**Eutrophication Series**

# Ecological Quality Objectives for the Greater North Sea with Regard to Nutrients and Eutrophication Effects

OSPAR Commission
2005

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

*La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l'Espagne.*



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# Executive Summary

The overall general ecological objective is to achieve by the year 2010 a healthy marine environment where eutrophication does not occur. This implies a situation where the OSPAR Convention area classifies as “non-problem area” in the meaning of, and in accordance with the assessment under, the OSPAR Common Procedure for the Eutrophication Status of the OSPAR Maritime Area (the “Common Procedure”).

The relevant ecological quality issues for eutrophication include ‘Nutrient budgets and production’, ‘Phytoplankton communities’, ‘Oxygen consumption’, and ‘Benthic communities’. For these, five EcoQOs related to eutrophication were developed in parallel with, and derived from, the assessment parameters and the assessment levels established under the Common Procedure. For the purpose of eutrophication, the desired level of an ecological quality (EcoQO) is referred to as area-specific “assessment level” which has been set in relation to area-specific reference levels. Assessment levels for concentrations, for example, are set in relation to area-specific and/or salinity-related background concentrations.

The specific EcoQOs for eutrophication, as agreed for the North Sea pilot project and as slightly edited to ensure consistency with the terminology of the Common Procedure are:

a. Winter DIN and/or DIP should remain below a justified salinity-related and/or area-specific % deviation from background not exceeding 50%;

b. Maximum and mean chlorophyll *a* concentrations during the growing season should remain below a justified area-specific % deviation from background not exceeding 50%;

c. Region/area-specific phytoplankton eutrophication indicator species should remain below respective nuisance and/or toxic elevated levels (and there should be no increase in the duration of blooms);

d. Oxygen concentration, decreased as an indirect effect of nutrient enrichment, should remain above area-specific oxygen assessment levels, ranging from 4-6 mg oxygen per litre;

e. There should be no kills in benthic animal species as a result of oxygen deficiency and/or toxic phytoplankton species.

The five EcoQOs form an integrated set of EcoQOs for nutrients and eutrophication effects as one sub-set of the OSPAR EcoQOs to describe the overall ecological quality of the marine ecosystem. The items are strongly interlinked along a cause/effect chain from nutrient enrichment to direct effects (chlorophyll *a* and phytoplankton nuisance and toxic indicator species) and indirect effects (oxygen deficiency and benthos kills). The process of their integration is detailed in the Common Procedure. This sub-set of EcoQOs forms part of the target-oriented approach of the OSPAR Eutrophication Strategy and has a clear link to human activities resulting in increased inputs of nutrients to the marine environment. It provides the operational, specific framework for evaluating the 50% nutrient (nitrogen and phosphorus) reduction target and for assessing whether the overall general ecological goal with regard to eutrophication is achieved by 2010.

The EcoQOs for eutrophication have been evaluated taking account of advice on their use and implementation given by the International Council for the Exploration of the Sea (ICES). The evaluation showed that more work needs to be done to develop ecological quality elements into EcoQOs for eutrophication. This requires, however, to ensure that first area-specific background concentrations and assessment levels are established before new EcoQOs for eutrophication are developed. As a result of the evaluation, for example, the robustness of the range 4-6 mg oxygen per litre for the EcoQO on oxygen concentration would need to be explored further. So far, an EcoQO for changes in zoobenthos was premature but work will continue to this end, including identifying a list of area-specific (groups of) benthic indicator species in relation to long-term eutrophication through ICES.

Since the sub-set of EcoQOs for eutrophication are linked to the Common Procedure and existing monitoring programmes, including relevant monitoring guidelines, high quality information is available for the EcoQOs and supporting environmental information for the OSAPR Convention area. Therefore, the application of the EcoQOs to the wider OSPAR area should be considered.

Finally, despite differences in approaches and geographical coverage, possibilities for synergies between OSPAR EcoQOs for eutrophication and the ecological quality status of surface water under the EC Water Framework Directive exist. Synergies should also be sought with the emerging European Marine Strategy.

# Récapitulatif

L'objectif écologique général est de parvenir, d'ici l'an 2010, à un milieu marin sain où l'eutrophisation ne se produise pas. Ceci implique une situation dans laquelle la zone de la Convention OSPAR est classée dans les « zones sans problème » au sens qui lui est donné dans la Procédure commune OSPAR (dite « Procédure commune ») de l'eutrophisation de la zone maritime d'OSPAR ainsi que conformément à l'évaluation correspondante.

Les questions de qualité écologique pertinentes dans le cas de l'eutrophisation sont notamment les « Bilans et la production des nutriments », les « Communautés du phytoplancton », la « Consommation d'oxygène » et les « Communautés benthiques ». Au titre de ces questions, cinq EcoQO visant l'eutrophisation ont été élaborés parallèlement aux paramètres d'évaluation et aux niveaux d'évaluation fixés dans la procédure commune, et en ont été déduits. Aux fins de l'eutrophisation, le niveau souhaité de qualité écologique (EcoQO) est dit « niveau d'évaluation » spécifique à une zone, niveau fixé en fonction des niveaux de référence propres à la zone. Par exemple, les niveaux d'évaluation des teneurs sont fixés en fonction des teneurs ambiantes propres à la zone et/ou des teneurs ambiantes en fonction de la salinité.

Les EcoQO spécifiques à l'eutrophisation, tels qu'ils ont été convenus pour le programme pilote mer du Nord et légèrement rectifiés pour qu'ils coïncident avec la terminologie de la Procédure commune sont les suivants :

a. En hiver, le DIN et/ou le DIP devraient rester au-dessous d'un pourcentage d'écart par rapport à la teneur ambiante, qui soit justifié et lié à la salinité et/ou propre à la zone, sans pour autant dépasser 50% ;

b. Les teneurs maximales et moyennes en chlorophylle *a* pendant la saison de croissance devraient être inférieures à un pourcentage d'écart justifié et propre à la zone par rapport à la teneur ambiante, sans pour autant être supérieures à 50% ;

c. Le niveau des espèces de phytoplancton indicatrices d'une eutrophisation propres à une région ou à une zone devrait rester inférieur aux niveaux respectifs de nuisance et/ou aux niveaux toxiques aigus (sans que de plus, il y ait une augmentation de la durée des éclosions) ;

d. La teneur en oxygène, en baisse comme un effet indirect de l'enrichissement en nutriments, devrait rester supérieure aux niveaux de la teneur en oxygène propre à la zone, et se situer entre 4 et 6 mg d'oxygène par litre ;

e. Il ne devrait y avoir aucune mortalité des espèces d'animaux benthiques en conséquence de la déficience d'oxygène et/ou de la présence de phytoplancton toxique.

Les cinq EcoQO constituent une série intégrée d'EcoQO concernant les nutriments et les effets d'eutrophisation, se présentant sous forme d'une sous-série d'EcoQO OSPAR décrivant la qualité écologique générale de l'écosystème marin. Les éléments en sont puissamment corrélés le long de la chaîne de cause à effet, allant de l'enrichissement en nutriments aux effets directs (nuisance provoquée par la chlorophylle *a* et par le phytoplancton, et espèces toxiques indicatrices) ainsi qu'aux effets indirects (déficience d'oxygène et mortalités du benthos). Le processus de leur intégration est indiqué en détail dans la Procédure commune. Cette sous-série d'EcoQO fait partie intégrante de l'approche ciblée de la Stratégie OSPAR visant l'eutrophisation, et a un lien clair avec les activités de l'homme aboutissant à une augmentation des apports de nutriments au milieu marin. Elle constitue un cadre opérationnel et spécifique permettant de juger si l'objectif de réduction de 50% des nutriments (azote et de phosphore) ainsi que de savoir si le but écologique général visant l'eutrophisation seront atteints d'ici 2010.

Les EcoQO applicables à l'eutrophisation ont été évalués en tenant compte des avis émis par le Conseil International pour l'Exploration de la Mer (CIEM) quant à leur utilisation et leur mise en œuvre. L'évaluation a prouvé qu'il y avait lieu de poursuivre les travaux pour transformer des éléments de qualité écologique en EcoQO d'eutrophisation. Ceci exige toutefois que l'on définisse tout d'abord les teneurs ambiantes et les niveaux d'évaluation propres à la zone en cause avant que de nouveaux EcoQO eutrophisation soient mis au point. Par exemple, en conséquence de l'évaluation, la solidité de la fourchette de 4 à 6 mg d'oxygène par litre dans le cas de l'EcoQO concernant la teneur en oxygène devra être étudiée plus avant. Jusqu'à présent, un EcoQO relatif aux changements du zoobenthos était prématuré, mais le travail se poursuivra à cette fin, dont la mise sur pied, par le biais du CIEM, d'une liste d'espèces benthiques indicatrices (ou de groupes d'espèces benthiques indicatrices) aux fins de l'eutrophisation sur le long terme.

La sous-série d'EcoQO eutrophisation étant liée à la Procédure commune et aux programmes de surveillance en place, y compris aux lignes directrices pertinentes de la surveillance, l'on dispose de renseignements de haute qualité pour les EcoQO ainsi que d'informations environnementales connexes pour la zone de la Convention OSPAR. Par conséquent, il conviendrait d'envisager d'appliquer les EcoQO à l'ensemble de la zone OSPAR.

Enfin, en dépit des différences d'approche et de couverture géographique, il existe des possibilités de synergie entre les EcoQO d'OSPAR visant l'eutrophisation et l'état de la qualité écologique des eaux de surface en vertu de la Directive communautaire européenne cadre relative à l'eau. Il conviendrait par ailleurs de rechercher aussi des synergies avec la Stratégie marine européenne émergente.

# 1 Introduction

## 1.1 Background

OSPAR 2002 agreed to further develop and implement the Ecological Quality Objectives (EcoQOs) as agreed by Ministers at the 5th North Sea Conference. This included applying ten agreed Ecological Quality Objectives in a pilot project for the North Sea (five pilots prepared by BDC and the integrated set of five pilot EcoQOs for eutrophication prepared by EUC). The whole suite of EcoQOs will form an important operational framework and tool for applying the Ecosystem Approach. EcoQOs will describe a desired level of Ecological Quality against which the effects of human activities can be judged, and against which the effectiveness of measures taken to achieve a healthy marine (North Sea and OSPAR-wide) environment can be assessed. They can also be used as communication tools, since they provide the basis for establishing common understanding and agreements with the various stakeholders on long-term ecological objectives. The concept of the OSPAR EcoQOs can also be linked to the activities within the EU (Water Framework Directive, European Marine Strategy) and other regional fora (e.g. HELCOM, Barcelona Convention).

The development of EcoQOs with respect to nutrients and eutrophication effects (the EcoQOs for eutrophication) is an important element of the OSPAR Eutrophication Strategy. This target-oriented approach allows for evaluating the 50% nutrient (nitrogen and phosphorus) reduction target and for assessing whether the general goal "to achieve by the year 2010 a healthy marine environment where eutrophication does not occur" is achieved, and for identifying the need for further action.

The EcoQOs for eutrophication have been developed in parallel with the harmonized assessment criteria of the OSPAR "Comprehensive Procedure" within the Common Procedure, which are established to assess and classify the eutrophication status of the OSPAR maritime area, including their local areas, into problem areas, potential problem areas, and non-problem areas (OSPAR Agreement 2005-3)[1]. The Common Procedure forms an integral part of the OSPAR Eutrophication Strategy. A first application of the Comprehensive Procedure by the Contracting Parties resulted in a first classification of marine areas with respect to their eutrophication status (OSPAR 2003a).

This document summarizes information on the progress and agreements on the integrated set of EcoQOs for eutrophication, concludes on its status for implementation, and provides recommendations.

## 1.2 Good EcoQOs

In the selection and development of EcoQOs, several qualities were considered. According to the report from OSPAR on which the Fifth North Sea Conference based its conclusions on EcoQOs, a good EcoQO will unite the following qualities:

a. the EcoQO will have a clear scientific basis, linking it to significant aspects of the quality of a marine ecosystem;
b. data on the EcoQO can be collected effectively and economically across the whole range to which it applies;
c. there is a clear reference level or "target" (assessment level, related to background concentrations) against which the data on the EcoQO can be evaluated;
d. there is general acceptance of the validity of the EcoQO by all relevant stakeholders.

To achieve these qualities, EcoQOs will be better the more they are:

a. relatively easy to understand by non-scientists and those who will decide on their use;
b. sensitive to manageable human activity;
c. relatively tightly linked in time to that activity;
d. easily and accurately measured, with a low error rate;
e. responsive primarily to a human activity, with low responsiveness to other causes of change;
f. measurable over a large proportion of the area to which the EcoQ metric is to apply;
g. based on an existing body or time-series of data to allow a realistic setting of objectives.

1 OSPAR agreement on the Common Procedure for the Identification of the Eutrophication Status of the Maritime Area of the OSPAR Convention (the "Common Procedure", reference number: 2005-3), updates and supersedes the previous Common Procedures (reference number: 1997-11) and the agreement on Common Assessment Criteria, their Assessment Levels and Area Classification within the Comprehensive Procedure of the Common Procedure (reference number: 2002-20).

These seven (technical) criteria, proposed by ICES, have later been used to check the performance of the EcoQOs. Apart from a general criterion ("easy to understand") three basic elements in the ICES criteria of a "good EcoQO" can be recognised:

I. understandable to facilitate common understanding within and outside the OSPAR community (point a)
II. to show a cause/effect relationship with a certain manageable human activity (points b, c, e)
III. to be related to the aspect of monitoring: availability of data, monitoring at place (points d, f, g).

Other, practical, proposed criteria can also be used: the availability of resources (capacity, financing), and the potential of an EcoQO to fill a gap in the overall framework for EcoQOs. All these criteria have been used to test whether the EcoQOs are suited for their aim.

## 1.3 Integrated set of EcoQOs for Nutrients and Eutrophication Effects

The full set of Ecological Quality Objectives will be used to describe the desired overall ecological quality of the marine ecosystem. The full set of EcoQOs has several subsets that can be seen as indicators of ecosystem health, and responding to different human pressures. The integrated cause/effect related EcoQOs for eutrophication are one such subset, responding to nutrient enrichment. The means of integrating the subset of the five EcoQOs for eutrophication is described in the Comprehensive Procedure, applied for the OSPAR maritime area, which forms the basis for the EcoQOs for eutrophication.

### *Overall general (overarching) objective*

*The overall general ecological objective is to achieve by the year 2010 a healthy marine environment where eutrophication does not occur.* This actually implies a situation where areas are indicated as non-problem areas with respect to eutrophication, as assessed by applying the Common Procedure, which consists of a one-off Screening and the iterative Comprehensive Procedure.

This general ecological objective is part of the target-orientated approach in the OSPAR Eutrophication Strategy (OSPAR ref. no. 2003-21). It is tightly linked to the source-orientated approach of that same Strategy: to reduce nitrogen and phosphorus inputs, in the order of 50% compared with 1985, into those areas where they cause directly or indirectly (potential) problems with regard to eutrophication (PARCOM Recommendations 88/2, 89/4, and 92/7).

### *Specific EcoQOs for eutrophication*

The specific Ecological Quality Objectives for eutrophication agreed at the 5$^{th}$ North Sea Conference (Bergen Declaration 2002) are:

- Winter DIN and/or DIP should remain below elevated levels, defined as concentration > 50% above salinity related and/or region-specific natural background concentrations;
- Maximum and mean region-specific chlorophyll *a* concentrations during the growing season should remain below region-specific elevated levels, defined as concentrations > 50% above the spatial (offshore) and/or historical background concentration;
- Region/area-specific phytoplankton eutrophication indicator species should remain below respective nuisance and/or toxic elevated levels (and increased duration);
- Oxygen concentration, decreased as an indirect effect of nutrient enrichment, should remain above region-specific oxygen deficiency levels, ranging from 4-6 mg oxygen per litre;
- There should be no kills in benthic animal species as a result of oxygen deficiency and/or nuisance/toxic phytoplankton indicator species for eutrophication.

An important feature of the above mentioned EcoQOs for eutrophication is that they are area-specific and that the evaluation or assessment should be made on the integrated set. The integration step is explained in detail in the Comprehensive Procedure. Its aim is to classify areas into problem area, potential problem area, or non-problem area (see Table 2).

## 1.4 Integration of EcoQOs for eutrophication

As agreed by Ministers at the 5$^{th}$ North Sea Conference and OSPAR 2002, the five available pilot EcoQOs for eutrophication are an integrated set and cannot be considered in isolation (Bergen Declaration 2002, Annex 3 Table B). They were developed in parallel to, and derived from, the Comprehensive Procedure assessment parameters and their respective assessment levels (see Table 1). They should be viewed in a sequence of cause/effect relationship, according to the harmonised assessment parameters and their respective assessment levels, in the assessment step, the integration step, and the overall area classification step under the Comprehensive Procedure (Figure 1). Additional criteria could be developed into EcoQOs. Their development strongly depends on the progress that can be made in establishing their respective assessment levels. A candidate for developing EcoQOs for eutrophication is macrophytes, for which area-specific assessment levels and criteria are in advanced progress (e.g. Danish waters).

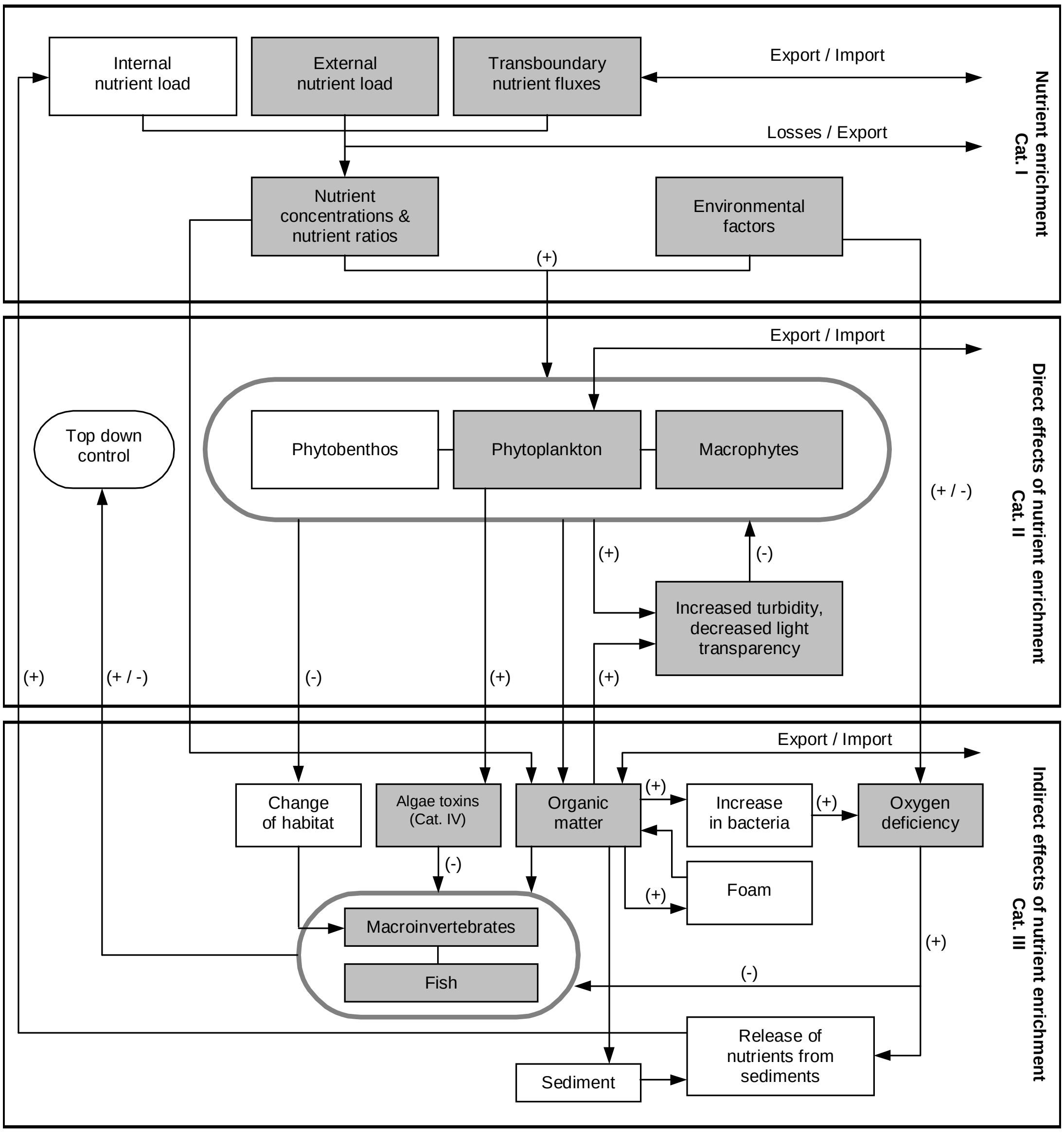
The scores for each of the parameters in Table 1 is the departing point for the second step in the classification process. The scores attained from the application of the assessment parameters in Table 1 are integrated in a table with the criteria categories and the area classes for an initial area classification (step 2) (cf. Table 2 for guidance). This Table 2 provides examples of the actual integration step.

**Table 1. Harmonised assessment parameters and related elevated levels. Those corresponding to the EcoQOs for eutrophication are underlined**.

*Note: Parameters found at levels above the assessment level are considered as "elevated levels". For concentrations, the "assessment level" is defined as a justified area-specific % deviation from background not exceeding 50%.*

| **Assessment parameters** | | |
|---|---|---|
| **Category I** | | **Degree of nutrient enrichment** |
| | **1** | **Riverine inputs and direct discharges[2] (area-specific)**<br>Elevated inputs and/or increased trends of total N and total P<br>(compared with previous years) |
| | **2** | **Nutrient concentrations (area-specific)**<br><u>Elevated level(s) of winter DIN and/or DIP</u> |
| | **3** | **N/P ratio (area-specific)**<br>Elevated winter N/P ratio (Redfield N/P = 16) |
| | | |
| **Category II** | | **Direct effects of nutrient enrichment (during growing season)** |
| | **1** | **Chlorophyll *a* concentration (area-specific)**<br><u>Elevated maximum and mean level</u> |
| | **2** | **Phytoplankton indicator species (area-specific)**<br><u>Elevated levels of nuisance/toxic phytoplankton indicator species (and increased duration of blooms)</u> |
| | **3** | **Macrophytes including macroalgae (area-specific)**<br>Shift from long-lived to short-lived nuisance species (e.g. *Ulva*). Elevated levels (biomass or area covered) especially of opportunistic green macroalgae). |
| **Category III** | | **Indirect effects of nutrient enrichment (during growing season)** |
| | **1** | **Oxygen deficiency**<br><u>Decreased levels (< 2 mg/l: acute toxicity; 2 - 6 mg/l: deficiency) and lowered % oxygen saturation</u> |
| | **2** | **Zoobenthos and fish**<br><u>Kills (in relation to oxygen deficiency and/or toxic algae)</u><br>Long-term area-specific changes in zoobenthos biomass and species composition |
| | **3** | **Organic carbon/organic matter (area-specific)**<br>Elevated levels (in relation to III.1) (relevant in sedimentation areas) |
| **Category IV** | | **Other possible effects of nutrient enrichment (during growing season)** |
| | **1** | **Algal toxins**<br>Incidence of DSP/PSP mussel infection events (related to II.2) |

2 Principles of the Comprehensive Study on Riverine Inputs and Direct Discharges (RID). (reference number: 1998-5, as amended).




| | |
|---|---|
| **Figure 1.** | Generic conceptual framework to assess eutrophication in all categories of surface waters |
| Note: | Shaded boxes indicate components relevant for the Comprehensive Procedure.<br>'+' indicate enhancement; '–' indicate reduction |
| Cat. I | = Category I. Degree of nutrient enrichment (causative factors) |
| Cat. II | = Category II. Direct effects of nutrient enrichment |
| Cat. III | = Category III. Indirect effects of nutrient enrichment |
| Cat. IV | = Category IV. Other possible effects of nutrient enrichment |

It follows from Table 2 that it is initially appropriate to classify an area as potential problem area if the area shows an increased degree of nutrient enrichment (Category I) but where data on direct, indirect/other possible effects are not sufficient to enable an assessment or are not fit for this purpose (as indicated by '?' in Table 2). In such a situation section 3.2(b) of the OSPAR Eutrophication Strategy applies. It requires urgent implementation of monitoring and research in order to enable a full assessment of the eutrophication status of the area concerned within five years of its classification as potential problem area with regard to eutrophication. In addition, it calls for preventive measures to be taken in accordance with the Precautionary Principle.

It should be pointed out that, despite large anthropogenic nutrient inputs and high nutrient concentrations, an area may exhibit few if any direct and/or indirect effects. However, Contracting Parties should take into account the risk that nutrient inputs may be transferred to adjacent areas where they can cause detrimental environmental effects and Contracting Parties shall recognise that they may contribute significantly to so called ‘transboundary affected’ problem areas and potential problem areas with regard to eutrophication outside their national jurisdiction.

**Table 2. Examples of the integration of categorised assessment parameters (see Table 1) to give an initial classification. The eutrophication EcoQOs are indicated in bold.**

| | Category I<br>Degree of nutrient enrichment<br>Nutrient inputs<br>**Winter DIN and DIP**<br>Winter N/P ratio | Category II<br>Direct effects<br>**Chlorophyll *a***<br>**Phytoplankton indicator species**<br>Macrophytes | Categories III and IV<br>Indirect effects/other possible effects<br>**Oxygen deficiency**<br>Changes/**kills in zoobenthos**, fish kills<br>Organic carbon/matter<br>Algal toxins | Initial Classification |
|---|---|---|---|---|
| a | + | + | + | problem area |
| | + | + | - | problem area |
| | + | - | + | problem area |
| b | - | + | + | problem area[3] |
| | - | + | - | problem area[3] |
| | - | - | + | problem area[3] |
| c | + | - | - | non-problem area[4] |
| | + | ? | ? | potential problem area |
| | + | ? | - | potential problem area |
| | + | - | ? | potential problem area |
| d | - | - | - | non-problem area |

(+) = Increased trends, elevated levels, shifts or changes in the respective assessment parameters in Table 1

(-) = Neither increased trends nor elevated levels nor shifts nor changes in the respective assessment parameters in Table 1

? = Not enough data to perform an assessment or the data available is not fit for the purpose

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.

# 2 Information availability

## 2.1 Background

The EcoQOs for eutrophication need to be applied on an area-specific basis, i.e. different background concentrations, and related assessment levels are implemented for specific areas within the North Sea (and other areas of the OSPAR maritime area).

## 2.2 Monitoring

The availability of an existing body or time-series of data to allow a realistic setting of objectives is one of the requirements for ‘good EcoQOs’.

The Eutrophication Monitoring Programme and its adherent guidelines are available, providing adequate monitoring data, including supporting environmental information. Monitoring should be performed in a coherent way, to reflect the cause/effect relationship, according to OSPAR JAMP and related guidelines. The risk of misinterpretation of the causes of direct and indirect effects is substantially reduced when all categories (nutrient enrichment, direct effects, and indirect effects) as well as supporting environmental information are monitored and assessed together.

[3] For example, caused by transboundary transport of (toxic) algae and/or organic matter arising from adjacent/remote areas.

[4] The increased degree of nutrient enrichment in these areas may contribute to eutrophication problems elsewhere.

The OSPAR Eutrophication Monitoring Programme (OSPAR Agreement 2005-4) and the adherent JAMP Eutrophication Monitoring Guidelines (reference numbers: 1997-2 to 1997-6) require regular, coherent and integrated mandatory monitoring of nutrients in conjunction with the direct and indirect effect parameters (see OSPAR Strategy for a Joint Assessment and Monitoring Programme (JAMP), reference number: 2003-22 as amended) as follows:

- winter nutrients DIN and DIP (µmol/l) (JAMP Guidelines, reference number: 1997-2): annually during winter, when algal growth activity is lowest, in Problem Areas (PA) and Potential Problem Areas (PPA), and every three years during winter in Non-Problem Areas (NPA);
- chlorophyll *a* (µg/l) (JAMP Guidelines, reference number: 1997-4): annually during the algal growing season in PA and PPA;
- nuisance/toxic phytoplankton eutrophication indicator species (cells/l) (JAMP Guidelines, reference number: 1997-5): annually during the algal growing season in PA and PPA. In case of toxic phytoplankton growth exceeding toxic levels, one should also monitor algal toxins (DSP/PSP mussel infection events);
- degree of oxygen deficiency, including % saturation (JAMP Guidelines, reference number: 1997-3): annually during the algal growing season in PA and PPA;
- changes/kills in zoobenthos (biomass and species composition) (JAMP Guidelines, reference number: 1997-6): annually during the algal growing season in PA and PPA. In areas where little change is expected sampling every 5 to 10 years would be sufficient.

Guidelines and quality assurance procedures are available from the OSPAR Eutrophication Monitoring Programme and the related JAMP guidelines and quality assurance procedures, and the reporting requirements to ICES, as well as the Comprehensive Study of Riverine Inputs and Direct Discharges (RID, reference number 1998-5).

Recent monitoring information is presented in “the OSPAR Integrated Report 2003 on the Eutrophication Status of the OSPAR Maritime Area based upon the First Application of the Comprehensive Procedure”(OSPAR 2003a). It appears that there are some deficiencies in the available monitoring data and their quality as delivered by many Contracting Parties, concerning all EcoQOs for eutrophication with the exception of *winter nutrients DIN and DIP* (Table 3).

Monitoring includes estuaries, coastal and offshore areas, and has therefore a broader scope than monitoring requirements for the Water Framework Directive. For some (sub)areas, spatial and temporal coverage should be improved. In problem areas and potential problem areas, monitoring should include all EcoQOs for eutrophication and accompanying environmental factors every year. In non-problem areas only nutrients need to be monitored, and only once per three years.

**Table 3. Overview of (in)sufficiency in temporal and spatial monitoring of assessment parameters of the Comprehensive Procedure, in estuaries, coastal and offshore areas**

| CP's/area classified as PA or PPA | Frequency / Spatial Coverage<br>Category I<br>Degree of nutrient enrichment | | Frequency / Spatial Coverage<br>Category II<br>Direct effects | | Frequency / Spatial Coverage<br>Category III and IV<br>Indirect/other possible effects | | | |
|---|---|---|---|---|---|---|---|---|
| **Belgium** | NI | **Not used in COMPP** | *Ca* | + (all areas) | $O_2$ | + Not relevant | At | No events known |
| | *DI* | + (all areas) | *Pis* | + (all areas) | C*k* | No events known | | |
| | NP | **Not used in COMPP** | Mp | Not relevant | Oc | **- (all areas)** | | |
| **Denmark** | NI | + (all areas) | *Ca* | + (all areas) | $O_2$ | + (all areas) | At | + (all areas) |
| | *DI* | + (all areas) | *Pis* | + (all areas) | C*k* | + (all areas) | | |
| | NP | + (all areas) | Mp | + (all areas) | Oc | **- (all areas)** | | |
| **France** | NI | **Not used in COMPP** | *Ca* | **+/- (some areas)** | $O_2$ | + (all areas) | At | +(all areas) |
| | *DI* | **Not used in COMPP** | *Pis* | + (all areas) | C*k* | **- (all areas)** | | |
| | NP | **Not used in COMPP** | Mp | + (all areas) | Oc | **- (all areas)** | | |
| **Germany** | NI | + (all areas) | *Ca* | + /- (**some areas**) | $O_2$ | **+ /- (some areas)** | At | +musselcultures |
| | *DI* | + (all areas) | *Pis* | **+ /- (some areas)** | C*k* | **+ /- (some areas)** | | |
| | NP | + (all areas) | Mp | **+ /- (Wadden Sea)** | Oc | **+ /- (some areas)** | | |
| **Ireland** | NI | **Not used in COMPP** | *Ca* | **+/- (coast)** | $O_2$ | + (all areas) | At | **- (all areas)** |
| | *DI* | + (estuaries) | *Pis* | **- (all areas)** | C*k* | **- (all areas)** | | |
| | NP | **Not used in COMPP** | Mp | **- (all areas)** | Oc | **- (all areas)** | | |
| **Netherlands** | NI | + (all areas) | *Ca* | + (all areas) | $O_2$ | +/- (**offshore**) | At | **+/-some area** |
| | *DI* | + (all areas) | *Pis* | + (all areas) | C*k* | +/- (**offshore)** | | |
| | NP | + (all areas) | Mp | + (in Wadden Sea) | Oc | **- (sedimentat. areas)** | | |
| **Norway** | NI | + (all areas incl. transb.) | *Ca* | + (all areas) | $O_2$ | +/-(**some areas**) | At | + (all areas) |
| | *DI* | + (all areas) | *Pis* | + /-**?** (all areas) | C*k* | +/-(**some areas**) | | |
| | NP | + (all areas) | Mp | **-?** | Oc | **- (all areas)** | | |
| **Portugal** | NI | **Not used in COMPP** | *Ca* | **- (all areas)** | $O_2$ | **- (all areas)** | At | **- (all areas)** |
| | *DI* | + (estuaries) | *Pis* | **- (all areas)** | C*k* | **- (all areas)** | | |
| | NP | + (one estuary) | Mp | **- (all areas)** | Oc | **- (all areas)** | | |
| **Spain** | NI | **Not used in COMPP** | *Ca* | **- (all areas)** | $O_2$ | **- (all areas)** | At | **- (all areas**) |
| | *DI* | + (estuaries) | *Pis* | **- (all areas)** | C*k* | **- (all areas)** | | |
| | NP | + (estuaries) | Mp | **- (all areas)** | Oc | **- (all areas)** | | |
| **Sweden** | NI | + (all areas incl. transb.) | *Ca* | + (all areas) | $O_2$ | +/- (**some areas**) | At | **- some areas)** |
| | *DI* | + (all areas) | *Pis* | + /- (**some areas)** | C*k* | +/-(**some areas**) | | |
| | NP | + (all areas) | Mp | **- (all areas)** | Oc | +/-(**some areas**) | | |
| **UK** | NI | + (all, **except 15 areas**) | *Ca* | +(all, **except 15 areas)** | $O_2$ | +/- (**some areas**) | At | **+/-some areas)** |
| | *DI* | + (all**, except 15 areas**) | *Pis* | **- (all areas)** | C*k* | +/-(**some areas**) | | |
| | NP | + (all, **except 15 areas**) | Mp | + /-**?** (all areas) | Oc | +/-(**some areas**) | | |

**Key to Table**:

| | | |
|---|---|---|
| | NI | Riverine total N and total P inputs and direct discharges |
| | *DI* | *Winter Din and DIP concentrations (available EcoQ for eutrophication)* |
| | NP | winter N/P ratios (Cat. I) |
| | *Ca* | *Maximum and mean chlorophyll a concentration (available EcoQO for eutrophication)* |
| | *Pis* | *Region/area specific phytoplankton indicator species (available EcoQO for eutrophication)* |
| | Mp | shifts to nuisance Macrophytes including macroalgae |
| | $O_2$ | *Degree of oxygen deficiency (available EcoQO for eutrophication)* |
| | C*k* | Changes/*kills in zoobenthos* and fish kills *(available EcoQO for eutrophication)* |
| | Oc | Organic carbon/organic matter |
| | At | Algal toxins (DSP/PSP mussel infection events) |

+ = sufficient, **- = insufficient**

## 2.3 Derivation of area-specific background and assessment levels

For each parameter listed in Table 1 an assessment level has been developed, based on a level of increased concentrations and trends, shifts, changes or occurrence. For nutrient inputs, insight is needed into both, increased concentrations and an examination of trends. The assessment level is defined, in general terms, as a certain percentage above an area-specific background concentration, thus allowing a certain "level of eutrophication". The background concentration is defined, in general, as salinity-related and/or specific to a particular area, and which has been derived from data relating to a particular (usually offshore) area or from historic data.

## 2.4 Assessment parameters, their levels and corresponding EcoQOs for eutrophication

The assessment levels are set as levels of elevation based on justified area-specific % deviation from background not exceeding 50%, thereby taking into account natural fluctuations, and allowing a certain level of eutrophication. The slight deviation from the background level is actually corresponding to the distinction in good/high status, as defined in the WFD (see Figure 2 in section 4). The elaborated EcoQOs for eutrophication should, *inter alia*, be considered as an integrated set to help evaluate the 50% nutrient (nitrogen and phosphorus) reduction target in relation to the general objective, which is to achieve by the year 2010 a healthy marine environment where eutrophication does not occur. They form an integral part of the OSPAR Eutrophication Strategy. The Eutrophication Monitoring Programme and its adherent guidelines are available, guaranteeing the production of monitoring data, including supporting environmental information.

The actual area-specific assessment levels / EcoQOs for eutrophication and guidance for their application are described in the Comprehensive Procedure of the Common Procedure for the identification of the eutrophication status of the OSPAR Maritime Area (Reference number: 2005-3). Examples of area-specific background concentrations and elevated levels are presented in Tables 4, 5 and 6 below. Consult the Comprehensive Procedure for the actual derivation and guidance on the application of the assessment levels.

### *EcoQO for winter nutrient (DIN and/or DIP) concentrations*

Widely used in comparable assessments are total dissolved inorganic nitrogen compounds ($NO_3$ + $NO_2$ + $NH_4$ (DIN)) and ortho-P (DIP) for winter time (when algal activity is lowest), see Comprehensive Procedure.

For salinity gradient riverine influenced waters, the widely used uniform assessment procedure with respect to yearly trends and elevated levels in DIN and DIP winter concentrations is as follows:

a. Mixing diagrams and salinity specific background concentrations:

   In marine coastal waters with salinity gradients yearly trends in winter nutrient concentrations are assessed by plotting the winter nutrient concentrations of each year in relation to the respective measured salinity values ("mixing diagrams"). In winter, defined as period when algal activity is lowest, DIN and DIP show a conservative behavior and, therefore, a good linear relationship with salinity (decreasing concentration with increasing salinity from coast to offshore).

b. Trends and elevated levels compared with salinity specific background concentrations:

   In order to compensate for differences in salinity at the various locations and during the various years, nutrient concentrations are normalized for salinity. This is done by calculating the winter nutrient concentration at a given salinity (e.g. 30) from the mixing diagram of a particular year. The salinity normalized nutrient concentration (with 95% confidence interval) is plotted in relation to the respective year in order to establish trends in the winter nutrient concentrations and the level of elevation (compared with background concentration).

In areas without salinity gradients, there is no relationship between salinity and winter nutrient concentrations. Nutrient levels can be simply assessed by calculating mean values for the winter period and compared to area-specific background concentrations.

An overview of specific information is provided in Table 4.

The agreed EcoQO for eutrophication is that *winter DIN and/or DIP* (that is, dissolved inorganic nitrogen and dissolved inorganic phosphate) *should remain below elevated levels, defined as concentrations >50% above salinity-related and/or region-specific natural background concentrations.* Within the eutrophication cause/effect scheme, this EcoQO for eutrophication is a parameter for nutrient enrichment. Monitoring of this EcoQO and the other EcoQOs for eutrophication, should be performed in a coherent way.

**Table 4. The area-specific background concentrations of nutrients during winter (XI-II) in relation to salinity, and their related elevated levels**

| | Region | Salinity | Background concentration | Elevated levels | Background concentration | Elevated levels |
|---|---|---|---|---|---|---|
| | | | DIN µmol/l | DIN µmol/l | DIP µmol/l | DIP µmol/l |
| **North Sea** | Belgium | | | | 0.6 | >0.8 |
| | Coast | | | | 0.6 | >0.8 |
| | Denmark | >34.5 | <10 | >12.5 | 0.6-0.7 | >0.8 |
| | Coast | <34.5 | 10-20 | >13-25 | 0.6 | >0.8 |
| | Germany | >34.5 | 8-9 | 12-14 | 0.6 | 0.9 |
| | Coast | <34.5 | 9-16 | 14-24 | 0.5-0.6 | 0.75-0.9 |
| | Netherlands | >34.5 | 10 | >15 | 0.6 | >0.8 |
| | Coast | <34.5 | 14-24 | >21-36 | 0.6 | >0.8 |
| | Norway | | | | 0.6 | >0.8 |
| | Coast | | | | 0.6 | >0.8 |
| | UK | >34.5 | 10 | >15 | 08 | >1.2 |
| | Coast | <34.5 | 10-21 | >21 | 0.8 | >1.2 |
| **Channel** | | >34 | 9 | >15 | 0.4 | >0.8 |
| | France | >34.5 | 10 | > 15 | 0.8 | > 1.2 |
| **Wadden Sea** | Denmark | <30 | 6.5 | >7 | 0.5 | >0.7 |
| | Germany | 29-32 | 10-20 | 15-30 | 0.5-0.6 | 0.75-0.9 |
| | Netherlands | <30 | 6.5 | >7 | 0.5 | >0.7 |
| **Skagerrak** | Denmark | 32-34 | <10 | >12.5 | 0.5 | >0.7 |
| | Norway | 33 | 10 | >15 | 0.5 | >0.7 |
| | Sweden | | 10 | >15 | 0.6 | 0.9 |
| **Kattegat** | Denmark | | 4-5 | >6-7 | 0.4 | >0.5-0.6 |
| | Sweden | | 4-5 | >6-7 | 0.4 | >0.5-0.6 |
| **Atlantic** | France | > 34.5 | 10 | > 15 | 0.8 | > 1.2 |
| | Ireland coast | > 34.5 | | | | |
| | Norway | | | | | |
| | Portugal | | | | | |
| | Spain | >34.5 | 10 | >15 | | |
| | coast | | | | | |
| | UK/Scotland | >34.5 | 8 | >12 | 0.6 | >0.9 |
| | coast | <34.5 | 8 | >12 | 0.8 | >1.2 |
| **Southern Irish Sea and Eastern Celtic Sea** | Ireland Offshore | >34.8 | 8 | >12 | 0.5 | >0.8 |
| **Atlantic to Irish Sea** | Coast | >34.5 | 12 | >18 | 0.8 | >1.25 |
| **Estuaries** | Belgium | | | | | |
| | Denmark | | | | | |
| | France | | | | | |

| | **Region** | **Salinity** | **Background concentration** | **Elevated levels** | **Background concentration** | **Elevated levels** |
|---|---|---|---|---|---|---|
| | | | DIN µmol/l | DIN µmol/l | DIP µmol/l | DIP µmol/l |
| | Germany | 0-30 | 12-30 | 18-45 | 0.5-0.8 | 0.75-1.2 |
| | Ireland | Referenced to 30 psu | | >42 | | |
| | Netherlands | <30 | 9-15 | >18-30 | | |
| | Western Scheldt | | | | | |
| | Ems Dollar | | | | | |
| | Norway | | | | | |
| | Portugal: | | | | | |
| | Sado | | 16 | >32 | | |
| | Tagus | | 25 | >51 | | |
| | Mondego | | 33 | >66 | | |
| | Spain | | | | | |
| | Sweden | | | | | |
| | UK | | | | | |

### *EcoQO for phytoplankton chlorophyll a*

There is a large fluctuation in chlorophyll *a* (chl. *a*) concentrations between years and seasons as well as spatial differences (in general, higher in nutrient enriched coastal waters, at frontal systems, and in (offshore) stratified waters compared to unstratified offshore waters). The latter difference often reflects the difference in nutrient enrichment levels (higher in coastal and stratified waters compared with unstratified offshore waters). This direct effect parameter of nutrient enrichment is furthermore highly influenced by other environmental factors (such as light availability, phytoplankton species composition and their physiological state (type of growth-limitation), and the variable grazing pressure). Nevertheless, this parameter is considered to be a useful direct effect assessment parameter of nutrient enrichment, and therefore listed in Table 1.

Environmental data such as phytoplankton chl. *a* exhibits periodicity and episodic change and as a result tends to be asymmetrically distributed with few high values (outliers or spikes) and many low values. While the mean and maximum chl. *a* values are currently recommended as assessment tools an alternative approach is to employ box-whisker plots and derive $90^{th}$ percentile values. The $90^{th}$ percentile value is then compared with the threshold value derived from appropriate reference conditions. Such an approach eliminates outliers, increases confidence in the assessment and also has the advantage of bringing the OSPAR assessment into alignment with the approach adopted in freshwater under the WFD.

In determining the maximum and mean chlorophyll *a* levels in estuaries, chlorophyll *a* concentrations should be averaged over the estuarine salinity range during the growing season, see also the Comprehensive Procedure.

An overview of specific information is provided in Table 5.

The agreed EcoQO for eutrophication is that *maximum and mean chlorophyll* a *concentrations during the growing season should remain below elevated levels, defined as concentrations > 50% above the spatial (offshore) and/or historical background concentration.* Within the eutrophication cause/effect scheme, this EcoQO for eutrophication is a direct effect of nutrient enrichment. Monitoring of this EcoQO and the other EcoQOs for eutrophication should be performed in a coherent way.

**Table 5. The area-specific background concentrations of chlorophyll *a* during growing season (III-X) in relation to salinity, and their related elevated levels**

| | Region | Salinity | Background concentration | Background concentration | Elevated levels |
|---|---|---|---|---|---|
| | | | Chlorophyll *a* µg/l, means | Chlorophyll *a* µg/l, maxima | Chlorophyll *a* µg/l, means |
| **North Sea** | Belgium | | 10 | 15 | |
| | Coast | | 10 | | >15 |
| | Denmark | >34.5 | 2-4 | | >4.5 |
| | Coast | <34.5 | 2-10 | | |
| | Germany | >34.5 | 2 | 10-13 | 3 |
| | Coast | <34.5 | 2-4 | 13-18 | 3-6 |
| | Netherlands | >34.5 | 2-4 | | >4.5 |
| | Coast | <34.5 | 10 | 10 | >15 |
| | Norway | | 2-4 | | >4.5 |
| | Coast | | 2-10 | | |
| | UK | >34.5 | 5-10 | 10 | >10 |
| | Coast | <34.5 | 8-12 | 15 | >20 |
| **Channel** | France | >34 | 2 | 10 | > 4 |
| **Wadden Sea** | Denmark | <30 | | | >22-24 (needs verification) |
| | Germany | 29-32 | 2-4 | 12-20 | 3-6 |
| | Netherlands | <30 | | 16 | >22-24 (needs verification) |
| **Skagerrak** | Denmark | 32-34 | <1.25 | | |
| | Norway | 33 | | | |
| | Sweden | | 1.5 | | >2 |
| **Kattegat** | Denmark | | 1.5 | | >2 |
| | Sweden | | 1.5 | 1.5 | >2 |
| **Atlantic** | France | | 2 | 10 | >4 |
| | Ireland coast | >34.5 | <7 | | >10 |
| | Norway | | | | |
| | Portugal | | | | |
| | Spain | >34.5 | | | >12 |
| | coast | | | 8 | |
| | UK/Scotland | >34.5 | 5 | 10 | >10 |
| | coast | <34.5 | 10 | 15 | >15 |
| **Southern Irish Sea and Eastern Celtic Sea** | Ireland Offshore | >34.8 | | | |
| **Atlantic to Irish Sea** | Coast | >34.5 | <7 | | >10 |
| **Estuaries** | Belgium | | | | |

| | **Region** | **Salinity** | **Background concentration** | **Background concentration** | **Elevated levels** |
|---|---|---|---|---|---|
| | | | Chlorophyll *a* µg/l, means | Chlorophyll *a* µg/l, maxima | Chlorophyll *a* µg/l, means |
| | Denmark | | | | |
| | France | | | 13 (variable at sal <30) | >18-20(variable at sal < 30) |
| | Germany | 0-30 | 5-8 | 12-40 | 7.5-12 |
| | Ireland | | | | |
| | Netherlands | <30 | | 2-6 | |
| | Western Scheldt | | | | >9-10 |
| | Ems Dollar | | | | >18-20 |
| | Norway | | | | |
| | Portugal: | | | | |
| | Sado | | 10? | | >9 |
| | Tagus | | | | >14 |
| | Mondego | | 10? | | >9 |
| | Spain | | | | |
| | Sweden | | | | |
| | UK | | | | |

### *EcoQO for phytoplankton indicator species*

Two types of phytoplankton indicator species should be distinguished, nuisance species (forming dense “blooms”) and toxic species (already toxic at low cell concentrations).

Area-specific phytoplankton indicator species, such as nuisance species (*Phaeocystis*, *Noctiluca*) and potentially toxic (e.g. dinoflagellates) species (e.g. *Chrysochromulina polylepis*, *Gymnodinium mikimotoi*, *Alexandrium* spp., *Dinophysis* spp., *Prorocentrum* spp.) are direct effect assessment parameters. The nuisance species show elevated “bloom” levels (cell concentrations) and increased duration of “blooms” compared with previous years. It should be noted that there is scientific uncertainty in the use of toxic phytoplankton species as indicators of direct eutrophication effects. However, there is evidence that elevated levels of some toxic species are caused by nutrient enrichment and elevated N/P ratios, namely for *Chrysochromulina polylepis* and *Gymnodinium mikimotoi* in Skagerrak and, for the latter species, in the sedimentation area Oysterground and in the Frisian front area during stratification

The agreed EcoQO for eutrophication is that “*region/area-specific phytoplankton eutrophication indicator species should remain below respective nuisance and/or toxic elevated levels (and increased duration)*”. Within the eutrophication cause/effect scheme, this EcoQO for eutrophication is a direct effect of nutrient enrichment.

Examples of levels considered as elevated levels and their effects are provided in Table 6.

**Table 6. Elevated levels of area-specific nuisance and toxic phytoplankton indicator species and the type of their effects**

| **Phytoplankton indicator species** | **Elevated levels** | **Effects** |
|---|---|---|
| **Nuisance species** | | |
| *Phaeocystis* spp. (colony form) | > $10^6$ cells/l (and >30 days duration) | nuisance, foam, oxygen deficiency |
| *Noctiluca scintillans* | > $10^4$ cells/l (area coverage > 5 $km^2$) | nuisance, oxygen deficiency |
| **Toxic (toxin producing) species** | | |
| *Chrysochromulina polylepis* | > $10^6$ cells/l | toxic; fish and benthos kills |
| *Gymnodinium mikimotoi* | > $10^5$ cells/l | toxic; fish kills, PSP mussel infection |
| *Alexandrium* spp. | > $10^2$ cells/l | toxic; PSP mussel infection |
| *Dinophysis* spp. | > $10^2$ cells/l | toxic; DSP mussel infection |
| *Prorocentrum* spp. | > $10^4$ cells/l | toxic; DSP mussel infection |

### *EcoQO for oxygen deficiency*

The degree of oxygen deficiency is widely used as an indirect assessment parameter for nutrient enrichment. Oxygen deficiency, induced by decaying algal blooms and long-term nutrients and associated organic matter enrichment, is observed in areas, especially in those that are susceptible for eutrophication effects, e.g. sedimentation areas, areas with long residence time, but also in (shallow) waters covered with surface algal "blooms" of increased nuisance algal species.

Assessment levels of the various degrees of oxygen deficiency show ranges for the various areas in the North Sea: < 2 mg/l: acute toxic (ca. 75 % deficiency); 4 - 5 mg/l (ca. 50 % deficiency) and < 5 - 6 mg/l: deficient. Oxygen concentrations above 6 mg/l are considered to cause no problems. The area-specific assessment levels that are now used are ranging from 4-6 mg/l to judge whether oxygen is scored as an undesired oxygen deficiency level for that particular area.

The agreed EcoQO for eutrophication is that *oxygen concentrations, decreased as an indirect effect of nutrient enrichment, should remain above region-specific oxygen deficiency levels, ranging from 4-6 mg oxygen per litre.* Within the eutrophication cause/effect scheme, this EcoQO is an indirect effect of nutrient enrichment. Monitoring of this EcoQO and the other EcoQOs for eutrophication, should be performed in a coherent way.

### *EcoQO for (changes)/<u>kills</u> in zoobenthos in relation to eutrophication*

These parameters are indirectly related to nutrient enrichment. A distinction can be made between acute toxicity kills directly related to oxygen deficiency and/or toxic blooms), and long-term changes in zoobenthos species composition as a result of long-term increased eutrophication. However, the latter can also be caused by other factors like fisheries which may have an overriding effect compared with eutrophication effects.

The assessment guidance for "kills in zoobenthos" in relation to eutrophication is a "yes-or-no" assessment parameter (occurrence scored with '+', non-occurrence with '-') and should be based on supporting information on the occurrence of toxic phytoplankton species and oxygen levels. Assessment guidance for "long-term changes in zoobenthos species composition and biomass" might become available from Contracting Parties and ICES in the near future.

The agreed EcoQO for eutrophication is that *there should be no kills in benthic animal species as a result of oxygen deficiency and/or the presence of toxic phytoplankton species*. Within the eutrophication cause/effect scheme, this EcoQO on zoobenthos kills relates to an indirect effect of nutrient enrichment. Monitoring of this EcoQO and the other EcoQOs for eutrophication, should be performed in a coherent way.

# 3 Availability of Measures

The availability of measures is one of the important criteria linked to the requirements for 'good EcoQOs', namely the link through a cause/effect relationship with a certain manageable human activity.

To achieve the overall general ecological objective with regard to eutrophication, a source-oriented approach was agreed to reduce nitrogen and phosphorus inputs (OSPAR Recommendation 88/2), in the order of 50% compared with 1985 into those areas where they cause directly or indirectly (potential) problems with regard to eutrophication. It has to be evaluated if this reduction in nutrient inputs will lead to achieve the overall objective.

In general, the reduction of nutrient discharges is pursued from diffuse sources, point sources and atmospheric deposition. Management measures have been decided upon. The measure under evaluation by means of the set of EcoQOs for eutrophication is to reduce nitrogen and phosphorus inputs in the order of 50% compared with 1985. It has to be evaluated if this reduction in nutrient inputs will result in achieving the overall objective. Since the nitrogen reduction has not been achieved in many areas (generally about 30%), additional attention should be paid to the reduction of inputs from agriculture, industries, households, and sewage treatment plants. Tools are available through OSPAR recommendations and EU Directives. Although phosphorus reductions have been successful, nutrient enrichment is still relevant as a result of sediment releases. Alternative measures may be considered to reduce the impacts from nutrient releases, e.g. by creating marsh areas on the fresh-marine interface that store or process nutrients.

## 3.1 Relation to human activities

Main current nutrient sources of OSPAR countries (excluding France) are shown in Table 7 (from OSPAR 2003b).

**Table 7. Losses and discharges of nutrients (tonnes) from anthropogenic sources in 2000, and their relative contributions**

| | N | P | N% | P% |
|---|---|---|---|---|
| Diffuse losses | 510118 | 21324 | 65% | 47% |
| Sewage treatment works, sewerage [1)] | 205692 | 16702 | 26% | 37% |
| Households not connected [2)] | 27299 | 3662 | 3% | 8% |
| Industry [3)] | 38519 | 3904 | 5% | 9% |
| Aquaculture | 1331 | 121 | 0% | 0% |
| Total | 782959 | 45713 | 100% | 100% |

1) Includes discharges of nitrogen and phosphorus by combined sewer systems, by separate sewer systems, by systems that are not connected to wastewater treatment plants and households within the agglomeration which are not connected to a public sewer system, but that are expected to be connected in the near future.

2) Households not connected to public sewage systems include both scattered dwellings and households within urban areas that are not likely to be connected in the near future (five to ten years).

3) Concerns industrial plants with direct discharges of nitrogen and phosphorus from production water into surface waters.

The reduction in inputs (average of the reduction percentage per country) between 1985 and 2000 (Table 8), especially shows a lag in achievement of the reduction in diffuse losses.

**Table 8. Percentage of nutrient inputs (average of the reduction percentage per country) between 1985 and 2000**

| % reduction (average of countries) | N | P |
|---|---|---|
| Diffuse losses | 16 | 3 |
| Sewage treatment works, sewerage | 35 | 65 |
| Households not connected | 57 | 68 |
| Industry | 63 | 72 |

Diffuse losses are the most important sources of both nitrogen and phosphorous. Diffusive sources mainly represent losses from agricultural activities and, in some catchments, from run-off from paved areas, and by atmospheric depositions. Agricultural losses, the main source of nutrients, arise from manure and fertilizers.

## 3.2 Management measures

The EcoQOs for eutrophication will be used (according to the mechanism as described in the Comprehensive Procedure) to evaluate whether the 50% nutrient (N and P) reduction target (OSPAR Recommendations 88/2, 89/4, and 92/7) is at present sufficient to reach the general ecological objective to achieve by the year 2010 a healthy marine environment where eutrophication does not occur.

Available measures to reduce the inputs for nutrients are part of the source oriented approach of the OSPAR Eutrophication Strategy (OSPAR reference number 2003-21).

The source-oriented approach has the following main elements (see Eutrophication Strategy):

> Throughout the Convention area national or international measures, as adopted by the individual Contracting Parties, need to be implemented to reduce the nutrients in discharges/emissions from industry, sewage treatment plants, agriculture and other diffuse sources. In addition, good housekeeping of industry and sewage treatment and of good agricultural practice needs to be promoted.

Furthermore, the PARCOM recommendations listed above and other defined OSPAR recommendations and (inter)national measures should be implemented in all areas where nutrient inputs are likely, directly or indirectly, and contribute to inputs into problem areas with regard to eutrophication.

Further measures should be applied where anthropogenic nutrient inputs to the maritime area continue to affect problem areas with regard to eutrophication or to be a cause for concern i.e. the most appropriate combination *inter alia* of BAT specifically designed for nitrogen and phosphorus removal from urban and industrial sewage, BAT and/or BEP for agriculture (including horticulture), forestry and aquaculture, other measures relating to other sectors.

In all areas from which nutrient inputs are likely, directly or indirectly, to contribute to inputs into potential problem areas with regard to eutrophication, preventive measures have to be taken in accordance with the precautionary principle. Contracting Parties concerned should report to the Commission on proposed action in this respect and should explain their expected results.

In addition to the OSPAR related measures, EU-regulations apply. These include the:

- EC Water Framework Directive (Directive 2000/60/EC; see also Chapter 4);
- Directive 91/271/EEC on Urban Waste Water Treatment (amended by Directive 98/15/EC);
- Directive 91/676/EEC on Nitrates from Agricultural Sources.

# 4 Possibilities of synergy (with EU-WFD and/or EU Marine Strategy)

Developments related to EcoQOs for eutrophication and to the EC Water Framework Directive (WFD) could well benefit from each other. There are obvious similarities, but also differences in approaches and in quality elements. The OSPAR classification could be further specified according to the WFD classification into high, good (both non-problem areas), moderate, poor and bad (all problem areas) quality status, where the EcoQOs for eutrophication provide the borderline between good quality (with 'slight signs of disturbance') and moderate quality (see Figure 2, below).

Another difference is the geographical coverage, namely: The WFD covers waters up to one nautical mile seaward from the coastal baseline for biological quality elements, including nutrients and oxygen. OSPAR has a much broader geographical coverage (North-East Atlantic) and includes estuaries as well.

Since background (reference) levels and assessment levels are area-specific, the approach of EcoQOs for eutrophication could also be applied for OSPAR wide marine/estuarine waters and other EU marine/estuarine waters. The link with the European Marine Strategy, presently under preparation, is currently subject to examination.

In the context of eutrophication, the OSPAR Comprehensive Procedure seeks to finally divide waters into two classes, non-problem areas (high/good under the WFD), which is the desired state, and problem areas (moderate/poor/bad under the WFD). There is a possibility within the OSPAR Comprehensive Procedure to further discriminate classes of problem areas into moderate, poor and bad. In addition, water bodies which show an elevated level of nutrient enrichment but no or yet unknown levels of eutrophication effects are initially classified as potential problem areas. Latest within five years of their classification, monitoring and assessment in conformity with the Comprehensive Procedure and/or research has to prove whether they finally classify as non-problem or problem areas. It should be noted however, that for example chemical contamination might alter the status of an area from that derived from assessment of eutrophication only. Thus a non-problem area with regard to eutrophication may have moderate to bad quality due to effects of hazardous substances.

As a starting point, the assessment level for some of the assessment parameters established in the first application of the Comprehensive Procedure was defined as a maximum % deviation of 50 compared to the natural background level. For the second application of the Comprehensive Procedure the assessment level for concentrations, except for oxygen, and for N/P ratios shall be determined as a justified area-specific deviation from background not exceeding 50%. In relation to this, the OSPAR assessment for the coastal areas and the Water Framework Directive's intercalibration process complement each other. In the context of eutrophication, the area-specific boundary between a problem area and a non-problem area in the coastal region should align with the boundary between the good and the moderate ecological status in the WFD.

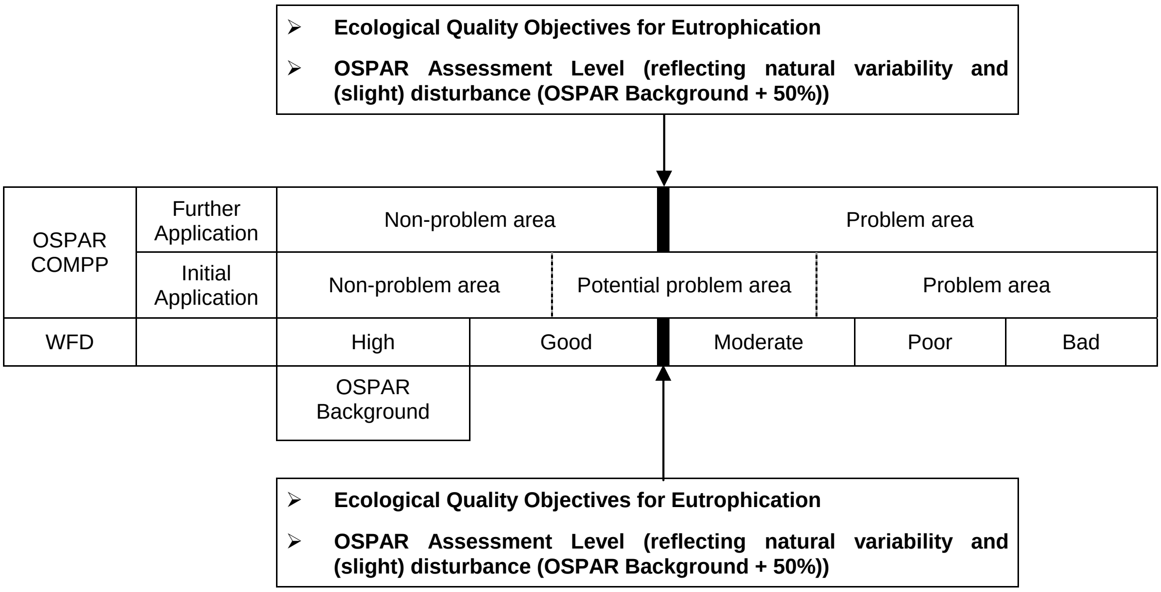



**Figure 2.** Relationship between the classification under the Comprehensive Procedure, the integrated set of EcoQOs for eutrophication and the Water Framework Directive.
**Note:** Assessment levels are based on a justified area-specific % deviation from background not exceeding 50%.
OSPAR COMPP = the Comprehensive Procedure; WFD = the Water Framework Directive.

# 5 Overall evaluation of EcoQOs for eutrophication

The EcoQOs for eutrophication, being part of the North Sea Pilot project, have been evaluated according to the criteria listed in chapter 1.2, to meet the requirements of 'good EcoQOs'. This evaluation is summarized in Table 9.

The comments (right hand column) in Table 9 are based on previous documents to ETG/EUC and on the latest ICES advice in 2004, namely from the SGEUT and ICES ACE report 2004.

ICES was asked to give advice on the use and implementation of the current integrated set of EcoQOs for eutrophication and to develop a list of zoobenthos indicator species in relation to long-term eutrophication. The evaluation by ICES was done mainly at the scale of EcoQ elements because the data necessary to provide a quantitative basis for the review of the EcoQOs area by area were not available. ICES found the five EcoQ elements to be useful, and supported their use as an integrated set. ICES noted, however, that more work was needed in developing the EcoQs into EcoQOs for eutrophication. ICES evaluated the EcoQ elements both individually and in the context of their application as an integrated set. As already indicated in the Comprehensive Procedure, the risk of misinterpretation of the causes of direct and indirect effects is substantially reduced when all categories (nutrient enrichment, direct effects, and indirect effects) as well as supporting environmental information are assessed together. More detailed information on the evaluation by ICES is provided in Annex 1.

ICES supported the area-specific aspect as formulated now in the present EcoQOs for eutrophication. ICES noted, however, that the appropriate spatial scale chosen for an area on which to set EcoQOs for eutrophication is not clear and recommended further work on this spatial scale aspect.

In Table 9 and below a further technical evaluation is made for each of the EcoQOs for eutrophication of the integrated set.

## 5.1 EcoQO for winter nutrient (DIN and DIP) concentrations in relation to eutrophication

ICES considered winter nutrient concentrations as very useful EcoQ element, since they directly respond to nutrient loads. It was recommended that the EcoQO should be developed only at area-specific scales and that assessments should include the entire water column and salinity gradient in order to determine the concentrations at a relevant, area-specific reference salinity.

The following reformulation of this eutrophication EcoQO is suggested in order to take account of the area-specific aspects: *Winter DIN and/or DIP should remain below a justified salinity-related and/or area-specific % deviation from background not exceeding 50%.*

## 5.2 EcoQO for phytoplankton chlorophyll *a* in relation to eutrophication

ICES considered chlorophyll to be a useful indicator of nutrient conditions and should be included in the suite of eutrophication indicator variables. In this respect it is very important to perform the required monitoring on the area-specific chlorophyll *a* in conjunction with environmental physical and biological conditions (such as light climate and grazing) as prescribed in the Comprehensive Procedure, the OSPAR eutrophication monitoring programme and its adherent guidelines. Although there is no fixed relationship that can be generally applied, there is a positive trend whereby concentrations of chlorophyll *a* are seen to increase with increasing nutrient inputs. Reference conditions (background concentrations) should be determined which will be dependent upon the local conditions in the different types of areas. ICES advised that the robustness of using a constant value of 50% above natural background conditions should be explored for a range of local conditions, to evaluate whether there are circumstances where a different value than 50% could be used to achieve the intent of this EcoQO.

The following reformulation of this eutrophication EcoQO is suggested in order to take account of the area-specific aspects: *Maximum and mean chlorophyll* a *concentrations during the growing season should remain below a justified area-specific % deviation from background not exceeding 50%.*

## 5.3 EcoQO for phytoplankton indicator species for eutrophication

Two types of phytoplankton eutrophication indicator species should be distinguished: nuisance and toxic species. ICES considered that harmful algal blooms most often have no direct relevance to eutrophication, and that toxic algal blooms in response to eutrophication should be regarded as second-order rather than first-order responses.

There is evidence that certain nuisance species blooms are reliable, area-specific indicators of increased nutrient loading and changed N/P ratios in some areas. With respect to toxic species, becoming toxic at low levels, the relationship with nutrient enrichment is less clear. There is some evidence, however, that there may be a relationship with nutrient enrichment and elevated N/P ratios, e.g. for the elevated levels of *Chrysochromulina polylepis* and *Gymnodinium mikimotoi* in Skagerrak and, for the latter species, also in the sedimentation area Oysterground and in the Frisian Front area during stratification. In this respect it is very important to perform the required monitoring on the area-specific phytoplankton indicator species in conjunction with environmental physical and biological factors as prescribed in the Comprehensive Procedure, the eutrophication monitoring programme and its adherent guidelines.

## 5.4 EcoQO for oxygen in relation to eutrophication

ICES considered that oxygen is a useful indicator of eutrophication and should be included in the suite of eutrophication indicator parameters. ICES advised that the development of EcoQOs at area-specific scales should continue, based on measurements taken close to the bottom at the time of year of the annual minimum (autumn). The robustness of the range 4-6 mg oxygen per litre should be explored for a range of local conditions, to evaluate whether there are circumstances where the appropriate value to achieve the intent of this EcoQO may be outside this range. ICES noted that this EcoQO may not be relevant for some areas where a cause/effect relationship cannot be established.

ICES confirmed, as mentioned also in the Comprehensive Procedure, that the risk of misinterpretation of the cause of oxygen depletion is substantially reduced when monitored together with the other categories, e.g., nutrients, and phytoplankton, and the area-specific supporting environmental factors.

## 5.5 EcoQO for changes/kills in zoobenthos in relation to eutrophication

Two elements are recognized: kills in zoobenthos, and long-term changes in species composition of the zoobenthos. As indicated in the formulation of the EcoQO for eutrophication (see Chapter 2), only kills and not changes in the zoobenthos are considered. With regard to kills in zoobenthos in relation to eutrophication, the relationship is clear in case the impact is assessed in relation to the cause/effect scheme that interrelate the different EcoQOs for eutrophication. Whereas kills in shallow areas may arise in the short-term, it may take several months to years before oxygen deficiency may be established in deeper areas as a result of long-term eutrophication.

ICES considered that an EcoQO for changes in zoobenthos was premature and that the element needed further development and implementation. ICES advised, however, that the EcoQ element should be retained since the (macro)zoobenthos community provides an integrated response to processes in the water column. Specific actions recommended by ICES included identification of area-specific macrozoobenthos species or groups which are particularly sensitive to oxygen depletion and eutrophication, and the identification of background concentrations (reference levels) and assessment levels for those species and areas. In the view of ETG/EUC, an EcoQO on changes in zoobenthos can be further developed by proposing a list of region-specific benthic indicator species in relation to long-term eutrophication, for which no proposals were provided yet by ICES.

Effects on zoobenthos resulting from eutrophication can sometimes be hard to discriminate from those due to other sources of disturbance (sediment contamination, dredging, bottom trawl fishing, etc.). The risk of misinterpretation of the cause of changes in the zoobenthos community is substantially reduced when monitored together with the other eutrophication categories, e.g., nutrients, organic matter, phytoplankton and near-bottom oxygen concentration, as well as by monitoring of other relevant activities in the wider context of the JAMP.

**Table 9. Evaluation of the integrated set of the five EcoQOs for eutrophication**

| | | |
|---|---|---|
| **a.** | **ICES Criteria** | **General and specific comments are based on ETG/EUC documents (Comprehensive Procedure and EcoQO for eutrophication documents), and ICES, see reference list and Annex 1** |
| | Relatively easy to understand by non-scientists and those who will decide on their use | Yes, there is growing awareness about the importance of nutrient levels and their related effects in ecosystems (also as a result of the implementation of the WFD for fresh and marine waters). |
| | Sensitive to a manageable human activity (in relation to measures) | Yes, the EcoQOs for eutrophication are interrelated, following a cause/effect relationship where the cause is linked to anthropogenic inputs of nutrients. Since other environmental factors and human activities may be contribute to the response as well, the risk of misinterpretation of this cause/effect relationship is substantially reduced when a coherent monitoring is performed of all relevant parameters involved (Fig.1 ). |
| | Relatively tightly linked in time to that activity (in relation to measures) | The response is more direct and more tightly linked for the direct effect EcoQOs. The links between nutrient input and direct and indirect effects of eutrophication may, however, be spatially and temporally separated through transboundary effects. Ecosystem or environmental factors (e.g. nutrient dynamics in sediments) may cause time lags. |
| | Easily and accurately measured, with a low error rate (monitoring) | Yes, all elements are part of the JAMP monitoring programme and guidance is available for accurate measurement, including monitoring of the relevant supporting environmental factors (such as salinity, and temperature) Monitoring of direct and indirect effects should be performed in a coherent way, and with appropriate frequency and area coverage. |
| | Responsive primarily to a human activity with low responsiveness to other causes of change (in relation to measures) | Yes, whereby an integrated monitoring and assessment of the cause/effect related parameters is needed in order to relate the response to human activities, taking into account environmental factors and (local) ecosystem properties. |
| | Measurable over a large proportion of the area to which the EcoQ metric is to apply (monitoring) | Yes, all EcoQO for eutrophication metrics are measurable in all areas. |
| | Based on an existing body or time series of data to allow a realistic setting of objectives (monitoring) | Yes/No. For a number of North Sea areas there are time-series available going back to at least 1990. For some areas, however, there is insufficient information on the EcoQOs for eutrophication for phytoplankton indicator species, oxygen deficiency and changes/kills in zoobenthos. Furthermore, frequency and spatial coverage of monitoring has not been satisfactory for some areas. |
| **b.** | **Ecological relevance/basis for the metrics** | The integrated set of EcoQOs for eutrophication is region specific and the ecological relevance is high |
| **c.** | **Current and historic levels (including geographic areas)** | Yes, Current region specific levels are available through the Eutrophication Monitoring Programme and other sources of information. Historic levels on most of the elements are available for some areas. |
| **d.** | **Reference level (= area-specific background concentrations)** | Yes, area-specific reference values have been derived, on the basis of historic levels, offshore levels, or by following the salinity-dependent approach. Since the approach used for the setting of reference levels considers area-specific levels, the approach can be applied for other OSPAR and EU marine/estuarine waters. |
| **e.** | **Limit points** (area-specific assessment levels) | Yes, assessment levels are area-specific, and allow a certain deviation (to a maximum of 50%) from the related area-specific background to take account of natural variability. The region specific assessment levels approach, allowing a certain level of deviation, links to the WFD approach in terms of good and high ecological quality (see text and figure in section 6).Kills of zoobenthos is an ultimate “limit point” and there is some physiological basis for the limit for oxygen. For the other EcoQOs for eutrophication there is no clear “limit point” (assessment level) elaborated on a biological or ecological basis, except perhaps for some area-specific nuisance and toxic phytoplankton indicator species. |

| | | |
|---|---|---|
| **f.** | **Time frames** | Detectable changes are estimated to be demonstrated in five to ten years. According to the OSPAR Strategy, eutrophication should no longer occur by the year 2010. Some level of eutrophication is, however, acceptable as long as areas are classified as non-problem areas (see Figure 2). |
| **g.** | **Advice on EcoQO options (scenarios)** | - |
| **h.** | **Monitoring regimes** | Monitoring of the EcoQOs for eutrophication is established in the Eutrophication Monitoring Programme, which is implemented in all OSPAR areas, including the North Sea. Monitoring includes estuaries, coastal and offshore areas, and has therefore a broader scope than monitoring requirements for the Water Framework Directive. For some (sub)areas, spatial and temporal coverage should be improved. In problem areas, and potential problem areas, monitoring should include all EcoQOs for eutrophication and accompanying environmental factors every year. In non-problem areas only nutrients need to be monitored, and only once per three years. |
| **i.** | **Management measures to achieve EcoQOs** | In general: Reduction of nutrient discharges from diffuse sources, point sources and atmospheric deposition. Management measures have been decided upon. The measure under evaluation by means of the set of EcoQOs for eutrophication is to reduce nitrogen and phosphorus inputs in the order of 50% compared with 1985. It has to be evaluated if this reduction in nutrient inputs will lead to achievement of the overall objective. Since the nitrogen reduction has not been reached in many areas (generally about 30%), additional attention should be paid to reduction of inputs through agriculture, industries, households, and sewage treatment plants. Tools are available through the OSPAR recommendations and EU Directives. Although phosphorus reductions have been successful, nutrient enrichment is still relevant as a result of sediment releases. Alternative measures may be considered to reduce the impacts from nutrient releases, e.g. by creating marsh areas on the fresh-marine interface that store or process nutrients. |

# 6 Conclusions and Recommendations to OSPAR 2005

## 6.1 Conclusions

1. The integrated set of five area-specific EcoQOs for eutrophication is useful and at present has been developed to the extent possible. They were developed in parallel to the Comprehensive Procedure as part of the target-oriented approach of the OSPAR Eutrophication Strategy. They are interrelated through a eutrophication cause/effect scheme and already incorporated in the OSPAR Eutrophication Monitoring Programme. Through practical application they may undergo further development and improvement.

2. An EcoQO on changes in zoobenthos can be developed in relation to long-term eutrophication effects by proposing a list of area-specific (groups of) benthic indicator species.

3. In some areas, monitoring on direct and indirect effects in relation to EcoQOs for eutrophication and the Comprehensive Procedure should be more frequent and have a better coverage. The monitoring should be performed in a coherent way.

4. Results from the first application of the Comprehensive Procedure contained in the “OSPAR integrated report 2003 on the eutrophication status of the OSPAR maritime area based upon the first application of the Comprehensive Procedure”, show that there are several problem areas, indicating that the integrated set of EcoQOs for eutrophication has not been met.

5. Evaluation during the North Sea pilot project shows that application of the present integrated set of five EcoQOs for eutrophication in the wider OSPAR maritime area is possible. The possible need for further developments depends on the experience from their practical application.

6. The EcoQOs for eutrophication and the Comprehensive Procedure approach of OSPAR, used for all types of marine waters, allow for formulating area-specific Ecological Quality Objectives and for area-specific assessments. Therefore these have potential to be used for other European marine waters that fall under the EC Water Framework Directive (estuaries and coastal waters) and for the implementation of a European Marine Strategy (all types of marine waters).

## 6.2 Recommendations to OSPAR

1. The present integrated set of five EcoQOs for eutrophication can be adopted within the OSPAR framework and implemented for the North Sea.
2. A new overall OSPAR EcoQO for eutrophication could be formulated as: *All parts of the North Sea should have by 2010 the status of non-problem areas with regard to eutrophication, as assessed under the OSPAR Common Procedure for the Identification of the Eutrophication Status of the OSPAR Maritime Area (which consists of the (one-off) Screening Procedure and the (iterative) Comprehensive Procedure).*
3. Some further development of EcoQOs for eutrophication is recommended, especially an EcoQO for changes in zoobenthos in relation to long-term eutrophication. This requires a list of area-specific (groups of) benthic indicator species to be provided by ICES.
4. Further development of the EcoQOs for eutrophication should be considered when experience from their practical application has been gathered.
5. The present integrated set of five area-specific EcoQOs for eutrophication should be considered for application in the wider OSPAR area. Monitoring should be performed in a coherent way, according to OSPAR JAMP and related Guidelines.
6. If additional EcoQOs for eutrophication need to be developed because of area-specific ecosystem properties (e.g. zoobenthos (groups of) indicator species, macrophytes) then this could be done after establishing first the area-specific background concentrations and assessment levels.
7. OSPAR is asked to urge all Contracting Parties to be involved in the application of the integrated set of EcoQOs for eutrophication.

# 7 References

Bergen Declaration 2002: Fifth International Conference on the Protection of the North Sea, 20-21 March 2002, Bergen Norway, ISBN-82-457-0361-3

OSPAR reference number 2003-21: 2003 Strategies of the OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic

PARCOM Recommendation 88/2 on the Reduction in Inputs of Nutrients to the Paris Convention Area

PARCOM Recommendation 89/4 on a Coordinated Programme for the Reduction of Nutrients

PARCOM Recommendation 92/7 on the Reduction of Nutrient Inputs from Agriculture into Areas Where these Inputs are Likely, Directly or Indirectly, to Cause Pollution

OSPAR Agreement 2005-3: Common Procedure for the Identification of the Eutrophication Status of the OSPAR Maritime Area, superseding the previous OSPAR Common Procedure (reference number 1997-11) and OSPAR Agreement on Common Assessment Criteria, their Assessment Levels and Area Classification within the Comprehensive Procedure of the Common Procedure (reference number 2002-20)

OSPAR Agreement 1998-5: Principles of the Comprehensive Study on Riverine Inputs and Direct Discharges (RID)

OSPAR Agreement 2003-22: Strategy for a Joint Assessment and Monitoring Programme (JAMP)

OSPAR Agreement 2005-4: Eutrophication Monitoring Programme, updating and superseding the Nutrient Monitoring Programme, reference number 1995-5

OSPAR JAMP Guidelines (reference number: 1997-2): Eutrophication Monitoring Guidelines: Nutrients

OSPAR JAMP Guidelines (reference number: 1997-3): Eutrophication Monitoring Guidelines: Oxygen

OSPAR JAMP Guidelines (reference number: 1997-4): Eutrophication Monitoring Guidelines: Chlorophyll *a* in Water

OSPAR JAMP Guidelines (reference number: 1997-5): Eutrophication Monitoring Guidelines: Phytoplankton Species Composition

OSPAR JAMP Guidelines (reference number: 1997-6): Eutrophication Monitoring Guidelines: Benthos

OSPAR 2003 a: Integrated Report 2003 on the Eutrophication Status of the OSPAR Maritime Area Based Upon the First Application of the Comprehensive Procedure. OSPAR publication no. 189, ISBN: 1-904426-25-5

OSPAR 2003 b: Nutrients in the Convention area - Inputs of Nutrients into the Convention area - Implementation of PARCOM Recommendations 88/2 and 89/4, OSPAR publication no. 191, ISBN 1-904426-16-6

SGEUT (2004): Report of the Study Group to Review Ecological Quality Objectives for Eutrophication. 17-19 May, 2004. ICES CM 2004.ACE:04

ACE (2004): Report of the ICES Advisory Committee on Ecosystems 2004. Chapter 2.1.7.1 Ecological Quality Objectives

Water Framework Directive: Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy

Urban Waste Water Treatment Directive: Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment

Nitrates Directive: Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources

# Annex 1 ICES Evaluations

In this Annex, summary tables from the evaluations by ICES are listed, including a general assessment by the ICES Advisory Committee on Ecosystems (ACE) and of the individual EcoQs provided by the ICES Study Group to Review Ecological Quality Objectives for Eutrophication (SGEUT) (ICES CM 2004/ACE:04, on request by OSPAR ETG/EUC).

SGEUT evaluated EcoQO elements as "an integrated and coherent set sensitive to required metrics, time and geographical areas within OSPAR purview". In the ACE summary table (Table 1) it is concluded that "all EcoQOs for eutrophication are useful, but that the EcoQO for changes is zoobenthos is premature".

**Table 1**. Summary of the ICES evaluation of the EcoQ elements, and where relevant, the status of the EcoQOs related to eutrophication. All EcoQOs for eutrophication are part of the North Sea pilot project

| Ecological quality element | Good EcoQ element? | Good EcoQO? |
|---|---|---|
| **(q) Phytoplankton chlorophyll *a*** | Useful | Suggestion offered |
| **(r) Phytoplankton indicator species for eutrophication** | Useful (needs development) | Needs work |
| **(t) Winter nutrient (DIN and DIP) concentrations** | Useful | Reformulation offered |
| **(u) Oxygen** | Useful | Reformulation offered |
| **(m) Changes/kills in zoobenthos in relation to eutrophication** | Useful | Premature |

### Technical evaluation tables according to ICES ACE 2004, and in brackets SGEUT 2004

### EcoQ Winter nutrient (DIN and DIP) concentrations in relation to eutrophication

Anthropogenic nutrient input increases the nutrient loads and nutrient pools in coastal and marine waters. During the period of minimum phytoplankton production in winter, this may be reflected in increased levels of the inorganic forms of nitrogen and phosphorus nutrients.

| | | Comments | |
|---|---|---|---|
| **a.** | **ICES criteria** | (SGEUT) | |
| | Relatively easy to understand by non-scientists and those who will decide on their use | Occasionally (yes) | Some public awareness has been raised about the importance of nutrient levels in ecosystems. |
| | Sensitive to a manageable human activity | Usually (yes) | There is generally a relationship between input and winter nutrient concentrations. |
| | Relatively tightly linked in time to that activity | Usually (yes) | There may be time delays due to retention and recycling of pools of nutrients in the environment. |
| | Easily and accurately measured, with a low error rate | Usually (yes) | Salinity-normalized winter nutrient concentrations can be measured using standard oceanographic methods. Coastal area flushing rates are more problematic. |
| | Responsive primarily to a human activity, with low responsiveness to other causes of change | Occasionally, Usually (yes/no) | Depends on the magnitude of inputs and flushing rate of receiving coastal water body. Climatic variability (e.g. precipitation, runoff and ocean circulation) may also influence winter nutrient concentrations. |
| | Measurable over a large proportion of the area to which the EcoQ metric is to apply | Usually (yes) | The measurement of coastal nutrients is standard in many monitoring programmes while the measurement of offshore nutrient concentrations is less common. |
| | Based on an existing body or time series of data to allow a realistic setting of objectives | Occasionally (yes/no) | Most available data are from the period after anthropogenic sources began to increase. Some information which can be used to estimate historical inputs and, possibly, concentrations is available. |
| **b.** | **Ecological relevance/basis for the metric** | High relevance, as nutrients are at the basis of phytoplankton biomass formation. | |

| | | | |
|---|---|---|---|
| **c.** | **Current and historic levels (including geographic areas)** | At present, there are elevated concentrations to a varying degree in some coastal areas, compared to historical levels. Historical levels are poorly known for almost all areas, however. | |
| **d.** | **Reference level** | Two options: either use offshore (unaffected) values or a salinity-dependent approach based on reconstructing or extrapolating to historical loads. The EcoQO should be developed on an area-specific scale. | |
| **e.** | **Limit point** | Values are only meaningful on an area-specific scale. | |
| **f.** | **Time frames** | *Detection of change* | About ten years.<br>If correction for runoff is possible, maybe five years. |
| | | *Use in advice* | Application on an area-specific scale. |
| **g.** | **Advice on EcoQO options (scenarios)** | | |
| **h.** | **Monitoring regimes** | High spatial coverage in winter focusing on the salinity gradient. | |
| **i.** | **Management measures to achieve EcoQO** | Reduction of anthropogenic nutrient discharges from diffuse sources, point sources, and atmospheric deposition, including transboundary ocean fluxes. | |

### EcoQ Phytoplankton chlorophyll *a* in relation to eutrophication

Anthropogenic input of nutrients leads to increased growth of plants including phytoplankton. The increased growth is often associated with an increased amount of phytoplankton. This is reflected in an increase in the concentration of the plant pigment chlorophyll *a* which is an indicator of phytoplankton biomass.

| | | **Comments** | |
|---|---|---|---|
| **a.** | **ICES Criteria** | (SGEUT) | |
| | Relatively easy to understand by non-scientists and those who will decide on their use | Occasionally (yes) | The public and managers are generally aware of the problem of excessive algal growth although they may not be aware of chlorophyll *a* as an entity itself. |
| | Sensitive to a manageable human activity | Occasionally (yes (clear waters)) | Usually in clear-water areas, but not in turbid waters (e.g. parts of the Wadden Sea) or where grazers and other controlling factors keep chlorophyll *a* low. |
| | Relatively tightly linked in time to that activity (i.e., nutrient loading) | Occasionally (yes) | |
| | Responsive primarily to a human activity, with low responsiveness to other causes of change | Occasionally (yes) | Chlorophyll a responds also to natural conditions, e.g. physical events and changes in grazer communities. |
| | Easily and accurately measured, with a low error rate | Usually (yes) | Analytical and sampling procedures are very well known for chlorophyll *a*. |
| | Measurable over a large proportion of the area to which the EcoQ metric is to apply | Usually (yes) | Satellite remote-sensing technology enables estimates of chlorophyll *a* concentrations over large areas. |
| | Based on an existing body or time series of data to allow a realistic setting of objectives | Occasionally (yes) | (But in some areas too low frequency / area coverage of monitoring) |
| **b.** | **Ecological relevance/basis for the metric** | Chlorophyll *a* responds directly to nutrients through the growth of phytoplankton, which are consumed by grazers and lead to consumption of oxygen during decomposition. | |
| **c.** | **Current and historic levels (including geographic areas)** | Historical time-series data exist for some areas. Where such data are not available, modeling results or offshore data may be used. Tested models exist which could be parameterized to serve this purpose for some areas. | |
| **d.** | **Reference level** | See comment for c). These should be made relevant to the area that is being described. | |
| **e.** | **Limit point (thresholds)** | | Difficult to determine |
| **f.** | **Time frames** | | Need to be developed for specific geographical locations |
| **g.** | **Advice on EcoQO options (scenarios)** | | |

| | | |
|---|---|---|
| **h.** | **Monitoring regimes** | Chlorophyll *a* is included in the OSPAR eutrophication monitoring programme. Sampling frequency should be at least monthly and the spatial coverage should be adequate to describe the conditions within the entire water body. |
| **i.** | **Management measures to achieve EcoQO** | Reduction of nutrient discharges from the relevant diffuse sources, point sources, and atmospheric deposition, taking into account transboundary fluxes in the sea. |

## EcoQ Phytoplankton indicator species for eutrophication

Increased input of nutrients to coastal and marine waters lead to stimulated growth of phytoplankton, including nuisance and/or toxic species. Such species may therefore be used as potential indicator species for eutrophication.

| | | **Comments** | |
|---|---|---|---|
| **a.** | **ICES criteria** | (SGEUT) | |
| | Relatively easy to understand by non-scientists and those who will decide on their use | Occasionally (yes) | Individual species are easy to understand but there is low public awareness of the importance of individual species. |
| | Sensitive to a manageable human activity | Occasionally (yes) | Individual species have been demonstrated to be related to known human activities in certain areas. |
| | Relatively tightly linked in time to that activity | Occasionally (yes) | Where links exist, these are usually tightly linked in time. |
| | Easily and accurately measured, with a low error rate | Usually, rarely (yes) | Laboratory analysis is accurate with specialist people; however, it is time-consuming, so not *easily* measured. (SGEUT concludes that it can be accurately measured by specialist people.) |
| | Responsive primarily to a human activity, with low responsiveness to other causes of change | Occasionally (yes/no) | In defined areas, the response can be linked to nutrient enrichment (but in open waters it may be more difficult to link.) |
| | Measurable over a large proportion of the area to which the EcoQ metric is to apply | Usually (yes) | Phytoplanktons are measurable over all waters (and should already be at place according to the monitoring programme.) |
| | Based on an existing body or time series of data to allow a realistic setting of objectives | Occasionally (yes/no) | Time series of phytoplankton species counts exist for some areas (whilst it should be available for all OSPAR areas, according to the monitoring programme.) |
| **b.** | **Ecological relevance/basis for the metric** | Understanding of phytoplankton dynamics (both individual species and functional groups) and primary production is essential in defining ecological structure. However, phytoplankton dynamics are highly variable in space and time, and need to be related to specific areas and seasons. | |
| **c.** | **Current and historic levels (including geographic areas)** | There exist a few long, high-quality time series on phytoplankton occurrence (>25 years). | |
| **d.** | **Reference level** | Dependent on area. Expert groups responsible for monitoring in each area should define reference conditions and action levels. | |
| **e.** | **Limit point** | "Limit" in this case may be *upper* limit for abundance of indicator species. Limits will have to be species-specific and area-specific. (OSPAR data and eco-physiological information is however available (see Comprehensive Procedure)) | |
| **f.** | **Time frames** | *Detection of change* | Observed changes need to be stable over time to be conclusive. They should deviate substantially from a reference trend. Dependent on the natural variability in the area; responses rarely detectable on time scales of less than five to ten years. |
| | | *Use in advice* | Unknown until better developed, but likely to require assessments on an annual basis. |
| **g.** | **Advice on EcoQO options (scenarios)** | | |

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| **h.** | **Monitoring regimes** | Selection of main observation areas for sampling, usually with need for taxonomic expertise to be available where samples are processed. |
| **i.** | **Management measures to achieve EcoQO** | Reduction of nutrient discharges from diffuse sources, point sources, and atmospheric deposition. |

## EcoQ Oxygen in relation to eutrophication

Increased input of nutrients leads to stimulated growth of phytoplankton. This may in turn lead to increased consumption of oxygen by animals nourished by the plants and by micro-organisms decomposing the organic material from plant production. This may cause conditions of low or no oxygen in deeper water layers particularly during periods of stagnation.

| | | **Comments** | |
|---|---|---|---|
| **a.** | **ICES criteria** | (SGEUT) | |
| | Relatively easy to understand by non-scientists and those who will decide on their use | Usually (yes) | The public and decision-makers are generally aware of the importance of oxygen in water. |
| | Sensitive to a manageable human activity | Occasionally (yes) | There may be clear relationships between anthropogenic nutrient load and oxygen in some areas. However, low oxygen events may also be caused by natural physical and biological conditions. |
| | Relatively tightly linked in time to that activity | Occasionally (no) | Oxygen depletion may occur far away (in space and time) from the causal nutrient source due to ocean circulation and stagnation. |
| | Easily and accurately measured, with a low error rate | Usually (yes) | Methods for measuring oxygen are well known and standardized. |
| | Responsive primarily to a human activity, with low responsiveness to other causes of change | Rarely (no) | Bottom-water oxygen concentrations are determined by a number of different processes besides eutrophication. |
| | Measurable over a large proportion of the area to which the EcoQ metric is to apply | Usually (yes) | Use of 3-D models |
| | Based on an existing body or time series of data to allow a realistic setting of objectives | Occasionally (yes/no) | For some areas, time series dating back to the 1960s or earlier exist. |
| **b.** | **Ecological relevance/basis for the metric** | Oxygen values vary regionally, depending on cause/effect relationships. However, the amount of oxygen in the water can be a critically important property of local areas. | |
| **c.** | **Current and historic levels (including geographic areas)** | Area-specific values exist for many areas. | |
| **d.** | **Reference level** | Area-specific pre-eutrophication levels and natural variability. Can in some cases be determined by the use of numerical models. | |
| **e.** | **Limit point** | Area-specific limit points can be set based on physiological tolerance of species or groups of organisms. | |
| **f.** | **Time frames** | *Detection of change* | Five to ten years. |
| | | *Use in advice* | Depends on local oxygen dynamics; may require frequent sampling, at least at some times and places. |
| **g.** | **Advice on EcoQO options (scenarios)** | | |
| **h.** | **Monitoring regimes** | Oxygen is included in the OSPAR eutrophication monitoring programme.<br>Measurements should be obtained during the annual minimum (autumn), but the annual cycle in oxygen should also be described. Oxygen profiles with depth should be examined. | |

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| **i.** | **Management measures to achieve EcoQO** | Reduction of nutrient discharges from diffuse sources, point sources, and atmospheric deposition, where relevant, and to levels necessary to remove oxygen depletion problems. |

## EcoQ Changes/kills in zoobenthos in relation to eutrophication

Increased production of plants caused by eutrophication may lead to low oxygen events or blooms of toxic species that may in turn lead to mortality of benthic animals.

| | | **Comments** | |
|---|---|---|---|
| **a.** | **ICES criteria** | (SGEUT) | |
| | Relatively easy to understand by non-scientists and those who will decide on their use | Usually (yes) (yes) | Changes in zoobenthos are already widely in use in monitoring of human impact on the marine environment. Kill events can receive substantial public awareness if they occur in accessible areas. |
| | Sensitive to a manageable human activity | Occasionally (yes) | Zoobenthos change or kills can be the result of natural processes not associated with eutrophication. |
| | Relatively tightly linked in time to that activity | Occasionally (yes) | When kills are the result of eutrophication, they will be linked closely in time to oxygen depletion, but oxygen depletion may not be linked closely in time to anthropogenic causes of eutrophication. |
| | Easily and accurately measured with a low error rate | Occasionally (yes) | Monitoring experience shows that, with a feasible standard sampling regime designed to account for spatial variability, changes are measured with low error. |
| | Responsive primarily to a human activity, with low responsiveness to other causes of change | Occasionally (yes) | Oxygen depletion due to natural causes may cause kills of zoobenthos in some areas. Changes in zoobenthos may also occur due to other human activities such as fishing and dredging. |
| | Measurable over a large proportion of the area to which the EcoQ metric is to apply | Usually (yes) | Measurable in all waters where eutrophication is a problem. |
| | Based on an existing body or time series of data to allow a realistic setting of objectives | Occasionally (yes/no) | Time series of zoobenthos kills are not numerous, but are also not necessary for setting realistic EcoQOs. Sound monitoring regimes have been developed which can allow the incidence of kills to be detected. Interpreting the meaning of a kill event requires knowledge of the cause of the kill (see "Sensitive to a manageable human activity") more than historical rates. |
| **b.** | **Ecological relevance/basis for the metric** | The zoobenthos community provides an integrated response to processes including eutrophication in the water column and in the sediments; thus, responses in the zoobenthos community are useful as an EcoQO of eutrophication, so long as other factors causing zoobenthos change are taken into account. It should be related to the other eutrophication EcoQs. | |
| **c.** | **Current and historic levels (including geographic areas)** | Information on some zoobenthos kill events is available but time series of such events are limited. (SGEUT gives more detail) | |
| **d.** | **Reference level** | No kills of species or substantial changes in the benthic community, caused by eutrophication. | |
| **e.** | **Limit point** | Kills on scales or with frequencies that place the continuity of the zoobenthos community at risk of irreversible change. | |
| **f.** | **Time frames** | *Detection of change* | Depends on factors such as water depth and community type. Zoobenthos kills may require months to years of oxygen depletion to develop. |
| | | *Use in advice* | Annual monitoring, which would allow annual advice. Opportunistic investigation of kills might allow "fast-track" advice. |

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| **g.** | **Advice on EcoQO options (scenarios)** | | (See SGEUT p. 5) |
| **h.** | **Monitoring regimes** | Zoobenthos is included in several monitoring programmes. To be able to document the maximum effects of eutrophication on the zoobenthos, sampling should be undertaken annually just after the annual bottom oxygen minimum period, in addition to a reference monitoring in late spring. Determining the time for optimal sampling may be facilitated by ancillary measurements, e.g., concentrations of nutrients, chlorophyll *a*, and organic matter in the upper mixed layer, and sedimentation rates of particles to the benthos. | |
| **i.** | **Management measures to achieve EcoQO** | Control (reduction) of nutrient discharges from diffuse sources, point sources, and atmospheric deposition (if eutrophication is identified as a cause of zoobenthos change). | |