

**DANISH ASSESSMENT OF
EUTROPHICATION STATUS IN THE
NORTH SEA, SKAGERRAK AND KATTEGAT:
OSPAR COMMON PROCEDURE 2001–2005**



Photos are kindly provided by Bjarne Andresen, Christen Jensen and Kristine Garde.

Danish assessment of eutrophication status in the North Sea, Skagerrak, and Kattegat: OSPAR Common Procedure 2001–2005

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1 SUMMARY

The Danish parts of the North Sea, Skagerrak and Kattegat contain a number of unique and fragile ecosystems. Unfortunately, most parts of these areas are considered to be ‘eutrophication problem areas’, where the ecological quality objectives set up by national authorities (sometimes as a spin-off from international agreements) are not fulfilled.

Pollution by excessive nutrients (primarily nitrogen and phosphorus), that is, nutrient enrichment or eutrophication, is one of the biggest concerns. Nutrients as such are not ‘bad’; they are natural components of the ecosystem. The problems of eutrophication become visible when the inputs of nutrients exceed the losses and the system becomes over-enriched. Eutrophication and nutrient over-enrichment can be described as ‘too much of a good thing’.

The effects of eutrophication are well known: algal blooms resulting in green water, reduced depth distribution of submerged aquatic vegetation, increased growth of nuisance macroalgae, increased sedimentation, increased oxygen consumption, oxygen depletion in bottom waters, and sometimes dead benthic animals and fish. The causes behind eutrophication in the Danish parts of the OSPAR Convention Area are also well known: discharges, losses, and emissions of nitrogen and phosphorus to the aquatic environment. Reductions of discharges from municipal wastewater treatment plants and industries have been in focus for many years. So have losses and emissions of nitrogen compounds from agriculture and traffic.

Eutrophication status 2001–2005

The eutrophication status in the Danish parts of the OSPAR Convention Area has been assessed in a two step procedure. Firstly, data on reference conditions and current status (2001-2005) has been gathered and quality assured, and acceptable deviation from reference condition has been set according to the OSPAR Comprehensive Procedure or Danish Governmental positions in regard to the EU Water Framework Directive intercalibration process, e.g. the NEA GIG. Information on reference conditions, acceptable deviation and current status have been combined and used for an interim assessment according to the OSPAR Comprehensive Procedure. Areas have been classified as either ‘eutrophication non-problem area’ or ‘eutrophication problem areas’.

Secondly, the interim assessment has been subject to a succeeding assessment in accordance with the requirements of the EU Water Framework Directive, e.g. use of the ‘one out – all out’ principle, calculation of ecological quality ratio (EQR), and classification in five classes (high, good, poor, moderate, poor and bad, where high and good are similar to ‘eutrophication non-problem area’ and vice versa). The second step, which has used the draft HELCOM Eutrophication Assessment Tool (HEAT), has also built-in an accuracy assessment in order to get a provisional perceptive of the robustness and quality of the outcome of the classifications.

The conclusions of the assessment are:

- All Danish fjords and estuaries located within the OSPAR Convention Area are classified as ‘eutrophication problem areas’.

- All coastal areas are classified as ‘eutrophication problem areas’.
- The open parts of the Skagerrak are together with a strip in the northern parts of the North Sea classified as ‘eutrophication non problem areas’.
- An area in the North Sea located in between (a) the ‘non-problem area’ strip mentioned above and (b) the coastal waters being classified as ‘eutrophication problem areas’ has been classified as a ‘potential eutrophication area’.

Towards better assessment and management of eutrophication

The OSPAR Comprehensive Procedure is a valuable tool for interim assessments of eutrophication status. One of the strength of this tool is that it actually works well and is being used by many countries. However, the tool is too stringent since it applies a ‘one out – all out’ principle on the level of assessment criteria (indicators). Further, it does not meet the requirement of European legislation, e.g. the EU Water Framework Directive.

The HEAT tool has been used to supplement to OSPAR Comprehensive Procedure and the advantages include: (1) Quantification of eutrophication status, (2) correct use of the ‘One out – all out’ principle *sensu* the EU Water Framework Directive, and (3) an interim estimation of the accuracy and precision of the assessment results.

Taking into account that the majority of the Danish parts of the OSPAR Convention Areas are being classified as ‘eutrophication problem areas’, the next steps should be to reduce the extent of the problem.

The general recipe to mitigate eutrophication is simple: nutrient inputs should be reduced further and to levels that do not put at risk the ecological target values for Danish parts of the North Sea, Skagerrak and Kattegat.

The results of the OSPAR Comprehensive Procedure should be used for setting up an integrated management strategy to combat eutrophication in the OSPAR Convention Area. Among recommended actions are the following:

- Water managers must incorporate safety margins when designing programmes of measures to fulfil the OSPAR Eutrophication Strategy and other relevant strategies. These safety margins should allow for excessive pressure during extreme or rare climate conditions.
- A North Sea-wide (including the Skagerrak and Kattegat areas) adaptive management strategy should include a close and continuous dialogue with relevant stakeholders, especially from the agricultural sector.

In addition, an adaptive management strategy for the North Sea including the Skagerrak and Kattegat areas should be based on the following two principles: Firstly, nutrient inputs should in no case be allowed to increase compared to the present levels — any increase should immediately be reported and reduced to the present level. Secondly, management plans must be adaptive in order to deal with uncertainty and at the same time include elements of ‘learning-by-doing’ and feedback from research and monitoring activities. Programmes of measures should be implemented, also when cause-effect relationships are not 100% scientifically documented.

2 INTRODUCTION

Walking along the shore of the Danish coasts along the North Sea, Skagerrak and Kattegat or sailing these areas is often a pleasant thing to do. The seascapes are nice and watching leisure or commercial activities at the shore or on the sea is interesting.

Looking at the water might however show a quite different picture with waters looking like green paint because of algae blooms (Figure 2-1), foam on the shores, piles of drifting macro-algae, and dead fishes or dead benthic animals washed ashore.



Figure 2-1 A harmful algal bloom in the southern parts of the Kattegat. Photo: Kristine Garde.

Below the surface, deterioration is sometimes even more severe than those observed at the sea surface with dying plants (Figure 2-2, A and B), impoverished bottom fauna (Figure 2-2, C and D) and oxygen depletion (Figure 2-3).

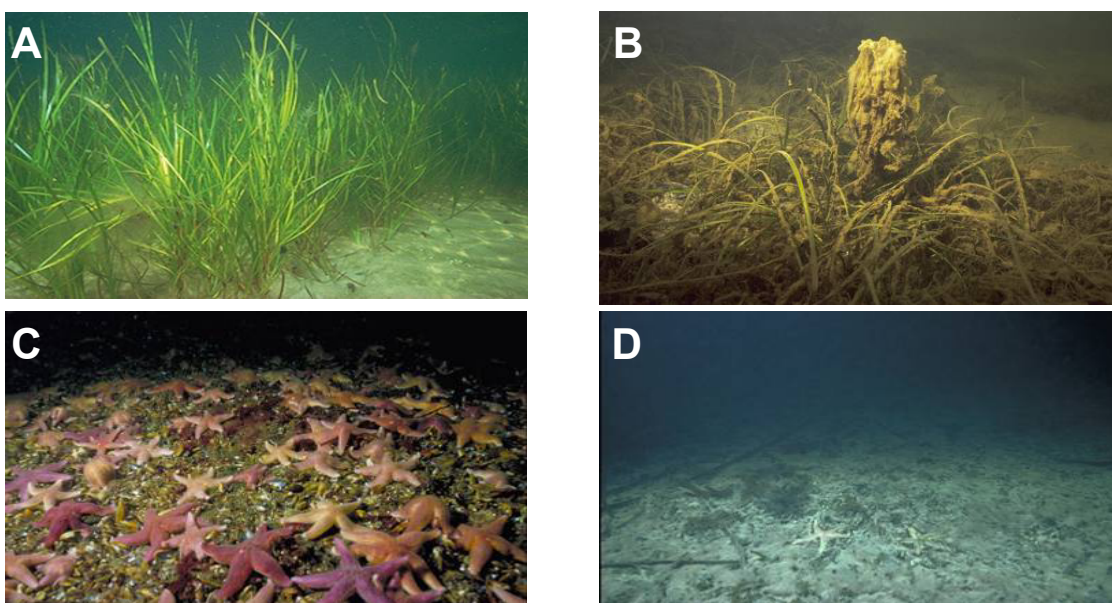


Figure 2-2 Nutrient enrichment and eutrophication affect benthic communities. Panel A and B illustrate the difference between an eelgrass bed subject to only modest nutrient enrichment eutrophication and an eelgrass almost vanished because of nutrient enrichment. Panel C and D illustrate the difference between benthic fauna communities in areas without and with oxygen depletion. Photos: Nanna Rask.



Figure 2-3 Fish killed due to oxygen depletion. Photo: Christen Jensen.

2.1 **What is Nutrient Enrichment and Eutrophication?**

The present impaired conditions can be attributed to several, mostly human-generated, causes, e.g. resource exploitation (e.g. fisheries), pollution (nutrients and hazardous substances), physical modification of habitats, introduction of non-native species, and climate changes.

Pollution from excessive nutrients (nutrient enrichment; mainly compounds of nitrogen and phosphorus) is a major concern. This type of pollution is termed 'eutrophication'. The word 'eutrophication' has its root in two Greek words: 'eu' which means 'well' and 'trophe' which means 'nourishment'. The modern use of the word eutrophication is related to the inputs and effects of nutrients in aquatic systems.

Many initiatives have been launched and much work has been put into mitigation of the consequences of eutrophication, especially in relation to the reduction of inputs of nutrients from point sources (e.g. towns and industries). Focusing on nutrients and the reduction of nutrient inputs is sensible because eutrophication is a process being fuelled by excessive nutrient releases from various human-related sources. This increased flow, or flux, of nutrients into a marine ecosystem may increase the concentrations of nutrients which, taken together with the availability of light and certain minerals, may cause an increase in primary production, for example, by microscopic planktonic algae.

2.2 What are the Effects and Consequences of Eutrophication?

Nutrient enrichment by nitrogen, phosphorus, and sometimes organic matter can result in a series of undesirable effects. The major effects of eutrophication include changes in the structure and functioning of the entire marine ecosystem and a reduction in stability.

The first response to increased nutrient inputs is a corresponding increase in nutrient concentrations. Despite variations in runoff and precipitation, the result of increased nutrient inputs (e.g. nitrogen or phosphorus) is an increase in nutrient concentrations. Another effect is a change in the ratio between dissolved nitrogen and phosphorus in the water. The optimal DIN:DIP ratio (N/P ratio) for phytoplankton growth is 16:1 (based on molar concentrations); this is called the Redfield ratio. A significantly lower N/P ratio indicates potential nitrogen limitation, while a higher N/P ratio implies potential phosphorus limitation of phytoplankton primary production. Deviations from the Redfield ratio might limit the production of phytoplankton and affect phytoplankton biomass, species composition, and consequently food web dynamics.

Primary production is most often limited by the availability of light and nutrients. Nutrient enrichment will therefore cause an increase phytoplankton primary production. Thus, there will be an increase in phytoplankton biomass and ultimately a decrease in light penetration through the water column. Decreased light penetration is often measured as a decrease in Secchi depth and can ultimately reduce the colonisation depth of macroalgae and seagrasses.

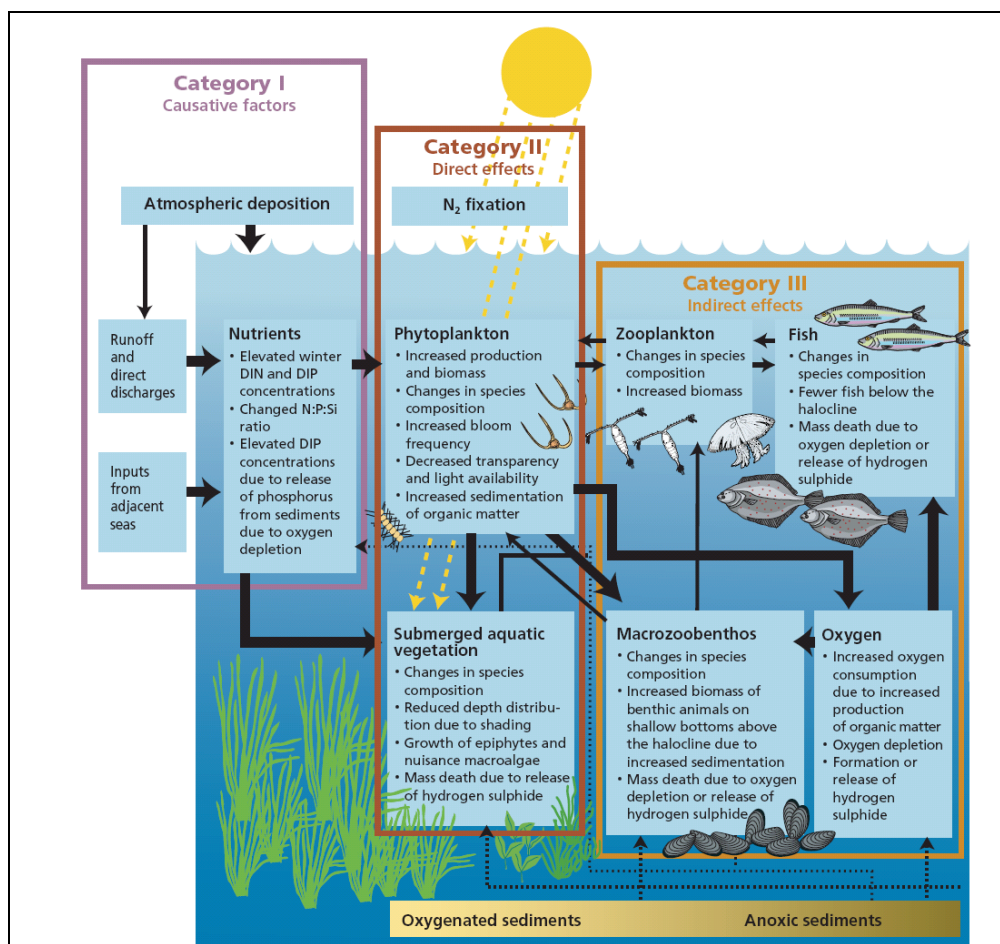


Figure 2-4 Conceptual model of coastal eutrophication. Based on Ærtebjerg et al. (2003).

The general responses of pelagic ecosystems to nutrient enrichment can, in principle, be a gradual change towards: (1) increased planktonic primary production compared to benthic production, (2) a dominance of microbial food webs over linear planktonic food chains, (3) a dominance of non-siliceous phytoplankton species over diatom species, and (4) a dominance of gelatinous zooplankton (jellyfish) over crustacean zooplankton.

Eutrophication issues are often divided into three groups: (1) causative factors, (2) direct effects, and (3) indirect effects. The causative factors deal with inputs, elevated nutrient concentrations, and changes in the Redfield ratio. Direct effects are related to the primary producers, namely: (1) phytoplankton and (2) submerged aquatic vegetation. Secondary effects are related to: (1) zooplankton, (2) fish, and (3) invertebrate benthic fauna, that is, animals living on the seafloor. Some of the best-known and most easily understood primary and secondary effects of eutrophication are explained and discussed on the following pages.

2.3 *OSPAR and Assessing the Status of the Maritime Waters*

The status of the Danish marine environs is currently assessed in both national and international context. The Convention for the Protection of the Marine Environment of the North-East Atlantic (the “OSPAR Convention”) is one such context. OSPAR defines eutrophication as “the enrichment of water by nutrients causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms”; in particular referring to “effects resulting from anthropogenic enrichment by nutrients” (OSPAR 2003).

A principal element of the OSPAR Strategy to Combat Eutrophication is the Common Procedure for the identification of the eutrophication status of the maritime Area (the Common Procedure). This Procedure was adopted in 1997, and sets the framework within which the OSPAR Contracting Parties have to assess the eutrophication status of their parts of the OSPAR maritime area. On the basis of the Common Procedure assessment the maritime areas must be classified as non-problem, problem or potential problem areas.

Presently, the OSPAR Integrated Report on the Eutrophication Status of the OSPAR Maritime Area in 2001-2005 is in progress and assessment presented in this report is the Danish contribution to this report. The core documents supporting this assessment are: (1) OSPAR 2005: Examples of reporting result of annual assessments for 2001-2005 (OSPAR 2005a).; (2) OSPAR 2006: Guidance on the contents of the national assessment under the Common Procedure (OSPAR 2006); and (3) OSPAR 2005: ”Draft Update of the Common Procedure for the Identification of the Eutrophication Status of the OSPAR Maritime Area” (OSPAR 2005b).

Assessment of primary and secondary effects of eutrophication and their consequences is normally done in a way resulting in classification in two classes: ‘eutrophication problem areas’ or ‘non-problem areas. Sometimes the principles used for classification of eutrophication status, because of uncertainty in relation to the classification, include three classes: ‘eutrophication problem areas’, ‘potential problem areas’ and ‘non-problem areas’. Recently, and mainly because of the EU Water Framework Directive which requires classification of ecological status in five classes (‘good’ and ‘high’ being equivalent to ‘non-problem areas’ and ‘moderate’, ‘poor’ and ‘bad’ being equivalent to

‘eutrophication problem areas’), some assessment tools have been modified/developed in accordance with the principles of this directive.

In this assessment of eutrophication status of Danish parts of the North Sea, Skagerrak and Kattegat the tools used include both a robust but simple tool (the OSPAR Comprehensive Procedure) and a more refined assessment tool (the draft HELCOM Eutrophication Assessment Tool, HEAT), which is based on the principles of the Water Framework Directive.

3 DESCRIPTION OF THE ASSESSED AREAS

The Danish maritime areas covered by the OSPAR convention include the national parts of the North Sea, the Skagerrak, and the Kattegat. A total of 22 coastal water bodies and open water bodies have been assessed, cf. Table 3-1 and Figure 3-1.

Table 3-1 Areas included in the assessment of eutrophication status.

Name	Type
1. North Sea – open waters	Open
2. North Sea – southern coastal waters	Coastal
3. North Sea – coastal waters	Coastal
4. Wadden Sea – Danish parts	Coastal
5. Ringkøbing Fjord	Coastal (lagoon)
6. Nissum Fjord	Coastal (lagoon)
7. Skagerrak – coastal waters	Coastal
8. Skagerrak – open waters	Open
9. Limfjorden – western parts	Coastal (fjord)
10. Limfjorden – central parts	Coastal (fjord)
11. Limfjorden – southern parts	Coastal (estuary)
12. Limfjorden – eastern parts	Coastal (fjord)
13. Kattegat – northern open waters	Open
14. Kattegat – central open waters	Open
15. Kattegat – western coastal waters	Coastal
16. Kattegat – southwestern coastal waters	Coastal
17. Kattegat – southern open waters	Open
18. Kattegat – southern coastal waters	Coastal
19. Mariager Fjord	Coastal (fjord)
20. Randers Fjord	Coastal (estuary)
21. Isefjorden	Coastal (fjord)
22. Roskilde Fjord	Coastal (fjord)

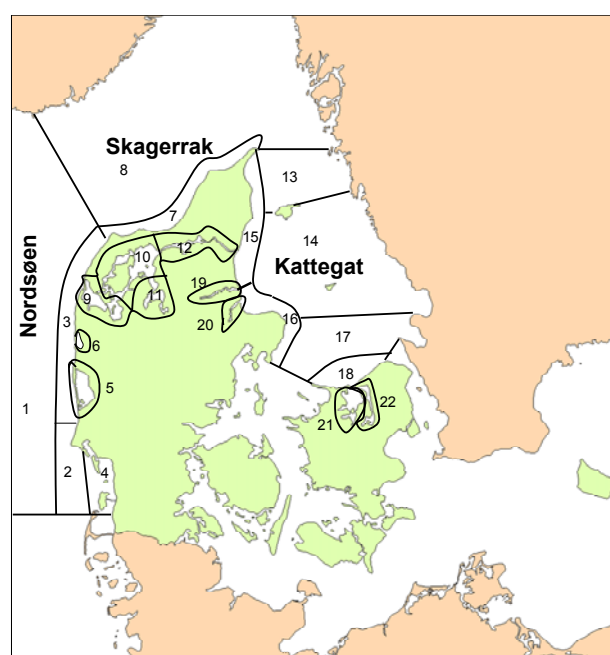


Figure 3-1 Location of areas included in the assessment.

The outline of the Danish parts of the OSPAR maritime area is shown in Figure 3-2 together with the bathymetry. Danish marine waters are mostly shallow (<30 m). The deepest parts are in the central Skagerrak (>100m, area 8 in Table 3-1), the most western part of the Danish North Sea (30-50m, area 1 in Table 3-1) and the north-eastern Kattegat (>50m, area 13 and 14 in Table 3-1).

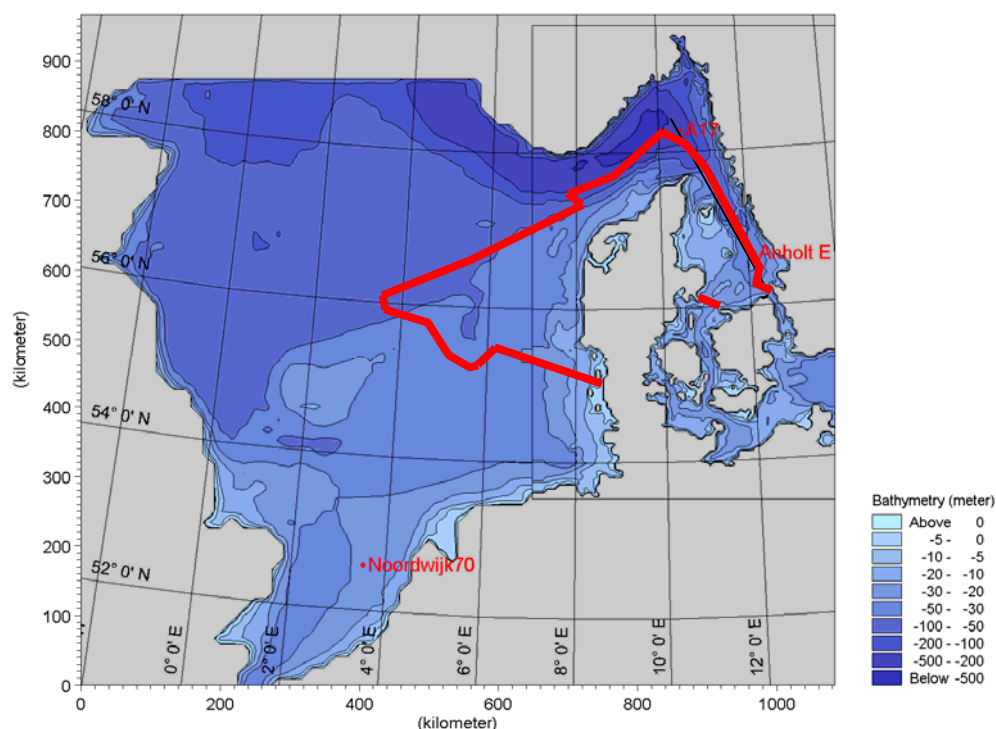


Figure 3-2 Bathymetry of the OSPAR maritime area with the outline of the Danish waters indicated by a red line. Location and names of the assessed areas appear from Table 3-1.

The salinities vary from above 34 psu in the central North Sea to almost fresh waters where the estuaries are dominated by outflows from rivers and streams. Along the Danish North Sea Coast water is transported from south to north in the Jutland Coastal Current (Figure 3-3), the northward extension of the current varies). In the south the current is heavily influenced by the runoff to the German Bight. The salinity increases northwards along the Danish coast as the water in the current mixes with water from the central North Sea.

Kattegat is a transitional water body between the Skagerrak-North Sea and Baltic Sea, dominated in the bottom layer by the inflow of the saline water from the Skagerrak and in the surface layer by the brackish water outflow from the Baltic Sea. The salinities of the surface layer are around 20-30 psu depending on the distance from the borders to the Baltic Sea, the intensity of the outflow and the mixing with the saline bottom water. The nutrient loading is attributable to Danish run-off and atmospheric deposition (32%), likewise contribution from Sweden and Germany (total 22%) and the adjacent seas (Skagerrak 19% and Baltic Sea 14%) (Ærtebjerg et al. 2003).

In general, run-off from agriculture is the dominant source to nutrient enrichment of Danish maritime areas.

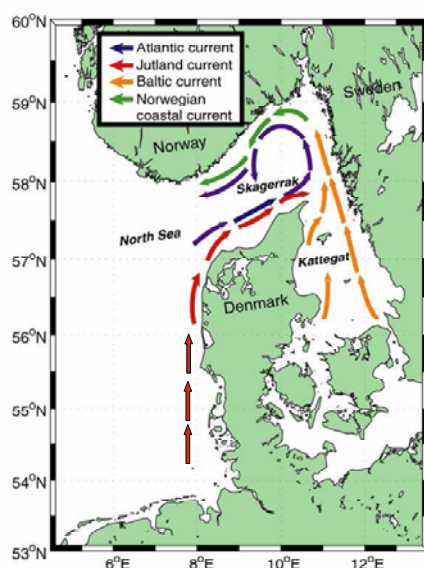


Figure 3-3 Generalized current pattern in the Eastern North Sea, Skagerrak and Kattegat area.

The Danish Wadden Sea (area 4, Table 3-1) constitutes the most northern part of the international water body the Wadden Sea. The area comprises of extensive salt marshes, tidal mud flats, deeper tidal trenches and islands bordering the areas towards the North Sea. The area is highly dynamic due to its tight interaction with the North Sea and the tides resulting in significant daily changes in salinity, light, oxygen and temperature. The water quality is influenced by the North Sea as well as activities in the catchment area (Essink et al. 2005).

Further north along the Danish North Sea coast, the two lagoons Ringkøbing Fjord (area 5, Table 3-1) and Nisum Fjord (area 6, Table 3-1) are located. Ringkøbing Fjord is the largest Danish lagoon with an area of ca. 290 km² and a mean depth 1.9 m (deepest area 5,1m). About one fourth of the fjord is shallower than 0.5 m and one third is between 2.5-3.5m deep. The interaction with the North Sea is controlled by a sluice keeping the water level below +25 cm (DVR) and the salinity between 6-15 psu. The lagoon receives freshwater corresponding to 2-3 times its volume; mainly from the stream Skjern Å. Since the 1980s the nutrient loading has been reduced significantly due to improved waste water treatment and reduced discharge from agriculture (Gertz et al. 2004).

Nisum Fjord (area 6, Table 3-1) just north of Ringkøbing Fjord is a 77 km² lagoon divided into 3 basins. The mean depth is 1 meter with a deeper area in each basin (2-2.5m deep). The exchange with the North Sea is regulated by a sluice. The stream Storåen is the major freshwater source with its outflow in the innermost part of the lagoon. The salinity varies from 0 to 33 psu; the range depending on the basin, and the (seasonal) balance between freshwater outflow and saltwater inflow. Since the 1980s the nutrient loading has been reduced significantly due to improved waste water treatment and reduced discharge from industries and agriculture (Gertz et al. 2004).

About 25 km north of Nisum Fjord, the estuarine 'channel' Limfjorden cuts west-east through Jutland connecting the North Sea with the Kattegat (areas 9-12 in Table 3-1). Limfjorden is around 1468 km². It comprises a number of basins connected by a navigation route running through the whole fjord (170 km long). The average water depth is 4.3m with a maximum of 28m. Salinity varies typically from 20 to 30 psu. The catchment area is one sixth of the total area of Denmark (7608 km²). Around 65 % of

the area is arable land with a high density of livestock, 15% is forest while the remainder is nature and urban areas. Since the 1980s, nutrient loading has been reduced, mostly due to improved sewage treatment. Presently, agriculture contributes to 70% of the nitrogen inputs and 37% of the phosphorus inputs (Anon. 2005a).

Mariager Fjord is situated on the east coast of Jutland, Denmark (area 19 in Table 3-1). It consists of an inner 10-30 m deep basin with nearly stagnant bottom water connected to the Kattegat by a narrow, winding, 6 m deep channel surrounded by tidal plains with water depths around 1 m. The water exchange between the sea and the basin is thus restrained by a very long threshold. Salinity is typically 12-17 psu in the surface water and 18-24 psu in the bottom water of the inner basin with a permanent halocline in 10-15m and anoxic conditions in the bottom water which are released only shortly every second or third year due to inflow of saline Kattegat water. The salinity in the Outer Fjord is 20-25 psu. Low oxygen concentrations occur in short periods in late summer. Since the Outer Fjord acts as a threshold, the water exchange with Kattegat is very slow, especially for the bottom water in the Inner Fjord. Due to the slow water exchange the concentrations of nutrients are among the highest in Danish waters although nutrient loading from the catchment area is similar to other areas in Denmark. Agriculture is a significant contributor to the loading (Fallesen et al. 2000).

Randers Fjord is a 27 km long shallow estuary located south of Mariager Fjord (area 20 in Table 3-1). The water exchange with the Kattegat is determined by a navigation channel running throughout the fjord. The channel is about 7m deep while the surrounding flats are below 2m. The horizontal salinity gradient is steep ranging from 0 in the inner part where 2 streams discharge into the estuary, to 18 psu (mean salinity). Correspondingly freshwater species dominate the inner estuary, brackish species the central parts and marine species the mouth of the Fjord. The water column of the navigation channel is generally stratified. Due to high organic loading, oxygen depletion occurs in the inner part of the Fjord. Abatement of nutrient loading was initiated in the 1970s, and phosphorus loading has declined significantly, mainly due to improved sewage treatment, while nitrogen loading from agriculture is still in excess (Nielsen et al. 2003).

The 2 estuaries Isefjord and Roskilde Fjord have a shared entrance to the southernmost part of Kattegat. Isefjord (area 21 in Table 3-1) is one of the largest Danish estuarine water bodies with an area of 307 km² and a water volume of 1560m³. It comprises of a large central basin connected to a number of sub-basins and to the Kattegat. The water exchange with Kattegat is restrained by a sill with a water depth of 3m. The average water depth is 5-7m. The largest depth (17m) is observed at the entrance to the southern sub-basins. The average salinity varies between 17 and 23 psu (range 15-28 psu) with seasonal and spatial gradients. Measures against nutrient loading have reduced the nutrient input since the 1990s; this is particularly significant for phosphorus. Runoff from agriculture is the dominant nutrient source (Anon. 2005b).

Roskilde Fjord (area 22 in Table 3-1) is smaller than Isefjord – 123 km² – and it is connected to the Kattegat through the most northern part of Isefjord. A sill divides the fjord into 2 distinct water bodies and cuts off the southern fourth resulting in limited water exchange resulting in a long residence time in the inner basin. The salinity varies between 14 and 23 psu in the northern part and between 10 and 17 psu in the southern part. Nutrient loading is dominated by diffuse run-off constituting about 80% and 34% of the N and P load respectively. In addition internal nutrient loading from the sediment is important, in particular in the southern basin (Hedal et al. 2005, Refsgaard 2007).

4 METHODS AND DATA

Two main data sources have formed the basis of this assessment: data from the national monitoring programme and data from mathematical modelling of the hydrological and ecological dynamics of the North Sea-Baltic Sea area.

In addition information has been gathered from assessments of the monitoring data (national and regional reports), and reports on modelling results. These are quoted in the text where used.

4.1 Inventory of Available Data

4.1.1 The Danish National Aquatic Monitoring and Assessment Programme

As basis for the assessment, the Environment Centres under the Danish Spatial and Environmental Planning Agency (Ministry of the Environment) made aggregated data from the monitoring in 2001-2005 available by answering a questionnaire. The data was delivered as yearly values estimated according to the national guidelines (<http://www.dmu.dk/Overvaagning/Fagdatacentre/Det+Marine+Fagdatacenter/>). These data was when needed supplemented with data downloaded from the national marine database MADS (<http://mads.dmu.dk>) and the international ICES databases, and personal communication with data holders, amongst others the Environment Centres.

The delivered data included: surface winter means of dissolved inorganic nitrogen and phosphorus (DIN and DIP) and surface annual means of chlorophyll-a (chl-a), information on algal blooms where available, lowest observed oxygen concentration in the bottom water, depth limit of eelgrass, and abundance and biomass of soft bottom invertebrate fauna (not monitored in all areas).

4.1.2 Marine Modelling

Two of DHI's model set up for the North Sea- Baltic Sea area were used for the assessment. The set up formerly used for simulation of pristine conditions was used for defining the reference condition of the open sea areas (DHI 2003, Erichsen et al. 2007). The model has recently been further refined under the BANSAL project (Skogen et al. 2006) and this model set up was used to estimate the status for 2001-2005 of coastal and open sea areas.

The model area covers the entire Baltic Sea, the transition area and the North Sea, with an open boundary to the north between Stavanger and Scotland (latitude app. 59°) and an open boundary to the south-west in the English Channel (latitude app. 51°). The model area is shown in Figure 4-1. In the transition area between the Baltic Sea and the North Sea an interactive two-way nesting technique is applied allowing a grid resolution of 3 nautical miles in this area. For the present study data from grids within the Danish OSPAR area (Figure 3-2) have been extracted (3nm in most cases and 9 nm for the central North Sea). For further information see Annex B and the reports quoted.

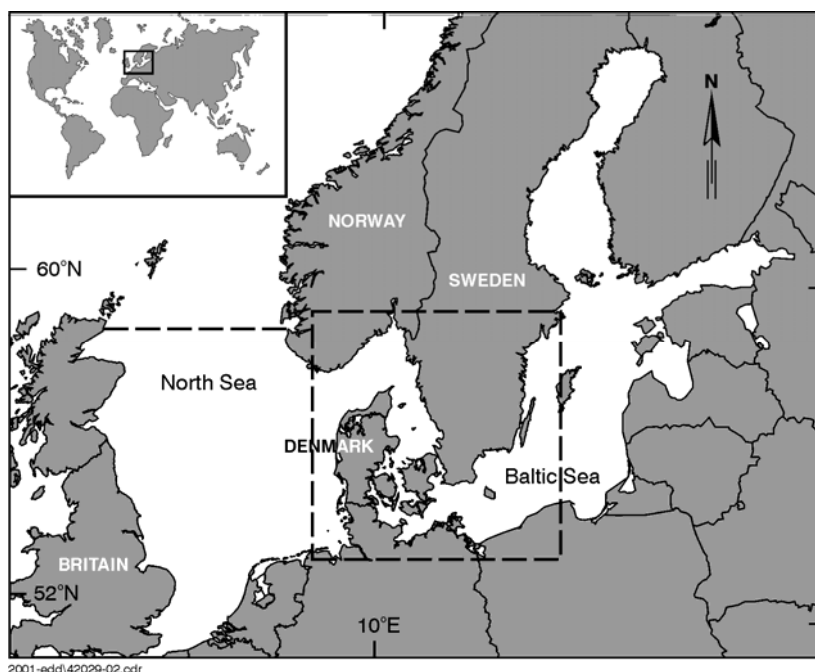


Figure 4-1 The regional model area. The dotted line between Scotland and Norway indicates an external boundary whereas the dotted square shows the area with the finer grid resolution.

4.2 Status and Temporal Trends

Assessment of status and trend were made based on status reports published by the former Danish counties (covering 2001-2004) and NERI, and data from 2001-2005 delivered by the Environment Centres and extracted from the mathematical model simulations as well as data extracted from the national marine database system MADS (<http://mads.dmu.dk>) and ICES databases.

The areas covered by the Environment Centres were classified as either estuarine or coastal areas. Estuarine area: The Wadden Sea (area 4), Ringkøbing Fjord (area 5), Nissum Fjord (area 6), areas of Limfjorden (areas 9-12), Mariager Fjord (area 19), Randers Fjord (area 20), Isefjord (area 21) and Roskilde Fjord (area 22). Coastal areas: Southern North Sea (area 2), Eastern North Sea coast (area 3), Southern coast of Skagerrak (area 7), Western coast of Kattegat (areas 15 and 16), Southern Kattegat (area 18).

While the data delivered by the Environment Centre present results from fixed station, the data extracted from the modeling cover whole areas, i.e. they are surface layer means (upper 5m) for the each of the near coast and open sea areas shown in Figure 4-1.

4.3 Methods for Consideration of Environmental Factors in the Assessments

Eutrophication status of Danish parts of the North Sea, Skagerrak and Kattegat has been assessed by using two different tools: 1) the OSPAR Comprehensive Procedure (OSPAR COMP) and 2) the draft HELCOM Eutrophication Assessment Tool (HEAT), which is based on the principles of the EU Water Framework Directive.

Focus has been on production of integrated assessment by these tools, and not on parameter related assessments, since the latter is only used indirectly for the final classification of the water bodies in question.

4.3.1 OSPAR COMP

The OSPAR Comprehensive Procedure is based on: 1) harmonised assessment criteria (Table 4-1), a list of qualitative assessment parameters (Table 4-2), and 3) a matrix for integration of categorised assessment parameters (Table 4-3).

Table 4-1 The agreed Harmonised Assessment Criteria and their respective assessment levels of the Comprehensive Procedure.

Assessment parameter		
Category I	Degree of nutrient enrichment	
	1	Riverine total N and total P inputs and direct discharges (RID) Elevated inputs and/or increased trends (compared with previous years)
	2	Winter DIN- and/or DIP concentrations Elevated level(s) (defined as concentration >50 % above salinity related and/or region specific background concentration)
	3	Increased winter N/P ratio (Redfield N/P = 16) Elevated cf. Redfield (>25)
Category II	Direct effect of nutrient enrichment (during growing season)	
	1	Maximum and mean Chlorophyll a concentration Elevated level (defined as concentration > 50 % above spatial (offshore) / historical background concentrations)
	2	Region/area specific phytoplankton indicator species Elevated levels (and increased duration)
	3	Macrophytes including macroalgae (region specific) Shift from long-lived to short-lived nuisance species (e.g. Ulva)
Category III	Indirect effect of nutrient enrichment (during growing season)	
	1	Degree of oxygen deficiency Decreased levels (< 2 mg/l: acute toxicity; 2 - 6 mg/l: deficiency)
	2	Changes/kills in Zoobenthos and fish kills Kills (in relation to oxygen deficiency and/or toxic algae) Long term changes in zoobenthos biomass and species composition
	3	Organic Carbon/Organic Matter Elevated levels (in relation to CIII.1) (relevant in sedimentation areas)
Category IV	Other possible effects of nutrient enrichment (during growing season)	
	1	Algal toxins (DSP/PSP mussel infection events) Incidence (related to CII.2)

The parameters, their harmonised assessment criteria and agreed level of acceptable deviation from background levels, as well as the principles for integration of categorised assessment parameters are straight forward: The OSPAR Comprehensive Procedure is a simple indicator (parameter) based assessment tool resulting in a multi-metric classification of eutrophication status.

For indicators which have positive response to nutrient inputs, e.g. Chl-a:

1. If 'eutrophication status' < RefCon + AcDev, then EutroQO (or target) is fulfilled.
2. If 'eutrophication status' ≥ RefCon + AcDev, then EutroQO is not fulfilled.

The parameters available within an area / water body are integrated as illustrated in the example in Table 4-4.

Table 4-2 The OSPAR Common Procedure qualitative assessment parameters.

A: The causative factors: the degree of nutrient enrichment • with regard to inorganic/organic nitrogen • with regard to inorganic/organic phosphorus • with regard to silicon taking account of: • sources (differentiating between anthropogenic and natural sources) • increased/upward trends in concentration • elevated concentrations • increased N/P, N/Si, P/Si ratios • fluxes and nutrient cycles (including across boundary fluxes, recycling within environmental compartments and riverine, direct and atmospheric inputs) B: The supporting environmental factors, including: • light availability (irradiance, turbidity, suspended load) • hydrodynamic conditions (stratification, flushing, retention time, upwelling, salinity, gradients, deposition) • climatic/weather conditions (wind, temperature) • zooplankton grazing (which may be influenced by other anthropogenic activities) C: The direct effects of nutrient enrichment: i. phytoplankton; • increased biomass (e.g. chlorophyll a, organic carbon and cell numbers) • increased frequency and duration of blooms • increased annual primary production • shifts in species composition (e.g. from diatoms to flagellates, some of which are nuisance or toxic species) ii. macrophytes, including macroalgae; • increased biomass • shifts in species composition (from long-lived species to short-lived species, some of which are nuisance species) • reduced depth distribution iii. microphytobenthos; • increased biomass and primary production D: The indirect effects of nutrient enrichment: i. organic carbon/organic matter; • increased dissolved/particulate organic carbon concentrations • occurrence of foam and/or slime • increased concentration of organic carbon in sediments (due to increased sedimentation rate) ii. oxygen; • decreased concentrations and saturation percentage • increased frequency of low oxygen concentrations • increased consumption rate • occurrence of anoxic zones at the sediment surface ("black spots") iii. zoobenthos and fish; • mortalities resulting from low oxygen concentrations iv. benthic community structure; • changes in abundance • changes in species composition • changes in biomass v. ecosystem structure; • structural changes E: Other possible effects of nutrient enrichment: i. algal toxins (still under investigation - the recent increase in toxic events may be linked to eutrophication)
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Table 4-3 The OSPAR COMP integration of categorised assessment parameters.

	Category I Degree of nutrient enrichment	Category II Direct effects	Category III and IV Indirect effects/ Other possible effects	Classification
A	+	+	and/or +	Problem area
B	—	+	and/or +	Problem area
C	+	—	—	Potential problem area
D	—	—	—	Non-problem area

'+' = Increased trends, elevated levels, shifts or changes in the respective assessment parameters in Table 4.1.

'—' = Neither increased trends nor elevated levels nor shifts nor changes in the respective assessment parameters in Table 4.1. Note: Categories I, II and/or III/IV are scored '+' in cases where one or more of its respective assessment parameters is showing an increased trend, elevated level, shift or change.

Table 4-4 A constructed example of integration and final classification.

	Assessment criteria (indicator)	Reference conditions	Acceptable deviation	Status (2001-2005)	Score (+/—)
Cat I	N load (total annual landbased input)	2626 t y ⁻¹	+50%	11242 t y ⁻¹	+
	P load (total annual landbased input)	54 t y ⁻¹	+50%	339 t y ⁻¹	+
	DIN (annual mean)	12.4 µM	+50%	24,64 µM	+
	DIP (annual mean)	0.39 µM	+50%	0.74 µM	+
	Sum for Category I (one out, all out)				+
Cat II	Chlorophyll-a (annual mean)	1.5 µg l ⁻¹	+50%	3.0 µg l ⁻¹	+
	Sum for Category II (one out, all out)				+
Cat III	Eelgrass depth limit	7.7 m	+25%	5.4 m	+
	Sum for Category III (one out, all out)				+
Cat IV	Abundance of <i>Aphanizomenon</i> sp.	12500 unit l ⁻¹	+50%	31654 l ⁻¹	+
	Sum for Category IV (one out, all out)				+
	Final classification:				+

The approach used by the OSPAR COMP is simple and transparent and has been applied in coastal waters of the North-West Atlantic (OSPAR 2001) and the Baltic Sea (Andersen et al. 2006). However, the OSPAR COMP does not fully meet the requirements of the EU Water Framework Directive. Applying the OSPAR's approach together with other relevant principles have led to suggestions on how these could be improved by including WFD requirements without losing simplicity and transparency.

4.3.2 HEAT

In contrast to the OSPAR COMP, the draft HELCOM Eutrophication Assessment Tool (HEAT) meets the requirements of the EU Water Framework Directive (Andersen et al. 2005).

Most of the principles behind OSPAR COMP and HEAT are identical. However, in HEAT: (1) the categories used by OSPAR COMP have been shifted to quality elements (QE) *sensu* WFD; (2) the Ecological Quality Ratio (EQR) where the present status (observed values) is compared to reference conditions has been calculated; and (3) the "one out, all out" principle corresponds to the principle used in the WFD.

HEAT has been structured to comply with the requirements of the WFD. The tool is based on quantitative information on reference conditions *sensu* the WFD, and corresponding current conditions based on recent monitoring and assessment activities.

The overall classification of eutrophication status can be summarised in 5 equations:

1. $\text{EutroQO} = \text{RefCon} \pm \text{AcDev}$,
where EutroQO is “eutrophication quality objective” (or target) corresponding to the boundary between good and moderate ecological status, RefCon is “reference condition” and AcDev is “acceptable deviation”.

For indicators which have positive response to nutrient inputs, e.g. Chl-a:

2. If ecological status $< \text{RefCon} + \text{AcDev}$, then EutroQO (or target) is fulfilled.
3. If ecological status $\geq \text{RefCon} + \text{AcDev}$, then EutroQO is not fulfilled.

For indicators which have a negative response to nutrient inputs, e.g. Secchi depth:

4. If ecological status $> \text{RefCon} - \text{AcDev}$, then EutroQO (or target) is fulfilled.
5. If ecological status $\leq \text{RefCon} - \text{AcDev}$, then EutroQO is not fulfilled.

In other words: When the eutrophication status is within the range defined by the acceptable deviation from reference conditions, the eutrophication quality objective (per indicator) is fulfilled and the site in questions is considered to be an “eutrophication non-problem area”. When the eutrophication status is outside the range defined by the acceptable deviation from the reference conditions, the eutrophication quality objective is not fulfilled and the site in question is considered to be an “eutrophication problem area”.

A critical decision in implementing WFD is to define the boundary between ‘good ecological status’ and ‘moderate ecological status’. Setting the breakpoint between ‘good’ and ‘moderate’ status is despite the work related to the WFD Intercalibration in 2004 - 2007 still an unresolved issue in the implementation of WFD. To that end HEAT offers a total flexibility of defining the boundaries not only between good and moderate status but between high/good, moderate/poor and poor/bad eutrophication status. In principle, HEAT can cope with ‘acceptable deviation’ ranging from 15% to infinity. Table 4.5 presents the most commonly used ‘definitions’ of the boundary between ‘good’ and ‘moderate’.

Table 4-5 Examples of the most commonly used quality classes used. The classes are expressed as EQR values. Please note that GMB denotes the boundary between ‘acceptable’ and ‘unacceptable’ deviation from RefCon, e.g. the Good/Moderate boundary, which is indicated with a bold line.

AcDev	Ecological Quality Ratio (EQR)					
	RefCon	High	Good	Moderate	Poor	Bad
+50%	[1.000-0.950]	[0.950-0.808]	[0.808-0.667]	[0.667-0.525]	[0.525-0.383]	[0.383-0.000]
+25%	[1.000-0.950]	[0.950-0.875]	[0.875-0.800]	[0.800-0.725]	[0.725-0.650]	[0.650-0.000]
+20%	[1.000-0.950]	[0.950-0.892]	[0.892-0.833]	[0.833-0.775]	[0.775-0.717]	[0.717-0.000]
+15%	[1.000-0.950]	[0.950-0.910]	[0.910-0.870]	[0.870-0.829]	[0.829-0.789]	[0.789-0.000]
±50%	[1.000-0.950]	[0.950-0.725]	[0.725-0.500]	[0.500-0.275]	[0.275-0.050]	[0.050-0.000]
±25%	[1.000-0.950]	[0.950-0.850]	[0.850-0.750]	[0.750-0.650]	[0.650-0.550]	[0.550-0.000]
±20%	[1.000-0.950]	[0.950-0.875]	[0.875-0.800]	[0.800-0.725]	[0.725-0.650]	[0.650-0.000]
±15%	[1.000-0.950]	[0.950-0.090]	[0.090-0.850]	[0.850-0.800]	[0.800-0.750]	[0.750-0.000]

It should be noted that the lower value (boundary) of a given quality class, the classification result is deferred to the quality class below. For example, using an acceptable deviation of 50%, the EQR is 0,667 and the quality class is 'moderate', not 'good'.

The first step of the assessment made by HEAT is done per indicator, then averaged per quality element and finally made applying the "one out, all out" principle meaning that the lowest EQR for a QE determines the overall outcome of ecological state. This is, compared to the OSPAR COMP, an important advantage. It should, as a precautionary note, be mentioned that the final assessments 'produced' by HEAT has been compared to those 'produced' by OSPAR COMP and that the status classification is almost identical (see Andersen et al. 2005 for details).

Another advantage of HEAT is that it enables users to make an interim confidence assessment and hence to judge the quality of the final assessment, e.g. to check whether the assessment is to be trusted or not? The principles for the interim confidence assessment are still under development, but are introduced in order to demonstrate ways to further develop the OSPAR COMP and/or HEAT. The approach currently being developed is simple: The data regarding RefCon, AcDev and Status is scored for each indicator. The scoring card is also very simple: excellent data quality is given the score 1; fair data quality is given the score 2; and low data quality is given the score 3. Hence, each indicator has a minimum score of 3×1 indicating a very good quality and a maximum score of 3×3 indicating a very low quality. 'Indicator quality' is then combined per QE and subsequently calculated as an overall confidence rating, the latter expressed as 3 classes (I = excellent, II = fair, and III = low). Examples of scoring are included in Annex E. The tool is expected to be improved and take into account information on the number of indicators and quality elements used for the assessment. A final, tested and documented tool for confidence assessment of eutrophication assessments is expected to be published in December 2008.

5 EUTROPHICATION ASSESSMENT

5.1 Status and Temporal Trends

The status and temporal trends have been assessed for the key elements in Danish monitoring within the OSPAR categories I-IV and the key findings are presented below. A summary of the overall assessment, the present status and the long term trend of the assessed areas are given in Table 5-3.

5.1.1 Category I. Degree of Nutrient Enrichment

Nutrients

The overall trend in nutrient concentrations (total nitrogen TN, dissolved inorganic nitrogen DIN, total phosphorus TP and dissolved inorganic phosphorus DIP) in Danish maritime water shows decreasing concentrations since the early 1990s and mid 1990s for phosphorus and nitrogen respectively (Ærtebjerg et al. 2007).

For phosphorus the concentrations stabilized in the late 1990s and have since 2000 fluctuated around a constant level. The winter concentrations of the assessed OSPAR areas followed this overall trend with some local variation in the year-to-year trends (Annex C showing winter means of DIP concentrations). On a national basis there was a tendency towards increasing DIP and TP in 2005 (Ærtebjerg et al. 2007). This trend was not recognized in the winter means of the OSPAR areas, neither when based on fixed station monitoring nor when drawing on the means extracted from the modeling.

The winter means of inorganic phosphorus based on fixed station measurements mostly vary between 5 and 40 µg/L (Annex C). Two areas, Mariager Fjord and Roskilde Fjord, deviate significantly showing values between 70 and 100 µg/L resulting in overall means varying between 30-40 µg/L for estuarine areas and 15 and 25 µg/L for coastal areas.

For nitrogen the concentrations shows a tendency to stabilize after 2003 although with indications of a continuous less marked decline after 2003 (Ærtebjerg et al. 2007). This decreasing trend is also observed in the 2001-2005 data from the OSPAR areas. An extended period is however needed to verify if this is a consistent trend. As for phosphorus the winter concentrations of assessed area show some variation in the year-to-year fluctuations (Annex C showing winter means of DIN concentrations).

The winter means of inorganic nitrogen based on fixed station measurements mostly vary between 80 and 1000 µg/L (Annex C). However, four areas deviate significantly from this range. In Nissum Fjord and Randers Fjord the means are between 1800 and 2700 µg/L, and in Mariager Fjord and Ringkøbing Fjord means between 1200 and 1650 µg/L are observed. Thus the resulting overall means varies between 940-1150 µg/L for estuarine areas and 170-230 µg/L for coastal areas.

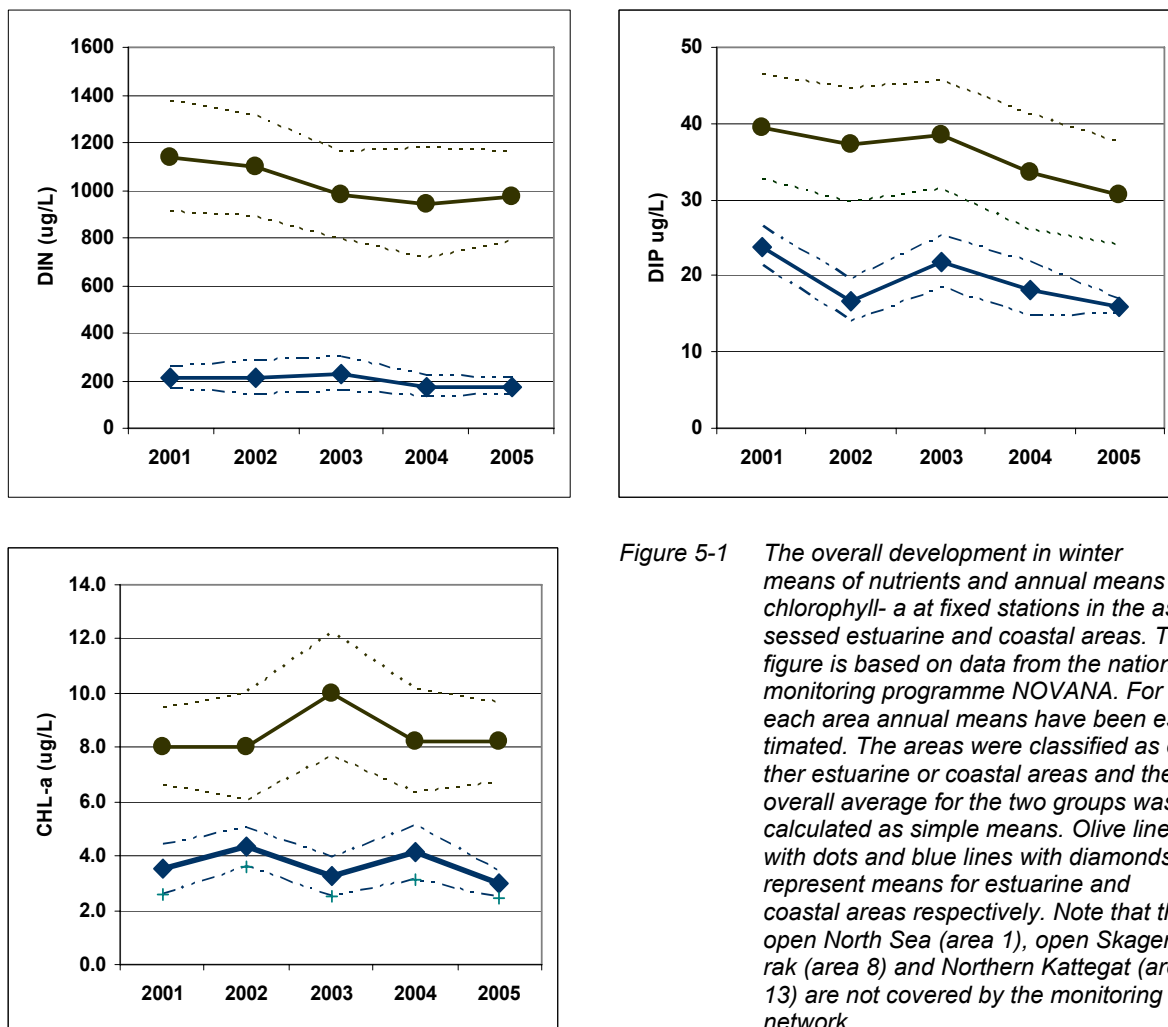


Figure 5-1 The overall development in winter means of nutrients and annual means of chlorophyll- a at fixed stations in the assessed estuarine and coastal areas. The figure is based on data from the national monitoring programme NOVANA. For each area annual means have been estimated. The areas were classified as either estuarine or coastal areas and the overall average for the two groups was calculated as simple means. Olive lines with dots and blue lines with diamonds represent means for estuarine and coastal areas respectively. Note that the open North Sea (area 1), open Skagerrak (area 8) and Northern Kattegat (area 13) are not covered by the monitoring network.

5.1.2 Category II. Direct Effects of Nutrient Enrichment

Chlorophyll

Following the long term decline in nutrient enrichment, the concentrations of chlorophyll in the water column and thus phytoplankton, are reduced in Danish estuarine water bodies. Annual means of the chlorophyll-a in Danish estuarine areas show a significant decreasing trend since 1989 when normalized to run-off, while a similar relationship is not observed for the coastal and open waters (Ærtebjerg et al. 2007).

The latter is demonstrated for the Danish OSPAR area in Table 5-1 exemplifying the development in chl-a at 4 stations along a transect from the southern North Sea to the southern Kattegat. Correspondingly the area-integrated means show very little variation in 2001-2005 (Figure 5-2) with aggregated means between 2.5 and 3.2 $\mu\text{g/L}$ (range of area-integrated values is 1.5 and 4.5 $\mu\text{g/L}$). When assessed based on fixed stations (Figure 5-1) the aggregated annual means for 2001-2005 are a little higher, varying between 3.0 and 4.2 $\mu\text{g/L}$ with an aggregated mean for the period of 3.5 $\mu\text{g/L}$ (Table 5-). The reason for this discrepancy is probably a combination of the rather coastal location of the fixed station and the differences in scaling of the station and the modeling approaches (temporally and spatially).

Table 5-1 Range and annual means of chlorophyll-a concentration in the assessed coastal and estuarine areas respectively. Based on monitoring of fixed stations. * = maximum value when the 2 high level fjords are omitted.

2001-2005	Coastal areas	Estuarine areas
Range of annual means	0.9 – 8.5 µg/L	2.7 – 27.1(13.4)* µg/L
Average	3.5 µg/L	8.5 µg/L
Trend	none	none

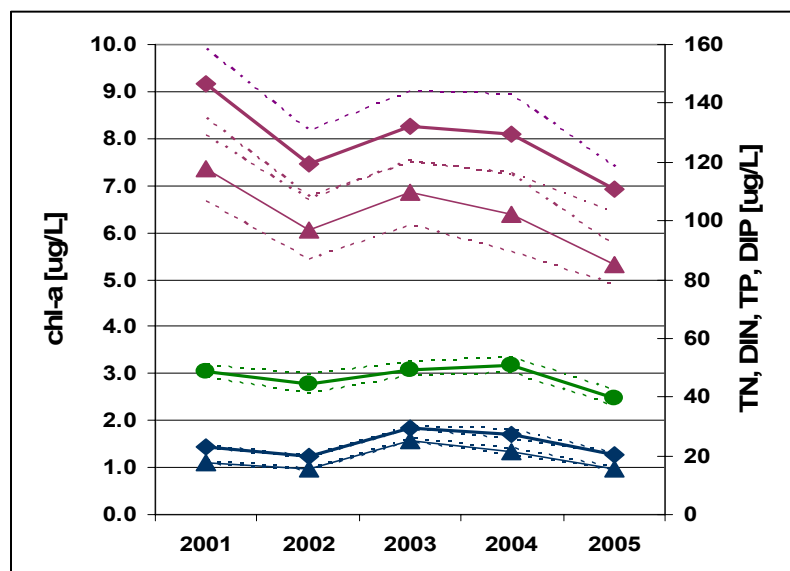


Figure 5-2 The overall development in winter means of nutrients and annual means of chlorophyll- a in the surface layer (5m) of the assessed coastal and open sea areas based on data extracted from the mathematical modelling. The model grids are classed in the defined assessment areas and the areal means are calculated for each area. Solid purple lines represent means of TN (diamonds) and DIN (triangles). Solid blue lines represent means of TP (diamonds) and DIP (triangles). Solid green lines represent means of chl-a. The dotted lines show the standard errors.

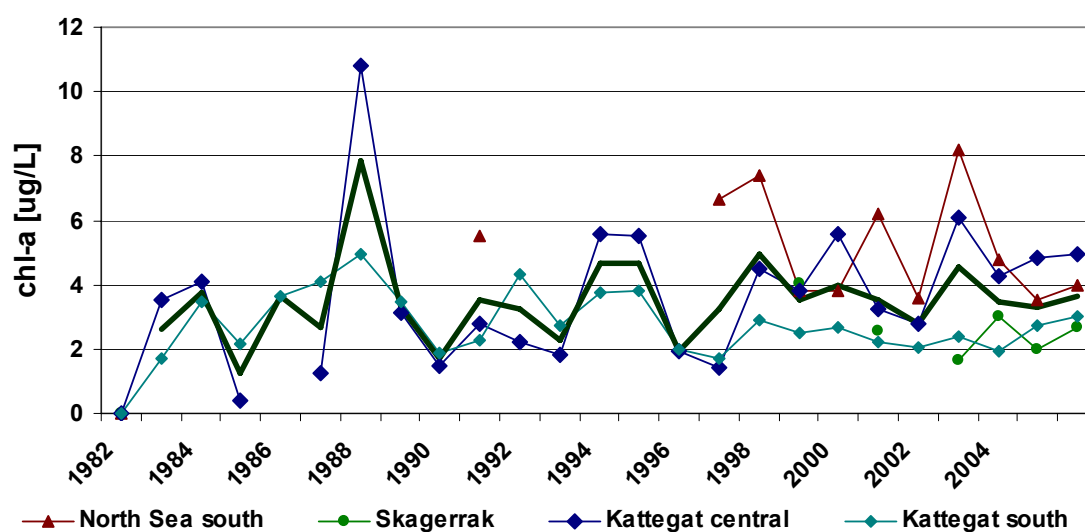


Figure 5-3 Long term development in annual means of chl-a along a transect from the southern North Sea (area 2) through the coastal area of Skagerrak (area 7) and central Kattegat (area 14) to the southern Kattegat at the entrance to Storebælt (area 17). Data extracted from the MADS and the ICES databases. The thick solid line represents the mean of the areas.

Eelgrass

Reduction in chlorophyll level and the associated improvements of the Secchi depth has been expected to promote the distribution of bottom vegetation, i.e. in Danish waters primarily the vertical and horizontal dispersal of eelgrass. This has however not been the case. On the contrary the maximum depth limit is reduced in the inner basins of the estuarine areas and other indicators do not verify any positive trend neither in the estuarine waters nor in the coastal and open sea (Ærtebjerg et al. 2007).

For the assessed OSPAR areas, the maximum depth limit of eelgrass only approaches the reference condition in the Isefjord where the index (ratio) status:reference condition varies between 79 and 99% in 2001-2005 (Annex C). For the remaining areas the index varies within the range 25-70%. The mean index value for all areas is 48% implying the depth distribution of eelgrass on average is half of the reference condition (Figure 5-4).

The reasons for the lack of positive effects of declining nutrient enrichment are under discussion. Major factors suggested to deaden the positive impact are occurrences of oxygen depletion and insufficient physical-chemical quality of the sediment (Ærtebjerg et al. 2007).

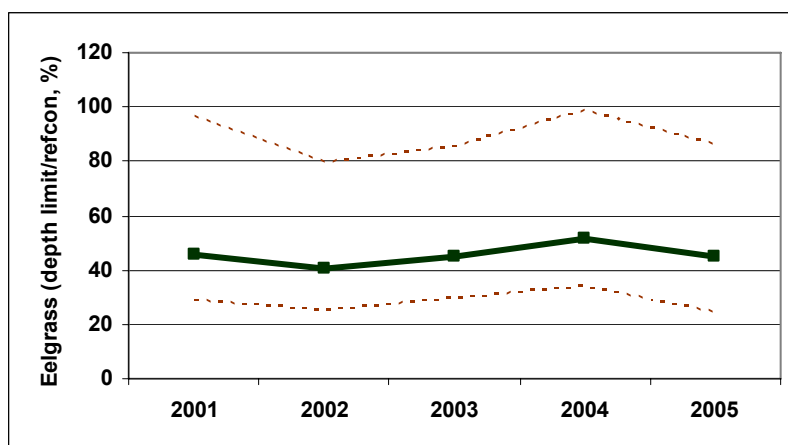


Figure 5-4 The depth limit of eelgrass in the assessed areas calculated as percentages of the reference condition, cf. Annex E. the solid line represents the aggregated mean calculated from the index status:reference condition of each area in the individual years. The dotted lines give the minimum and maximum ratios respectively for the included areas. Note that data was available for 11 out of the 22 areas.

5.1.3 Category III. Indirect effects of Nutrient Enrichment

Oxygen depletion

Oxygen depletion is common in Danish coastal waters and in the Kattegat. In the Skagerrak and the North Sea, oxygen deficiencies are only observed in the southern North Sea where concentrations between 2-4 mg/L are measured on rare occasions. The degree of the oxygen depletion depends on the strength and temporal extension of the stratification of the water bodies, which again are determined by the wind velocity and direction and for the Kattegat the inflow of saline bottom water from the Skagerrak. In addition, the nutrient loadings have a significant impact on the oxygen consumption in the bottom waters.

In 2001-2005, the oxygen conditions did not deviate from the preceding period. Only in 2002, severe oxygen depletion was observed (see Figure 5-65 and Annex B (giving the annual means of the assessed areas)). In the autumn the inner Danish coastal waters experienced widespread and in places long lasting hypoxia with O₂ concentrations in the bottom waters lower than 2 mg/l. The area affected was about twice the one influenced in the remaining years of the period. In the Kattegat, the southern part was particularly affected.

Amongst the assessed areas low oxygen concentration occurred annually in Nissum Fjord, the southern Limfjord, Mariager Fjord and along the western coast of Kattegat. In the shallow Nissum Fjord no trend is detectable while in the Limfjord and the estuarine areas on the west coast of Kattegat as well as in the Kattegat a significant decline has been demonstrated for the mean bottom water concentration during periods with marked stratification (Ærtebjerg et al. 2007).

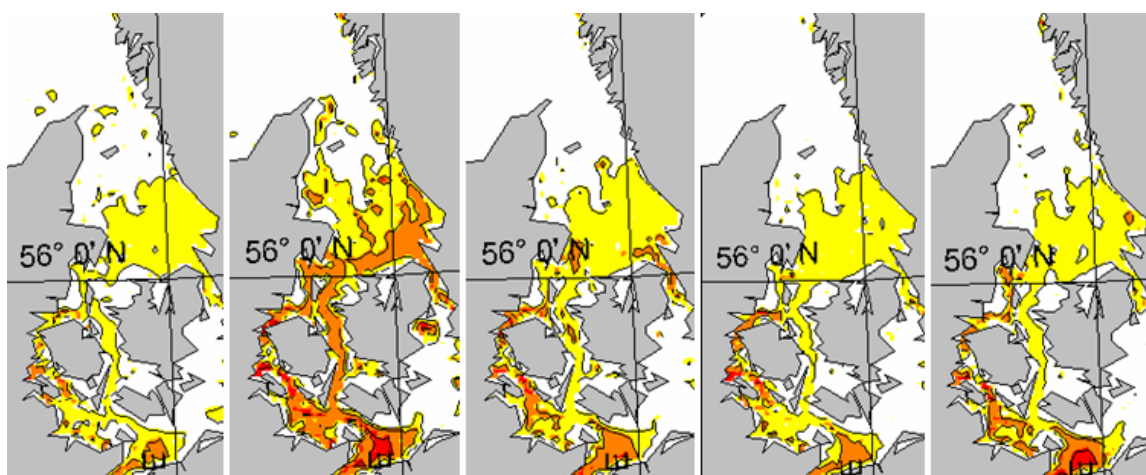


Figure 5-5 Maps showing the extension of low oxygen content in the bottom water of the inner Danish maritime waters in 2001(left)-2005(right). Data extracted from dynamic modeling of the oxygen condition.

Table 5-2 Total and relative area influenced by oxygen depletion below 2 mg/L in the Kattegat and Limfjorden. Source: Ærtebjerg et al. 2007.

Area	Size (km ²)	Oxygen concentrations < 2 mg/L				
		2001	2002	2003	2004	2005
Kattegat, northern parts	4405	0	0	0	0	0
Limfjorden	1522	329 (22%)	251 (17%)	344 (23%)	180 (12%)	254 (17%)
Kattegat, central parts	8491	8 (0%)	524 (6%)	160 (2%)	8 (0%)	8 (0%)
Kattegat, southern parts	9432	93 (1%)	1360 (14%)	331 (4%)	43 (0%)	194 (2%)

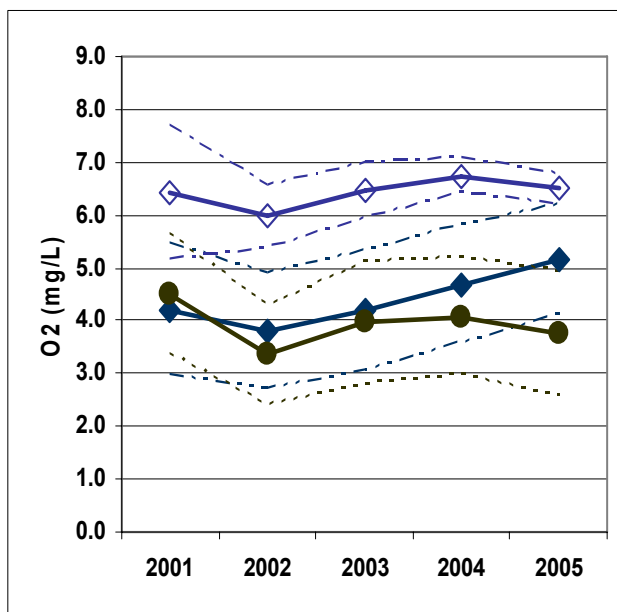


Figure 5-6 Lowest oxygen concentration (mg/L) observed by the Environment Centres at the monitoring stations in the assessed areas. Measurement are made as close to bottom as possible.

The olive curve with dots: aggregated estuarine means. The blue lines with solid diamonds: all coastal and open sea areas while the curve with open diamonds shows average where the Central and Western Kattegat are excluded.

Note that for a few of the areas data was not available and that the open North Sea (area 1), open Skagerrak (area 8) and Northern Kattegat (area 13) are not covered by the monitoring network.

Soft bottom benthic fauna

In general the soft bottom fauna does not show any uniform trends. In the individual estuarine areas both abundance and biomass fluctuates from year to year (Figure 5-7). Oxygen depletion temporarily impoverishes the fauna and in severe cases it takes a few years before the fauna is recovered.

The extensive oxygen depletion in Kattegat in 2002 had a clear impact on the bottom fauna (Figure 5-8). Considering the long term development in Kattegat, unexplainable reduction is observed in species richness, and also in a new multi-metric quality index DKI which combines species richness and occurrence of sensible species show corresponding decline (Ærtebjerg et al. 2007). No relationship to eutrophication has been established and the cause of the benthic fauna impoverishment is unknown.

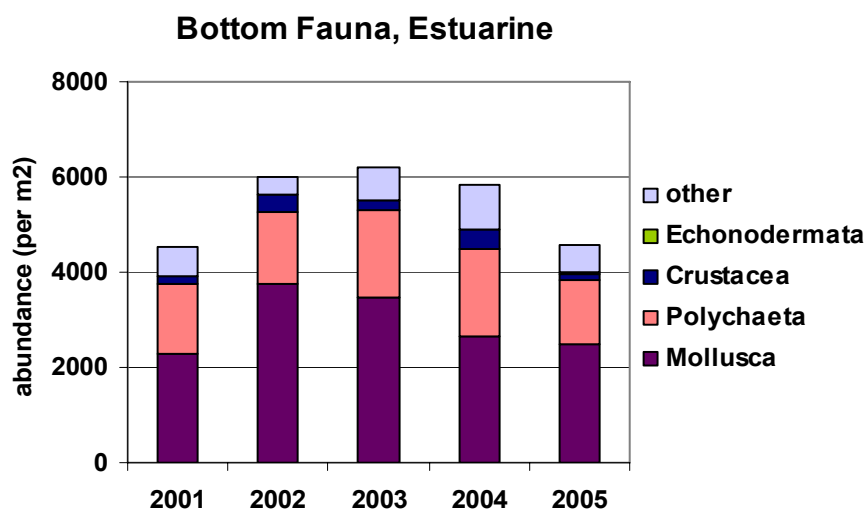


Figure 5-7 Mean abundance of soft bottom fauna in estuarine areas. Means are calculated by averaging means of each of the assessed OSPAR areas where bottom fauna are monitored.

Western Kattegat (area 16)

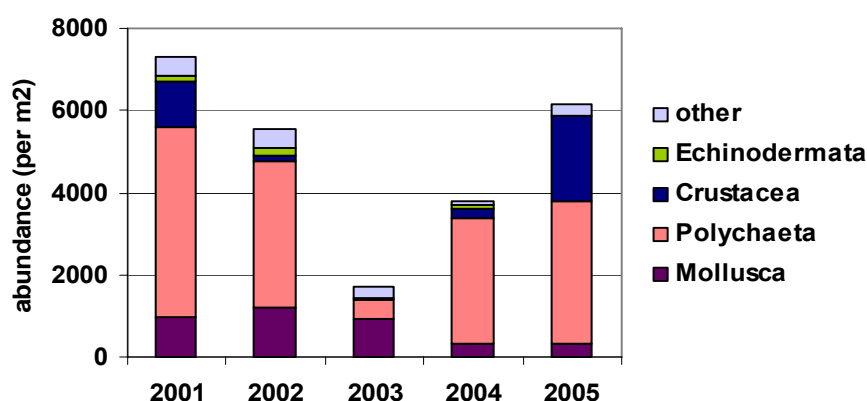


Figure 5-8 Mean abundance of soft bottom fauna in the southern part of the south-western Kattegat (area 16).

5.1.4 Category IV. Other Possible Effects of Nutrient Enrichment

Toxic algae

Blooms of potential toxic algae occur regularly in Danish maritime waters. The species observed in high concentrations in the OSPAR areas in 2001-2005 are shown in Table 5-3. *Chattonella* and *Chrysochromulina* may cause death of fish and bottom fauna but no effects were related to the occurrences observed in 2001-2005. In the southern North Sea a decline in occurrences of *Noctiluca scintilans*, *Phaeocystis* and *Pseudo-nitzschia delicatissima* has been noticed since 2001. The blooming of *Dinophysis* in 2002 caused close-down of the mussel harvesting for long periods in some areas. The occurrences resulted in critical levels of DSP in mussels and two fatale incidents with dogs in the Southern North Sea were attributed to DSP in mussels (Rasmussen et al. 2003).

Table 5-3 Potential toxic algae occurring in high concentrations in 2001-2005 in the Danish OSPAR areas. Timing of the blooming and the areas with high concentrations are given for each year. Source: Ærtebjerg et al. 2002, 2004, 2005, 2007 and Rasmussen et al. 2003.

Species	2001	2002	2003	2004	2005
<i>Chattonella</i>	Spring Roskilde Fjord, Isefjord, Ringkøbing Fjord			Southern Limfjord, Southern North Sea	Summer Southern Limfjord
<i>Dinophysis</i>		Summer-early au- tumn Wadden Sea, Southern North Sea			
<i>Pseudo-nitzschia</i> *			Summer-early au- tumn South-western Kat- tegat		Summer-autumn Southern North Sea, Central and Southern Limfjord, Kattegat, Roskilde Fjord, Isefjord
<i>Chrysochromulina</i>					Early summer Roskilde Fjord

* Concentrations not high but above the guideline for harvesting mussel.

5.1.5 Compilation

In Table 5-4 the assessment of the status and trends in the OSPAR areas are summarised. The information given in the above paragraphs and in the table has together with the data been used as the input to the overall assessments discussed in chapter 6.

Table 5-4 Compilation of the information on the assessed OSPAR areas based on available data and regional and governmental status and development reports.

Status		
	2001-2005	Long term trends
North Sea, open waters (area 1)	Northern part: Concentrations of nutrients are not elevated. Central part: Nutrient concentrations elevated due to Jutland Coastal Current.	
	n/a	n/a
Southern North Sea (area 2)	Nutrient and chl-a concentrations elevated due to local inputs and inputs from Jutland Coastal Current.	
	Concentrations fluctuate around constant level. No oxygen depletion observed.	No trends in TN, DIN. No trends in winter TP, DIP in but significant reduction during summer since 1989. No trends in chl-a concentrations. No trends in algal biomass.
North Sea coastal waters (area 3)	Nutrient concentrations elevated due to local inputs and input from the Jutland Coastal Current.	
	Nutrient and chl-a concentrations fluctuating with a decreasing trend in 2003-2005. Chl-a concentrations fluctuate around constant level.	Summer (May-Sep) mean of chl-a declining since 1989.
Danish Wadden Sea (area 4)	Nutrient concentrations elevated. Tendency towards reduction in bottom fauna biomass.	
	Nutrients fluctuating around constant level. No oxygen depletion observed.	No trends in TP and DIP. No trends in winter TN and DIN. In summer both have declined significantly in the northern part of the area since 1989 while in the same period chl-a has increased significantly. No trends in the rest of the Danish Wadden Sea.
Ringkøbing Fjord (area 5)	Nutrient and chl-a concentrations elevated. Oxygen depletion rare. Depth limit and coverage of eelgrass reduced.	
	Nutrient concentrations fluctuate around constant level while chl-a shows an upward trend. Noxious and potential toxic algae: <i>Alexandrium Prorocentrum</i> , <i>Chattonella</i> , and in particular <i>Chrysochromulina</i> . Depth limit of eelgrass fluctuate around 44% of reference condition. Bottom fauna biomass dominated by <i>Mya arenaria</i> and increasing 2001-2005.	A regime shift due to change in sluice practice hampers long term analyses. Since change in practice, there have been no unambiguous developments attributable to eutrophication.
Nisum Fjord (area 6)	Nutrient and chl-a concentrations elevated. Oxygen depletion occurs annually. Depth limit and coverage of eelgrass reduced.	
	Nitrogen level the highest amongst the assessed areas. Noxious and potential toxic algae: <i>Prorocentrum</i> (<i>P. minimum</i> blooms), <i>Prymnesium Pseudo-nitzschia</i> , <i>Chrysochromulina</i> and several cyanobacteria. Annual oxygen depletion for brief periods. Depth limit of eelgrass fluctuate around 37% of reference condition. Bottom fauna abundance and biomass fluctuate.	Nutrient development ambiguous. Decreases in winter nitrogen (TN and DIN) and summer DIP but no trend in winter DIP. Significant reduction in chl-a in the innermost basin. Cyanobacteria almost disappeared since late 1990s. Depth limit of bottom vegetation increasing except for recent years while area coverage decreasing. Bottom fauna abundance and biomass fluctuate.

	Status	
	2001-2005	Long term trends
Skagerrak coastal waters (area 7)	<i>Nutrient and chl-a concentrations elevated due to input from the Jutland Coastal Current.</i>	
	Nutrients and chl-a fluctuate around constant level. No oxygen depletion. Bottom fauna abundance, biomass and species diversity varying.	Winter TN decreasing in surface water in 1992-2005 while TP, DIN and DIP fluctuate around constant level. No oxygen depletion. No trend in bottom fauna 1986-2005, biomass and diversity relatively high.
Skagerrak Open waters (area 8)	<i>Concentrations of nutrients are not elevated.</i>	
	Nutrient and chl-a concentrations fluctuated around constant level. No oxygen depletion.	n/a
Western Limfjord (area 9)	<i>Nutrient and chl-a concentrations elevated. Oxygen depletion rare. Depth limit and coverage of eelgrass reduced. Bottom fauna deteriorated.</i>	
	(Nissum Bredning) Summer-autumn blooms of diatoms. Noxious and potential toxic algae: <i>Noctiluca</i> , <i>Pseudo-nitzshia</i> , <i>Dinophysis</i> , <i>Chattonella</i> , <i>Gymnodinium</i> , <i>Karenia</i> , <i>Prorocentrum</i> and <i>Alexandrium</i> . Temporary problems with algal toxins. No oxygen depletion observed. Improved depth limit of eelgrass (43->52% of reference condition). Bottom fauna abundance, biomass and species diversity varying.	TN, DIP, TP concentrations reduced late 1980s – late 1990s (TP significant). Compared to the previous assessment period (1998-2001) nutrient concentrations elevated in 2001-2003. Chl-a fluctuates around constant level throughout both periods. No long term trend in chl-a concentration. Oxygen depletion rare. Eelgrass depth limit and coverage declining, i.e. no overall improvement. Bottom fauna abundance, biomass and species diversity varying without any trend.
Central Limfjord (area 10)	<i>Nutrient and chl-a concentrations elevated. Oxygen depletion common. Depth limit and coverage of eelgrass reduced. Bottom fauna deteriorated.</i>	
	(Løgstør Bredning) Summer-autumn blooms of diatoms and <i>Heterocapsa triquetra</i> . Noxious and potential toxic algae: <i>Noctiluca</i> , <i>Pseudo-nitzshia</i> , <i>Dinophysis</i> , <i>Chattonella</i> , <i>Gymnodinium</i> , <i>Karenia</i> , <i>Prorocentrum</i> and <i>Alexandrium</i> . Temporary problems with algal toxins. Oxygen depletion occurs annually. Eelgrass depth limit slightly increasing but still markedly lower than reference condition (32->38% of RC). Bottom fauna abundance, biomass and species diversity varying.	TN, DIP, TP concentrations reduced from late 1980s till late 1990s (TP significant). Compared to the previous assessment period (1998-2001) nutrient concentrations elevated in 2001-2003. Chl-a fluctuates around constant level throughout both periods. No long term trend in chl-a concentration. Oxygen depletion common without any trend. Eelgrass depth limit and coverage declining, i.e. no overall improvement. Bottom fauna abundance, biomass and species diversity varying without any trend.
Southern Limfjord (area 11)	<i>Nutrient and chl-a concentrations elevated. Severe oxygen depletion common. Depth limit and coverage of eelgrass reduced. Bottom fauna deteriorated.</i>	
	(Skive Fjord) Summer-autumn blooms of diatoms and <i>Prorocentrum minimum</i> . Noxious and potential toxic algae: <i>Pseudo-nitzshia</i> , <i>Dinophysis</i> , <i>Chattonella</i> and <i>Prorocentrum</i> . Temporary problems with algal toxins. Oxygen depletion in 5 of 5 years. Improved depth limit of eelgrass but still markedly lower than reference condition (30->44% of RC). Bottom fauna abundance, biomass and species diversity varying.	TN, DIP, TP concentrations reduced late 1980s – late 1990s (TP significant). Compared to the previous assessment period (1998-2001) nutrient concentrations elevated in 2001-2003. Chl-a fluctuates around constant level through both periods. No trend in chl-a concentration. Yearly oxygen depletion. Eelgrass depth limit and coverage declining, i.e. no overall improvement. Bottom fauna abundance, biomass and species diversity varying without any trend.

	Status	
	2001-2005	Long term trends
Eastern Limfjord (area 12)	<i>Nutrient and chl-a concentrations elevated. Oxygen depletion rare. Depth limit and coverage of eelgrass reduced. Bottom fauna deteriorated.</i>	
	(Nibe Bredning) No oxygen depletion. Improved depth limit of eelgrass but still markedly lower than reference condition (29->35% of RC). Bottom fauna abundance, biomass and species diversity varying.	TN, DIP, TP concentrations reduced late 1980s – late 1990s (TP significant). Compared to the previous assessment period (1998-2001) nutrient concentrations elevated in 2001-2003. No long term trend in chl-a concentration. Oxygen depletion rare. Eelgrass depth limit and coverage declining, i.e. no overall improvement. Bottom fauna abundance, biomass and species diversity varying without any trend.
Northern Kattegat (area 13)	<i>Nutrient and chl-a concentrations elevated</i>	
	Nutrient and chl-a concentrations fluctuated around constant level. No oxygen depletion.	n/a
Central Kattegat (area 14)	<i>Nutrient and chl-a concentrations elevated. Oxygen depletion common.</i>	
	Nutrient and chl-a concentrations fluctuated around constant level. Oxygen depletion in most year – intensity varies	Decline in TP from mid 1980s – early 1990s. No uniform long term trends in other nutrient. No trend in chl-a. Oxygen content in bottom water during stratification declining. Bottom fauna deteriorated.
Western Kattegat (area 15 and 16)	<i>Nutrient and chl-a concentration elevated. Oxygen depletion occurring regularly. Distribution of eelgrass reduced. Bottom fauna indicators indicate deteriorate status.</i>	
	Nutrients and chl-a fluctuate around constant level. Summer-autumn blooms of diatoms. Noxious and potential toxic algae: <i>Pseudonitzschia</i> , <i>Dinophysis</i> , <i>Prorocentrum</i> , <i>Alexandrium</i> , <i>Chattonella Dictyocha</i> , <i>Chrysochromulina</i> , <i>Phaeocystis</i> , <i>Anabaena</i> , <i>Nodularia</i> . In a few cases blooming. Oxygen depletion most years; severe in 2002 and 2003. No trend in depth limit of eelgrass (in area 11 about 30% of reference condition).	TN, DIP, TP winter concentrations decreasing 1989->2000 while DIN fluctuates around constant level. chl-a fluctuate around constant level. Oxygen depletion common without any trend. No trend in eelgrass or in bottom fauna.
Southern Kattegat (area 17 and 18)	<i>Nutrient and chl-a levels elevated. Oxygen depletion occurring regularly. Severe oxygen depletion common.</i>	
	Nutrient concentrations fluctuating with a decreasing tendency for phosphorus. Phosphorus level amongst the highest in the assessed areas. Chl-a level varying. Oxygen depletion occurring occasionally at the entrance to Øresund.	Winter concentration of nutrient show significant reduction since 1990. Chl-a fluctuating around constant level. Minimum oxygen varies with no trend. No significant development in bottom fauna.
Mariager Fjord (area 19)	<i>Nutrient and chl-a concentration elevated. Oxygen depletion regularly reaching surface/shallow waters (<10m). Distribution of eelgrass reduced. Bottom fauna deteriorated.</i>	
	Nutrients fluctuate around constant level. Phosphorus level amongst the highest in the assessed areas. Summer-autumn blooms of diatoms (<i>Skeletonema costatum</i>). Permanent oxygen depletion in deep of inner basin. Distribution of oxygen depletion in shallower areas varies from year to year. Eelgrass distribution and bottom fauna abundance and biomass fluctuate without any trend.	Phosphorus (TP, DIP) show declining trend while nitrogen concentrations fluctuate around constant level Chl-a similarly fluctuating without specific pattern. Distribution of oxygen depletion shows no trend. Eelgrass distribution fluctuates without any trend. Bottom fauna improved since 1997 but still deteriorated.

	Status	
	2001-2005	Long term trends
Randers Fjord (area 20)	<i>Nutrient and chl-a concentration elevated. Oxygen depletion occurring. Distribution of eelgrass reduced</i>	
	Nutrients and chl-a fluctuate around constant level. Nitrogen level amongst the highest in the assessed areas. Occurrence of oxygen depletion varying from year to year. Depth limit of eelgrass about 25% of reference condition.	Nutrient winter concentrations show no obvious trend. Summer chl-a decreased significantly since 1989. Oxygen depletion common in some parts, without any trend. Eelgrass shows no particular trend.
Isefjord (area 21)	<i>Nutrient and chl-a concentrations elevated. Toxic algae rare and no problems observed. Slightly decreased depth limit of eelgrass – around 90% of reference condition.</i>	
	Nutrients fluctuating with an overall downward tendency. Chl-a concentration and eelgrass depth limit fluctuating around constant level. Summer-autumn blooms of diatoms. Benthic fauna biomass shows large variation.	Significant reduction in phosphorus since 1989. Nitrogen fluctuating without overall trend. Tendency towards reduction in chl-a and planktonic algae. Distribution of eelgrass increasing in outer part. Frequent oxygen depletion. Benthic fauna biomass in general low and fluctuating without general trend.
Roskilde Fjord (area 22)	<i>Nutrient and chl-a concentrations elevated. Phosphorus particular high in inner part. Decreased depth limit of eelgrass. No oxygen depletion.</i>	
	No trends in nutrient, chl-a or depth limit of eelgrass. Phosphorus level amongst the highest in the assessed areas. Summer-autumn blooms in inner basin of cryptophycean, chlorophycean, <i>Katadinium</i> and ciliate <i>Mesodinium rubrum</i> ; in outer basin diatoms. Noxious algae: <i>Prorocentrum minimum</i> and <i>Pseudo-nitzschia</i> . No oxygen depletion. Increasing bottom fauna biomass in inner fjord.	Until late 1990s, downward trends in nutrient and chl-a; subsequent fluctuating around constant level. No overall trends in depth limit of eelgrass or benthic fauna.

5.2 Overall Assessment (OSPAR COMP and HEAT)

The overall assessment of eutrophication status of the Danish parts of the North Sea, Skagerrak and Kattegat is based on a combination of the OSPAR Comprehensive Procedure (OSPAR COMP) and the draft HELCOM Eutrophication Assessment Tool (HEAT). This combined approach has been chosen to take advantage of the strengths of both tool and to overcome some weaknesses related to OSPAR COMP.

The results of the application of the OSPAR COMP and HEAT are presented and discussed in the following sections (5.2.1 and 5.2.2). The combined result of the overall assessment is presented in Figure 5-9.

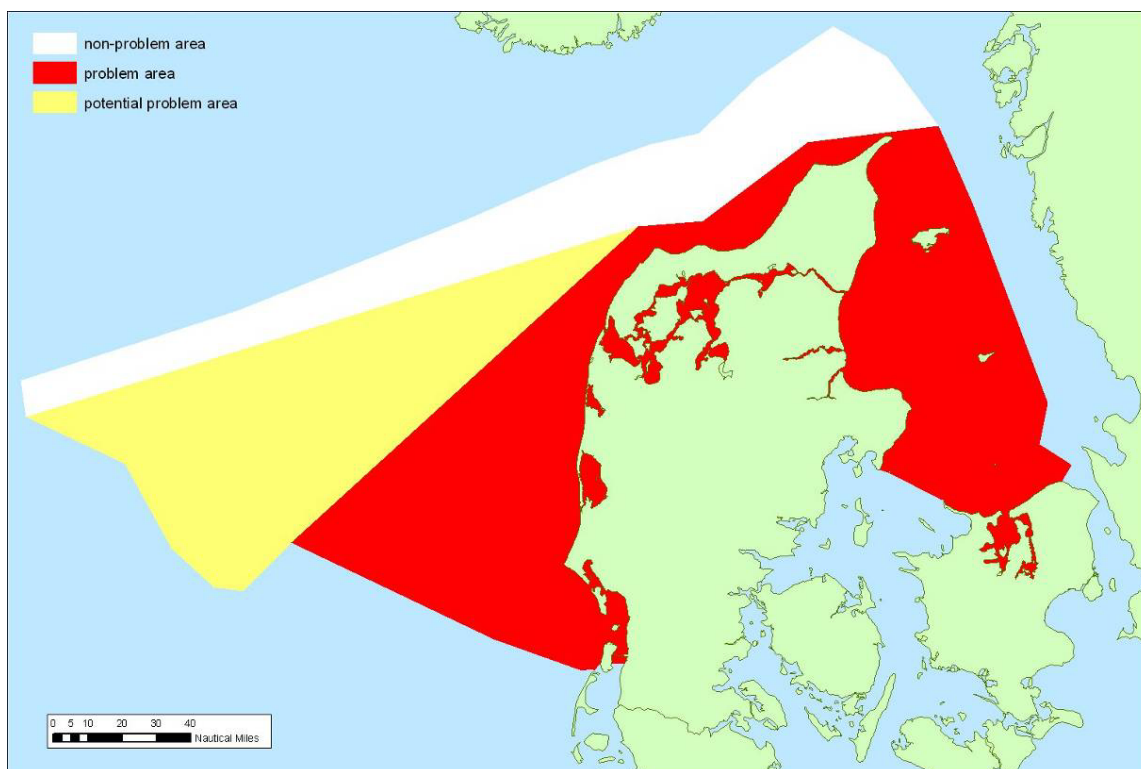


Figure 5-9 Maps showing area classified as “eutrophication problem areas” (red), “potential problem areas” (yellow); and “non problem areas” (white) in the Danish parts of the North Sea, Skagerrak, and Kattegat, 2001-2005.

5.2.1 The OSPAR Common Procedure (COMP)

The initial application of the OSPAR COMP reveals that all 22 areas included in this assessment are classified as ‘eutrophication problem areas’, cf. Table 5-5.

However, two of these areas, the open parts of the North Sea (area 1) and the open water of the Skagerrak (area 8) are regarded as ‘false positives’. For area 1, the final classification is caused by 3 out of 8 Category I parameters deviating more than 50% from reference conditions. For area 8, only 1 out of 8 Category I parameters are deviating more than 50%. This situation can best be described as a ‘one out, all out’ principle used not per category (equivalent to quality element) but per parameter (indicator) resulting in integrated assessment where a single parameter (indicator) out rules all other parameters.

Since the final outcome of assessments based on the OSPAR COMP can be ‘controlled’ by a single parameter disregarding all other available information, the OSPAR COMP is being considered too stringent.

Similar results have achieved for the Baltic Sea, where open basin as the Bothnian Sea and the Bothnian Bay tentatively have been classified as ‘eutrophication problem area’ despite a common Baltic Sea-wide understanding that these areas are oligotrophic and as such to be classified as ‘non-problem areas’ with respect to eutrophication. These false positive classifications were in fact a motivation for the development of the draft HELCOM Eutrophication Assessment Tool.

Table 5-5 Initial classification based on OSPAR COMP. ‘+’ = ‘eutrophication problem area; ‘÷’ = ‘non problem area’, and n.i. = no information available. Background information can be found in Annex E.

	Interim assessment (per categories)				Interim integrated status
	C I	C II	C III	C IV	
1. North Sea – open waters	(+)	÷	n.i.	n.i.	(+)
2. North Sea – southern coastal waters	+	+	n.i.	n.i.	+
3. North Sea – coastal waters	+	+	n.i.	n.i.	+
4. Wadden Sea – Danish parts	+	+	n.i.	n.i.	+
5. Ringkøbing Fjord	+	+	+	n.i.	+
6. Nissum Fjord	+	+	n.i.	n.i.	+
7. Skagerrak – coastal waters	+	+	n.i.	n.i.	+
8. Skagerrak – open waters	(+)	÷	n.i.	n.i.	(+)
9. Limfjorden – eastern parts	n.i.	+	n.i.	n.i.	+
10. Limfjorden – central parts	n.i.	+	+	n.i.	+
11. Limfjorden – southern parts	+	+	+	n.i.	+
12. Limfjorden – western parts	÷	+	+	n.i.	+
13. Kattegat – northern open waters	+	+	n.i.	n.i.	+
14. Kattegat – central open waters	+	+	n.i.	n.i.	+
15. Kattegat – western coastal waters	+	+	n.i.	n.i.	+
16. Kattegat – southwestern coastal waters	+	+	+	n.i.	+
17. Kattegat – southern open waters	+	+	n.i.	n.i.	+
18. Kattegat – south coastal waters	+	+	n.i.	n.i.	+
19. Mariager Fjord	+	n.i.	+	n.i.	+
20. Randers Fjord	+	+	+	n.i.	+
21. Isefjorden	n.i.	÷	+	n.i.	+
22. Roskilde Fjord	+	+	+	n.i.	+

5.2.2 The draft HELCOM Eutrophication Assessment Tool (HEAT)

The application of the draft HELCOM Eutrophication Assessment Tool results in a classification where 20 out of 22 areas assessed are classified as ‘eutrophication problem areas’. Two areas are classified as ‘non-problem areas’, e.g. the open parts of the North Sea (area 1) and the open parts of the Skagerrak (area 8). These findings are in accordance with earlier assessment results and the current conceptual understanding of eutrophication status of these areas. The final classification as ‘non-problem areas’ for area 1 and 8 is also confirmed by the fact that two quality elements per area are classified as non-problem areas (see Table 5-6 for details, which also presents information regarding the confidence assessment, cf. Section 4.3.2).

The conclusion of the interim confidence rating is that the final assessment results are trustworthy. However, this particular type of assessment does not take the number of parameters/indicators used into account. Further work during 2008 will improve the confidence assessment and allow users of HEAT to take into account the quality of the monitoring activities and data availability.

Table 5-6 *Ecological Quality Ratio (EQR) for relevant QEs and interim assessment of overall eutrophication status in Danish parts of the North Sea, Skagerrak and Kattegat. PC = physico-chemical indicators, PP = phytoplankton, SAV = submerged aquatic vegetation, and BIF = benthic invertebrate fauna. 'n.i.' denotes no information available. Background information can be found in Annex E. Please note that "high" and "good" are matching "eutrophication non-problem area" and that "moderate", "poor" and "bad" are matching "eutrophication problem area" sensu OSPAR COMP.*

		Ecological Quality Ratio				Overall status	Interim confidence assessment	
		Primary effects		Secondary effects				
		PC	PP	SAV	BIF			
1.	North Sea – open waters	Northern	No HEAT classification available					
		Central	0.789	0.722	n.i.	n.i.	GOOD	Class II
2.	North Sea – southern coastal waters		0.554	0.612	n.i.	n.i.	MODERATE	Class II
3.	North Sea – coastal waters		0.710	0.594	n.i.	n.i.	MODERATE	Class II
4.	Wadden Sea – Danish parts		0.574	0.473	n.i.	n.i.	MODERATE	Class II
5.	Ringkøbing Fjord		n.i.	0.850	0.629	0.162	BAD	Class II
6.	Nissum Fjord		n.i.	n.i.	0.500	n.i.	BAD	Class II
7.	Skagerrak – coastal waters		0.795	0.650	n.i.	n.i.	MODERATE	Class II
8.	Skagerrak – open waters		0.834	0.914	n.i.	n.i.	HIGH	Class II
9.	Limfjorden – eastern parts		n.i.	n.i.	0.321	n.i.	BAD	Class I
10.	Limfjorden – central parts		n.i.	0.712	0.339	0.301	BAD	Class II
11.	Limfjorden – southern parts		0.402	0.596	0.554	0.335	BAD	Class II
12.	Limfjorden – western parts		0.890	0.464	0.300	n.i.	BAD	Class II
13.	Kattegat – northern open waters		0.845	0.603	n.i.	n.i.	MODERATE	Class II
14.	Kattegat – central open waters		0.668	0.440	0.549	n.i.	POOR	Class II
15.	Kattegat – western coastal waters		0.739	0.570	n.i.	n.i.	MODERATE	Class II
16.	Kattegat – southwestern coastal waters		0.716	0.460	n.i.	0.584	BAD	Class II
17.	Kattegat – southern open waters		0.561	0.351	n.i.	n.i.	POOR	Class II
18.	Kattegat – south coastal waters		0.469	0.398	n.i.	n.i.	POOR	Class II
19.	Mariager Fjord		0.432	n.i.	n.i.	0.369	BAD	Class I
20.	Randers Fjord		0.369	0.562	0.325	0.578	BAD	Class II
21.	Isefjorden		n.i.	n.i.	0.894	0.029	BAD	Class I
22.	Roskilde Fjord		0.763	n.i.	0.644	0.412	BAD	Class I
High ecological status Good ecological status Moderate ecological status Poor ecological status Bad ecological status No or insufficient data								

5.3 Comparison with Preceding Assessment

The first Danish application of the OSPAR Common Procedure concluded that eutrophication effects have been documented in all Danish marine waters every year since the beginning of the 1980s (Ærtebjerg et al., 2003). Most of the areas assessed were classified as "eutrophication problem areas". Only a few areas either located in the open parts of the North Sea or in the Skagerrak, were classified as "non-problems areas".

This second application of the OSPAR Common Procedure confirms that most of the Danish waters in the North Sea, Skagerrak and Kattegat are "eutrophication problem areas". It also confirms that the open parts of the North Sea and Skagerrak are "non-problem areas". However, the present assessment suggests that the coastal waters of the Skagerrak should be classified as an "eutrophication problem areas" and the central parts of the North Sea should be classified as "potential problem areas", cf. Table 5-6.

Table 5-7 Temporal trends in assessment of eutrophication status. “green” = eutrophication non-problem area; “yellow” = potential eutrophication problem area; and “red” = eutrophication problem area. Assessment results for the period 1989-1997 are based on Ærtebjerg et al. (2005). Assessment results for the period 1998-2000 are based Ærtebjerg et al. (2003). Assessment results for the period 2001-2005 are based on this report.

Area	89	90	91	92	93	94	94	96	97	98	99	00	01	02	03	04	05
North Sea																	
1. North Sea – northern open waters																	
2. North Sea – southern coastal waters																	
3. North Sea – coastal waters																	
4. Wadden Sea – Danish parts																	
5. Ringkøbing Fjord																	
6. Nissum Fjord																	
Skagerrak																	
7. Skagerrak – coastal waters																	
8. Skagerrak – open waters																	
Kattegat																	
9. Limfjorden – eastern parts																	
10. Limfjorden – central parts																	
11. Limfjorden – southern parts																	
12. Limfjorden – western parts																	
13. Kattegat – northern open waters																	
14. Kattegat – central open waters																	
15. Kattegat – western coastal waters																	
16. Kattegat – southwestern coastal waters																	
17. Kattegat – southern open waters																	
18. Kattegat – southern coastal waters																	
19. Mariager Fjord																	
20. Randers Fjord																	
21. Isefjorden																	
22. Roskilde Fjord																	

5.3.1 Description of Changes in Quality Status of the Areas

The areas that have a different status compared to the first application of the OSPAR Common Procedure are: 1) the central parts of the Danish North Sea waters, and 2) the coastal water in the Danish parts of the Skagerrak. The justifications for changing the classification of eutrophication status of the Danish parts of the central North Sea are:

- The 2003 classification of the central parts of the North Sea was based on data from monitoring of winter nutrient concentration not representing the spring bloom and eutrophication signal during the summer and autumn.
- The present assessment of the central North sea, which is based on combined hydrodynamic and ecological modelling covering the period 2001-2005, is assumed to give a more accurate picture of the eutrophication status compared, especially regarding nutrient and chlorophyll-a concentrations.
- The 2003 assessment of the coastal water of Skagerrak classified these as ‘potential problem areas’, but now it is apparent that these should be classified as ‘eutrophication problem areas’.

Further, as a cautionary note, it should be emphasised that: 1) the 2003 North Sea classification is based on winter nutrient concentrations, 2) the present assessment (2001-

2005) includes nutrient concentrations (annual mean) and chlorophyll-a, and 3) the interim confidence assessment shows that that data assessment is class II (fair quality). Hence, the final assessment is considered reliable, but with some room for improvements, e.g. by including information on benthic communities.

6 LINKS WITH EUROPEAN EUTROPHICATION RELATED POLICIES

For more than 25 years a lot of work has been carried out to reduce coastal eutrophication in Danish marine waters. Emphasis has been placed on reduction of nutrient inputs to coastal and open waters through national action plans, international marine conventions (HELCOM and OSPAR) and EU legislation (Danish EPA 1991, Iversen et al. 1998, Danish EPA 2000, Ærtebjerg et al. 2003).

The first national initiative adopted by the Danish Parliament in order to improve the aquatic environment was the 1985 NPo Action Plan (Danish EPA 1984). This plan implemented a suite of measures in relation to the discharge of nitrogen (N), phosphorus (P) and organic matter (OM) from agriculture and wastewater. The means included a ban on direct discharges from farms, a ban on the application of manure on frozen or sloping fields, and regulation of animal density. Municipal wastewater treatment plants were required to improve efficiency in relation to phosphorus discharges. The NPo plan did not include specific reduction or discharge targets.

Since then, numerous initiatives have contributed to the fulfilment of the goals of the 1985 NPo Action Plan. Sometimes the drivers have been European directives directly or indirectly dealing with mitigation of eutrophication effects, sometimes the driver has been a national agenda to reduce discharges in order to improve eutrophication status leading to adoption of comprehensive national Action Plans on the Aquatic Environment. These initiatives are interlinked in specious ways and it is unclear which initiative is the most stringent.

The key EU directives (being the Nitrates Directive, the Urban Waste Water Treatment Directive and the Water Framework Directive) and the Danish Action Plans on the Aquatic Environment are described in the following sections.

6.1 Nitrates Directive and Urban Waste Water Treatment Directive

Both the Nitrates Directive and the Urban Waste Water Treatment Directive are ‘eutrophication directives’ focusing on different sectors and sources.

The objective of the EC Nitrates Directive (Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agriculture) is to reduce water pollution caused or induced by nitrates from agricultural sources and to prevent further such pollution. EU Member States shall designate vulnerable zones, which are areas of land draining into waters affected by pollution and which contribute to pollution. Member States shall set up where necessary action programmes promoting the application of the codes of good agricultural practices. Member States shall also monitor and assess the eutrophication status of freshwater, estuaries and coastal waters every four years.

The objective of the EC Urban Waste Water Directive (Directive 91/271/EEC of 21 May 1991 concerning urban waste water treatment) is to protect the environment from the adverse effects of discharges of waste-water. The directive concerns the collection,

treatment and discharge of urban waste water and the treatment of discharges of waste water from certain industrial sectors. The degree of treatment (i.e. emission standards) of discharges is based on assessment of the sensitivity of the receiving waters. Member States shall identify areas, which are sensitive in terms of eutrophication. Competent authorities shall monitor discharges and waters subject to discharges.

The implementation of these two directives has only been partly successful. Discharges of nutrients and organic matter from urban waste water treatment plants (UWWTPs) have been significantly reduced. Losses of nitrates from agriculture have not been reduced in a way comparable with the point sources. This has been evident for many years and was indirectly the reason for the development of an EU Ecological Directive, a process that ultimately resulted in the adoption of the EU Water Framework Directive.

6.2 Water Framework Directive

In December 2000 the EU Water Framework Directive (WFD) came into force. This Directive provides a framework for the protection of ground water, inland surface waters, transitional waters (estuaries) and coastal waters (Anon. 2000). The overall aim of the WFD is (1) to prevent further deterioration, protect and enhance the environmental status of aquatic systems, and (2) to promote the sustainable use of water, while progressively reducing or eliminating discharges, losses and emissions of pollutants and other pressures for the long-term protection and enhancement of the aquatic environment.

The WFD provides national and local authorities with a legislative basis for the maintenance and recovery of water quality to achieve good ecological and chemical status for all surface waters and good chemical status for groundwater. Accordingly, the WFD is considered to be the most significant piece of legislation regarding water policy produced in the last 20 years. The Directive puts emphasis on both legally binding programs of measures and environmental objectives. In practice, the future management of coastal waters will be based on environmental objectives being defined as “slight” or “minor” deviations from reference conditions and the implementation of measures necessary to achieve “good ecological status” at the latest 15 years after the date of entry into force of the Directive. These necessary measures have to be implemented in the upstream catchment to the coastal waters in question.

In Denmark, the implementation of the WFD has high priority and especially the fulfilment of the overarching objective of achieving ‘good environmental status’. However, preliminary analysis indicate that the environmental objectives of several estuaries and coastal water bodies can only be met if the inputs of nitrogen are reduced below the present Danish national reduction objective of 50% (80% for phosphorous).

6.3 Danish Action Plans for the Aquatic Environment

In 1986 widespread hypoxia occurred in the Danish Straits. The Danish Parliament adopted an agenda urging the Government to reduce the discharges and losses of nitrogen (by 50%) and phosphorus (by 80%) from agriculture, urban wastewater treatment plants, and separate industrial discharges.

This strategic aim was transformed into sector specific reduction objectives, reduction percentages and discharge targets (Folketinget 1987). These were set up for the 3 most

important sources: (1) discharges and losses from agriculture, (2) discharges from municipal wastewater treatment plants, and (3) discharges from industries with individual discharges. Annual losses of nitrogen from cultivated fields and direct discharges from farmyards should, according to Action Plan I, be reduced from ca. 260.000 to 133.000 tons (Folketinget 1987), corresponding to a decrease of 49%. The reduction objective was 127.000 tons, of which ca. 100.000 tons were from agricultural fields and ca. 27.000 from farms. The annual discharge of phosphorus from farms was to be reduced from ca. 4.400 to 400 tons. Losses of phosphorus from fields were not included, because of a large uncertainty associated with the estimation of the loss. The measures included: (i) specific discharge standards in relation to the size of the wastewater treatment plants, (ii) optimal utilization of livestock manure, and (iii) a program for improved utilization of fertilizer.

The annual discharge of nitrogen from municipal wastewater treatment plants was to be reduced from ca. 18.000 to 6.600 tons, while annual discharges of phosphorus were to be reduced from ca. 4.470 to 1.220 tons (Danish EPA 1991). Separate discharges of nitrogen and phosphorus from industries should have been reduced from ca. 5.000 to 2.000 ton for nitrogen and from 1.250 to 200 tons for phosphorus (Miljøministeriet 1987 and Danish EPA 2000). The deadline set in 1987 for fulfilment of the specific reduction objectives and discharge targets was negotiated to 3 years. It soon became apparent that this was not possible and consequently the deadline was prolonged until 1 January 1993.

The reduction targets for both municipal wastewater treatment plants and industries were met in 1995 while the specific objectives and targets for agriculture were difficult to meet within the original time limit. A number of amendments to Action Plan I have been adopted by the Danish Parliament. In 1991 the Action Plan on Sustainable Agriculture was adopted, focusing on the reduction of losses from fields. New measures were adopted in order to meet the reduction objective of 100.000 tons nitrogen. These measures included: (i) improved utilization of livestock manure, (ii) a reduction in commercial fertilizer consumption, (iii) a reduction in agriculture acreage, and (iv) structural development.

An Action Plan on the Aquatic Environment II was adopted in 1998 due to a major hypoxia in Mariager Fjord in 1997 and the requirements of the EC Nitrates Directive (Anon. 1991). Action Plan II focuses on the reduction objective of 100.000 tons of nitrogen from agricultural fields. The supplementary measures include: (i) restoration of wetlands, (ii) forestation, (iii) improved fodder utilization, (iv) more strict requirements on utilization of the N content of manure, (v) catch crops on a further 6% of fields, and (vi) a 10% reduction in nitrogen standards for crops.

An Action Plan III was adopted in 2004. The political discussions focused on losses of phosphorus from agriculture, not on further reductions of nitrogen losses. It is reasonable to put more focus on diffuse losses of phosphorus, as these so far have not been dealt with. However, taking the impaired conditions of Danish coastal waters into consideration, further reductions in nitrogen inputs may be needed.

Table 6-1 Summary of the Danish Action Plans of the Aquatic Environment. Please note that the diffuse losses of phosphorus are not included in in Action Plan I and II and hence not in the table.

Sector	Nitrogen (TN)					Phosphorus (TP)				
	1987	÷	Reduction	%	= Target	1987	÷	Reduction	%	= Target
Agriculture	311.000	÷	152.400	49	= 158.600	4.400	÷	4.000	91	= 400
UWWTPs	18.000	÷	11.400	63	= 6.600	4.470	÷	3.250	73	= 1.220
Inductries	5.000	÷	3.000	60	= 2.000	1.250	÷	1.050	84	= 200
Total	334.000	÷	166.800	50	= 167.200	10.120	÷	8.300	82	= 1.820

The three Danish Action Plans on the Aquatic Environment are a compelling example of Strategic Environmental Planning (SEP) / Environmental Management Systems (EMS) that has gradually developed. In 1994, the SEP concept became an official strategy of the Danish Ministry for the Environment. Basically, the concept includes 4 steps: (1) policies and overall objectives, (2) strategies and measures, (3) monitoring and assessment, and (4) evaluation(s). The latter has a feedback to step 1. Either it is concluded (i) that the objectives have been met, (ii) that the objectives have not been met and supplementary measures are needed and consequently adopted, or (iii) that the objectives have not been met and have to be reconsidered and consequently amended. The concept of strategic environmental planning is of course based on research. A problem has to be identified before policies can be formulated and negotiated. This can be seen in the Danish case study, where a combination of basic and applied research in the late 70's and early 80's documented that coastal eutrophication and hypoxia was a large-scale problem (Danish EPA 1984).

The reduction objective for losses of nitrogen from agriculture has been based on an assumption that the annual losses from agriculture in the mid 80's were in the order of 260.000 tons nitrogen. However, it has for some time been discussed if this estimate was accurate. A recently published report suggests that the losses were significantly larger, perhaps around 311.000 ton nitrogen (Grant & Waagepetersen 2003). A new national evaluation of the losses of nitrogen from Danish agriculture to the aquatic environment is acceptable based on the now realized and accepted higher losses. In addition, this evaluation assumes that the already agreed and implemented changes in agricultural practices will in the longer term result in an annual reduction of losses from fields in the order of 149.000 tons nitrogen, corresponding to a reduction of 48% which is close to the target of 49% (Grant & Waagepetersen 2003). This is a significant step forward which will improve the ecological status of the aquatic environment. However, focusing only on the 49% reduction target in Action Plan II raises the discharge target of 133.000 tons in Action Plan I to 158.600 tons due to the new estimation of losses from agriculture in the 80's. In terms of strategic environmental planning this can be compared to an amendment of the original target objective.

There is not doubt that the Danish Action Plans have been successful, both in relation to point sources and diffuse sources. The reason is mainly due to a long term political will to solve problems related to eutrophication plus the fact that monitoring, including funding and evaluations strategies were closely linked to the Action Plans. Despite the successes in term of reducing discharges and losses of both nitrogen and phosphorous, the ecological status of most Danish marine waters is still not acceptable. Implementation of additional reduction goals seems necessary in order to reach 'good ecological status' or 'good environmental status' in the future.

7 PERSPECTIVES

Danish transitional, coastal and marine waters have had a long record of eutrophication symptoms ranging from nutrient enrichment to direct effects, including increased (1) primary production, (2) phytoplankton biomass, and (3) growth of short-lived macroalgae, as well as indirect effects, including (1) loss of long-lived submerged aquatic vegetation, (2) decreasing bottom oxygen concentrations, and (3) structural changes in benthic invertebrate communities (Ærtebjerg et al. 2003).

Reduction of eutrophication effects in Danish transitional, coastal and marine waters can only be achieved if concentrations of nutrients, especially nitrogen and phosphorus, are lowered. For more than 2 decades, significant measures have been taken to reduce discharges, losses and emission of nitrogen and phosphorus from Danish sources. The overarching aim has been to reduce inputs of nitrogen to the aquatic environment with 50% and to reduce discharges of phosphorus with 80%, cf. Table 6-1. These nutrient reduction targets now appear within reach after several consecutive reduction measures are fully implemented, particularly toward discharges from point sources and losses from diffuse sources. Reduced nutrient concentrations are actually beginning to be observed. These first signs of trend reversal and environmental recovery were most distinct in estuaries and coastal waters but also were apparent in open waters of the Kattegat, the Sound, and the Belt Sea.

Eutrophication is not just a local or regional problem. It also needs to be recognized as a global change owing to the changes in phytoplankton diversity caused by eutrophication and the resultant influence on element cycling and food web structure, as well as its influence on the increased marine production and release of nitrous oxide, a potent greenhouse gas. Climate change and eutrophication are manifestations of the same process - inadvertent changes resulting from human activities. The Earth functions as a single system that is more than the sum of its individual components. Human activities have always interacted within the Earth's systems and, as these activities have intensified particularly over the past 50 years, their impacts have also become more obvious. Among the changes to the Earth's system that have been occurring with growing intensity are increases in atmospheric concentrations of carbon dioxide, nitrous oxide, and methane, an increase in surface temperature, overexploitation of fisheries, changes in coastal zone biogeochemistry such as in nitrogen fluxes, loss of tropical forests, and extinctions of tens of thousands of species. These interactions with the Earth's system can give rise to unexpected responses as human activity influences and changes the function of the system.

7.1 *Implemented and Further Planned Measures*

Since the adoption of the Danish Action Plan 3 on the Aquatic Environment, discharges, losses and emission of nutrient have been reduced further compared to the starting point of the plan. Although there are time lags from adoption and implementation of a given measure until the effects are manifested in the aquatic environment, it is raised beyond any doubt that these measures will ultimately result in lowered inputs to Danish transitional, coastal and marine waters.

Reductions of loads with all other things being equal lead to: (1) lowered nutrient concentrations, (2) lowered primary production, (3) reduced phytoplankton biomass, and (4) reductions in secondary effects (e.g. oxygen depletion, structure changes in benthic communities). As a word of caution, it should be remembered that the way back towards better ecological status is not necessarily the same as the one made once the systems were enriched. Threshold effects are likely to occur and the consequence might be that inputs have to be reduced even more than generally accepted (Scheffer et al. 2001).

In November 2007, the Danish Government launched an initiative confirming that a Action Plan on the Aquatic Environment no. 4 will be considered in order to: (1) follow up on the previous 3 action plan in regard to discharges, emission and losses of nutrients, especially losses for phosphorous from diffuse sources, and (2) to implement measures relevant in order to achieve 'good ecological status' *sensu* the Water Framework Directive. It is still unclear what the contents of Action Plan IV will be, but no matter the eventual content and level of ambitions, this plan will contribute to the ongoing improvement of environmental status of Danish transitional, coastal and marine waters, cf. Carstensen et al. 2006. It is assumed that focus will be on basis measures (e.g. reductions), but to some degree also on supplementary measures (e.g. buffer strips along streams, nature restoration, etc.).

Reducing inputs is the key when it comes to mitigation of eutrophication effects. However, it should also be taken into account that whenever we analyse what we consider being an 'eutrophication signal', e.g. an increase in chlorophyll-a concentrations, we are in reality focusing on an indicator which responds to multiple stressors. It is commonly agreed that changes in chlorophyll-a concentrations are a result of changes in nutrient concentrations and inputs, but other factors might play a role as well, e.g. changes in top/down control, hazardous substances, introduction of non-native species, habitat availability as well as climate change. An illustrative example would be the distribution and density of long-lived macroalgae, e.g. *Fucus* sp. and *Laminaria* sp. The depth distribution is correlated to Secchi depth as such an 'eutrophication signal' (reduced depth distribution is an effect of reduced light penetration). The density is correlated to the growth of epiphytes (being an 'eutrophication signal') as well as damages caused by trawling or removal of stones (being a signal of 'physical disturbance'). In other words: reduced distribution of submerged aquatic vegetation is not only an effect of eutrophication. In a situation where inputs gradually are being reduced but without significant improvement in ecological status it should be recognised that reduced physical disturbance would contribute to improvements of ecological/eutrophication status. A number of activities focusing on restoration of hydro-morphological quality elements (equivalent to nature restoration) are currently taking place in Limfjorden and the northern part of Kattegat. The results of these activities will indirectly develop concepts and methods similar to so-called 'supplementary measures' *sensu* the Water Framework Directive. Preliminary results indicate that a balanced combination of nutrient reduction and nature restoration will significantly improve ecological/eutrophication status of these areas and possibly also other coastal and marine waters.

7.2 Outlook

The Danish experience from the years 1996 and 1997, when precipitation and runoff were very low and the 50% reduction target for nitrogen reduction was actually met, clearly shows that the reduction target of 50% in the input to the marine area considera-

bly improves the quality status of the marine environment. The 50% reduction in nitrogen inputs, therefore, needs to be met in order to reduce eutrophication problems in marine areas. Trends in nutrient reductions are on the right track, both with respect to the reduction of discharges, emissions and losses of nutrients to marine waters and to the quality of the marine environment. But the road to fulfilment of eutrophication quality criteria is long and winding. The existing criteria and the acceptable deviations from reference conditions should be regarded as a starting point. The variability found for different parameters is naturally large. It might therefore be reasonable to develop global or type-specific assessment criteria and, taking these as a starting point, to develop site-specific assessment criteria. Focusing on national reductions in inputs is reasonable. But inputs from adjacent seas should also be taken into account. It is likely that these inputs will decrease. However, future enlargement of the European Union is likely to result in a development of the agricultural sector in Poland and the Baltic States. This may result in an increase in losses from cultivated farmland and eventually an increase in inputs to the Baltic Sea, and thus an increase in the inputs to Danish waters from the Baltic Sea. However, nutrient enrichment, eutrophication and oxygen depletion are naturally occurring phenomena. It is the extent in space and the duration and strength that is affected by human activities. These undesirable effects in our marine waters can not be avoided, but the anthropogenically induced strengthening of these phenomena should be reduced.

The implementation of the Water Framework Directive has to take the Habitat Directive and EU Marine Strategy into account, especially with regard to the objectives on ecological and conservation status. If not, the management of the ecosystems and resources in the Danish marine water will face different protection levels and thus be complicated beyond reason.

It is likely that the implementation of the Water Framework Directive will lead to implementation of so-called supplementary measures in catchment areas to specific coastal waters as vulnerable and sensitive estuaries and enclosed bays. The combination with legally binding quality objectives and integrated strategic management should make it possible to calculate backwards from the normative definition of good ecological status to concentrations, inputs, and other human activities affecting eutrophication status of marine waters. The key question in the future is whether diffuse sources can and will be adequately managed.

8 CONCLUSIONS

The Danish achievements which have led to reduced nutrient concentrations in coastal waters are to our knowledge the first national or international efforts which have been able to manage and reduce inputs from both point and diffuse sources. The management of Danish coastal waters is based on legal and political requirements in Danish laws and Action Plans, EU Directives and international conventions (HELCOM and OSPAR). It is not always clear which of these obligations is the most significant. The success of Danish nutrient enrichment management can be explained by the scope and timing of strategies, measures, research, monitoring together with regular evaluations and feedback to the political level.

The eutrophication status in the Danish parts of the OSPAR Convention Area has been assessed in a two step procedure. Firstly, data on reference conditions and current status (2001-2005) has been gathered and quality assured, and acceptable deviation from reference condition has been set according to the OSPAR Comprehensive Procedure or Danish Governmental positions in regard to the EU Water Framework Directive intercalibration process, e.g. the NEA GIG. Information on reference conditions, acceptable deviation and current status have been combined and used for an interim assessment according to the OSPAR Comprehensive Procedure. Areas have been classified as either 'eutrophication non-problem area' or 'eutrophication problem areas'.

Secondly, the interim assessment has been subject to a succeeding assessment in accordance with the requirements of the EU Water Framework Directive, e.g. correct use of the 'one out – all out' principle, calculation of ecological quality ratio (EQR), and classification in five classes (high, good, poor, moderate, poor and bad, where high and good are equivalent to 'eutrophication non-problem area' and vice versa). The second step, which has used the draft HELCOM Eutrophication Assessment Tool (HEAT), has also built-in an accuracy assessment in order to get a provisional perceptive of the robustness and quality of the outcome of the classifications.

The conclusions of the assessment are:

- All Danish fjords and estuaries located within the OSPAR Convention Area are classified as 'eutrophication problem areas'.
- All coastal areas are classified as 'eutrophication problem areas'.
- The open parts of the Skagerrak are together with a strip in the northern parts of the North Sea classified as 'eutrophication non problem areas'.
- An area in the North Sea located in between (a) the 'non-problem area' strip mentioned above and (b) the coastal waters being classified as 'eutrophication problem areas' has been classified as a 'potential eutrophication area'.

The OSPAR Comprehensive Procedure is a valuable tool for interim assessments of eutrophication status. One of the strength of this tool is that it actually works well and is being used by many countries. However, the tool is too stringent since it applies a 'one out – all out' principle on the level of assessment criteria (indicators). Further, it does not meet the requirement of European legislation, e.g. the Water Framework Directive.

The HEAT tool has been used to supplement to OSPAR Comprehensive Procedure and the advantages include: (1) Quantification of eutrophication status, (2) correct use of the ‘One out – all out’ principle *sensu* the EU Water Framework Directive, and (3) an interim estimation of the accuracy and precision of the assessment results.

Taking into account that the majority of the Danish parts of the OSPAR Convention Areas are being classified as ‘eutrophication problem areas’, the next steps should be to reduce the extent of the problem.

The general recipe to mitigate eutrophication is simple: nutrient inputs should be reduced further and to levels that do not put at risk the ecological target values for Danish parts of the North Sea, Skagerrak and Kattegat.

The results of the OSPAR Comprehensive Procedure should be used for setting up an integrated management strategy to combat eutrophication in the OSPAR Convention Area. Among recommended actions are the following:

- Water managers must incorporate safety margins when designing programmes of measures to fulfil the OSPAR Eutrophication Strategy and other relevant strategies. These safety margins should allow for excessive pressure during extreme or rare climate conditions.
- A North Sea-wide (including the Skagerrak and Kattegat areas) adaptive management strategy should include a close and continuous dialogue with relevant stakeholders, especially from the agricultural sector.

In addition, an adaptive management strategy for the North Sea including the Skagerrak and Kattegat areas should be based on the following two principles: Firstly, nutrient inputs should in no case be allowed to increase compared to the present levels — any increase should immediately be reported and reduced to the present level. Secondly, management plans must be adaptive in order to deal with uncertainty and at the same time include elements of ‘learning-by-doing’ and feedback from research and monitoring activities. Programmes of measures should be implemented, also when cause-effect relationships are not 100% scientifically documented.

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Links of interest:

ASSETS: <http://www.eutro.org>

European Environment Agency: <http://www.EEA.europa.eu>

Eutrophication in Danish Marine Waters 2003: <http://eutro.dmu.dk>

HEAT: <http://heat.dhigroup.com>

HELCOM: <http://www.HELCOM.fi>

OSPAR: <http://www.OSPAR.org>

The Water Forecast: <http://waterforecast.dhi.dk>

Annex A: Glossary

Algae – a large assemblage of lower plants, formerly regarded as a single group, but now usually classified in eight separate divisions or phyla, including the blue-green algae (Cyanophyta), green algae (Chlorophyta), brown algae (Phaeophyta), red algae (Rhodophyta), diatoms, and golden-brown algae (Chrysophyta). Marine macroalgae are commonly known as seaweeds.

Anoxia – a state of oxygen depletion with lack of oxygen.

Aquatic – growing or living in or near water.

Atmospheric deposition – deposition of nutrients, heavy metals, and other pollutants from the atmosphere.

Benthic – see benthos.

Benthos – organisms attached to, living on, in, or near the sea bed.

Biomass – the weight of organisms in a certain area either described with reference to volume or area.

Blue-green algae – marine and freshwater unicellular, colonial, or filamentous bacteria. Resemble algae in the way that they have chlorophyll pigments and can perform photosynthesis.

Chlorophyll – any of several green pigments found in the chloroplasts of plants and in other photosynthesizing organisms. They mainly absorb red and violet-blue light energy for the chemical processes of photosynthesis.

Chlorophyll-a – a specific plant pigment essential for photosynthesis. It is quantitatively the most important pigment found in all photosynthetic phytoplankton cells.

Cyanobacteria – see blue-green algae.

Denitrification – a bacteria-mediated process in which nitrate is reduced to nitrogen gas

DIN – dissolved inorganic nitrogen. The sum of nitrate, nitrite, and ammonium, i.e., nitrogen forms that can be absorbed by plants.

DIP – dissolved inorganic phosphorus. The chemical form in which phosphorus can be absorbed by plants.

EcoQO – Ecological Quality Objective.

Eelgrass (*Zostera marina*) – a submerged flowering plant that grows along the major part of the coasts of the Baltic Sea.

Epiphyte – a plant that grows on or attached to another living plant.

EU – European Union.

Food chain – refers to direct links between organisms that describe how food energy is transferred through the ecosystem from the smallest primary producers to top predators. An example from the marine ecosystem is planktonic algae → copepods → fish → seal.

HELCOM – the Helsinki Commission.

H₂S – hydrogen sulphide.

Hypoxia – a state of low oxygen values.



- Macroalgae – plants that lack true roots, stems, leaves, or flowers. They mostly live attached to a hard substrate.
- Macrozoobenthos – animals larger than 1 mm living attached to, on, in, or near the sea bed, river bed, or lake floor.
- Marine – of, or pertaining to, the sea, the continuous body of water covering most of the earth's surface and surrounding its land masses. Marine waters may be fully saline, brackish, or almost fresh.
- Nitrate (NO₃) – an important nitrogen-containing nutrient. The chemical form in which plants take up most of their nitrogen. It is the salt of nitric acid.
- Nitrogen (N) – a chemical element that constitutes about 80% of the atmosphere by volume. Nitrogen is an important part of proteins and is essential to living organisms.
- Nutrient – a chemical element which is involved in the construction of living tissue that is needed by both plants and animals. The most important in terms of amount are carbon, hydrogen, and oxygen, with other essential elements including nitrogen, potassium, calcium, sulphur, and phosphorus.
- Organism – an individual form of life. An animal, plant, or bacterium.
- Oxygen – a non-metallic element constituting 21 percent of the atmosphere by volume. Oxygen is produced by autotrophic organisms and is vital to oxygen-breathing organisms.
- Oxygen depletion – a situation where the demand for oxygen has exceeded its supply, leading to low concentrations of oxygen. Low oxygen concentrations are normally found in the water close to the sea bottom. In the Baltic Sea area, concentrations below 4 mg O₂ per litre are defined as oxygen depletion and concentrations below 2 mg O₂ per litre are defined as severe acute oxygen depletion.
- Pelagic – living and feeding in the open sea; associated with the surface or middle depths of a body of water; free swimming in open waters, not in association with the bottom
- Phosphate (PO₄) – an important phosphorus-containing nutrient. It is the chemical form in which plants take up phosphorus.
- Phosphorus (P) – a non-metallic chemical element.
- Phytoplankton – the plant plankton and primary producers (i.e., drifting, more or less microscopic, photosynthetic organisms) of aquatic ecosystems.
- Plankton – free passively floating organisms (animals, plants, or microbes) in aquatic systems.
- Primary production – the production by autotrophs.
- psu – practical salinity unit (almost equivalent to parts per thousand or ‰).
- Secchi depth – a measure of the clarity of the water.
- TN – total nitrogen, which includes dissolved inorganic nitrogen and organically bound nitrogen.
- Tot-N – see TN.
- Tot-P – see TP.
- TP – total phosphorus, which includes dissolved inorganic phosphorus and organically bound phosphorus.



Zooplankton – small planktonic animals in fresh or sea water with almost none or no swimming capacity. They are, therefore, transported randomly by water movements.

Annex B: Description of MIKE 3 HD and EcoLab

Model software

The applied hydrodynamic model, MIKE 3 HD, is a fully three-dimensional, non-hydrostatic model, based on the Reynolds-averaged Navier-Stokes equations and the conservation of mass, salinity and temperature (Rasmussen, 1991). For this study a bio-geochemical model has been developed and adapted into the ECO Lab module (for further descriptions of MIKE 3 and ECO Lab see www.dhigroup.com/Software and DHI 2000).

The state variables included in the model are:

- Sea level, salinity, temperature and current (speed and direction).
- Nutrients, inorganic and total N and P, and dissolved oxygen.
- Detritus C, N & P.
- Phytoplankton biomass in C, N & P, and chlorophyll-a.
- Phytoplankton primary production.
- Zooplankton C.

The fluxes of C, N & P are presented in Figure A1.

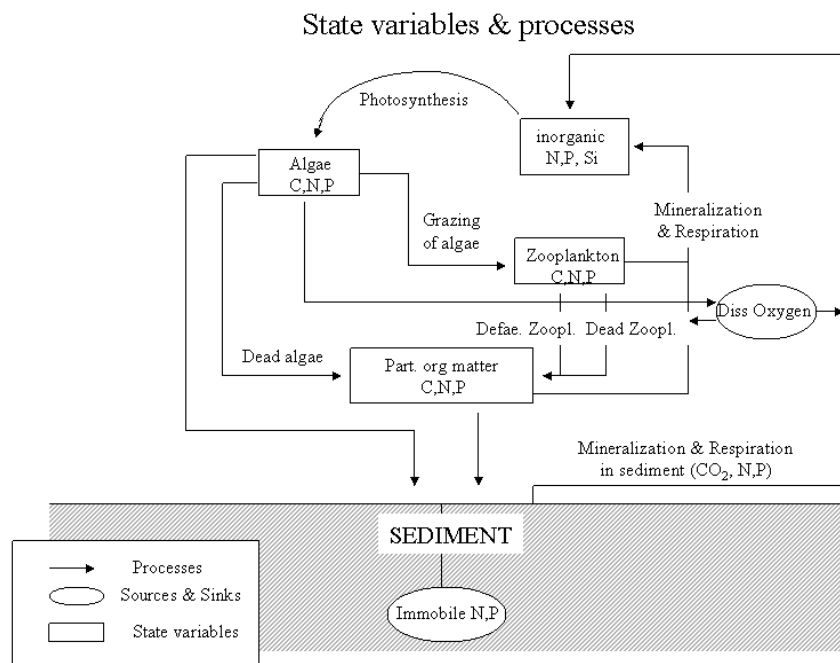


Figure A1: A schematic flow diagram of state variables and processes in the standard eutrophication model.

The most important element in the model is the growth of phytoplankton. The growth of phytoplankton is mainly controlled by nutrient availability, sedimentation, turbidity, temperature and light intensity. Bacterial degradation of organic matter in the water phase and in the sediment releases inorganic nutrients which then become available for new primary production in the photic zone.

Grazing on phytoplankton by zooplankton (including other filter-feeders) can have a regulating effect on the phytoplankton biomass; hence, grazing on algae is modelled explicitly. The model does not include secondary producers at a higher level than zooplankton. Predation (e.g., by fish) on zooplankton is handled indirectly by applying a higher death rate for zooplankton.

Grazing and decay transforms phytoplankton to zooplankton and detritus respectively. The processes involved do however also transform a small part of the phytoplankton N & P directly into inorganic N & P, the latter accounting for some kind of internal microbial loop.

The organic material produced in the surface (or subsurface waters) will settle with time. The bacterial degradation of this material in the sediment and in the water column utilizes oxygen and can depending, among other things, on the strength of the pycnocline, result in anoxic conditions. The model does not specifically include bacteria biomass, but the effects of bacteria are parameterized mainly based on temperature.

In the biochemical model the dependency of nutrients on growth of phytoplankton is described in a two-step process. Firstly, the inorganic nutrients are taken up into an internal pool in the algal cells. Secondly, nutrients from this pool are utilized in production of organic matter. This approach has proved to be very strong in modelling the growth of phytoplankton.

Parts of the Baltic Sea today are at times dominated by nitrogen fixing cyanobacteria. This N fixation is regarded an important source of N to the Baltic Sea and estimates suggests that N fixation is comparable to the land-based N load to the Baltic Sea (Elmgren, 2001). However, N fixation is closely linked to the phosphorous concentration in the Baltic Sea which again is dominated by anthropogenic loads. In a reference condition P loads will be reduced more than N and therefore the problem of cyanobacteria is less pronounced, though not eliminated entirely.

The model applied does not include cyanobacteria and a potential additional load of N is therefore unaccounted for. New model runs including more species of algae are at the moment underway in various projects, such as the Eutrophication Maps funded by Nordic Council of Ministers.

The release of nutrients from the sediment is simulated in the model by a relationship between the actual sedimentation rate and the water temperature. Thus, the model describes the system in a situation with equilibrium with respect to input-output to the sediment. The basic module and the different governing processes included are described in more detail in (DHI, 2000).

In the Baltic Sea substantial amounts of dissolved organic matter (C, N and P) are present. The biogeochemical model does not include either of these parameters explicitly, however, some of the features of DOC/DON are taken into account: DOC is included indirectly as contribution to the background shading effect, whereas DON is neglected by removing the bio-unavailable N, and modelling only the bio-available N.

Model set up

The model setup was developed and used in Edelvang et al. (2005) and Edelvang et al. (2001). Subsequently, the model area was enlarged and the bio-geochemical model refined as part of the NOCOMMENTS project (DHI, 2001) and establishment of an operational water forecast service (www.waterforecast.com), see also Sørensen et al. (2002) and Erichsen & Rasch (2001). The model has recently been further refined (DHI, 2003).

The model area covers the entire Baltic Sea, the transition area and the North Sea, with an open boundary to the north between Stavanger and Scotland (latitude app. 59°) and an open boundary to the south-west in the English Channel (latitude app. 51°). The model area is shown in Figure 4-2.

The applied model is set up with a horizontal resolution of 9 nm (nautical miles). However, in the transition area between the Baltic Sea and the North Sea an interactive two-way nesting technique is applied allowing a grid resolution of 3 nm in this area.

The bathymetry of the model domain is based on available surveys. However, some adjustments have been made in the narrow Danish Straits to ensure an appropriate representation of the deeper trenches, which are very important for the formation of the stratification in the Belt Sea.

The model has a vertical resolution of 2 m between –6 and –220 m. Below –220 m a bottom-boundary fitted approximation is applied to the remaining part of the local water column. The surface layer varies with the free surface elevation and extends down to level –6 m (or local depths at shallower depths). The model is run with a time step of 300 sec.

Boundaries and forcings

To run the hydrodynamic model, some external forcings, boundaries, and initial conditions are required. The required data and their origin are listed in Table A1.

With respect to the North Sea boundary no modifications have been made to account for reference conditions. This might cause some interference in the Skagerrak and potentially in Kattegat. However, the direct transport from the North Sea boundaries is small, and less significant than the loadings from the German and Dutch rivers (which have been reduced properly). The effects from these rivers are regarded as much more important. Furthermore, the northern boundary is close to North Atlantic waters which are less influenced by anthropogenic loadings.

Table A1: Data required running the model.

HYDRODYNAMIC MODEL	Data origin
Open marine boundaries	
Astronomical tides (corrected for actual atmospheric pressure)	
Climatological ¹⁾ values of temperature and salinity distribution in sections (linearly interpolated to cover the entire sections)	ICES ²⁾ database (on request)
Initial fields	
North Sea and Baltic Sea; Salinity, temperature	ICES database (on request)
Interconnecting Seas; Salinity, temperature	NERI ³⁾ (MADS database)
Run-off	
Actual monthly values of flow for Danish, Swedish, Norwegian rivers to Skagerrak, Kattegat, and the Belt Sea	NERI SMHI ⁴⁾ (on request)

Climatological ¹⁾ values for the remaining rivers (Great Britain, Netherlands, Belgium, Germany, Poland, Norway, Russia, Finland, Sweden)	IMR ⁵⁾ (on request) HELCOM/OSPAR
Air-sea exchange	
Climatological ¹⁾ values of net precipitation	
Actual 3-hourly 10 m wind and air pressure fields	HIRLAM, DMI ⁶⁾
Actual 3-hourly 2 m air temperature fields	HIRLAM, DMI ⁶⁾
Climatological ¹⁾ clearness information	

1) 10 years of monthly mean.

2) International Council for the Exploitation of the Seas, see <http://www.ices.dk> for further information.

3) National Environmental Research Institute, see <http://www.neri.dk> for further information.

4) Swedish Meteorological and Hydrological Institute, see <http://www.smhi.se> for further information.

5) Institute of Marine Research, see <http://www.imr.no> for further information.

6) Danish Meteorological Institute, see <http://www.dmi.dk> for further information.

Estimation of reference conditions

The reference conditions in this study are estimated from the present nutrient loads, assuming that today's load is 50% higher than the loading under pristine conditions. This represents the scenario of minimum anthropogenic loading. It is not possible to say exactly when this level of loading occurred but it is somewhere between the pristine state, without any human influence, and before the introduction of intensive farming.

The absolute reductions (of approx. 60-70% N and P) do however correspond to the reduction estimated from Schernewski & Neumann (2005). Here the loads are calculated by applying concentrations to various Baltic rivers which approximate the concentrations measured around the 1950's – 1960's.

For this study the information on “pristine loads” of N and P from Denmark originates from NERI (pers. com. Jens Bøgestrand). According to Jens Bøgestrand the loading corresponding to the weather in year 2000 equals 2.36 kg N/ha/year and 0.07 kg P/ha/year. These estimated “pristine scenario” loads compared with the actual loads for year 2000 represent a reduction of 67% which is then applied to the Swedish and German local loads as well as to the regional loads to the North Sea. This same reduction is applied for all years.

For the regional loading to the Baltic Sea an area-specific N loading of 1.5 kg N/ha/year is applied. This corresponds to a 4-fold increase from the pristine state up to today.

The atmospheric deposition of nitrogen is set at 1 kg N/ha/year. This corresponds to approximately 5% of present atmospheric loads (pers. com. Ole Hertel, NERI). This value compares to the estimated nitrogen deposition for the period 1958-59 for the most northerly part of the Baltic Sea of approx. 1 kg N/ha/year. The loadings are estimated and shown in Table A2.

Table A2: Background loading data.

	Inner Danish Waters		Total Baltic Sea/North Sea	
	Ton N	Ton P	Ton N	Ton P
In total	44,000	1,200	640,000	26,100
From land	41,300	1,200	553,000	26,100
From atmosphere	2,700	0	87,000	0

Initial fields

The distribution of initial concentrations is based on profile measurements obtained from NERI and ICES databases. Interpolation is carried out applying objective analysis, and the data included covers December/January year 2000 measurements in the Danish Waters (NERI) and December/January measurements from the years 1995-1999 for the North Sea and Baltic Sea (ICES online database).

These data fields have then been corrected by 0 % in the North Sea and approximately 80 % in the Baltic Sea. Hereafter the physical year 2000 has been modelled cyclically for 5 years using the resulting concentrations from one year's simulation as the initial fields for the following year. After 5 years the results were more or less in equilibrium in the North Sea, Baltic Sea and the transition area and so the simulations were ended. Hence, the results presented here are from the 5th simulation.

Because the model has been calibrated only to include bio-active nitrogen, the year 2000 initial fields of total N have been reduced by approx. 20 $\mu\text{mol/l}$ in the Baltic Sea and 10 $\mu\text{mol/l}$ in Skagerrak. The following results of total N represent therefore only the bio-active component of total N.

In a system like the Baltic Sea with residence times of up to 30 years and large sediment pools of nutrients, initial fields of both the sediment and the pelagic phase are important in the evaluation of the reference situation. In this study we focus on the pelagic system with an attempt to reach an equilibrium situation.

The results obtained with this modelling approach are in accordance with expectations for a steady state situation with respect to organic matter and nutrients pools in the sediment and with respect to the water column. With this approach we estimate the expected concentrations when steady state is reached but we do not make any estimation of time needed to reach steady state.

The system does appear to reach a state of equilibrium after 5 consecutive model runs with the applied assumptions for new initial conditions. In reality, the adjustment to significantly reduced loads will take 20-50 years. No account has been taken of variations in conditions between different years (meteorology, runoff, etc.). This model has only been tested under the conditions of year 2000 and should really be tested against conditions which occurred during other years and perhaps even against predicted climate changes.

References

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Schernewski, G. & T. Neumann (2005): The Trophic State of the Baltic Sea a Century Ago: A Model Simulation Study. *Journal of Marine Systems* 53:109-124.

Sørensen, J.V.T., H. Madsen, H. Madsen, H.J. Jensen, P.S. Rasch, A.C. Erichsen K.I. Dahl-Madsen (2002): Data assimilation in an operational forecast system of the North Sea – Baltic Sea system. Conference Paper at EuroGOOS 2002.

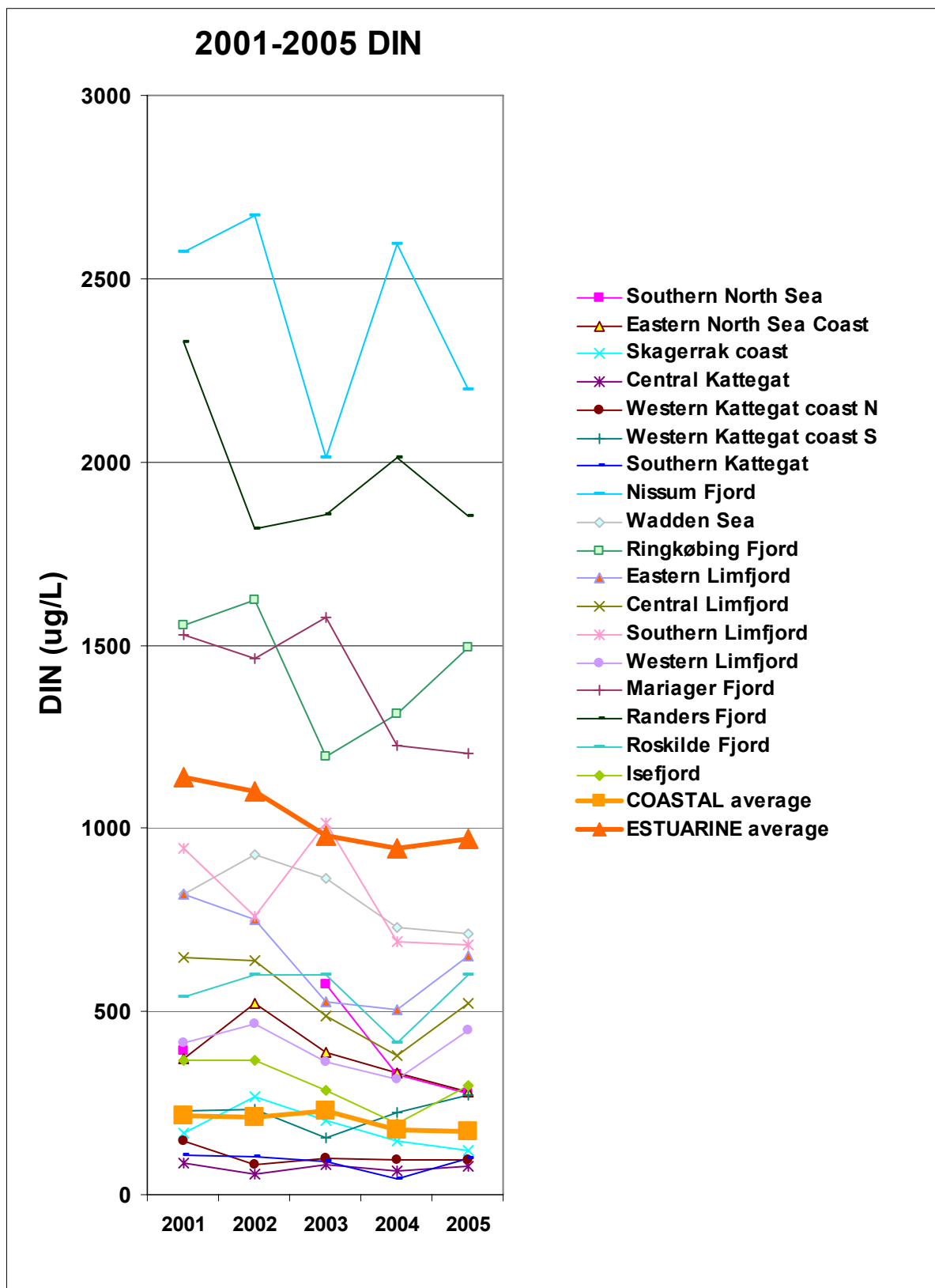
Annex C1: Data made available by the regional Environment Centres

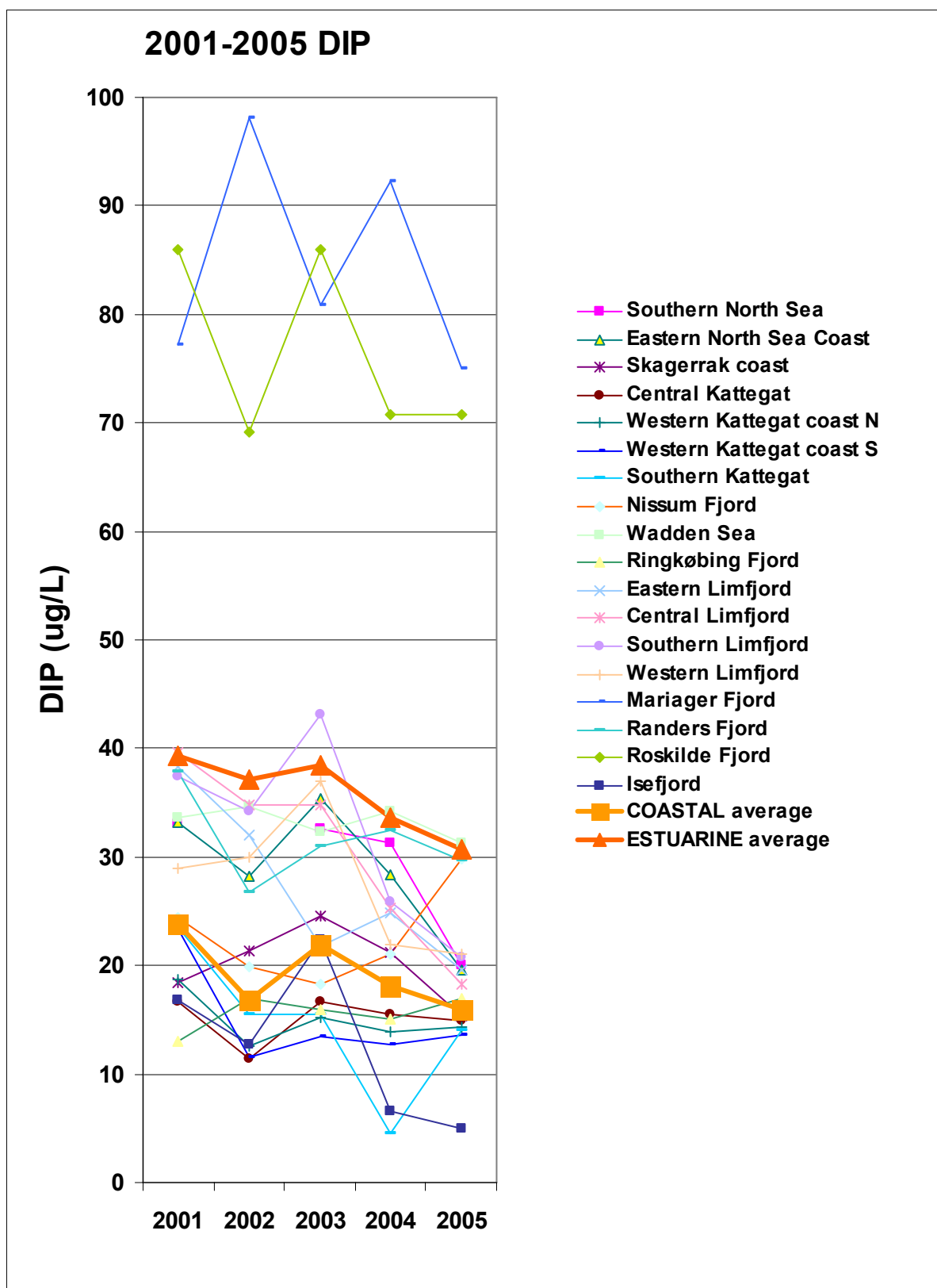
Annual means have been estimated for each assessed area for DIN, DIP, chl-a, O₂ and depth limit of eelgrass. Not all parameters have been reported for all area. Area 1, 8, 9 and 19 are not covered by the regional monitoring.

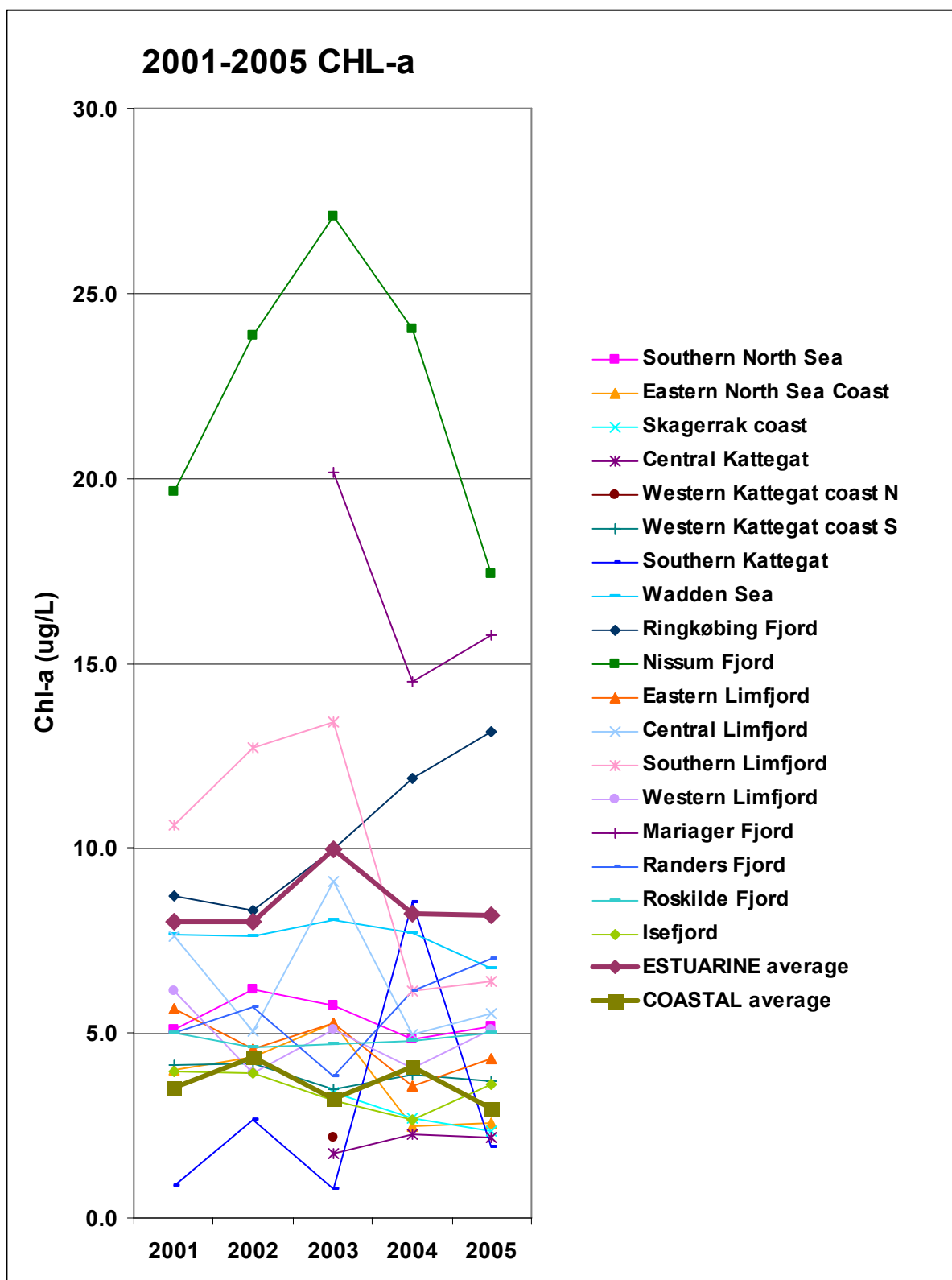
DIN, DIP, chl-a concentrations are all in µg/L.

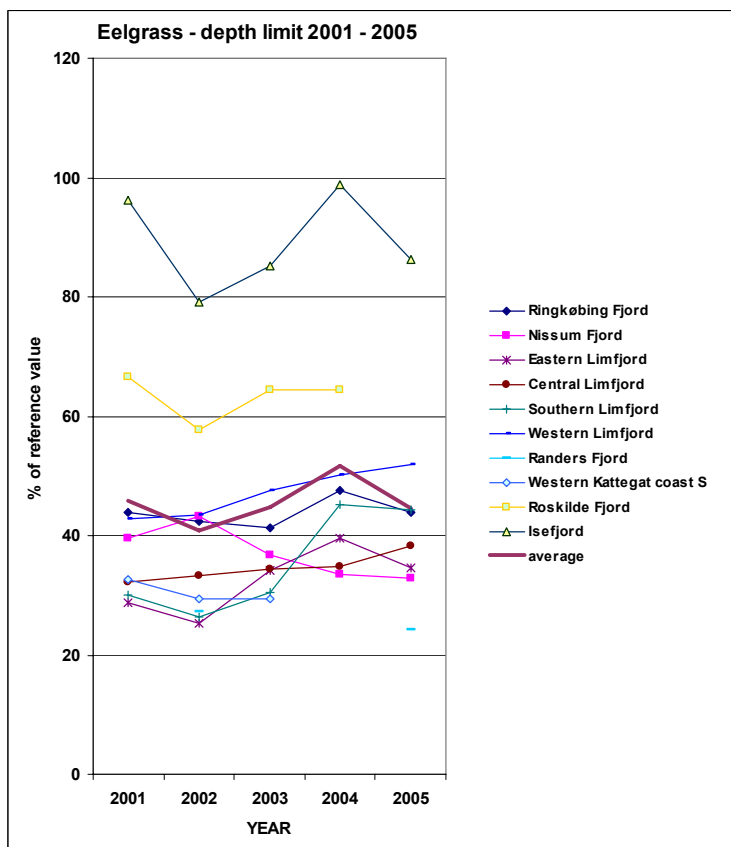
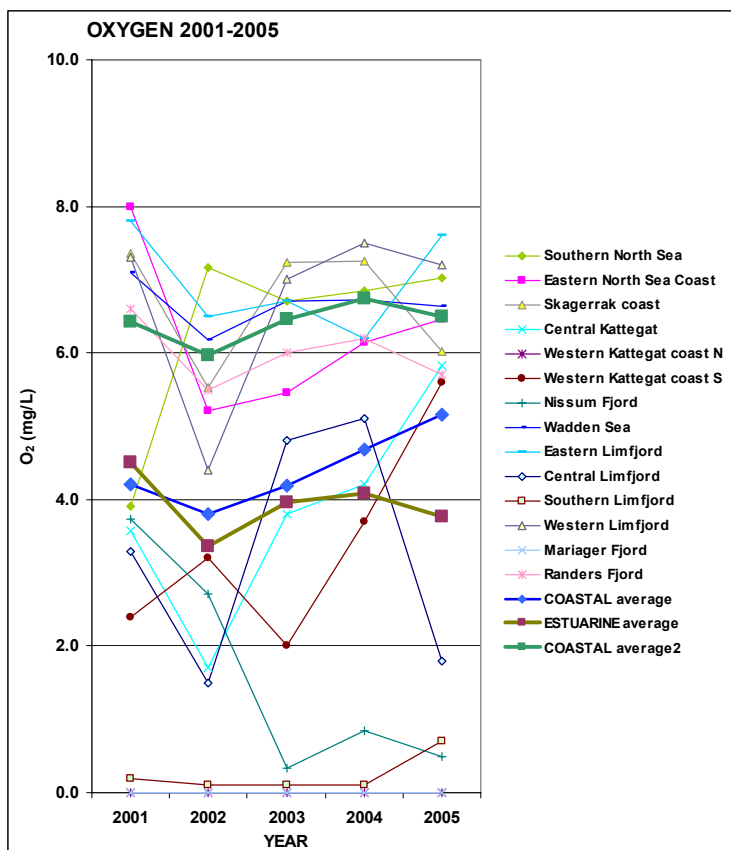
O₂ is the lowest value (mg/L) observed in the bottom water at the monitoring stations. Oxygen depletion may occur outside the monitored areas.

The depth limits of eelgrass have been related to the reference condition stated for the individual area in Annex E, i.e. the unit is percentage.



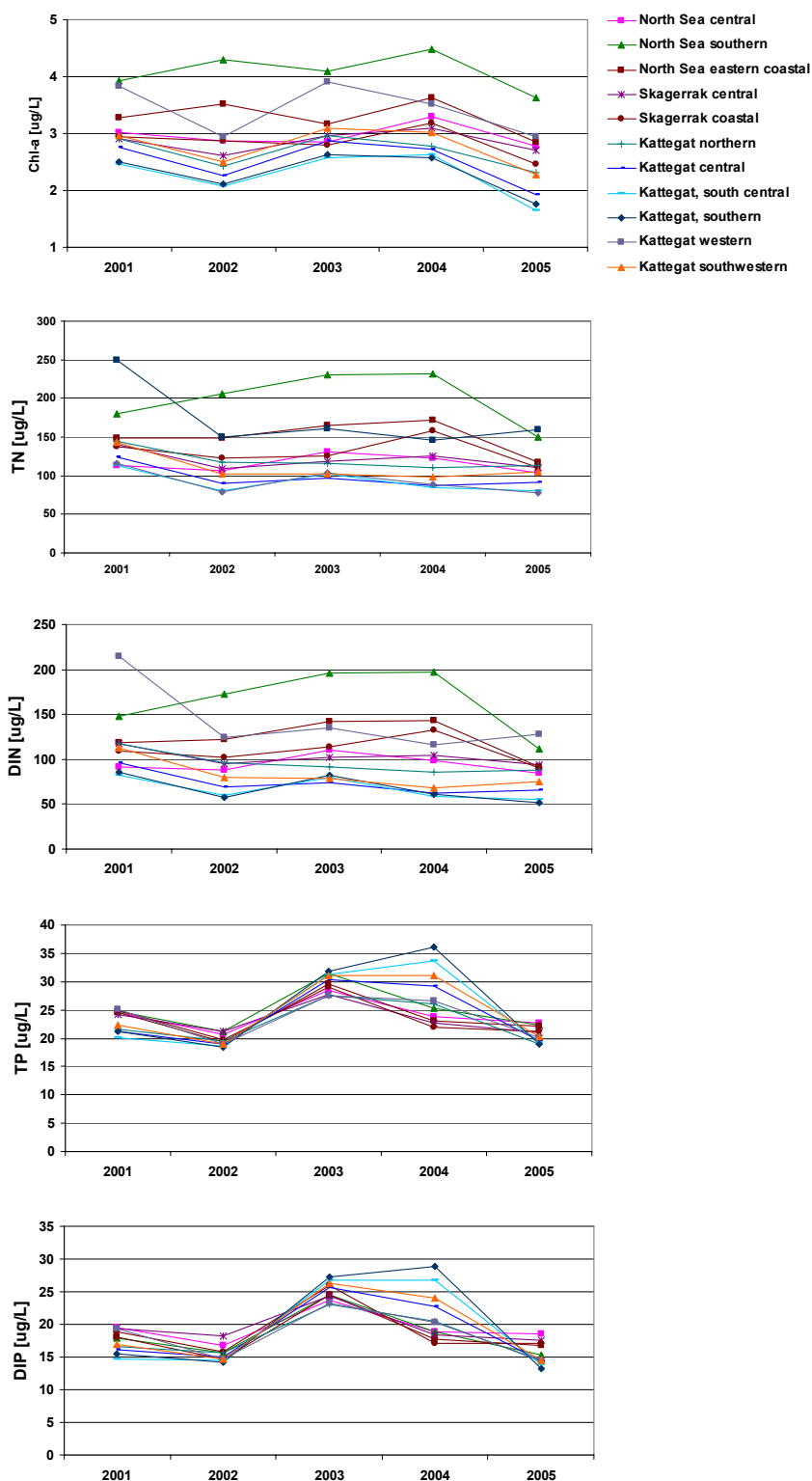






Annex C2: Annual average extracted from BANSAL model

For each area in the open and coastal North Sea, Skagerrak and Kattegat, averages of surface (5m) chlorophyll-a (annual), and nutrients (TN, DIN, TP and DIP; winter 1 December – 1 March) are estimated from the results of simulation with the DHI BANSAL model through 2001-2005.





Annex D: Overall OSPAR Common Procedure classification

Abbreviations:

NI: Riverine total N and total P inputs and direct discharges
DI: Winter DIN and/or DIP concentrations
NP: Increased winter N/P ratio
Ca: Maximum and mean Chl-a concentration
Ps: Region/area specific phytoplankton indicator species

Mp: Macrophytes including macroalgae
O2: Degree of oxygen depletion (hypoxia)
Ck: Changes/kills in zoobenthos and fish kills
Oc: Organic carbon/organic matter
At: Algal toxins (DSP/PSP/ASP, mussel infection events)

PA: Problem area
NPA: Non-problem area
PPA: Potential problem area

Area	Cat. I Causative factors	Cat. II Direct ef- fects	Cat. III and IV Indirect effects/ other possible effects	Initial clas- sification	Overall appraisal of all relevant information	Final classification	Assessment period
1. The North Sea, open waters	NI – DI + NP –	Ca + Ps – Mp –	O2 – At – Ck – Oc –	PA	<i>Northern part: Concentrations of nutrients are not elevated. Central part: Nutrient concentrations elevated due to the Jutland Coastal Current.</i>	NPA/ PPA/ PA	2001-2005
2. The North Sea, southern coastal waters	NI – DI + NP –	Ca + Ps – Mp –	O2 – At – Ck – Oc –	PA	<i>Nutrient and Chl-a concentrations elevated due to local inputs and inputs from the Jutland Coastal Current.</i>	PA	2001-2005
3. The North Sea, coastal waters	NI – DI + NP –	Ca + Ps – Mp –	O2 – At – Ck – Oc –	PA	<i>Nutrient concentrations elevated due to local inputs and input from the Jutland Coastal Current.</i>	PA	2001-2005
4. The Wadden Sea	NI – DI + NP –	Ca + Ps – Mp –	O2 – At – Ck (+) Oc –	PA	<i>Nutrient concentrations elevated. Tendency towards reduction in bottom fauna biomass.</i>	PA	2001-2005
5. Ringkøbing Fjord	NI + DI – NP –	Ca + Ps – Mp +	O2 (+) Ck + Oc –	PA	<i>Nutrient and Chl-a concentrations elevated. Oxygen depletion rare. Depth limit and coverage of eelgrass reduced.</i>	PA	2001-2005
6. Nissum Fjord	NI + DI – NP –	Ca (+) Ps – Mp +	O2 (+) Ck – Oc –	PA	<i>Nutrient and Chl-a concentrations elevated. Oxygen depletion occurs annually. Depth limit and coverage of eelgrass reduced.</i>	(PA)	2001-2005
7. The Skagerrak, coastal waters	NI – DI + NP –	Ca + Ps – Mp –	O2 – At – Ck – Oc –	PA	<i>Nutrient and Chl-a concentrations elevated due to input from the Jutland Coastal Current.</i>	PA	2001-2005
8. The Skagerrak, open waters	NI – DI + NP –	Ca + Ps – Mp –	O2 – At – Ck – Oc –	NPA	<i>Concentrations of nutrients are not elevated.</i>	NPA	2001-2005
9. Limfjorden, western parts	NI – DI + NP –	Ca – Ps – Mp +	O2 (+) Ck + Oc –	PA	<i>Nutrient and Chl-a concentrations elevated. Oxygen depletion rare. Depth limit and coverage of eelgrass reduced. Bottom fauna deteriorated.</i>	PA	2001-2005



Area	Cat. I Causative factors	Cat. II Direct effects	Cat. III and IV Indirect effects/ other possible effects			Initial clas- sification	Overall appraisal of all relevant information	Final classification	Assessment period
10. Limfjorden, cen- tral parts	NI – DI – NP –	Ca + Ps – Mp +	O2 (+) Ck + Oc –	At –	–	PA	<i>Nutrient and Chl-a concentrations elevated. Oxygen depletion common. Depth limit and coverage of eelgrass reduced. Bottom fauna deteriorated.</i>	PA	2001-2005
11. Limfjorden, southern parts	NI – DI + NP –	Ca + Ps – Mp +	O2 (+) Ck + Oc –	At –	–	PA	<i>Nutrient and Chl-a concentrations elevated. Severe oxygen depletion common. Depth limit and coverage of eelgrass reduced. Bottom fauna deteriorated.</i>	PA	2001-2005
12. Limfjorden, eastern parts	NI – DI – NP –	Ca – Ps – Mp +	O2 (+) Ck (+) Oc –	At –	–	PA	<i>Nutrient and Chl-a concentrations elevated. Oxygen depletion rare. Depth limit and coverage of eelgrass reduced. Bottom fauna deteriorated.</i>	(PA)	2001-2005
13. The Kattegat, northern open waters	NI – DI + NP –	Ca + Ps – Mp –	O2 – Ck – Oc –	At –	–	PA	<i>Nutrient and Chl-a concentrations elevated</i>	PA	2001-2005
14. The Kattegat, central open waters	NI – DI + NP –	Ca + Ps – Mp –	O2 (+) Ck + Oc –	At –	–	PA	<i>Nutrient and Chl-a concentrations elevated. Oxygen depletion common.</i>	PA	2001-2005
15. The Kattegat, western coastal waters	NI – DI + NP –	Ca + Ps – Mp (+)	O2 (+) Ck (+) Oc –	At –	–	PA	<i>Nutrient and Chl-a concentration elevated. Oxygen depletion occurring regularly. Distribution of eelgrass reduced. Bottom fauna indicators indicate deteriorate status.</i>	PA	2001-2005
16. The Kattegat, south-western coastal waters	NI – DI + NP –	Ca + Ps – Mp –	O2 (+) Ck + Oc –	At –	–	PA	<i>Nutrient and Chl-a concentration elevated. Oxygen depletion occurring regularly. Distribution of eelgrass reduced. Bottom fauna indicators indicate deteriorate status.</i>	PA	2001-2005
17. The Kattegat, southern coastal waters	NI – DI + NP –	Ca + Ps – Mp –	O2 (+) Ck – Oc –	At –	–	PA	<i>Nutrient and Chl-a levels slightly elevated. Severe oxygen depletion common.</i>	PA	2001-2005
18. The Kattegat, southern open waters	NI – DI + NP –	Ca + Ps – Mp –	O2 (+) Ck – Oc –	At –	–	PA	<i>Nutrient and Chl-a levels slightly elevated. Severe oxygen depletion common.</i>	PA	2001-2005
19. Mariager Fjord	NI – DI + NP –	Ca – Ps – Mp (+)	O2 (+) Ck + Oc –	At –	–	PA	<i>Nutrient and Chl-a concentration elevated. Oxygen depletion regularly reaching surface/shallow waters (<10m). Distribution of eelgrass reduced. Bottom fauna deteriorated.</i>	PA	2001-2005
20. Randers Fjord	NI – DI + NP –	Ca + Ps – Mp +	O2 (+) Ck + Oc –	At –	–	PA	<i>Nutrient and chl-a concentration elevated. Oxygen depletion occurring. Distribution of eelgrass reduced</i>	PA	2001-2005
21. Isefjord	NI – DI – NP –	Ca (+) Ps – Mp +	O2 – Ck + Oc –	At –	–	PA	<i>Nutrient and Chl-a concentrations elevated. Toxic algae rare and no problems observed. Slightly decreased depth limit of eelgrass – around 90% of reference condition.</i>	PA	2001-2005
22. Roskilde Fjord	NI – DI + NP –	Ca (+) Ps – Mp +	O2 (+) Ck + Oc –	At –	–	PA	<i>Nutrient and Chl-a concentrations elevated. Phosphorus particular high in inner part. Decreased depth limit of eelgrass. No oxygen depletion.</i>	PA	2001-2005



Annex E: Overview of the OSPAR Common Procedure assessment and the HEAT assessment

The areas assessed are:

1. North Sea – open waters
2. North Sea – southern coastal waters
3. North Sea – coastal waters
4. The Wadden Sea – Danish parts
5. Ringkøbing Fjord
6. Nissum Fjord
7. Skagerrak – open waters
8. Skagerrak – coastal waters
9. Limfjorden – eastern parts
10. Limfjorden – central parts
11. Limfjorden – southern parts
12. Limfjorden – western parts
13. Kattegat – northern open waters
14. Kattegat – central open waters
15. Kattegat – western coastal waters
16. Kattegat – south western coastal waters
17. Kattegat – southern open waters
18. Kattegat – southern coastal waters
19. Mariager Fjord
20. Randers Fjord
21. Isefjorden
22. Roskilde Fjord

Abbreviations used:

QE = quality element
PP = phytoplankton
SAV = submerged aquatic vegetation
BIF = benthic invertebrate fauna
PC = physico-chemical supporting features
RefCon = reference conditions
AcDev = acceptable deviation
Sc = score (in relation to ‘quality’ of RefCon, AcDev and current status)
EQR = ecological quality ratio
Ind-conf = ‘confidence’ estimated per indicator
We = weight (between indicators)
QE-EQR = ecological quality ratio calculated per quality element
QE-stat = eutrophication status per quality element
QE-conf = ‘confidence’ estimated per quality element
QE-we = weight between quality elements



Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/−)	RefCon source	Status source
I:	• TN, annual mean	5.5	μmol/l	50%	8.0	+	DHI, 2003*	This study
	• TN, winter max.	5.9	μmol/l	50%	8.5	÷	DHI, 2003*	This study
	• DIN, annual mean	1.4	μmol/l	50%	3.1	+	DHI, 2003*	This study
	• DIN, winter max.	3.9	μmol/l	50%	6.9	+	DHI, 2003*	This study
	• TP, annual mean	0.66	μmol/l	50%	0.6	÷	DHI, 2003*	This study
	• TP, winter max.	0.78	μmol/l	50%	0.8	÷	DHI, 2003*	This study
II:	• DIP, annual mean	0.32	μmol/l	50%	0.3	÷	DHI, 2003*	This study
	• DIP, winter max.	0.57	μmol/l	50%	0.6	÷	DHI, 2003*	This study
	• <i>Sum for Cat. I (one out – all out)</i>					+		
	• Chlorophyll-a, annual mean	2.3	μg/l	50%	3.0	÷	DHI, 2003*	This study
	• Chlorophyll-a, summer mean	2.1	μg/l	50%	2.7	÷	DHI, 2003*	This study
	• <i>Sum for Cat. II (one out – all out)</i>					÷		
III + IV:	• No information	—	—	—	—	—	—	—
	• <i>Sum for Cat. III (one out – all out)</i>					—		
	Final assessment					+		

B: Assessment made with HEAT:

[illegible]



2: The North Sea, southern coastal waters

A: Initial assessment made by using OCP-2:

Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, annual mean	7.1	µmol/l	50%	13.9	+	DHI, 2003*	This study
	• TN, winter max.	6.1	µmol/l	50%	14.2	+	DHI, 2003*	This study
	• DIN, annual mean	1.4	µmol/l	50%	5.9	+	DHI, 2003*	This study
	• DIN, winter max.	3.5	µmol/l	50%	11.8	+	DHI, 2003*	This study
	• TP, annual mean	0.55	µmol/l	50%	0.7	÷	DHI, 2003*	This study
II:	• TP, winter max.	0.64	µmol/l	50%	0.8	÷	DHI, 2003*	This study
	• DIP, annual mean	0.21	µmol/l	50%	0.3	÷	DHI, 2003*	This study
	• DIP, winter max.	0.40	µmol/l	50%	0.6	+	DHI, 2003*	This study
	• Sum for Cat. I (one out – all out)					+		
	• Chlorophyll-a, annual mean	2.5	µg/l	50%	4.1	÷	DHI, 2003*	This study
III + IV:	• Chlorophyll-a, summer mean	1.9	µg/l	50%	3.5	+	DHI, 2003*	This study
	• Chlorophyll-a, 90% March-September	4.0	µg/l	85%	5.3	÷	Danish EPA, 2007	Henriksen, pers. comm.
	• Sum for Cat. II (one out – all out)					+		
	• No information	—	—	—	—	—	—	—
	• Sum for Cat. III (one out – all out)					—		
	Final assessment					+		

* Data are extracted from DHI's modelling database.

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind-conf	We	QE-EQR	QE-stat	QE-conf	QE-we	Classification
PP:	• Chlorophyll-a, annual mean	2.5	µg/l	2	50%	2	4.1	2	0.610	4 / 7	40%					
	• Chlorophyll-a, summer mean	1.9	µg/l	2	50%	2	3.5	2	0.543	4 / 7	40%					
	• Chlorophyll-a, 90% March-September	4.0	µg/l	2	85%	2	5.3	1	0.755	5 / 7	20%					
											100%	0.612	MODERATE	11 / 19	50%	
SAV:	• No information	—	—	—	—	—	—	—								
BIF:	• No information	—	—	—	—	—	—	—								
PC:	• TN, annual mean	7.1	µmol/l	2	50%	2	13.9	2	0.511	4 / 7	15%					
	• TN, winter max.	6.1	µmol/l	2	50%	2	14.2	2	0.430	4 / 7	10%					
	• DIN, annual mean	1.4	µmol/l	2	50%	2	5.9	2	0.237	4 / 7	15%					
	• DIN, winter max.	3.5	µmol/l	2	50%	2	11.8	2	0.297	4 / 7	10%					
	• TP, annual mean	0.55	µmol/l	2	50%	2	0.7	2	0.786	4 / 7	15%					
	• TP, winter max.	0.64	µmol/l	2	50%	2	0.8	2	0.800	4 / 7	10%					
	• DIP, annual mean	0.21	µmol/l	2	50%	2	0.3	2	0.700	4 / 7	15%					
	• DIP, winter max.	0.40	µmol/l	2	50%	2	0.6	2	0.667	4 / 7	10%					
											100%	0.554	MODERATE	25 / 49	50%	
															100%	
																MODERATE
																CLASS II



3: The North Sea, coastal waters

A: Initial assessment made by using OCP-2:

Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, annual mean	5.8	µmol/l	50%	9.9	+	DHI, 2003*	This study
	• TN, winter max.	6.0	µmol/l	50%	10.7	+	DHI, 2003*	This study
	• DIN, annual mean	1.2	µmol/l	50%	4.0	+	DHI, 2003*	This study
	• DIN, winter max.	3.9	µmol/l	50%	8.	+	DHI, 2003*	This study
	• TP, annual mean	0.59	µmol/l	50%	0.6	÷	DHI, 2003*	This study
	• TP, winter max.	0.81	µmol/l	50%	0.8	÷	DHI, 2003*	This study
	• DIP, annual mean	0.25	µmol/l	50%	0.3	÷	DHI, 2003*	This study
	• DIP, winter max.	0.61	µmol/l	50%	0.6	÷	DHI, 2003*	This study
II:	<i>Sum for Cat. I (one out – all out)</i>							
	• Chlorophyll-a, annual mean	2.1	µg/l	50%	3.3	+	DHI, 2003*	This study
	• Chlorophyll-a, summer mean	1.6	µg/l	50%	2.9	+	DHI, 2003*	This study
	• Sum for Cat. II (one out – all out)					+		
III + IV:	• No information	—	—	—	—	—	—	—
	• Sum for Cat. III (one out – all out)					—		
	Final assessment					+		

* Data are extracted from DHI's modelling database.

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind-conf	We	QE-EQR	QE-stat	QE-conf	QE-we	Classification
PP:	• Chlorophyll-a, annual mean	2.1	µg/l	2	50%	2	3.3	1	0.636	5 / 7	50%					
	• Chlorophyll-a, summer mean	1.6	µg/l	2	50%	2	2.9	1	0.552	5 / 7	50%					
SAV:	• No information	—	—	—	—	—	—	—			100%	0.594	MODERATE	9 / 13	50%	
	• No information	—	—	—	—	—	—	—								
PC:	• TN, annual mean	5.8	µmol/l	2	50%	2	9.9	2	0.586	4 / 7	15%					
	• TN, winter max.	6.0	µmol/l	2	50%	2	10.7	2	0.561	4 / 7	10%					
	• DIN, annual mean	1.2	µmol/l	2	50%	2	4.0	2	0.300	4 / 7	15%					
	• DIN, winter max.	3.9	µmol/l	2	50%	2	8.	2	0.488	4 / 7	10%					
	• TP, annual mean	0.59	µmol/l	2	50%	2	0.6	2	0.983	4 / 7	15%					
	• TP, winter max.	0.81	µmol/l	2	50%	2	0.8	2	1.000	4 / 7	10%					
	• DIP, annual mean	0.25	µmol/l	2	50%	2	0.3	2	0.833	4 / 7	15%					
	• DIP, winter max.	0.61	µmol/l	2	50%	2	0.6	2	1.000	4 / 7	10%					
											100%	0.710	GOOD	25 / 49	50%	
															100%	
											Final eutrophication status:			Interim confidence rating:		
											MODERATE			CLASS II		



Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, annual mean	8.4	µmol/l	50%	17.9	+	DHI, 2003*	This study
	• TN, winter max.	16.1	µmol/l	50%	24.0	÷	DHI, 2003*	This study
	• DIN, annual mean	2.4	µmol/l	50%	9.3	+	DHI, 2003*	This study
	• DIN, winter max.	11.5	µmol/l	50%	20.5	+	DHI, 2003*	This study
	• TP, annual mean	0.46	µmol/l	50%	0.6	÷	DHI, 2003*	This study
	• TP, winter max.	0.63	µmol/l	50%	0.9	÷	DHI, 2003*	This study
	• DIP, annual mean	0.18	µmol/l	50%	0.3	÷	DHI, 2003*	This study
	• DIP, winter max.	0.40	µmol/l	50%	0.6	÷	DHI, 2003*	This study
II:	• <i>Sum for Cat. I (one out – all out)</i>					+		
	• Chlorophyll-a, annual mean	2.7	µg/l	50%	4.6	+	DHI, 2003*	This study
	• Chlorophyll-a, summer mean	1.9	µg/l	50%	3.8	+	DHI, 2003*	This study
III + IV:	• Chlorophyll-a, 90% March-September	4.0	µg/l	85%	21.2	+	Danish EPA, 2007	Henriksen, pers. comm.
	• <i>Sum for Cat. II (one out – all out)</i>					+		
	• No information	–	–	–	–	–	–	–
	• <i>Sum for Cat. III (one out – all out)</i>							
	Final assessment					+		

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind- conf	We	QE- EQR	QE- stat	QE- conf	QE- we	Classifi- cation
PP:	• Chlorophyll-a, annual mean	2.7	µg/l	2	50%	2	4.6	2	0.587	4 / 7	40%					
	• Chlorophyll-a, summer mean	1.9	µg/l	2	50%	2	3.8	2	0.500	4 / 7	40%					
	• Chlorophyll-a, 90% March-September	4.0	µg/l	2	85%	2	21.2	1	0.189	5 / 7	20%					
SAV: BF: PC:	• No information	—	—	—	—	—	—	—			100%	0.473	POOR	11 / 19	50%	
	• No information	—	—	—	—	—	—	—								
	• TN, annual mean	8.4	µmol/l	2	50%	2	17.9	2	0.469	4 / 7	15%					
	• TN, winter max.	16.1	µmol/l	2	50%	2	24.0	2	0.671	4 / 7	10%					
	• DIN, annual mean	2.4	µmol/l	2	50%	2	9.3	2	0.258	4 / 7	15%					
	• DIN, winter max.	11.5	µmol/l	2	50%	2	20.5	2	0.561	4 / 7	10%					
	• TP, annual mean	0.46	µmol/l	2	50%	2	0.6	2	0.760	4 / 7	15%					
	• TP, winter max.	0.63	µmol/l	2	50%	2	0.9	2	0.700	4 / 7	10%					
	• DIP, annual mean	0.18	µmol/l	2	50%	2	0.3	2	0.600	4 / 7	15%					
	• DIP, winter max.	0.40	µmol/l	2	50%	2	0.6	2	0.667	4 / 7	10%					
											100%	0.574	MODERATE	25 / 49	50%	
															100%	
													Final eutrophication status:			POOR
													Interim confidence rating:			CLASS II



Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/÷)	RefCon source	Status source
I:	• N input	504	ton	50%	5025	+	Hansen, pers. comm.	Ibid.
	• <i>Sum for Cat. I (one out – all out)</i>					+		
II:	• Secchi depth	> 2	m	25%	1.7	+	Riemann et al. 2004	Hansen, pers. comm
	• Eelgrass, depth limit	> 2.5	m	25%	1.67	+	Riemann et al. 2004	MC Ringkøbing, 2007
	• Ruppia sp., depth limit	3.25	m	25%	1.67	+	Riemann et al. 2004	Hansen, pers comm.
	• <i>Sum for Cat. II (one out – all out)</i>					+		
III + IV:	• Biomass, benthic invertebrate fauna	73	g/m2	50%	450	+	Riemann et al. 2004	MC Ringkøbing 2007
	• <i>Sum for Cat. III (one out – all out)</i>					+		
	Final assessment					+		

[illegible]



Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/÷)	RefCon source	Status source
I:	• N input	750	tons	50%	2049	+	Rasmussen & Uhrenholdt, 2006	Ibid.
	• P input	42	tons	50%	58	÷	Rasmussen & Uhrenholdt, 2006	Ibid.
	• <i>Sum for Cat. I (one out – all out)</i>					+		
II:	• Eelgrass depth limit	1.8	m	25%	0.9	+	Rasmussen & Uhrenholdt, 2006	MC Ringkøbing, 2007
III + IV:	• <i>Sum for Cat. II (one out – all out)</i>					+		
	• No information	–	–	–	–	–	–	–
	• <i>Sum for Cat. III (one out – all out)</i>					–		
	Final assessment					+		

[illegible]



7: The Skagerrak, coastal waters

A: Initial assessment made by using OCP-2:

Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, annual mean	5.5	µmol/l	50%	8.3	+	DHI, 2003*	This study
	• TN, winter max.	6.3	µmol/l	50%	9.3	÷	DHI, 2003*	This study
	• DIN, annual mean	1.6	µmol/l	50%	3.6	+	DHI, 2003*	This study
	• DIN, winter max.	4.9	µmol/l	50%	7.8	+	DHI, 2003*	This study
	• TP, annual mean	0.63	µmol/l	50%	0.6	÷	DHI, 2003*	This study
	• TP, winter max.	0.79	µmol/l	50%	0.8	÷	DHI, 2003*	This study
II:	• DIP, annual mean	0.31	µmol/l	50%	0.3	÷	DHI, 2003*	This study
	• DIP, winter max.	0.61	µmol/l	50%	0.6	÷	DHI, 2003*	This study
	• Sum for Cat. I (one out – all out)					+		
	• Chlorophyll-a, annual mean	2.2	µg/l	50%	2.9	÷	DHI, 2003*	This study
	• Chlorophyll-a, summer mean	1.8	µg/l	50%	2.5	÷	DHI, 2003*	This study
	• Chlorophyll-a, 90% summer mean	2.0	µg/l	100%	6.8	+	Danish EPA, 2007	Henriksen, pers. comm.
III + IV:	• Sum for Cat. II (one out – all out)					+		
	• No information	—	—	—	—	—	—	—
	• Sum for Cat. III (one out – all out)					—		
	Final assessment					+		

* Data are extracted from DHI's modelling database.

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind-conf	We	QE-EQR	QE-stat	QE-conf	QE-we	Classification
PP:	• Chlorophyll-a, annual mean	2.2	µg/l	2	50%	2	2.9	2	0.759	4 / 7	40%					
	• Chlorophyll-a, summer mean	1.8	µg/l	2	50%	2	2.5	2	0.720	4 / 7	40%					
	• Chlorophyll-a, 90% summer mean	2.0	µg/l	2	50%	2	6.8	1	0.294	5 / 7	20%					
SAV:	• No information	—	—	—	—	—	—	—			100%	0.650	MODERATE	11 / 19	50%	
BIF:	• No information	—	—	—	—	—	—	—								
PC:	• TN, annual mean	5.5	µmol/l	2	50%	2	8.3	2	0.663	4 / 7	15%					
	• TN, winter max.	6.3	µmol/l	2	50%	2	9.3	2	0.677	4 / 7	10%					
	• DIN, annual mean	1.6	µmol/l	2	50%	2	3.6	2	0.444	4 / 7	15%					
	• DIN, winter max.	4.9	µmol/l	2	50%	2	7.8	2	0.628	4 / 7	10%					
	• TP, annual mean	0.63	µmol/l	2	50%	2	0.6	2	1.000	4 / 7	15%					
	• TP, winter max.	0.79	µmol/l	2	50%	2	0.8	2	0.988	4 / 7	10%					
	• DIP, annual mean	0.31	µmol/l	2	50%	2	0.3	2	1.000	4 / 7	15%					
	• DIP, winter max.	0.61	µmol/l	2	50%	2	0.6	2	1.000	4 / 7	10%					
											100%	0.795	GOOD	25 / 49	50%	
															100%	
																MODERATE
																CLASS II



8: The Skagerrak, open waters

A: Initial assessment made by using OCP-2:

Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, annual mean	5.5	µmol/l	50%	7.5	÷	DHI, 2003*	This study
	• TN, winter max.	7.1	µmol/l	50%	8.6	÷	DHI, 2003*	This study
	• DIN, annual mean	2.0	µmol/l	50%	3.4	+	DHI, 2003*	This study
	• DIN, winter max.	5.5	µmol/l	50%	7.3	÷	DHI, 2003*	This study
	• TP, annual mean	0.65	µmol/l	50%	0.7	÷	DHI, 2003*	This study
	• TP, winter max.	0.84	µmol/l	50%	0.8	÷	DHI, 2003*	This study
	• DIP, annual mean	0.37	µmol/l	50%	0.4	÷	DHI, 2003*	This study
	• DIP, winter max.	0.68	µmol/l	50%	0.6	÷	DHI, 2003*	This study
II:	<i>Sum for Cat. I (one out – all out)</i>							
	• Chlorophyll-a, annual mean	2.4	µg/l	50%	2.9	÷	DHI, 2003*	This study
	• Chlorophyll-a, summer mean	2.5	µg/l	50%	2.4	÷	DHI, 2003*	This study
	• Sum for Cat. II (one out – all out)					÷		
III + IV:	• No information	—	—	—	—	—	—	—
	• Sum for Cat. III (one out – all out)					—		
	Final assessment					+		

* Data are extracted from DHI's modelling database.

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind-conf	We	QE-EQR	QE-stat	QE-conf	QE-we	Classification
PP:	• Chlorophyll-a, annual mean	2.4	µg/l	2	50%	2	2.9	1	0.828	5 / 7	50%					
	• Chlorophyll-a, summer mean	2.5	µg/l	2	50%	2	2.4	1	1.000	5 / 7	50%					
SAV:	• No information	—	—	—	—	—	—	—			100%	0.914	HIGH	9 / 13	50%	
	• No information	—	—	—	—	—	—	—								
PC:	• TN, annual mean	5.5	µmol/l	2	50%	2	7.5	2	0.733	4 / 7	15%					
	• TN, winter max.	7.1	µmol/l	2	50%	2	8.6	2	0.826	4 / 7	10%					
	• DIN, annual mean	2.0	µmol/l	2	50%	2	3.4	2	0.588	4 / 7	15%					
	• DIN, winter max.	5.5	µmol/l	2	50%	2	7.3	2	0.753	4 / 7	10%					
	• TP, annual mean	0.65	µmol/l	2	50%	2	0.7	2	0.929	4 / 7	15%					
	• TP, winter max.	0.84	µmol/l	2	50%	2	0.8	2	1.000	4 / 7	10%					
	• DIP, annual mean	0.37	µmol/l	2	50%	2	0.4	2	0.925	4 / 7	15%					
	• DIP, winter max.	0.68	µmol/l	2	50%	2	0.6	2	1.000	4 / 7	10%					
											100%	0.834	HIGH	25 / 49	50%	
															100%	
											Final eutrophication status:			Interim confidence rating:		
																HIGH
																CLASS II



Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, annual mean	30	µmol/l	50%	33.7	÷	Christiansen et al., 2006	MADS, 2007
	• <i>Sum for Cat. I (one out – all out)</i>					÷		
II:	• Eelgrass depth limit	5.6	m	25%	2.6	+	Christiansen et al. 2006	MC Ringkøbing, 2007
	• <i>Sum for Cat. II (one out – all out)</i>					+		
III + IV:	• Biomass, filter feeders, Nissum Brd.	5.8	gC/m2	50%	17.7	+	Møhlenberg, pers. comm.	Ibid.
	• Biomass, detritivores, Nissum Brd.	53.4	gC/m2	25%	12.7	+	Møhlenberg, pers. comm.	Ibid.
	• Biomass, filter feeders, Kaas Brd.	9.9	gC/m2	50%	34.0	+	Møhlenberg, pers. comm.	Ibid.
	• Biomass, detritivores, Kaas Brd.	23.6	gC/m2	25%	8.1	+	Møhlenberg, pers. comm.	Ibid.
	• <i>Sum for Cat. III (one out – all out)</i>					+		
	Final assessment					+		

[illegible]



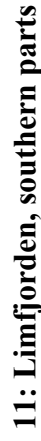
10: Limfjorden, central parts

A: Initial assessment made by using OCP-2:

Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• No information	—	—	—	—	—	—	—
	• <i>Sum for Cat. I (one out – all out)</i>					—		
	• Secchi depth	5.2	m	25%	3.7	+	Christiansen et al. 2006	MADS, 2007
II:	• Eelgrass depth limit	5.6	m	25%	1.9	+	Christiansen et al. 2006	MC Ålborg, 2007
III + IV:	• <i>Sum for Cat. II (one out – all out)</i>					+		
	• Biomass, filter feeders, Løgstør Brd.	40.2	gC/m2	50%	191.6	+	Møhlenberg, pers. comm.	Ibid.
	• Biomass, detritivores, Løgstør Brd.	26.9	gC/m2	25%	6.8	+	Møhlenberg, pers. comm.	Ibid.
	• Biomass, filter feeders, Thisted Brd.	19.5	gC/m2	50%	52.8	+	Møhlenberg, pers. comm.	Ibid.
	• Biomass, detritivores, Thisted Brd.	18.3	gC/m2	25%	5.5	+	Møhlenberg, pers. comm.	Ibid.
	• Benthic fauna, DKI	1.0	—	73%	0.341	+	Karup, pers. comm.	Ibid.
	• <i>Sum for Cat. III (one out – all out)</i>					+		
	Final assessment					+		

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind-conf	We	QE-EQR	QE-stat	QE-conf	QE-we	Classification
PP:	• Secchi depth	5.2	m	2	25%	2	3.7	1	0.712	5 / 7	100%	0.712	MODERATE	5 / 7	33%	
SAV:	• Eelgrass depth limit	5.6	m	2	25%	1	1.9	1	0.339	6 / 7	100%					
BIF:	• Biomass, filter feeders, Løgstør Br.	40.2	gC/m2	2	50%	2	191.6	1	0.210	5 / 7	20%	0.339	BAD	6 / 7	33%	
	• Biomass, detritivores, Løgstør Brd.	26.9	gC/m2	2	25%	2	6.8	1	0.253	5 / 7	15%					
	• Biomass, filter feeders, Thisted Br.	19.5	gC/m2	2	50%	2	52.8	1	0.369	5 / 7	20%					
	• Biomass, detritivores, Thisted Brd.	18.3	gC/m2	2	25%	2	5.5	1	0.301	5 / 7	15%					
	• Benthic fauna, DKI	1.0	—	2	73%	1	0.341	1	0.341	5 / 7	30%					
											100%	0.301	POOR	22 / 31	33%	
PC:	• No information	—	—	—	—	—	—	—								
															100%	
													Final eutrophication status:			BAD
													Interim confidence rating:			CLASS II



Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, annual mean	23	μmol/l	50%	57.2	+	Christiansen et al. 2006	MADS, 2007
	• <i>Sum for Cat. I (one out – all out)</i>					+		
II:	• Secchi depth	5.2	m	25%	3.1	+	Christiansen et al. 2006	MADS, 2007
	• Eelgrass depth limit	5.6	m	25%	2.0	+	Christiansen et al. 2006	MC Ringkøbing, 2007
	• <i>Sum for Cat. II (one out – all out)</i>					+		
III + IV:	• Biomass, filter feeders	12.4	gC/m2	50%	47.8	+	Møhlenberg, pers. comm.	Ibid.
	• Biomass, detritivores	22.5	gC/m2	50%	48.9	+	Møhlenberg, pers. comm.	Ibid.
	• Benthic fauna, DKI	1.0	—	33%	0.31	+	Karup, pers. comm.	Ibid.
	• <i>Sum for Cat. III (one out – all out)</i>					+		
	Final assessment					+		

[illegible]



12: Limfjorden, eastern parts

A: Initial assessment made by using OCP-2:

Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	- No information - Sum for Cat. I (one out – all out)	—	—	—	—	—	—	—
II:	Eelgrass depth limit	5.6	m	25%	1.8	+	Christiansen et al. 2006	MC Ålborg, 2007
III + IV:	- Sum for Cat. II (one out – all out) - No information - Sum for Cat. III (one out – all out)	—	—	—	—	—	—	—
	Final assessment					+		

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind-conf	We	QE-EQR	QE-stat	QE-conf	QE-we	Classification
PP:	No information	—	—	—	—	—	—	—	—	6 / 7	100%	—	—	—	—	—
SAV:	Eelgrass depth limit	5.6	m	2	25%	2	1.80	1	0.321	6 / 7	100%	0.321	BAD	6 / 7	100%	—
BIF:	No information	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
PC:	No information	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
															100%	—
																BAD
																CLASS I



13: The Kattegat, northern open waters

Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, annual mean	4.4	µmol/l	50%	6.7	+	DHI, 2003*	This study
	• TN, winter max.	27.5	µmol/l	50%	8.6	÷	DHI, 2003*	This study
	• DIN, annual mean	1.6	µmol/l	50%	2.5	+	DHI, 2003*	This study
	• DIN, winter max.	22.8	µmol/l	50%	6.8	÷	DHI, 2003*	This study
	• TP, annual mean	0.51	µmol/l	50%	0.6	÷	DHI, 2003*	This study
	• TP, winter max.	0.72	µmol/l	50%	0.7	÷	DHI, 2003*	This study
	• DIP, annual mean	0.26	µmol/l	50%	0.3	÷	DHI, 2003*	This study
	• DIP, winter max.	0.56	µmol/l	50%	0.6	÷	DHI, 2003*	This study
II:	• <i>Sum for Cat. I (one out – all out)</i>					+		
	• Chlorophyll-a, annual mean	1.8	µg/l	50%	2.7	+	DHI, 2003*	This study
	• Chlorophyll-a, summer mean	1.5	µg/l	50%	2.5	+	DHI, 2003*	This study
	• Chlorophyll-a, 90% summer mean	1.5	µg/l	167%	3.13	÷	Danish EPA, 2007	Henriksen, pers. comm.
III + IV:	• <i>Sum for Cat. II (one out – all out)</i>					+		
	• No information	—	—	—	—	—	—	—
	• <i>Sum for Cat. III (one out – all out)</i>					—		
	Final assessment					+		

B: Assessment made with HEAT:

[illegible]



14: The Kattogat, central open waters

A: Initial assessment made by using OCP-2:

Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, annual mean	3.2	µmol/l	50%	5.6	+	DHI, 2003*	This study
	• TN, winter max.	5.2	µmol/l	50%	7.0	÷	DHI, 2003*	This study
	• DIN, annual mean	0.9	µmol/l	50%	1.7	+	DHI, 2003*	This study
	• DIN, winter max.	3.7	µmol/l	50%	5.2	÷	DHI, 2003*	This study
	• TP, annual mean	0.46	µmol/l	50%	0.7	÷	DHI, 2003*	This study
II:	• TP, winter max.	0.66	µmol/l	50%	0.8	÷	DHI, 2003*	This study
	• DIP, annual mean	0.24	µmol/l	50%	0.3	÷	DHI, 2003*	This study
	• DIP, winter max.	0.51	µmol/l	50%	0.6	÷	DHI, 2003*	This study
	• Sum for Cat. I (one out – all out)					+		
	• Chlorophyll-a, annual mean	1.4	µg/l	50%	2.5	+	DHI, 2003*	This study
III + IV:	• Chlorophyll-a, summer mean	0.8	µg/l	50%	2.5	+	DHI, 2003*	This study
	• Sum for Cat. II (one out – all out)					+		
	• Benthic fauna, DKI	1.0	—	33%	0.549	—	Karup, pers. comm.	Ibid.
	• Sum for Cat. III (one out – all out)					—		
	Final assessment					+		

* Data are extracted from DHI's modelling database.

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind-conf	We	QE-EQR	QE-stat	QE-conf	QE-we	Classification
PP:	• Chlorophyll-a, annual mean	1.4	µg/l	2	50%	2	2.5	1	0.560	5 / 7	50%					
	• Chlorophyll-a, summer mean	0.8	µg/l	2	50%	2	2.5	1	0.320	5 / 7	50%					
SAV:	• No information	—	—	—	—	—	—	—			100%	0.440	POOR	9 / 13	33%	
	• Benthic fauna, DKI	1.0	—	2	33%	1	0.549	1	0.549	6 / 7	100%					
PC:	• TN, annual mean	3.2	µmol/l	2	50%	2	5.6	1	0.571	5 / 7	15%	0.549	MODERATE	6 / 7	33%	
	• TN, winter max.	5.2	µmol/l	2	50%	2	7.0	1	0.457	5 / 7	10%					
	• DIN, annual mean	0.9	µmol/l	2	50%	2	1.7	1	0.529	5 / 7	15%					
	• DIN, winter max.	3.7	µmol/l	2	50%	2	5.2	1	0.719	5 / 7	10%					
	• TP, annual mean	0.46	µmol/l	2	50%	2	0.7	1	0.657	5 / 7	15%					
	• TP, winter max.	0.66	µmol/l	2	50%	2	0.8	1	0.825	5 / 7	10%					
	• DIP, annual mean	0.24	µmol/l	2	50%	2	0.3	1	0.800	5 / 7	15%					
	• DIP, winter max.	0.51	µmol/l	2	50%	2	0.6	1	0.850	5 / 7	10%					
											100%	0.668	GOOD	33 / 49	33%	
											100%				100%	
											Final eutrophication status:					
											Interim confidence rating:					
											POOR					
											CLASS II					



Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, annual mean	4.4	μmol/l	50%	9.8	+	DHI, 2003*	This study
	• TN, winter max.	13.2	μmol/l	50%	12.4	÷	DHI, 2003*	This study
	• DIN, annual mean	1.3	μmol/l	50%	4.6	+	DHI, 2003*	This study
	• DIN, winter max.	9.8	μmol/l	50%	10.3	÷	DHI, 2003*	This study
	• TP, annual mean	0.51	μmol/l	50%	0.6	÷	DHI, 2003*	This study
	• TP, winter max.	0.72	μmol/l	50%	0.8	÷	DHI, 2003*	This study
II:	• DIP, annual mean	0.25	μmol/l	50%	0.3	÷	DHI, 2003*	This study
	• DIP, winter max.	0.55	μmol/l	50%	0.6	÷	DHI, 2003*	This study
	• <i>Sum for Cat. I (one out – all out)</i>					+		
	• Chlorophyll-a, annual mean	2.0	μg/l	50%	3.4	+	DHI, 2003*	This study
	• Chlorophyll-a, summer mean	1.6	μg/l	50%	2.9	+	DHI, 2003*	This study
	• <i>Sum for Cat. II (one out – all out)</i>					+		
III + IV:	• No information		—	—	—	—	—	—
	• <i>Sum for Cat. III (one out – all out)</i>					—		
	Final assessment					+		

B: Assessment made with HEAT:

[illegible]



Table 1. Summary of assessment metrics of water quality										
Category	Assessment criteria (indicator)			RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:		• TN, annual mean		3.3	µmol/l	50%	6.4	+	DHI, 2003*	This study
		• TN, winter max.		10.2	µmol/l	50%	7.9	÷	DHI, 2003*	This study
		• DIN, annual mean		1.0	µmol/l	50%	2.2	+	DHI, 2003*	This study
		• DIN, winter max.		6.6	µmol/l	50%	5.9	÷	DHI, 2003*	This study
		• TP, annual mean		0.45	µmol/l	50%	0.7	+	DHI, 2003*	This study
		• TP, winter max.		0.62	µmol/l	50%	0.8	÷	DHI, 2003*	This study
		• DIP, annual mean		0.24	µmol/l	50%	0.3	÷	DHI, 2003*	This study
		• DIP, winter max.		0.46	µmol/l	50%	0.6	+	DHI, 2003*	This study
II:		• Sum for Cat. I (one out – all out)						+		
		• Chlorophyll-a, annual mean		1.5	µg/l	50%	2.8	+	DHI, 2003*	This study
		• Chlorophyll-a, summer mean		1.0	µg/l	50%	2.6	+	DHI, 2003*	This study
III + IV:		• Sum for Cat. II (one out – all out)						+		
		• Benthic fauna, DKI		1.0	—	23%	0.584	+	Karup, pers. comm.	Ibid.
		• Sum for Cat. III (one out – all out)						+		
	Final assessment							+		

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind- conf	We	QE- EQR	QE- stat	QE- conf	QE- we	Classifi- cation
PP:	• Chlorophyll-a, annual mean	1.5	µg/l	2	50%	2	2.8	1	0.536	5 / 7	50%					
	• Chlorophyll-a, summer mean	1.0	µg/l	2	50%	2	2.6	1	0.385	5 / 7	50%					
											100%	0.460	POOR	9 / 13	33%	
SAV:	• No information	—	—	—	—	—	—	—								
BIF:	• Benthic fauna, DKI	1.0	—	2	23	1	0.584	1	0.584	6 / 7	100%					
		—	—		—		—				100%	0.584	BAD	6 / 7	33%	
PC:	• TN, annual mean	3.3	µmol/l	2	50%	2	6.4	1	0.516	5 / 7	15%					
	• TN, winter max.	10.2	µmol/l	2	50%	2	7.9	1	1.000	5 / 7	10%					
	• DIN, annual mean	1.0	µmol/l	2	50%	2	2.2	1	0.455	5 / 7	15%					
	• DIN, winter max.	6.6	µmol/l	2	50%	2	5.9	1	1.000	5 / 7	10%					
	• TP, annual mean	0.45	µmol/l	2	50%	2	0.7	1	0.643	5 / 7	15%					
	• TP, winter max.	0.62	µmol/l	2	50%	2	0.8	1	0.775	5 / 7	10%					
	• DIP, annual mean	0.24	µmol/l	2	50%	2	0.3	1	0.800	5 / 7	15%					
	• DIP, winter max.	0.46	µmol/l	2	50%	2	0.6	1	0.767	5 / 7	10%					
											100%	0.716	GOOD	33 / 49	33%	
											100%				100%	
													Final eutrophication status:			BAD
													Interim confidence rating:			CLASS II



17: The Kattegat, southern open waters

Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, annual mean	2.7	µmol/l	50%	5.2	+	DHI, 2003*	This study
	• TN, winter max.	3.8	µmol/l	50%	6.6	+	DHI, 2003*	This study
	• DIN, annual mean	0.7	µmol/l	50%	1.6	+	DHI, 2003*	This study
	• DIN, winter max.	2.3	µmol/l	50%	4.8	+	DHI, 2003*	This study
	• TP, annual mean	0.34	µmol/l	50%	0.7	+	DHI, 2003*	This study
	• TP, winter max.	0.54	µmol/l	50%	0.8	÷	DHI, 2003*	This study
	• DIP, annual mean	0.21	µmol/l	50%	0.3	÷	DHI, 2003*	This study
	• DIP, winter max.	0.40	µmol/l	50%	0.6	+	DHI, 2003*	This study
II:	• <i>Sum for Cat. I (one out – all out)</i>					+		
	• Chlorophyll-a, annual mean	1.0	µg/l	50%	2.3	+	DHI, 2003*	This study
	• Chlorophyll-a, summer mean	0.6	µg/l	50%	2.2	+	DHI, 2003*	This study
	• Chlorophyll-a, 90% summer mean	1.5	µg/l	167%	4.4	+	Danish EPA, 2007	Henriksen, 2007
III + IV:	• <i>Sum for Cat. II (one out – all out)</i>					+		
	• No information	—	—	—	—	—	—	—
	• <i>Sum for Cat. III (one out – all out)</i>					—		
	Final assessment					+		

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind- conf	We	QE- EQR	QE- stat	QE- conf	QE- we	Classifi- cation
PP:	• Chlorophyll-a, annual mean	1.0	µg/l	2	50%	2	2.3	1	0.435	5 / 7	40%					
	• Chlorophyll-a, summer mean	0.6	µg/l	2	50%	2	2.2	1	0.273	5 / 7	40%					
	• Chlorophyll-a, 90% summer mean	1.5	µg/l	2	50%	2	4.4	1	0.341	5 / 7	20%					
											100%	0.351	POOR	13 / 19	50%	
SAV:	• No information	—	—	—	—	—	—	—								
BIF:	• No information	—	—	—	—	—	—	—								
PC:	• TN, annual mean	2.7	µmol/l	2	50%	2	5.2	1	0.519	5 / 7	15%					
	• TN, winter max.	3.8	µmol/l	2	50%	2	6.6	1	0.576	5 / 7	10%					
	• DIN, annual mean	0.7	µmol/l	2	50%	2	1.6	1	0.438	5 / 7	15%					
	• DIN, winter max.	2.3	µmol/l	2	50%	2	4.8	1	0.479	5 / 7	10%					
	• TP, annual mean	0.34	µmol/l	2	50%	2	0.7	1	0.486	5 / 7	15%					
	• TP, winter max.	0.54	µmol/l	2	50%	2	0.8	1	0.675	5 / 7	10%					
	• DIP, annual mean	0.21	µmol/l	2	50%	2	0.3	1	0.700	5 / 7	15%					
	• DIP, winter max.	0.40	µmol/l	2	50%	2	0.6	1	0.667	5 / 7	10%					
											100%	0.561	MODERATE	33 / 49	50%	
															100%	
													Final eutrophication status:			MODERATE
												Interim confidence rating:				CLASS II



18: Kattagat, southern coastal waters

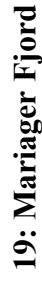
A: Initial assessment made by using OCP-2:

Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, annual mean	2.8	µmol/l	50%	53	+	DHI, 2003*	This study
	• TN, winter max.	4.1	µmol/l	50%	6.7	+	DHI, 2003*	This study
	• DIN, annual mean	0.7	µmol/l	50%	1.6	+	DHI, 2003*	This study
	• DIN, winter max.	2.4	µmol/l	50%	4.8	+	DHI, 2003*	This study
II:	• TP, annual mean	0.38	µmol/l	50%	0.7	+	DHI, 2003*	This study
	• TP, winter max.	0.51	µmol/l	50%	0.8	+	DHI, 2003*	This study
	• DIP, annual mean	0.21	µmol/l	50%	0.4	+	DHI, 2003*	This study
	• DIP, winter max.	0.36	µmol/l	50%	0.6	+	DHI, 2003*	This study
III + IV:	• <i>Sum for Cat. I (one out – all out)</i>					+		
	• Chlorophyll-a, annual mean	1.1	µg/l	50%	2.3	+	DHI, 2003*	This study
	• Chlorophyll-a, summer mean	0.7	µg/l	50%	2.2	+	DHI, 2003*	This study
	• <i>Sum for Cat. II (one out – all out)</i>					+		
Final assessment	• No information	—	—	—	—	—	—	—
	• <i>Sum for Cat. III (one out – all out)</i>					—		
	• <i>Final assessment</i>					+		

* Data are extracted from DHI's modelling database.

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind-conf	We	QE-EQR	QE-stat	QE-conf	QE-we	Classification
PP:	• Chlorophyll-a, annual mean	1.1	µg/l	2	50%	2	2.3	1	0.478	5 / 7	50%					
	• Chlorophyll-a, summer mean	0.7	µg/l	2	50%	2	2.2	1	0.318	5 / 7	50%					
SAV:	• No information	—	—	—	—	—	—	—			100%	0.398	POOR	9 / 13	50%	
	• No information	—	—	—	—	—	—	—								
BIF:	• TN, annual mean	2.8	µmol/l	2	50%	2	53	1	0.053	5 / 7	15%					
	• TN, winter max.	4.1	µmol/l	2	50%	2	6.7	1	0.612	5 / 7	10%					
PC:	• DIN, annual mean	0.7	µmol/l	2	50%	2	1.6	1	0.438	5 / 7	15%					
	• DIN, winter max.	2.4	µmol/l	2	50%	2	4.8	1	0.500	5 / 7	10%					
	• TP, annual mean	0.38	µmol/l	2	50%	2	0.7	1	0.543	5 / 7	15%					
	• TP, winter max.	0.51	µmol/l	2	50%	2	0.8	1	0.638	5 / 7	10%					
	• DIP, annual mean	0.21	µmol/l	2	50%	2	0.4	1	0.525	5 / 7	15%					
	• DIP, winter max.	0.36	µmol/l	2	50%	2	0.6	1	0.600	5 / 7	10%					
											100%	0.469	POOR	33 / 49	50%	
											100%				100%	
Final eutrophication status:											Interim confidence rating:					
											POOR					
											CLASS II					



Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/÷)	RefCon source	Status source
I:	• TN, annual mean	60	µmol/l	50%	115.7	+	Ellegaard et al. 2005	MADS, 2007
	• <i>Sum for Cat. I (one out – all out)</i>					+		
II:	• No information	–	–	–	–	–	–	–
	• <i>Sum for Cat. II (one out – all out)</i>					–		
III + IV:	• Benthic fauna, DK1	1.0	–	33%	0.379	+	Karup, pers. comm.	Ibid.
	• <i>Sum for Cat. III (one out – all out)</i>					+		
	Final assessment					+		

[illegible]



20: Randers Fjord

A: Initial assessment made by using OCP-2:

Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, summer mean, inner parts	42.89	µM	50%	128.57	+	HELCOM, 2006	Ibid.
	• TN, summer mean, outer parts	14.29	µM	50%	71.43	+	HELCOM, 2006	Ibid.
	• TP, summer mean, inner parts	1.29	µM	50%	2.90	+	HELCOM, 2006	Ibid.
	• TP, summer mean, outer parts	0.97	µM	50%	1.95	+	HELCOM, 2006	Ibid.
II:	• <i>Sum for Cat. I (one out – all out)</i>					+		
	• Chl-a, summer mean, inner parts	9	µg/l	50%	13	+	HELCOM, 2006	Ibid.
	• Chl-a, summer mean, outer parts	3	µg/l	50%	6.94	+	HELCOM, 2006	Ibid.
	• Eelgrass, depth limit, outer parts	6.6	m	25%	1.7	+	HELCOM, 2006	MC Århus, 2007
III + IV:	• Macroalgae species richness, i.p.	15	n	50%	3	+	HELCOM, 2006	Ibid.
	• Macroalgae species richness, o.p.	12	n	50%	7	÷	HELCOM, 2006	Ibid.
	• <i>Sum for Cat. II (one out – all out)</i>					+		
	• Zoobenthos species richness, i.p.	16	n	50%	24	+	HELCOM, 2006	Ibid.
Final assessment	• Zoobenthos species richness, o.p.	94	n	25%	46	+	HELCOM, 2006	Ibid.
	• <i>Sum for Cat. III (one out – all out)</i>					+		
	Final assessment					+		

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind-conf	We	QE-EQR	QE-stat	QE-conf	QE-we	Classification
PP:	• Chl-a, summer mean, inner parts	9	µg/l	2	50%	2	13.0	1	0.692	5 / 7	50%					
	• Chl-a, summer mean, outer parts	3	µg/l	2	50%	2	6.94	1	0.432	5 / 7	50%			9 / 13	25%	
SAV:	• Eelgrass, depth limit, outer parts	6.6	m	1	25%	2	1.7	1	0.258	7 / 7	50%					
	• Macroalgae species richness, i.p.	15	n	1	50%	3	3	1	0.200	5 / 7	25%					
	• Macroalgae species richness, o.p.	12	n	1	50%	3	7	1	0.583	5 / 7	25%					
BIF:	• Zoobenthos species richness, i.p.	16	n	1	50%	3	24	1	0.667	5 / 7	50%			15 / 19	25%	
	• Zoobenthos species richness, o.p.	94	n	1	50%	3	46	1	0.489	5 / 7	50%					
PC:	• TN, summer mean, inner parts	42.89	µM	2	50%	2	128.57	1	0.334	5 / 7	25%					
	• TN, summer mean, outer parts	14.29	µM	2	50%	2	71.43	1	0.200	5 / 7	25%			9 / 13	25%	
	• TP, summer mean, inner parts	1.29	µM	2	50%	2	2.90	1	0.445	5 / 7	25%					
	• TP, summer mean, outer parts	0.97	µM	2	50%	2	1.95	1	0.497	5 / 7	25%					
Final assessment											100%	0.369	BAD	17 / 25	25%	
											100%				100%	
											Final eutrophication status:					
											Interim confidence rating:					
											BAD					
											CLASS II					



21: Isefjorden

A: Initial assessment made by using OCP-2:

Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	- No information - Sum for Cat. I (one out – all out)	—	—	—	—	—	—	—
II:	Eelgrass depth limit	4.7	m	25%	4,2	÷	Holmboe, pers. comm.	MC Roskilde, 2007
III + IV:	- Sum for Cat. II (one out – all out) - Biomass, benthic invertebrate fauna - Sum for Cat. III (one out – all out)	14.0	g/m ²	50%	489	+	HELCOM, 2006	MC Roskilde, 2007
	Final assessment					+		

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind-conf	We	QE-EQR	QE-stat	QE-conf	QE-we	Classification
PP:	No information	—	—	—	—	—	—	—	—	6 / 7	100%	—	—	—	—	—
SAV:	Eelgrass depth limit	4.7	m	1	25%	1	4.2	1	0.894	6 / 7	100%	0.894	HIGH	6 / 7	50%	—
BIF:	Biomass, benthic invertebrate fauna	14.0	g/m ²	2	50%	1	489	1	0.029	5 / 7	100%	0.029	BAD	5 / 7	50%	—
PC:	No information	—	—	—	—	—	—	—	—	—	100%	—	—	—	—	—
															100%	—
																BAD
																CLASS I



22: Roskilde Fjord

A: Initial assessment made by using OCP-2:

Category:	Assessment criteria (indicator)	RefCon	Unit	AcDev	Status	Score (+/-)	RefCon source	Status source
I:	• TN, annual mean • <i>Sum for Cat. I (one out – all out)</i>	50	µM	15%	65.5	+	Andersen et al., 2004	MADS, 2007
II:	• Eelgrass depth limit	4.5	m	25%	2.9	+	Möhlenberg, pers. comm.	MC Roskilde, 2007
III + IV:	• <i>Sum for Cat. II (one out – all out)</i> • Benthic invertebrates, DKI • <i>Sum for Cat. III (one out – all out)</i>	1.0	—	23%	0.412	+	Karup, pers. comm.	Ibid.
	Final assessment					+		

B: Assessment made with HEAT:

QE	Indicator	Ref Con	Unit	Sc	Ac Dev	Sc	Status	Sc	EQR	Ind-conf	We	QE-EQR	QE-stat	QE-conf	QE-we	Classification
PP:	• No information	—	—	—	—	—	—	—	—	6 / 7	100%	0.644				
SAV:	• Eelgrass depth limit	4.5	m	2	25%	1	2.9	1	0.644	6 / 7	100%	0.644	POOR	6 / 7	33%	
BIF:	• Benthic fauna, DKI	1.0	—	2	23%	1	0.412	1	0.412	6 / 7	100%	0.412	BAD	6 / 7	33%	
PC:	• TN, annual mean	50	µM	2	15%	2	65.5	1	0.763	5 / 7	100%	0.763	POOR	5 / 7	33%	
											100%				100%	
													Final eutrophication status:			BAD
													Interim confidence rating:			Class I