Technical report No 17

Integration of information on Europe's marine environment

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Introduction

Integration of information is one of the key issues in order to ensure the supply of objective and comprehensive information on Europe's marine and coastal environment. Work carried out by National Centres, International Organisations, Marine Conventions and the European Environment Agency (EEA) should be coordinated in order to avoid duplication. At the same time comparable methods and information are needed in order to be able to assess the European state of marine and coastal environment in a more comprehensive and reliable way.

The objectives of this report are to identify the existing sources of information in the marine and coastal environment at European level, to analyse the current gaps between the required and available information and to suggest the way forward in order to achieve integrated information that meets the requirements of EEA.

1. Requirements from EU legislation and EEA Work Programme-identified environmental issues

1.1. Requirements from EU legislation and EEA Work Programme

Water legislation from the European Community Water Policy (EC 1996) imposes certain requirements on EU countries to provide information on state, pressures and impact on the marine and coastal environment.

The EEA Work Programme states clearly that there is a need for improvement of information on coastal and marine water quality in Europe. One of the mandates is to facilitate the exchange of information in order to improve and ensure cooperation of a European monitoring network.

1.1.1. Monitoring requirements

Water management is not possible without reliable data upon which to base decisions. Most EC water legislation include obligations to monitor the quality of relevant waters and/or to monitor activities that may affect said quality. Member States incorporate such requirements into their national or regional monitoring networks.

A primary requirement of policy framing and complementation at European level is the need for comparability of data across Europe. EEA is established to work with the European Commission, Member States and others to develop ways in which this can be improved and the Agency will work closely with the European Commission and Member States when considering the monitoring implications of the Water Policy Framework Directive.

1.1.2. The Dangerous Substances Directive (76/464/EEC)

Objective - to control the pollution of surface water with dangerous substances.

Key Features - The Directive applies to all surface waters and requires Member States to control emissions of dangerous substances, primarily by means of permits issued to industrial installations and by improved urban waste water treatment. The conditions for permits for the more dangerous substances are established at Community level by a series of "daughter Directives". The Directive contains two alternative methods for setting these conditions; Member States have the choice between applying emission "limit values" based upon the best available techniques, or they can base their permits on the limits required to meet specified "quality objectives" in the receiving body of water including the marine waters. List

II substances are dealt with by Member States which have to produce reduction programmes.

1.1.3. The Urban Waste Water Treatment Directive (91/271/EEC)

Objective - to reduce the pollution of surface waters with nutrients (particularly nitrates and phosphates) from urban waste water which is one of the major sources of nutrient pollution and hence, of eutrophication. (The Directive also has the objective of reducing nitrate concentrations in potable water).

Key Features - The Directive establishes conditions for the collection, treatment and discharge of urban waste water and waste water from certain industrial sectors. It establishes a timetable for the provision of waste water collecting systems and treatment plants as well as establishing the level of treatment required of the plants. The timetable and requirements vary depending on the size of the agglomeration and the sensitivity of the receiving waters, including marine waters, which must be established by monitoring.

1.1.4. The Nitrates Directive (91/676/EEC)

Objective - to complement the Urban Waste Water Treatment Directive by dealing with nitrate pollution from agricultural sources; another major source of nitrate pollution.

Key Features - The Directive requires Member States to produce and promote Codes of Good Agricultural Practice in order to reduce the level of nitrate loss to surface water (marine waters included) and groundwater from agriculture. It contains monitoring requirements and, in areas identified as being vulnerable to nitrate pollution, it imposes Action Programmes with legally enforceable constraints on agricultural practices together with limits on the spreading of organic manure.

1.1.5. The Environmental Impact Assessment Directive (85/337/EEC)

Objective - to ensure that the impact of new development projects on the environment is assessed before planning consent is given.

Key Features - The Directive requires projects considered likely to have a significant effect on the environment to be assessed for their impact upon a wide range of environmental factors (including, inter alia, human beings, flora, fauna and water). The relevant authorities must take all such information, together with the views of the public and interested bodies, before granting development consent.

1.2. Recognised environmental issues

Europe's Environment - The Dobris Assessment and the Second Assessment
The key environmental issues and problems facing Europe's seas identified in The Dobris Assessment report (Stanners & Bourdeau, 1995) are:

- Coastal zone pollution
- Eutrophication
- Overexploitation of resources (biological and physical)
- The long-term, but potentially very serious, effects of climate change and sea-level rise.

Environmental assessments and status reports for the entire European area were updated in 1998 for the Second Assessment Report. The key environmental issues are identified for the whole area. But the member nations will give priority to issues relevant and important for their regions. According to the Dobris Assessment report the most important pollutants in the coastal zone are synthetic organic compounds, microbial organisms, oil, nutrients, litter and generally to a lesser extent, heavy metals and radionuclides.

The main conclusions of "Europe's Environment: The Second Assessment" report of were that synthetic organic compounds and heavy metals were still important contaminants in the coastal zone; that there is high pressure on the coasts; that nutrient loads are still key issue in most European Seas and that most Regional Seas are overfished (EEA, 1998).

Marine environmental monitoring issues

In the Mediterranean Action Plan (MAP) of the United Nations Environment Programme (UNEP), and the Joint Assessment and Monitoring Programme (JAMP) of the Oslo and Paris Commissions, respectively, a number of environmental issues are identified. These can be listed under 6 categories of effects of human activities on the marine environment:

1. Contaminants
2. Nutrients and eutrophication
3. Litter
4. Fisheries
5. Mariculture
6. Habitats and health of ecosystems.

These issues were identified as being important in the assessment of both the Mediterranean and North Seas (UNEP, 1996, NSTF 1993). The most recent environmental assessment of the Baltic Sea covers the period 1989-1993 (e.g. HELCOM, 1996). New environmental assessments and status reports will be prepared for the whole OSPAR maritime area by the year 2000. These assessments will be done for 5 areas (Arctic waters, North Sea, The Celtic Seas, Bay of Biscayne and Iberian coast, and the wider Atlantic) and for the whole region. For each region, the list of issues included in the JAMP has been reviewed, and priority is given to issues which are relevant and important for that region.

Within each main category of issues, a number of specific topics, questions or hypotheses have been identified. An overview of the general issues and the specific questions or hypotheses is given in Table 1.

Table 1. An overview of the general issues and the specific questions or hypothesis identified by the Joint Assessment and Monitoring Programme (JAMP) (OSPARCOM 1995)

Issues/Parameters	Specific Questions/Hypothesis
1. CONTAMINANTS:	
Cadmium, Mercury and Lead	1.1. Are agreed measures effective in reducing inputs?
	1.2. What are the concentrations and fluxes in sediments and biota?
Tributyltin (TBT)	1.3. To what extent do biological effects occur in the vicinity of major shipping routes, offshore installations, marinas and shipyards?
Polychlorinated Biphenyls (PCBs)	1.4. What are the sources and input pathways and how large are the inputs?
	1.5. Are agreed measures effective in reducing inputs?
	1.6. Do high concentrations in marine mammals disturb enzyme systems?
	1.7. Do high concentrations pose a risk to the marine ecosystem?
	1.8. Do high concentrations of non-ortho and mono-ortho CBs in seafood pose a risk to human health?
Polycyclic Aromatic Hydrocarbons (PAHs)	1.9. What are the major sources and how large are the inputs?
	1.10. What are the concentrations in the maritime area?
	1.11. Do PAHs affect fish and shellfish?
Other Synthetic Organic Compounds	1.12. How widespread are synthetic organic compounds within the maritime areas?
Offshore Chemicals	1.13. Which chemicals are discharged and in what quantities?
	1.14. How and to what extent do the discharges affect marine organisms?
Chlorinated Dioxins and Dibenzofurans	1.15. What concentrations occur and have the policy goals (for the relevant parts of the maritime area) been met?
Environmental Transport and Fate of Pollutants	1.16. What are the fluxes and environmental pathways? Where do persistent pollutants end up? What are the Biological Effects of Pollutants?
	1.17. Where do pollutants cause deleterious biological effects?
Oil	1.18. What are the inputs and concentrations in the maritime area and what are the effects on benthic communities and seabirds? Are agreed measures (for the shipping and offshore industries) effective?
	1.19. What are the effects of aromatics discharged with production water?
Radionuclides	1.20. What are the sources, inputs and temporal trends?
Accidents in the Shipping and Offshore Industries	1.21. What is the risk of accidental losses of oil and other chemicals to the maritime area? What is the risk of their transport to coastal and offshore ecosystems?
1. EUTROPHICATION:	
Nutrients	2.1. Are agreed measures effective in reducing inputs?
Phytoplankton	2.2. Where do elevated nutrient concentrations or fluxes from anthropogenic sources cause an increase in the frequency and/or magnitude and/or duration of phytoplankton blooms and a change in species composition?
	2.3. How and to what extent does increased phytoplankton abundance and/or changed phytoplankton species composition and/or the presence of toxic phytoplankton species result in ecological disturbance?

Issues/Parameters	Specific Questions/Hypothesis
3. LITTER	
Sources and Occurrence	3.1. What are the sources, composition and occurrence of litter at the sea surface, on the seabed and along shorelines?
	3.2. Are agreed measures effective?
Effects on Birds and Marine Organisms	3.3. What are the effects of ingesting small plastic particles on marine coastal birds and other marine organisms?
4. FISHERIES	
Impact of Fisheries on Ecosystems	4.1. How and to what extent do fisheries (including industrial fisheries) affect stocks of target and non-target species and benthic communities?
5. MARICULTURE	
Genetic Disturbance	5.1. To what extent do cultured fish and shellfish stocks affect the genetic composition of wild stocks?
Transfer of Diseases and Parasites	5.2. What risk do cultured fish and shellfish stocks pose to wild stocks by possibly introducing diseases?
Chemicals used	5.3. In which areas do pesticides and antibiotics affect marine biota?
6. HABITATS & ECOSYSTEM HEALTH	
Ecosystem Health	6.1. How can ecosystem health be assessed in order to determine the extent of human impact?
Habitat Changes	6.2. What are the extents of the area, frequencies and inter-relations between the different types of habitat within the coastal and offshore environment?
	6.3. What are the roles of different habitat types in the ecological functioning and the integrity of marine and coastal ecosystems?
	6.4. How and to what extent do dredging and sand and gravel extraction affect communities (particularly benthic communities), coastal habitats and spawning areas?
	6.5. How and to what extent do coastal protection schemes and land reclamation activities affect coastal habitats, communities and species?

2. Information needed in relation to the environmental issues

The present situation in Europe's seas show that some of the water bodies have environmental problems associated with human activities, and, for many seas, the scale of the problems has not been fully quantified or understood. In order to improve this situation, detailed quality and status assessment are required. For some of the European seas, establishing a baseline of quality in terms of input loads, contamination levels and biological status and effects would be a useful starting point of improvement.

2.1. The interlinked nature of the environmental issues and expression of ecological quality

The human influence on the coastal and marine environment affects various processes and components of the ecosystem. These components are interlinked and an effect on one component can indirectly affect other parts of the ecosystem through trophodynamic or other couplings. Different human activities will therefore often affect, directly or indirectly, the same components of an ecosystem. Major challenges in an environmental assessment are to separate the influence due to human activities from natural variability and to establish links between observed effects and causal agents.

The identified environmental issues should not be viewed in isolation, but their combined effects on marine ecosystems needs to be taken into account. There are two sides to the issue of combined effects. On one hand, there is a commonality of information which is needed in order to describe the ecosystem as a basis for assessing whether a human activity has a significant effect in relation to the natural variability of the system, for e.g., due to climatic variability. On the other hand, the overall state of the system needs to be characterised as a basis for assessing the combined effects of different human activities. In this context, the concept of Ecological Quality Objectives (EcoQOs) will prove invaluable. In order to establish such objectives, it is first necessary to characterise the ecological quality to which the objectives are to be attached. The proposed European Framework Directive dealing with the ecological quality of water is a concrete step in this direction.

Ecological Quality (EcoQ) has been defined as:

> "Ecological quality of surface water is an overall expression of the structure and function of the aquatic systems, taking into account the biological community and natural physiographic, geographic and climatic factors as well as physical and chemical conditions including those resulting from human activities."

EcoQ can be expressed as a core set of information on the ecosystem including both state and flux variables. The information should reflect basic ecosystem properties on one hand and human influences on the other. The core set of information is related to the different environmental issues as identified, e.g., in JAMP (Figure 1). The information includes variables describing physiographical, physical, chemical and biological features of the environment. In addition it includes biological effects variables, which can provide information links between effects, for example from contaminants, and variables describing human influences or use of the marine environment.

Figure 1. Core information for expressing EcoQ

Variables		Issues
Physical		Contaminants
		Eutrophication
Chemical		Litter
Biological	↔	Microbiological pollution
		Fisheries
Biological effects		Mariculture
		Habitat changes
Human uses		Disturbances

EcoQ is expressed as a core of information (state and flux variables) reflecting basic ecosystem properties and human influences. The core of information is related to the different relevant issues for given ecosystems or regions.

A conceptual framework for the methodology of describing EcoQ and providing linkages to the environmental issues, for example JAMP, is shown in Figure 2. The ecosystem is depicted in a very simple representation. The physical part includes among other factors light which drives primary production, and currents which transport and disperse plankton and contaminants. Nutrients are used to fuel the growth of phytoplankton and are being regenerated in the pelagic and benthic food webs. Phytoplankton is grazed by zooplankton which is grazed by fish and other organisms in the pelagic food web. Phytoplankton also forms, directly or indirectly, an important food source for the benthic food web. Decomposition of dead organic material (detritus) and respiration by benthic animals and zooplankton consume oxygen.

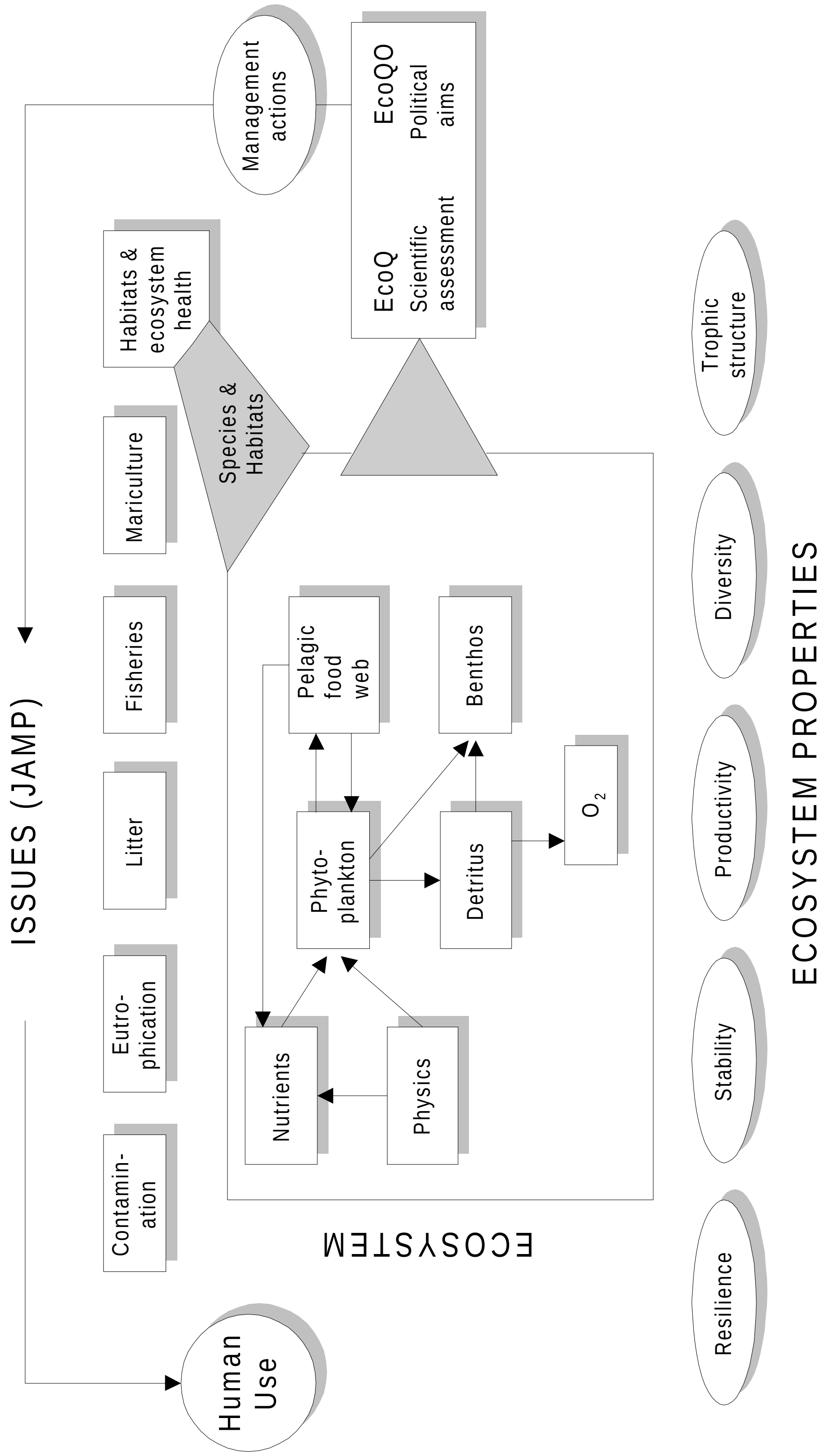
The different human uses and impacts on the ecosystem need to be quantified in a manner which makes them intercomparable with the properties of the ecosystem. This can be exemplified for some selected issues. In the eutrophication issue, anthropogenic nutrient input to the marine areas is quantitative information which can be compared and interlinked with information on nutrient pools, plankton production and cycling of nutrients in the environment. The currents may distribute the nutrients, and nutrients assimilated by plankton or as constituents of dead organic material from one region to another. Thus, quantitative information on currents is required in order to link inputs of nutrients in one region with possible effects with a time delay in a different region.

Amounts and sources of contaminant inputs from man's activities are quantitative information which can be linked with information on quantities, transport and effects of contaminants in the marine environment. Many contaminants are lipophilic and to a large degree associated with particles. Their transport and distribution are partly dependent on the currents but modified by their interactions with chemical and biological processes. Transport of the contaminants in the food web depends on the bioaccumulation properties of the substances and the number of steps in the food chain. Many of the persistent substances, such as PCBs, accumulate in the food chain and exert their biological effects at high trophic levels where they may, for example reduce the reproduction of certain species. This may effect their population dynamics and size.

The issue of contaminants is interlinked with other issues such as eutrophication and fisheries. Eutrophication alters the magnitude and pattern of production and plankton biomass. This can in turn alter the physical transport of contaminants and their transport and effects in the food web. Fishing activity can directly affect the population dynamics of targeted and non-targeted fish stocks, thereby making it difficult to separate effects of contaminants from effects of fishing pressure. Fishing can also alter the trophic structure and thereby affect the flow and effects of contaminants. Fishing activity can also disturb the seabed and cause resuspension of sediments, thereby affecting their physical transport and availability for incorporation into pelagic and benthic food webs.

Biological components of the ecosystem can be affected, directly or indirectly, by several human influences. Benthic soft-bottom communities can be used as an example to illustrate this. Benthic communities can change or fluctuate in response to natural climatic variability or changes in biological conditions due to predation or competition. Benthic communities can also change in response to several human influences. Eutrophication can alter the amount and quality of food available for benthic deposit or suspension feeders. Contaminants may effect the physiology, reproduction and population dynamics of benthic species. Fishing activities can directly affect benthic communities by killing individuals and altering the substrate. Fishing can also indirectly affect the benthos through alteration in the food web and thereby the predation pattern on benthos. Use of benthic communities for monitoring purposes may therefore need supporting information in order to interpret observed changes and establish links to causal agents. Such links are necessary if cost-efficient measures are to be taken where needed.

Figure 2. Conceptual framework for the methodology of describing Ecological Quality (EcoQ) and setting Ecological Quality Objectives (EcoQOs)[1].



[1] EcoQ is an integral expression of the state of an ecosystem, reflecting basic ecosystem properties and human use. The human use is linked to the issues of the Joint Assessment and Monitoring Programme (JAMP), and provide a basis for setting objectives related to management actions.

A summary of parameters or variables needed to characterize a marine ecosystem and provide information which may be needed for an environmental assessment, is listed in Table 2. This table also indicates which information may be required in relation to different environmental issues. As is apparent from the table, there is a broad overlap in the information required. In any given instance, depending on the specific marine environment or ecosystem and the specific issues of concern for the given area, the needed information may be more limited than the full list in Table 1. For a large marine ecosystem like the North Sea, on the other hand, all the information may be required if the aim is to provide a reliable assessment and statement on the state of the environment and to provide advice on remedial actions as part of improved management of the living marine resources and the marine environment.

In the following sections, the information need is considered in more detail for a selection of issues, mainly eutrophication, contamination, fisheries, and coastal habitats.

Table 2. Parameters or variables needed for an environmental assessment

		Contamination	Eutrophication	Fisheries	Coastal habitats
	Topography	b	b	b	b
	Bottom type		E	s	s
Physical	Water transport	s	E	b	s
	Hydrography	E	E		s
	Tides	b	b	b	b
	Light climate	b	E		s
	Meteorology	s	E	E	s
	Sediment characteristics	E	s	s	s
Chemical	Seston	E	E		s
	Nutrients	s	E		s
	Oxygen, pH	s	E		E
	Organic substances	s	s		
	Metals	E	s		s
	Organic Pollutants	E	s		E
	Oil hydrocarbons	E			s
	Contaminant flux	E	s		s
Biological	Primary production	s	E		s
	Phytoplankton biomass	s	E		s
	Phytoplankton species composition	s	E		
	Zooplankton biomass		E		E
	Zooplankton species composition	s	s		s
	Zooplankton transport		s		E
	Microbial activity	s	s		
	Zoobenthos biomass	s	E		E
	Community structure	E	E		E
	Phytobenthos	s	E	s	s
	Fish	E	s		E
	Sea birds	E		s	E
	Sea mammals	E	s	s	E
	Fish diseases and parasites	E	s		E
Biological Effects	Enzyme methods	E			
	Physiological methods	E			
	Bioassays	E			

E = Essential. s = supplementary. b = background

2.2. Physical and hydrological nature (physical features)

Several of Europe's seas have large multinational catchments, and contaminants from these areas may originate thousands of kilometers from estuaries. Comparison of riverine inputs has failed since separate riverine data are not available for some regions. Most of the comparisons undertaken is of gross loads, as they do not take into account non-conservative estuarine processes which would remove a proportion of the riverine loads before reaching the main body of the sea. In addition, the Dobris Assessment report indicates that in general no attempt has been made to separate the dissolved component from the particulate component of the load. (However, in some countries this has been done for several years). Thus, data on riverine input, effective catchment management and pollution control measures require concerted internationals efforts and cooperation.

In addition to pollution data, measurements of freshwater flow will be an important parameter. Reduction in freshwater flow generally means a reduced sediment load which may enhance coastal erosion. The lack of effective coastal zone management can lead to the loss of important components of the ecosystem.

The key requirement for the collection of baseline data is the application of appropriate standard methods and quality control procedures. It is evident that such baseline data have not been collected, or are not available, for many of the European seas, thus making quantitative comparisons of, for example contamination levels between seas, very difficult. To achieve quality improvements, there is a clear need for enhanced international collaboration and agreement.

2.3. Eutrophication

Eutrophication is a term from limnology that has been adopted also for marine waters, often without clear definition and with different meanings.

In the Council Directive of 21 May 1991 concerning urban waste water treatment, eutrophication is defined in Art. 2 No. 11: "eutrophication" means the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance of the balance of organisms present in the water and to the quality of the water concerned. Figure 3 shows the sequence of events and biological effects of increasing nutrient loads.

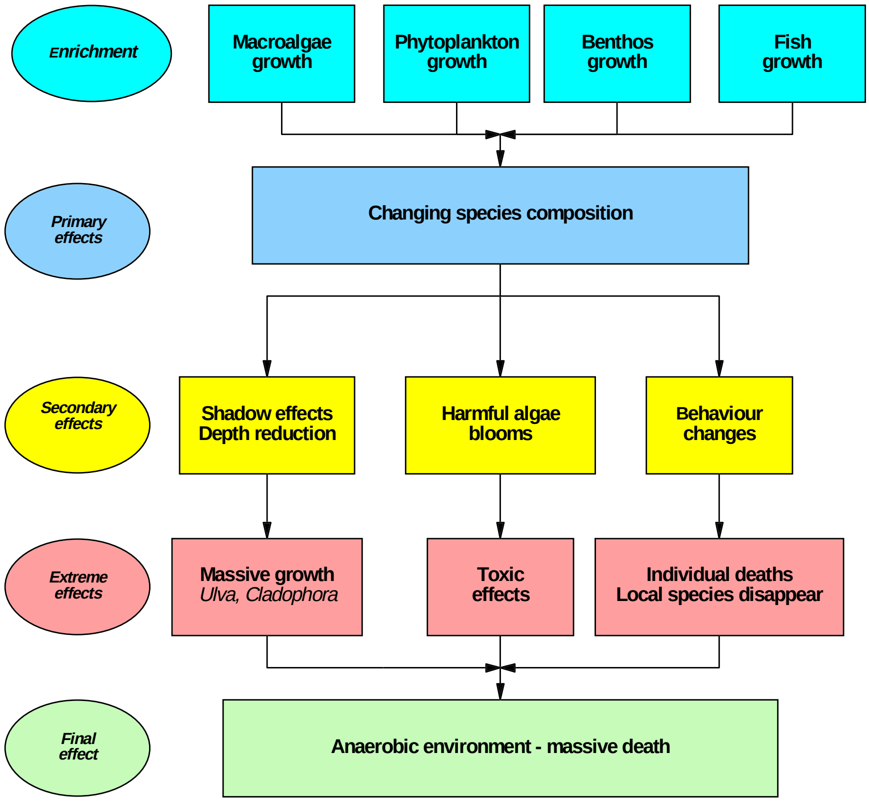
Eutrophication in marine waters leads either to increased concentrations of nutrients in seawater and/or to increased assimilation of nutrients and increased production and biomass by plankton and benthic organisms. Due to the time response in the ecosystem, eutrophication is a process that develops through several stages as illustrated in Figure 3. In the initial enrichment phase, increased input of nutrients leads to changes in the growth rate of phytoplankton, phytobenthos, microorganisms and animals that derive their food from plants (herbivores). Changes in growth rates may lead to changes in species composition as a primary effect. These changes and increases in the overall biomass may lead to secondary effects such as shading and shallowing of the upper euphotic zone and the proliferation of harmful algal blooms. If the input of nutrients is large, extreme effects may be massive growth of some macroalgae (e.g. "green tide"), toxic effects, and/or local extinction of species. The ultimate effect is anoxic conditions in sediments and bottom water, leading to mass mortality of benthos.

In considering eutrophication, the spatial and temporal aspects of the links between inputs and effects are important. The anthropogenic input of nutrients come as a mixture of large point sources such as rivers and a multitude of many small and diffuse sources. The freshwater-borne nutrients are influenced by mixing and dispersal in the coastal zone. This leads to dilution and transport of the nutrients by the main current systems. At the same time the nutrient concentrations are modified by biological uptake and use by phytoplankton and bacteria. Along a gradient from the river mouth through the estuary and downstream along the coast, the riverine nutrient input is converted first into increased biomass of phytoplankton and phytobenthos and secondly into increased heterotrophic production and biomass of zooplankton and zoobenthos. The stimulated production leads to an increased amount of living and dead organic material which is transported with the currents. This can lead to an increased utilization of oxygen in areas "down-stream" of the region where the main input of nutrients takes place. Under stratified hydrographic conditions this may cause oxygen depletion and mortality of benthos.

An example of eutrophied waters is the North Sea where there is a clear pattern associated with large inputs of nutrients to the coastal zone of the shallow southern North Sea (NSTF 1993). These inputs lead to enhanced production and export of surplus nutrients (particularly in winter and spring) and plankton and seston by the Jutland Current along the Danish west coast into the stratified waters of the Eastern Skagerrak and Kattegat. Here the increased oxygen consumption, due to the nutrient and organic enrichment, contributes along with local nutrient inputs to oxygen depletion of the lower water layer in the Kattegat and in basin fjords in the Norwegian Skagerrak coast (Aure et al. 1996).

The types of information needed to describe and assess the eutrophication status of an area is briefly reviewed below with reference to Table 2.

Figure 3. Biological effects at increasing nutrient load. (After Gray 1992).



Bottom topography - Information on the bottom topography is needed as a basic input to 3-D modelling of hydrodynamics, currents and phytoplankton growth.

Water transport - Estimates of water transport are important information for calculating nutrient and production/biomass budgets and for providing spatial links between inputs and effects of nutrients. Such estimates can be derived from the use of numerical water circulation models or obtained from measurement programmes of currents and hydrography.

Hydrography - Information about hydrography is required for three main reasons. Firstly, the hydrographic processes and structures are key elements for determining the conditions for growth of phytoplankton and thereby consumption and cycling of nutrients in coastal and marine waters. Secondly, hydrographic information is required in order to calculate mixing of water masses and nutrient budgets for estuarine and coastal waters. Thirdly, hydrographic information is needed to initiate and validate results from numerical simulation models of hydrodynamics, nutrients and plankton growth.

Tides - Information about tides is required as background information when assessing eutrophication. Tidal mixing is an important process governing oceanographic structures such as fronts between tidally mixed and stratified waters. Tides are also important for littoral and sublittoral benthic communities which may be affected by eutrophication.

Light - Light governs the growth of phytoplankton and phytobenthos. Information about light conditions is required as a basis for calculating or modelling primary production. Changes in the amount and quality of light may lead to changes in phytoplankton species composition.

Meteorology - The meteorological conditions constitute an important element for physical and biological ocean dynamics. Meteorological data are required in relation to 3-D modelling with episodic weather events included. Such data are also required for analysis of possible relationships between eutrophication trends and climatic changes.

Freshwater discharge - Information on the amounts, sources and seasonal patterns of freshwater discharges is needed for several purposes. It is required for physical and coupled physical-chemical-biological models. It is also required for calculating budgets and mixing between different water masses as a basis for estimating the dilution and dispersion of pollutants.

Nutrients - Data are required on nutrient input from point and diffuse land sources as well as via the atmosphere. Data are also required on nutrient concentrations in riverine, estuarine, coastal and marine waters as a basis for calculation of nutrient and element budgets and for assessing spatial and temporal trends. Information is required on both inorganic and dissolved organic forms of N and P. Nutrient data are needed for initialization and validation of coupled physical-chemical-biological models that can be used as a tool in eutrophication assessment work.

Sediment characteristics - Sediments may play an important role for the nutrient cycling in estuaries and shallow coastal waters. Data on sediment characteristics may be needed as supporting information when assessing eutrophic conditions.

Oxygen - Data on oxygen concentrations can provide useful supporting information on the balance between autotrophic and heterotrophic processes. Eutrophication can lead to increased oxygen consumption and oxygen depletion in deeper water layers. Data on oxygen are therefore essential information with regard to eutrophication effects.

Organic substances - Dissolved organic substances probably play important roles in the chemistry and biology in marine waters. Organic substrates may be important growth factors for some species or groups of phytoplankton. Eutrophication may lead to altered amounts and composition of such dissolved organic substances.

Metals and organic contaminants - These contaminants may have an effect on the growth, reproduction and species composition of planktonic and benthic communities. Data on contaminant levels in seawater, sediments and biota may therefore be useful supplementary information when assessing eutrophication.

Contaminant flux - The horizontal and vertical fluxes of plankton and dead organic matter are likely to be important mechanisms for physical transport and transport in the food web of contaminants. Increased flux of organic material from the coastal zone to offshore deposition areas may be associated with an increased flux and load of contaminants. Data on the contaminant flux may therefore be required in order to address the issue of interaction and synergetic effects between eutrophication and contaminants.

Seston - The load of organic and inorganic suspended material is important in relation to eutrophication. Seston influences light conditions and thereby the conditions for growth and nutrient assimilation by phytoplankton and phytobenthos. Increased production may lead to increased seston load, both as living plankton organisms and dead organic material. This in turn may affect the feeding conditions for benthic communities and the oxygen levels in sediments and deeper water layers. Data on the content of N, P and C in seston are particularly required for calculation of nutrient budgets.

Microbial activity - Bacteria and other microorganisms play central roles for the cycling of nutrient elements in marine systems. Microbial processes such as nitrification or denitrification can be of importance for the N cycle in some areas. Viral influence on phytoplankton species dynamics may also play a role with regard to harmful algal blooms. Information on microbial activities may be useful as supporting information in assessments of eutrophication and nutrient budgets.

Phytoplankton primary production - Data on phytoplankton primary production are required in order to allow budget calculations of nutrients and production, including estimates of new production due to anthropogenic nutrient input to a coastal or marine area. Data on primary production may be obtained through measurement programmes or estimated from data on phytoplankton biomass and physical driving forces, or through a combination of measurements and modelling.

Phytoplankton biomass - Increased phytoplankton biomass can be a common feature of eutrophication. Data on phytoplankton biomass are required to assess spatial and temporal trends and as input and for validation of models. Data on phytoplankton biomass are also required as a basis for assessing trophic effects of eutrophication. Phytoplankton biomass can be estimated indirectly from measurements of plant pigments, e.g. chlorophyll a, or through more laborious procedures involving microscopic counts and size determinations. Information on phytoplankton biomass can also be gained from determination of the amount of suspended particulate organic material (e.g. POC, PON, POP) or from automated analysis of numbers and size of particles.

Zooplankton biomass - Increased phytoplankton production can result in increased biomass of zooplankton. The abundance of zooplankton can on the other hand influence the amount of phytoplankton through grazing. Data on zooplankton biomass are therefore important for assessing eutrophication effects. Such data are also required as input to mathematic models to calculate grazing pressure and mortality of phytoplankton.

Zooplankton production - New methods to determine zooplankton production, such as determination of egg production, may provide useful information related to changes in population dynamics and species composition of zooplankton.

Zooplankton species composition - Increased production and/or biomass of phytoplankton due to eutrophication may lead to changes in species composition and dominance in coastal and marine waters. Data on zooplankton species composition may therefore provide useful information for assessment of trends in relation to eutrophication.

Zooplankton transport - Due to their relatively long generation times, zooplankton transport by currents can play an important or dominant role for the zooplankton dynamics in a given coastal or marine area. Information on zooplankton transport can therefore be important supporting information when assessing eutrophication. Information on zooplankton transport can be derived from data on zooplankton abundance and biomass combined with data on currents and water transport.

Phytobenthos - Eutrophication can lead to changes in species composition and depth distribution of phytobenthos. Data on phytobenthos can therefore provide important information with regard to eutrophication assessments.

Zoobenthos biomass - Eutrophication may lead to increased amounts of seston and vertical flux of organic matter to deeper water layers and sediments. The zoobenthos biomass may increase in response to the increased input of organic material. If the increase is too large the resulting oxygen consumption may lead to oxygen depletion and mass mortality of zoobenthos. Zoobenthos is stationary and will therefore reflect the local conditions.

Zoobenthos species composition - Eutrophication will generally lead to changes in the species composition of benthic communities. Zoobenthos is therefore commonly used for monitoring purposes. Data on zoobenthos species composition are required for assessing status and spatial and temporal trends in eutrophication of coastal and marine waters.

Fish - Changes in primary production can result in changes in production and biomass at higher trophic levels. Oxygen depletion due to eutrophication can result in mortality or emigration of fish from affected areas. Data on abundance and production of fish stocks may provide useful information on the trophic structure of marine systems. Large natural variability and large impact by fisheries on fish stocks make it difficult, however, to distinguish effects due to eutrophication.

Sea mammals - Algal toxins may affect sea mammals through their diet. Information on stocks and mortality of sea mammals may therefore be of some relevance in relation to assessments of eutrophication.

2.4. Contaminants

Evaluation of cause-effect relationships and successful implementation of mitigating measures require precise knowledge of causes. Consequently, reliable information about sources and load is sine qua non in rational pollution control. Likewise, with regard to damage at the population and community level, it is important to clarify the role of physical factors, for example habitat destruction and fisheries activities (including killing of seabirds and mammals in fishing nets).

To the extent that such information is lacking or difficult to obtain, co-operation between international environmental protection agencies is needed in order to achieve regular publishing of updated state of the art reports.

Metals

Metals are natural constituents of the marine environment. Natural background concentrations of metals in water, sediments, and biota vary from area to area, depending on mineralisation and other local conditions. Inputs of metals from land via rivers and direct run-off contain a natural component that depends on the geology of the catchment area, as well as an anthropogenic component that arises from industrial, urban, and other sources. Atmospheric deposition is a further source of certain metals, particularly lead and cadmium.

In most coastal areas it is apparent that inputs of metals into marine waters have decreased, but significant downward trends in concentrations in the environment have been detected in only a few cases (NSTF 1993) due to lack of information.

In many cases it is difficult to draw firm conclusions because of the influence of changes in analytical methods, a general lack of accuracy and precision associated with sampling, analytical, and input-load estimation methods, and high natural variability.

Although concentrations may be enhanced under the influence of local inputs, metals do not generally accumulate over time in the water column, owing to their reactive nature and various removal processes. However, they can be accumulated in marine organisms, and on particulate matter, especially fine-grained material, which ultimately settles in sediment deposition areas. In coastal areas of the Kattegat and Skagerrak, metal concentrations are up to ten times higher than in open Atlantic water, probably reflecting the freshwater discharge in those regions. In coastal areas of the southern North Sea, higher concentrations reflect the influence of river inputs. Reliable information on trends in concentrations of dissolved metals is not available.

Offshore regions were generally found to be only slightly contaminated, with the exception of areas that are known or presumed deposition areas.

Concentrations of cadmium and copper in sediments from the central Dutch coastal waters decreased significantly between 1981 and 1991. Information on trends in contaminants in sediments from other areas is still inconsistent and hence not yet available in a form considered suitable for assessment.

Relative to their concentrations in sea water, metals bioaccumulate in marine organisms, such as fish and shellfish, and top predators, such as seabirds and marine mammals. Only some of the data on contaminant levels in biota are suitable for accurate assessment of trends, but the picture is generally encouraging: most of the downward trends in metal concentrations in biota reported in the 1980s have continued into 1990s. However, in some areas, increased concentrations are reported, for example, for mercury and lead in fish and cadmium in mussels. Concern has been expressed about the potential effects of high concentrations of lead, mercury, and cadmium in relation to top predators such as seals and certain seabirds.

However, in some areas, the concentrations of certain metals in stocks of mussels that are not commercially exploited exceed health standards.

Two major points that remain to be clarified:

- the biological significance of maximum concentrations of metals in both total and fine fractions of sediments; and
- the rate of decrease in concentrations in areas affected by metal contamination following decreases in inputs.

Polycyclic aromatic hydrocarbons

Sources of polycyclic aromatic hydrocarbons (PAHs) include shipping, offshore oil and gas operations, the burning of fossil fuels in, e.g., energy production, and other industrial activities. The contribution from natural sources (e.g., forest fires and volcanic activity) is unclear, owing to a lack of relevant data.

High concentrations of PAHs in sediments have been recorded in some estuaries surrounding the North Sea. Their occurrence in the Norwegian Trench indicates that long-range transport via the atmosphere as well as transport and deposition of fine sedimentary material both play an important role in determining the distribution of PAHs in sediments.

An increased frequency of fish liver tumours, reduced growth in mussels, and induction of certain detoxification enzymes in flatfish liver have been attributed to elevated levels of PAHs in some North Sea sediments (NSTF 1993).

Persistent organic contaminants

A large number of synthetic (man-made) organic compounds that are persistent in the marine environment are mainly introduced into the European Seas by atmospheric deposition, riverine inputs, and leakages from waste sites along the coasts. It is not possible to quantify these inputs with accuracy, owing to a lack of adequate data even for well-studied substances. Improved information is required on inputs of these known substances and, for the synthetic organic chemicals that are difficult to characterize and chemically identify in marine samples, there is a need to evaluate the relative risk from different groups of these substances in terms of toxicity, persistence, and amounts produced and potentially discharged into the sea. Many of the synthetic organic contaminants entering the North Sea are degraded very slowly (if at all) and bioaccumulate and biomagnify in marine food chains. They occur in water, sediments, and biota, and generally the highest concentrations are found in marine biota, associated with the lipids in their tissues. This has implications for top predators with large fat deposits, such as marine mammals.

Although most of the persistent organic contaminants that have been identified, e.g., polychlorinated biphenyls (PCBs), hexachlorocyclohexane (HCH), and DDT, are widespread, higher concentrations are clearly identifiable in certain areas close to the major sources, and in sedimentation areas. Information on trends is limited, but in severeal areas a decreasing trend of PCBs in certain species has been reported (NSTF 1993).

High levels of PCBs and other organic contaminants found in sediments from the Skagerrak and Kattegat reflect long-range transport and deposition of PCBs from the atmosphere, and sedimentation and accumulation of particle-bound PCBs transported by water currents from sources farther south in the North Sea and from the Baltic Sea.

There is insufficient information to assess biological effects of most persistent organic contaminants. Although such substances are acutely toxic to most species at high concentrations, it is difficult to obtain information on effects due to low-level exposure to concentrations typically found in the environment or due to bioaccumulation of the contaminants in the organism, which are considered to be the main risks in nature. There are also problems of identification and quantification of these substances in different environmental compartments, and little understanding of potential synergistic effects from combinations of substances.

Some synthetic organics, including PCBs, have been associated with reproductive failure and suppression of the immune system in marine mammals. Laboratory experiments have also shown that several organochlorines, in particular dieldrin, DDTs, and to a lesser extent PCBs, in fish ovarian tissue reduce the hatching success of the eggs of sensitive fish species. The high levels of PCBs and certain other organic contaminants in biota continue to justify the attention focused on efforts to minimize inputs of these substances to the marine environment.

Because of the widespread use of synthetic organic compounds and their high potential for creating an environmental risk, this is clearly a topic on which further information is required. However, only a relatively small number of synthetic organic compounds (out of a potentially large number) have yet been identified and quantified in the marine environment. Many others probably exist and may or may not cause effects. There is a need to establish methods to trace sources of these substances and their effects in the environment. This will give a better picture of the total threat to the European Seas.

Tributyl tin

The use of tributyl tin (TBT) in anti-fouling paints for pleasure boats and commercial vessels has clearly led to contamination of harbours, with associated effects on a number of marine organisms. Molluscs are affected at very low concentrations of TBT, and a sensitive indicator of the toxicity of TBT to marine organisms is its effect on the dogwhelk, a gastropod which manifests reproductive disturbances (imposex) at concentrations below those known to affect other marine organisms. Historical records show that dogwhelks have disappeared from several areas over the past decade.

Surveys at locations close to harbours and at open coastal sites around the North Sea have shown significant reproductive disturbance of dogwhelks in most of the areas studied. In many areas the effects on these populations are likely to be catastrophic.

In some estuaries close to marinas a marked decrease in TBT concentrations has been observed, following a ban on the use ot TBT-based paints on yachts less that 25 m, and ecological recovery has been observed. However, concentrations in some harbour and dock areas remain high and variable.

General needs

In order to assess the degree of pollution by chemical substances knowledge on background concentrations of natural compounds is required.

Due to agreement under several conventions, namely OSPARCOM and HELCOM, the achievement of substantial emission reductions is now under way for many substances. However it remains important to develop policies to ensure that the reductions are at least maintained during the next decades.

Large quantities of chemicals are used offshore by the oil industry and their discharge to the marine environment continues with varying degrees of control. Additional measures are under consideration within the Paris Commission to regulate and reduce emissions of chemicals from offshore platforms.

Heavy metals **-** The existing reduction goals of 50% made from OSPARCOM and HELCOM for inputs of metals could be suggested for all European regional Seas. The high concentrations of cadmium found in liver tissue of fish from the central North Sea indicate that cadmium is a priority substance in this respect and should be made subject to more stringent and specific reduction goals for atmospheric emissions.

In general, there is a need to pay more attention to reduction measures directed towards atmospheric emissions of heavy metals.

Organic contaminants. **-** For many organic contaminants TBT and hexachlorocyclohexane (HCH) included, no conclusions can be drawn as to whether the existing goals and measures for the North Sea and the Baltic Sea (OSPARCOM and HELCOM) are sufficient. Further reductions in the use of TBT, or even a ban on its use, should have high priority in these organisations, especially in areas where measures to date have had little effect. The possible total ban on the use of TBT also implies the need to identify safe substitution products.

For other organic substances (e.g., PCBs and DDT) concentrations in the North Sea and the Baltic Sea indicate that there are still problems. It is important that sources of PCBs and DDT be located in the different regional seas so that adequate strategies can be developed to prevent them from entering the marine environment.

There are also substances (e.g., PAHs) that have not yet been identified as priority substances within the framework of the North Sea Conferences, although they are found in the North Sea in concentrations that may affect the health of the ecosystems (NSTF 1993). For these substances, reduction policies should be considered by the International European and national authorities. In order to reduce emissions of PAHs, international goals and measures are required, and attention should be paid to emissions in water as well as into the air, for both land-based and sea-based sources.

The Precautionary Principle is applicable to substances that are toxic and persistent and detectable in the marine environment.
There are a large number of synthetic organic chemicals in current use that may, on the basis of comparative toxicity and other studies, be toxic and persistent if they are discharged into the marine environment and that may, thus, affect marine life. Many of these chemicals are difficult to

characterise in marine samples and are commonly referred to by chemists as "unknown" substances. There is a need to evaluate the relative risk from different groups of these substances in terms of toxicity, persistence, and amounts produced and potentially discharged into the sea.
Although there is insufficient information on the occurrence of high-risk substances in sea water, sediments, and marine biota their damage to the marine environment is evident.

Knowledge about which synthetic organic compounds occur in the European Seas and at what concentrations is scarce. The effects of PCBs on the susceptibility of seals to infectious diseases and on their reproductive capacity require attention. The effects of co-toxicant (combining organic substances and metals) anti-fouling substances on ecosystems also need clarification. In general, information is still needed on the relationship between inputs of organic contaminants and the concentrations of these contaminants observed in sediments and biota, and their effects on the latter.

There is a need to develop adequate and duly validated tools to assess progress in reaching the defined goals. These tools should make use of background levels and, where this is not possible of ecotoxicological information. For specific coastal areas, estuaries, and fjords, detailed assessments should be conducted. Consequently, while developing the assessment tools, the fact that these areas may have different background levels, or differences in vulnerability to specific substances, should be taken into account.

Monitoring to evaluate the effectiveness of regulatory measures should be carried out as closely as possible to the sources of inputs and in sedimentation areas.

2.5. Fisheries

There has been an increasing awareness in recent years of the ecological effects of fisheries on coastal and marine ecosystems (ICES 1995). The ecological effects of fisheries can be broadly classified into direct and indirect effects. Direct effects can again be separated into those affecting target and non-target fish or other species.

For commercial target fish species, fishing may cause a major component of the mortality for the stocks. Fishing mortality may therefore play a large role for the stock structure and dynamics. Overfishing is a common practice, for many and complex reasons, that can lead to depleted stocks and threaten their recovery. Many fisheries are non-selective. Thus, mortality due to fishing can play a large role in the population dynamics and status of non-target species, including benthic organisms which are often also caught and killed or damaged by bottom trawls.

Commercial fish species which form the basis for large fisheries, are typically ecologically important with regard to structure and energy flow in marine ecosystems. The direct effects on the targeted species by fisheries will therefore also have indirect effects on other components of the ecosystem which are trophically linked to the target species. Small pelagic fish species may form an important component in the diet of larger predatory fishes, seabirds and sea mammals. Overfishing of the small pelagic species may therefore alter the feeding conditions of these species at higher trophic levels and indirectly affect their populations. Overfishing of larger predatory fish species such as cod may on the other hand reduce the predation mortality on smaller prey fish species and indirectly cause an increase in their populations.

Offal and discard of catch at sea represent an extra food supply for seabirds which feed at the sea surface. This practice has lead to a marked increase in many seabird populations in the North Sea. Such increase in seabird populations can in some respects be seen as positive effects of fishing activities. At the same time, the resulting population size may exceed the natural carrying capacity of the marine ecosystems, making them dependent on the extra food supplied by fisheries and vulnerable to famine should their natural prey species decline for natural or anthropogenic reasons.

Heavy bottom trawling gears may have an indirect effect by altering the benthic habitats. Habitats with restricted areal extent such as cold-water coral or polychaete reefs may be damaged or destroyed, with possible effects on biodiversity associated with such habitat-forming species. Trawling may also affect the soft-bottom sediments and reduce the habitat diversity associated with fine scale structures in the substrate.

Lost fishing gear which continue to trap fish or which may cause entanglement of seabirds or sea mammals, is a special problem associated with fisheries. This is often considered as a part of the litter issue and is not included among the priority issues included in JAMP.

Assessment of the direct and indirect effects of fishing through trophic interactions requires a thorough description and understanding of the marine ecosystem. Data on fish stocks used for stock assessment and fishery management are often sufficient to assess the direct effect of fishing through fishing mortality. Inaccurate reporting of catches and discards affect the quality of data and constitute a major problem in both fish stock and environmental assessments.

Fish stocks show large natural variability. Recruitment is also highly variable, and in many cases related to variation in climatic forcing. At the same time, there are trophodynamic links among the fish stocks, and between fish stocks and other parts of the ecosystem. The large stocks of plankton-feeding fish depend on the production and transport of plankton.

2.6. Disturbance of coastal habitats

The North Sea and its coastal zones provide a rich diversity of habitats for biota. However, these habitats are affected by a variety of human activities, many of which result in disturbance or even permanent destruction of parts of these habitats.
Changes in habitat size, resulting from coastal protection works, land reclamation activities, and the construction of harbours and industrial and tourist facilities, have occurred particularly around the Mediterranean Sea. These changes are permanent, and have resulted in the shrinking or disappearance of some habitats, although in other cases new types of marine habitat have subsequently developed.
Other changes in habitat conditions are very often a result of disturbance by human activities and mainly result in temporary effects. Such disturbances may result from the extraction of bottom material, changes in water balance or currents, or the simple presence of human beings.

In offshore habitats, such changes may also be caused by, for example, offshore mining and fisheries activities.

General needs

Individual species require particular habitats. Specific habitats can be of value because they represent important or unique ecosystems. Although the Third International Conference on the Protection of the North Sea has taken a first step towards protecting species and habitats, including calling attention to the need to identify marine sites of national or international importance, improving the quality of the seas requires that more emphasis be given to species and habitat protection (NSTF 1993). As far as individual species are concerned, this is especially true for marine mammals, seabirds and coastal birds, and benthic and long-lived species.

Generally, coastal areas are habitats which have special ecological significance. Many of these habitats are interlinked through ecological relationships and also play a role in the life cycle of a number of species.

The protection of species and habitats should not be based on a number of separate measures directed towards the protection of certain species on the one hand and certain habitats on the other. The protection of species and habitats needs an integrated ecosystem approach, based on the conviction that an ecological network should be protected and restored where necessary.

It should also be realised that pollution reduction plays an important role. In this context, it is important to note that concentrations of hazardous substances are generally higher in coastal areas compared with open sea areas. In addition, many of the species mentioned above are top predators and, therefore, at the end of the bioaccumulation process.

In the further development of a strategy to protect species and habitats, the following should be considered:

- Implementation, with high priority, the provisions of the Declaration of the Third International Conference on the Protection of the North Sea concerning the protection of species and habitats, i.e., the identification of marine sites (including coastal, estuarine, and open sea areas) of national and international importance;
- Identification of an ecological network of habitats in the European Seas
- To use the elements (species and habitats) of this network, and the identified marine sites of national or international importance, for the further elaboration of ecological objectives;
- Implementation of the Habitat Directive
- Development of special protection regimes for these habitats (including coastal, estuarine, and open sea areas), including, inter alia, measures to reduce particular sea uses and to establish water quality objectives;
- Establishment programmes for the protection and/or recovery of selected species.

Marine biodiversity is a matter of growing concern for the protection of species and habitats, but there is a basic need to define "biodiversity" in terms of the marine environment.

Monitoring habitats is necessary. The monitoring programme should be able to provide information that will be useful in guiding the restoration and protection of European marine resources by maintaining long-term continuity. Not enough is known about diet, food ecology, and the complex relationships between plankton, fish, birds, mammals, etc. and the other components of the ecosystem.

3. Comparison of information needed in relation to information available from the main regional conventions

An overview of the information available from the international conventions, organisations and programmes is presented in Table 3. Table 4 gives additional information on obligatory and tentative determinants monitored by the main regional conventions. This information is briefly commented upon in the following, with emphasis on comparison with the information needed for the purpose of carrying out environmental assessments.

Bottom topography - Information on bottom topography is generally available as maps or in digitized form from national institutions. Detailed maps on the fine scale topography and sedimentary conditions are available from marine geological surveys in some, but not all, European Sea areas.

Freshwater discharge - Information on river flows and freshwater discharge is reported to HELCOM, OSPARCOM, and nominally to MAP. The information is provided along with information on input of contaminants and is generally available as monthly mean values. More detailed information on river flows is generally available from national hydrological institutions.

Hydrography and water transport - Data on temperature and salinity are reported to the conventions as supporting information to the chemical measurements of contaminants. More extensive data on hydrography are available in the ICES data base and from the World Oceanographic Data Center (WDC). Additional hydrographic data resides in national institutes and data centers.

Current measurements are mainly available at national institutes and data centres. Water transport and residence times can be estimated from hydrographic data or calculated using numerical models. Such models can be 3-D, and rely on meteorological driving forces to simulate the magnitude and variability of currents under specific conditions. Time series and climatological averages of modelled currents and water transport are available at national institutes for some sea areas. One of the objectives of GOOS is to provide such data based on real-time data collection to be used for nowcasts and forecasts.

Tides - Information on tides is generally available from national institutions.

Light, climate and meteorology - There is a large amount of meteorological data available from national and international meteorological institutes and organisations. This includes climatological data as well as updated information from networks of measurement sites and modelling activities. There is much less data on underwater light conditions.

Eutrophication - Overloading by nutrients from agriculture, sewage and riverine discharges may cause eutrophic conditions in the coastal water, fjords and estuaries. Thus, it is important to obtain good quality data and analyse for nutrient compounds.

Heavy metals - In the Joint Assessment and Monitoring Programme (JAMP) analyses of the heavy metals cadmium, mercury and lead are obligatory, while copper and zinc are tentative. In addition, some species of molluscs are used by HELCOM as indicators of toxicity for tributyl tin. Mediterranean Action Plan (MAP) data sets through the MEDPOL Programme have, for all the “hot spots”, data for cadmium mercury lead and copper in marine biota, mainly molluscs and fish.

Petroleum and polycyclic aromatic hydrocarbons - Petroleum hydrocarbons are analysed from fish, molluscs and isopodes by JAMP. Polycyclic Aromatic Hydrocarbons (PAH) are not included in the monitoring programme of HELCOM.

Persistent organic components - Some of the most persistent organic contaminants, for e.g. polychlorinated biphenyls (PCBs), DDT, HCB and HCH are analysed from water, sediments and biota under HELCOM (see Table 4). Chlordanes and dieldrin are sampled tentatively, while the polychlorinated dibenzo-p-dioxins and dibenzofurans will be monitored in the future. Non-ortho and mono-ortho PCBs and Toxaphene are not included in the monitoring programme of HELCOM. PCBs in general were also been monitored in the Mediterranean Sea (UNEP/MAP).

Biological effects - For all the contaminants a question of great interest is the relation between existing diffuse concentrations, individually and together, and possible effects.

The Biological Effects Monitoring could provide an early warning system (bio-markers). The identification of sources of pollution (e.g., non-point sources in agriculture) and biological effects of long-range pollutants is of priority at a European level and all Regional Conventions strongly support the idea of this kind of monitoring which could provide eventually the establishment of biochemical stress indicators, and their possible relation to population damage

Phytoplankton biomass - Phytoplankton biomass is often estimated from measurements of the pigment chlorophyll a. Data on phytoplankton biomass as chlorophyll a are reported to HELCOM and OSPARCOM as part of the monitoring requirements with regard to eutrophication. Data on chlorophyll are also available from research cruises and fisheries resource investigations. Such data reside mainly in national laboratories.

The international JGOFS programme has developed a decentralised data base system for data exchange and communication within the programme. In addition, algorithms for converting data from remote sensors on satellites to phytoplankton biomass have also been developed in relation to this programme. A relative measure of chlorophyll a and phytoplankton biomass is obtained by use of in situ fluorometers. These can be mounted on vertically profiling sondes, buoys or ships to provide data on phytoplankton distribution with high spatial and temporal resolution. Such data mainly reside in national laboratories.

Phytoplankton primary production - Measurements of phytoplankton primary production are included in the HELCOM BMP and results are reported to HELCOM. For other sea areas, there is a substantial body of data on primary production, mainly from research cruises. These data reside mainly in national laboratories. There have been differences in methodology and intercalibration exercises in ICES have revealed large discrepancies in results. ICES has therefore decided to exclude primary production data.

Phytoplankton species composition - Phytoplankton species composition is recorded in the HELCOM BMP and in several national monitoring programmes aimed at detecting and advising on the occurrence and effects of harmful algae. There is also much information on phytoplankton species composition from research activities by national laboratories.

Zooplankton biomass - Data on zooplankton biomass are reported to HELCOM. Data on zooplankton biomass is also collected in national monitoring programmes mainly aimed at providing supporting information to fisheries investigations. There are plans in ICES to assemble data on zooplankton from the national programmes and assess them for a larger part of the ICES area.

Zooplankton production - New and indirect methods for determining zooplankton production, e.g. the egg production method, shows promise in detecting changes in rates of reproduction and production in future monitoring programmes. Such data are now collected within research projects.

Zooplankton species composition - Data on zooplankton species composition are reported to the main regional conventions. Such data are also collected in national monitoring programmes and research projects. The Continuous Plankton Recorder (CPR) Survey of the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) has been carried out by ships of opportunity in the North Atlantic for several decades. This has provided a long time series of information which now proves its usefulness in hindcastanalyses of changes in species composition and dominance in relation to climatic fluctuations and changes. The CPR data are contained in a database at SAHFOS and are available for use by countries and institutions which support the survey.

Zooplankton transport - Some information is available from recent research activities where a combination of measurements and modelling have been used. Measurements relating to zooplankton transport have been initiated under several national monitoring programs.

Fish - Abundance and distribution of fish stocks are extensively monitored in national and internationally co-ordinated surveys and are reported to ICES.

Table 3. Information collected by the Conventions and international organisations.

		HELCOM	MAP	OSPARCOM	AMAP	ICES	OTHER
	Bottom topography						GOOS
	Sediment char	x	x	x	x	x	
	Freshwater discharge	?	x	x	x		
Physical	Water transparency.						
	Hydrography	x	x	x	x	x	WOCE, JGOFS, WDC
	Tides		x				GOOS
	Light climate		x				
	Meteorology		x				GOOS
	Seston	x	x	x			JGOFS
	Nutrients	x	x	x	x	x	JGOFS, WOCE
	Oxygen, pH	x	x	x		x	
Chemical	Organic substances		x	x			
	Metals	x	x	x	x	x	
	Organic contamination	x	x	x	x	x	
	Petroleum hydrocarbons	x	x	x	x	x	
	Contaminant flux						
	Primary Production	x					JGOFS
	Phytoplankton Biomass	x	x	x		x	JGOFS
	Phytoplankton species composition	?	x	x			JGOFS, SAHFOS
	Zooplankton biomass			x			JGOFS, GLOBEC
	Zooplankton prod.			x			JGOFS, GLOBEC
	Zooplankton species composition	x		x			GLOBEC, SAHFOS
	Zooplankton transport						JGOFS
Biological	Microbiological activity		x	x			
	Zoobenthos biomass			x		x	
	Zoobenthos species composition	x		x		x	
	Phytobenthos			x			
	Fish			x		x	
	Seabirds			x			
	Sea mammals			x		x	
	Fish diseases			x		x	
	Enzyme methods			x			
Biol. effects	Physiological methods						
	Bioassays			x			

National laboratories and institutions cover all parameters to various degrees.

AMAP:	Arctic Monitoring and Assessment Programme
GLOBEC.	Global Ocean Ecosystems Dynamics
GOOS:	Global Ocean Observing System
HELCOM:	Baltic Marine Environment Protection Commission
ICES:	International Council for the Exploration of the Sea
JGOFS:	Joint Global Oceans Flux Study
MAP:	Mediterranean Action Plan
OSPARCOM:	Oslo and Paris Commissions
WOCE:	World Oceans Circulation Experiment
WDC:	World Data Centre

Table 4. Information needed. Information available from the Conventions.

Categories	Parameters		HELCOM			MAP			OSPARCOM			AMAP		
			W	S	B	W	S	B	W	S	B	W	S	B
	total P		o	o ?		o	o	o	o	o	o			
	phosphate		o	o ?		o			o	o	o			
	total N		o	o ?		o		o	o	o	o			
	nitrate./ammonia		o	o ?		o			o	o	o			
	Silicate		o/ t			o			o	o	o			
	heavy metals	Cd/Hg/Pb	t	o ?	t	t	o[1]	o[1]	o	o	o	t	o	o
		Cu/Zn	t	t?	t	t	o	o	o	t	t		t	t
	total .Sn/TBT		t	?		t	t	t	o	t	o		t	t
Hydrochemistry	Petroleum. HC		t	?		o	o							
		PAH			t	t	t	t	o	t	t		t	t
	Chlorinated HC	DDT/PCB	t	o ?	o	o	o	o	o	t	o		t	o
		HCB/HCH	t	o ?	o	o	o	o	o	t	t		t	t
	dioxin	PCDD/Fs		n ?	n	o	o	o		t?	t		t?	t
	toxaphener	PCCs		n ?	n						t			t
	biphenyl ethers										t			t
	chlorinate Naphthalene										t			t
		chlordanes/ dieldrines		t?	t	t	t	t	o	t?	t		t?	t
	phytoplankton	primary production	o						o					
		chl-a/pigments.	t			t			o					
		species composition.	o						o					
		no/biomass	o			o			o					
	zooplankton	species composition.	t						o					
		transport	t											
		abund./ biomass	t						o					
	macrozoobenthos	biomass			o				o					
Biota		species composition.			o				o					
	soft bottom	species composition.			o				o					
		abundance biomass			o				o					
	microorganisms	tot no./biomass			t	o	o	o	o					
		microb.activity			t	o	o	o	o					

	phytobenthos	species composition.												
		Biomass												
		common function												
	fish	fish diseases							o					
		fishery activities							o					
	sea mammals								o					
Biological Effects	Enzyme methods								t?					
	Physiological methods													
	Bioassays								t?					

W= water, S = sediment, B = biota o= obligatory, t = tentative, n = investigations in the future (new),

[1] Cd and Hg.

4. Analysis of current gaps between required and available information

Conditions in the European Seas are characterised by a high degree of variability, both geographically and temporally. Temporal variability on seasonal, annual, and longer scales is mainly caused by variations in surface heat exchange, wind field, inflow of Atlantic water, and freshwater input. Short-term fluctuations are also very important. This variability in physical conditions and processes has a strong influence on chemical and biological conditions and processes, and creates a backdrop of uncertainty to assessments of the impact of anthropogenic influences on the natural conditions and processes in the seas.

Anthropogenic influences on marine ecosystems are listed in 6 categories in the OSPAR-JAMP (Table 1, Figure 2). For each of these there is a need to separate the effect of anthropogenic impact from the natural variability. This is the first challenge. A second challenge is to separate the effect of one type of human activity from that of other human influences. This is required to take the necessary and correct remedial actions to improve a deteriorated environmental situation. A third challenge is to have knowledge about the spatial and temporal aspects linking the human activities which release nutrients and/or contaminants with their resulting environmental effects. Fishing activities could also be included in these activities that have an environmental impact.,

There is now substantial information from some of Europe's seas. However, the seas are complex systems, and a complete understanding of the ecosystems will probably never be achieved. Certain areas where there is an urgent need to fill gaps in knowledge have been identified.

Information on currents and water transport is of central importance for an environmental assessment but such information is generally not available from the Conventions. It is possible to obtain such information from current measurement data or modelling activities or from a combination of data and modelling. The international GOOS programme and EuroGOOS aim at providing such information based on updated oceanographic measurements from automated buoys and other measurement platforms. Estimates of water transport need to be made available for use in environmental assessments as a basis for calculating fluxes and budgets of contaminants and plankton.

Much of the data on contaminants held by the Conventions have been collected for the purposes of revealing spatial and temporal trends. Much of the data are from sediments or for selected species and tissues of biota. The quality of older data is often poor or questionable. Due to analytical difficulties and/or lack of general QA procedures, some parameters are measured only on a voluntary and not on a mandatory basis. This contributes to a lack in consistency and regularity in many existing data sets with regard to spatial and temporal coverage.

Concentrations of contaminants are used to assess their spread, transport and effects in the marine environment. There is generally a great need for more information of contaminant levels in biota for the purpose of assessing their biological and ecological consequences. This requires a good background knowledge on the relations between contaminant loadings, body burdens and biological effects. Such knowledge will form an integrated part of ecotoxicological assessment criteria. In this respect, it will be important to increase our knowledge and capabilities to assess the combined effects of several contaminants which are simultaneously present in marine organisms.

In addition to environmental concentrations, there is a need for information on fluxes of contaminants in the marine environment. This is required to provide a better description of the spatial links between sources of contaminants and biological effects, to allow budget calculations of contaminants, and to assess the relation between exposure and uptake of contaminants. Estimates of water transport will be a necessary basis for calculation of contaminant fluxes, particularly for water soluble contaminants. Many of the contaminants are lipophilic and are associated with living and dead particles. Information on contaminant levels in suspended particulate material can be used along with estimates of water transport and sediment resuspension to calculate fluxes. Data on contaminant concentration in suspended particulate material and estimates of contaminant fluxes are generally scarce or lacking.

In addition to physical transport there is also a transport of contaminants in the marine food webs. Contaminants adsorbed or associated with sedimented or suspended particles can be incorporated in sediment or suspension feeding zooplankton or zoobenthos. Substances which bioaccumulate can be concentrated and exert their strongest biological effects high in the food web. More information on contaminant levels at different trophic levels in the marine food webs are required along with information related to their possible biological effects. There is generally a lack of data and information on biological effects parameters in the data held by the Conventions. ICES recommends an integrated chemical and biological effects approach to future monitoring and a number of biological effects techniques are proposed to be used for this purpose. Among these are different biochemical biomarker and bioassay techniques. More work is still needed, however, to clarify and verify their potential usefulness in monitoring programmes.

Benthic communities have been commonly used in national and international monitoring programmes to indicate effects of eutrophication and other human activities. Benthic communities are resident and reveal the accumulated impact in an area. Although, most of work has used soft bottom communities, hard bottom communities may also provide useful information on long term changes, and should be more widely used in monitoring and environmental assessments.

Data on phytoplankton primary production are relevant with regard to the issue of eutrophication as well as in relation to fisheries. A lot of data on primary production exists at the national level but it is only HELCOM which has included them into its monitoring programme. Standardisation and QA have proved difficult and for this reason ICES has concluded that it is still premature to include measurements of primary production in routine monitoring programmes and in data bases. There is therefore a need for increased effort on QA work so as to include phytoplankton primary production in monitoring and assessment programmes.

Data on zooplankton biomass are collected in various national monitoring and research programmes. Such data are useful for assessing the trophic status of a marine area with regard to both the issues of eutrophication and fisheries. There is a need to compile such information and to include zooplankton biomass in future integrated monitoring programmes. Zooplankton transport with the ocean currents are an important element with regard to productivity and potential for production of fish and other higher trophic level organisms in an area. Zooplankton transport is being addressed in several national and international research projects such as the EU/MAST-III OMEX project. It is possible to estimate zooplankton transport based on estimates of water transport and data on zooplankton concentration and vertical distribution.

5. Proposal on ways to integrate information to meet the EEA requirements

Environmental assessments of the conditions of the European Seas by the EEA can be based on either a regional or thematic approach, or a combination of both. A regional approach has several advantages. It will correspond more closely with the areas or subdivisions of areas used by the regional Conventions and will facilitate coordination and cooperation between them. It will also allow a more holistic appraisal of the environmental impact by the different human influences in a region. Comparability in methodology and data comparability among the different regions also becomes less critical. It is therefore recommended for marine and coastal assessments that EEA should follow an approach with regional focus.

There is a large amount of data available at national level. This information should be used in addition to what is being reported to the Conventions and other international organisations. Support from EEA could greatly facilitate the use of such additional national information and add value to the existing reporting routes and uses of data. National focal points and national data centres should play central roles in coordinating the use of additional national data for integrated environmental assessments by the EEA.

To facilitate the availability and use of additional national information in environmental assessments, there is a need to strengthen quality control and data banking. This could be done by establishing good links between the international data banks and national data centres and assuring that data are available for the initial integrated data assessment as a first step in the environmental assessment process.

The marine environment consists of open ecosystems with a high degree of internal dynamics and considerable exchange with neighbouring systems. Efforts should therefore be invested in providing information on fluxes of water, contaminants and biota. This can be done by a combination of data collection and modelling through promotion of GOOS related activities.

For the assessment of the biological effects and ecological consequences of contaminants there is a need to strengthen the amount of available data on contaminant levels in biota and biological effects. This is an area where the EEA could cooperate with the Conventions to promote the required research activities and the subsequent implementation of a more fully integrated chemical and biological effects approach to monitoring.

Following a step-by-step approach, the ETC/MCE could also develop a procedure in order to harmonise the data quality control used by the

Conventions and facilitate the data flow from/to the Conventions and EEA. The most appropriate level of aggregation of data, depending on the environmental issues to be studied, could also be investigated by the ETC/MCE.

Cooperation of the ETC/MCE with ICES (for OSPARCOM and HELCOM) and MAP could result in testing procedures by compiling some databases containing the required parameters with the appropriate spatial and time aggregation in specific issues. One of these issues could be for example eutrophication.

The same procedure could be developed by the ETC/MCE in cooperation with the Member States. First the appropriate data flow should be investigated with the cooperation of the National Focal Points and a selected number of national organisations and laboratories so that direct links can be established between the ETC/MCE and the national bodies. The harmonisation of sea water quality could be investigated as well by the ETC/MCE. The further compilation of the above mentioned databases could then be carried out. Specific issues could also be addressed.

This procedure will allow both ETC/MCE and the national organisations to have access to databases containing data at European level with a well define a quality control and the most appropriate level of aggregation.

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