Marts 2023

Comments to setting reference conditions – eelgrass and chlorophyll.

Author: Flemming Gertz, SEGES Innovation

Please cite: Gertz F, 2023. Comments to setting reference conditions – eelgrass and chlorophyll. Technical note from SEGES Innovation.

Chlorophyll-a and eelgrass are centrale in the Danish River Basin Management Plans (RBMP's) for achieving good ecological status (GES) in coastal waters according to the Water Framework Directive (WFD).

Two approaches were discussed by authorities in an early phase of the planning of RBMP for setting the reference conditions for chlorophyll-a in Danish coastal waters (Ref1):

1) Historical secchi depth correlated to chlorophyll-a
2) Reference/historical nitrogen loads used in a model to find reference chlorophyll-a levels.

In approach number 1, observations of secchi depth at around the year 1900 were used to estimate the chlorophyll-a concentration around the year 1900. The year 1900 was chosen because of the eelgrass depth limits observations at many locations in Danish coastal waters (Ref2). The reference conditions of eelgrass distribution are based on the observations from 1900. In approach number 2, the reference chlorophyll-a concentration was calculated by using a simple relation between N-loads from Danish catchments and the corresponding chlorophyll. It was decided to carry on with number 2 leaving an important question. What nitrogen load to the coastal waters should be used to calculate the reference conditions of chlorophyll? Originally, the idea was to use the N-load around the year 1900 because that would be consistent with using the eelgrass depth limit around 1900 as the reference for eelgrass.

In RBMP 2 (2. Cycle 2015-21), the N-load for the year 1900 was used, and it was based upon so-called "nature catchments" with no or little agriculture and point sources. A report from several Danish institutes (Ref3) documented that the N-load for the year 1900 from Danish land to coastal waters was higher (approx. 2/3 of today) than the estimate used in RBMP 2. Aarhus University (and therefore also the ministry) abandoned the idea of using the N-load around 1900 (ref4) for the RBMP 3 (3. Cycle 2021-27):

"Since the results from the 1900 project (ref3, red) *cannot be regarded as a reference input under the Water Framework Directive, AU proposes to use the same reference input as was used for RBMP 2. This reference input is based on concentrations in smaller watercourses, which drain catchment areas with a very small level of cultivation multiplied by a present-day waterflow. This calculation method is the closest that one can get in Denmark to an unaffected or almost unaffected situation"* (ref4)

The Chlorophyll-a reference in Danish coastal waters is then basically calculated the same way in RBMP 2 (2015-21) as in RBMP 3 (2021-27) by using an N-load without diffuse or point sources.

This is a situation very far from the situation in the year 1900 with an agriculture having approximately same farm land area as today and the same number of livestock as today (Ref3).
In RBMP 3, it was decided still to use eelgrass depth limit around the year 1900 as the reference conditions for angiosperms (Ref4):

"In Denmark, the 1900 period has so far been regarded as a usable reference period. This is primarily due to the fact that a large amount of historical data (mainly between 1880-1910) is available on the depth distribution of eelgrass in Danish waters. The data shows that environmental conditions around 1900 were significantly better than today. It was assessed, therefore, that the spread of eelgrass in 1900 reflected a reference condition"

This decision by Aarhus University – to use eelgrass from 1900 and chlorophyll based on N-loads from "nature catchments" that refers to a historical time very far from 1900 - produces not only a 1) scientific challenge but also a 2) management challenge and a 3) legal challenge according to the WFD.

Aarhus University explains the discrepancy this way (Ref4):

*"The apparent discrepancy between the historical eelgrass observations and the preliminary results from the 1900 project (*Ref3, red*), which indicate extensive human impact, may be due to the time delays in the manifestation of the effects. It takes time (several years) before increased nutrient inputs fully impact light conditions. Moreover, healthy eelgrass beds are relatively robust, which means that they can tolerate more stress over a longer period compared to weaker growths. The time delay means that historical eelgrass depth limits from around 1880-1910 probably reflect nutrient inputs that pre-date 1900. The eelgrass had not necessarily been visibly negatively affected by the increased nutrient inputs around 1900. It cannot, however, be excluded that, in certain places, the eelgrass had been negatively affected by nutrient inputs from land by 1900"*

The problem with the "delay explanation" is that a situation where Danish land areas are more or less without agriculture or point sources dates back way before the Viking Age. Hence the "delay explanation" should cover at least several hundred years.

Scientifically, the "delay explanation" is not aligned with the observations reported by Aarhus University in the report regarding the eelgrass observations around the year 1900 (Ref2), and it is not explained why it was possible to obtain a stable eelgrass level from the late 1800 to the outbreak of the eelgrass disease in the 1930s (Ref2):

"The 306 observations of the depth limit of the eelgrass from the 1880s to 1930 gave a nationwide picture of the depth distribution of the eelgrass. The information was mainly based on studies in the 1890s and 1900s, where the literature emphasized that the eelgrass was widespread along all our coasts and formed extensive and continuous underwater meadows (Ostenfeld 1908, Petersen 1901 and 1914). The historical literature gave no indication that the populations first described in the 1900s changed before the early outbreak of eelgrass disease of the 1930s"

From a management perspective the updated N-load for the year 1900 (Ref3) gives raise to the question whether to use the N-load for the year 1900 or to use an N-load closer to a situation with little or no N-load affected by humans. The Ministry implemented the latter in the RBMP3 based on the recommendation from Aarhus University (ref4):

"The approach of using data from (present-day) areas with a small amount of cultivation to establish a reference input of nutrients would be in full accordance with the Water Framework Directive which recommends that one uses data from existing areas with no or minor disturbance (reference areas). Moreover, in determining reference areas, areas with no or low agricultural activity should be identified and few point sources. AU therefore recommends that this approach is used to calculate reference inputs to RBMP 3 and that a qualitative assessment be made of the uncertainty factors in this approach."

From a management perspective it is difficult to justify the decision. Countries around DK is generally using the year around 1900 as reference. Why is the same assumption not made in the Danish case? According to GIS guidance no 14 annex III: "*Because the intercalibration results will influence water management decision across Europe, the process must be transparent and verifiable. Harmonization based on reference sites is difficult to verify if these reference sites are identified by the member states themselves. Therefore the benchmarking process must use harmonised criteria independent of national classifications (i.e. countries cannot simply nominate the sites they classify as high status as being their benchmark sites without further checking)."* And hence the DK decision to use N-loads from a time before Viking age is not aligned with neighboring countries using N-loads from 1880-1920. And more from GIS guidance no 14 annex III: "*Reference conditions do not equate necessarily to totally undisturbed, pristine conditions. They may include very minor disturbance which means that human pressure is allowed as long as there are no or only very minor ecological effects. Therefore, sites subject to a greater anthropogenic disturbance can be used as reference sites provided the relevant biological quality element parameters do not differ from true reference biological conditions*"

By focusing on an estimated N-load that would relate to a period in time way before the year 1900 and not addressing the N-load for the year 1900 (Ref3) to the coastal status in the year 1900, Aarhus University and the Ministry thereby opted out not only to be aligned with neighboring countries but also to understand how it was possible to obtain the N-load the year 1900 and at the same time observe eelgrass at great water depth. When bypassing this important scientific question there is a risk of not addressing the right measures to achieve GES.

From a legal perspective it is problematic according to the WFD to chose eelgrass in the year 1900 as the reference and at the same time use a calculated chlorophyll-a reference based upon loads from a period in time very far from the year 1900.

"Type-specific biological reference conditions based on modelling may be derived using either predictive models or hindcasting methods. The methods shall use historical, palaeological and other available data and 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." (WFD annex II; 1,3 V)

This issue was reviewed by international experts in a report to SEGES in 2021 (Ref5)

"The Danish method examined in this report employs different historical periods for the quality elements of one and the same water unit. It also combines hard historical data for one indicator, with reconstructed data for another. This in our view endangers a sufficient level of confidence and rules out consistency. It makes proper implementation efforts for the surface water body type concerned highly questionable."

References

Ref1: JRC Scientific and Technical Reports Water Framework Directive intercalibration technical report Part 3: *Coastal and Transitional waters* Edited by Alessandro Carletti and Anna-Stiina Heiskanen, 2009. https://apambiente.pt/dqa/assets/intercalibration-2003-2007-technical-report---coast.pdf

Ref2: Krause-Jensen, D. & Rasmussen, M.B. 2009: *Historisk udbredelse af ålegræs i danske kystområder*. Danmarks Miljøundersøgelser, Aarhus Universitet. 38 s. – Faglig rapport fra DMU nr. 755. http://www.dmu.dk/Pub/FR755.pdf

Ref3: Jung-Madsen, S. and Bach H. (red.) 2022. *Transport of nitrogen and phosphorus from land to sea around year 1900*. Aarhus University, DCE – Danish Centre for Environment and Energy, 192 pp. Scientific Report No. 498 http://dce2.au.dk/pub/SR498.pdf

Ref4: Karen Timmermann, 2020. *Referencetilførsler af kvælstof til brug for Vandplan 3.* Notat fra DCE - Nationalt Center for Miljø og Energi Dato: 6. januar 2020..
English: Timmermann K, 2020. *Reference loads of nitrogen for RBMP 3*. Note from DCE - National Centre for the Environment and Energy. Date: 6 January 2020. Institute for Bioscience
Link: https://www.landbrugsinfo.dk/-/media/landbrugsinfo/public/4/9/9/cowi_report_reference_loads_of_nitrogen_for_rbmp_3

Ref5: Calster G, Ferreira J G, Garnett K, Oenema O. (2021). *REFERENCE CONDITIONS IN DANISH COASTAL WATERS UNDER THE EUROPEAN UNION WATER FRAMEWORK DIRECTIVE. AN INTEGRATED LEGAL AND SCIENTIFIC APPRAISAL*. Resume.
Link: https://www.landbrugsinfo.dk/-/media/landbrugsinfo/public/9/D/9/cowi_report_reference_conditions_in_danish_coastal_waters
Calster G, Garnett K (2021). Reference conditions' under the EU Water Framework Directive - legal point of view. Report.
Link: https://www.landbrugsinfo.dk/-/media/landbrugsinfo/public/B/E/9/cowi_report_reference_conditions_under_the_eu_water_framework_directive
Ferreira J G 2021. Type-specific biological reference conditions in Danish coastal waters Analysis of the 'Composition and abundance of other aquatic flora' biological quality element of the Water Framework Directive. Report.
Link: https://www.landbrugsinfo.dk/-/media/landbrugsinfo/public/E/2/4/cowi_report_type_specific_biological_refence_conditions_in_danish_coastal_waters
Oenema O 2020. Estimations of background N loads to rivers and coastal waters in Denmark for defining reference conditions – a review. Report.
Link: https://www.landbrugsinfo.dk/-/media/landbrugsinfo/public/5/F/7/cowi_report_estimations_of_background_n_loads_to_rivers_coastal_waters_in_denmark