Testing of indicators for the marine and coastal environment in Europe

Part 1: Eutrophication and integrated coastal zone management

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Summary

Indicator reporting by the European Environment Agency (EEA) is based on information collected regularly, much of it on an annual basis. Indicators are being developed to facilitate communication on the present and future state of the environment in relation to European environmental policies. Indicator testing and reporting by the European Topic Centres (ETCs) are necessary for the further harmonisation of assessment reports from the EEA and organisations administering the regional conventions for European marine waters.

This report is the first of three volumes, which describe the development of coastal indicators by the European Topic Centre on Marine and Coastal Environment (ETC/MCE) during the years 1998–2001. It explains the process and results of a study of potential pressure and state indicators for eutrophication. This study involved identification of data availability (initial phase) and subsequent processing of a selected set of descriptive parameters for eutrophication (detailed assessment). The report also describes the development of, and information gathering for, a response indicator measuring progress in integrated coastal zone management (ICZM) at the subnational (regional) level within the European Union. The primary aim of this report is to test indicators for EEA reporting in relation to the development of a core set of indicators and not to make assessments.

Data availability
Data availability was investigated by means of an ETC/MCE indicator questionnaire circulated to EEA member countries (EIONET) and the International Council for Exploration of the Sea (ICES) at the beginning of 1999. The OSPAR, Helsinki Commission (Helcom) and United Nations Environment Programme/Mediterranean action plan (UNEP/MAP) secretariats were asked directly for data not available at ICES.

The questionnaire concentrated on descriptive parameters for eutrophication and pollution. The responses have enabled the ETC/MCE to extend its databases of marine information on European coastal zones. The ETC/MCE database on characteristics of coastal waters, estuaries, lagoons and fjords is described separately (Nygaard et al., 2001).

The information received directly from countries proved insufficiently comparable at the international level to be useful for further study alongside what had been received from ICES. No use was made of UNEP/MAP data, because the Medpol database concerns hazardous substances, while this study deals with eutrophication.

The ICES databases, containing data obtained either from international research or through OSPAR and Helcom, should be a valuable source for the ETC/MCE indicator database. The data are updated yearly, quality assured, and based on standardised protocols for monitoring and good laboratory practice. The potential indicator for integrated coastal zone management was developed using information obtained from experts and from literature in the public domain. There is still no regular mechanism in place for the collection of data on ICZM at national or European level.

Trend detection
Time series analysis performed for this study indicated that progress on measures reported at the national level was reflected in changes in the state of the environment at various locations. The changes appeared to be detected best at those locations which are regarded as references for larger catchment areas. Where changes were not detected, the buffering effect of the natural environment and the effect of meteorological conditions may have played a role in obscuring trends. The length of time series and different starting years influenced the ability to detect statistically significant trends.

Conclusions
The monitoring obligations and maintenance of the Medpol database, to which all the countries around the Mediterranean contribute, are not at present adequate to meet the data needs identified in this report for the Mediterranean coastal zones of France, Greece, Italy and Spain. There is a need either to improve data

collection through the Medpol database or to organise direct data gathering through national databases in order to improve the ETC/MCE indicator database.

A necessary first step towards the development of the ETC/MCE indicator database is that the countries themselves should identify the stations to be used for this purpose. The details of this process are to be worked out together with the countries involved, as agreed at the EIONET meeting held in La Spezia, Italy, in November 1999. The process of common identification and selection of stations to be used for indicator reporting at the European level should preferably be developed within the context of future obligatory reporting under the EU water framework directive. To this end, coastal zones should be related to catchment areas.

This report also identifies in section 2.5.3 on improvement of eutrophication indicators some concrete further work on data flow, selection and aggregation, as well as for the use of targets and statistical tools for indicators on nutrient concentrations, bottom oxygen and riverine and atmosperic inputs.

Countries are now working on the definition of their coastal zones. This will make it easier for them to report in future on the marine and coastal environment in the context of integrated coastal zone management. Important information on the land side is available from a range of other databases, including the Eurostat GISCO database, the Lacoast database at the Joint Research Centre (JRC), the Corine land cover database and databases in other topic centres. This information on the land side makes it possible to gain a more complete picture across the DPSIR (driving forces, pressures, states, impacts, responses) framework and therefore to achieve greater understanding on which to base changes to current policies and the development of new ones.

The findings from the ICZM indicator development confirm the importance of better organisation and greater public availability of data and information on the ICZM process. This report therefore recommends in its section 3.4.1 on improvement of the ICZM indicator several activities for further development of this indicator regarding data collection, development of an ICZM network and aggregation level of information.

A joint working group of the regional convention organisations and the EEA member countries has been working on the harmonisation of indicator development. To this end, this report recommends a joint work plan based on a multi-year programme giving priority to the development of agreed protocols for trend detection using indicators and a European classification of coastal and marine water quality based on background or reference values specific to individual waters.

1. Introduction

1.1. Background

The development of indicators has been an ongoing process at the ETC/MCE.

A preliminary set of indicators was defined in 1996 (EEA, 1998b). A list of data requirements has also been produced and a study of marine data from the coastal zones of the Netherlands was conducted in 1997. Due to a lack of comparable European data, this study concentrated on the aggregation method used in relation to the establishment of reference values. There has been further data gathering in the context of the preparation of the marine and coastal environment chapters in the EEA state and outlook reports discussed below.

In 1998, the EEA presented a report entitled *Europe's environment: The second assessment* (EEA, 1998a). The main subjects identified as matters of concern in the marine and coastal environment chapter are eutrophication, contamination, overfishing and the degradation of coastal zones. The report's data on eutrophication and chemical substances are based on a selected set of data collected under the marine conventions. The report also includes a graphical representation and classification of yearly figures for concentrations and loads of nutrients, pollutants and oil (both in direct discharges and in rivers). The results make it clear that the regular updating of data calls for the development of proper methods of data processing.

This was followed in 1999 by a report *Environment in the European Union at the turn of the century* (EEA, 1999a), which assesses the actual and foreseeable state of the environment in the EU and the accession countries. The predictions are based on socioeconomic and environmental policies assumed to have been implemented by 2010. The report describes the interrelationships between human activities and the environment, and is intended to inform policy-makers on developments in environmental parameters and the effects of measures taken. As such, it provides a background for strategic policy development. The analysis starts with driving forces (or human activities) which lead to pressures on the environment (e.g. emissions). The resulting changes in the state of the environment may lead to adverse impacts, and responses must then be defined to reduce these.

The report reviews the main challenges and problems in the coastal zones of four regional seas: the Atlantic, the North Sea, the Baltic and the western Mediterranean. The pressures of economic growth and spatial development differ within regions and the varying ecological qualities of the coastal zones of the regional seas mean that they display different degrees of sensitivity to the pressures on them (Box 1.1).

The present study on indicators was launched in 1998 as part of the ETC/MCE work programme. Amongst other parameters, the suitability of phosphate and nitrate for use as indicators was examined. They were included as indicators of the state of coastal waters under the theme of eutrophication in the first report produced by the EEA in a series of regular indicator-based reports entitled *Environmental signals 2000* (EEA, 2000). The results presented there were based on a random selection of 50 % of the data selected for testing. The present report covers 100 % of the data selected for testing. There is no substantial change in the major conclusions.

1.2. Objectives

The need to develop a common set of indicators was stressed at the Fourth European Conference of Ministers for the Environment, held in Aarhus in June 1998. Indicators can play a vital part in focusing attention on environmental change and the progress of sustainability and illuminating its real significance. Indicators are quantified information which help to explain how things are changing over time or vary spatially.

The consistent and timely provision of reliable and relevant data and information to support widely agreed key indicator sets should be a main objective of action to improve monitoring and data gathering. To

Box 1.1. An overview of the main challenges and problems in the selected regions — this shows that, although there are common pressures, the impacts on the marine parts of the coastal zones differ in the major EU maritime regions

Atlantic	North Sea	Baltic	Western Mediterranean
Dichotomy between underexploitation of abandoned areas and overexploitation of increasingly populated areas under development. Risks linked to natural conditions (insufficient drinking water, erosion, fires, flooding). Threat to coastal ecosystems from coastal erosion, regression of beaches and scarcity of water resources in humid southern zones. Seasonal pressure of tourism, especially in southern Brittany. Qualitative degradation of rivers and seawater (industrial dumping and abandoned mining sites). Appearance of extreme situations in agriculture: overexploitation of certain zones, abandonment of others. Growing urban pressure, especially around 'capitals' and coastal cities, and diffuse and uncontrolled urbanisation in interior zones.	Strong consensus in favour of integrated management of coastal areas. Improve quality and availability of operational information for spatial planning. Encourage renewable forms of energy. Coastal erosion. Reduce level of marine pollution. Concern to protect natural areas still untouched by economic development.	Increase in eutrophication leading to the proliferation of algae. Origin of major problems: nitrogen due to combustion of fossil fuels, agriculture and landfills; added phosphorus (agriculture and landfills). Numerous hot spots (direct industrial discharges). Overall vulnerability of the Baltic Sea due to less saline water, shallow water, complex coastal morphology and its nature as a closed sea (narrow exchange corridors with the North Sea).	Conscious of rich natural heritage which is threatened and is at risk (natural risks, agriculture, tourism, transport, urbanisation in coastal areas). Prospects for fragile or low-density areas in all aspects. Control of tourism development. Manage and protect inland and marine waters; specific problems in semi-arid zones; regulating debit and quality of water, provision of water and risks linked to natural conditions (erosion, desertification, saline intrusions in groundwater).

Sources: EEA (1999a); NFP Finland

achieve this, the EEA is acting as a facilitator mediating between member countries, Community institutions and other environmental organisations and programmes.

The aim of this study of a set of provisional indicators derived from readily available data is therefore to enable concise, reliable, quantitative information to be supplied on a regular basis to support EEA reporting. The objective is to assist the development of an indicator database supplying basic (indicator) information on European coastal zones within the DPSIR assessment framework.

1.3. Scope

This report describes the findings of a study of indicators relating to the themes of eutrophication (Chapter 2) and integrated coastal zone management (Chapter 3).

In order to ensure the step-by-step transparency of the data processing, so that it can be used for other possible assessments relating to indicator reporting, a full account of the aggregated data is available from the EEA on CD-ROM.

2. Eutrophication indicators

2.1. Methodology

The following steps were taken to assess the indicators.

1. Checks on the availability of data on descriptive parameters with indicator potential:
   - Definition of criteria for potential indicators
   - Development of questionnaires on data availability (potential parameters, definition of locations)
   - Data collection from countries and from ICES

2. Further assessment:
   - Assessment of adequacy of time series and spatial coverage
     — Data handling
     — Selection of the trend detection method
   - Data processing by aggregation
     — Results of the data processing
   - Mapping

These steps are described below.

2.2. Data availability

2.2.1. Selection criteria

In order to select parameters potentially able to meet the EEA's need for suitable indicators, the following selection criteria were applied:

- relevance to the coastal zone (according to expert opinion);
- relevance to European policy (based on the inventory of directives in EEA, 1999a);
- availability of adequate time series and reasonable spatial coverage (the preferred time series requested in the questionnaire was 1985–97);
- comparability of the data;
- availability of standards/reference values.

Issues of concern

The following issues were taken into account when assessing the suitability of particular parameters to serve as indicators.

- Degree of independence of natural weather-related fluctuations.
  Natural parameters play an active role in biological processes and biological parameters are subject to natural fluctuations. Their possible usefulness for trend detection is determined by the frequency of monitoring and the presence of adequate statistical methods.

- Spatial aggregation.
  To present data on a European scale, the numbers of stations to be used per country need to be related in a consistent way to the length of coastline. There are countries with large numbers of stations and a short coastline and vice versa.

- Explicit relevance to models (Van Buuren and van der Falk, 1999).
  Modules describing the internal relationships within the DPSIR framework are indispensable to the use of indicators in strategic environmental assessments.

2.2.2. Questionnaire development

Draft meta-data questionnaire on data availability

In a first attempt to identify the availability of data relating to a key set of indicators, a tentative list of indicators for eutrophication, harmful substances, and fisheries was drafted (Box 2.1), and a questionnaire was developed focusing on the meta-data on the following issues: data availability (yearly or seasonal basis), the temporal and spatial coverage of the data, and the availability of reference values and models. The questionnaire was also designed to check national (trend) monitoring plans (draft questionnaire, ETC/MCE, July 1998).

This questionnaire on meta-data was seen as a first step, in advance of a request for real data. It was discussed between the ETC/MCE partners and the EEA. The main argument against it was that it would delay the eventual collection of actual data, but its advocates pointed out that the proposed level of aggregation for the indicators might prove to be too high to detect minor changes.

The subsequent detailed assessment was thought to be the most important part of the study. Or, to quote the experience of the UK

Box 2.1. Examples of an overview of the list of indicators following the DPSIR framework for the marine and coastal environment

ISSUE: EUTROPHICATION	
State:	**Pressure:**
The total concentration of the various forms of nitrogen in mg/l, the total concentration of orthophosphates in mg/l, the total concentration of dissolved oxygen in mg/l.	The load of total nitrogen in tonnes per year and the load of total orthophosphates in tonnes per year.
Impact:	**Response:**
The algal blooms expressed as (frequency x extent) in km^2/year.	Environmental: The rate of restoration expressed as a percentage of the base level of total dissolved oxygen.
	Policy: The rate of progress in nutrient discharge control measures.
ISSUE: CHEMICAL POLLUTION	
State:	**Pressure:**
The concentration of metals (Hg, Cd, Pb) in rivers or seawater, the concentration of organo-halogenated compounds in rivers or seawater, the volume of mineral oil spills per year.	The total load of metals and the total load of organo-halogenated compounds.
Impact:	Response:
The overall relative trend shown by bioaccumulation of substances or groups of substances in biota.	Environmental: The rate of restoration of baseline conditions concerning the level of metals in seawater. Environmental: The rate of restoration of baseline conditions concerning the level of organo-halogenated compounds in seawater.
	Policy: The rate of convergence between the observed value and an existing target value.
ISSUE: FISHERIES	
State:	**Pressure:**
The spawning stock biomass.	The total level of catch or landings per year. The proportion of by-catch as a percentage of the total catch. Fishing mortality.
Impact:	Response:
The overall relative trend in the ratio of short-lived species to long-lived species. The spawning stock for vulnerable non-commercial species.	Environmental: The percentage of the total commercial catch achieved in sustainable conditions.
	Policy: The rate of convergence between the observed spawning stock values and an existing target value.

Department of the Environment as presented at the European Conference on Bridging the Gap, held in London in May1998, the best way to proceed with indicators is by 'just doing it'.

In the end it was decided not to circulate the questionnaire on meta-data, but to develop another questionnaire asking directly for data to be used both for the characterisation of estuaries, lagoons and fjords and for the assessment of indicators for the coastal zones.

In view of the results of the assessment, the above tentative list will be discussed further in the context of aggregation.

Data gathering through the ETC/MCE indicator questionnaire 1999: selection of parameters

The general aim of this questionnaire was defined as the gathering of data relevant to the characterisation of environmental state and pressure for coastal ecosystem quality at the European level, in order to produce information to be used for the following specific purposes:

- EEA reporting;
- to develop databases on coastal typology and on environmental indicators for the themes relevant to EU policy on ecosystem quality (eutrophication, harmful

substances, oil pollution). Later, this may be extended to biodiversity, ICZM and spatial development;
- publication via the world wide web (Internet);
- public dissemination at all levels;
- further development of national databases as gaps in knowledge and information become apparent.

Initial versions of the questionnaire (see the draft meta-data questionnaire described above) addressed only a limited number of parameters. However, because of the dual aim of the indicator questionnaire, it was decided to extend the number of possible parameters to reflect possible local needs in relation to the characterisation of coastal zones.

This resulted in a dual target approach:

- the assessment of indicators using the data gathered;
- the development of the database using the data gathered from ICES and from the individual countries.

These activities had to take place simultaneously in different institutes. Some data handling processes were more or less the same, although carried out in different settings. The questionnaire and database relate both to marine quality parameters (in water, sediment and biota) and to input parameters (from rivers and direct). The development of the database (Marinebase) is implemented in Access 97 and is considered a pilot version.

2.2.3. Data collection

Water quality data
A full list of parameters was included in the questionnaire sent to the countries and to ICES. This list is presented in Appendix 1.

In order to integrate the data available in existing databases, the ICES and UNEP/MAP secretariats were asked to gather together aggregated data from the OSPAR, Helcom and Mediterranean Sea organisations. The cooperation of the individual countries was then sought in gathering additional national data complementary to this. The list of potential parameters available from ICES is shown in Box 2.2 (see details in Section 2.4).

These data were not requested from the countries again.

Box 2.3 contains an overview of the total database of descriptive water quality parameters (aggregated monthly or quarterly) relevant to potential indicators, as obtained from ICES.

The requested period for data collection from both the individual countries and the marine convention organisations was 1985–97. Some data were also obtained for 1998.

The data received from the countries had to be made available for data handling through the development of the database (Marinebase) and could not be investigated in detail in this assessment. Initial checks on Excel files from individual countries showed that data validation through communication with the data providers is an essential step. Therefore, no Mediterranean data on eutrophication were tested in this report. In the report *Eutrophication in Europe's coastal waters* (Ærtebjerg et al., 2001), the Mediterranean data provided by the countries are assessed.

Input of nitrogen and phosphorus
Data on the input of nutrients into the sea are updated yearly within OSPAR and Helcom working groups.

Box 2.2. List of potential indicators available from ICES

Eutrophication	Harmful substances
Total phosphorus (January–February) Total nitrogen (January–February) Nitrite, nitrate Phosphate Ammonium Nitrite + nitrate/orthophosphate ratio (to be calculated) Chlorophyll a Bottom oxygen Silicate	Metals in sediment and biota PCB and PAH

Box 2.3. Aggregated 10 x 10 km square water quality data from the ICES oceanographic database

Period	Abbre-viation (*)	Parameter	Number of records
Apr.–Sept.	schla	Chlorophyll a	2 666
Jan.–Feb.	salky	Total alkalinity	(**)
	sdoxy	Dissolved oxygen	(**)
	sh2sx	Hydrogen sulphide	(**)
	sntot	Total nitrogen	1 263
	sntra	Nitrate	6 281
	sntri	Nitrite	3 991
	sphos	Phosphate	6 230
	sphph	Hydrogen ion concentration (pH)	736
	spsal	Salinity	(**)
	sslca	Silica	4 696
	samon	Ammonium	3 553
	stemp	Temperature	(**)
	stphs	Total phosphorus	1 870
Sept.–Oct.	b %O_2	Oxygen saturation	(**)
	bdoxy	Dissolved oxygen	3 112

(*) Initial s = surface value; initial b = bottom value.
(**) These data are not used in this report.

Data on riverine loads and direct input of total nitrogen and total phosphorus within the OSPAR area were available for trend detection over the 1990–96 period. They were received in the form of a hard copy of the draft 1998 OSPAR summary report on riverine inputs and direct discharges (RID). These data are the best currently available (see OSPAR, 1998).

The data on loads are aggregated at country level and were used to carry out trend detection as described in Section 2.3.3. The results are given in Section 2.4.4.

Helcom data relate only to input in 1995. The assessment performed for input in 1990 is not comparable with that in 1995. For this region, therefore, no trend detection was possible.

2.3. Further assessment

2.3.1. Data selection

The assessment of state indicators described in this report covers only the data selected from the 20 km zone of the ICES oceanographic database for the theme of eutrophication. No use could be made of the data collected through the countries as this assessment took place before the finalisation of the database.

The process of indicator assessment proceeded in parallel with the preparation of the 1999 yearly indicator report (YIR). The publication in that report of two suitable state indicators for eutrophication followed the assessment of six parameters.

It should be noted that there are some differences between the results presented in the 1999 YIR and the data given in this report. The version of the results given here is the latest one.

The initial selection of potential indicators for further assessment considered both state and pressure. Their role in the cycling of nutrients and in eutrophication abatement policies make nitrate and phosphate the most suitable potential state indicators. The ecological effect of reducing nitrate will be greater than that of reducing phosphate, since eutrophication of larger parts of the European coastline is dependent on the availability of nitrate for a longer period. Total nitrogen and phosphorus are, in principle, also suitable (SFT, 1997; Swedish EPA, 1999), but data on dissolved nutrients are generally more widely available, especially in the Mediterranean.

Bottom oxygen and chlorophyll are susceptible to natural variation induced by

Box 2.4. Eutrophication parameters of ICES data selected for further assessment as potential indicators

Parameter	Source	Period
PO_4	ICES oceanographic database	Jan.–Feb. (mean)
NO_3	ICES oceanographic database	Jan.–Feb. (mean)
Bottom oxygen	ICES oceanographic database	Sept.–Oct. (mean)
Input N_{tot} (riverine + direct input)	OSPAR, Helcom	OSPAR years 1990–96 Helcom year 1995
Input P_{tot} (riverine + direct input)	OSPAR, Helcom	OSPAR years 1990–96 Helcom year 1995

meteorological conditions. Only bottom oxygen was selected, although the chosen statistical method imposes possible constraints on coping with these types of data. Bottom oxygen is an important descriptive parameter (and potential state indicator) in areas at high risk of oxygen depletion. Such high-risk areas are the Baltic Sea, the German Bight and all coastal zones characterised by stratification of the water in summer.

On the basis of the data currently available, the only possible pressure indicators were the total riverine and direct input of total nitrogen and total phosphorus.

The resulting selection for further assessment is listed in Box 2.4.

ARC-INFO database of squares in defined coastal zones

Geographically referenced monitoring data were received from the ICES Oceanographic Data Centre (covering all marine and coastal OSPAR and Helcom stations). At present, OSPAR and Helcom countries allow ICES to supply only aggregated information. These data were aggregated by ICES for the purpose of this testing in 10 x 10 km squares. The coordinates of the data are the centre of each square.

The Norwegian Institute for Water Research (NIVA) selected squares within a 20 km offshore zone. These were then used by the Rijksinstituut vor Kust en Zee (RIKZ) for further data selection.

Geographical information systems (ARC-INFO 7.0 and ArcView 3.1) were used to perform the following steps.

1. European coastal boundaries were taken from GISCO (1998).

2. A marine 20 km zone was defined as a polygon.

3. The NIVA 20 km zone data were imported from Excel into ArcView.

4. The regional divisions of the OSPAR and Helcom areas were drawn by hand using original OSPAR and Helcom maps showing the following divisions (Appendix 2):

   B-I Baltic Sea
   O-I Arctic Waters
   O-II Greater North Sea
   O-III The Celtic Sea
   O-IV Bay of Biscay and Iberian Coast
   O-V Wider Atlantic.

The subsea division was based on the OSPAR and Helcom regions. In those regions, country boundaries were added in order to be able to present trends on the national level. This created a subregional definition for further use (see Box 2.5).

Maps 1, 2a and 2b in Appendix 2 show the overall regions identified and the ICES squares with data aggregated in 10 x 10 km squares for the OSPAR and Helcom areas.

ICES could not supply data for the Mediterranean.

The spatial aggregation of data was made by using ARC-INFO based on the outline coordinates of the polygons of the subregions per country and the coordinates of the squares contained within the 20 km zone.

The set-up of the ICES database is shown in Box 2.6.

Further manipulation of the data was done in Excel spreadsheets.

Next, the mean values of the squares matching the selected 20 km zone were retrieved from the ICES data.

This resulted in a base file with mean water quality values per 10 x 10 km square in the

Box 2.5. OSPAR and Helcom subregions for EU-15 and Norway (country code ISO 3166)

OSPAR	Code	Country code		Helcom	Code	Country code
Norwegian Sea	O-I-1	N		Belt Sea	B-I-1	D, DK
Barents Sea	O-I-2	N		Baltic Proper	B-I-2	D, S
Skagerrak	O-II-1	DK, N, S		Gulf of Finland	B-I-4	FIN, S
Kattegat	O-II-2	DK, S		Gulf of Bothnia	B-I-5	FIN, S
North Sea	O-II-3	B, D, DK, N, NL, S, UK				
Channel	O-II-4	F, UK				
Irish Sea	O-III-1	IRL, UK				
Celtic Sea	O-III-2	IRL, UK				
Atlantic	O-III-3	IRL, UK				
Bay of Biscay and Iberian Coast	O-IV-1	E, F, P				

20 km marine coastal zone, for each subregion and country. It was not possible directly to average all data in one subregion, as the time series differed between squares.

2.3.2. Time series selection

The available data covered the period 1985–98. However, less than 10 % of the squares had uninterrupted time series since 1985.

The two criteria used independently for the selection of time series for trend detection were:

- five or more years available since 1985, not necessarily uninterrupted;
- availability in the series of 1996, 1997 or 1998 plus at least two other years. (This was added to ensure the use of recent data.)

The application of these criteria resulted in a selection of mean value series (see example in Box 2.7).

Box 2.6. Example of the ICES database for a certain parameter; data are seasonally aggregated for each year

Latitude	Longitude	Year	n	Mean (µmol/l)	Standard deviation	Minimum	Maximum
52.5	– 35.8	1988	1	0.3	0	0.3	0.3
52.7	– 35.8	1988	4	0.2875	0.0083	0.28	0.3

Box 2.7. Base data on phosphate — example

20 regions	169 squares		1 284 values
Region	**Square number**	**Year**	**Mean (µmol/l)**
B-I-1-DK	316	1986	0.81
		1987	0.73
		1988	0.37
		1989	0.84
		1990	0.91
		1991	0.93
		1992	0.63
		1993	0.77
B-I-1-DK	388	1988	2.91
		1989	1.26
		1991	1.73
		1992	0.61
		1993	2.12

Maps providing an overview of square locations are given in Appendix 2.

A full overview of water quality base data as used in the indicator assessment is available on CD-ROM from the European Topic Centre on Marine and Coastal Environment.

2.3.3. Selection of the statistical method

Trend detection — selection
There are two main approaches to the assessment of an indicator.

1. Statistical trend detection.
2. Comparing the value with a reference value determined by experts ('distance-to-target' methodology). This approach is useful when only limited time series are available.

For nutrients, however, there is no such internationally agreed set of reference values for indicators at either regional or European level. For that reason, this study included no assessments using background or reference concentrations/values (B/RCs) or targets.

Trend calculation
Trend detection for each time series was performed using the Trend-y-tector.

The Trend-y-tector was discussed by a joint ICES/OSPAR working group, which recommended improvements. It consists of a combination of three statistical methods in a suite for both water quality data and data on loads.

The starting method is the Mann-Kendall test (MK), since this is the simplest method that is robust in detecting downward trends. But the MK test is not the most powerful method for the detection of a linear trend. If MK detects no significant trend, an attempt to detect one will be made using classical linear regression (LR), which is more powerful in this respect.

When both methods fail to detect any significant monatomic trend, it is still possible that a non-linear trend exists. In that case, a smoother test will be used, since this is the most powerful method of detecting non-linear trends.

This so-called Warren Suite application decides whether or not there is a significant (downward) trend.

Trend analysis of water quality should be performed on data no more than once a month. At shorter intervals, serial dependence may become strong and seasonally ill-defined. These characteristics can seriously disturb trend analysis. The input for the suite consists, for example, of yearly data. In general, the Warren Suite application can be used to evaluate trend analysis on time series with a maximum of 32 independent observations.

The steps involved are as follows.

0. Set up the statistical criteria.
1. Import data.
2. Calculate the Mann-Kendall statistics.
3. Test the hypotheses for Mann-Kendall.
4. Calculate the Theil slope.
5. Perform the runs test.
6. Estimate the trend size.
7. Calculate the smoother curve.
8. Test the hypotheses for the smoother test.
9. Present output in case of a significant trend.
10. Present output in case of no significant trend.

The trend analyses of both the water quality data and the input data were performed on the log-transformed time series using a two-sided test with a significance level of 5 %. For the smoother test, the significance level was adjusted by a factor of 0.8 (to 4 %). This was done as a consequence of the advice of the ICES statistical working group on the use of the Trend-y-tector. The Trend-y-tector is described at: http://www.waterland.net/rikz/osparwg/trend-y-tector/forms.htm.

The use of the Trend-y-tector on input data has been discussed within OSPAR. Because of the influence of the natural variability of the river flow, there is a preference to use riverine input data with adjustments for the flow variability. Then the data might show a better relationship with emission reduction at the sources. The methodology for this further refinement is worked out within OSPAR.

The results shown here indicate the current available information and assessment on riverine and direct input as such. It should be noted that this information can be better linked to water concentration levels in the coastal waters.

Box 2.8 shows the type of Excel files produced as a result of the trend calculation

Box 2.8. Trend calculation results for phosphate — example

20 regions	169 squares			1 284 values		
Region	**Square**	**Period**	**End-year**	**Number of years**	**Complete**	**Trend (%)**
B-I-1-DK	316	1986–93	1993	8	y	0
B-I-1-DK	388	1988–93	1993	5	y	0
B-I-1-DK	390	1986–93	1993	6	n	0
B-I-1-DK	479	1988–97	1997	5	n	0
B-I-1-DK	500	1985–98	1998	14	y	– 50
B-I-1-DK	513	1988–92	1992	5	y	0

Box 2.9. Mapping criteria

> = 50 % decrease	green	'decrease'
> = 50 % no/limited trend	blue	'no/limited trend'
> = 50 % increase	red	'increase'
50 % decrease and 50 % no/limited trend	green	'decrease'
50 % no/limited trend and 50 % increase	red	'increase'
50 % decrease and 50 % increase	blue	'no/limited trend'

With three different outcomes, the highest value determines the colour.
With two identical outcomes for decrease and no/limited trend the colour green is chosen. With two identical outcomes for increase and no/limited trend the colour red is chosen.

for the concentrations. For each square, indications were given of the period, the completeness of the data set, the number of years and the trend value. In the example, the trend value of –50 % means a downward decrease of 50 %.

The base data (aggregated data from ICES) and a full overview of trend calculations for nutrient concentrations is available on CD-ROM within the EEA. The results of the trend detection for inputs are described in Section 2.4.4 (see especially Table 2.4).

2.3.4. Aggregation and presentation

The results of the trend detection for each square are classified as follows: score >10 % positive: increase; score >10 % negative: decrease; trend between 0 and 10 %: no/ limited trend. The number of squares for each class are expressed as a percentage of the total number of squares in each subregion per country. This is represented in the figures in Section 2.4. The margin of 10 % in the positive or negative trend takes into account any possible inaccuracy in chemical analysis results or calculations. The results are presented in Excel figures.

For geographical presentations in the maps, the maximum of three categories per country region have been further aggregated into one overall judgment in accordance with the criteria presented in Box 2.9.

2.3.5. Discussion

Use of real data

The methodology was not discussed in advance within the EIONET or any marine convention organisation. The selection of data based on information aggregated per square has the disadvantage that it makes it more difficult for the countries themselves to check the data than it would have been if the geographical coordinates of the stations had been used.

In fact, the whole procedure described here for setting up an indicator database would be much more effective and reliable if countries agreed on the set of monitoring stations they wanted to use for the establishment of the ETC/MCE indicator database. Anticipating future end-user requirements, a decision would need to be taken within the marine convention organisations to give access to data for data processing by the EEA/ETC on the basis of the coordinates of the stations. There would then have to be further discussion on the methodology for the selection of stations per country. For countries with a long coastline, spatial relevance would have to be balanced against relevance of assessing compliance with policy. Guidance developed within the framework of the water framework directive and Eurowaternet could be helpful.

Selection of stations using ArcView
The selection of stations in a 20 km zone using ArcView was done both by NIVA and RIKZ. Because different maps of the coastline of Europe were used, the resulting selections were not identical. It was decided, therefore, to continue with the data set based on the NIVA selection. This problem would no longer exist if there were agreement between the countries on the stations to be used. However, for other assessments using ICES data, the EEA will have to decide on the type of projection to be used for mapping the European coastline. Whether it is to be based on the GISCO database or on other available European maps is also a matter needing to be discussed in relation to the ICZM base and biodiversity base data to be developed.

Selection of regions for aggregation
The choice of regions for aggregation made in this report is preliminary only.

The use of OSPAR/Helcom regional subdivisions needs to be discussed further with countries and the marine convention organisations. Regions will probably have to be defined differently for different purposes. Where marine status indicators are concerned, reporting per regional sea is significant as prioritisation is important at this level (see also Box 1.1). The number of stations to be used for further assessment is also relevant in this context. See also the discussion in Section 2.4.4.

The use of background values and generic classification systems
An international workshop on background concentrations of natural compounds in the North Sea (Laane, 1992) discussed background concentrations of phosphate, silicate, nitrite and nitrate for several regions with defined salinity: waters flowing in from oceanic regions, coastal regions and central parts of the North Sea. The experts were of the opinion that no actual or hypothetical data existed on concentrations of nutrients in the North Sea in pristine times and they chose therefore the next-best pre-1950 data. Ranges in background concentrations are given only for coastal waters in the southern North Sea. These data indicate that the classification used to assess nutrient levels in European coastal and marine waters (EEA, 1999b) ignores regional differences in background concentrations. Such classifications, therefore, might result in false comparisons between different coastal waters. Therefore, no background values have been used in this study.

2.4. Results

2.4.1. Introduction
Measures to reduce the input of anthropogenic nutrients and to protect the marine environment are being taken as a result of various initiatives at all levels (national, European and global, including regional conventions and ministerial conferences). marine conventions acknowledge the importance of compliance with EU directives and corresponding national legislation. Some of the programmes are listed in Box 2.10.

Box 2.10. Main international programmes

- UN Global Programme of Action for the Protection of the Marine Environment from Land-based Activities
- Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area 1992
- OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic 1998
- EU directives: Draft water framework directive; nitrate directive
- Mediterranean action plan

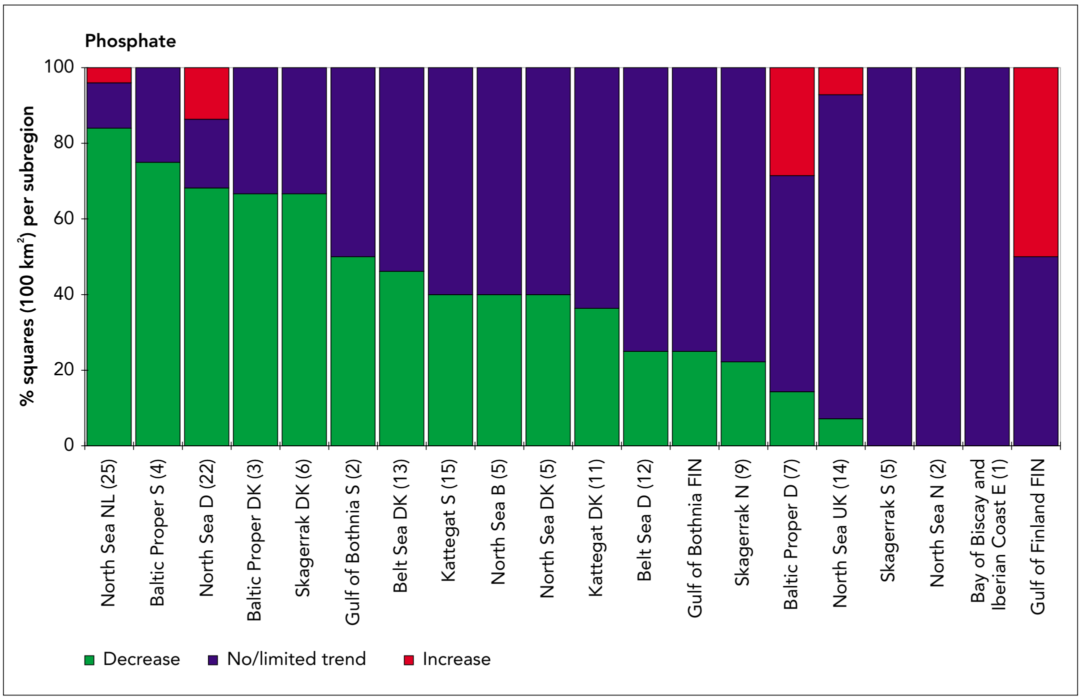
In the description of the results, references to the progress of countries on implementing measures are based on the assessment of emission data.

2.4.2. Nitrate and phosphate

Introduction

The indicator is for winter concentrations (in January and February). This period sees the least biological activity. There is a relationship between riverine loads of nitrogen and phosphorus and the concentration of nutrients in coastal waters, estuaries, fjords and lagoons. Nutrient concentrations are basic factors affecting the biological state and, in particular, phytoplankton, biomass, light conditions in the water column, distribution of benthic vegetation and secondary production of benthic fauna (Borum, 1996). Adverse effects of eutrophication include low oxygen and anoxic conditions and the occurrence of

Trends in phosphate concentrations Figure 2.1.



noxious algae blooms. Due to variations in freshwater run-off and hydrogeographic variability of the coastal zone and internal cycling processes, it is impossible directly to relate trends in nutrient concentrations to measures taken.

Results for phosphate

Temporal and spatial coverage

The basic database on phosphate contains more than 600 squares within the 20 km zone. A total of 169 squares were selected on the basis of the criteria described above. As Figure 2.1 shows, the number of squares containing ICES data varies per country from 25 for the North Sea (the Netherlands) to 1 for the Iberian coastal zone of Spain. The spatial coverage per coastline is high in some countries, but could probably be improved in others.

Trends

Main results:

Half of the coastal waters show little or no change in phosphate concentrations. However, 45 % of the time series data show a substantial decrease, while about 5 % show an increase.

'Eleven signatories to the final declaration of the Third International Conference on the Protection of the North Sea have achieved the conference's objective of a 50 % reduction in phosphorus inputs into surface waters' (Andersen and Niilonen, 1995), but the results of this study show that this emission reduction is not reflected in all European coastal waters.

The reduction of phosphorus in detergents and other measures in the catchment area have resulted in a fall in phosphate concentrations in parts of the coastal zones in some regions, for example, the Skagerrak, the Kattegat, the German Bight and the Dutch coastal zone. The mean decrease in phosphate concentrations over the 1985–97 period was 43 %, reflecting the reduction in inputs.

Reduced phosphate loads in the Rhine have resulted in an average reduction of 50 % in concentrations in the Dutch coastal zone since 1985 and a decline in phytoplankton biomass. Present phosphate concentrations in the area are still two to three times higher than marine background levels (De Vries et al., 1998). In the Gulf of Finland, leaching from sediment has caused phosphate concentrations to increase recently despite the decrease in external nutrient inputs. Overall, the presence of a large buffer of phosphorus in coastal sediments has prevented the reduction of phosphate inputs being immediately reflected in a reduction of phosphate in coastal waters.

Aggregation and presentation

The results shown in Figure 2.1 are sorted for the 'decreases' category first, followed by the 'no/limited trend' category and finally the 'increase' category. This produces an overall picture for Europe that can be taken in at a glance. This is actually European information at the highest aggregation level. However, the presentation cannot be used to compare individual countries at the moment, because of imperfections in the data availability with an imbalance in the number of squares along Europe's coastlines.

Since the country-level aggregation does not permit any overview of the results per regional sea, a further aggregation has been produced. This is presented in Table 2.1 and the map showing trends in nitrate and phosphate in Appendix 3.

The aggregation presented in Figure 2.1 reveals a predominant decrease in phosphate along the North Sea coasts of the Netherlands and Germany. Around those of Belgium and Denmark, there is predominantly no/limited trend and no/ limited trend is likewise found along the coasts of the United Kingdom and Norway. In the Kattegat and Skagerrak, the overall picture is one of little or no change. In the Swedish part of the Baltic Proper, phosphate has decreased, while on the German side there is little or no change. The Belt Sea shows little or no overall change and the Gulf of Finland shows both an increase and little/ no trend in equal proportions. The Gulf of Bothnia shows a slightly positive picture.

Note that Finland regards the ICES base data for Finland as inappropriate and therefore provided its own estimates for trends. These are given in Table 2.1.

Suitability of the indicator

Phosphate is a useful indicator for trend detection at the European level.

There needs to be further discussion with the Member States to determine whether this indicator assessment can be performed using real values from stations defined for this purpose. Spatial coverage of squares needs to be related to the catchment areas of main rivers. For those coastal zones where the main input of nutrients is from direct run-off,

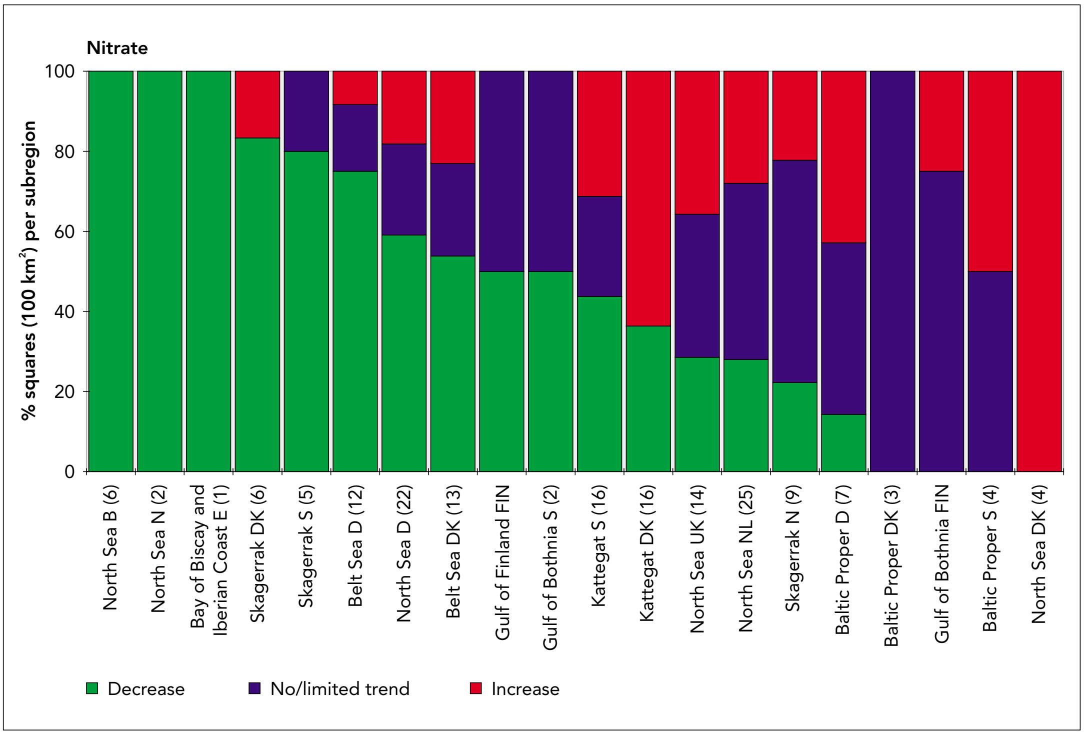
Table 2.1. **Trends in phosphate concentrations**

Trends — phosphate region		Number of squares				Data for mapping — phosphate %					Result
		De-crease No	Limi-ted trend	In-crease	Total						
O-II-3-NL	North Sea NL (25)	21	3	1	25	84	12	4	100	North Sea NL (25)	green
B-I-2-S	Baltic Proper S (4)	3	1	0	4	75	25	0	100	Baltic Proper S (4)	green
O-II-3-D	North Sea D (22)	15	4	3	22	68	18	14	100	North Sea D (22)	green
B-1-2-DK	Baltic Proper DK (3)	2	1	0	3	67	33	0	100	Baltic Proper DK (3)	green
O-II-1-DK	Skagerrak DK (6)	4	2	0	6	67	33	0	100	Skagerrak DK (6)	green
B-I-5-S	Gulf of Bothnia S (2)	1	1	0	2	50	50	0	100	Gulf of Bothnia S (2)	green
B-I-1-DK	Belt Sea DK (13)	6	7	0	13	46	54	0	100	Belt Sea DK (13)	blue
O-II-2-S	Kattegat S (15)	6	9	0	15	40	60	0	100	Kattegat S (15)	blue
O-II-3-B	North Sea B (5)	2	3	0	5	40	60	0	100	North Sea B (5)	blue
O-II-3-DK	North Sea DK (5)	2	3	0	5	40	60	0	100	North Sea DK (5)	blue
O-II-2-DK	Kattegat DK (11)	4	7	0	11	36	64	0	100	Kattegat DK (11)	blue
B-I-1-D	Belt Sea D (12)	3	9	0	12	25	75	0	100	Belt Sea D (12)	blue
B-I-5-FIN	Gulf of Bothnia FIN	25 %	75 %	0	100 %	25	75	0	100	Gulf of Bothnia FIN	blue
O-II-1-N	Skagerrak N (9)	2	7	0	9	22	78	0	100	Skagerrak N (9)	blue
B-I-2-D	Baltic Proper D (7)	1	4	2	7	14	57	29	100	Baltic Proper D (7)	blue
O-II-3-UK	North Sea UK (14)	1	12	1	14	7	86	7	100	North Sea UK (14)	blue
O-II-1-S	Skagerrak S (5)	0	5	0	5	0	100	0	100	Skagerrak S (5)	blue
O-II-3-N	Skagerrak S (5)	0	2	0	2	0	100	0	100	Skagerrak S (5)	blue
O-IV-1-E	Bay of Biscay and Iberian coast E (1)	0	1	0	1	0	100	0	100	Bay of Biscay and Iberian coast E (1)	blue
B-I-4-FIN	Gulf of Finland FIN		50 %	50 %	100 %	0	50	50	100	Gulf of Finland FIN	red
		73	81	7	161						
		45.3 %	50.3 %	4.3 %	100 %	(excl. FIN)					

Criteria:

> = 50 % decrease	green	'decrease'
> = 50 % no/limited trend	blue	'no/limited trend'
> = 50 % red	red	'increase'
50 % decrease and 50 no/limited	green	'decrease'
50 % no/limited and 50 % increase	red	'increase'
50 % decrease and 50 % increase	blue	'no/limited trend'

Trends in nitrate concentrations — Figure 2.2.



a selection of stations for indicator reporting at the European level would be welcome. Use of symbols to indicate the strength of the trend could improve the presentation and overall quality of the indicator.

Results for nitrate
Temporal and spatial coverage
The basic database for nitrate contains more than 600 squares within the 20 km zone. A total of 170 squares were selected on the basis of the criteria described above. As Figure 2.2 shows, the number of squares per country varies from 25 for the North Sea (Netherlands) to 1 for the Iberian coastal zone of Spain.

Trends
No signatory State to the final declaration of the Third International Conference on the Protection of the North Sea has achieved the conference's objective of reducing nitrogen inputs into surface waters by 50 %, but all North Sea States are expected to have achieved a substantial reduction of nitrogen inputs into surface waters in the order of 25 % by the target date (Andersen and Niilonen, 1995).

Main results:
Nearly half of the time series data showed a downward trend in nitrate concentrations in coastal waters, though there were also increases.

Table 2.2 and Figure 2.2 show for 45 % of the squares per subregion a downward trend in nitrate concentrations in coastal waters. A 100 % decrease is restricted to subregions with only one to six squares and may therefore be a result of the limited amount of time series data available. The mean decrease in nitrate concentration (calculated exclusively on the basis of the negative trends) is 38 %: higher than would be expected on the basis of 1995 country data about national efforts to reduce inputs. Part of the decrease appears to be due to very low run-off from rivers in 1996 and 1997.

About 25 % of the squares per subregion show an increase in nitrate concentrations. These are mostly subregions of the Baltic Sea, Kattegat and Skagerrak, where the increased nitrate concentrations probably relate to internal fluxes (remineralisation of nitrogen).

The mixed negative and positive results in the squares from the Dutch coast should be related to the influence of biological processes.

Table 2.2. **Trends in nitrate concentrations**

Trends — nitrate region		Number of squares				Data for mapping — nitrate %					Result
		Decrease No	Limited trend	Increase	Total						
O-II-3-B	North Sea B (6)	6	0	0	6	100	0	0	100	North Sea B (6)	green
O-II-3-N	North Sea N (2)	2	0	0	2	100	0	0	100	North Sea N (2)	green
O-IV-1-E	Bay of Biscay and Iberian Coast E (1)	1	0	0	1	100	0	0	100	Bay of Biscay and Iberian Coast E (1)	green
O-II-1-DK	Skagerrak DK (6)	5	0	1	6	83	0	17	100	Skagerrak DK (6)	green
O-II-1-S	Skagerrak S (5)	4	1	0	5	80	20	0	100	Skagerrak S (5)	green
B-I-1-D	Belt Sea D (12)	9	2	1	12	75	17	8	100	Belt Sea D (12)	green
O-II-3-D	North Sea D (22)	13	5	4	22	59	23	18	100	North Sea D (22)	green
B-I-1-DK	Belt Sea DK (13)	7	3	3	13	54	23	23	100	Belt Sea DK (13)	green
B-I-4-FIN	Gulf of Finland FIN	50 %	50 %		100 %	50	50	0	100	Gulf of Finland FIN	green
B-I-5-S	Gulf of Bothnia S (2)	1	1	0	2	50	50	0	100	Gulf of Bothnia S (2)	green
O-II-2-S	Kattegat S (16)	7	4	5	16	44	25	31	100	Kattegat S (16)	green
O-II-2-DK	Kattegat DK (16)	4	0	7	11	36	0	64	100	Kattegat DK (16)	red
O-II-3-UK	North Sea UK (14)	4	5	5	14	29	36	36	100	North Sea UK (14)	red
O-II-3-NL	North Sea NL (25)	7	11	7	25	28	44	28	100	North Sea NL (25)	blue
O-II-1-N	Skagerrak N (9)	2	5	2	9	22	56	22	100	Skagerrak N (9)	blue
B-I-2-D	Baltic Proper D (7)	1	3	3	7	14	43	43	100	Baltic Proper D (7)	red
B-I-2-DK	Baltic Proper DK (3)	0	3	0	3	0	100	0	100	Baltic Proper DK (3)	blue
B-I-5-FIN	Gulf of Bothnia FIN		75 %	25 %	100 %	0	75	25	100	Gulf of Bothnia FIN	blue
B-I-2-S	Baltic Proper S (4)	0	2	2	4	0	50	50	100	Baltic Proper S (4)	red
O-II-3-DK	North Sea DK (4)	0	0	4	4	0	0	100	100	North Sea DK (4)	red
		73	45	44	162						
		45.1 %	27.8 %	27.2 %	100 %	(excl. FIN)					

Criteria:

> = 50 % decrease	green	'decrease'
> = 50 % no/limited trend	blue	'no/limited trend'
> = 50 % red	red	'increase'
50 % decrease and 50 no/limited	green	'decrease'
50 % no/limited and 50 % increase	red	'increase'
50 % decrease and 50 % increase	blue	'no/limited trend'

Aggregation and presentation

The results are presented in Figure 2.2 on a falling scale with an initial selection for the decreases, followed by the 'no/limited trend' category and finally the 'increase' category. This produces an overall picture for Europe that can be taken in at a glance. However, the presentation cannot be used to compare individual countries because of the imbalance in the number of squares.

Since the country-level aggregation does not permit any overview of the results per regional sea, a further aggregation has been produced. This is presented in Table 2.2 and the map showing trends in nitrate and phosphate in Appendix 3.

The results shown in Figure 2.2 and in the map reveal a fairly positive picture which is slightly dominated by the regions with a restricted number of squares showing a 100 % decrease. The mapped results show that nitrate concentrations are declining in the majority of the regional seas, while the Baltic Proper and the Dutch part of the North Sea still show increases and therefore give cause for concern.

Suitability of the indicator

Nitrate is a useful indicator for detection of trends in eutrophication at the European level.

There needs to be further discussion between the Member States to determine whether this indicator assessment can be performed using raw data from stations instead of spatially aggregated data per square. Spatial coverage of squares needs to be related to the catchment areas of main rivers. For those coastal zones where the main input of nutrients is from direct run-off, a selection of stations for indicator reporting at the European level would be welcome. The use of symbols to indicate the strength of the trend could improve the presentation and overall quality of the indicator.

Again, Finland provided its own overall trend figures for use in Table 2.2.

2.4.3. Bottom oxygen concentrations

Introduction

The indicator describes the mean September–October concentrations of near-bottom oxygen. At this time of the year, the oxidation capacity of the sediment is nearly exhausted and its oxygen consumption increases markedly. The Baltic area and the German Bight are the areas most susceptible to oxygen deficit due to their stratified waters. When oxygen falls below 125 µM/l (2mg O_2/l), benthic fauna is affected. Raised input of nutrients into coastal waters increases the risk of oxygen deficit. Areas of oxygen deficit are probably far more widespread than one would expect from the data collected so far and delivered to ICES.

In theory, the best indicator for oxygen deficiency should be the number of days in which the oxygen concentration is below 125 µM/l. However, the maximum frequency of monitoring on a comparable basis is once every 14 days.

This means that bottom oxygen concentration cannot be regarded as a potential effect indicator, although it should be considered as a potentially robust state indicator. The available data at least reveals the problem areas. There are no data from countries where the problem does not exist. The problem areas have a natural sensitivity to oxygen deficiency, related to hydrological conditions, so the indicator is valuable only as a warning signal.

Results for bottom oxygen

Temporal and spatial coverage

The main period covered by ICES was found to be 1988–96. Appropriate time series data were available for the North Sea, the Baltic, the Skagerrak, the Kattegat and the German Bight. A total of 121 time series were selected. The most data were available for the Skagerrak N and the Kattegat S. Recent years were available for the aforementioned regions, the Swedish coastal waters and the coastal zone of Germany in the Baltic Proper. The trends are presented in Figure 2.3.

Trends

Mean values per subregion are all above the threshold level of 125 µM/l. For the interpretation of the data, it should be noted that — unlike in the case of nutrients — a decrease in mean oxygen values is a negative result.

Main results:

No overall trend in bottom oxygen in the Baltic. More than 50 % of the squares show no/limited trend. Decreases and increases are found in equal numbers.

At the subregional level, the pattern is variable, but findings of no/limited trend or decreases occur in more regions than increases. In those regions with the longest time series, the pattern for each subregion included increase, decrease and no/limited trend.

Trends in bottom dissolved oxygen concentrations Figure 2.3.

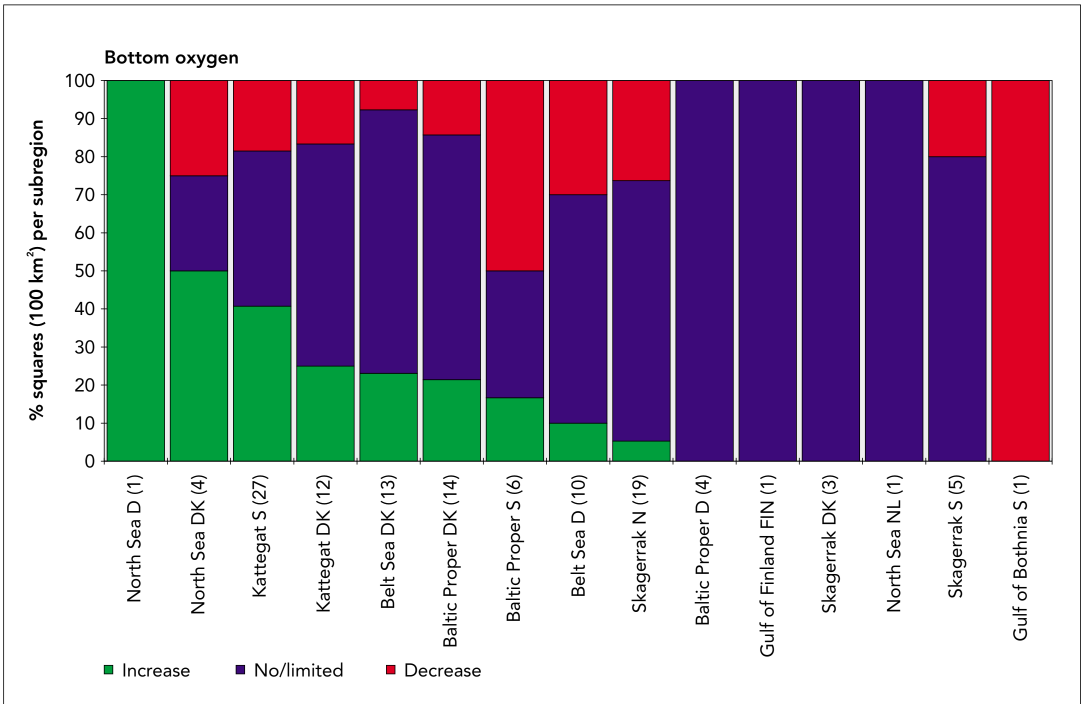


Table 2.3. **Trends in bottom dissolved oxygen concentrations**

Trends — bottom oxygen region		Number of squares				Data for sorting — bottom oxygen %				
		De-crease No	Limi-ted trend	In-crease	Total					
O-II-3-D	North Sea GE (1)	0	0	1	1	0	0	100	100	North Sea GE (1)
O-II-3-DK	North Sea DK (4)	1	1	2	4	25	25	50	100	North Sea DK (4)
O-II-2-S	Kattegat S (27)	5	11	11	27	19	41	41	100	Kattegat S (27)
O-II-2-DK	Kattegat DK (12)	2	7	3	12	17	58	25	100	Kattegat DK (12)
B-I-1-DK	Belt Sea DK (13)	1	9	3	13	8	69	23	10	Belt Sea DK (13)
B-I-2-DK	Baltic Proper DK (14)	2	9	3	14	14	64	21	100	Baltic Proper DK (14)
B-I-2-S	Baltic Proper S (6)	3	2	1	6	50	33	17	100	Baltic Proper S (6)
B-I-1-D	Belt Sea D (10)	3	6	1	10	30	60	10	100	Belt Sea D (10)
O-II-1-N	Skagerrak N (19)	5	13	1	19	26	68	5	100	Skagerrak N (19)
B-I-2-D	Baltic Proper D (4)	0	4	0	4	0	100	0	100	Baltic Proper D (4)
B-I-4-FIN	Gulf of Finland FIN (1)	0	1	0	1	0	100	0	100	Gulf of Finland FIN (1)
O-II-1-DK	Skagerrak DK (3)	0	3	0	3	0	100	0	100	Skagerrak DK (3)
O-II-3-NL	North Sea NL (1)	0	1	0	1	0	100	0	100	North Sea NL (1)
O-II-1-S	Skagerrak S (5)	1	4	0	5	20	80	0	100	Skagerrak S (5)
B-I-5-S	Gulf of Bothnia S (1)	1	0	0	1	100	0	0	100	Gulf of Bothnia S (1)
		24	71	26	121					
		19.8 %	58.7 %	21.5 %	100.0 %	(excl. FIN)				

Suitability of the indicator
The methodology and frequency of data collection follow OSPAR and Helcom requirements, subject to the ICES reporting format. The most commonly used measurement probes do not meet the requirements for measuring just a few centimetres above the sea floor (Danish Environmental Protection Agency, 1998). Oxygen concentrations can vary markedly from day to day. Routine measurements will fail to detect episodes of sudden oxygen deficit. The frequency of sampling does not always permit the occurrence of anoxic events to be monitored in detail.

This study indicates that, under the conditions of the Trend-y-tector currently in use, oxygen concentration seems to be too susceptible to natural variation to be useful as a stable indicator.

Given these reservations, it is conceivable that an improved method of trend detection based on the ICES data, but taking account of the variability of those data, might produce a satisfactory potential indicator, defined as the frequency of low oxygen values in the relevant season (September–October).

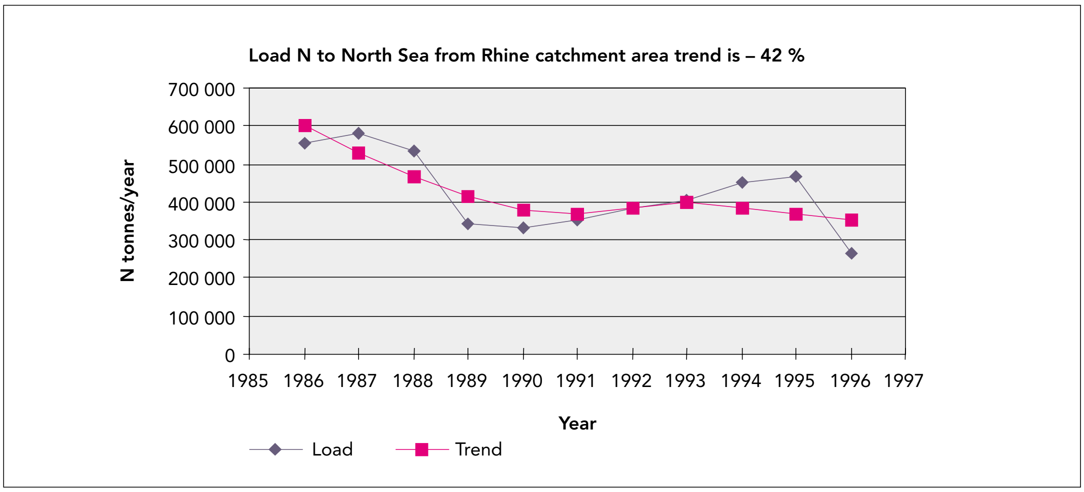
2.4.4. Input of nitrogen and phosphorus

Introduction: policy relevance
There is a direct relationship between riverine and direct loads of nitrogen and phosphorus and the concentrations of nutrients in coastal waters, estuaries, fjords and lagoons, which, in turn, affect the biological state. In the case of nutrients, most of the signatory States have managed since 1985 to achieve a substantial reduction in inputs in the order of 50 %, but this is not true of nitrate (see also Section 2.4.2). The method of measuring input on the basis of the total of riverine input, direct input and atmospheric input has been subject to change.

Success in meeting the 1985-based input targets for nitrogen and phosphorus cannot be assessed using the OSPAR figures for total load (direct and rivers) because the non-standard methods of calculation used before 1990 render the figures from that period non-comparable with those after that date. Success could only be judged if there were a consistent data set for the input of the Rhine catchment area over the entire 1985–97 period (Figure 2.4). This catchment area accounts for 25 % of the total input (direct and rivers) of the OSPAR region. The Baltic Sea is the second largest brackish water area in the world and is therefore the regional sea most vulnerable to eutrophication. Almost all coastal areas are affected.

Results for nitrogen and phosphorus loads
Temporal and spatial availability
Due to incompleteness and non-comparability of the older data, the best data sets available at the moment are the OSPAR data for the 1990–96 period and the 1995 Helcom data for the sum of riverine inputs and direct discharges.

The decrease in the input of nitrogen into the Rhine over the 1985–97 period — Figure 2.4.



Source: RIKZ.

Since the 1995 loads for the EU Baltic countries cannot be compared with previous figures, no complete picture can be obtained.

No data are available for the EU countries in the MAP region.

Figures 2.5 and 2.6 present the riverine and direct loads of phosphorus and nitrogen.

Trends
The results of the trend detection are presented in Table 2.4 and the map in Appendix 8 showing inputs of nutrients. Given the yearly flow variations and the short time series, the conclusions given below are of limited value.

Main results:
For the OSPAR region as a whole, there is no trend in nitrogen and phosphorus loads for the 1990–96 period. High loads in 1994, 1995 and 1996 are attributed to high flow rates.

At the regional level, there is a decrease in nitrogen loads in the Kattegat and in the Atlantic region (UK and Portugal).

Increasing nitrogen load is found in the coastal zones of the Rhine catchment area, but the figures are biased by the shortness of the time series and the dominance within it of the high flow rates for 1994 and 1995 (see also Figure 2.4).

An increase in nitrogen load is found for the Channel region, dominated by the River Seine. Here, too, the total input is related to the flow rates, with high figures for 1994 and 1995. An increased nitrogen load is also found for the Celtic Sea.

There has been a decrease in phosphorus load in the Kattegat, and a more gradual downward trend in the Skagerrak, Channel and Irish Sea. A slight increase in the loads in the Celtic Sea and Norwegian Sea can be related to higher flow rates.

Suitability of the indicator
Because of the shortness of the time series, combined with the heavy dependence on natural yearly variations in the river flows, the input data currently available do not permit sufficiently accurate identification of this potential indicator to justify its inclusion in the indicator database.

Atmospheric inputs of nitrogen, which account for about 25 % of the total input, have recently been analysed together with the direct and river inputs (OSPAR, 2000). No trend in atmospheric input of nitrogen was observed.

Longer time series might be constructed if the recent load quantification methods were to be applied to the older (pre-1990) data. In that way, more reliable trend analyses could be performed.

2.5. Discussion

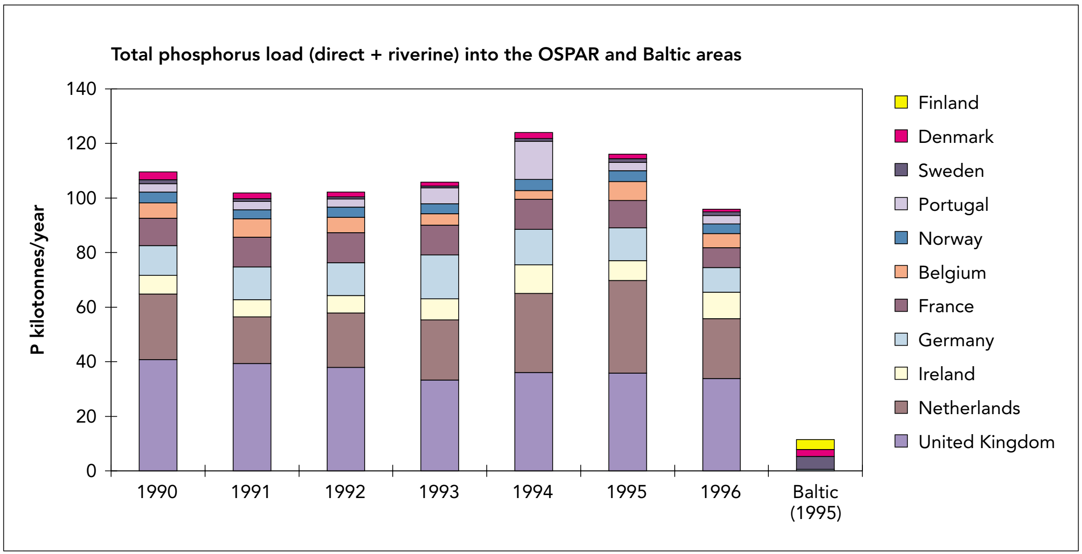
2.5.1. Data availability

The ICES oceanographic database is, in principle, a good source of longer time series relating to eutrophication indicators. However, its spatial coverage of nitrate and phosphate data for the coastal zones of Spain and Portugal is restricted.

In order to be able to make use of the patchy country-level data on nutrients along the

Figure 2.5. **Total phosphorus load in coastal waters (north-east Atlantic, North Sea, Baltic, for EU-15 + Norway and Iceland), 1990–96**

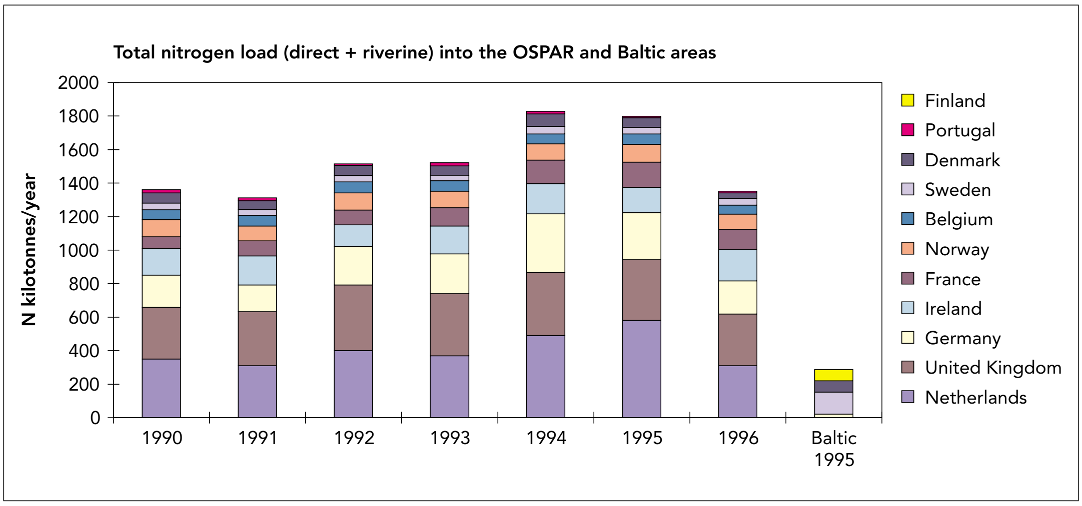
Sources: OSPAR; Helcom.



Note: The load of only four countries is presented for the Baltic Sea.

Figure 2.6. **Total nitrogen load in coastal waters (north-east Atlantic, North Sea, Baltic, for EU-15 + Norway and Iceland), 1990–96**

Sources: OSPAR; Helcom.



Note: The load of only four countries is presented for the Baltic Sea.

Table 2.4. **Trends in input (direct + riverine) of total phosphorus and total nitrogen into OSPAR regions, 1990–96**

Region	P	N
I(1) Norwegian Sea	15	– 3
I(2) Barents Sea	0	8
II(1) Skagerrak	– 4	3
II(2) Kattegat	– 41	– 17
II(3) North Sea	6	23
II(4) Channel	– 25	43
III(1) Irish Sea	– 25	– 2
III(2) Celtic Sea	22	27
III(3) Atlantic	0	– 17
IV Bay of Biscay and Iberian Coast	0	– 6

coast of the Mediterranean Sea in France, Italy and Spain, a central database comparable to the existing ICES ones would have to be developed.

For future assessments, in view of the water framework directive, a distinction needs to be made between coastal zones reflecting the major input of nutrients coming from rivers and a selected set of coastal zones reflecting direct run-off.

2.5.2. Data processing

The selection of data within the 20 km zone using ArcView is sensitive to the geographic projection of the coastline and the scale used. In this study, the estuarine data were excluded from the selection, but some data suggest estuarine squares.

Data processing of material from inshore stations using GIS therefore calls for basic standards for defining the geographical coastline. This study used the GISCO definition of the coastline. Further investigation is required to establish whether this choice can be recommended in the future, or whether a modification of this definition is required in view of specific marine and coastal zone assessments.

The aggregation methods should be the subject of further discussion with the EEA Member States. The use of real data rather than aggregated data per 100 km^2 square is recommended in order to increase the transparency of the information management process.

Aggregated values based on the geographical coordinates of the squares (centre) are not easy to compare with national data.

The method of trend detection requires further examination in relation to those indicators which are highly susceptible to natural variations. Possible modifications must be evaluated. As the ICES organisation has recently assessed the use of the Trend-y-tector for the detection of trends in riverine input data, it might be the best body to take a further look at this type of data as well.

2.5.3. Improvement of indicators

Further work is required on data and indicators.

- Nitrate and phosphate concentrations: Future work on the presentation of these indicators could make use of salinity data from these squares in order to compare absolute values expressed at zero salinity. These values can be compared with background concentrations. Based on the work which has been done so far, especially for the coastal zone, a more precise set of reference values for nutrients would be advisable. Also, the meteorological and hydrological conditions should be taken into account when the indicators are developed further because they can affect the nutrient concentrations.
  Efforts should be made to establish an indicator database for nutrients for those EU countries with Mediterranean coastal zones facing eutrophication problems.

- Bottom oxygen concentrations: Oxygen deficit is a parameter relevant to the more in-depth assessment of the quality status. As oxygen conditions are heavily affected by local meteorological and hydrographical conditions, this parameter cannot be judged correctly without additional information. As an indicator for eutrophication, it does not appear to be as robust as nutrient concentrations. It is conceivable that an improved method of trend detection based on the ICES data but taking account of the variability of the data might produce a satisfactory potential indicator, defined as the frequency of low oxygen values in the relevant season (September–October).

- Atmospheric inputs of nitrogen, which account for approximately 25 % of the total input, have recently been analysed together with the direct and river inputs into the North Sea (OSPAR, 2000). No trend in atmospheric input of nitrogen was observed. In the Baltic Sea, a 20–30 % decrease of nitrogen deposition was observed (Helcom, 2001). The total sum of atmospheric, direct and river inputs will be presented in the next YIR on the subject of eutrophication.

- Longer time series might be constructed if the recent load quantification methods were to be used on older (pre-1990) data. This would permit more reliable trend analyses to be performed.

3. Progress in integrated coastal zone management

3.1. Introduction

Integrated coastal zone management (ICZM) is a dynamic, continuous and iterative process of sustainable management designed to achieve sustainable use of the coastal zone for all the various interest groups, including nature protection organisations.

Common problems in the European coastal zones relate to unplanned development, decline of traditional sectors, coastal erosion and lack of appropriate communications and transport networks. Each of the regional seas faces different coastal pressures (see also Chapter 1).

Both densely populated and remote areas are taken into consideration.

A European ICZM strategy has been developed (European Commission, 2000a and 2000b). It was announced by the European Commission in 2000 and is now being implemented. This strategy consists of a package of tools, methods and instruments that the Commission is and will be using to promote ICZM. One such step is the proposal by the Commission for a European Parliament and Council recommendation to the Member States. The issue of the need for national monitoring and information diffusion systems is included in the draft recommendation. The ICZM strategy also touches on the issue of the need for information at the EU level. In this respect, it notes the role of the EEA and the European topic centres, both in generating specific products like an update of the 'Corine erosion atlas' and the Corine land cover 2000 project, but also in the more general problem of ICZM information. Therefore the 'EU strategy on ICZM' is not a substitute for continued action by the EEA — on the contrary, the EU strategy needs to be implemented through action by the EEA to produce information and indicators about the coastal zone.

Over recent years, ICZM has been developed mainly at regional and local levels and through the European demonstration programme (European Commission, 1999a and 1999b). Two interrelated approaches are important: on the one hand, the availability of information and, on the other, the communication process within and between the administration, the sectors involved and the general public, reflecting the development of multidisciplinary management strategies and operational programmes. Adequate information is a prerequisite for developing the understanding of solutions to the problem of sustainable development. The main characteristics of the communication aspect are:

- horizontal integration with a view to integrated planning, relating to both socioeconomic and ecological aspects and involving relevant stakeholders;
- vertical integration of the various administrative bodies. The level of communication between national government and lower administrative levels;
- the importance of public participation. Although there are obviously cultural differences, public participation is an essential part of the communication process at all levels in every country.

The proposed indicator for progress in ICZM is based on the above set of relevant aspects related to communication for management only and therefore serves as a potential response indicator.

Many studies on the different aspects of ICZM have already been published in North America. One example of this is *A manual for assessing progress in coastal management* (Olsen et al., 1999), which offers a five-step approach reflecting the coastal management cycle. This is covered by an overall questionnaire containing 126 questions. No attempt has yet been made to identify progress in Europe on the basis of a restricted set of criteria. The attempt presented here, originally undertaken for *Environmental signals 2000*, should therefore be seen as an exercise directed at encouraging further development of the indicator.

3.2. Methodology

This ICZM indicator has been investigated in collaboration with the non-governmental organisation European Union for Coastal Conservation (EUCC), which has reported separately in Elburg-Velinova et al. (1999). These reports are regarded as internal documents, but can be made available by RIKZ at the request of EEA national focal points (NFPs) for country verification.

In collaboration with the EUCC, a set of questions has been developed for a questionnaire designed to assess the different aspects of progress in ICZM (Box 3.1).

These questions were discussed at two workshops:

- The Norcoast Seminar in Aalborg, Denmark (31 May 1999).
- The Coastline '99 Conference in Miedzyzdroje, Poland (7 to 11 June 1999).

Representatives of regions with ICZM expertise contributed to both.

Box 3.1. EUCC questions on progress in ICZM

1. **What is the present status of ICZM in your country or region?**
2. **What is the status of integrated analysis and planning for the coastal zone (land and sea)?**
3. **What is the status of horizontal coordination?**
4. **What is the progress in vertical integration of administrative bodies?**
5. **What is the degree of public participation?**
6. **What is the status of the actual implementation of ICZM projects (see also question 1)?**

The percentage of coastline was initially suggested as the unit of measurement.

From the discussions with experts, it became clear that there is not at present enough regional-level information available at the right time to produce more than one indicator for ICZM. It emerged that regional-level administrative units were likely to be a better unit of measurement than the percentage of coastline.

A 'progress in ICZM in coastal regions per country' indicator was then identified. From the EUCC questions, three criteria were selected: horizontal integration, vertical integration and public participation. Fully established ICZM per region should show developments in all these directions.

The degree to which these criteria were met was judged on the basis of expert opinion gleaned through discussion with EUCC project officers. The number of experts consulted varied from one to three per country.

Low response to the questionnaire has been followed up through personal contacts with country experts.

Based on the answers obtained and on additional information, four categories have been established for the indicator (Table 3.1).

Category 4, 'Little or no progress', is also used where no information is available. This is the case for about 10 % of the regions.

3.3. Results

Progress in ICZM was assessed for a total of 181 regions in 14 different countries. Germany supplied its own information. Appendix 5 provides a full overview of the regions and their status scores, while Figure 3.1 gives an overview of progress per country and per region.

Appendix 6 shows progress in ICZM in the form of an overview of the results of the EUCC assessment. The scale of the map does not allow the categories to be represented exactly on the boundaries of the regions.

From this overview, the following conclusion can be drawn.

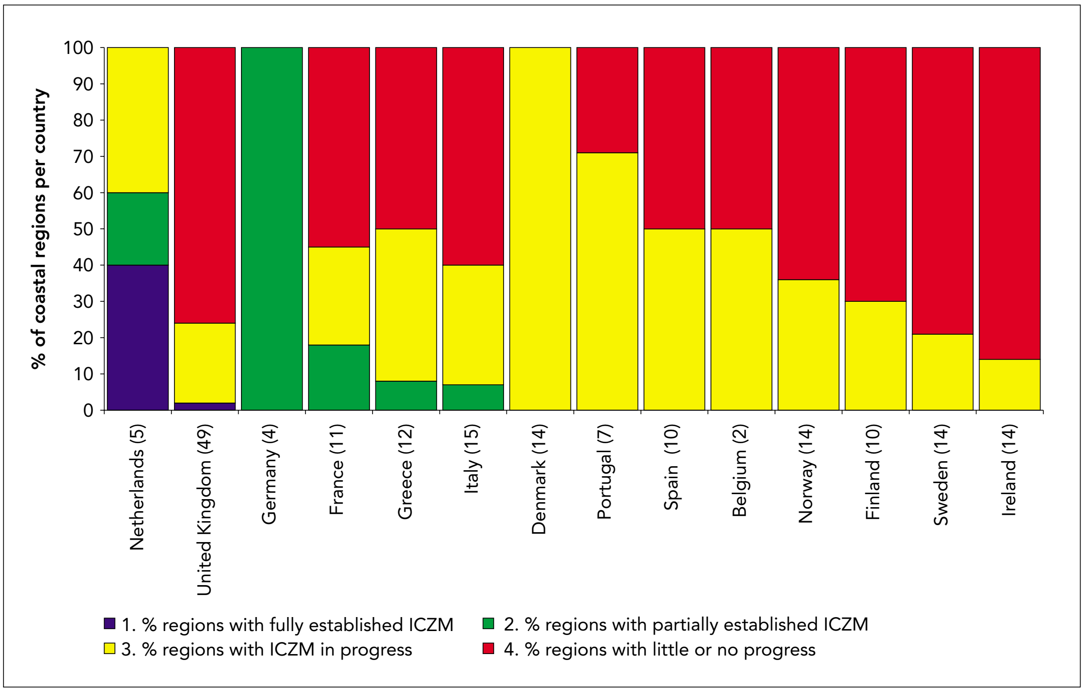
Main result:
In most countries, some progress has been made in ICZM but ICZM has been fully established in only a few regions.

Figure 3.1 may be somewhat misleading as regards the number of regions placed in Category 4. This may be biased by the fact that no information was available for a number of regions. There may also be differences of opinion between experts. Sweden may be underestimated for this reason.

Table 3.1. **Criteria used to determine progress in establishing ICZM**

Category	Extent of progress	Criteria
1	Fully established ICZM	Refers to those regions where ICZM is in operation for the whole coastal area. In these cases, the ICZM process includes the following key elements. *Horizontal integration*: Integrated approach to planning (including environmental and economic issues). *Vertical integration*: Administrative bodies working together at both State and regional levels. *Public participation*: Public participation or consultation in cross-sectoral planning.
2	Partially established ICZM	Regions where ICZM is in operation in specific areas of the coast, but not for the region's coast as a whole.
3	ICZM in progress	Regions where ICZM has reached the stage of active preparation for the whole or part of the coast.
4	Little or no progress	Regions where there are some environment and spatial planning tools, but key elements of ICZM are still missing. Regions where ICZM is not even being considered.

Figure 3.1. **Progress in integrated coastal zone management**



Based on the EUCC report in Elburg-Velinova et al. (1999), the following general conclusions can be drawn for the different countries. At the national level, integrated coastal zone management is not always identified as a specific policy issue, although basic features of it are gradually being incorporated into the ongoing harmonisation and coordination of administrative and legislative frameworks and physical planning systems. In Denmark, for instance, the Danish Planning Act prescribes contact between the State, the counties and the municipalities in top-down and bottom-up communication.

In the Netherlands, national policy planning for environmental and spatial planning and water management includes procedures for both horizontal and vertical integration and ICZM is fully established in the Dutch part of the Wadden Sea.

In France, the ICZM concept has made rapid progress over recent years and there are two regions where ICZM has been partly established. In Germany, the development of national parks in the coastal zone is playing an important role in coastal zone management. In the Scandinavian countries, some progress is being made at the local level, but information for the whole of the coastline is limited.

Basic data ICZM — Table 3.2.

Country	Coastal regions Total #	1. Regions with fully established ICZM	2. Regions with partially established ICZM	3. Regions with ICZM in progress	4. Regions with little or no progress
Netherlands	5	2	1	2	0
United Kingdom	49	1	0	11	37
Germany	4	0	4	0	0
France	11	0	2	3	6
Greece	12	0	1	5	6
Italy	15	0	1	5	9
Denmark	14	0	0	14	0
Portugal	7	0	0	5	2
Spain	10	0	0	5	5
Belgium	2	0	0	1	1
Norway	14	0	0	5	9
Finland	10	0	0	3	7
Sweden	14	0	0	3	11
Ireland	14	0	0	2	12
	181	3	9	64	105

Sources: Elburg-Velinova et al. (1999); for Germany: NFP, Umweltbundesamt.

Note: For the purposes of this table, the term 'coastal regions' means administrative bodies with principal responsibility for spatial and environmental planning.

In the United Kingdom, most initiatives are locally based with strong public consultation. The Dorset coast strategy's principles and action plans include key elements of horizontal and vertical integration as well as public participation. In several other regions, ICZM is in progress.

Ireland is working on a national-level ICZM policy and ICZM is in progress in some regions. In Spain, most of the autonomous regions have elements of ICZM incorporated into their planning systems. Vertical integration is not strongly developed and there are overlaps in management responsibilities at national and regional levels. Good examples also exist at the local level. In Portugal, coastal zone planning principles exist at the national level and offer a good framework for horizontal and vertical integration. Regional plans are in development, some of them at an advanced stage. In Greece, efforts are being made to improve coordination between ministries. Efforts to reduce the effects of water pollution are a major priority in this respect. On the island of Rhodes, there is an integrated management programme and in the Cyclades major efforts are being made with local communities and municipalities. Several EU-funded projects are supporting ICZM development at the regional level.

3.4. Discussion

3.4.1. Improvement of indicators

A more transparent system of data collection, division of coastal regions and criteria for expert judgment is necessary to achieve acceptance of the ICZM indicator. Building this indicator on internal EUCC reports is not a transparent approach, but was the only option in this first approach to a response indicator on ICZM. Any further development of this indicator should built on publicly available data and information.

Basic features of the ICZM process are horizontal integration of all sectors and stakeholders involved, vertical integration between the different administrative levels, the level of participation and the availability of adequate information. Cultural differences in the interpretation of these elements call for a tailor-made general assessment framework. There is thought to be a need to work with representatives of the relevant stakeholders and administrative levels to identify critical success factors based on more quantifiable criteria. This should be seen in the context of the ICZM strategy of the European Commission. Systematic data flow on ICZM progress can be stimulated through the European ICZM strategy. New efforts by the European Union to encourage the development of ICZM should take account of the need for a practical attitude towards the use of a European indicator for progress in ICZM. The classification used in this study has proved to be of operational value.

The progress in ICZM indicator could be developed in a more quantitative way than has been done in this study. A more detailed checklist, drawn up in collaboration with regional experts, would surely deepen understanding of the progress made and the problems encountered.

To achieve a rapid and systematic exchange of information on this indicator, it is essential to produce a proper definition of the network involved and the basic (administrative) level of information gathering. The boundaries of the coastal regions in which ICZM is in progress do not always coincide with those of the administrative units. It may be feasible to collect the necessary information in 181 regions, but the only way to provide proper insight into the information obtained is to map it.

The national-level aggregation practised in this study has the disadvantage of hindering comparison between countries. Although this should not be attempted, the presentation in Figure 3.1 invites it. Alternatives to the aggregation of regional information at national level are best worked out in collaboration with the ICZM contact persons.

Without proper support from a European ICZM strategy, it is unlikely that the regions will cooperate fully with a regular regional assessment.

The use of the EIONET to set up a framework for regional assessment should be investigated further with the EEA member countries.

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Appendices

Appendix 1
Full list of parameters from the ETC/MCE indicator questionnaire 1999

Parameters	Units
Sheet: General	
TABLE 1: General characteristics	
TABLE 2: Biological characteristics	
Sheet: Eutrophication	
TABLE E-1: TOTAL P (year-round)	µmol/l
TABLE E-2: TOTAL P (winter)	µmol/l
TABLE E-3: ORTHOPHOSPHATE (winter)	µmol/l
TABLE E-4: TOTAL N (year-round)	µmol/l
TABLE E-5: TOTAL N (winter)	µmol/l
TABLE E-6: NITRATE (winter)	µmol/l
TABLE E-7: NITRITE (winter)	µmol/l
TABLE E-8: NITRATE + NITRITE (winter)	µmol/l
TABLE E-9: AMMONIUM (winter)	µmol/l
TABLE E-10: TOTAL N/TOTAL P RATIO (year-round)	value
TABLE E-11: NITRATE + NITRITE/PHOSPHATE RATIO (year-round)	value
TABLE E-12: DISSOLVED OXYGEN or SATURATION	mg/l
TABLE E-13: SILICATE	µmol/l
TABLE E-14: ALGAL BLOOMS (choose appropriate units)	km^2/year/number/number 10^6/l
TABLE E-15: TOXIC ALGAE (species 1)	10^6 cells/l
TABLE E-16: TOXIC ALGAE (species 2)	10^6 cells/l
TABLE E-17: TOXIC ALGAE (species 3)	10^6 cells/l
TABLE E-18: PHAEOCYSTIS SP.	10^6 cells/l
TABLE E-19: DIATOM/FLAGELLATE RATIO (spring — based on biovolume/l)	dimensionless value
TABLE E-20: DIATOM/FLAGELLATE RATIO (summer — based on biovolume/l)	dimensionless value
TABLE E-21: CHLOROPHYLL A (summer)	µg/l
TABLE E-22: SEA GRASSES (cover *Zostera* sp. or *Posidonia* sp.)	ha
TABLE E-23: SEA GRASSES (maximum depth of occurrence)	m
TABLE E-24: SEAWEEDS (cover)	ha
TABLE E-25: SEAWEEDS (maximum depth occurrence)	m
TABLE E-26: MICROPHYTOBENTHOS (biomass)	mg chlorophyll/m^2
TABLE E-27: SOFT BOTTOM MACROZOOBENTHOS (>1 mm) biomass	g/m^2 ash free dw
TABLE E-28: INPUT TOTAL P entering water system	10^3 kg
TABLE E-29: INPUT TOTAL N entering water system	10^3 kg
TABLE E-30: INPUT TOTAL C entering water system	10^3 kg
TABLE E-31: Relevant literature/reports/other information on eutrophication	
Sheet: Harmful substances	
TABLE HS-1: Cd in sediment	mg/kg dw

Parameters	Units
TABLE HS-2: Cr in sediment	mg/kg dw
TABLE HS-3: Cu in sediment	mg/kg dw
TABLE HS-4: Hg in sediment	mg/kg dw
TABLE HS-5: Pb in sediment	mg/kg dw
TABLE HS-6: Zn in sediment	mg/kg dw
TABLE HS-7: PAH in sediment	mg/kg dw
TABLE HS-8: PCB in sediment	µg/kg dw
TABLE HS-9: TBT in sediment	µg/kg dw
TABLE HS-10: DDT in sediment (sum DDT + DDE + DDD)	mg/kg dw
TABLE HS-11: PAH in suspended matter	mg/kg dw
TABLE HS-12: PCB in suspended matter	mg/kg dw
TABLE HS-13: TBT in suspended matter	mg/kg dw
TABLE HS-14: RADIATION	mBq/l
TABLE HS-15: Cd IN MUSSEL dry tissue	µg/kg dw
TABLE HS-16: Cr IN MUSSEL dry tissue	µg/kg dw
TABLE HS-17: Cu IN MUSSEL dry tissue	µg/kg dw
TABLE HS-18: Hg IN MUSSEL dry tissue	µg/kg dw
TABLE HS-19: Pb IN MUSSEL dry tissue	µg/kg dw
TABLE HS-20: Zn IN MUSSEL dry tissue	µg/kg dw
TABLE HS-21: DDT IN MUSSEL dry tissue (sum DDT + DDE + DDD)	µg/kg dw
TABLE HS-22: PAH IN MUSSEL dry tissue	µg/kg dw
TABLE HS-23: PCB IN MUSSEL dry tissue	µg/kg dw
TABLE HS-24: TBT IN MUSSEL dry tissue	µg/kg dw
TABLE HS-25: RADIONUCLIDES IN MUSSEL dry tissue	µg/kg dw
TABLE HS-26: Cd IN FISH (please specify tissue)	µg/kg dw
TABLE HS-27: Cr IN FISH (please specify tissue)	µg/kg dw
TABLE HS-28: Cu IN FISH (please specify tissue)	µg/kg dw
TABLE HS-29: Hg IN FISH (please specify tissue)	µg/kg dw
TABLE HS-30: Pb IN FISH (please specify tissue)	µg/kg dw
TABLE HS-31: Zn IN FISH (please specify tissue)	µg/kg dw
TABLE HS-32: DDT IN FISH (please specify tissue) (sum DDT + DDE + DDD)	µg/kg dw
TABLE HS-33: PAH IN FISH (please specify tissue)	µg/kg dw
TABLE HS-34: PCB IN FISH (please specify tissue)	µg/kg dw
TABLE HS-35: TBT IN FISH (please specify tissue)	µg/kg dw
TABLE HS-36: RADIONUCLIDES IN FISH (please specify tissue)	µg/kg dw
TABLE HS-37: DDT IN MAMMAL (sum DDT + DDE + DDD)	µg/kg dw
TABLE HS-38: PCB IN MAMMAL	µg/kg dw
TABLE HS-39: INPUT Cd entering water system	10^3 kg
TABLE HS-40: INPUT Cr entering water system	10^3 kg
TABLE HS-41: INPUT Cu entering water system	10^3 kg
TABLE HS-42: INPUT Hg entering water system	10^3 kg
TABLE HS-43: INPUT Pb entering water system	10^3 kg
TABLE HS-44: INPUT Zn entering water system	10^3 kg
TABLE HS-45: INPUT DDT entering water system (sum DDT + DDE + DDD)	10^3 kg
TABLE HS-46: INPUT PAH entering water system	10^3 kg
TABLE HS-47: INPUT PCB entering water system	10^3 kg
TABLE HS-48: INPUT TBT entering water system	10^3 kg
TABLE HS-49: Relevant literature/reports/other information on harmful substances	

Sheet: Oil pollution

Parameters	**Units**
TABLE OP-1: OIL SPILLS on surface	1 000 kg
TABLE OP-2: COASTLINE AFFECTED	km
TABLE OP-3: BIRDS AFFECTED	number
TABLE OP-4: MAMMALS AFFECTED	number
TABLE OP-5: INPUT: OIL AND GAS INDUSTRY (direct)	1 000 kg/year
TABLE OP-6: INPUT: ACCIDENTS	1 000 kg/year
TABLE OP-7: INPUT: SHIP DISCHARGES	1 000 kg/year
TABLE OP-8: INPUT: RIVERINE INPUT	1 000 kg/year
TABLE OP-9: Relevant literature/reports/other information on oil pollution	

Definition of summer/winter:
Recipients of the questionnaire were asked to indicate in the relevant tables which periods were considered 'spring' and 'summer' for these parameters.
For winter, they were asked to use the two-month period in January and February, while it was suggested that spring and summer should be the two or three months with least production.

Appendix 2
Six maps: Locations of selected squares for phosphate, nitrate and bottom oxygen

Map 1: **Regions of OSPAR and Helcom per country**

Map 2a: **ICES data aggregated in 10 x 10 km² squares in the coastal zone (20 km) — north-east Atlantic**

Map 2b: **ICES data aggregated in 10 x 10 km² squares in the coastal zone (20 km) — Baltic Sea**

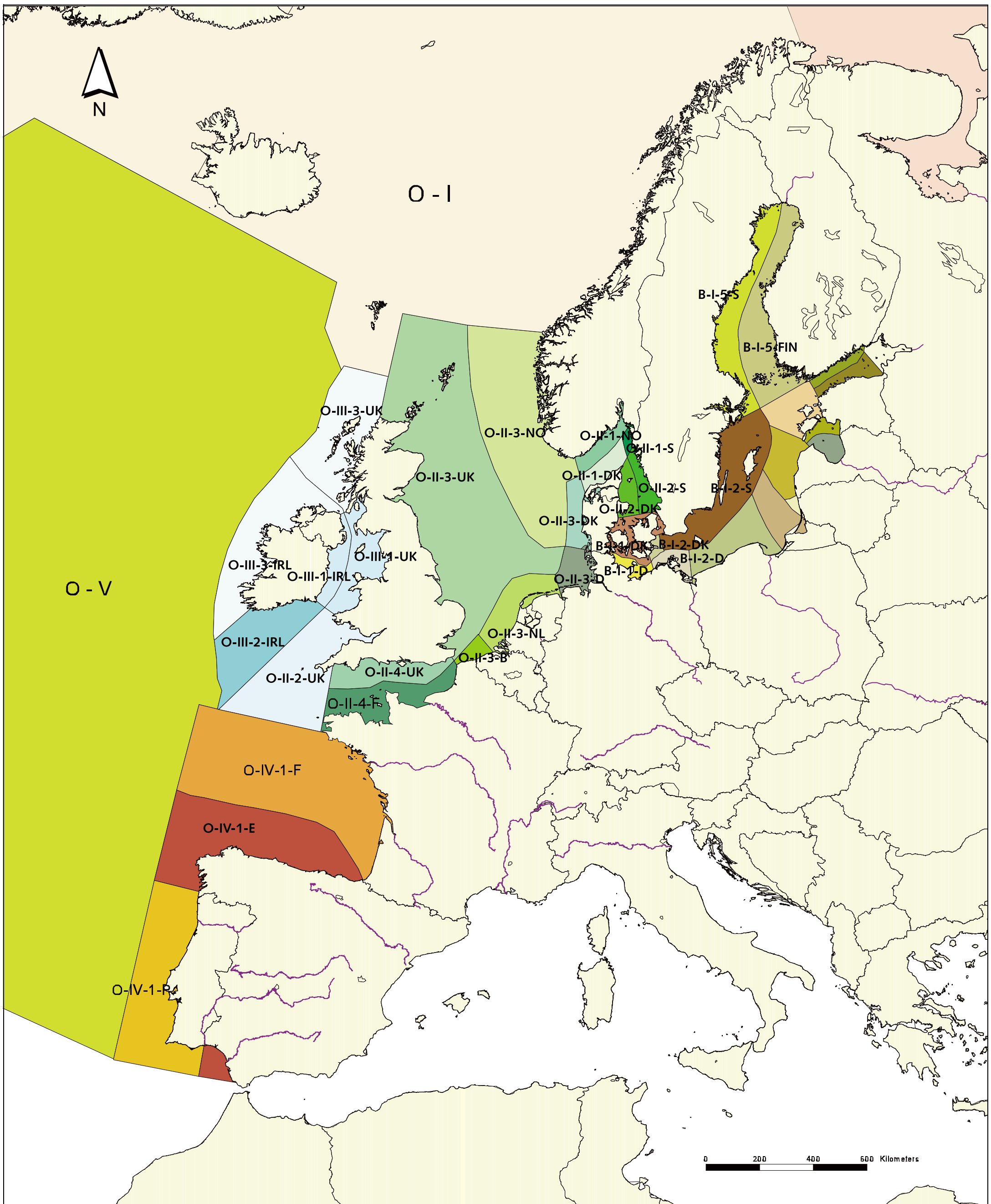
Map 3: **Selected squares of phosphate**

Map 4: **Selected squares of nitrate**

Map 5: **Selected squares of bottom oxygen**

Note: Neighbouring squares may appear as larger single clusters.
Colours define country zones per regional sea.

Regions of OSPAR and Helcom per country Map 1

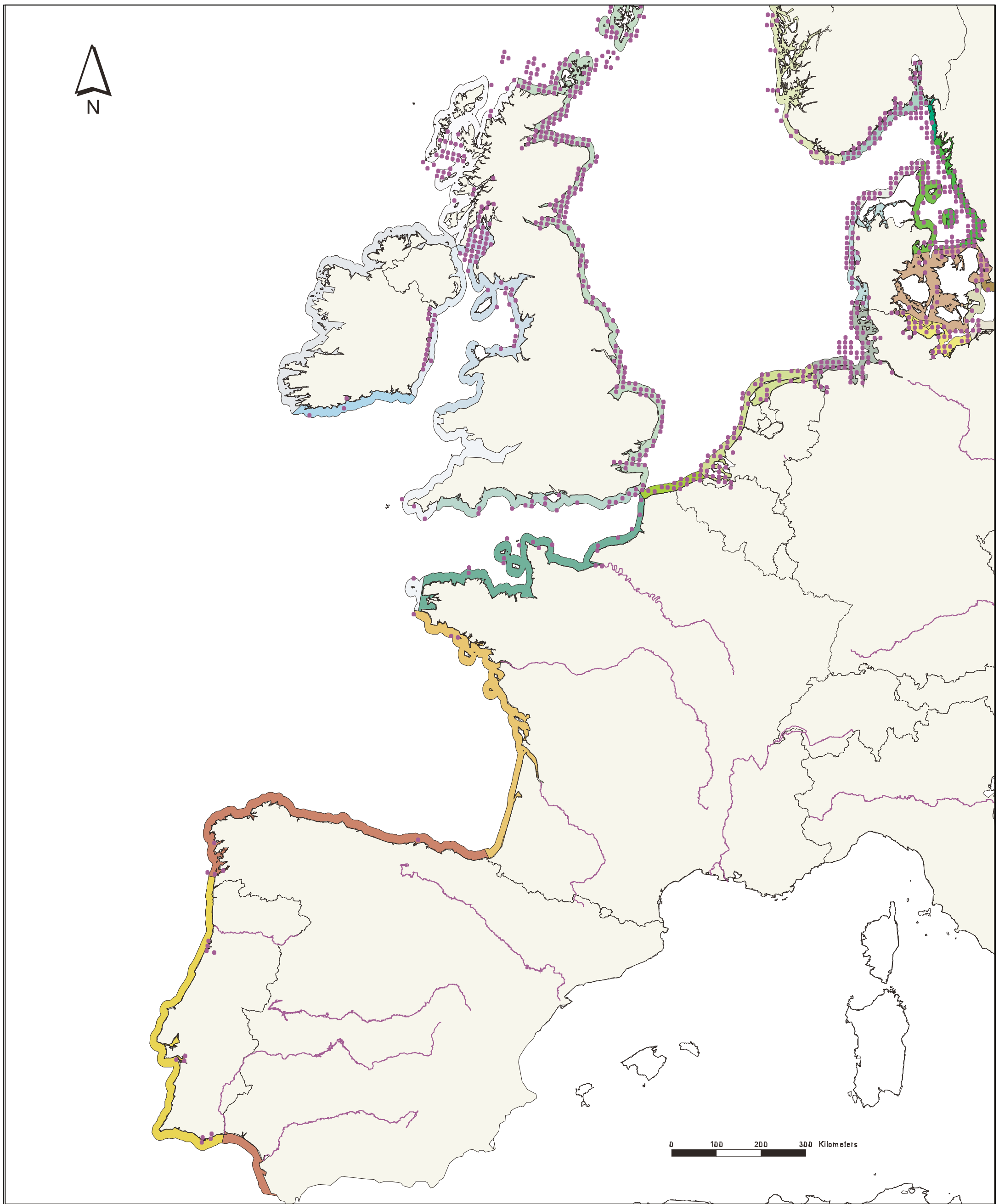


Regions of OSPAR and HELCOM (Baltic) per country

source: RIKZ

B — Baltic area
O — OSPAR area
B-I = Baltic Sea
O-I = Arctic Waters
O-II = Greater North Sea
O-III = The Celtic Seas
O-IV = Bay of Biscay an Iberian Coast
O-V = Wider Atlantic

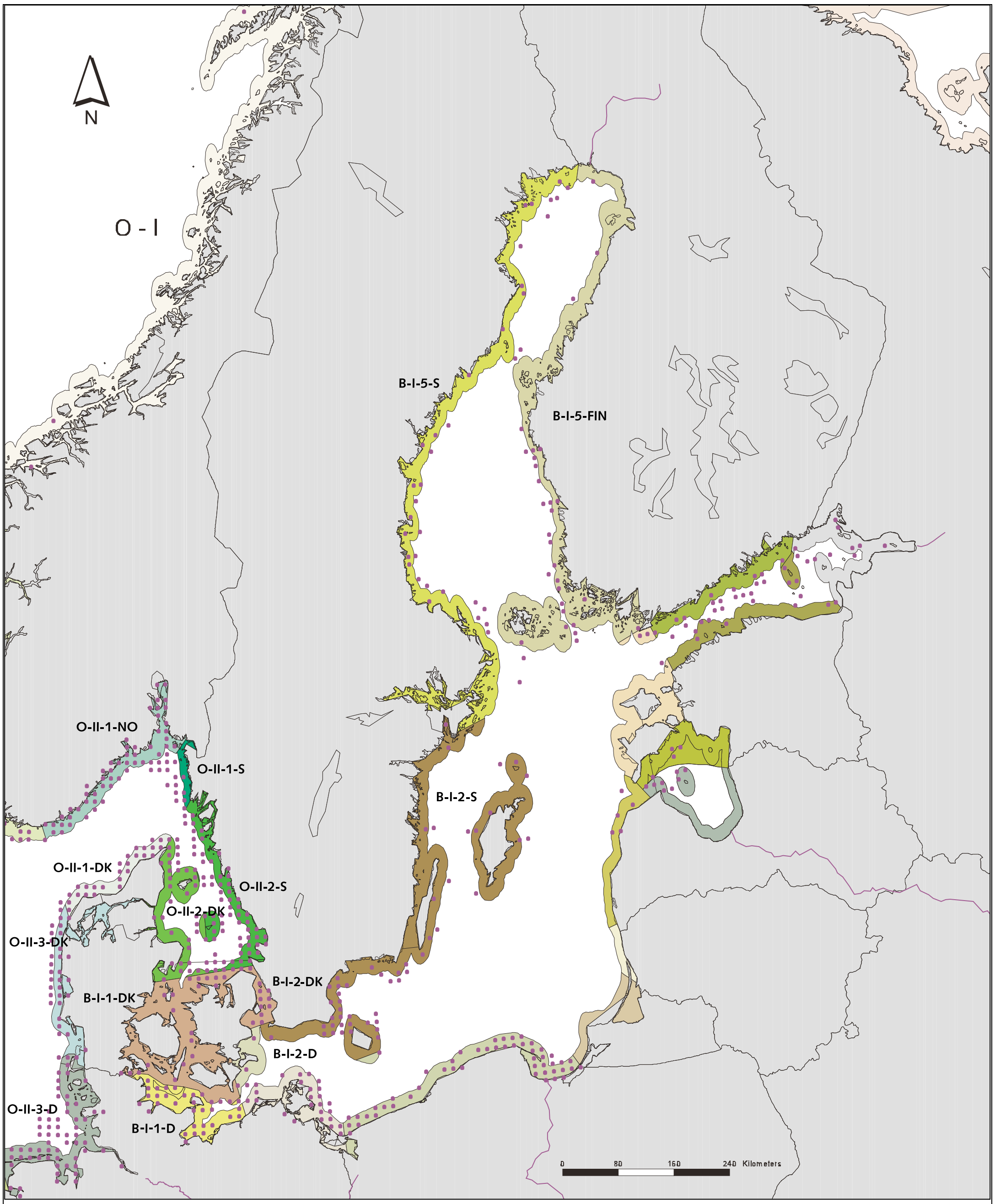
Map 2a — **ICES data aggregated in 10 x 10 km² squares in the coastal zone (20 km) — north-east Atlantic**



Ices data aggregated in 10x10 km² squares in the coastal zone (20 km)

source: GISCO 1998
Ices
Data compilation RIKZ

ICES data aggregated in 10 x 10 km^2 squares in the coastal zone (20 km) — Baltic Sea Map 2b



Ices data aggregated in 10x10 km^2 squares in the coastal zone (20 km)

Regions of OSPAR and HELCOM (Baltic) per country

B — Baltic area
O — OSPAR area
B-I = Baltic Sea
O-I = Arctic Waters
O-II = Greater North Sea
O-III = The Celtic Seas
O-IV = Bay of Biscay an Iberian Coast
O-V = Wider Atlantic

sources: GISCO 1998, Ices Data compilation RIKZ

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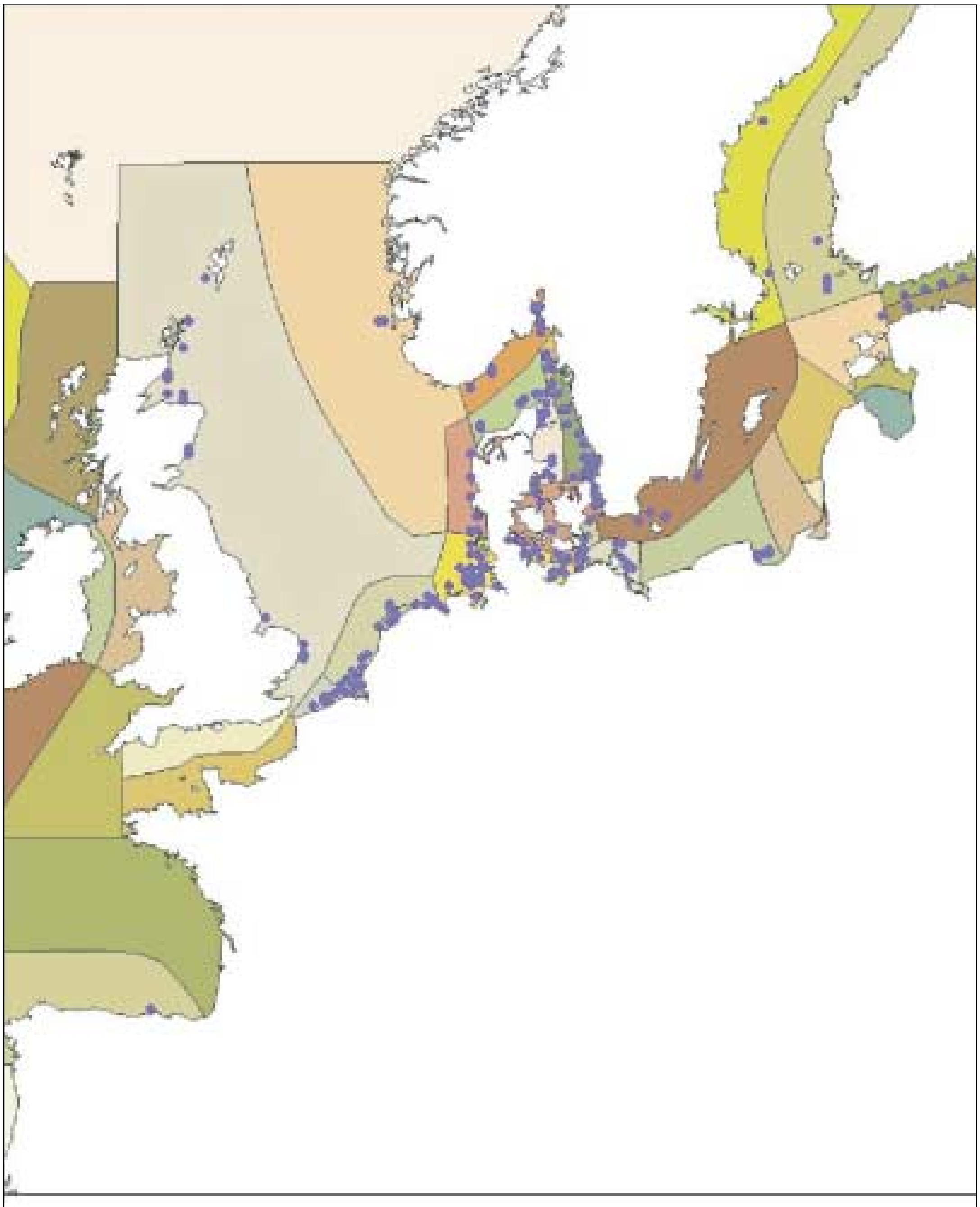
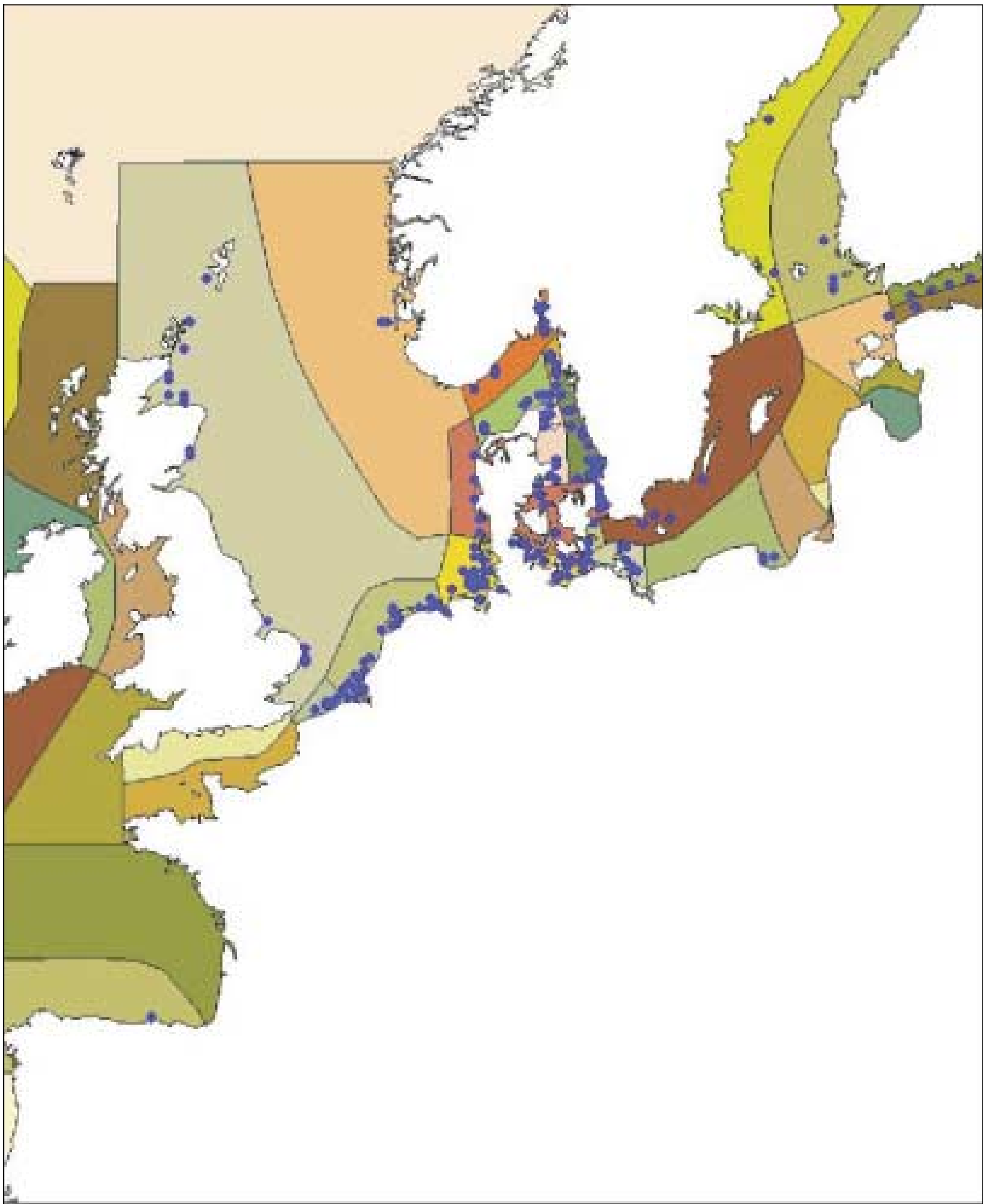
Map 3 **Selected squares of phosphate**



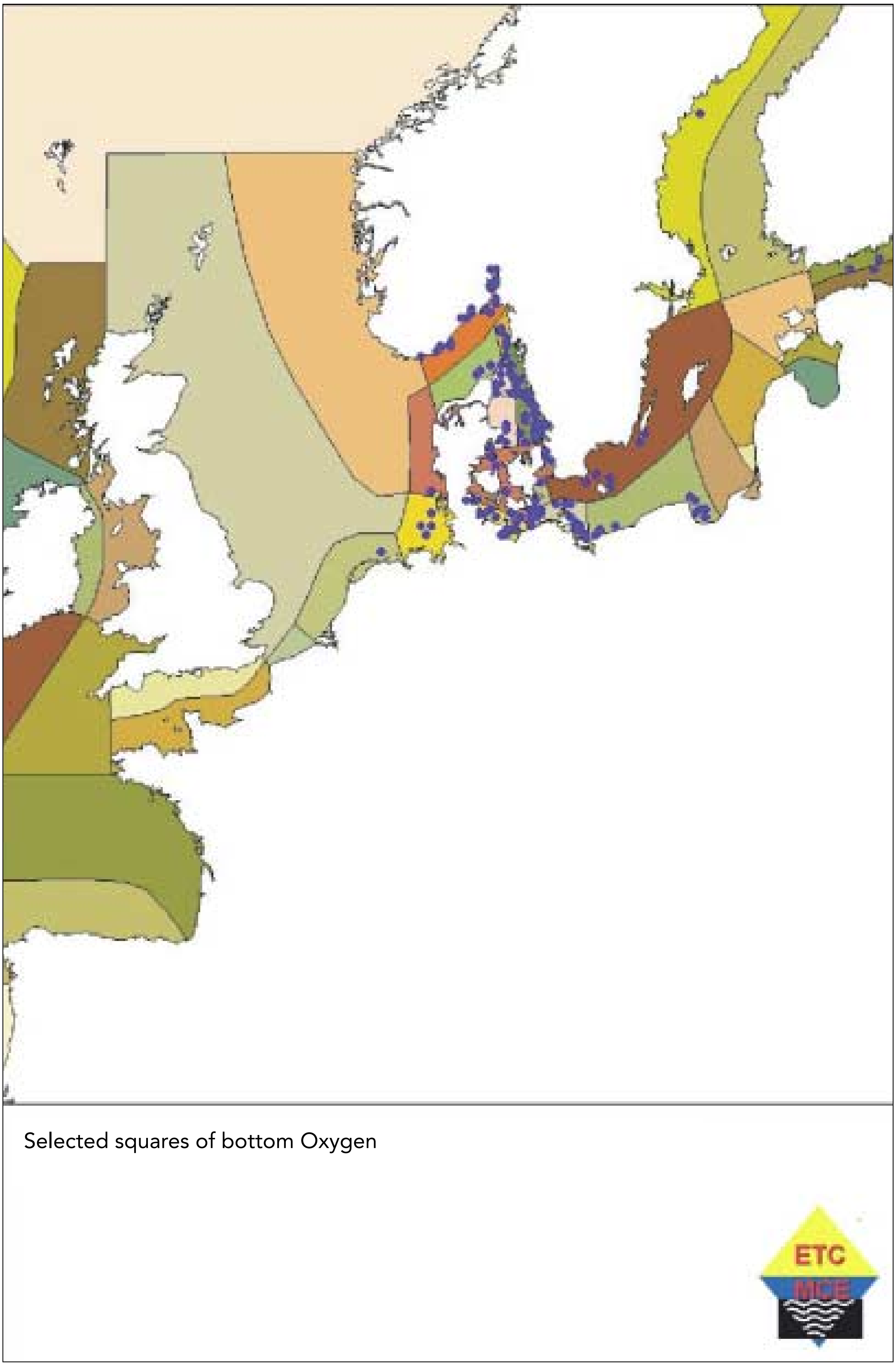
Selected squares of Phosphate

Selected squares of nitrate | Map 4



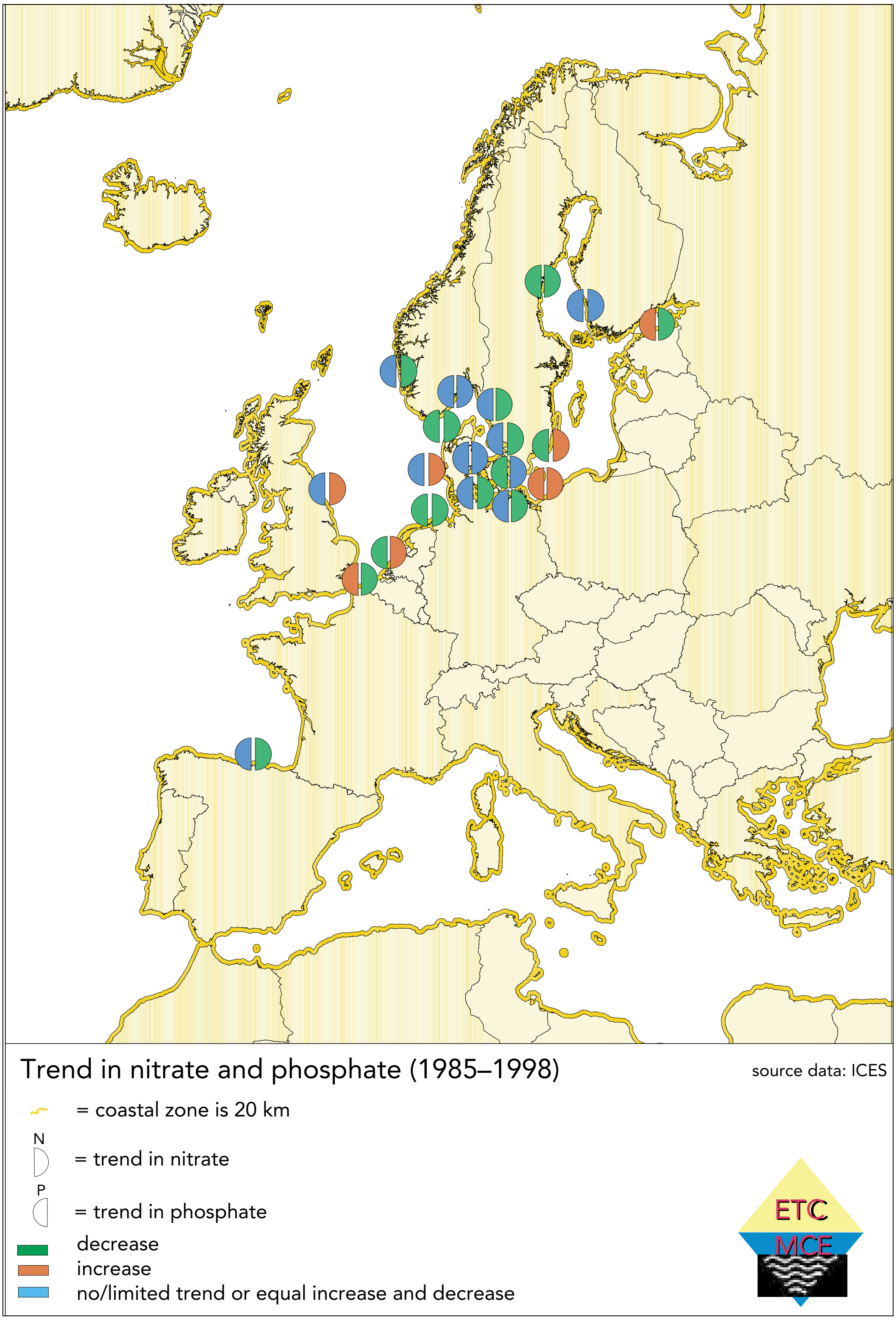
Selected squares of Nitrate

Map 5 **Selected squares of bottom oxygen**



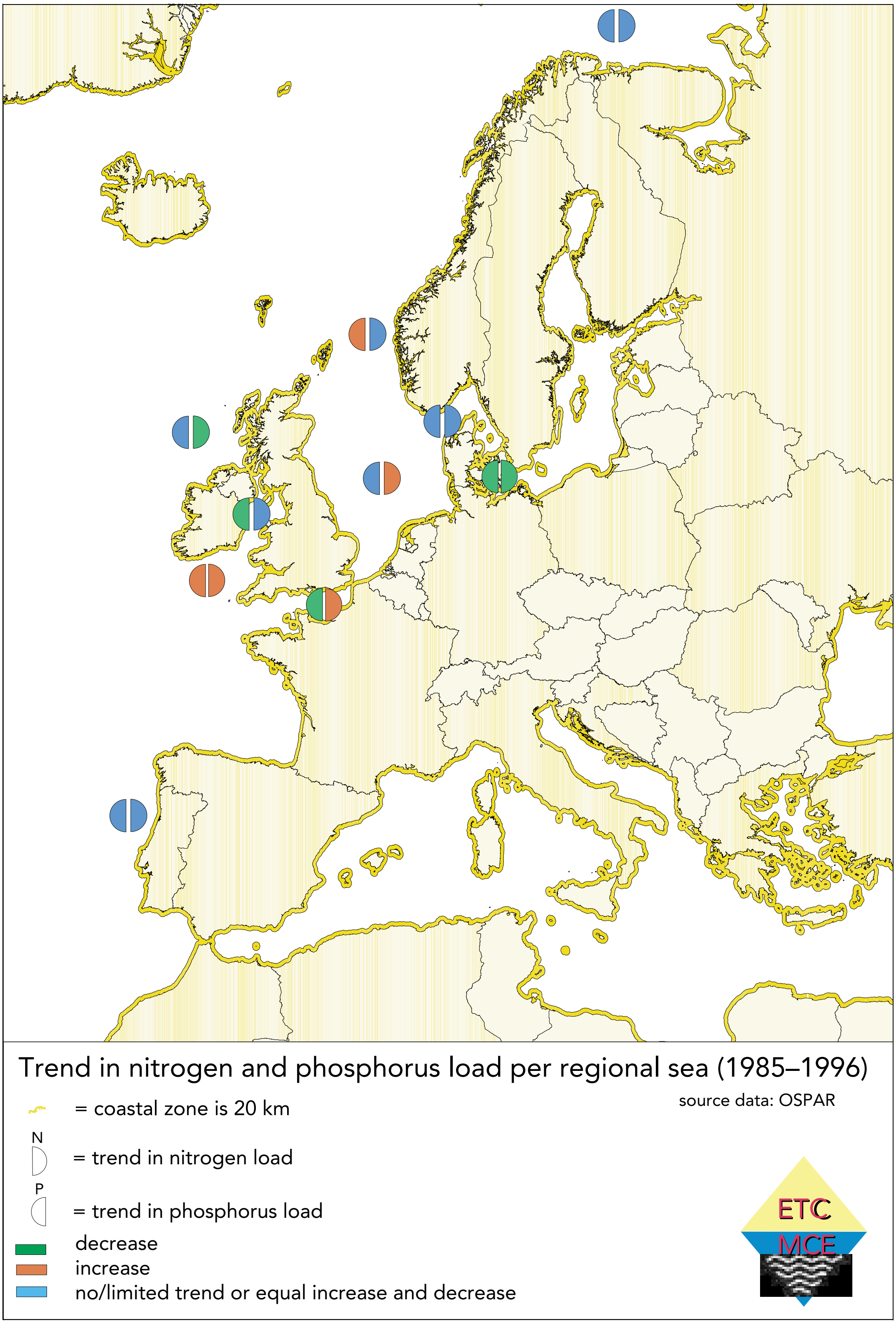
Appendix 3
Map: Trends in nitrate and phosphate

Trends in nitrate and phosphate — Map 6



Appendix 4
Map: Trends in nitrogen and phosphorus loads per regional sea

Map 7 **Trends in nitrogen and phosphorus loads per regional sea**



Appendix 5
ICZM progress per region per country

Country	Region	Level
Belgium	West-Vlaanderen	3
	Antwerpen-Scheldemond	4
Denmark	København	3
	Frederiksborg	3
	Roskilde	3
	Storstrøm	3
	Vestsjælland	3
	Fyn	3
	Vejle	3
	Århus	3
	Viborg	3
	Nordjylland	3
	Ringkjøbing	3
	Ribe	3
	Sønderjylland	3
	Bornholm	3
Finland	Kymenlaakso	3
	Itä-Uusimaa	3
	Helsinki	4
	Uusimaa	3
	South-western Finland	4
	Åland	4
	Satakunta	4
	County of Vaasa	4
	Northern Ostrobothnia	4
	Lapland	4
France	Nord — Pas-de-Calais	3
	Picardie	4
	Haute-Normandie	2
	Basse-Normandie	2
	Bretagne	2
	Pays de la Loire	4
	Poitou-Charentes	3
	Aquitaine	3
	Languedoc-Roussillon	4
	Provence-Alpes-Côte d'Azur	4
	Corse	4
Germany (*)	Baltic Sea Mecklenburg-Vorpommern	2
	Baltic Sea Schleswig-Holstein	2
	North Sea Schleswig-Holstein	2
	North Sea Niedersachsen	2

Country	Region	Level
Norway	Finnmark	4
	Troms	4
	Nordland	4
	Nord-Trondelag	4
	Sør-Trondelag	4
	Møre og Romsdal	4
	Northern Fjord-Region (Sogn og Fjordane	4
	Southern Fjord Region (Hordaland)	3
	Rogaland (with Stavanger)	3
	Vest-Agder (with Kristiansand)	3
	Aust-Agder (with Arendal)	3
	Telemark (with Skien)	3
	Vestfold	4
	Ostfold (with Frederikstad)	4
Portugal	Norte	3
	Centro	3
	Lisboa e Vale do Tejo	4
	Alentejo	4
	Algarve	3
	Açores	3
	Madeira	3
Spain	País Vasco	3
	Cantabria	4
	Asturias	4
	Galicia	4
	Andalucía	3
	Murcia	4
	Comunidad Valenciana	3
	Cataluña	3
	Baleares	3
	Canarias	4
Sweden	Bohuslän	3
	Hallands län	4
	Kristianstads län	4
	Malmöhus län	4
	Blekinge Län	3
	Kalmar län	4
	Östergötlands län	4
	Söndermanlands län	3
	Stockholms län	4
	Uppsala län	4
	Gävleborgs län	4
	Västernorrlands län	4
	Västerbottens län	4
	Norrbottens län	4

Source: Elburg-Velinova et al. (1999).

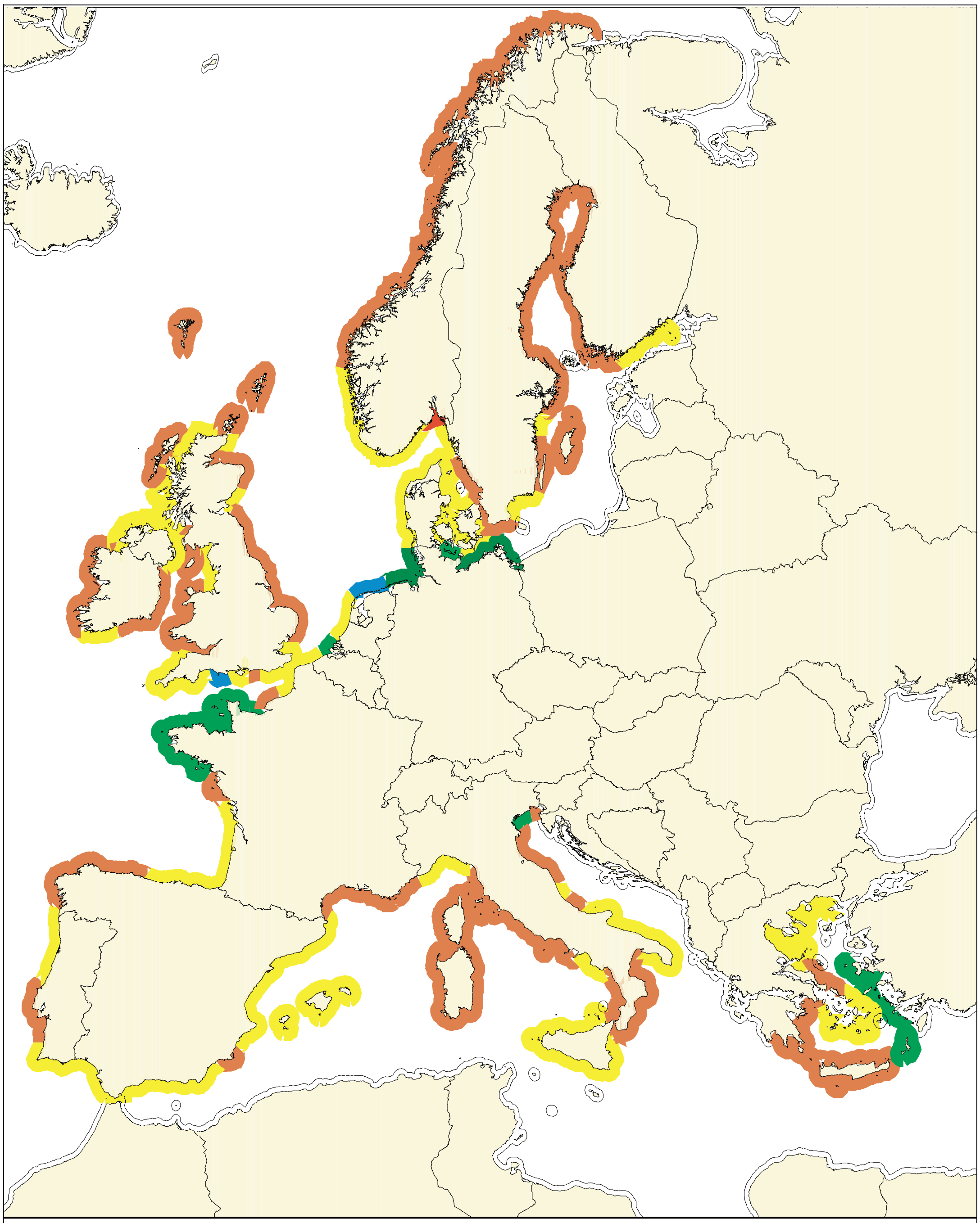
Country	Region	Level
Greece	Epirus	3
	West Greece	4
	Ionian Islands	4
	Sterea	4
	Peloponnese	4
	Attica	3
	Thessaly	3
	Central Macedonia	3
	East Macedonia	3
	Islands of North Aegean	4
	Islands of South Aegean	2
	Crete	4
Ireland	Louth	4
	Meath/Louth	4
	Dublin	4
	Wicklow	4
	Wexford/Kilkenny	4
	Waterford	4
	Cork	3
	Kerry	4
	Limerick	4
	Clare	4
	Galway	4
	Mayo	4
	Sligo	4
	Donegal	3
Italy	Liguria	3
	Toscana	4
	Lazio	4
	Campania	3
	Basilicata	4
	Calabria	4
	Puglia	3
	Molise	4
	Abruzzo	3
	Marche	4
	Emilia-Romagna	4
	Veneto	2
	Friuli	4
	Sicilia	3
	Sardegna	4
Netherlands	Zeeland	2
	Zuid-Nederland	3
	Noord-Nederland	3
	Groningen	1
	Friesland	1

Country	Region	Level
United Kingdom	Kent	3
	Essex	4
	Suffolk	4
	Norfolk	4
	Lincolnshire	4
	Humberside	4
	North Yorkshire	4
	Cleveland	4
	Durham	4
	Sunderland	4
	Northumberland	4
	Borders	4
	Lothian	3
	Central	4
	Fife	4
	Tayside	3
	Grampian	4
	Highland	3
	Orkney Islands	4
	Shetland	4
	Western Isles	4
	Strathclyde	4
	Dumfries and Galloway	4
	Cumbria	3
	Lancashire	3
	Liverpool	4
	Cheshire	3
	Clwyd	4
	Gwynedd	4
	Dyfed	4
	West Glamorgan	4
	Mid-Glamorgan	4
	South Glamorgan	4
	Gwent	4
	Gloucestershire	4
	Avon	4
	Somerset	4
	Devon	3
	Cornwall	3
	Dorset	1
	Hampshire	4
	Isle of Wight	3
	West Sussex	4
	East Sussex	3
	Isle of Man	4
	Down/Ulster	3
	Antrim/Ulster	4
	Derry or Donegal	3
	Channel Islands	4

(*) Adapted following NFP Germany comments.

Appendix 6
Map: Progress in ICZM

Progress in ICZM Map 8



Progress in Integrated Coastal Zone Management (ICZM) per region.

- established ICZM
- partially established ICZM
- ICZM in progress
- little or no progress

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