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

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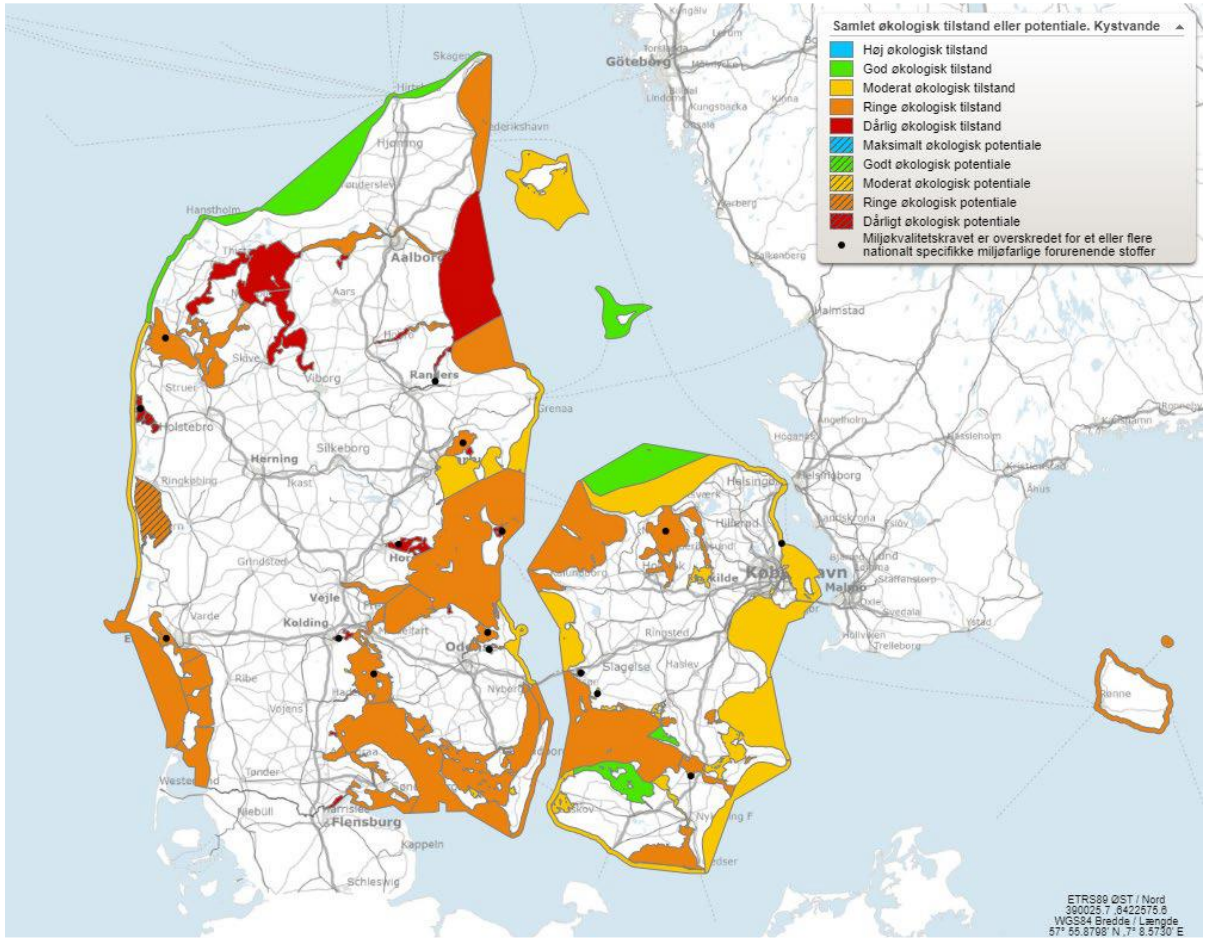
The problem

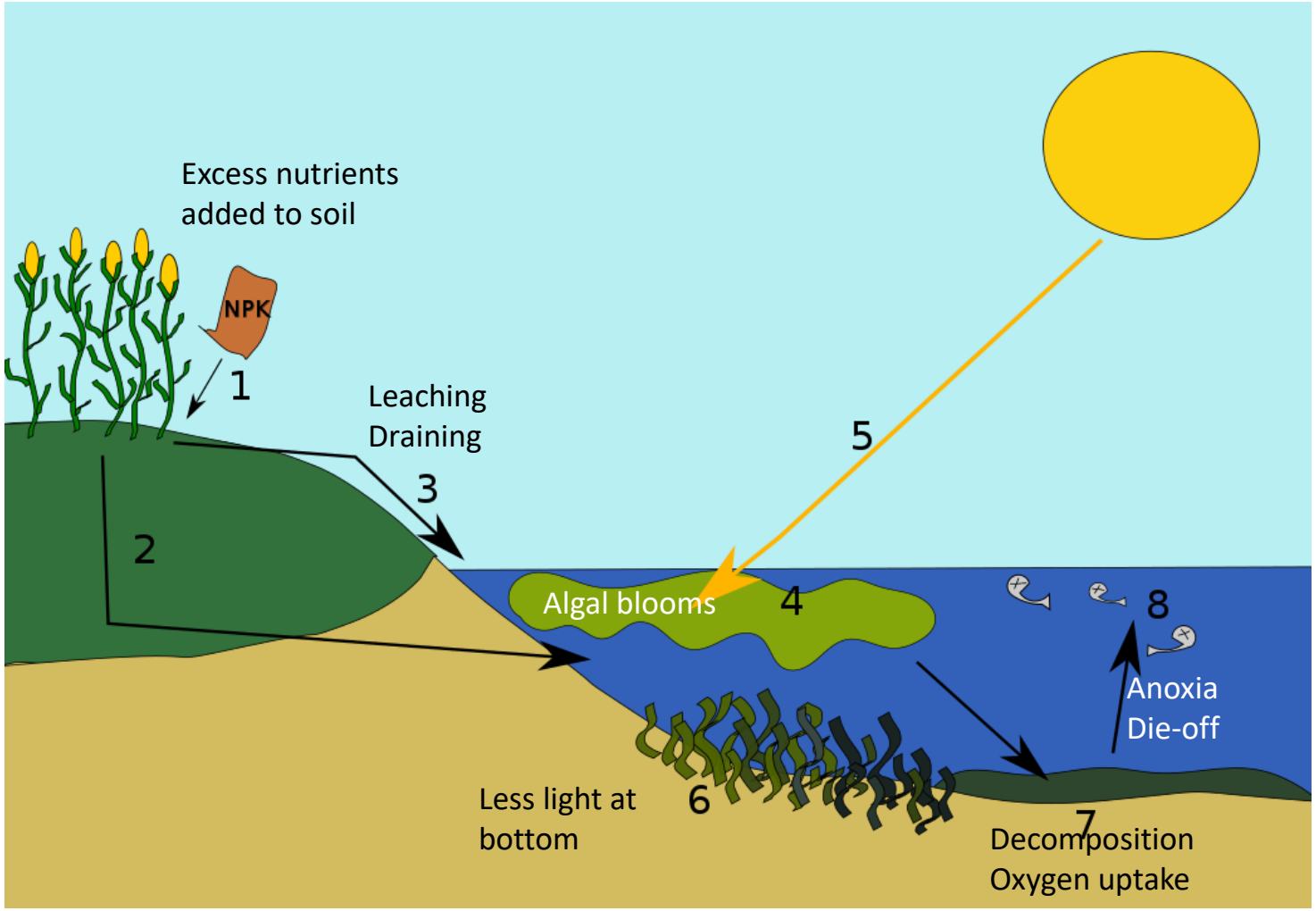


Assessment of ecological status of Danish marine water bodies (Miljøgis: https://mim.dk)

Few water bodies in Good Ecological Status

- Abundant signs of eutrophication:
  - Hypoxia / anoxia
  - Excess water turbidity
  - Lack of biodiversity
- Indicators:
  - Too much chlorophyll in water
  - Eelgrass restricted to shallow depths

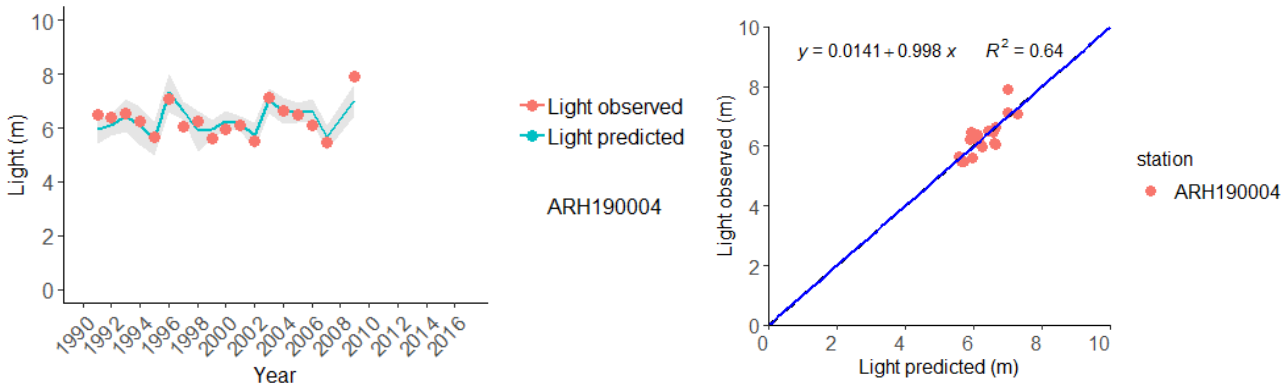
What is eutrophication?



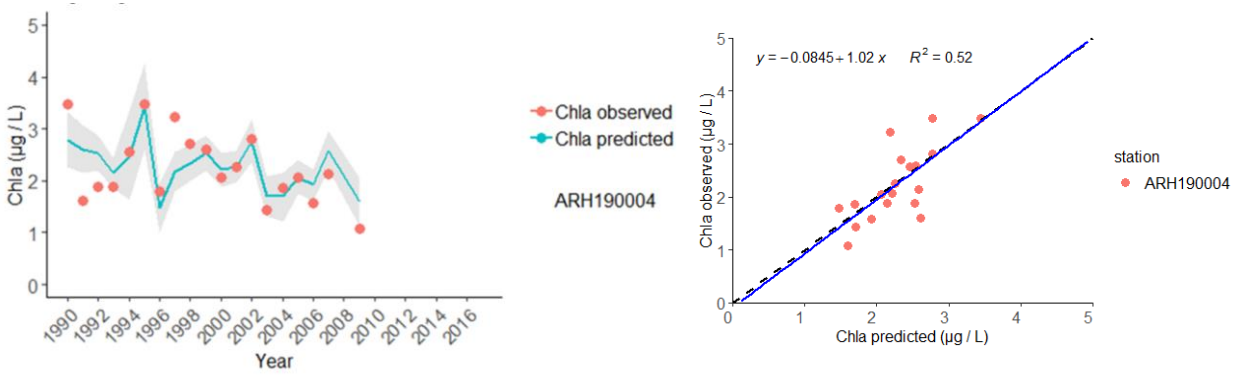
Danish approach to WFD

- WFD requires all coastal waters in Good Ecological Status by 2027:
  - Define what GES means
  - Evaluate current status
  - Investigate cause-effect chains (e.g. nutrient load -> eutrophication signs)
  - Derive maximum allowable nutrient inputs
  - Take the most effective measures to reduce nutrient inputs
- Statistical and mechanistic models quantify nutrient – eutrophication relation
  - Used to derive chl-a reference conditions, and from there Good/Moderate boundary
  - Used to derive N-MAIs
  - Used to investigate scenarios
- Exemptions from the rule may be granted in very specific circumstances

RBMP3 Statistical models

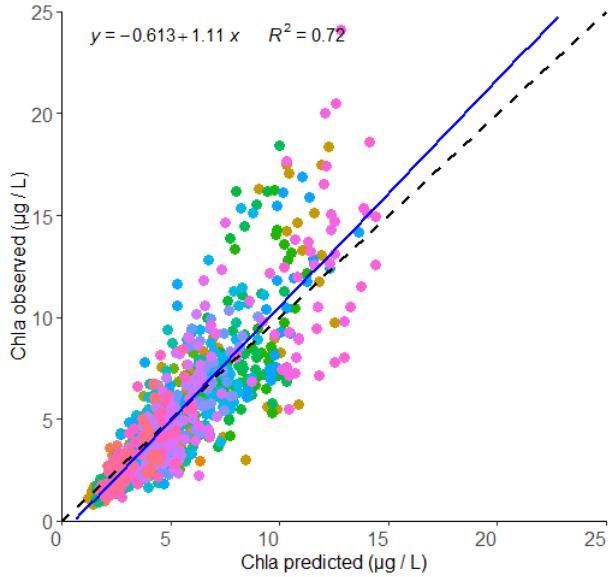


Hevring Bugt: Light = f(Nutrients, salinity, temperature, irradiance)



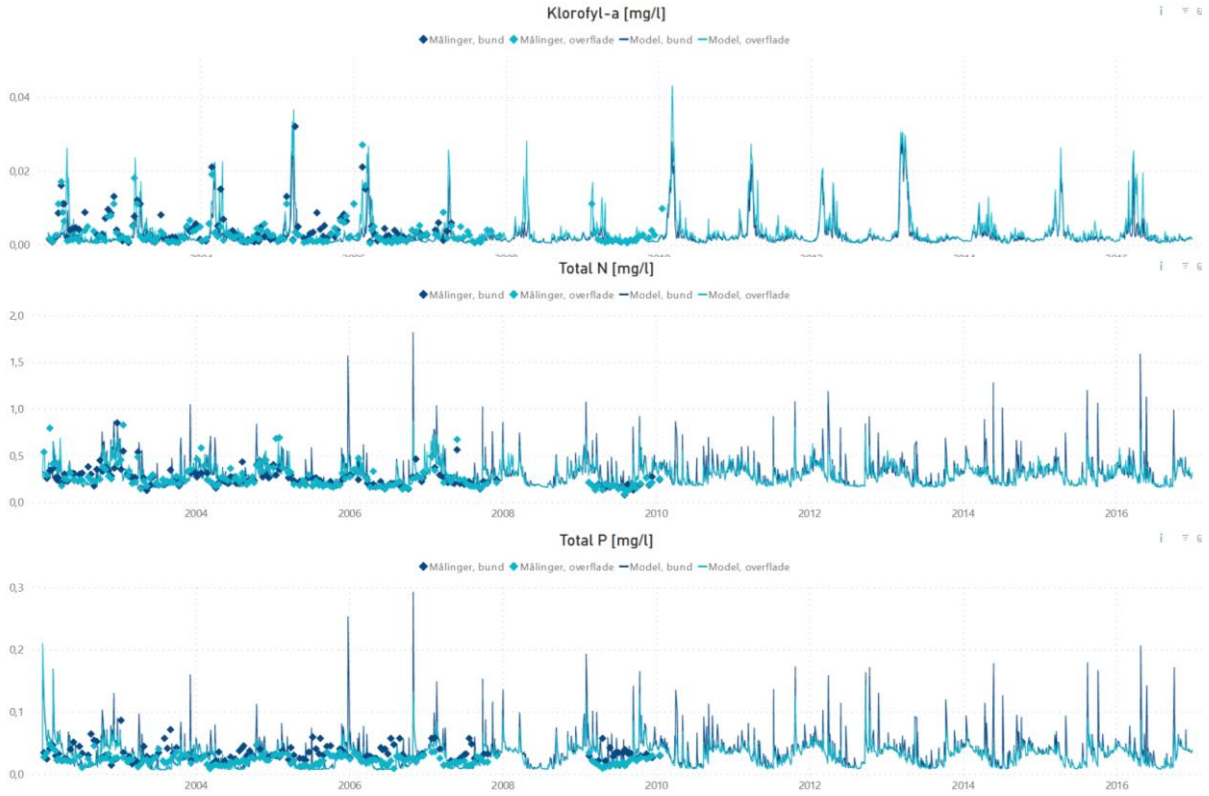
Hevring Bugt: Chl-a = f(Nutrients, salinity)

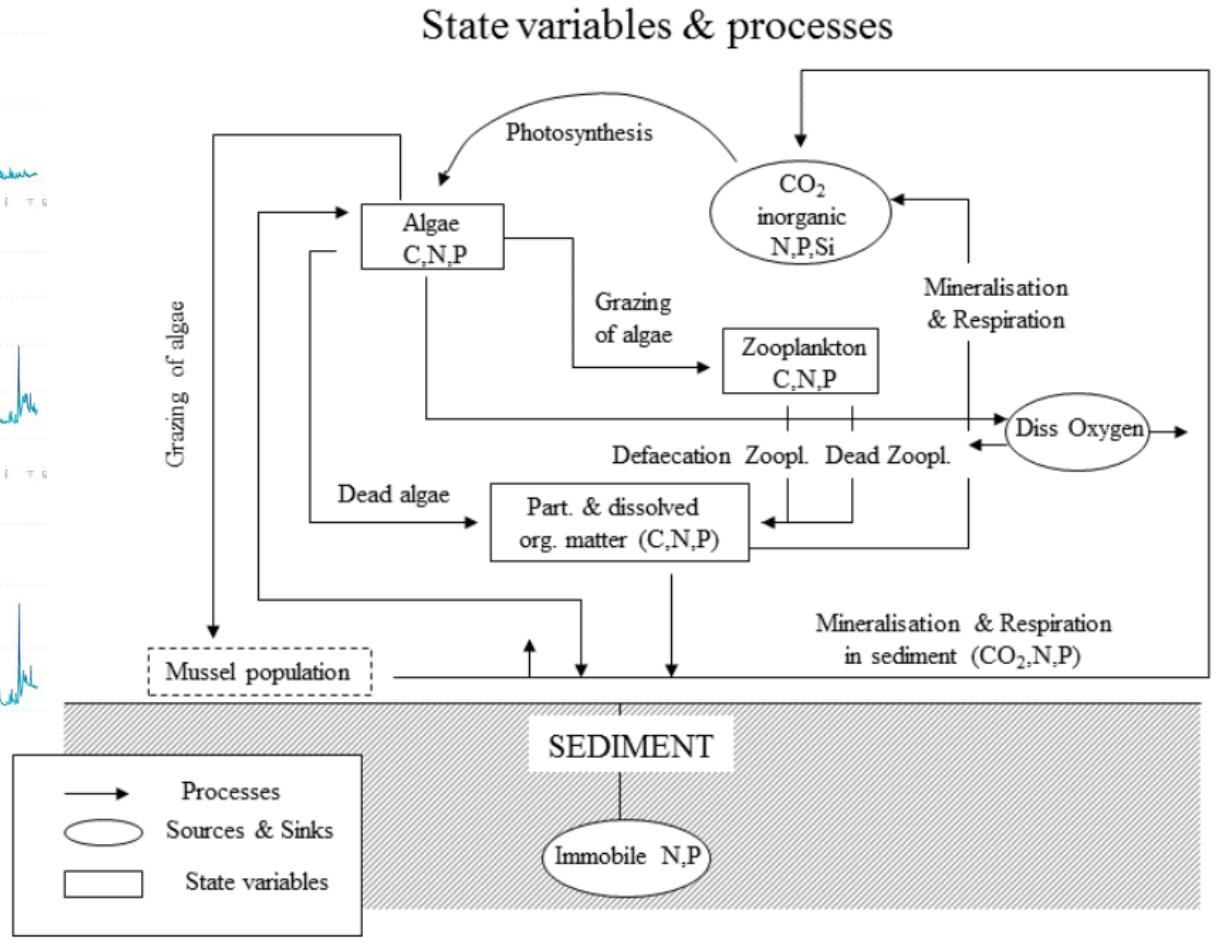
Relate Light and Chl-a to nutrient loads and other forcing factors, based on the data base



Christensen et al. 2021; Shetty et al. 2021

RBMP3 mechanistic models





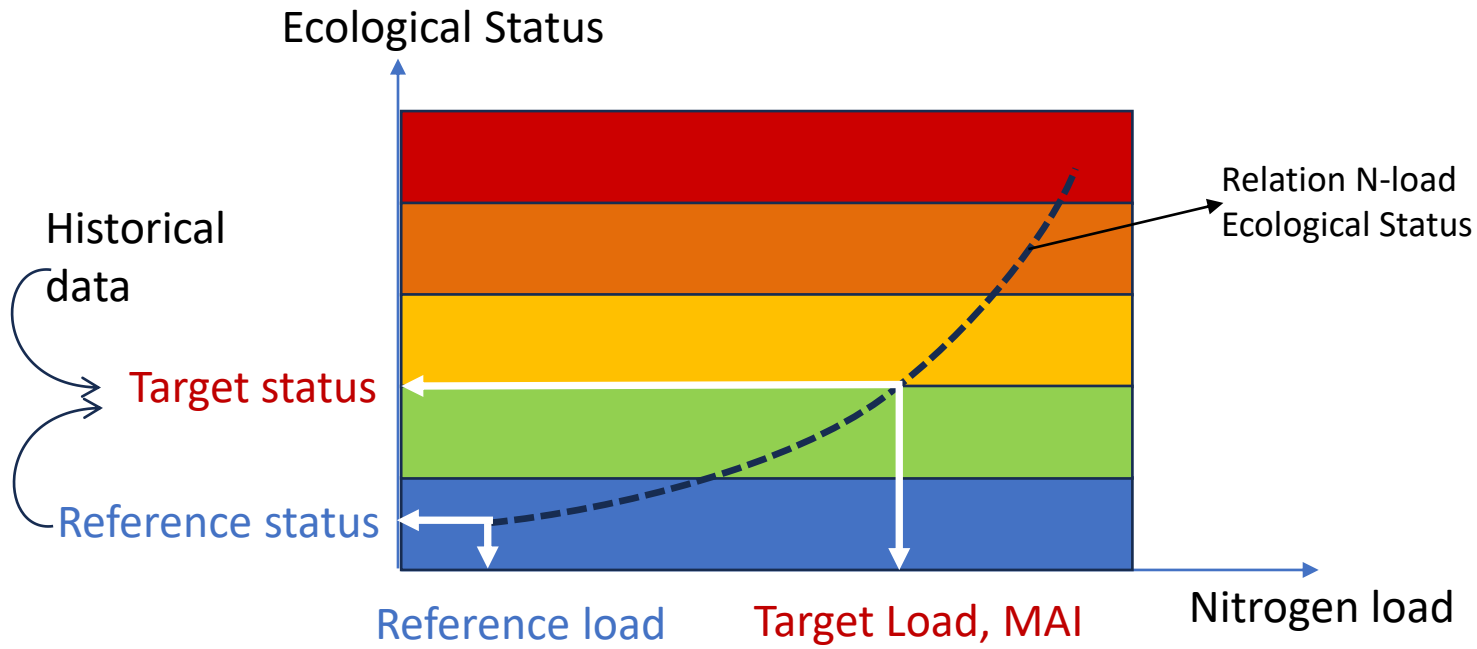
Erichsen & Birkeland, 2019

Validity of the model calculations: assessment

- The quality of the models improved from RBMP2 to RBMP3:
  - Models are fit for purpose
  - Models are exemplary in reflecting specific features of very different water bodies
  - Coherent, consistent and robust basis for estimation of MAI
  - No reason to further refine the models, although locally some attention may be needed
- Future studies should focus on the portfolio of measures, their effectivity and cost-effectiveness
- Monitoring effectiveness should be essential part of implementation of measures

From models to N-MAI

- What is the Maximum Allowable Input of Nitrogen to ensure reaching the Good-Moderate transition in Ecological Status?

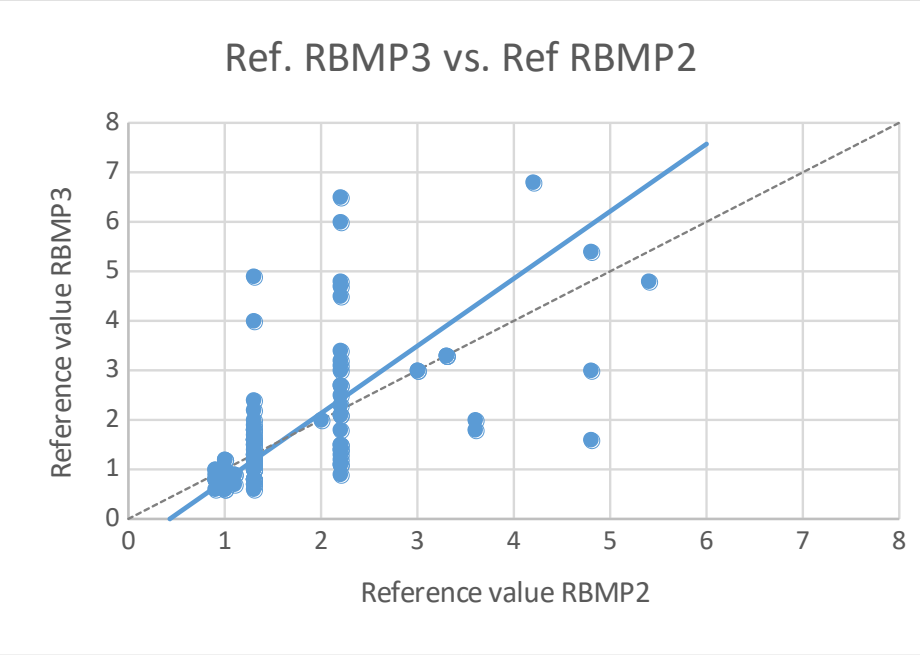


Reference and target conditions

- “Reference conditions” loosely defined as the ecological status before significant human impairment.
  - For Eelgras depth limit: derived from observations around 1900
  - For Chlorophyll-a: derived from model calculations, using N-loads as in undisturbed watersheds
- Are Ref conditions for chl-a and eelgrass consistent, in the light of re-estimated 1900 N loads?
- Remaining debate on 1900 loads, but:
- Model-calculated reference conditions (method of chl-a) very close to historical 1900 observations. This resolves the consistency problem.

Recalculated chl-a reference conditions

- Reference conditions now calculated per water body, not per type
- Recalculation of Baltic boundary conditions: lowering for open coastal waters.
- Affects target conditions, due to fixed ratio of reference to G/M boundary conditions
- Problems with new open water targets: (1) legal – intercalibration, (2) ecological: targets not reachable



Ref. and boundary conditions - assessment

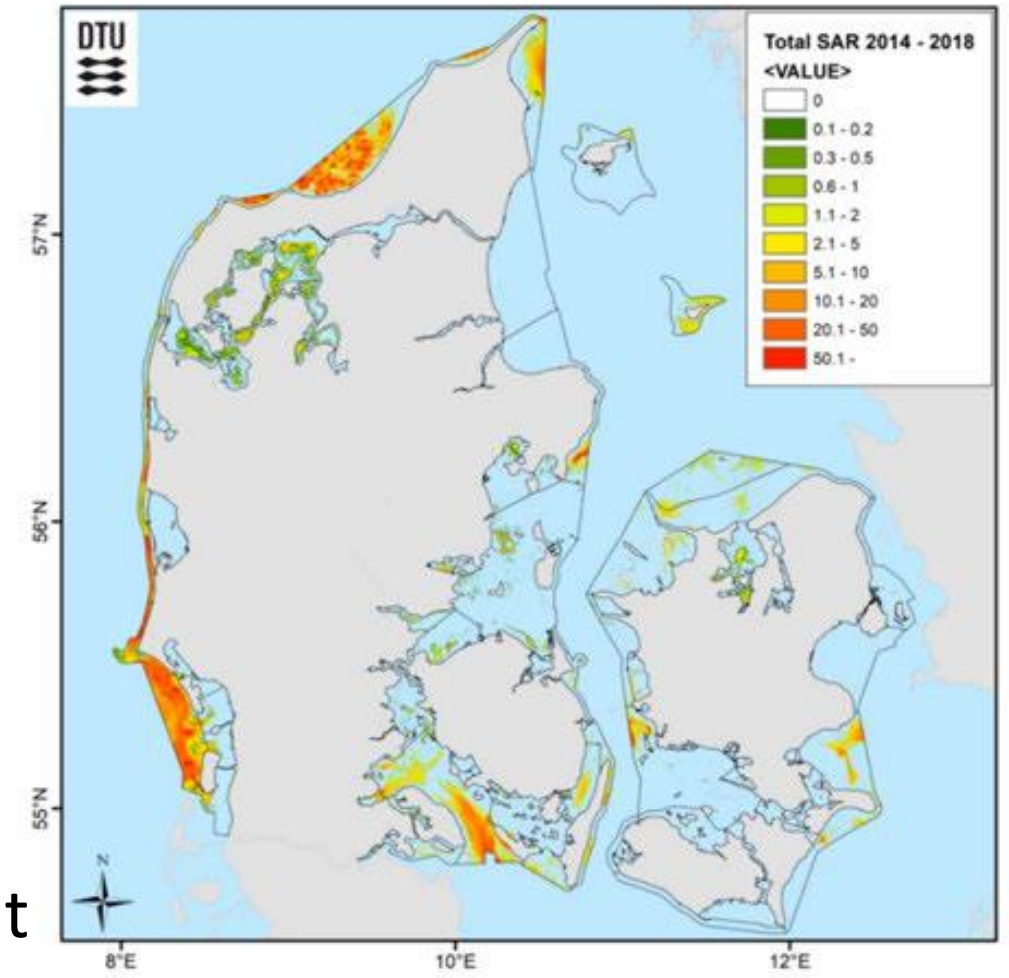
- Panel supports averaging the N-MAIs, but for the future suggests to re-divide tasks between MECH and STAT models
- Panel advises to rescale boundary values to intercalibrated values in open waters – this will also improve coherence with HELCOM targets
- Re-adjusting boundaries in open waters will solve part of the burden distribution problems. Other solutions can be found in exemptions due to natural causes. This is not a reason, however, to do nothing.

Ref. and boundary conditions - assessment

- Panel sees no inconsistency between reference values for rooted angiosperm depth limit (observations 1900) and Chl-a.
- Scientific discussion on year 1900 loadings is, however, not resolved
- Panel advises to truncate boundaries for angiosperm depth limit to maximum depth of water body
- Panel advises to achieve scientific consensus on data base prior to performing of model calculations.
- No reason now for urgent recalculation

Other stressors

- Can we be sure that reducing nutrient loads will lead to Good Ecological Status?
- Not if other stressors deteriorate the ecosystem: fisheries, invasive species, chemical pollution, climate change, extraction/dumping minerals, dams, …
- Especially fisheries is potentially important (destruction of eelgrass, disturbance of benthos, increasing turbidity, affecting food webs)



Swept Area Ratio (number of times disturbed during 2014-2018).

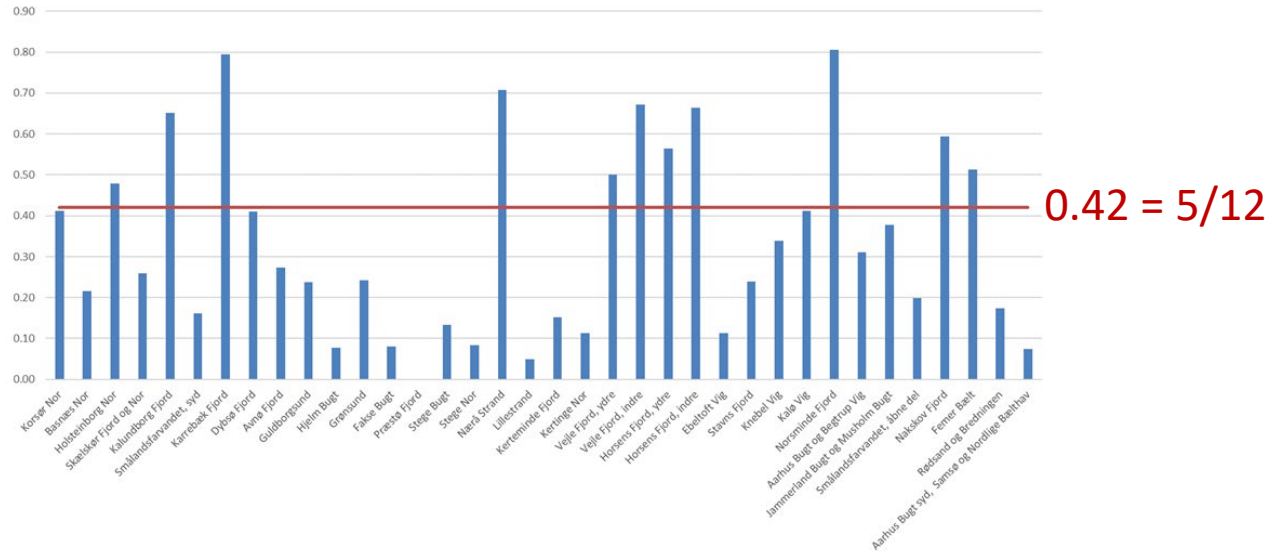
Other stressors - assessment

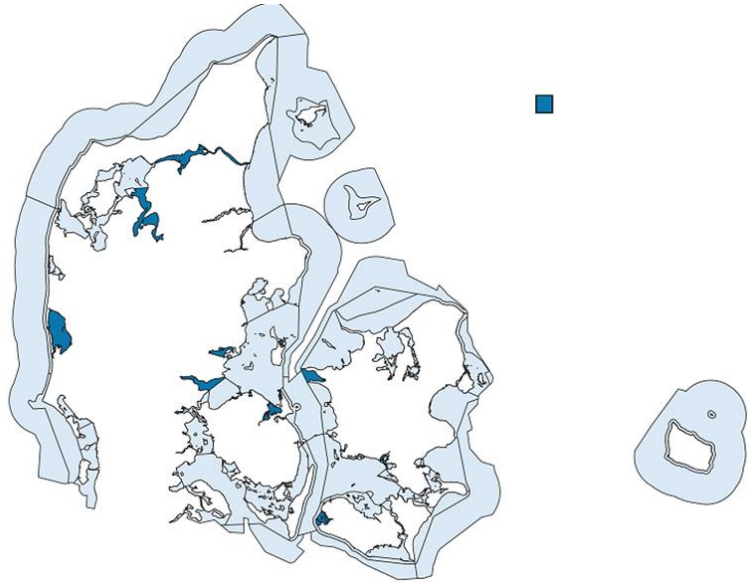
- Other stressors than nutrient loading are important for Good Ecological Status
- No evidence that improving these stressors can *replace* reduction of nutrient loads
- Measures addressing other stressors may be needed *in addition* to nutrient reduction
- Some stressors (e.g. chemical pollution) may need immediate action.
- Others (e.g. fisheries, state of sediments) will be more meaningful after nutrient status is brought under control

Seasonal load reduction measures

- Some water bodies are more sensitive to N reduction in May-Sept than to year-round N reduction

Ratio effects 30% reduction May-Sept to 30% reduction year-round

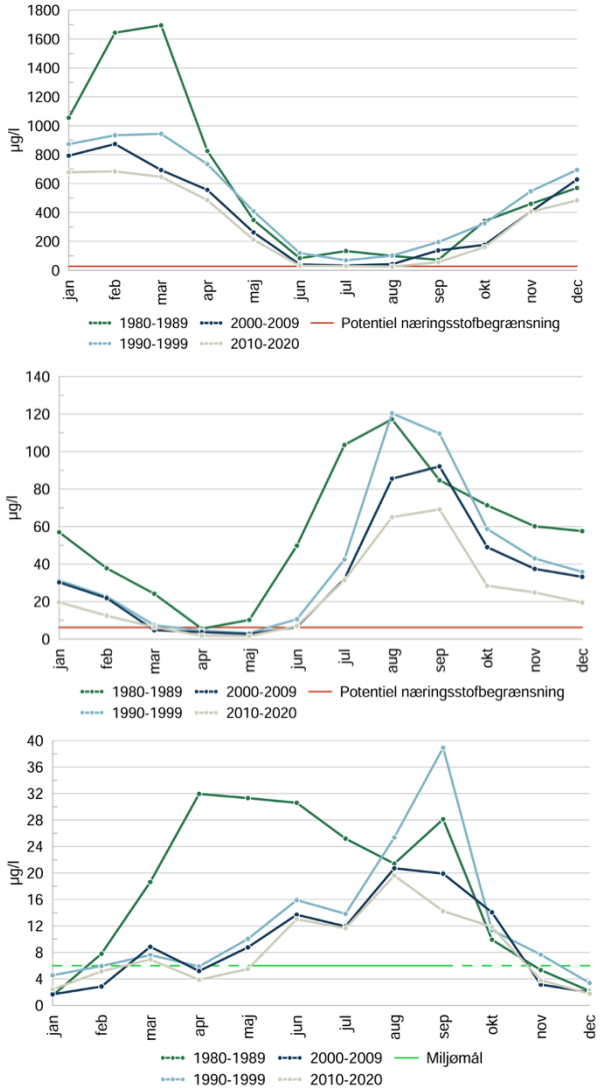




Seasonality - assessment

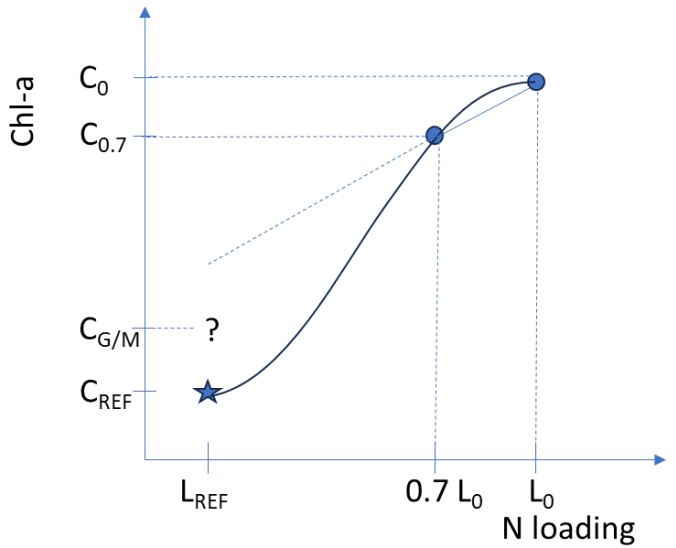
- Panel advises to maintain annual MAIs as binding for the watersheds, BUT
- Seasonally variable measures, in particular wetlands, can be more efficient in summer than in winter. This could be accounted for by ‘seasonal N reduction equivalents’
- Apart from wetlands, few possibilities for summer-only reduction measures have been found
- Possible downstream effects deserve attention
- Local knowledge can be used, especially for design of wetlands and similar landscape measures

Phosphorus load reduction instead of N?



Skive Fjord – Gertz et al. 2022

- In some water bodies, chl-a development is not (yet) limited by Nitrogen. Does it make sense to reduce N input here, or should one work on P?
- Usually caused by strong N overloading. N reduction then makes perfect sense
- Limitation in model scenarios to estimate MAI correctly



P reduction - assessment

- Discussion on P removal has two aspects:
  - Should point sources be treated further? Expected low marginal gains, with notable exception of stormwater overflows
  - Should joint N/P reduction measures be used? Where possible, yes. Trade P reduction for equivalent N reduction, using model output as basis
- Forthcoming results of Phase III may further refine this discussion
- Local initiatives are welcomed, but ensure that clear, nationally consistent framework based on annual N-MAIs is in place

Baseline load / effectiveness of measures

- Appropriate estimate of baseline load 2027
- Need for further improvement of N-flow models in landscape, incorporating experience from ongoing measures – need for monitoring and knowledge development
- During 2010s, a decade has been lost for effective measures
  - Not due to inherently ineffective measures
  - Related to political changes and standstill
- Panel can only hope that a steadfast and sustained political environment will implement the necessary measures

Legal analysis

- Panel finds COWI/NIRAS' statement that there is *no available room for exemptions* is too strict
- Reaching Good Ecological Status in all water bodies by 2027 is unlikely, hence exemptions should be considered.
- There are well-defined requirements for use of exemptions 4.4 (time exemption) and 4.5 (less stringent objectives)
- Use of exemption 4.4 can in no way lead to abandonment of well-defined plans (+ binding time path) to significantly improve water quality
- Extensive knowledge, including socioeconomic analysis (for 4.5 'disproportionate costs') are needed for each water body
- Use exemptions wisely as part of a strategy to achieve environmental goals in an orderly and socially acceptable way

Summing up: ‘Room for manoeuvring’?

- Assumptions and scenarios in models leave no additional room for manoeuvring: all the room has already been used up
- There is room for manoeuvring by resetting boundary values for open waters to intercalibrated G/M boundaries
- Resetting G/M boundaries in open waters will also alleviate burden distribution problem
- Use of exemptions offers more flexibility than previously estimated, but does not provide a free ride

Responses to stakeholder comments

- The Panel thanks the stakeholders for thorough reading and constructive comments
- All comments have been replied to, often with amendments to the report text

SELECTED COMMENTS FROM THE STAKEHOLDERS	REPLIES AND REFERENCE TO REVISIONS BY PANEL	SECTIONS MODIFIED
Danish Agriculture and Food Council (DAFC)		
How can strong changes between RBMP2 and RBMP3 be reconciled with small uncertainty reported in RBMP2	The uncertainty reported was the uncertainty on the models and a fair estimate. It did not account for additional uncertainty stemming from lumping water bodies in too crude classes. It is not clear how well this was communicated, but it does not have strong consequences for RBMP3	none
Ch.1 (B). Have reference values been updated after the discovery of an analytical error	The Panel has investigated this. Reference conditions have not been recalculated. The way this was treated has been added to the report in section 1.4.6, including the Panel's assessment of the process	section 1.4.6 (new section)
Ch.1 (C). does adjustment of G/M boundary to intercalibration lead to adjustments for inner waters, otherwise EQR would differ	There is no scientific reason to adjust G/M boundaries for inner waters, as these were not affected by the boundary and initial conditions in the Baltic that influenced the reference values in open waters. EQRs can be water type specific and need not be the same across all water bodies. This is now explained in the text.	section 1.4.5 (end of section)
Ch.2 (A). why are responsed of Chl-a and Kd to nutrients "reasonably accurate", and what does that mean exactly?	As explained in the text, it can be expected that Chl-a and Kd have short-term variability that is not perfectly modelled. The Panel has asked and received comparisons at seasonal scale, which were in general satisfactory. In particular, as stressed in the report, the ability of the models to predict the level of eutrophication correctly in very diverse water bodies with very different levels of nutrien input, was quite impressive	none
Ch.2 (B). how to reconcile large changes between RBMP2 and RBMP3 with low levels of reported uncertainty	The overall uncertainty in RBMP2 on MAI, was mostly caused by the type classification rather than the intrinsic model uncertainty. The crude classification was - correctly - pointed out by stakeholders as a weakness of the approach, and changes to this aspect were requested by the 2017 International Panel. This request was granted, thanks to large efforts of researchers and Ministries. The Panel assesses these changes as a significant improvement. It is impossible to achieve a significant improvement without changing things. Stakeholders who requested such improvements should not complain that they change things, as long as the changes are for the better.	none
Ch.2 (B). Are uncertainties estimated better this time?	Definitely yes, as stated in the report	none
Ch.2 (B). Are uncertainties higher at water body level than at model level?	In RBMP3, where most variables are water body specific, the difference should be small	none
Ch.2 (C). Does the Panel still agree with downweighting Kd as suggested in 2017?	a section 1.4.8 has been added to the report, detailing the Panel's position	section 1.4.8 (new section)
Ch.3 (A). Errors in the status load calculation for two water bodies	It was outside the Panel's scope and abilities to check all calculations on all water bodies. A general remark on errors and how to cope with them, if unfortunately they occur, has been added to the text.	section 3.4.1
Ch.3 (B). Time has been lost. Emphasis on wetlands and landscape changes	The Panel is delighted to read this confirmation of shared concern. As for wetlands and similar approaches, more emphasis has been added to the report in chapter 5 (seasonality) and chapter 3.	section 3.4.3 / section 5.4.3

Final note: ‘Trust building’

- ‘Trust’ correctly emphasized by DAFC and SEGES as essential in societal process
- Denmark has a solid, state-of-the-art, world-class model suite as a basis of its policy. This model basis is trustworthy. Discussion and research should move on to measures
- “Trust comes on foot and leaves on horseback”. Trust building is a common responsibility
- The Panel hopes it has been able to contribute to trust building and future-oriented, constructive discussion