EP

United Nations
Environment
Programme

UNEP(DEC)/MED WG.231/14
30 April 2003

ENGLISH

MEDITERRANEAN ACTION PLAN

Meeting of the MED POL National Coordinators

Sangemini, Italy, 27 - 30 May 2003

EUTROPHICATION MONITORING STRATEGY OF MED POL

UNEP
Athens, 2003

Table of Contents

Page No.

Foreword

Although the open waters of the Mediterranean Sea have always been considered as oligotrophic, the available data and information show that eutrophication phenomena are of concern for the coastal waters of some of the regions of the Mediterranean. In addition, many Mediterranean countries have recorded cases of eutrophication in their enclosed bays, river estuaries and other hot spots.

The issue was first raised by the last National Coordinators' Meeting (Venice, Italy, 28-31 May 2001) which recommended to the Secretariat to elaborate a draft programme for monitoring of eutrophication in Mediterranean coastal waters. The draft (UNEP(DEC)/MED WG.196/4) was first presented to Government Experts at the Review Meeting on MED POL – Phase III Monitoring Activities (Rome, Italy, 5-7 December 2001) and later discussed at a Consultation Meeting on MED POL Eutrophication Monitoring Strategy (Athens, Greece, 20 September 2002). As a result, the draft monitoring programme was thoroughly reviewed by the experts (see Annex to the current document), the strategy for short-term was finalized and recommendations were formulated for planning mid- and long-term phases of the overall programme. National Coordinators of MED POL have been informed of the finalized programme proposal (see report of the Meeting UNEP(DEC)MED WG.218) and of the data quality assurance activities of the year 2003.

The present document aims at presenting both the short-term monitoring strategy and the foreseen perspectives of the medium/ long term activities for approval. The approval of the programme would lead MED POL to start its activities and enter into the implementation phase. Since the data quality assurance activities have already been initiated, the Secretariat would like to acknowledge both IAEA/MEL and ICRAM for their significant contribution and cooperation.

I. Short term Monitoring Strategy

I.1. Site typology

Three sites are proposed to be selected by the countries: a marine, an off-shore fish farm and a lagoon site.

For the *marine site* it is proposed

- to select hot spot site(s)- affected area- according to criteria given in Box 1
- to adopt the parameters supporting TRIX index given in *"monitoring plan"* below
- to adopt spatial coverage and frequency recommended within the *"monitoring plan"*
- to choose a reference[1] site adopting the same monitoring plan and sampling strategy of affected area

For the *off-shore fish farm* it has been agreed that

- the off–shore fish farming is an increasing activity in Mediterranean countries and fish production is an important point source of nutrients and organic matter. This could, mainly in sensitive areas, have a huge impact on the ecosystem and might form potentially risk areas for eutrophication
- each country has to choose such a site adopting the same monitoring plan of the marine site (hot spot and reference area; parameters etc.)
- to better characterize the site also fish production data must be collected

For the *coastal lagoon* following is realized that

Mediterranean coastal lagoons[2] are very important sites for biodiversity protection and as nurseries for the marine species

For the routine monitoring of coastal lagoons a stepwise approach is proposed:

First step

- collect an inventory of national lagoons and chose at least one site considered important at national level

Second step

- provide information on general hydrology and morphology
- collect information on water basin use and frequency of dystrophic events
- choose a representative station and measure salinity on a seasonal basis and DO (24 hours cycles in warm season)
- mapping distribution of submersed vegetation (sea grass and seaweed) on an annual basis

Third step

- After the first assessment a monitoring plan will be adapted to the trophic state as defined after step 2 (this will be discussed in a future meeting in the framework of MEDPOL eutrophication monitoring).

[1] Reference area has to be chosen as more similar (ecosystem characteristics) to the affected area having minimum influences from human activities

[2] Coastal lagoons are not yet unequivocally defined in the Mediterranean and further step to define has to be taken

Box 1

Site Selection criteria

- representative at national level: being related to the back lying catchment areas, receiving loads from rivers, direct discharges of domestic and industrial wastes, loads from mariculture activities and/or diffuse sources;
- being sensitive to eutrophication phenomena (enclosed coastal bay and estuaries, shallowness, limited water recycling, etc.), in order to be able to distinguish -as much as possible- between natural fluctuations and anthropogenic pressures;
- being suitable to assess the general progress in the adoption of EU rules (nitrate directive, etc.), urban waste management, agriculture, etc.
- having the main morphological characteristics that should be well described together with drivers, pressures, meteorological and hydrodynamic parameters;
- having the historical records of ecological events and socio-economical trends in land use.

I.2. Monitoring plan

I.2.1 Parameters

The following parameters have been adopted as the basic determinants of the short-term eutrophication monitoring programme.

Table 1 Mandatory parameters to be monitored by each country

Temperature (C°)	**Dissolved oxygen (mg/L, %#)**
pH	**Chlorophyll "a" (µg/L#)**
Transparency	**Total Nitrogen (N µmole/L)***
Salinity (psu)	**Nitrate (NO_3-N µmole/L, µg/L#)**
Ortophosphate (PO_4-P µmole/L, µg/L#)	**Ammonium (NH_4-N µmole/L, µg/L#)**
Total phosphorus (P µmole/L, µg/L#)	**Nitrite (NO_2-N µmole/L, µg/L#)**
Silicate (SiO_2 µmole/L)	**Phytoplankton (total abundance, abundance of major groups, bloom dominance)**

***** not mandatory, only recommended regarding the methodological difficulties
# units supporting TRIX index ("trix" box below)

I.2.2 Sampling frequency

Mandatory sampling frequency would be seasonal. However, it is strongly recommended to perform monthly sampling or a sampling strategy arranged to follow the seasonal cycle meaning to be more frequent during certain periods of higher variability and less frequent at more stable periods. The criteria defined in Box 2 could be considered as a basis for setting up the strategy for sampling frequency.

Box 2

Criteria set for Sampling Frequency

The optimal sampling frequency should be chosen as a right compromise between a high frequency able to cover the parameter variability that is in most of the cases site dependent and the best cost-effective strategy of the sampling programme. Each country has its own responsibility for the best choice according to the parameter variability in the affected area. The sampling frequency chosen by each country has to take account the objective to detect a change in concentration over a selected period (e.g. 10 years).

I.2.3 Spatial coverage

Wherever possible at least four transect and three sampling stations at each transect would be applied as recommended in Box 3.

Box 3

Criteria set for Spatial Coverage

Each country is responsible for the choice of the most representative sampling stations in order to detect changes over a selected period (e.g. 10 years). The spatial distribution of the monitoring stations should take account of inputs and the oceanographic characteristics of each area. In most cases it will be possible to decide only after sampling and after a statistical analysis of the bulk of data of the whole monitoring plan.

A minimum sampling plan can be suggested as follow:

1. Design one transect perpendicular to the coast line of the affected area
2. Chose three sampling stations for each transect according to the bottom typology
    a. High slope (more than 50 m. depth at 3000 m. from coastline).
    b. Medium slope (more than 5 m. at 200 m. and less than 50 m. at 3000 m. from coast line)
    c. Low slope (less than 5 m. at 200 m. from coastline)

    a) Distance from the coastline= 1 at 100 m., 2 at 3000 m., 3 between the first two if the distance is more than 1000 m. Otherwise only the first two.
    b) Distance from the coastline= 1 at 200 m., 2 at 1000 m., 3 at 3000 m.
    c) Distance from the coastline= 1 at 500 m., 2 at 1000 m., 3 at 3000 m.

Vertical profiles:

It is obligatory to collect more samples for each sampling station in order to have vertical profiles for all parameters. The number of vertical samples must not be less than three (surface, medium depth, bottom). It is recommended in particular to collect continuous profiles for salinity, temperature and oxygen trough the use of a CTD multiprobe apparatus.

Important note on sampling strategy

For the proper application of TRIX on annual basis it would be required to collect at least a minimum of 48 data both for the hotspot and the reference area. The combination of sampling design and frequency has to meet this minimal requirement. (Ex: If the sampling frequency is seasonal –4 times/year-, selection of 4 transects with 3 sampling stations was recommended as a minimum requirement for the affected site and the reference site that is totally providing a data set of 96 records for each parameter supporting TRIX index)

Trophic Index : TRIX (Vollenweider et al., 1998)

TRIX Index assigns a numerical value (a measure) to the trophic levels of coastal waters.
The final formulation adopted was the following:

TRIX Index = (Log10 [ChA·aD%O·DIN·TP]+ k)·m

where:
ChA = Chlorophyll a concentration as µg/L;
aD%O = Oxygen as absolute % deviation from saturation;
DIN = Dissolved Inorganic Nitrogen, N-(NO3+NO2+NH4) as µg/L;
TP = Total Phosphorus as µg/L.
k=1.5
m = 10/12 = 0.833
The parameters k and m are scale coefficients necessary to fix the lower limit value of the Index and the extension of the related Trophic Scale, i.e. from 0 to 10 TRIX units.

Referring to the ChA and aD%O components, it has to be remarked that these factors are direct indicators of productivity, in terms of both the amount of phytoplankton biomass produced and the dynamic of that production, respectively. In other words, the TRIX Index summarises what the coastal system does (by including the contribution of the direct indicators of productivity, as "actual productivity") and what the coastal system could do (contribution of the nutritional factors components, as "potential productivity"). As a result of the Log-transformation of the four original variables, the annual distributions of TRIX over homogeneous coastal zones are usually of normal kind, and show a quite stable variance, with STD around 0.9. As for the interpretation of TRIX values, those exceeding 6 TRIX units are generally associated to highly productive coastal waters, where the effects of Eutrophication are represented by frequent episodes of anoxia in bottom waters. Values lower than 4 TRIX units are typical of scarcely productive waters, while values lower than 2 are generally associated to the open sea.

Vollenweider, R.A., Giovanardi F., Montanari, G., Rinaldi A., 1998. Characterization of the trophic conditions of marine coastal waters, with special reference to the NW Adriatic Sea: proposal for a trophic scale, turbidity and generalized water quality index, *Environmetrics*, 9, 329-357.

I.3. Data Quality Assurance

Considering the need to organize data quality assurance activities as priority and to launch them as a mandatory action before starting the short term monitoring programme, a QA programme has already been organized for both the mandatory chemical (basically nutrients) and the biological (chlorophyll-a and phytoplankton) parameters. As a first step, a reference methods manual has been prepared including pre-analysis steps and analytical methods for the nutrient and chlorophyll analysis. A training course on phytoplankton and zooplankton taxonomic identifications has been scheduled for the period of 9-13 June 2003. The course will also provide an intercalibration exercise among the participants for the identification and counting of the species, on-board work and lectures on specific topics.
After the training course and the analysis of its results, the Secretariat will plan the further steps of the Eutrophication-QA activities for the next biennium.

II. Medium/ Long Term Strategy

II.1. Pilot Parameters

For a medium/long term strategy the development of pilot studies for the adoption of new parameters/indicators is proposed. It is needed to introduce biological parameters both for the phytoplankton population dynamics and for the benthic component. However, it should be recognized that work still need to be performed to identify the proper parameters and, results and suggestions can be obtained by the Black Sea and EEA relevant working groups, as well as by national monitoring and research programmes that are experiencing these studies in the Mediterranean area.

A list of new group of parameters has been proposed as:

- *Dissolved Oxygen* - Daily variations of vertical DO profiles in critical season (together with vertical profiles of T°C, Salinity, Chl “a” and nutrients if possible). This proposal could be performed by the adoption of new monitoring techniques as for example a specific buoy application.

- *Phytoplankton* – Species composition and biomass estimates in spring-autumn period. On this group parameters there has been a long discussion on the difficulties of performance of taxonomic studies, therefore, it has also been suggested to experiment for the Mediterranean the adoption of the technique based on HPLC-phytoplankton pigment studies that can sensitively be used in biomass and taxonomic work.

- *Benthos* – Specific composition and population dynamics of phyto-, meio- and macro-zoobenthos are considered very important parameters for an effective assessment of the trophic state of an area if used in combination with other environmental data (e.g. chemical data). It was decided that an operative proposal has to be built on existing Mediterranean programmes.

- *Residence time* – Prevailing current patterns, water mass dynamics and a realistic estimation of residence time in the areas under considerations

II.2. Supplementary techniques

- *Remote sensing* – Remote sensing techniques would be a useful tool for estimating chlorophyll, suspended material distributions as well as turbidity. For example, maps of chlorophyll distribution can operationally be generated by using integrated remote sensing and in situ data. Moreover, remote sensing can contribute to monitoring network optimisation. On a regional scale the remote sensing tool could be useful to identify emerging problem areas, in particular if combined with previous historical images. In fact, the availability of 'old' images allows this survey use. Pilot programme(s) has been strongly recommended to be carried out at the sub-regional scale to test the integration of remote sensing with *in-situ* data aiming at the routine eutrophication monitoring programmes.

- *Automatic Buoy* – The automatic buoys (fixed and drifting platforms for real time measurements) and the ferry-box (onboard continuous sampling and analysing units) were considered as useful tools for continuous monitoring of environmental water quality parameters (dissolved oxygen, chlorophyll-a as fluorescence and recently some of the nutrients). Recent developments on both coastal systems allowed an extensive use of them in different regions of the world for the monitoring of eutrophication. There are some applications in the Mediterranean as well and some other pilot studies will soon be operational. However, there are still some limits and gaps regarding these techniques. For example, bio-fouling affects sensors' accuracy and require continuous and expensive maintenance and calibration, therefore, buoys systems can only be used for following the short-term events. On the other hand, accuracy of ferry-box systems is much better and long-standing as the sensors are in a protected dry environment allowing the detection of both short-term and inter-annual variability. A particular buoys application was proposed under the DO pilot programme.

II.3 Historical data

Since eutrophication is a long term process, historical data would be useful to reconstruct the story of the site and support the assessment and management of the area according to ICZM approach. It is proposed to collect the historical data and to leave to the countries the choice to perform this as facultative activity for the affected sites.

Which ideal data and information are to be collected?

- Any scientific study on the area under consideration.

- Grey literature and technical reports even unpublished dealing with any type of event occurred both in the marine and catchment's basin.

- Information concerning socio-economic development of the catchment's area and land use modifications. Any information concerning human activities both in marine and land area (industrial, agricultural, tourism, urban development, fishery, etc.)

Documents should be organized in an easily accessible way but no interpretation would be requested.

ANNEX

MONITORING OF MEDITERRANEAN MARINE EUTROPHICATION:

STRATEGY, PARAMETERS AND INDICATORS

TABLE OF CONTENTS

Page No.

1. INTRODUCTION

Since the 1980s the MED POL Programme, the marine pollution assessment and control component of the Mediterranean Action Plan, has been organizing and following up a regional marine monitoring programme, together with Mediterranean scientific institutions. Since then, and until now, in addition to complementary parameters chosen by the countries, only three groups of parameters have been considered mandatory, i.e. heavy metals in biota and sediments, halogenated hydrocarbons in biota and sediments and microbiological parameters for bathing waters.

During the last Meeting of MED POL National Coordinators (28-31 May 2001, Venice), it was decided that eutrophication parameters would become mandatory and would be included in the MED POL Phase III monitoring programme. As a result, the MED POL secretariat has worked on the definition of a set of indicators and a monitoring strategy for monitoring eutrophication in the Mediterranean Sea.

MED POL intends to propose a simple monitoring strategy in which the selected parameters should preferably be comparable with others already existing and being used in the region and elsewhere.

The aim of this report is to propose a first set of parameters and indicators and the relevant sampling strategy for monitoring and assessing the eutrophication phenomenon at the Mediterranean level.

2. BACKGROUND INFORMATION AND RATIONALE

2.1 Mediterranean eutrophication

The scientific awareness of the eutrophication phenomenon has evolved in the last twenty years and the definitions given to describe them have evolved as well. The following definitions ranging from 1968 to 1999 show the main progress done:

“Eutrophication in its most generic definition that applies to both fresh and marine waters, is the process of enrichment of waters with plant nutrients, primarily nitrogen and phosphorus, that stimulates aquatic primary production. Its most serious manifestations are algal blooms (red tides), algal scum, enhanced algal growth, and at times a massive growth of submersed and floating macrophytes (Vollenweider, 1968; 1981). Sometimes, these manifestations are accompanied by or alternate with cycles of visible bacteria blooms (Aubert, 1988) and fungal development”.

“Eutrophication is a process in which the bioavailability of nutrients in the considered recipient is increased. It becomes a nuisance if the concentration in nutrients exceeds some threshold values that vary in a large range according to the typology of the ecosystem. This state of nuisance results in lack of diversity and complexity of the considered ecosystem, involving perturbation (if not disappearance) of the secondary productivity level. Eutrophication may be linked to and be part of both organic and biological pollution on the one hand, and may cause toxic effects on the other hand”. (Carbenier, 1990).

“Eutrophication is an excessive increase in primary production, generally caused by excess in available phosphorus” (Labroue et al., 1995).

“Eutrophication (noun) - an increase in the rate of supply of organic matter to an ecosystem.”

The “organic matter” sources are both autochtonous and allochthonous. (Scott W. Nixon, 1995).

“Eutrophication is an environmental perturbation caused by an excess in the rate of supply of organic matter (both autochtonous and allochthonous) to an ecosystem. (G.Izzo, in: EEA 1999a).

In all the above definitions there is a general agreement in identifying nutrients as the main cause of eutrophication, although only some identify both inorganic and organic nutrients (organic carbon included); the real progress, a part the evident reduction of the number of words, is the substitution of the term increase (of nutrients) with the term excess. This is the most important improvement because it implicitly recognizes the existence of a characteristic threshold in the environment. This threshold is not easily identified in each environment, but at least for shallow marine ecosystems, it could be found as “an increased production of biomass which exceeds the recycling (aerobic materialization) capacity of the ecosystem” (G.Izzo, in: EEA 1999a).

In summary, eutrophication is caused by the load of nutrient (i.e. nitrogen, phosphorus and organic carbon) from human activities in quantity exceeding the carrying capacity of the receiving environment. The morphological and hydrological characteristics of a water body like shallowness and/or limited water recycling enhance the sensitivity to eutrophication problems. This is typical of coastal bays and lagoons that are more at risk for the vicinity to the urbanized coast. Nevertheless even larger basins as the Adriatic, Gulf of Lions and the northern Aegean Sea suffer from eutrophication problems. The main sources of nitrogen are the run-off from agricultural land and atmospheric deposition. Most of the phosphorus comes from point sources, urban and industrial wastewaters raw or poorly treated. Cage culture fish farming also often causes eutrophication problems at a local level.

Mediterranean surface waters in the open sea are classified among the poorest in nutrients (oligotrophic) of the world’s oceans. The morphology, the hydrology and the absence of significant up welling of the Mediterranean basin as a whole are considered the general characteristics that keep the nutrients out of the biological recycling process. Evaporation exceeds precipitation and freshwater load. The water deficit caused by evaporation is mainly compensated for by the net inflow of Atlantic Water through the Strait of Gibraltar of about 500 km^3 $year^{-1}$, the water contribution from the Black Sea that is about 160 km^3 $year^{-1}$, by the river discharge that is about 260 km^3 $year^{-1}$ and by precipitation that is about 780 km^3 $year^{-1}$ (Mariotti et al.2001). According to G. Manzella: “due to the Gibraltar Sill the Mediterranean sea imports heat and exports salt” (EEA/UNEP 1999). The estimated water residence time in the basin proper is around 75-100 years. These recently updated data raise the question: is there a risk for the eutrophication of the Mediterranean Sea as a whole?

Eutrophication in the Mediterranean basin, at the moment, appears to be limited mainly to specific coastal and adjacent offshore areas. Several and sometimes severe cases of eutrophication are evident, especially in sensitive areas as enclosed coastal bays which receive elevated nutrient loads from rivers, together with direct discharges of untreated domestic and industrial waste (EEA/UNEP 1999; Fig. 1).

Algal blooms, diversity reduction of marine species and depletion of oxygen as well as potential human health risks related to the ingestion of seafood contaminated by pathogens or toxic algal blooms are some of the problems associated with Mediterranean eutrophication. Side effects (e.g. hypoxia/anoxia, algal blooms) have been reported in several places in the Mediterranean Sea, but they are confined to limited areas rather than widespread phenomena. In the report “State and pressures of the marine and coastal Mediterranean environment” (EEA Environmental assessment series N°5; EEA/UNEP 1999) a first attempt to summarize in a table a list of observed events caused by eutrophication have been made.

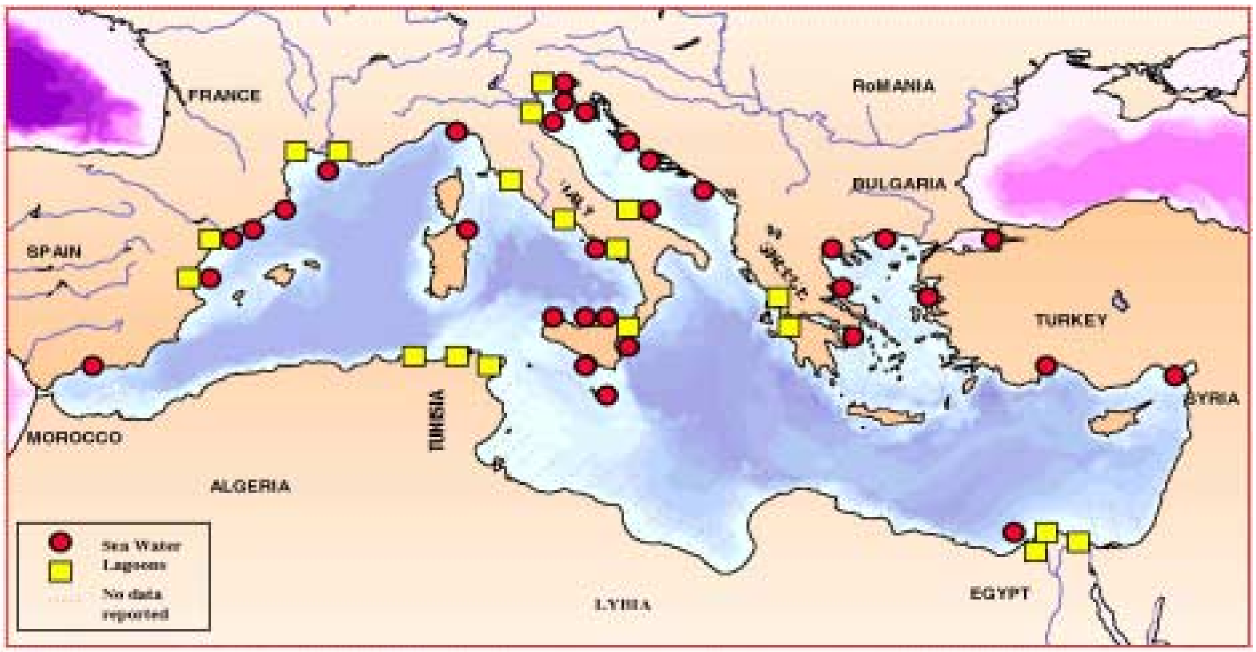

FIG. 1 Mediterranean areas where eutrophication phenomena have been reported. Source: EEA/UNEP 1999

The Adriatic, the Gulf of Lions and the northern Aegean Sea are areas with relatively higher mean nutrient concentrations, higher primary and secondary production and, sometimes, local algal blooms related sporadically to hypoxic or anoxic conditions and rarely to toxic algal blooms (EEA/UNEP 1999). Discharges of nitrogen and phosphorus to the Adriatic region are of the order of 270 000 and 24 000 t, respectively. The north Aegean Sea receives annually 180 000 t nitrogen and 11 000 t phosphorus from the Black Sea, which is comparable with the inputs from land-based sources to the northeast of the Mediterranean Sea (EEA/UNEP 1999).

2.1.1 River loads

With a few exceptions, all river systems discharging in the Mediterranean Sea are small. The Rhone, Ebro and Po have catchment's areas extending to 96 000, 84 000 and 69 000 km^2 respectively. The discharge of freshwater from the main rivers is about 260 km^3 per year. Net inflow from the Black Sea amounts to 163 km^3 per year.

Besides urban (and industrial) sewage, agriculture is a major anthropogenic nutrient source to the Mediterranean Sea. Due to the specific morphology of the Mediterranean basin, intense agricultural activity is carried out in the limited coastal plains, often as a result of reclamation of wetlands. The main pressures from agriculture are soil erosion and nutrient surplus from excessive fertilization and livestock.

Also large river basins like the Nile, Rhone and Po Basins are subjected to agricultural pressures. The first six drainage regions, following a tentative ranking of the risk of soil erosion and nutrient losses, are found in peninsular Italy, Sicily, Sardinia, Greece, Turkey and Spain (EEA/UNEP 1999). In EEA/UNEP (1999) a list of the 50 largest rivers flowing to the Mediterranean Sea is given with the mean annual water flow and for some of the rivers also the mean concentrations of nitrate, ammonium and phosphate. The total estimated loads are about 304,000 ton/year N and 22,000 ton/year P.

The nutrient levels found in Mediterranean rivers are about four times lower than those in western European rivers, but in all documented cases the nitrate levels are dramatically increasing (EEA/UNEP 1999). Never the less, depending on the river size and location, the concentration ranges are enormous, over an order of magnitude for nitrate and more for ammonia and phosphate as compared to the open waters (EEA/UNEP 1999). A recent paper emphasized the change in N: P ratio and a dramatic silicate decrease in Mediterranean waters due to Danube and Nile rivers damming (Turley, 1999). This means that silica requiring phytoplankton do not have their essential growth nutrients and may explain the unbalanced growth of other toxic forms which do not require silica.

2.1.2 Total nutrient loads

In UNEP/FAO/WHO (1996) an estimation of the total load is made on the basis of population density, fertilizer use, land use and livestock populations for three different scenarios. The calculations revealed that the most likely actual total nitrogen load from land based sources would lie within the range of 1.5 to 2.5 million tons, and that for phosphorus between 0.15 and 0.25 million tons per year. More recently in the reports “Identification of priority pollution hot spots and sensitive areas in the Mediterranean” (UNEP/MAP 1999) and “State and pressures of the marine and coastal Mediterranean environment” (EEA/UNEP 1999) new calculations revealed an underestimate for phosphorous (Table 1).

About 450 million people live in the Mediterranean coastal states, and more than 135 million tourists visit the coastal regions per year. Out of 230 coastal cities, with information available, about 45% were without sewage treatment plants, and about half of the total volume of sewage is discharged untreated. Where treatment plants were present only 38% of them had secondary treatment (UNEP/MAP 1999). In UNEP/MAP (1999) an identification of priority pollution hot spots and sensitive areas in the Mediterranean region is made and the nutrient load mainly from sewage to the areas given.

Table 1. Nutrient load to the Mediterranean Sea from agriculture and aquaculture in t y^{-1}. Source: Agriculture (EEA 1999); mixed (domestic + industrial) UNEP/MAP 1999; Aquaculture: data calculated from FAO database applying the formula used by Ackefors & Enell (1990). The relation between food and biomass is expressed by the Food Conversion Factor (FCR=kg of food/kg of living biomass), for which a mean value of 1.5:1 was applied for all countries.

	P	N	C	BOD	COD
Agriculture	976000	1570600	16941000		
Mixed	75234	259691		804244	1729853
Aquaculture	394	8678	38225		

Marine aquaculture has shown a large expansion in production in a number of Mediterranean countries over recent decades, and increases from 1693 metric tons in 1970 to 131493 tons in 1999 (fin fish only). Since marine intensive aquaculture is a relatively new sector in the Mediterranean and concerns mainly shellfish and some fish species, the impact is - according to EEA/UNEP (1999) - still rather limited and localised. Never the less the nitrogen load from marine fish farming, at least locally is a major nutrient source which can cause eutrophication effects (Table 1; Fig. 2).

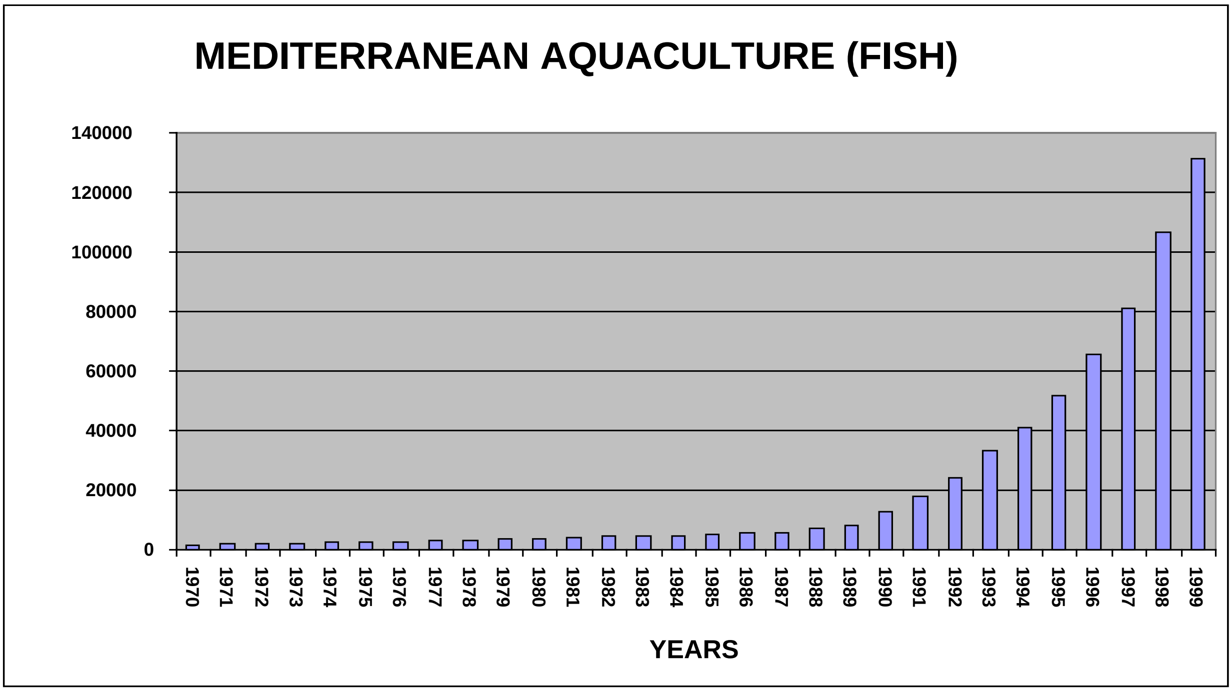

FIG. 2. Trend of marine aquaculture (fish only) from 1970 to 1999. Source: FAO database

2.2 Indicators and DPSIR approach

The term "indicator" generally describes a compact yet effective way to present given environmental information in a format that is best suited to inform subsequent response in environmental management. The definition of an indicator according to OECD, 1993 is: "**Indicator/parameter or a value derived from parameters, which points to, provides information about / describes the state of a phenomenon / environment / area and has further implications for the environment. The indicator is not necessarily an environmental parameter, but it could be the expression of a parameter or a pool of environmental parameters. A good indicator has to meet a set of criteria**".

In relation to policy-making, environmental indicators are used for three major purposes:

1. to supply information on environmental problems, in order to enable policy-makers to assess their seriousness;
2. to support policy development and priority setting, by identifying key factors that cause pressure on the environment;
3. to monitor the effects of policy responses.

In addition, environmental indicators may be used as a powerful tool to raise public awareness on environmental issues. Providing information on driving forces, impacts and policy responses, is a common strategy to strengthen public support for policy measures.

When selecting parameters and relative indicators must be kept in mind that there is a difference between the scientific research perspective and the environmental research perspective (Fig. 3). The environmental monitoring needed to support the management of an environmental issue is different from what is needed for the purpose of scientific research. Nevertheless scientific research has to feed environmental management by helping in the selection of the best available parameters to be used as indicators.

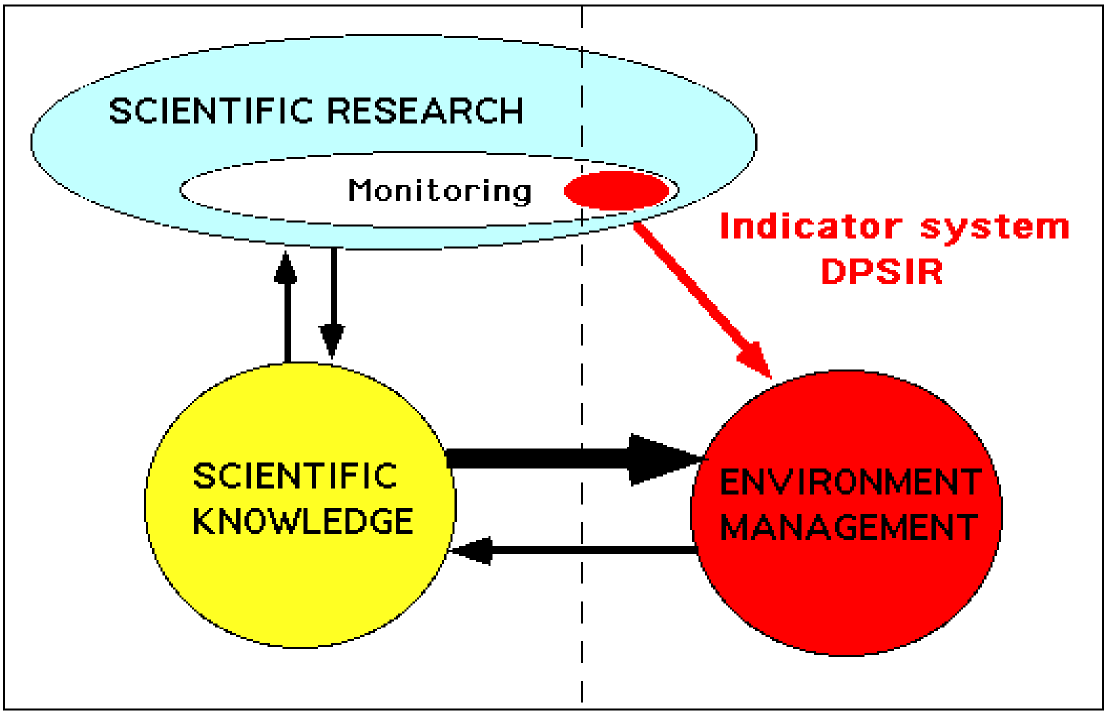

FIG.3- The relation between scientific and management perspective for environmental monitoring

The DPSIR is an approach to the system of indicators widely accepted for the marine environment and coastal zone to obtain: - an information reporting system (a structure for organising and reporting on monitoring data); - a tool for communicating with policy-makers in particular, and also with the general public (Fig.4).

DPSIR is also a tool for improved understanding of environmental problems; - an information and assessment tool for the identification of environmental problems and a tool to set priorities for regional environmental problems. Many different frameworks and sets of indicators have been reported in industrialised countries. The most thoroughly discussed system is the *"pressure-state-response" (PSR)* framework of the OECD (1993). The PSR framework and alternatives connect pressures caused by human activities with changes in the state of the environment and responses aimed at improving the state of the environment by reducing the pressures. This framework is chosen as a starting point because of its simplicity and wide acceptance, and the fact that it can be applied on any scale. Modifications of the OECD PSR framework have resulted in alternative frameworks, e.g. the *PSR/Effects* (PSR/E) model of the EPA in the US (EPA, 1994), the PS/Impact/R model of the LTNEP (Swart et al, 1995) and the *Driving forces/PS/Impact/R* (DPSIR) model introduced by the RIVM in 1995 and used by the EEA (Wieringa, 1996). The framework adopts a causal approach and identifies the causal chain. The indicators are the attributes of the framework; they summarise information or, more specifically, the raw data concerning a selected issue or problem.

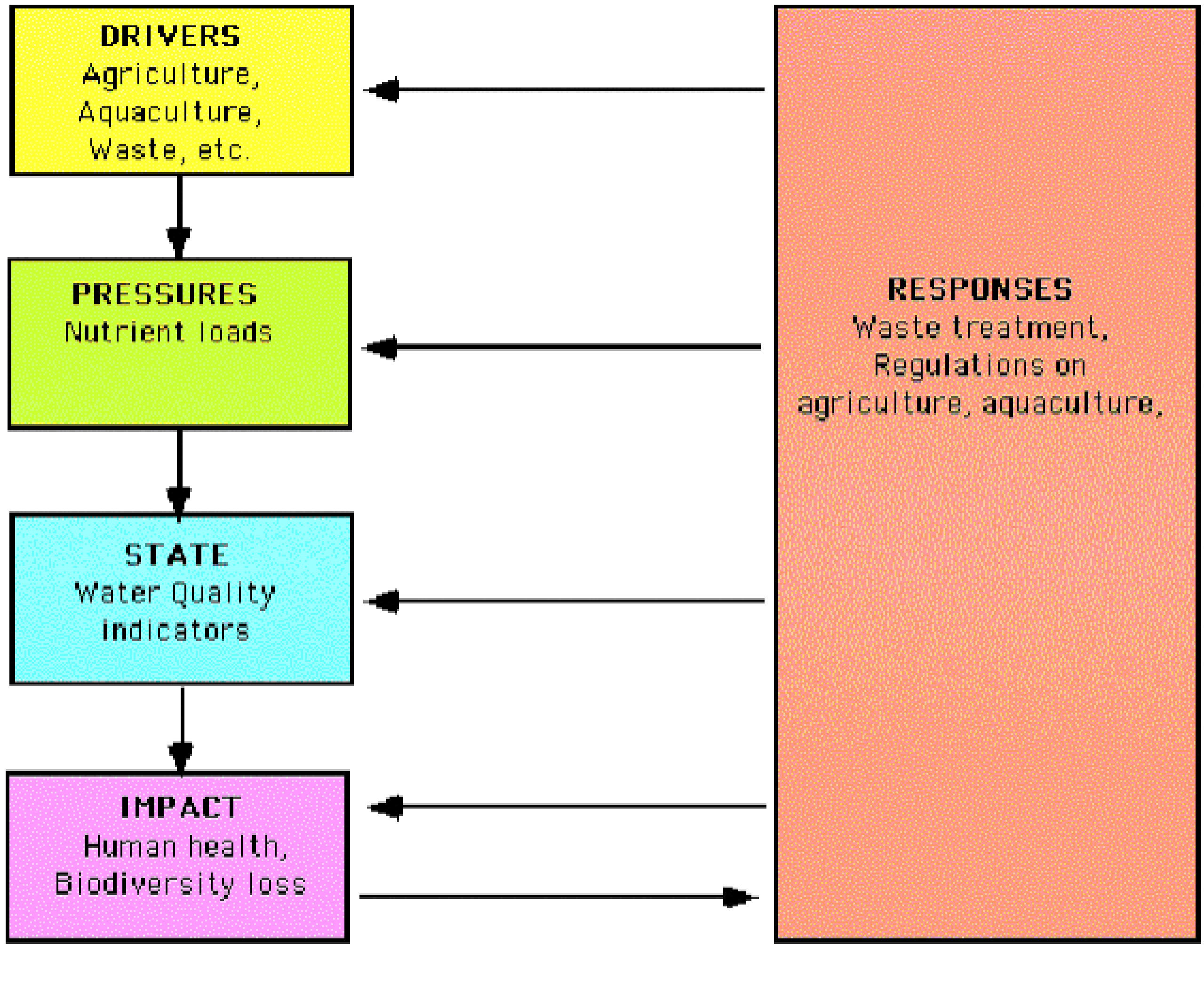

Fig. 4 The DPSIR Framework applied to eutrophication

In order to select parameters potentially able to be used as indicators for the coastal zone, the following selection criteria should be applied:

- Relevance to the coastal zone (according to expert opinion);
- Relevance to Mediterranean countries policy (e.g. European policy);
- Availability of adequate time series and reasonable spatial coverage;
- Comparability of the data;
- Availability of standards/reference values;
- Degree of independence of natural weather-related fluctuations;
- Spatial aggregation.

- Explicit relevance to models. Modules describing the internal relationships within the DPSIR framework are indispensable to the use of indicators in strategic environmental assessments.

2.3 UNEP activities on eutrophication

UNEP has considered eutrophication a relevant issue for the Mediterranean Sea and as published three important documents on this topic:

1. UNEP/FAO/WHO 1996. Assessment of the state of eutrophication in the Mediterranean Sea. *MAP Technical Reports Series* No. 106. UNEP, Athens, 211 pp.
2. EEA/UNEP 1999. State and pressures of the marine and coastal Mediterranean environment. EEA Environmental assessment series N°5
3. UNEP/WHO 1999. Identification of priority pollution hot spots and sensitive areas in the Mediterranean. *MAP Technical Reports Series* No. 124. UNEP, Athens, 90 pp.

The first report (UNEP/FAO/WHO, 1996) is a huge and quite recent report dealing with all the aspects of Mediterranean eutrophication and identifying a series of gaps for the detailed assessment of the phenomena at the regional level. The report recommends to extend and coordinate a monitoring action within the MED POL programme, linked to “a geo-related inventory of land based sources”. Moreover it stresses the need for a scientific action focused on the following objectives:

- Factors controlling eutrophication processes;
- The structure and function of eutrophic ecosystems and the relevant hydrodynamics as the basis for the determination of their receiving capacities for eutrophicants;
- Classification of the stages and degrees of eutrophication on the basis of quantitative parameters;
- Investigation of the recovery processes in ecosystems that have been modified due to anoxia and mortalities induced by eutrophication;
- Further development of scientific methods as needed, particularly for the monitoring and ecological assessment programmes.

This list implicitly recognizes the existing uncertainty on marine eutrophication, that is also stressed in the identification of monitoring parameters: quote” No single analytical tool is adequate to measure the degree of eutrophication of a given water body- and moreover – The ecological assessment of the state and the extent of eutrophication requires an investigation of community structure and diversity, ...”unquote.

The second report (EEA/UNEP, 1999) jointly produced by EEA and UNEP, identifies eutrophication as one of the main issue of concern for Mediterranean coastal zone. In section 4.1 the most relevant available information on Mediterranean eutrophication is presented. A particular effort has been done to summarise in a synoptic table the main ecological effects of eutrophication as reported by different countries. In this report it is also stressed that is not possible to assess Mediterranean eutrophication phenomena solely on nutrient concentration.

In the third report (UNEP/WHO, 1999), although the identified gaps in data gathering, there is an inventory of land based sources and sensitive areas in Mediterranean region. The most relevant data of eutrophication pressures are summarized in Table 1. From this report it appears clearly that although eutrophication in the Mediterranean is mainly limited to the coastal zones it is an issue of concern since it interests areas of important economic and natural value where there is a high density of population.

2.4 Mediterranean countries' activities on eutrophication

All Mediterranean countries are affected by marine eutrophication although to a different level (Fig.1) and national monitoring programmes are already being performed. The sampling strategy and the parameters adopted are not the same for all countries nevertheless it appear to be a general good knowledge of the affected areas. In table 2 are summarised the Mediterranean countries' monitoring activities in the framework of MED POL.

Table 2 Inventory of the computerized data regarding the eutrophication parameters in MED POL database

COUNTRY	SAMPLING PERIOD	NUMBER OF STATIONS	SAMPLING (3) FREQUENCY / YEAR	PARAMETERS (4)
Algeria	1989-1990	10	2-4	BOP, NUT, Chl-a
Croatia	1992	4	3	BOP, NUT
Cyprus	1999-2000	28	1-2	NUT
Ex-Yugoslavia	1983-1991	27	2-4	BOP, NUT
Greece	1987-1990 1995	13 9	4 11	Chl-a BOP, NUT, Chl-a
Italy (1)	1987-1989 1992, 1994, 1997	126 31	4-12 12	BOP, NUT, Chl-a
Lebanon	1984-1988	10	5-8	BOP, NUT
Morocco	1983-1990 1993	8 8	2-4 3-4	BOP, NUT NUT
Slovenia	1996-2000	15	1-12	BOP, NUT, Chl-a, TRIX
Spain (2)	1991	31	1	BOP, NUT, Chl-a
Turkey	1986 1995	15 67	3 1-2	BOP, NUT

(1) More data exist on paper
(2) Some more data exist on diskettes (unreadable)
(3) Sampling frequencies might change with respect to parameters and stations
(4) Parameters like Chl-a and TRIX were occasionally measured

2.5 EEA approach to eutrophication

The European Environment Agency identified marine eutrophication as one of the main issue affecting European coastal zones and dedicated a strong effort to manage this phenomenon at an European scale; in this paragraph are reported the selected indicators and the whole process followed to reach this result.

The mission of EEA is to deliver timely, targeted, relevant and reliable information to policy makers and the public for the development of sound environmental policies in the European Union and other member countries. In order to present scientific information in a form that answers the questions of policy makers, EEA is producing indicator-based reports.

Indicators have been chosen as the best way to present data from different environmental and sectored areas in a comparable and structured way. The DPSIR assessment framework is being followed, which stands for **D**riving Force, **P**ressures, **S**tate, **I**mpact and **R**esponses (EEA Technical report No 25, http://reports.eea.eu.int/TEC25/en).

The obligation to publish regular reports on related environmental indicators is especially significant and is a key task for the agency in the future.

Eutrophication has been identified has one of the main issues of the European coastal zones.

In March 1999, a questionnaire covering eutrophication was submitted to the National Focal Points in Belgium, Denmark, Finland, France*, Germany, Greece*, Iceland, Ireland, Italy*, the Netherlands, Norway, Portugal, Spain*, Sweden and U.K. (* Mediterranean countries). Data were received up to mid-August in 1999 and were gathered in a database (MARINEBASE) that was used for testing the parameters as indicators.

In November 2000 a first draft report “Testing of Indicators for the Marine and Coastal Environment in Europe” was circulated and, after receiving and accommodating comments, was printed in June 2001 as a Final Draft.

In June 2001 the same working group of ETC/ Water also produced a report titled: “The potential core set of indicators for the Marine and Coastal Environment where the indicators are aggregated according to the requirement of the Water Framework Directive”.

On 14-15 June 2001 an IRF (Inter Regional Forum) **“**EEA - MARINE CONVENTIONS JOINT WORKSHOP ON INDICATORS” was held in Ispra, Italy. The ETC work programme on indicators and the reporting needs of the European environmental policy were discussed (Annex1).

As a follow up of the IRF meeting the 17th July 2001 EEA Topic Team for Water produced a document titled: Towards a core set of indicators for water environment.

All the above mentioned documents have been discussed in a meeting in Vienna June the 19th 2001, to achieve an agreement on a final document “ a core set of indicators for water environment “ to be delivered in autumn.

The core set of EEA (state/pressure) indicators for marine eutrophication is being identified trough the following process:

- ETC questionnaire (March 1999) to the regional conventions and NRC;
- organisation of the database (MARINEBASE) on delivered data (autumn 1999);
- testing of indicators included in the MARINEBASE and preliminary conclusions (spring 2000);
- proposal for “a potential core set of indicators” (June 2001);
- IRF meeting 14-15 June 2001;
- elaboration of an EEA official position on requirements for the core set of indicators (expected for July 2001);
- possible conclusions and final proposal by the end of 2001.

In the whole process the study has been carried out on the basis of available data delivered trough the questionnaire. Only in the EEA' July document produced by the ETC/water topic team is outlined the difference between using existing data and identifying the need for new data and tools/methodologies for constructing indicators. Moreover in the same report we find that: "The indicators proposed to date have therefore tended to concentrate on making best use of available data rather than starting with the questions first". This statement identifies the need for new and more effective indicators for eutrophication assessment.
This need is also found in the recommendations of Inter-Regional Forum Workshop on marine indicators :

- develop maps on EU Eutrophication Risk index and use of remote sensing for chlorophyll "a" indicator/maps
- test phytoplankton indicators
- test indicator of phytotoxins and macrozoobenthos (2nd priority)
- develop indicator on phytobenthos at European scale
- take the OSPAR common procedure (OSPAR, 1997) into account when developing eutrophication indicators

The potential set of indicators identified by the work programme of EEA Topic Centre for Marine and coastal environment (ETC/MCE) for assessing the eutrophication state of a marine environment are integrated in the theme Water Quality as table 4.1 and 4.2 of the report (EEA Technical Report, 2001 under preparation) and are showed below in Table 3.

Table 3 EEA selected indicators for state assessment of marine eutrophication

Headline *Indicator*	**EEA Indicator theme**	**General description**	*Indicator parameters*	*Comments*
	Nutrients	Concentrations of substances	**winter conc. NO2 +NO3, PO4, N/P ratio,**	Mean summer tot-P, tot-N, in N forms, P04
			Chlorophyll a	Spring peaks, seasonal
			Bottom oxygen	Mean, annual minimum duration of low oxygen values,
			TRIX (Trophic Index)= **=(Log(Chl-a*aD%O*DIN*TP) + 1.5) / 1.2**	TRIX index allows for Spatial information using SeaWifs images

3. UNEP/MED POL PROPOSAL FOR MEDITERRANEAN EUTROPHICATION MONITORING AND MANAGEMENT

The development of indicators is a world wide ongoing process. The European Environment Agency (EEA) in particular has extensively worked on the selection and testing of a preliminary set of indicators for assessing marine eutrophication on the basis of available data. The common view expressed in EEA documents and discussed in the IRF (Inter Regional Forum) meetings is that further work as to be carried out to identify and test new indicators for the assessment of marine eutrophication. OSPAR is identifying indicators for biological state variables to be applicable for the development of ecological quality objectives and HELCOM started developing new indicators for eutrophication in the Baltic Sea.

The MED POL Programme is at the beginning of this process although some Mediterranean countries have both long experiences in the study of eutrophication processes and are partners of ETC/MCE (now ETC/Water) consortium.

There is in fact a need to improve data collection by organizing direct data gathering through the development of specific monitoring activities.

As a result, it is suggested by UNEP/MEDPOL to adopt the EEA approach and start developing a regional approach in the identification of new eutrophication indicators and data needs that meets the specificity of the Mediterranean environment.

The main difficulty in identifying a list of suitable parameters for monitoring marine eutrophication is to find a cost-effective strategy. No single analytical parameter is adequate to measure the degree of eutrophication of a given water body. It is generally accepted that a good assessment should be done on the basis of the structure and diversity both of plankton and benthos communities. Nevertheless such an approach would be rather costly. Therefore it is necessary to make a proper selection of monitoring parameters.

Vollenweider (UNEP/FAO/WHO 1996) proposes a major list of parameters containing suspended solids, light penetration, chlorophyll, dissolved oxygen, nutrients and organic matter to be determined either at the surface or at various depths.

A French group of experts from IFREMER proposes a list of parameters capable to trace the “disequilibrium in the ecosystem”. The dissolved oxygen and chlorophyll are on the top of the list; nutrients also are considered to be useful descriptors.

EEA after the testing of a huge database gathered in ICES has restricted the list of mandatory parameters and sampling period as showed in Table 3.

A group of Italian experts working for the Environmental Ministry propose to adopt the “TRIX INDEX” for assessing Mediterranean eutrophication (this is also recommended by EEA) (Vollenweider et al. 1998). The trix index is a dimensional number obtained by applying a mathematical formula to the results of monitoring parameters as nutrients, oxygen and chlorophyll.

All these proposals are oriented towards adopting “traditional” monitoring parameters (such as nutrients, chlorophyll and oxygen) as a basis for selecting indicators that are slightly different only in the computational system applied to the parameters. Although this is a reasonable proposal, it nevertheless leaves some gaps in the final assessment. In fact the indicators supported by the aforesaid parameters are able to assess “ a trophic potential” of a water mass, but do not inform on the actual state of the affected environment and on changes in biological communities. Moreover, while designing the monitoring strategy in terms of sampling frequency and spatial coverage, it should be taken account that most of the above mentioned parameters are non-conservative and are affected by short-term variations. Eutrophication is a long-term process and an effective assessment should be done on the basis of those parameters that change on a long time scale (e.g. biological communities) (Fig.5).

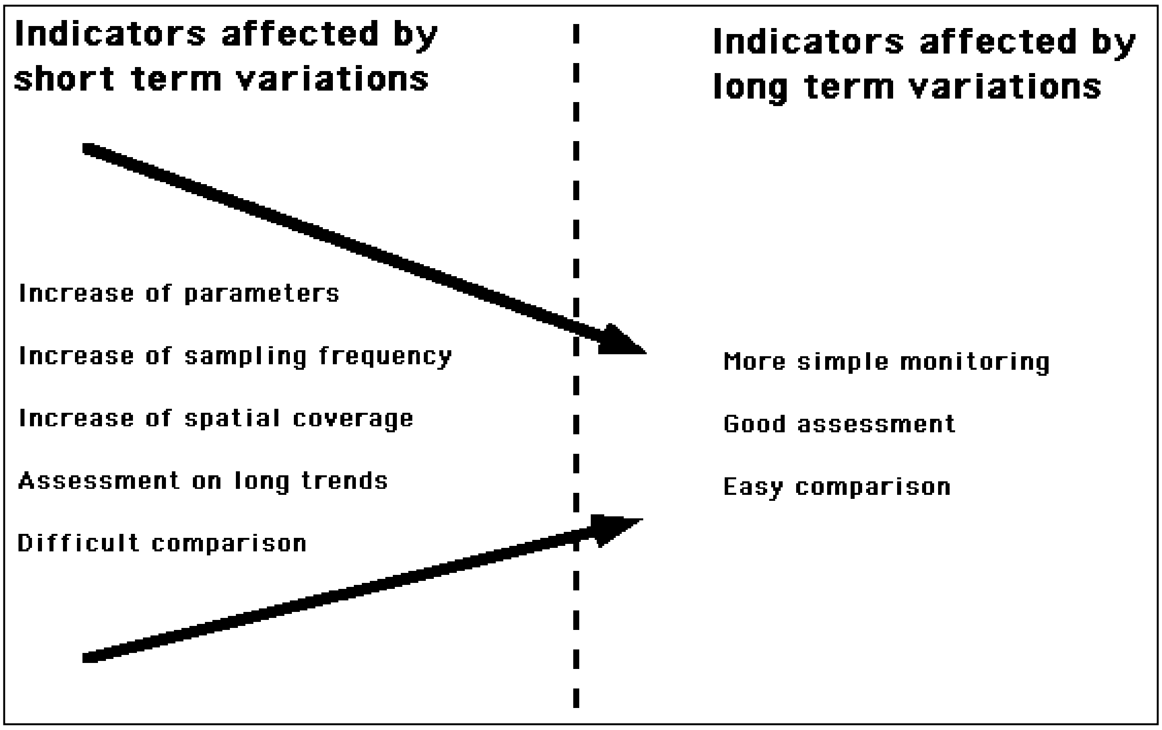

FIG. 5 Monitoring strategy and effective assessment. In this figure are summarised two different approaches that can be followed in the choice of parameters and indicators for the assessment of eutrophication: the choice of indicators supported by parameters affected by short term variations (right side of the figure) results in a more complex monitoring and a less effective assessment; the choice of indicators supported by parameters mainly affected by long term variations results in a less complex monitoring and a more effective assessment.

Unfortunately there is not yet a general agreement on which biological parameters should be used for the development of new indicators. A useful suggestion comes from a scientific paper from Gray (1992). The author proposes a general model of the long term environmental changes induced by eutrophication (Fig. 6).

Gray's approach emphasizes the long term changes induced by eutrophication on the affected ecosystem and proposes a grading of the main observed events. This model needs to be discussed and tested in the Mediterranean region to see if it is generally applicable and what changes can be introduced in the different grades. It would be advisable that a group of regional experts build such a model for the Mediterranean affected areas.

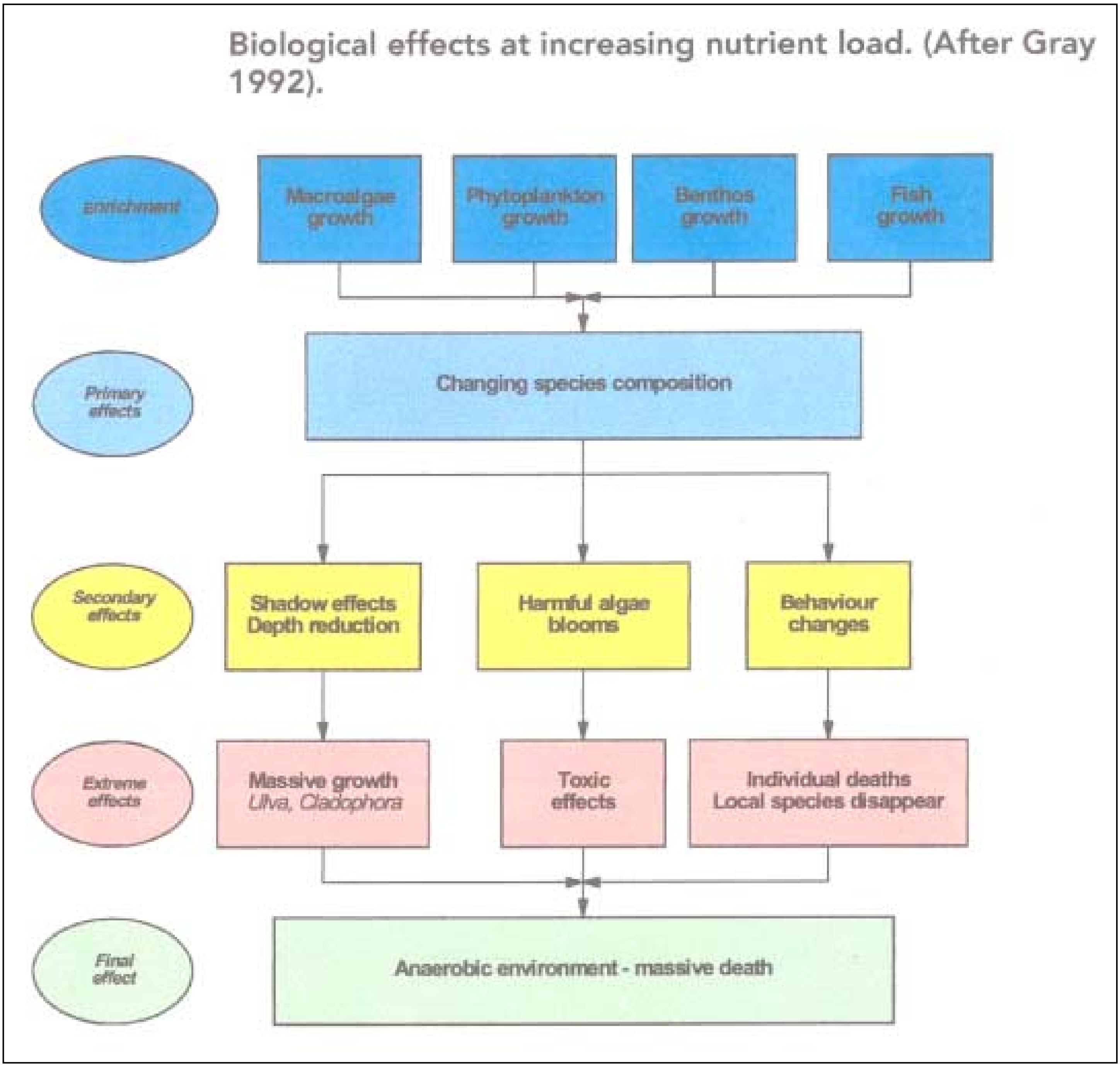
Biological effects at increasing nutrient load. (After Gray 1992).
Enrichment
Macroalgae growth
Phytoplankton growth
Benthos growth
Fish growth
Primary effects
Changing species composition
Secondary effects
Shadow effects Depth reduction
Harmful algae blooms
Behaviour changes
Extreme effects
Massive growth *Ulva, Cladophora*
Toxic effects
Individual deaths Local species disappear
Final effect
Anaerobic environment - massive death

FIG. 6

3.1 UNEP/ MED POL monitoring strategy for assessing Mediterranean eutrophication

All the above-mentioned experiences, gaps and recommendations bring to propose a general MEDPOL strategy based on three different lines:

1. In the short term adopt a group of basic parameters/indicators as showed in Table 4;
2. In the medium term start collecting historical records of events and data (algal blooms, bottom anoxia, nutrients, chlorophyll, etc.) for each affected area in the Mediterranean;
3. In the long term start developing new more effective indicators trough the coordination of a Mediterranean working group of experts.

3.1.1 Short term strategy

The short-term activities propose a minimal monitoring activity to adopt the parameters supporting the EEA state indicators and TRIX index, but also in parallel starting to develop pilot activities aimed to identify new more effective indicators. Therefore, as a first step following list of mandatory parameters (Table 4) should be adopted in a national monitoring plan for each affected area.

Table 4 Mandatory parameters to be monitored by each country

Temperature (C°)	**Dissolved oxygen (mg/l)**
pH	**Chlorophyll "a" (µg/l)**
Trasparency	**Total Nitrogen (N µg-at/L)***
Salinity (psu)	**Nitrate (NO_3-N µg-at/L)**
Ortophosphate (P –PO_4 µg-at/L)	**Ammonium (NH_4-N µg-at/L)**
Total phosphorus (P µg-at/L)	**Nitrite (NO_2-N µg-at/L)**
Silicate (SiO_2 µg-at/L)	**Phytoplankton (number and species composition)***

* not mandatory ?

A precise identification of each affected area to establish the network of monitoring sites is crucially necessary since eutrophication in the Mediterranean basin appears to be a local phenomenon limited mainly to specific coastal and adjacent offshore areas. On the other hand, there are only few evident cases, like the Adriatic Sea, involving more than one country. Considering both this fact and the MAP/MED POL monitoring objectives, the coastal zones selected for eutrophication monitoring and management should be related to the back lying catchment's areas. Therefore, the monitoring plan will be carried out on selected sites which should meet a certain criteria;

- representative at national level: being related to the back lying catchment areas, receiving loads from rivers, direct discharges of domestic and industrial wastes, loads from mariculture activities and/or diffuse sources;
- being sensitive to eutrophication phenomena (enclosed coastal bay and estuaries, shallowness, limited water recycling, etc.), in order to be able to distinguish -as much as possible- between natural fluctuations and anthropogenic pressures;
- being suitable to assess the general progress in the adoption of EU rules (nitrate directive, etc.), urban waste management, agriculture, etc.
- having the main morphological characteristics that should be well described together with drivers, pressures, meteorological and hydrodynamic parameters;

- having the historical records of ecological events and socio-economical trends in land use.

In parallel to the mandatory parameters (Table 4) that should be adopted for all affected areas, the parameters presented in Table 5 (pg 19) provides a wide list of parameters that could be utilized for the selection of monitoring parameters for different site typologies.

The next priority of the short-term activities is to start to work on a new list of parameters (mainly biological) to be tested for future adoption. The biological parameters listed in Table 5 can be considered as an initial exercise for this purpose and it will be amended with the possible disposal of all the available efforts made by national/international programmes that are already testing “new” parameters.

3.1.2 Medium term strategy

For each affected area, observations and data will be gathered in a database of historical records of events to support a better assessment of the eutrophication phenomena and the ecosystem quality. Eutrophication is a long term process, more than 100 years old in some case and more recent in others. For many sites there is a rich literature available for the last 50-100 years that has never been accurately collated in a data base and analyzed with a methodological approach. The contents of the database need to be discussed together with the adoption of new and supplementary techniques for monitoring and assessment of eutrophication. Remote sensing technique for the monitoring of chlorophyll has been a well-known tool and applicability of this method together with its calibration needs, gaps, etc. should be highlighted. On the other hand, the possible monitoring of some of the eutrophication parameters with buoys networks should also be taken into account and its possible applicability should be cross-examined. Finally, the establishment of models predicting coastal eutrophication in the Mediterranean with different possible future scenarios will be considered within the mid-term activities.

3.1.3 Long term strategy

Organize a working group of regional experts that develop, test and propose a new indicator system based mainly on sensitive biological communities and defines the content of the database of historical records to be fed from each country.

3.2 Sampling strategy

A necessary first step towards the development of the UNEP/MED POL proposed indicator database is that the countries themselves should identify the monitoring stations at the selected sites and the sampling frequencies able to detect temporal trends.

3.2.1 Sampling frequency

The optimal sampling frequency should be chosen as a right compromise between a high frequency able to cover the parameter variability that is in most of the cases site dependent and the best cost-effective strategy of the sampling programme. Each country has its own responsibility for the best choice according to the parameter variability in the affected area. The sampling frequency chosen by each country has to take account the objective to detect a change in concentration over a selected period (e.g. 10 years).

The minimum mandatory sampling frequency is seasonal. A monthly sampling frequency is strongly recommended.

3.2.2 Spatial coverage

Each country is responsible for the choice of the most representative sampling stations in order to detect changes over a selected period (e.g. 10 years). The spatial distribution of the monitoring stations should take account of inputs and the oceanographic characteristics of each area. In most cases it will be possible to decide only after sampling and after a statistical analysis of the bulk of data of the whole monitoring plan.

A minimum sampling plan can be suggested as follow:

1. Design one transect perpendicular to the coast line of the affected area
2. Chose three sampling stations for each transect according to the bottom typology
    a. High slope (more than 50 m. depth at 3000 m. from coastline).
    b. Medium slope (more than 5 m. at 200 m. and less than 50 m. at 3000 m. from coast line)
    c. Low slope (less than 5 m. at 200 m. from coastline)

        a) Distance from the coastline= 1 at 100 m., 2 at 3000 m., 3 between the first two if the distance is more than 1000 m. Otherwise only the first two.
        b) Distance from the coastline= 1 at 200 m., 2 at 1000 m., 3 at 3000 m.
        c) Distance from the coastline= 1 at 500 m., 2 at 1000 m., 3 at 3000 m.

Vertical profiles:

It is obligatory to collect more samples for each sampling station in order to have vertical profiles for all parameters. The number of vertical samples must not be less than three (surface, medium depth, bottom). It is recommended in particular to collect continuous profiles for salinity, temperature and oxygen trough the use of a CTD multiprobe apparatus.

Before the beginning of the regional monitoring programme on eutrophication a quality assurance programme should be organized by UNEP MED POL as it is going on for inorganic and organic pollutants (see UNEP(DEC)/MED WG. 196/3).

Table 5 An example of mandatory and supplementary **list of parameters to be selected for each different site typology**

Matrix/Group of parameters	Parameter description
Sea water	**Temperature (C°)**
	PH
	Transparency (Secchi disc)
	Salinity (psu)
	Ortophosphate (P –PO_4 µg-at/L)
	Total phosphorus (P µg-at/L)
	Silicate (SiO_2 µg-at/L)
	Dissolved oxygen (mg/l) and % saturation
	Total Nitrogen (N µg-at/L)
	Nitrate (N-NO_3 µg-at/L)
	Ammonium (N-NH_4 µg-at/L)
	Nitrite (N-NO_2 µg-at/L)
	Suspended particulate matter (mg l^{-1})
	TOC (mg l^{-1})
	Water colour
	H_2S (mg l^{-1})
Phytoplankton	**Chlorophyll-a (µg/l)**
	Biomass of each phytoplankton species (mg m^{-3})
	Total phytoplankton biomass (mg m^{-3})
	Density of each phytoplankton species (cells l^{-1})
	Phytoplankton species composition - % composition of key groups (number and biomass)
	Seasonal succession of key phytoplankton species (cells l^{-1})
	Annual maximum density (cells l^{-1}) of each blooming phytoplankton species
	Specific production of dominant phytoplankton species d^{-1}
	Total number and species composition)*
Zooplankton	Number of neustonic copepods (family Pontellidae) (ind m^{-3})
	Number of Polychaeta larvae in total number of meroplankton (%)
	Total biomass of zooplankton (mg m^{-3})
	Specific production of dominant zooplankton species
	Total biomass of phytoplankton/Total biomass of zooplankton (d^{-1})
	Total Pelagic Biomass/Total benthic biomass
	Number and Biomass of *Noctiluca scilntillans* in the total zooplankton (%)
	Average biomass of the jellyfish *Aurelia aurita* (g m^{-2})
	Total biomass of exotic Ctenophora species (*Mnemiopsis* and *Beroe* genera) (g m^{-2})
Benthos	
Macrophytes	Total primary production (mg Corg m-2 month-1)

Matrix/Group of parameters	Parameter description
	Total macrophyte biomass (mg m^{-2})
	Biomass of dominant macrophyte species (g m^{-2})
	Key groups: Chlorophyta, Rhodophyta, Phaeophyta (%biomass)
	Key genera (presence/absence)
	Specific production of the dominant species of macrophytobenthos (d^{-1})
Other parameters?	

4. REFERENCES

Aubert, M. & Aubert J. 1986. Eutrophie et dystrophye en milieu marin. Phénomènes planctoniques et bactériens. *Rev. Int. Oceanogr. Med.*, 83-84: 3-302

Carbiener, R. 1992. Compositions lessivielles avec eau sans phosphates et protection des milieux aquatiques. Rapport au secrétaire d'état auprès du premier minister, chargé de l'environment. 182 pages.

EEA 1999. Yearly Indicator Report: Eutrophication.

EEA 1999a. Nutrients in European ecosystems. *Environmental Assessment Report* No. 4, 155 pp.

EEA 1999b. Environment in the European Union at the turn of the century. E*nvironmental Assessment Report* No. 2, 446 pp.

EEA 2001. Testing of Indicators for the Marine and Coastal Environment in Europe. Technical report/ in preparation.

EEA, in prep. Development of European estuaries/lagoons and fjords inventory and data base. Collection of data on European coastal Zone. Further development and testing of a system of indicators.

EEA/UNEP 1999. State and pressures of the marine and coastal Mediterranean environment. EEA Environmental assessment series N°5 Environmental indicators: Typology and overview EEA Technical report No 25, http://reports.eea.eu.int/TEC25/en). EPA, 1994. A conceptual framework to support the development and use of environmental information. EPA 230-R-94-012

Gray J.S. 1992. *Eutrophication in the sea*. pp 3-15. In: 'Marine eutrophication and population dynamics'. Colombo, G., Ferrari, I., Ceccherelli, V.U., Rossi, R., Eds. Olsen and Olsen publishers, Fredensborg. Denmark

Mariotti, A., Struglia, M.V., Zeng, N. Lau, K.-M. The hydrological cycle in the Mediterranean region and implications for water budget of the Mediterranean Sea. Accepted subject to revision, Journal of Climate, 2001.

Nixon, S.W. 1995. Coastal marine eutrophication: A definition, social causes, and future concerns4 *Ophelia* 41: 199-219.

OECD, 1993. OECD core set of indicators for environmental performance reviews. OECD/GD (93) 179

OSPAR, 1997. JAMP Eutrophication Monitoring Guidelines. OSPAR Technical Report. Ref. No: 1997- 1 to 6

Swart, R., J. Bakkes, L. Niessen, J. Rotmans, B. De Vries, R. Weterings, 1995. Scanning the global environment, a framework for UNEP's reporting functions, UNEP/EAP. TR/95-01

Turley, C.M. 1999.The changing Mediterranean Sea – a sensitive ecosystem? *Progress in Oceanography* 44 (1999) 387-400

UNEP/FAO/WHO 1996. Assessment of the state of eutrophication in the Mediterranean Sea. *MAP Technical Reports Series* No. 106. UNEP, Athens, 211 pp.

UNEP/WHO 1999. Identification of priority pollution hot spots and sensitive areas in the Mediterranean. *MAP Technical Reports Series* No. 124. UNEP, Athens, 90 pp.

Vollenweider, R.A. 1968. *Scientific fundamentals of eutrophication of lakes and flowing waters, with particular reference to nitrogen and phosphorus as factors in eutrophication.* Tech.Rep.DAS/CSI/68.27., Ed. O.E.C.D., Paris

Vollenweider, R.A. 1981. *Eutrophication – a global problem.* WHO Water Quality Bullettin, 6

Vollenweider, R.A., Giovanardi, F., Montanari, G & Rinaldi, A., 1998 - Characterization of the trophic conditions of marine coastal waters with special reference to the NW Adriatic sea: proposal for a trophic scale, turbidity and generalized water quality index. *Environmetrics*, **9**: 329-357

Wieringa, K., 1996. Towards integrated environmental assessment supporting the community's environmental action programme process. ESEE Inaugural International Conference "Ecology, Society, Economy", May 1996