Baltic Sea Environment Proceedings No. 104

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Helsinki Commission

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# Contents

# 1 Preface

This report is the result of the HELCOM Pilot Project "Development of tools for a thematic eutrophication assessment (HELCOM EUTRO)".

One of the priority goals set by HELCOM is to reduce eutrophication in the Baltic Sea. This requires achieving consensus on assessment procedures, as well as a subsequent linking of effects with activities taking place in the drainage basin. The Pilot Project was established to develop assessment tools for a Baltic Sea-wide harmonization of eutrophication assessment criteria and procedures, including the establishment of reference conditions for different parts of the Baltic Sea.

The objectives of the project have been: (1) to develop a tool for assessment of the eutrophication status of the Baltic Sea, (2) to base the tool on reference conditions, sometimes referred to as background values, (3) to base the work on currently available data and information, and (4) to develop and assess different scenarios for the definition of acceptable deviations from reference conditions.

The outcome of HELCOM EUTRO includes three elements:

1. A test of existing tools based on tentative values for reference conditions and adapted to meet the special features of the Baltic Sea.
2. A discussion of the strengths and weaknesses of the above tools.
3. Suggestions on how to improve the existing tools, e.g., the draft HELCOM Eutrophication Assessment Tool (HEAT).

The test for suitability of the existing assessment tools has indirectly resulted in an interim classification of eutrophication status. This should not be interpreted as a HELCOM eutrophication assessment.

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# 2 Introduction

The Baltic Sea is the only inland sea in the European Union and one of the largest brackish-water basins in the world. It is divided into several subregions and a transition zone to the North Sea (the Belt Sea and Kattegat area), consisting of basins separated by sills, cf. Figure 2.1 and Table 2.1.

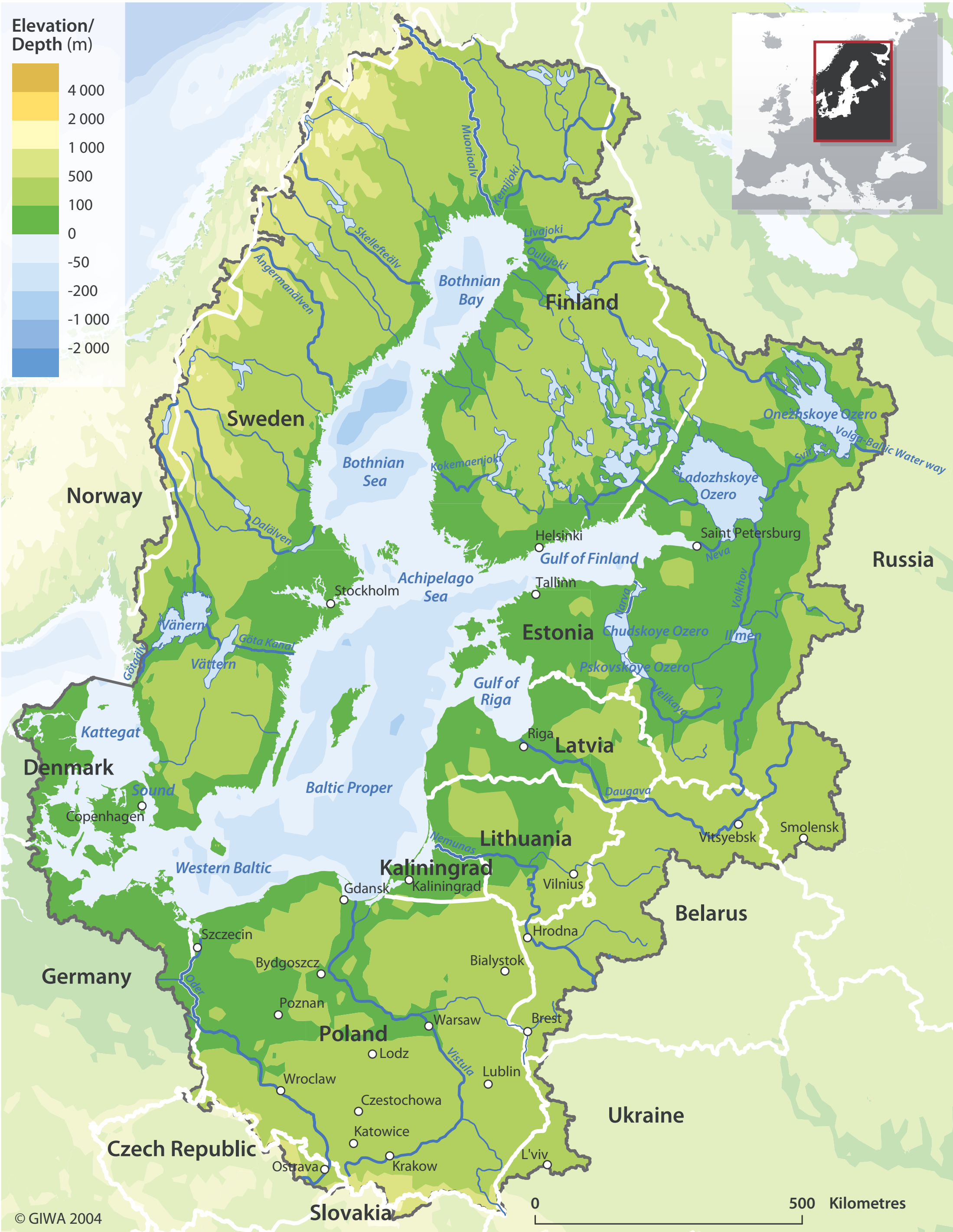


**Figure 2.1**
Map of the Baltic Sea and its upstream catchment area /1/.
© GIWA

**Table 2.1**
Physical characteristics of the Baltic Sea, its main sub-regions (1–4), and the transition zone to the Skagerrak/North Sea area (5) /2/.

| Sub-area | Area | Volume | Maximum depth | Average depth |
|---|---|---|---|---|
| | $km^2$ | $km^3$ | m | m |
| 1. Baltic Proper | 211,069 | 13,045 | 459 | 62.1 |
| 2. Gulf of Bothnia | 115,516 | 6,389 | 230 | 60.2 |
| 3. Gulf of Finland | 29,600 | 1,100 | 123 | 38.0 |
| 4. Gulf of Riga | 16,300 | 424 | > 60 | 26.0 |
| 5. Belt Sea/Kattegat | 42,408 | 802 | 109 | 18.9 |
| Total Baltic Sea | 415,266 | 21,721 | 459 | 52.3 |

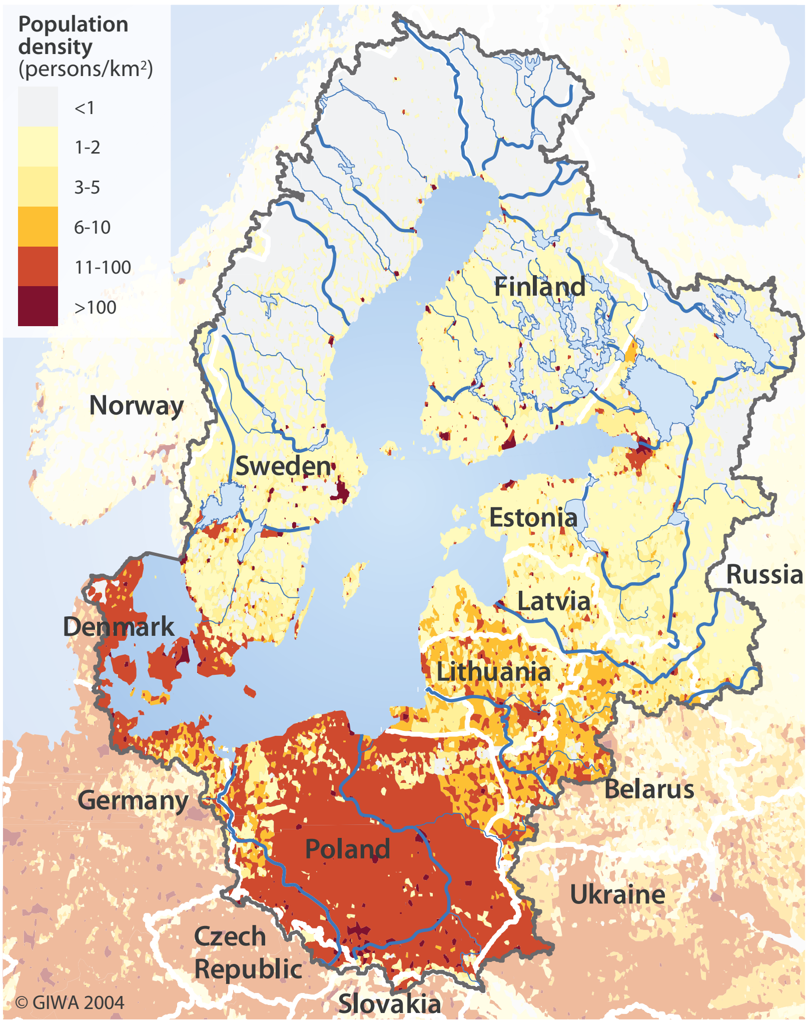


**Figure 2.2**
Population density in the Baltic Sea catchment area /1/. © GIWA

The Baltic Sea has an average depth of 52 m, with a volume of 21 700 $km^3$ and a surface area of 415 200 $km^3$. The different basins or sub-areas of the Baltic Sea vary considerably from north to south, and from east to west, cf. Table 2.1.

The catchment area of the Baltic Sea is more than 1 700 000 $km^2$, with a population of approximately 85 million inhabitants. The population density varies from less than 1 person/$km^2$ in the northern and northeastern parts of the catchment to more than 100 persons/$km^2$ in the southern and western parts, cf. Figure 2.2.

The land-use structure follows the same pattern as the population density, with a high proportion of arable land in the eastern, southern, and western parts, and predominantly forest and wooded land in the northern part. The combination of a high population density, a well-developed agricultural sector, and other human activities, such as emissions from energy production and transport, has resulted in large inputs of nutrients to the Baltic Sea (Table 2.2). The inputs of nutrients, mainly compounds of nitrogen and phosphorus, have led to nutrient enrichment, which on the scale of the Baltic Sea is well understood and documented /3, 4, 5, 6/.

**Table 2.2**
Surface areas of the Baltic Sea catchment area by sub-region, total runoff, and inputs of nitrogen (TN) and phosphorus (TP) in 2000. The inputs include riverine, direct, and atmospheric inputs /7/.

| Sub-region | Catchment | Runoff | TN-water | TN-air | TN-total | TP |
|---|---|---|---|---|---|---|
| | $km^2$ | 106 $m^3$ | t | t | t | t |
| Bothnian Bay | 260,675 | 155,480 | 69,893 | 11,600 | 81,493 | 3,451 |
| Bothnian Sea | 220,765 | 124,150 | 71,522 | 30,000 | 101,522 | 2,769 |
| Archipelago Sea | 9,000 | 3,840 | 11,143 | 6,000 | 17,143 | 901 |
| Gulf of Finland | 413,100 | 107,340 | 113,561 | 15,800 | 129,361 | 6,029 |
| Gulf of Riga | 127,840 | 28,750 | 70,076 | 11,400 | 81,476 | 2,209 |
| Baltic Proper | 574,545 | 115,580 | 293,236 | 140,200 | 433,436 | 16,046 |
| Belt Sea | 27,365 | 6,670 | 41,740 | 25,000 | 66,740 | 1,270 |
| The Kattegat | 86,980 | 42,380 | 73,696 | 24,100 | 97,796 | 1,814 |
| Total | 1,720,270 | 584,190 | 744,867 | 264,100 | 1,008,967 | 34,489 |

## 2.1 Definition of eutrophication

The word "eutrophication" has its root in two Greek words: "eu", which means "well", and "trope", which means "nourishment". The modern use of the term eutrophication is related to the inputs and effects of nutrients in aquatic systems.

Many European coastal waters do not have a pristine or good ecological status. This is due, *inter alia*, to discharges, losses, and emissions of nutrients and their effects in the aquatic environment /5/. Until now, the management of coastal eutrophication has focused on (i) discharges from point sources, (ii) losses from cultivated land, and (iii) emissions to the atmosphere. Many national and international initiatives have been agreed upon and partly implemented in order to reduce nutrient emissions, discharges and losses, with the strategic objective of combating eutrophication. The measures have focused on the sources and sectors causing eutrophication. Consequently, eutrophication has been defined in relation to sources and/or sectors. For example, within the European Union, eutrophication has been defined as:

> "*the enrichment of water by nutrients, especially nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of water concerned*" /8/,

or as:

> "*the enrichment of water by nitrogen compounds causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of water concerned*" /9/.

The difference between these two definitions is due to the focus of the EC Nitrates Directive (the source of the second definition), which for natural reasons focuses on nitrogen losses from agriculture.

The above definitions can be and have been greatly discussed, mainly owing to the strong focus on nutrients and the fact that it is unclear what an "undesirable disturbance" might be.

The most common use of the term is related to inputs of mineral nutrients, primarily nitrogen and phosphorus. Consequently, eutrophication deals with two processes: the effects associated with nutrient enrichment, and natural versus anthropogenically caused eutrophication.

So far, HELCOM has not agreed on a definition of eutrophication within the Convention area. However, this does not pose a problem because all Contracting Parties obviously share a common understanding of eutrophication and of which causes, direct effects, and indirect effects are relevant when assessing the eutrophication status of the different basins and coastal waters of the Baltic Sea. In other words, the countries bordering the Baltic Sea share a common conceptual understanding of eutrophication and the underlying causes and pressures.

## 2.2 Conceptual understanding of eutrophication

Based on the definitions of eutrophication, a very simple conceptual model can be set up, starting with inputs of nutrients and resulting in a sequence including nutrient concentrations, phytoplankton, zooplankton, and fish. It is generally accepted that such a simple and short food chain is a characteristic of balanced, non-eutrophic marine waters.

When nutrient inputs result in their enrichment in water and an unbalanced ecosystem according to the definition of eutrophication, the relationships between the ecosystem compartments are not always as simple as those described above. For example, eutrophication can lead to an accelerated growth of phytoplankton. The result will very often be an increase in phytoplankton biomass and a subsequent reduction in the amount of light reaching the sea floor. Seagrasses and/or macroalgae are distributed over depths according to the light conditions. Increased phytoplankton biomass may result in an environment where less light will be available for growth, and consequently these organisms will no longer be present at their maximum potential depth limit, cf. Figure 2.3.

This model, which is very illustrative despite its lack of detail, includes the drivers (inputs), the causes (nutrient enrichment), the direct

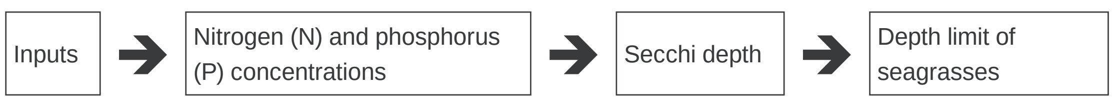


**Figure 2.3**
Simple conceptual model of eutrophication, from /10/.

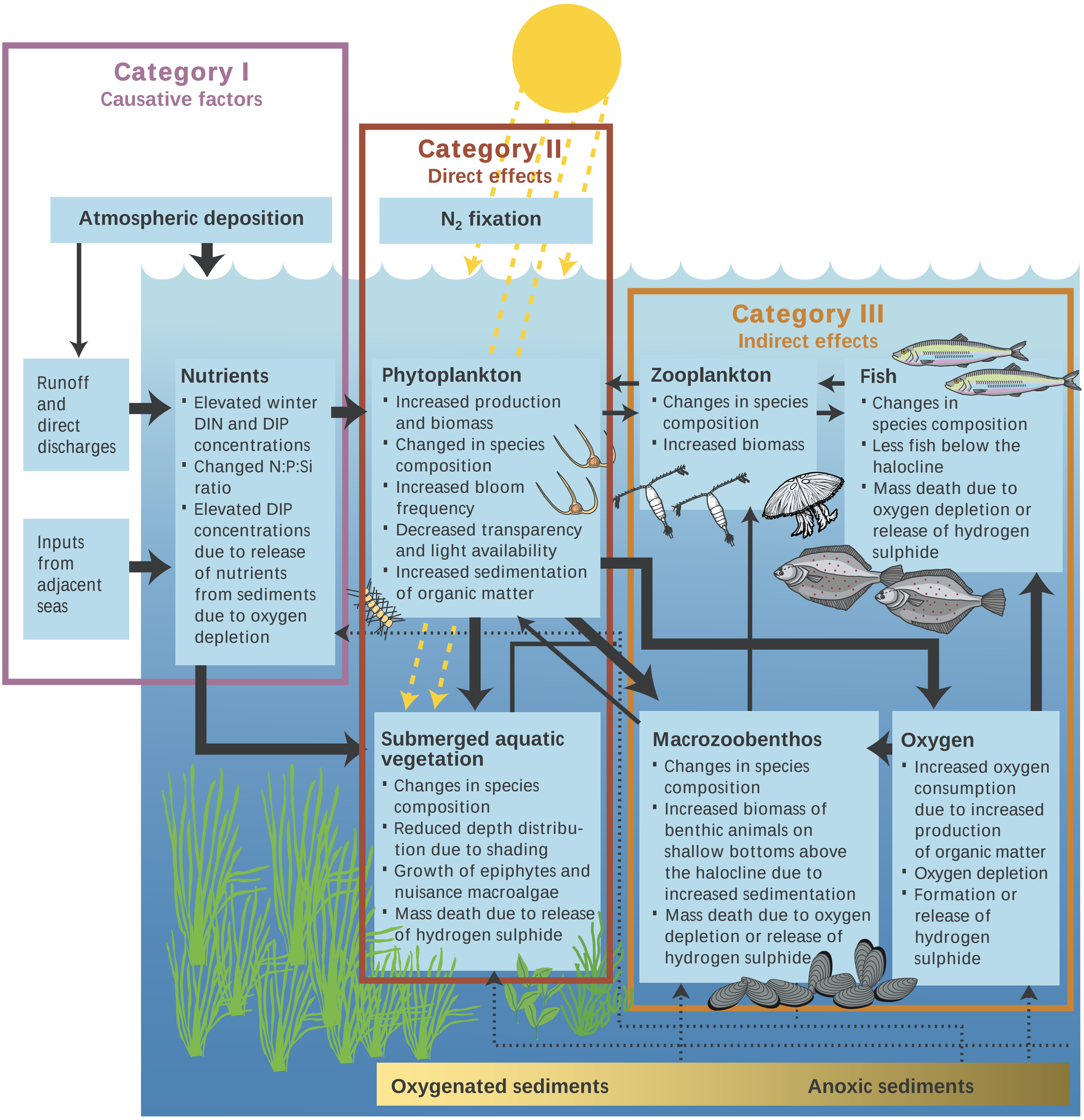


**Figure 2.4**
Conceptual model of eutrophication. The arrows indicate the interactions between different ecological compartments. A balanced coastal ecosystem in the southwestern Baltic is supposedly characterized by: (1) a short pelagic food chain (phytoplankton → zooplankton → fish), (2) a natural species composition of plankton and benthic organisms, and (3) a natural distribution of submerged aquatic vegetation. Nutrient enrichment results in changes in the structure and function of marine ecosystems, as indicated by bold lines. Dashed lines indicate the release of hydrogen sulphide ($H_2S$) and phosphorus, which is positively linked to oxygen depletion. Modified from /11/.

(primary) effects (reduced Secchi depth), and indirect (secondary) effects (reduced depth limit of seagrasses). However, marine ecosystems are more complex than indicated in Figure 2.3 and include many biogeochemical components (parameters, indicators, etc.) sensitive to eutrophication. The model in Figure 2.4 takes into account this complexity and the fact that the eutrophication process is fuelled by excessive nutrient inputs from different sources, as well as by light availability.

Monitoring and assessing the eutrophication status of the Baltic Sea must be based on a common understanding of root causes, inputs, nutrient concentrations, and transport effects in relation to relevant biogeochemical components.

It is well known that the effects of nutrient-driven eutrophication can be far less linear and more complicated in their expression /12, 13/. Understanding functional responses and stability in the extremely heterogeneous Baltic Sea requires much basic research, which is still in an early phase. However, an understanding of thresholds, “points-of-no-return”, and regime shifts is a prerequisite for the development of an informed and adaptive management of eutrophication in the Baltic Sea area.

## 2.3 Coordination with other related international activities

In the Baltic Sea area, HELCOM plays a leading role in the realization of the vision of a healthy Baltic Sea by deciding on internationally agreed protective measures. The European Marine Strategy, which will involve separate action plans for each European sea, provides extra political momentum to coordinated international efforts to solve the problems affecting the Baltic marine environment. The natural balance of the Baltic Sea has been seriously disrupted by excessive nutrient inputs. These inputs originate from diffuse sources such as over-fertilized farmland and air pollution, as well as point sources such as sewage treatment plants and industrial wastewater outlets. The HELCOM EUTRO project is a specific HELCOM initiative with targeted objectives, i.e., the development of tools for thematic assessments of eutrophication in the Baltic Sea. At the same time, the work is closely timed and coordinated with a suite of related activities such as the EU Water Framework Directive, including the European Eutrophication Activity, other directives in the field of eutrophication, the aforementioned European Marine Strategy, and two HELCOM Projects to develop Ecological Quality Objectives and to revise the HELCOM system of monitoring and assessments. These activities are briefly described below.

The most recent European water legislation is the Water Framework Directive (WFD), which provides a framework for the protection of ground water, inland surface waters, transitional waters (e.g., estuaries), and coastal waters /14/. The WFD provides national and local authorities with a legislative basis for the maintenance and recovery of water quality so as to achieve good ecological and chemical status for all surface waters and a good chemical status for groundwater.

The coastal waters covered by the WFD with respect to biological features are generally limited to one nautical mile from the baseline. With respect to chemical features, the limit is 12 nautical miles. Open marine waters are not covered by the WFD. However, the WFD is likely to influence the management of all marine ecosystems, as all land-based inputs of pollutants pass through the coastal zone to the open waters.

The WFD requires EU Member States to monitor and classify the ecological status of all surface waters. The assessment tools shall be based on reference conditions, divided into five classes (high, good, moderate, poor, and bad status), where the border between good and moderate status is the target for measures to improve the ecological status.

The WFD is not the only directive seeking to improve the eutrophication status of European coastal waters. Other important directives are the Nitrates Directive and the Urban Waste Water Treatment Directive /8, 9/.

The objective of the Nitrates Directive is to reduce water pollution caused or induced by nitrates from agricultural sources and to prevent further such pollution. EU Member States shall designate vulnerable zones, which are areas of land draining into waters affected by pollution and which contribute to pollution. Member States shall set up action programmes promoting the application of the codes of good agricultural practices, where necessary. Member States shall also monitor and assess the eutrophication status of freshwaters, estuaries, and coastal waters every four years.

The objective of the Urban Waster Water Treatment Directive (UWWTD) is to protect the environment from the adverse effects of discharges of wastewater. The Directive concerns the collection, treatment, and discharge of urban wastewater, and the treatment of discharges of wastewater from certain industrial sectors. The degree of treatment (i.e., emission standards) of discharges is based on an assessment of the sensitivity of the receiving waters. Member States shall identify areas that are sensitive in terms of eutrophication. Competent authorities shall monitor discharges and waters subject to discharges.

Other directives, e.g., the Habitats Directive /15/ and the Birds Protection Directive /16/, indirectly influence management practices via the "favourable status of conservation" (i.e., objectives for abundance of species or food availability), which can be influenced by nutrient enrichment and eutrophication.

Currently, there is no European legislation dealing with the ecological status of open marine areas, but a European Marine Strategy (EMS), which might over a longer perspective result in a European Marine Framework Directive, is under development. Both the strategy and the future directive are based on an Ecosystem Approach to the Management of Human Activities, a principle also adopted by HELCOM (2003 HELCOM/OSPAR Ministerial Declaration). This implies that management decisions should be based on sound scientific advice, i.e., scientific assessments, and that the development of assessment tools, such as Ecological Quality Objectives (EcoQOs), indicators, and reference conditions, will be founded on our current best knowledge of ecosystem structure, function, and stability. By establishing a system for the classification of open-water areas based on WFD principles, the implementation of a marine strategy will be coherent with the strategy applied for coastal waters.

The Common Implementation Strategy of the WFD and the development of a European Marine Strategy (EMS) have revealed the need for a coordinated effort and streamlining of pan-European eutrophication assessment activities (the European Eutrophication Activity) focusing, for example, on an overall conceptual framework for the assessment of eutrophication, including the harmonization of assessment criteria /17/.

Pursuing the HELCOM Monitoring and Assessment Strategy, HELCOM EUTRO focuses on the Baltic Sea as a whole, including both the coastal waters *sensu* the WFD and the open waters.

The HELCOM Project to develop Ecological Quality Objectives (EcoQOs) for the Baltic Sea is likely to assist the implementation of the European Marine Strategy. The rationale behind the EcoQO project is that the development of ecological quality objectives for the Baltic Sea within HELCOM is part of the process of regional implementation of the Ecosystem Approach – HELCOM Action Plan.

Another HELCOM Project is revising HELCOM monitoring programmes to bring them in line with the Ecosystem Approach, the WFD, and the EMS, as well as with current scientific knowledge providing the basis of data collection for reliable assessment.

The HELCOM Projects, the European Eutrophication Activity, the European Marine Strategy, and the directives directly or indirectly dealing with eutrophication are linked and relatively well coordinated, both in terms of classification and of the assessment of ecological status, monitoring requirements, and management standards. The correspondence suggested between the management standards, which have been discussed widely and now are generally accepted, is outlined in Figure 2.5.

**Figure 2.5**
Suggested correspondences between HELCOM EUTRO, the Water Framework Directive, and other eutrophication activities, modified from /11/. OSPAR COMPP: OSPAR Comprehensive Procedure for the Identification of the Eutrophication Status of the Maritime Area.

| | | | | | |
|---|---|---|---|---|---|
| HELCOM EUTRO | Non-polluted water | | Eutrophic conditions/polluted water | | |
| EU WFD | High | Good | Moderate | Poor | Bad |
| European Marine Strategy | Non-polluted water | | Polluted water | | |
| Nitrates Directive | Non-polluted water | | Polluted water | | |
| UWWTD | Non-sensitive area | | Sensitive area | | |
| HELCOM EcoQO project | Non-polluted area | | Polluted area | | |
| OSPAR COMPP | Non-problem area | | Problem area | | |

# 3 Sites, principles, and metrics

The approach used for the development of tools for assessing eutrophication in the Baltic Sea and adjacent sea areas has been discussed and agreed between the Contracting Parties and the participants at meetings of HELCOM EUTRO, cf. /18, 19, 20/. The approach involved the following steps: (1) selection of sites or basins, (2) data mining in terms of synoptic information on reference conditions and present status, (3) definition of acceptable deviation from reference conditions, and (4) compilation of national reports for HELCOM EUTRO. The reports on which HELCOM EUTRO is based are listed in Box 3.1.

## 3.1 Sites

A total of 42 sites or basins have been reported and are included in HELCOM EUTRO, cf. Table 3.1 and Figure 3.1. The 42 sites or basins cover, in principle, the entire Baltic Sea from north to south and from east to west, and comprise 13 basins and 29 water bodies or larger coastal areas. Consequently, the information on which the tools for assessing eutrophication will be based ranges from almost unaffected waters in the open parts of the Bothnian Bay, to areas in the central, eastern, southern, and western Baltic, which are generally regarded as eutrophication problem areas, cf. /3, 11/.

**Box 3.1**
List of reports for HELCOM EUTRO.
N: national report;
O: other type of report.

| Ref. | Title | N | O |
|---|---|---|---|
| 21 | Aigars, J. & B. Müller-Karulis (2005): Central Gulf of Riga and Transitional Water of the Gulf of Riga Assessment Schedules. 1 pp. | | × |
| 22 | Håkansson, B., M. Hansson & P. Axe (2005): Swedish National Report on Eutrophication of the Bothnian Sea. Internal Report, HELCOM EUTRO Project. 6 pp. | × | |
| 23 | Håkansson, B., P. Axe & M. Hansson (2005): Swedish National Report on Eutrophication of the Western Gotland Basins. Internal Report, HELCOM EUTRO Project. 8 pp. | × | |
| 24 | Håkansson, B., M. Hansson & P. Axe (2005): Swedish National Report on Eutrophication of the Northern Gotland Basins. Internal Report, HELCOM EUTRO Project. 5 pp. | × | |
| 25 | Karup, H.P. & G. Ærtebjerg (2005): Kattegat and the Belt Sea Region. Danish report to HELCOM EUTRO. 9 pp. | × | |
| 26 | Laamanen, M, V. Fleming, P. Kauppila & R. Olsonen (2005): HELCOM EUTRO – The Bothnian Bay Basin report. Finnish Institute of Marine Research & Finnish Environment Institute. 11 pp. | × | |
| 27 | Laamanen, M., V. Fleming, P. Kauppila, H. Pitkänen, S. Bäck, A. Jaanus & R. Olsonen (2005): HELCOM EUTRO – The Gulf of Finland Basin report. Finnish Institute of Marine Research, Finnish Environment Institute & Estonian Marine Institute. 20 pp. | × | |
| 28 | LANU (2005): HELCOM EUTRO. National Report by Germany: Baltic GIG Germany Water Body Open Coast Geltinger Bucht. | × | |
| 29 | Łysiak-Pastuszak, E., A. Osowiecki, M. Filipiak, A. Olszewska, G. Sapota, J. Woroń & W. Krzymiński (2005): Eutrophication assessment in selected areas of the Polish sector of the southern Baltic Sea. Polish national report to HELCOM EUTRO. Institute of Meteorology and Water Management - Maritime Branch, Poland. 28 pp. | × | |
| 30 | Nausch, G. (2005): HELCOM EUTRO. National report by Germany: Arkona Sea, Bornholm Sea, Eastern Gotland Sea. 14 pp. | × | |
| 31 | Martin, G. (2005): Northern Gulf of Riga coastal waters assessment schedule. 1 pp. | | × |
| 32 | Olenina, I., J. Dubra, E. Siupiniene, A. Jasinskaite, I. Vysniauskas, L. Siauliene & A. Kubliute (2005): Assessment of Eutrophication Status in the south-eastern Baltic Sea. Lithuanian national report to HELCOM EUTRO. Centre of Marine Research. 16 pp. | × | |
| 33 | Weber, M. (2005): Baltic GIG Germany Water Body Open Coast Penninsula Zingst. German national report to HELCOM EUTRO. State Agency of Mecklenburg-Western Pomerania for the Environment, Nature Protection and Geology. 6 pp. | × | |

**Table 3.1**
Sites and basins included in HELCOM EUTRO. Blue denotes open waters. BSRP: Baltic Sea Regional Project.

| | Area | Reported by | Reference |
|---|---|---|---|
| 1. | Kattegat – open sea | Denmark | Karup & Ærtebjerg 2005 |
| 2. | Outer Randers Fjord | Denmark | Nielsen et al. 2003 |
| 3. | Inner Randers Fjord | Denmark | Nielsen et al. 2003 |
| 4. | Danish Straits - Aarhus Bay | Denmark | Karup & Ærtebjerg 2005 |
| 5. | Danish Straits – north of Funen | Denmark | Karup & Ærtebjerg 2005 |
| 6. | Odense Fjord – outer parts | Denmark | Karup & Ærtebjerg 2005 |
| 7. | Isefjorden – outer parts | Denmark | Karup & Ærtebjerg 2005 |
| 8. | The Sound – central coastal waters | Denmark | Karup & Ærtebjerg 2005 |
| 9. | Southern Little Belt | Denmark | Karup & Ærtebjerg 2005 |
| 10. | Arkona Basin – Fakse Bay | Denmark | Karup & Ærtebjerg 2005 |
| 11. | Arkona Basin – Hjelm Bay | Denmark | Karup & Ærtebjerg 2005 |
| 12. | Arkona Basin – open sea | Germany | Nausch 2005 |
| 13. | Bornholm Basin – open sea | Germany | Nausch 2005 |
| 14. | Eastern Gotland Basin – open sea | Germany | Nausch 2005 |
| 15. | Zingst Peninsula – open coast | Germany | Weber 2005 |
| 16. | Geltinger Bay – coastal water | Germany | LANU 2005 |
| 17. | South East Gotland Basin – open sea | Poland | Łysiak-Pastuszak et al. 2005 |
| 18. | Gdansk Deep – open sea | Poland | Łysiak-Pastuszak et al. 2005 |
| 19. | Rowy-Jaroslawiec – coastal water | Poland | Łysiak-Pastuszak et al. 2005 |
| 20. | Dziwna-Swina – coastal water | Poland | Łysiak-Pastuszak et al. 2005 |
| 21. | Outer Puck Bay – transitional water | Poland | Łysiak-Pastuszak et al. 2005 |
| 22. | Lithuanian open waters | Lithuania | Olenina et al. 2005 |
| 23. | Lithuanian coastal waters | Lithuania | Olenina et al. 2005 |
| 24. | Lithuanian transitional waters | Lithuania | Olenina et al. 2005 |
| 25. | Gulf of Riga – open water | BSRP | Aigars & Müller-Karulis 2005 |
| 26. | Gulf of Riga – transitional waters | BSRP | Aigars & Müller-Karulis 2005 |
| 27. | Gulf of Riga – northern coastal waters | BSRP | Martin 2005 |
| 28. | Western Gotland Basin – open sea | Sweden | Håkansson et al. 2005a |
| 29. | Western Gotland Basin – Askö | Sweden | Håkansson et al. 2005a |
| 30. | Northern Gotland Basin – open sea | Sweden | Håkansson et al. 2005b |
| 31. | Gulf of Finland – open sea | Finland | Laamanen et al. 2005a |
| 32. | Gulf of Finland – coastal type A | Finland | Laamanen et al. 2005a |
| 33. | Gulf of Finland – coastal type B | Finland | Laamanen et al. 2005a |
| 34. | Gulf of Finland – coastal type C | Finland | Laamanen et al. 2005a |
| 35. | Gulf of Finland – coastal type E | Finland | Laamanen et al. 2005a |
| 36. | Gulf of Finland – Tallinn Bay | Estonia | Laamanen et al. 2005a |
| 37. | Gulf of Finland – Narva Bay | Estonia | Laamanen et al. 2005a |
| 38. | Bothnian Sea – open sea | Sweden | Håkansson et al. 2005c |
| 39. | Bothnian Sea – Örefjärden | Sweden | Håkansson et al. 2005c |
| 40. | Bothnian Bay – open sea | Finland | Laamanen et al. 2005b |
| 41. | Bothnian Bay – coastal type J | Finland | Laamanen et al. 2005b |
| 42. | Bothnian Bay – coastal type K | Finland | Laamanen et al. 2005b |

The wide geographical coverage is sufficient for developing tools for the assessment of eutrophication in various parts of the Baltic Sea. The HELCOM EUTRO Pilot Project does not resemble the planned HELCOM thematic eutrophication assessment, as this is expected to include information on root causes, sectoral policies, inputs, and an evaluation of the effectiveness of implemented measures.

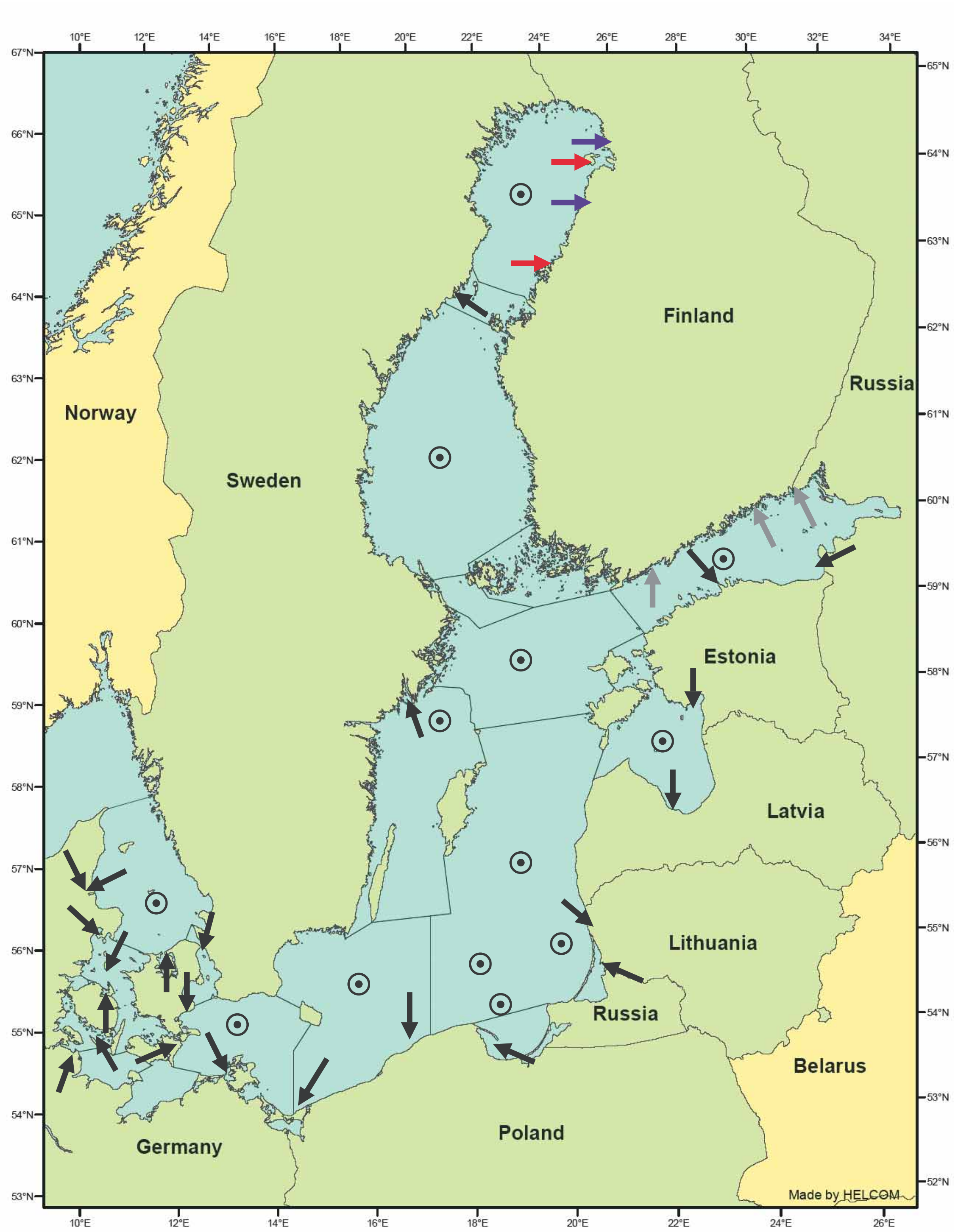


**Figure 3.1**
Location of sites and basins listed in Table 3.1. Circles show basins; arrows show coastal water bodies. In the Bothnian Bay, blue arrows are coastal type K, red arrows are coastal type J. The arrows in the Finnish coastal waters of the Gulf of Finland represent coastal water types A, B, C, and E; see Finnish national reports for details.

## 3.2 Assessment principles

As previously mentioned, the approach used for assessing the eutrophication status of a given area was pragmatic. The classification of eutrophication status can be summarized in five equations:

1. EutroQO = RefCon ± AcDev,
   where
   EutroQO is "eutrophication quality objective",
   RefCon is "reference condition", and
   AcDev is "acceptable deviation".

**Table 3.2**
HELCOM EUTRO assessment criteria, modified from /34/. Target value = RefCon ± AcDec.

| | Assessment criteria |
|---|---|
| **Cat. I:** | |
| **Causative factors** | **1. Land-based inputs (TN, TP) by basin**<br>Elevated inputs (total amount plus concentrations in rivers) and/or increased trends (compared with previous years). |
| | **2. N-deposition (TN) by basin**<br>Elevated deposition (total amount and concentrations) and/or increased trend (compared with previous years). |
| | **3. Winter DIN and DIP**<br>Elevated concentrations compared to target conditions (defined as an acceptable deviation from region/basin/type/site-specific reference conditions), including definition of winter period. |
| | **4. Winter N:P(:Si) ratio**<br>Deviation from region/basin/type/site-specific reference conditions, including definition of winter period. |
| | **Other relevant category I indicators**<br>Deviations compared to target conditions (defined as an acceptable deviation from region/basin/type/site-specific reference conditions). |
| **Cat. II:** | |
| **Direct effects** | **5. Chlorophyll-*a***<br>Maximum and mean chlorophyll-*a* concentration.<br>Elevated levels compared to target conditions (defined as an acceptable deviation from region/basin/type/site-specific reference conditions). |
| | **6. Indicator species**<br>Region/area-specific phytoplankton indicator species.<br>Elevated levels (and increased duration) compared to target conditions (defined as an acceptable deviation from region/basin/type/site-specific reference conditions). |
| | **7. Harmful algal blooms**<br>Elevated frequency compared to target conditions (defined as an acceptable deviation from region/basin/type/site-specific reference conditions). |
| | **8. Secchi depth**<br>Decreased levels compared to target conditions (defined as an acceptable deviation from region/basin/type/site-specific reference conditions). |
| | **9. Submerged aquatic vegetation/macroalgae**<br>Deviations compared to target conditions (defined as an acceptable deviation from region/basin/type/site-specific reference conditions). |
| | **Other relevant category II indicators**<br>Deviations compared to target conditions (defined as an acceptable deviation from region/basin/type/site-specific reference conditions). |
| **Cat. III:** | |
| **Indirect effects** | **10. Algal mats and foam**<br>Presence of drifting algal mats and/or foam on beaches. |
| | **11. Zooplankton**<br>Changes in dominance of taxonomic groups. |
| | **12. Biomass of benthic invertebrates**<br>Elevated levels compared to target conditions (defined as an acceptable deviation from region/basin/type/site-specific reference conditions). |
| | **13. Hypoxia and anoxia**<br>Low concentrations (2-4 mg/l and below 2 mg/l). Changes in geographical coverage. |
| | **14. Kills in benthic invertebrates and fish**<br>Kills in relation to low oxygen concentrations or toxic algae. |
| | **Other relevant category III indicators**<br>Deviations compared to target conditions (defined as an acceptable deviation from region/basin/type/site-specific reference conditions). |

| | Category I | Category II | Category III | Final classification |
|---|---|---|---|---|
| A | + | + | + | + |
| | + | + | – | + |
| | + | – | + | + |
| B | – | + | + | + |
| | – | + | – | + |
| | – | – | + | + |
| C | – | – | – | – |

**Table 3.3**
Combination matrix illustrating the integration of categorized assessment criteria. In the final classification, + denotes “eutrophication problem area” and – denotes “eutrophication non-problem area”. From /34/. Please see /35/ for detailed explanations.

For indicators that have a positive response to nutrient inputs:

2. If ES < RefCon + AcDev, then EutroQO is fulfilled,
   where ES is “eutrophication status”.
3. If ES > RefCon + AcDev, then EutroQO is exceeded.

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

For indicators that have a negative response to nutrient inputs:

4. If ES > RefCon – AcDev, then EutroQO is fulfilled (non-problem area).
5. If ES < RefCon – AcDev, then EutroQO is exceeded (problem area).

The classification has been developed for three categories of assessment criteria:
Category I - degree of nutrient enrichment (causative factors),
Category II - direct effects, and
Category III - indirect effects.

Within each of the categories, a set of indicators (sometimes referred to as parameters) has been suggested. This set is to some extent based on experience in other fora (European Eutrophication Activity and OSPAR), and is also supplemented with some Baltic Sea-specific indicators (see Table 3.2).

For the Baltic Sea, the basic indicators in relation to causative factors (category I) are: (1) land-based inputs (TN, TP), (2) atmospheric deposition (TN), (3) winter concentrations of nutrients (DIN, DIP), and (4) N:P ratio. An option to allow the inclusion of other indicators was established in order to use indicators related to these, or to include other relevant proxies.

The indicators included in relation to direct effects (category II) are: (1) chlorophyll-*a*, (2) phytoplankton indicator species, (3) harmful algal blooms, (4) Secchi depth, and (5) submerged aquatic vegetation. An option to include other relevant indicators was also provided.

The indicators in relation to indirect effects (category III) are: (1) algal mats and foam, (2) zooplankton, (3) biomass of benthic invertebrates, (5) hypoxia and anoxia, and (5) kills of benthic invertebrates and fish. The total number of “basic” indicators is thus fourteen, cf. Table 3.2.

The overall classification has been developed according to a “one out, all out” principle, meaning that if one of the indicators used within one of the categories I to III is outside an acceptable deviation from reference conditions, then the category is considered to be “out”, leading to the conclusion that the area in question is a “eutrophication problem area”. Table 3.3 illustrates how the additive category-by-category assessment was integrated. The combination titled “C” shows the only way to reach a classification as a “non-problem area”.

A prerequisite for the inclusion and use of an indicator is that information on reference conditions and recent sufficient monitoring data are available. In many areas of the Baltic Sea, the assessment of eutrophication status is restricted by the availability of either (1) information on reference conditions or (2) monitoring data describing the recent status. Consequently, HELCOM EUTRO has focused on sites and areas where data have been easily available. The objective of HELCOM EUTRO has been restricted to the development and testing of eutrophication

**Table 3.4** Normative definition of high status (WFD Annex V) /14/.

| Element | High status |
|---|---|
| *Biological Quality Elements* | |
| Phytoplankton | • The composition and abundance of the phytoplanktonic taxa are consistent with undisturbed conditions.<br>• The average phytoplankton biomass is consistent with the type-specific physico-chemical conditions and is not such as to significantly alter the type-specific transparency conditions.<br>• Planktonic blooms occur at a frequency and intensity which is consistent with the type-specific physico-chemical conditions. |
| Macroalgae and angiosperms | • All disturbance-sensitive macroalgal and angiosperm taxa associated with undisturbed conditions are present.<br>• The levels of macroalgal cover and angiosperm abundance are consistent with undisturbed conditions. |
| Benthic invertebrates | • The level of diversity and abundance of invertebrate taxa is within the range normally associated with undisturbed conditions.<br>• All the disturbance-sensitive taxa associated with undisturbed conditions are present. |
| *Physio-chemical Quality Elements* | |
| General conditions | • Temperature, oxygen, and transparency do not reach levels outside the ranges established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.<br>• Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements. |

assessment tools. Considering that the deadlines for the compilation of various national reports were short, the information from the 42 areas in question has been judged as being satisfactory for the purpose (e.g., to develop a tool). In this context, it is very important to note that the reference conditions are the starting point or anchor of the classification. The definition of an acceptable deviation from reference conditions is the yardstick for assessment, and this is discussed in the following Sections 3.3 and 3.4.

## 3.3 Reference conditions

Reference conditions are the starting point for any assessment. Consequently, their definition is an important step for the assessment of the eutrophication status of a given water body or basin. According to the WFD, the reference condition for a given indicator is a description of the chemical and biological quality elements that exist, or would exist, at high status according to the EU Water Framework Directive, that is, with no or only very minor disturbance from human activities.

Reference conditions must be described according to the definitions of quality elements at high status in WFD Annex V Table 1.2.3 and Table 1.2.4, cf. Table 3.4.

Reference conditions may be "*either spatially based or based on modelling, or may be derived using a combination of these methods. Where it is not possible to use these methods, Member States may use expert judgement to establish such conditions*". Consequently, reference conditions may be defined by a hierarchal approach using the various methods: (1) reference sites, (2) historical data, (3) modelling, and (4) expert judgement.

In general, using reference sites is not applicable for the Baltic Sea or its coastal and transitional waters, as for many years they have been influenced by fishing (top-down control), inputs (e.g., nutrients and contaminants), and physical modification, etc. /36/.

Throughout the Baltic Sea area, there are many good historical data sets which could be used, e.g., /10, 37, 38/. These data sets are site-specific by nature, and thus useful for HELCOM EUTRO if the historical data are of assured quality. As a precautionary note, it must be emphasized that if reference conditions are derived from historical conditions, these should be based upon the condition of water bodies at times of no, or only very minor, anthropogenic influence, especially with respect to eutrophication.

There are several numerical models specific to the Baltic Sea which have been validated and could be used to define reference conditions /39, 40/. HELCOM EUTRO has included reference conditions based on modelling, to the extent possible. The modelling methods have been considered both to provide a sufficient level of confidence about the values for the reference conditions, and to ensure that the conditions so derived are consistent and valid for each basin and water body concerned.

All methods for establishing reference conditions will to a certain extent require expert judgement: (1) the possible use of reference sites will require expert judgement in deciding which sites are pristine (equivalent to high ecological status) or representative for other areas, (2) the use of historical data will require expert judgement in deciding which data are appropriate, and (3) modelling results can only be developed by using data plus expert judgement. When information from reference sites, historical data, and modelling (methods 1–3) are missing, experts can be involved in the estimation of values representing reference conditions.

The reference conditions used by HELCOM EUTRO involve all four methods and combinations of them, cf. Annex B. At this stage, the reference values used should be considered tentative; this does not imply that the values are false or useless. The values simply represent the best practice, given the tight deadlines and existing sources of easily available information.

As indicated above, the Contracting Parties involved have used various methods for establishing information and/or values representing reference conditions. In the following, brief descriptions of the methods applied have been summarized and presented together with information on specific references.

***Denmark***: Reference conditions have been established using a suite of methods, including historical data, various types of modelling, expert judgement, as well as combinations of methods.

- Historical data have been used to establish reference values for primary production, eelgrass depth limit, and zoobenthos /37, 41, 42/.
- Numerical modelling has been used for basins and most of the open coastal waters /38, 39, 43/ in order to establish reference values for a suite of indicators.
- For some areas, recent monitoring data were used to establish Secchi depth–chlorophyll-*a* relationships. In addition to chlorophyll-*a*, suspended particles and dissolved organic matter (DOM) will affect Secchi depth. Therefore, relationships between Secchi depth and chlorophyll-*a* showed a very large scatter, with a range of chlorophyll-*a* values corresponding to each Secchi depth, in particular at the numerically low Secchi depths. To compensate for the lack of complementary data on factors other than chlorophyll-*a* influencing Secchi depth, relationships were established using boundary functions describing the upper bounds of the distributions /44, 45/. The rationale behind this approach was that the higher the chlorophyll-*a* values at individual Secchi depths, the higher the contribution from chlorophyll-*a* to the total light attenuation and thereby its influence on Secchi depth. Furthermore, analyses were performed only on summer samples (May–September) to reduce the likelihood of strong wind events potentially leading to heavy resuspension of sediment. During this period, the growth of phytoplankton is predicted to be limited by the availability of nutrients rather than light, and chlorophyll-*a* is expected to be a major contributor to light attenuation in the water column. Data were grouped into classes representing 1-m Secchi depth intervals. For each interval, the maximum and 90th percentile of the concurrent chlorophyll-*a* measurements were calculated. Subsequently, correlations between Secchi depth and chlorophyll-*a* were established from regression analyses assuming exponential relationships. Historical Secchi depth measurements dating back to the early 1900s, or for the area west of Bornholm to the 1950s, were obtained from the ICES database. Data originated from a Secchi depth data mining study /46/. Estimates of "historical" chlorophyll-*a* values were calculated by applying the Secchi depth–chlorophyll-*a* correlations from the different sites to an average of historical Secchi depth measurements in the vicinity of the sites.

***Estonia***: For the coastal waters of the northern Gulf of Riga, reference conditions have been established using the following methods:

- Winter surface concentrations of TN are developed using backward regression of existing monitoring data sets and nutrient loading data.

- Winter surface concentrations of TP and summer chlorophyll-*a* concentrations are based on numerical modelling /40/.
- Secchi depth is based on a combination of existing data and expert judgement.
- *Fucus* depth distribution as well as vegetation maximum depth limits are based on a combination of historical data, regression models, and expert judgement. A scientific paper is currently in preparation covering an overview of the three different techniques.

***Finland***: Reference conditions have been established in open and coastal Finnish waters in the following ways:

- The tentative reference conditions for the open Gulf of Finland and the open Bothnian Bay were derived either by using historical data alone for summer (June to September) Secchi depths (data from 1905 to 2004) and *Aphanizomenon flos-aquae* abundance (data from [1887] 1968 to 2004), or by using a combination of historical data and expert judgement. The earliest reliable observations and long-term trends were examined for winter (December to February) concentrations of the sum of nitrite and nitrate nitrogen and phosphate phosphorus, as well as for summer (June to September) chlorophyll-*a* concentrations. It was concluded that the reference condition concentrations must be lower than the first reliable concentrations, which were from the 1960s and 1970s. The trends from the early observations were extrapolated to the period before the 1950s, which was considered an appropriate period for reference conditions. The results of the extrapolation were compared to and adjusted with those derived by model simulations /40/. The derived tentative reference conditions will be further examined and validated using empirical modelling.
- In the coastal Gulf of Finland and the coastal Bothnian Bay, the tentative reference conditions for each coastal type were derived both empirically by analyses of the relationship between Secchi depth and chlorophyll-*a*, and from the statistical frequency distribution data by using 10% deviation from the lowest value as the boundary between high and good status. The data originated mainly from the national monitoring programme of the Finnish Environment Administration between 1962 and 2004. The old Secchi depth data in the northern Baltic Sea originated from the Nautilus cruises of the Institute of Marine Research between 1910 and 1930. Empirical methods could only be used for the outer coastal types, as there were no old Secchi depth data available for the inner coastal types. Therefore, the reference values for chlorophyll-*a*, estimated from the frequency distribution data, were proportioned with the values estimated by the empirical method. Reference conditions were established for the summertime (July to August) chlorophyll-*a* and Secchi depth and the wintertime (January to March) concentrations of phosphate-P and the sum of the concentrations of nitrate-N and nitrite-N. The estimated reference values were compared to the model simulations, see /40/.

***Germany***: The reference conditions applied to coastal sites have been taken from R&D projects /47, 48, 49, 50/. The objective of these research projects was the implementation of the WFD in the coastal waters of the German Baltic Sea. A project concerning macrophytes is anticipated to be completed by the end of 2005. A basis for the definition of type-specific reference conditions and of classification systems for biological quality elements has been proposed. The deduction of these reference conditions is described in these R&D reports.

In the open-sea areas, historical data were used for nutrient concentrations and Secchi depth. Modelling and expert judgment were also applied.

***Latvia***: The following approach was used, where possible, to establish reference conditions in the coastal and transitional waters of the Gulf of Riga:

- Historical published and unpublished sources were searched. For winter nitrate ($NO_3^-$) and phosphate ($PO_4^{3-}$), two historical publications were found, as well as one on water transparency:
  - The plume region of the river Daugava (transitional waters) has been investigated. Observations were made from 1951 to 1959 /51/. In total, 82 samples were analysed.
  - Hydrochemical investigations in the Gulf of Riga were conducted from 1957 to 1962 /52/. In this period, 2200 samples were analysed. However, of 41 stations visited, only nine corresponded geographically to the central part of the Gulf of Riga, and six to transitional waters.

- A hydrological study was conducted in the Gulf of Riga from 1949 to 1960, in which water transparency measurements were included /53/. Observations were conducted from April to October on a monthly basis. The number of observations varied between stations and months. As for the previously described investigations, nine sampling stations corresponded to the central area and six to transitional waters.

- Results obtained were compared with model results and, in general, they agree fairly well.
- Further tentative reference values were tested against long-term data series. For nitrate and phosphate, monitoring data are available since 1973, though with large gaps. Long-term observational data for water transparency are available since 1963.
- For summer chlorophyll-*a*, no historical values exist. Modelled values from /38/ are expressed as an annual mean. Therefore, reference values were obtained from the correlation of chlorophyll-*a* with water transparency (Secchi depth). Thereafter, the values obtained were tested against those of /40/.

***Lithuania***: Information on how reference conditions have been established by Lithuania can to some extent be found in the national report /33/.

***Poland***: Reference conditions for hydrochemical parameters, i.e., nutrients, Secchi depth, and oxygen concentrations, in the open-sea areas (Gdańsk Deep and southeastern Gotland Basin) have been determined based on scarce historical data (dissolved phosphate, Secchi depth, and oxygen) from the years 1938–1960 /54, 55, 56, 57, 58/ and by the extrapolation of linear temporal trends /59/, mainly for the data prior to 1985, which were collected in the oceanographic database of the Institute of Meteorology and Water Management in Gdynia between 1959 and 2004. The earliest data from regular monitoring activities within the Polish sector of the southern Baltic Sea related to the HELCOM BMP, and succeeded by the HELCOM COMBINE programme, are from 1979. Prior to that time, data were collected on random occasions within various scientific oceanographic projects. Reference conditions for chlorophyll-*a* concentrations were determined solely by expert judgment. Reference conditions for macrozoobenthos were determined from historical data /60, 61, 62/.

***Sweden***: Reference conditions have been established using a suite of methods:

- Results from a nutrient model (TRK-transport, retention, and source apportionment) and calculations were used to estimate the background load of N and P to the sea /63/.
- Reference conditions for winter DIN and DIP were found from historical data records sampled at various hydrographic sampling stations.
- Reference conditions for winter N:P:Si ratios (the Redfield ratio) were used, generally believed to be the optimal N:P ratio for phytoplankton.
- Reference conditions for Secchi depth were calculated from historical time series /64/.
- Chlorophyll-*a* reference conditions were found from the correlation between Secchi depth, chlorophyll-*a*, and the historical data record of the former parameter.
- Reference condition values for primary production (PP) were calculated from results obtained by /65/ based on the saturation of oxygen in the surface layer, taking into account that net PP and total gross annual PP are linked by the f-ratio (about 0.3 in the Baltic). The reference condition values were obtained by extrapolation of the long-term annual mean PP covering the period 1957–1987 backward over time.
- Reference condition and assessment metrics for benthic invertebrates are based on a biodiversity index, which is still preliminary. The method is described in /66/. Presently the methods, metrics, and reference values are under revision in Sweden.

## 3.4 Acceptable deviation and assessment metrics

What is an acceptable deviation from reference conditions? This question has to be answered in order to establish metrics for the assessment of eutrophication or ecological status. But before trying to answer it, experiences from other fora are presented and discussed.

In 2002/2003, the first application of the OSPAR Common Procedure (the tool on which HELCOM EUTRO is based) was made by the OSPAR Contracting Parties. The acceptable deviation was expressed as a percentage deviation from background values (equivalent to reference conditions), and was set at 50% in order to reflect low disturbances and natural variability. However,

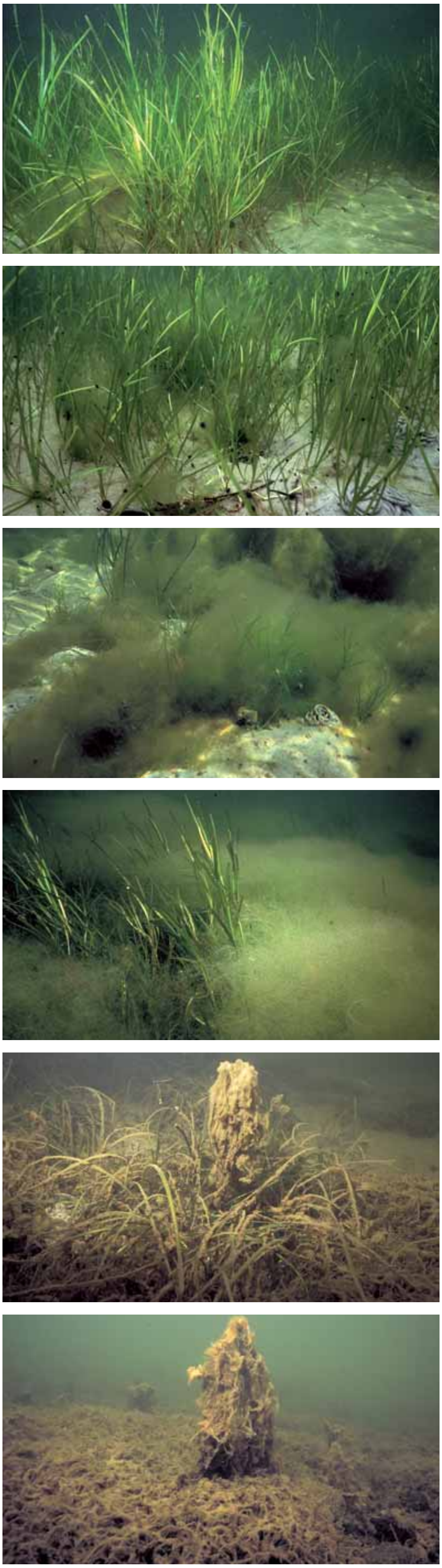

**Figure 3.2**
Changes in eelgrass depth limit and epiphyte biomass with increasing eutrophication status. Pictures by Nanna Rask, Funen County.

lower values could be used, if justified. The 50% deviation was the most commonly used metric in the first application round. Only Denmark opted for lower values, e.g., 25%, cf. /11/. The reasoning allowing Denmark to use 25% was justified by analyses of the depth distribution of submerged aquatic vegetation /11, 37/.

Today, more than four years after the development of the Common Procedure and more than two years after the first application, there is a growing acceptance of lower percentages, also taking into account possible gradients, for example, in nutrient concentrations and/or direct/indirect effects from the coast to the open waters. This might result in a range of percentages being used, starting with 50% in estuaries and transitional waters, and ending with 10% or 15% in offshore areas. In June 2005, discussions within OSPAR resulted in an important change in the way that acceptable deviations were defined. From that time on, the acceptable deviation will have to be justified, with 50% as an upper limit /37/. In addition, the implementation of the EU WFD has led to a mutual understanding of what constitutes an acceptable deviation in relation to the normative definitions in WFD Annex V. The management objectives in the Directive are to achieve at least good ecological status, and to maintain existing high and good status. The border between good and moderate ecological status is the line at which measures have to be taken in order to improve any lower ecological status to good status:

- Good Ecological Status – the values of the biological quality elements show low levels of distortion resulting from human activity.
- Moderate Ecological Status – the values of the biological quality elements deviate moderately from those normally associated with the coastal water body type under undisturbed conditions.

An acceptable deviation is considered to be synonymous with the border between good and moderate ecological status. The task is to transform the normative definitions included in Annex V of the WFD into operational values. In other words, to translate the difference between low and moderate distortion/deviation into values or percentages based on reference conditions (high status). At the first meeting of HELCOM EUTRO, it was agreed that the Contracting Parties should justify the acceptable deviations (expressed as percentages) from reference conditions, with 50%

as a maximum /18/. At the second meeting of HELCOM EUTRO, the experiences gained from the application of the draft guidance, especially the use of 50%, were discussed, and it was recognized that some indicators could not deviate more than 100% from reference conditions, e.g., Secchi depth and the depth limit of submerged aquatic vegetation. For such indicators, where the reference condition is the maximum value, it was agreed that the acceptable deviation from reference conditions should be 25% as a starting point, and if higher deviations are used for these indicators, a satisfactory site-specific justification should be given /19/.

The notion of "acceptable deviation" might have only little meaning. The effects in relation to anthropogenic pressure(s) are often easily understood (see Figure 3.2), but are rarely illustrated.

It is important to visualize the effects, in particular the structural and functional changes that take place when marine ecosystems are subject to pressures which result in unacceptable changes. An illustrative example from shallow coastal waters is given in Figure 3.2. The pictures should be viewed starting from the top (which represents a balanced ecosystem deemed most likely to be within an acceptable deviation) to the bottom (which represents an ecosystem where the deviation from reference conditions is unacceptable). Other examples are presented in Figures 3.3, 3.4, 3.5 and 3.6.

Within HELCOM EUTRO, 50% has been used as an acceptable deviation from reference conditions. There are some exceptions, e.g., for Secchi depth and the depth distribution of submerged aquatic vegetation. For Secchi depth, the acceptable deviation was set at 25% of the reference conditions. The main reason for selecting an acceptable deviation lower than 50% is that the relationship between Secchi depth and chlorophyll-*a* concentrations is not linear. When moving from high Secchi depth transparencies to lower Secchi depths, the corresponding change in chlorophyll-*a* concentrations is faster at the lower end of Secchi depths. Therefore, it is reasonable to consider that the change in Secchi depths should not exceed a 25% decrease from reference conditions. However, in the central and transitional waters of the Gulf of Riga, the water transparency measurements by Secchi disk exhibit large variability both within seasons and between years. The largest variability between measurements, which

**Figure 3.3**
Changes in *Fucus* density and epiphyte biomass with increasing eutrophication status. Pictures by Georg Martin, University of Tartu.

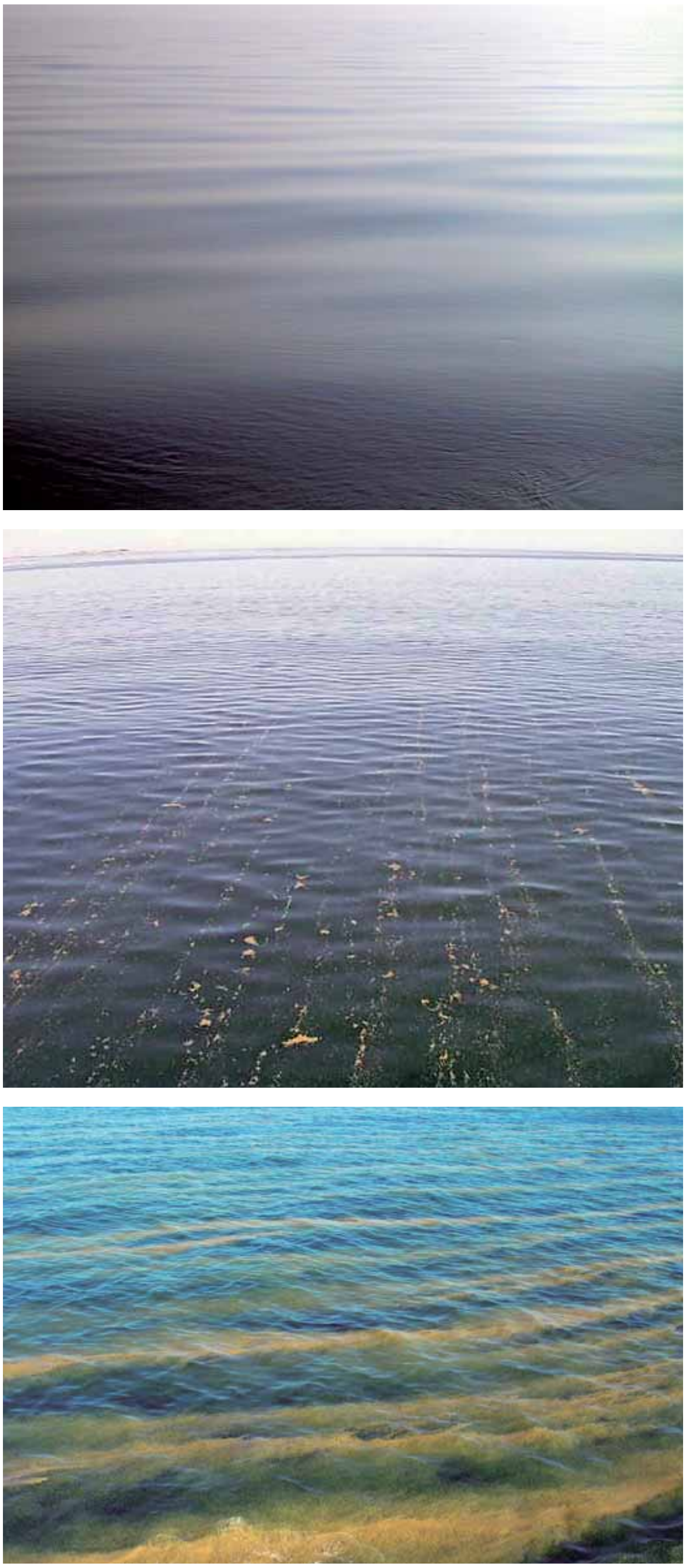

**Figure 3.4**
Phytoplankton production and phytoplankton biomass are direct effects of nutrient enrichment and useful indicators of eutrophication effects. The pictures show a variety of intensities of blue-green algae blooms. Pictures provided by Maria Laamanen, FIMR.

may be up to four metres, can be observed within seasons, while the variability of seasonal means between years is significantly lower, reaching 1.5 m. The variability of water transparency observed in transitional waters was larger than that in the central parts due to the more pronounced influence of river discharge. In order to take the observed variability into account, it is proposed to use a 34% and 40% deviation from reference conditions for the central and transitional waters of the Gulf of Riga, respectively.

Denmark has applied 25% as a general acceptable deviation from reference conditions and based the justification on a suite of scientific publications and reports /37, 42/.

The Danish justification is based on the sensitivity of eelgrass (*Zostera marina*), macroalgae, and chlorophyll-*a* to nutrient enrichment, and further analyses may lead to the conclusion that even a deviation of 25% leads to structural changes in the functioning of ecosystems.

There is no exact scientific definition of hypoxia (oxygen depletion). The assessment values for oxygen ($O_2$) have been 2–4 mg $l^{-1}$ and < 2 mg $l^{-1}$, which are arbitrary values. These values have been in use since the mid-1980s and have proved to work well. This may to some extent be explained by the fact that many soft-bottom invertebrates have an immediate response to values below 2–3 mg $l^{-1}$. The values for oxygen are now assumed to be consistent also with the WFD, which for oxygen stipulates that the values shall "*not reach levels outside the ranges established so as to ensure the functioning of the ecosystem and the achievement of the values specified*" … "*for the biological quality elements including fish*".

For nutrients, 50% has been applied by all countries except Denmark. For practical reasons, this level is supposed to be consistent with the WFD, which stipulates that concentrations should "*not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified*" … "*for the biological elements*". The Danish justification is based on /11, 67/, the latter indicating that the acceptable deviation could be as low as 15% in shallow sensitive estuaries.

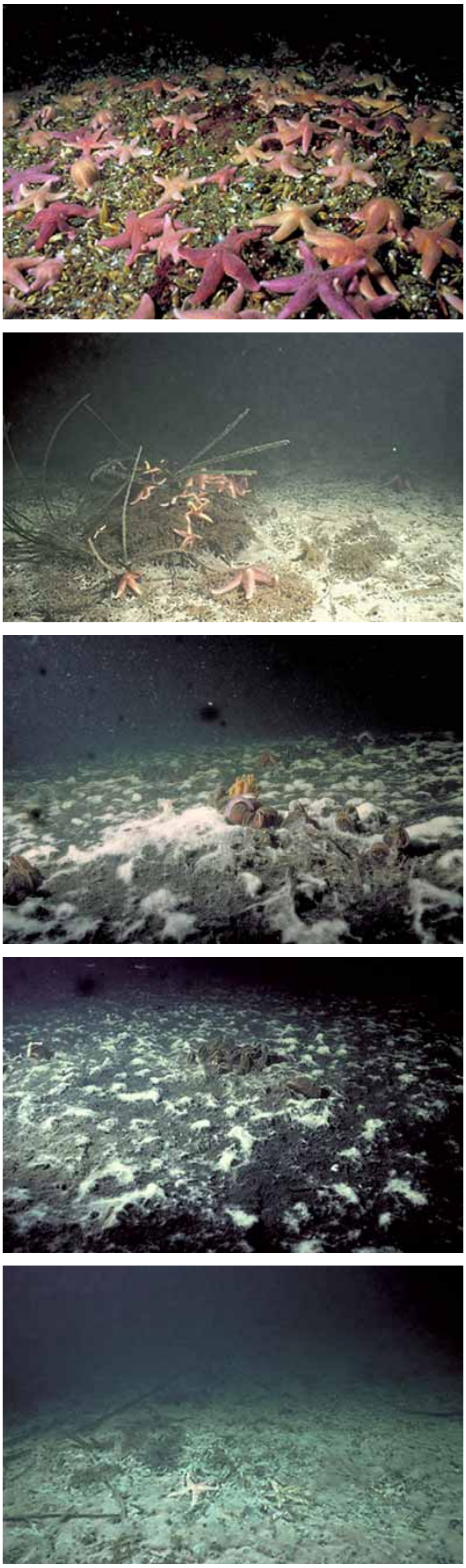

**Figure 3.5**
Changes in soft-bottom benthic communities with decreasing oxygen concentrations. Pictures by Nanna Rask, Funen County.

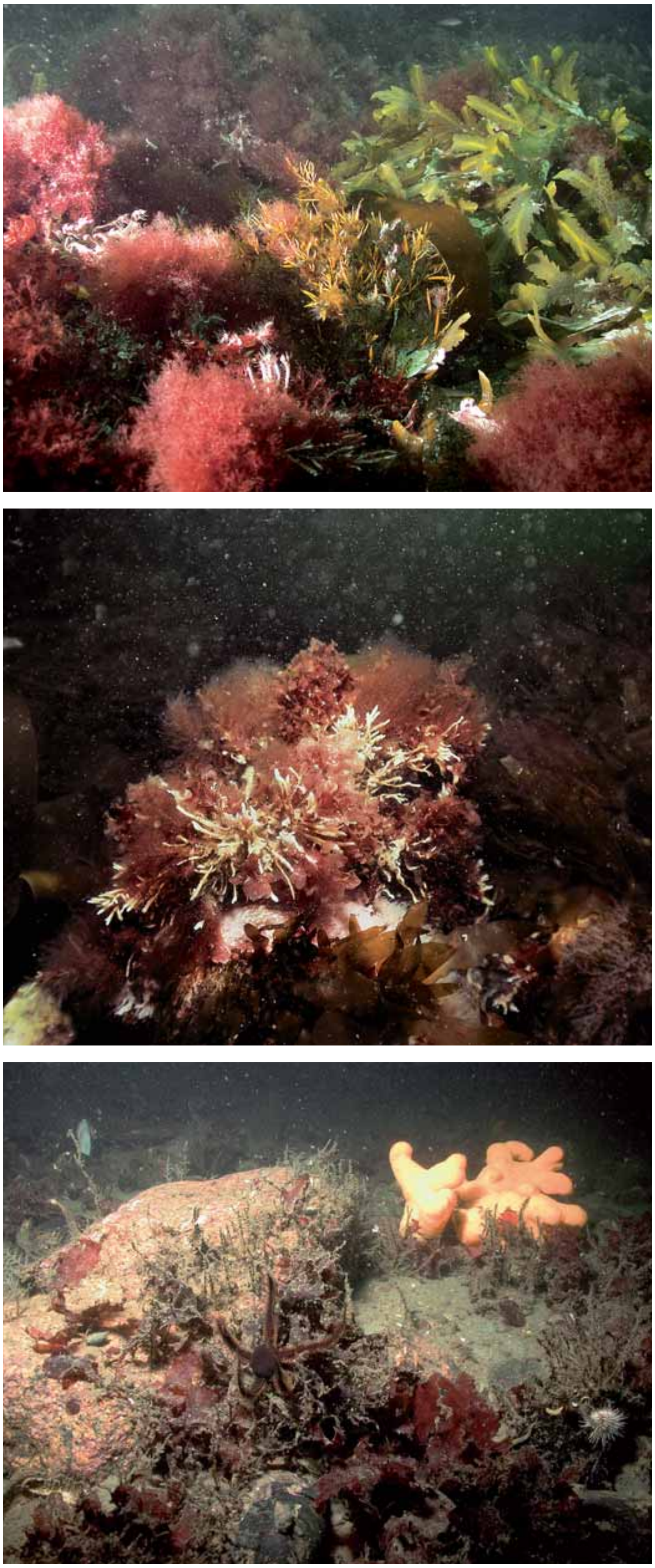

**Figure 3.6**
Changes in long-lived macroalgae density and composition. The pictures are from 7, 11, and 18 metres depth. The influence of depth is identical, to a large extent, with the influence of eutrophication. At shallow depths or without eutrophication, the vegetation should be dense and multi-layered and include several species of large brown and red algae. With increasing depth or eutrophication, the vegetation becomes scattered. Pictures by Karsten Dahl, NERI.

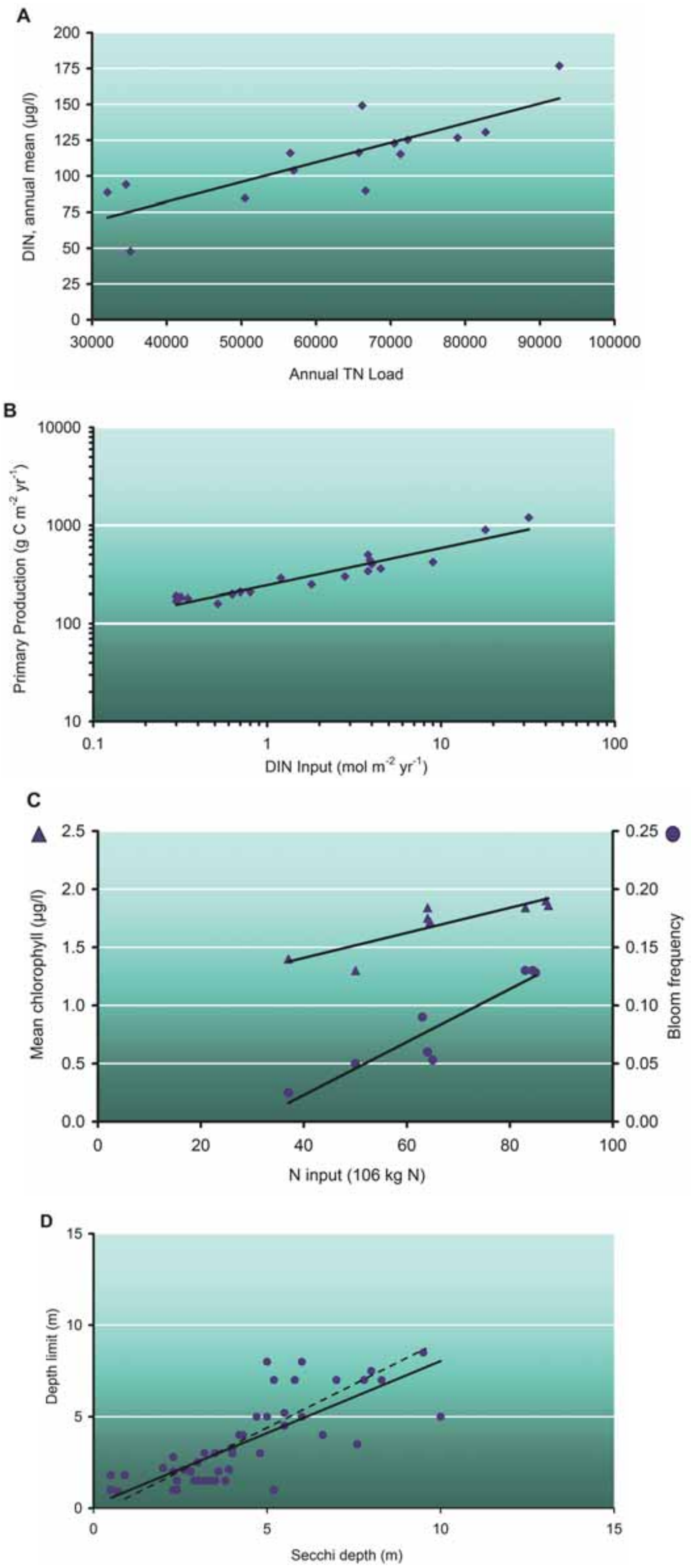


**Figure 3.7**
Examples of positive response curves. A: TN inputs to coastal waters (tonnes $yr^{-1}$) vs. annual mean DIN concentrations (µg $l^{-1}$); B: specific DIN loading (mol $m^{-2}$ $yr^{-1}$); C: N inputs ($10^6$ kg N) vs. mean chlorophyll-a concentration (ug $l^{-1}$) and bloom frequency; and D: Secchi depth (m) vs. depth limit of Zostera marina (For Zostera sp. depth limit, please see Figure 3.2). A is based on /11/, B on /68/, C on /69/, and D on /70/.

## 3.5 Dose-response relationships

The linkage of inputs with effects is visualized in order to achieve a better understanding of what constitutes an acceptable deviation. The next step is to link effects to concentrations and/or inputs and to establish dose-response curves, sometimes referred to as functional relationships. Examples of dose-response relationships are illustrated in Figure 3.7A–D.

Regarding the causative factors, it should be noted that an increase in a nutrient that is limiting for primary production will have a more positive effect on primary production than an increase in any other nutrient.

Not all indicators have a uni-directional or unambiguous response to a change in pressure. For example, the biomass of benthic animals can respond positively to increased loading until a threshold is reached where the loading results in hypoxia (oxygen depletion), which affects the animals detrimentally.

However, the indicators for which response curves are sketched (Figure 3.7) are all likely to respond to reduced nutrient inputs. The result will be improved ecological status through direct or delayed responses, or alternatively through threshold mechanisms /12, 13/.

# 4 Results and discussion

Based on the information available and the agreed assessment principles, it can be concluded that: (1) 13 out of 13 open-sea basins are classified as "eutrophication problem areas", and (2) 29 out of 29 coastal water bodies or larger coastal areas are classified as "eutrophication problem areas", cf. Table 4.1.

**Table 4.1**
Summary of classification (by categories and final). Blue denotes open waters.
(n.i. = no information)

| | Area | Cat I. | Cat II. | Cat III. | Final |
|---|---|---|---|---|---|
| 1. | Kattegat – open sea | + | + | + | + |
| 2. | Outer Randers Fjord | + | + | + | + |
| 3. | Inner Randers Fjord | + | + | + | + |
| 4. | Danish Straits – Aarhus Bay | + | + | n.i. | + |
| 5. | Danish Straits – north of Funen | + | + | + | + |
| 6. | Odense Fjord – outer parts | + | + | + | + |
| 7. | Isefjorden – outer parts | n.i. | n.i. | + | + |
| 8. | The Sound – central coastal waters | + | + | + | + |
| 9. | Southern Little Belt | + | + | + | + |
| 10. | Arkona Basin – Fakse Bay | + | + | n.i. | + |
| 11. | Arkona Basin – Hjelm Bay | n.i. | + | n.i. | + |
| 12. | Arkona Basin – open sea | + | + | n.i. | + |
| 13. | Bornholm Basin – open sea | + | + | n.i. | + |
| 14. | Eastern Gotland Basin – open sea | + | + | n.i. | + |
| 15. | Zingst Peninsula – open coast | + | + | n.i. | + |
| 16. | Geltinger Bay – coastal water | + | + | n.i. | + |
| 17. | South East Gotland Basin – open sea | + | + | + | + |
| 18. | Gdansk Deep – open sea | + | + | + | + |
| 19. | Rowy-Jaroslawiec – coastal water | + | + | + | + |
| 20. | Dziwna-Swina – coastal water | + | + | – | + |
| 21. | Outer Puck Bay – transitional water | + | + | + | + |
| 22. | Lithuanian open waters | – | + | + | + |
| 23. | Lithuanian coastal waters | + | + | n.i. | + |
| 24. | Lithuanian transitional waters | + | + | n.i. | + |
| 25. | Gulf of Riga – open water | + | + | n.i. | + |
| 26. | Gulf of Riga – transitional waters | + | + | – | + |
| 27. | Gulf of Riga – northern coastal waters | + | + | + | + |
| 28. | Western Gotland Basin – open sea | + | + | n.i. | + |
| 29. | Western Gotland Basin – Askö | + | + | + | + |
| 30. | Northern Gotland Basin – open sea | + | + | n.i. | + |
| 31. | Gulf of Finland – open sea | + | + | + | + |
| 32. | Gulf of Finland – coastal type A | + | + | n.i. | + |
| 33. | Gulf of Finland – coastal type B | + | + | n.i. | + |
| 34. | Gulf of Finland – coastal type C | + | + | n.i. | + |
| 35. | Gulf of Finland – coastal type E | + | + | n.i. | + |
| 36. | Gulf of Finland – Tallinn Bay | + | + | + | + |
| 37. | Gulf of Finland – Narva Bay | n.i. | + | n.i. | + |
| 38. | Bothnian Sea – open sea | + | – | n.i. | + |
| 39. | Bothnian Sea – Örefjärden | + | – | + | + |
| 40. | Bothnian Bay – open sea | + | + | n.i. | + |
| 41. | Bothnian Bay – coastal type J | + | + | n.i. | + |
| 42. | Bothnian Bay – coastal type K | + | + | n.i. | + |
| | ∑ + | 38 | 39 | 18 | 42 |

The advantage of the principles used by HELCOM EUTRO is related to its simplicity and transparency. In a short-term perspective, the limitations are very few and include: (1) the inclusion of pressure information (loading) into the classification, and (2) a lack of information on which nutrient(s) are actually limiting primary production at the site or area in question. In a longer perspective, the limitations are related to a conspicuous mismatch with the WFD, where the assessment will be done by quality element.

The classification established by HELCOM EUTRO is based on a "one out, all out" principle, cf. Table 4.2. The examples from the Gulf of Finland (A) and the Bothnian Sea (B) exemplify the simplicity and transparency of the classification tool. All examples are straightforward: i) reference conditions are described, ii) an acceptable deviation is defined, and iii) it is determined whether the actual status is within an acceptable deviation or not. If it is, the score is "–" (non-problem area); if not, the score is "+" (indicating that the area in question is a eutrophication problem area).

In example A (Gulf of Finland), the "one out, all out" principle is used for category I, where two indicators point towards it being a non-problem area and two indicate that it is a problem area. Category II indicators also reveal that the Gulf of Finland is a problem area. Consequently, the final classification is "eutrophication problem area", cf. Table 3.3. Example B (Bothnian Sea) and the Bothnian Bay are tentatively classified as "eutrophication problem areas" in the HELCOM EUTRO context. This conclusion should be

**Table 4.2**
Classification of eutrophication status in the Gulf of Finland and the Bothnian Sea. RC: reference conditions, AM: assessment metrics, and AD: assessment data. The score is expressed as "+" or "–". (n.i. = no information)

| A: Gulf of Finland – open waters | RC | AM | AD | Score | |
|---|---|---|---|---|---|
| Category I (causative factors): | | | | | |
| • Winter surface water concentrations of nitrate+nitrite | 2.5 µM | + 50% | 8.8 µM | + | |
| • Winter surface water concentration of DIP | 0.30 µM | + 50% | 0.9 µM | + | |
| • Winter DIN:DIP | 16 | ± 50% | 10.5 | – | |
| • Winter DIN:$SiO_4$ | 1 | + 50% | 0.1 | – | |
| • Sum for Category I (one out = all out) | | | | | + |
| Category II (direct effects): | | | | | |
| • Summer chlorophyll-*a* concentration | 1.2 µg $l^{-1}$ | + 50% | 4.9 µg $l^{-1}$ | + | |
| • Secchi depth | 8 m | – 25% | 4.0 m | + | |
| • Abundance of *Aphanizomenon flos-aquae* (Jul–Aug) | 12500 $l^{-1}$ | + 50% | 74369 $l^{-1}$ | + | |
| • Sum for Category II (one out = all out) | | | | | + |
| Category III (indirect effects): | | | | | |
| • No information available at present | n.i. | n.i. | n.i. | n.i. | |
| • Sum for Category III (one out = all out) | | | | | n.i. |
| Final assessment | | | | | + |
| **B: Bothnian Sea – open sea** | **RC** | **AM** | **AD** | **Score** | |
| Category I (causative factors): | | | | | |
| • Land-based inputs (TN) | 22025 t $y^{-1}$ | + 50% | 33200 t $y^{-1}$ | + | |
| • Land-based inputs (TP) | 1820 t $y^{-1}$ | + 50% | 2430 t $y^{-1}$ | – | |
| • Atmospheric deposition | n.i. | + 50% | n.i. | n.i. | |
| • Winter surface water concentrations of nitrate+nitrite | 2.0 µM | + 50% | 2.71 µM | – | |
| • Winter surface water concentration of DIP | 0.2 µM | + 50% | 0.17 µM | – | |
| • Winter DIN:DIP | 16 | ± 50% | 16 | – | |
| • Winter DIN:$SiO_4$ | 1 | ± 50% | 0.23 | + | |
| • Sum for Category I (one out = all out) | | | | | + |
| Category II (direct effects): | | | | | |
| • Summer chlorophyll-*a* concentration | 1.0 µg $l^{-1}$ | + 50% | 1.0 µg $l^{-1}$ | – | |
| • Secchi depth | 9.0 m | – 25% | 7.0 m | – | |
| • Biovolume of phytoplankton | 0.3 $mm^3$ $l^{-1}$ | + 50% | 0.3 $mm^3$ $l^{-1}$ | – | |
| • Sum for Category II (one out = all out) | | | | | – |
| Category III (indirect effects): | | | | | |
| • No information available at present | n.i. | n.i. | n.i. | n.i. | |
| • Sum for Category III (one out = all out) | | | | | n.i. |
| Final assessment | | | | | + |

| A | Category I indicators | RS | HD | M | EJ | ∑ | NI |
|---|---|---|---|---|---|---|---|
| 1. | N inputs | 0 | 0 | 5 | 6 | 11 | 31 |
| 2. | P inputs | 0 | 0 | 5 | 1 | 6 | 36 |
| 3. | N concentrations | 0 | 9 | 16 | 14 | 39 | 3 |
| 4. | DIP concentrations | 0 | 9 | 17 | 12 | 38 | 4 |
| | ∑ | 0 | 18 | 43 | 33 | – | – |
| **B** | **Category II indicators** | **RS** | **HD** | **M** | **EJ** | **∑** | **NI** |
| 1. | Primary production | 0 | 1 | 7 | 3 | 11 | 31 |
| 2. | Chlorophyll-*a* concentrations | 0 | 4 | 13 | 24 | 41 | 1 |
| 3. | Secchi depth | 0 | 19 | 7 | 14 | 40 | 2 |
| 4. | Harmful algae blooms | 0 | 3 | 0 | 3 | 6 | 36 |
| 5. | Submerged aquatic vegetation depth limit | 0 | 11 | 1 | 0 | 12 | 30 |
| | ∑ | 0 | 38 | 28 | 44 | – | – |
| **C** | **Category III indicators** | **RS** | **HD** | **M** | **EJ** | **∑** | **NI** |
| 1. | No. of species of phytobenthos | 0 | 1 | 0 | 0 | 1 | 41 |
| 2. | No. of species of benthic animals | 0 | 9 | 0 | 4 | 13 | 29 |
| | ∑ | 0 | 10 | 0 | 5 | – | – |
| | **Grand total** | **0** | **66** | **71** | **82** | – | – |

**Table 4.3**
Methods used for establishing reference conditions for selected category I, II, and III indicators. RS: reference sites, HD: historical data, M: modelling, and EJ: expert judgement. NI denotes no information. Please note that ∑ + NI is 42.

considered very carefully and perhaps also seen as either a false positive result or as a "potential eutrophication problem area" *sensu* OSPAR. For the Bothnian Sea, the result is based on pressure information (inputs) and skewed DIN:$SiO_4$ ratios. The latter may perhaps not be relevant in an area where primary production is generally considered to be limited by phosphorus. Other features which need careful consideration are that (1) the reference condition for nitrate+nitrite is higher than the actual monitored values, and (2) Secchi depth values for both reference conditions and actual monitored data have been amended and still need verification. For the Bothnian Bay, the result is triggered by DIN concentrations, DIN:DIP ratios, and chlorophyll-*a* concentrations. The Bothnian Bay is considered to be P limited, and the elevated N concentrations with a surplus of N compared to P would have only limited effects on the production and eutrophication status of the bay. However, nutrients can be exported to other regions where they can have effects (transboundary effects). In relation to the elevated chlorophyll-*a* concentrations, it can be discussed whether these are eutrophication signals or not. However, the examples illustrate that the reference conditions are the anchor for the classification, and consequently a very important step for the assessment of the eutrophication status. Establishing reference conditions is a task which should be carried out by scientists. The methods with which reference conditions are established will improve over the coming years, primarily due to research and development projects and activities supporting the implementation of the WFD. For selected indicators, the methods used to establish reference conditions are presented in Table 4.3.

As shown, reference sites are not available within the Baltic Sea. Some historical data are available for a limited number of basins and coastal waters. Old data sets are site-specific by nature. However, the information inherent in historical data could be used in adjacent water bodies and at comparable sites, e.g., in the same eco-region. Work supporting the development of methods and guidance for this transposition should be initiated. As can also be seen from Table 4.3, the most commonly used Category I indicators are N and DIP concentrations. For nitrogen, there is a considerable variation: for some areas nitrate+nitrite is used, for others TN or DIN. There is a need for improvement, both in terms of coordination and further harmonization of the data types being reported for the assessment and probably also of what is actually being monitored.

The basins and water bodies listed in Table 4.1 and used for HELCOM EUTRO are located along a salinity gradient. Consequently, a plot of selected indicators such as TN, nitrate+nitrite, and DIP could be a preliminary method to prove the variation within the reference values and to spot outliers, cf. Figure 4.1A, B, and C.

Figure 4.1A, B, and C should at this stage be regarded as a first, rough attempt to illustrate some important features. Any conclusion based on these illustrations should be considered very carefully for a number of reasons, as explained on next page.

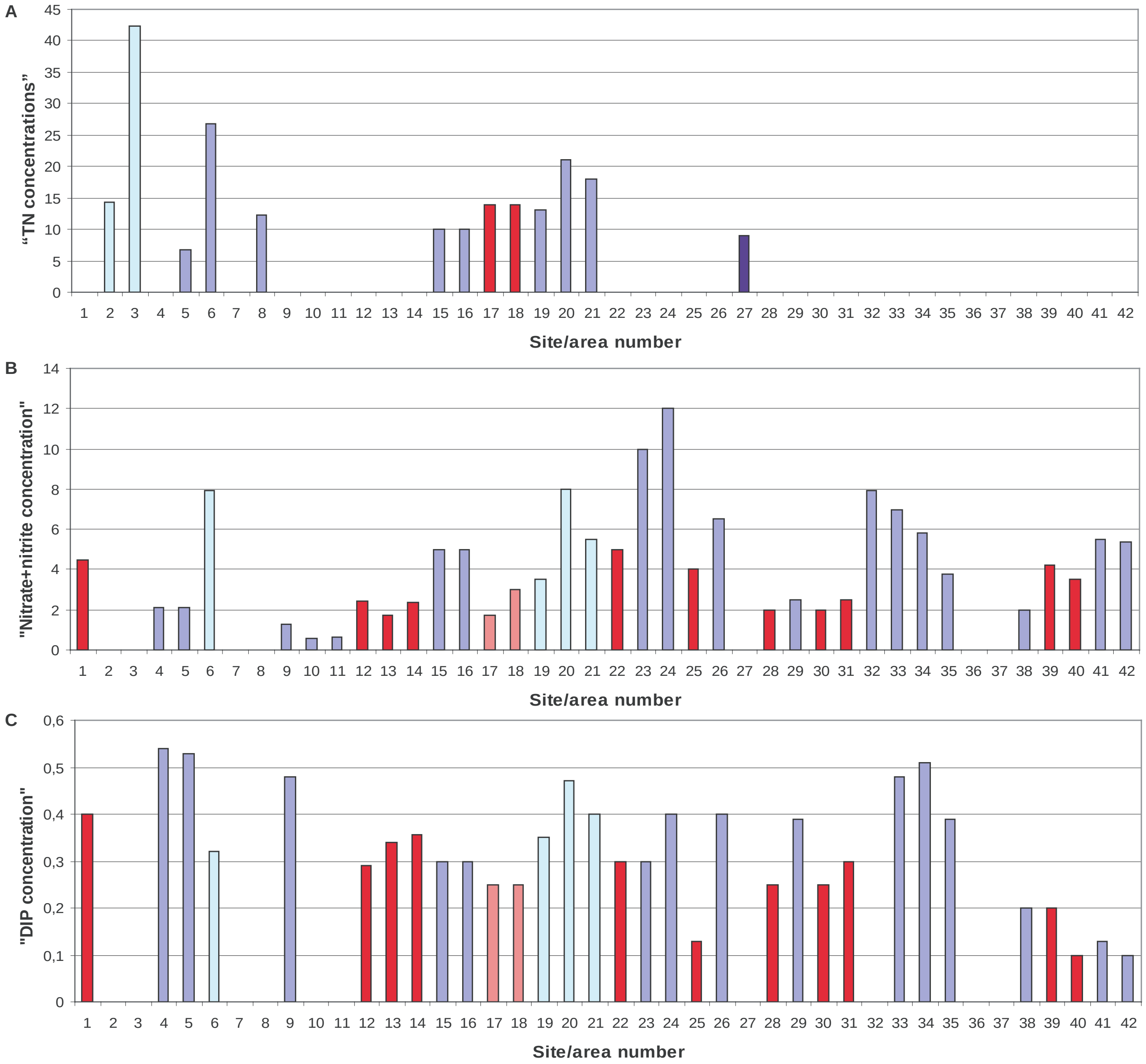


**Figure 4.1**
Illustration of the range in reference values for TN, nitrate+nitrite, and DIP. The names matching the site/area numbers can be found in Tables 3.1 and 4.1. Background data can be found in Annex C 1-42. Please see the text for explanations.

Figure 4.1A shows reference “TN concentrations” in µM. However, the figure is a mixture of “mean summer concentrations of TN” (light blue), “annual mean TN concentrations” (medium blue), and “winter mean concentrations of TN” (dark blue) at coastal sites/areas. The open-water areas are shown in red. Any direct comparisons between sites or areas are not possible at present. The only possible firm conclusion is that further coordination is needed.

Figure 4.1B is a composite of nitrite+nitrate concentrations and DIN concentrations (in µM). The data are deliberately mixed in order to at least outline the variation in reference values for these indicators. Red denotes open basins and blue denotes coastal waters. As for “TN concentrations” in Figure 4.1A, “winter means” (blue and red) are mixed with “annual means” (light blue and light red). And again, any firm conclusions should be considered carefully at this stage. However, it can seen that coastal waters in the northern, eastern, and southern Baltic Sea seem to have higher reference values compared with open waters. Again, the only firm conclusion to draw is that further coordination is needed.

Figure 4.1C shows DIP reference values (in µM). Red and light red denote “winter means” and “annual means”, respectively, in open waters. Blue and light blue denote “winter means” and “annual means”, respectively, in coastal waters. As in Figure 4.1B, it seems that coastal waters have higher reference values than open waters. And once again, the only firm conclusion is that further coordination is needed.

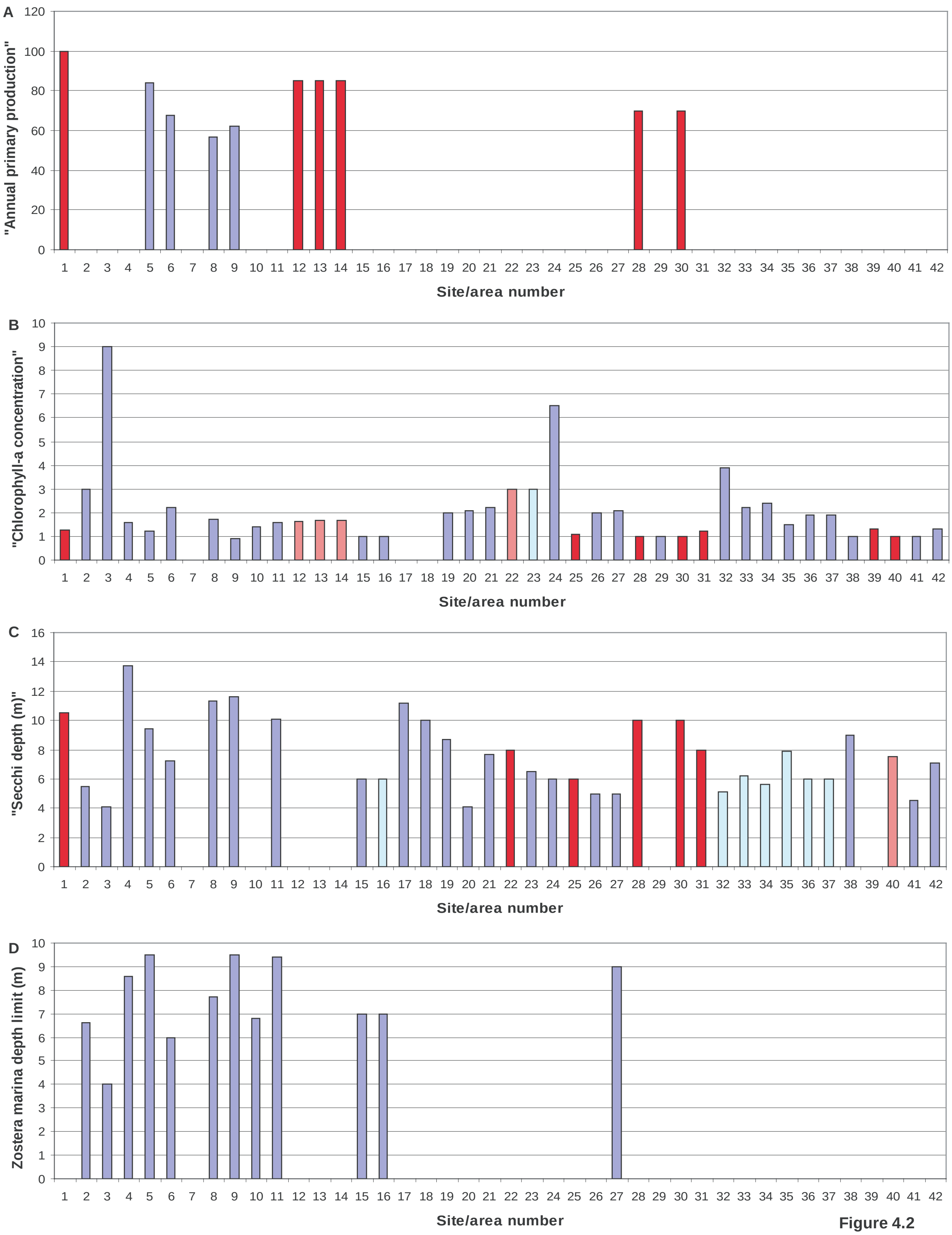


**Figure 4.2**
Illustration of the range in reference values for primary production, chlorophyll-a, Secchi depth, and *Zostera marina* depth limit. The numbers refer to the sites, cf. Tables 3.1 and 4.1. Please see the text for explanations.

The variation within the reference conditions for primary production (in gC $m^{-2}$ $yr^{-1}$) in open waters (red) and coastal waters (blue), chlorophyll-*a* concentrations (in µg $l^{-1}$), Secchi depth (in m) and depth limit of *Zostera marina* (in m) in coastal waters is shown in Figure 4.2A, B, C, and D.

Figure 4.2A (annual primary production) and Figure 4.2D (*Zostera marina* depth limit) are straightforward. More sites or areas are needed if any firm conclusions are to be drawn.

Figure 4.2B is a composite of “annual means” (red and blue) and “summer means” (light red and light blue). Again, any firm conclusions should be avoided. However, it seems that high chlorophyll-*a* concentrations are generally found in enclosed coastal waters bodies close to freshwater inputs.

The Secchi depth reference values in Figure 4.2C are a composite. Red and blue denote “annual means” for open water and coastal waters, respectively. Light red and light blue denote “summer means” for open water and coastal waters, respectively. Any firm conclusions cannot be drawn at this stage - further coordination and analyses are needed to detect natural variations in reference values within the Baltic Sea and to improve the quality of information available, e.g., in terms of accuarcy and precision.

Reference conditions are not permanent. Changes in climate and land cover in upstream catchments occur, and marine ecosystems vary naturally. Consequently, the reference conditions should be reviewed and amended if relevant. As knowledge of transitional and coastal waters increases, it is likely that the existing predictive models will be further developed, thus reducing the degree of expert judgement required in the process.

Despite the advantages of the principles and metrics used by HELCOM EUTRO, the shortcomings in relation to some of the requirements of the WFD have initiated discussions. The following changes have been suggested:

1. Firstly, the categories I, II, and III should be changed in order to comply with the quality elements used by the WFD, which in the context of eutrophication include: i) phytoplankton, ii) submerged aquatic vegetation, iii) benthic macroinvertebrates, and iv) supporting physio-chemical factors (oxygen, temperature, nutrients).
2. Secondly, the Ecological Quality Ratio (EQR), where observed values are compared to reference conditions and expressed as a value between 1 and 0, should be used, as required by the WFD.

Furthermore, a method for weighting the indicators within quality elements should be considered and examined as not all indicators may have equal sensitivity to anthropogenic pressures. It has been suggested to rank the indicators accordingly: 1 = minor importance, 2 = moderate importance, 4 = high importance, and 8 = very high importance.

The changes suggested have been tested for fifteen Danish coastal waters. The approach in the Danish case study follows the HELCOM EUTRO methodology: step 1) site-specific reference conditions have been established; step 2) different scenarios for acceptable deviations have been set up (15%, 25%, and 50%); step 3) a weighting of indicators within quality elements has been introduced and tested; and step 4) the “one out, all out” principle has been applied according to the WFD. The sensitivity of reference conditions to changes or inaccurate information has also been examined. All in all, the Danish case study is considered to follow the WFD Annex V in principle.

The draft tool, which includes the above suggested changes, has been tested in Danish coastal waters /72/. The tool has, owing to its origin, tentatively been named draft HELCOM Eutrophication Assessment Tool (HEAT). Some preliminary results of the test of HEAT are that: (1) the use of Quality Elements, reference conditions, acceptable deviation, five quality classes, and the expression of an Ecological Quality Ratio makes HEAT more consistent with WFD principles than the pragmatic approach used by HELCOM EUTRO and others; (2) the background of HEAT, as well as the principles applied, are easy to communicate; (3) increasing the number of indicators makes the Ecological Quality Ratio robust to uncertainties in reference conditions; and (4) the results produced by HEAT confirm the results of currently scientifically sound, but at the same time more or less subjective, assessments of eutrophication status in these fifteen areas. So far, the result of the Danish test has been reported as a technical report to the Danish Environmental Protection Agency. Consequently, the HEAT template spreadsheet is publicly available and can be used free of charge. The report will be summarized in the near future with the aim of publishing a scientific, peer-reviewed paper describing the HEAT methodology in detail, including its strengths and weaknesses.

# 5 Conclusions, recommendations, and perspectives

This chapter provides the overall conclusions of HELCOM EUTRO, recommendations for the planned HELCOM thematic assessment on eutrophication, as well as thoughts on how the tools and recommendations could be implemented.

## 5.1 Conclusions

The objectives of HELCOM EUTRO have been: (1) to develop a tool for assessment of the eutrophication status of the Baltic Sea; (2) to base the tool on reference conditions, sometimes referred to as background values; (3) to base the work on already available data and information; and (4) to develop and assess different scenarios for the definition of acceptable deviations from reference conditions. All the objectives have been fulfilled and reported accordingly.

The interim classifications of the 42 sites/areas included in HELCOM EUTRO are based on reference conditions and available recent data and information. Based on the classification made, it can be concluded that:

- Information on reference conditions is an anchor in the process of assessing the eutrophication status of the Baltic Sea and its coastal waters. The tools used and developed do not work without information on reference conditions.
- The methods used to establish reference conditions included historical data, modelling, and expert judgment. Existing reference sites were not found in the Baltic Sea.
- HELCOM EUTRO has defined an upper limit in relation to acceptable deviation from reference conditions. As a general rule, the deviation shall be justified, but not exceed 50%. For indicators where the reference condition is the maximum value and the deviation therefore is limited to 100% (e.g., Secchi depth and the depth limit of submerged aquatic vegetation), the acceptable deviation from reference conditions should not exceed 25%.
- The use of 50% is to a certain extent arbitrary and based on expert judgment. Consequently, there is a need to improve the scientific justification concerning why an acceptable deviation has been set to a given percentage. The rationale behind using 25% for Secchi depth and the depth limit of submerged aquatic vegetation seems to be justified at present.
- The availability of synoptic data (meaning both data on reference conditions, and data from a monitoring system securing regular measurements with a frequency matching the temporal variation in the assessment site in question) is a prerequisite for classification and assessment of the eutrophication status in the Baltic Sea. The data originating from monitoring can be supplemented with data from research or other sources.
- The most widely used indicators for the classification have been:

  Category I: Nutrients (N, P, and N:P ratio).
  Category II: Chlorophyll-*a* concentrations, Secchi depth, the depth limit of submerged aquatic vegetation, and primary production.
  Category III: Oxygen concentrations.
- Nutrient ratios (e.g., N:P, N:P:Si) should be interpreted with care as they are at present based purely on theory. Their application and their acceptable deviations should be carefully considered in each region and in relation to the eutrophication status in the region.
- Various methods have been used to describe the present eutrophication status, e.g., winter means, summer means, annual means, minimum and maximum values, and five-year means. This makes comparisons between different parts of the Baltic Sea difficult. A further harmonization seems to be a prerequisite for future eutrophication assessments to allow transparency and comparability of the assessment results between countries, areas, and sites.
- The classification tool used by HELCOM EUTRO is pragmatic and transparent and has been proven to work, but future improvement is needed. A few changes, including reorganization whereby categories I, II, and II are shifted to quality elements, would make the tool more consistent with WFD requirements.
- Pressure information (inputs) is relevant for understanding why an area is a “eutrophication problem area” and for the establishment of programmes of measures. However, pressure information should not be included in classification of eutrophication status.

Furthermore, the following can be concluded:

- all thirteen open-sea basins are classified as "eutrophication problem areas";
- two out of the thirteen open-sea basins classified as "eutrophication problem areas" are normally considered to be "non-problem areas" (Bothnian Sea and Bothnian Bay), and the outcome of the classification is considered to be either a false positive result due to constraints in the principles used by HELCOM EUTRO or a "potential eutrophication problem area"; and
- all 29 coastal sites/waters are classified as "eutrophication problem areas".

## 5.2 Recommendations

Based on the experience gained via HELCOM EUTRO and the progress achieved so far, a number of recommendations have been discussed. The recommendations which are presented below are purely those of the authors and should not in any circumstances be regarded as an official position of HELCOM.

- There is an urgent need for further coordination and harmonization in terms of indicators and time periods that the assessment should cover (seasonally and/or single year, multiple year (mean, running mean)).
- There is a need to include more biological indicators, especially regarding benthic organisms, in future eutrophication assessments. National monitoring programmes and the HELCOM COMBINE might need to be adapted in accordance with the WFD (where relevant) and the guidance from the European Eutrophication Activity.
- Synoptic data, meaning combined data sets on both (1) reference conditions and (2) from a monitoring system securing regular measurements with a frequency matching the temporal variation in the assessment site concerned, are needed in order to improve the spatial coverage of the future assessments of eutrophication status in the Baltic Sea.
- There is a need to change from the three categories used by HELCOM EUTRO to a grouping into quality elements according to the EU Water Framework Directive and the upcoming guidance from the European Eutrophication Activity.
- The draft HELCOM Eutrophication Assessment Tool (HEAT) and other relevant tools should not be regarded as static tools. Instead, they should be seen as prototypes, which should be improved in terms of accuracy and precision.
- It is recommended to continue work on the draft HELCOM Eutrophication Assessment Tool (HEAT) and other relevant tools to obtain further improvements in relation to the planned thematic assessment of eutrophication in the Baltic Sea.

The future process leading to the planned thematic assessment of eutrophication in the Baltic Sea should focus on: i) reference conditions, including validated values which are tentative at present (especially for biological elements), ii) functional relations, sometimes referred to as cause-effect relations, which link pressures to ecological effects and are thus the direct connection to programmes and measures, and iii) acceptable deviations from reference conditions, which should be scientifically justified.

As a precautionary note, and as this report is not an assessment report, it is noted that the planned thematic assessment of eutrophication in the Baltic Sea should not only focus on the eutrophication status. The assessment should also include information on root causes, inputs from upstream catchments and the atmosphere, advective transports, as well as an assessment of the effectiveness of already implemented strategies and measures.

A list of indicators to be used for future assessments is proposed. The list is hierarchical: at least one indicator listed at level I is required, indicators listed at level II should be included to the extent possible (if applicable):

- Plankton:
  - I: Chlorophyll-*a* and primary production.
  - II: Plankton biomass, abundance of harmful species/groups, bloom frequency, absence/presence of key species, and zooplankton biomass.
- Submerged aquatic vegetation (macroalgae, angiosperms, benthic microalgae):
  - I: Maximum depth limit or density at a given depth.
  - II: Abundance and absence/presence of key species.
- Benthic invertebrates:
  - I: Biomass and abundance.
  - II: Diversity and presence/absence of key species/sensitive species.

- Physio-chemical factors, including nutrients:
  - I: Secchi depth, nutrients (DIN and DIP), and oxygen.
  - II: TN, TP, and silica.

The above list is not final. Revisions are possible due to (1) the EU Water Framework Directive, (2) the European Marine Strategy, or (3) new developments.

## 5.3 Perspectives

The period between HELCOM EUTRO and the planned thematic assessment of eutrophication in the Baltic Sea should be used to prepare the assessment tools as well as possible and to improve the data on which the assessment will be based.

Work should focus in particular on:

- ***Reference conditions***: Reliable data on reference conditions is the anchor for assessing the eutrophication of the Baltic Sea. The majority of the reference conditions used in HELCOM EUTRO are tentative and/or based on expert judgement. There is an urgent need to improve this situation. Existing historical data should be used and eventually transposed to adjacent sites/areas. Models are a useful tool for the purpose of establishing reference conditions. However, both (1) the reference loading data on the basis of which the model calculates the reference conditions for the quality elements and (2) the model results should be compared and improved.
- ***Justification of acceptable deviation***: The scientific justification of the percentages used when defining an acceptable deviation from reference conditions should be improved. Ideally, there should be a reference for the percentages for all indicators and sites/areas. There is no doubt that the implementation of the Water Framework Directive will contribute to an improved justification. However, it is not realistic that this process will improve the justification for open-water sites/areas. Consequently, a coordinated Baltic Sea-wide initiative is needed.
- ***Targeting of monitoring programmes***: In general, monitoring should not be carried out without a EutroQO or EcoQO for the site/area where the monitoring takes place and *vice versa*. Monitoring should be targeted for assessing whether the EutroQOs or EcoQOs are fulfilled or not. A tighter coordination between: (1) HELCOM COMBINE, including MON-PRO, (2) the HELCOM EcoQO project, and (3) the process leading to the planned assessment of eutrophication is urgently needed.
- ***Dose-response curves***: Graphs quantifying functional relations between pressures and ecological indicators are needed for several reasons: (1) they are easily understood; (2) they illustrate the range of pressures and ecological responses; (3) they are useful when justifying and explaining the notion of acceptable deviations; and (4) they are the basis for establishing programmes and measures. For certain areas of the Baltic Sea and/or for certain indicators, much has been done already. The existing experience should, in principle, be transposed and used for establishing response curves for other sites and areas.
- ***Visualization***: Pictures showing how marine ecosystems respond to nutrient enrichment and input reductions are needed to make the public, stakeholders, and politicians aware of the problem. The pictures illustrate the ecological consequences, both if action for improvement is taken and what happens if it is not.

Within the framework of HELCOM EUTRO, a draft tool more consistent with the WFD requirements has been developed, named HELCOM Eutrophication Assessment Tool (HEAT); it aims at future assessments of the eutrophication status in the Baltic Sea and adjacent marine waters. This tool has been tested successfully in fifteen areas of the Danish marine waters. The results of the test are: (1) the use of Quality Elements, reference conditions, acceptable deviations, five quality classes, and an expression of an Ecological Quality Ratio makes HEAT more consistent with WFD principles than the pragmatic approach used by HELCOM EUTRO and others; (2) the background of HEAT, as well as the principles applied, are easy to communicate; (3) increasing the number of indicators makes an Ecological Quality Ratio robust against uncertainties in reference conditions; and (4) the results produced by HEAT confirm the outcomes of currently scientifically sound, but at the same time more or less subjective, assessments of eutrophication status in these fifteen areas. Although HEAT is still a prototype and further improvements are needed, it might turn out that this simple tool is helpful and easy to use when assessing the eutrophication status of a site or area, irrespective of the context (e.g., HELCOM, WFD, or the European Marine Strategy). However, further testing and discussion within HELCOM are needed before adoption.

In future work, it should be recognized that ecological processes are often non-linear and that such processes may include points-of-no-return and time lags. This can result in discontinuities and various types of uncertainty. Management plans have to be adaptive in order to deal with such uncertainty, and at the same time include elements of "learning-by-doing" and feedback from research and monitoring activities. Action plans should be adopted and programmes of measures should be implemented, even when cause-effect relationships are not entirely scientifically documented (the Precautionary Principle). The plans and programmes must be updated as new knowledge is generated or produced and the cause-effect relationships are documented.

# 6 References


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# 7 Glossary and abbreviations

The glossary and list of abbreviations is based on Ærtebjerg et al. (2003) (available via http://www2.dmu.dk/1_Viden/2_Miljoe-tilstand/3_vand/4_eutrophication/glossary.asp and the European Environment Agency's multilingual environmental glossary (available via http://glossary.eea.eu.int/EEAGlossary/).

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

Anoxic – the state of oxygen depletion with absence of oxygen. Anoxic sediments and anoxic bottom waters are commonly produced where there is a depletion of oxygen, owing to very high organic productivity, and a lack of oxygen replenishment to the water or sediment, as in the case of stagnation or stratification of the body of water.

Aquatic – growing or living in or near water.

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

Benthic – see benthos.

Benthos – those organisms attached to, living on, in, or near the sea bed, river bed, or lake floor.

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

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

C – carbon, see carbon biomass.

Carbon biomass – biomass as the amount of carbon (C) in a given area or volume.

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

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

Cyanobacteria – see blue-green algae.

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

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

EcoQO – Ecological Quality Objective.

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

Estuary – the transition area between a river and the sea, i.e., an estuary is a body of water that is formed when fresh water from a river flows into and mixes with salt water from the ocean. In estuaries, the fresh river water is blocked from directly entering the open ocean either by the surrounding mainland, peninsulas, barrier islands, or fringing salt marshes.

EU – European Union.

Eutrophication – See page 2-2

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

$H_2S$ – hydrogen sulphide.

HELCOM – the Helsinki Commission.

Hypoxia – see oxygen depletion.

Macroalgae – plants that lack true roots, stems, leaves, or flowers. They mostly live attached to a hard substrate.

Macrozoobenthos – animals larger than 1 mm living attached to, on, in, or near the sea bed, river bed, or lake floor.

Marine – of, or pertaining to, the sea, the continuous body of water covering most of the earth's surface and surrounding its land masses. Marine waters may be fully saline, brackish, or almost fresh.

μ(prefix) – micro, $10^{-6}$.

Molar – designating a solution that contains one mole of solute per litre of solution.

N – see nitrogen.

Nitrate ($NO_3$) – an important nitrogen-containing nutrient. The chemical form in which plants take up most of their nitrogen. It is the salt of nitric acid.

Nitrogen (N) – a chemical element that constitutes about 80% of the atmosphere by volume. Nitrogen is an important part of proteins and is essential to living organisms.

Nutrient – chemical elements which are involved in the construction of living tissue that are needed by both plants and animals. The most important in terms of amount are carbon, hydrogen, and oxygen, with other essential elements including nitrogen, potassium, calcium, sulphur, and phosphorus.

Oligotrophic – applies to waters or soils that are poor in nutrients and have low primary productivity.

Organic – organic compounds contain the element carbon. Of, relating to, or derived from living organisms.

Organism – an individual form of life. An animal, plant, or bacterium.

OSPAR COMPP – OSPAR Comprehensive Procedure for the Identification of the Eutrophication Status of the Maritime Area

Oxygen – a non-metallic element constituting 21 percent of the atmosphere by volume. Oxygen is produced by autotrophic organisms and is vital to oxygen-breathing organisms.

Oxygen depletion – a situation where the demand for oxygen has exceeded its supply, leading to low concentrations of oxygen. Low oxygen concentrations are normally found in the water close to the sea bottom. In Denmark, concentrations below 4 mg $O_2$ per litre are defined as oxygen depletion and concentrations below 2 mg $O_2$ per litre are defined as severe acute oxygen depletion.

P – see phosphorus.

Phosphate ($PO_4$) – an important phosphorus-containing nutrient. It is the chemical form in which plants take up phosphorus.

Phosphorus (P) – a non-metallic chemical element.

Phytoplankton – the plant plankton and primary producers (i.e., drifting, more or less microscopic, photosynthetic organisms) of aquatic ecosystems.

Plankton – free passively floating organisms (animals, plants, or microbes) in aquatic systems.

Primary production – the production by autotrophs.

Secchi depth – a measure of the clarity of the water.

TN – total nitrogen, which includes dissolved inorganic nitrogen and organically bound nitrogen.

Tot-N – see TN.

Tot-P – see TP.

TP – total phosphorus, which includes dissolved inorganic phosphorus and organically bound phosphorus.

WFD – EU Water Framework Directive.

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

# Appendices

# Appendix A
## Pan-European checklist for a holistic assessment of eutrophication

### Checklist for a holistic assessment

**The qualitative assessment parameters are:**

a. *The causative factors:*

The degree of nutrient enrichment:

With regard to inorganic/organic nitrogen
With regard to inorganic/organic phosphorus

Taking account of:

Sources (differentiating between anthropogenic and natural sources)
Increased/upward trends in concentration
Elevated concentrations
Change in N/P ratios
Fluxes and nutrient cycles (including internal nutrient loading, direct and atmospheric inputs).
Changes in hydromorphology.

b. *The environmental factors:*

Light availability (irradiance, turbidity, suspended load, shading)
Hydromorphology (e.g., water depth, velocity, flood frequency, substrate type and mobility, stratification, deposition)
Climatic/weather conditions (rainfall, temperature)
Chemical status (e.g., suppression of algae growth by pesticides).

c. *The direct effects of nutrient enrichment/eutrophication:*

i. Phytoplankton:
Increased biomass (e.g., chlorophyll-*a*, organic carbon, and cell numbers or volume)
Increased frequency and duration of blooms
Increased annual primary production
Shifts in species composition (e.g., from diatoms to green algae or cyanobacteria, some of which are nuisance or toxic species)

ii. Macrophytes:
Increased biomass
Shifts in species composition (from long-lived species to short-lived species, some of which are nuisance species)
Reduced depth distribution

iii. Phytobenthos:
Increased biomass
Increased spatial cover on substrate
Shifts in species composition (e.g., from diatoms to green algae or cyanobacteria)

d. *The indirect effects of nutrient enrichment/eutrophication:*

i. Organic carbon/organic matter:
Increased dissolved/particulate organic carbon concentrations
Occurrence of foam and/or slime
Increased concentration of organic carbon in sediments (due to increased sedimentation rate)

ii. Oxygen:
Decreased concentrations and saturation percentage
Increased frequency of low oxygen concentrations
More extreme diurnal variation
Occurrence of anoxic zones at the sediment surface (“black spots”)

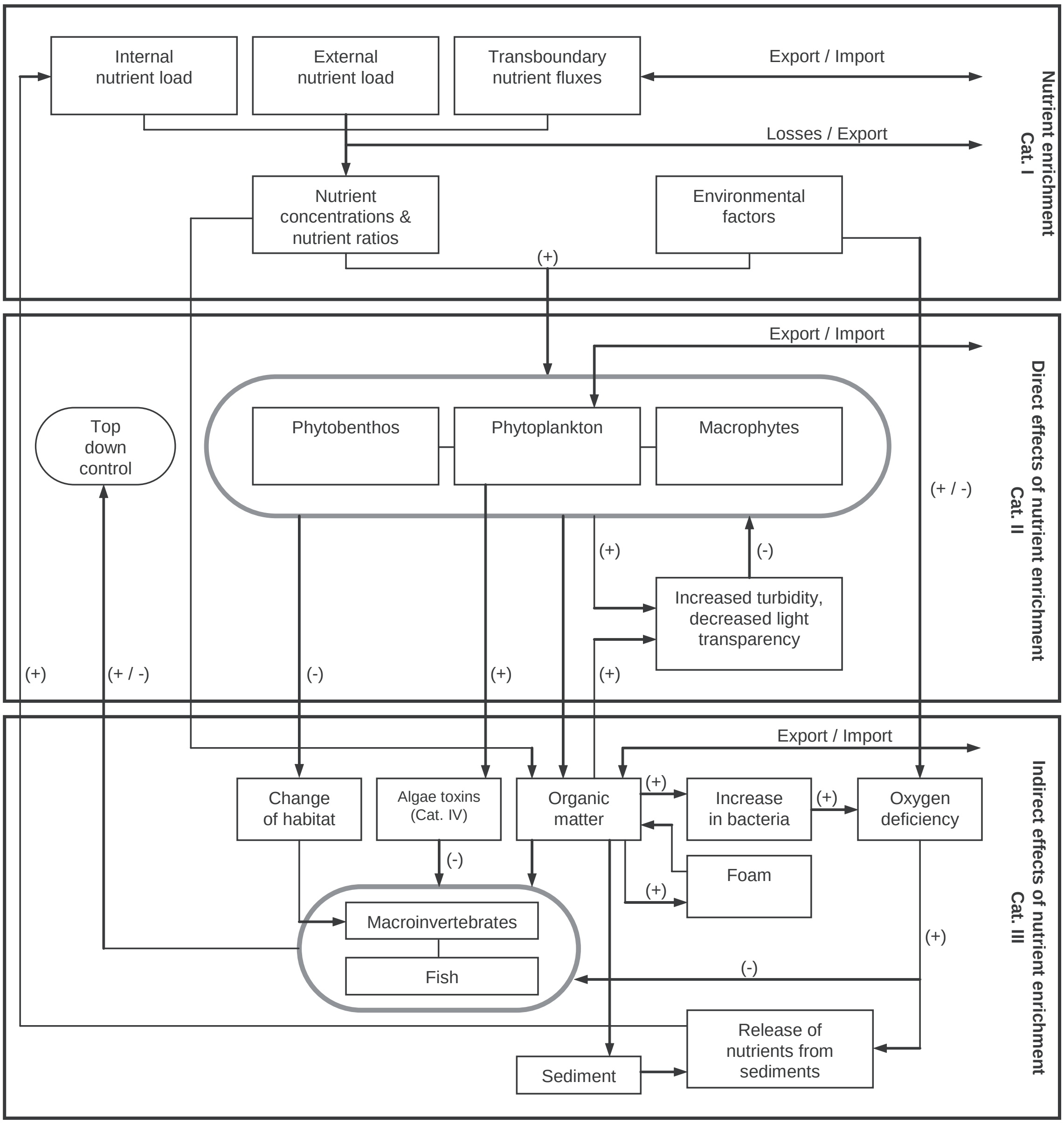
iii. Fish:
   Mortalities resulting from low oxygen concentrations
   Changes in species composition
   Changes in abundance
   Disruption of migration or movement
iv. Benthic invertebrate community:
   Changes in abundance
   Changes in species composition
   Changes in biomass
v. Increased growth and biomass of benthic heterotrophic organisms, such as fungi and bacteria

*e. Other possible effects of nutrient enrichment:*

i. Algal toxins (still under investigation—the recent increase in toxic events may be linked to eutrophication).
ii. Amenity values compromised, e.g., clogging of pipes and filters, build-up of iron deposits due to low DO, amenity value of the river.

# Appendix B

## Pan-European Eutrophication Activity conceptual framework




The general conceptual framework to assess eutrophication in all categories of surface waters. “+” indicates enhancement, “−” indicates reduction. Round boxes indicate quality elements of the WFD.

# Appendix C

## Site- or basin-specific assessments based on national reporting

This annex contains 38 assessment tables, one for each of the sites or basins reported to HELCOM EUTRO.

The tables all originate from the national reports. However, some editing has taken place in order to streamline them. Please note that the streamlining was discussed and agreed at the joint HELCOM EUTRO/Baltic GIG workshop on 20–22 September 2005 in Stockholm.

As a precautionary note, it is emphasized that reference conditions are tentative or preliminary. The majority need further elaboration, verification, and validation. The tables include an indication of how the reference values have been derived: RS denotes reference sites, HD denotes historical data, NM denotes numerical modelling, SM denotes statistical modelling, and EJ denotes expert judgement.

In some cases, the tables have been corrected by the Contracting Parties after the submission of their national reports. Consequently, there are instances where the tables in the national reports are not up to date.

| 1 | **Kattegat – central sea** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Land-based inputs (TN) | 30000 t/y | EJ | + 25% | 55, 00 t/y | + | |
| | • Winter surface water concentrations of DIN | 4.5 µM | NM | + 25% | 8.26 µM | + | |
| | • Winter surface water concentration of DIP | 0.4 µM | NM | + 25% | 0.59 µM | + | |
| | • Winter DIN:DIP | 11.25 | EJ | ± 25% | 14 | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 1.25 µg $l^{-1}$ | SM | + 25% | 1.8 µg $l^{-1}$ | + | |
| | • Primary production | 100 | HD | + 25% | n.i. | (+) | |
| | • Secchi depth | 10.5 | HD | – 25% | 8.5 | + | |
| | • Density of macroalgae at 18 m | 80 % | SM | – 25% | 60 % | – | |
| | • Density of macroalgae at 20 m | 60 % | SM | – 25% | 45 % | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Anoxia and hypoxia | n.i. | EJ | < 4 mg $l^{-1}$ | n.i. | + | |
| | • Kills in benthic invertebrates and fish | n.i. | n.i. | n.i. | n.i. | (+) | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 2 | **Outer Randers Fjord** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Mean summer concentration of TN (March – October) | 14.29 µM | NM | + 25% | 71.43 µM | + | |
| | • Mean summer concentration of TP (March – October) | 0.97 µM | NM | + 25% | 1.95 µM | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 3 µg $l^{-1}$ | NM | + 25% | 6.94 µg $l^{-1}$ | + | |
| | • Secchi depth | 5.5 | NM | – 25% | 3.1 | + | |
| | • Eelgrass maximum depth limit | 6.6 m | HD | – 25% | 1.2 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Macroalgae species richness | 12 | HD | – 25% | 7 | + | |
| | • Zoobenthos species richness | 94 | HD | ± 25% | 46 | + | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 3 | Inner Randers Fjord | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Mean summer concentration of TN (March – October) | 42.89 µM | NM | + 25% | 128.57 µM | + | |
| | • Mean summer concentration of TP (March – October) | 1.29 µM | NM | + 25% | 2.90 µM | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 9 µg $l^{-1}$ | NM | + 25% | 13 µg $l^{-1}$ | + | |
| | • Secchi depth | 4.1 | NM | – 25% | 1.7 | + | |
| | • Eelgrass maximum depth limit | 4.0 m | HD | – 25% | extinct | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Macroalgae species richness | 15 | HD | – 25% | 3 | + | |
| | • Zoobenthos species richness | 16 | HD | ± 25% | 24 | + | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 4 | Danish Straits – Aarhus Bay | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of DIN | 2.1 µM | NM | + 25% | 9.50 µM | + | |
| | • Winter surface water concentrations of DIP | 0.54 µM | NM | + 25% | 0.68 µM | – | |
| | • TP (summer) | 0.41 µM | NM | + 25% | 0.78 µM | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 1.6 µg $l^{-1}$ | SM | + 25% | 3.0 µg $l^{-1}$ | + | |
| | • Primary production | 259 mgC $m^{-3}$ $d^{-1}$ | NM | + 25% | 320 mgC $m^{-3}$ $d^{-1}$ | – | |
| | • Secchi depth | 13.7 m | HD | – 25% | 8.9 m | + | |
| | • Eelgrass maximum depth limit | 8.6 m | HD | – 25% | 5.7 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 5 | Danish Straits – north of Funen | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • TN (annual mean) | 6.8 µM | EJ | + 25% | 18.5 µM | + | |
| | • Winter surface DIN | 2.1 µM | NM | + 25% | 9.9 µM | + | |
| | • TP (annual mean) | 0.41 µM | NM | + 25% | 0.7 µM | + | |
| | • Winter surface DIP | 0.52 µM | NM | + 25% | 0.68 µM | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 1.2 µg $l^{-1}$ | NM | + 25% | 3.4 µg $l^{-1}$ | + | |
| | • Primary production | 84 gC $m^{-2}$ $y^{-1}$ | NM | + 25% | 248 gC $m^{-2}$ $y^{-1}$ | + | |
| | • Secchi depth | 9.4 m | HD | – 25% | 7.1 m | – | |
| | • Eelgrass maximum depth limit | 9.5 m | HD | – 25% | 5.5 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Zoobenthos species richness | 75 | HD | ± 25% | 130 | + | |
| | • Zoobenthos biomass | 120.8 gWW $m^{-2}$ | HD | ± 25% | 369.3 gWW $m^{-2}$ | + | |
| | • Mollusc biomass | 72.8 gWW $m^{-2}$ | HD | ± 25% | 353.3 gWW $m^{-2}$ | + | |
| | • Echinoderm biomass | 34.5 gWW $m^{-2}$ | HD | ± 25% | 2.9 gWW $m^{-2}$ | + | |
| | • Echinoderm : Mollusc ratio (biomass) | 0.474 | HD | ± 25% | 0.008 | + | |
| | • Zoobenthos abundance | 390.8 ind. $m^{-2}$ | HD | ± 25% | 1861 ind. $m^{-2}$ | + | |
| | • Echinoderm : Mollusc ratio (ind. $m^{-2}$) | 0.935 | HD | ± 25% | 0.005 | + | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 6 | Odense Fjord, outer parts | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • TN (summer mean) | 19.8 µM | HD | + 25% | 40.4 µM | + | |
| | • TN (annual mean) | 26.7 µM | HD | + 25% | 56.3 µM | + | |
| | • DIN (annual mean) | 7.9 µM | NM | + 25% | 31.4 µM | + | |
| | • TP (annual mean) | 0.32 µM | NM | + 25% | 1.53 µM | + | |
| | • DIP (annual mean) | 0.32 µM | NM | + 25% | 0.77 µM | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 2.2 µg $l^{-1}$ | NM | + 25% | 4.2 µg $l^{-1}$ | + | |
| | • Primary production | 190 mgC $m^{-3}$ $d^{-1}$ | NM | + 25% | 276 mgC $m^{-3}$ $d^{-1}$ | + | |
| | • Secchi depth | 7.2 m | HD | – 25% | 3.5 m | + | |
| | • Eelgrass maximum depth limit | 6.0 | HD | – 25% | 2.8 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 7 | Isefjorden, outer parts | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | n.i. |
| Cat. II: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | n.i. |
| Cat. III: | • Biomass | 13998 mg DW $m^{-2}$ | HD | + 25% | 97634 mg DW $m^{-2}$ | + | |
| | • Bivalve biomass | 6299 mg DW $m^{-2}$ | HD | ± 25% | 88740 mg DW $m^{-2}$ | + | |
| | • Crustacean biomass | 326 mg DW $m^{-2}$ | HD | ± 25% | 76 mg DW $m^{-2}$ | + | |
| | • Echinoderm biomass | 877 mg DW $m^{-2}$ | HD | ± 25% | 57 mg DW $m^{-2}$ | + | |
| | • Deep-deposit feeder biomass | 3951 mg DW $m^{-2}$ | HD | ± 25% | 986 mg DW $m^{-2}$ | + | |
| | • Surface-deposit feeder biomass | 3727 mg DW $m^{-2}$ | HD | ± 25% | 1255 mg DW $m^{-2}$ | + | |
| | • Suspension feeder biomass | 4831 mg DW $m^{-2}$ | HD | ± 25% | 92300 mg DW $m^{-2}$ | + | |
| | • Individual weight (relative) | 0.52 | HD | ± 25% | 0.08 | + | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 8 | The Sound – central coastal waters | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • N load (The Sound as a whole) | 2626 t $y^{-1}$ | EJ | + 25% | 11242 t $y^{-1}$ | + | |
| | • P load (The Sound as a whole) | 54 t $y^{-1}$ | EJ | + 25% | 339 t $y^{-1}$ | + | |
| | • TN (annual mean) | 12.26 µM | NM | + 25% | 24.64 µM | + | |
| | • TP (annual mean) | 0.39 µM | NM | + 25% | 0.74 µM | + | |
| | • TN:TP | 31.74 | NM | ± 25% | 33.21 | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Primary production | 160 mgC $m^{-3}$ $d^{-1}$ | NM | + 25% | 280 mgC $m^{-3}$ $d^{-1}$ | + | |
| | • Phytoplankton, biomass (5 m) | 0.128 mg $l^{-1}$ | NM | + 25% | 0.215 mg $l^{-1}$ | + | |
| | • Summer chlorophyll-*a* concentration | 1.7 µg $l^{-1}$ | NM | + 25% | 3.2 µg $l^{-1}$ | + | |
| | • Secchi depth | 11.3 m | NM | – 25% | 8.5 | + | |
| | • Eelgrass maximum depth limit | 7.7 m | HD | – 25% | 6.0 m | – | |
| | • Eelgrass biomass | 10 gC $m^{-2}$ | NM | ± 25% | 14 gC $m^{-2}$ | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Zooplankton biomass (5m) | 0.006 gC $m^{-2}$ | NM | + 25% | 0.010 gC $m^{-2}$ | + | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 9 | Southern Little Belt | | | | | | |
|---|---|---|---|---|---|---|---|
| | Assessment criteria (indicator) | Reference conditions | Method | Assessment metrics | Assessment data | Score (+/÷) | |
| Cat. I: | • Winter surface water concentrations of DIN | 1.25 µM | NM | + 25% | 7.6 µM | + | |
| | • Winter surface water concentrations of DIN | 0.48 µM | NM | + 25% | 0.71 µM | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 0.9 µg $l^{-1}$ | NM | + 25% | 3.2 µg $l^{-1}$ | + | |
| | • Primary production | 62 gC $m^{-2}$ $y^{-1}$ | NM | + 25% | 273 gC $m^{-2}$ $y^{-1}$ | + | |
| | • Secchi depth | 11.6 m | HD | – 25% | 7.6 | + | |
| | • Eelgrass maximum depth limit | 9.5 m | HD | – 25% | 5.9 m | + | |
| | • Macroalgae maximum depth limit | 32.5 m | HD | – 25% | 15 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Oxygen depletion coverage | 36 $km^2$ | NM | + 25% | 474 $km^2$ | + | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 10 | Arkona Basin – Fakse Bay | | | | | | |
|---|---|---|---|---|---|---|---|
| | Assessment criteria (indicator) | Reference conditions | Method | Assessment metrics | Assessment data | Score (+/÷) | |
| Cat. I: | • Winter surface water concentrations of DIN | 0.60 µM | NM | + 25% | 9.60 µM | + | |
| | • TP (summer) | 0.21 µM | NM | + 25% | 0.87 µM | + | |
| | • DIN (winter) | 0.22 µM | NM | + 25% | 0.51 µM | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 1.4 µg $l^{-1}$ | SM | + 25% | 1.66 µg $l^{-1}$ | – | |
| | • Eelgrass maximum depth limit | 6.8 m | HD | – 25% | 5.5 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 11 | Arkona Basin – Hjelm Bay | | | | | | |
|---|---|---|---|---|---|---|---|
| | Assessment criteria (indicator) | Reference conditions | Method | Assessment metrics | Assessment data | Score (+/÷) | |
| Cat. I: | • Winter surface water concentrations of DIN | 0.65 µM | NM | + 25% | 6.07 µM | + | |
| | • TP (summer) | 0.22 µM | NM | + 25% | 0.67 µM | + | |
| | • DIN (winter) | 0.26 µM | NM | + 25% | 0.54 µM | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 1.6 µg $l^{-1}$ | SM | + 25% | 1.91 µg $l^{-1}$ | – | |
| | • Secchi depth | 10.1 m | HD | – 25% | 7.9 m | – | |
| | • Eelgrass maximum depth limit | 9.4 m | HD | – 25% | 6.6 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 12 | **Arkona Basin – open sea** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Inputs (waterborne and atmosphere) | – | EJ | + 50% | – | + | |
| | • Winter surface water concentrations of nitrate | 2.44 µM | HD | + 50% | 3.86 µM | + | |
| | • Winter surface water concentration of DIP | 0.29 µM | HD | + 50% | 0.54 µM | (+) | |
| | • N/P ratio (winter) | – | – | – | – | n.s. | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Primary production | 80-90 $gCm^{-2}yr^{-1}$ | EJ | + 50% | 190 $gCm^{-2}yr^{-1}$ | + | |
| | • Chlorophyll-*a* concentration (annual mean) | 1.4-1.9 mg $m^{-3}$ | EJ/NM | + 50% | 2.37 mg $m^3$ | (+) | |
| | • Secchi depth | n.i. | HD | – 25% | n.i. | (+) | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Oxygen depletion | – | – | – | – | n.s. | |
| | • Macrozoobenthos | – | – | – | – | n.s. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.s. |
| | **Final assessment** | | | | | | **+** |

| 13 | **Bornholm Basin – open sea** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Inputs (waterborne and atmosphere) | – | EJ | + 50% | – | + | |
| | • Winter surface water concentrations of nitrate+nitrite-N | 1.70 µM | HD | + 50% | 3.72 µM | + | |
| | • Winter surface water concentration of DIP | 0.34 µM | HD | + 50% | 0.63 µM | + | |
| | • N/P ratio (winter) | – | – | – | – | n.s. | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Primary production | 80-90 $gCm^{-2}yr^{-1}$ | EJ | + 50% | 193 $gCm^{-2}yr^{-1}$ | + | |
| | • Chlorophyll-*a* concentration (annual mean) | 1.4-1.9 mg $m^3$ | EJ/NM | + 50% | 2.42 mg $m^3$ | (+) | |
| | • Secchi depth | n.i. | HD | – 25% | n.i. | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Oxygen depletion | – | – | – | – | n.s. | |
| | • Macrozoobenthos | – | – | – | – | n.s. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.s. |
| | **Final assessment** | | | | | | + |

| 14 | **Eastern Gotland Basin – open sea** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Inputs (waterborne and atmosphere) | – | EJ | + 50% | – | + | |
| | • Winter surface water concentrations of nitrate+nitrite-N | 2.29 µM | HD | + 50% | 3.72 µM | + | |
| | • Winter surface water concentration of DIP | 0.35 µM | HD | + 50% | 0.63 µM | + | |
| | • N/P ratio (winter) | – | – | – | – | n.s. | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Primary production | 80-90 $gCm^{-2}yr^{-1}$ | EJ | + 50% | 208 $gCm^{-2}yr^{-1}$ | + | |
| | • Chlorophyll-*a* concentration (annual mean) | 1.4-1.9 mg $m^3$ | EJ/NM | + 50% | 2.61 mg $m^3$ | (+) | |
| | • Secchi depth | n.i. | HD | – 25% | n.i. | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Oxygen depletion | n.i. | n.i. | n.i. | n.i. | n.s. | |
| | • Macrozoobenthos | n.i. | n.i. | n.i. | n.i. | n.s. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.s. |
| | **Final assessment** | | | | | | **+** |

| 15 | **Zingst Peninsula – open coast** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of NO3-N (Dec. – Feb.) | < 5 µM | SM | + 50% | 3.0 µM | – | |
| | • TN (annual mean) | < 10 µM | SM | + 50% | 19.4 µM | + | |
| | • Winter surface water concentration of DIP | < 0.3 µM | SM | + 50% | 0.67 µM | + | |
| | • TP (annual mean) | < 0.6 µM | SM | + 50% | 0.77 µM | – | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | 7.3 | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | < 1 µg l$^{-1}$ | SM | + 50% | 3.3 µg l$^{-1}$ | + | |
| | • Phytoplankton volume | < 1 mm$^{3}$ l$^{-1}$ | SM | + 50% | 0.4 mm$^{3}$ l$^{-1}$ | – | |
| | • Secchi depth | > 6 m | SM | – 25% | 6.2 m | – | |
| | • *Zostera marina* depth limit | 6-8 m | HD | – 25% | 4-7 m | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 16 | **Geltinger Bay – coastal waters** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of nitrate (NO3) | < 5 µM | SM | + 50% | 5.8 µM | – | |
| | • Winter surface water concentration of TN | < 10 µM | SM | + 50% | 17.4 µM | + | |
| | • Winter surface water concentration of DIP | < 0.3 µM | SM | + 50% | 0.77 µM | + | |
| | • Winter surface water concentration of TP | < 0.6 µM | SM | + 50% | 0.48 µM | – | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | 8.9 | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Spring chlorophyll-*a* concentration (Mar-May) | < 1 µg l$^{-1}$ | SM | + 50% | 2.5 µg l$^{-1}$ | + | |
| | • Secchi depth (March – May) | > 6 m | SM | – 25% | 6.2 m | – | |
| | • Eelgrass maximum depth limit | 6-8 m | HD | – 25% | 4.5 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 17 | South-eastern Gotland Basin – open sea | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • DIP | 0.25 µmol dm$^{-3}$ | HD/SM | + 50% | 0.53 µmol dm$^{-3}$ | + | |
| | • TOxN [TOxN=NO3+NO2] | 1.75 µmol dm$^{-3}$ | SM/EJ | + 50% | 2.97 µmol dm$^{-3}$ | + | |
| | • DIN | 2.50 µmol dm$^{-3}$ | SM/EJ | + 50% | 3.31 µmol dm$^{-3}$ | – | |
| | • TP | 0.6 µmol dm$^{-3}$ | SM/EJ | + 50% | 0.60 µmol dm$^{-3}$ | – | |
| | • TN | 14.0 µmol dm$^{-3}$ | SM/EJ | + 50% | 20.6 µmol dm$^{-3}$ | – | |
| | • N:P | 10 | SM/EJ | ± 50% | 6.24 | – | |
| | • N:P:Si | [0.7] | SM/EJ | ± 50% | [0.6] | (–) | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Chlorophyll-*a* concentration (summer, August mean) | n.i. | EJ | + 50% | 2.00 | n.i. | |
| | • Chlorophyll-*a* concentration (annual, March-November, mean) | n.i. | EJ | + 50% | 2.32 | n.i. | |
| | • Secchi depth (spring mean ) | 13.0 m | HD/SM | – 25% | 9.97 m | – | |
| | • Secchi depth (summer – August mean) | 8.0 m | HD/SM | – 25% | 7.60 m | – | |
| | • Secchi depth (annual mean) | 11.2 m | HD/SM | – 25% | 9.82 m | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Phytoplankton (AB [mio. unit m$^{-3}$], BI [mg C m$^{-3}$]) | n.i. | n.i. | n.i. | (213.9, 2.81) | n.i. | |
| | • Mesozooplankton (AB [ind.m$^{-3}$], BI [mg m$^{-3}$]) | n.i. | n.i. | n.i. | (17463, 61.87) | n.i. | |
| | • Macroinvertebrates (TR [N of sp.], AB [N m$^{-2}$], BI [g m$^{-2}$]) | 6.8, 548,19.7 | HD | ± 50% | 2.5, 82, 12.6 | + | |
| | • Oxygen concentrations (summer) | 5.29 mg l$^{-1}$ | HD | n.i. | 3.04 mg l$^{-1}$ | n.i. | |
| | • Oxygen concentrations (min.) | n.i. | – | < 2 mg l$^{-1}$ | 1.87 mg l$^{-1}$ | + | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment`** | | | | | | **+** |

| 18 | Gdansk Deep – open sea | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • DIP | 0.25 µmol dm$^{-3}$ | HD/SM | + 50% | 0.46 µmol dm$^{-3}$ | + | |
| | • TOxN | 3.00 µmol dm$^{-3}$ | SM/EJ | + 50% | 4.05 µmol dm$^{-3}$ | – | |
| | • DIN | 4.25 µmol dm$^{-3}$ | SM/EJ | + 50% | 4.51 µmol dm$^{-3}$ | – | |
| | • N:P | 17.0 | SM/EJ | ± 50% | 13.8 | – | |
| | • N:P:Si | [0.5] | SM/EJ | ± 50% | [1.1] | (–) | |
| | • TN | 14.0 µmol dm$^{-3}$ | SM/EJ | ± 50% | 20.6 µmol dm$^{-3}$ | – | |
| | • TP | 0.6 µmol dm$^{-3}$ | SM/EJ | ± 50% | 0.57 µmol dm$^{-3}$ | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Chlorophyll-*a* concentration (summer, August mean) | ? mg m$^{-3}$ | EJ | + 50% | 1.51 mg m$^{-3}$ | ? | |
| | • Chlorophyll-*a* concentration (annual, March-November, mean) | ? mg m$^{-3}$ | EJ | + 50% | 3.34 mg m$^{-3}$ | (+) | |
| | • Secchi depth (spring mean) | 9.2 m | HD/SM | – 25% | 6.03 m | + | |
| | • Secchi depth (summer – August) | 7.5 m | HD/SM | – 25% | 5.90 m | – | |
| | • Secchi depth (annual mean) | 10.0 m | HD/SM | – 25% | 7.73 m | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Phytoplankton (AB [mio. unit m$^{-3}$], BI [mg C m$^{-3}$]) | n.i. | n.i. | n.i. | (63.3, 6.18 ) | n.i. | |
| | • Mesozooplankton (AB [ind.m$^{-3}$], BI [mg m$^{-3}$]) | n.i. | n.i. | n.i. | (13789, 115.3) | n.i. | |
| | • Macroinvertebrates (TR [N of sp.], AB [N m$^{-2}$], BI [g m$^{-2}$]) | 1.9, 42.9, 19.1 | HD | ? | 0-1,0-4,0-0.05 | (+) | |
| | • Oxygen concentrations (summer) | 1.74 mg l$^{-1}$ | HD | < 4 mg l$^{-1}$ | – 0.95 mg l$^{-1}$ | + | |
| | • $H_2S$ (summer) | [12 µmol dm$^{-3}$] | | ? | 27.5 µmol dm$^{-3}$ | + | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 19 | Rowy-Jaroslawiec – coastal water | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • TDP (Pomeranian rivers) | 0.5 µmol dm$^{-3}$ | EJ | + 50% | 50.2 µmol dm$^{-3}$ | + | |
| | • N (Pomeranian rivers) | 70.8 µmol dm$^{-3}$ | EJ | + 50% | 777 µmol dm$^{-3}$ | + | |
| | • N-air | 68 mg N m$^{-2}$ | EJ | + 50% | 644 mg N m$^{-2}$ | + | |
| | • DIP | 0.35 µmol dm$^{-3}$ | HD/SM | + 50% | 0.50 µmol dm$^{-3}$ | – | |
| | • TOxN | 3.50 µmol dm$^{-3}$ | SM/EJ | + 50% | 4.64 µmol dm$^{-3}$ | – | |
| | • DIN | 4.00 µmol dm$^{-3}$ | SM/EJ | + 50% | 5.10 µmol dm$^{-3}$ | – | |
| | • N:P | 11.4 | SM/EJ | ± 50% | 9.94 | – | |
| | • N:P:Si | [0.8] | SM/EJ | ± 50% | [0.72] | (–) | |
| | • TN | 13.0 µmol dm$^{-3}$ | SM/EJ | ± 50% | 20.3 µmol dm$^{-3}$ | + | |
| | • TP | 0.6 µmol dm$^{-3}$ | SM/EJ | ± 50% | 0.89 µmol dm$^{-3}$ | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Chlorophyll-*a* concentration (summer, August mean) | 2.10 m | EJ | + 50% | 2.22 m | – | |
| | • Chlorophyll-*a* concentration (annual, March-November, mean) | n.i. | EJ | + 50% | 2.51 m | n.i. | |
| | • Secchi depth (spring mean) | 10.0 m | HD/SM | – 25% | 6.98 m | + | |
| | • Secchi depth (summer - August) | 7.5 m | HD/SM | – 25% | 6.34 m | – | |
| | • Secchi depth (annual mean) | 8.7 m | HD/SM | – 25% | 6.93 m | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Phytoplankton (AB [mio. unit m$^{-3}$], BI [mg C m$^{-3}$]) | n.i. | n.i. | n.i. | (106.1, 49.1) | ? | |
| | • Mesozooplankton (AB [ind.m$^{-3}$], BI [mg m$^{-3}$]) | n.i. | n.i. | n.i. | (13461, 93.2) | ? | |
| | • Macroinvertebrates (TR [N of sp.], AB [N m$^{-2}$], BI [g m$^{-2}$]) | 3.7, 187, 18.5 | HD | ? | 11.8, 2109, 80 | + | |
| | • Oxygen concentrations (summer) | > 8.57 mg l$^{-1}$ | HD/SM | ? | 8.72 mg l$^{-1}$ | – | |
| | • Oxygen concentrations (min.) | n.i. | – | < 4 mg l$^{-1}$ | 7.00 mg l$^{-1}$ | – | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 20 | Dziwna-Swina – coastal water | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • TDP (Oder) | 0.6 µmol dm$^{-3}$ | NM | + 50% | 7.79 µmol dm$^{-3}$ | ? | |
| | • DIN (Oder) | 71.5 µmol dm$^{-3}$ | NM | + 50% | 231 µmol dm$^{-3}$ | ? | |
| | • DIP | 0.47 µmol dm$^{-3}$ | HD/SM | + 50% | 0.63 µmol dm$^{-3}$ | – | |
| | • TOxN | 8.00 µmol dm$^{-3}$ | SM/EJ | + 50% | 16.4 µmol dm$^{-3}$ | + | |
| | • DIN | 9.0 µmol dm$^{-3}$ | SM/EJ | + 50% | 16.6 µmol dm$^{-3}$ | + | |
| | • N:P | 19.1 | SM/EJ | ± 50% | 26.3 | – | |
| | • N:P:Si | [1.45] | SM/EJ | ± 50% | [1.54] | (–) | |
| | • TN | 21.0 µmol dm$^{-3}$ | SM/EJ | ± 50% | 23.9 µmol dm$^{-3}$ | – | |
| | • TP | 0.9 µmol dm$^{-3}$ | SM/EJ | ± 50% | 0.83 µmol dm$^{-3}$ | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Chlorophyll-*a* concentration (summer, August mean) | 2.10 mg m$^{-3}$ | EJ | + 50% | 3.74 mg m$^{-3}$ | + | |
| | • Chlorophyll-*a* concentration (annual, March-November, mean) | n.i. | EJ | + 50% | 4.43 mg m$^{-3}$ | n.i. | |
| | • Secchi depth (spring mean) | 3.7 m | HD/SM | – 25% | 3.8 m | – | |
| | • Secchi depth (summer - August) | 6.0 m | HD/SM | – 25% | 3.9 m | + | |
| | • Secchi depth (annual mean) | 4.1 m | HD/SM | – 25% | 4.18 m | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Oxygen concentrations (summer) | > 8.57 mg l$^{-1}$ | SM/EJ | n.i. | 7.72 mg l$^{-1}$ | – | |
| | • Oxygen concentrations (min.) | n.i. | – | < 4 mg l$^{-1}$ | 4.80 mg l$^{-1}$ | – | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | – |
| | **Final assessment** | | | | | | **+** |

| 21 | Outer Puck Bay – transitional water | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • TDP (Vistula) | 0.6 μmol $dm^{-3}$ | NM | + 50% | 9.0 μmol $dm^{-3}$ | + | |
| | • N (Vistula) | 71.5 μmol $dm^{-3}$ | NM | + 50% | 123 μmol $dm^{-3}$ | + | |
| | • DIP | 0.4 μmol $dm^{-3}$ | HD/SM | + 50% | 0.46 μmol $dm^{-3}$ | + | |
| | • TOxN | 5.50 μmol $dm^{-3}$ | SM/EJ | + 50% | 5.08 μmol $dm^{-3}$ | – | |
| | • DIN | 6.50 μmol $dm^{-3}$ | SM/EJ | + 50% | 6.18 μmol $dm^{-3}$ | – | |
| | • N:P | 16.3 | SM/EJ | ± 50% | 16.9 | – | |
| | • N:P:Si | [1.0] | SM/EJ | ± 50% | [2.7] | (+) | |
| | • TN | 18.0 μmol $dm^{-3}$ | SM/EJ | ± 50% | 25.8 μmol $dm^{-3}$ | + | |
| | • TP | 0.7 μmol $dm^{-3}$ | SM/EJ | ± 50% | 1.04 μmol $dm^{-3}$ | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Chlorophyll-*a* concentration (summer, August mean) | 2.10 | EJ | + 50% | 7.01 | + | |
| | • Chlorophyll-*a* concentration (annual, March-November, mean) | 2.2 | EJ | + 50% | 5.57 | + | |
| | • Secchi depth (spring mean) | 6.5 m | HD/SM | – 25% | 4.7 m | + | |
| | • Secchi depth (summer - August) | 6.0 m | HD/SM | – 25% | 3.5 m | + | |
| | • Secchi depth (annual mean) | 7.7 m | HD/SM | – 25% | 4.7 m | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Phytoplankton (AB [mio. unit $m^{-3}$], BI [mg C $m^{-3}$]) | n.i. | n.i. | n.i. | (492.4, 11.13) | n.i. | |
| | • Mesozooplankton (AB, BI) | n.i. | n.i. | n.i. | (37275, 180.6) | n.i. | |
| | • Macroinvertebrates (TR [N of sp.], AB [N $m^{-2}$], BI [g $m^{-2}$]) | 4.7, 482, 89.2 | HD | n.i. | 9.6, 3123, 245 | + | |
| | • Oxygen concentrations (summer) | > 8.57 mg $l^{-1}$ | HD | n.i. | 7.96 mg $l^{-1}$ | – | |
| | • Oxygen concentrations (min.) | n.i. | – | < 4 mg $l^{-1}$ | 2.53 mg $l^{-1}$ | + | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 22 | Lithuanian open waters | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of DIN | 5 µM | EJ | + 50% | 6 µM | – | |
| | • Winter surface water concentration of DIP | 0.3 µM | EJ | + 50% | 0.5 µM | – | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | < 16 | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | – |
| Cat. II: | • Chlorophyll-*a* concentration (annual mean) | 3 µg $l^{-1}$ | EJ | + 50% | 4.03 µg $l^{-1}$ | – | |
| | • Phytoplankton biomass (annual mean) | 1.5 mg $l^{-1}$ | EJ | + 50% | 1.3 mg $l^{-1}$ | – | |
| | • Secchi depth | > 8 m | EJ | + 25% | 5.7 m | + | |
| | • Harmful algae (biomass) (June – September) | 0.5 mg $l^{-1}$ | EJ | + 50% | 0.5 mg $l^{-1}$ | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Oxygen | n.i. | n.i. | < 4 mg $l^{-1}$ | < 2 mg $l^{-1}$ | + | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 23 | Lithuanian coastal waters | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat I: | • Winter surface water concentrations of DIN | 10 μM | EJ | + 50% | 15 μM | + | |
| | • Winter surface water concentration of DIP | 0.3 μM | EJ | + 50% | 0.6 μM | + | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | 35 | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration (annual mean) | 3 μg l$^{-1}$ | EJ | + 50% | 4.52 μg l$^{-1}$ | + | |
| | • Phytoplankton biomass (annual mean) | 1.5 mg l$^{-1}$ | EJ | + 50% | 2.0 mg l$^{-1}$ | – | |
| | • Secchi depth | > 6.5 m | EJ | – 25% | 4.3 m | + | |
| | • Harmful algae (biomass) (June – September) | 0.5 mg l$^{-1}$ | EJ | + 50% | 0.6 mg l$^{-1}$ | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 24 | Lithuanian transitional waters | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Land-based inputs (TN) | 25000 t/y | EJ | + 50% | 26000 | – | |
| | • Land-based inputs (TP) | 1400 t/y | EJ | + 50% | 1500 | – | |
| | • Winter surface water concentrations of nitrate+nitrite-N | 12 μM | EJ | + 50% | 23 μM | + | |
| | • Winter surface water concentration of DIP | 0.4 μM | EJ | + 50% | 0.6 μM | + | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | 43 | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 6.5 μg l$^{-1}$ | EJ | + 50% | 8.64 μg l$^{-1}$ | – | |
| | • Secchi depth | > 6 m | EJ | – 25% | 3.1 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 25 | Gulf of Riga – central open parts | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of nitrate+nitrite-N | 4 μM | EJ | + 50% | 11.2 μM | + | |
| | • Winter surface water concentration of DIP | 0.13 μM | EJ | + 50% | 0.85 μM | + | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | 13 | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 1.1 μg l$^{-1}$ | EJ | + 50% | 5.1 μg l$^{-1}$ | + | |
| | • Secchi depth | 6 m | EJ | – 34% | 3.37 m | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 26 | Gulf of Riga – transitional waters | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of nitrate+nitrite-N | 6.5 µM | EJ | + 50% | 21.73 µM | + | |
| | • Winter surface water concentration of DIP | 0.4 µM | EJ | + 50% | 0.97 µM | + | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | 22 | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 2 µg $l^{-1}$ | EJ | + 50% | 9.0 µg $l^{-1}$ | + | |
| | • Secchi depth | 5 m | EJ | – 40% | 2.3 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Zoobenthos Biotic Index | 0-1 | EJ | > 2 | 1,8 | – | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | – |
| | **Final assessment** | | | | | | **+** |

| 27 | Gulf of Riga – northern coastal waters | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of TN | 9 µM | EJ | + 50% | 27.44 µM | + | |
| | • Winter surface water concentration of TP | 0.25 µM | NM | + 50% | 0.65 µM | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 2.1 µg $l^{-1}$ | NM | + 50% | 6.0 µg $l^{-1}$ | + | |
| | • Secchi depth | 5 m | EJ | – 25% | 2.2 m | + | |
| | • *Fucus* depth distribution | 6 m | EJ | – 25% | 1.5 m | + | |
| | • Vegetation depth distribution | > 9 m | HD | – 25% | 8.5 m | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • Zoobenthos Biotic Index | 0-1 | EJ | + 50% | 4 | + | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 28 | Western Gotland Basin – open sea | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Land-based inputs (TN) | 4275 t $y^{-1}$ | NM | + 50% | 25500 t $y^{-1}$ | + | |
| | • Land-based inputs (TP) | 230 t $y^{-1}$ | NM | + 50% | 1310 t $y^{-1}$ | + | |
| | • Winter surface water concentrations of nitrate+nitrite | 2.0 µM | HD | + 50% | 3.0 µM | – | |
| | • Winter surface water concentration of DIP | 0.25 µM | HD | + 50% | 0.52 µM | + | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | 6.81 | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Primary production (annual) | 70 gC $m^2$ $y^{-1}$ | SM | + 50% | 150 gC $m^2$ $y^{-1}$ | + | |
| | • Primary production (Net) | 22 gC $m^2$ $y^{-1}$ | SM | + 50% | 45 gC $m^2$ $y^{-1}$ | + | |
| | • Summer chlorophyll-*a* concentration | 1.0 µg $l^{-1}$ | HD | + 50% | 2.58 µg $l^{-1}$ | + | |
| | • Secchi depth | 10 m | SM | – 25% | 5.7 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 29 | Western Gotland basin – Askö | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of nitrate+nitrite | 2.5 µM | HD | + 50% | 5.6 µM | + | |
| | • Winter surface water concentration of DIP | 0.39 µM | HD | + 50% | 0.7 µM | + | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | 8 | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 1.0 µg $l^{-1}$ | HD | + 50% | 1.7 µg $l^{-1}$ | + | |
| | • Phytoplankton biovolume | 0.16 $mm^3$ $l^{-1}$ | HD | + 50 % | 0.33 $mm^3$ $l^{-1}$ | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • BQI (> 20 m) | > 8.5 | EJ | ± 50% | 5.2 | (+) | |
| | • BQI (< 20 m) | > 11.5 | EJ | ± 50% | 5.6 | + | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 30 | Northern Gotland basin – open sea | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of nitrate+nitrite | 2.0 µM | HD | + 50% | 3.0 µM | – | |
| | • Winter surface water concentration of DIP | 0.25 µM | HD | + 50% | 0.51 µM | + | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | 7.1 | + | |
| | • Winter DIN: SiO4 | 1 | EJ | ± 50% | 0.39 | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Primary production | 70 gC $m^2$ $y^{-1}$ | SM | + 50% | 150 gC $m^2$ $y^{-1}$ | + | |
| | • Summer chlorophyll-*a* concentration | 1 µg $l^{-1}$ | HD | + 50% | 2.2 µg $l^{-1}$ | + | |
| | • Secchi depth | 10 m | SM | – 25% | 5.5 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 31 | Gulf of Finland – open sea | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of nitrate+nitrite | 2.5 µM | EJ | + 50% | 8.8 µM | + | |
| | • Winter surface water concentration of DIP | 0.30 µM | EJ | + 50% | 0.9 µM | + | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | 10.5 | – | |
| | • Winter DIN:SiO4 | 1 | EJ | + 50% | 0.1 | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 1.2 µg $l^{-1}$ | EJ | + 50% | 4.9 µg $l^{-1}$ | + | |
| | • Secchi depth | 8 m | HD | – 25% | 4.0 m | + | |
| | • Abundance of *Aphanizomenon flos-aquae* (July – August) | 12500 units $l^{-1}$ | HD | + 50% | 74369 units $l^{-1}$ | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 32 | Gulf of Finland – coastal type A | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of nitrate+nitrite | 7.9 µM | EJ | + 50% | 15.7 µM | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration (July – August) | 3.9 µg $l^{-1}$ | EJ | + 50% | 8.1 µg $l^{-1}$ | + | |
| | • Secchi depth (July – August) | 5.1 m | EJ | – 25% | 2.4 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 33 | Gulf of Finland – coastal type B | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of nitrate+nitrite | 7 µM | EJ | + 50% | 12.8 µM | + | |
| | • Winter surface water concentration of DIP | 0.48 µM | EJ | + 50% | 1.16 µM | + | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | ? | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration (July – August) | 2.2 µg $l^{-1}$ | EJ | + 50% | 5.3 µg $l^{-1}$ | + | |
| | • Secchi depth (July – August) | 6.2 m | EJ | – 25% | 3.1 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 34 | Gulf of Finland – coastal type C | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of nitrate+nitrite | 5.8 µM | EJ | + 50% | 19 µM | + | |
| | • Winter surface water concentration of DIP | 0.51 µM | EJ | + 50% | 0.63 µM | – | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | ? | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration (July – August) | 2.4 µg $l^{-1}$ | EJ | + 50% | 5.7 µg $l^{-1}$ | + | |
| | • Secchi depth (July – August) | 5.6 m | EJ | – 25% | 2.3 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 35 | **Gulf of Finland – coastal type E** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of nitrate+nitrite (Jan–Mar) | 3.8μM | EJ | + 50% | 7.9 μM | + | |
| | • Winter surface water concentration of DIP (January – March) | 0.39 μM | EJ | + 50% | 0.87 μM | + | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | ? | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration (July – August) | 1.5 μg $l^{-1}$ | EJ | + 50% | 4.0 μg $l^{-1}$ | + | |
| | • Secchi depth (July – August) | 7.9 m | EJ | – 25% | 3.7 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 36 | **Gulf of Finland – Tallinn Bay** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • No information available at present | n.i. | n.i. | + 50% | n.i. | n.i. | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | n.i. |
| Cat. II: | • Summer chlorophyll-*a* concentration (June – September) | 1.9 μg $l^{-1}$ | EJ | + 50% | 3.6 μg $l^{-1}$ | + | |
| | • Secchi depth (June – September) | 6 m | EJ | – 25% | 4.2 m | + | |
| | • Abundance of *Aphanizomenon flos-aquae* (July – August) | 31520 units $l^{-1}$ | HD | + 50% | 85800 units $l^{-1}$ | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 37 | **Gulf of Finland – Narva Bay** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • No information available at present | n.i. | n.i. | + 50% | n.i. | n.i. | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | n.i. |
| Cat. II: | • Summer chlorophyll-*a* concentration (June – September) | 1.9 μg $l^{-1}$ | EJ | + 50% | 5.5 μg $l^{-1}$ | + | |
| | • Secchi depth (June – September) | 6 m | EJ | – 25% | 2.7 m | + | |
| | • Abundance of *Aphanizomenon flos-aquae* (July – August) | 31520 units $l^{-1}$ | HD | + 50% | 83425 units $l^{-1}$ | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 38 | **Bothnian Sea – open sea** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Land-based inputs (TN) | 22025 t/y | NM | + 50% | 33200 t/y | + | |
| | • Land-based inputs (TP) | 1820 t/y | NM | + 50% | 2430 t/y | – | |
| | • Atmospheric deposition | ? | ? | + 50% | ? | ? | |
| | • Winter surface water concentrations of nitrate+nitrite | 2. μM | HD | + 50% | 2.71 μM | – | |
| | • Winter surface water concentration of DIP | 0.2 μM | HD | + 50% | 0.17 μM | – | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | 16 | – | |
| | • Winter DIN: SiO4 | 1 | EJ | ± 50% | 0.23 | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 1 μg l$^{-1}$ | HD | + 50% | 1.0 μg l$^{-1}$ | – | |
| | • Secchi depth | 9 m | SM | – 25% | 7 m | – | |
| | • Phytoplankton biovolume | 0.3 mm$^3$ l$^{-1}$ | EJ | + 50% | 0.3 mm$^3$ l$^{-1}$ | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | – |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 39 | **Bothnian Sea – Örefjärden** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of nitrate+nitrite | 4.2 μmol l$^{-1}$ | HD | + 50% | 5.6 μmol l$^{-1}$ | – | |
| | • Winter surface water concentration of DIP | 0.2 μmol l$^{-1}$ | HD | + 50% | 0.23 μmol l$^{-1}$ | – | |
| | • Winter DIN:DIP | 16 | EJ | ± 50% | 10 – 15 | – | |
| | • Winter DIN:SiO4 | 1 | EJ | ± 50% | 0.21 | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 1.3 μg l$^{-1}$ | HD | + 50% | 1.8 μg l$^{-1}$ | – | |
| | • Phytoplankton biovolume (June-August) | 0.3 mm$^3$ l$^{-1}$ | EJ | + 50% | 0.38 mm$^3$ l$^{-1}$ | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | – |
| Cat. III: | • BQI (> 20 m) | > 10.8 | EJ | ± 50% | 6.1 | + | |
| | • BQI (< 20 m) | > 10.8 | EJ | ± 50% | 4.9 | + | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | + |
| | **Final assessment** | | | | | | **+** |

| 40 | **Bothnian Bay – open sea** | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of DIN | 3.5 μM | EJ | + 50% | 7.1 μM | + | |
| | • Winter surface water concentration of DIP | 0.10 μM | EJ | + 50% | 0.04 μM | – | |
| | • Winter surface water DIN:DIP ratio | 16 | EJ | ± 50% | 190 | + | |
| | • Winter surface water DIN:SiO4 ratio | 1 | EJ | ± 50% | 0.24 | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration (June – September) | 1.0 μg l$^{-1}$ | EJ | + 50% | 1.8 μg l$^{-1}$ | + | |
| | • Summer Secchi depth (June – September) | 7.5 m | EJ | – 25% | 5.8 m | – | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 41 | Bothnian Bay – coastal type J | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of nitrate+nitrite | 5.5 μM | EJ | + 50% | 15 μM | + | |
| | • Winter surface water concentration of DIP | 0.13 μM | EJ | + 50% | 0.39 μM | – | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 1.0 μg $l^{-1}$ | EJ | + 50% | 1.8 μg $l^{-1}$ | + | |
| | • Secchi depth | 4.5 m | HD | – 25% | 2.2 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

| 42 | Bothnian Bay – coastal type K | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Assessment criteria (indicator)** | **Reference conditions** | **Method** | **Assessment metrics** | **Assessment data** | **Score (+/÷)** | |
| Cat. I: | • Winter surface water concentrations of nitrate+nitrite | 5.4 μM | EJ | + 50% | 8.6 μM | + | |
| | • Winter surface water concentration of DIP | 0.10 μM | EJ | + 50% | 0.19 μM | + | |
| | • *Sum for Cat. I (one out = all out)* | | | | | | + |
| Cat. II: | • Summer chlorophyll-*a* concentration | 1.3 μg $l^{-1}$ | EJ | + 50% | 2.5 μg $l^{-1}$ | + | |
| | • Secchi depth | 7.1 m | EJ | – 25% | 3.5 m | + | |
| | • *Sum for Cat. II (one out = all out)* | | | | | | + |
| Cat. III: | • No information available at present | n.i. | n.i. | n.i. | n.i. | n.i. | |
| | • *Sum for Cat. III (one out = all out)* | | | | | | n.i. |
| | **Final assessment** | | | | | | **+** |

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