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POLLUTION OF THE MEDITERRANEAN SEA

Pollution Research and Environmental Monitoring : Analyses, recommendations and assessment of the scientific and technological options.

Expert Report

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Directorate General for Research

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The Mediterranean is not simply a geographical entity. Its frontiers are neither in space nor in time. We cannot see how, nor on which basis, to define them, They are neither historical, nor ethnic, nor national, nor of any State: a circle drawn in chalk unceasingly traced and erased, which wind and wave, labour and inspiration, enlarge or curtail. It is here, along this coast, that passed the silk and the amber routes ; here, the salt and spice, oil and perfume paths, the channels for tools and weapons, for the arts and for knowledge, for prophecy and faith, intersected. Europe was born in the Mediterranean.

(Predrag Matvejevitch, *Bréviaire méditerranéen*)

PREAMBLE

This report has been prepared at the request of the Office of Scientific and Technological Options Assessment (STOA) of the European Parliament, by a group of independent experts, originating from various geographic horizons and distinct professional areas. The collective experience of the authors covers a broad spectrum, ranging from pure physical oceanography and modelling, to the management of international research and training networks; from the latest developments in satellite technology, to marine geochemistry; from the conservation of marine biodiversity, to pollution control technologies ...

These areas were not chosen at random, but in response to the wide diversity of questions raised by STOA. This report is not exhaustive, of course, but it attempts to provide european policy-makers with a clear synthesis on the broad issue of coastal / marine pollution and rehabilitation in the Mediterranean. As emphasized repeatedly in the text, the balanced, healthy, development of the region is seen as most critical to the future well-being and security of Europe.

A deliberate effort has been made to provide the reader with action-oriented recommendations and a choice of concrete options. This synthesis is backed up by a 200-page technical Annex, providing detailed information and an enlarged bibliography on the various points covered here.

The opinions expressed in this Report are those of the authors, and do not necessarily reflect those of their respective institutions. Particular thanks are expressed to Prof. Victor Axiak, Prof. Marko Branica, Dr Aldo Fanchiotti, Dr Scott Fowler, Dr H. Kaberi, Dr Pere Oliver and Dr C. Zeri for their constructive inputs on parts of the manuscript. The assistance of Mrs McLaughlin was critical at various stages of the production of this Report and is gratefully acknowledged.

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CONTENTS

I - GUIDING PRINCIPLES

The analysis presented in this Report applies to a very particular geographic context. *Mare nostrum* for the ancients, "mer Intérieure" dear to Fernand Braudel, the Mediterranean cannot be reduced, even for scientific purposes, simply to the status of a maritime area today threatened by pollution. The Mediterranean is also, and has been for millennia, a sea of exchange, a sea of commerce between coasts rich with diverse civilizations and traditions. The object of this study must therefore be approached not only as a particularly fragile part of the world to which bordering countries (and, more particularly, Europe - we will come back to this) should give priority attention, but also as a truely extraordinary area, a multi-cultural mosaic with immense resources of human adaptability and inventiveness, a space where distinct destinies, perceptions and the imaginary have been meeting, confronting each other and coming together since the beginning of time.

The Mediterranean is also a quite unique environment which was set in place as the outcome of geological conditions created a few million years ago only by the slow advance northwards of the continent of Africa. This area falls into a geomorphological context marked by the various parts of mountain ranges delimiting a whole series of rapidly evolving regions. These regions are closely intertwined and participate in the general dynamics of the Mediterranean system, although each of them retains a strong specificity.

In order to be effective, the strategies and proposals developed for the Mediterranean should never be too far away from this complex reality. One must avoid comparisons with regional systems - in apparence similar but in fact extremely different - as well as hasty and straightforward generalizations which nowadays clutter the all-encompassing discussions on "sustainable development". The Mediterranean has always been held its ground against foreign models. This is no coincidence. The more the solutions put forward will be weaved from its singular geo-cultural fabric, the more realistic they shall seem to us.

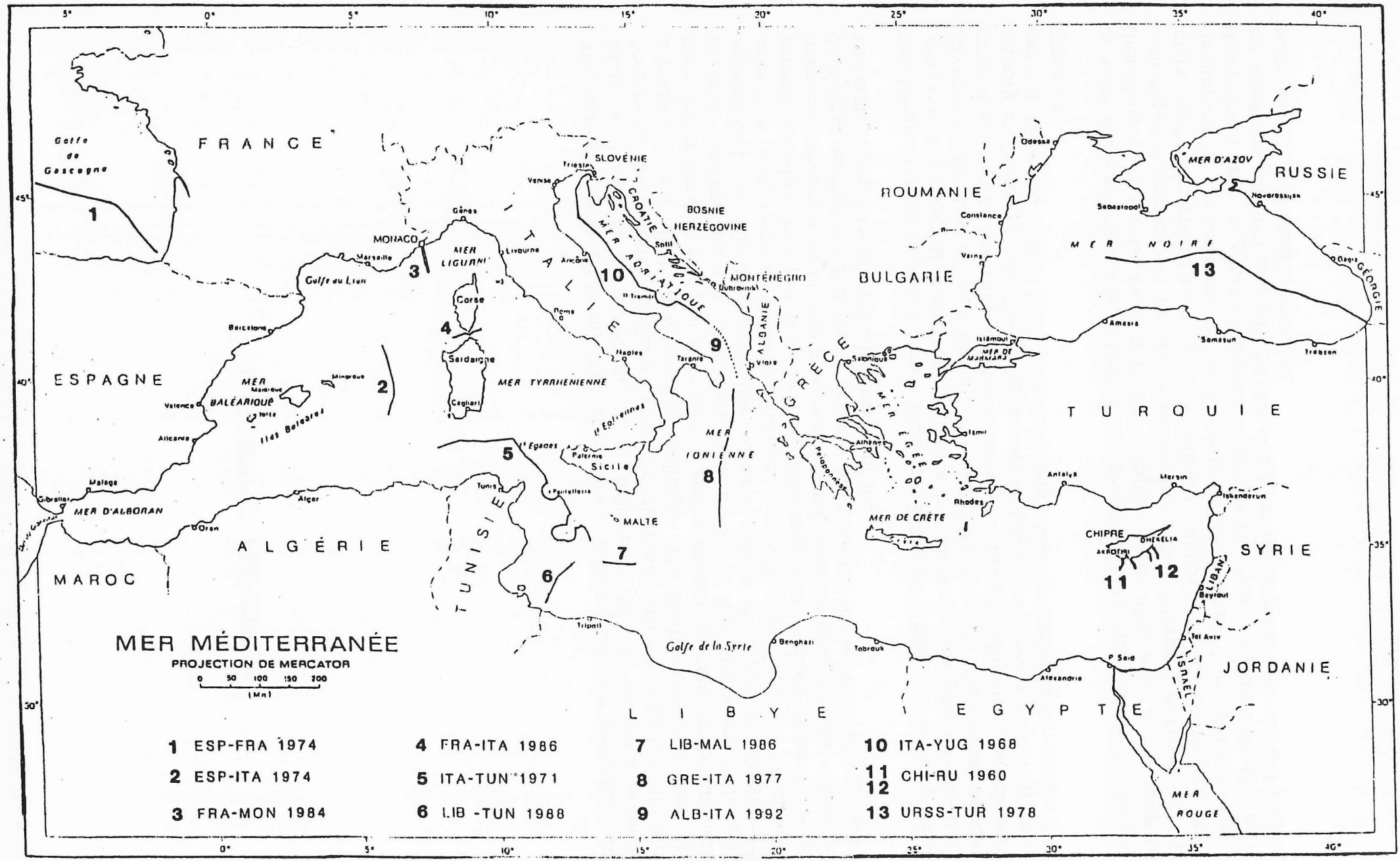


Fig. 1. - Mer Méditerranée

Traités de délimitation du plateau continental et / ou de la mer territoriale existants au 31 mars 1993.

It is therefore with this "Mediterraneity" in mind that we have tackled this study, basing our work, from the start, on few essential observations or postulates:

- the failure of sectorialism:
Only a multilateral and interdisciplinary approach seems to have any chance of sustainable success in the region. The Mediterranean, a small area of the globe shared by about twenty bordering countries, is today the victim of a fragmented, divided mode of decision-making. This microcosm illustrates most of the planet's problems (population explosion, desertification, coastal erosion, over-fishing, massive accumunation of contaminants, ...), and it would be futile to suggest non-integrated working methods which would treat problems one at a time, independently.

- the limitations of bilateralism - towards a reformed Mediterranean policy:
Following this same way of thinking, the conventional channels of bilateral cooperation for development between northern and southern Mediterranean nations - a custom often inherited from recent colonial history - seem ill-suited to provide the new insights required for managing the Mediterranean ecosystem as a whole. Yet bilateralism still generally dominates the approach to development in the whole region. So, today, the relationship between the European Community and the Mediterranean area largely revolves around separate, bilateral cooperation agreements between the EEC and seven countries on the southern shore.

The European Community must therefore pursue its efforts to open up towards the Mediterranean as a whole, and decisively follow the path it marked out for itself in its recent document entitled *Towards a reformed Mediterranean policy. Proposals for the period 1992-1996*, particularly by creating more opportunities for dialogue with all of its partners in the Mediterranean Basin, namely, dialogues on economic, social, scientific, cultural and political issues of common interest. As the document states, "thess dialogues shoud be on a political level as well as a technical one, held, as appropriate, with individual Mediterranean countries, with groups of countries, or even with the Mediterranean non-member States as a whole."

The significance of such a prospect brings us right to the heart of the problem: whether we are talking about bilateralism or multilateralism, the EC must "reform the style and content of Cooperation Councils, so as to transform them into bodies of genuine political and economic exchanges."

- the need for an ecosystemic approach, aiming for sustainable development:
For some years, the Twelve have been speaking out clearly in the international arena in favour of an integrated approach to sustainable development, playing a major role at the United Nations Conference on Environment and Development in Rio de Janeiro (1992). There is, therefore, nothing to prevent applying to the Mediterranean what is preached to the rest of the world, starting with the excellent principles of "Agenda 21", dedicated to the sustainable management of the oceans and coastal zones, principles with particular emphasis on the need to combine development, research, training and conservation in a concerted approach, integrating the whole ecosystem.

In the Mediterranean, a landlocked sea with multiple and complex interactions

between the various components of the ecosystem, pragmatism and experience obviously dictate an integrated approach. Thus the grave pollution affecting the Mediterranean has its origin not out at sea, but on the continents, sometimes carried over long distances by rivers and winds. Research and monitoring must therefore enlarge their scope to cover the watershed basins, the coastline, the continental plateau, and the sea/atmosphere interface, as a whole.

Unless we can reconcile the legitimate demands of economic development and environmental protection, the degradation of the Mediterranean coastline shall drastically increase over the next fifty years under the irresistible pressures of demography and tourism. Any reductive attempt which takes no account of the dynamic interaction between economic poles, migratory fluxes and exploitation of the ecosystem, will be doomed to failure.

- promoting solutions by and for the Mediterraneans with EEC support:
For reasons mentioned above, relating to the rich cultural identity of the region, approaches to sustainable management of the Mediterranean ecosystem must develop with strong regional colour, and be based on solid concertation between countries on both shores. For reasons of solidarity, good intelligence and, therefore, to mutual advantage, with neighbouring countries on its southern side, and also because of its disproportionate responsibilities in the degradation of the Mediterranean (directly *via* its four bordering countries, and indirectly through its tourists and telluric influences from other member States), the EEC should - with the support of other international institutions concerned - take up a long-awaited and decisive role as "leader" in this arena, mobilizing its technological power, its training skills and its financial resources in the service of this stricken area.

- the need to reestablish balance in European geopolitics:
Unfortunately, the Twelve remain largely divided on the importance to be given to Mediterranean policy. The southern States - namely, France, Greece, Italy and Spain - often find it difficult to raise an awareness of mediterranean issues in their northern partners. As a result, the guidelines of the "reformed Mediterranean policy" remain on the level of statements of principle or dispersed intervention here and there, and this is precisely when policies in developing countries express renewed interest in the European Community.

Yet dialogue and cooperation between the two shores have never been as necessary, even crucial, to security in Europe and to stability in the South. Over the last fifty years indeed, the Mediterranean world - which lived in relative stability since the fall of the ottoman Empire - has entered a new phase of fractures, upheavals and convulsions. the analysis of which lies of course beyond the scope of this Report, without being totally foreign to it. Today, the danger of the region breaking up through centrifugal exclusion forces is very real, and North and South should waste no time in initiating common reflexions.

So the European Community must encourage the efforts of those of its members who, well aware of the converging interests between the Northern and Southern Mediterranean, seek to offer countries on "the other shore" new prospects for shared development.

The Twelve can no longer sit back and consider the Mediterranean area simply as a field for research or for implementing their top-notch technologies. To begin with, they should no longer make choices without prior consultation with the non-member States concerned. They should apply themselves to backing all technical/scientific actions with a new communication policy, with a commitment to train teachers, and support the efforts of certain non-member States in the dissemination of scientific knowledge.

Obviously, these new proposals and prospects must rely on a common, concerted, thorough understanding of the problems posed by environment and development in the Mediterranean. In this area, which is less charged with political ideology than others and leaves therefore less room for any suspicions of "interference", Europe is awaited, Europe heralds hope. It will have to implement projects urgently at a regional level, so as to open up perspectives for local development while enhancing the protection of the environment. It is this last aspect - control and monitoring of Mediterranean pollution - with which our Report deals specifically, in the hope that its recommendations will further the cause of a major European initiative in the Mediterranean.

II - THE MEDITERRANEAN MARINE ENVIRONMENT - ISSUES AND PERSPECTIVES

2.1 Water circulation : transport and diffusion of pollutants

The Mediterranean is a concentration basin - fresh water supply being lower than loss incured through evaporation - the main dynamic characteristics of which are dictated by climate. Thus, one finds:

- superposed and opposing fluxes across the straits of Gibraltar and Sicily (surface flux from West to East, deep flux from East to West);
- in the large basins, superficial cyclonic circulation (anti-clockwise for an observer facing North);
- in winter, in the northern regions (Gulf of Lions, Ligurian Sea, the Adriatic, the Aegean and the Levantine basin), a transformation of surface waters into dense waters which leave the surface and supply the deep flux.

The deep waters which leave the Basin are composed of water originating from the Atlantic and slowly transformed into the Mediterranean by evaporation and by the incorporation, in a dissolved form, of various elements of natural origin and/or anthropic elements, supplied by atmospheric circulation, by run-off, human waste and the activity of the ecosystem. The transportation of some "passive" elements is directly linked to water circulation, whilst for other "biological" elements the passage through the ecosystem implies a capital role of transformation.

Horizontal and vertical circulation resulting from concentration basin dynamics is often vigorous. It can be modified locally by specific climatic conditions (wind, fresh water drift ...) and by the relief of the sea bed near the coasts.

In coastal waters, local circulation, which conditions the transport and spread of land-source pollutants, is dependent on large-scale surface water circulation as well as on local phenomena.

General circulation is characterized by speeds of several tens of km/day and by a vertical span of several hundred meters. In simple terms, we can consider that in the southern regions general circulation is to a large extent dependent on the presence of whirlpools 50 to 200 km in diameter and with a lifespan of several months, if not a year and more; in the North, this circulation is more stable and runs along the continental slope, around the less stratified areas of the open sea. The transport of pollutants from coastal zones to the centre of the basins is thus relatively restricted in the North and easy in the South.

As for the direction of the general current, it is always the same in the North, while in the South it can be reversed for months due to the temporary presence of whirlpools. In the northern regions, water circulation is sometimes disrupted by instabilities which take the form of meanders and therefore does not always have the same incidence on isobaths. Furthermore, through friction with the relief, it generates small-scale turbulence (a few km, for a few days) which concern a coastal strip several km wide. Circulation in the coastal area is therefore relatively variable.

Wind is the main phenomenon conditioning coastal water circulation. It engenders vertical movement, which can bring back to the coast products dumped several hundred meters deep, and horizontal movement, which may return dissolved products to the initial disposal area. Strong winds encourage the dilution of pollutants, stirring up the surface water and coastal sediment by means of waves and the swell. But gentle winds, which prevail in the summer, tend to push the surface water and floating products towards the coast.

Coastal areas thus appear more favourable to the dilution of pollutants than to their transportation over long distances. More so than in other fields, understanding the patterns of water circulation must rely on the joint utilization of observations and models (general and coastal).

2.2. The Mediterranean, indicator of environmental and climatic change

Oceanographic surveys carried out in the western basin of the Mediterranean during the period 1959-1989 reveal a warming trend in the deep water layer (0.12°C) and a rise in salinity (0.03 salinity units) (see details in the Annex). These variations are brought about by much greater modifications (factor of 5) in the surface layer, still masked by the strong seasonal and year-to-year variability of this surface layer, and likely to modify the ecosystem in the course of a few decades. For many experts, these developments are linked to anthropic activity, either by a direct impact of drinking water consumption on the influx from rivers to the sea, or by the indirect effect of pollution on climate through greenhouse-effect gases.

Deep water phosphate concentrations have also increased since the 60s, which coincides with a rise in telluric inputs linked to industrial, agricultural and urban activities. The calculation of an increase of 3% per year is consistent with the Blue Plan data (for the period 1960-1983) which shows annual increases of 1.6% per year in the coastal population of the Mediterranean, of 4.7% in gross national product and 6% in energy consumption. The impact of telluric phosphate inputs (the anthropic fraction of which is still to be properly determined) on the sea's fertility is apparent in satellite images of the colour of the sea at the outlet of the Black Sea, the Po, Rhone and Ebro

rivers. It is also a local disaster, stimulating red tides, and it has a more diffuse impact on the biological productivity of the Mediterranean, which must, in all probability, increase. If the inputs of salt nutrients continue at the same rate of yearly growth over the next 30 to 50 years, productivity could be quadrupled, inducing oxygen deficiencies which could considerably disrupt the deep sea ecosystem.

On the basis of marine concentration measurements, it is also possible to note a yearly growth in the anthropic input of metals to the Mediterranean: 6%/ yr for zinc and lead, 2% for cadmium and copper between 1960 and 1983. Conversely, the European directives of the 80s and 90s, reducing lead additives in petrol, have resulted in a drop of the lead content measured in the aerosols and rain over Monaco and Cap Ferrat between 1987 and 1990, and in lead dissolved in the surface layer of the Ligurian Sea between 1988 and 1992 (see details in Annex). Abnormal concentrations of various elements of anthropic origin found on the surface of the sediments are further evidence of environmental change.

In the western part of the Mediterranean basin the last decades have witnessed therefore marked changes in the physico-chemical characteristics of water. This is qualitative evidence of a change in climate and environment in the Mediterranean. Quantitative analysis of marine signals to determine the change in external forces (climate and environment), requires modelling marine dynamics and biological activity (the latter affecting the vertical transfer of chemical elements). From a climatic point of view, the Mediterranean would be a excellent test zone to study ocean-atmosphere interactions.

From an environmental point of view, the geochemical evolution of water is consistent both with the socio-economic data coming out of the recent Blue Plan surveys (i.e. the negative impact on the coasts of increased population pressure, standard of living, consumption of energy and number of cars) and with the positive consequences of the European regulations on lead emission.

On long time and space scales, the Mediterranean therefore constitutes an ideal observatory, requiring only a limited number of quality marine measurements. It leads however to redefining the framework and the end goal of atmospheric and land studies, generally carried out on a small time and space scales, so as to adapt them to global approaches.

On smaller time and space scales, especially in coastal areas, the spatio-temporal variability of waste and dilution calls for numerous surveys. Notwithstanding the immediate health and toxicity issues tackled by the MEDPOL programme, environmental change of diffuse origin, for example, atmospheric pollution or climatic change, will only be discerned in long time series, through the analysis of multiple parameters, paying particular attention to various chemical and biological indicators of change in the ecosystem (in particular, biodiversity, eutrophication, appearance of new species).

2.3. Pollution

Mediterranean geochemistry depends on its exchanges with the Atlantic, the atmosphere, the continents and sediments, as well as on biological activity. It has

always been subject to natural inputs linked to soil erosion, water run-off, volcanism and atmospheric transport (the red clay rains from the Sahara, for example).

Since the 60s, inputs caused by anthropic activities have largely supplanted natural inputs: this is the case with trace metals such as lead, cadmium, copper or zinc. Moreover, elements entirely linked with human activity can be traced throughout the water column, down to the surface of the deepest sediments: pesticides, antifouling agents, freon, artificial radionuclides and all sorts of waste. It is this growing difference between artificial and natural inputs which generates pollution in the Mediterranean. Various assessments of the state of pollution in the Mediterranean Sea have been carried out until now, largely based on data collected from monitoring programmes within the framework of UNEP/MAP (see for example UNEP 1990, 1989). The vast majority of these programmes have concentrated their work on the analyses of a relatively short list of chemical substances in few abiotic compartments (seawater, coastal and some offshore sea-bottom sediments; to a lesser extent suspended particles; very few samples of marine aerosols; and rarely sea-surface films and interstitial waters) and in few biological species (mainly mussels and red mullet; to a lesser extent plankton, other benthic species and fish).

Investigations on the fate and transformations of substances in the Mediterranean are still too few, but they are developing rapidly and will certainly improve the data base used in future assessments. Because pollutants are produced, used, taken up by biota and affected by the prevailing physico-chemical phenomena and bio-geo-chemical mechanisms in different ways, the reader should be fully aware that generalisations about pollution can be misleading and is therefore refered to the Annex of this Report for a detailed technical review.

Our present assessment indicates that the Mediterranean still receives high pollution loads despite already invested efforts and funds. In parts of the Basin the state of the environment is clearly worsening, whereas in other parts the situation has been stabilised, with improvements at the horizon.

One important new element emerging from our assessment is the massive contribution to Mediterranean pollution of long distance atmospheric transport (winds, and rain), besides the loads already contributed by sewage outlets, rivers and agricultural runoff.

For a number of substances such as certain trace metals (lead, cadmium, copper, zinc), organohalogen compounds and radioactive substances, the atmospheric inputs are the prevailing ones, sometimes exceeding almost by an order of magnitude the ones contributed by liquid discharges.

The latter however, result in the accumulation of pollutants around "hot spots" (ports, enclosed bays and estuaries...) where appears a high concentration of industries. We emphasize that most pollution inputs - and particularly those associated with liquid discharges - have the tendency to be trapped in a narrow nearshore zone, mainly on the continental shelf. In several cases, however, we have evidence that, under favourable hydro-meteorological conditions, fine sediments and nepheloids may be trapped and accumulate in underwater canyons, generating turbidity currents which will carry them to the open sea.

Another important element brought forward in this Report is the strong evidence, from chemical analyses combined with mineral magnetic measurements in particulates and sediments, that deep Mediterranean sediments (of more than 1000 m depth) are affected by anthropogenic particles brought there also through the atmosphere and scavenged, at least partly, with Saharan dust inputs. These mechanisms require further study and understanding, as well as the significant inputs of several metals (zinc, copper, etc..) originating from the Atlantic Ocean and the Black Sea as well as from underwater volcano activity.

The Mediterranean, with less than 1/100 of the surface of the world ocean, receives the pressure from at least 20%-25% of the world transport of oil carried by ships (recent,accurate data are not available). This fact, combined with a lack of proper port reception facilities, poorly monitored and controlled offshore drilling activities and shore operations, and with the existence of many crude-oil refineries and store-tanks for oil around the Mediterranean, has resulted in extremely high petroleum hydrocarbon concentrations (one order of magnitude higher than in the Atlantic), particularly near shipping lanes and crude-oil refineries. Oil alters altogether the composition and function of the surface microlayer and often directly affects the equilibrium of coastal ecosystems, the touristic industry, as well as the life of birds, marine mammals and certain benthic species.

Another important pollution for the Mediterranean is the persistent marine litter - mostly plastic - which reaches the sea as drainage from land or left by beach users or discarded from ships. Esthetically unacceptable and thus costly in terms of its impact on tourism, it is also known to endanger the life of many species, such as marine turtles and dolphins. It should be noted that a large amount of marine litter finally sinks down to the bottom of the sea; there, protected from U.V. degradation, plastics will remain for a long time.

2.4. Living resources

Linked to the external conditions of the Atlantic, the Mediterranean environment and the climate, the biological compartment of the ecosystem is not rigid : rapid transformations have recently appeared, mostly attributable to anthropic activity. For example, in the Eastern Basin, the drastic reduction in the inflow from the Nile (after the closure of the Aswan dam) induced the decline in sardine fishing. Secondly, the change in the Nile's debit and the deepening and broadening of the Suez Canal have facilited the invasion of about 350 species from the Red Sea (lessepsian migrants), significantly altering catches and causing a spectacular increase in jellyfish, such as Rhopilema nomadica which has plagued the waters off the Levantine coasts for nearly ten years.

In the north of the Western basin, the appearance of barracudas or young groupers, until now confined to the south may be a sign of anthropic and/or climatic change. The proliferation of the tropical green alga Caulerpa taxifolia (aquariology) or the arrival of many foreign algal species along with the spat of Japanese oysters (oyster beds) are a fine illustration of how the accidental introduction of new species may modify the ecosystem. A knowledge of biodiversity clearly constitute an essential basis

for proper ecosystem monitoring.A knowledge of biodiversity is the cornerstone of ecosystem monitoring.

biodiversity

Biodiversity is difficult to assess, whether in marine or terrestrial systems : indeed, it is clear that the great majority of species have yet to be catalogued and properly described. In total, almost 10,000 species (fauna and flora) have been counted in the Mediterranean, which makes it (in comparison with its area) one of the riches seas in the world. Approximately 20% of these species exist only in the Mediterranean; they are known as "endemic" species.

Human activities likely to undermine biodiversity are (i) coastal development (with irreversible covering of the shallows: ports, artificial beaches, embankments), (ii) overfishing (both commercial, in particular trawling, and maybe amateur), (iii) pollution (nutrients, organic matter, heavy metals, turbidity) et (iv) dumping (solid waste). Such activities mainly concern the continental shelf and, more particularly, the sublittoral stratum (0 to 30-40 m deep), which is the main reservoir of biodiversity.

For the moment, no species seems to have disappeared completely from the Mediterranean. Nevertheless, several species have already disappeared from relatively large areas and are likely to disappear competely in the near future. This is the case for the monk seal Monachus monachus, a species symbolic of the Mediterranean. Once to be found throughout the Mediterranean, it now survives only in Greece, Turkey, Algeria, Morocco (including the Spanish Chafarinas islands) and perhaps Libya and Albania, and is certainly one of the most endangered species in the world. The causes of the monk seal's decline are a case in point. They include: (1) shrinkage of its natural habitat (beaches, caves) in the face of development and tourism, (ii) over-exploitation of the fish stocks reserves on which it feeds, and (iii) its accidental elimination by fishermen.

If the monk seal were to disappear - and its rate of population decline leads us to predict this outcome during the first decade of the 21st century - the consequences of such a disappearance would go much beyond the particular case of the monk seal; it would prove that, at the dawn of the 3rd millenium, Europe is incapable of preventing the extinction of a spectacular species, on its own doorstep, despite public awareness, and the material and financial financial resources at its disposal; in such circumstances, it is difficult to see what credibility the conservationist movement could retain in regions of the world faced with many other (economic and social) problems quite apart from the extinction of animal species.

Biotopes, such as the Poseidonia beds and the corallines are also threatened. Both environment types represent main poles of biodiversity in the Mediterranean, so that their regression is likely to affect the numerous species which they support. Particularly threatened are facies and landscapes, because they are fragile and impossible to restore, since they are the outcome of centuries or millennia of slow evolution: for example the barrier reefs of Posidonia oceanica or the "trottoir" of calcareous algae.

Harmful algal events

The phytoplankton consists of a variety of microscopic algae which live in suspension in the water and provide the food basis for the living resources of the fresh-water and marine ecosystems. Spring and autumn proliferations of phytoplankton are typical of the seasonal cycle in the Mediterranean. Apart of the seasonal maxima, algal blooms (often called red tides) may occur when adequate nutrient supply coincides with high stability of the water column, so that phytoplankton grows and/or accumulates faster than it is dispersed by flushing. In some cases, phytoplankton blooms have adverse effects for the marine fauna and for human health. In addition, some algal species may cause harmful effects at low population densities.

Although the Mediterranean is, globally considered, an oligotrophic (nutrient poor) sea, there are relatively rich offshore areas such as the Almeria-Oran front and the Liguro-Provençal-Catalan zone. In the coastal region, estuaries, lagoons and other semi-enclosed areas present naturally high productivity. Typical examples of these environments are the bays of the Ebre delta and the Albufera of Valencia, in Spain, the coastal lagoons of southeastern France, the lagoon of Tunis, Kastela Bay in Croatia, and Izmir Bay in Turkey. Many of these zones show signs of eutrophication, due to anthropogenically enhanced nutrient discharges from rivers and sewage outlets, and are often occupied by dense phyoplankton blooms. A special mention must be made of the Adriatic Sea. Its shallow northern part, which receives a large nutrient load from the Po river, is repeatedly affected by intense algal blooms and, on occasions massive quantities of mucilage are produced ("mare sporco").

Basically, two types of harmful effects can be distinguished :

(1) Events caused by toxic species, which may be present or not at high abundances. Human intoxications are due to ingestion of natural or cultured shellfish that has been feeding on toxic algae. The toxicity episodes reported in Mediterranean waters include PSP (paralytic shellfish poisoning), DSP (diarrhetic shellfish poisoning) and fish and marine fauna mortalities.

(2) Harmful effects associated to the presence of high biomass of non-toxic species. Anoxia is due to oxygen consumption by decaying organic matter and may lead to mortality of benthic organisms and fish. Other effects are mechanical, such as the irritation of fish gills. The intense production of mucus which may occur under certain conditions (Phaeocystis blooms and mucilage episodes of "mare sporco", for example) may produce clogging of fishing nets and aesthetic impacts affecting tourism.

At present, there is evidence that increased occurrence and intensity of blooms of non-toxic algae may be associated to nutrient enrichment. However, there is no convincing evidence linking blooms of toxic algal species and "mare sporco" episodes with anthropogenic nutrient enrichment. Reports of toxic outbreaks may have increased due to the spread of aquaculture and increased environmental awareness which have lead to the establishment of regular phytoplankton monitoring programs.

Fishing activities

Fishing modifies the environment, frequently against its own benefit, not only reduces the abundance of target population, but also, as secondary effect, that of other

biota directly affecting the relative composition of species, both commercial and non commercial, in the exploited community. Fishing gears have different selection rates for different species and lengths. In consequence the ecosystem is simplified by reduction of energetic pathways and the decrease of number of species. An excessive fishing effort, or an inapropriate exploitation pattern, can produce dramatic effects on the whole ecosystem. Several fishing activities can also degrade the seabed. Benthos can be severely damaged, or even destroyed, by the inappropriate use of dredges, trawls, and other bottom towed gears. Seagrass beds (e.g. Posidonia beds) and rocky bottoms are particularly vulnerable.

The total marine catches reported in Mediterranean and Black seas reached almost 1.5 million tons. This figure represents a 1.79% of the World catches (near 83 million tons). On recalls that the surface of our sea represents only 0.8% of the world marine surface. In Mediterranean the shelfs, where most of fishing activities is done, are very narrow. Only the Adriatic, the gulf of Gabès (Tunisia), and some other similar areas present extense fishing grounds and are very much productive. The catch trends followed by the countries of EEC are more or less stable while in the other countries, including those of the southern part of the Mediterranean, continuous increasing trends are patent. Italy is the country presenting higher catches with a local 1985 maximum.

Many commercial species (more than 100) are demersal (living near the bottom). The main gears exploiting these species are bottom trawls, gillnets, trammel nets, traps, and bottom longlines. The demersal fisheries are generally multispecific and representing near 55% of the total catches.

The fish living in midwater or near the surface, known as pelagics, are gregarious, and form schools. Among the small ones anchovy and pilchard are the most important. Despite the fact that the number of small pelagic species is much lower than the demersals, their catches represent around 40% of total catches. The large pelagics are migrants and gregarious. Swordfish, several species of tunas, and pelagic sharks are the species included in this group. One of the gears employed for these species are the large driftnets, despite they are banned ; their continuing use poses a major problem in the Mediterranean. Large pelagic catches represent 4% of the total.

There are many management measures. Most of the regulations are adressed to bottom trawl since this gear is the most significant regarding demersal catches. For all measures, the control and surveillance problem has to be taken into account. In the Mediterranean, there are lots of excellent, non enforced measures. The main possible measures are : regulation of gears, effort and catches, seasonal closures, permanent protected zones, and trawl mesh size regulation.

Regarding the Mediterranean resource, in particular the demersal one, it can be asserted that the exploitation pattern (fishing mortalities by age or length) is unapropriate. The recovering of a fishing resource can carry some trouble. The resource has more inertia to react to changes than the fishermen economy does, which means that any management measure adressed to recover an overexploited resource will yield tangible results in a medium term (a few years), while the time scale of fishermen is always shorter. The crisis will be short but deep if the measures were severe.

Studies on fisheries economics are scarce in the Mediterranean. The main identified problems are the existence of artificial mechanisms allowing to have benefits of overfishing. The carburant tax exemptions for fishing vessels, a common practice in many countries, acts as a stimulus for fishermen to increase effort and has negative consequences on the preservation of the resource.

III - PRIORITIES FOR ACTION AND RESEARCH

One should consider the priorities presented here as complementary. By no means limitative, they will be be most effective if accompanied by a series of further actions in the areas of training, information and legislation. They are not classified as a fonction of their relative importance, but simply as a logical follow-up of the concerns expressed in the preceding chapter.

3.1. A priority area: the coastal zone

In the Mediterranean - even more so than in other regional seas - coastal areas warrant specific attention, not just because of the fragility of this environment, but also because of the characteristically rapid morphological evolution patterns.

These areas, where constant and considerable exchanges take place between the continent and the marine environment, are submitted to disruptions linked with the terrigenous processes and react diversely according to the degree of marine activity. Multiple complex factors come into play in the coastal zone, where population density is particularly high.

Chapter 17 of Agenda 21, as adopted by the United Nations Conference of Rio, did underline in field A of the program its interest in the "Integrated management and sustainable development of coastal zones". Inventory lists, planning and management of coastal ressources are defined as priorities.

Coastal areas clearly deserve the particular attention of european framework programs. The following systems, which constitute interesting references for generalisations, would provide a useful start for investigations :

Estuaries, deltas and plumes (critical watershed rivers)

Rhone : industries on the outskirts of Lyon, electronuclear plants, and nuclear research sites and centers; Ebro; Medjerda; rivers spilling into Salonica Bay : Akeloos, Axios (Vardar in the former Yugoslavia), Gallikos; special case of the Nile...

The fate of sediments carried by rivers to their estuaries can be quantitatively evaluated. However, in most cases, there is no accurate cartographic, topographic, display of sediment distribution at sea along river plumes.

For those rivers cited above, our ignorance on this point has already had drastic consequences on the coastal environment. Their sediments, rich in chemical contaminants are more and more cause for concern, particularly due to the increasing presence of heavy metals.

It is urgent to reduce the levels of such inputs which threaten the health of coastal populations. To this end a proper analysis of the fate of these sediments, of their deposition pattern in relation to coastal hydro-dynamics, and an objective assessment of the degree of chemical or radioactive contamination, must be considered as priorities.

Coastal lagoons :

Lagunar environments represent particularly sensitive areas, due to very strong anthropogenic influences. Many studies on lagoon development have been performed on the Atlantic facade in tropical or temperate climate. Thorough examination of this type of coastal construction in the Mediterranean would allow comparisons that are necessary to the drafting of a charter of intervention operations, combining knowledge, protection, sustainable development and management.

Insular environments:

This issue was the object of specific propositions during the United Nations Rio Conference. A program of integrated actions (jointly managed by CIESM and UNESCO/IOC) has now been prepared, using two "pilot" islands (Cyprus, Malta). In this vein, the island of Corfou located at the entry of the Adriatic could represent a highly specific environment. The comparison of coastal processes would have applications to all islands in the Mediterranean, and perhaps elsewhere.

Coastal erosion :

Coastal processes drive the sedimentary budgets of the littoral. River dams often block terrigenous inputs, facilitating erosive phenomena, which are in turn related to basic coastal morphology and marine kinematics. The resulting disruptions are considerable, and they must be better managed if one wishes to control the socio-economic consequences. The Mediterranean is rich in erosive zones (for example along the coast of Morocco and Algeria; ..) which must be rapidly protected.

Future european initiatives in this area should take advantage of the two European networks of scientific and technical cooperation now being established around these priority issues.

3.2. Sustainable management of marine/coastal ressources

3.2.1. Priority Actions

Biodiversity

(1) Creation of marine/coastal Reserves. Marine reserves - an essential instrument of conservation policy - are rare in the Mediterranean where they involve only small areas : less than 1/10,000 of sea bottoms between 0 and 20m. When they exist, they are often little more than parks on paper, that is, legally protected areas where protection is ineffective (insufficient level of protection; lack of management staff; lack of material means to ensure protection). The creation of protected areas remains a largely random, opportunistic, process which deserves a considerable push.

Protected areas serve also to repopulate peripheric zones in exploited species. As is happens, the sexual characteristics of many coastal fish species change during their life cycle : female when young, then male, or vice-versa. In populations subjected to overfishing, where large individuals are absent, a deficit in the number of individuals in one of the two sexes will therefore follow. Furthermore, sexual reproduction is often a collective phenomenon, with pairings involving many individuals of different ages. Through local limitation of fishing, marine reserves will favor the reproduction of marine species (fish especially), and help restore population stocks in peripheral zones where fish catches are seen to increase. Professional fishermen are therefore the main beneficiaries of protective measures. Table I below lists priority areas for protection (see also recommendations 3 and 5).

Table I : Areas requiring protection to maintain marine biodiversity (and ecodiversity) in the Mediterranean. Several non-EEC sites are listed when they are considered as basic elements in a global protection strategy. Minimal protection measures required to ensure adequate protection : A = no coastal development allowed; NT = no trawling allowed; M50 = no open berth for ships over 50 m; N = no navigation allowed; AF = no amateur fishing allowed; POL = pollution control; PF = no professional fishing allowed; QS = established quotas for scuba-diving.

Country Site	Species, biotopes or seascapes requiring priority protection	Specific protection measures
Spain		
Cabo de Gata (1) Banc d'Alboran	Monachus monachus (2) Laminaria ochroleuca	PF AF
France		

Archipel de Riou (Marseille)	Grottes sous-marines	PF AF QS
Lagune du Brusc (Var)	Récif-barrière Posidonies, Cymodocea	N POL A
Rade d'Hyères (Var)	Herbier de Posidonies, Pinna nobilis	POL M50 NT
Anse du Croton (Alpes-Ma.)	Caulerpa ollivieri	A
Saint-Florent (Corse)	Récif Posidonies	N POL A
Santa Manza (Corse)	Penicillus capitatus	A POL
Italy		
Marsala : Stagnone (Sicile)	Récif-barrière et herbier tigré Posidonies	A N POL
Taormina (Sicile)	Schimmelmannia ornata	A POL
Détroit de Messina (Sicile)	Laminaria ochroleuca	POL
La Madalena (Sardaigne)	Herbier de Posidonie, Patella ferruginea	AF POL A NT
Greece		
To be completed :		
Tunisia		
Golfe de Gabès	Herbier tigré de Posidonies	POL
Algeria		
El Kala (1)	Monachus monachus (2)	AF A QS
Banc de Matifou	Laminaria ochroleuca	NT POL
Iles Habibas-Mersat Medakh	Patella ferruginea, Monachus monachus	PF AF A QS
Rachgoun - Ras Kela	Monachus monachus (2)	AF A QS

(1) The terrestrial component is already protected.
(2) The species was present in the recent past and might be reintroduced if the proposed protective measures are implemented.

(2) Legal protection of species

Compared to terrestrial species, very few marine organisms benefit from legal protection. Table II hereafter lists those marine species, either vulnerable or threatened, which urgently require such a status.

While the legal protection of species is necessary, it is not sufficient. Legal protective measures must first be effectively applied, which is not the case for the monk seal for example. They must also be accompanied by measures to safeguard the natural habitats of protected species : creation of natural reserves, limited development and urbanization of coastal areas (see Recommendations **1, 5, 7, 8**). Financial compensation for socio-economic groups (fishermen, for example, in the case of the monk seal) or territorial collectivities (in the case of the nesting grounds of marine turtles) must be foreseen.

Table II : Threatened species requiring legal protection status (species already protected do not appear in this table). Unless otherwise indicated, this entails prohibiting collection, transportation, detention and commercialization. Geographical distribution : RR = very rare; R = rare; FC = fairly common; C = common, ? = presence to be confirmed; > = rapidly declining populations. The regions involved by protection : EEC = all EEC countries; S = Spain; F = France; I = Italy; GR = Greece.

Phylum / Species	Geographic distribution: Spain	France	Italy	Greece	W.Med	E.Med	Oth.	Protection required (region, type)
Rhodophyta								
Goniolithon byssoides		RR	RR	?	RR	?		EEC
Lithophyllum lichenoides	R	C>	FC>	RR	R	RR	R	GR
Ptilophora mediterranea				R				EEC or GR
Schimmelmannia ornata			RR			RR	RR	EEC
Fucophyceae								
Cystoseira sedoides			RR		R			EEC or I
Laminaria ochroleura	RR		RR		R			EEC or I
Laminaria rodriguezii	R	RR	R		R			F
Chlorophyta								
Caulerpa ollivieri	RR	RR	?			RR	RR	EEC
Penicillus capitatus (1)		RR	RR				FC	EEC
Phanerogama								
Posidonia oceanica	C>	C>	C>	C>	C>	R		EEC (2, 3)
Zostera marina	R	R	R	RR	RR	RR	FC	EEC (3)
Mollusca								
Patella ferruginea	R	RR>	RR>			RR		EEC (2)
Patella nigra	RR		?			RR	R	EEC ou S
Pinna nobilis	R>	RR>	R>	FC	R	FC		S and I (2)
Crustacea								
Scyllarides latus	R	RR	RR	R	FC	FC	R	I (2)
Pisces								
Epinephelus guaza	R	RR	RR	R	FC	R	R	F and I (4)
Umbrina cirrosa	R	RR	RR	R	R	R		I (4)
Sciaena umbra	RR	R	R	FC	FC	FC	FC	F and I (5)

(1) Penicillus stage only
(2) Species protected in France
(3) Species protected in Catalugna and Pais Valenciano (Spain)
(4) Recommended protection limited to prohibiting underwater fishing
(5) Recommended protection limited to establishing minimal catch size, i.e. 30 cm total length.

(3) Protection of biotopes and underwater landscapes. The biotopes or seascapes requiring priority protection are listed in the following Table :

Table III : Populations and underwater landscapes in the Mediterranean which must be protected in order to preserve ecodiversity and biodiversity.

Geographical distribution : S = Spain; F = France; I = Italy; GR = Greece; W = other regions of western Mediterranean, East = other regions of eastern Mediterranean; O = outside the Mediterranean waters; + = presence

Ecological interest : B = biodiversity (very original fauna/flora), E = endemic pole. ED = ecodiversity (rare or disappearing populations); I = importance for other populations (matter exports, bird feed, etc...); IR = irreversible damage (reconstitution will require centuries or millenia); PR = high productivity; R = large reservoir for biodiversity (very rich fauna and flora).

Economic interest : A = Aquaculture; SG = spawning grounds and/or nurseries for species of economic interest; L = control of beach line stability; F = fishing; T = tourism (underwater diving).

Biotope or seascape	Geographic distribution							Ecological Interest	Economic interest
	S	F	I	GR	W	East	O		
Lagunes littorales	+	+	+	+	+	+	+	I PR	F A
Encorbellements à Lithophyllum	+	+	+	+		+		B IR ED	
Trottoirs à vermets		+	+	+	+	+	+	ED	
Forêts à Cystoseira mode battu	+	+	+	+	+	+	+	ED	
Forêt à Cystoseira mode calme	+	+	+	+	+	+	+	ED	
Herbier à Posidonia oceanica	+	+	+	+	+	+		E R I IR PR	SG F L
Récif-barrière de Posidonies	+	+	+		+	+		ED IR	
Herbier tigré de Posidonies			+		+	+		ED IR	F
Herbier à Zostera marina	+	+	+	+		+	+	ED	
Grottes sous-marines	+	+	+	+	+	+	+	ED B	T
Coralligène	+	+			+		+	R E	T F
Maërl	+	+			+		+	ED	

(4) Legislation on species introductions. Deliberate species introductions for fish-farming purposes require the outmost care. The ICES "Code of Practice to reduce the risks of adverse effects arising from introductions and transfers of marine species" should have legal value (for the moment it is only a set of recommendations). One must note that, once introduced, biological species ignore administrative boundaries, and that decisions cannot be made at local or national levels. Very stringent quarantine measures must apply to deliberate species introductions in order to avoid associated accidental introductions. Transferring aquaculture products from one basin to another, within one country, or within the EEC, must not only cover the risks inherent to pathology transfer, but also those inherent to the transfer of associated organisms.

Legislation (modeled after that adopted by the USA) must be drafted on the monitoring of ballast waters for ships . Further legislation is needed to control the transport of live species (deliberately or not) when reaching the frontiers of the European Community (such a law exists in Canada, Australia, etc...). Legislation on aquariums (public or private) containing exotic species which could be released to the sea must also be developped.

Coastal protection

(5) Enforcement of legislation on coastal wetland conservation. Coastal wetlands are known to play a crucial role as sediment and pollution "traps" and filters, and in the preservation of biodiversity. Despite national and international legislation (e.g., 1982 Protocol of Barcelona Convention ; Ramsar Convention ; Bird and Habitat Directives of the EC) the destruction of these ecosystems continues on the mediterranean littoral. Urgent measures are needed for the proper implementation and enforcement of the relevant conventions, for extending the list of the protected sites, and for preventing further damages.

(6) Environmental impact assessment for projects affecting the Mediterranean. All major development projects and programmes in the Mediterranean should have a thorough environmental impact assessment at an early stage of their design, with common guidelines on methodology, procedures and follow up. Efforts should be made to define and use the ecocapacity of the recipient coastal systems as a useful operational tool.

(7) Limitation of offshore and coastal works affecting the sublittoral. Considering the importance of the sublittoral seabottom for the healthy survival and development of ecosystems and species, it is roughly estimated that at least 85% of the present Mediterranean sea bottom of less than 20 m depth should remain free of any infrastructure or direct disturbance.

(8) Water, agriculture and terrestrial infrastructures. Several of the pollution problems are directly or indirectly connected with freshwater shortage - related in turn to the destruction of plant cover and forest fires - as well as with the works required by traffic, urban and touristic expansion. These closely interrelated themes need further study in a holistic way. New approaches aiming at the reduction of unsustainable modes of agriculture, at the reduction of mobility and at the minimisation of heavy infrastructures (coastal highways, dams, etc) must be tested.

Pollution monitoring and control

(9) Connecting pollution with the very issue of sustainable development in the Mediterranean is of great concern. As emphasized in section 3.3. below, one of the keys to address this problem is to speed up clean production processes, promote the transfer of clean technology from North to South within the Mediterranean, and facilitate the development of sustainable technologies (clean and others) across the Basin.

(10) Implement a new strategy for monitoring mediterranean waters, focused on specific processes (such as the CO2 cycle, eutrophication, the ecotoxicological impact of anthropogenic substances), and on specific sites such as the physical boundaries between marine subcompartments (halocline, thermocline ...). This non-classical approach shall also involve an interdisciplinary program on the distribution of substances which are catalysing or inhibiting the rate-controlling processes of biogeochemical cycles.

One now knows that these compounds present a more pronounced ecotoxicological risk in certain environmental compartments, which can be better recognized by this

targeted approach than by the traditional mass-balance approach. Thus, there should be a focus on systems where transport and mixing of water masses cause complex instabilities and heterogeneities in the ecosystem. In particular air/water, water/water (at the thermocline and halocline), and water/sediment interfaces deserve closer investigations, as they often represent thresholds where drastic shifts occur in the physical, chemical and biological conditions. Thus, even when the average bulk concentrations of ecotoxic substances are far below hazardous levels in the water column, it is precisely at the halocline (or thermocline) interface that their concentration may exceed the hazard limits. It is there that environmental stability must be monitored, through very specific physico-chemical and biogeochemical characterization.

(11) Monitor pollution in the open sea and in deep waters. Trends are difficult to detect in coastal waters marked by a high variability of contaminant levels. Further, the stability, or even an observed decrease, in coastal pollution levels can be quite misleading, as contaminants are diluted in the open sea and in deep waters, where their concentration continues to increase. Some experts predict that such an accumulation process in deep waters might trigger an anoxic crisis with severe consequences on marine life as early as the first half of the 21st century. It is imperative that studies be performed to determine the reality of the risk involved.

(12) Monitoring of aerosols, water and particulate matter. We need a systematic, very selective, well organized programme of monitoring of aerosols, water, particulate matter in the water column and sediments. To this end a network of few but well chosen sites, placed in coastal and open waters throughout the Mediterranean, is needed so as to collect reliable information about fluxes and concentrations of several crucial substances.
Today's numerous studies, spread over many sites and involving a large number of parameters, seem largely useless. Further monitoring activities shall also increasingly make use of "biological indicators" (species whose presence, or absence, translates average water quality).

(13) Reduction of atmospheric pollution. Most of the atmospheric inputs are closely connected with combustions - and thus with CO_2 emissions and climatic change. The introduction of the energy/CO_2 tax, the eventual decrease of emissions, the promotion of energy saving as well as the development of wind and solar energy production and use, would all greatly help in reducing atmospheric pollution and thus the resulting marine pollution.

(14) Oil and litter pollution : equipment of ports. Approaches recommended long ago for the reduction of oil and litter from the ships (setting up modern, efficient port reception facilities; strengthening effective systems for prevention and management of risk,...) are still needed urgently in the Mediterranean. Mediterranean ports should be equiped urgently with the necessary means for the implementation of MARPOL and of its protocols. Jettisoning litter must be strictly forbidden, either nearshore or offshore.

(15) Clean-up of the continental shelf. Fishermen, especially those working with trawler boats, sweep the continental shelf zone all year long, sometimes catching more litter than fishes, and usually throwing back at sea the litter. Fishermen should be made aware that this goes against their own interest since litter strongly reduces the

efficiency of trawls. Several actions might be considered in this respect, such as offering a premium as a function of the amount of litter brought back from the sea.

Harmful algal events

(16) Careful site, species and method selection in aquaculture. This involves finding a compromise between a desirable high productivity of the area, and the likelihood of appearance of harmful blooms. Historical records of phytoplankton composition and previous knowledge of the oceanographic conditions in the zone are important for a successful choice. Selection of species and culture methods may help to reduce toxicity problems.

(17) Long term monitoring of harmful algae. There are two main aspects of monitoring : for phytoplankton and for the presence of toxins. Phytoplankton monitoring may provide early warning of the occurrence of future problems and allow the adoption in time of management strategies for reducing negative economic impacts. Monitoring for the presence of toxins in shellfish destined for consumption is necessary to protect human health. The collection of time series of data on environmental variables and phytoplankton composition is important to optimize monitoring and management strategies.

Fisheries

(18) Fishing management measures. Large surface driftnets must be effectively banned. Bottom trawl activities must be limited to deep and muddy grounds (in order to preserve, in particular, Posidonia beds). Catches of small and immature fish must be avoided. Scuba diving collection of specific species (such as sea-urchins) must be more rigourously controlled to avoid local depletion and/ or large modifications of the ecosystem.

(19) Control. To be efficient, management measures must be easy to control. Regulation of time of fishing (days in a week, or hours in a day), prohibition of some gears, seasonal closures and establishment of protected zones, would be more effective than quota or, even, than mesh size regulations.
We wish to emphasize that the recovery and sustainability of fishery stocks largely depend on the implementation of strong protection measures concerning critical coastal habitats (see recommendations 1 to 4). In addition, the development - which we discuss later - of a reliable monitoring system combined with a regional data base is essential.

(20) Experimental regulation plans, which have proved to be useful management tools within a limited and well controlled area, should be extended to a larger number of geographical sites in the whole Basin.

(21) Governmental interventions must contribute to protect the resource and optimize its use. In the Mediterranean, this means to reduce fishing effort. Some regulations perform this objective, but others, like the tax exemption for combustibles, have counter-productive results, leading to an increase of the fishing effort.

(22) Increased regional scientific cooperation. The recent international Workshop, organised by the EEC (Ancona, November 1992) on coastal fisheries and living resources in the Northern Mediterranean, did underline the need to strengthen the scientific basis for selecting the proper methodologies and for defining the correct research priorities for living resource management in the region. To this end it is recommended that EEC/ DGXIV adopt a more open, truly multi-lateral, approach, and consider setting up concrete mecanisms for concerted action between the EEC, CGPM and CIESM, which have obvious complementarities in this domain.

3.2.2. Research priorities

Biodiversity

(23) Draw up an inventory of biodiversity. While the study of systematics (description and identification of species) is often considered as obsolete, and the number of systematicians is dropping in several European countries, it is clear that the inventory of existing species is far from finished. Programs on biodiversity and conservation come up against this obstacle; and species will become extinct before having been identified. The inventory of Mediterranean species must therefore be actively engaged, particularly in those regions where research has not been considerable (Albania, Algeria, Libya, northern coast of Morocco). A specialized marine biodiversity data base, such as MEDIFAUNE developed at the University of Nice, would be a precious tool for processing such collected data.

(24) Study the status of threatened species. Rare and threatened species must accurately be evaluated in terms of status (stocks, distribution) and population variations over time. At this time, we have no existing data on most of these species. A kinetics of rapide decline, even when the risk is short-term, constitutes an alarm signal and must lead to implementing voluntaristic conservation actions.

(25) Evaluate the economic impact of coastal conservation. One considers more and more that the quality of coastal areas, a result of both protection measures and investments in wastewater treatment, represents a high added value for both tourism and professional fishing. Coralligenous populations, inclines, productive underwater caves, among others, are strongly attractive features for the rapidly growing activity of leisure scuba-diving. Data supporting these observations are still too scarce.

(26) Develop efficient quarantine systems, in order to avoid or limit the extent of accidental species introductions. The current practice is often highly empirical : for example, placing the Japanese seed-oysters Crassostrea gigas in freshwater for one hour, as is theoretically practiced in France.

(27) Assess the impact of introduced species on biodiversity. There are few available data on this issue. We suppose (without evidence) that scarce, small species have little effect. We also suppose that large, dominating species have greater impact. As to a possible effect of synergy between introduced species which can co-exist in the same biotope, it remains to be considered, at least in Europe.

Pollution and harmful effects

(28) Critical review of on-going monitoring projects. The current monitoring projects which are run by national or regional authorities in the framework of UNEP-MAP need a thorough, critical revision by a Task Force of independent experts. A particular effort should be made so that the type of monitoring and choice of parameters are compatible with the methodologies that will be developped by the European Agency for the Environment.
Furthermore, a critical assessment of the underlaying "philosophy" of ongoing monitoring programmes, and a reactualization of their objectives, are very much needed.

(29) Thorough investigations of the inputs from the Black Sea and the Atlantic Ocean, appear very important for some elements and artificial radionuclides.

(30) Determination of the history of mediterranean pollution. The marine pollution records need to be thouroughly assessed (e.g. for Pb, Cd, Hg, eutrophication, anoxia, radionuclides, ...) from the analysis of sediment cores taken in the vicinity of river estuaries.

Harmful algal events

(31) Improve the methods of toxin analysis. The mouse bioassay is the generally accepted method by regulatory agencies, but there are concerns about the specificity and reproducibility of the results and about the ethics of using experimental animals. Chemical methods and alternative biological techniques need to be improved and compared with the standard bioessays. International organisations such as the BCR Programme of the European Commission are taking action in this direction.

(32) Promote research on taxonomy, physiology and population dynamics of the causative organisms. Our lack of understanding of many aspects concerning these questions hinders the development of effective prediction tools and management strategies.

Fisheries

(33) Upgrade mediterranean fishery science by incorporating the impact of local environmental factors on the biology and productivity of fisheries, by analysing the potential and actual states of exploitation, and so develop the knowledge necessary for the proper sustainable management of this resource.

(34) Promote the study of selectivity, efficiency and environmental impact of the different gears (including those employed by the amateur fishermen), as well as the competition among them for the same resource.

3.3. Monitoring the Mediterranean ecosystem

Sustainable development within Mediterranean Countries will depend to a large extent on the capacity to minimize environmental damage. This goal requires efforts in two directions:

- elaboration of reliable, fast and economic methods for the monitoring and surveillance of the environment and design of appropriate equipment for their realisation;
- development and availability to all mediterranean countries of appropriate techniques and systems to protect and rehabilitate the environment.

With respect to monitoring, we propose a series of actions - all largely related - which aim to fulfill four critical objectives:

a) acquire a satisfactory knowledge of the main geographical, environmental and oceanographical aspects of the Mediterranean sea ;

b) render the data presently available homogeneous and compatible ;

c) provide, through appropriate surveying and monitoring operations, evaluation means of the main environmental parameters changes, including the morphological compatibility ;

d) provide through appropriate display techniques, evaluation and decisions elements for managing coastal zones development and emergency pollution situations.

To this extent, the following set of realistic actions and interventions, which are analysed in detail in the Annex of this Report, are proposed :

- Development of a regional data base;
- Creation of a global appropriate geographical information system (GIS);
- Real time monitoring system for pollution assessment;
- Implementation of a marine traffic control;

3.3.1. Regional data base

The development of a data bank on the mediterranean marine environment, which would be interactive, and easily accessible to scientists, coastal managers and concerned decision-makers on both shores is, of course, a necessity.

Since the Council's decision to develop the european data base CORINE, much work has been accomplished to gather data, in a systematic fashion, on several themes (biotopes, atmospheric emissions, land cover, erosion, water resources, etc.). Nothing of the sort, however, has been accomplished on the marine environment ... except for

the repeated wishes of the European Parliament, which underline the importance of disposing of comparable data on the state and trends of the seas bordering the EC.

There is indeed a real need and an urgency to build a european marine data base - all of the scientists contacted during the course of this study did say so. A priority recommendation of this Report is, therefore, for the EC to quickly establish a Working Group on the subject in order to define the methodologies, the selection of parameters, the data compatibility, and mode of access - on both shores of the Mediterranean - of this future information system.

Two obstacles, among others, must be avoided :
- too large an emphasis on the North Sea in the initial collection of data, which would not take the specific character of the Mediterranean sufficiently into account;
- the temptation to limit the exercise, by facility, to gathering data on the quality of bathing sites, an issue of importance, but much less crucial indeed than that of globally monitoring the sensitive ecological balances at the land / sea interface .

This work shall naturally be developed in close concertation with that on the future mediterranean GIS (see below).

3.3.2. GIS for coastal zones

The GIS required shall be developed initially with a strong emphasis on the coastal realm. It should cover the following aspects (see Fig. 2) :

a) coastal topography, including sensible protected areas, like natural sites, sanctuaries, archeologic and historical sites, ...;

b) bathymetry and sedimentology, including submarine archeological sites and marine protected areas;

c) oceanographic information (hydrology, coastal circulation patterns, tides, waves);

d) information on sensitive coastal / marine biota;

e) urban development.

e) main pollution sources, such as :

- petroleum hydrocarbons
- halogenated hydrocarbons
- trace metals
- nutrients
- pesticides

caused by:
- acidents at sea
- shipping
- seabed exploitation

- urban discharges (sewage systems)
- industrial discharges
- power plants
- port activities
- unauthorized discharges (rivers, ships, tenders)

The data collection must be carried out in a very systematic way, both in time and in space, following commonly accepted standard procedures, such as those established by the International Hydrographic Organization. It should be noted that the development of the GIS data base would be much facilitated, if based on a cooperation with the various National Hydrographic Services, which have the vocation to carry out systematic surveys and are capable of storing and analysing a great mass of data.

During the building phase of this system, much consideration shall be given to facilitate its use of access, its updating capacity, and its compatibility with supra-regional information systems such as CORINE.

3.3.3. Remote sensing of pollution

In order to monitor long-term trends in marine pollution and to localize and trace sporadic events of illegal discharges of pollutants into the Mediterranean, the implementation of a marine monitoring system appears absolutely necessary. Such a system must include in-situ measuring and remote sensing devices.

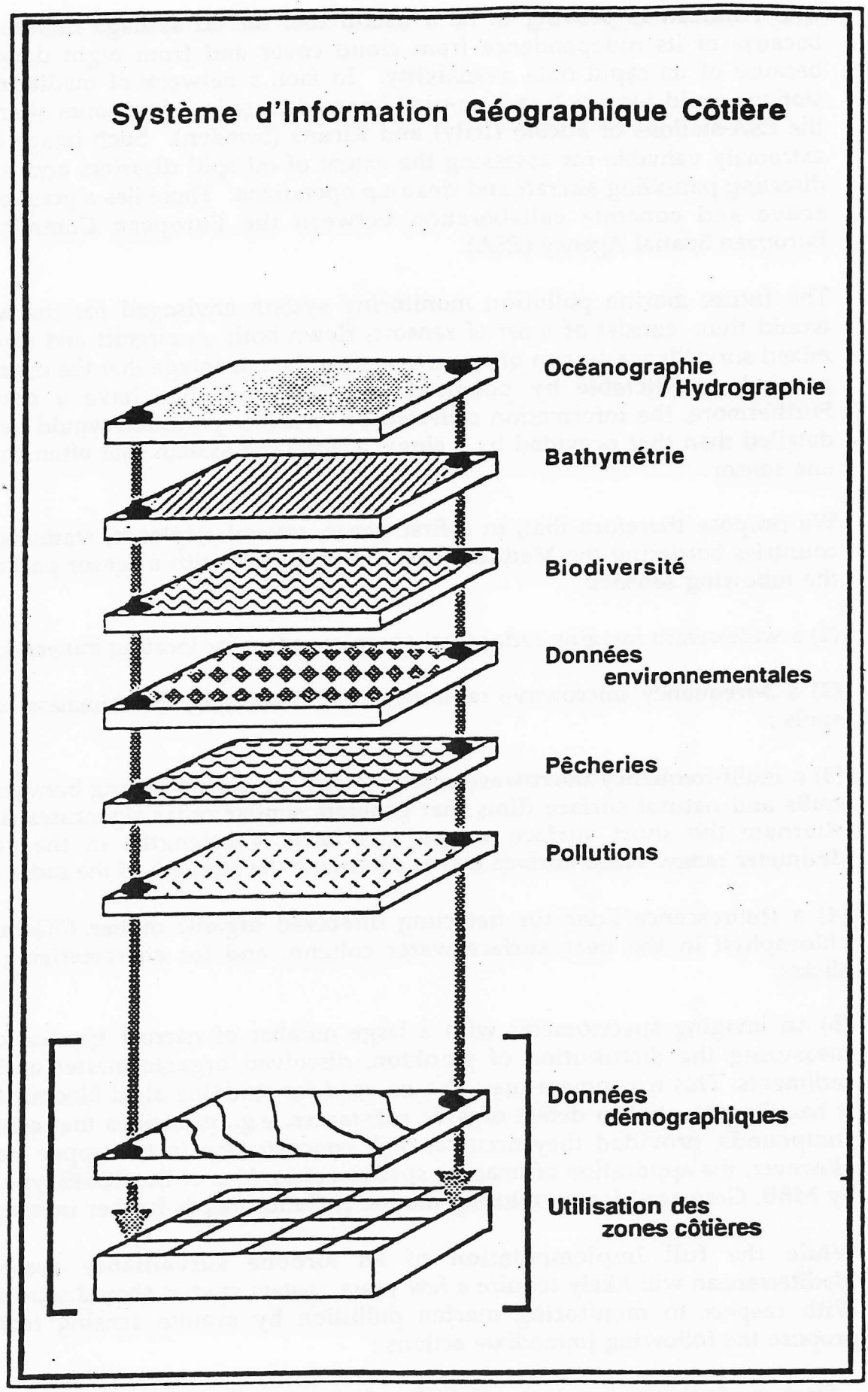
In-situ measuring instruments should be installed in several selected sites where marine pollution is known to be of great concern. In particular they should be placed near the estuaries of rivers on which industrial plants are located, as these are suspected to release deliberately or accidentally often large amounts of pollutants into the river.

Keeping in-situ measuring instruments in operation (maintenance, calibration, data transmission, loss of equipment) is often difficult and expensive, but is cannot be neglected in the planning, if the pollution monitoring system is to be efficient on the long-term.

Remote sensing instruments flown on aircrafts and satellites have the potential to survey large sea areas. However, the extraction of information on sea pollution from the remote signals is more difficult and requires further research on the part of the EC.

The spatial and temporal coverage achievable by remote sensing instrumentation flown on satellites is usually not sufficient for identifying the broad spectrum of pollution. However, the recent development of recent radar sensors (such as SAR flown on the european satellite ERS-1) is already showing great potential, e.g. for gathering statistical information on oil discharges from ships and for studying the evolution and motion of mineral oil patches originating from oil tankers accidents (see Fig. 3) or offshore platforms, which is of great value for oil recovery operations. To date this potential remains largely unexploited, except for coastal monitoring surveys by the norwegian authorities.

Fig. 2


Système d'Information Géographique Côtière
Océanographie / Hydrographie
Bathymétrie
Biodiversité
Données environnementales
Pêcheries
Pollutions
Données démographiques
Utilisation des zones côtières

ERS-1 indeed is proving to be a useful tool for oil spillage monitoring, not only because of its independence from cloud cover and from night darkness, but also because of its rapid data availability. In fact, a network of mediterranean ground stations could receive "ready-to-use" image data only a few hours after acquisition at the ESA-stations of Fucino (Italy) and Kiruna (Sweden). Such image data would be extremely valuable for assessing the extent of oil spill disasters and most useful for directing patrolling aircraft and clean-up operations. There lies a great opportunity for active and concrete collaboration between the European Commission and the European Spatial Agency (ESA).

The future marine pollution monitoring system envisaged for the Mediterranean would thus consist of a set of sensors, flown both on aircraft and satellites. Such a mixed surveillance system of sea areas offers the advantage that the overflights are not precisely predictable by potential pollutors and thus have a deterrent effect. Furthermore, the information collected on marine pollution would be clearly more detailed than that provided by a single spaceborne system that often consists of only one sensor.

We propose therefore that, in a first phase, several airplanes, stationed in different countries bordering the Mediterranean, be equipped with a sensor package including the following sensors:

(1) a wide-swath imaging radar (real aperture radar) for locating mineral oil spills ;

(2) a 3-frequency microwave radiometer for measuring the thickness of mineral oil spills ;

(3) a multi-frequency microwave scatterometer for discriminating between mineral oil spills and natural surface films that generate similar radar signatures (i.e, they both alternate the short surface waves that have wavelengths in the centimeter to decimeter range. These surface waves determine the strength of the radar echo);

(4) a fluorescence lidar for detecting dissolved organic matter ("Gelbstoffe") and chlorophyll in the near surface water column, and for characterizing mineral oil slicks;

(5) an imaging spectrometer with a large number of narrow spectral channels for measuring the distribution of plankton, dissolved organic matter and suspended sediments. This instrument may also be used for studying algal blooms; furthermore, it has the potential to detect organic substances, e.g., pesticides that contain organic compounds, provided they occur at high concentration in the upper water column. However, the application of imaging spectrometers, (e.g. of the ROSIS type - developed by MBB, Germany) for monitoring marine pollution needs further investigation.

While the full implementation of an airbone surveillance system for the Mediterranean will likely require a few years, system studies should start immediately. With respect to monitoring marine pollution by remote sensing techniques we propose the following immediate actions :

- First, a rigourous analysis of ERS-1 SAR, Landsat-TM and SPOT-HVR images

acquired over the Mediterranean with the aim of gathering information on :

- the frequency of discharges of oil from ships in different sea areas;
- the areal extent of the oil spills released from ships;
- the location of sources (sewage and industrial plants) releasing organic pollutants into the Mediterranean which float on the sea surface.

- Furthermore, we propose for 1994 to start analyzing SeaWIFS (Sea-Viewing Wide-Field-of-View Sensor) ocean colour data from the future American SeaStar satellite (envisaged launch date : January 1994) for measuring chlorophyll and algal blooms, and the distribution of suspended sediment and dissolved organic matter in the Mediterranean.

- Last, the results of advanced research activity in LIDAR will have to be taken into account.

3.3.4. Implementation of Marine traffic control

We recommend to implement a vessel traffic control for oil and dangerous cargoes extended to the whole Mediterranean area. We also suggest to create a vessel traffic service for ships approaching the main ports and crossing the straits (some of these VTCs already exist, as in Marseilles, and in the Messina Strait)

3.4. Technological and engineering actions

We emphasize at the outset that, without strong measures leading to the proper harmonization and enforcement of existing laws and regulations (analysis beyond the scope of this Report), the implementation of the initiatives proposed in this domain shall remain largely insufficient.

The success of any technological program will depend to a large extent on the implementation of innovative and effective physical / mathematical models, aiming at the technological and economic optimization.

3.4.1. Assessment of pollution abatement technologies

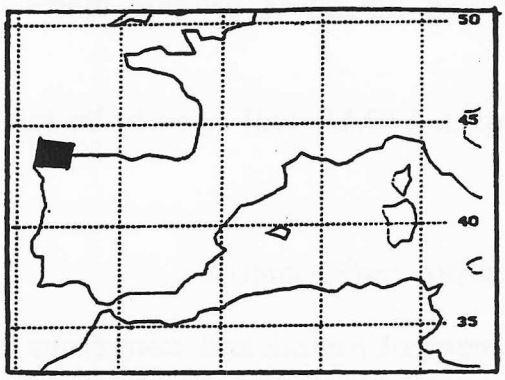
An Environmental Action Programme in the field of technology has to define the broad lines of a waste-management policy :

- prevention and control of anthropological aggressions to the ecological sites ;
- prevention of the production of waste ;
- recycling and reuse of waste ;
- safe disposal of non-recyclable residues ;
- a rigorous evaluation, control and protection of the coastal zones, in order to avoid any visual and perceptive alteration should be continuously carried out.

Preventing waste production is undoubtedly the first guideline for a waste

Fig. 3. ERS-1 SAR images of the December 1992 oil spill near La Coruna (Spain).

Courtesy of Dr Jürg Lichtenegger, ESA (ESRIN, Frascati).



On the 3rd of December 1992, the Greek oil tanker "Aegean Sea" ran aground near the entrance of the Ria de Coruna, and La Coruna harbour, Spain. The 291m tanker, carrying over 79,000 tons of Brent type crude oil, broke up and exploded. Practically all of the oil was released into the sea. Over 200 km of shore was affected. The oil spread initially to the northeast, and then spread along the southern coast. In the second half of December wind ranged from southeast to northeast, pushing the oil out to sea. Wind velocities were at all dates of ERS-1 passes very favorable to oil slick observation.

Fig. 3 a:

<u>SAR image of 23 October 1992.</u>

Image obtained before the oil spill. The Atlantic is to the left, the NE coast of Spain to the right. La Coruna is marked by bright points on a peninsula near the right edge of the image. The Ria de Coruna is the estuary to the east of the town.

Fig. 3b:

SAR image of 13 December 1992.

Ten days after the disaster. From comparisons with the patrolling aircraft, we know that the very dark area is heavily polluted sea, while the dark grey area is older, more dispersed oil.

Fig. 3c:

SAR image of 17 January 1993.

The oil slick has largely disappeared. There are some remaining dark areas near the harbour of La Coruna, which may correspond to wind-sheltered areas.

management strategy ; this issue has been confirmed by the Fourth Environmental Action Programme (1987-1992) which more specifically emphasizes, the "urgent" need for "clean" technologies.

The importance of preventive actions does not reduce the need of qualitative recovery activities and appropriate resource management, applying well known technologies.

The broad family of environmental protection technologies is comprehensive of :

- cleaner technologies ;
- recycling technologies ;
- emission abatement technologies ;
- treatment and disposal of waste ;
- risk assessment for and restoration of contaminated industrial sites.

Cleaner and appropriate technologies

Existing conventional industrial processes have to be examined in order to identify those steps in the process which create major pollution, and to investigate possibilities where the concept of cleaner technologies could be introduced, resulting in new or modified, less polluting process steps.

This will include the examination of process modification such as :

- changes from wet to dry processes ;
- chemical to physical, or chemical to biotechnological processes ;
- reduction of process temperatures and/or pressures by the use of selective catalysts.

Industrial sectors with highest priority are :

- chemical industry ;
- pulp and paper industry ;
- food industry ;
- metal finishing industry ;
- textile industry.

Topics to be developed are :

- process optimization based on numerical simulation ;
- substitution of harmful or toxic substances, in particular VOCs ;
- appropriate selection or precleaning of raw materials ; development of closed loops in individual process steps (e.g. for process water) ;
- development of specific in-process purification steps ;
- on-line process control for a higher efficiency and reduced emissions ;
- development of systems for early warning purposes, with a feedback to process-specific mass flow patterns. (This item could include the development of suitable sensors and / or biosensors) ;
- specific activities are required in the field of the handling of waste produced on board of ships.

Recycling technologies

It is necesssary to promote cost-effective systems for recycling valuable materials from industrial processes, aimed at reducing the consumption of primary raw materials and wastes.

It is also desirable to improve sampling and separation schemes for wastes and used products for recycling of materials from selected industrial wastes. The research on product recycling has to cover the whole life cycle of the product : starting from raw material extraction to the production processes, to the re-manufacturing of the used products, including their collection and the separation of individual components and maetrials.

High priority has to be given to the recycling of products and of waste originated from industrial processes.

The main issues concerned are :

- recycling of plastic materials (thermo and non thermo-plastics, e.g. high quality polymer products) ;
- recycling of composite materials (e.g. electronical equipments, printed circuits, etc.) ;
- recycling of household appliances, cars, etc.

Emission abatement technologies

Improvement of existing abatement technologies should receive high priority, in particular in the area of thermal and catalytic processes for cleaning gas emissions from stationary sources (e.g. small combustion units). Where possible, in-process air purification should be further developed, with due regard to biotechnological processes.

In the field of water pollution special attention should be paid to the introduction of new treatment systems working on a biological basis. The treatment of municipal sewage and that of industrial waste water streams have already been identified as major problem areas.

Water consumption and re-use of process water should be investigated, especially in the food industry.

The approach and the research tasks have to be classified referring to :

- emissions to the atmosphere;
- emissions to water bodies.

As far as emissions to the atmosphere are concerned, research shall concentrate on :

- the reduction of gaseous and particulate emissions from stationary sources (e.g. small heat/or power producing units and incinerators). Nitrogen oxides,

hydrocarbons and inhalable particulate matter are considered as priority pollutants.

- the improvement of catalytic end-of-pipe technologies for stationary sources, with special emphasis on volatile organics and halogenated hydrocarbons originating from industrial production processes ;

- the improvement of abatement technologies such as filtration and biofiltration including the development of appropriate filter regeneration techniques.

As far as the emission to water bodies are concerned the most important topics are :

- optimisation of flow patterns for integrated nitrogen, phosphorus and BOD removal in a cost-effective way, and development of techniques for process control and monitoring, including the development of new sensors for on-line control ;

- research on disinfection and storage of water for supply purposes to be used (e.g. for irrigation), taking into consideration odours, nuisances and sanitary risks.

A more detailed analysis of abatement technologies, aiming also at defining the state of the art, is developed in the Annex of this Report, in the section dealing with technologies for the reduction of emissions to atmosphere as well as in the section discussing the technologies for the reduction of emissions to water bodies.

Treatment and disposal of wastes

Available knowledge about on-going changes in landfill sites is unsatisfactory : mass flows and the composition of landfill gas and leachates over time are hardly known.

The main objective should be the study of the conditions for chemical/biological reactions in waste disposal sites in order to predict the environmental impacts ; while the lack of knowledge on the long-term geophysical behaviour of disposal sites should be made up. Emphasis should also be placed on the preparation, the operation and the after-care of disposal sites.

The most important topics are :

- stabilisation and reduction of volume of wastes using, for instance recycling, detoxification or destruction of toxic industrial wastes ;
- identification of the most appropriate pre-treatment technologies ;
- investigation, description and modelling of degradation processes inside the disposal site.

Risk assessment for and restoration of contaminated industrial sites

The objective is to develop reliable, reproducible, comparable and fast techniques and practices for risk and hazard assessment and for the identification of the appropriate remedial action referring to the characteristics of various types of contaminated sites.

A multy-disciplinary approach shall be used in carrying out research activities in this field ; the expected result is a common protocol for site appraisal and the related standards.

The knowledge of major industrial hazards is necessary for :

- the identification of accident hazards and the assessment of their risk to the general population and the environment ;
- the development of technologies for preventing and mitigating such accidents ;
- the development of technologies for environmental restoration ;
- the development and sorting regulatory activities derived from Council Directive 82/501/EEC.

A detailed analysis of emission reduction measures is included in the Annex of this Report.

3.4.2. Technologies for oil pollution events

Annual transportation of oil across the Mediterranean Sea amounts to about 305 million tons; this is about 25% of the total world oil traffic (Medugno, 1992). Transport, storage, and use of hydrocarbons in the Mediterranean area produces an inevitable flux of pollutants toward the Sea which constitutes a heavy pollution load for the closed Mediterranean basin. According to 1988 UNEP estimates more than 600,000 tons of hydrocarbons reach annually the Mediterranean Sea (see following Table).

Inputs of oil pollutants to the Mediterranean Sea (mt/year x 1000), according to UNEP (1988)

- From marine transportation of hydrocarbons (Operational discharge, marine terminals, etc.)	330
- From municipal wastewater and urban runoff	160
- From industrial wastewater and discharges	110
- From atmosphere	35
TOTAL	635

In addition, the deliberate - illegal - discharges of oil by ships in the open sea, for tank cleaning purposes, are believed by many to push this annual figure much higher, between one and perhaps one a half million tons. Accidental spills further significantly contribute to the total oil pollution, especially those occurring during sea transportation of petroleum products (see following Table).

Oil spills due to tanker catastrophic accidents in the Mediterranean Sea

Name of tanker	Date	Place	Quantity of Oil (mt)
Indipendentia	Nov. 1979	Bosphorus (Turkey)	94.600
Irenes Serenade	Feb. 1980	Bail Nevorino (Greece)	40.000
Juan A. Lavalleja	Dec. 1980	Arzew (Algeria)	39.000
Cavo Cambanos	Jul. 1981	Corsica (France)	18.000
Haven	Apr. 1991	Genoa (Italy)	30.000

Efficient strategies against the risk of hydrocarbon pollution of the sea must be based on preventive actions such as: reduction of sea transportation by promoting pipeline construction, renewal or substitution of older tankers, tighter environmental regulations, redefinition of oil routes avoiding sensible coastal regions, and development of a reliable remote-sensing monitoring system (see section 3.3.3. above).

However, due to the enormous volume of oil to be shipped across the Mediterranean Sea, hydrocarbon pollution risks will always be high; for this reason much R&D effort is presently devoted to develop efficient technologies for mitigating oil spills environmental impact.

Presently available technologies for the treatment of sea and beaches polluted by hydrocarbons can be divided into four main categories:

- confinement of the spill by floating barriers and removal of the entrapped oil
- use of dispersing agents
- use of oil-absorbing substances
- use of oleophilic fertilizers aimed to speed natural biodegradation processes

These technologies are discussed in greater detail in the Annex of the Report.

3.4.3. Coastal restoration technologies

Visual Impact

Along with the above-mentioned water and atmospheric pollution problems, visual pollution is an issue that cannot be neglected.

Mediterranean coastal ecosystems are dependent on "short term" interventions and demonstrate the negative impact of non-controlled anthropic erosion. For many coastal ecosystems, degraded by uncontrolled anthropic erosion, it is essential to restore the original characteristics of the sites, safeguarding their "essence" and their "specificity". This will require the use of adjusted, innovative and non-destructive technologies:

- perception and identification techniques for all main elements of the physical environment, both natural and artificial;

- specific sectorial techniques, relying on controlled transformation processes. These criteria will be defined in terms of adequate integration - within landscapes and

environment - of coastal protection interventions. To this end a knowledge of the most appropriate technologies on record, depending on the main typology of coastal development, will be needed.

Technological interventions can be natural (dune preservation, recovery, excavation), artificial or mixed. The application of both perception and sectorial techniques is compatible, provided that it is simultaneous, so as to avoid current practice which only involves technology-oriented interventions, without integrating the perception of persistent and site-specific characteristics.

Development of directives for restoration techniques

The use of restoration techniques (particularly when they are not yet fine-tuned) must not be abusive or haphazard. For example, planting new Posidonia grassbeds, immerging rubble misleadingly labeled "artificial reefs", setting up artificial reefs in unappropriate sites, etc..., should no longer serve as alibi for further destructions linked to new developments. The outlines for such a code of practice will be found in the Annex.

3.5. Towards a communications policy

At the risk of sounding repetitive, one must insist upon the importance of developing an information and communications policy in the Mediterranean. Despite the renovated mediterranean policy, the grounds remain empty, except for a small number of experiments which are difficult to consider as political stepping-stones.

To begin with, the Universities, within the scope of their expertise, manage information and undertake communication activities, without any real concertation between them. The Mediterranean Third Countries (MTC) remain poorly informed of the research and training programmes developped by European Universities, and know even less about the guiding principles involved.

As a first step, why not develop a prototype involving, for example, three European Universities and the same number of MTC Universities around a computer link, and put at their disposal data on research and specialized training (graduate level) ? This idea should be thoroughly examined, as it meets the needs often expressed by MTC Universities. Within any given area, such as marine pollution, it would be clearly in the interest of the European Community to inform MTC Universities and Research Centers, in a multilateral perspective, of all the research actions and relevant training programmes.

An existing EC programme (MED-MEDIA) already aims at creating networks between corporations and organizations, to coproduce the exchanges of programs, professional training and technology transfer... Although the importance of this program is not in question, there are several aspects which call for improvement : it does not, for example, take into account the training requirements expressed by MTC Schools of journalism and communication. Yet, reinforcing such institutions remains an absolute priority in this area.

In this context, new linkages should be initiated between Universities and the major European television channels, to initiate a remote-teaching program between institutions on both sides of the Mediterranean. This issue ought to receive particular attention from the "European Coordination Committee" (recommended in the next chapter), which will initiate the close collaboration of the various EC General Directorates involved.

Mediterranean scientific research remains constantly hampered by long delays in obtaining ready access to results, both in the scientific community and in the public at large. There is similarly, on the other shore, a marked interest for the circulation of scientific information (e.g. City of Science in Tunis) which is so useful in raising public awareness on all issues related to the conservation and sustainable development of the region.

Developing high-quality information on a rigourous scientific basis, along with improved communication channels can greatly assist the choice of policy-makers. As an experiment in this area, we advance a concrete recommendation, for a simulation study of specific coastal regions, articulated around two main axes : (a) full conservation of the environment in one case, and (b) massive economic exploitation in the other. The outcome would be a simple communications scheme (graphics, videos, etc...), giving decision-makers a clear visual display of the various options.

All these approaches do not exclude, of course, the reliance on traditional communication means (books, brochures...). To this end it is imperative to create networks associating publishers and universities from both sides of the Mediterranean.

This last example emphasizes once again the fact that, in order to be efficient in the long term, any approach (communications included) must rely on reinforcing thematic networks or coordination networks, and on promoting, wherever needed, the creation of such new networks.

In this area, all correspondents, and all sectors, contacted during the course of this study have emphasized three main recommendations :

- Exchange of scientific knowledge and expertise. The effective exchange of scientific knowledge and expertise among scientists working in the area should be encouraged : (i) International congresses and conferences, which involve scientists from the different corners of the Mediterranean, should be strengthened by EEC support so that more scientists from developing countries can attend, present their results, and see them published. (ii) Thematic workshops of scientific groups on priority issues should be organised more frequently. (iii) Exchange of researchers (particularly people already working in the various governmental departments and in universities), experts and students are particularly worthy of support.

- The efficient and rapid interpretation of scientific findings for use by policy makers, and for the proper development of public awareness. This requires a system of rapid collection and transmission of treated and raw data and other information which should be collected at a focal point, connected electronically to the EEA and eventually national focal points and/or cooperating institutes. Adequate funds should be allocated for the development, training of personnel and proper maintenance and

functioning of such a network. This network could be combined with other existing ones and/or used for a number of other services (e.g. provision of bibliography, legal or emergency advice to governments and other users). Users from the private sector (companies, consultants, etc...) would be connected against the provision of annual fees. In addition, it would be useful to strengthening the communication work of those NGOs which have a demonstrated ability to influence public opinion, as well as the capacity to work in collaboration with universities and other learned institutions.

- Improve the dissemination of information. Cooperate with actions under consideration by international agencies such as : (i) organise training courses towards the acquisition of critical skills ; (ii) publish relevant manuals to be distributed freely to developing countries; (iii) establish a communication centre responsible for the screening, synthesis, and dissemination of information.

RECOMMENDED ACTIONS FOR THE EUROPEAN COMMUNITY

A - POLICY OPTIONS FOR THE EC

Since drawing up its reformed Mediterranean policy in 1990, the EEC has implemented various programmes such as MEDURBS, MEDCAMPUS and MEDMEDIA, and has launched pilot activities in the field of research, such as AVICENNE.

These initiatives have arisen thanks to a considerable effort on the part of the EEC with a view to improving its relationship with Third Mediterranean Countries (TMC). They contribute to the development of a cooperation process between the two shores in so far as training, research, communications sciences, the professional environment and local collectivities are concerned.

One must recognize, however, that each programme does not necessarily take into account the principles and motivating forces behind the proposal for a reformed Mediterranean policy. This policy shall necessarily be limited as long as it continues to rely only on the juxtaposition of specific actions, with no overall strategy. Interaction between these programmes, for example, seems inadequate compared to the Commission's stated desire for a "quantitative and qualitative leap" between the EEC and the TMC.

This is why operational mechanisms must be highlighted to enhance articulation between the principles of the reformed Mediterranean policy and their actual application. The following propoals go some way towards this. While conceived in the specific context of protecting and monitoring the marine/coastal environment, they can easily be transposed, with slight adaptation, to other fields of EC action in the environment.

Option 1 : Status Quo

Remarks : static; marked by the absence of interdisciplinarity between programmes; develops individualized approaches, contrary to trends now accepted as the norm. Difficult to support, since it cannot anticipate evolution or changes and, therefore, cannot respond to them.

This proposal confines itself to following the various initiatives already undertaken by the European Community in the Mediterranean area. Without denying their intrinsic value, we note that these programmes answer more frequently to a sectorial, independent logic than to a multilateral, interdisciplinary, ecosystemic approach (with two marked exceptions; the "Mediterranean Targeted Project" of the MAST programme for its ecosystemic dimension; and the "Avicenne Initiative" for its multilateral synergy on regional impact between the northern shore and the TMC).

For reasons discussed previously (the importance of considering the Mediterranean as a complex, interactive ecosystem; the need for an interdisciplinary approach, the necessity for genuine collaboration and multilateral cooperation between the EC and TMC), we consider that the static option is in the end the most risky, because of its poor cost/benefit ratio, as it dissipates efforts and financial investment with little hope of integrated management in the long run.

Option 2 : Promote Program integration and complementary

Proposal 1: Set up a European Coordination Committee for the Mediterranean

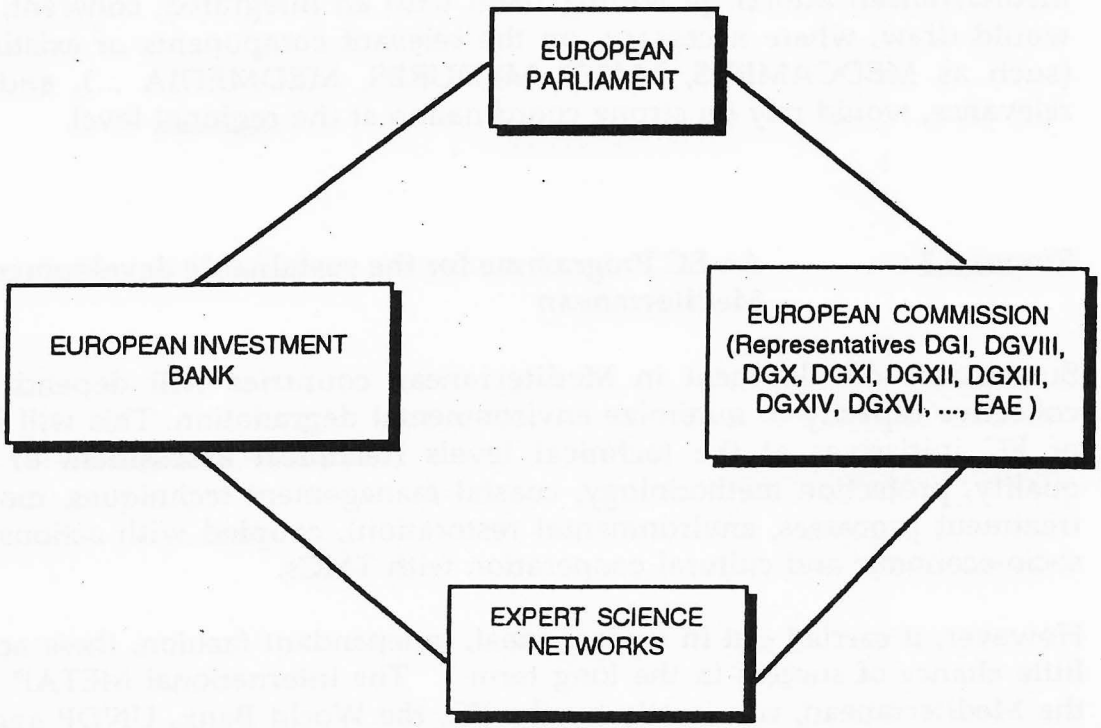
This is a matter of setting up a horizontal "Mediterranean" unit, based on European Commission structures, which would bring together:

(1) representatives from the most concerned Directorates General of the EEC - particularly DGI, DGVIII, DGX, DGXI (including the future European Environment Agency), DGXII, DGXIII, DGIV, DGXVI;
(2) representatives from the European Parliament, including the "Mediterranean" InterGroup and the Research Directorate;
(3) representatives from the European Investment Bank, for better integration of the Community's programme objectives and financial policies;
(4) representatives from expert science networks in the Mediterranean: these are particularly well placed to promote interdisciplinarity, and their presence would certainly improve the communication process - considered often difficult between the EC and the scientific community at large.

This unit would be automatically consulted for any EC programme or project affecting the region. To avoid potential, counter-productive, conflicts of interest between DGs, it appears advisable that this Committee be steered and convened by the European Parliament.

Fig. 4

Suggested Coordination Committee



Remarks:

This would be a consultative group, who would be called upon periodically to propose or revise major programme orientations, and to enhance complementarities between the various Directorates General and other relevant structures. In order to maintain an integrated transnational approach, this structure should be as flexible as possible, avoiding formal representation on a State by State basis.

Such a structure would steer the reflexion and help coordinate human and financial resources, first of all on existing programmes, then on innovative themes selected acording to supra-regional priorities, such as the development of satellite monitoring of the Mediterranean, teacher training, the implementation of a GIS adapted to the management of coastal areas, etc...

N.B.: This structure could be set up quickly, without any particular costs.

Proposal 2 : Technological coordination of EC programmes for the protection and sustainable management of the Mediterranean coast

As emphasized in UNCED Agenda 21, and hammered out repeadetly in our report, the coastline is a priority area for intervention. It is there that concerted actions for sustainable protection and development must first apply. Unfortunately, in the absence of a well-organized lobby, this ecosystem is very much "under-represented" in

the various national and EC programmes.

We propose in a first phase that a specific MEDCOAST program be launched by the EC. It would regroup all scientific projects and initiatives that deal specifically with the mediterranean littoral, providing them with an integrated, coherent, perspective. It would draw, where necessary, on the relevant components of existing programmes (such as MEDCAMPUS, MAST, MEDURBS, MEDMEDIA ...), and, for increased relevance, would rely on strong coordination at the regional level.

Proposal 3 : An EC Programme for the sustainable development of the Mediterranean

Sustainable development in Mediterranean countries will depend largely on our collective capacity to minimize environmental degradation. This will involve a series of EC initiatives at the technical levels (technical assessment of environmental quality, protection methodology, coastal management techniques, monitoring, waste treatment processes, environmental restoration), coupled with actions in the field of socio-economic and cultural cooperation with TMCs.

However, if carried out in a piece meal, independant fashion, these actions will have little chance of success in the long term. The international METAP Programme for the Mediterranean, run jointly by the EC, the World Bank, UNDP and IEB, operates largely through bilateral agreements. This is not enough, and it is only by setting up explicit integration mecanisms, that the European Community can hope to make a lasting difference in the region.

In this perspective we recommend that the European Coordination Committee for the Mediterranean (see proposal 1) work gradually towards gathering all EC mediterranean activities under one umbrella: an EC programme for the sustainable development of the Mediterranean, which might benefit from the experience gained by the programme TACIS devoted to Eastern Europe.

Proposal 4 : Enhance the cooperation between programmes and institutions on both shores.

The object is to encourage collaboration, with the active support of the EC and through existing networks, between scientific communities on both shores, and to develop common programmes with clearly defined objectives, not only on research but also on training (particularly the training of teachers) and scientific appraisal.

Remarks:

Universities and Research Institutes are priviledged partners for some of the programmes implemented by the Commission in the Mediterranean, largely because of the acknowledged importance of teacher training. This activity constitutes a key proposal in seeking more equity in the relationship between the North and South of the region, encouraging the implementation of a system linked to human resources and destined to remain part of the TMC's heritage.

Experience to date in Europe in carrying out concerted research and training activities shows that the most efficient route lies in the use of cooperation networks: such structures guarantee an interdisciplinary effort and make it possible to improve the necessary complementaries. Yet the Community programmes, which follow essentially sectorial priorities, do not allow the intrinsic potentialities of the networks to be exploited.

Proposal 5 : Develop a Mediterranean communication policy

Developing communication and information-exchange implies seeking instances of complementarity so as to have the widest choice of alternatives for effective action. It is a step which is indispensable in any quality action in a domain which is so highly nuanced as is the Mediterranean environment.

Bearing in mind the complexity of the fields involved, the management and protection of coastal environments demand strict coordination between all structures likely to be mobilized. These structures themselves bring about an exchange of information which must find its place in a global communication strategy between both shores of the Mediterranean. As an indication, the relevance of scientific dissemination and of multilateral cooperation between the media must be emphasized.

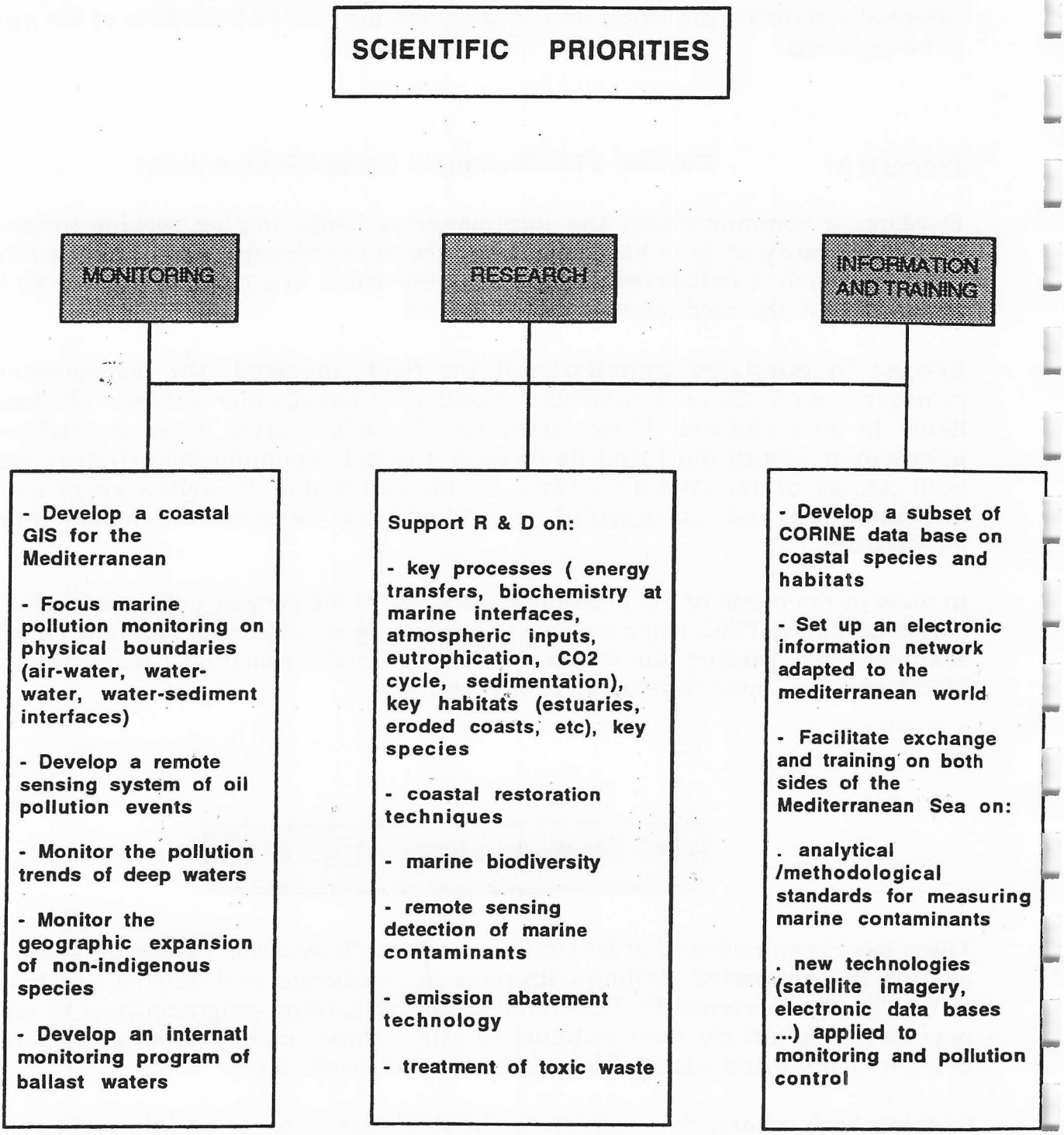
In view of the needs of the decision-makers and of the general public, as expressed in particular by the TMC, being capable of responding to conjectural demands remains an acknowledged priority for which the "European Coordination Committee for the Mediterranean" must develop an *ad hoc* strategy.

B - MAIN SCIENTIFIC TARGETS

These have been reviewed at length in our report. They cover a range of issues, many of them interconnected, dealing with research, monitoring and training (see synthesis in Fig. 2). The concerned EC Directorates, through existing programmes or by creating new ones, should do their outmost to attain those objectives, so as to facilitate decision-making and sustainable management in coastal areas.

Ranking high among these targets is the implementation of an information system based on regional monitoring. This will involve the development, in close cooperation with university and industry circles, of a coastal Geographic Information System (GIS), which would be readily accessible to national and regional decision centres on both shores.

Fig. 5


SCIENTIFIC PRIORITIES
MONITORING
RESEARCH
INFORMATION AND TRAINING
- Develop a coastal GIS for the Mediterranean
- Focus marine pollution monitoring on physical boundaries (air-water, water-water, water-sediment interfaces)
- Develop a remote sensing system of oil pollution events
- Monitor the pollution trends of deep waters
- Monitor the geographic expansion of non-indigenous species
- Develop an internatl monitoring program of ballast waters
Support R & D on:
- key processes (energy transfers, biochemistry at marine interfaces, atmospheric inputs, eutrophication, CO2 cycle, sedimentation), key habitats (estuaries, eroded coasts, etc), key species
- coastal restoration techniques
- marine biodiversity
- remote sensing detection of marine contaminants
- emission abatement technology
- treatment of toxic waste
- Develop a subset of CORINE data base on coastal species and habitats
- Set up an electronic information network adapted to the mediterranean world
- Facilitate exchange and training on both sides of the Mediterranean Sea on:
. analytical /methodological standards for measuring marine contaminants
. new technologies (satellite imagery, electronic data bases ...) applied to monitoring and pollution control

This system will have the capacity to supply syntheses on the basis of the analysis of carefully selected variables covering key oceanic parameters, coastal use, vulnerable species and biotopes, and demographic and industrial evolution on a zone-per-zone basis. It will be designed so as to provide concrete facts quickly, to facilitate decision-making process.

It will include a data gathering system based on remote sensing and in situ measurements, and an interactive data bank, accessible to governmental agencies and to scientific institutions on both shores. This will obviously take into account the compatibility requirements between the various computer and telecommunication systems involved in the region. Initially developed as a prototype covering a sub-regional entity, on the basis of national structures, it shall integrate, and enrich, the European system CORINE, which to this day largely ignores marine ecosystems.

C - OPERATIONAL ELEMENTS

Proposal 6: Creation of a European Observatory for the Mediterranean Sea

To enhance efficiency and interactions we propose that the nucleus of the activities just described be working in interaction under the same roof. To this end the creation of a European Observatory for the Mediteranean Sea is called for. The Observatory would be made up of a small Unit of 12-15 experts/technicians. They would benefit from the latest technological facilities (such as satellite imaging, interactive data bank, electronic coastal mapping, GIS, etc ...), so as to detect early warning signals of incoming problems, react to them and alert the relevant national and international agencies.

Remarks:

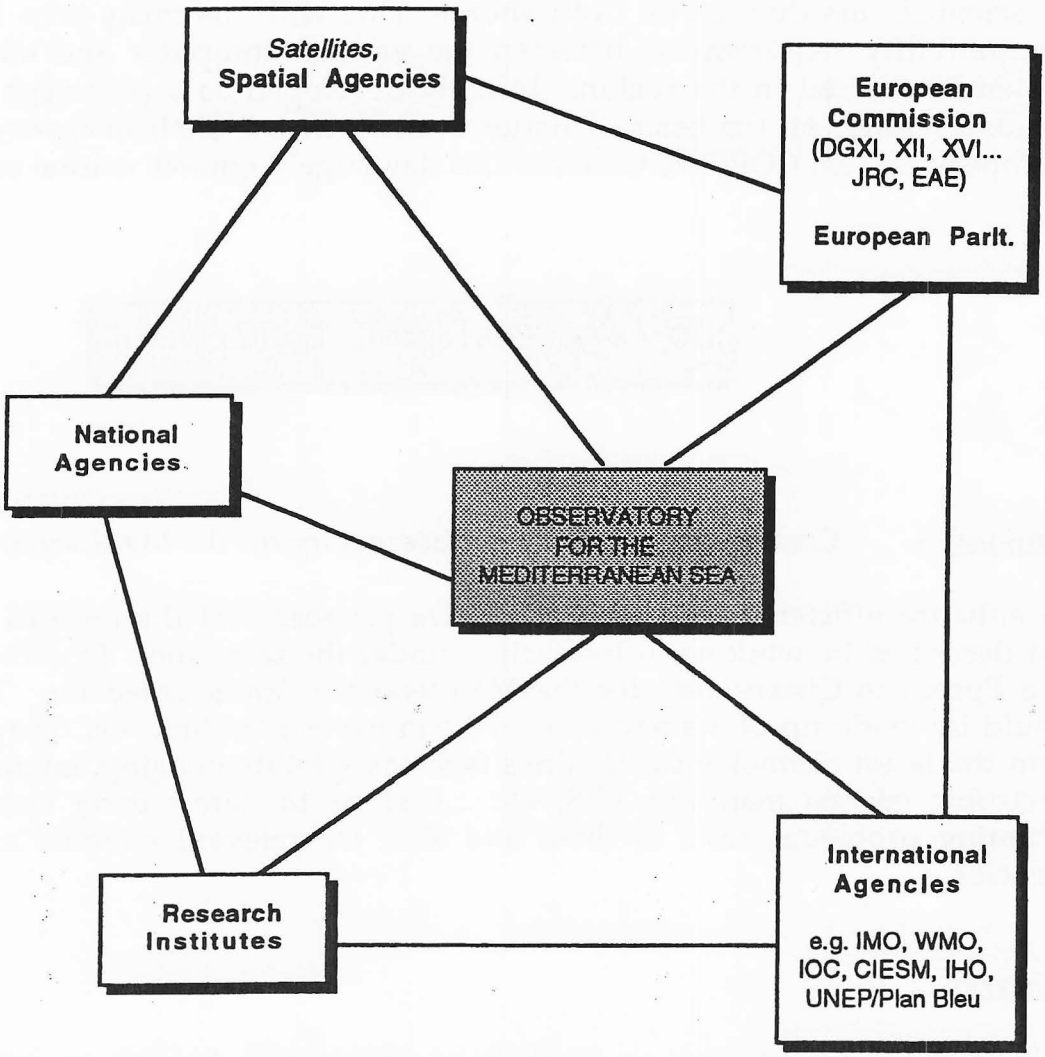
This would be in fact a "sensitive membrane," with a highly effective, interdisciplinary field of observation, so as to collect reliable data, available for comparisons throughout the whole Mediterranean perimeter. The state of the Mediterranean could thus be studied and monitored in real time.

This Centre could operate, for one thing, as an "operational antenna" for the future European Agency for the Environment. It must retain at all costs a small critical size, optimizing its reaction time and flexibility, while minimizing "red tape" and the risk of becoming yet another bureaucracy.

N.B.: This option would have manifold consequences, giving Europe a remarkable tool for decision-making, which could be tested first in a restricted pilot area - recording the data collected by two or three countries - before adaptation to the whole Mediterranean.

Fig. 6

Proposed interactions for the Mediterranean Observatory



<u>Proposal 7</u>: Legal enforcement and coordination

Without a stronger EC jurisdiction for the protection of the marine environment, the above proposals will have a limited impact in the field. The EC should support the consolidation, strict application and better coordination of the legal instruments aiming to protect the marine environment in general, and particularly the Mediterranean.

V - SELECTED REFERENCES

Alpers, W. and H. Hühnerfuss. 1989. The damping of ocean waves by surface films: a new look at an old problem. J. Geophys. Res. 94: 6251-6265.

Barth, H. and L. Fegan. 1990. Eutrophication–related phenomena in the Adriatic Sea and in other Mediterranean coastal zones. Water Pollution Research Report, 16. Commission of the European Communities, Brussels, 255 p.

Béthoux, J.P. 1989. Oxygen consumption, new production, vertical advection and environmental evolution in the Mediterranean Sea. Deep-Sea Research, 36, 769-781.

Béthoux, J.P., Gentili B., Raunet J. and D. Tailliez. 1990. Warming trend in the Western Mediterranean deep water. Nature, 347, 660-662.

Béthoux, J.P., Courau P., Nicolas E. and D. Ruiz-Pino. 1990. Trace metal pollution in the Mediterranean Sea. Oceanologica Acta, 13, 481-488.

Boudouresque, C.F. et 18 collaborateurs. 1990. Livre rouge des végétaux, peuplements et paysages marins menacés de Méditerranée. UNEP public. 250 p.

Boudouresque C.F., Avon M., Gravez V. (eds). 1991. Les espèces marines à protéger en Méditerranée. GIS Posidonie publ. 448 p.

Braudel, F. 1966. La Méditerranée et le monde méditerranéen à l'époque de Philippe II (3 volumes). Armand Colin, Paris.

Briand, F. (ed.). 1992. Avancées en océanologie méditerranéenne. Bull. Inst. Océanogr. Monaco, no spécial 11, 324 p.

Briand, F. 1992. Priorities for research and pollution control in the Mediterranean sea. A preliminary report for the European Parliament. PE 158.304, Luxembourg, 46 p.

Caddy, J.F. 1990. Options for the regulation of mediterranean demersal fisheries. Natural Resource Modeling, 4(4): 427-475.

Caddy, J.F. and R.C. Griffiths. 1990. Tendances récentes des pêches et de l'environnement dans la zone couverte par le Conseil Général des Pêches pour la Méditerranée (CGPM). Etudes et Revues, CGPM, 63 : 92 p.

CGPM / ICCAT. 1990. Report of the Expert Consultation on Evaluation of Stocks of Large Pelagic Fishes in the Mediterranean Area. FAO Fish. Report no. 449, 282 p.

CGPM. 1992. Report of the Forth Session of the Technical Consultation on Stock Assessment in the Eastern Mediterranean. FAO Fish. Report no 477, 172 p.

Charbonnier, D. et al.. 1990. Pêche et aquaculture en Méditerranée. Etat Actuel et Perspectives. Les Fascicules du Plan Bleu, no 1, Economica, Paris, 94 p.

CIESM. 1988. Condensés des Travaux présentés lors du XXXIème Congrès de la Commission à Athènes, Grèce. Rapp. Comm. int. Mer Médit. vol. 31, Monaco, 384 p.

CIESM. 1990. Condensés des Travaux présentés lors du XXXIIème Congrès de la Commission à Perpignan, France. Rapp. Comm. int. Mer Médit. vol 32, Monaco, 366 p.

CIESM. 1992. Condensés des Travaux présentés lors du XXXIIIème Congrès de la Commission à Trieste (Italie). Rapp. Comm. int. Mer Médit. vol. 33, Monaco, 408 p.

Cini, R.; P. P. Lombardini and H. Hühnerfuss. 1983. Remote sensing of marine slicks utilizing their influence on wave spectra. Int. J. Remote Sensing 4 : 101-110.

Commission des Communautés Européennes. 1990. Evaluation des applications possibles des données satellitaires d'observation de la Terre aux politiques communautaires. Rapport final XII/ 467/ 90 édité par Scot Conseil, Bruxelles, 2 volumes, 360 p.

Commission des Communautés Européennes. 1991. Résultats du programme CORINE. SEC (91) 958, Bruxelles, 119 p.

Council of Europe. 1992. Conservation of the Mediterranean monk seal - Technical and scientific aspects. Envir. Encounters 13 : 1-94.

FAO. 1985. Atlas of the Fisheries of the Western and Central Mediterranean. Ed. by D. Charbonier and S. Garcia. FAO-CGPM and CEE, 14 charts.

FAO. 1993. Examen de l'état des ressources ichtyologiques mondiales. Première partie. Ressources marines. FAO Circ. sur les pêches no 710, FAO, Rome, 123 p.

Fredj, G. 1973. Stockage et exploitation des données en écologie marine. B. Collecte des données en mer et archivage (stations ponctuelles dans l'espace et dans le temps). Mém. Inst. océanogr. Monaco, 5 : 1-60.

GESAMP. 1985. Atmospheric transport of contaminants into the Mediterranean region. UNEP Regional Seas Reports and Studies no 68, 58 p.

Gizard, X. (ed). 1993. La Méditerranée Inquiète. Datar / Editions de l'aube. Paris, 192 p.

Grenon, M. and M. Batisse. 1989. Futures of the Mediterranean Basin - The Blue Plan. Oxford University Press.

Hengstermann, T. and R. Reuter. 1990. Lidar fluorosensing of mineral oil spills on the sea surface. Appl. Opt. 29 : 202-208.

ICES. 1991. Report of the ICES Advisoty Committee on Marine Pollution. Cooperative Research Report, no. 177, Copenhagen, 103 p.

ICES, International Council for the Exploration of the Sea. 1992. Effects of Harmful Algal Blooms on Mariculture. ICES Cooperative Research Report, no. 181, Copenhagen, 38 p.

ICES. 1992. Report of the study group on ecosystem effects of fishing activities. ICES, C.M. 1992/G:11 Ref.: Session T, 144 p.

IMO, International Maritime Organization. 1991. Proceedings, International Seminar on Protection of Sensitive Sea Areas, Malmö, Sweden.

IOC, Intergovernmental Oceanographic Commission. 1992. Guide to satellite remote sensing of the marine environment. SC-92/WS/30, UNESCO, Paris, 178 p.

IOC/FAO. 1992. Intergovernmental Panel on Harmful Algal Blooms. First Session. IOC/FAO IPHAB I/3, Paris.

Jeftic, L., Milliman J.D. and G. Sestini (eds). 1992. Climatic change and the Mediterranean. E. Arnold, London, 674 p.

Lebullenger, J. and D. Le Morvan (eds). 1991. La Communauté Européenne et la Mer. Economica, Paris, 830 p.

Malanotte-Rizzoli, P. and A. Hecht. 1988. Large-scale properties of the eastern Mediterranean: a review. Oceanologica Acta, 11: 323 - 335.

Marchetti, R., Gaggino G.F. and A. Provini. 1988. Red tides in the Northwest Adriatic. UNESCO reports in marine science, 49, 133-142.

Margalef, R. (ed.). 1985. Western Mediterranean. Pergamon Press, Oxford, 363 p.

Marmanteau, C. and A. Veglia. 1992. Determination of seasonal variations in the atmospheric concentrations of lead, cadmium and polycyclic aromatic hydrocarbons in Monaco. WMO/UNEP/MAP Tech.Rep.Series, 64, 57-65.

Millot, C. 1991. Mesoscale and seasonal variabilities of the circulation in the western Mediterranean. Dynamics of Atmospheres and Oceans, 15: 179 - 214.

Millot, C. 1992. Are there major differences between the largest mediterranean seas ? A preliminary investigation. Bull. Inst. Océanogr. Monaco, 4: 3 - 25.

Nemrow, N. L. and A. Dasgupta. 1991. Industrial and Hazard Waste Treatment, Van Nostrand Reinhold, New York.

Olivier, J., Gérardin N. and A. Jeudy de Grissac (eds). 1992. Economic impact of the Mediterranean coastal protected areas. MEDPAN - METAP Program, Medpan News, 3 : 1-98.

Petit, M. and J.M. Stretta (eds). 1990. Halieutique, océanographie et télédétection.

Bull. Inst. Océanogr. Monaco, no spécial 6, 229 p.
Reuter, R. and R.H. Gillot (eds). Proceedings of the 1987 International Colloquium on Remote Sensing of Pollution of the Sea, Oldenburg, Germany. Commission of the European Communities, Brussels, S.P.I. 87.46.

Robinson, A.R. et al. 1991. The eastern Mediterranean general circulation: features, structure and variability. Dynamics of Atmospheres and Oceans, 15: 215 - 240.

Skea J. 1992. Environmental issues facing the oil industry, Energy Policy, Butterworth - Heinemann Ltd, London.

Suau, P., 1979. Un ejemplo de regulación de la pesquería. Inv. Pesq., 43(1): 21-29.

Suess J. M., Grefen K. and W.D. Reinisch. 1985. Ambient air pollutants from industrial sources; a reference handbook, (World Health Organization, Regional Office for Europe), Elsevier.

Theis, R., W. Alpers, V. Wismann and H. Hühnerfuss. 1992. The damping of ocean surface waves by monomolecular sea slicks of different visco-elastic properties measured by a 4-frequency scatterometer aboard a helicopter, Proceedings of the 1992 International Geoscience and Remote Sensing Symposium (IGARSS'92), Houston, Texas, USA, Vol.II, 865-868.

UNEP. 1984. Pollutants from land-based sources in the Mediterranean. UNEP Regional Seas Reports and Studies, 32, 97p.

UNEP/ Mediterranean Action Plan, 1987. Evaluation de l'état actuel de la pollution de la mer Méditerranée par les hydrocarbures de pétrole. Athènes, 104 p.

UNEP. 1989. State of the Mediterranean Marine Environment. MAP Technical Report Series No. 28. Athens, 225 p.

UNEP/FAO. 1990. Final reports on research projects dealing with eutrophication and plankton blooms. MAP Technical Report Series no. 37, Athens, 74 p.

UNEP/ WMO. 1992. Airborne pollution of the Mediterranean Sea. MAP Technical Reports Series no 64, Athens, 246 p.

Vollenweider, R. A., Marchetti, R. and R. Viviani (eds.). 1992. Marine coastal eutrophication, Elsevier, Amsterdam.

The World Bank, The European Investment Bank. 1989. The Environment Program for the Mediterranean. Preserving Shared Heritage and Managing a Common Source, Proceedings of the "World Bank-Investment Bank Workshop on the Environmental Program for the Mediterranean", Paris, December 7-8, 1989.

Zibrowius H. 1991. Ongoing modification of the Mediterranean marine fauna and flora by the establishment of exotic species. Mésogée, 51 : 83-107.