis than the other parameters (Berg et al. 2018). For *Fucus*, which is used for hard bottom biotopes, input parameters are the depth limit and dominance of *Fucus serratus* and/or *Vesiculosus*. Finally, for red algae, which is used for hard bottom biotopes, input parameters are the biomass share of opportunistic algae, reduction of selected species, and biomass of *Furcellaria lumbricais*.

Thereby, the seagrass element of the BALCOSIS index corresponds to the Danish use of seagrass. Table 3-17 below presents the RC and class limits of the *Zostera marina* elements as per the BALCOSIS index. The RC for the depth limit is thus set at 9.4 metres, and was determined in the 1st Phase IC and intercalibrated with Denmark by a simple comparison (EC-JRC 2009 IC report) and the result was included in the CD on IC [122]. The boundary for a good status is a deviation of no more than 25 per cent of the reference depth, or a depth limit of 7.0 metres (or an EQR of 0.74). The classifications below the good boundary are defined by the deviation from the historic maximum area extent.

Table 3-17: Status classes for the depth limit of eelgrass in the BALCOSIS index for macrophytes in BC8 water types

Status	Depth limit (*Zostera marina*)	Deviation from reference depth	Deviation of historic maximum area extent
High	9.4-8.5 m	≤ 10%	
Good	8.5-7.0 m	10-25%	
Moderate	7.0-4.5 m		5-25%
Poor	4.5-0.5 m		25-50%
Bad	< 0.5 m		> 50%

Source: Nickel et al. (2019b)

Sweden

The Swedish BQE for macroalgae uses a point system on the depth limit of a set of macroalgae species. For the coastal waterbodies located on the Swedish west coast – Skagerrak, Kattegat, and Øresund – only coastal water typologies 1, 5, 6 and 7 include *Zostera marina*.[123] For typology 25, depth limits are reported as 'missing' in the legislation.

[122] Commission Decision 2008/915/EU

[123] Annex 4,2, Havs- och vattenmyndighetens föreskrifter (2019:25) om klassificering och miljökvalitetsnormer,

For each species, a point scale is defined, ranging from 5 to 1 point, where 5 points is given for highest depth limit. The unweighted average of all species divided by 5 provides the corresponding EQR ratio. The EQR thresholds for H/G and G/M are, respectively, set at 0.8 and 0.6.[124] If all species thus have a depth limit corresponding to 5 points, the RC is achieved. Accordingly, i) the 5 point values in Table 3-18 below present the RC, ii) the 4 point value presents the H/G status threshold, and iii) the 3 point value presents the G/M threshold.

A notable consideration in this regard is that if an EQR is calculated based on the depth limit, the EQR at the G/M boundary corresponds to 0.375, which is a fundamentally different result than as per the points system.

Table 3-18: Overview of Swedish Zostera Marina depth limits for water typologies in BC6 and NEA8b typologies

IC type	SE type	RC (5 points)	H/G threshold (4 points)	G/M threshold (3 points)
BC6	7	8 metres	6 metres	3 metres
BC6	8, 9	Not applicable	Not applicable	Not applicable
NEA 8b	1, 5, 6	8 metres	6 metres	3 metres
NEA 8b	4	Not applicable	Not applicable	Not applicable
NEA 8b	25	Not available	Not available	Not available

Source: Appendix 4.2, Havs- och vattenmyndighetens föreskrifter (2019:25) om klassificering och miljökvalitetsnormer

3.8.3 Concluding remarks

For Chl-a, Denmark, Germany and Sweden have taken a similar approach in establishing RC by using a combination of historical data. As no existing sites in the Baltic Sea can be found in a status of RC, the reference values are derived as virtual reference. However, all three countries' calculations result in a reference concentration at the same level with a very small margin.

As a basis for deriving RC, the German model uses historic data, using 1880 as reference year – a period without industrialisation and agricultural intensification. For that reason, modelling results are subject to large uncertainties, but are internally consistent. The model calculates the relative difference of Chl-a values between the current and the reference situation and it does not directly estimate the reference values.

All three countries address the pressure-impact relationship between the TN concentration and the Chl-a concentration that is documented to be significant

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https://www,havochvatten,se/download/18,4705beb516f0bcf57ce1f17d/1600942126042/2%20Makroalger%20och%20g%C3%B6mfr%C3%B6iga%20v%C3%A4xter%20i%20kustvatten,pdf

[124] For example, the depth limit at the G/M boundary of three metres gives 3 points, which must be divided by 5, yielding an ERQ of 0.6. At the reference depth limit of eight metres, 5 points divided by 5 leads to an EQR of 1.

by all countries, showing no significant difference between Denmark[125] and Germany and Sweden. Background N concentration representing RC in open coastal waters was estimated at the same level – with a very small margin for Sweden – as the background concentrations found in the Danish contribution to the 1st Phase IC. Germany reported a somewhat lower value, however, representing true pristine conditions not impacted by anthropogenic pressure.

For the Chl-a G/M class boundary setting, all three countries have taken the initial approach of setting the boundary at 50 per cent deviation (increase) from the RC value in accordance with the HELCOM Eutro approach. Coming from the 1st Phase IC – where the boundaries were set on a provisional basis – the 2nd and 3rd Phase ICs have resulted in adjustment based on a solid scientific basis. The CD adopted equidistant EQR values for the phytoplankton classification systems in BC8, with a G/M value of 0.6. This value corresponds to an EQR of 0.67 for the Chl-a parameter in the German classification, which matches the HELCOM approach. This EQR was then generally applied for all Danish coastal water types in the RBMP2 – except for the North Sea types – and later brought into the 3rd Phase IC as an initial value in the IC with Sweden (Carstensen 2016).

As regards the findings on macroalgae and depth limit of eelgrass, the underlying methods have some differences. Sweden operates with a point system for the depth limits of a variety of macroalgae that are specific to the individual water types. In this system, the EQR of 0.6 for the G/M boundary corresponds to the points resulting from the measurement. If only the depth limit for eelgrass is considered, the depth of three metres at the G/M boundary would correspond to a theoretical EQR of 0.375 when measured against the reference depth of eight metres.

The German method, denoted the BALCOSIS index, uses vegetational stocks of various types of macroalgae, building both on the area extent and depth limit. In Germany, however, eelgrass is weighted twice in the overall assessment, due to the better scientific basis for eelgrass. For the intercalibration of macroalgae in BC8 waters, only the depth limit and corresponding EQRs could be intercalibrated between Denmark and Germany, yielding a G/M boundary of seven metres and an EQR of 0.74.

The results can be considered rather robust, and more data (or other data) cannot be expected to give major changes in the values.

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[125] Danish contribution to the 1st Phase intercalibration

3.9 Task 9: Other press factors

Press factors are processes that affect the environmental status negatively, except for N load and climate change.

3.9.1 Objective

The review of the importance of the impact of other press factors than N load and effects from climate change on target, discharge and measures is based on existing analyses of the potential effects of press factors.

The review must include an assessment of the scientific basis for the analyses of the effects of alternative press factors as well of their limitations.

3.9.2 Analysis and assessment

Reduction of P-load

The effect of increased P-load reduction and corresponding possibility to increase in N-MAI is modelled for all management scenarios. For scenario 2e, the potential effect is illustrated in Figure 3-38 (Erichsen et al. 2021b). The figure only includes water areas with a potential of more than 100 tN/y in case of a 50 per cent reduction of P load. The water areas in Figure 3-38 are sorted according to increased potential for increase of N-MAI (P50% case). For reference, the potential N-MAI increase at national level is given at the right end of the figure, provided that the P loads to all water areas are reduced by 50 per cent.

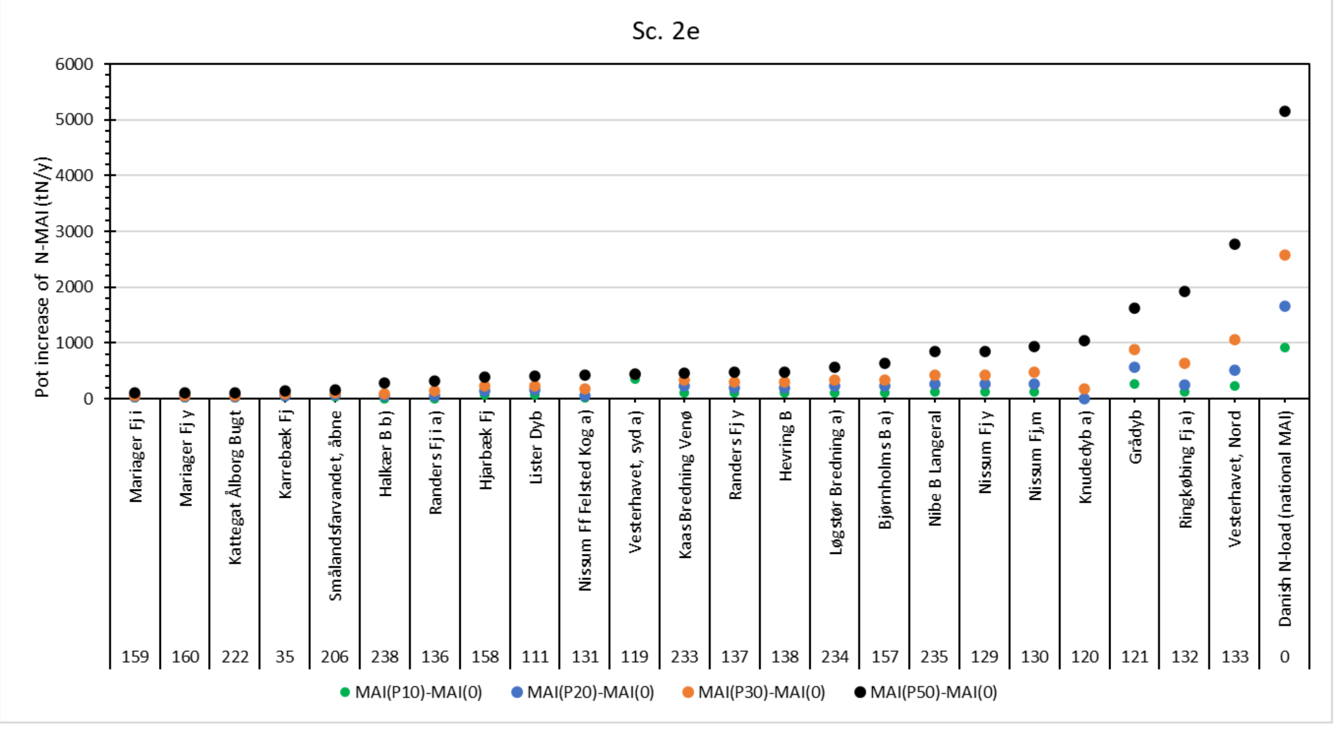

Figure 3-38: Potential increase of N-MAI for different P load reductions, scenario 2e. Water areas with N-MAI reductions larger than 100 tN at a 50 per cent reduction of P load are selected.

It is seen that most of the national N-MAI increase stems from water areas at the North Sea: 135 (Vesterhav Nord), 132 (Ringkøbing Fjord), 130 (Grådyb), 120 (Knudedyb), 129 (Nissum Fj). Note: The diagram describes main areas as well as subareas, therefore the Danish N-load reduction (at the right side) is not the sum of the other N-load reductions.

The performed modelling of enhanced P-reduction is carried out on the summer period, which according to EU is May to September. The period where P-limitation of Chl-a is observed is March to April. This could imply an underestimating of the effect of increased P-load reduction. However, with regards to light (eelgrass) the summer period (March to September) covers the growth season for eelgrass. If the spring months March and April should be included in the modelling, the following difficulties arise:

- Measuring challenge: Measurements of spring bloom must resolve events with a period of few days. Events occur at different days in different water areas.

- Requirement of EU-wide consensus.

The practical difficulties in measuring and, hence, quantifying the spring bloom, including the dynamic nutrient processes, are probably the main reason for not including this phenomenon in the analysis of the Chl-a indicator.

The impact of omitting the spring period in the Chl-a parameter is hence assessed to be of secondary importance compared with the summer period given be EU.

The effect and the cost efficiency of N-MAI by further reduction of P load depends on the specific water area and should be investigated in detail specifically for each individual water area.

At national level, only limited modification can be achieved. For a ten per cent P load reduction at national level, 100 tN/year can be achieved, corresponding to two per cent of the N-MAI.

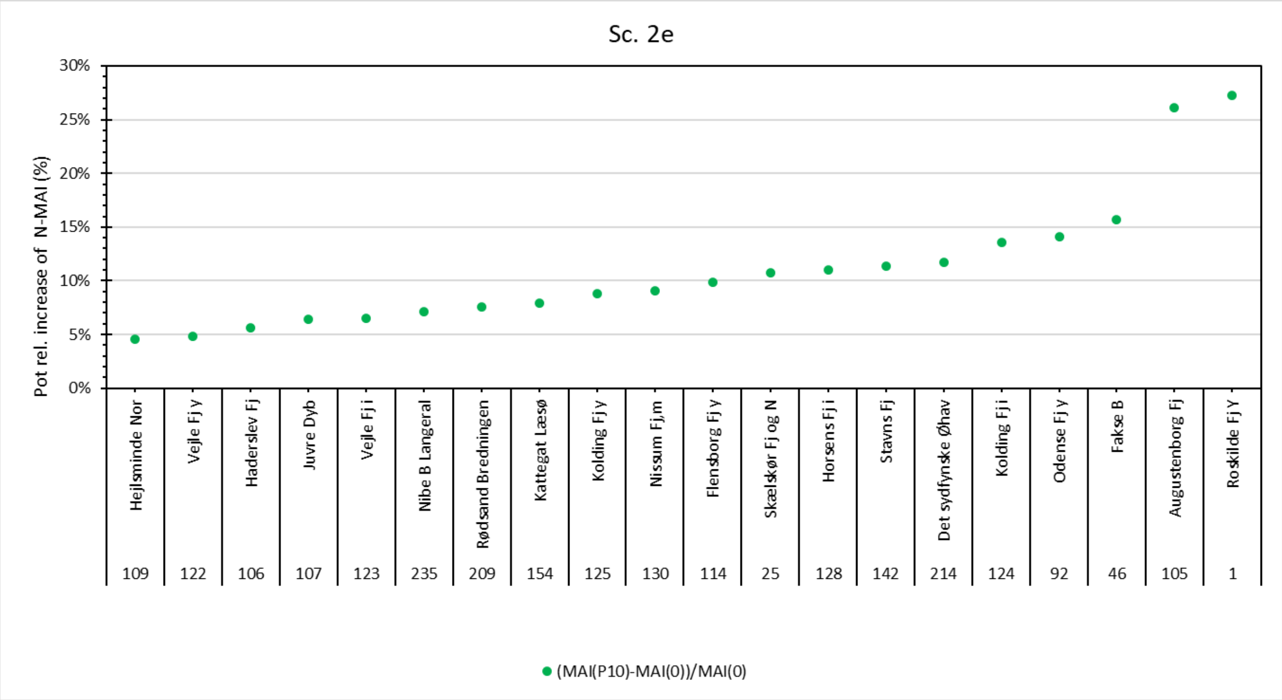

Figure 3-39: Potential relative increase of N-MAI for a ten per cent P load reduction, scenario 2e.

The above listing of water areas may indicate what areas may be of interest for modifying N-MAI by reduction of P loads.

Such modification requires more detailed studies of each individual water area.

Additional press factors

The assessment[126] is based on studies that contain documented and verifiable effects. Assessment of the effects of alternative press factors does not involve models for the effects of N load and P load and can hence be regarded as independent.

Summarising the outcome of the documents mentioned above, the impact of nine press factors – other than N load, P load and climate change – is studied:

- sand extraction
- dumping and dredging
- physical structures
- hazardous substances
- ship traffic
- plastic

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[126] The assessment of other press factors is based on the following documents: Petersen 2021: DTU Aqua-rapport nr. 381-2021; Petersen 2018: DTU Aqua rapport nr. 336-2018; Høgslund et al. 2019: Videnskabelig rapport fra DCE nr. 323; Stæhr et al. 2019: DTU Aqua rapport nr. 353-2019; Petersen et al. 2020b: DTU Aqua rapport nr. 358-2020; Petersen et al. 2020c: DTU Aqua r rapport nr. 361-2020; Petersen et al. 2020d: DTU Aqua rapport nr. 359-2020; Helmig et al. 2020: DTU Aqua rapport nr. 360-2020; Petersen et al. 2020a: DTU Aqua rapport nr. 365-2020.

- invasive species
- fishery.

The effects of sand extraction, dumping, dredging, physical structures and hazardous substances on the 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 press factors 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 press factors have potentially significant impacts at water body level.

The effects of ship traffic, plastic and invasive species are more complex, and quantitative models for assessing these effects on quality elements are not readily available.

If the effect of the relatively most important press factor, fishery, is to be included in the MAI analyses in a way that the effect can be compared quantitatively with the effects of N load and P load, from a scientific point of view, the dominating effects of fishery on the quality elements must be described to a degree of validity that is comparable to the degree of validity of the models that describe the effects of N and P loads. Models of such validity are not available.

Although the effect of fishery is considered uncertain and secondary compared to nutrient load, it is obvious that fishery has local impacts as described in Petersen (2021):

"It can be readily assumed that fishing with bottom trawls can have a very 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 concentration 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."

The limitations of the analysis of sand extraction, dumping, dredging and physical structure lie in the scale of their impact. Their scale is mostly much smaller than the scale of the water areas of RBMP, the masses involved and the time scale of a plan period.

The limitations of the analyses of fishery, ship traffic, plastic and invasive species lie in the concept of the analysis, i. e. that it must compare impacts where a scientific impact-response-relation is not available. Therefore, the analysis of these press factors is qualitative and to a large degree based on expert judgement on orders of magnitudes.

3.9.3 Concluding remarks

The potential effect of other press factors (on target, discharge and measures) is investigated in several reports, e. g. Petersen (2021). The following is concluded:

Eight press factors that are different than N load are studied:
Sand extraction, dumping/dredging, physical structures, fishery, ship traffic, plastic, hazardous substances, and invasive species.

- Each of the investigated alternative press factors is assessed to have less effect on the environmental quality elements than the nutrient and climate change effects.

- Among the alternative press factors, fishery has the highest relative impact.

Impact of fishery on the quality elements cannot be modelled to a degree of accuracy that can justify modification of MAI.

4 Analysis of the legal and scientific room for manoeuvring

4.1 Legal: Objectives and RC

From a legal normative perspective, the WFD sets the framework related to the establishing of type-specific RC for coastal water in Annex II, 1.3.(i) with reference to the normative definition of high ecological status classification, Annex V, 1.2.4, to the Comparability of biological monitoring results, including IC, Annex V, 1.4.1, and to the classification and presentation of ecological status (Annex V, 1.4.2).

Based on the normative legal framework and definitions, the actual implementation and interpretation of such, including the determination of boundaries between the defined categories involved, takes place upon sound expert judgement[127]. This involves sound deliberation and reasoning by members states guided by the outcome of the CIS process and the CIS GDs. As argued in Chapter 2.1 above, the outcome of such CIS deliberation (i. e. in terms of CIS GDs and other consolidated outcome) based on expert judgement is likely to have significant legal effect, where CIS exhaustively have addresses the matter in question. Therefore, the CIS outcome is relevant for the normative legal implementation of the WFD, and for the related interpretation of the meaning, interphases and boundaries of and between the definitions, categories and legal wording of the WFD and its annexes. It also follows that any applied deviation from such CIS guidelines carries a significant risk for legal action before the EUCJ.

With regard to a possible legal RFM, a legal analysis raises two interrelated questions: First, do the legal objectives of the WFD and the Nitrates Directive in overall terms allow RFM in terms of possible lowering efforts in preventing and reducing nitrogen pollution of surface waters, even as a result of a possible different interpretation and use of the criteria and methodology for RC and definition of water body status in Annex II and V?

Second, does the legal wording of the WFD leave RFM in terms of applying other methodologies and approaches to determine the basis for establishing the measures for preventing and reducing nitrogen pollution?

Question 1: Do the legal objectives of the WFD and the Nitrates Directive in overall terms allow room for manoeuvring in terms of possible lowering efforts in preventing and reducing nitrogen pollution of surface waters, even as a result of

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[127] Expert judgement to be understood in the wider context of applying the norms, methodology and conditions set out in the directives (opposite the narrow use of expert judgement as referred to, for instance in Annex II, 1.3 (iii, second sentence).
In general, expert judgement is required when defining all RC using various methods, see CIS Guidanec Document 5 on Transitional and Coastal Waters – Typology, RC and Classification Systems, 2003, at p. 41ss, sections 4.5.1 and 4.5.10

a possible different interpretation and use of the criteria and methodology for reference conditions and definition of water body status in Annex II and V?

The legal objectives of the WFD Article 1, and especially the Nitrates Directive art 3 are very clear in providing no further room for deviating from the overall objective of ensuring a constant drive towards preventing and reducing nitrogen pollution (nitrate pollution specifically targeted by the Nitrates Directive) of surface waters. Taken into consideration the current state of nitrate pollution of the Danish coastal waters, it underpins the legal requirement of both the WFD and the Nitrates Directive to maintain measures to reduce and prevent nitrate pollution. The need for effective measures and action is even emphasised as a consequence of applying the nitrate action programme to the entire territory of Denmark as a protected area according to the Nitrates Directive. Also, action and conservation measures are required by the Habitat Directives in case nitrate pollution leads to deterioration of natural habitats and the habitats of species, including relevant Natura 2000 sites designated. This obligation to assess the independent requirement for measures, to avoid deterioration of natural habitats caused by nutrients, stands regardless of whether the relevant measures are handled in the RBMP or in the Natura 2000 plans.

The WFD and Nitrates Directive apply different approaches to regulating and handling pollution, the WFD by setting a normative framework for defining and setting targets for water status and obligations to reach said status whereas the Nitrates directive takes a more traditional route of setting a normative framework for establishing when nitrate pollution requires measures to be taken to reduce and mitigate pollution.

This then raises the question of interconnectedness in the normative framework between WFD and the Nitrates Directive as to 1) definition of water status (WFD) and 2) nitrate pollution requiring measures to be taken (Nitrates Directive).

The WFD defines biological and physco-chemical quality elements for establishing a water body's status and setting targets. These quality elements (descriptors) can be found in the WFD Annex V, 1.2, and comprise descriptors all affected by nutrient enrichment, i. e. eutrophication.

The Nitrates Directive defines nitrate pollution as *"(…) the discharge, directly or indirectly, of nitrogen compounds from agricultural sources into the aquatic environment, the results of which are such as to cause hazards to human health, harm to living resources and to aquatic ecosystems, damage to amenities or interference with other legitimate uses of water"* (Nitrates Directive Article 2(j)). Eutrophication is in Article 2(i) defined as *"means the enrichment of water by nitrogen compounds, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned*". However, it shall be noted that eutrophication is applied only in Annex 1 of the Nitrates Directive as a criterion *inter alias* in defining waters referred to in Article 3.1 of the directive (waters affected/could be affected by pollution).

As highlighted above there is no harmonised definition between the two directives of e. g. eutrophication and/or what constitutes nitrate pollution between the two directives. This is a result of the two directives having different approaches to regulating nitrate pollution in water bodies.

The definition of eutrophication in the Nitrates Directive and the definition of physico-chemical quality elements in the WFD together define the framework/boundaries for (scientific) modelling of reference conditions, a topic elaborated on in section 3.1 and the potential room for manoeuvring analysed below in section 4.4.

As discussed in further detail below in section 4.4 it should be noted that the CIS Guideline 23, and therefore also the EU Commission, encourages Member States to apply a unified conceptual framework for measuring and analysing the effects of eutrophication when implementing both the WFD, Nitrates Directive, Habitats Directive, MSFD and other directives regulating the aquatic environment[128].

It shall be noted that the achievement of these legal objectives of the WFD and the Nitrates Directive are mandatory regardless of a RC and classification of water body status according to the WFD, even as a result of a possible different interpretation and use of the criteria and methodology for such. As such, no separate legal room for manoeuvring can take place under each directive, where this may hinder or jeopardise the implementation of the objectives of both directives. It can even be argued that more effective measures are in higher demand the more severe the pollution of the water body. This is further underlined by case *C-197/18 – Wasserleitungsverband Nördliches Burgenland* calling for additional measures and reinforced actions to prevent or reduce nitrate pollution where the contribution of N from agriculture makes a significant contribution to water pollution. It follows that the (risk of) exceedance of the 50 mg/l threshold at one measuring point is sufficient to require action. Thus, if nitrate pollution cannot be seen to be reduced and/or max nitrate levels of 50 mg/l cannot be met or risk being exceeded, additional measures must be taken under the Nitrates directive, specifically included in Nitrates Action Programme legislation subject to the Nitrates Directive Article 5.4 and 4.5.

It shall be note that the case C-197/18 requires *additional* measures and *reinforced* actions when nitrate from agricultural sources constitute a "significant" contribution to pollution of a specific waterbody. In a prior case, the EUCJ has found that 17% nitrate contribution from agricultural sources was significant Nitrate pollution under the 17% threshold is still subject to the legal

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[128] Facilitating the understanding of good status, the 1998 EC explanatory memorandum accompanying the WFD proposal (related to Annex Annex II og V) points out in para. 15 "… *However, in order to ensure complete consistency with the objectives of the Nitrates and Urban Waste Water Treatment Directives, the definition in relation to the parameter phytoplankton (i.e. the target status of the water in relation to eutrophication) is made completely consistent with the target state implicit in the definition of eutrophication in those two Directives"*, see COM 1998 PC0076 EN_TXT Amendment to COM(97) 49 final, Annex V - Including Explanatory Memorandum.

objectives of the Nitrates Directive of reducing and preventing nitrate pollution based on effective measures.

Further, it is also of key importance to note that the EUCJ has confirmed the importance of the Nitrates Directive Article 5.3(a) and (b) as requiring Member States to base their Nitrates Action Programmes on the *"best available scientific and technical data and the physical, geological and climatic conditions of each region"*.[129]

Thus, potentially required additional measures implemented through Nitrates Action Programmes may not be postponed due to on-going scientific discussions and further research on methodology etc.

To conclude on Question 1: The legal objectives are clear in scope requiring a constant drive towards preventing and reducing nitrogen pollution of water bodies, regardless the choice of methodology applied related to RC and normative status of water bodies. This is even supported by both the EU Commission and the case law of the EUCJ, as presented in Chapter 2.3-5 above. Therefore, the legal normative wording provides no further room for deviating from the overall objective of ensuring a constant drive towards preventing and reducing nitrogen pollution of surface waters[130].

However, the precise definition of the needed measures, and the level hereof, depends on the robustness of the methodology and the basis for establishing the measures. As such, question 2 focuses on the legal boundaries for applying other methodologies and approaches.

Question 2: Does the legal wording of the WFD leave room for manoeuvring in terms of applying other methodologies and approaches to determine the basis for establishing the measures for preventing and reducing nitrogen pollution?

It is not the mandate of this report to analysis a full legal conformity study of the Danish implementation of the WFD. However, and as the review of the environmental status (in Chapter 4 on Scientific Basis below) describe, the current Danish application and use of the methodological approach as set out in the WFD is in overall terms in alignment regarding the normative RC and the definition of status of coastal waters. It is also found that any change in the methodology applied requires involvement and adaptation at CIS level[131].

The WFD legal framework does not hinder possible changes and updates in the CIS guidance on the methodology recommended/applied as a result of the ongoing deliberation process. It may even be expected that such guidance may

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[129] C-197/18, paragraph 58 and C-237/12, paragraph 29.

[130] Also, the Member States shall take due relevant account of the TFEU Precautionary Principle when implementing the WFD and the setting of measures, as uncertainty related to the WFD methodological approach in general terms cannot lead to reduced efforts in addressing nitrogen pollution.

[131] If not directly by formal technical adaptation or legal revision of the WFD, Article 20 and 21.

be updated as a result of the consolidated learning experiences amongst the Member States. However, until such updates may take place the current set of CIS guidance carry significant legal meaning for the legal interpretation of the WFD legal regimes.

Based on the above, any change in methodology, or in the use hereof, cannot deviate from the legal objectives and requirement for a continuous drive towards preventing and reducing nitrogen pollution of coastal waters. The possible use of other methodologies or interpretation related to RC and normative definitions applied after Annex II.1.3, Annex V, 1.2 and 1.2.4 do not in legal term waive the strict objective of preventing and reducing nitrogen pollution.

The WFD itself, or the preparatory works provides no further detailed legal understanding beyond the wording of the WFD itself regarding the establishing of RC or the ranking of models in Annex II.1.3[132]. It also does not provide further legal guidance into the normative definition of the difference between "undisturbed conditions" and "slight signs of disturbance" as generally applied by Annex V.1.2.4 for High Ecological Status and Good Ecological Status respectively[133]. Similar, it provides no further legal interpretation of the meaning or definition of consistency and validity, and for the use of historical data in Annex II.1.3(v). As such, the determination of border definitions in Annex V.1.2.4, and as well as the fulfilment of these conditions in Annex II.1.3(v) shall be met by sound scientific justification and plausible arguments within the scope of the WFD framework and CIS guidance[134].

In terms of RC, it shall be noted that 2003 CIS GD 5 provided some early guidance in chapter 4.5 to the use of models (4.5.1), and the use of historical data (4.5.7). However, the provided guidance is rather limited, which leaves discretion to the Member States for sound implementation also using historical data subject to justification in meeting the conditions stated in Annex II.1.3(v).

[132] RC have been addressed as part of the WFD preparatory works preparatory works: As also described below in the analysis of Task Group 3, definition of typology and type-specific RC were introduced in the proposed amendments (COM (98) 76 final) to the proposal for the WFD of 1997 (COM (97) 49 final). The Explanatory memorandum of (COM(98) 76) describes the use of the typology and type-specific RC as core elements in implementation of the directive (COM(98) 76, Explanatory Memorandum Para 20-30 and proposal for Annex V, section 1.1.3). With the proposal for amendments (COM (1999) 271 final) the now existing structure and content of the WFD Annex II was introduced.

[133] The related scientific assessments are guided by CIS Guidance Document 2 on *Identification of Water Bodies,* and CIS Guidance Document 13 *on Overall approach to the classification of ecological status and ecological potential.*

[134] As a general note, CIS Guidance document No. 23, at para. 47-65, and in Table 5 provides comparison of the WFD normative status definitions and the eutrophication categories in other directives, and HELCOM and OSPAR.

The foundation for exercising the scientific assessments involved has subsequently been further detailed by more elaborated CIS GDs. GD 10[135] provides more insight in the use of RC compared to the wording of GD 5. However, both GDs are from 2003 and prior the experiences gained from the following first phase IC. As such, GD 14 provides further useful insight into IC and RC based on the experiences gained from the first phase IC[136].

This means that the possible room for uncertainty and/or deviations between RC and normative status of the water body is not further defined by legal terms. The same goes for a definition of the consistency between RC. It also applies for the meaning in Annex II, 1.3 (v) for RC based on modelling, which methods shall "provide a sufficient level of confidence about the values for the RC to ensure that the conditions so derived are consistent and valid for each surface water body type". The legal validity of the defined needed "sufficient level" and the fulfilment of being "consistent and valid" depends on the strength of the specific scientific argumentation. The conditions in paragraph (v) are equal in rank and cumulative, which means they all need to be fulfilled.

As such, the WFD legal framework itself provides no hinderance for the Danish implementation and application of RC. However, the legal text also implies that the final answer to the Danish conformity with the applied methodology lies within the sound scientific justification and plausible argument for ensuring consistency and validity. As such, the findings of the following scientific analysis below in this Chapter 4 will bring this analysis further in this regard.

4.2 Legal: Exemption in Art. 4.4 Extension of Deadline

As described in Chapter 2.1, the WFD sets out strict conditions for applying exemptions to fulfil the environmental objectives set out in Article 4.1. of the Directive.

Supposing that the application of Article 4.4. does not lead to *"further deterioration … in the status of the affected body of water"*, the most relevant discussion from a legal point of view is the field of application for:

- Natural conditions – Article 4.4 (a), iii and (c)
- Reasons are specifically set out and explained in the RBMP – Article 4.4. (b) and (d)

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[135] CIS Guidance Document 10 on *Transitional and Coastal Waters - Typology, reference conditions and Classification Systems*. Although not focusing on coastal waters, this GD provides more detailed understanding into the methodological use of RC.

[136] Also as addressed below in the analysis of Task Group 3, Guidance Document 14 on the Intercalibration Process incorporates experience from the 1st Phase intercalibration and which refers to and includes major parts of the "Guidelines to translate the intercalibration results into the national classification systems and to derive RC" presented together with the Commission Decision CD 2008/915/EC.

- How the two other EU regions that are in the scope of this study, Schleswig-Holstein in Germany and Southern Sweden, have applied Article 4.4[137]
- Application of the joint conditions for applying exemptions – Article 4.8 and 4.9
- Ensuring that the application of exemptions do not compromise environmental objectives concerning protected areas

4.2.1 The field of application for "natural conditions"

Importantly, the use of an extension of the deadline after 2027 requires the application of the reason that "natural conditions" do not allow timely improvement in the status of the body of water. Thus, the reasons for exemptions applied by Denmark in the first two RBMPs – "technical feasibility" and "disproportionately expensive" – are no longer applicable (WFD Article 4.4.c).

The concept of "natural conditions" is defined in the 2017 CIS GD as "*the conditions which dictate the rate or possibility of natural recovery*"[138]. This is in recognition that natural conditions may affect the possibility for reaching the conditions necessary to restore good status or potential of surface waters or the time needed to reach those conditions. This concerns, in particular, the decrease of pollutant concentrations and the re-colonisation or re-establishment by plants and animals."

Thus, "natural conditions" covers the time lag of the recovery of the water environment to a good status.

Nor the WFD, EUCJ, relevant guidance material or the EC has established an ultimate deadline for when the environmental objectives must be met at the latest after application of the exemption of extended deadline. Similar, it is established in the 2017 CIS GD complementing CIS guidance no. 20 that no time limitation is specified for the extension of the deadline on grounds of natural conditions[139].

Furthermore, it is also established in the 2017 CIS GD[140] that the application of WFD Article 4.4. requires that the measures needed to achieve good status have been taken by 2027 at the latest, but the characteristics of the river basin or water body are such that the recovery to good status is expected to take a longer time period.

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[137] The implementation methods applied by 3rd countries does not have any impact on the Danish legal obligations under the WFD. 3rd countries implementation measures are solely included for comparison in this analysis of the Danish potential room for manoeuvring.

[138] CIS Guidance Document 2017, page 4," *Natural Conditions in relation to WFD Exemptions*"

[139] Ibid., page 5

[140] Ibid, section 2.2

The EC has further elaborated on this point in the fitness check from 2021[141], thus stating that "*After 2027, the possibilities for exemptions are reduced, as 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*".

Based on the above, it is the finding of this report that the WFD by "measures taken at 2027 at the latest" requires that measures must be adopted and thus, legally binding as well as economically funded by 2027. Thus, the obligation to establish measures, including sufficient reductions in the nitrogen emissions, and ensuring that they have been taken by 2027 at the latest, leaves no room for later measures targeting nitrogen reductions after 2027.

Furthermore, following the directions given by the EUCJ, the EC and the wording of the WFD the deadline for meeting the environmental objectives in WFD Article 4.1 cannot be extended beyond the time lag of the recovery for the individual quality elements. Thus, the determination of time lag associated with the individual parameters/quality elements sets in the individual case the ultimate deadline for the extension of the deadline. Such determination shall be based on a sound scientific assessment allowing no further delay in time than justified by such assessment.

Therefore, "natural conditions" cannot apply in general terms, for instance accommodating a possible wish for later introduction of measures (after 2027) where new technology could be expected to achieve the environmental objectives in more effective manners. The Member States are always required to revise/update/introduce measures ongoingly under the schemes stated in the WFD. In addition, the CIS has pointed out that the TFEU precautionary principle calls for decisions based on the best information available at any given moment; "*Full certainty is not possible and should not act as a barrier to delay taking action*."[142]

Based on the above discussion on "natural conditions" in Article 4.4 (a) (iii) there is no further room for manoeuvring after 2027.

4.2.2 Reasons are specifically set out and explained in the RBMP

Furthermore, the WFD requires detailed information in the RBMP of the reasons for the extension for the individual water body, as the necessary measures required under the WFD Article 11 as well as the expected timetable for their implementation (Article 4.4. b) and d). Thus, the overall assessment and conclusion from the Commission on the Danish implementation of the WFD, going forward, is that the use of exemptions should be documented to a higher

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[141] See note 34.

[142] See page 7 in 2017 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*

degree than was the case with the second RBMPs, i. e. that the relevant criteria for use of the exemptions should be (further) documented.

In the light of the recent feedback from the EC, as presented in Chapter 2, it can be concluded that further application of extended deadlines – to the extent such an extension is legally possible – will presuppose more detailed reasoning. The EC also states that applying an extension of the deadline for the individual water body also involves the required measures necessary for obtaining the objective within a reasonable time frame not longer than what can be justified in natural processes.

4.2.3 Application of Article 4.4. in 3rd countries

In the two other EU regions that are in the legal scope of this study, Schleswig-Holstein in Germany and Southern Sweden, a wide-spread application of article 4.4 can be found based on the reason of "natural conditions".

All coastal waters in Schleswig-Holstein, both in the Baltic Sea and North Sea, have exemptions beyond 2027 due to natural conditions. It is assessed that about 50% of coastal waters will achieve a good status before 2039, and respectively 25% before 2045 and after 2045. The German body coordinating the Directive's implementation in Germany, LAWA, has issued guidance which thoroughly substantiates the wide-spread application of 'natural conditions'. In accordance with article 4.4(d) of the WFD, the RBMPs provide a justification for the delay of measures, including a timeline of measures to be taken and timeline when the environmental objectives are expected to be achieved.

The use of exemptions for 'natural conditions' in Southern Sweden differs between the Baltic Sea and North Sea. 75% of the Baltic Sea coastal waters are expected to achieve good status between 2027 and 2039, due to a time lag in the recovery of phytoplankton and/or from nutrients among others. The picture is less severe in the North Sea, where 10% of coastal waters are expected to achieve a good status between 2027 and 2039. Nutrient pollution is the reason in about 2/3 of the cases, whereas phytoplankton applies to only 1/3 of the waters. The Swedish RBMPs provide an overview of the financing and effect of measures implemented after 2027. However, no extensive overview for the timeline of the delayed measures can be identified in the RBMPs or digital information system (VISS), although this is stated to be provided in the RBMP.

A notable aspect in both the German and Swedish implementation is that the measures on agriculture will not be fully implemented by 2027. In Schleswig-Holstein, all measures will be at least on-going (or beyond the preparation phase). Due to, among others, an overburdening of the financing sources for measures, some measures need to be stretched into 2033. According to the plans, most of these measures refer to hydromorphology. It is unclear whether agricultural measures are also subject to completion beyond 2027. In any case, the plans highlight an attempt to be transparent on this subject matter.

In Southern Sweden, agricultural measures will be executed in two batches in 2022-2027 and 2027-2033 due to cost-effectiveness considerations. The supporting documentation does however not provide any further rationale as to why measures are being implemented after 2027, and whether it is regarded that this approach is compliant with the WFD.

It is thus for both Schleswig-Holstein and Southern Sweden that time exemptions due to natural conditions are widely applied (albeit to an only small degree in the Swedish North Sea). It is further evident that both interpretations have an understanding that the measures must be initiated, but not completed, before 2027. It would appear, that the governments of Germany and Sweden consider this in line with the obligation - as interpreted in the CIS Guidance and the EC - to ensure that measures "have been taken" by 2027 at the latest.

It goes beyond the scope of this study to assess whether the German and Swedish interpretation of the RFM when applying Article 4.4. after 2027 is compliant with the WFD. In this analysis the conclusion, however, is that all necessary measures needed to achieve good status should be taken by 2027 at the latest.

4.2.4 Application of the joint conditions for applying exemptions – Articles 4.8 and 4.9

The RFM is further narrowed down by the strict conditions set out in Article 4.8 and 4.9. of the WFD thus obligating Member States to ensure – when applying Article 4.4 and 4.5 – that 1) the extended deadline does not lead to the non-achievement of the environmental objective in other water bodies or 2) not guaranteeing the same level of protection as the existing Community legislation such as the Nitrates Directive and the Habitat Directive.

Ensuring that the application of exemptions do not lead to non-achievement of objectives in other water bodies – WFD Article 4.8

The condition in Article 4.8 entails that Member States are to justify that the application of among others Article 4.4 and 4.5 for one water body does not "permanently exclude or compromise the achievement of the objectives of this Directive in other bodies of water within the same river basin district and is consistent with the implementation of other Community environmental legislation."

Thus, the application of Article 4.4 as well as Article 4.5 prerequisites an assessment of the effect on adjacent bodies of water of extending the deadline/setting a less stringent environmental objective in order to be able to ensure that the application does not permanently exclude or compromise the achievement of the objectives of this Directive or is not consistent with the implementation of other Community environmental legislation i.e. the Nitrates and Habitats Directives.

Ensuring that the application of exemptions guarantees the same level of protection as the existing Community legislation - WFD Article 4.9

According to the WFD Article 4.9 Member States must ensure that the application of, among others, Article 4.4 and 4.5 guarantees at least the same level of protection as the existing Community legislation.

As already addressed above in Chapter 2, the WFD shall respect the objectives of the other directives meaning that not only the conditions in Article 4.4 / 4.5 of the WFD must be met but also the obligations in other relevant directives namely the Nitrates Directive, the Habitats Directive and the MSFD.

To elaborate further on the findings in Chapter 2 as regards the Nitrates Directive, the following obligations must all be fulfilled regardless of how the WFD is implemented – and thus regardless of any potential extensions and/or changes to targets:

- If nitrate pollution cannot be seen to be reduced and/or max nitrate levels of 50 mg/l cannot be met or risk being exceeded, additional measures must be taken under the Nitrates directive, specifically included in Nitrates Action Programme legislation subject to the Nitrates Directive article 5(4) and (5). This follows from EUCJ case law, specifically the ruling in case C-197/18.

  In case C-197/18 the EUCJ found that the Nitrates Directive requires the adoption of action programmes and, if necessary, additional measures and reinforced actions where the contribution of N from agriculture makes a significant contribution to water pollution.

  In a specific case, 17% N contribution from agricultural sources was deemed significant by the EUCJ. See the discussion regarding case C-197/18 in section 2.5.4 above.

- The above stated obligation is highlighted in the Commission's latest implementation report regarding the Nitrates Directive. The Commission highlights the obligation, albeit without reference to case C-197/18: *"The Nitrates Directive requires that Member State take preventive action when the quality of water stagnates and does not improve."*. See Chapter 2.3 and 2.4 above regarding the Commissions' latest implementation report regarding the Nitrates Directive.

  Thus, if an extension of deadline or the setting of less stringent objectives is implemented, Denmark will still have to document towards the Commission that nitrate pollution is still reduced, regardless of if/how WFD extensions and target reductions are applied, i.e. that this will not lead to reduction of nitrate pollution from agricultural sources being stalled. The trend towards reduction of nitrate pollution from agricultural sources has to remain intact for any one and for all waters.

In this regard should be noted that the Commission has highlighted Denmark as being among Member States standing out due to a large number of waters that are eutrophic and having recorded bad water quality all around their territory and a systemic problem to manage nutrient loss from agriculture.[143]

- Such additional measures subject to the Nitrates Directive article 5.5 must be adopted at the earliest time when Member States become aware that such measures are necessary to achieve the goals of the Nitrates Directive.[144]

- National legislation must contain rules relating to limits on the land application of fertilisers based on a balance between the foreseeable N requirements of crops and the N supply to crops from the soil and from fertilisation, those rules having to take the form of use standards.[145]

- Denmark has failed to report information about the contribution of agriculture to N discharge to the aquatic environment. This should be remedied.[146]

- When assessing implementation of both the Nitrates Directive and WFD, the Commission recommends assessing trophic status of water bodies using the classification system described in the CIS GD 23 under the WFD regarding eutrophication.[147]

In the case of the Habitats Directive, the extended deadline and establishment of less stringent environmental objectives for a water body will not only require assessments related to Article 4.4 and 4.5 of WFD. It will also require an appropriate assessment in accordance with Article 6.3. of the Habitats Directive and potentially that the strict conditions for derogations under Article 6.4. of the Habitats Directive are fulfilled. The purpose of the exercise is to establish that a less stringent environmental objective will not jeopardize the objectives established for the individual Natura 2000 site and the general objective of the Directive to maintain or restore favourable conservation status. A described in Chapter 2, it shall be noted that the Habitats and Birds Directives do not include a possibility to exempt from or set less stringent objectives.

Similarly, the extension of the deadline after WFD Article. 4.5 will also presuppose that the same assessment as described above is carried out by the Member States.

It should also be considered whether the application of Article 4.4. and 4.5. in coastal water bodies that includes Natura 2000-sites, which are already affected negatively by nutrients, is compatible with the obligation in the Habitats

[143] Nitrates Directive 2021 report, page 10.
[144] C-322/00, paragraph 166
[145] C-322/00, paragraph 84-85 and 94.
[146] Nitrates Directive 2021 report, page 3. See also note 56.
[147] Nitrates Directive 2021 report, page 6.

Directive Article 6.2 to take appropriate steps to avoid deterioration of natural habitats and the habitats of species.

It should furthermore be noted that if the proposal on nature restoration[148] is adopted, it must be expected to pose a significant obligation on the Member States to establish the necessary restoration measures to contribute to ensuring that in 2050 all ecosystems are restored, resilient and adequately protected. Thus, indirectly a deadline for meeting the objective of the Habitats and Birds Directive will be set if the proposal on nature restoration is adopted. This could lead to an even stricter interpretation as to whether the conditions in Article 6.2 – 6.4 of the Habitats Directive can be met when applying Article 4.4 and 4.5 of the WFD. It goes beyond the scope of this study to address this issue further.

Thus, the use of exemptions after WFD Article 4.4. and 4.5 prerequisites the documentation that the extension of the deadline and the setting of less stringent environmental objectives will not adversely affect the integrity of relevant Natura 2000 sites or the fulfilment of the strict conditions for derogation under Article 6.4 of the Habitats Directive.

The EU Commission has highlighted the recommendation that Denmark needs to establish objectives for its relevant Protected Areas for surface and groundwater.[149] This recommendation is also related to Natura-2000 areas and points out the implementation methods which require further development to even consider the implementation compliant.

This gives a clear indication on which steps the Commission views as necessary to achieve and maintain compliance with the Habitats Directive when (also) implementing the WFD.

Ensuring that the application of exemptions does not compromise environmental objectives concerning protected areas

The condition in WFD Article 4.9 furthermore needs to be addressed in connection with the obligation to set environmental objectives regarding Protected Areas.

As defined in Chapter 2, the obligation concerning Protected Areas entails that the Protected Areas (which includes among others both Natura 2000-sites and areas covered by the Nitrates Directive, as just described in the previous section) are covered by a multiple set of environmental objectives. It is furthermore stated by WFD Article 4.2 and Article 10.3 that the most stringent [environmental objective] shall apply. Thus, the application of Article 4.4 or 4.5 of the WFD calls upon the Member States in meeting the objectives set for individual Protected Areas.

In practice WFD Article 4.1.c) – as supported by Article 6 and to emphasising Protected Areas - has a similar scope to Article 4.9 in the sense that both

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[148] COM (2022) 304

[149] The 5th Implementation Report regarding Denmark page 18.

provisions require that Member States ensure that exemptions after the WFD must not compromise other EU legislation. It is however important to stress the fact that the Article 4.1 (c) has a broader scope making it an additional requirement after the WFD to achieve objectives established under the EU-legislation covered by Protected Areas. Thus, the objective to achieve favourable conservation status for habitat types and species covered by the Habitat Directive is also an objective after the WFD and subject to the same deadlines.

In the ECs' Fifth Implementation Report on the WFD[150], the EC recommended that Denmark needs to establish environmental objectives for its relevant Protected Areas for surface water and groundwater particularly relating to the Natura 2000 sites.[151] Denmark has subsequently clarified that no specific water objectives have been set to protect dependent habitats and species because the achievement of WFD good status is sufficient to achieve favourable conservation status.[152] It must thus be assumed that the environmental objective after the WFD for habitats and species within the Protected Areas is good status and that the deadline for achieving this objective follows the deadline for the body of water which the relevant Natura 2000-site lies within.

Furthermore, the EUCJ states in the Doñana case that Member States can be in breach of their obligations under WFD Article 11 of Directive 2000/60, read in conjunction with Article 4.1(c) if they do not lay down, in the programme of measures, any measure to prevent disturbance of the protected habitat types. Thus, the ruling does not only confirm the double set of environmental objectives, stated in the WFD Article 4.1(c) but introduces an obligation on the Member States to actively include in the programmes of measures relevant measures to meet the objectives after other EU-legislation, e.g. The Nitrates Directive and the Habitats Directive. Thus, the WFD – as interpreted by the EUCJ in the Doñana case – imposes an obligation to establish measures to meet environmental objectives after not only WFD Article 4.1 but also environmental objectives in relevant EU-legislation covering Protected Areas.

In Denmark, most of the coastal waters have not yet achieved the established environmental objectives. Thus, Denmark is according to the WFD obliged to establish sufficient additional measures to achieve established objectives after both the WFD and other relevant EU-legislation covering Protected Areas.

As earlier stated, CIS GD 20 states that the exemptions in Articles 4.4 and 4.5 are applicable to all environmental objectives in Article 4.1, thus also to Article 4.1(c) regarding Protected Areas. The application of the exemptions in the WFD can however not be applied to deviate from objectives and obligations in other EU-legislation. Thus, Article 4.9 is clear in its obligation that when applying the exemptions of Article 4, the same level of protection should be given as in

[150] Ibid.

[151] Ibid. Page 20.

[152] See note 35.

existing Community legislation[153]. This means that exemptions from the WFD environmental objectives cannot be used to deviate from objectives and obligations set by other pieces of EU legislation. Namely the Nitrates Directive and possibly also the Habitats and MSFDs will, according to our assessment, stand in the way of fulfilling the requirement in Article 4.9 of the WFD.

4.2.5 Other relevant discussions

The conditions for applying Article 4.4 should further be seen in conjunction with the obligation set out in Article 11.5 of the WFD which obliges Member States to establish additional measures where necessary to achieve the established objectives, in situations where the environmental objectives set under Article 4 for bodies of coastal waters are unlikely to be achieved. This provision is a general obligation.

Also, Article 11.7 includes an obligation for Member States to ensure that Programmes of measures are made operational with specific deadlines (at the latest 9 and 12 years respectively after the entry into force of the WFD in December 2000). The WFD Article 11.8 furthermore obligates Member States to regularly review and if necessary, update their Programmes of Measures at the latest 15 years after the date of entry into force of this Directive and every six years thereafter. Lastly the provision entails an obligation for Member States to make operational within three years of their establishment "any new or revised measures established under an updated programme."

The three-year period in Art. 11.8 allows for sound preparation up till three years after establishment of the measure. However, this cannot override the fulfilment of the overall objectives of the WFD unless clearly stated. As such, Art 11.8 cannot extend the deadline set by Art 4 in achieving the objective of the water body by 2027. As described in Art 4.4 (c), only natural conditions may allow for later realisation of such objective. It follows that Member States should observe the 2027 deadline, and accordingly adopt and plan measures prior in time in meeting the 2027 deadline.

4.2.6 Conclusion on the further application of WFD Art 4.4.

Based on Chapter 2 and the above analysis, the conditions for applying Article 4.4 in the 3rd RBMP - as interpreted in CIS GDs, case law from the EUCJ and statements from the EC in e.g. the fitness check – can be summarised as follows:

- It can be justified that no further deterioration occurs in the status of the individual, affected body of water.

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[153] " Existing Community legislation" is here understood in terms of other legislation in force, and not as a narrow understanding referring to the" existing legislation" only at the time of the WFD entering into force.

- All relevant measures needed to achieve good status have been taken by 31st of December 2027 at the latest, including sufficient reductions in the nitrogen emissions.

- Relevant and sufficient measures should be adopted and legally binding as well as economically funded on the 31st of December 2027 at the latest.

- Only the time lag of the recovery of the water environment to a good status can be outstanding, for the reason of "natural conditions" to apply. The exact establishment of when the environmental objective shall be obtained, shall be based on a scientific estimation of the time lag for the individual QEs.

- An extension of the deadline, and the reasons for it, are to be specifically set out and explained in the RBMP together with a summary of the measures required under Article 11 and the expected timetable for their implementation.

- Member States shall ensure that the application does not permanently exclude or compromise the achievement of the objectives of this Directive in other bodies of water within the same river basin district and is consistent with the implementation of other Community environmental legislation.

- Member States shall guarantee at least the same level of protection as the existing Community legislation when applying Article 4.4 and the extension of deadline may not prevent Member States meeting the objectives set for individual Protected Areas.

It follows from the above that the application of Article 4.4 from a legal point of view provides no further RFM leading to a reduced approach in measures and actions.

The understanding of the ultimate deadline for meeting the objective of good status for coastal waters – all relevant and sufficient measures should be taken by the end of 2027 – is boiled down to one aspect. Only the time lag of the recovery of the water environment to a good status can remain after 2027, for the reason of "natural conditions" to apply. The exact establishment of when the environmental objective shall be obtained, shall be based on a scientific estimation of the time lag for the individual QEs.

It follows from the description in this report that Denmark together with other Member states have not fulfilled the objectives of good status for coastal waters within the original deadline of the WFD in 2015 and thus, have applied Article 4.4 and the possibility to extend the deadline in both RBMP 1, 2 and the draft 3rd RBMP. As an observation, and in line with the forthcoming WFD Art 4.4 deadline of 2027 in reaching the environmental objectives, the EC and EUCJ seems to emphasise (in the recent communication and caselaw, as quoted in this report) the required Member States responsibility in meeting these objectives. A message also underlined by the 2022 proposal for a regulation on nature restoration introducing new obligations on Member States to apply necessary restoration measures by 2050. This also introduces an indirect deadline for meeting the objective of the Habitats and Birds Directive.

4.3 Legal: Exemption in Art. 4.5 Less Stringent environmental Objectives

As described in section 2.2, Article 4.5 sets out the strict conditions under which Member States can set a less stringent environmental objective for a specific water body. CIS has detailed this by stating that "*[T]he application of Article 4(5) should be grounded on a particularly solid evidential basis; furthermore, the less stringent objectives have to be reviewed every 6 years,"*[154] and "*The achievement of a so called "less stringent objective" may require the implementation of measures that are as stringent, if not more so, than the measures that are required for water bodies for which the objective is good status*."[155]

It shall be noted that Denmark has not earlier applied this possibility to set less stringent environmental objectives for coastal waters. It is not part of the earlier RBMPs or part of the draft 3rd RBMP.

The conditions for applying Article 4.5 of the WFD

One of two preliminary conditions set out in Article 4 (5) must apply: 1) The specific water body is "*so affected by human activity, as determined in accordance with Article 5 (1)"*, or 2) "*their natural conditions are such that the achievement of these objectives would be infeasible or disproportionately expensive*".

The first condition must apply in the sense that the nitrogen emission to the coastal waters to a wide extent is caused by ongoing agricultural practice.

As to the second condition, application of a less stringent environmental objective presupposes that "the achievement of good status would be either 'infeasible' or 'disproportionately expensive". Although "natural conditions" is not an exemption ground after Article 4.5, the same argument of "natural conditions" may take place as part of the justification for non-achievement of the objectives set.

There is little guidance on the interpretation of infeasibility and disproportionality. CIS Guidance no. 20 states that the term 'infeasible' includes technical infeasibility but could also refer to situations where addressing a problem is out of the control of a Member State." According to the CIS Guidance no. 20, page 13 'Disproportionality', as referred to in Article 4.4 and 4.5, is 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

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[154] 2017 CIS Guidance Document *Natural Conditions in relation to WFD Exemptions*, p. 11.

[155] See CIS Guidance Document 20, page 22.

on exemptions." Thus, especially the second condition contains an assessment that includes political as well as economic considerations.

The provision should however be interpreted considering the overall purpose of the Directive as well as the supplementing cumulative conditions in Article 4.5.(a) – (d) which all needs to be met.

Especially the test in Article 4.5 (a) is highlighted in the CIS Guidance no. 20 as decisive for the applicability of the provision; "*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.*" Thus, the human activity – in this case nitrogen emissions caused by agriculture – needs to cover both environmental and socioeconomic needs that cannot be achieved by other means.

Even if it could be argued that agriculture (e. g. food production) constitutes a socioeconomic need, it is a also a requirement that it can be justified to constitute an environmental need. As the impact of nitrogen emissions from agriculture affects both the coastal waters and the species and natural types inhabiting in the coastal waters negatively, it is unlikely that that nitrogen emissions from agriculture from af legal perspective fulfil the criteria of meeting an environmental need and thus, the condition in Article 4.5 (a) cannot be met.

It may be argued from a global environmental impact point of view that the Danish agriculture could constitute an "environmental need" even if it requires setting less stringent environmental objectives after the WFD. The argument goes that keeping such production in Denmark would give less global environmental impact instead of moving the food production to other countries operating under even less strict environmental requirements. However, as described in section 2.1 above the TFEU principle of environmental damage should be rectified at source opposes such an approach. The EU environmental Acquis provides no legal justification for a global "trading scheme" or equivalent regulatory levelling mechanism on reduction and prevention of nitrogen pollution. 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.

It shall be mentioned that in the unlikely event that a case meet the test in Article 4.5 (a), the following further conditions need to be met:

- The highest ecological and chemical status possible is achieved (Article 4.5 (b)
- No further deterioration occurs in the status of the affected body of water (Article 4.5 (c)
- A specific mentioning of the establishment of less stringent environmental objectives and the reasons for it in the RBMP (Art. 4.5 (d)).

The difficulty in passing the test of other means, and the condition that the ongoing agricultural practice leading to nitrogen emissions should serve an environmental need, is further stressed by the assessment from the EC. It is stated that when applying Article 4.5, and potentially designing revised RBMP's, it should be done in a manner comprising better documentation for the methods used to assess the fulfilment of mandatory criteria. This is highlighted in the following manner by the Commission:

> *"(t)he reasons for exemptions were reported at the water body level. Justifications for exemptions were reported in WISE. However, whether there are clear criteria that have been developed for the application of "technical unfeasibility", "disproportionate costs" and "natural conditions" cannot be assessed due to the lack of reported methodological documents for the application of exemptions in surface and groundwater bodies*.[156]

Thus, it can be concluded that the EC, when reviewing the 3rd and following RBMP, will be particularly focussed on the reasons for exemptions applied by the Member States.

Application of Article 4.5 in 3rd countries

Denmark has not earlier applied Article 4.5 to coastal waters. It follows that no Danish experience has been gained on possible justifications related to an exemption for such specific Danish coastal waters.

Of the two 3rd country regions taking part of this legal study, only Southern Sweden has made use of Article 4.5 in the 3rd RBMP. However, it has been applied only to 3% of its coastal water bodies (8 out of 289).

All exemptions are motivated by the hydromorphologic status and the hydrogeographic conditions which only support a 'moderate' environmental objective. All the waterbodies subject to a less stringent environmental objective are adjacent to harbour activities where it has been judged that the harbours fulfil an environmental and socio-economic need that cannot be met in any way that is better for the environment without disproportionate costs. The exemptions are thus motivated by the disproportional costs required to achieve a 'good' environmental status.

It goes beyond the scope of this study to assess whether the Swedish interpretation of Article 4.5 (a) is in line with the WFD. The rationale that port operations fulfil an important and specific socioeconomic need and that a 'good' status would require disproportionate costs (e. g. reconstruction of port infrastructures) are however sound. Furthermore, the use of article 4.5 on such a small number of coastal waters is also in line with the fact that this derogation is meant for specific cases.

In continuation of the Swedish example, it is important to stress that both reasons in Article 4.5 (a) should be met and that the exemption can only be

[156] See the 5th Implementation Report regarding Denmark pages 14-15 and 111-112.

applied when the human activity serves both "environmental *and* socioeconomic" needs.

Furthermore, according to CIS GD no. 20, page 20, "*a 'less stringent objective' does [...] not mean that (a) the other quality elements are permitted to deteriorate to the status dictated by the worst affected quality element or (b) the potential for improvement in the condition of other quality elements can be ignored*." On that basis, a less stringent environmental objective is therefore only applicable to the specific QE in question, and it can therefore not be concluded that the Swedish case can be applied to the Danish context: Even if a waterbody has a derogation for a reduced environmental objective due to e.g. hydromorphology, it would not exempt from the timely implementation of the measures associated with a 'good' status on the remaining QEs.

Application of the joint conditions for applying exemptions – Articles 4.8 and 4.9

Similar to the analysis above on Article 4.4, the application of Article 4.5 is further narrowed down by the strict joint conditions set out in Article 4.8 and 4.9 of the WFD thus obligating Member States to ensure – when applying Article 4.4 and 4.5 – that

1) the extended deadline or the less strict environmental objective does not lead to the non-achievement of the environmental objective in other water bodies, and

2) to ensure that all objectives and levels of protection in existing Community legislation such as the Nitrates Directive and the Habitat Directive, are fully met.

Please refer to section 4.2.4. for at substantial analysis of the prerequisites for applying Article 4.5 in respect of the joint conditions in the WFD Articles 4.8 and 4.9.

4.3.1 Exemptions in a transboundary context

When it comes to transboundary pollution/emissions from other countries (cf. also Task 5 on burden distribution), CIS guidance no 20, *Annex II: Exemptions in a transboundary context* states that the condition required by WFD Article 4.5 ("*so affected by human activity, as determined in accordance with Article 5(1)*") cannot apply where the human activity causing the pollution or the ecological impacts is outside the jurisdiction of the Member State. In case of transboundary effects, there is no human activity within the Member States' competence that can be compared with another. As such, this condition does not apply in case of transboundary pollution or transboundary ecological impacts.

For international river basin districts established after WFD Art 3.3, Art 13.2 requires the Member States to seek developing an international RBMP. Where such an international RBMP is not produced, Member States shall produce RBMPs covering at least those parts of the international river basin district falling within their territory to achieve the objectives of the WFD. To this end, WFD Art 3.4 require Member States to achieve coordination amongst the RBMPs and programme of measures, also by use of existing structures stemming from international agreements, and eventually by facilitation by the EC. As such, and also following from other EU or international legal commitments, the Member states are required individually and as a joint effort to address transboundary pollution, where such have an impact on the implementation of the WFD. Where relevant, this shall also involve the related coordination of measures to address such transboundary emissions, and the coordinated use of exemption, if and where applicable.

Where a Member State identifies an issue, which has an impact on the management of its water but cannot be resolved by that Member State, WFD Art. 12 allows the Member State to report the issue to the Commission and any other Member State concerned and may make recommendations for the resolution of it. This may also be applied in case of emissions from 3rd countries although Art 12 tells nothing about the outcome or consequences of such reporting in terms of use of exemptions. CIS guidance no 20, Annex II is rather weak in its language guiding this possible use of Art 12 stating that it "*might be invoked for various situations related to exemptions. It might for example be applied in cases where no information on exemptions is provided, or it might be applied to solve the issue for which an exemption needs to be applied by a neighbouring Member State*". It also provides a rather open-ended take on possible actions of the EC; "*The possible reaction by the Commission will vary depending on the issue*".

This means that Art 12 must be seen as a last resort for a Member State based on an open-ended plead for mitigation, negotiation, coordination, action, or other measures to be taken. It is last resort as CIS guidance no 20, Annex II states that the key issue invoking Art. 12 is the demonstration of evidence that Member States have taken all reasonable actions to fulfill the legal obligations. This also includes the required coordination attempts for international RBMPs, WFD Art. 3.4 and Art. 13.2.

As such, Art 12 cannot be viewed as a clear or predictable legal avenue to allow WFD exemptions leading to reduce in measures and actions.

4.3.2 Conclusion on the further application of WFD Art. 4.5

In summary the conditions for applying Article 4.5 in the 3rd RBMP - as interpreted in CIS GDs, case law from the European Court of Justice and statements from the EC in the Fitness Check and Fifth Implementation Report – are as follows:

- One of the two preliminary conditions is fulfilled:

  a) The specific water body is "so affected by human activity, as determined in accordance with Article 5 (1)", or

b) “their natural conditions are such that the achievement of these objectives would be infeasible or disproportionately expensive”.

- All the four supplementary conditions are fulfilled:

  a) the environmental *and* socioeconomic needs served by human activity cannot be achieved by other means which are a significantly better environmental option not entailing disproportionate (ongoing agriculture),

  b) the highest ecological and chemical status possible is achieved,

  c) no further deterioration occurs in the status of the affected body of water, and

  d) the establishment of less stringent environmental objectives, and the reasons for it, are specifically mentioned in the RBMP.

- Member States shall ensure that the application does not permanently exclude or compromise the achievement of the objectives of this Directive in other bodies of water within the same river basin district and is consistent with the implementation of other Community environmental legislation. (Article 4.8).

- Member States shall guarantee at least the same level of protection as the existing Community legislation when applying Article 4.5 (Article 4.9) and the extension of deadline may not compromise Member States in meeting the objectives set for individual Protected Areas (Article 4.1(c).

It follows from the above that the application of Article 4.5 from a legal point of view provides little further RFM leading to a reduced approach in measures and actions. This conclusion follows the strict conditions for applying the provision, namely Article 4.5 (a) and also the recent statement from the EC in the Fifth Implementation Report. Here, the need for better documentation for the methods used to assess the fulfilment of mandatory criteria when applying exemptions is emphasised. Also, it is argued that the use of the exemption is not intended for general application for the majority of water bodies but shall only be applied in special cases.

In addition, Article 4.5 cannot stand alone. A significant impediment for applying Article 4.5 sits with the obligation of Article 4.8 and in particular 4.9 of the WFD mentioned above obligating Member States to ensure that other EU-legislation is not compromised when applying exemptions after the WFD. Thus, the following obligations following from the Nitrates Directive will most likely in practice make it impossible to set less stringent environmental objectives leading to larger emissions of nitrate.

- If nitrate pollution cannot be seen to be reduced and/or max nitrate levels of 50 mg/l in groundwater cannot be met or risk being exceeded, additional measures must be taken under the Nitrates directive, specifically included in Nitrates Action Programme legislation subject to the Nitrates Directive article 5(4) and (5).[157]

- It is of key importance when assessing potential RFM within the WFD framework to keep in mind the obligation to implement additional measures/reinforced action to reduce and prevent nitrate pollution from agricultural sources, when contribution from agricultural sources is *"significant"*.

- It is also of key importance to note that the EUCJ has confirmed the importance of the Nitrates Directive Article 5(3)(a) and (b) as requiring Member States to base their Nitrates Action Programmes on the *"best available scientific and technical data and the physical, geological and climatic conditions of each region"*.[158]

- Thus, potentially required additional measures implemented through Nitrates Action Programmes may not be postponed due to on-going scientific discussions and further research on methodology etc.

Furthermore, the application of Article 4 (5) could potentially lead to infringement of obligations after the Habitats and the Marine Strategy Framework Directive. Application of Article 4.5 - the setting of less strict environmental objectives - would prerequisite that the conditions in Article 14 to exempt from the environmental targets in the MSFD are met. Furthermore, application of Article 4.5 for a specific coastal water body which include a marine Natura 2000 site would at least prerequisite an appropriate assessment to establish that a less stringent environmental objective after the WFD, and the related accompanying measures applied, will not jeopardize the objectives established for the individual Natura 2000 site and the general objective of the Directive to maintain or restore favourable conservation status. A clearer conclusion of the link between the directives would however require an estimation on a specific water body as to whether the specific objectives after the directives will be compromised by larger emissions of Nitrogen.

4.3.3 End note related to the ToR

Based on the above, it is not relevant from a legal perspective to go into details on how to apply/develop less stringent objectives, or into reflections on possible alternative routes to implement the objectives.

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[157] C-197/18, paragraph 64-68

[158] C-197/18, paragraph 58 and C-237/12, paragraph 29.

4.4 Task 10: Reference condition

4.4.1 Objective

Assess possible room for manoeuvring in relation to establishing the reference condition and the environmental targets. Description of one to two alternatives for determining the reference condition,

Sub tasks:

- Based on existing study from AU, a description of one to two alternatives for determining the reference condition for coastal waters are presented.
- A review of the possibility for applying methods and preconditions (within EU directives and guidelines) from neighbouring countries.
- Assessment of scientific playing field for determining the reference N load (for reference condition).
- Review of the applicability of such alternatives as well as their limitations.

4.4.2 Analysis and assessment

Determining reference conditions

The WFD, Annex V, 1.2, normative definitions define a link between the status of biological quality elements and supporting physico-chemical quality elements; the provisions of Annex II, 1.5, on assessment of impact require assessment of surface water status related to pressures; and the provisions of Annex V, 1.4, on developing class boundaries and classification of ecological status stipulate status classification according to a scale (EQR) that describes the relationship between class boundaries and reference conditions. In cases where reference conditions cannot be established by use of 'true' reference sites or by comparison with other relevant water body types, Member States are left to use historical data, if necessary, in combination with hindcasting modelling, in order to establish the link between the reference conditions for the biological quality element and the reference conditions for the supporting quality element (WFD, Annex II, 1.3 (iii) and (v)). The CIS-GDs No. 5, No. 10, No.13 and in particular No. 14 (2008-2011 version) specify the Commission's understanding of how these provisions should be interpreted scientifically – also see Section 3.1.

In their contribution to the 1st Phase intercalibration process Denmark, Germany and Sweden used a combination of monitoring data; historical data; and regression modelling for establishing a pressure-impact relationship. Particularly between nitrogen/Chl-a concentrations in their derivation of reference conditions for Chl-a. For Chl-a, the same method was the basis for the 2nd Phase intercalibration between Denmark and Germany. Denmark also used such method regarding eelgrass depth limit where reference conditions were established based on historical data and the reference condition values were associated with a pressure-impact relationship between ‘nitrogen concentration’ and ’eelgrass depth limit’ in a first exercise of determination of the H/G and G/M class boundaries for nitrogen concentration. The results of this approach for Chl-a were approved by the Commission and included in the intercalibration decision (European Commission (EC), 2008a).

As concluded in Sections 3.1 and 3.2, the documentation on RBMP2 and RBMP3s does not present such pressure-impact relationships (gradients) covering the full pressure range including reference conditions, neither for Chl-a nor for eelgrass depth limit. Producing pressure-impact relationships for both Chl-a and eelgrass depth limit (including K_d proxy) and, in particular, nitrogen concentration and water transparency would assist in the assessment of the consistency in the established reference conditions as described below.

Based on the analysis in Sections 3.1 and 3.2 of the application of different statistical approaches for the two STAT models used in the RBMP2 and the RBMP3, an advantage of using the one over the other could not be identified. However, the findings that the statistical analyses did not include analyses forced by the conceptual relationship, which was used in previous derivation of reference conditions, as prescribed by the CIS guidance documents, lead to a conclusion that the Danish methods could benefit from including conceptual pressure-impact relationships in the STAT models.

In both RBMPs, the MECH models build intrinsically on conceptual relationships, but the focus has been on demonstrating pressure-impact-gradients between nutrient load and Chl-a, nutrient concentrations, and the K_d proxy for eelgrass depth limit. Pressure-response gradients are only demonstrated for the calibration range for the purpose of determining MAI of nitrogen. The model, however, should be capable of producing pressure (nitrogen concentration)-impact-gradients for nutrient concentrations versus Chl-a concentration and covering a full pressure range including reference conditions.

Reference conditions in the present Danish RMBPs are derived by model-calculations of the Chl-a reference condition values based on nutrient inputs from catchment areas to the individual water bodies. The nutrient input is calculated based on concentration data representing ‘undisturbed’ streams – including 10-20% agriculture land-use, no or very few point sources from scattered households, and atmospheric depositions. As such it can be considered a ’background’ load close to ‘zero’ impact from human activities.

Here, it is important to underline that it is not a reference load representing a single year or a specific period in time (e.g., nitrogen input in ‘year 1900’) that determines reference conditions for the biological elements – it is the level of impact/change – described by the status of the biological element that must show “no, or only very minor evidence of distortion”– see below, and Section 3.1 and 4.[159]

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[159] See Section 4.5 options for revising established reference conditions and EQRs

An alternative way to establish reference conditions is to follow CIS-GD No. 14's Annex III: Guidelines for deriving reference conditions and defining benchmarks for intercalibration[160] as described in Section 3.1 and used as described below in the section on 'Nitrogen load in reference condition' and onwards. In combination with the present Danish approach, it would contribute to increasing the level of confidence in the resulting reference condition values.

Data used for deriving reference conditions

Considering that neither 'true' reference sites nor historical data exist for Chl-a concentration, to derive reference conditions for this quality sub-element, one has to use existing monitoring data that represents elevated eutrophication status; to choose the appropriate option; and to apply the procedures and methods for deriving reference conditions as described in Section 3.1. In the case of the 2nd and 3rd RBMP, the applied approach follows these principles and provides ways of differentiating reference conditions for individual water bodies that probably not could be achieved in an alternative way. Including use of the conceptual relationship between nitrogen concentration and Chl-a concentration, generated based on monitoring data including data and observations from other countries sharing ecotypes, and statistical analysis, and comparing the results with other countries could contribute to an increased level of confidence in the derived reference conditions. Furthermore, it would contribute to achieving compliance with the WFD normative definitions by establishing the link between the biological quality element and the supporting quality element(s). Regardless of this, it is the assessment of the 2nd opinion team that bringing more focus on this issue would not change the estimated MAIs significantly.

For eelgrass depth limit, historical observations exist, representing high ecological status, but the same considerations as for Chl-a apply regarding linking the biological quality element to the supporting quality element(s).

Critics have been raised on using 'light on the bottom' as a proxy descriptor (by the light attenuation parameter K_d) for eelgrass depth limit. As highlighted in Section 3.1 and 3.4 it is important to distinguish between the proxy K_d descriptor and the parameter K_d used for describing actual light attenuation. For the purpose of model estimation of MAIs, any proxy for eelgrass depth limit will do as long as a strong conceptual correlation can be demonstrated between the two as is the case for K_d. Anyway. Modelling of transparency or the light condition at the seabed is one essential prerequisite for assessing whether these conditions would be able to support the achievement of good status for the eelgrass quality element.

However, it must be underlined that the K_d proxy value cannot be used in classification of biological quality status based on monitoring data on transparency expressed by K_d. There, only monitoring data on the eelgrass depth limit applies. Nonetheless, in the classification of ecological status,

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[160] In spite of being included in Guidance Document No, 14 (2008-2011) on intercalibration, the Annex's specifies the European Commission 2008 "Guidelines to translate the intercalibration results into the national classification systems and to derive reference conditions" (EC 2008b) that applies to all coastal waters,

monitoring data on transparency serves the assessment of whether the monitored light conditions are sufficient for supporting the achievement of good status for eelgrass/(angiosperms).

Other biological quality elements

Denmark has developed other indicators and assessment tools for phytoplankton macroalgae and benthic fauna. Two of the indicators, phytoplankton biomass and macroalgae indicators, are directly associated with eutrophication pressure. The development of indicators is not concluded and not yet finally intercalibrated. Finalising and making use of these indicators by pairing them with the existing indicators could also contribute to decreasing uncertainty and increasing the level of confidence in deriving reference conditions and calculation of MAIs.

Neighbouring countries

Member States are free to choose methods for deriving reference conditions and developing classification systems for their implementation of the WFD requirements, provided that they follow the provisions of the WFD. The WFD intercalibration system provides the procedure and method for ensuring comparability between such methods and classification systems. The experience from the intercalibration process shows, in some cases, that the classification systems are developed using the same scientific approach in different Member States, but in many cases, the systems are developed according to national traditions, e.g., for monitoring methods and data collection as well as scientific methods; however, by applying the same conceptual scientific approach.

In establishing reference conditions and determining ecological class boundaries for Chl-a, Germany and Sweden basically took the same approach as Denmark in deriving reference conditions initially in the 1st Phase intercalibration by using historical data combined with data from present years and by hind-cast modelling. A rather simple modelling approach was applied by all three countries based on the pressure-impact relationship established between Chl-a and nitrogen concentration by regression models and model-estimated nitrogen loads.

Any new documentation by Germany and Sweden into the intercalibration process on possibly revised methods for deriving reference conditions has not been identified by this review. However, the description of the German reference conditions for Chl-a in Section 3.8 shows that the German approach for the reference condition was revised for the Baltic Sea for the RBMP2. Confirmation of such development and analysis of the methodology applied for an assessment of whether it would be useful for the Danish methodology to apply the method would require more extensive resources than allocated to this review (Section 3.8). The German method on macrophytes operates with an index (BALCOSIS-Index) that builds on the vegetational stocks of seagrass, *Fucus*, and red algae. The index includes eelgrass, which is weighed twice in the index as it rests on a better scientific data basis than other macroalgae. Status classification builds on depth limit as well as the deviation of the historic maximum area extent.
The approach in Sweden builds on a point system for the depth limit of a variety of macroalgae found in each specific coastal water type.

Nitrogen concentration in reference conditions

The WFD's normative definition of ecological status classifications defines reference conditions for surface waters equal to high ecological status. Section 3.1 highlighted these normative definitions:

"There are no, or only very minor, anthropogenic alterations to the values of the physico-chemical and hydromorphological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions.
The values of the biological quality elements for the surface water body reflect those normally associated with that type under undisturbed conditions and show no or only very minor, evidence of distortion.
These are the type-specific conditions and communities".

For the biological impact, the definition of high status describes a class covering a range from '*no*' to '*very minor*' impact due to anthropogenic alterations of – in this case – nutrient concentration, and states that 'reference conditions' shall be established, representing the values of the biological quality elements at high ecological status within this range showing "*no or only very minor evidence of distortion*". For all the biological elements, the WFD specifies the definition of high status by, in general, the presence of species composition and abundance that "*totally or nearly totally correspond undisturbed conditions*"; and, as described in Section 3.1, the WFD establishes a link between the status of the biological elements under high status and the nutrient concentrations by "*Nutrient concentrations remain within the range normally associated with undisturbed conditions"* – in this case – N concentration.

This relationship is an essential key element for assessing the nitrogen concentration level that supports the high status[161], and hence, this nitrogen concentration level will be a basis for assessing the level of nitrogen input associated with the high ecological status. In cases where 'true' reference sites (regarding eutrophication) are available, a relationship between the biological element and the N concentration can be established based on monitoring data. For this purpose, the WFD require identification of a range of sites representing water body sites present in the ecoregion that correspond to reference conditions and to the H/G and G/M class boundaries[162]. Recognising that 'true' reference sites may not be available, such that this relationship cannot be established based on monitoring data, the relationship between the nominal BQE values for the H/G and G/M and the associated nutrient concentrations needs to be established based on historical, palaeological or other available data. This may include data from a site of the same type, comprising either current monitoring data from a site of high status, or data from a site of lower status in combination with modelling.

Nitrogen load in reference conditions

Whereas both N and P are associated quality elements regarding eutrophication, the focus of this section is on N. However, since focus has been on the seasonal variability of the N load and the role of P in substituting some of the N load

[161] Establishing reference conditions using pressure-impact relationships is further described in Section 3.1
[162] WFD Annex II, 1.3 (iv) and Annex V, 1.4.1 (v)

reduction needed to achieve the environmental objectives, and because the model's complexity allows estimation of environmental interaction caused by both N and P, more focus should be given to establishing reference values for P.

An answer to the question about how and at what level the nitrogen load should be determined for the coastal waters to be at high status/reference conditions takes a point of departure in how 'reference conditions' and 'high status' should be understood'. As described in Section 3.1, reference conditions should **not** be understood as water bodies in 'pristine conditions'. Rather, it should be understood as *"low pressure, without the effects of major industrialisation, urbanisation and intensification of agriculture, and with only very minor modification of physicochemistry, hydromorpology and biology".* This was recognized already with the proposal for the WFD (EC 1998) which refers the whole 'high status' class to reference conditions, hence this implies that there should be no fixed temporal or spatial benchmark that defines the reference conditions, and the guidance document proposes "*that a flexible temporal benchmark best fits the legislative intention" (*CIS, 2003). Regarding eutrophication, several countries including Denmark consider the period in the late 1800s to at least around 1900 representing conditions in coastal waters being at high ecological status. That is not to say that the status of all coastal waters can be considered to have had that status at that time. Neighbouring water bodies to urban concentrations and other intensive organic/nutrient inputs would probably not have had high status conditions.

In RBMP1, estimated loads based on 'year 1900' nitrogen surplus, was initially considered associated with reference conditions status in the Danish coastal waters assuming the human impact was minimal. Even if RBMP2 referred to 'year 1900' loads, both RBMP2 and RBMP3 left this concept and reference TN and TP loadings from Danish catchment areas were estimated as 'background' loads (not referring to year 1900) based on concentrations of TN and TP in streams draining catchment areas – with a low (< 10 per cent for TN and < 20 per cent for TP) proportion of agricultural land-use and no or very few point sources from scattered households – multiplied by the corresponding catchment-specific water flow. Later studies, however (Jung-Madsen & Bach 2022), have shown that the N load in 1900 must have been higher than previously assumed in both RBMP1 and RBMP2, leading to a conclusion that the actual 'year 1900' nutrient load to the marine area cannot be assumed to have been unaffected by human activity (Timmermann 2020). In RBMP3, no temporal benchmark is used to describe the applied reference load or RCs in general, although historic observations from around 1900 are used for the eelgrass RCs under the assumption that eelgrass depth limits had not yet been affected by anthropogenic pressures. A discussion has then been raised whether a year-1900 nutrient load or the 'background' load should be used in defining the RC.

As defined by the WFD normative definitions and described above the directive does not focus on a specific nutrient load in reference conditions, but on the impact in the status of the biological elements and the associated nutrient concentration. As described in Section 3.2 some biological quality elements can expose resilience against drastic changes in the ecological status in response to an increased pressure. A closer look at the historical observations of eelgrass distribution can illustrate the directive's understanding of reference conditions and the associated pressure. A visual inspection of the development in the observed eelgrass depth distribution figures from 1880 to 1900 indicates a downward trend - Figure 4-1. Whether the observations represent a factual trend – if any - cannot be concluded without a more thorough analysis of observations representing the same water bodies throughout the period.

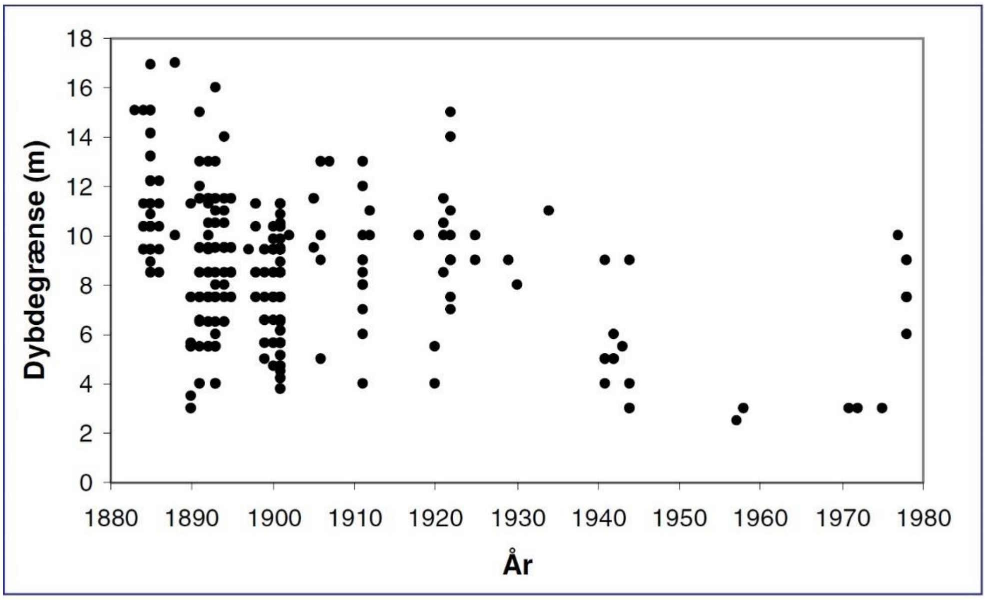

Figure 4-1 Eelgrass depth distribution in Danish coastal waters 1880-1980 (from Krause-Jensen & Rasmussen 2009)

As the established reference conditions for eelgrass depth limit is based on the upper 90%ile of the observed values covering the whole period they could most likely be considered representing the first part of the period in case that a trend was to be taken into account. Hence, the H/G class boundary (10 per cent deviation from reference conditions) would represent the status with an increased pressure at a later point in time as illustrated in Figure 4-2: Illustration of the WFD definition of RC.

As the WFD defines reference conditions by the 'high status' as described above and in Section 3.2 the values for the biological element are associated with nutrient concentrations in water bodies covering the whole range of the 'high status' class. All nutrient loads, which can be associated with those concentrations, would be considered the range of reference loads that was present through that period. Hence, the lowest 'background' load would be associated with the established RBMP reference eelgrass depth limit values and a higher increased load (i.e., 'background' load plus some anthropogenic load) would be associated with the H/G class boundary value.

In the existing reference conditions for eelgrass a trend is not considered, but a level of 'no' impact throughout the period. An increased nitrogen load around 1900 load compared with the 'background' reference load used in the establishment of the RBMP reference conditions, and the assumption of no development of the eelgrass depth distribution throughout the late 1800th can describe the impact on eelgrass to have exposed a 'discontinued' response due to resilience to the increased nutrient load. In this case the increase in the level of the nutrient load throughout the period must also be associated with the range of reference loads from the 'background' until a point in time – maybe around 1900 maybe later – when the load reached the load associated with crossing of the H/G class boundary. Which specific load that corresponds to the H/G class boundary can be assessed either by statistical modelling using a developed pressure-impact-gradient for the eelgrass depth limit (or its proxy) covering the H/G class boundary or by trial-and-error calculation with a dynamic model verified for the calculation of the impact and load ranges covering all environmental status classes.

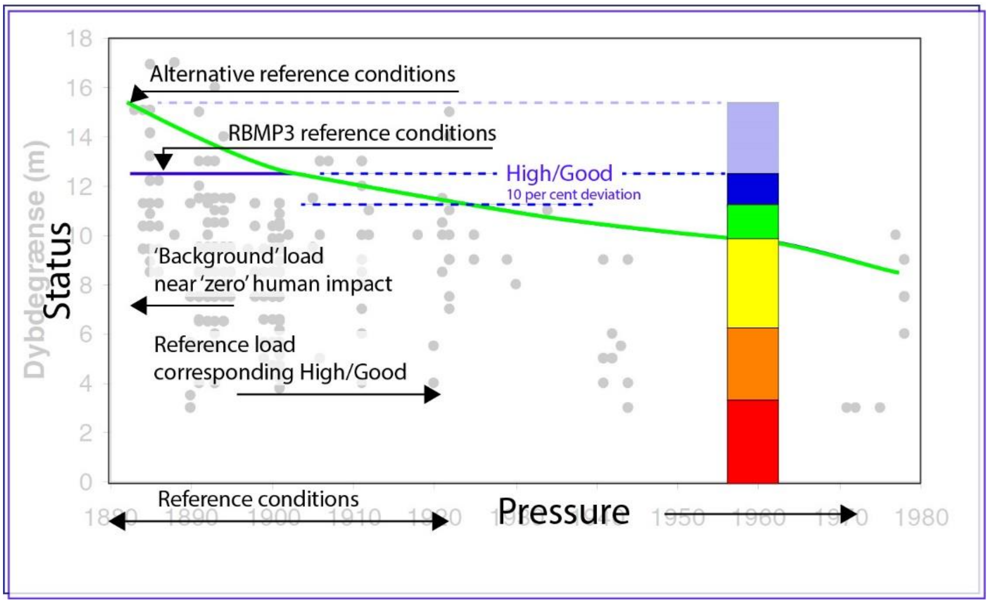

Figure 4-2: Illustration of the WFD definition of RC and how it is related to pressure and the 'high status' classification. The blue solid line illustrates how the RBMP3 considers the eelgrass depth distribution to have developed in the last part of the 1800th century. The green line illustrates how the eelgrass depth distribution could have developed with increasing pressure if a resilience would not be considered in the late part of the 1800th century.

Alternative eelgrass depth limit reference conditions

In RBMP3, the eelgrass depth limit reference conditions are determined by an average upper level of the historical observations from the period from 1880 to around 1900, assuming that the eelgrass depth distribution was rather stable throughout that period (Figure 4-2 blue line).

As described above and taking account the concluded increase in the nutrient load level from a lower level through the 1880-1900 period with eelgrass observations, the eelgrass reference value represents a 'discontinuity' in the pressure-impact relationship during this period, since it no trend is considered while the loads are increasing. Such discontinuity can be considered stretching further back in time until a reference point of near 'zero' anthropogenic induced load. As such, the 'background' load used in RBMP2 and RBMP3 can be considered representing a benchmark associated with the established RCs for eelgrass as described above.

Alternatively (here as an example), if a downward trend of the eelgrass depth distribution through the 1880-1900 period can be scientifically verified and if pressure impact response can be considered a continuum - Figure 4-2 (green line) – the observations from the first part of the period would be the basis for the reference condition leading to larger values (depth limits). However, these values cannot be used with intercalibrated EQR value because the H/G class boundary nominal value and EQR of the existing classification system is bound to each other and to the existing approach for determining reference conditions.

Therefore, it will require considerations of either changing the EQR H/G value by keeping the nominal H/G-value fixed (which would result in a lower EQR value than 0.90) or changing the nominal value for the H/G class boundary by keeping the EQR fixed or only slightly changed (which will result in stricter nominal H/G class boundary values). The same considerations apply for the G/M class boundaries. Section 4.5 describes the steps needed to be taken in case the classification assessment method is revised.

Alternative determination of Chl-a reference conditions

For Chl-a, the same considerations can be made as for eelgrass depth limit. However, as no sufficient historical data exists for Chl-a, another approach must be considered. The developed models for RBMP3 have been concluded to be robust and validated tools for calculation of MAIs and have successfully been used in derivations of reference conditions for Chl-a. Therefore, the 2nd opinion team assesses that not much room for manoeuvring can be anticipated by alternative methods. However, there is a room for improving quality assurance of the method for deriving reference conditions and ensuring improved compliance with the provisions of the WFD.

The applied modelling approach follows the overall approach of the WFD by establishing strong direct relationship between pressure and environmental status for calculation of MAIs. However, where this approach is preferable for calculation of MAIs by keeping uncertainty low by not introducing too many steps in the calculations, it misses essential elements regarding the establishment of reference conditions by not considering the intermediate generic relationship between the nutrient concentration and the Chl-a concentration. This is most relevant for the STAT modelling, as it (unlike MECH) does not consider this relationship whereas the MECH modelling should be able to generate it.

Options are missed regarding determination of associated values for the supporting quality elements – here nutrient concentrations, and by solely focusing on individual water bodies the option is missed for identifying water bodies with common ecological response regarding Chl-a to changes in nutrient concentrations. Established nutrient/Chl-a concentration relationship could provide a basis for an ecological grouping of water bodies into ecological types, which can be linked to the common intercalibration types. For water bodies, which have significant different ecological characteristics, it can explain how reference condition values for the common intercalibration types and H/G and G/M class boundary values are translated into the classification for these water bodies. Carstensen (2008) found that a generic (statistical) Nitrogen/Chl-a relationship with a common 'slope' could be established based on monitoring data from Danish coastal waters and covering a major part of 39 water bodies - See also Annex F. Finally in case that a new intercalibration exercise for Chl-a would be required, establishing a nutrient/Chl-a concentration gradient is prescribed for assisting derivation of reference condition values and determination of H/G and G/M class boundaries.

The scientific methodologies and understanding and the amount of data, which can be used for developing generic pressure-impact relationships, have increased drastically since Carstensen (2008) established the basis for the 1st Phase intercalibration. Reviewing and applying Carstensen's approach in that perspective and seeing the statistical models as tools for establishing generic pressure (nutrient concentration)-impact (Chl-a) relationships, seeing the mechanistic models as tools for addressing individual water bodies, and using the generic relationships for validating the results of the MECH models would make the models complementary and would increase the transparency of how the reference conditions are established. It should be mentioned, however, that the suggested improvements most likely will have minor impact on the MAIs.

Level of confidence and consistency

In cases where 'true' reference sites are not present and where reference conditions are derived by modelling based on historical, palaeological and other available data, the methods used must provide a sufficient level of confidence about the values for the reference conditions to ensure that the conditions so derived are consistent and valid for each surface water body type (WFD, Annex II, 1.3(v)).

By 'sufficient level of confidence' the 'Guidelines to translate the intercalibration results into national classification systems and to derive reference conditions' (EC 2008b) additionally states "*To ensure sufficient level of confidence Member States should compare the model predictions with data from known reference sites, historical data or palaeological data; and/or undertake appropriate sensitivity analyses"*.

The procedures of CIS-GD No. 14 for deriving reference conditions and the principles for deriving reference conditions laid down in the 'Guidelines to translate the intercalibration results into national classification systems and to derive reference conditions' (EC 2008b) are developed in order to ensure compliance with WFD provisions. Included in these procedures are identification and establishment of pressure-impact-gradients covering a pressure range from reference conditions to the most impacted conditions by which data observations can be tested (level of confidence) and by which different quality elements responding to the same pressure can be paired.

Regarding consistency, the guidelines refer to the WFD normative definitions and the procedures and criteria, which, in the intercalibration process, were followed to ensure consistency with normative definitions. As such consistency applies to the methods used for deriving reference conditions, determination of class boundary values, and translation of intercalibration results into national coastal waters which are not covered by the intercalibration.

Consistency between Chl-a and eelgrass depth limit

As an example, and for illustration of how a check of level of confidence and consistency can be made, a first step could be comparison of the two biological parameters used in the derivation of reference conditions (Chl-a and eelgrass depth limit) by comparing values of the two parameters. Figure 4-3 (left) shows the reference condition values of RBMP3 for eelgrass depth limit based on historical observations (invers EDL, vertical axis) versus Chl-a concentrations (horizontal axis) estimated by model calculations. The comparison includes Danish coastal waters except North Sea water bodies and heavily modified water bodies.

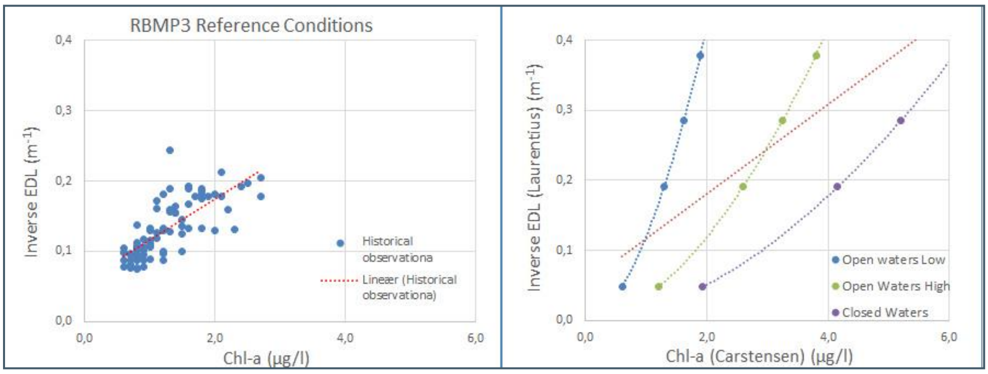

Figure 4-3: Comparison between RMBP3 RCs for Chl-a and inverse eelgrass depth limits (EDL) for RC in coastal waters with historical observations (left); and comparison between tendency line of the left figure with similar calculated values based on developed generic pressure-impact-gradients for Chl-a (Carstensen 2008) and for eelgrass depth distribution (Nielsen 2002) (right)

The figure shows correlation between the two parameters. Whether the correlation is also consistent with a general understanding of the relationship between the two parameters the correlation can be compared with correlation based on monitoring data (for eelgrass not including data from water bodies under recovery). General relationships between Chl-a concentrations and eelgrass depth distribution in Figure 4-3 (right) shows – still as an example - the same comparison of Chl-a and eelgrass depth limit values generated by the two generic pressure-impact relationships developed by Carstensen (2008) for nitrogen concentration-Chl-a and Nielsen (2002) for nitrogen concentration-EDL as referred to in Section 3.1 and Annex F[163].

Together with the overall tendency line of the left figure, the right figure shows trends, which from the generic relationships should be expected for open coastal waters (between the blue and green trend lines) and for fjords and closed coastal waters (between the green and purple trend lines). Based on the differences between the slopes of generic trend lines and the slope of tendency line for the RBMP3 RC values in the left figure, a further examination should be considered regarding a discrimination of the reference condition values according to groups of types including open coastal water types and types

163 With reservation of this as an example and that newer analysis methods and more data available for the analysis could qualify the established generic relationships.

including fjords and closed coastal waters. Similar consistency checks would add to the H/G and G/M class boundary values.

4.4.3 Concluding remarks

Given the lack of 'true' reference sites in Danish coastal waters, where associated values for biological quality elements and supporting quality elements can be measured, Denmark has established reference conditions for Chl-a and eelgrass depth limit in accordance with the WFD by using either predictive models or hindcasting methods based on historical paleological and other available data.

Taking the robustness of the applied methodology the 2nd opinion team assesses that not much room for manoeuvring can be anticipated by alternative methods. However, there is a room for improving quality assurance of the method for deriving reference conditions and ensuring improved compliance with the provisions of the WFD. The suggested improvements will most likely have insignificant influence on the already calculated MAIs, but improved quality assurance and level of confidence can be anticipated.

It is important to highlight that the reference condition represents ecological quality status being at 'high' status determined by 'no or very minor' evidence of distortion, meaning that all status classifications that fall between zero impact and the H/G class boundary are considered being in reference conditions.

Establishing reference conditions – the 'high' class range - must be based on an assessment of changes in the parameter values for biological quality elements and the associated supporting elements (nutrient concentrations). Therefore, the nutrient load of a single year, which falls within the range of 'no' human impact and 'only very minor' human impact is considered one benchmark and cannot alone be used in establishing reference conditions. A 'background' close to zero impact from human activities and associated nominal values of the biological elements should preferably be chosen in the establishment of reference conditions.

The Danish approach in RBMP3 focuses on a pressure-impact relationship directly between the nutrient (nitrogen) load and the status of the biological quality element. Whereas this approach is preferable for calculation of MAIs by keeping uncertainty low by not introducing too many steps in the calculations, it misses essential elements regarding the establishment of reference conditions by not considering the intermediate generic relationship between the nutrient concentration and the Chl-a concentration.

Alternative – or rather supplementing – methods for establishment of reference conditions are suggested including developing/revising pressure-impact-gradients for nutrient concentration/Chl-a relationship, thereby establishing a basis for determining class boundaries for the supporting nutrient element, identification of common ecological response characteristics, which can be used for 'anchoring' national water bodies to the common intercalibration types, and for comparing the results of the mechanistic models with those from the statistical models taking the CIS GD No. 23's conceptual framework for assessing eutrophication and the CIS GD No. 14's prescriptions for deriving reference conditions into account.

It is the 2nd opinion team's assessment that including the elements described above is not likely to reduce the calculated need for reduction of the nitrogen load, but it will increase transparency and the level of confidence in model results, and it will assist in ensuring compliance with WFD normative definitions.

Regarding the critique raised on using light attenuation (K_d) as a proxy for the eelgrass depth limit it is the second opinion COWI team's assessment, as stated in Section 3.4, that the 'K_d-proxy' is a valid parameter to be used as proxy for the ecological G/M class boundaries in model calculations.

In the 1st and 2nd Phase IC, Denmark, Germany and Sweden used developed pressure-impact gradients as a basis for deriving reference conditions. Further development of the German methods goes along the same line as the Danish development of models. The conclusion on the possibility for applying these methods in Denmark will require assessment in more detail, and this may be an issue for the second phase of the second opinion.

A simple comparison of the RBMP3 reference condition values for Chl-a and eelgrass depth limit shows a general good correlation leading to a conclusion that the two parameters are consistent for use in model calculations of MAI. However, further examination of whether the found correlation (slope) agrees with a general understanding of the relationship between the two parameters should be made in a comparison with the same relationship generated based on monitoring data.

4.5 Task 11: Revision of scientific basis for EQR

4.5.1 Objective

Assess possible room for manoeuvring in relation to establishing the reference condition and the environmental targets. Options for revising the scientific basis for the EU inter-calibrated EQR values, including the steps necessary for involving other EU Member States and the European Commission in such a process.

Sub tasks:

- Description of the possibilities
  - to revise scientific basis for EU-intercalibration,
  - EU-approved intercalibrated EQR ratios.
- Description of the process that will be necessary to conduct such revision in relation to other Member States as well as the European Commission.
- Review on the scientific applicability of such revision as well as its limitations.

4.5.2 Analysis and assessment

"Member States that wish to modify a classification method included in the Commission Decision may do so provided that they demonstrate that the definition of reference conditions and the high-good and good-moderate class boundary values for those types are still consistent with the normative definitions and comparable with the other Member States sharing the common type. This should be done by following the appropriate procedure agreed by the ECOSTAT GIG Working Group which is described in detail in the intercalibration technical report", (EC 2008b - Guideline, 2,4).

When an opportunity for revising the scientific basis for the EU intercalibrated EQR occurs, requirements for the scientific process are specified in CIS-GD No. 14 and No. 30 on 'Procedure to fit new or updated classification methods to the results of a completed intercalibration exercise'. The workflow specifying steps to be taken by Member States starts with planning, including check points; goes through the intercalibration exercise and ends with the approval of the results. The point of departure is Guidance Document No. 14, which forms the key reference with regard to intercalibration aims, methods and criteria. It specifies the data basis for the intercalibration and the intercalibration requirements and it defines a 'revised national classification method' as *"a method that was already intercalibrated for a certain common intercalibration type but has since been modified with regard to: data acquisition (e.g. sampling design, sample treatment); numerical evaluation (e.g. metric selection, indicator scores, combination rules); or classification (e.g. reference definition, boundary setting).*

As changes to any of these components may affect the comparability with the intercalibrated standard it sets up a procedure for how to fit boundaries to the revised methods".

In cases where the new boundaries are higher (more stringent) or similar to the established (existing) boundaries, a 'fitting' procedure is prescribed. In cases where the new boundaries are lower (less stringent) than the old boundaries, the comparability with the intercalibrated standard needs to be checked since the criteria for boundary bias might no longer be satisfied. In these cases, the procedure for 'full intercalibration' exercise of the classification method must be carried out, following a procedure similar to the steps required by the intercalibration procedure of Guidance Document No. 14. Relevant parts of this procedure related to the Danish classification methods for Chl-a and eelgrass depth limit are summarised in Section 3.2 and Appendix F section on determination of class boundaries.

As the prescriptions in Guidance Document No. 30 are formed in a strict and concise way, there is no point to elaborating further on the summary of the requirements.

In case 'fitting' is required, a revision of a Danish classification method could be carried out without involving other Member States in the scientific exercise as it was done with the revised Danish classification method for angiosperms[164]. However, further steps in the process involve reporting to the CIS ECOSTAT WG, describing WFD compliance and the compliance with established (existing) intercalibration results. ECOSTAT will then obtain an opinion by an 'Intercalibration review panel' and will, after discussion and – if necessary – revision of the report/method, approve the revised method and forward it for approval through the CIS Strategic Coordination Group for final adoption by the WFD, Article 21 regulatory committee and inclusion in a revised Commission Decision on intercalibration results.

For Denmark, in case where a revised classification does not qualify for the 'fitting' procedure, but where a 'full intercalibration' will be required, Germany and/or Sweden needs to participate in the process as the intercalibration results could have consequences for their class boundary setting. Apart from this, the procedure will be the same as for the 'fitting' procedure.

Opportunity of revising EQR

As highlighted in Section 3.2 and Appendix F it is important to have in mind that the EQR is **not**, at face value, an expression of the deviation of a status class boundary from reference conditions, but simply a ratio that divides the ecological status classes into five sections on a scale from zero to one, which serves the presentation of monitoring results; classification of ecological status; and assessment of comparability of classification methods between Member States[165]. Therefore, there is no point in talking about revision of an EQR

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[164] Carstensen 2016

[165] See Appendix F Section on Determination of class boundaries.

without considering revising the nominal values of the associated class boundary for the biological quality element in question.

An opportunity for revising ecological status boundaries could, e. g., be: development of improved scientific assessment methods; extended data set which covers a wider range of measured pressure-impact conditions; an opportunity for paring pressure-impact relationships for two or more biological quality elements across the same pressure; inclusion of one or more 'true' reference sites; or if flaws are identified in the established intercalibration results.

Deviation from reference conditions

The WFD, Annex V, normative definitions for the good ecological status may raise the question of how big deviation from reference condition can be accepted, while meeting the requirements laid down in the definition of achieving the good status objective. For the biological quality elements, the question is how to understand the terms 'slight signs', 'slight changes', 'slight increase', 'slightly outside', which describe a deviation from reference conditions. CIS-GD No. 13 "Overall Approach to the Classification of Ecological Status and Ecological Potential" provides some examples of indicative parameters for the benthic fauna quality element that point in a direction of understanding (Table 4-1). However, it also states that *"The meaning of slight deviation is being considered as part of the intercalibration exercise"*.

Table 4-1: Examples of the sorts of parameters that may be useful in estimating the condition of a biological quality element (CIS GD No. 13, Table 2).

Example Biological Quality Element	**Example (type-specific) conditions specified for the element at good status**	**Examples of indicative parameters (metrics) based on measurements of composition and abundance**	
Benthic Invertebrate Fauna (rivers)	THERE MUST BE NO MORE THAN SLIGHT CHANGES IN COMPOSITION AND ABUNDANCE THERE MUST BE NO MORE THAN SLIGHT CHANGES IN THE RATIO OF DISTURBANCE SENSITIVE TAXA TO INSENSITIVE TAXA THERE MUST BE NO MORE THAN SLIGHT SIGNS OF ALTERATION TO THE LEVEL OF DIVERSITY	Presence or absence of particular species or groups of species Overall richness or richness of particular taxonomic groups Relative number of taxa in particular taxonomic groups Abundance of particular species or groups of species Relative abundance of particular species or groups of species Overall diversity, or diversity within particular taxonomic groups	Taxa could be selected and/or grouped by known sensitivity/tolerance, feeding type, habitat preferences, etc

As such, the maximum deviation, which could be accepted by determining the G/M class boundary, will be based on Member States' data and scientific assessments of that data through the intercalibration process that concludes with the technical-political adoption by Member States and the European Commission, according to the committee procedures laid down in the WFD, Article 21, after which the Commission will issue a Commission Decision on intercalibration results. Therefore, until an intercalibration exercise has been carried out for a certain quality element, there is no way of telling how big deviation from reference conditions will be accepted.

Chl-a
EQR

In Section 3.2, it is concluded that the G/M class boundaries for Chl-a of the RBMP3 are lower (more stringent) than the intercalibrated boundaries for the common IC types in BC 6 and NEA 8b. According to the CIS-GD No. 30, this finding would, at first sight, require a 'fitting' to the established intercalibration with Sweden. But as the revised reference conditions also impact the G/M class boundaries for the common IC type in BC 8, it would also require 'fitting' to the results of the Danish-German intercalibration in 2013. As the Danish application of the intercalibration results of the 2nd Phase intercalibration did not include the transformation back of the EQRs to the 'Danish coastal phytoplankton method' (see Sections 3.2 and 3.8), this could be rectified through a 'fitting' or – if necessary – 'full intercalibration' exercise with Germany. Thereby, the 'fitting' exercise could also facilitate elimination of the issue of the lack of transformation back of the Commission Decision (2018/229/EU) EQRs. In any case, presenting the issue and seeking advice from the ECOSTAT WG could assist considerations on how to proceed with matter.

Eelgrass depth limit
EQR

In the lack of specific scientific arguments for determining the G/M class boundary for eelgrass/angiosperm quality element, the boundary was set based on technical-political decisions, based on environmental quality criteria set by the regional planning through more than a decade – see Section 3.2. After communication with the Commission[166], the deviation was decided to be a 26 per cent deviation from the reference conditions; a deviation a bit higher than the median of the criteria set in the regional water quality plans. For this biological sub-element, the deviation is equal to the EQR of 0.74.

New specific scientific arguments and information could support either confirmation or a revision of the deviation that determines the G/M class boundary, here the EQR of 0.74. However, in the documentation and in scientific documents supporting the preparation of the Danish RBMPs, the 2nd opinion team has not found new scientific arguments on a qualification of the criteria for determining the G/M class boundary for eelgrass depth limit. Therefore, and based on the procedures and principles of the WFD guidelines, the 2nd opinion team strongly believes that changing the objective to, e.g., a deviation of 30 per cent would require support from scientific analysis and argumentation. In addition, Denmark stands alone with the eelgrass depth limit as parameter as it can only be compared and not intercalibrated with the neighbouring countries due to differences in assessment methods on angiosperms, and because of that it will not be possible to set new boundaries via an intercalibration. A change of the value for the deviation would undoubtedly require substantial scientific arguments, including a description of compliance with the WFD normative definitions, and a report to the ECOSTAT WG, which is supposed to review the report before approval, will be required.

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[166] Letter to the European Commission, 13 March 2008, J.No. BLS-480-00072.

Comparison of indicators

The principles for determining ecological quality status class boundaries are specified for the intercalibration exercise in CIS-GD No. 14 (2008-2011 version) and the relevant parts for the present review are summarised in Section 3.2. One of the steps in this exercise includes pairing the pressure-impact-gradients for two or more quality element metrics across the same descriptor of relevant supporting elements in order to analyse, in particular, the agreement between the class boundaries for the paired quality elements. Pairing the 'eelgrass depth limit' with the Chl-a concentration against a common pressure (supporting quality element, e.g., nitrogen concentration and transparency) would also assist in assessing determination of corresponding reference conditions and class boundary values for the common supporting element and, thereby, provide a higher level of confidence for the determined class boundaries.

Application of revised EQRs

In case an EQR for the G/M ecological class boundary would be revised, it will be based on revised nominal class boundary values that may also have a consequence for the other class boundaries, in particular for the M/P and P/B boundaries.

Revised EQRs and the associated nominal class boundaries have to be applied in the Danish ecological status classification system for the biological quality elements. The existing ecological status classifications, using the Article 5 analysis based on monitoring results for all water bodies, need to be reviewed according to the revised classification system. As revised EQRs would also have implications for the assessment of the need for preventive or remedial measures – in particular with regard to estimation of the need for reduction of nutrient input to coastal waters – existing estimations based on the result of the scientific application of EQRs in model calculations need to be revised.

In case of changes to ecological status classifications and changes to estimated nutrient input reduction targets, updates need to be amended in the Article 5 analysis and the RMBP and reported to the Commission, according to the requirements of WFD, Article 3, and, in particular, Article 15, which requires information to be provided to the Commission. That is also the case for the analysis carried out according to Article 5; the established monitoring programmes; and the River Basin Management Plan(s). These requirements are specified in CIS-GD No. 20, "Guidance for reporting under the Water Framework Directive" (2009).

4.5.3 Concluding remarks

Member States that have developed a new classification method or wish to modify a classification method included in the Commission Decision, for instance to account for improvements in scientific knowledge, technical methodologies or the amount and quality of relevant data, may do so. These Member States have to show that their new or revised classification is compliant with the WFD normative definitions and that their class boundaries are in line with results of completed intercalibration exercise. CIS-GD No. 30 on 'Procedure to fit new or updated classification methods to the results of a completed intercalibration exercise' describes the steps to be taken by Member States in a workflow including planning; specification of the scientific basis and 'fitting' or 'full intercalibration' procedures to be applied; and concluding with a reporting to the ECOSTAT WG for approval and forwarding, if necessary, for adoption through the WFD committee procedure. A first step before deciding, which of the two exercises that needs to be carried out and which formal procedure should be followed, the issue could be presented in ECOSTAT WG (in which the Commission shares the lead with Joint Research Centre) seeking further advice on how to proceed on the matter both technically and procedurally.

Considering that the EQR is not, at face value, an expression of the deviation of a status class boundary from reference conditions, but simply a ratio, which serves the presentation of monitoring results and serves assessment of comparability between Member States; and that deviation from reference conditions for values describing biological quality status must be scientific based criteria related to the biological quality element, an opportunity for revising ecological status (nominal) boundary values could, e.g., be: 1) development of improved scientific assessment methods and new scientific knowledge about determination of class boundaries; 2) extended data set which covers a wider range of measured pressure-impact conditions; 3) an opportunity for paring pressure-impact relationships for two or more biological quality elements preferably across the same pressure; 4) inclusion of one or more 'true' reference sites or changed scientific approach for derivation of reference conditions; or 5) if flaws are identified in the established intercalibration results.

The lack of back-transformation of intercalibrated EQR results for Chl-a for Denmark and Germany to the 'Danish phytoplankton method' classification system (for BC 8 in 2013, see Section 3.2 and 3.8) had also impact on the results of the later intercalibration with Sweden (BC 6 and NEA 8b in 2016), thereby introduced a risk of setting incorrect (less stringent) G/M class boundaries for all Danish water bodies. Furthermore, new and developed models (STAT and MECH) used a different scientific approach for deriving reference conditions, than was applied in the existing intercalibration, and the resulting revised reference condition values in RBMP3 have caused nominal G/M class boundaries for the common IC types, which are lower (more stringent) than the intercalibrated nominal class boundaries. Taking these two issues together, it cannot without a more thorough examination be assessed whether the effect of the two will outbalance each other or not. Anyway, the revised Danish classification system for Chl-a would be considered changed in a way that it, at least, would be subject to going through a 'fitting' procedure.

When considering that lower (more stringent) G/M class boundaries already have been applied in RBMP3, due to the more stringent reference conditions, and also taking potential improvements of the modelling system, as described above, into account, the result of a 'fitting' or 'full intercalibration' procedure will most likely result in only minor adjustments of the calculated MAIs. The adjustments by a correction caused by the lacking back-transformation will most probably result in higher EQR (more stringent) values, thereby causing lower MAIs and hence imply increased need for reduction, and thereby, a reduced room for manoeuvring.

Based on the background that the determination of the G/M class boundary for eelgrass depth limit was decided in a technical-political process, that no specific scientific arguments were associated with decision, and that it has not shown feasible to intercalibrate the classification system, except for a direct comparison with German reference condition values G/M boundary values, a revision of the G/M boundary value, and hence the EQR, would undoubtedly require substantial scientific arguments, including a description of compliance with the WFD normative definitions, and submission of a report to the ECOSTAT WG for approval.

4.6 Task 12: Target load

4.6.1 Objective

The objective of task 12 is to assess room for manoeuvring regarding target load, baseline load, model assumptions, press factors and P-load reduction.

4.6.2 Analysis and assessment

Target and G/M class boundary

By choosing the boundary value between G/M status, in 50 per cent of the time, all water bodies do not fulfil the requirement of good environmental status (Erichsen et al. 2021b). From a scientific point of view, this makes little sense, since a habitat cannot be in a good status part-time.

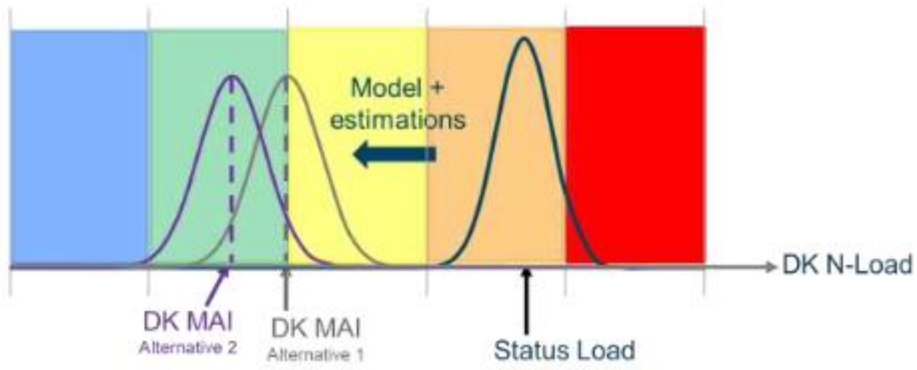

Figure 4-4: Calculation of MAI when the target is defined as the boundary separating moderate (yellow) and good (green) status classes (alternative 1) or when the target is centrally placed within good ecological status class (alternative 2). The present-day status load results a status value in the orange field (Status Load).

The effect of changing the target from being the boundary between good and moderate status towards being centrally in high is illustrated in Table 4-2 below:

Table 4-2 Difference in N-MAI when selecting a central target for environmental status being at the G/M class boundary and being centrally in the good class.

Target (scenario)	National N-MAI (tN/y)
Boundary between good and moderate environmental status (2e, 20%)	37.254
Halfway between good and high environmental status (WFD 1a)	27.555
Difference	9.699 (26%)

From a scientific point of view, aiming at the G/M class boundary and thereby accepting that 50 per cent of the water bodies will not reach good environmental status represents to the understanding of the 2nd opinion team an inconsistency and a logical deficiency. This means that DK will not reach good environmental status for all Danish waters in 2027 as required by Water Framework Directive. Reference is further made to the legal chapters of this review.

As illustrated in Figure 4-4 the different water bodies will have a distribution around the required boundary value between Good and Moderate status. The RBMP does not require a maximum variance or certain percentiles for the distribution of the water bodies, corresponding to limitations of the width of the bell in Figure 4-4. Without such requirement some water bodies may be in environmental classes even lower than moderate.

Target load and RBMPs for individual water bodies

For the individual water bodies, overall MAIs are determined as a part of the present RBMP3.

Plans for how these MAIs are achieved can be developed locally through local RBMPs. However, the overall target of MAI is not up for discussion, only the method for how to achieve Good Environmental Status by defining MAIs. The common development of local RBMPs contains the opportunity to achieve local ownership and commitment by involving local stakeholders, such as municipalities, agricultural organisations, non-governmental organisations (NGOs) (nature protection organisation, etc.).

Local plans may involve some of the alternative measures outlined above for applying less strict N load reduction (such as increased P load reduction or reduced summer load).

Status and baseline

The baseline builds on measured loads in combination with forecasted effects of planned measures. The 2nd opinion team assesses that the measurements of the present loads are developed to a high level. Denmark has through three generations of RBMPs developed its monitoring and measurement system to an advanced level and to high accuracy. Hence, there is no further significant room for manoeuvring in this respect.

The forecasted effects of new and planned measures entail, by definition, a certain degree of uncertainty. Hence, we cannot establish with a high degree of certainty to what degree the measures included in the baseline forecast will affect the nutrient load when fully implemented. Until this uncertainty is reduced, there is no scientific argument for increased MAIs (i. e. less strict limits).

The second opinion team assesses that changed technical details (e.g., different averaging period or update of data of status loads up to 2021) will not add significantly to the robustness of the calculated results. The status load may be slightly different, but it is not given if these changes will point towards increased og decreased MAIs. It is the understanding of the reviewers that possible effects of changing technical details in the calculations are to be compared with the overall uncertainty of the baseline including the uncertainties of the forecasted effects of planned measures.

Model assumptions

It is outlined under task 4 that the model approach leaves no RFM regarding a bigger N-MAI. Even if a refined process description for P reduction or seasonal nutrient load reductions should be developed, the order of magnitude of N-MAIs is not expected to change significantly. Whereas the model uncertainty might be reduced, it is uncertain if such refinement would result in bigger or smaller N-MAIs. The MECH model system is highly complex and advanced. The averaging of MAI regarding the two biological quality elements (chl-a and light) instead of application of the "one out all out"-principle represents the concept, that estimates of both elements are expression of the same environmental status, and that the MAIs therefore should be estimates of the same value. If these two elements are of equal validity and the methods to model the elements are of equal quality, then the averaging process is scientifical valid. The "one out all out"-principle requires that the environmental status depends on the biological quality element for which the ecological quality class boundary is exceeded first. This requires accurate knowledge of the functionality of the ecosystem that, according to the judgement of the reviewer, is not available at present. Therefore, the averaging method is from a scientific point of view defendable.

It is assessed by the 2nd opinion team that further development of this model can be achieved by incorporation of new insight into estuarine and coastal systems with very low nutrient loads – close to reference conditions. This would require the implementation of pilot project as explained in task 4.

Since STAT models, despite their complexity and high degree of development, lacks conceptual insight it may be assumed that inclusion of causal relations refinement will lead to increased certainty of the models. It is expected that model development will not lead to room for manoeuvring with regards to increased N-MAI. It can be considered to choose the MECH model for MAI assessment and the STAT model for verification purposes. This option can also be considered as room for manoeuvring. In line with recommendations from earlier international reviewers it shall be avoided to introduce specific rules (expert judgement) in the assessment of N-MAIs.

It is envisaged that excluding STAT results in the assessment of MAI may lead to slightly reduced N-MAIs, i. e. a higher need for reductions.

Press factors others than N load

As described in task 9 the investigated alternative press factors are found not to have impact on the nutrient conditions in the coastal waters that are comparable to the impacts from N and P-load. Furthermore, no models are available that might compare the effect of the investigated press factors with the effect of nutrient loads. Therefore, 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 GES.

Enhanced P load reduction

The effect of increased P load reduction and the corresponding possibility to increase N-MAI is modelled for all management scenarios. For scenario 2e, the potential effect on national level is found to be approx. 1000 tN at 10% load reduction, corresponding to two per cent of the N-MAI. The majority of the potential N reduction is found for water bodies at the North Sea.

It could be considered to include the effect of spring bloom in the analysis of the summer Chl-a concentration. This, however, will present considerable practical and administrative challenges given the need to change procedures in all EU countries and the need to develop monitoring techniques in all countries, see also chapter 3.9.

The effect and the cost efficiency of N-MAI increases by further reduction of P load depends on the specific water body and should be investigated in detail specifically for each individual water body.

Delayed effects, ecosystem effects and increased efficiency in agriculture

Some effects that are encountered for in the model system are included in a way that is not clearly described leaving some uncertainty at the reviewers to what degree these measures will actually function. The effects are:

- Time lag between initiation of a measure and full implementation of its nutrient reducing effect
- Tim lag between nutrient reduction and full response on the quality parameters (Chl-a and eelgrass) due to reaction time of the ecosystem
- Implementation of innovative measures within the agricultural sector that increase its efficiency and hence reduce nutrient loss to the coastal waters.

These effects are all affected by a certain uncertainty. More precise descriptions of these processes may increase the overall understanding. It is not expected that they imply room for manoeuvring.

4.6.3 Concluding remarks

As for the extent to which the scientific basis can provide Room for Manoeuvring (RFM) regarding target load to obtain an increased MAI, the following conclusion is made:

Table 4-3: Conclusion on RFM regarding target load

Potential options in the identified Room for Manoeuvring	Expected effect on MAI (N, P)
Increased P-reduction in relevant water bodies	local increases in NMAI
Several measures are expected to come into effect after end of plan period (2027). It is unclear to what degree these effects are accounted for in the 2027 baseline.	no indication
Delayed response of the ecosystem (system contribution) is accounted for before 2027. This could be taken out of calculations.	reduces MAI
Efficiency effects in agriculture are included in baseline although not sufficiently documented. This could be taken out of calculations.	reduces MAI
Targeting at the G/M class boundary gives a 50 per cent probability of not reaching the target. The target could be increased to give a higher probability of reaching GES.	reduces MAI
Excluding the STAT model results may lead to smaller RC values and hence tougher requirements.	reduces MAI
Other press factors than N and P reduction. Their effect cannot be modelled to a credibility that can justify measures.	no indication

Note: reduces MAI = more strict MAI limits (higher need for reductions)

The above Table 4-3 illustrates that a long list of options are examined regarding their potential RFM.

It is found that there may be water bodies of interest for modifying N-MAI by reduction of P loads. Such modification requires more detailed studies of each individual water body.

Two topics are assessed to give no clear RFM, but they will most likely reduce uncertainties.

Four topics are estimated to have the opposite effect – as they are expected to lead to reduction in MAIs and hence more strict MAI limits.

The major issue in the above list of topics is considered the 50 per cent target at the G/M.

4.7 Task 13: Seasonality, baseline, neighbouring countries

4.7.1 Objectives

The objective of the present task is to assess RFM regarding seasonality, baseline and effects from neighbouring countries.

4.7.2 Analysis and assessment

Seasonality effects

What here is called "seasonality effect" describes further reduction of nutrient load during summer season to achieve a potential for increased nutrient load during the remaining seasons and keeping the environmental status/class. This effect is investigated in (Erichsen et al. 2021b). The advanced MECH models are applied, providing that the methods for investigating seasonal variability are on a scientifically high level.

The results show that introduction of seasonal reduction of N load may have potential for increased annual N-MAIs in selected water bodies. Out of in all 109 water areas nine areas are found to have large potential and further nine areas for medium potential. The areas are given in the lists below.

Water areas with 'large potential':
1. Karrebæk Fjord
2. Nærå Strand
3. Odense Fjord, i
4. Haderslev Fjord
5. Hejlsminde Nor
6. Kolding Fjord, i
7. Ringkøbing Fjord
8. Hjarbæk Fjord
9. Halkær Bredning

Water areas of 'medium potential':
10. Horsens Fjord, i
11. Nakskov Fjord
12. Kalundborg Fjord
13. Vejle Fjord, y
14. Odense Fjord, y
15. Vejle Fjord, i
16. Norsminde Fjord
17. Bjørnholms Bugt, etc
18. Nibe Bredning og Langerak

Although the above (9+9) potential areas are identified it is still so that diffuse contribution during summer is dominating for almost all areas. Since diffuse contributions are difficult to reduce, it is emphasised to apply annual load reduction measures on annual time scale.

Effect of measures in neighbouring countries

The effect of nutrients reaching Danish Coastal waters that are discharged in coastal waters in neighbouring countries or transport to Denmark via the atmosphere is also called "Burden distribution". This is investigated in the management scenarios of scenario group 2 (Erichsen et al. 2021b).

One of the results is quoted below: If neighbouring countries do not reduce their load, the effect on the Danish N-MAI is illustrated in Table 4-4.

Table 4-4: Difference in N-MAI for a scenario where Danish and neighbouring areas meet BSAP targets and a scenario, where neighbouring areas discharge without load reduction.

Target (scenario)	National N-MAI (tN/y)
New BSAP targets. Additional Wadden Sea P reduction (2e, 20%)	37,254
No reduction in neighbouring countries (2c)	29,553
Difference	7,701 (21%)

It is seen that the reduction in the neighbouring countries has a certain effect on the Danish N-MAIs. For the Danish water bodies in general, the effect of neighbouring loads is of secondary importance. Even without impacts from neighbouring countries, the loads from Denmark will give rise to water quality issues of the same order of magnitude as presently observed. For some water areas, in particular those in the vicinity of the Danish borders (e.g., the Wadden Sea, Flensburg Fjord and the Baltic Sea), good environmental status cannot be reached by Danish measures alone. However, legal disputes on EU-level may be expected if Denmark does not live up to its obligations and leaves more reduction to a neighbouring country. Therefore, there is no RFM regarding burden distribution.

4.7.3 Concluding remarks

As for the extent to which the scientific basis can provide RFM regarding seasonality and burden distribution to obtain an increased MAI, the following conclusion is made:

Table 4-5: Conclusion on RFM regarding seasonality and burden distribution

Potential options	RFM
Burden distribution is modelled on a high scientific level. No significant effect on national level.	no indication of RFM
Seasonality: N load reduction during summer season may be a tool for specific water bodies.	indication of RFM

The above Table 4-5 illustrates that only N load reduction during the summer season (seasonality) may give RFM for specific water bodies, with expected limited effect and expected considerable effort for monitoring and control (cost/benefit).

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, especially in the more closed marine waters and fjords. Therefore, burden distribution gives no clear RFM.

Establishing additional management scenarios (i. e. assessing the burden distribution between Denmark and its neighbouring countries) may strengthen the managerial basis for establishing measures. This may leave room for manoeuvring in specific water bodies, e. g. Wadden Sea, Flensburg Fjord and Bornholm. Such additional scenario modelling shall not, however, delay the implementation of measures to reduce nutrient loads.

Appendix A Overview of tasks

Table 4-6 Task Group 1: Nitrogen Load
(the task numbers refer to the numbers in the task list in chapter 1).

Task 3 Status load, baseline 2027 load (incl. necessary N reduction)	**Objective** Review on methods, data, calculations for determination of status load and baseline 2027 load. **Scope** › Brief description of applied methods for determining the status loads (based on 2016-2018 data) and the used preconditions. Methodological approvements introduced in RBMP 3 plan period. › Assessment of the impact of the improvements on the certainty of the load calculation. › Brief description of applied method calculation of baseline load (2027) and the used precondition › Scientific evaluation of the area of applicability of the applied improvements of the methods for load calculation and their limitations. **Basis** RBMP3, interviews with the Resource group (RG) consisting of DHI and DCE/AU, and with MST, 2. Review of selected documents from the list of literature provided by MOE and Ministry of Finance (MoF). **Interface** Feeds into task 6 and into the activities of task Group 2: Modelling **Deliverables from the Client** List of necessary background literature, participation at planned meetings, response to questions and draft documents in due time. **Deliverables** Report **Team members** **Deadline:** 28/6/22: Status report Conducted work, achieved results, plan for remaining task, specific issues 26/8/22: Tentative results First results (60%), plan for remaining task, specific issues 14/10/22: Draft report Draft report for commenting by MOE/MOF

	27/10/22: Final report Final report including comments by MOE/MOF.
Task 6 Target load, target achievement	**Objective** Precondition for target N-discharge (MAI, Maximum Allowable Input of Nitrogen) and certainty for achievement of target N-discharge **Scope** › Brief description of method for determining the target load (2027) that will support achieving the environmental objectives. Description of methodological approvements introduced in plan period 3 (PP3). › Model-uncertainty for achievement of target load given the precondition for calculated target loads › Assessment of the impacts of the improvements of the technical data from 2nd RBMP to 3rd RBMP on the certainty of the target load calculation. › Scientific evaluation of the main area of applicability of the applied methods for target load calculation and their limitations. › Description of all elements that MAI are dependent on; defined reference condition, environmental target, model preconditions etc. **Basis** RBMP 3, interviews with the RG and MST, review of selected documents from the list of literature provided by MOE and MOF. **Interface** Feeds into the activities of task Group 2: Modelling **Deliverables from the Client** List og necessary background literature, participation at planned meetings, response to questions and draft documents in due time. **Deliverables** Report **Team members** **Deadline:** 28/6/22: Status report Conducted work, achieved results, plan for remaining task, specific issues 26/8/22: Tentative results First results (50%), plan for remaining task, specific issues 14/10/22: Draft report Draft report for commenting by MOE/MOF

	27/10/22: Final report Final report including comments by MOE/MOF.
Task 7 Seasonal variability	**Objective** Review on introduction of seasonal variability of N-load. Review on impact of choice of measures with high impact on N-load during summer season on will affect the N-load during the summer months and on the possibilities for optimising the choice of measures accordingly and based on existing calculations[167]. **Scope** › This task is based on existing studies prepared by AU › Review on scientific background for the methods applied to assess the effect of seasonal variability of N-load on calculation of status load, baseline load and target load (emphasis on effect on summer discharge) › Scientific evaluation of the main area of applicability of the applied methods for seasonal subdivision of the N-load calculation and their limitations. **Basis** Study by AU on seasonal variability of load calculation. RBMP3, interviews with the RG, review of selected documents from the list of literature provided by MOE and MOF. **Interface** Feeds into the activities of task Group 2: Modelling **Deliverables from the Client** List og necessary background literature, participation at planned meetings, response to questions and draft documents in due time. **Deliverables** Report **Team members** **Deadline:** 28/6/22: Status report Conducted work, achieved results, plan for remaining task, specific issues 26/8/22: Tentative results First results (30%), plan for remaining task, specific issues 14/10/22: Draft report Draft report for commenting by MOE/MOF

167 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

	27/10/22: Final report Final report including comments by MOE/MOF.
Task 12 Room for manoeuvring: Target load (MAI)	**Objective** Room for manoeuvring in relation to calculating target loads (MAI) and need for reduction (incl. defined reference condition, environmental target, load and baseline loads, model preconditions etc. other press factors, especially phosphorous). The assignment should take its outset in existing studies and description of alternative measures which take into account other press factors when determining target loads and needs for measures. These methods are assessed regarding their scientific basis and applicability. The study can for instance investigate whether specific Phosphorous reducing measures can lead to reducing the Nitrogen measures – and including an assessment of the economic consequences of such changes. **Scope** › Identification of alternative measures based on readily available studies (AU). › Scientific evaluation of the basic methodologies for load calculations, and their implications on applicability and limitations? › Room for manoeuvring (Impact om the calculated MAI) dependent on the choice/precondition for, reference value and environmental targets, calculated Nitrogen and P loads, baseline 2027, model precondition (one out all out, "systembidrag"), uncertainty, preconditions regarding achieving MAI, preconditions regarding contribution from other countries (water/air), **Basis** Existing document on alternative measures (AU). RBMP3, interviews with the RG, review of selected documents from the list of literature provided by MOE and MOF. **Interface** Feeds into the overall analysis of scientific playing field **Deliverables from the Client** Provision of existing document on alternative measures. Dialogue on formulation of playing field results. **Deliverables** Report **Team members** **Deadline:** 28/6/22: Status report Conducted work, achieved results, plan for remaining task, specific issues 26/8/22: Tentative results First results (20%), plan for remaining task, specific issues

	14/10/22: Draft report Draft report for commenting by MOE/MOF 27/10/22: Final report Final report including comments by MOE/MOF.
Task 13 Room for manoeuvring: Target load, (seasonality)	**Objective** Room for manoeuvring in relation to calculating target loads and necessary measures (incl. baseline load and other press factors, incl. phosphorous and fisheries). The assignment should take its outset in existing studies and description of alternative measures which take into account other press factors when establishing target loads and needs for measures. These methods are assessed regarding their scientific basis and applicability. Room for manoeuvring in relation to seasonal measures (summer) on N-loads are to be analysed separately from the room for manoeuvring in relation and the effect N-loads in neighbouring countries and areas. The goal is an optimised set of measures for N-load reduction. This can be based on the conducted scenario analyses regarding distribution of burden. **Scope** › Review on scientific basis of seasonal measures describe in existing and readily available studies. › Review on the scientific basis to re-calculate the target N-load from point sources and diffuse sources due to introduction of seasonal measures. › Review on the scientific basis to include the effect of seasonal measures applied in adjacent water areas. › Scientific evaluation of the main area of applicability of the applied methods for load calculation and their limitations. **Basis** Existing document on alternative measures, RBMP3, interviews with the RG and MST, review of selected documents from the list of literature provided by MOE and MOF. **Interface** Feeds into the overall analysis of scientific playing field **Deliverables from the Client** Provision of existing relevant documents. Dialogue on formulation of playing field results. **Deliverables** Report **Team members** **Deadline:** 28/6/22: Status report Conducted work, achieved results, plan for remaining task, specific issues

	26/8/22: Tentative results First results (0%), plan for remaining task, specific issues 14/10/22: Draft report Draft report for commenting by MOE/MOF 27/10/22: Final report Final report including comments by MOE/MOF

Table 4-7 Task group 2: Model

Task 4
Model Basis
	Objective
	
	Review on statistical and mechanistic models, and the resulting calculations.
	
	Scope
	
	› Review on the changes and improvements in RBMP3 on the statistical and mechanistical models with respect to
	   › applied methodologies
	   › pre-conditions for the calculations.
	› The Review shall include on the effects of changes on the applicability of the applied models as well on the introduced limitations.
	
	Basis
	RBMP3, interviews with the RG, review of selected documents from the list of literature provided by MOE and MOF.
	
	Interface
	Feeds into the activities of task Group 2: Modelling
	
	Deliverables from the Client
	Provision of existing relevant documents. Dialogue on methods and presentation of results.
	
	Deliverables
	Report
	
	Team members
	
	Deadline:
	28/6/22: Status report
	Conducted work, achieved results, plan for remaining task, specific issues
	
	26/8/22: Tentative results
	First results (80%), plan for remaining task, specific issues

	14/10/22: Draft report Draft report for commenting by MOE/MOF 27/10/22: Final report Final report including comments by MOE/MOF

Task 5
Burden distribution
	Objective
	
	Preconditions for and the method used to include N-contributions from other countries via atmosphere and waters, especially with respect to the effect of measures in Danish coastal waters.
	
	Scope
	
	› Description of the method applied in RBMP3 (compared to RBMP2) to determine the effect of N-loads from other counties
	    › via atmospheric deposition
	    › via oceanographic transports
	› Review on impact of foreign loads on the determination of the target loads for de Danish Coastal Waters. The review will not include quantitative analyses but will be based on existing studies (if such exist) and on qualitative assessments (expert judgements). Note: Apply the results from changed distribution of burden in scenarios 2a-e.
	› The Review shall include an assessment of the effects of the applicability of the applied methods as well on their limitations.
	
	Basis
	Existing relevant studies (if existing), RBMP3, interviews with the RG, review of selected documents from the list of literature provided by MOE and MOF.
	
	Interface
	Feeds into the activities of task Group 2: Modelling
	
	Deliverables from the Client
	Provision of existing relevant documents. Dialogue on methods and presentation of results
	
	Deliverables
	Report
	
	Team members
	
	Deadline:
	28/6/22: Status report
	Conducted work, achieved results, plan for remaining task, specific issues

	26/8/22: Tentative results First results (30%), plan for remaining task, specific issues 14/10/22: Draft report Draft report for commenting by MOE/MOF 27/10/22: Final report Final report including comments by MOE/MOF
Task 9 Other press factors	**Objective** Review on importance of other press factors (on target, discharge, measures) based on existing press factor analyses **Scope** › Review on existing analyses on other environmental press factors than N-load. › The Review shall include an assessment of the scientific basis for the analyses of the effects of alternative press factors as well on their limitations. **Basis** Existing relevant studies (AU), RBMP3, interviews with the RG, review of selected documents from the list of literature provided by MOE and MOF. **Interface** Feeds into the activities of task Group 2: Modelling **Deliverables from the Client** Provision of existing relevant documents. Dialogue on methods and presentation of results. **Deliverables** Report **Team members** **Deadline:** 28/6/22: Status report Conducted work, achieved results, plan for remaining task, specific issues 26/8/22: Tentative results First results (10%), plan for remaining task, specific issues 14/10/22: Draft report Draft report for commenting by MOE/MOF

	27/10/22: Final report Final report including comments by MOE/MOF

Table 4-8 Task group 3: Environmental Condition

Task 1 Reference Condition	**Objective** Review on changes and improvements in RBMP3 in methods, data, calculations for determination of ecological reference condition **Scope** › Review on methodological improvements in RBMP3 to determine the ecological reference situation › Review on improvements in RBMP3 of the applied data basis to determine the ecological reference situation › Review on improvements in RBMP3 of the conducted calculations to determine the ecological reference situation **Basis** Existing relevant studies (AU), RBMP3, interviews with the RG, review of selected documents from the list of literature provided by MOE and MOF. **Interface** Feeds into the activities of task Group 3: Environmental condition **Deliverables from the Client** Provision of existing relevant documents. Dialogue on methods and presentation of results. **Deliverables** Report **Team members** **Deadline:** 28/6/22: Status report Conducted work, achieved results, plan for remaining task, specific issues 26/8/22: Tentative results First results (80%), plan for remaining task, specific issues 14/10/22: Draft report Draft report for commenting by MOE/MOF 27/10/22: Final report Final report including comments by MOE/MOF

Task 2 Environmental objective	**Objective** Review on environmental objectives for coastal waters. Basis for determination of environmental target (EU's EQR values) **Scope** › Review on the scientific basis for methodological improvements introduced in RBMP3 to determine the environmental objectives (good ecological condition). Could DK have reported other data for intercalibration, and would it give other objectives? › The review shall include a description of basis used for establishing the environmental target, i.e. the basis used for establishing the EU inter-calibrated EQR values (i.e. the factor used for defining the difference between 'good condition' and the reference value). › The Review shall include an overall assessment of the applicability of the analyses of determining the ecological objective as well on its limitations. **Basis** RBMP3, interviews with the RG, review of selected documents from the list of literature provided by MOE and MOF. **Interface** Feeds into the activities of task Group 3: Environmental condition **Deliverables from the Client** Provision of existing relevant documents. Dialogue on methods and presentation of results. **Deliverables** Report **Team members** **Deadline:** 28/6/22: Status report Conducted work, achieved results, plan for remaining task, specific issues 26/8/22: Tentative results First results (50%), plan for remaining task, specific issues 14/10/22: Draft report Draft report for commenting by MOE/MOF 27/10/22: Final report Final report including comments by MOE/MOF
Task 8 Environmental objective, other	**Objective**

countries and areas	Review on the Danish objectives and the Danish measures compared with those in relevant neighbouring countries/water areas. **Scope** › Comparison between the Danish objectives and the Danish measures with those in relevant neighbouring countries/water areas. › Evaluation of the scientific basis to conduct such comparisons › Review on the applicability of such comparisons of objectives and measures as well as their limitations. **Basis** RBMP3, interviews with the RG, review of selected documents from the list of literature provided by MOE and MOF. **Interface** Feeds into the activities of task Group 3: Environmental condition **Deliverables from the Client** Provision of existing relevant documents. Dialogue on methods and presentation of results. **Deliverables** Report **Team members** **Deadline:** 28/6/22: Status report Conducted work, achieved results, plan for remaining task, specific issues 26/8/22: Tentative results First results (30%), plan for remaining task, specific issues 14/10/22: Draft report Draft report for commenting by MOE/MOF 27/10/22: Final report Final report including comments by MOE/MOF
Task 10 Room for manoeuvring: Reference condition	**Objective** Assess possible room for manoeuvring in relation to establishing the reference condition and the environmental targets. Description of 1-2 alternatives for determining the reference condition

	Scope › Based on existing study from AU a description of 1-2 alternatives for determining the reference condition for coastal waters is presented › A review on the possibility for applying methods and preconditions (within EU directives and guidelines) from neighbouring countries › Assessment of scientific playing field for determining the reference N-load (for reference condition) › Review on the applicability of such alternatives as well as their limitations. **Basis** RBMP3, interviews with the RG, review of selected documents from the list of literature provided by MOE and MOF. **Interface** Feeds into the activities of task Group 3: Environmental condition **Deliverables from the Client** Provision of existing relevant documents. Dialogue on methods and presentation of results. **Deliverables** Report **Team members** **Deadline:** 26/6/22: Status report Conducted work, achieved results, plan for remaining task, specific issues 26/8/22: Tentative results First results (30%), plan for remaining task, specific issues 14/10/22: Draft report Draft report for commenting by MOE/MOF 27/10/22: Final report Final report including comments by MOE/MOF
Task 11 Room for manoeuvring: Revision of scientific basis for EQR	**Objective** Assess possible room for manoeuvring in relation to establishing the reference condition and the environmental targets. Options for revising the scientific basis for the EU inter-calibrated Ecological Quality Ratio (EQR) values, including the steps necessary for involving other EU Member States and the EU Commission in such a process. **Scope**

	- Description of the possibilities to revise
	  - scientific basis for EU-intercalibration
	  - EU approved intercalibrated EQR values.
	- Description of the process that will be necessary to conduct such revision in relation to other member countries as well as the EU-Commission
	- Review on the scientific applicability of such revision as well as its limitations.
	
	Basis
	RBMP3, interviews with the RG, review of selected documents from the list of literature provided by MOE and MOF.
	
	Interface
	Feeds into the activities of task Group 3: Environmental condition
	
	Deliverables from the Client
	Provision of existing relevant documents. Dialogue on methods and presentation of results.
	
	Deliverables
	Report
	
	Team members
	
	Deadline:
	26/6/22: Status report
	Conducted work, achieved results, plan for remaining task, specific issues
	
	26/8/22: Tentative results
	First results (30%), plan for remaining task, specific issues
	
	14/10/22: Draft report
	Draft report for commenting by MOE/MOF
	
	27/10/22: Final report
	Final report including comments by MOE/MOF

Appendix B International evaluation

Panel of international experts. *International evaluation of the Danish marine models.* Miljø- og Fødevareministeriet, 10. October, 2017:

"Overall assessment and conclusions

The WFD aims at restoring Good Ecological Status in surface waters in Europe. The Scientific Documentation Report proposes measures of nutrient load reduction to reach this Good Ecological Status in Danish transitional and coastal waters. The Panel fully endorses the importance attached to nutrient reductions as a necessary requirement to reach this Good Ecological Status and stresses the importance of nutrient conditions as a modulating factor interacting with any additional measures taken to improve the state of the system.

In comparison with many other European countries, Denmark has excellent databases, models and scientific expertise as a basis for the implementation of the WFD. The Panel was delighted to see that these resources have been mobilised to achieve a leading position at the European scale. The Panel was impressed by the openness and transparency of the interaction between government, researchers and stakeholders as well as by the high intellectual level of the discussions. This open exchange of ideas and opinions is a perfect basis for a further improvement of the scientific basis for the WFD implementation.

The Panel has reviewed the choice of indicators and procedures, in the context of the WFD requirements and specifications, and found that the indicators, the methods to determine RC and the methods to determine required actions were WFD compliant. The Danish implementation is based on either direct historical observation or model determination of RC. Little or no uncontrollable "expert judgement" is involved. In that respect, the Danish models are attaining the highest possible standard of WFD implementation.

The Panel has analysed the consequences of using a relatively coarse typology of coastal waters for calculating RC, targets and MAIs of N. The Panel concludes that the use of a coarse typology has led to reduction requirements that are not optimal for each of the individual water bodies. The Panel is convinced that the full use of available data and models would allow Denmark to forego the typology and develop advanced, specific reduction targets for each water body. The Panel recommends focusing on the water body scale of resolution throughout the scientific process. The regional grouping of reduction measures should be decided upon only at the stage of translating scientific advice into management action plans.

The Panel has analysed the indicators used and concluded that chlorophyll-a is a useful intercalibrated indicator of phytoplankton, while Kd is less optimal as an indicator of benthic angiosperms and macrophytes. The other indicators, used in the STAT modelling only, currently present methodological problems and are not yet mature enough for inclusion in the management plans. The Panel has identified promising developments in the modelling with respect to angiosperm and macrophyte indicators and made recommendations on how to extend and develop the indicator set in the future.

In view of the large efforts in the past to remove P load from point sources, the Panel endorses the emphasis placed in the Scientific Documentation Report on reducing N loads from diffuse sources. However, at least in principle, there could be an additional role for P load reduction and for seasonal regulation of the N load. The Panel is of the opinion that these options merit further scientific exploration, especially in watersheds where high efforts for N load reduction are required.

Although the maintenance of two parallel modelling lines (STAT and MECH) may seem redundant at first sight, the Panel strongly endorses maintaining these lines. Given the wealth of data available, it provides unique possibilities for evidence-based checking of MECH model results. The Panel assesses the MECH model as a state-of-the-art, very comprehensive tool, but emphasises that independent checking on data as well as uncertainty analysis remain necessary and can be performed by the statistical approach. This coherence can be optimised by improving the approach and methods of the STAT modelling.

The Panel endorses the general logic of the methodology to derive reference and target values from the models and to calculate the required N load reduction to reach the targets. The Panel has identified several points in the workflow where averaging is performed. This results in interdependence of model types, loss of indicator resolution and loss of spatial resolution. It also adds complexity to the procedure and makes it very difficult to understand. None of these losses are necessary since the model results and database do permit a fully transparent derivation of water body-specific required nutrient reduction.

Summing up these different aspects of the work, the Panel positively evaluates that nutrient load reductions are based on solid scientific evidence and generally high-level modelling approaches. The Panel is very positive about the near lack of expert judgment in the work and is of the opinion that in the few places where it does occur, it is not necessary and can be removed. The general (country-averaged) level of required nutrient load reduction compares favourably with independent efforts in similar areas and seems a robust measure of what is needed. At the same time, the Panel assesses the spatial resolution of the required efforts as unnecessarily coarse. The Panel is convinced that the rich database, combined with an improved statistical approach and the high-resolution MECH modelling tools, are able to derive improved, water body-specific MAI values. Current scientific insight endorses the view that the overall reductions proposed are necessary, but cannot guarantee that they will be sufficient. Especially for benthic angiosperms and macrophytes, additional measures may be needed.

Recommendations for going further

Monitoring: The Danish national monitoring programme used in the Scientific Documentation Report includes more than 90 stations along the coast and in the sea. It is very comprehensive and is generally well adjusted to the WFD requirements. It forms the basis for the further development of models, for most calculations and is required to evaluate the success of measures and whether the targets of the WFD are met. The Panel recommends maintaining this monitoring system at full strength and assessing if additional monitoring stations will be required for a water body-specific management.

Typology: The typology has weaknesses in reflecting the individual properties of fjordic water bodies. Instead of suggesting a refinement of the existing typology, we recommend calculating RC and targets for each of the 119 water bodies in Denmark. Denmark is one of the few countries in Europe, where the necessary data, expertise and models are available for such a comprehensive approach. By taking specific conditions and individuality of every water body into account, the calculated targets and water body-specific MAIs will be optimised and lead to minimal waste of resources. For purposes of IC, a robust typology can be based on the results of the water body-specific analyses.

Choice of indicators: Chlorophyll-a is a generally accepted and intercalibrated indicator of phytoplankton. Kd, as a measure for macrophytes and angiosperms, has certain limitations. The Panel recommends building on recent efforts towards comprehensive modelling of eelgrass in order to derive a better indicator of macrophytes, but to keep Kd as a proxy meanwhile. The other indicators used in the STAT modelling address important ecological questions, but are not mature in the sense that they lack a clear quantitative relation with nutrient loading. The Panel recommends leaving them out of the present modelling and developing targeted modelling directed at their incorporation into the indicator system.

STAT modelling: The Panel sees great merit in the strategy to maintain two independent lines of modelling, one based on statistical data analysis and the other based on MECH modelling. The Panel recommends reorienting the STAT modelling towards optimal estimation of the long-term slopes of the indicators on nutrient loading in a cross-systems analysis way and keeping in principle both N and P loading as explanatory variables. The Panel recommends elaborating the uncertainty analysis in the STAT modelling and suggests that this will be facilitated when a single cross-system advanced modelling approach is chosen.

MECH models: MECH models are state-of-the-art, both in terms of numerical technique and included processes. They are powerful tools for providing a sound scientific basis for the implementation of the WFD in Denmark. A shortcoming is that they do not cover all water bodies. As a consequence, different approaches were used for the definition of RC, targets and MAI in different water bodies. We recommend extending a MECH modelling approach to as many water bodies as possible to ensure that, in future, a uniform methodology can be used for the definition of water body-specific MAI.

Methods to derive targets and MAI from the models: The Panel recommends simplifying the calculation procedure by removing the averaging steps between models, between indicators, between water bodies within types and between water bodies on a regional basis. In this way, the differences and correspondences between modelling approaches, indicators and water bodies will become clear and can be further analysed. Cross-checking of results of the STAT and MEHC model approaches in systems, where both are available, will form a basis for extrapolation to all systems. The Panel recommends deriving one MAI per water body in this way and only deciding in a later phase on regional averaging or lumping, when scientific results are translated into management actions.

River basin interactions: River basin models allow calculating the load reduction potential of N and phosphorus for each river basin, the development of water body-specific N and phosphorus load reduction scenarios and cost estimates. Further, they allow addressing seasonal load and limitation patterns. The Panel recommends a combination of river basin and coastal water models to enable the development of water body-specific optimised management concepts that consider both N and phosphorus.

International approach: The technical WFD implementation guidelines force similar approaches in all Member States. As a consequence, requirements, modelling and challenges are similar in different countries. Further, the WFD asks for an IC and harmonisation of targets with neighbouring countries. Therefore, the Panel recommends a co-ordinated joint scientific approach, especially between Denmark, Germany and Sweden."

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Appendix D The Danish RBMP3 – implementation of the WFD

The general implementation legal framework

The WFD is implemented in the Danish Act, '*lov om vandplanlægning*' and several accompanying Secondary Orders, namely the two normative Secondary Orders; '*miljømålsbekendtgørelsen*'[168] and '*indsatsbekendtgørelsen*'[169].

'*Miljømålsbekendtgørelsen*' sets out in Annex 1-4 the legally binding specific environmental objectives for each coastal water distributed between the four river basin districts as well as the deadline for achieving the objectives.

'*Indsatsbekendtgørelsen*' establishes the basic measures and supplementary measures that after the directive are required to achieve the environmental objectives.

Furthermore, four technical Secondary Orders contribute to the implementation of the WFD; 'v*anddistriktbekendtgørelsen*'[170], 'b*asisanalysebekendtgørelsen*'[171], '*bekendtgørelse om fastsættelse af miljømål*'[172] and '*overvågningsbekendtgørelsen*'[173]. The four Secondary Orders establishes the

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[168] *Bekendtgørelse nr. 448 af 11. april 2019 om miljømål for overfladevandområder og grundvandsforekomster*. An amendment of the Secondary Act is currently under revision based on a public consultation proces together with the public hearing of the compiled material relating to the 3rd RMBP. Høringsdetaljer - Høringsportalen (hoeringsportalen.dk)

[169] *Bekendtgørelse nr. 449 af 11. april 2019 om indsatsprogrammer for vandområdedistrikter*. An amendment of the Secondary Act is currently under revision based on a public consultation proces together with the public hearing of the compiled material relating to the 3rd RMBP. Høringsdetaljer - Høringsportalen (hoeringsportalen.dk)

[170] *Bekendtgørelse nr. 119 af 7. februar 2014 om vandområdedistrikter og hovedvandoplande.* An amendment of the Secondary Act is currently under revision based on a public consultation proces together with the public hearing of the compiled material relating to the 3rd RMBP. Høringsdetaljer - Høringsportalen (hoeringsportalen.dk)

[171] Beken*dtgørelse nr. 837 af 27. juni 2016 om basisanalyser.* An amendment of the Secondary Act is currently under revision based on a public consultation proces together with the public hearing of the compiled material relating to the 3rd RMBP. Høringsdetaljer - Høringsportalen (hoeringsportalen.dk)

[172] Bekendtgørelse nr. 1625 om fastlæggelse af miljømål for vandløb, søer, ov*ergangsvande, kystvande og grundvand.* An amendment of the Secondary Act is currently under revision based on a public consultation proces together with the public hearing of the compiled material relating to the 3rd RMBP. Høringsdetaljer - Høringsportalen (hoeringsportalen.dk)

[173] *Bekendtgørelse nr. 1001 af 29. juni 2016 om overvågning af overfladevandets, grundvandets og beskyttede områders tilstand og om naturovervågning af internationale naturbeskyttelsesområder.* An amendment of the Secondary Act is currently under revision based on a public consultation proces together with the public hearing of the compiled material relating to the 3rd RMBP. Høringsdetaljer - Høringsportalen (hoeringsportalen.dk)

technical basis on which the Danish authorities base their administration and management within the next period of planning covering 2021-2027.

The legally binding legislation is supplemented by the RBMPs which Member States after the WFD Article 13 are required to produce. In the Danish implementation the RBMP's are from the second period of planning not legally binding but of a more informative character.

The Secondary Orders are updated and amended in continuation of the RBMPs on a six yearly basis. The RMBP 3 will thus expectedly be issued together with the legally binding Secondary Acts in December 2022 based on a substantive public consultation process.

Protected areas

As described in this report above in chapter 2.1.4, the protected areas are covered by multiple environmental objectives; both the environmental objective set out for the specific water body after WFD and the environmental objective that follows from the other EU-regulation which the water body is also covered by.

The list of protected areas set out in Annex IV of the WFD is implemented in § 16 of the Danish Act, *'lov om vandplanlægning*' being:

1) beskyttede drikkevandsforekomster, jf. § 10 i lov om vandforsyning m.v.,
2) beskyttede skaldyrvande, jf. § 18, stk. 3,
3) områder udpeget som badeområder, jf. § 16 i lov om miljøbeskyttelse,
4) relevante internationale naturbeskyttelsesområder, jf. miljømålslovens § 36,
5) næringsstoffølsomme områder.

The obligation to ensure that environmental objectives after both the WFD and among others the nitrate and Habitats Directives are met is set out in § 7, (2) and (3) of '*lov om vandplanlægning*'. The provisions stipulate that:

- If other legislation sets stricter obligations regarding the quality of the water body, such obligation will apply for environmental objective.

- If other legislation sets a shorter time limit for fulfilling environmental objectives, such time limits will apply.

Characteristics and minimum requirements related to RC and status based on technical specifications

The WFD requirements to carry out an analysis of the characteristics of each river basin district (Article 5), to establish environmental objectives (Article 4) and issue programmes of measures (Article 11) are mainly implemented in '*miljømålsbekendtgørelsen*' and *'indsatsbekendtgørelsen*'.

The technical specifications set out in Annex II of the Directive as well as the QEs for the classification of ecological status and the normative definitions of ecological status classifications set out in Annex V of the directive are mainly implemented through '*basisanalysebekendtgørelsen*', *miljømålsbekendtgørelsen*' and '*overvågningsbekendtgørelsen*'.

Extension of deadline for achieving the objectives and less stringent environmental objectives

The option in Article 4.4. and 4.5 of the WFD enabling Member States to – under certain conditions - extend the deadline for achieving the objectives of the directive and achieve less stringent environmental objectives are implemented in "l*ov om vandplanlægning*" namely §§ 7, 10 and 11.

The provisions in the Danish Act are authorizing the Minister of the Environment to establish further provisions on environmental objectives and programmes of measures, including the possibility to extend the deadline for achieving the environmental objectives provided that no further deterioration occurs in the status of the affected body of water and the conditions set out in Article 4.4. of the directive are met. It is explicitly stated in the Danish Act § 10, 3, that the deadline can only be extended until the December 22th 2027 "*except in cases where the natural conditions are such that the objectives cannot be achieved within this period*". This is accordance with Article 4.4, litra c of the directive.

The Minister of the Environment is furthermore empowered to establish less stringent environmental objectives for specific water bodies in accordance with the conditions set out in Article 4.5 of the directive.

More detailed provisions on the conditions under which the deadline for achieving environmental objectives can be extended, are set out in *'bekendtgørelse om fastsættelse af miljømål'*. Here, as well as in the draft version from 2022, it is established that if a less stringent environmental objective is set or the deadline is extended, it must be specified which conditions, QEs or time limit that are covered by the exemption from the environmental objective.

Description of the specific use of the possibility to extend the deadline for achieving the environmental objectives

The Danish application of exemptions

Draft version of 3rd River Bassin Management Plan

In the draft version of 3rd RBMP, the environmental objectives for coastal waters are set out in section 6.4[174].

All coastal waters in Denmark as well as territorial waters are covered by specific environmental objectives. The specific environmental objectives for coastal waters are set out as good ecological status and good chemical status. The specific environmental objectives for coastal waters designated as heavily modified bodies of surface water are set out as good ecological potential and

[174] vandomraadeplanerne-2021-2027.pdf (mim.dk)

good surface water chemical status. The specific environmental objective for territorial waters is good chemical status.

In the current draft version of the RBMP 3, the deadline for achieving the environmental objectives has been extended for the majority of the coastal waters to after 2027 based on the specific reason that "natural conditions are such that the objectives cannot be achieved within this period." (Article 4.4.c)).

At the web page '*MiljøGIS for høring af vandområdeplaner 2021-2027*' it is illustrated through interactive maps which specific water bodies are covered by the extended deadline beyond 2027[175].

See below a table from the draft version of 3rd RBMP covering the expected relevant deadline for achieving the environmental objective.

6.4.1 Kystvande og territorialfarvande

TABEL 6.9 Mål og frister for kystvande og territorialfarvande på landsplan.

Samlede antal	123 (14 kun kemisk tilstand)
God tilstand senest 2021	8
God tilstand senest 2027	11
God tilstand efter 2027 pga. naturlige forhold	104

God tilstand: God økologisk tilstand/godt økologisk potentiale og god kemisk tilstand (territorialfarvande kun god kemisk tilstand)

1st and 2nd River bassin management plans

The first two Danish RBMP's also made use of the possibility in WFD Article 4.4. to extend the deadline for achieving the environmental objectives for a number of coastal waters.

RBMP 1 covers the period 2009-2015[176]. The reason given in the RBMP are primarily based on the argument that 'completing the improvements within the timescale would be disproportionately expensive' as well as 'the scale of improvements required can only be achieved in phases exceeding the timescale, for reasons of technical feasibility'.

RBMP 2 covers the period 2015-2021[177]. The RBMP describes in accordance with the WFD the reasons and explanation for the extension of the deadline for 72 water bodies.[178] The reason given in the RBMP are primarily based on the argument that 'completing the improvements within the timescale would be disproportionately expensive'.

Thus RBMP 1 and 2 made use of the first two reasons in the WFD Article 4.5; 'technical feasibility' and 'disproportionately expensive' for extending the

175 Miljøgis (mim.dk)

176 Link to '*Vandplaner for 1. vandplanperiode*': Vedtagne vandplaner 2009-2015 (mst.dk)

177 Link to '*Vandområdeplaner for 2. vandplanperiode*': Vandområdeplaner (mst.dk)

178 The reasons are elaborated for the individual water body in MiljøGIS

deadline beyond the concerned period of planning, whereas the draft version of RBMP 3 is making use of the third reason; 'natural conditions' which is the only reason that applies according to the WFD Article 4.5.c) after the first two updates of the RBMP (after 2027).

Application of less stringent environmental objectives

According to Article 4.5. of the WFD, Member States may aim to achieve less stringent environmental objectives than those required under the directive for specific bodies of water when specific conditions are met, including that water bodies are 'affected by human activity' or 'their natural condition is such that the achievement of these objectives would be infeasible or disproportionately expensive'.

In the draft version of RBMP 3 it is described that the specific water bodies for which less stringent environmental objectives are set out for the third period of RBMP can be viewed in interactive maps at MiljøGIS[179].

It is furthermore described in the draft version of RBMP 3 that Denmark has made use of the possibility to set less stringent environmental objective for 57 water bodies. No coastal water bodies are covered by less stringent environmental objectives.

With reference to 3rd RBMP, overall significant differences (from a legal perspective) applied as compared to 2nd RBMP.

The scientific basis for the RBMP has been substantially improved between the 2nd and the draft 3rd RBMP[180]. Among others, the marine ecosystem models have been further developed and the methods for establishing the required measures have been improved, including the establishment of nutrient loads required to achieve good ecological basis for coastal waters.

Furthermore, the scientific basis for the identification and characterization of water body typology has been examined which has led to an adjustment of the identification of the individual coastal waters compared to the identification of coastal waters in the 2nd RBMP.

This adjustment means according to the MoE that the assessment of status of the coastal waters is not directly comparable between RBMP 2 and 3[181].

Apart from the scientific improvements and minor adjustments in the Secondary Orders accompanying the draft RBMP3, the main principles of the legal basis of RBMP3 remains unchanged from RBMP2.

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[179] Miljøgis (mim.dk)

[180] Draft 3rd RBMP, Section 1.2.2.3

[181] Ibid.

Appendix E 3rd Country RBMP

Status and reasoning for applying extension in time and less stringent environment objectives. The cases of Schleswig-Holstein and Southern Sweden (Support to Legal Chapter 2)

Schleswig-Holstein, Germany

Overview of exemptions on coastal waters

Schleswig-Holstein makes use of an extension of the deadline from achieving a good ecological status by 2027 under WFD-article 4.4 on all coastal waters.[182] Schleswig-Holstein does not apply derogations for less stringent environmental objectives (Article 4.5), a temporary deterioration of the status (Article 4.6) or hydromorphological changes (Article 4.7). Table 4-9 below presents the exemptions applied under article 4.4 for the coastal waters in the Baltic- and North Sea. All coastal waters have an exemption on the basis of natural conditions. Disproportionate costs are also applied, but primarily in the Baltic Sea and to only half of the coastal waters.

- *Table 4-9 Exemptions applied for the 3rd RBMPs on coastal waters (excl. Territorial waters) in Schleswig-Holstein*

Art.	Description	Baltic Sea *number (%)*	North Sea *number (%)*	Total *Number (%)*
4.4a	Technical feasibility	-	-	-
4.4b	Disproportionate costs	13 (48%)	2 (15%)	15 (38%)
4.4c	Natural circumstances	27 (100%)	13 (100%)	40 (100%)

Source: Ch. 5.2 of the 3rd RBMPs for Schlei/Trave, Eider, and Elbe (MELUND-SH, 2021)

Motivation for exemptions according to article 4.4

The German implementation of the WFD is coordinated by a WG, LAWA, which has issued guidance on the application of exemptions.[183] The implementing legislation requires that every exemption has to be technically substantiated, comprehensible, and transparent, and must be accompanied by a time plan to fulfill the environmental objective.[184] As per the WFD, an exemption for natural conditions further requires that all measures required to achieve a good status, as identified in the gap analysis.[185]

One driver behind the high number of exemptions is that despite the execution of all necessary measures, a long latency in the recovery of waterbodies must be

[182] MELUND-SH (Ministry of energy transition, agriculture, environment, nature, and digitisation of Schleswig-Holstein), 2021, Bewirtschaftungspläne, 3. Bewirtschaftungszeitraum 2022 – 2027, i) FGE Schlei/Trave, ii) SH-Anteil der FGE Elbe, iii) FGE Eider

[183] LAWA, 2020, Gemeinsames Verständnis von Begründungen zu Fristverlängerungen nach § 29 und § 47 Absatz 2 WHG (Article 4 Abs. 4 WRRL) und abweichenden Bewirtschaftungszielen nach § 30 und § 47 Absatz 3 Satz 2 WHG (Article 4 Abs. 5 WRRL), Microsoft Word - 03_Anlage_3_LAWA-HA_Fristverl.docx (wasserblick.net)

[184] §83 (2), 2, Bewirtschaftungsplan, Wasserhaushaltsgesetz (WHG)

[185] §29 (3), 2, Wasserhaushaltsgesetz (WHG)

expected.[186] There are a variety of explanations behind the exemptions as per article 4.4(c) (natural conditions) provided in the RBMPs (see *Table 4-10* below). In the Baltic Sea (of Schleswig-Holstein), a time lag in the ecologic regeneration is an explanation that applies to all (100%) coastal waters.[187] However, also a time lag in the restoration in the water quality applies to about 90% of the Baltic Sea coastal waters. For the North Sea (of Schleswig-Holstein), the same explanations apply to all coastal waters, with the exception of one coastal water regarding the restoration of water quality.

Other relevant explanations that apply to a much lesser degree are i) a time lag in the restoration of hydromorphologic conditions from pressures like coastal protection measures, waterway maintenance, dredging materials, raw material extraction, port facilities, bridge construction, and bottom-contact fishing (38% of all coastal waters), and ii) a time lag in the restoration of the water table (13% of all coastal waters).

Table 4-10 Explanations behind the use of an exemption as per article 4.4c (natural conditions) on coastal waters in Schleswig-Holstein

Explanation	Baltic Sea *number (%)*	North Sea *number (%)*	Total *number (%)*
Time lag in restoration of water quality	24 (89%)	13 (100%)	37 (93%)
Time lag in restoration of hydromorphologic conditions	13 (48%)	2 (15%)	15 (38%)
Time lag in ecologic regeneration	27 (100%)	12 (92%)	39 (98%)
Time lag in restoration of water table	5 (19%)	-	5 (13%)
Number of coastal waters	27	13	40

Source: Ch. 5.2 of the 3rd RBMPs for Schlei/Trave, Eider, and Elbe (MELUND-SH, 2021)

In the following paragraphs, further context will be provided for the time lags in the restoration of water quality due to nutrients, and the ecologic restoration of phytoplankton and macrophytes.

Restoration of water quality - nutrients

Nutrient emissions are the dominating pressure for Germany's coastal waters. The German implementation of the WFD operates with orientation values for

[186] MELUND-SH (Ministry of energy transition, agriculture, environment, nature, and digitisation of Schleswig-Holstein), 2021, Bewirtschaftungspläne, 3. Bewirtschaftungszeitraum 2022 – 2027, i) FGE Schlei/Trave, ii) SH-Anteil der FGE Elbe, iii) FGE Eider

[187] MELUND-SH (Ministry of energy transition, agriculture, environment, nature, and digitisation of Schleswig-Holstein), 2021, Bewirtschaftungspläne, 3. Bewirtschaftungszeitraum 2022 – 2027, i) FGE Schlei/Trave, ii) SH-Anteil der FGE Elbe, iii) FGE Eider

nutrient concentrations in the estuaries to the Baltic- and North Sea. A reduction of nutrient concentrations below these orientation values are associated with a level of nutrient loads that supports the environmental objectives of German coastal waters. For the coastal waters of the North Sea, a TN target of 2,8 mg/l has been defined at the limnic-marine mixing point of estuaries mouthing into the North Sea (BLANO 2018a). The most recent assessment shows that for the period of 2011-2015, only the Rhine (out of nine rivers) has achieved that target at the point entering into the Netherlands, whereas the other rivers still exceed the target. For the Baltic Sea, a TN target of 2,6 mg/l was defined, which has been met by 3 out 24 estuaries (BLANO 2018a).

The LAWA reports that German N emissions into coastal waters have been reducing at an annual rate of 2% per year, while virtually no recent reductions were observed for phosphorus (LAWA 2019). This is combined with an assessment that the coastal biology generally only slowly reacts to nutrient reductions.

Accordingly, it is necessary to maintain nutrient concentrations that correspond to the environmental objectives in the long term, if the BQEs are to achieve a good status (BLANO 2018a). Furthermore, the estuaries and Wadden Sea function as nutrient sinks from which significant nutrient releases are to be expected from the sediment due to redissolution processes. Similarly for the Baltic Sea, it is assessed that a substantial amount of TP has accumulated over the past decades, which risks being released from the sediments in the coming decades, leading to exceeding Chl-a concentrations. In some waters, the redissolution rates of TP even exceed the loads entering coastal waters. Finally, high nutrient loads from the Netherlands and Poland can overshadow the nutrient reductions achieved on the national level.

Ecologic regeneration - phytoplankton

Research has shown that despite the achieved nutrient load reductions, a sufficient regeneration with respect to phytoplankton will require further decades (Murray, et all 2019 and Saraiva, et all 2019). Particularly for the Baltic Sea, this is explained by the applicable hydromorphology (water exchange only through the Kattegat/Skagerrak), long water residence time (~30 years), stratification behaviour (that is similar to lakes), and low water exchanges with the North Sea.

In the North Sea, unnaturally high N:P ratios (375:1), due to relatively more effective reductions in phosphorus loads, had negative impacts on the species constellation. Therefore, there is also a need to establish a nutrient balance that supports the environmental objectives.

Overall, the LAWA approximates, through expert judgement, that the time lag for the restoration of phytoplankton will be at least 10-15 years in the North Sea and 15-20 years in the Baltic Sea. Accordingly, the environmental objectives will not be met before 2037 in the North Sea and 2042-2047 in the Baltic Sea.

Ecologic regeneration – macrophytes

The eutrophication of the inner coastal waters of the Baltic Sea has led to a systemic change from a macrophyte-dominated to a phytoplankton-dominated community, whereas macrophytes are only found rudimentarily.[183] Despite the nutrient reductions to date, the macrophyte community has only limitedly recovered with few exceptions. The origins behind the slow recovery are reasoned by the non-linear process of recovering to a mesotrophic state, combined with the nutrient redissolution processes described above. The LAWA concludes that the non-linear recovery process of macrophyte communities can be expected to require decades, and even remain absent.

Expected timeline of achieving the environmental objectives

Based on the above guidance issued by the LAWA, it is expected that about half of the coastal waters in SH will achieve their environmental objective between 2027 and 2039 (53%). One-quarter of the coastal waters will respectively achieve their objective between 2039 and 2045 (23%) or even after 2045 (25%). The Baltic Sea is on average more delayed than the North Sea. Whereas about two-thirds of the coastal waters in the North Sea are expected to achieve their environmental objective before 2039, slightly less than half of the waters of the Baltic Sea will do so.

Table 4-11 Number of coastal waters expected to achieve good environmental status by 2027, 2039, 2045, or after 2045, in Schleswig-Holstein

Year	Baltic Sea *number (%)*	North Sea *number (%)*	Total *number (%)*
By 2027	-	-	-
Before 2039	12 (44%)	9 (69%)	21 (53%)
Before 2045	7 (26%)	2 (15%)	9 (23%)
After 2045	8 (30%)	2 (15%)	10 (25%)
Number of coastal waters	27	13	40

Source: Ch. 5.4 of the 3rd RBMPs for Schlei/Trave, Eider, and Elbe (MELUND-SH, 2021)

As concerns the measures required to support the environmental objectives, the German implementation foresees that all measures will be "initiated" *(German: ergriffen)* by 2027.[188] The LAWA has defined that the term "initiated" entails measures that are "on-going" or "completed". This includes measures for which only concepts have been developed, financing has been granted, or measures in the law-formation process.

Measures that are "in preparation" or have "not started" are in turn not considered as "initiated". Thus, the German plans foresee to "initiate" all measures by 2027, with a "completion" of measures after 2027. For those measures where an overburdening of finances is the case, the measures will be "on-going" by 2033. Whereas the plans explain that most delays are due to measures concerning hydromorphology, it is not possible to identify whether and to which extent agricultural measures are included.

[188] MELUND-SH (Ministry of energy transition, agriculture, environment, nature, and digitisation of Schleswig-Holstein), 2021, Bewirtschaftungspläne, 3. Bewirtschaftungszeitraum 2022 – 2027, i) FGE Schlei/Trave, ii) SH-Anteil der FGE Elbe, iii) FGE Eider

Southern Sweden

Overview of exemptions on coastal waters

In southern Sweden also a high number of exemptions for coastal waterbodies are found (*Table 4-12*). Only 25% of water bodies in the Baltic Sea will achieve their environmental objective by 2027, whereas the remaining 75% will achieve their objective after 2027 but before 2039.[189] The picture is more positive in the North Sea, where only 10% of the coastal waters will achieve their environmental objective after 2027.

As regards the use of exemptions, 47% of coastal waters in both RBMPs have an exemption beyond 2027 due to natural conditions (as per Article 4.4c). Sweden has also applied reduced environmental objectives for a minority of waterbodies to 3% of waterbodies (as per Article 4.5) and with a delayed environmental objective (2%-points of 3%). One exempted water body will fulfil its objective by 2033. However all other exemptions expect the objectives to be fulfilled by 2039.

Table 4-12 Environmental objectives for coastal water bodies in Southern Sweden

Year	Env. Qual.	Baltic Sea (Södra Östersjön)	North Sea (Västerhavet)	Total
2021	Good	1 (1%)	28 (25%)	29 (10%)
Before 2027	Good	43 (24%)	72 (65%)	115 (40%)
	Moderate	1 (1%)	-	1 (>0%)
Before 2033	Good	-	1 (1%)	1 (>0%)
Before 2039	Good	128 (72%)	8 (7%)	136 (47%)
	Moderate	5 (3%)	2 (2%)	7 (2%)
	Total	178	111	289

Source: Ch. 7.1 of the 3rd RBMPs for Västerhavet & Södra Östersjön (Vattenmyndigheterna, 2022), and VISS (VISS, 2022)

A comparison with the draft versions of the plans shows a slightly increased ambition, as the draft foresaw a good status after 2027 for 5 more coastal waterbodies.[190] Furthermore, the draft foresaw 2 waterbodies with a 'poor' environmental objective.

[189] Vattenmyndigheterna, 2022, Förvaltningsplan för vatten 2021—2027, i) Västerhavets vattendistrikt (Förvaltningsplan för vatten 2022–2027 Västerhavets vattendistrikt (vattenmyndigheterna.se)), and ii) Södra Östersjöns vattendistrikt (Förvaltningsplan för vatten 2022-2027 Södra Östersjön (vattenmyndigheterna.se))

[190] Vattenmyndigheterna, 2021, Förslag till Förvaltningsplan för vatten 2021—2027, i) Västerhavets vattendistrikt (Förslag till förvaltningsplan 2021-2027 Västerhavet (vattenmyndigheterna.se)), and ii) Södra Östersjöns vattendistrikt (Förslag till förvaltningsplan 2021-2027 Södra Östersjön (vattenmyndigheterna.se))

Motivation for exemptions according to article 4.4

The environmental pressures on coastal waterbodies with exemptions beyond 2015 are primarily nutrient pollution from primarily agriculture, forestry, and wastewater. Other pressures are hydromorphologic modifications from hydropower, and priority substances, of which particularly mercury and PBDE.

The water board judges that not all of the necessary measures in agriculture can be implemented in full by 2027 due to cost effectiveness considerations. Therefore, these measures are implemented in two parts: December 2022-2027 and 2027-2033. In many cases, the waterbodies will need additional time to recover after the full implementation of measures in 2027. In these cases, a deadline of 2033 is applied for the natural recovery of waters. However, depending on the priority of measures implemented upstream, the deadline may extend to 2039.

Table 4-12 below presents the number of coastal water bodies that have an exemption beyond 2027 and their reasons provided for the exemption beyond 2027. Multiple reasons can apply, and any reasons only valid until 2027 are excluded in this presentation. The table shows that nutrients and phytoplankton are reasons for an exemption for about 90% of the coastal waters in the Baltic Sea. The picture is less extreme in the North Sea, but nutrients are still the dominating reasoning for nearly two-thirds of the exempted coastal waters.

Table 4-13 Number and % of coastal water bodies with nutrient-related motivations for an exemption beyond 2027. Multiple motivations can apply. List of motivation is non-exhaustive, but limited to nutrient-related motivations.

Reasoning	Baltic Sea *number (%)*	North Sea *number (%)*	Total *Number (%)*
Nutrients	116 (87%)	7 (64%)	123 (85%)
Phytoplankton	121 (91%)	4 (36%)	125 (87%)
Benthic fauna	4 (3%)	3 (27%)	7 (5%)
Light conditions	12 (9%)	-	12 (8%)
Exempted beyond 2027	*133*	*11*	*144*

Source: VISS (VISS, 2022)

Motivation for exemptions according to article 4.5

The Swedish implementation of the WFD interprets that reduced environmental objectives can be applied if it is impossible or unreasonably expensive to achieve the good status. It defines that the impact on water quality depends on human activity that meets certain environmental and/or socio-economic needs that cannot be achieved in any other way that is significantly better for the environment.

The water delegations can also decide on less stringent objectives if the natural conditions of water bodies make it impossible to achieve a good status.

The water authorities (Vattenmyndigheterna) have derived a definition for the WFD's requirement that "environmental and socio-economic needs cannot be achieved in any other way that is significantly better for the environment."[191] The starting point of this definition are the societal benefits mentioned in national guidelines, important values or qualities within the EU or nationally, or are covered by some form of legal designation or protection such as national interests. In a second step, the water authority has defined environmental needs that cannot be achieved in any other way, for example the need for water supply, sewage treatment and landfills.

In a, currently still on-going, third step, socioeconomic needs remain to be defined, where the water authority will draw on existing national economic theory, to define production factors in society that fulfil needs of the social economy that cannot be fulfilled in any other way. With these three steps, the authority considers that the concept of environmental and socio-economic needs is defined for the Swedish context.

The relevant societal benefits identified and used so far, are

- balancing and regulating power in Sweden's electricity system,
- national interests for shipping and public ports,
- urban land use in urban areas,
- national interests for valuable substances and materials,
- National interest for cultural environmental values
- World heritage
- Building monuments,
- National interest for total defence,
- Agriculture,
- Municipal WWTPs, and
- Public water sources.

Although the above definitions are not yet fully in place according to the 3rd RBMPs, reduced environmental objectives have been allocated to a total of 8 coastal water bodies (or 3% of all coastal water bodies in Southern Sweden). For all water bodies, the same reasons are provided that the hydromorphologic status and hydrogeographic conditions of these coastal waters do not support a higher than moderate environmental objective. As also presented above, 6 out of 8 exemptions are found in the Södra Östersjön RBMP.[192]

All of these water bodies are in proximity to harbour facilities. The RBMPs provide a basis for a reduced environmental objective in harbour regions, as these are judged to provide a socio-economic need that cannot be met in any way that is better for the environment without disproportionate costs. The reduced objective can however only be allocated under the following conditions: i) the ecological status largely depends on the port, ii) the status classification for hydromorphology is reliable, iii) the good status cannot be achieved without

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[191] Vattenmyndigheterna, 2022, Förvaltningsplan för vatten 2022—2027, Södra Östersjöns vattendistrikt, p. 186

[192] VISS, 2022, Miljökvalitetsnormer för ytvattenförekomster (vattendrag, sjöar och kustvatten), https://viss.lansstyrelsen.se/Exports.aspx

substantial changes to the port, and iv) the reduced objective does not conflict with other environmental provisions.

Appendix F Reference conditions and environmental objectives

Reference conditions for phytoplankton in Danish waters

Chl-a reference conditions 2004-2006

The first reference conditions for the phytoplankton quality element for Danish coastal waters were established during the IC 1st Phase of the EU intercalibration 2004-2006. Chl-a concentration was chosen as an indicator for phytoplankton biomass. The existing intercalibrated reference conditions and H/G and G/M class boundaries are based the scientific approach applied in the Danish contribution to the 1st Phase intercalibration in 2004-2006.

The following includes a summary of exerts from relevant parts of the Joint Research Centre's technical report on the 1st Phase intercalibration[193] and the underlying Danish contribution.

Scientific approach

Two methods were used to establish reference conditions for phytoplankton expressed as Chl-a in Danish waters:

1. Development of reference conditions using historical Secchi depth measurements and relationships between Secchi depth and Chl-a obtained from recent monitoring data from Danish coastal waters. Reference conditions for Chl-a were calculated as predictions from the relationships, corresponding to an average Secchi depth around the beginning of the 20th century.

2. Reference conditions were estimated from a combination of 1) hind-casted nutrient inputs (loading of total nitrogen) to the Danish straits based on estimates of the nitrogen surplus[194] from Danish agriculture and estimated changes in point sources, 2) characterisation (expert judgment) of reference loading using the hind-casted estimates, and 3) historical nitrogen inputs

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193 European Commission (EC), Joint Research Center (JRC), 2009: Water Framework Directive intercalibration technical report, Part 3: Coastal and Transitional waters, EUR 23838 EN/3 – 2009, ISBN 978-92-79-12568-3;
Carstensen, J,, Krause-Jensen, D,, Dahl, K, & Henriksen, P, 2008: Macroalgae and phytoplankton as indicators of ecological status of Danish coastal waters, National Environmental Research Institute, University of Aarhus, 90 pp,
- NERI Technical Report No, 683,

194 Newer studies show that using nitrogen surplus alone is a too simple approach for estimating the N-load (Timmermann 2020 and Jung-Madsen & Bach2022).

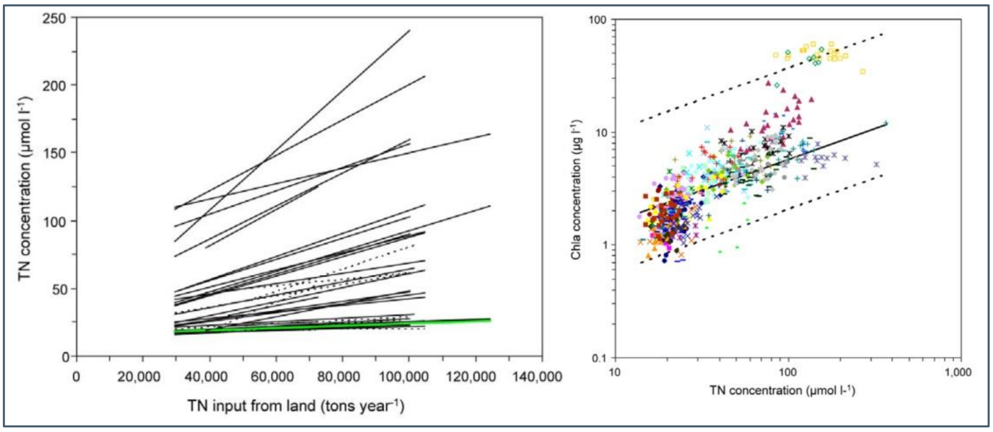
projected into total nitrogen (TN) concentration levels and related to Chl-a levels in coastal waters[195],[196].

Denmark discovered that the approach using Secchi depth (Method 1) resulted in less reliable and higher reference concentrations than the calculated results based on hind-casted estimates of reference loading and nutrient inputs, relating historical nitrogen inputs with total nitrogen levels and then with Chl-a concentrations (Method 2). So the latter approach was chosen by Denmark. By using Method 2, reference conditions and boundaries between ecological status classes were found based on two pressure-impact relationships: 1) between the load of TN and the TN concentrations (linear) for the same water bodies, and 2) a generic relationship (power) between the concentration of TN and the Chl-a concentration in the coastal water bodies.

The scientific background for establishing reference conditions and class boundaries for phytoplankton is documented in the NERI Technical Report No. 683 (Carstensen et al, 2008) and annexed to European Commission–Joint Research Centre, WFD Intercalibration technical report, Part 3 (EC-JRC 2009).

TN load – TN concentration

Based on data from the Danish national monitoring program, site-specific relationships between annual nitrogen input from land and yearly means of TN concentrations (January-June) were found for 39 Danish water bodies, 33 sites had a significant relationship. Few sites with intercepts that deviated most from this value were Nissum Fjord and Ringkøbing Fjord, both sluice-controlled estuaries exchanging with the North Sea and Mariager Fjord, which is the only true Danish fjord having a sill and high retention time (**Error! Reference source not found.**Figure 1 left).



[195] More detailed presentation of the methods and procedure is presented in Annexes 3,1 and 3,2 of JRC 2009, which are extracts from Petersen et al, 2005 and from Carstensen et al. 2008.

[196] Newer studies have shown that 'nitrogen surplus' cannot be used alone in estimation of nitrogen load around 1900. The nitrogen reference load was updated for RBMP2 and RBMP3. See Section 4.4 for an assessment using different reference loads in relation to establish reference conditions.

Figure 1: Relationship between TN load and TN concentration, and between TN concentration and Chl-a. The regression TN input/TN concentration line (left figure) for open-water stations in the Danish straits is highlighted (bold, green) (Carstensen et al, 2008).

The regression lines had different slopes, in particular for fjords and closed coastal waters, but most of the regression lines appeared to have a common intercept that corresponded to the intercept obtained from open-water stations in the Danish straits, describing an open-water value for the TN concentration. This observation confirmed the assumption that the TN concentrations in all coastal waters eventually should have the open-water concentration when the load of TN from land is blocked. Consequently, for all sites, except those on the west coast, the intercept was fixed to the open-water value of 15,46 µmol l^{-1} (~220 µg/l) for open coastal waters and site-specific slopes were estimated.

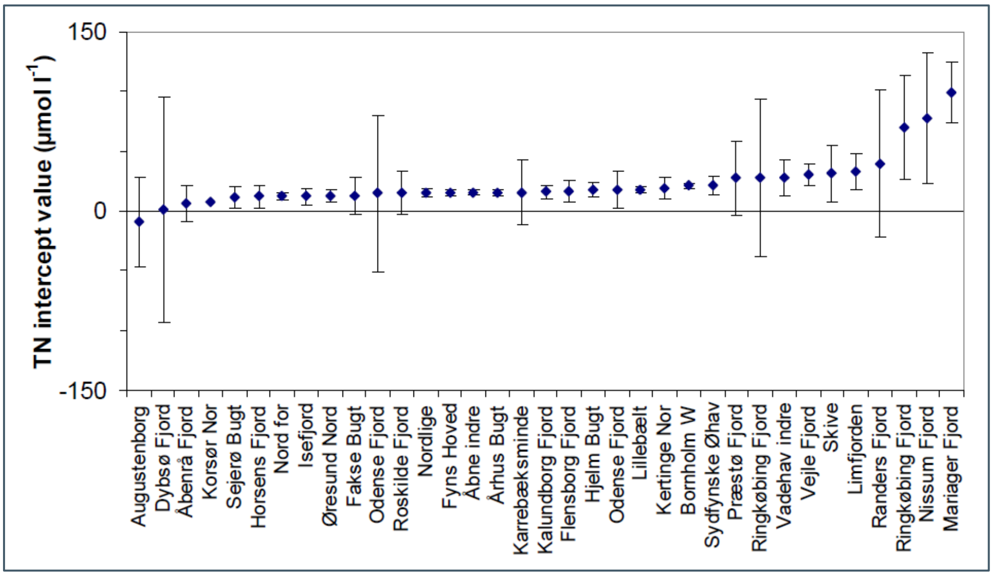


Figure 2 Estimated intercept values for 35 different sites and 95% confidence intervals for the estimate. Estimates have been sorted by increasing intercepts.

'Year 1900' TN reference load

In order to establish reference conditions for TN concentrations, a nutrient reference TN input was interpreted as the diffuse input around the year of 1900 and proposed via hind-casting based on estimates of nitrogen surplus from Danish agriculture and estimated changes in point source discharges (Figure 3) (Carstensen et al, 2008). The 'Year 1900' nitrogen reference load to the inner Danish coastal waters was proposed to have been 14 kton N $year^{-1}$. For 39 different water bodies, reference conditions for the TN concentration were predicted from the regression model based on the nutrient reference TN load, and using the fixed intercept of 15,46 µmol l^{-1} and the site-specific slopes.

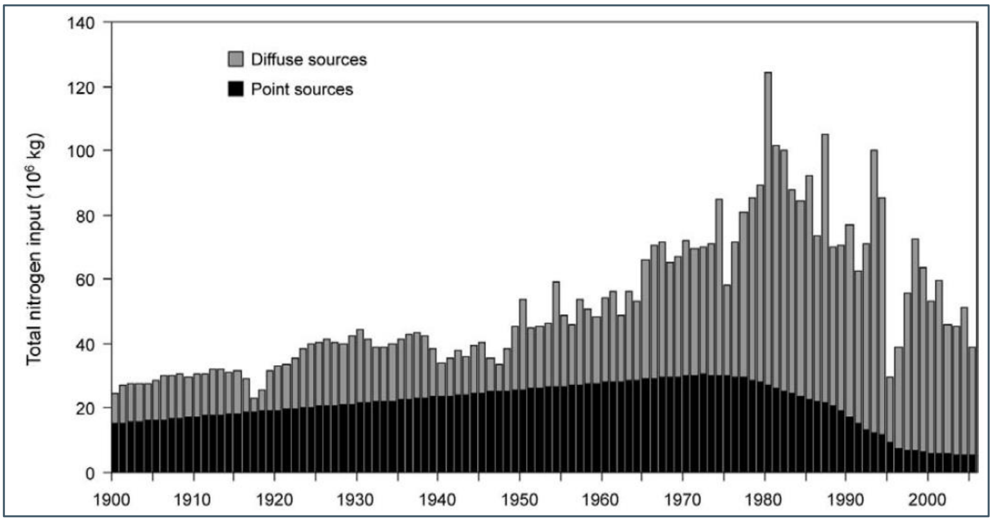


Figure 3 Long-term trends in nitrogen input from Denmark to the Danish straits. From Conley et al., (2007)- included in (Carstensen et al. 2008)

TN concentration – Chl-a-concentration

From the acknowledgement that summer primary production in Danish coastal waters is nitrogen-limited due to the exchange with phosphate-rich open waters, the summer phytoplankton biomass was considered related to the nitrogen levels. A generic relationship was assumed between phytoplankton biomass, proxied by Chl-a, and bioavailable TN by means of a power function.

Based on monitoring data from 41 coastal waters of annual values of summer Chl-a concentration (May-September) were related to winter TN concentration (January-June) by means of the functional relationship (Chl-a=k(site)×TN^{α}) that included a 'site-specific' factor (k) in order to reflect the differences between open coastal waters and closed estuaries and a 'slope' factor (α) describing a generic relationship between the Chl-a and TN concentrations (Figure 1 right).

The regression showed that most of the sites had comparable slopes values, suggesting that a generic slope was valid. Using a fixed 'slope' factor, 'site-specific' k-factors were estimated (Figure 4). Through an analysis of the regression results and an analysis of the relationship between the bioavailable fraction of TN during the winter months and the 'site-specific' factors, an agreement was found with the conceptual theory that a proportional relationship should exist for this relationship. An alternative functional (quadratic) relationship was investigated, and the linear (log-log) relationship was chosen as being most representative.

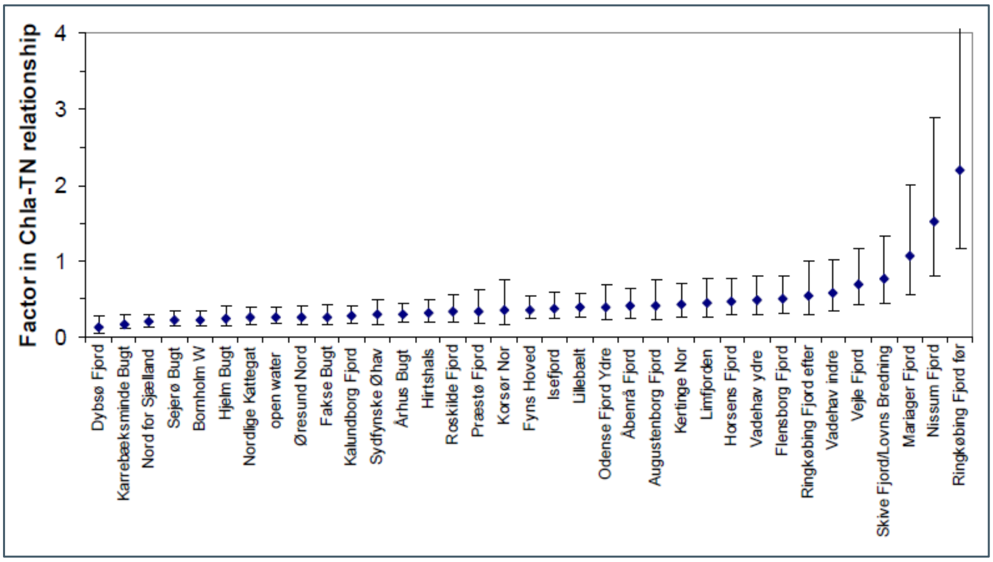


Figure 4 Estimated site-specific factors ranked by magnitude. Error bars show the 95% confidence intervals of the estimates. (From Carstensen et al. 2008)

Reference concentrations for Chl-a ('virtual' reference) for the individual water bodies were calculated from the Chl-*a*/TN concentration regression with input from the corresponding values for TN reference concentrations found by the TN input/TN concentration regression. For a number of coastal sites, reference conditions values could not be determined because of different characteristic behaviours differently from the general responses of Danish coastal water bodies, and because they did not entirely meet the assumptions of the approach. Until better models were available for these water bodies, the calculated values were recommended as the best estimate.

Results from the WFD intercalibration were used for establishing reference conditions and setting boundaries for the ecological quality status classification in the common EU intercalibration sites. The results for a few sites were included in the European Commission Decision on the intercalibration results (EC 2008a: CD/2008/915/EU). For Denmark, mainly for a few open water types that formed the basis for preparation of the Danish 1st RBMP. However, they were not used for estimation of maximum allowable nitrogen inputs.

For 34 national coastal water bodies not covered by the intercalibrated reference conditions. Carstensen et al. 2008 estimated and suggested reference values based on the same regression method. A few coastal waters deviated from the overall pattern of the regression. For these water bodies, specific reference condition values were suggested.

RBMP2 Chl-a reference conditions

For the RBMP2, the Scientific Documentation (Erichsen & Timmermann 2017) describes the development of a methodology for establishing Chl-a reference conditions and corresponding WFD target values applicable to all Danish WFD water bodies located south of Skagen. The methodology includes model estimation of reference condition values based on both STAT models and water body specific MECH models. In order to reduce (some of) the uncertainties a typological approach was applied where site-specific model results were used to establish robust type-specific reference and target values transferable to Danish water bodies. In order to support the derivation of Chl-a reference conditions. The typology was a modified version of the typology for Danish waters developed and applied for the 1st RBMP (Dahl et al. 2005). With focus on the water bodies' sensitivity to fresh water and anthropogenic pressures, the original number of 12 estuarine water body types was reduced to three estuarine, one sluice type. And the four open water types including four subtypes were reduced to one type.

STAT models used to calculate Chl-a concentration in a reference situation were developed. Chl-a concentration from May to September was chosen as response variable and estimated based on monitoring data from 1990 to 2012. The bulk suite of explanatory variables consisted of site-specific estimations of nutrient (N and P) loading, freshwater discharge, solar radiation, temperature, salinity, buoyancy and wind. Remaining explanatory variables are similar to the model development (1990-2012). Explanatory variables for each coastal site were selected using MLR and PLS regression. And the final site-specific models were used to simulate the summer Chl-a reference concentration by only changing N and P loadings to a situation with year 1900 N loadings. It is noted the authors that the regression models were not used to test the hypothesis that, e.g., Chl-a concentration is dependent on the nutrient loadings.

The MECH models used to calculate Chl-a concentration in a reference situation include the inner Danish water model (IDW) and the three estuary models, Odense Fjord, Roskilde Fjord and the Limfjorden. These models (IDW, Odense Fjord, Roskilde Fjord and the Limfjorden models) were forced with reference N and P loadings, reference boundaries and reference N depositions to account for reference conditions. In addition, the N and P sediment pools were also adjusted for the IDW model, Model forces (other than N and P loadings, reference boundaries and reference N depositions) were identical to the model development (2002-2011), meaning that meteorological and physical forces are identical to the present day (status) modelling, Chl-a data was extracted for the past five years.

RBMP2 Reference nutrient input

Since data on nutrient concentrations from around year 1900 are very scares and, therefore, was unsuitable for the RBMP2 simulation of Chl-a concentrations in reference conditions, "nutrient loadings were estimated from a) background concentrations (riverine) of TN, TP, dissolved nitrogen and dissolved phosphorus and b) present day's freshwater discharges" (Erichsen & Timmermann 2017). Even if the reference nutrient loadings in RBMP2 was referred to as 'year 1900' load it was estimated from concentrations of TN and TP in streams draining catchment areas with a low (< 10% for TN and < 20% for TP) proportion of agricultural land and no or very few point sources from scattered households and multiplied by the corresponding catchment-specific water flow. As newer studies have shown that nitrogen load in 1900 must have been higher than can be assumed to be representing a reference load, the 'year 1900' concept was left and replaced by the term 'background' load (Jung-Madsen & Bach 2022, and Timmermann2020). The 'background load was used for deriving the reference condition Chl-a concentration inRBMP2. Both the statistical and MECH models were forced with year 'background' nutrient loadings from Danish catchment areas. For nitrogen concentration, it was possible to establish average concentrations on the scale of water bodies, whereas larger catchment areas (geo-regions) were applied for phosphorus.

The aggregation of annual N loadings in a reference condition used for RBMP2 calculates at 17 kton N year-1 from all Danish catchment areas and 12 kton N year-1 when only considering loadings to inner Danish waters. In RBMP3, nitrogen reference input is calculated at 16 kton N year^{-1} from all Danish catchments and 11 kton N year^{-1} from inner Danish waters (Erichsen & Timmermann 2022). Compared with reference input to the Danish straits that was used for deriving Chl-a reference conditions during the IC 1st Phase EU intercalibration and the 1st RMBP, the NERI TR 683 study (Carstensen et al. 2008) proposed 14 kton N year^{-1} for the inner Danish waters. The nitrogen reference input for RBMP2 is nearly ten per cent lower and for RBMP3 a little more than 10 per cent lower.

In order to obtain robust estimates of the Chl-a reference values, a type-specific approach was used. For the estuarine types, an ensemble modelling approach was applied involving results from statistic and MECH modelling to further increase the robustness of the estimates and reduce the influence of potential model bias.

Ensemble modelling of reference Chl-a concentration was possible, resulting in type-specific reference values for water bodies belonging to two of the estuarine types, the sluice type and the open water type. For a few of the estuarine water bodies, it was not possible to derive type-specific reference values due to either lack of available ensemble models or specific water body conditions. Therefore, these water bodies were analysed separately, and reference values were derived accordingly.

The results of the study were included as the basis for preparation of the RBMP2 and they were eventually included in the revised Statutory Order on monitoring the status of surface waters and ground waters[197].

Chl-a intercalibration 2015

In 2015, the results of the study including the established Chl-a reference condition values and class boundaries were taken through a more comprehensive intercalibration of Chl-a in coastal waters. It took place between Denmark, Norway and Sweden, addressing five different common IC types in the Baltic Sea (BC 6) GIG and the North East Atlantic (NEA 8b) GIG (Carstensen 2016). Differences in the reference condition values between Denmark and Sweden were generally small and the intercalibration resulted in only minor

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[197] Bekendtgørelse nr. 1001 af 29/06-2016 om overvågning af overfladevandets, grundvandets og beskyttede områders tilstand og om naturovervågning af internationale naturbeskyttelsesområder (in force)

adjustments of values for reference condition. The intercalibration is described further in Task 11.

For the EU common IC types, the adjusted values are included in the latest Commission Decision 2018/229/EU on the values of the Member State monitoring system classifications as a result of the intercalibration exercise.

Task 2 - Determination of ecological quality class boundaries

Determination of high/good (H/G) and good/moderate (G/M) class boundaries is part of the intercalibration process, and Guidance Document No. 14, Annex V, on the development of a boundary-setting protocol for the purpose of this process, elaborates on how class boundaries should be set. After identification of qualifying criteria for type-specific reference conditions for the chosen metric, it must be assessed whether it responds to the gradient of impact contained in the available data set and, if so, any discontinuities in the relationship must be identified (Figure 5). It is the case for both Chl-a and ‘eelgrass depth limit’ that relationships with eutrophication pressure are identified and that conceptual models can be established either with nutrient concentrations or light climate as pressures and that pressure-impact-gradients can be found. So far, according to the 2nd opinion teams’s knowledge, no discontinuities have been identified for the two quality sub-elements; however, in particular for ‘eelgrass depth limit’, the historical observations have not – to the 2nd opinion team’s knowledge – been sufficient to determine whether such discontinuity could be identified. Whereas the pressure(N-concentration)-impact-gradient Chl-a in general has been documented to be continuous, discontinuity could be expected to have been the case for the eelgrass distribution in the last part of the 1800, which forms the basis for establishment of reference conditions, even if the nutrient load increased during that period. From a general understanding of ecosystems some biological elements expose resilience against changes in the ecological status, when put on pressure in an undisturbed (steady state) condition. This could be the case for eelgrass’ reaction to an increase in the nutrient load late part of 1800 as described by Timmermann (2020) and in Aarhus University’s note annexed to the answer to the Parliament Committee on Environment and Food (MOF alm. del 681[198]). The relevance of this to determining a reference nutrient load is addressed in Section 4.4 in more detail.

Even if the lack of historical data on the pressure descriptor makes it difficult to establish the gradient covering reference conditions, the use of defining alternative benchmarks for both Chl-a and ‘eelgrass depth limit’ as described in Section 3.1 has proven possible.

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[198] Note included in the Danish Ministry of Environment and Food's answer to the Danish Parliament 24. March 2020.

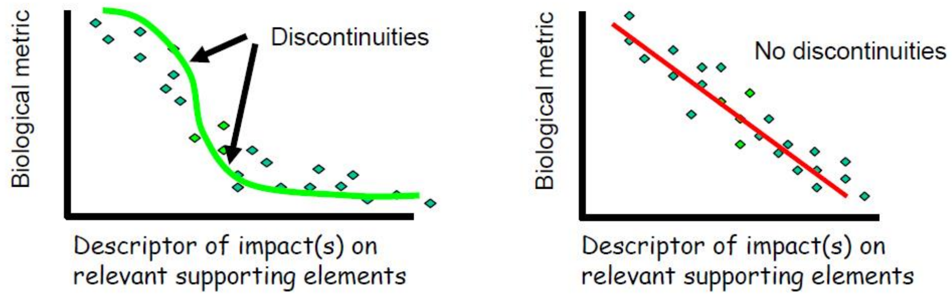

Figure 5: Determination of pressure-impact-gradient (CIS-GD No. 14)

In cases where two metrics respond in different ways to the influence of the pressure it should be assessed whether class centres or class boundaries can be located using paired metrics as shown in Figure 6.

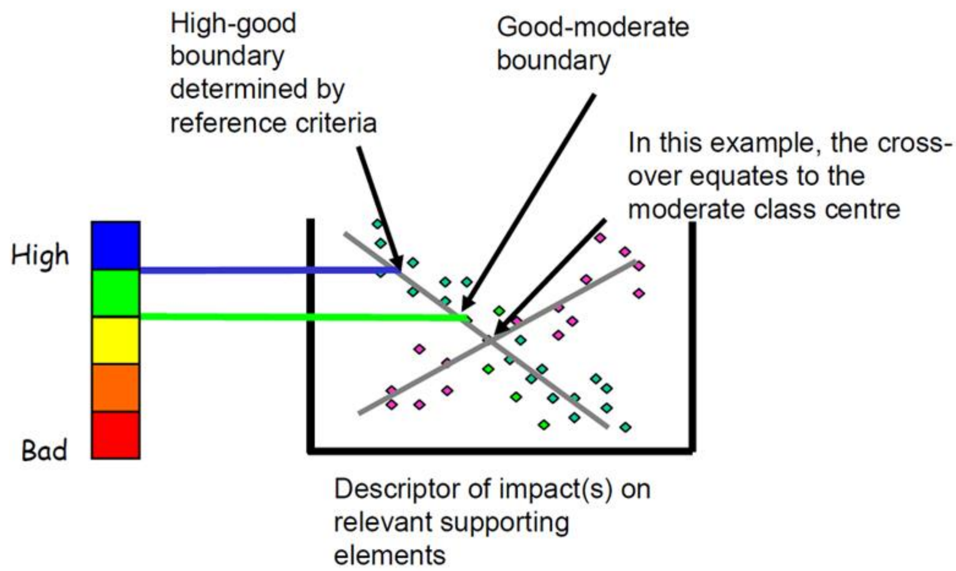

Figure 6: Paired metric analysis (CIS-GD No, 14),

In cases where the relationship between the quality element and the pressure-impact-gradient is a continuum and where pairing metrics cannot be applied, a starting point could be to divide the continuum of impact below the high-good boundary (established with the reference conditions) into four equal classes, provided that the data set covers the full spectrum of impact.

WFD Intercalibration process

The European Commission has facilitated three phases of the intercalibration (IC) through the Joint Research Center (JRC), and for many biological quality elements (BQE), this intercalibration exercise has been completed. The results of the exercises are laid down in a Commission Decision (Commission Decision (EU), 2018-229)[199] and the scientific background for the results is documented

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[199] 2018/229/EC - the latest of three decisions – the first (2008/915/EC) and the second (2013/480/EC) are repealed.

in technical reports from the EC-JRC. Since the results included in the Commission Decision are consistent with the normative definitions set out in the WFD, Annex V, 1.2, the respective boundary values should be used in the Member States' monitoring systems classifications. Consequently, the same values should be used in calculations that form a basis for adoption of measures required in order to achieve the environmental objectives.

To facilitate the IC process, four guidance documents[200] were prepared under the WFD Common Implementation Strategy (CIS). The guidance documents provide guidance on the WFD, Annex V, 1.4.1, intercalibration exercise. They provide an overview of the key principles of the intercalibration process and the options for carrying out the exercise, including timescales and reporting requirements. They also provide a procedure for how to fit new or revised national classification methods to the harmonised definition of good ecological status.

The intercalibration process is aimed at ensuring comparability of the classification results of the WFD assessment methods developed by the Member States for the biological elements (WFD, Annex V, 1.4.1). It is the intercalibration process that must establish the values for the boundary between the classes of high and good status and the boundary between good and moderate status, which are consistent with the normative definitions of those class boundaries given in WFD, Annex V.

The intercalibration process is undertaken within geographical intercalibration groups (GIGs) under the CIS working group ECOSTAT (WG ECOSTAT). The GIGs consist of Member States sharing common intercalibration types (common IC types) of surface water (here, coastal and transitional). For the marine area, the common IC types cover the main coastal and transitional water types occurring in the GIG. Denmark belongs to two intercalibration groups. One for the Baltic Sea (Baltic GIG) another for the North East Atlantic (NEA GIG). Within these intercalibration groups. Denmark only shares common IC types with Sweden (BC6 and NEA 8b) and with Germany (BC8 and NEA 26c).

The common IC types cover mainly open coastal waters or water bodies strongly influenced by open waters (e.g., open bights and straits). For other water bodies, Member States need to identify which national types correspond to which common IC types. For national coastal and transitional water types that are not intercalibrated in the intercalibration exercise, the IC boundaries of high-good and good-moderate status classes need to be translated accordingly to these water bodies. If a significant number of national types do not match the common intercalibration types, this has to be reported to the CIS WG ECOSTAT, (ref Typology section in Section 3.1)

The CIS-GD No. 14 – the 2008-2011 version – sets up a procedure for how to carry out the technical intercalibration process. Main steps of the process are

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[200] CIS Guidance Document No, 6, No, 14 (two versions) and No, 30

identified, and questions are asked to check these steps. These checks are related to the main tasks of the intercalibration process, which comprises:

- Documentation of national assessment methods including response to pressures and class boundary setting
- Evaluation of general method comparability for intercalibration ('IC feasibility checks')
- Collation of common intercalibration data set
- Definition of intercalibration reference conditions/benchmark including description of the respective biological community
- Common boundary setting/analysis of boundary comparability
- Description of biological communities at conditions representing the harmonised good-moderate boundary ('borderline conditions').

In order to choose an appropriate intercalibration option that addresses the differences in Member States, national data and assessment methods need to be assessed in order to choose the right option. The guidance document describes three different options that can be used for intercalibration of WFD-compliant methods. The choice of the appropriate intercalibration option depends on how comparable the approaches of the national methods are:

- Option 1: Same data acquisition and same numerical evaluation means that Member States are using a common assessment method and intercalibration then concentrates on the **harmonisation** of reference conditions and class boundary comparison/setting,
- Option 2: Different data acquisition and numerical evaluation requires the development of **common metrics** for intercalibration,
- Option 3: Similar data acquisition, but different numerical evaluation necessitates **direct comparisons** (Option 3) in which the pairwise differences of national assessment results are investigated. Common metrics are highly recommended as a supporting approach to evaluate the influences of biogeographical differences, the definition of reference conditions and the actual boundary setting.

The choice of option depends primarily on assessment methods used and data available in the participating Member States sharing an IC common type. A mix of the options can also be applied.

The results of the intercalibration must be reported to the European Commission according to a common procedure laid down in a 'boundary setting protocol'[201] prepared by the European Commission. The protocol must include documentation of how the various steps in the intercalibration exercise are carried out. The main points are:

1. Identification of qualifying criteria for type-specific reference conditions and description of how they are used to define reference conditions values and the high-good boundary.
2. Description of how the biological quality element

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[201] CIS-GD No, 14, Annex IV

   a. is expected to change as the impact of pressure or pressures on supporting elements increase
   b. relate to the WFD normative definitions.
3. Choice of one or more suitable metric(s) (indicator data) of the quality element; assessment of whether the metric(s) responds to the pressure-gradient contained in the data set; and quantification of the reference conditions for the metric.
4. Identification of any discontinuity in the relationship between the metric and the pressure-impact-gradient represented by the data set and, if so, if the discontinuity relates to a class boundary or class centre.
5. Taking into account the results of step 2, assessment of whether class centres or class boundaries can be located using paired metrics (adding another indicator for the same quality element), determining whether values from the paired metric analysis correspond to the class centres or class boundaries.

If the relationship between the quality element and the pressure-gradient is continuous and if the class boundaries cannot be identified based on paired metric assessments, example approaches are given for how the class boundaries should be identified.

Appendix G Reference Group comments to the report

Reference Group comments to the report

- Danish Agriculture and Food Council (Landbrug & Fødevarer)
- The Danish society for Nature Conservation (Danmarks Naturfredningsforening)
- Bæredygtigt Landbrug
- Green Transition Denmark (Rådet for Grøn Omstilling)
- SEGES Innovation
- Danish Sportsfisher Association (Danmarks Sportsfiskerforbund)
- Ocean Institute (Tænketanken Hav)
- Fair Spildevand
- University of Aarhus - Danish Centre for Environment and Energy
- Danish Hydraulic Institute (DHI), Technical University of Denmark (DTU), and University of Aarhus (AU) (Coastal modelling group)

Comments from Danish Agriculture and Food Council (DAFC) (Landbrug & Fødevarer)

In the present report, COWI draws the overall conclusion regarding Danish RBMP3 (Vandplan 3) that the scientific basis for the modelling work is of high scientific quality, and that the "room for maneuvering", from a legal perspective, is very limited. However, COWI's conclusions are based on an incomplete statement of the scientific and legal basis, along with misconceptions of fundamental principles in the RBMPs.

In phase II of the 2nd opinion on Danish RBMP3, it is essential that the expert panel is not limited in any way by the normative assessments made by COWI, is openly provided with all necessary information regarding the basis for RBMP3 and is able to obtain further information when the present report is at fault. This is crucial to ensure an open and thorough process and enable the experts to analyze and draw conclusions based on full disclosure.

In the following, general comments to the COWI report will be made, followed by comments related specifically to the six work packages / tracks as defined in the terms of reference for 2nd opinion.

General comments

In section 1.2 "Approach and method", it is described that the assessment is based on "iterative dialogue with stakeholders". It should be clear, though, that the DAFC has not been included in any way, interviews or other, in the process of the COWI report. At a reference group meeting in May 2022, stakeholders were informed about the overall process of the 2nd opinion; the meeting was purely for passing on information.

It is stated that COWI has interviewed and communicated with Ministry of Environment, Ministry of Finance, DHI and AU. In other words, aside from Ministry of Finance, COWI has apparently only had communication with partakers in the development of the RBMPs, or the "first opinion". This approach suggests that COWI's views are hardly independent as is expected of a 2nd opinion.

According to the terms of reference for the 2nd opinion, Phase I includes only a statement of the current legal and scientific basis and room for maneuvering within the Water Framework Directive (WFD).

COWI unfortunately delivers an incomplete statement, with an addition of highly questionable analyses and normative assessments leading to conclusions reflecting a lack of scientific and legal understanding. It is crucial to the 2nd opinion process as such, and out of respect for the terms of reference, that the expert panel is not limited in any way in their analyses by COWI's analyses and normative assessments, which were not invited in the terms of reference.

The task of analyzing and making normative assessments on RBMP3 is assigned to an expert panel in Phase II. When COWI makes normative assessments on central elements in the legal and scientific basis for RBMP3 during Phase I, the names, academic degrees and experience of the experts doing the analysis for COWI should at least be provided.

1. Reference and target setting for good ecological status

The COWI report concludes that the scientific basis for the modelling work of RBMP3 is "substantial in content and of high scientific quality".

The modelling can hardly be found to be of high scientific quality. Nitrogen load and quality parameters correlate poorly. This includes reference levels, where for instance eelgrass depth limits are determined with an uncertainty of 1.6 m – depth limits are determined using 10 cm intervals. The expert panel in Phase II will need to go into details with the comprehensive modelling procedures and resulting correlations.

Further, COWI's statement does not give full disclosure as to what takes place during modelling. In a high number of water bodies, e.g. 36 in scenario 1, the calculated MAI (Maximum Allowable Input; the nitrogen load limit) for one or both quality elements is lower than background level. This obscure situation is handled by discarding the calculated results and inserting the background level instead before proceeding with the calculation of a final MAI for the water body.

During Phase II, it must be ensured that the expert panel has access to full information regarding modelling procedures and data, including correlations between stressor/effect and actual/predicted data.

MAI has in some water bodies changed tremendously from RBMP2 to RBMP3. As an example, for Bornholm, MAI has decreased from 961.7 tonnes nitrogen to 521.5. No drastic changes have occurred in the meantime, on land, in the catchment, nor in the water. Changes at similar orders of magnitude can be found in a high number of other water bodies, not only on MAI but also on status load.

The changes are far beyond the claimed 10 pct. uncertainty on MAI, an uncertainty that was estimated at the same level in RBMP2. Hence, both estimates cannot be true.

Uncertainty of data, covering all model results, from estimates of reference values and status load to the final MAIs, is a matter that the expert panel in Phase II needs to look into to enlighten policy decisions.

Reference conditions for chlorophyll and eelgrass are derived using different methods: modelling back to pristine conditions and historic data from around year 1900, respectively. The expert panel is strongly encouraged to explore the possibilities of using year 1900 conditions for both quality elements, as was the case in RBMP2, but using the new and solid estimates for nitrogen load year 1900.[1]

2. Time series of load data

COWI concludes that the calculation methods to estimate nitrogen load have been improved for RBMP3 compared to RBMP2.

However, the statement does not include any considerations on the importance of including various years in status load, specifically 2019-2022, as asked for in the work track of the terms of reference.

Hence, the expert panel must be provided with the necessary information to be able to understand, analyze and conclude on this subject during Phase II.

3. Burden sharing

COWI concludes that the nitrogen contribution from neighboring countries is secondary to the nitrogen load from Denmark. However, in the scientific basis for RBMP2, the significance of the Danish nitrogen load, and thereby indirectly also of non-Danish nitrogen load, on quality parameters was published[2]; demonstrating that in the majority of water bodies, Danish load was clearly secondary to contributions

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[1] AU (2022): Transport of nitrogen and phosphorus from land to sea around year 1900 https://dce2.au.dk/pub/SR498.pdf

[2] https://mst.dk/media/121311/mvv_documentation_dhi_model_metode-slutrap-del2.pdf , Figure 11 and Table 3

from other countries. An updated version of the table and figure has not been provided for RBMP3, but in order to analyze options for burden distribution in Phase II, this should be provided.

Burden distribution is defined by COWI as "*Covers 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.*"

This description does not, however, seem to reflect the term burden distribution, but rather describes the consequences of a failed burden distribution.

Because of this misunderstanding, COWI fails to provide a statement on burden distribution.

COWI further dismisses the possibility of referring to transboundary sources of pollution in exemption possibilities. However, CIS guideline 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 analyzing solutions for handling non-Danish stressors.

In the modelling input, one prerequisite is implementation of RBMP2 in all EU countries. COWI unfortunately fails to clarify that no country has reached, or has planned to reach, good ecological status in RBMP2. Thus, the prerequisite implicitly forces Denmark to take measures to compensate for nutrient load from other countries.

Burden distribution is very important for Denmark, with our long coastline and geographical location. It is therefore important that the expert panel, in Phase II, discusses possible steps to establish a fair burden sharing; something that should be reflected in the final MAIs.

It is not unlikely that an illogical burden distribution, i.e. Denmark taking an unnatural high proportion of the burden, is related to the modelling results leading to MAIs below background levels. This should be considered by the expert panel.

4. Seasonal variation

COWI concludes that the effect on MAIs of including seasonal variation in the modelling work will be "insignificant" on a national scale.

However, in water bodies with fast water exchange, which includes the majority of Danish fjords and obviously all open coasts, nitrogen load from fall/winter will be gone before algal spring bloom starts. Nitrogen leaching during spring/summer will have much larger biological effect, as algae are ready to take it up immediately and convert into biomass.

Nutrient leaching during spring/summer from agriculture is generally low if not negligible. Instead, sewage water, both cleansed and overflow, are active sources throughout the year, with a relatively much larger significance during summer. COWI, however, fails to address any other nutrient load than agriculture-derived in their statement to describe the possible advantages of including seasonal variation in the modelling.

This also means that the discussion of possible measures is largely at fault for only addressing agriculture.

In Phase II, the expert panel should explore the possible effects on MAI of including seasonal variation in the vast majority of Danish water bodies that have fast water exchange.

5. Exemptions

With regard to Article 4.4, extension of time, COWI states that measures should be in place before 2027 (legally binding and financially funded). 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 Article 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.

Furthermore, the exemption decision tree included in the CIS Guideline 20 suggests a different reading than the COWI Report. This includes, but is not limited to, looking into technical feasibility and possibly disproportionate costs (very much so if MAI is below background load).

In discussing the exemptions of Articles 4.4 and 4.5, COWI refers to Article 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. COWI also refers to the recent EU proposal on nature restoration to conclude that a non-compliance with the Habitats Directive would be the likely result from applying the WFD exemption regime if this proposal would enter into law.[3]

However, the nature restoration proposal does not set emissions caps on nitrogen or phosphorus inputs, and it is not entirely clear what the underlying scientific evidence is for the COWI Report to come to this conclusion. And with regard to the Nitrates Directive; in 2021 the European Commission came to the following conclusion in the assessment of Denmark's Programme of Measures for the 2nd cycle RBMPs:

"F*or nitrates, rules are in line with the fulfilment of the Nitrates Directive across all river basin districts".*[4]

Thus, we do not consider there to be any legal nor scientific basis to imply non-compliance with the Nitrates Directive.

The COWI Report does not go into the possibility of applying Article 4.7 of the WFD, arguing the CIS Guideline 20 excludes projects in which deterioration is caused by inputs of pollutants, and because it applies to new projects and not ongoing activities as agricultural management.[5] However, it is important that the RBMP's do not exclude the possibility for Article 4.7 to be relied upon for certain projects which are of high public interest in Denmark.

6. Stressors

COWI concludes that nutrients and climate effects are the stressors with most effect on the environmental quality elements.

We will not dispute this conclusion but simply add that "less effect" on environmental quality elements is not the same as no effect, which is why the conclusion is of little use.

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[3] Case C-461/13 *Bund für Umwelt und Naturschutz Deutschland eV v Bundesrepublik Deutschland*, ECLI:EU:C:2015:433 (1 July 2015).
[4] Assessment of Member States' progress in Programmes of Measures during the second planning cycle of the Water Framework Directive, Denmark, December 2021.
[5] section 2.2.4 of the second opinion report.

Other stressors may affect quality elements in different ways than eutrophication. By managing, and reducing, these stressors, the need for nutrient reductions may decrease. For this reason, the effect of other stressors, directly and indirectly, on quality parameters needs to be assessed.

Reference is made to studies of other stressors, but a very thorough, peer-reviewed, study specifically on Danish waters is missing.[6] We encourage the expert panel to explore the effects of all relevant stressors, including climate change.

[6] Andersen *et.al* (2020): Relative impacts of multiple human stressors in estuaries and coastal waters in the North Sea–Baltic Sea transition zone. Science of the Total Environment, 704.

Comments from The Danish society for Nature Conservation (Danmarks Naturfredningsforening)

Danmarks Naturfredningsforening (DN) will support the COWI report's conclusions, which points out several important factors that should be looked at in connection with the international scientific evaluation of the water action plans. We would especially recommend that the chosen boundary between Good and Moderate classification and the logical deficiency in the chosen target value to be looked at critically. We also support that the use of the baseline is viewed critically, as it has never been possible to find it in the measured load of N in the past many years. In addition, DN support it to be investigated what role the seasonal variation in the N load has for the individual water bodies but would point out that it is too narrow to isolate this to "summer load", as algae growth often starts as early as February-March.

DN will finally emphasize the urgent need to act now to find the necessary reductions in N load. We know from the past that it often takes many years to get the necessary means implemented and it takes several more years before we see the full effect in practice, so there is absolutely no time to waste. The need for action will in any case be so great that it does not matter for the first several years whether the load must be reduced by 15.000 or 18.000 tonnes.

Comments from Landsforeningen Bæredygtigt Landbrug

General remarks

In their report, COWI tackles issues that are not within the scope of the report and neglects other issues that *are* within the scope of the report. Therefore, we would like to stress that the assessments in the report, should not be seen as binding for the expert panel.

It is misunderstood, that the Water Framework Directive (WFD) mainly is concerning eutrophication. WFD is a framework directive, that sets environmental targets and establishes an overall framework for planning and implementing measures - and most importantly: Monitoring of the water environment.

COWI has not looked at the required maximum allowed input (MAI) of 38,300 tonnes of Nitrogen, which we consider totally unrealistic and unattainable. Since the entire regulation is expected to come from the diffuse contribution (area-wise), this corresponds to a reduction of the area contribution by as much as 42 %, compared to emissions in 2016-2020. This required reduction of the diffuse contribution is more than what has been achieved in 30 years from 1990-2020 (36 %) (source: Brian Kronvang, Aarhus University).

Moreover, the emissions have not changed in the last 15-16 years, despite massive regulatory measures having been implemented, which underlines that the set target for nitrogen is not realistic.

1. Legal remarks

A number of issues need to be examined but have not been included in the order of the COWI report. These issues have not been investigated, nor analysed:

a. The Monitoring Program of the Water Framework Directive – can it be said to have been implemented, especially taking into consideration testing of priority substances and other pollutants? Please note that the Danish Ministry of Environment acknowledges that at least 94% of the Danish rivers have not been tested.

b. The implementation of the directive – can it be said to have been correctly implemented when the objectives cannot be legally evaluated until after the measures have been implemented? And how is the lack of monitoring, laid down in the directive, handled? In other words, the measures are implemented without considering if they will actually work in reality.

c. Derogations according to the Water Framework Directive:
Basically, three conditions; 1) Human activity may constitute an exception. 2) Possibility to make a temporary exception (one plan period at a time). 3) Possibility to make general exceptions.

   Considering that the legal evaluation will not take place before the implementation of the measures, it must be considered relevant to use exceptions and ensure that the authorities responsible for the project are able to evaluate the application of exceptions and determine the detailed requirements for how and when the exceptions must be used. Today, the exemptions are implemented by the local authorities having to ask the Ministry of Environment. Is this a correct and legal implementation?

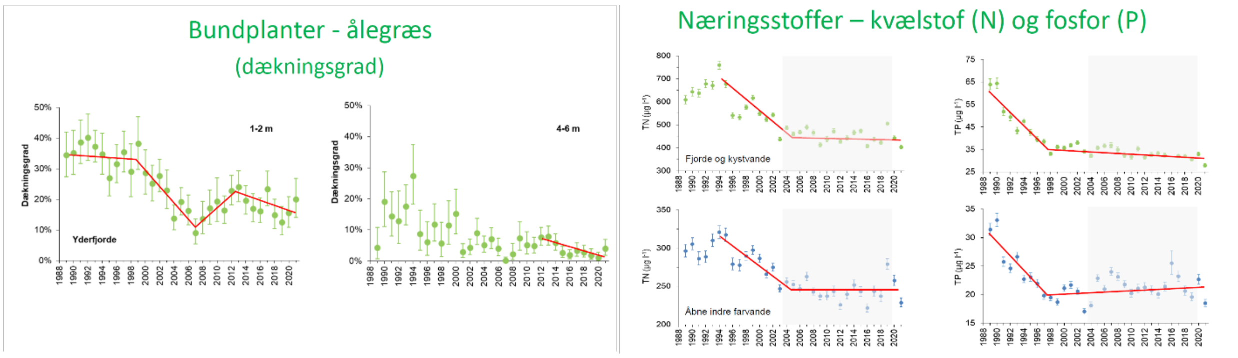
d. The Nitrates Directive
The Nitrates Directive seems to be mentioned together with the Water Framework Directive as if

they are connected. This is far from the case. The possibility to designate vulnerable zones should be clearly stated - instead of (as is the case today) designating the whole of Denmark as nitrate sensitive area. Once it made sense, but today there is a significantly better overview of the surface water resources, and there is a scientific basis for changing the basic designation

2. Environmental objective

Whereas the pressure (N-concentration)-impact-gradient Chl-a in general has been documented to be continuous, discontinuity could be expected to have been the case for the eelgrass distribution in the last part of the 1800, even if the nutrient load increased during that period.

We find that the COWI report has not evaluated why the distribution of the Danish indicator plant has been put under pressure since the eelgrass disease a hundred years ago and why the spatial distribution has been reduced almost in line with reduced content of TN in both coastal waters and fjords since 1990. We do not find that the pressure-impact of TN corresponds to the biological elements. It's a common understanding that one important reason for reduced distribution of eelgrass might be that germination of the seeds is very poor in the soft sediments made of organic nutrient rich material in fjords and coastal waters.



Figures: From NOVANA 2022

As mentioned in the former international panel in 2017 both the panel and the stakeholders miss a justification of the fundamental choice to focus exclusively on reduction of (diffuse) N sources as the main means to improve water quality. The Panel analyzed the indicators used and concluded that chlorophyll-a is a useful intercalibrated indicator of phytoplankton, while Kd is less optimal as an indicator of benthic angiosperms and macrophytes. The other indicators, used in the STAT modelling only, currently present methodological problems and are not yet mature enough for inclusion in the management plans.

As explained by Professor Joao G. Ferreira in a meeting at Christiansborg most of the chlorophyll in the water is not driven only by Danish N-loading and that chlorophyl plays only a part in reduction of water clarity.

3. Seasonal variability

COWI mention that the Scientific evaluation of the main area of applicability of the methods applied for seasonal subdivision of the N load calculation are based on few scientific reports with focus on diffuse discharge of N. This diffuse discharge of N during the summer is limited from agricultural land and experience from summer measures introduces considerable uncertainty to the model results, and nutrient load reductions on annual scale. We find the yearly diffuse discharge of N during the past 20 years has been unchanged when data has been normalized for precipitation.

It's necessary to include the effect of ortho-phosphate in the analysis of the effects of seasonal variation as the concentration of water-soluble phosphate often is the limited factor for the phytoplankton growth during spring, while N concentrations often is limiting during summer. However, the discharge from agricultural areas is in general low from April to August. Instead, sewage water, both cleansed and overflow, are active sources throughout the year, with a relatively much larger significance during summer.

We do not agree when COWI concludes that the effect on MAIs of including **seasonal** variation in the modelling work will be "insignificant" on a national scale. For most Danish fjords and all open coasts, nitrogen load from fall/winter will be gone before algal spring bloom starts.

4. Environmental objective, other countries, and areas

COWI mention in relation to contributions of TN to the marine environments from other countries, that only Germany and Sweden have been intercalibrated values.

COWI concludes that the nitrogen contribution from neighboring countries is secondary to the nitrogen load from Denmark. We find this is not correct. The significance of the Danish nitrogen load, and thereby indirectly also of non-Danish nitrogen load, on quality parameters was published demonstrating that in most water bodies, Danish load was clearly secondary to neighboring contributions. For phase II an updated version should be provided.

COWI states that it is not possible to find any existing sites in the Baltic Sea in the status of RC (reference conditions), so it has been virtually calculated (p. 187). Why does COWI not clarify that no country has reached, or has planned to reach, good ecological status in RBMP2. Burden distribution is defined by COWI as "Covers the effect of nitrogen loads from neighboring countries (via atmosphere and waters) and their effect on the condition in Denmark compared to the nitrogen load from Denmark." It's our opinion that the COWI report fails to provide a statement on burden distribution and dismisses the possibility of referring to transboundary sources of pollution in exemption possibilities.

We recommend that the expert panel should consider both options, fair burden sharing and exemptions, when analyzing solutions for handling N and P etc. In the modelling input, one prerequisite is implementation of RBMP2 in all EU countries. Thus, the prerequisite implicitly forces Denmark to take measures to compensate for nutrient load from other countries and this will never be possible with the long coastline and geographical location between the North Sea and the "nutrient rich" Baltic Sea. For phosphorus (orthophosphate), significant increasing trends are observed in some parts of the Baltic Sea between 1980 and 2019, whereas a decreasing trend is observed in the North Sea [Nutrients in transitional, coastal and marine waters in Europe (europa.eu)](https://www.eea.europa.eu).

5. Other press factors

We find the COWI report too short on the effect of other press factors. Many Danish Fjords have received huge amounts of orthophosphate, organic matter, and other stressors from wastewater discharge during decades. The role of nutrient rich sediments with a high content of organic matter seems to overrule the effect and the cost efficiency of N-MAI. A deep investigation of the sediment's chemical and physical content and its influence on the fact that the eelgrass has never regained the distribution in the Danish fjords that it had 100 years ago are missing in the COWI report. It must be top of mind, as the eelgrass is an indicator plant in our coastal waters and we find that new and thorough, peer-reviewed, study specifically on Danish waters (fjords) is missing.

The book-keeping of the nutrient loads in discharge water from publics sewage-companies is now under investigation by Rigsrevisionen.

We recommend a deep study on why the simple focus on nitrogen and the reason to why there has been no reductions in nitrogen discharge from terrestrial sources despite huge investments in agricultural regulations (mandatory catch crops, set aside, mandatory nitrogen accountants and restrictions for maximum application etc.). Nitrogen in the root-zone of agricultural land has in average decreased by respectively 0,27 mg/l and 0,58 mg/l in sandy- and clay soils – but without effect on the discharge to coastal waters and the BQE.

6. Room for maneuvering, seasonality, baseline, neighboring countries

CIS guideline 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.

It's not possible for Denmark to take measures to compensate for nutrient load from other countries or international water bodies.

Burden distribution is very important for Denmark, with our long coastline and geographical location between the Baltic Sea and the North Sea. Therefor we encourage the expert panel to discusses a realistic burden sharing to be reflected in the final N-MAI and consider both options, fair burden sharing and exemptions, when analyzing solutions for handling non-Danish press-factors.

Comments from Green Transition Denmark (Rådet for Grøn Omstilling)

Based on the conclusions of the COWI-report, Rådet for Grøn Omstilling finds that the expert panel should focus on the following points.

1. The logical deficiency of the boundary value between Good and Moderate classification and whether the target value should rather be placed in the middle of the Good classification or somewhere else from both technical and legal perspectives in order to ensure that water bodies will actually reach good ecological status.
2. Adjustments to baseline calculations in regards to lack of documented effect of measures. Is a more conservative assessment of the effect of certain measures likely to deliver realistic baseline effects?

Comments from SEGES Innovation

It is **SEGES** view that the report from COWI//NIRAS is flawed and incoherent concerning many of the critical important focus points. In some areas the authors have a good understanding of the problems – for example with the STAT models – but the problems from the analysis are not reflected in the conclusions. In other areas there have been a superficial analysis - for example concerning the calibration of the MECH models – and then the conclusions more reflects a believe in the models rather than based on knowledge. In other areas it seems like the authors do not have the full understanding of the problem – for example concerning the N- seasonality. All in all, the scientific level of the work is weak and the conclusions not justified.

An appendix to this text is available with more detailed comments to the report.

SEGES recommend that the following issues will be further investigated by the team of international scientists in the Second Opinion. The list is prioritized with no1 most important:

1. Season variation - N-seasonality. Potentially it can have a very significant impact on MAI. Due to water exchange most nitrate loads from land is washed out of the small Danish estuaries before May/June when N becomes the limiting factor. This is not investigated sufficient in the report and the conclusion by COWI is the direct opposite of the conclusion from the DHI report from 2017 and partly from the DHI report 2021 investigation this subject. Judged on the statements in the COWI report is seems like the authors do not have the full understanding of the complexity concerning N-seasonality.

2. Setting reference conditions. The problem is here whether it is according to the WFD to set the reference for eelgrass at the year around 1900 and then also setting the chlorophyll reference by using N-loads from a time period more than 1000 years ago. The way COWI conclude on “consistency” seems scientifically flawed and not according to the WFD.

3. Calibration and use of models. The STAT models had undergone a critical review in the COWI report, but the views have not been reflected in the conclusions. The MECH models had not been critical viewed or only very superficially reviewed and several calibration issues have not been looked at. The modelling system have been used to set the reference for chlorophyll far away from calibration range, but it has not been noted by authors that DHI/AU have avoided to use the year 1900 data in the calibration. Using 1900 N-load would have been an obvious thing to do for testing the models with data out of calibration range.

4. COWI describes the 2 original methods for setting the reference for chlorophyll. The authorities did choose to go with “N-load method” which have several complications since other pressures are left out but N. It needs more clarification why the other method, that seems closer to data, was ignored.

5. To achieve GES for eelgrass or angiosperm is in the WFD defined by the word “abundance”. But in the Danish context this is translated into “eelgrass depth limit” and thereby ignoring “eelgrass cover”. This has many complications, but COWI do not in the report make any reflections concerning this problem. The use of Kd as a proxy for eelgrass is a simplification that have several complications besides not dealing with eelgrass cover and an example of this is that the goal for eelgrass depth limit (Kd) is higher than the water depth in at least 1 water body. Further the model for eelgrass reference is not evaluated sufficiently in the COWI report and for example the lagoons on the west coast of Jutland

have much resuspension effecting the Kd and deviates significantly from the data on which the model is build.

6. P and other stress factors are not well investigated. The role of P in the ecosystem is not well defined in the COWI report and the role P plays for conditions in the Baltic Sea have not been investigated and therefore neither the role P plays for a still high eutrophication level in the Baltic and the delay P adds to the Danish coastal systems. Neither is the rather large amount of DIN from the North Sea brought into the discussion.

7. The discussion concerning “typology” is incoherent. A deeper investigation is needed concerning what is the reel demand regarding the WFD and what makes sense to get the best knowledge and to make to best planning.

8. COWI do not reflect over the decision that DK do not include “transitional waters”. Including transitional waters would incl fish as quality element and therefore be important. Most part of Danish coastal waters could be considered transition water between the Baltic Sea and the North Sea.

9. Two HMWB have been appointed - two lagoons on the west coast of Jutland and both with a sluice. But other water bodies have sluices or have the water exchange modified but are not appointed as HMWB. The process towards appoint HMWB seems unclear and have not been touched in the COWI report.

Comments from Danish Sportsfisher Association (Danmarks Sportsfuskerforbund)

The Danish Sportsfisher Association finds the FINAL REPORT: Second opinion on the need for reduction of nitrogen in the third RBMP for 2021-2027, Phase I, and its conclusions clear and unambiguous.

We would like to acknowledge the great work that has been done and are impressed by the thoroughness with which the 3 objectives are treated in the report. We have no further comments or questions.

Comments from Ocean Institute (Tænketanken Hav)

Ocean Institute notes that an important overall conclusion of the report is that *the scientific basis for the modelling work of RBMP3…..is substantial in content and of high scientific quality* (p. 17). Given this, it must be assumed that the Danish efforts for reducing nitrogen emissions and achieving a good ecological status in Danish coastal waters (*sensu* the Water Framework Directive) in general is solidly based on facts and in accordance with a scientific consensus.

Having said that, it must be noted that it is the nature of comments like these to focus on issues where there is room for improvement and to a lesser degree on the merits of the work on hand.

The report goes through the modelling basis of the RBMP in some detail, and although the general conclusion (as stated above) is that the scientific basis in general is sound, it is also clear from the report that there are many uncertainties and several issues where different types of models (STAT and MECH) disagree and potentially do not paint a "true" picture of the real world. It is not clear from the report if the current models meet a "gold standard" and as such are the "best possible" models or if they rather represent the "best available models at this point in time" and if so, what can be done to amend this.

Even if the models used to link the current ecological status to previous, perceived, reference conditions, it seem to be clear that a certain amount of expert opinion has been used to define and grade previous ecological states in relation to the levels of the Water Framework Directive. It is, however, not really clear how formal this establishment of expert opinions was. Was a formalized procedure such as Delphi or similar used?

Ocean Institute finds that in accordance with EU regulation, an ecosystem-based approach should be used in environmental management. This implies, among other things, that all stressors (press factors) should be considered as well as their cumulative effects, including any synergies ("cocktail effects"). The report states that eight stressors (press factors) has been evaluated but that none of these were found to "have any significant impact on the nutrient conditions" (p. 11). While this may be correct, it is important to note that these stressors (press factors) can very well exert their own stress on the marine ecosystem, even if they do not affect the nutrient condition as such.

While a marine area under the EU Water Framework Directive should be managed in accordance with its identified type, rather than as an individual water body, under an ecosystem-based concept any management initiatives should be formulated for the specific ecosystem in question. This is relevant in this context as the report notes that the inclusion of seasonality will be relevant for some specific water bodies, which is also the case regarding the reduction of P-loads to modify N-MAI in some water bodies. In general, it is encouraging that old, established, knowledge regarding seasonality in the relative importance of P- vs. N-limitation as well as co-limitation by the two nutrients is becoming included in the models, rather than focusing solely on N. The notion that the spatial resolution of models is increasing (p. 19) is a step in the same, right, direction.

The current assessments of burden-sharing does not seem to take into account that the quality of nitrogen as an algal nutrient may very well be different for different chemical forms of nitrogen from various sources. Nitrogen from agricultural run-off is mainly nitrate and some ammonia, readily available as a nutrient, while there are scientific reports indicating that a relatively large fraction of the nitrogen emanating from Baltic is in the form of refractory organic matter, not readily available as a nutrient.

Comments from Fair Spildevand

Author: Jørn Rasmussen (the association of "Fair Spildevand")

A different legal interpretation of The Water Framework Directiv, subsection 1.1 (COWI 2023). Should The River Basin Management Plan be based on total quantities or concentrations?

This paper focus on how to interpret The Water Framework Directive in such way, that water born nitrogen and phosphorus best support the ecological state of the fresh or salted surface water. Here we talk about nutrient conditions supporting the biological elements, subsection 3.2.1 (COWI 2023).

The nutrient ratio together with 4 other chemical and physical-chemical elements support the biological conditions:

1. Thermal conditions
2. Oxygen conditions
3. Salinity
4. Acidification state
5. Nutrient ratio

How should this elements be perceived?

Ad 1) Thermal conditions,temperature, is something you measure at a given location and is somewhat atypical compared to the other four elements.

Ad 2) Oxygen conditions, O2, are difficult to calculate in total quantities and make only sense if measured as concentrations.

Ad 3) Salinity, salt content. It does not make sense to measure it in total quantities, it must be measured in concentrations.

Ad 4) Acidification state, pH value only make sense as concentrations.

Therefore

Ad 5) Nutrient ratio (or Nutrient conditions) only make sense when measured as concentrations.

In particular, it will be problematic to calculate nitrogen in total quantities, as it constantly interacts with the atmosphere, often depending on a given amount of phosphorus. The way in which Danish authorities have measured and calculated land-based water born nitrogen in the period from 1990 to 2021 is closely described in the paper from Bjarne Brønserud below.

Calculation of nitrogen target as an amount in waterbodies gives no sense and is a misinterpretation of EUs Water Framework Directive. Achievement a good conditions in the coastal waters depends on the concentrations and not the amounts of nitrogen, which are the correct legal interpretation. In the report this fundamental distinction are absent, subsection 3.2.2 (COWI 2023).

In the costal waters nutrient from the Danish diffuse sources have only a small share compared with nutrient coming from the Baltic Sea, Skagerrak and Nord Sea. In just the opposite way serious discharges from points can destroy the good water conditions for a shorter or longer period. This aspect are missing in the report (COWI 2023).

We will not fail to draw attention to additional advantages of leaving total quantities.

In EUs Water Framework Directives there are described the principle of "environmental damage should, as a priority, be rectified at source and that the polluter should pay". It will be shown in the paper below from Bjarne Brønserud, that the limit of nitrate concentrations from the open land has been low in the period starting in 1990 and till now. There is no evidence for talking of pollution or to talk about paying for any pollution from the open land in general terms. The error seems to depend on whether you make calculations based on flow measurements or use models. Talks based on models give a bad dialog or no dialog at all. And measurements are what EUs Nitrate Directive demands.

In Fair wastewater, we believe that with much greater focus on measurements of concentrations on all parameters from the real world, the focus will be directed towards our wastewater management, which in our world is the biggest obstacle to achieve a good ecological condition in our surface water.

To elaborate on the above the articles give more information:
1. The 30-year war against the ecosystem. https://ing.dk/blog/30-ars-krigen-mod-okosystemet-116913
2. Nitrogen more friend than enemy. https://www.fairspildevand.dk/wp-content/uploads/Det-glade-budskab-til-second-opinion-3.pdf
3. Lack of authority behind water environment plans. http://uretten.dk/wp-content/uploads/2022/10/Manglende-hjjemmel-bag-vandomraadeplaner-2022-10-22_Effektivt_Landbrug.pdf
4. Understand the meaning of nitrogen in ten minutes - https://www.fairspildevand.dk/wp-content/uploads/Understand-the-importance-of-nitrogen-in-tenminutes-1.pdf

Author: consultant Bjarne Brønserud, cand. oecon.

This paper focus on the uncertainties in the data concerning nitrogen (N) and phosphorus (P). In this connection all sources of loss for the Danish waterborne supply to the coastal waters are relevant to assess in more detail.

The scattered buildings in the open land constitute a smaller part of the diffuse loss of nitrogen and phosphorus. Consequently, the measured concentrations of nitrogen and phosphorus in the stream water constitute the sum from agriculture land, forests and pasture, roads, and scattered buildings. Since 2011 the DCE at Aarhus University is responsible for the statements and measurements (Novana Vandløb 2023). Before 2011 it was The Ministry of the Environment through The National Environmental Research Institute (DMU), who was responsible from the beginning of the measurements in 1990.

For the big towns especially those placed near the fjords and coasts, the losses of nitrogen and phosphorus are calculated directly by the waste water companies owned by the municipalities. These statements are gathered in the annual Punktkilderapport issued by The Ministry of the Environment (Punktkilder 2021).

The calculation of the total loading of nitrogen and phosphorus from point sources are mostly based on models and only a small part is based on flow measurements on a daily basis. Therefore, the wastewater from industry and the towns is only based on sporadic measurements of concentrations. Both from the single-line and the two-line sewerages unintended overflow is substantial, which also happens through bypass discharges directly from the wastewater plants (Punktkilder 2021).

In the period since 1990 there has not been a demand for flow measurements on the wastewater plants' direct discharge to the fjord and coastal waters and the streams. Therefore, there is a high probability that the losses of N, P, BI5 and COD are underestimated in the calculations made by The Ministry of the Environment. For the same reason subsection 3.3.2 (COWI 2023) should contain an investigation into the mentioned deficiencies, omissions and errors in the calculations, of which there are many examples (Knud

Jeppesen 2023). it should also be stated that, for the same reason, the losses of nitrogen and phosphorus from the open land are overestimated in the case where the loading points of wastewater are placed before the permanent measuring stations in the streams.

In the 1990s there were no registrations from the overflow caused by rainfalls and therefore these losses were automatically calculated as coming from the open land (DCE 2013).

When the permanent measuring stations in the largest streams were established in 1989, only about half of the Danish area was covered by these measurements (Novana Vandløb 2008). In the period of 1990 to 2018, the remaining half of the land near the coastal areas were therefore calculated based only on assumptions of the concentrations and runoff water. The Ministry of the Environment supposed the calculation of the diffuse runoff was the same as the average per hectare in the measured areas. This prejudice has been heavily revised later –the first time in 2009 and the second time in 2020. Consequently, a reduction of the amounts of nitrogen and phosphorus coming from the intensive agricultural areas and the scattered residencies has been made for all the years between 1990 and 2018. For the specific year 1990, the loss of nitrogen from the unmeasured areas has been reduced by 45%, or what corresponds to approximately 11 kilogram N per hectare (Novana 2019 and Novana 2009). Also, the phosphorus runoff was severely cut down in the unmeasured areas (Novana 2019 and Novana 2009). The revisions have therefore shown an extremely high uncertainty in the scientifically based calculations of the diffuse loss of nitrogen and phosphorus from the unmeasured open land areas. This fact does not appear from the report (COWI 2023).

In part 1.2 of the report (COWI 2023) the background material from the international evaluation in October 2017 has been specifically included (Panel 2017). As previously mentioned, the data from the Danish loss of nitrogen and phosphorus were severely overestimated for the open land in 2017. In addition, the information given by Aarhus University and DHI to the panel was not accurate (AU og DHI 2017). In figure 2.2 (AU and DHI 2017) the land-based runoff of nitrogen and phosphorus is shown for the period of 1990 to 2011. This graphic illustration cannot be found in the specified source and afterwards The Ministry of the Environment has not been able to define the catchment areas for this figure. Furthermore, the figure 2.1 (AU og DHI 2017) ought to be used with great caution, because there are no measurements showing the connection between the theoretical surplus of nitrogen from the agricultural areas and runoff to streams for the specified period of 1900 to 2005. Based on these shortcomings as well as the drastic revision in the report "Novana Vandløb 2018" (Novana 2019), the conclusions from the evaluation should be disqualified (Panel 2017).

A thorough review of the permanent measurement stations has shown that only 91 stations out of 179 have a complete series of data for total nitrogen and total phosphorus for theperiod of 1990 to 2021 (DCE 2023). These 91 stations cover approximately 41% of the Danish land area. The calculation in this new report shows an average content of total nitrogen for 2021 of 3.2 milligram per liter, whereas the diffuse part can be calculated to 3.0 milligram per liter. The corresponding measurement for the period of 1990 to 1994 showed a content of approximately 5.1 milligram per liter for the diffuse runoff water.

Of the 91 permanent stations only 75 stations have a complete series of measured concentration of nitrate-nitrogen for the period of 1990 to 2021 (DCE 2023). These stations cover approximately 38% of the Danish land area, and they are representative with respect to the agricultural part of the area. Measurements for the period of 2010 to 2021 show a stable level of approximately 3.0 milligram nitrate-nitrogen per liter in the streams. This low level was the same in the beginning of the 1990s where the average was 5.0 milligram per liter nitrate-nitrogen. Compared with the maximum limit of 11.3 milligram nitrate-nitrogen in the EU's Directive for regulating nitrate used in agricultural areas, the measured Danish level which is relevant for the open land shows very low levels on a constant basis. Consequently, in that respect there has never been justification for speaking about a pollution as defined in the EU's Directive regulating the agricultural use of nitrate in Denmark.

In the reports subsection 2.4.1 (COWI 2023) must be corrected to include the mentioned results of the measurements in the Danish streams.

Based on the above-mentioned uncertainties in the calculations of the Danish nitrogen runoff to the coastal waters, and the gross model based overestimation, it is clear in the subsection 2.4.1 (COWI2023) from the EU Commission's comments that the Commission has been misinformed for many years. in The Water Framework Directive as well as The Nitrate Directive only measurements of the concentration of nitrogen and phosphorus in the streams are mentioned. This must be thoroughly explained in the report (COWI 2023). Furthermore, it must be stated that there is no over fertilization in the fields in agriculture in Denmark compared with the principle of balanced fertilization mentioned in The Nitrate Directive. And that we cannot talk about nitrate pollution from Danish agriculture in terms of article 2 in The Nitrate Directive. This information does not appear from subsection 2.3.1 of the report (COWI 2023).

The low level of nitrogen in the surface and underground water from the open land is also confirmed by measurements in the Danish groundwater statistics. In the EU's Water Framework Directive, the groundwater is defined singularly, and it is where the Danish drinking water can be extracted in a stable quality and without any direct influence from the surface water through the superposed layers of earth. For the period of 2016 to 2020, publicly controlled measurements from approximately 6,000 drinking water drillings distributed all over the Danish open land show that 99.6% have a lower content of nitrate than was the maximum limit in the EU's Directive for Drinking Water, which is also mentioned identically in the EU's Water Framework Directive (Geus 2021). This low level of nitrate concentration in the groundwater was also true already in the beginning of the 1990s where the measurements contained an average of 6.22 milligram nitrate per liter in approximately 7,000 drillings supplying water of drinking quality. The requirement in the EU's Drinking Water Directive is therefore abundantly fulfilled as the stipulated limit is 50 milligram nitrate per liter. The corresponding requirement is also mentioned in the EU's Water Framework Directive with 11.3 milligram nitrate-nitrogen per liter instead measured in the surface waters. In the report a clear and adequate statement of the mentioned Danish measuring results is missing (COWI 2023).

It does not appear from the report how it is possible to make environmental damage with these low concentrations in the Danish coastal waters due, in particular, to nitrogen coming through fresh surface waters or from seeping groundwater (COWI 2023). Through the chapters of the report, it is obvious that there is no focus on concentrations at all, but alone on the total amount of plant nutrients per year. Nowhere in the text of the EU's Directives it is mentioned, that there is an obligation to calculate an amount of nutrient per year. Therefore, the Danish implementation of The Water framework Directive appears to have no connection to the quality requirements in the EU's Directives for fresh surface waters and drinking groundwater.

References:

1. **(DCE 2023)**
https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Foreloebige_udgaver_novana_2021/Vandloeb.pdf

2. **(Miljøministeriet 2021)** https://www2.mst.dk/Udgiv/publikationer/2021/12/978-87-7038-368-4.pdf

3. **(COWI 2023)** Second opinion on the need for reduction of Nitrogen in the third RBMP for 2021 –2027, Phase 1, COWI 2023.

4. **(Knud Jeppesen 2023)** Access to documents about registrations of overflow and bypass discharges in Middelfart, Kalundborg og Varde municipalities.

5. **(Novana 2019)** Novana Vandløb 2018, DCE at Aarhus University, revised in February 2020.

6. **(Novana 2009)** Novana Vandløb 2005, DCE atAarhus University, 2009.

7. **(Panel 2017)** (Microsoft Word -Evalueringsrapport om de danske kv\346lstofmodeller_endelig_inkl rigtige bullets OG fuld proces) (mst.dk)

8. **(AU og DHI 2017)**
https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Oevrige_udgivelser/RBMP_models_sd_2017__002_.pdf

9. **(Geus 2021)**
https://www.geus.dk/Media/637753297725753222/Resume%20af%20Grundvand%201989-2020_a.pdf

10. **(DCE 2013)** https://dce2.au.dk/pub/TR31.pdf

11. **(Novana Vandløb 2008)** https://dce.au.dk/udgivelser/tidligere-udgivelser/udgivelser-fra-dmu/faglige-rapporter/nr.750-799/abstracts/fr764

Comments from University of Aarhus - Danish Centre For Environment And Energy (DCE - Nationalt Center for Miljø og Energi)

General comments

The Following conclusion needs to substantiated.

"Regarding the effect from neighbouring countries (burden distribution) the following conclusions are made: 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."

According to Ellermann et al., 2021, the atmospheric N-deposition on Danish sea area is about 60.000 ton N of which 87% originates from other countries (52.200 tonN). The load from Danish land areas is for 2020 57.000 (Thodsen et al., 2021) ton N + 7.800 ton N from Danish atmospheric sources = about 65.000 tonN (about 55-56%). The number will vary between years (2021 values will be available soon). Therefore, the conclusion that the contribution from neighboring countries is secondary seem wrong/over stated as it in some years probably will be larger than that of Danish sources. It might be that the above statement is aimed at "Inner Danish waters" but that isn't stated.

Ellermann, T., Bossi, R., Sørensen, M.O.B., Christensen, J., Løfstrøm, P., Lansø, A. S., Monies, C., Geels, C., & Poulsen, M. B., 202x: Atmosfærisk deposition 2020. NOVANA. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi. 95s. – Videnskabelig rapport fra DCE – Nationalt Center for Miljø og Energi nr. 471. http://dce2.au.dk/pub/SR471.pdf

Thodsen, H., Tornbjerg, H., Rolighed, J., Baattrup-Pedersen, A., Larsen, S.E., Ovesen, N.B., Blicher-Mathiesen, G. & Kjeldgaard, A. 2021. Vandløb 2020. NOVANA. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 82 s. - Videnskabelig rapport nr. 473 http://dce2.au.dk/pub/SR473.pdf

1. Regarding the *"estimated "reference" nutrient load"* (on page 17).

Reference nitrogen loads are in calculation of the third RBMP 2021-2027 based on total-nitrogen concentrations measured in streams in small "nature catchments" in 2011 (Bøgestrand et al., 2014). The laboratory method used in analyzing these samples has since been shown to underestimate the concentration of total nitrogen with an average of 13.5 % (Larsen et al. 2022). The total-nitrogen concentrations for the streams in "nature catchments" has then in 2022 consequently been corrected in accordance with Larsen et al. (2022).

An estimation of how much this would affect the reference loads would require a recalculation with the recent corrected TN-concentrations.

Bøgestrand, J., Kronvang, B., Windolf, J, & Kjeldgaard, A. 2014. Baggrundsbelastning med total N og nitrat-N. Notat fra DCE - Nationalt Center for Miljø og Energi. P 11. https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Notater_2014/Baggrundsbelastning_med_total_N_opdatering.pdf

Larsen, S.E., Tornbjerg, H. & Kronvang, B. 2022. Udvikling af en korrektionsformel for kvælstofkoncentrationer analyseret i naturvandløb i perioden 2009-2015. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi, 19 s. – Fagligt notat nr. 2022|64 https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Notater_2022/N2022_64.pdf

Comments from Danish Hydraulic Institute (DHI), Technical University of Denmark (DTU), and University of Aarhus (AU) (Coastal modelling group)

General comments

A large part of the document seems to be addressing the intercalibration process and how this was handled in previously RBMP. The conclusion is, however, still, that the SO team does not expect an update to change the final outcome of the MAIs calculated with the two model-approaches. We agree, that a potential update of the EQRs will not change the MAIs.

1. Comments to 3.1 Task 1: Reference condition

We have developed a method that allows for individual assessment of the various water bodies. If needed for intercalibration or comparing 'like with like' the individual targets etc. could be grouped into fewer types, than we operate with. However, a number of the Danish water bodies will not compare with either German or Swedish water bodies, why the 'like with like' comparison exercise is difficult anyway.

The SO team suggest using types for reference and target values, but the status is based on observations in the individual water bodies.

In p. 74 just before the figure, it is mentioned that reference values are estimated based on Bayesian statistics – this can be read as no MECH models are included, which is not the case. Both type of models are included in a combined meta-model in a mixed-model-like approach using forward selection and MLR.

The SO team suggest developing models that describe TN load -> TN concentration and then TN concentration -> chlorophyll-a. The SO team assesses our approach is not sufficient, but do not at all assess potential difficulties or uncertainties of making multi step models.

p.94 "*the results of the statistical models could be improved by focusing on nutrient-load/nutrient-concentration relationships for individual water bodies and on a nutrient/Chl-a concentrations conceptual relationship for development of a generic*". We do agree that this could be a strategy too, but we also acknowledge the simplicity of directly coupling input to the quality measures in the ecosystem. Firstly the two variables are truly independent (in contrast to e.g. chlorophyll-a and TN or TP concentration) and secondly the variation in the bioavailable/refractory ratio of TN is huge within Danish water bodies and hence a generic nutrient – chlorophyll-a relationship is not easily found.

The SO team mention that the MECH models is not calibrated within the entire span of present-day and background loadings. This is the problem for all models and methods, and not something that can be solved.

p. 96 "*Consequently, reference condition concentrations for the nutrient supporting quality element are not derived.*" FYI Threshold values for supporting nutrient quality elements are in progress but have not been published yet.

2. Comments to 3.2 Task 2 - Environmental objective

The SO team concludes that it might be fine with one EQR for eelgrass, as this is considered technical feasible, but suggest type specific EQR-values for chlorophyll-a.

In principle we use water body specific EQR values for Chlorophyll-a based on Carstensen et al., 2016 (see report on Chlorophyll-a reference conditions https://dce2.au.dk/pub/SR461.pdf)

3. Comments to 3.3 Task 3 - Status load, 2027 baseline

The baseline is assessed in the report, but only few comments on why we see almost no trend over the last 10-15 years normalized yearly loads.

4. Comments to 3.4 Task 4 – Model basis

p.135-136 "*It is not given that an input of the chosen six parameters (Nutrient input, salinity, temperature, buoyancy frequency, irradiation wind energy) will provide a causal relationship of the parameters included in the multiple regression"…. "Comments to the relevance of some of the descriptors are given below:…."* The causality is justified here *Development of models and methods to support the establishment of Danish River Basin Management Plans (https://mst.dk/media/232618/development-of-models-and-methods-to-support-etc-evalueringsgrundlag.pdf) table 6.2. But this should of cause have been repeated in the relevant reports.*

p.137 The authors describe a simple box model as the correct way to model the concentration of interest C: $C = 1/Qe \cdot L + Cb$. The choice of modelling tool is dependent of scope and time scale. In the STAT-models a relation between annual load (L) and annual mean summer/growth-season concentration in recipient (C) over a 15-30 year period is estimated. On this time scale the boundary concentration (Cb) can often be regarded as relatively constant (nutrient concentration has been decreasing slightly over the period, see blue line in figure 1 from NOVANA report SR532.pdf (https://dce2.au.dk/pub/SR532.pdf) and with negligible year-to-year variation, which is the main variation described in the STAT-models. The same goes for the exchange rate (Qe), which is important when generalizing across systems or on short time scales, but relatively constant from year-to-year. With these assumptions the illustrated box model can be reduced to C=L which is basically the concept of the STAT-models. Of course this gives some limitations when the models are used in scenarios where internal nutrient fluxes or boundary conditions are changed significantly. *As the statistical models cannot account for reference conditions in other nutrient sources than Danish (local) riverine nutrient inputs, the calculated reference chlorophyll-a concentrations were adjusted using results from mechanistic models. The method for accounting for neighboring countries is described in Erichsen et al. 2020* https://dce2.au.dk/pub/SR461.pdf

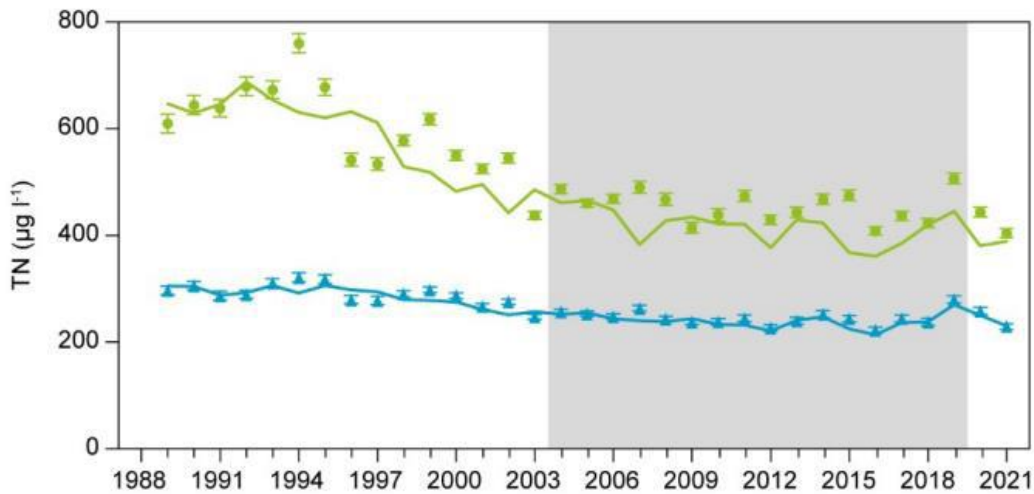


Figure 1 Green line and dots are averaged TN concentrations in Danish estuaries and coastal waters. Blue line and dots are TN concentration in open inner Danish waters.

In the modelling development behind RBMP 2015-2021, we did a selection of MECH models before STAT models in open waters – that was criticized by the international expert panel, why we have chosen not to do a selection as described by the SO team.

p. 139 All models have been carefully evaluated and if we find reasons not to trust a model result, e.g. the STAT models for Mariager Fjord and Odense Fjord, then the results are not used for estimation of MAI.

p 142-145. "*Systematic deviations between slopes modelled by MECH and STAT*" Figure 3-24 – 3-27. Here the SO-team-authors introduces a bias in their own "analysis" of the slopes. They claim that the differences should be "*would randomly be positive and negative if the models were neutral*" and illustrates this with a band of +/- 50% of the MECH slope – calculated as (STAT-MECH)/MECH. This factor has a skewed distribution ranging from -1 to +∞. In the case where the STAT-slope is 50% of the MECH-slope the result is -0.5 but if the MECH-slope is 50% of the STAT-slope the result becomes +1 (and not +0.5). And as the STAT-slope approaches 0% of MECH-slope the result approaches -1 (STAT-slope -> 0, (STAT-MECH)/MECH -> -1) while the opposite situation where MECH-slope approaches 0% of STAT-slope the result approaches infinity (MECH-slope -> 0, (STAT-MECH)/MECH -> +∞). Therefore the bias that are illustrated in these figures are self-introduced and has nothing to do with the deviations in the RBMP-models.

p 149 Here the SO team again introduces a bias in their analysis of MAI (figure 3-31. The differences and uncertainty between the MAIs from the different model approaches are discussed in *Development og Mechanistic Models, RBMP 2021-2027 (https://dce.au.dk/fileadmin/dce.au.dk/Udgivelser/Eksterne_udgivelser/CertaintyEstimationDecember.pdf)*

The SO team state that the models cannot describe Kd in a reference situation. Model results from the MECH model, presented to stakeholders, clearly show an almost 1:1 relation between modelled Kd in a reference situation and Kd based on historic eelgrass depth limits.

We have read the comments from the SO-team regarding the RMBP models and been inspired for future improvements. That said we are fully aware of the pros and cons of the two different modelling approaches, that have been stated here and we believe that we have reduced the uncertainties by having two independent models and furthermore have combined the strength of both modelling strategies in a balanced way.

5. Comments to 3.5 Task 5: Burden distribution

It is stated by the SO team that the WFD-scenarios are only included to show the range of MAIs based on the modelling, and that we have not established a situation where GES will be achieved with a larger certainty that aiming at the border between good and moderate status. The WFD-a scenario actually, show the MAI if we aim in the center between high and good status.

6. Comments to 3.7 Task 7: Seasonal variability

The growth season analysis was carried out based on a somehow idealized situation to clarify if there is a potential for growth season sensitivities in more water bodies.