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Although this report was prepared at the beginning of 1995, some statistical information (e.g. Tables I, III and IV), obtained from various documents, covers the period from 1968 to 1990. For that reason some data in this report are referred to as ex-Yugoslavia, unless data specific to any particular new country are available and used herein.

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Executive Summary

The Contracting Parties to the Barcelona Convention require the Coordinating Unit for the Mediterranean Action Plan to provide periodic reviews of the state of the Mediterranean coastal and marine environment to assist them in determining the evolution of the Action Plan and possibly that of the Convention, its Protocols and the Common Measures already adopted.

The present document is the second review of this type, the previous one having been produced in 1989. It attempts to evaluate, as far as possible, trends in the state of the marine and coastal environment as a basis for dealing with new environmental problems, as and when they arise and are confirmed by scientific investigation.

The document has three main parts: (i) an introduction (section 1) giving the background, aims and objectives, and the geographical and ecological setting; (ii) the main body (sections 2 and 3) which outlines the major factors (human appellation pressure and economic activities, for example) involved in the generation of the main pollutants and the principal factors of environmental degradation; and (iii) an overall assessment of the situation and conclusions.

The Mediterranean, as a semi-enclosed sea, with a very high ratio of sea area to basin area, presents a number of physical and geographical features that, in turn, determine which environmental factors play an important role in degrading the marine and coastal environment which makes up nearly all the basin. There are also some factors that the basin has in common with other regions.

The presence of coastal mountains

around most of the basin, hence the historical tendency for populations to settle around natural port areas strongly isolated from each other, has favoured maritime interchange, rapid fresh-water/riverine run-off, hence strong soil erosion and sometimes heavy flooding in the few main river-basin plains (notably, the Ebro, the Rhone, the Po and the Nile), though depriving the basin, as a whole, of the possibility to stock large amounts of fresh water.

The generally pleasant climate (except in mid-summer, possibly), in addition to the comparative isolation of coastal communities in the past, has helped to foster some of the world's greatest civilizations. Thus, the climate, the often spectacular landscape and sites of great historical, architectural and archaeological interest has made the Mediterranean the objective of the world's most intensive tourism, and the coastal zone the objective of a large majority of the resident population.

Although the growth in the human population, both resident and seasonal (international tourists) is continuing, the rate of growth overall is expected to decrease gradually into the next millennium, but the relief that this decrease in pressure might be expected to bring to the environment cannot be relied upon to avert serious environmental problems in the region.

Of the economic and related activities that have the greatest impact now, and for the foreseeable future, the following are the most important:

- Urbanization, which is intensive around the major port-cities and extensive along most of the coast, especially on

the northern side of the basin, in response to the high demand for residential and recreational facilities. The treatment and disposal of urban solid and liquid wastes continues to constitute one of the major environmental factors, especially in the summer months when the population of many sea-side resort towns is increased several times relative to the stable resident population. Urbanization is increasing the demand for domestic drinking and washing water from a relatively precarious resource, and is reducing the ecological space necessary to the survival of flora and fauna, hence to the maintenance of biological diversity.

- Industry, which generally becomes established around the main port-city conurbations or, for those industries requiring abundant cooling water and a relatively easy way to dispose of wastes, on the coastline or along the major rivers. Although the basin is not a major industrial area, the growth in industrial activity, especially on the southern and eastern sides is considerable and will continue for the foreseeable future. The environmentally sound disposal of industrial solid and liquid wastes is also one of the major factors and includes a major contribution to air pollution. Industry is also having a significant adverse effect on the flora and fauna of the basin.

- Energy generation and consumption, as a natural consequence of increased population and increased industrial activity, contributes mainly to atmospheric pollution in the region, through the burning of fossil fuel for vehicles and domestic heating, and to the degradation of aquatic ecosystems through the discharge of heated cooling water. Energy-generating plants and hydroelectric generators, in particular, have a strong impact on the ecosystems in their vicinity. The exploitation of petroleum degrades the environment in its vicinity during the drilling stage and during maritime shipment insofar as soil tankers

discharge dirty bilge water or clean their tanks in the Mediterranean. The increasing amount of refinement in the countries of origin, while not necessarily increasing the overall risk, spreads that risk over a greater number of sites (the refineries) and, likewise, the environmental pollution (notably air pollution).

- Transportation systems, also as a response to increased population growth and demands, including those of tourism, are growing steadily, using up land and generating atmospheric pollutants and noise. These factors also have a significant adverse impact on historical buildings. The long-standing need to increase communication between the numerous coastal valleys has led to a considerable amount of tunnelling to create motorways running parallel to the coast and from the coast to the hinterland, to move people and goods. The Suez Canal also continues to ensure a high level of maritime navigation, with an increasing risk of accidents involving hazardous substances. The numbers of motor vehicles, ships and aircraft operating in the basin is growing, and faster even than the population.

- Agriculture is losing, in terms of land space, to the foregoing factors, but the demand for agricultural products, mainly to meet the basin's needs, is also growing. The principal response is to intensify agricultural production, which places increasing demands on water resources for irrigation and on industry for pesticides, herbicides and fertilizers. The move to intensive horticultural production is continuing and is likely to grow, especially to meet the very high seasonal demand of the tourist population. The demand for meat, and sometimes the shortage of suitable land, lead to overgrazing and destruction or degradation of significant areas of open land and of forests. The washing out of pollutants (pesticides and herbicides) and excess fertilizers to the sea directly, by land run-off, or indirectly, via rivers, creates

a significant negative impact on coastal marine ecosystems. In the case of fertilizers (based mainly on nitrogen and phosphorus compounds), serious disturbance of the marine ecosystem, in the form of eutrophication (see below), occurs in inshore coastal waters.

- Fisheries are as much, or more, adversely affected by over-fishing than by environmental pollutants, but the addition of the two factors is creating a serious danger to fishery resources in the basin, particularly since the main habitat of the resources is the coastal/inshore sea and the continental shelf, which is relatively narrow in most areas because of the strongly sloping mountainous coastal terrain. The growth of mariculture is a response to the demand for fish and the decreasing prospects for the capture fisheries. Mariculture is both a victim of environmental degradation (e.g., siltation) and pollution, wherever toxic wastes are discharged into coastal bays and lagoons, and a cause of such degradation in its vicinity insofar as the cleaning out or flushing of mariculture sites releases excess food material and, in some cases, chemicals (e.g., fungicides) used in mariculture.

- Forests are being increasingly endangered by the increasing number of forest fires; reforestation does not appear to be keeping up with the loss of forests from exploitation and fires. Forests are an important factor in soil conservation, hence their destruction or loss adds to this major environmental factor.

- Mining is the cause of extensive eyesores due to the area of land surface destroyed, in open-cast mining, and that occupied for the disposal of mine tailings and slurries. The destruction of the local ecosystem is usually assured. The negative effect of sea-bed mining for sand and gravel for building materials is relatively short-lived (a few weeks) once the dredging ceases; the heavy siltation in some

areas helps to restore the sea bed to re-establish benthic communities.

The occupation of the land and the pollution of the sea affect the distribution, abundance and survival of the related flora and fauna; and of the ecosystems into which they are organised; the human population nevertheless depends directly or indirectly on the success and survival of many of these species. In certain areas, this occupation of the land interferes seriously with the seasonal migration of birds, and tourist pressure may also compromise the breeding of marine turtles and the monk seal.

The levels of all the main marine pollutants, in terms of the minimum and maximum values observed overall, in sea water, in biota and in marine sediments are, as far as reliable data are available, given in section 3 together with the main effects, as far as they have been observed, on the marine biota, on species of commercial interest and on human beings exposed to them through contact or through consumption of contaminated food.

As indicated above, air pollution is a serious problem in the region, especially over the major conurbations. In some cases, the local meteorology is not favourable to the dispersion of this pollution, which arises from motor-vehicle exhausts, domestic heating systems, most industrial processes (especially metal smelting and refining) aided and abetted by carbon soot, Saharan dust and other solid particles in the atmosphere which provide a vehicle for many pollutants: metals, many organohalogenes and hydrocarbons, in particular. Pollutants from sources well within Europe are known to reach the Mediterranean within 24-48 hours.

Section 3.6 briefly describes the implications of climatic change for the region; many of these changes spring from the air pollution, in the form of the "greenhouse" gases responsible for global warming: carbon dioxide, nitrous oxide, methane, for example, as well as water vapour.

In the face of the growing pollution of all the main environmental compartments (water, organisms, sediments, air, human beings), efforts have increased, relatively

slowly still, to establish protected areas and to protect endangered species. Some of these protected areas, which are sites of natural beauty, ecological interest, or historical and architectural interest, are not universally welcomed by the local populations concerned or are subject to ecological attack at a distance, mainly in the form of waterworks (dams, irrigation systems etc.) upstream of the protected areas.

The legal and institutional framework in which protected areas operate remain inadequate or very complex, with considerable overlap of responsibilities between national and local entities, governmental or non-governmental.

This is now less true for environmental management as a whole, since all the countries of the region have established some

form of specific governmental structure with responsibility for such management and control. There is still, in most cases, too great a dispersion of responsibility, but the situation has evolved considerably in the last few years.

The Barcelona Convention, its Protocols and Common Measures provide the principal guidelines, and much national policy, as well as that of the Mediterranean Action Plan, is guided by these dispositions.

The regional mechanisms established under the Action Plan - the Regional Activity Centres and the Mediterranean Pollution Monitoring and Research Programme (MED POL) - and the continued support of the concerned UN agencies, are meeting some of the requirements for establishing a basis for sustainable development in the region.

1. Introduction

1.1 Background

The Coordinating Unit for the Mediterranean Action Plan is required to provide the Contracting Parties to the Barcelona Convention with a periodic review of the state of the marine and coastal environment in the Mediterranean Sea. A previous report on this subject was issued in 1990. These reviews contribute to the information base on which the Contracting Parties determine the evolution of the Action Plan and, possibly, that of the Barcelona Convention, its Protocols and the associated Common Measures. This evolution is currently embodied in the draft Barcelona Resolution, to be considered by the next meeting of the Contracting Parties in June 1995, and expressed in the related proposals for a Phase II of the Action Plan and for the Activities to be approved for 1996-2005.

The previous and the present document on the state of the Mediterranean environment are based primarily on information and/or data submitted to the Coordinating Unit by: (i) the Contracting Parties and their specialized environmental and marine scientific institutions; this information (*sensu lato*, here including data) is itself basically that, obtained in the context of MAP projects undertaken by the aforementioned institutions; (ii) the MAP Regional Activity Centres, through their regular activities, which are approved by the Contracting Parties; and (iii) UN agencies cooperating with UNEP.

To assist the Action Plan Coordinating Unit in the preparation of the present report and for other relevant purposes, the countries were invited to submit national reports on their activities relating to the Plan. Israel, Malta,

Monaco and Slovenia submitted responses based on the proposed structure of the document, while Albania, Croatia, Egypt, France, Greece, Italy, Lebanon, Morocco, Spain, Syria, Tunisia and Turkey submitted national documents with a relevant but wider purpose.

1.2 Aims and Objectives

The principal aim of a periodic review is to allow the Contracting Parties to evaluate, as far as possible, trends in the state of the marine and coastal environment, in general, to enable them to deal with new environmental problems, as and when they arise and are confirmed by the results of scientific investigation, monitoring and environmental impact assessment.

What can be measured and where and when it can be measured (given the wide range of operational and analytical capabilities - normal in so large a region as the Mediterranean) makes it extremely difficult to monitor over a long period and a large area the numerous key pollutants in all the main environmental compartments (air, coastal land and rivers, sea water, sea bed, marine and littoral organisms). Moreover, the measurement or assessment of the effects, good as well as bad, of individual pollutants is still very much experimental, at best, and anthropocentric, at worst. And, finally, marine scientists are much less interested, if at all, in routine monitoring than in what might loosely be called marine environmental chemistry.

It has not been possible in the present review to explore more than very superficially the scientific literature, except insofar as the available MAP documentation itself comprises

specific reviews in particular areas or subjects.

At the same time, it is not simply an update of the report by Jeftic *et al.* (1990), partly because its structure is somewhat different. It attempts to summarize the main economic activities in the region, emphasizing those that have a significant, and generally adverse, impact on the marine and coastal environment and the associated resources. It then indicates the levels of key pollutants or contaminants in the main environmental media (water, sediments, biota and air) and their main effects on the resources and on human beings. The general policy, legislative and institutional context is covered to show the framework in which the Mediterranean Action Plan operates, then the main conclusions and overall assessment of the state of the Mediterranean marine and coastal environment are exposed.

A particular effort has been made to relate human population pressures and economic activities to the environment in which they are developing (and must continue to develop, preferably in a sustainable way, if the region is to be saved from deep and long-lasting degradation) and to the effects of the pollution that such activities generate - on the human population itself and on the animals and plants, and the ecosystems into which they are organized for their survival, on which the human population so intimately depends for its own survival.

The immense complexity of the Mediterranean basin also makes it virtually impossible to provide a simple, straightforward description of the state of the marine and coastal environment. An attempt has therefore been made to avoid providing a huge mass of diverse data, but rather to present an overall picture of the problems, even if most of these are familiar to all those involved in Mediterranean affairs. Some, however, are not so well known, and a few potential problems are also suggested. In any case, the danger of not dealing with such problems on the grounds that they are too complex or too variable from sub-region to sub-region, if not from place to place, must be avoided.

The basin as a whole was last "coordinated" under the Roman Empire, to serve the interests of that Empire. The Mediterranean Action Plan is a present attempt

to engage a modern era of regional coordination, in the interests, fundamentally, of the whole human race.

1.3 Geographic and Ecological Setting

The geographical and ecological setting of the Mediterranean Sea has been suitably described in the Blue Plan (Grenon and Batisse, 1989) and by Jeftic *et al.* (1990), subjects. It is therefore only necessary to recall here some basic information, particularly that which is helpful in explaining the state of the Mediterranean coastal and marine environment as it is today and as it is evolving under the impact of human activity in this environment and in its immediate hinterland.

The Mediterranean Sea covers an area of some 2.5 million km², with an average depth of 1.5km and a volume of 3.7 million km³. It is some 3800km wide, from west to east, and has a maximum N-S distance of 900km (between France and Algeria). It comprises two main basins, the Western and the Eastern, connected principally by the Strait of Sicily, which is 150km wide and about 400m deep, at most. The Western Basin, covering an area (at the sea surface) of some 0.85 million km², has a secondary basin: the Tyrrhenian Sea. The Eastern Basin covers an area of some 1.65 million km² (Fig. 1).

Although almost an enclosed sea, the Mediterranean is connected to the Atlantic Ocean by the Strait of Gibraltar, which has a sill 15km wide and 290m deep (at maximum depth), and to the Sea of Marmara (and thus the Black Sea) by the Dardanelles Strait, which has a width between 450m and 7.4km and a maximum depth of 55m. It has also, since the late-19th century, been connected to the Red Sea by the Suez Canal (120m wide and 12m deep).

The Mediterranean Sea is essentially a relic of the once great Tethys Sea that largely separated the European tectonic plate (continent), to the north, from the African plate (continent), to the south and west (originally, some 200 million years ago). The eastward, then northward, movement of the African plate allowed the Tethys Sea to link what is now the North Atlantic Ocean and now the Indian Ocean (Masclé and Rehault, 1991).

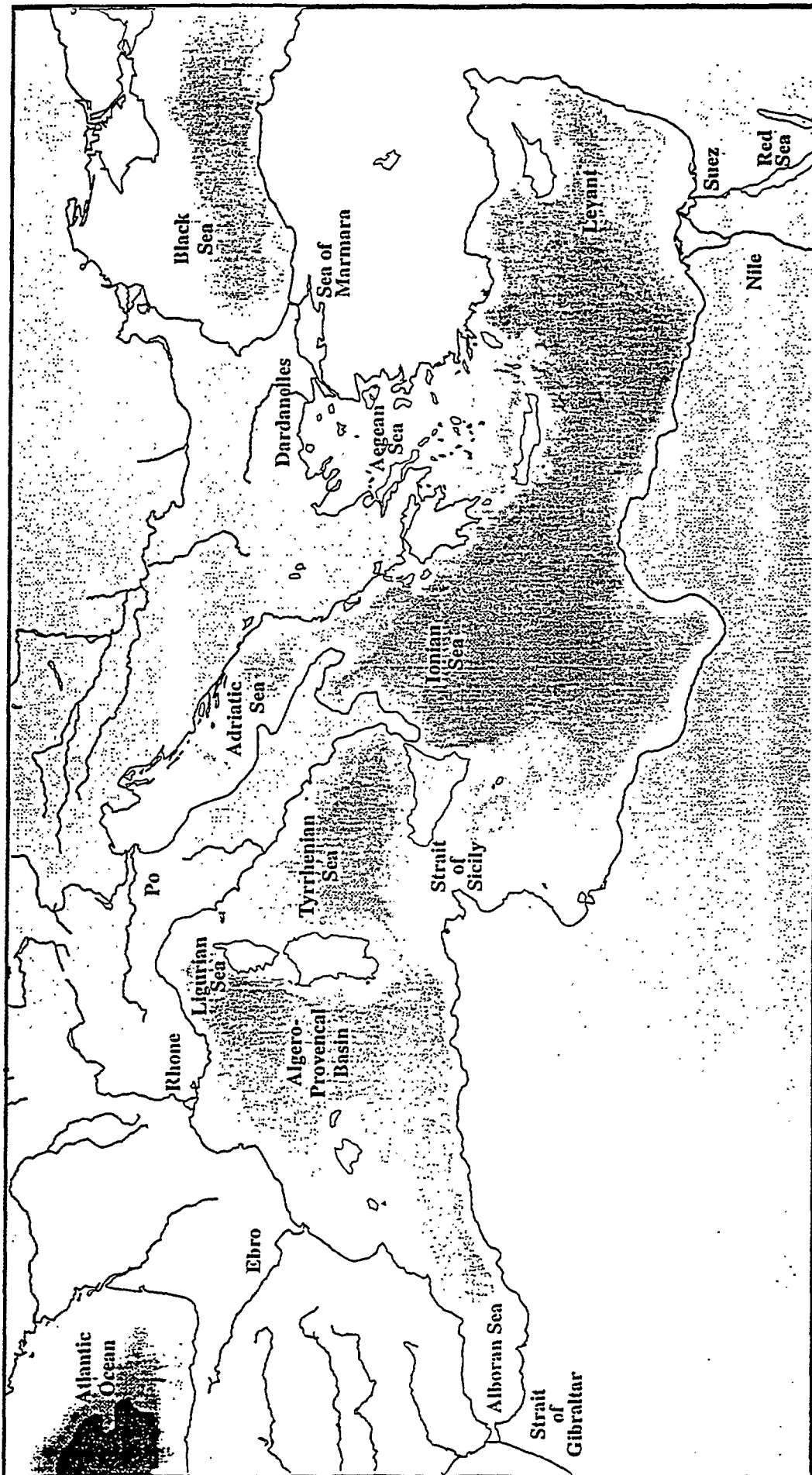


Fig. 1. The Mediterranean Sea

The impact of the African crustal plate against the Eurasian plate has raised mountain ranges all along the northern side: the Sierra Nevada (Spain); the Pyrenees (Spain-France); the Alps (France-Switzerland-Austria-Italy-Slovenia); the Apennines (Italy); the Dinaric Alps (ex-Yugoslavia); and the Taurus (Turkey). It has also led to the formation of the Atlas mountains in northwestern Africa, but, between Tunisia and the Near East, there is a vast mountainless desert. The main results of this tectonic activity (the subduction of the African plate under the Eurasian plate), which is of considerable relevance to the present-day marine and coastal environment, are: (i) the creation of a virtually enclosed sea; (ii) the high ratio of the area of the Mediterranean Sea to that of its drainage basin; (iii) marine basins of considerable maximum depth (>4000m); (iv) the high level of volcanic and seismic activity; (v) a much damped tidal regime; and (vi) a specific wind regime.

Factor (i) - enclosed sea - means a slow replacement of the sea water from the Atlantic and, to a much lesser extent, from the Black Sea, hence the means for the Mediterranean region to leave a very strong "imprint" (as very high salinity, due to high evaporation) on its sea water, which can be traced at depth (about 500m) throughout the central Atlantic Ocean after having exited over the Gibraltar sill below the incoming Atlantic surface water.

Factor (ii) - small drainage basin - means that coastal mountains slope steeply into the sea, creating: a generally limited natural freshwater supply; a very narrow littoral zone (enhanced also by factor (v)); a narrow continental shelf which leads to low volume of shelf sea water, hence a limited amount of marine resources, living and non-living, within easy reach of the human populations on land; and, until relatively recently, a certain isolation of coastal populations around ports themselves isolated by the same mountains. This isolation has disappeared, superficially at least, as a result of modern transport and communication systems, tourism etc., but remains ingrained in the culture of coastal populations which have traditionally shown considerable independence, hence resistance to coordination on a regional basis, but also a disposition to regional trade.

Factor (iii) - great basin depth - is

essentially an obstacle to nature in the renewal of the sea water in these basin depths, and to Man in the exploitation of the resources thereof, as well as being an encouragement to their use as a place to dump, in one way or another, human waste (especially litter and garbage); a process of degradation of the deep water, comparable to, but potentially far more disastrous than, that of the Black Sea is probably under way and progressing.

Factor (iv) - high volcanic and seismic activity - speaks for itself: it represents, especially in the eastern Mediterranean, an ever present risk to the human population and to the natural resources of the region; it plays an important role in the biogeochemical cycles of the main elements on which life and human survival depend in subtle, long-term ways.

Factor (v) - damped tidal regime - generally favours coastal stability, but reduces its coastal faunal and floral diversity; it favours maritime trade and fishery, but slows the degradation and spread of floating or suspended marine pollutants such as oil.

Factor (vi) - specific wind regime - tends to act against factor (v), notably maritime trade and fishery, and floating marine pollutants.

The northern mountain ranges present significant barriers to air movement which is channelled by the mountains leading to strong wind systems; of these, the most notable are: the tramontana or cers, channelling air southeastwards across the Languedoc region in southwestern France north of the Pyrenees; the mistral, channelling air southwards down the Rhone valley; the bora, likewise, at the head of the Adriatic Sea; and the meltemi wind at the head of the Aegean Sea. These are essentially venting systems imposed by the local topography but related to the major high/low pressure fields competing over the European continent; these strong winds are of comparatively short duration, as well as being seasonal, mainly spring and summer.

On the other hand, the scirocco or the khamsin wind blows more persistently and northwards from the African or Arabian subcontinents bringing hot desert air (subsequently humidified while traversing the Mediterranean) and desert dust to the northern

side of the region.

The same mountains play a major role in the rainfall patterns of the Mediterranean Sea, the northern side being subject to seasonally heavy rains in spring and autumn, the southern side, to annual rainfall of <200mm in certain regions, mainly in the winter. The mountains also ensure a rapid and sometimes disastrous run-off leading from time to time to heavy flooding in the main river plains and deltas, notably those of the Rhone and Po.

The water balance, hence mean sea level, of the Mediterranean is maintained by the input of water from the Atlantic Ocean (at the surface through the Strait of Gibraltar), from the Sea of Marmara (also at the surface, through the Dardanelles), from rivers and direct run-off from the land, and from rainfall, to replace the loss due to evaporation. The estimated contributions are summarized in section 2.2.8, below. The residence time of the water is often cited to be about 80 years which is actually the time it would take to fill an "empty" Mediterranean with the incoming water from the above-mentioned sources. However, it may be safely assumed that some of the incoming water that finds its way into the basin depths may take 100-300 years to return to the Atlantic Ocean or the Sea of Marimara, whereas some of it may exit in only a few decades. There are thus factors favouring the acquisition of typical Mediterranean water characteristics, including those relatable to specific pollutants, and others that may allow the incoming water to emerge much less affected. Local or subregional circulation patterns are therefore of considerable importance in determining the local state of the marine environment.

With the further northward movement of the African plate towards the European plate, the embryonic Mediterranean Sea became separated completely from the Indian Ocean, probably some 50 million years ago, the "seal" being the present Levantine region. Such separation led inevitably to the virtually independent evolution, in the Mediterranean Sea and the Indian Ocean, of the species that once occupied the Tethys Sea.

At the western end of the Mediterranean, however, there has nearly

always been a connection between the Mediterranean Sea and the North Atlantic Ocean, via the Strait of Gibraltar, except for a geologically short period some 5-6 million years ago that seems to have allowed the evolution of endemic Mediterranean species. The reopening of the connection has allowed some species, especially the naturally migratory ones to become common to the Mediterranean and the eastern Atlantic.

In recent times, since the opening of the Suez Canal, certain Indian Ocean species have progressively "infiltrated" the eastern Mediterranean, sometimes competing with cousin species there. The result is an increasing "market share", ecologically speaking, if not yet in purely fishery economics terms.

The latest "invader", but from an entirely different source, is the green alga *Caulerpa taxifolia*; it was apparently introduced as a decorative aquarium alga, but eventually found its way into the sea where it is making its presence felt rather uncomfortably in the northwestern Mediterranean. A related, asiatic species, *C. racemosa*, has also been observed in Cyprus.

The species that evolved in the Mediterranean, or invaded it whenever geological opportunities to do so arose, have not marked and moulded the Mediterranean basin so much as Man. Many of the world's major civilizations have been established or have flourished there: Egyptian, Minoan, Greek (Mycænean, Hellenic), Etruscan, Phoenician, Roman, Arab, Ottoman, for example. And likewise, major religions: Judaism, Christianity, Islam.

These various civilizations, many based on empire, have considerably modified the pristine environment by the same means, practically speaking, as those used today: the growth of cities and ports, agriculture, water exploitation, industry, recreation if not tourism, as well. They have also bequeathed us a major architectural wealth, now part of the World Heritage established under the auspices of UNESCO, and a history whose influence is still with us and will be for many centuries to come.

2. Human Pressures and Economic Activities

2.1 Population Growth and Distribution

The main population parameters (total fertility rate, gross birth rate, gross death rate and rate of natural increase) for the Mediterranean countries as a group have been discussed in the Blue Plan (Grenon and Batisse, 1989); the trends are all downwards, with a rate of natural increase expected to fall below 1% early in the next millennium. Three groups of countries with differing parameters within each group are distinguished, however: (i) Spain, France, Italy, (ex-)Yugoslavia and Greece, in which the natural rate of increase is expected to fall below 0.2% by 2010; (ii) Monaco, Malta, Albania, Cyprus, Lebanon, and Israel, in which the rate is expected to fall to about 1.2% by 2010; and (iii) Turkey, Syria, Egypt, Libya, Tunisia, Algeria, and Morocco, in which this rate is expected to fall below 1.5% around 2010.

The downward trends in population growth, taken alone, suggest that the pressure due to the human population (under a specific set of socio-economic conditions) will decrease, but the significant seasonal, though perennially persistent, increase in the tourist population must be added to this population pressure.

However, in view of the close relationship between population growth (whether perennial or seasonal) and coastal development, including coastal urbanization and building and public works, with the associated and serious problems of waste treatment, energy supply, transport (of people, of goods and of hazardous substances), coastal industry and mining, among others, there is also a significant risk of a downturn in Mediterranean "international" tourist population as the "resources" - scenery, clean and

extensive beach sand, clean and healthy bathing water, for example - become degraded by the very development the tourism has largely induced.

There is thus a possible "qualitative" effect, not directly related to population growth, as well as the usual "quantitative" effect. Grenon and Batisse stress the likelihood of more and more "specialized" or "thematic" tourism, possibly involving fewer numbers paying higher amounts for the rewards sought (see section 2.2.4, below).

A distinction should perhaps be made between, on the one hand, tourists simply going from one Mediterranean country, where they reside, to another, where they holiday, and, on the other hand, those from non-Mediterranean countries (or, perhaps, from distant parts of certain Mediterranean countries themselves; e.g., France, Spain); this is because the pressure on the Mediterranean basin coastal and marine environment as a whole is likely to be less affected simply by temporary population shifts within the basin than by massive "importation" of tourists from "tourist-exporting" countries. The data do not allow such distinctions to be easily made, and the problems are treated on the basis of the temporary, seasonal influx of non-residents to tourist resorts and sites. Grenon and Batisse (1989) distinguish between domestic and international tourists and project growth in the number of international tourists from their 1985 baseline, of about 120 million, to between 150 and 225 million at the turn of the millennium, to be compared with an estimated total (international plus domestic) of 308 to 409 million.

Regarding the distribution or redistribution of population in the basin, the

main characteristics were or are: (i) the rural exodus, which reaches a natural climax, after which, the source "dries up", as is generally the case in the northern countries of the basin; (ii) in some cases, another kind of exodus, intra-regional migration, sometimes with an extra-legal component which tends to be associated with the "port of entry", is imposed on the rural exodus; (iii) industrialization, to the extent that it offers employment, is an important, but not the only, cause of the rural exodus (increase in agricultural efficiency being another factor favouring job losses in the rural society); not all industrialization has taken place in the coastal zone, however (see section 2.2.5).

2.2 Economic Activities and Coastal Development

There is a very close relationship between economic activity and coastal development. The former, even if conducted on an ideal sustainable basis, makes a number of demands on the environment, including the natural resources, in which it takes place. And, together with coastal development, it inevitably has effects on the human beings, who are the agents thereof, and on the natural resources (and the ecosystems into which such resources are normally organized). The coastal zone is subject to multiple uses by human beings; overall, a majority of them live near to or beside the sea, the main reason being the water, because of its very high heat capacity (it stores heat, thus alternately cooling the ambient air and warming it by evaporation, which cools the sea), and of its value as a solvent and as a sure source of salt.

The main uses of the coastal area, in no particular order of importance, are: construction of human habitations and related infrastructure; domestic waste disposal; industrial waste discharge and plant cooling; marine mining; tourism and recreation; fishing; mariculture; shipping. Sometimes, specific areas in the coastal zone may be declared protected areas or reserved for military use. The aesthetic pleasures of the sea along the seashore (waves, surf, sailing and fishing boats, marine odour, sea birds etc.) are an additional "use".

Agriculture in the hinterland, if not a "use" of the coastal zone, has a significant

impact, environmentally by way of release of pesticides and fertilizers, and, economically, by competing with certain fishery products (Caddy and Griffiths, 1995); this aspect is discussed in section 2.2.5.

There is also a relationship between economic policy and environmental degradation. This relationship is still not well understood, but the cornerstone is inappropriate value that is still being attached to natural resources and their exploitation. This problem is discussed in WB/EIB (1990) from which the following very brief summary of ideas is largely taken.

In the fields of industry and energy (see sections 2.2.2 and 2.2.11, below), energy subsidies, for example, discourage efficient use of resources in energy-intensive industries (e.g., metallurgy, cement, chemicals, pulp and paper, and fertilizers), in which energy represents 20-30% of total costs. Industrial subsidies also tend to discourage the use of wastes for the manufacture of secondary products or for recovery (prevention of product loss). For example, effluents high in ammonia and ammonium nitrate from fertilizers plants could be usefully recovered if the original fertilizer product can be sold in a freer and higher, pricing regime, but not where the price is kept artificially low. A cement plant may discharge several thousand tons of cement dust into the atmosphere every year, not only contributing to atmospheric pollution but losing money at the same time, if the cement price is kept artificially low - "to promote the building industry", perhaps. Low-quality fuel (e.g., high-sulphur coal or lignite), if used in a subsidised industry depending on it, promotes air pollution. Any form of overall price fixing (i.e., setting prices lower than that corresponding to real value), so as to deliver a product to the consumer at an artificially low price, discourages recovery of useful industrial discharges.

Water resources (see section 2.2.8, below) were, traditionally, regarded as free to the consumer, and this notion persists in the public mind, tempting or obliging governments or local authorities to subsidise the water supply; but this reduces incentives to conserve water, treat and re-use waste water and prevent the contamination of water bodies. Irrigation water (occupying up to 90% of the

demand in some Mediterranean countries) is widely subsidised to as low a level as 20% of real value, to promote or intensify agriculture.

Land is in a comparable position in many countries of the region; grazing and the collection of fuel wood are often free, as may be hunting and gathering minor forest products. There is therefore a reduced incentive to burn fuel wood frugally or reforest to meet future needs, to control grazing (hence its negative impact on vegetation). Even the value of timber is sometimes reduced, perhaps by failure of governmental authorities to monitor lumbering and to recover the initial value (price) of the timber from public forests.

Besides subsidies, many other economic instruments are applied to economic activities and the management of resources in the countries of the region as a means of limiting environmental impact, although, as noted above, the result is not always as expected. Economic instruments are discussed in UNEP (1994; 1994a) and include, besides subsidies: charges, artificial market creation, deposit-refund facilities, and financial enforcement incentives.

A number of difficulties are encountered in the application of economic instruments: insufficient cooperation between potential or actual polluters and the relevant authorities mainly because of poor organization and application of the system (failure to collect charges, monitor execution, insufficient level of fines for non-compliance etc.); lack of simplicity of application.

At the regional level, there is very little in the way of economic policy. The European Commission's Common Agricultural Policy obviously only applies to the four Mediterranean member countries. The Commission's Common Fisheries Policy is not, in practice, obligatory in the Mediterranean for these same countries. The FAO's General Fisheries Council for the Mediterranean has only advisory powers, although it has some influence on the shaping of national fishery policies.

Therefore, the relevant economic policies in the region are at the national level. To the extent that they are related to environmental policies, they are discussed,

briefly, in sections 4.1.1 and 4.1.3, below.

An effort is made in the following subsections to stress the relationship between economic activity and environmental impact, although the latter, in terms of effects of pollutants, is discussed in more detail in section 3, on the state of the marine and coastal environment.

2.2.1 Urbanization

As already noted, the Mediterranean population has always been constrained in its physical expansion by its mountainous terrain, except for a few major river basins, so that human settlements have historically been concentrated in ports, either because of the difficulties of exploiting nearby mountainous terrain or because of the need to transport (and trade) the products of the hinterland (river basin) to other countries or quasi-landlocked towns and cities elsewhere along the coast. Major urban centres have therefore grown around the original coastal settlements and ports. This underlying factor, and the persistent downward trend in the agricultural population, noted in all industrial and post-industrial economies, towards a level of 3-5% of the national workforce, and the corresponding, though upward, trend in the urban population, has contributed to continuing urbanization of the coastal area and all that flows from it: building and public works, energy generation and consumption, transport requirements, waste management, and so on, discussed in other sections of this paper, with the corresponding pressures on natural living and non-living resources of the coastal zone.

These trends are not, obviously, uniform throughout the region; they are described in some detail in the Blue Plan (Grenon and Batisse, 1989) on the basis of three groupings of countries, as mentioned in section 2.1, above.

Urbanization involves, essentially, the construction of human habitation, public buildings, hospitals, roads, garages, petrol stations, sport facilities, marinas, and the associated public services (broadcasting and communications, water and energy supplies, waste treatment and disposal, transport); the creation or preservation of urban green spaces and other environmental amenities go hand in

hand with successful urbanization.

In the Mediterranean, urbanization may be taken to encompass not only the growth of towns but also the occupation of the coastal strip between towns mainly as tourist accommodation or, in some countries, secondary residences for the citizens, whether local or from far inland, and recreation facilities. There is, for example, a heavy occupation (>70%) of the sea front from Barcelona to Naples, with relatively few untouched spaces, and other areas of the Mediterranean, such as Greece and Turkey, in certain places, are following suit.

The demands of urbanization on the environment, as those attributable to population growth, hence to economic activity, are essentially as follows.

First, the use, in the horizontal dimension, of land that was rural and/or agricultural, compromising, in some cases, the local food supply for the increased population, or, in the coastal area, land needed to ensure the conservation of coastal resources and species of economic, ecological or social interest, or to provide sporting and other facilities for tourists. There is also the use of land, in the vertical direction, to build skyscrapers of ever-increasing size, leading to more intense water-supply and sanitation problems and eventually to the creation of microclimates in large cities.

Urbanization, including tourist and recreation facilities, occupies a considerable amount of land surface in the Mediterranean basin. It is, however, not currently feasible to specify an amount, mainly because of the lack of a precise definition of urbanization itself, which is only partly the occupation of land formerly unexploited or devoted exclusively to intensive agriculture, and partly the expansion and consolidation of pre-existing areas of "low-density" habitation; it may or may not include areas that remain essentially unchanged (e.g., sports stadia, cemeteries) even if engulfed in urban sprawl.

Second, in the management of water (see section 2.2.8), there is the problem of ensuring an adequate supply of water for human use and consumption, with some difficulties to supply the horizontal network (to

keep up with urban sprawl) or the vertical network (to ensure supplies to the highest buildings): in short, the plumbing. There is also a potentially serious problem inasmuch as urbanization means the covering of substantial areas with impermeable concrete (for roads, building bases etc.) thus blocking rainwater from permeating the soil (and filling natural subterranean water systems) and thus greatly speeding run-off into rivers (themselves sometimes with concrete banks to channel discharge) leading to increased incidence of flooding.

Third, the management of the drainage of sewage and other waste waters, which suffers similar problems to those of domestic water supply, is made increasingly difficult unless the urbanization is rationally carried out.

Fourth, the increased air pollution and noise associated with urbanization, due mainly to cars and buses, but also to industry, which tends to be established in the vicinity of conurbations. The quality of the air is, of course, greatly determined by the local meteorological conditions (winds, rainfall).

Urbanization and coastal development in general continue apace in the Mediterranean basin. The spread of uncontrolled or poorly managed coastal development, particularly in the form of tourist accommodation and facilities, by creating increasing pressure on dwindling resources in terms of land and drinking water, also creates increasing pressure for some form of longer-term development policy in most coastal countries. Spain, France, Italy and Greece, in particular, partly under the pressure of the Commission of the European Union, are now paying considerable attention to improving bathing-water and beach quality.

Regarding the effects, urbanization, in particular, and coastal construction, in general, by substantially modifying the coast itself, adversely affect local flora and fauna, displacing it to ever-shrinking land space of a suitable nature.

Given the concentration of human population and urbanization around natural and long-established harbours and ports, as well as the continued development of the civil infrastructure in such areas, the historic and natural heritage of these ports are particularly

threatened by urban economic development. Present efforts to improve and modernize all the European ports will cause serious damage, historically and ecologically, in these areas which have been occupied by Man since ancient times. It will therefore be necessary to compile systematic and ongoing inventories of the flora and fauna and urban and port structures of historic significance.

Urbanization and coastal construction may not themselves directly affect fishermen (who stand to benefit, at least initially, from the correspondingly increased demand for their catches from the increased human population), but significantly impacts the local marine ecosystems, particularly by altering the drainage and sedimentation pattern in the coastal zone, and often forces the fishermen to change their gear/methods and target species. The traditional practice, in many coastal countries, of landing fish directly on the beach and selling the catch directly to the public and to the seaside restaurants may be no longer feasible; fishermen may be forced to go farther to reach the nearest fishing port, for example, which may force an "improvement" in mechanization of the fishing boats and in the marketing of the fish, but often leads to higher costs for the fishermen and the need to increase fishing effort to meet these higher costs.

Coastal construction may thus improve the capacity of seaside resorts to receive visitors or new residents while making it harder to feed them, as far as the sea-food component of their diet is concerned.

Post-industrialization - the shift to a service and communication economy - requiring a generally high level of education and specialized skills in its employees, hence generally drawing them from the industrialized-urbanized population, and not being so limited physically to a particular place - has, together with the increased transport facilities (see section 2.2.3), lead to a spread in urbanization away from (or at least to the suburbs of) the major urban centres, but with a possible preference for the coastal zone insofar as this zone offers pleasant living conditions for a sophisticated workforce. In this case, it is often the smaller towns that grow the fastest, since the major urban centres generally have fewer physical and administrative possibilities for

great expansion. There is some sign that, in some countries, the promise of industrialization, if not post-industrialization, has led to substantial movement of population from rural areas to urban centres in advance of the industrialization that elsewhere had constituted a justification for the migration.

The mass migration of populations towards the major urban centres has obviously, in some countries, if not in all to some degree, quite overstrained the labour and housing markets and the associated public services (water, roads, sanitation, transport), as well as efforts to conserve the historical, cultural and architectural heritage (see section 3.5). In countries with a marked mountainous coastal terrain, the physical possibilities for expansion are limited and add to the intensity of the problem in some cases.

2.2.2 Industry

Those industries preferring the coastal zone as a location generally do so because of a marked need for cooling water or for receiving water for wastes created by the industrial processes involved, the inland rivers and water bodies being already over-used, over-protected (for their flora and fauna) or with too low a capacity to dilute and transport away the generated heat or waste quickly enough. Power-generating plants are often established along rivers or in the coastal zone for such reasons. Desalination plants, by definition, are sited at the coast; besides heat, they may discharge hot brines which modify the local ecosystem.

The development and present level of industrialization in the Mediterranean are reviewed in Fascicule 4 of the Blue Plan (Giri *et al.*, 1991). There was exceptional development between 1950 and 1980. This development was, however, mainly concentrated on the northern side, especially in France and Italy, followed by a notable though more modest development in Spain and Turkey and by Syria and Egypt; in the Maghreb countries, marked industrial development occurred in the 1970s, while recession hit the main northern countries.

In the 1980s, however, industry, especially on the northern side of the basin, underwent a substantial transformation. Thus,

steelmaking, which had previously become established in the Mediterranean basin, the cement industry, oil refining and the associated petrochemicals industry entered a period of firm and lasting recession. On the southern-eastern side, industrial development slackened less but nevertheless became irregular and variable from country to country depending to a marked extent on indigenous adaptability to the industrial evolution of this period and to a considerable loss of revenue from oil exports which declined (in value) as Europe recovered from the oil crisis of the mid-1970s.

At the end of the 1980s, the gap in industrial development between the northern and southern-eastern sides of the basin remained considerable, although it has narrowed since 1950. In terms of added value in the manufacturing industries (which are much more important than the extractive industries), France and Italy together account for 72%, followed by Spain (15%), ex-Yugoslavia and Turkey (3.6%, each), and the rest (6%), out of a total of 506 billion dollars. At 7.3% of the world population, the basin contributed 16% of the world production.

Within the Mediterranean basin proper, these figures are significantly modified, since much of the manufacturing capacity of Spain, France and Turkey, in particular, is located outside the basin itself. Thus, in descending order, the corresponding values are: Italy (64%), France (13%), Spain (10%), Algeria, ex-Yugoslavia and Greece ($\approx 3\%$, each), and the rest ($\approx 4\%$). The overwhelming industrial predominance of Spain, France and Italy, together, over the rest of the Mediterranean countries remains unchanged at 87%. This value is only slightly reduced, to 82%, if the calculations are limited strictly to the coastal provinces of each country; in this case, the shares of these three countries become: Italy (52%), Spain (19%), France (8%), followed by ex-Yugoslavia, Greece and Algeria (with $\approx 4\%$, each) and the rest (9%).

Industry, besides occupying land area, may also use the land to receive solid wastes, possibly in the form of land fill; this is particularly true of mining (see section 2.2.10, below), but may include the ash of processes such as steel-making. Industry also discharges waste waters, more or less directly to rivers (thence to the sea) or to the sea through

coastal outfalls; these constitute an important use of the sea (see below). The pollutants arising from industrial processes are discussed in section 3.3.1.

There is usually a conflict between industry and human habitation, on the one hand, and between industry and local inshore fishery or faunal/floral conservation, on the other.

The main conclusions, from the environmental standpoint, are: the important contribution of manufacturing industry to the so-called littoralization of the coast (i.e., human implantation in the coastal zone); the problems posed by industry as a principal land-based source of pollutants, especially the problems relating to the management and reduction of industrial wastes in general and of hazardous wastes in particular; and the inappropriate siting of industrial installations.

2.2.3 Transport

Transport is a corollary of coastal urbanization and industry; it takes three main forms: land, sea and air, and has two main purposes: transport of human beings and animals; transport of raw materials of industry and goods of commerce. A further consideration is the transport of hazardous substances, discussed later in this section.

Land transport of people, animals, raw materials and goods is effected mainly by road, but also by rail. Modern boring techniques have allowed places once practically isolated by local mountainous terrain to be linked by motorway and coastal road. Although major road-building has probably reached a peak in most of the northern Mediterranean countries, there is still scope for considerable increase in the southern countries.

The Mediterranean has never been attractive from the standpoint of railways, again because of the mountainous terrain, and the main modern development is that of high-speed trains from the hinterland (the major inland cities) to the coast, notably in France and Spain.

The maritime transportation of people and, on a smaller scale, animals is mainly by ferry between mainland countries and offshore

islands or between neighbouring countries. According to REMPEC (1994), some 200 ferries and passenger vessels are at sea in the Mediterranean at any one time; no figures are available on the number of passengers. Likewise, there are about 1500 cargo vessels of >150 gross registered tons (GRT) and 2000 commercial vessels of >100GRT. Around 200,000 vessels ply the Mediterranean annually, of which, the large majority are simply in transit (i.e., do not put into a Mediterranean port).

In terms of Flag State registrations, Greece, Cyprus and Malta, together, account for over 70% of the gross registered tonnage.

Merchant vessels in the basin come from or go to 305 ports therein (approximately 1 port for every 150km of coastline). The ports fall into three categories: (i) small ports that, nevertheless, contribute to national economy; (ii) single-user complexes owned/operated by a major industrial entity (public or private); (iii) multi-purpose ports.

Most Mediterranean ports are focuses of significant urbanization (primary examples are Barcelona, Marseilles, Genoa, Naples, Piraeus, Alexandria, Tunis and Algiers).

Grenon and Batisse (1989) observe that general cargo transfer accounts for a majority of port operations. Another notable feature is the slow penetration of container shipping into intra-basin maritime transport, whereas roll-on/roll-off traffic has increased considerably.

Air transport refers mainly to the movement of people, notably tourists between their countries of origin and of Mediterranean destination, as well as to intra-regional traffic, although there is an increasing tendency to move certain products by air freight, notably marine and short-lived agricultural products. It still suffers from the continuing need to pass through the major gateway airports, such as Madrid, Paris, Frankfurt, Geneva and Zurich, and the major regional airports, such as Barcelona, Marseilles, Nice, Rome, Athens, Istanbul, Cairo and Tel-Aviv, but smaller, more "local" air transport nodes are also developing.

Regarding the effects of developing transport systems, the transport of people has

meant, and will continue to mean, more cars and buses, hence more roads, petrol stations and garages (for car parking and car repair) and more air pollution from exhaust gases and more terrestrial and marine pollution from the uncontrolled disposal of lubricating oils. The roads include motorways, especially those running parallel and near to the coastline, as well as those leading to the main urban centres in the hinterland. Growth in motor-vehicle stock is expected to increase considerably overall between now and 2025, by about 12% in Spain, France, Italy and Greece, about 80% in ex-Yugoslavia, Turkey, Cyprus, Malta and Israel, about 200% in Syria, Lebanon, Egypt, Libya, Tunisia, Algeria and Morocco, according to the Average Scenario of Grenon and Batisse (1989).

Roads use up valuable agricultural or horticultural land and disturb, for a long time if not permanently, local flora and fauna; roads also lead inevitably to growth in hotel accommodation, shops, petrol stations etc. Under most reasonable hypotheses of growth, an increase in land use for roads of at least 25% can be expected by 2025 (Grenon and Batisse, 1989).

Railways have effects on the environment comparable to those of roads, consuming and partitioning valuable agricultural/horticultural land. Nevertheless, from the environmental standpoint, rail transport is the least polluting and the most economical in energy use.

Busy commercial shipping routes may impede commercial fishing. Oil tankers and other commercial vessels, as well as pleasure craft, contribute to the deterioration of the marine environment, shorelines and ports by the discharge, albeit illegally, of garbage, litter and, sometimes, hazardous substances; tankers may wash out their oil tanks (also illegally) thus giving rise to a form of oil pollution that degrades the marine environment, restricting the full use of the sea shore for recreation, tainting fish flesh, oiling fishing gear, especially nets, etc. Major oil spills may be local catastrophes from the recreation and fishery standpoints; however, on the whole, oil and gas transport is not, in itself, a major threat to fishery, and few are ready to argue the greater economic importance of fishing over oil/gas extraction and trade.

The main effects of air transport are additional air pollution, noise (which can be a serious nuisance not only for human beings, but also for local fauna and domestic and farm animals in the vicinity of airports) and used lubricating oils.

Regarding the transport of hazardous substances, there is likely to be a drop in the transport of crude oil as a result of an increase in the proportion of crude oil being refined in the countries of origin, hence also, probably, in the amount of oil derivative products. It therefore seems likely that the amount of potentially hazardous substances transported, besides crude oil, will rise, increasing the risk of environmental damage from spills and accidents. This trend is slowly being accompanied by the installation of more portside facilities to handle dangerous cargoes, including deballasting facilities.

REMPEC (1994a), drawing partly on Grenon and Batisse (1989), provides some details of the transport of hazardous substances in the Mediterranean basin.

In 1990 about 130×10^7 metric tons of goods were handled (loaded/unloaded) in Mediterranean ports, of which, about 57×10^7 metric tons were crude oil and 17×10^7 metric tons, refined oil products.

In 1989, the amount of natural gas imported/exported by France, Italy, Spain, ex-Yugoslavia, Algeria, Tunisia and Libya, together, was about $97 \times 10^9 \text{m}^3$.

Insufficient data are available to quantify the transport of specific chemicals, but ethylene, propane, propylene, vinyl chloride, ammonia, methanol, benzene, toluene, glycols, styrene, sulphuric and phosphoric acids and caustic soda are known to be transported by ship in significant (hence significantly dangerous quantities, in some cases), as are ores (e.g., alumina, barite, bauxite, bentonite, magnesite, potash, pyrites), coal and grain, the latter two being imported mainly. Annex II of the MARPOL Convention (see sections 4.1.1 and 4.1.4) covers the carriage of hazardous and noxious liquids in bulk and indicates the substances considered to fall into these two categories.

Twenty-seven major marine accidents

(out of 96 maritime accidents reported, in all) were reported to the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea between January 1990 and June 1994 (REMPEC, 1992; 1994b), of which, 9 were due to grounding or sinking, 9 were due to collision or sinking, 6 were due to operational failures (rupture of pumping hoses during unloading or tank cleaning, or leakage from vessel or pipeline) and 3 were due to fire or explosion. The cargoes involved were mostly oil (crude oil, fuel oil or gas oil) - the predominant hazardous cargo - and acetonitrile, ammonia, barite, dichloro-ethane, potash, propylene, sulphuric acid, terephthalic acid.

There are several increasing trends in the structure and operation of world manufacturing and trade that suggest that there will be an increase in the transport, by ship, of more or less hazardous substances, hence in the risks to which the marine environment will be exposed. Such trends are: the globalization/relocation of manufacturing (the competition between low labour costs, raw material delivery and low transportation and distribution costs); changes in production techniques (e.g., "just-in-time" delivery of raw materials and chemicals, rather than accumulation of high inventories at the production site); integration of regional markets (leading to an increased flow of goods, even if the mass is stable); value-adding at source (e.g., increased oil refining by the oil producer). However, an increasing conservation and environmental concern may lead to improvements in tanker design, maritime traffic schemes, and emergency response facilities.

REMPEC's possibilities for providing emergency assistance is greatly hampered by the general failure of the competent national authorities of the Contracting Parties to report major maritime pollution accidents immediately and directly to REMPEC; the majority of reports received by REMPEC come via Lloyds (of London) Casualty Reporting Service. Nevertheless, REMPEC provided various kinds of assistance from its own limited resources, promoted international assistance or activated the Mediterranean Assistance Unit (MAU), which are summarized in REMPEC (1992a; 1994c). A detailed MAU Mission Report is provided in REMPEC (1994b); such reports, which include firm recommendations drawn

from the experience of each mission, go a long way to helping national authorities to face similar accidents better in the future.

2.2.4 Tourism and Recreation

The recreation of residents and tourists is a major economic activity in many countries, whether rich or poor. With respect to the coastal zone, wherever clean beaches, calm seas, high levels of sunlight and all the attendant local infrastructure (hotels, places of entertainment, good sanitary installations, banks, post offices, shops, tennis courts, golf clubs etc.) can be found, human beings who can afford to do so and so wish will go there and will pay money to do so.

The Mediterranean basin offers a wide variety of possibilities for recreation, from skiing (mainly in the Alps and the Pyrenees), via

mountaineering and rambling, tennis and golf, to the customary "water" sports: swimming/sunbathing, surfing, water-skiing, snorkelling and submarine diving (whether for spear-hunting or for amateur archaeology), yachting/sailing, marine angling (from the beach or from pleasure cruisers offshore).

Tourism and recreation are a key element in coastal development because they force many aspects of urbanization, notably the construction of hotels, restaurants, shopping centres, sport facilities, marinas, public services and buildings. Many a coastal resort's resident population will be multiplied several (3-5, if not more) times during the holiday season. This situation places a heavy burden on local authorities who are faced with the difficult choice of whether to install waste- and sewage-treatment capacity for the peak population, knowing that this capacity will only be half (or

A CASE STUDY OF THE TOURIST CARRYING CAPACITY OF THE ISLAND OF RHODES (UNEP, 1993)

The island of Rhodes lies in the south-eastern Aegean Sea and has an area of about 1400km². Its population of some 100,000 is growing presently at 2% per year. The coast is the dominant element in the landscape and the most used for economic development, mainly through tourism. Up to a million tourists arrive annually, fortunately not all at the same time, but the tourist accommodation is concentrated in the vicinity of the principal city, Rhodes. The annual income from tourism is about \$450 million. Agriculture and manufacturing are of limited significance.

The land-based sources of pollution are mainly liquid wastes from households, tourist accommodation, restaurants, the port and, to a small extent, manufacture. This poses a pollution threat rather than a serious problem. The areas mainly affected by this pollution are: the bay of Ixia, the port area and, to a lesser extent, the Faliraki coast.

The cost of the environmental damage, overall, is about \$15 million a year, and consists mostly of loss of tourist revenue. To control and reduce the impact of these waste waters on the coastal environment, and to improve the quality of the island's environment, the Dodecanese Prefecture has instituted several measures and planned future ones in this sense. The principal measure is a central sewer system for the Rhodes urban area. This required an initial investment of \$24.2 million, with a further \$36 million required for completion, but it is expected to generate benefits of over \$10 million per year. The benefits are direct, in terms of tourist income and cost savings, and indirect, in terms of amenity, enhanced property values and other qualitative benefits.

The case study, although incomplete and expected to be pursued, examined a range of projects aimed at improving the environment of the island and enhancing, qualitatively and quantitatively, its capacity to receive, each year, a number of tourists up to, if not more than, ten times its resident population.

less than half) used outside the seasonal peak, or to deal with peak output (of sewage and waste) on an *ad hoc* basis with the risk of creating local environmental catastrophes precisely during the peak holiday season. If the authorities do not provide facilities or services, especially to deal with the increased waste, the coastal sea is relied upon to handle that which cannot be treated. While the sea's capacity to do so may be considerable, it may depend quite heavily on the rate at which the local sea is changed (flushed) by local currents. Untreated-waste discharge leads to increased litter in the sea and on the sea bed, and to higher than usual incidence of potentially dangerous micro-organisms (especially bacteria and viruses; see section 3.3.1).

So-called eco-tourism and eco-recreation are increasingly placing emphasis on the persistence of unchanged and unexploited (i.e., conserved) ecosystems; examples are bird-watching, in particular, and wildlife-watching, in general, including photography in all its forms (still, video, cinema) and bird-call recording, butterfly watching and collecting, landscape art, submarine exploration. However, even these activities are not sustainable in the face of unlimited access. Conservation of marine habitat, even if only for such purposes, is progressively being associated by the public with conservation of ecosystem complexity and biodiversity, and the intangible benefits of conservation are receiving an increasingly higher profile as the public becomes more aware of impacts on marine wildlife.

An upward evaluation of this non-exploitive use is to be expected. Moreover, some habitats, suitably conserved, play a natural role in pollution abatement and the mitigation of natural environmental impacts on coastal systems.

With the currently increasing trends in resident population size and density, and the likelihood of similar trends in the non-resident, tourist population, access to modern sanitation services has considerably improved. And as the demand for increased quality, particularly in food and accommodation, has increased in the tourist "exporting" countries, so it has been progressively better supplied in the tourist "importing" countries.

Regarding effects, the occupation of

land surface for tourism and recreation means, essentially, a loss of habitat for many wildlife species, even if there may be signs that some species (especially birds) adapt to these changes and establish a reasonable co-habitation with human beings in recreation. It also implies a diffusion of sources of waste (notably litter) and a consequent cost of maintaining ski domains, golf courses, beaches, tennis courts and mountain pathways free of such waste, for aesthetic, ecological and sanitary reasons.

The occupation of the sea space is very much restricted to the littoral zone, since most activities take place on the beach or within 50m seaward, except for yachting/sailing or offshore marine angling. Nevertheless, the effect on the local species is, even if not well known, almost certainly considerable. The beaches or thrown directly into the sea along the beach. It is possible that certain plastic or metal objects (bottles, cans, containers etc.) on the sea bed may, at a particular density, serve as niches for certain kinds of marine organisms, whereas, at a higher density, may simply act as a bar to such organisms. Little is known of this aspect of sea-bed litter, but, in view of the importance of the littoral zone for marine wildlife, its importance cannot be discounted.

2.2.5 Agriculture

Given that the present paper deals with the coastal and marine environment, agriculture is not itself a predominant economic activity in this narrow zone. The Blue Plan (Grenon and Batisse, 1989) describes succinctly the state of agriculture in the Mediterranean basin, as well as its prospects.

The principal economic aim of agriculture in the Mediterranean drainage basin is to meet the food demand of the resident and, as necessary, the tourist populations. In this respect it resembles the Mediterranean fisheries for the most part. The present percentage of agriculture in the Gross Domestic Product of the basin as a whole is under 20% and food supply from domestic agriculture is falling behind population growth in the basin; moreover, agricultural growth is also falling behind that of industry and of economic growth in general. Agricultural productivity also varies widely throughout the basin (Table I).

Table 1. Agricultural Resources and Inputs in Mediterranean Countries, 1968-1970 and 1988-1990 (mean annual values)

Country	Fertilizer consumption				Arable land			Irrigated land			
	Total (10 ³ t/yr)		Per cropping area (10 ³ kg/ha/yr)		Potential area (10 ³ ha)	Actual area, 1988-90		Area (10 ³ ha)		As % of arable land	
	1968-70	1988-90	1968-70	1988-90	(10 ³ ha)	(% of total)	1968-70	1988-70	1968-70	1988-90	
Albania	39	102	66.8	143.3	-	-	263	422	45.0	59.4	
Algeria	83	138	12.2	18.2	7,700	99	237	336	3.5	4.4	
Cyprus	26.0(*)	22.2(*)	163.6(*)	142.5(*)	400	39	30	34	18.9	22.0	
Egypt	347	990	122.9	381.9	2,900	89	2,826	2,591	100.0	100.0	
France	4,300	5,929	223.7	309.9	-	-	740	1,159	3.8	6.1	
Greece	325	674	83.1	171.3	-	-	718	1,190	18.4	30.3	
Israel	52	106	127.8	244.4	-	-	167	213	40.9	48.9	
Italy	1,243	1,897	82.6	157.8	-	-	2,537	3,100	16.9	25.8	
Lebanon	34	25	105.3	83.7	300	100	68	86	21.2	28.6	
Libya	10	81	5.2	37.9	2,100	102	170	242	8.4	11.3	
Malta	1	1	37.7	47.7	-	-	1	1	7.1	7.7	
Morocco	93	315	12.5	34.8	7,700	118	915	1,265	12.3	14.0	
Spain	1,132	2,041	55.0	100.3	-	-	2,376	3,358	11.6	16.5	
Syria	33	278	5.7	49.9	6,000	93	491	671	8.3	12.1	
Tunisia	34	96	7.7	20.8	4,600	100	85	273	1.9	5.9	
Turkey	419	1,766	15.4	63.4	28,000	99	1,700	2,340	6.2	8.4	
ex-Yugoslavia	589	893	71.5	115.2	-	-	126	176	1.5	2.3	

(*) From 1974 onwards data refer to part of the country only.

(Adapted from UNEP, 1993)

Agriculture is strongly conditioned by the basin's terrain: mountains, hence extensive hillside stock raising (sheep, goats); few alluvial plains (Ebro, Rhone, Po and Nile) for more classical agriculture/horticulture (pulses, grains, sugar beet, tomatoes, citrus and other fruits, beans, chick peas, in particular) or intensive pig and beef raising, the mainstays of the cow-milk, beef, veal, pork and delicatessen trade. Elsewhere, often in relatively narrow coastal valleys and on coastal slopes, generally fairly arid, the main crops are olives, almonds, pistachios and grapes.

Agriculture, *sensu lato*, in the coastal zone has generally declined in the face of urbanization, mainly, and of some forms of industry. Thus, the traditional task of preventing soil loss to the sea, by terracing coastal slopes and by physical transport of topsoil upland, has greatly weakened; and, as agro-industry has developed in the main river valleys and plains, also not without competition from urbanization, the husbandry of the coastal slopes has steadily decreased and continues to do so, adding to soil erosion.

The proportion of erodable soil in the Mediterranean basin is more than half in a large majority of the riparian countries; the relevant values are summarized in UNEP (1994).

There has also been a steady growth of covered or semi-covered horticulture which occupies space (agricultural and peri-urban) but, being an intensive and more or less closed system, does not contribute to soil erosion. It is, however, demanding of fresh-water supply, fertilizers and pesticides.

Agriculture and horticulture occupy by far the greatest amount of land surface, and make the heaviest demand on fresh-water resources of all current land uses, generally occupying 60% or more of the available resources (UNEP, 1994).

The intensification of Mediterranean agriculture is strongly constrained by the need for improved irrigation (in a context of relatively scarce and uneven fresh-water supply), by soil erosion due to the heavy but seasonal rain aided by the general decline in husbandry of the coastal slopes as coastal urbanization has encroached on agricultural land farther and

farther up the slope, and by the need for fertilizers and pesticides. The terrain also often makes mechanization of the agriculture problematical, as does the traditional preference for small landholdings. Nevertheless, Grenon and Batisse (1989) indicate potential possible increases of 2- to 5-fold or more for most vegetables and fruits and for some meat and dairy products, if modern and well adapted farming methods are widely adopted throughout the basin.

Regarding effects, agriculture itself has (with urbanization and industry) contributed to a loss of the specialized flora (e.g., garrigue, grassland and forests) that went a long way to preventing soil erosion, since agricultural crops are, in many cases (e.g., sugar beet), planted, grown and removed annually, thus not creating a soil structure resistant to erosion by wind and rain.

Protective (erosion-abating) plant cover has not only been progressively and sometimes severely reduced by growing demand for food, hence by intensive agriculture and overgrazing, but also by a progressive parcelling of the land for the many uses already evoked. This parcelling, however, makes it increasingly difficult to ensure soil conservation on an ecosystem basis, since the coordinated action of a large number of land owners or exploiters is much harder to achieve than it might be for a few owners. Yet, even where centralized government and public ownership might have guaranteed some hope of success, the means for, and public acceptance of, a sub-regional management scheme can rarely be assured, and the more so if prior environmental impact assessments are thought essential to such a scheme.

Agriculture, as a source of (excess) pesticides and fertilizers, in the hinterland, as well as in the coastal zone itself, may have a substantial effect on the coastal area environment, but also on the coastal-zone economy through the competition of its products with other food products, notably fish and fish products.

Pesticides, which are often over-applied, may be washed by rain from the cultivated land surface directly into the sea, or indirectly via rivers debouching into the sea, with sometimes adverse affects on the coastal

marine fauna and species of fishery interest. Pesticides also put pressure on human health standards for drinking water and for shellfish-growing water (see section 3.3.2).

Fertilizers (often over-applied in agriculture) are washed or discharged into the sea. The effects of fertilizers and pesticides are discussed in section 3.3.2.

Products of agriculture compete with those of a fishery in a national economy, so that, in the long term, fishermen and, even less, fish processors and marketers, cannot remain indifferent to agriculture. Consumers may prefer meat to fish, or vice versa, on their dinner table, but at market the lower cost product may win the battle for the consumers' money, other things (such as freshness, appeal etc.) being equal.

2.2.6 Fisheries and Mariculture

The physical features of the Mediterranean, which largely determine the composition of the living resources, have been generally described in section 1.3, above.

From the fishery standpoint, the two main basins (the Eastern and the Western Mediterranean Basins), being relatively deep (maximum depth in excess of 4000m) and with generally narrow continental shelves (down to 200m depth), are not exploited; nor are they likely to be, for three main reasons: (i) the cost, in physical and financial terms, of operating fishing gear at considerable depth cannot easily be justified, at least under present and foreseeable economic and technical circumstances; even the exploitation of the continental slope is not currently cost-effective; (ii) the slow replacement (probably 100-300 years) of the deep water of these basins implies very low levels of dissolved oxygen, hence a scarcity of suitable living resources at depth; (iii) the steady accumulation of non-degradable litter in these basins, while initially being possibly advantageous (by providing microniches for various species) must eventually render the sea bed uninhabitable by species of fishery or ecological interest, even if conditions (i) and (ii) are not operative.

The bulk of the living marine resources are therefore found, and exploited, on the continental shelf (depth less than about 200m)

or in the upper 100m of the open sea. The former are referred to as benthic (living on or close to the sea bed) or neritic (swimming above the sea bed over the continental shelf), and the latter, as pelagic (swimming in the body of the sea, not normally near the sea bed). In practice, pelagic species are only fishable if they form schools or are individually large enough to justify the fishing effort required to capture them. They are rarely taken below 300-400m depth, and usually at much lesser depths.

The main features of the Mediterranean fisheries have been described in Fascicule 1 of the Blue Plan (Charbonnier *et al.*, 1990) and the trends in catches and landings, from 1972 to 1991, have been summarized by Stamatopoulos (1993).

The principal species groups, as defined by FAO for its Fisheries Yearbooks (FAO, 1993), that are the object of commercial or extensive artisanal fishery are given in Table II.

The data given by Stamatopoulos (1993) for 1972, 1982 and 1991 show also that, in the Mediterranean, as well as in the Black Sea, there was a steady growth (roughly a doubling) in overall catch in the first of these two decades, and a marked decline (of roughly 28% in the Mediterranean and of roughly 70% in the Black Sea) in the second decade. These may be considered as representing the expansion of the fisheries (in line with population growth - resident and non-resident/tourist - and improving living standards), followed by a decline due mainly to over-fishing and increasing marine environmental pollution. They have been accompanied by an increase in mariculture which, in 1990, produced almost 120,000 metric tons (Stamatopoulos, 1993).

The principal fish, shellfish and other species exploited by the marine capture fisheries in the Mediterranean are given by Charbonnier *et al.* (1990). Detailed descriptions of the Mediterranean marine fauna and the marine aquatic flora may be found in Fischer *et al.* (1987).

The main fishing nations, with respect to the Mediterranean Sea, are Italy, Spain, Greece, Tunisia, France, Algeria and ex-

Yugoslavia. There is no immediate prospect of markedly increasing the current total catch of marine capture fisheries, if only because such an increase would have to come from small pelagic species which are not, at this time, in high demand as sea food, whether for direct consumption or as fish products (canned, smoked, frozen etc.).

Capture fisheries are limited by the relative narrowness, in most places, of the continental shelf, the general and persistent overfishing of the natural stocks and the general lack of coordination between countries in the management of those stocks (the majority) that overlap national jurisdictions.

Charbonnier draws attention to the numerous difficulties there still are in obtaining reliable catch, fishing effort and distribution data. The main reasons are: (i) the greater part of the fishing in the basin is artisanal, with many small boats discharging their landings at numerous points along the coast on which they fish, often directly to local buyers, for which a system of statistical control is too complex and costly; (ii) in some fishing fleets there is a seasonal migration between two distinct fishing areas (e.g., the western Mediterranean and the Atlantic Ocean, or the Black Sea and the Sea of Marmara and the Mediterranean) whereas landings are often reported for a vessel's home port only; (iii) in some fisheries, especially trawler fleets, a quite important proportion of the catches is discarded at sea (because not saleable) but not quantified in the catches; (iv) it is often difficult, for a particular fishing method and fleet, to specify a unit of fishing effort such that the catch per unit of fishing effort reflects sufficiently well the true density of the fish stock at the time and place at which it is being fished. The alternative solutions - to assess real abundance by means of acoustic surveys, or to undertake careful experimental or test fishing - are time-consuming and expensive.

The great variety of fish (and shellfish) species taken in the Mediterranean fisheries means that similar species are sometimes confounded in the statistics or attributed to one or the other species only. This variety also makes reliable assessments of the state of the stocks difficult, especially since the majority of stocks overlap national jurisdictions, and international cooperation in the collection and

analysis of relevant data is still not adequate to allow effective stock assessments to be made to determine the state of each stock, especially as regards saturation fishing or biological overfishing.

Judging from the average size of the fish caught relative to the "maximum" size, for each species of concern, the majority of demersal fish stocks are over-exploited, so that no fishery in this situation is covering its investments (nor, sometimes, even its expenses) from its own financial resources.

Another sign is the predominance of relatively short-lived pelagic species in the overall landings; this may be partly explained by the fact, already noted, that bottom trawling is largely limited to the rather narrow continental shelf, but, here too, a trend has developed in which the high-seas trawlers have been fishing closer to shore in recent years, for lack of adequate offshore stocks, often causing conflicts with inshore artisanal trawl fishermen and other inshore users of the marine environment. In 1991, the European pilchard and the European anchovy, together, out of the top 28 species of fishes and shellfishes, occupied nearly 30% of the total landings (Stamatopoulos, 1993), although this proportion has been high at least since 1972.

In view of the comparatively poor state of the fish stocks, moves have been made by the General Fisheries Council for the Mediterranean (GFCM), the International Commission for the Conservation of Atlantic Tunas (ICCAT) and, for its four Mediterranean members, the European Union to improve fisheries management and fish-stock conservation in the region. Although the GFCM has only advisory and recommendatory powers, it has pressed for such actions as the necessary increases in fish-net mesh size, seasonal or longer-term closure of fishery areas in which stocks are under particular stress, reduction in fishing effort, minimum landing sizes for certain species under fishery and/or environmental stress, and restriction or prohibition of certain types of fishing gear. It cooperates closely with ICCAT, in respect of tunas and billfishes. The European Union's Common Fisheries Policy finds limited application in the Mediterranean, although it is in general agreement with the measures promoted or applied by GFCM and ICCAT. It

Table II. Nominal catches (in metric tons) of the principal commercial species groups (as defined by FAO) in the Mediterranean and Black Seas for 1989 (FAO, 1993) with an estimate for the overall Mediterranean catch *.

FAO GROUP CODE	DESCRIPTION OF NOMINAL CATCH GROUPS	NOMINAL CATCHES FOR 1989	NOMINAL CATCHES FOR 1992
11	FRESHWATER: CARPS, BARBELS, OTHER CYPRINIDS	1 016	755
13	MISCELLANEOUS FRESHWATER FISHES	1 555	907
21	STURGEONS, PADDLEFISHES	602	1 050
22	RIVER EELS	3 679	3 386
24	SHADS	40 750	9 514
31	FLOUNDERS, HALIBUTS, SOLES	14 939	13 901
32	CODS, HAKES, HADDOCKS	74 927	84 669
33	REDFISHES, BASSES, CONGERS	164 369	178 458
34	JACKS, MULLET, SAURIES	198 147	125 133
35	HERRINGS, SARDINES, ANCHOVIES	645 763	567 070
36	TUNAS, BONITOS, BILLFISHES	61 474	56 064
37	MACKERELS, SNOEKS, CUTLASSFISHES	43 999	42 101
38	SHARKS, RAYS, CHIMÆRAS	20 011	20 713
39	MISCELLANEOUS MARINE FISHES	107 675	83 542
42	SEA-SPIDERS, CRABS	2 003	1 777
43	LOBSTERS, SPINY/ROCK LOBSTERS	7 727	8 605
45	SHRIMPS, PRAWNS	31 545	31 358
47	MISCELLANEOUS MARINE CRUSTACEA	8 538	9 986
52	ABALONES, WINKLES, CONCHES	0	14
53	OYSTERS	17 233	19 524
54	MUSSELS	127 623	137 900
55	SCALLOPS, PECTENS	1	0
56	CLAMS, COCKLES, ARKHELLS	47 570	83 360
57	SQUIDS, CUTTLEFISHES, OCTOPUSES	76 920	72 684
58	MISCELLANEOUS MARINE MOLLUSCS	22 779	17 202
72	TURTLES	100	3

74	SEA SQUIRTS, OTHER TUNICATES	35	164
76	SEA URCHINS, OTHER ECHINODERMS	237	390
	TOTAL NOMINAL CATCH	1 721 217	1 570 302
	ESTIMATED TOTAL NOMINAL CATCH FOR MEDITERRANEAN *	1 463 034	1 434 757

* Since these statistics are given for the Mediterranean + Black Sea (FAO Statistical Area 37), an estimation for the Mediterranean catches is based here on data given by Stamatopoulos (1993) for the total Mediterranean catches for 1991 in which about 85% of the total (Mediterranean + Black Sea) catch of marine and diadromous fishes, and nearly 100% of crustaceans and molluscs correspond to the Mediterranean; the same factor (85%) has been applied to the 1989 catches.

has, however, adopted a Conservation Policy on Marine Resources in the Mediterranean which embodies many aspects of the GFCM and ICCAT policies and seeks to involve non-EU countries in the Mediterranean.

It should be noted, in the present context, that the use of technical measures (e.g., obligatory mesh sizes) and Total Allowable Catches (TACs) for a given fish stock, as a policy for limiting fishing pressure, does not allow regulation of catch capacities and even encourages increases in catch capacity through excessive investment in more and more efficient fishing vessels and gear (CEC, 1994). Also, as long as consumers will pay the price, fishermen will be encouraged to catch the fish, even against all conservation and environmental wisdom.

Mariculture (or marine aquaculture) may provide a solution to shortage of high-priced species in high demand, which cannot be supplied by traditional capture fisheries. Most mariculture is still carried out in coastal lagoons and small, well protected bays not already ceded to sailing and other water sports or to infilling for the construction of resident and tourist accommodation, or worse, to industrial and/or domestic waste discharge. The principal outlets of Mediterranean mariculture are the restaurant trade and the local market.

The species that are principally the object of mariculture are the Mediterranean mussel (*Mytilus galloprovincialis*), flathead grey mullet (*Mugil cephalus*), carpet shells (*Tapes* spp.), European flat oyster (*Ostrea edulis*) and gilthead sea bream (*Sparus aurata*), but other

species are also the object of growing interest: sea bass (*Dicentrarchus labrax*); the European eel (*Anguilla anguilla*); rainbow trout (*Oncorhynchus mykiss*) and, occasionally, the sea trout (*Salmo trutta*); salmon (including Pacific salmon) of the genus *Oncorhynchus*; the Pacific cupped oyster (*Crassostrea gigas*); and Japanese clams (*Venerupis japonica*). Egypt specializes in tilapias (*Oreochromis* spp.), in the context of more traditional freshwater culture (aquaculture).

The culture of species of interest is sometimes based on natural stock entrapped in a lagoon or bay and then fed in enclosures until commercial size (especially for the restaurant trade in areas of high tourism).

It is not feasible yet to assess the effect on fish stocks of the discharge of wastes (harmful or otherwise) from the land to the coastal sea. There is a reasonable belief that nutrients (notably nitrate and phosphate) increase the production of phytoplankton, which occupy the bottom of the food chain, hence, in time, the zooplankton and small fishes, then larger fishes, but it is mainly a question of "dose". If eutrophication is induced (see section 3.3.2), it may have a serious adverse effect on some fishes; however, the adverse effects caused inshore in the vicinity of the discharge may be mitigated and then removed as the nutrient levels are reduced by turbulent mixing into deeper waters offshore where concentrations may have a beneficial effect. The measurement of the relationships involved is not an easy matter, however (Caddy and Griffiths, 1995). The effects of the main marine pollutants are also discussed in section 3.3.2.

Also, intensive mariculture (in cages or tanks) uses substantial amounts of chemicals to control parasitic and fungal infections in the cultured species, and this may cause local but serious environmental disturbance, sometimes at the expense of local capture fisheries which suffer from a loss or dispersion of local wild stocks.

Thirdly, as breeding and biotechnological techniques are increasingly used to produce specific varieties for mariculture purposes, there is a serious potential danger of unforeseen negative effects of interbreeding of these culture species with their wild counterparts as a result of escapement (often accidental during coastal storms, but perhaps also intentional) (see section 3.4.2).

Needless to say, fisheries and mariculture in the coastal zone are mainly in conflict with water sports and yachting marinas, both of which tend also to prefer coastal bays and lagoons; moreover, the stocks that are the object of fishery or mariculture are prejudiced also by uncontrolled/untreated waste discharge. At the same time, mariculture is a user of supplementary fish feeds to speed the "fattening" (i.e., rapid growth) of the cultured species and so may contribute to local eutrophication due to loss of such feed to the surrounding environment, perhaps causing plankton blooms (see section 3.3.2).

GESAMP (1991) has considered ways of reducing the environmental impact of coastal aquaculture. The environmental aspects of aquaculture have also been reviewed by UNEP (1987; 1994a), the latter with respect to shellfish culture in particular.

2.2.7 Forestry

The state of the Mediterranean forests and their prospects under the impact of human activities have been reviewed in detail in Fascicule 2 of the Blue Plan (Marchand *et al.*, 1990).

The natural pristine Mediterranean forest prevailing up to about 14,000 years ago was dense and extensive. During the neolithic revolution, some 6,000 years ago, first at the eastern end of the basin, then at the western end, there was a rapid growth of the human

population, and an agricultural economy replaced the hunting-gathering economy, thus creating a demand for arable land. This led to the very beginnings of human industrial activity, which created a demand for wood for combustion. Shipping also began to expand, creating demand for vessel construction. Nevertheless, in Greek and Roman times there was already some effort at forest conservation and even at reforestation.

Till the mid-19th century, the basin's population was relatively stable, mainly as a result of wars and epidemics, which allowed some recovery of the basin's forests, although the demand for wood for shipbuilding, mine-shaft scaffolding, metallurgy, glass-making, domestic fuel, charcoal production etc. continued to place considerable stress on the forest resources.

The roots of today's problem - loss and degradation of the basin's forest resources - therefore go very deep. Yet, it is not only a question of loss and degradation.

Forests stabilize soil distribution, thus counteracting erosion, conserve genetic resources by offering a relatively protected, semi-enclosed ecosystem. Besides wood for burning as domestic fuel, they also supply the raw material of wood products, such as furniture, building materials, cork, resin, seeds and handicrafts, and tanning chemicals. Imported Australian eucalyptus and American pine have helped to establish industrial plantations, especially for paper-pulp. As agriculture has become more intensive and, particularly on the northern side, has abandoned marginally exploitable land area, reforestation has been carried out. This, has, however, with increased tourism and recreation (forests being a significant attraction - camping, hiking etc.), contributed to an increase in the incidence of forest fires (see section 3.1.3). Forests also play an important part in stock raising, by serving as grazing areas.

The principal types of pristine forest in the basin are:

- Sclerophytic laurifoliate forests, in hot-temperate or hot zones, comprising two main types of tree: (i) oil-bearing, of small to medium size, of which the best known are the olive tree (*Olea*

europæa), the carob tree (*Ceratonia siliqua*) and the mastic tree (*Pistacia lentiscus*), which are widely distributed; (ii) shrub oaks, of which the main species are, in the west, the holm oak (*Quercus ilex*) and the cork oak (*Q. suber*), and, in the east, the Palestine oak (*Q. calliprinos*).

- Resinous forests, comprising four main types: (i) on low-lying terrain, Aleppo pine (*Pinus halepensis*), in the west and central sub-regions, and the Calabrian cluster pine or Pyrenean pine (*Pinus brutia*, taxonomically synonymous with *P. halepensis* or, at best, a sub-species), in the east, sometimes mixed with *P. mesogeensis*, *P. pinea* and *Cupressus sempervirens*; (ii) in the foothills of mountain ranges, black pine (*Pinus nigra*), and sometimes Scotch pine (*Pinus sylvestris*); (iii) in the highlands, fir (*Abies* spp.) and cedar (*Cedrus* spp.) forests, usually separate but occasionally mixed; (iv) on mountains, junipers (*Juniperus thurifera* and *J. excelsa*, among others).
- Deciduous forests, at middle altitudes and where rainfall is greatest, comprising: the deciduous oaks (*Q. faginea*, *Q. infectoria*, *Q. cerris*, *Q. ægilops*, *Q. ithaburensis*, among others); European hornbeam (*Ostrya carpinifolia*) and yoke-elm (*Carpinus orientalis*); flowering ash (*Fraxinus ornus*); beeches (*Fagus sylvatica*, *F. orientalis*).

The actual tree stands that may be encountered may, for many reasons, differ from the basic formations mentioned above. There are also degraded forests, classified as scrub forests (maquis, garrigue, matorral) which occupy the major part of the forested surface of the basin, notably in Spain, Turkey, ex-Yugoslavia, Albania and France.

2.2.8 Water Resources and Management

The water resources and their management have been well described in Fascicule 6 of the Blue Plan (Margat, 1994).

The natural input of fresh water to the

Mediterranean basin is directly by rainfall (and its indirect form, snow). There are two main seasons: a weak, spring season, and a strong autumn season, separated by a hot and dry summer season. Rainfall is commonly heavy but of short duration, leading to catastrophic flash flooding. Rainfall percolates through soil and permeable rocks, supplying rivers, lakes and subterranean aquifers. After removal of water by Man, rivers and some aquifers discharge their water into the sea.

River basins in the Mediterranean are all small, except that of the Nile whose water is mainly supplied by tropical rainfall (and subsequently stored in the Aswan reservoir; the non-Egyptian part of the Nile - the upper Nile - is not included in the present consideration). Only five river basins exceed an area of $50 \times 10^6 \text{ km}^2$. Nevertheless, nearly 60% of the land area of the Mediterranean basin is occupied by river valleys of less than 10^4 km^2 individual area. The broken geomorphology of the Mediterranean basin, especially on its northern, south-eastern and eastern parts, ensures relatively rapid riverine run-off.

The main annual average river discharges ($>5 \text{ km}^3/\text{year}$) are from the Rhone (54), Po (47), Ebro (17), Neretva (12), Drin (11), Meric-Evros/Ergene (10), Tiber (7), Ceyhan (7), Adige (7) and Seyhan (7). The Nile has a discharge of $89 \text{ km}^3/\text{year}$ at the level of the Aswan dam, but that at its interface with the sea (≈ 5) is greatly reduced by the high level of withdrawals (mainly for irrigation, domestic use and fish farming).

Aquifers (subterranean water bodies) and the related subterranean water courses are also affected by this particular geomorphology and are, therefore, generally of small size. There are two main types, corresponding to their matricial rock: karstic (e.g., Ebro valley, Jura and Apennine mountains, Dalmatia, Greece, southern Turkey, Levant, northern Egypt, northern Libya, Atlas mountains); and alluvial (e.g., Rhone, Po, Nile valleys). There are, however, often close connections between aquifers of the two types. Numerous coastal aquifers may be independent and submarine. Mediterranean aquifers show considerable variability and irregularity, depending on geological situation, rainfall patterns and snow melt (in the Alps). Minimum output (monthly average) may be as low as 1% of maximum

output (over the year), although the overall average ratio is about 20%.

There is some importation of fresh water from outside the basin, to the north (about 25km³/year) and to the south (about 56km³/year, from the upper Nile via the Aswan dam).

The simple balance sheet shown below hides the considerable differences between the northern and southern sides of the basin, which are analysed in some detail by Margat (1992). It also hides the possibilities for exploitation by Man, since not all water sources and courses, nor many karstic reservoirs, can be controlled and managed. Nevertheless, the management and exploitation of fresh water in the basin has been practised since time immemorial and by all the numerous civilizations that have been established or have flourished around the basin. The basin, as we now know it, and not least the water cycle thereof, has therefore been shaped by Man.

The mass balance for the Mediterranean basin can be briefly summarized by the following approximate "balance sheet" (drawn up in km³/year) presented below.

The principal factors have certainly been irrigation and domestic consumption, but deforestation has played a major role in modifying the hydrological regime by encouraging soil erosion and introducing irregularity into the natural system of run-off.

Deforestation (to provide wood for fuel, buildings, ships, bridges; to make room for human habitation, industry and other facilities; and to allow expansion of stock-raising and agriculture) has also had a major impact on the vegetation now typical of the basin; over-grazing by sheep and goats has, in turn, led mainly to the destruction of the ancient oak forests and their replacement by scrub vegetation (garrigue and maquis), thus closing a major loop in the system of degradation.

Water quality varies considerably, locally, but is generally adequate for the principal uses; there are two negative factors, however: (i) there is frequent turbidity during periods of peak flow, due to the very active soil/rock erosion (water courses have generally high slope owing to mountainous terrain). Sediment load over an average year is about 0.66kg/m³; (ii) high water hardness due to extensive calcareous terrain and a shortfall in purity due to often poor filtration by karstic-type terrain, itself often receiving surface water.

Also, subterranean aquifers in coastal areas are often invaded by sea water, especially when they are not kept full by the freshwater supply; on the southern side of the basin, the arid climate also raises the salinity of subterranean water.

Land and water are intimately related in Mediterranean littoral areas as a result of formation of coastal lagoons and of ponds in deltaic areas.

"Profits"		"Losses"	
Rainfall and snow melt	1100	Evapotranspiration	580
Importation: via the Nile	56	Evaporation	20
from north	25	Surface run-off to the sea	475
underground	1	Underground run-off to the sea	30
Water return (after use)	85	Water use	165
Total	1267		1270

2.2.9 Oil and Natural Gas

At present, the extraction of oil and gas, for energy and for chemical transformation, is the most important submarine activity. It takes place off the eastern Spanish coast, the eastern Italian coast, in the Gulf of Taranto, off southern Sicily, the Ionian Sea and northern Aegean Sea coasts of Greece, off Egypt, Libya, eastern Tunisia, and off eastern Algeria.

Oil drilling produces, at best, dirty waste water and oil which is dumped to the land, to rivers and to the sea. From the oil-industry point of view, this is a use of the land and/or sea that is hard to avoid; however, as soon as drilling has been completed and wells connected to the distribution system, this form of mining generally occupies little space and produces relatively little environmental nuisance, except when a major accident occurs, which is relatively rare on land (see also section 2.2.11).

2.2.10 Mining

Land mining is a major use of the land, mainly for: oil and natural gas (notably Algeria, Egypt, Libya and Syria, and Italy for natural gas); metallic ores, such as bauxite (notably France, ex-Yugoslavia and Greece), iron (Spain), chromite (Turkey), boron (Turkey); cement (notably Italy, Spain, Greece and Egypt), phosphate-bearing rock formations (Tunisia and Jordan), uranium ores (notably France, Algeria, Spain); lignite (Greece). Land mining often involves the dumping of mine tailings (coal slag heaps, for example) and ore slurry to the land, to rivers (hence to the sea) or to the sea directly. The use of the land for mining is vertical (coal pits) or horizontal (open-cast mining and quarrying for limestone, bentonite, lignite, asbestos).

Submarine mining in the Mediterranean comprises mainly drilling for oil and gas and dredging of gravel and sand. In fact, most sea-bed mining is more costly than land mining; so that this particular type of activity is at a relatively early stage of development. As already noted, the narrow continental shelf in for sea-bed mining. A special form of marine mining is salt extraction by evaporation in coastal salt beds.

In countries where building materials are in short supply or expensive, coastal sea-bed dredging for gravel and sand is often an important marine activity to provide such materials (ICES, 1992; Campbell, 1993).

2.2.11 Energy Generation and Consumption

The role of energy generation and use in determining environmental quality is discussed in detail in Fascicule 7 of the Blue Plan (Grenon *et al.*, 1993).

Since energy production (Table III), in particular, cannot be easily dealt with simply on a basin basis and statistics on consumption, on the same basis, are not readily available, these aspects of the energy question have been dealt with on a national basis. A distinction is made between the large and developed countries on the northern side (Spain, France, Italy, ex-Yugoslavia and Greece) and those on the southern and eastern sides (Turkey, Syria, Israel, Egypt, Libya, Tunisia, Algeria and Morocco).

For the northern group, the primary energy consumption, in 1990, in terms of oil equivalents in millions of tons, was 550MtPE (million tons of oil equivalents), of which France and Italy alone accounted for 70%, based on (in descending order of quantity): oil, nuclear power (predominantly French), coal, natural gas, hydroelectric power.

For the southern-eastern group, the corresponding consumption was 144MtPE, based on (also in descending order of importance): oil, natural gas, coal, hydroelectric power (no nuclear power). The leading consumers were Turkey, Egypt and Algeria. The difference between the two groups of countries is declining steadily, however.

Regarding primary energy production (as of 1990), the northern group produced only 208MtPE ($\approx 38\%$ of its consumption needs, in which France predominated); the main sources (in descending order) were: nuclear power (again, mainly France), coal, hydroelectric, natural gas, oil. In contrast, the southern-eastern group produced 264MtPE ($\approx 183\%$ of its consumption needs, in which Morocco, Tunisia and Libya predominated); the main

Table III. Production and Consumption of Commercial Energy for Mediterranean Countries, for 1990

Country	Primary energy production (10 ¹⁶ J)					Energy consumption (10 ¹⁶ J and 10 ⁹ J per caput)					P/C ratio *	
	Total	Solids	Liquids	Gas	Electricity	Total	Solids	Liquids	Gas	Electricity		Per caput
Albania	185	35	121	16	13	119	43	51	16	11	37	1.55
Algeria	4,593	0	2,617	1,975	0	1,084	36	295	753	0	43	4.24
Cyprus	-	-	-	-	-	52	3	49	-	-	74	-
Egypt	2,331	-	2,047	255	29	1,131	30	817	255	29	22	2.06
France ^b	1,959	362	143	117	1,337	6,528	805	3,209	1,340	1,174	116	0.30
Greece	329	283	35	4	7	896	321	562	4	10	89	0.37
Israel ^c	2	-	1	1	-	430	109	322	1	-	93	-
Italy ^c	944	12	196	599	138	6,150	565	3,779	1,543	263	108	0.15
Lebanon	2	-	-	-	2	121	0	118	-	2	45	0.02
Libya	3,239	-	2,868	371	-	629	0	306	323	-	138	5.15
Malta	-	-	-	-	-	21	8	14	-	-	59	-
Morocco	22	15	1	2	4	270	52	211	2	4	11	0.08
Spain	848	475	33	50	290	2,901	751	1,640	222	288	74	0.29
Syria	989	-	960	11	17	391	0	363	11	17 ^a	31	2.53
Tunisia	209	-	195	14	0	195	3	128	64	0	24	1.07
Turkey	712	500	121	7	84	1,701	654	846	120	81	30	0.42
ex-Yugoslavia	1,037	706	149	82	100	1,681	791	560	230	98	71	0.62

a. Production/consumption ratio; b. Includes Monaco; c. Includes San Marino

(Adapted from UNEP, 1993)

sources (in descending order) were: oil, natural gas, coal, hydroelectric power, (no nuclear power).

Mainly for economic and, increasingly, environmental reasons, there is a shift away from coal and oil (relatively "dirty" sources) to natural gas (relatively "clean"); and perhaps, in due course, nuclear power (which is relatively "clean" environmentally, if the problem of the safe disposal of waste nuclear fuel can be solved, but which also presents a number of strategic and political problems of national security).

Grenon *et al.* (1993) also outline the prospects for the so-called renewable sources of energy (i.e., depending more or less directly on the relatively constant input of solar energy to the Earth).

An increase in hydroelectric power production may be feasible in Morocco, Spain, ex-Yugoslavia and Turkey, although the construction of dams always raises important environmental conflicts which will be better understood as experience of previous installations is better assessed (the effects of the Aswan dam providing a particular example).

Geothermal energy sources are still only poorly known and exploited in the Mediterranean basin, although it is, in principal, an "active" region in this respect; distribution of this form of energy (mainly as hot subterranean water) presents some serious practical difficulties of distribution, however.

The possibilities for developing wind energy are obviously restricted to the windiest areas: notably France (Atlantic and the mistral winds), Greece (the meltemi wind) and

Morocco (also Atlantic wind), but also the Ebro valley and Andalucia, Sardinia and Sicily. This source of energy seems likely to supply only local electricity needs, but this could be important on islands (e.g., Crete) where winds are strong and persistent enough; a common use of wind power is to pump subterranean water to the surface.

Solar energy obeys some of the same constraints, being potentially useful, especially for local use (house heating, hot domestic water, for example), in the southern and eastern countries of the basin that have a high level of direct solar radiation.

Sources of biomass energy principally take the form of firewood, rural (crop) wastes and, partially, urban wastes. However, the possibilities of exploitation vary considerably from country to country, depending on such factors as the existing forest volume and potential biomass (if reforestation were practised assiduously), the nature and size of the local agriculture as a source of fermentable crop leftovers, and, similarly, for urban wastes, this source of thermal energy being related to urban population size and consumption, hence of the levels and nature of these wastes.

According to the OECD (Grenon *et al.*, 1993), energy production, transformation and consumption by Man account for 90% of all sulphur oxides and of lead released into the atmosphere; these pollutants are followed by nitrogen oxides (85%, and 60-75% for nitrous oxide alone), carbon dioxide (55-80%), volatile organic compounds (55%), particles (40%), carbon monoxide (30-40%), and man-made methane (15-40%).

3. State of the Marine and Coastal Environment

3.1 Coastal Zone

Caddy and Griffiths (1995) have summarized the main impacts of human activities on enclosed and semi-enclosed seas. The susceptibility of enclosed and semi-enclosed seas to human activities can be summarized under four headings (adapted from Caddy, 1993): (i) the scale of riverine, atmospheric and coastal (direct terrestrial runoff) inputs relative to the rate of flushing to the ocean, and the catchment area and its rainfall relative to the extent of the semi-enclosed sea; (ii) the extent to which sills or basins modify the exchange of water with the ocean and within the semi-enclosed sea itself; (iii) the latitude, depth and, consequently to a significant extent, the temperature and stratification of the water mass; and (iv) the size of the human populations residing along the littoral and within the catchment basin, the level of human activities and the land-use practices. A growing problem, however, globally as well as in the Mediterranean, is due to increased water withdrawals for human activities on land, which is often accompanied by increased loadings of nutrients and other materials in the remaining discharge; this changes the nature of marine aquatic systems in general and estuarine systems in particular.

Ever since it was established, the Mediterranean Action Plan has stressed the need to apply integrated management to the coastal zone and integrated planning to the environmental protection thereof. During its first decade, MAP concentrated on monitoring the state of the Mediterranean Sea and on interventions aimed at improving the state of the natural system. The understanding emerged that pollution sources were mostly (80%) on land, and that there was a need for the harmonization of development with the

receptive capacity of the environment; this calls for permanent integrated planning and rational management of the region's resources. This led MAP to concentrate on the coastal area and on carrying out the requirements of the Land-Based Sources Protocol of the Barcelona Convention (Jeftic, 1994). To this end, a first survey of such sources was completed in 1984 (UNEP, 1984); also, eighteen assessments of key pollutants (from the list in Annex I to the Protocol) have now been carried out, and have been used in the preparation of the present report.

The integration of environment and resource management policies with those on coastal-area development must therefore be based on the identification of complementary objectives and the use of policy instruments that are at once compatible and efficient (cost effective). In terms of coastal-area development, macro-economic policies must take into account, from their conception, their net impact on the planning and management of coastal-area development, tourism etc.

MAP's contribution to this end has been focused on the identification, evaluation and setting up of appropriate institutional, technical or policy-making mechanisms. Experience in this direction has shown that such integrated planning has not yet been fully applied to the coastal zone. Modern methods for this purpose have not been widely adopted and most of the plans already drawn up fail to take into account the roles of the atmosphere, the inshore and offshore sea use and human activities in the hinterland. The underlying objective must be to ensure a comprehensive coverage of a whole range of activities in a given coastal area. Basic information on coastal areas and resources for Mediterranean countries is presented in Table IV.

Table IV. Coastal Areas and Resources for Mediterranean Countries

Country	Length of Coastline (kilometres)	Maritime Area (thousand square kilometres)		Population in Coastal Urban Agglomerations (thousands)		Average Annual Volume of Goods Loaded and Unloaded 1988-90 (thousand metric tons)			Offshore Oil and Gas Resources					
		Shelf to 200-m Depth	Exclusive Economic Zone	Urban Agglomerations (thousands)		Petroleum		Dry Cargo	Annual Production		Proven Reserves			
				1980	2000	Crude	Products		Oil (thousand metric tons)	Gas (million cubic metres)	Oil (million metric tons)	Gas (billion cubic metres)		
													1982	1992
Albania	418	5.5	12.3	622	1,140	X	71	1,673	0	0	0	0	67	0
Algeria	1,183	13.7	137.2	3,493	7,613	29,110	24,409	15,266	0	0	0	0	0	0
Cyprus	648	6.5	99.4	291	457	545 ^b	502	4,586	0	0	0	0	0	0
Egypt	2,450	37.4	173.5	4,246	8,020	146,855	4,204	25,351	28,386	0	755	0	367	142
France	3,427	147.8 ^c	3,493.1	9,380	10,692	68,135	40,443	110,786	0	0	0	0	0	0
Greece	13,676	24.7	505.1	5,252	6,559	15,407	4,590	26,680	0	299	0	0	4	11
Israel	273	4.5	23.3	2,826	4,110	6,463 ^b	1,412	15,593	0	0	0	0	0	0
Italy	4,996	144.1	552.1	21,232	23,721	88,893	46,074	100,510	498	3,685	10,523	3,618	8	227
Lebanon	225	4.5	22.6	2,016	3,135	23 ^b	205 ^b	1,058	0	0	0	0	0	0
Libya	1,770	83.7	338.1	1,496	4,322	48,241 ^a	4,545	7,242	0	6,972	0	0	109	3
Malta	140	13.0	66.2	303	327	X	564	1,546	0	0	0	0	0	0
Morocco	1,835	62.1	278.1	5,543	11,472	4,910	140	28,990	0	0	0	0	0	0
Spain	4,964	170.5	1,219.4	13,903	17,925	47,932	22,958	89,71	1,413	697	0	920	1	7
Syria	193	X	10.3	266	853	16,233	3,287	6,070	0	0	0	0	0	0
Tunisia	1,143	50.8	85.7	2,476	4,540	4,330 ^a	937	13,762	1,520	1,245	0	0	34	0
Turkey	7,200	50.4	236.6	9,928	17,028	84,837	8,130	40,205	0	0	0	0	0	0
ex-Yugoslavia	3,935	36.7	52.5	1,236	1,767	8,827	3,044	22,946	0	0	0	0	1	0

a. Goods loaded; b. Goods unloaded; c. Includes overseas territory except French Polynesia and New Caledonia; 0 = zero or less than half the unit of measure; X = not available.

(Adapted from WIRI, 1994)

3.1.1 Urban Environment

In the Mediterranean, the human coastal population is about 130 million, although this figure depends very much on where the boundaries of the coastal zone are drawn. Grenon and Batisse (1989) used, *fautede mieux*, the administrative units bordering the sea in each country, although the areas of these units, in most cases, well exceed the usual idea of the coastal area as a strip of a few hundred to just a few thousand metres on either side of the coastline (sea-land interface); however, these units also tend to serve as "statistical" units for present purposes.

Of this population, about 40% is concentrated on the coast and it is expected to double by the year 2025. The urban development resulting from this concentration exerts great pressure on natural resources and areas, land (required for building) and water (section 2.2.8) and energy supply (section 2.2.11). The stress is also reflected on the increased demand for food (sections 2.2.5 and 2.2.6), transportation (section 2.2.3) and recreation facilities (section 2.2.4), and, beyond that, on health and quality of life, including employment, especially in the service sector, in which a high level of skills is usually required; those having such skills are generally more exigent as to living conditions.

It is hard to quantify the quality of the urban environment. The measurement of air pollution (section 3.2), for example, or the amount of domestic wastes produced (section 3.1.2), or even the percentage area given to green spaces in the urban environment, are only indicators of the overall quality.

3.1.2 Disposal of Industrial and Domestic Wastes

The amount of waste generated by human society is generally a direct function of its population size and industrial development, although the nature of a society and its industry may determine the nature and quantity of the waste produced.

The discharge of sewage occurs in the vicinity of all the major cities of the basin, and has drastically modified the ecosystem in this vicinity. The "dumping" of heat (cooling water) from coastal industrial and power-generating

plants in the Mediterranean may also have contributed to such modification. Moreover, pollution-combatting techniques are not being developed as fast as industry is expanding (Ramade *et al.*, 1990).

The dumping of industrial and urban wastes is an important use of the sea in the basin, the main routes being direct discharge, normally through coastal outfalls, indirect discharge via rivers, themselves discharging to the sea, and via the atmosphere from which wastes, especially particulates, are deposited dry on the sea surface or washed out by rain (see section 3.2). For some metals, organochlorines and some petroleum hydrocarbons, atmospheric deposition is a major form of marine pollution.

Direct industrial discharges to the sea are generally dispersed relatively quickly, mainly by the sedimentation of solid wastes and the dilution of liquid wastes, usually within only a few tens of kilometres of the point of discharge. Nevertheless, the flora and fauna are usually severely affected within this area (i.e., the so-called river or discharge plume). Dispersal and dilution are much slower if discharge is direct into rivers, and the flora and fauna correspondingly under much greater and more prolonged stress; moreover, estuaries and deltas often serve as spawning and nursery areas for many species of invertebrates and fishes, so the early-life stages can be severely prejudiced.

Gaseous wastes are mainly the gases of combustion (water vapour, carbon dioxide and monoxide, nitrogen and sulphur dioxides), methane, chlorofluorocarbons, volatile organic compounds, including solvents, heavy metals (generally released with volatile organics). There are quantitative and qualitative differences between those emitted by urban agglomerations and those by industry, but there is also appreciable overlap, qualitatively.

WHO and UNEP/MAP have carried out a questionnaire exercise on land-based sources of pollutants and, on that basis, have reviewed the related industrial and domestic waste management. Responses to the questionnaire were received from Albania, Algeria, Croatia, Cyprus, Egypt, France, Slovenia, Spain and Syria. It should be said, however, that responses to some questions were lacking or

incomplete. Nevertheless, a number of useful basic tabulations were prepared and the main results are mentioned in the following sub-sections. Although the responses were broken down by major conurbation and even by specific discharge point, only the general situation at the national and regional levels are considered here (UNEP/WHO, 1994).

Waste Waters

Urban liquid wastes comprise mainly dirty water (from domestic or industrial washing), detergents (usually with the dirty water) and lubricating oils; some solvents may also be part of such waste, but they normally evaporate at an early stage in the disposal chain. The amount of urban wastes, solid as well as liquid, is growing very fast, and especially in countries with intermediate average incomes (between \$6,000 and \$10,000 per year).

Industrial liquid wastes comprise waste water, oils, detergents, solvents, organic chemicals and heated cooling water.

The survey mentioned above showed that over 90% of the population (understood here as that of the Mediterranean basin parts of the responding countries) served by a wastewater collection system are so served by municipal sewer systems. Although the ratio of permanent residents to summer visitors (tourists etc.) is generally very high, France and Spain (of the responding countries) have ratios of 50-60% (i.e., roughly a doubling of the coastal population in the summer); by inference, Italy must also have a low ratio, and probably Greece and Turkey have fairly low ratios, as well.

Some 34% of the population (as specified in the preceding paragraph) have the disadvantage of no municipal sewage treatment, and about 58% have the benefit of secondary treatment (preliminary and primary treatment occupying the remainder, $\approx 8\%$; Table V).

Most waste water is reused: in irrigation ($\approx 95\%$), in recreational areas ($\approx 5\%$) and a little in industry, but when discharged, about 88% of it goes, directly or indirectly, to the sea; only about 12% is discharged onto the land or used further. Table VI gives the disposal of

municipal waste water for each of the responding countries.

Solid Wastes

Urban solid wastes comprise, basically, organic matter (e.g., food debris), paper, glass, wood, textiles, plastics and metals. A practical guide for the management of urban solid waste in coastal Mediterranean countries has been prepared by UNEP (1991). The solid wastes (mainly garbage) of human habitation and socio-economic activity are either used for land fill or, sometimes, dumped into the sea, although there is a growing recycling industry producing paper and packaging materials, composite insulation materials (shredded paper in a resinous matrix), glass for bottle-making, and scrap metal; such recycling only slows down the eventual discharge to the land or sea environments, however.

Industrial solid wastes comprise slag (from coal mining, coal processing and steel making), sludge (from the processing of, for example, bauxite and ilmenite, the main titanium ore), dust and combustion ashes, and mine tailings.

Regarding municipal sludge, the disposal of over 50% of it was not specified in the above-mentioned questionnaire responses; recognized discharge covers about 33% and about 10% goes to agricultural purposes. Table VII shows the amount of municipal sludge disposed of and its uses.

Over two million tons of solid wastes are disposed of by composting ($\approx 21\%$) or incineration ($\approx 7\%$), but over 70% of it is disposed of by unspecified means, again according to the afore-mentioned survey. Table VIII shows the amounts of municipal solid wastes produced and their treatment or disposition.

Hazardous Wastes

Whereas, in general, industry is a principal source of hazardous or toxic wastes, urban development is a principal source of microbiologically risky wastes (see section 3.1.2), as well as of detergents and lubricating oils (together with industry).

However, the draft Protocol (to be

Table V. Estimated Annual Amount of Municipal Waste Water Generated by Seven Mediterranean Coastal States, and the Corresponding Levels of Treatment (UNEP/WHO, 1994)

No.	COUNTRY	TOTAL WW 10 ⁶ m ³ /yr	UNTREATED WW 10 ⁶ m ³ /yr	%	TREATED WASTE WATER					
					PRELIM.	%	PRIM.	%	SEC.	%
1.	ALBANIA	8.52	8.52	100	0	0	0	0	0	0
2.	CROATIA	71.44	61.78	86	9.51	13	0	0	0.15	0.2
3.	CYPRUS	16.66	14.75	88	0	0	0	0	2.05	12
4.	FRANCE	361.02	47.70	13	0	0	0	0	313.20	87
5.	SLOVENIA	6.13	1.09	18	0	0	5.04	82	0	0
6.	SPAIN	589.29	180.62	31	45.22	8	17.30	3	346.15	59
7.	SYRIA	24.80	24.51	99	0	0	0	0	0.29	1
	TOTAL	1,077.86	339.02	31	54.73	5	22.34	2	661.84	61

Table VI. Disposal of Municipal Waste Water for Seven Mediterranean Coastal States (UNEP/WHO, 1994)

No.	COUNTRY	TOTAL URBAN WASTE WATER (million m ³ /year)	ESTIMATED ANNUAL DISCHARGE (million m ³ /year)				ESTIMATED ANNUAL AMOUNT OF WASTE WATER RE-USED (million m ³ /yr)								
			THROUGH MUNICIP. SEWER SYSTEM	THROUGH OTHER SEWER SYSTEM	SUB- TOTAL	ONTO LAND	INTO SUB-SOIL	OTHER	SUB- TOTAL	IN FISH PONDS	IN INDUSTRY	IN RECREAT. AREAS	IN RECHARGES	SUB- TOTAL	
1	ALBANIA	8.52	7.92	-	7.92	-	0.60	-	-	-	-	-	-	-	-
2	CROATIA	71.44	50.23	9.58	59.81	-	11.60	11.60	-	-	-	-	-	-	-
3	CYPRUS	16.66	-	-	-	0.36	14.38	0.84	15.58	-	-	1.11	-	-	1.11
4	FRANCE	361.02	359.52	-	359.52	-	1.50	-	1.50	-	-	-	-	-	-
5	SLOVENIA	6.13	5.08	-	5.08	-	0.94	0.11	1.05	-	-	-	-	-	-
6	SPAIN	589.29	489.08	5.68	494.76	0.33	-	-	0.33	-	0.05	3.69	-	-	94.98
7	SYRIA	24.80	24.45	0.35	24.80	-	-	-	-	-	-	-	-	-	-
	TOTAL	1,077.86	936.28	15.61	951.89	0.69	17.42	12.24	30.66	-	0.05	4.80	-	-	96.09

Table VII. Municipal Sludge Disposal for Seven Mediterranean Coastal States (UNEP/WHO, 1994)

No.	COUNTRY	TOTAL 10 ³ m ³ /yr	DISCHARGED 10 ³ m ³ /yr	AGRICULTURE 10 ³ m ³ /yr	DISCHARGED AND AGRICULTURE COMBINED 10 ³ m ³ /yr	OTHER OR NOT INDICATED 10 ³ m ³ /yr
1.	ALBANIA	0	0	0	0	0
2.	CROATIA	1.75	1.75	0	0	0
3.	CYPRUS	5.30	5.30	0	0	0
4.	FRANCE	1,207.37	251.26	155.05	24.62	776.44
5.	SLOVENIA	0	0	0	0	0
6.	SPAIN	3,980.85	1,460.95	381.05	194.99	1,943.87
7.	SYRIA	0	0	0	0	0
	TOTAL	5,195.27	1,719.26	536.10	216.61	2,720.31

Table VIII. Municipal Solid Wastes for Seven Mediterranean Coastal States (UNEP/WHO, 1994)

No.	COUNTRY	TOTAL 10 ³ tons/yr	INCINERATION 10 ³ tons/yr	COMPOSTING 10 ³ tons/yr	OTHER 10 ³ tons/yr	REMARKS
1.	ALBANIA	70.70	-	-	70.70	LANDFILL?
2.	CROATIA	189.75	-	-	189.75	LANDFILL?
3.	CYPRUS	97.30	8.30	-	89.00	S.LANDFILL
4.	FRANCE	-	-	-	-	
5.	SLOVENIA	29.39	-	-	29.39	S.LANDFILL
6.	SPAIN	1,771.28	154.44	431.58	1,184.67	
7.	SYRIA	144.88	-	44.00	100.88	LANDFILL?
	TOTAL	2,303.30	162.79	475.58	1,664.39	

submitted to the Contracting Parties to the Barcelona Convention) on the Prevention of Pollution of the Mediterranean Sea Resulting from the Transboundary Movements of Hazardous Wastes and their Disposal provides a list, in draft Annex I, of twenty-one categories of substances or materials that are considered to be hazardous, and twenty-seven kinds of substances, elements or compounds which, if present in wastes, are considered to render such wastes hazardous. The list covers all the elements, compounds and substances that are considered as pollutants in the present report, as well as some that are not specifically so considered. Also covered by the draft protocol are any substances or materials that have one or more of fourteen characteristics that could render them physically hazardous.

The draft protocol also specifies fifteen operations that do not lead to the possibility of resource recovery, recycling, reclamation, direct use or alternative uses, and thirteen that do. They are all based on actual or past applications. Hazardous wastes must, in any case, be managed in an environmentally sound manner, under this draft Protocol.

No attempt is made here to provide amounts of hazardous wastes handled by individual countries or transported between them. Although such quantities may provide an indication of the level of hazard, the nature of a given material or substance, the methods of disposal, and the quality of their application, will have a significant bearing on the risk involved under a given set of circumstances. The relevant regulations and controls, and whether or not they are properly enforced, are important factors in risk assessment. The nature of the risks in, for example, maritime transport in the Mediterranean have been briefly mentioned in section 2.2.3, above, for what amounts to a random selection of transported substances (mostly crude oil, in fact).

3.1.3 Soil Degradation, Desertification and Forest Fires

These three topics are closely related. Soil is degraded quantitatively by erosion and qualitatively by prolonged use for agriculture without adequate addition of fertilizer, by overgrazing, and by repeated heavy rainfall leading to leaching of essential chemicals and loss of fine-grained sediment, thus denying the

soil a suitable structure for plant root systems (a coarse-grained soil has poorer water retention capacity). In some areas, subject to long periods of insolation, soil may become crusted, thus preventing rapid or deep penetration by water when rainfall came.

Forest fires, by destroying the forest, deprive the soil of a major water-retention and anti-erosion system.

Soil erosion due to the removal of plant cover (e.g., deforestation) in watersheds increases sediment loading of rivers and changes the seasonal cycle and amount of fresh-water run-off to coastal seas, as well as the levels of siltation (GESAMP, 1993). High riverine sediment loads adversely affect anadromous species such as salmon and sturgeon, and estuarine organisms such as oysters. It also has a serious negative impact on aquatic vegetation which is often of key importance as fish habitat.

The end product of this system of degradation, aided by high temperatures and low rainfall, is desert. The main processes briefly outlined above are described in more detail by Mensching (1986).

The use of satellite remote sensing of the Mediterranean, as a means for assessing the spread of desertification and lesser forms of soil degeneration, as well as changes in vegetation cover, will be undertaken under the DAPHNE Project of the Regional Activity Centre for Environment Remote Sensing (UNEP, 1995).

Forest fires have increased considerably in frequency in recent decades (Marchand *et al.*, 1990; Ramade *et al.* 1990; Table IX), accidentally, due mainly to increased tourism and grazing, and to psychologically motivated pyromania, and intentionally, due to criminal pyromania, often inspired by an ambition to make land available for real-estate development (hotels, apartment buildings and secondary residences) or for grazing areas. These causes have been aided by poor forest management.

Not only does the table show the growth in the frequency of forest fires, but also the improved coverage of the data.

Table IX. Growth in the Number of Forest Fires in the Mediterranean Basin, for the years 1970-1985 (Adapted from Ramade *et al.*, 1990)

Country	1970-1975	1975-1980	1980-1985
Algeria	-	-	904
France	3559	5550	5350
Greece	-	1620	1184
Israel	-	-	899
Italy	4924	4074	11854
Morocco	-	-	185
Spain	3175	5612	8314
Tunisia	-	-	101
Turkey	-	1108	1204
ex-Yugoslavia	-	752	908
Totals	11 658	18 716	30903

The increasing frequency of fires reduces a forest's ability to recover. Holm oaks, cork oaks and Aleppo pines recover the most rapidly, but the recovery time for an Aleppo pine forest is ≈ 75 years, and for a holm-oak forest, ≈ 200 years.

3.2 Airborne Pollution

There are three aspects to the air-pollution problem: one is the pollution of the air itself, with its impacts on human health and possibly on weather and climate; another is the atmosphere's role in the transfer of pollutants; and a third is the contribution of the sea itself to atmospheric pollution.

GESAMP (1989) has reviewed the atmospheric input of trace chemical species to the world ocean and has summarized the data relevant to the Mediterranean Sea.

UNEP/WMO (1994) have undertaken a comprehensive review of airborne pollution of the Mediterranean Sea by sulphur and nitrogen compounds and heavy metals.

Two important regional projects have addressed pollutant-transfer aspects of air

pollution in the Mediterranean basin: DYFAMED (*Dynamique et Flux Atmosphériques en Méditerranée Occidentale* - France) addresses the problem specifically. Under EROS-2000 (European River-Ocean System), a project of the Commission of the European Union, it is one of six sub-projects.

The main objective of the WMO Global Atmospheric Watch (GAW), established in 1989, is to provide data and other information on the chemical composition and related physical characteristics of the atmosphere and its interactions with the oceans and the biosphere (Soudine, 1992).

One of the six sub-projects of EROS-2000 has attempted to compare riverine and atmospheric fluxes to the north-western Mediterranean. Saharan dust and some heavy metals are predominantly airborne. These and other relevant substances (e.g., nitrogen) play a major role in the key biogeochemical cycles, of which little is known in the Mediterranean region.

One of the main objectives of DYFAMED is the study of the dynamics of the atmospheric fluxes and their evolution in the

water column. DYFAMED results so far have revealed considerable seasonal fluctuation in the atmospheric inputs of pollutants to the sea, and there is also rapid downward transport in the marine water column.

The MED POL component of the WMO Global Atmospheric Watch comprises 15 monitoring stations; the suite of observations (not yet fully attained) is: in precipitation - pH, conductivity, sulphate, ammonia, nitrate, sodium, potassium, magnesium, calcium, chlorine, cadmium, lead, copper and zinc; in the air - cadmium, lead, total particulate matter, surface ozone. To these may be added, in due course, ^{137}Cs , transuranics, PCBs, DDTs, HCHs, PAHs and particulate hydrocarbons, the nutrients N and P, and carbon black, as a good inert tracer for validating model calculations (Soudine, 1993).

Mention has already been made of the predominance of the atmosphere in the transfer of some trace metals (as mercury, lead, zinc), most organochlorines (notably PCBs, DDT/DDE/DDD) and PAHs.

The fate of atmospherically transported trace metals deposited at the sea surface is critically determined by the degree of solubilization in sea water, since this controls the manner in which they take part in the biogeochemical processes in the mixed layer. Particulate/dissolved phase relationships of atmospherically transported particulate trace metals are determined by the solid-state speciation of the metals in aerosols. Gravitational deposition will deliver aerosols to the sea surface in a "dry" state; they will react directly with sea water. Particulate/dissolved phase changes can be initiated in rainwater, prior to deposition on the sea surface. This can be very important because the pH of rainwater can be considerably lower (more acidic) than that of sea water, leading to enhanced leaching of trace metals from aerosols (Liss and Slinn, 1983).

Martin *et al.* (1989) have compared, for the north-western Mediterranean (data for the eastern Mediterranean are still very scarce), the relative contributions of the atmosphere and the rivers to the input, to the sea, of several contaminants. Thus, the contribution (in ascending order) of ^{238}Pu , total phosphorus, ^{241}Am , total nitrogen, and

^{137}Cs is predominantly (mean percentage >50%) via riverine discharge; that of water is almost half and half atmospheric (rainfall) and river/land run-off; and (also in ascending order) the contribution of dissolved cadmium, $^{239+240}\text{Pu}$, dissolved copper, particles, particulate copper, particulate cadmium, particulate lead and dissolved lead are all predominantly (also >50%) via the atmosphere. The contribution of lead in both forms is >90%.

The available data (and model computations) from the GAW show (Soudine, 1992) that a significant proportion of the pollutants entering the Mediterranean Sea is transported via the atmosphere from coastal and remote land-based sources. By comparing specific cadmium sources and receptor points, using 36-hour atmospheric (wind) trajectories, the role of the atmosphere has been confirmed, and it may be concluded that pollutants emitted to the atmosphere on the European hinterland may reach the Mediterranean in 24-48 hours; it should be noted that the main trajectories are determined by the principal topographical features and the corresponding winds discussed in section 1.3, above. For cadmium, in particular, it has been shown that the Gulf of Lions, the Gulf of Genoa, the northern Adriatic and the Aegean Sea are the marine areas most affected by the long-range transport of cadmium from the major sources in Europe.

The principal available data for various atmospheric inputs to the Mediterranean Sea summarized by GESAMP (1989) refer almost entirely to the western basin or even just the north-western part. The main inputs are of the silicon, aluminium and iron minerals, which have total depositions of 1535, 435 and $360 \times 10^6 \text{kg/year}$, respectively. Of the trace elements, contaminant or not, the corresponding annual depositions of the predominant species are: zinc ($17 \times 10^6 \text{kg}$); phosphorus ($16 \times 10^6 \text{kg}$); lead ($14.5 \times 10^6 \text{kg}$); vanadium ($12.5 \times 10^6 \text{kg}$); manganese ($11 \times 10^6 \text{kg}$); well ahead of copper ($2.1 \times 10^6 \text{kg}$), cadmium ($0.5 \times 10^6 \text{kg}$) and arsenic ($0.5 \times 10^6 \text{kg}$). GESAMP also gives some percentages of European emissions from human activities entering the NW Mediterranean Sea via the atmosphere: zinc (21%), cadmium (19%), lead (12%) and copper (11%). For zinc and copper, at least, the ratio of wet to dry deposition is about 4:1. Also, atmospheric deposition fluxes are increased by rainfall, which scavenges the

atmosphere of aerosols.

No data on atmospheric mercury deposition are presented, either by GESAMP or by UNEP/WMO (1994). Goldberg (1976) points out the fact that mercury has not only a relatively high vapour pressure, but is also degassed from the Earth's crust, giving global degassing rates of 2.5×10^{10} to 1.5×10^{11} g/year and comparing them to estimated global riverine discharge of $< 3.8 \times 10^9$ g/year; global production of mercury amounts to about 10×10^9 g/year. The situation in the Mediterranean is not known, but Man's influence appears to be negligible except, no doubt, for localized "hot spots".

Some difficulties arise in the analysis of many synthetic organic compounds in the atmosphere, because, for example, the partitioning of these compounds between the gaseous and the particulate phases is highly influenced by carbon soot and dust, the effects of which are in turn highly dependent on particle size, which may greatly affect deposition rate (input to the sea).

Regarding synthetic organic chemicals in natural waters, the net flux has hitherto been from the air to the sea, but, recently, decreased production and emission of many hydrophobic organic chemicals (HOC), such as PCBs and PAHs, have resulted in lower levels of these compounds in the environment, so that HOC fluxes across the interface may have reversed and the sea may now be a source of organic contaminants to the atmosphere.

Very few data on atmospheric deposition of synthetic organic compounds are available for the Mediterranean. GESAMP (1989) give values for wet deposition of alpha-HCH (1.5×10^6 g/year), gamma-HCH (8.4×10^6 g/year), Σ HCH (9.9×10^6 g/year), Σ DDT (1.3×10^6 g/year), Σ PCB (6.8×10^6 g/year) and HCB (0.2×10^6 g/year). A corresponding value of 3.8×10^6 g/year for the riverine input of Σ PCB is also given. In general, the Mediterranean values are lower than those over the North Atlantic. Moreover, on a global basis, the atmospheric inputs of these synthetic organic compounds represent 85-99% of their total inputs (atmospheric + riverine).

The principal effects of sulphur oxides, lead, nitrogen oxides, carbon dioxide and

monoxide, volatile organics, molecular mercury, methane etc. on the atmosphere are those associated with the so-called "greenhouse" effect and those producing smog: in certain places under certain atmospheric conditions, particularly those prevailing over some big cities, the volatile organic compounds and nitrogen oxides are modified photochemically by solar radiation to produce so-called photochemical oxidants that, in association with dust particles (as condensation nuclei) and water vapour, produce the oppressive smoke-fog ("smog"). Added to the aforementioned forms of pollution, in some places, is that due to the burning of kerosene, coal or firewood for domestic heating, the products of which are mainly carbon dioxide and monoxide, volatile organic substances and sulphur oxides; their effects are similar to those described above.

There are a few other substances that play a role in atmospheric pollution, but not much is yet known about them in this sense. They are: dimethyl sulphide, carbonyl sulphide and methane, which have significant fluxes from the sea to the atmosphere, and nitrous oxide. They are discussed in a little more detail in the section 3.6, on climatic change.

Loye-Pilot *et al.* (1990) and Martin *et al.* (1989) present a body of data on the input of nitrogen to the sea via the atmosphere, and the results are summarized in GESAMP (1989). Some 350×10^6 kg N/year are so input to the ocean, compared to a value of 227×10^6 kg N/year via riverine discharge. This nitrogen contributes some 10% "new" primary production (i.e., relative to the average for the western basin) and perhaps as much as 50% under oligotrophic conditions (i.e., such as is more commonly found in the eastern basin).

Carbon soot arises from combustion of all kinds of organic compounds. Particle size is very small (micrometre range), thus providing adsorption of other chemical elements and compounds, including pollutants, and making the atmosphere an effective vehicle. Owing to its low chemical activity and low sedimentation rate in sea water, soot serves as a tracer of atmospheric fine-particle inputs to marine surface waters and of particle packaging and transport in sea water. Other particulate matter may play similar roles and be almost certainly important in the dispersion of pollutants in sea water.

Ramade *et al.* (1990), among others, has drawn attention to the often serious negative effects of polluted air (as manifested in, for example, acid rain) on buildings, hence on the region's architectural/archaeological heritage, the notable examples being Athens, Istanbul and Rome. Moreover, acid rain, and photo-oxidants generally, seriously affect the aerial parts of the vegetation.

3.3 Marine Environment

The monitoring of the sources, levels and effects of pollutants in the Mediterranean Sea, and the related research, have been one of the cornerstones of the Mediterranean Action Plan. The Coordinated Mediterranean Pollution Monitoring and Research Programme (MED POL Phase I) is the environmental assessment component of the Action Plan. It was mainly designed to help the Contracting Parties to the Barcelona Convention to participate in a full-scale marine pollution research and monitoring programme, as well as to provide continuous information on the pollution of the Mediterranean; it is described in UNEP (1984).

The monitoring of pollutants affecting the Mediterranean marine environment reflects primarily the immediate and long-term requirements of the Barcelona Convention and its Protocols, but also takes into account those factors directly relevant to understanding the relationship between the socio-economic development of the region and the pollution thereof. The monitoring under MED POL started in 1983 through the implementation of National Monitoring Programmes and, at present, 17 Mediterranean countries have ongoing activities and are submitting data. They are: Albania, Algeria, Croatia, Cyprus, Egypt, France, Greece, Israel, Lebanon, Libya, Malta, Monaco, Morocco, Slovenia, Spain, Syria and Tunisia. Through this programme, pollution is being regularly monitored at hundreds of sampling stations (Fig. 2).

Now, as result of concerted international efforts, current knowledge of the state of contamination of the Mediterranean Sea is now much greater than it was two decades ago. Through MED POL, the Mediterranean Action Plan has, since 1976, coordinated these efforts with the support of the governments of 20 Mediterranean coastal States, the European Union and the relevant

bodies of the United Nations (ECE, UNIDO, FAO, UNESCO, WHO, WMO, IMO, IAEA, IOC). The study has permitted the identification of the priority pollutants and the preparation of assessments thereof which, in some cases, have lead to proposals for control and abatement measures. It has also permitted the formulation and implementation of a long-term pollution monitoring and research programme - MED POL Phase II - which has been helping the Mediterranean countries to evaluate their own pollution problems, assess the effectiveness of control and abatement measures and allow long-term trend studies to be conducted.

The data generated through MED POL are used as the basis for the analysis of the present "state of health" of the Mediterranean Sea and the trends in pollution levels (Jeftic, 1991).

Perhaps the most important task of MED POL Phase II is closely connected with the implementation of the Land-Based Sources Protocol which foresees the formulation and adoption, by the Contracting Parties, of common measures (guidelines, standards, criteria) for substances listed in Annex I (Black List) and Annex II (Grey List) of the Protocol.

Most of the factual information in this section has been obtained from MAP/MED POL assessments and other technical documents.

3.3.1 Levels of Marine Pollution

The concentration of marine pollutants varies considerably, from one environmental medium to another, from one ecological province to another, from one faunal group to another, and even from one species to another, as well as from place to place. The confirmation of a trend is therefore not easy. Any trend in concentration of a major pollutant tends to be most easily related to human activities, since variations due to natural processes have tended to an equilibrium.

For any given environmental medium, ecological province, species of marine organism, and place, the concentrations of the key pollutants are unlikely to fall outside the ranges given by Jeftic *et al.* (1990) and UNEP (1993a). The sources, inputs, environmental and sea-food levels of the main marine

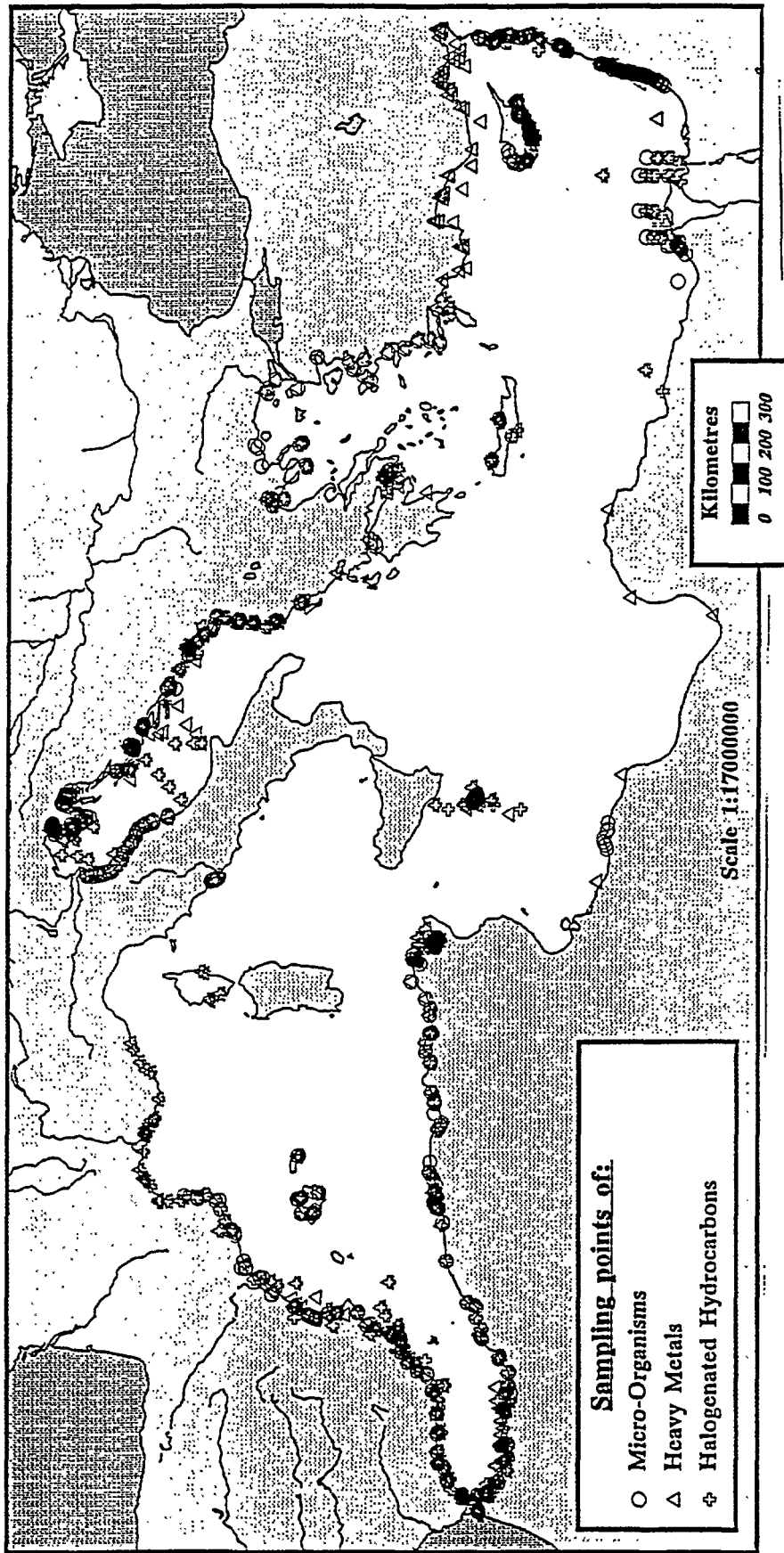


Fig. 2. Locations of Sampling Stations for the Monitoring of Marine Pollution in the Framework of the MED POL Programme (1983-1993)

contaminants are also summarized in WHO (1994).

Not only does human settlement bring with it the problems of contamination referred to elsewhere here, but it also threatens the habitat of many species of marine life: fish, turtles, birds, mammals and other organisms that habitually live in the coastal zone, in the sea or on the land nearby.

The main toxic substances emitted during the generation, transformation and consumption of energy by human beings are: benzene and other aromatic hydrocarbons, from crude-oil processing; heavy metals, notably lead from consumption of leaded petrol (although there is now a tendency to reduce such consumption); and even radioactive substances from the burning of coal and heavy fuels.

Trace metals

The main trace metals, in the context of the Mediterranean Sea, are: cadmium, mercury, lead, tin, copper and zinc, the latter two being considered as biologically necessary to organisms. Arsenic, which is a metalloid (i.e., can form "metallic" compounds such as arsenic sulphide and "non-metallic" ones such as sodium arsenate) has some environmental impact and can be conveniently dealt with in this sub-section.

There are undoubted problems in the measurement of trace metals in the marine environment and in drawing valid conclusions from the data, in terms of environmental quality and human health and safety. At the same time, there is always a need, in the context of the Mediterranean Action Plan, to show that a serious effort is being made to measure trace elements in the main environmental compartments. Jettic *et al.* (1990) have given adequate proof of such effort.

The main difficulties to be kept in mind, for purposes of environmental management, are as follows.

It is important, but also difficult, to ensure that measurements made at one time and place are of the same accuracy (closeness to the "truth") and precision (consistency between repeated measurements of the same

sample) as those made at another time and place, if differences between areas (e.g., eastern and western basin, inshore and offshore) are to be regarded as real. Moreover, such accuracy and precision must also survive in time within each analytical laboratory. Intercalibrations at regular intervals are necessary, even if the results are sometimes disconcerting. This requires carefully prepared reference standards for each trace element of interest and for each environmental medium. Such standards are not always available for all metals and media. The problems of data quality and the value of intercalibration are described in detail in UNEP (1993a).

Some of the so-called trace metals in the marine environment are subject not only to movement by Man in the course of his industrial and mining activities, but also to movement by Nature in the course of weathering of rocks, transport and discharge (into the sea) by rivers and release in the course of volcanic and tectonic activity; there is the well established case of high natural mercury levels in tuna (relative to most other fish) and of bioaccumulation in general in certain marine organisms (notably shellfish). The quantities mobilized by human activities are often small compared to those mobilized in the normal biogeochemical cycle (mercury being an example).

Another problem is the so-called chemical speciation of polyvalent metals (and arsenic), due to the fact that they have the capacity to enter into chemical combination in more than one way. The particular valency assumed depends mainly on the particular geochemical "history" of the metallic ions and the nature of the medium in which they might find themselves; the particular environmental pathway followed depends a lot on this process. It is still difficult to determine the partitioning of a particular trace metal, hence the likelihood of it ending up more or less directly in a sink (e.g., the sediments) or in biota in the food chain leading to Man. In some cases the analytical method itself "reduces" the metal present in an environmental sample to one valency state, and methods appropriate to the measurement of the principal valency states have, in some cases, yet to be developed.

Depending on local circumstances

(e.g., proximity to a point source) as well as the aforementioned factors, the observed ranges of most of the key trace metals are considerable in space; comparable observations in time (i.e., regular sampling at the same sites at regular intervals, with other parameters being kept as constant as possible) are less frequent. As Jetic *et al.* (1990), UNEP/IOC (1988), Alzieu *et al.* (1991), Gabrielides *et al.* (1990), UNEP/FAO (1986), UNEP/FAO/WHO (1994), UNEP/FAO (1987), UNEP/FAO/WHO (1989) and Michel (1992) show, there are considerable differences between the results reported by different reliable authors for a given element and environmental medium.

Although it is necessary to pursue serious routine monitoring, refining sampling and analytical methods continually, the predominant practical issue is to control the risk of human intake of toxic trace elements directly in food or indirectly via fish and shellfish cultivated in water so contaminated (see section 3.3.2, below).

The sources, main environmental pathways and levels of trace metals in Mediterranean sea water, sediments and biota, as far as these are known, are summarized below. In general, there is a tendency for sea-water values to decline with distance from the coast, but this may also be partly due to the fact that, except in the NW Mediterranean, the sampling depth was near the sea surface offshore. Also, some trace metals enter easily into strong stoichiometric associations with certain organic molecules, known as chelates, or adsorb strongly on to suspended particles, such that the fate of the metal is tied to that of the organic molecule or the particle; such molecules and particles are much more abundant in inshore waters.

The levels in the marine sediments are usually very much higher than those in the sea water and may be assumed to be in a long-term sink if at depths (in the sediment) greater than, say, 50cm; above this depth, recirculation to the sea water by organisms - bioturbation - or by physico-chemical activity in the pore waters may occur. Relatively little is known about these processes (except from very localized studies of them).

The levels of trace metals in marine organisms also vary over a wide range

generally exceeding the levels in the sea water and, in some cases, such as zinc, the levels in the sediments. In organisms, however, as noted, bioaccumulation may play an important role.

The differences between the main MED POL sub-regions of the Mediterranean are exposed by Jetic *et al.* (1990) and, for zinc and copper, UNEP/FAO/WHO (1994); in some cases, data for specific localities within sub-regions are given. "Within-subregion" ranges sometimes approach "between-subregion" ranges, but it should be stressed that there are often important differences between analysts for ostensibly comparable samples (as to medium and place).

The main sources (primary and secondary) of the principal trace metals are: rocks (mainly as sulphide ores); mining; ore processing; smelting (of copper, lead, nickel and zinc); agricultural, domestic and industrial wastes; combustion of fossil fuels.

The main environmental pathways are: rocks (following weathering by wind and water) and soil erosion → rivers → sea; or → run-off → rivers → sea; or (following combustion, metal processing, volcanic activity) → air → sea; or (from agricultural run-off, domestic, industrial effluents, via outfalls) → sea or → rivers → sea.

In considering the levels, presented here only in terms of range between the lowest and the highest values observed, the fact that the values come from a wide range of sampling sites and times must be kept in mind.

Cadmium comes from: copper refining (as a by-product); lead processing; electroplating; solders; batteries; production of alloys, pigments and PCBs; sewage sludges.

The levels in sea water cover a wide range (UNEP/FAO, 1986; UNEP/FAO/WHO, 1989; Jetic *et al.*, 1990) of values: open sea 0.004 - 0.06 $\mu\text{g/l}$ (recent and probably more reliable data); coastal sea <0.002 - 0.90 $\mu\text{g/l}$, with a tendency for high values to be related to sources (estuaries, coastal mining).

The levels in sediments cover a much wider range: 0.02 - 64 $\mu\text{g/g}$ dry weight.

The levels in biota likewise cover wide

ranges (depending on the groups of organisms considered; UNEP/FAO, 1986; UNEP/FAO/WHO, 1989): plankton 0.4 - 4.6 $\mu\text{g/g}$ d.w.; crustaceans 90 - 490 $\mu\text{g/kg}$ wet (or fresh) weight (w.w.); Mediterranean mussels 5 - 1060 $\mu\text{g/kg}$ w.w.; red mullet 1 - 590 $\mu\text{g/kg}$ w.w.

Mercury comes from rocks (mainly as sulphide ores), degassing (of elemental mercury) from the Earth's crust and oceans, volcanoes, chlor-alkali plants, petrochemical industry, sewage outfalls. A specific case study of mercury pollution in Kastela Bay, Croatia, has been made (UNEP 1990). In general, human emissions are substantially less than natural ones; ratios of 1:4 up to 1:30 have been derived, admittedly from very rough raw data. Goldberg (1976) indicates a ratio of two orders of magnitude between the mercury content of the world oceans and the amount mined (i.e., potentially mobilized) by Man.

The levels (of total mercury, Hg-T) in sea water cover a wide range of values (UNEP/FAO, 1987; Jetic *et al.*, 1990; Gabrielides, 1994): open sea 5 - 140ng/l; coastal sea 1.4 - 2.2ng/l, with a tendency for high values to be related to sources (notably coastal mining). However, in general, mercury levels in Mediterranean sea water are no higher, on average, than those elsewhere.

The levels (also of Hg-T) in sediments are: 0.01 - 0.97ng/kg d.w., but the common failure to apply and intercalibrate standard sampling and extraction techniques and to take into account the grain-size distribution in the analytical methods, impedes satisfactory interpretation of the results obtained so far.

The levels in biota cover wide ranges (depending on the groups of organisms considered; UNEP/FAO, 1987; Gabrielides, 1994): mixed plankton 15 - 4230 $\mu\text{g/kg}$ w.w.; crustaceans 10 - 3000 $\mu\text{g/kg}$ w.w.; molluscs 5 - 7000 $\mu\text{g/kg}$ w.w.; fishes 1 - 7050 $\mu\text{g/kg}$ w.w.; benthic organisms 190 - 2750 $\mu\text{g/kg}$ w.w. A significant proportion of the mercury in organisms may be in the form of methylmercury, from 10% - 100%, depending on a variety of factors, such as species, individual age and the tissue sampled. There is some association between amount of mercury in sediments and in the local benthic organisms.

Jetic *et al.* (1990) give special attention to mercury because it is already the object of legislation in several Mediterranean countries, in respect of sea food. They stress the great difficulty of comparing data from different countries because of the lack of intercalibration of analytical results. Total dissolved mercury levels, measured with present state-of-the-art methods, may reach 8 $\mu\text{g/l}$, but so-called reactive mercury (i.e., in a form susceptible to chemical reaction) reaches mean values only at the ng/l level. Comparable measurements elsewhere are usually lower.

Lead comes from: mining; smelting; steel-making; production of alloys; batteries; pigments; combustion of leaded (by lead tetraethyl) petrol. A ratio of 7:1 for industrial:domestic discharge has been calculated.

The levels in sea water cover a wide range (UNEP/FAO, 1986; Jetic *et al.*, 1990) of values: open sea 0.018 - 0.14 $\mu\text{g/l}$ (recent and probably more reliable data); coastal sea 0.016 - 20.5 $\mu\text{g/l}$, with a tendency for high values to be related to sources (lead tetraethyl production and estuaries).

The levels in sediments cover a much wider range: 3 - 3300 $\mu\text{g/g}$ d.w.

The levels in biota cover wide ranges (depending on the groups of organisms considered; UNEP/FAO, 1986); Mediterranean mussels 50 - 16100 $\mu\text{g/kg}$ w.w.; red mullet 23 - 610 $\mu\text{g/kg}$ w.w.

Tin comes from: antifouling additive in marine paints; fungicides; acaricides; molluscicides; wood and stone preservatives; disinfectants (the tin used in these applications is mainly in the form of tributyltin/TBT and triphenyltin); antihelminthics; stabilizers in PVC, catalysts in the production of silicones, polyurethanes etc. (dibutyltin/DBT and monobutyltin/MBT). Tin may also be present as methyltin (TMT/DMT/MMT) and as inorganic tin (Sn-I).

The main pathway to the marine environment is by leaching from treated cooling pipes and vessel (especially yacht) hulls into the ambient water.

The levels in sea water cover a wide range (UNEP/FAO, 1989; Gabrielides *et al.*,

1990; Jeftic *et al.*, 1990) of values, depending significantly on the level in the source and the dilution of the river, estuarine or sea water (marinas, ports etc.): mostly 100 - 1000ng/l; maximum ranges are: <2 - 12,150ng/l (TBT); <1 - 484ng/l (DBT); <0.5 - 2774ng/l (MBT), though values are generally much higher in the water surface microlayer. Alzieu *et al.* (1991) provided further data on TBT, DBT and TPT (triphenyltin) but these data fell within the ranges already cited.

The levels in sediments are only available, so far, for Alexandria harbour: 35-975ng/g d.w. (TBT); 10 -305ng/g d.w. (DBT); 0 - 330ng/g d.w. (MBT); 310 - 4720 (Sn-I).

There are no data available for levels in biota in the Mediterranean region (Gabrielides *et al.*, 1990).

Copper comes from: mining; alloys; metal plating; electricals; catalysts; jewellery; algicides; wood preservatives.

The levels in sea water cover a wide range (UNEP/FAO, 1986; Jeftic *et al.*, 1990; UNEP/FAO/WHO, 1994; UNEP/FAO/WHO, 1995) of values: open sea 0.04 - 0.70 µg/l (recent and probably more reliable data); coastal sea <0.01 - 50µg/l, with a tendency for high values to be related to sources (Nile discharge, coastal mining).

The levels in sediments cover a much wider range: 0.6 - 1890µg/g d.w.

The levels in biota, likewise cover wide ranges (depending on the groups of organisms considered; UNEP/FAO, 1986; UNEP/FAO/WHO, 1994; UNEP/FAO/WHO, 1995) microplankton 5.9 - 172µg/g d.w.; non-gelatinous macroplankton 12.6 -71.1µg/g d.w.; gelatinous macroplankton 2 - 22.4µg/g d.w.; Mediterranean mussels 2.4 - 154µg/g d.w.; red mullet 0.0025 - 2.7µg/g w.w.; seaweed (*Ulva lactuca*) 2.4 - 154µg/g d.w.

Zinc comes from: smelting; alloys; steel-making; metal-plating and galvanizing; paints and dyes; batteries; organic chemical production; oil refining; fertilizers; paper pulp; viscose rayon production. A ratio of 2.5:1 for industrial:domestic discharge has been calculated.

The levels in sea water cover a wide range (UNEP/FAO, 1986; Jeftic *et al.*, 1990; UNEP/FAO/WHO, 1994) of values: open sea 0.4 +/- 0.16 µg/l; coastal sea 0.20 - 210.0µg/l. UNEP/FAO/WHO (1994) give a range of 0.016 - 48µg/l for a wide variety of Mediterranean waters.

The levels in sediments cover a much wider range: 1.7 - 6200µg/g d.w.

The levels in biota likewise cover wide ranges (depending on the groups of organisms considered; UNEP/FAO, 1986; UNEP/FAO/WHO, 1994; UNEP/FAO/WHO, 1995): - microplankton 52 - 2500µg/g d.w.; non-gelatinous macroplankton 37 - 228µg/g d.w.; gelatinous macroplankton 17 - 312µg/g d.w.; Mediterranean mussels 12 - 644µg/g d.w.; red mullet 0.1 - 7.1µg/g w.w.; seaweed (*Ulva lactuca*) 33 - 1549µg/g d.w.

Arsenic is a by-product or waste of non-ferrous metal processing (copper, zinc, lead, gold and cobalt), of fossil-fuel burning and the processing of phosphate rock and bauxite (for aluminium).

The levels of total dissolved arsenic in sea water, in the western Mediterranean below the photic zone (since arsenic is metabolized by phytoplankton), are 1.3 - 1.4µg/l (Michel, 1992). In estuaries and rivers the values are much more variable: 1.5 - 3.75µg/l in the Rhone delta.

The levels in sediments cover a much wider range: values of 40µg/g d.w. and of ≈1400µg/g have been measured in the port of Athens and the Gulf of Saronikos, respectively; in deep-sea sediments, however, values tend to authigenic levels and the arsenic there is probably of oceanic origin. Particulate arsenic in suspension tends to decrease with increasing salinity.

The levels in biota likewise cover wide ranges (not only interspecifically but also intraspecifically) and often related to proximity to a point source (Michel, 1992): - seaweeds 3- >200µg/g d.w.; 6-19µg/g d.w. in sea lettuce (*Ulva*); 34-40µg/g d.w. in *Porphyra umbilicalis*; 9-59µg/g d.w. in Mediterranean mussels; 14-27µg/g d.w. in oyster (*Crassostrea gigas*); 3-26 in scallops (*Pecten maximus*); 7-14µg/g d.w. in shrimps (*Crangon crangon*). The values in

fishes are very variable, depending on species, individual size and dietary habits.

Organochlorines

The principal organohalogen contaminants in the Mediterranean marine and coastal environment are PCBs, DDT and its metabolites (DDE and DDD), hexachlorohexane (HCH), hexachlorobenzene (HCB), heptachlor, and the pesticides aldrin, dieldrin (the epoxide of aldrin) and endrin (a stereo-isomer of dieldrin) (UNEP/FAO/WHO/IAEA, 1991). The majority of organohalogens are released from their sources into the atmosphere, and in particular from soils by two possible processes, known as "wick-evaporation" and "absorption displacement" (Goldberg, 1976). Such mechanisms are necessary to explain their wide distribution in the atmosphere and in a variety of environmental media far from the main sources. Also, there is certainly some return from the sea to the atmosphere by molecular evaporation from the sea surface and purging by bubbles bursting at the sea surface or by "upward scavenging" by sea spray. Nevertheless, those (the majority) used in agriculture are also washed off the land into rivers, thence to the sea, or directly into the sea via outfalls or run-off.

Over 80% of the total input into sea is via the atmosphere, and less than 20% via rivers. The agricultural pesticides transported by the atmosphere from inland sources may reach the sea, but over a wide area (regional, if not global) so that the effect on the coastal sea is not easily quantifiable and is probably moderate (Goldberg, 1976). The majority of organohalogens appear not to persist in sea water or sediments, but do appear to have quite complex biogeochemical pathways (UNEP/FAO/WHO/IAEA, 1991 and UNEP/IAEA/IOC/FAO 1992).

The appreciable analytical uncertainty of the measurements of organochlorines in marine samples and, in the Mediterranean context, the extremely uneven coverage as to environmental compartments (as air, water, sediments and biota) and sampling sites, makes the evaluation of the data and results highly problematical.

There is a wide range of levels in sea water, depending on the type of water sample

(e.g., surface microlayer, surface water, sea-water-dissolved phase, subsurface water) and sampling site; only PCBs have been satisfactorily analysed in Mediterranean open-sea water samples.

Polychlorinated biphenyls (PCBs) are industrial hydrocarbons used as dielectric fluids in transformers and capacitors, as coolants in refrigerants, and as plasticizers in some paints. They are ubiquitous in the atmosphere and are transferred to the sea by scavenging by rain and by dry deposition. In the sea, they are particle-reactive compounds, partitioning between lipid and natural organic phases.

The levels in sea water are (UNEP/FAO/WHO/IAEA, 1991 and UNEP/IAEA/IOC/FAO 1992): up to 548ng/l in sea water itself and up to 597ng/l in the surface film.

The levels in sediments cover a much wider range: up to 16,000µg/kg d.w., although most minima observed are <0.1µg/kg d.w.

The levels in biota, likewise, cover wide ranges (UNEP/FAO/WHO/IAEA, 1991 and UNEP/IAEA/IOC/FAO 1992) and are very variable within most species, with some relation to proximity to a specific source, however: values up to 453µg/kg w.w., although most minima observed are <0.1µg/kg d.w.; PCBs are most abundant in mussels and fish.

DDT is a well known, potent insecticide used on a global scale especially to control the spread of malaria by mosquitoes. It has, however, also been implicated in the demise of bird populations through egg-shell thinning and in the premature calving of seals. Although banned from use in western Europe, it is used in some countries bordering the Mediterranean Sea. DDT is metabolized to DDE which is very persistent in the environment and is thought to be a metabolic dead-end with a considerable toxicity. DDT deposition in northern Europe today is some 5 to 10 times greater than that at similar latitudes in North America.

Like PCBs, DDT is most abundant in mussels.

Hexachlorohexanes (HCHs) are a mixture of isomers of which one (gamma-HCH, lindane) is an insecticide. The atmosphere is the main pathway (99% of total input) in the global

distribution of HCHs, but they are highly soluble in water so they may be washed out of the atmosphere by rain and accumulate in aquatic biota.

Hexachlorobenzene (HCB) is predominantly an industrial product, although its sources (as a marine contaminant) are still not precisely known. It is mainly used as a fumigant and a fungicide in grain storage. It may be enriched in aquatic environments in a similar manner to that of PCBs.

Heptachlor is an insecticide and is found in technical chlordane. It is degraded or metabolized in the environment and is often detected as its epoxide.

Agricultural pesticides

The commonest are aldrin, dieldrin and endrin, but others in common use in the Mediterranean basin are: chlordane; endosulfan or thiodan; toxaphene or campheclor; mirex; captan; dicofol or kelthane, 2,4-D, and dichlorophen. UNEP/IAEA/IOC/FAO (1992) stress, however, that they form only a small proportion of the total agricultural pesticides used.

Polar agricultural herbicides

The commonest herbicides found in the Mediterranean Sea are atrazine, simazine, alachlor, metolachlor and molinate, all widely used in agriculture and horticulture (Readman *et al.*, 1993), as well as the triazines used as biocide additives to marine paints (Readman *et al.*, 1993a).

The principal pathway for the former group is wash-out from agricultural land to rivers, hence to estuaries and the sea. In contrast to hydrophobic pesticides and organochlorines, such as DDT and PCB, these compounds bind poorly to soil, sediments, organic matter and organisms, and are transported primarily in the dissolved phase. The Mediterranean region, being the drainage basin of large agricultural areas, as those of the river plains of the Ebro, the Rhone, the Po and the Nile, probably has important concentrations of these polar compounds, but few specific studies have been made of them.

The levels in nine rivers, two Greek

gulfs and the northern Adriatic Sea are given by Readman *et al.* (1993). They are $<1.5\mu\text{g/l}$ and usually $<<1.5\mu\text{g/l}$. They are moderately persistent in sediments; measurements in the sediments of the two aforementioned gulfs and the deltas of the Ebro and the Nile are $<5\mu\text{g/g}$ d.w. and usually $<<5\mu\text{g/g}$ d.w. (Readman *et al.*, 1993). In general, the concentrations decrease seawards.

The levels of triazine in the inshore waters of the Côte d'Azur relate closely to sources (marinas, ports) and range from <5 to 280ng/l ; values in commercial ports tend to be less than those in marinas (Readman *et al.*, 1993a).

Organophosphorus compounds

These are synthetic organic compounds; some 58 OPs are used as pesticides and another 13 have non-pesticide uses (UNEP/FAO/WHO/IAEA, 1991a); in the last two decades, OP pesticides have tended to replace the persistent organochlorine pesticides. The main uses are as insecticides, acaricides, nematocides, antihelminthic agents, fungicides and herbicides, and, industrially, as flame retardants, plasticizers, solvent, antifoaming agents, hydraulic fluids, lubricants, dispersants and detergents.

In general, OPs are unstable in water, but some of them have a very high toxicity. Information on their levels in the Mediterranean marine environment is very scarce. The bulk of the research on OPs relates to their toxicity (UNEP/FAO/WHO/IAEA, 1991a).

Petroleum Hydrocarbons

Petroleum hydrocarbons and crude oil. The information available on inputs to the Mediterranean Sea is still limited, as it is for some key processes, as biodegradation, in the biogeochemical cycle. Even so, information on levels in water (dispersed/dissolved, particulate) and on beaches (tar) has increased considerably in recent years, whereas that on levels in sediments and organisms remains rather poor (UNEP/IOC, 1988).

The physicochemical complexity of oil, hence the analytical difficulties, has made intercomparison of samples (sites, environmental compartments etc.) very

problematical.

The levels of dissolved/dispersed oil in sea water range from 0µg/l to 5µg/l, with a few values exceeding 10µg/l. Tar, which floats in the sea until it is deposited on the sea shore, ranges (in sea water) from 0.6g/m² to 130g/m² and (on beaches) from 0.2 to 4388g/m. There is some suggestion of a reduction in these tar levels in recent years, notably in the eastern Mediterranean.

There is some indication, also, that petroleum hydrocarbons tend to accumulate in the sediments. A wide range of levels is given in UNEP/IOC (1988), and an attempt is made to construct a mass-balance statement. In terms of annual amounts (x1000 tonnes), the partition proposed is:

- surface microlayer: 0.018
- dissolved/dispersed: 30 (surface water) and 72 (subsurface water)
- tar: 8.8 (floating) and 100 (beached)
- sediments: 230 (superficial flocculent) and 120 (consolidated)
- organisms: 0.220
- atmosphere: 155

Lubricating oils, although derived from oil, are highly processed products with a wide range of industrial and domestic uses; besides the obvious use - as lubricants in engines and machinery - they are also used as cooling fluids (oils and oil-water emulsion) in most kinds of metalworking, in electrical transformers, rubber processing, spinning and natural gas transmission (UNEP/UNIDO/WHO, 1989). During the processing of lubricating oils, several other compounds are added, depending on the intended purpose of the oil; examples are barium, zinc, sodium and phosphorus compounds, oxidation and rust inhibitors. Also, some compounds, notably PAHs, are solvent-extracted during the processing.

Although it may be assumed that lubricating oils behave much as oils, no direct measurements have been made of this source of marine contamination, recourse being had to estimates based on such quantities as the number of cars in circulation, the amounts treated in municipal waste disposal systems etc. (UNEP/UNIDO/WHO, 1989). The major difficulties confronting such a study are the discrimination of lubricating oils and oils in the

marine environment and the dispersion of the sources of the lubricating oils relative to those of oils.

Polycyclic aromatic hydrocarbons

PAHs are a group of substances mainly formed by the incomplete combustion of organic materials (e.g., petrol, coal, oil). They are highly hydrophobic and are mainly transported to the sea by aerosols. Some are carcinogenic, and those that are carcinogenic are generally also mutagenic (UNEP/WHO/FAO, 1993 and WHO/UNEP, 1990).

Few data are available on the levels of PAHs in the marine environment. The range in mussels of the Ligurian coast, for eight PAHs, is from 0ng/g (for three PAHs) to 80.24 (for fluoranthene), apparently based on wet weight, since other data given in UNEP/WHO/FAO (1993) for the Ligurian Sea for *Mytilus* sp. range from 14 to 571ng/g d.w. The range for the Ebro delta and the Barcelona coast is much smaller, corresponding mainly to C₁-phenanthrenes.

The level in sediments for the Ebro delta range from 0.2 to 36.5ng/g d.w., and for the Barcelona coast, from 0 to 797ng/g d.w.

Radioactivity

There are at least 60 natural radionuclides, of which 14 are produced by radioactivation in the Earth's atmosphere by nuclear reactions or bombardment by cosmic-ray particles. The remainder are considered to have been present in the raw material of the Earth. Life has evolved in the presence of these nuclides, so the environmental problems refer mainly to those created or mobilized in the course of human activities (nuclear power plants, nuclear fuel reprocessing, nuclear weapon testing, medicine, nuclear physical research etc.). There are presently 29 nuclear power stations, with 4 more under construction, and 2 reprocessing plants in the Mediterranean basin, mostly sited along the Ebro, Rhone and Po rivers (UNEP/IAEA, 1992).

The environmental pathways and chemical behaviour of radionuclides is considered, *a priori*, to be the same as those of their stable (non-radioactive) counterparts,

although, in certain cases (ruthenium-106, cerium-144), the chemical form or species of the released radionuclide differs from that of its stable counterpart. The radioactivity itself, although often presenting a significant environmental risk, does not basically affect biogeochemical processes.

The radioactive contamination of the Mediterranean Sea, before and after the Chernobyl "injection" through fall-out is given in UNEP/IAEA, 1992).

Thus, the inventory of ^{137}Cs is now some 36% greater than it was in the western Mediterranean before Chernobyl accident; the added quantities are derived from fallout debris.

There remain higher-than-background concentrations of ^{137}Cs in the Levantine Intermediate Water mass. In contrast, the transuranic element ^{239}Pu associated with this water mass remains stable. The ^{137}Cs spike may be used as a tracer of the Levantine Intermediate Water mass in the western Mediterranean.

The present rate of removal of ^{239}Pu from the upper 1000m of the western Mediterranean to greater depths is estimated to be 2-4.5% of the annual standing inventory. Therefore, the vertical distribution of ^{239}Pu may be a valuable tracer of vertical transport of particles to deep waters.

Marine pathogenic organisms: water quality for bathing and shellfish waters

The health risks from pollution by pathogenic organisms in the Mediterranean marine environment have been summarized in UNEP/WHO (1991) and in WHO (1994). The principal organisms are: bacteria (mostly of the genera *Salmonella*, *Shigella*, *Vibrio*, *Staphylococcus*, *Pseudomonas*, *Clostridium*, *Campylobacter*, *Escherichia* and *Aeromonas*); viruses (mainly 5 types of enterovirus, including hepatitis A virus, and adenovirus and rotavirus); fungi (mainly of the genera *Candida*, *Penicillium*, *Aspergillus*, *Cladosporium*, *Mucor*, *Fusarium* and *Rhizopus*); microparasites (mainly of the genera *Entamoeba*, *Giardia*, *Balantidium* and *Nægleria*); and toxic algae (mainly of the dinoflagellate genera *Gonyaulax*, *Gymnodinium*, *Dinophysis* and *Alexandrium*).

These organisms are considered to enter the marine environment mostly through municipal waste water discharges, although the atmosphere may be a significant route and the contribution of sea bathers themselves cannot be discounted. The principal discharges of concern in the present context are the direct discharges into the coastal marine environment; discharges into rivers, although not to be neglected, are likely to arrive at the sea in a much altered state (of abundance, toxicity etc.).

Little is known of the fate, in the sea, of the non-marine micro-organisms mentioned above, especially of the viruses, fungi and microparasites. The salinity, temperature and solar irradiation of the sea water, as well as natural predators and the dissolved marine contaminants in the sea water, are, however, known to affect the survival of pathogenic organisms encountered. Flocculation of microbial cells and subsequent sedimentation may be important also, and may explain their enrichment in the superficial marine sediments. Faecal streptococci survive longer than the faecal coliforms.

The classical method for determining water quality from the microbiological or sanitary standpoint is by measurement of the coliform bacteria, faecal and non-faecal, and the faecal streptococci, which almost certainly explains why so little is known of non-bacterial pathogenic organisms (WHO, 1994a).

There has been a significant improvement in the quality of coastal bathing water in the Mediterranean basin in recent years, judging from EEC data for Spain, France, Italy and Greece, the current (1992) levels of acceptable bathing-water quality at established seaside resorts being 74%, 87%, 92% and 97%, respectively (WHO/UNEP, 1994). However, a number of other Mediterranean countries, including Albania, Algeria, Croatia, Cyprus, Egypt, Israel, Malta, Morocco, Syria and Tunisia, have also been monitoring the quality of bathing waters for the last few years, within the framework of the MED POL Programme Phase II; nevertheless good, comparable data are not yet available. These improvements have no doubt occurred in response to an increasing demand for such water quality from the tourist, as well as the resident, populations. More attention is now

being paid to beach sand, as well, since it may be contaminated by certain pathogenic organisms and ingested by swimmers and sunbathers (especially children).

The effects on human beings and key marine organisms are outlined in the next section, but indirect effects arise through the consumption of marine organisms themselves "infected" or "polluted" with the above-mentioned microbial organisms; this is particularly the case for shellfish cultured for human consumption, because of the concentration of the species under mariculture and their frequent proximity to their main market (the coastal urbanized populations, hence to the main sources of contamination - sewage outfalls). Thus, the quality of the shellfish themselves and of the water in which they are grown has been the main consideration (UNEP/WHO, 1987; UNEP/WHO, 1991a; UNEP/WHO, 1991b).

The results of a MED POL study (1976-1981) indicate that, while a majority of the sites sampled (47% - 86%, all data together) had satisfactory water quality, few (0% - 21%, all data together) had satisfactory shellfish quality (according to the criteria used in the project and without depuration of the shellfish in clean sea water). It may be expected that, with the increased demand for quality in food, from tourist and resident populations, the quality of shellfish flesh and shellfish-growing waters is improving.

Anionic detergents

The most important sources of anionic detergents in the Mediterranean Sea are land-based sources. Information on the amount of anionic detergents reaching the Mediterranean Sea is sparse (UNEP/WHO, 1994a). A pilot monitoring survey carried out in 1992 provided some information on levels of anionic detergents. Levels in sea water range from 0.01 to 4.2g/l, in effluents, from 0.11 to 34.07g/l, and in rivers, from 0.06 to 26.86g/l. This study, however, had to be restricted to a few coastal areas and the results cannot be interpreted as providing any indication of the situation prevailing in the Mediterranean as a whole.

Anionic detergents are often considered to be an environmental nuisance; although they

are rapidly metabolized in human beings, they may have some negative effects on ecosystems.

Man-made litter

It is no easy matter to quantify so heterogeneous a pollutant in the marine environment; the principal interest attaches to the persistent non-natural substances, the synthetic and plastic materials. The sources, inputs and distribution of garbage are summarized in UNEP/IOC/FAO (1991). A survey of thirteen Mediterranean beaches is reported by Gabrielides *et al.* (1991).

The main components of coastal litter are, in approximate descending order of abundance: plastics (fragments, sheets, bags, containers), wood (driftwood, crates), metal (especially drink and food cans, spray cans), glass (bottles), styrofoam (a special form of urethane plastic characterized by high buoyancy in water), fishing gear (currently rare, except in Turkey), construction materials (also currently rare, except in Sicily), rubber (but not rubber foam), and the rest (clothes, paper, cardboard, foodstuffs).

Floating litter is, by definition, limited to litter that floats, which depends, however, not only on density (e.g., wood, styrofoams) but also on form (e.g., empty bottles, cans).

The sea-bed litter is, likewise, that which sinks, and includes mainly metal, waterlogged wood, glass, fishing gear, some plastics (sheets, bags, containers).

The main sources are domestic and industrial activities and the main pathway is direct dumping into the sea or into coastal garbage dumps; users of beaches also leave substantial amounts on the beach; vessels, especially large (long-distance) fishing vessels, may also dump their garbage directly into the sea. It is obviously very difficult to specify sources in situations where the main sources are active at the same time. Inferential studies usually have to be employed. Several such studies are reported in UNEP/IOC/FAO (1991). With substantial variation, from place to place and time to time, in the composition of marine litter, and the relative usefulness of the counting or the weighing of objects, intra-regional comparisons are of doubtful value, but

the Mediterranean basin, as a semi-enclosed sea, appears to have a higher level of marine litter than most open-sea regions.

Dust load

Dust, although not a contaminant itself, is an important factor in the binding of pollutants; many of these attach preferentially to the dust particles in the atmosphere which are deposited dry on the sea surface or are washed out of the atmosphere by rain. Thus, Saharan dust, which is not itself significantly loaded with pollutants, helps to channel European pollutants into the Mediterranean Sea or its coastal zone. Calcium ions can be used to trace Saharan dust input, and the pH of marine precipitation can be used to differentiate between the dust of Saharan and industrial origins. Satellite remote sensing is a useful tool for assessing the Saharan dust over the Mediterranean (Moulin *et al.*, 1994).

Other possible contaminants/pollutants

Organosilicons may also be an environmental nuisance (UNEP, 1987a). There are two groups of organosilicons: silicon derivatives of organic compounds, which are potentially an open-ended group in which silicon can replace either carbon or hydrogen; and siloxanes. In the first group, the silicon does not change the basic characteristics of the parent organic compound, and siloxanes are rather inert. Organosilicons are used increasingly as polymers, especially in medical applications; the best known is silicone, whose physiological inertness is well known. In general, organosilicons, because of their stability, present little risk; no major adverse effects have been detected at present environmental levels. Nevertheless, chlorinated organosilicons may produce hydrochloric acid on breaking down (on moist membranes, for example), causing irritation in human beings.

Although fluorides are not, in themselves and at normal levels, major environmental pollutants, their production during the processing of bauxite to make aluminium is sufficiently high that they have a disastrous effect on the vegetation in the vicinity of the processing plant; perhaps fortunately, in this respect, such plants are not abundant in the region.

There are significant leather industries in Spain, Israel, Turkey, Greece and Egypt; two of their main waste products are chrome salts and odours. They therefore represent some danger to the living resources in their vicinity, but also reduce considerably the amenity value of the areas in which they are found; they are generally incompatible with tourism and recreation.

3.3.2 Effects of Marine Pollution

The effects of marine pollution on marine organisms have traditionally been related to contaminant concentrations in biotic material, and the objective was principally to measure these levels. This approach has now widened to include the measurement of a wide range of genetic, biochemical, physiological and ecological parameters of biological change. Such biological changes, biomarkers, can provide information on exposure to contaminants and sometimes on effects. If no changes are found in biomarkers, organisms or community structure, there is a sound basis for not pursuing investigation of potential pollution (UNEP, 1993a).

There is not always a straightforward relation between a concentration of a contaminant in an organism and the effect produced in that organism. The effect is registered as a departure from the normal condition of the organism, particularly in terms of such parameters as physiological or biochemical responses, at the cellular level, or as growth rate, natural mortality, reduced behavioural responses etc., at the individual level, or species abundance and community composition, at the population level. Since many animals, particularly filter-feeders, accumulate chemicals from their environment (sea water, sediments, food), they can provide early warning of potential pollution problems. Some organisms that respond rapidly to contaminants, can be used for toxicity testing and thus help to develop water-quality standards. These methods are discussed in some detail in Gray *et al.* (1992).

Some general comments may now be made on the effects of pollutants in the marine environment, after which, specific examples will be given under the same sub-headings as those used to discuss pollutant levels (section 3.3.1).

As already noted, a significant proportion of the discharges to the Mediterranean Sea comes from agriculture, especially as a result of excessive application of fertilizers and of intensive livestock rearing; in the latter case, a fraction of the nitrogen and phosphorus that finds its way into aquatic systems has its origin in marine sources in the form of fishmeal used in livestock feeds, thus providing a minor feed-back loop in the nutrient cycle. Some of the problems of the effects of agricultural fertilizers, with particular reference to nitrogen, have been discussed by Clarholm *et al.* (1988).

The discharge of nutrient-rich wastes to otherwise nutrient-poor seas, such as the Mediterranean, if in moderation and if contamination by toxic wastes can be excluded, can even somewhat enhance biological production in some fishery resources. However, nutrient enrichment inshore and imbalance of nutritive elements also lead to unusual and dense phytoplanktonic blooms which, on decomposition, produce unaesthetic conditions close to the points of discharge, thus adversely affecting coastal activities such as tourism; the Adriatic Sea is a good example (UNEP, 1994).

Agricultural fertilizer waste discharges, if uncontrolled, lead to eutrophication, subsequent oxygen depletion and seasonal anoxic conditions, as is often experienced in the upper Adriatic, in particular. There is an ecosystem adaptation up to the biological limits posed by the modified environment, but the components of this new ecosystem adapted to eutrophic conditions are rarely those of interest for human exploitation.

Unlike nitrogen, phosphorus compounds are not broken down to the gaseous inactive element, and a large proportion of phosphorus in run-off, although partially inactivated if stored in oxygenated sediments, may be more easily recycled from deoxygenated bottom sediments back into the pelagic food web, and contribute once again to eutrophication. From the standpoint of agriculture, this loss from terrestrial systems is surely not beneficial, and contributes to unnecessarily high fertilizer budgets (i.e., the over-application of phosphate fertilizer to make up the "loss").

Experience in the Mediterranean, which is basically an oligotrophic sea (characterized by low biomass, low availability of nutrients, trace metals and/or growth factors) suggests that moderate levels of enrichment of originally nutrient-limited marine systems may favour production and even suspension culture of some bivalve species, and higher production of small pelagic fish of low economic value, but they do so at the expense of more valuable bottom-dwelling fish and crustacea. Increased nutrient loads in the fresh-water run-off to semi-enclosed seas may also accelerate phytoplankton growth to the point that it adversely affects aquatic vegetation by reducing light penetration, especially if accompanied by a high load of suspended sediments.

Blooms of toxic phytoplankton species arising from the disposal of nutrients and other compounds into the sea can lead to diarrhoeic shellfish poisoning and other serious negative effects on health (ICES, 1992a; UNEP/FAO/WHO, 1995a), necessitating the temporary prohibition of the sale of affected fish products. Untreated sewage can lead to the risk of viral contamination of shellfish and consequent human illness. It should be noted that, even after primary or secondary treatment, the nutrient impact of sewage outflows remains unchanged. Consequent over-fertilization can cause fouling and clogging of nets and cages used in aquaculture. A recent European Union directive requires of its member countries tertiary treatment (e.g., denitrification and phosphorus reduction) for discharges into sensitive areas.

The Mediterranean, with a flushing time of some 80 to perhaps 300 years, allows nutrients and toxic materials to accumulate rapidly, which is most likely to lead to a decline in ecosystem diversity and to progressive dominance of the production system by short-lived, especially pelagic, species.

Recruitment, mortality and growth of a fish stock are affected by the impacts of other users of the aquatic habitat and its catchment area; such impacts arise potentially from all up-stream economic activities, such as industry and agriculture, as well as from fishing.

The adverse effects of marine pollutants can be viewed from more than one

standpoint: (i) the changes (such as turbidity, oxygen depletion, chemical contamination) caused in the water that alter its value as a medium for living animals and for human recreation and other uses; (ii) the changes (such as flocculation, oxygen depletion, chemical contamination) caused in the sediments on the sea bed that alter its value as a habitat for marine organisms, especially those of economic interest; (iii) the changes (such as tainting, poisoning/toxicity, growth/development inhibition) caused in marine organisms that are of economic or ecological value to Man; and (iv) changes in Man due to the consumption of altered marine organisms, to bathing in altered waters, and to breathing contaminated marine air.

There may also be some beneficial effects of contamination, but they are rarely the object of environmental research.

Some of these parameters of environmental effect cannot yet be measured adequately or have not yet been measured *in situ*, and, in some cases, recourse must be had to toxicity testing, in the laboratory, to establish levels at which discernible effects occur; it is not normally feasible to conduct such tests directly on human beings, so that most public health standards are based on effects observed on other, physiologically similar animals in the laboratory, leading to an assessment of risk to human health.

The very wide variety of effects observed can only be summarized very superficially here; most of the documents cited in section 3.3.1, above, have specified the best-known effects of marine contaminants, insofar as such effects have been clearly established, but this is not to say that they actually occur in the Mediterranean: only specific case studies can determine such effects in specific circumstances.

In very general terms, the majority of the socio-economic consequences of marine pollution are manifested as immediate or long-term effects on human health. In this context, the two main types of human exposure to pollutants in the marine environment are through direct contact with polluted seawater and/or beach sand, including ingestion of the former while swimming or bathing, and consumption of contaminated seafood

(UNEP/WHO, 1991a, 1991b).

A number of diseases have been tentatively associated with bathing in polluted waters. Such diseases have been reported to include bacterial diseases. In addition, a number of diseases and disorders affecting the ear, eye, skin, and upper respiratory tract have been associated with bathing.

With the exception of those associated with pathogens having a relatively low infective dose, diseases affecting the gastrointestinal tract are much more easily contracted by humans through the consumption of raw or partially cooked food, particularly shellfish. The number of epidemics and outbreaks of various diseases attributed to the consumption of contaminated shellfish is likely to be very high.

Pollution of the sea by persistent chemicals, such as mercury and other metals, DDT, PCBs and a number of other organic substances, creates a completely different hazard. Following entry into the marine environment, these chemicals accumulate in plants and animals as they pass through the marine food chain, reaching their highest levels in filter-feeders, such as bivalve molluscs, and in large predatory fish, such as tuna and swordfish. Effects on humans through the consumption of chemically contaminated seafood are essentially long-term, depending on the chemicals themselves, and the rate and amount of intake. In general, the principal risk is restricted to those individuals consuming seafood more than two to three times a week, although the risk varies with the type of seafood, the concentration of pollutant and the circumstances of the consumer.

Not only do coastal industries degrade the local marine environment where they discharge, but they also occupy the terrestrial environment in their vicinity at the expense of other biologically important critical habitats for marine and coastal species. To the extent that habitat loss and contamination depress the quality and abundance of the marine fauna, local fisheries are adversely affected by coastal industry; and, in the long term, the sum of all coastal industrial discharges not fully absorbed by the sea has the potential to affect adversely coastal marine fisheries in general. However, it is not always certain that fishes (of economic, fishery interest) are adversely affected by some

forms of chemical pollution. Nevertheless, on the whole, coastal industry (even including industrial-scale fish farming) has the potential to be prejudicial to coastal fishery interests.

Sea-bed mining, if it becomes widespread, and especially if some of the industrial processing is done at sea, may become important because of the discharge of waste rock dust into the sea to create significantly increased turbidity or increased concentrations of elements that are normally rare in sea water but become toxic at higher concentrations, for example.

Such extraction adversely affects benthic organisms by destroying habitats and *damaging spawning grounds of demersal and other fishes*; it also interferes with trawling and other bottom-fishing methods; however, the duration of the effects, once sea-bed mining has ceased, is relatively short.

The practical measures to control the effects of run-off relate largely to actions on land: to improve land-use strategies; to encourage local control of run-off into waterways; and to improve effluent treatment and discharge practices.

Concern has been expressed over the possible reduction of marine biomass due to the effects of toxic waste discharge into the sea. This biomass acts as a "sink" for carbon, and hence reduces the free carbon dioxide and methane in the atmosphere, thus limiting the so-called "sierra" or "greenhouse" effect. An alternative effect might follow from nutrient enrichment if a large proportion of organic material produced as a result of eutrophication enters carbon "sinks" such as bottom sediments underlying anoxic water masses. There is growing evidence that coastal sediments on clean bottoms of rock, gravel and sand in areas affected by nutrient enrichment are being converted by eutrophication into organic mud or muddy sand. Beside the effect the storage of carbon-containing material in bottom sediments might have on the benthic and demersal resources of an area, it may also be a significant factor in the context of global warming.

Sulphur and nitrogen oxides, which are emitted by thermal power plants, by a majority of industrial plants and by urban heating

systems, are the main cause of so-called acid rain which degrades building stonework, forests and water bodies.

The main effects of oil on water bodies, fresh or marine, are due to: direct discharge, intentionally or accidentally, leading to such now familiar problems as the tarring of marine animals, notably seabirds and marine mammals, and of fishing gear, degradation of beach quality, if the oil comes ashore, and the tainting of seafood. The "mining" of oil and geothermal energy often leads to the production of dirty water which, at best, degrades the quality of natural bodies of fresh water, and the effluents of thermal power plants may contain toxic substances that contaminate the waters, fresh or marine, depending on the site, receiving these effluents. Drainage water from coal mines may have comparable effects on subterranean water bodies.

Solid wastes from coal- or uranium-processing plants, for example, may be toxic or otherwise dangerous, and even non-toxic wastes, such as cinders from thermal power stations, may be so abundant as to constitute a serious environmental problem of disposal and of protection of subterranean water, if these cinders are left to be washed out by rain, for example.

Another form of waste related particularly to the production and transformation of energy is the heat due to the cooling of turbines and condensation towers; this heat is dumped with the cooling water back into the water body from which it came, creating a local environmental nuisance, modifying the pre-existing aquatic ecosystem, usually, but not always, for the worse.

Intensive aquaculture or mariculture may itself be a source of over-fertilization of semi-enclosed seas that have a limited exchange of water with the ocean, even though their sheltered conditions and ease of access make them initially attractive for aquaculture. Setting criteria for biological loadings of bays and lagoons as a result of cage culture of fish is already feasible, but defining a "favourable" level of aquatic enrichment, from the standpoint of the wild fishery resource, is still very difficult.

Discharge into the environment, and subsequent concentration in the food web, of

such contaminants as heavy metals, PCBs and dioxins, has begun to have a significant impact on fish-product quality.

In areas of oil exploitation, once the exploratory drilling phase is over, and the production platforms are in place, fishing is only likely to be seriously affected if these platforms are closely spaced, so that a substantial area of sea bed is closed to fishing; however, such "platform parks" may provide a haven for the fish, and thus eventually increase recruitment to the fished stock. Platform accidents, leading to discharge of substantial quantities of oil into the sea, are more likely to have adverse effects on human activities such as tourism and fishing.

Chemical pollution may influence fish production in numerous ways: reduction of stocks by mass mortalities; gradual decline, or changes in composition, of populations or entire ecosystems; increased occurrence of diseases; deterioration of fish-food quality; lowered growth rates. The seas, and land-locked water bodies, also receive a significant proportion of pollutant chemicals via the atmosphere, so that effects distant from the source cannot be discounted. Despite this, although such effects need much more rigorous control, there is pressure for some use of the marine environment for waste disposal, as a consequence of expected population growth and of the failure, in general, to provide sufficient landside facilities to handle and dispose of wastes in an environmentally sound way. It would be more practical to attempt to define the levels of pollution that cause no appreciable risk and the areas where such risk is most serious for living resources.

GESAMP (1986) has defined the ability of a component of the marine environment to accommodate a particular level or intensity of human activity as its environmental capacity. Intrinsic to this concept is the recognition that: (i) a certain level of contaminant will not produce an unacceptable impact on the living marine resources; (ii) the environment has a finite capacity to accommodate wastes without becoming significantly altered by them; (iii) such a capacity can be quantified.

The unrestrained use of rivers and estuaries for the discharge of nutrients and toxic compounds leads to significantly adverse

impacts on critical marine habitats, but water extraction and, more generally, the regulation of rivers for navigation and flood prevention have adverse effects on diadromous species (e.g., salmon, eels, shad). The effect of inappropriate land management within the watershed on siltation of coastal and estuarine areas, with its adverse effects on coastal habitats, is another environmental factor due to human activities in the coastal zone.

Trace metals

In discussing effects, it should be borne in mind that an effect may depend on many factors: (i) the ease with which a trace metal is taken up by a marine organism, or by a human being, or released by the body before it can do any harm; (ii) the form (e.g., ionic or chelated or otherwise bound to an organic molecule or in a particular valency state) in which the element is "available" for uptake; and (iii) the species and/or life-history stage and/or tissue concerned.

Cadmium enters the human body mainly via the food (notably crustaceans and molluscs), but only about 5% is absorbed into the bloodstream, the rest being rejected in the faeces; its main (adverse) effect is on the physiology of the kidney and, to a lesser extent, the liver. Although UNEP/FAO/WHO (1989) provided data on cadmium uptake, few data appear to be available on its actual effects on marine organisms; the principal effect of long-term cadmium contamination is growth inhibition/delayed development.

Mercury shows bioaccumulation with increasing age of an organism, but with strong variation between species. The value of most of the analytical data for mercury in organisms is greatly lowered by the lack of accompanying age data. Mercury is absorbed in the intestine and widely distributed in the tissues; it is also discharged in the faeces. There is some demethylation of methylmercury in the body. The organs most affected are the brain and nervous system

Lead is taken in mainly with food and water, but some absorption from the air via the lungs certainly occurs. At effective concentrations in the tissues it causes anaemia and degrades brain and nervous system function. Children are the most susceptible; the gastrointestinal

tract and the liver are also affected, and there may be some hormonal dysfunction. Little is known of the effects of lead on marine organisms, but they are generally thought to be similar, particularly in vertebrates, to those observed in human beings.

Tin in the form of triethyltin and trimethyltin is a neurotoxin in human beings, with some potential for carcinogenic, mutagenic or teratogenic effects, but the necessary clinical observations are still inadequate. These alkyltins can also cause shell-thickening in oysters.

Copper appears to present no hazard to human beings or marine organisms, at least at the levels likely to be found in sea water or seafood.

Zinc can cause coughing, dyspnea, muscle and joint pain, gastric irritation and peptic ulcers in human beings, but it is not carcinogenic, mutagenic or teratogenic. Little is known of the effects of zinc on marine organisms.

Arsenic bioaccumulates only slowly and, in marine organisms, mainly in the form of arseno-organic compounds, normally presents little risk to human consumers of sea food containing arsenic, which is all or nearly all excreted within 48 hours. Arsenic does present some toxicity to phytoplankton, reducing the growth in some species and the productivity, leading to modification of the phytoplankton composition which may have a "knock-on" effect on the zooplankton community.

Organochlorines

These compounds generally accumulate in fatty tissues in human beings and marine organisms. Organochlorines in seafood present a measurable risk of carcinogenesis.

PCB inhibits plant growth. Marine invertebrates and fishes are affected more at the juvenile stage than the adult. Birds are affected by PCBs, as well as DDT, egg-shell thinning and other pathological conditions being induced.

DDT is thought not to affect phytoplankton photosynthesis, but may alter the species dominance in a phytoplankton community. It may have a marked effect on crustacea. In fish,

it can pass from the female to her eggs and alters the natural mortality rate adversely. It may also induce premature pupping in seals. It appears to have no effect on human beings at the levels normally encountered in the food or in the atmosphere, tending generally to occupy the fatty tissues benignly.

HCH and the "drins" have little effect at the normal concentrations encountered in the marine environment.

Herbicides

At the observed concentrations, they are not likely to affect marine organisms, although they may modify the structure of phytoplankton communities.

Triazines

They have some adverse effect on phytoplankton photosynthesis.

Organophosphorus

There is no information on the effects of OPs on marine organisms or ecosystems.

Petroleum hydrocarbons

They have little effect on phytoplankton communities, but may have significant effects on littoral communities (notably at times of oil spills), but much depends upon the water mixing at a given time and place which would ensure dispersion of the PHCs in the marine environment; in some cases, several years are needed to restore the littoral floral and faunal communities, although a few weeks usually suffice. The larval and juvenile forms of marine organisms tend to be more affected than the adult stages.

Radioactivity

As already indicated in section 3.1.1, radioactive elements, as far as physiological functions are concerned, behave essentially as their stable counterparts (if these exist, which is not the case for the artificially produced "transuranic" elements). Since these elements and their counterparts are at very low concentrations in the marine environment, they have no major effects on organisms or human beings, except in unusual circumstances. There

is, however, a tendency to bioaccumulate in marine organisms and there is notable accumulation in marine sediments.

As far as their radioactivity is concerned, their effects depend on the nature of the decay sequence that each normally pursues (emission of alpha or beta particles or of gamma radiation). In the body, such emissions may have a mutagenic or carcinogenic effect, but there is only a very general association between exposure and actual effect.

Marine pathogenic organisms

Pathogenic organisms produce different diseases or adverse health effects in human beings and certain marine organisms. The main effects are:

Salmonella: they are the agents of typhoid and paratyphoid fevers, food poisoning and gastroenteritis, but they have only a short life in sea water; in contrast, they are accumulated in food and, if at a sufficient density, can cause disease.

Shigella: they are the agents of bacillary dysentery, but they have only a short life in sea water.

Vibrio: *V. cholerae* is the agent of cholera, but others are the agents of gastroenteritis, and still others are agents of otitis, sore throat and wound infections.

Staphylococcus: they may cause infections in the skin, skin glands and mucus membranes, meningitis, furunculosis, pyæmia, osteomyelitis, and food poisoning (*S. aureus*). These genera have a relatively long life in sea water.

Pseudomonas: they may cause infections of the ear and eye, of wounds, burns and the urinary tract, and enteritis.

Aeromonas: they may cause diarrhoea, pneumonia, abscesses and wound infections.

Enteroviruses: they may cause paralysis, meningitis, respiratory disease, rash, diarrhoea, fever, herpangina, myocarditis, pleurodynia, encephalitis, haemorrhagic conjunctivitis.

Man-made litter

The direct effects of litter are mainly aesthetic, although, on beaches, they also present a danger (accidental wounding) to swimmers and sunbathers. Some marine organisms, especially seals, turtles and birds

may become entrapped by certain components, such as rubber and plastic bands or rings, and fish netting, which passes over their head and become stuck, often eventually throttling them. Pieces of plastic in the sea are also mistaken for prey fish and are eaten; since they are indigestible, they block the alimentary canal and finally the digestion of food.

Nutrients and eutrophication

The principal marine nutrients, notably nitrogen and phosphorus, although not themselves contaminants, may have an important effect on the marine environment: eutrophication. Certain coastal zones become eutrophic due to high levels of nutrient discharge arising from human activities, although this may occur, to a lesser degree, naturally and more slowly in upwelling areas. Eutrophication is described in detail in UNESCO (1988) (UNEP/UNESCO/FAO, 1988, is the same document published in the MAP Technical Report Series and UNEP/FAO/WHO, 1995a).

Of particular concern is the nutrient transfer from terrestrial to freshwater and marine systems and, most particularly, the largely one-way flux of phosphorus from the terrestrial to the aquatic compartments of the environment. In its various forms, phosphorus is a key element in potentially limited supply for intensive agriculture, an important component of domestic and industrial wastes, and for which, unlike nitrogenous compounds, environmental transfer is largely aquatic. Human activities are estimated to have caused an approximately five-fold increase in river inputs of nitrogen to the oceans and a four-fold increase of phosphorus; it may only be assumed at present that these relative increases also hold true for the Mediterranean. The annual global input of phosphorus to the oceans is about 0.6Tmol (1 teramole of phosphorus represents about 31 million tons), compared to the global production of about 0.4Tmol of phosphorus (as phosphate fertilizer) and about 0.03Tmol (as phosphate detergent).

Not all phosphorus in suspension in the water is available to marine food webs, however; like silt, metals and many toxic compounds, much of the phosphorus is precipitated out to estuarine and marine sediments. Much scientific debate has focused

on whether primary production in aquatic systems is limited by phosphorus or by other nutrients or trace elements. The general consensus seems to be that nitrogen is usually limiting in coastal waters in northern temperate latitudes, although the precedent for considering available phosphorus as a measure of biological production throughout the food web appears to have been established (Andersen and Ursin, 1977); nevertheless, other elements than phosphorus and nitrogen, such as silicon and iron, should be given closer attention.

Eutrophication is normally manifested as a marked increase in the abundance of the phytoplankton, hence a very high primary production, as a result of the high nutrient levels, with substantial detrital "rain" promoting heterotrophic bacteria and flagellates, sometimes leading to seasonal or permanent anoxic zones in bottom water and sediments, with corresponding adverse impact on the benthos and on demersal food webs, but often sustaining a high standing crop of small pelagic fishes and zooplanktivores supported by high densities of planktonic herbivores feeding on the phytoplankton, if suitable conditions are present in the affected area (Jeftic *et al.*, 1990; Caddy, 1993).

The over-abundant plankton may lead to: (i) fish kills, by asphyxiation due to the clogging of fish gills and to the increasing consumption of the oxygen dissolved in the sea water in the oxidization (i.e., decomposition) of dead organic matter in the water; (ii) by reducing, consequently, the success of fertilization of fish eggs or the survival of fish larvae, or by inducing the displacement of older fish away from the usual fishing areas; and (iii) the fouling of fishing nets and the clogging of engine cooling systems. It may be that these various forms of clogging are due to polymers secreted into the water by the phytoplankters (especially dinoflagellates) involved; these polymers may also be responsible for the formation of slime and of surface foam (which dampens wave action and may even be a mechanism by which phytoplankton creates turbulence-free niches useful for its own survival).

Some algal blooms are due to certain species of dinoflagellates (such as *Noctiluca*, *Pyrodinium*) that produce what are known as

"red tides" which are, in the Mediterranean, widespread, seasonal and often site-specific. Several species of dinoflagellates produce toxins that may severely affect fish ingesting them and, once accumulated in fish or shellfish, may severely affect human beings eating infected sea food, causing such disorders as diarrhoeic or paralytic shellfish poisoning. Human beings may also be affected by the respiration of certain toxic dinoflagellates in aerosols.

The excess of nutrients close to the source, and possibly causing observable eutrophication, may become dispersed farther away and have beneficial effects on the pelagic food chain; thus, in the Adriatic, an increased abundance of small pelagic species, especially sardines, has been observed and persists even as fishing effort on such species tends to increase (Jeftic *et al.* 1990; Caddy, 1993). Jeftic *et al.* (1990) also report increased standing crops of mussels and oysters on the Istrian peninsula. There is also some indication that Kastela Bay (Croatia) and the Gulf of Saronikos (Greece) may follow the same evolution, provided that the discharge of toxic substances with the nutrients are controlled.

There is some reason to suppose that the conditions that favour eutrophication, if followed by dispersion and dilution of the excess nutrients, may also lead to an increase in productivity which, by increasing the amount of food available, may cause "plagues" of medusae, especially of the common species *Pelagia noctiluca* (UNEP, 1991a). However, other causes may be natural fluctuations in population abundance of the species, changes in the abundance of its predators, significant changes in water currents causing the sudden appearance and accumulation of jellyfish in a particular area at a particular time, or major hydroclimatic changes affecting factors that normally control jellyfish abundance.

There may also be some relation to the incoming Atlantic water inasmuch as this water is nutrient-poor but relatively well oxygenated; to the extent that early mixing can take place with eutrophied Mediterranean coastal waters, relatively productive water may result, and this may sometimes be the case in the Sea of Alboran.

3.4 Natural Resources, Protected Areas and Species

3.4.1 Natural Resources

The major part of the living resources (marine invertebrates and fishes, and forests) of the Mediterranean, and their present state, have been described succinctly in section 2.2.5, above. The effects of fishery are now fairly well, but far from perfectly, known; the effects of the degradation and pollution of the marine environment on the fish/shellfish resources are only just beginning to be known and understood. The state of the forests is now reasonably well known.

Although there is no urgent concern about most of the birds of the Mediterranean marine and coastal areas, the region lies on several migration routes of migratory birds, some of which are endangered (see sections 3.4.2, 3.4.3 and 4.3, below). The hunting of migratory birds has increased in recent years; all together, about 20 million birds are killed annually by hunting (Ramade *et al.*, 1990). Moreover, the drying of wetlands for agricultural or building purposes denies resting places for migratory birds and habitation for wading and swimming birds, leading to further reduction in their number. The increasing use of pesticides has also drastically reduced the numbers of prey birds, by interfering with their normal physiology, hence also the numbers of predator birds (Ramade *et al.*, 1990).

The situation with respect to marine mammals and turtles is dealt with in sections 3.4.3 and 4.3, below.

Besides the living resources taken in isolation, there is abundant natural landscape in the region which is affronted by many stress factors. There is a decline in natural beauty and loss of amenity due to the construction of overground electricity grid systems. Roads, though having as an objective an increase in amenity, also reduce natural beauty, in themselves and, some would argue, in the greater affluence of human beings the roads facilitate; human litter, if not promptly and continually removed, is a direct consequence of the facilitated access, together with vehicle exhaust gases. It is this consideration, perhaps most of all, that has lead to the steady growth of hiking or rambling, in which part of the

pleasure is getting to natural beauty spots with the least possible interference. Agriculture (directly by encroaching on land or indirectly by the adverse effects of pesticides and fertilizers), water use (notably dam construction, pipelines and storage tanks), industry and mining (also by occupying land and discharging wastes thereto) are also inevitable "enemies" of the natural landscape; so, evidently, is unchecked urban spread. The creation of protected areas (see section 3.4.4, below) is a first, but still inadequate step towards the protection of sites of natural beauty or ecological interest.

3.4.2 Biodiversity

Biological diversity (biodiversity) is a measure of the variety of genes, species and species assemblages (ecosystems); it is of value because we cannot be sure of the impact of removal of any component (e.g., variety, species or group of species) from a given ecosystem or from the Earth itself, owing to our weak understanding of how ecosystems function. Nevertheless, it should be realized that life itself is the greatest destroyer of biodiversity, especially at the gene and species level; but life is unreasoning, whereas Man is not, so Man's responsibility is unique and great.

Human activities are, by destroying natural habitats, polluting the environment and exploiting natural living resources, diminishing the number of wild animals and species; that is, eroding the biodiversity of the planet. Moreover, the breeding of specialized strains, and now their creation by genetic engineering, for agriculture, stock-raising, aquaculture, pharmaceuticals and specialty chemicals, is tending to reduce the genetic variety of cultivated species. Efforts to establish and maintain special depositories for plant and animal genetic material (rice, wheat, maize, microbiological banks, for example) are not, at present, keeping up with the rate of loss of potentially or actually valuable genetic combinations, which are likely to be needed to deal with environmental changes, and increasing resistance of infective organisms to pesticides, in areas where cultivated species now live, or to provide varieties for cultivation in new areas, in response to the demands of human populations. Although genetic engineering, by speeding up the creation of new and better adapted varieties, may appear

to be a possible means of raising biodiversity, it too depends on having available to it a high level of genetic diversity.

The introduction of new organisms, in the form of exotic species or highly cultivated strains of endemic species, nearly always poses a risk to the environment/ecosystem involved in the introduction, and therefore requires the greatest possible circumspection. However, Ramade *et al.* (1990) notes that no more than about 250 exotic plant species have been introduced into the Mediterranean basin, which constitute only about 1% of the total number in the basin.

The conservation of biodiversity of aquatic organisms is an attempt to counteract loss of species and local races, due to harmful practices such as overfishing, habitat destruction and pollution. Although relatively few species extinctions have resulted from overfishing, this is not true for some populations and races, and other impacts of human activities have been critical through their effects on species habitats.

The number of species foreign to a particular marine environment that have either been deliberately or accidentally introduced by man (*Caulerpa taxifolia*, mentioned in section 1.3, is an example in the Mediterranean, UNEP, 1995a) has increased considerably, and it is clear that changes in the environment due to human activities may facilitate this process. The establishment of exotic species has resulted in far-reaching changes to the faunal composition of many of the world's enclosed and semi-enclosed seas, estuaries and coastal marine waters. Many such species came through the Suez canal and are known, after the canal's builder, as Lessepsian species. Spanier and Galil (1991) discusses Lessepsian migration with particular reference to the Indian Ocean jellyfish, *Rhopilema nomadica*, which was first recorded in the south-east Mediterranean in 1977 and now forms enormous swarms in summer, from time to time. This may reflect the ecological success that sometimes falls to invaders initially rather than eutrophic or other aberrations of the marine environment; an equilibrium with native species often becomes established in due course.

The effects of such introductions

include: immediate ecological impacts at the community level through changes in inter-specific competition and predation; changes in the nature of the environment itself through the influence of certain organisms and possible genetic degradation of indigenous stocks. The co-introduction of pathogenic organisms has often adversely affected native and introduced species alike, particularly cultured shellfish.

The conservation of biodiversity of aquatic organisms poses problems at two main levels: firstly, for wild fish stocks, the loss of species and, more especially, local races, through environmental change, overfishing or competition through species introduction, is a real and persistent danger. The trend towards developing new, uniform strains adapted to rearing in captivity is increasing the dangers these inbred traits pose to wild populations as a result of the escape of cage-cultured strains, and consequent cross-breeding between cultured and wild strains. Such genetic "accidents" could reduce the variability of stocks needed to ensure resilience and adaptability in a changing environment.

One possible effect of intensive fishing on biodiversity is gear selection for specific fish sizes depending on the fishing method. Such pressures may also lead to selection for early-maturing or slow-growing individuals, with effects that are expected to be measurable over a limited number of generations. This type of effect may be reduced or reversed by alternative fishing strategies.

One special biodiversity problem relates to the influence of man-made canals linking faunistically different regions, and the influence of shipping in facilitating inadvertent transport of exotic species. The migration of some 500 Indo-Pacific species into the eastern Mediterranean since the construction of the Suez canal is a specific example of such effects (Por, 1968). This, and their subsequent spread westwards and northwards, was facilitated by the more saline conditions created by construction of the Aswan Dam and consequent removal of the low-salinity barrier created by the Nile discharge into the eastern Mediterranean Sea.

In general, the conclusion emerges that, as for terrestrial ecosystems, Man's intensive exploitation of all habitats and

ecosystems reduces their complexity and favours simple ecosystems and pioneering species of generalists, specialized for rapid growth and reproduction.

Cash crops of rice, fish and other products almost inevitably replace the less intensive benefits which may arise in the future from maintaining the genetic diversity of complex habitats (despite, for example, the latter's potential for production of new pharmaceuticals), and the less tangible and less enforceable common property benefits of preserving coastal vegetation for flood control, as ecological reserves and as nursery areas for coastal and shelf stocks of fish and shrimp.

It is, in any case, clear that sustainable development must include maintenance of the highest possible level of biodiversity.

Not much attention has yet been paid directly to biodiversity problems in the Mediterranean. IUCN organized a Biological Diversity Workshop in North Africa, held in Tunis in November 1993 (IUCN, 1993); reports on the situation in Morocco, Algeria, Tunisia, Libya and Egypt were considered.

The Convention on Biological Diversity, drawn up in Rio de Janeiro at the UN Conference on Environment and Development, in June 1992, entered into force at the end of 1993. It will require signatories to regulate access to genetic resources, control the origin, transfer (in trade or for research purposes) and destination of genetic material. Species inventories (taxonomy, distribution, abundance) are still very far from complete for most parts of the world; moreover, the changes taking place as a result of human activity require regular updating even of relatively complete inventories. In the light of this widespread ignorance, it is clearly necessary to apply the so-called "precautionary principle", which requires protection and conservation measures to be taken in advance of sufficient scientific knowledge and understanding and therefore forbids the needless destruction of flora and fauna. In other words, a high standard of living resource management, whether in exploitative or conservative situations, will be essential.

3.4.3 Endangered Species

The principal endangered species in

the marine and coastal environment of the Mediterranean Sea have been given by Ramade *et al.* (1990) and, in a legislative context, by De Klemm (1993). The European Red Book of endangered species is a formal listing of all relevant species for the European region (ECE, 1991). The most important, at least in terms of closeness to extinction, are:

Marine plants

- The sea grass (*Posidonia oceanica*), which not only contributes to the primary production but also provides important nursery areas for many species of fish and shellfish of commercial or ecological value; sea grass beds are, in certain areas, greatly damaged by trawling, dredging (for benthic fish or shellfish or for sand for construction) and the anchoring of numerous pleasure craft outside established ports and marinas.
- The brown sea weed (*Cystoseira stricta*), which also provides an ecotope suitable for several species of fish and shellfish, but which is highly susceptible to the discharge from sewage outfalls.

Marine mammals

- The monk seal (*Monachus monachus*); the fin whale (*Balaenoptera physalus*) and the common dolphin (*Delphinus delphis*), the latter two being, of course, much exploited outside the Mediterranean as well.

The monk seal is particularly adversely affected by the loss of the coastal habitat (to development, as described in section 3.1.3) which it needs for resting, mating and rearing the young; it is also subject to: accidental capture (if not also intentional capture, since fishermen may regard them as rival predators and still, probably, as a source of fur) in large-scale fisheries using, mainly, drifting or fixed gill nets, trawls and purse seines; marine litter in the form of plastic bags and pieces of styrofoam (which are mistaken for food organisms and eaten, often blocking the oesophagus and stomach), and polyethylene or monofilament nylon cord (from fishing netting) which may throttle them (as they grow), at

worst, or severely hamper their movement, at best, if they pass over the head, or, likewise, from plastic rings.

The current status of the monk seal in the Mediterranean, in terms of sightings and numerical estimations, as well as of main kinds of adverse impact, is summarized, on a country basis, in UNEP (1994b). UNEP has adopted an action plan on the monk seal (UNEP, 1990a).

The dolphin and the fin whale are mainly adversely affected by intentional fishing (fin whale) or accidental fishing (dolphin, which is highly susceptible to capture by large purse seines used to catch tuna, with which dolphins are frequently associated); they are also adversely affected by large-scale commercial fishing on their prey species (small pelagic fishes and squids, and small crustaceans, in particular); they are also affected by the ingestion of plastics and by ensnarement by remains of fish netting and plastic packaging. It is not known what effects chemical pollutants may have on these animals, but marine noise (from pleasure craft and commercial vessels) is thought to hamper their sonic communication systems significantly.

The current status of the cetaceans in the Mediterranean, in terms of sightings and numerical estimations, is summarized, on a country basis, in UNEP/Greenpeace/IUCN (1994). UNEP has also adopted an action plan on Mediterranean cetaceans (UNEP, 1991b).

Sea birds

The only species presently seriously threatened in the Mediterranean is the Audouin sea gull (*Larus audouinii*), but other sea birds are considered to be threatened within their European area of distribution; the Mediterranean region is not thus relieved of all responsibility to ensure its survival. They are the white and the dalmatian pelicans (*P. onocrotalus* and *P. crispus*, respectively), among others. The Mediterranean also lies on many of the main bird-migration routes between the African and European continents; since many of these birds are waders or ducks and geese, the loss of wetlands, mentioned above, places many of these species at greater risk.

Marine reptiles

The main species under threat in the Mediterranean are the green turtle (*Chelonia mydas*) and the loggerhead turtle (*Caretta c. caretta*), which nest in the Mediterranean. They are so endangered because they require undisturbed beaches on which to lay their eggs, then to allow them to incubate. The green turtle nests, at present, only on beaches in southern Turkey and northern Cyprus; the loggerhead turtles currently nests on Greek, Turkish, Cypriot, Israeli, Egyptian, Libyan and Tunisian beaches.

These two species, as well as the hawksbill turtle (*Eretmochelys i. imbricata*), are highly vulnerable to commercial fishing, often being taken incidentally or being the object of fishery themselves for their flesh and their carapace (tortoise shell). Whatever, their nesting habits, these species are known to migrate extensively within the Mediterranean Sea (this migration may also include at least the eastern Atlantic). Groombridge (1990) has summarized the distribution and population state of the five main species of marine turtle and the protection they are currently afforded. The resident and the reproductive populations are all seriously reduced in number. UNEP has adopted an action plan on marine turtles (UNEP, 1990b)

Marine fishes

Only two species are under some threat in the Mediterranean: the dusky grouper (*Epinephelus guaza*) and the brown meagre (*Sciaena umbra*). Although not in the category "endangered", they merit careful surveillance, since both are the principal objective of underwater spear-fishermen.

Two genera of coastal lagoon fishes, *Aphanus* and *Valencia*, of the family Cyprinodontidae, are also seriously threatened in lagoons along the French and Spanish Mediterranean coasts, as the human pressure on these biotopes has grown relentlessly.

No species of lower taxonomic orders is known to be endangered, but the populations of many of the main commercial fishery species and littoral/sublittoral species have declined as a result of exploitation and of environmental degradation. It is doubtful, however, that

commercial fishery of these species will reduce them to dangerously low levels before such fishery becomes itself economically unsustainable. The position is less clear with respect to environmental degradation, which is why, among other reasons, routine monitoring, in spite of its shortcomings, remains essential.

Ramade *et al.* (1990) also lists a number of species in the main taxa that are not exclusively, or even at all, associated with the coastal zone but which are members of Mediterranean ecosystems yet are also threatened with extinction at present.

3.4.4 Protected Areas

UNEP/MAP, through the Regional Activity Centre for Specially Protected Areas and with the collaboration of IUCN, has prepared a directory of marine and coastal protected areas of the Mediterranean region (UNEP 1994c), which lists, in Part 1, 233 sites of biological and ecological value, all under some degree of protection. The World Conservation Union (IUCN,) has also compiled a directory of the world's protected areas, of a much wider scope than that prepared by UNEP (1994c) and not limited to the coastal zone, however.

Ramade *et al.* (1990) discusses the Mediterranean ecosystems and species considered to be seriously endangered by human activities. The zone in greatest danger is the littoral.

On land, the littoral biotopes are impacted by physical alterations, such as infilling, for the construction of marinas, airports etc. or the creation of artificial beaches. Sand-dune systems are also being destroyed by too dense bathing populations or by occupation for the construction of seaside residences. Coastal lagoons, salt marshes and other wetlands are particularly threatened by drainage for agricultural purposes, or by dedication to aquaculture or for various other purposes, or by direct run-off of pesticides and other chemicals used in neighbouring agriculture and stock-raising, if not by direct dumping of industrial and urban wastes.

In the sea itself, the benthic and pelagic biotopes (living spaces) in close proximity to the shore, as well as the

supralittoral zone, are particularly exposed to the discharge of land-based pollutants. The abundance of such pollutants is, naturally, associated particularly with the major urban and industrial agglomerations and with the main tourist centres. Pollutants discharged at sea (notably oil) also have their greatest effect in the littoral zone.

Ramade *et al.* (1990) considers the present network of protected areas (see section 4.3, below) to be far from adequate to preserve at least one example of each type of ecosystem. Many protected areas are under threat from "upstream" use of water (including dam construction) and forest fires.

3.5 Historic Sites and Landscape

The Regional Activity Centre for the Priority Actions Programme has produced detailed guidelines for the rehabilitation of Mediterranean historic settlements (UNEP 1994d, volume I), backed up by five case-studies (UNEP, 1994e, volume II).

Some of the world's most significant periods of artistic and cultural development have been centred on the Mediterranean region. There, also, human architecture, on a small, individualistic scale, as well as on the grand scale of public buildings, has reached major peaks. Through the UNESCO International Convention on the Protection of the World Cultural and Natural Heritage, of 1972, the most important Mediterranean historical monuments and sites have been identified and listed; they constitute a majority of the whole number so listed. A hundred Mediterranean sites (Fig. 3), many, but not all, on the UNESCO World Heritage list, have been selected for especial attention under the Mediterranean Action Plan in collaboration with the Atelier du Patrimoine in Marseilles (UNEP 1995b).

Besides the 100 sites formally adopted, there are many other significant historical settlements of interest and concern from the environmental standpoint, as: (i) old towns or settlements of significant historical interest, or such areas within them, that reflect a particular form or style of urban or rural life or culture; (ii) sites of archæological interest representing ancient civilizations, whether such sites have been explored or not; (iii) buildings, or groups

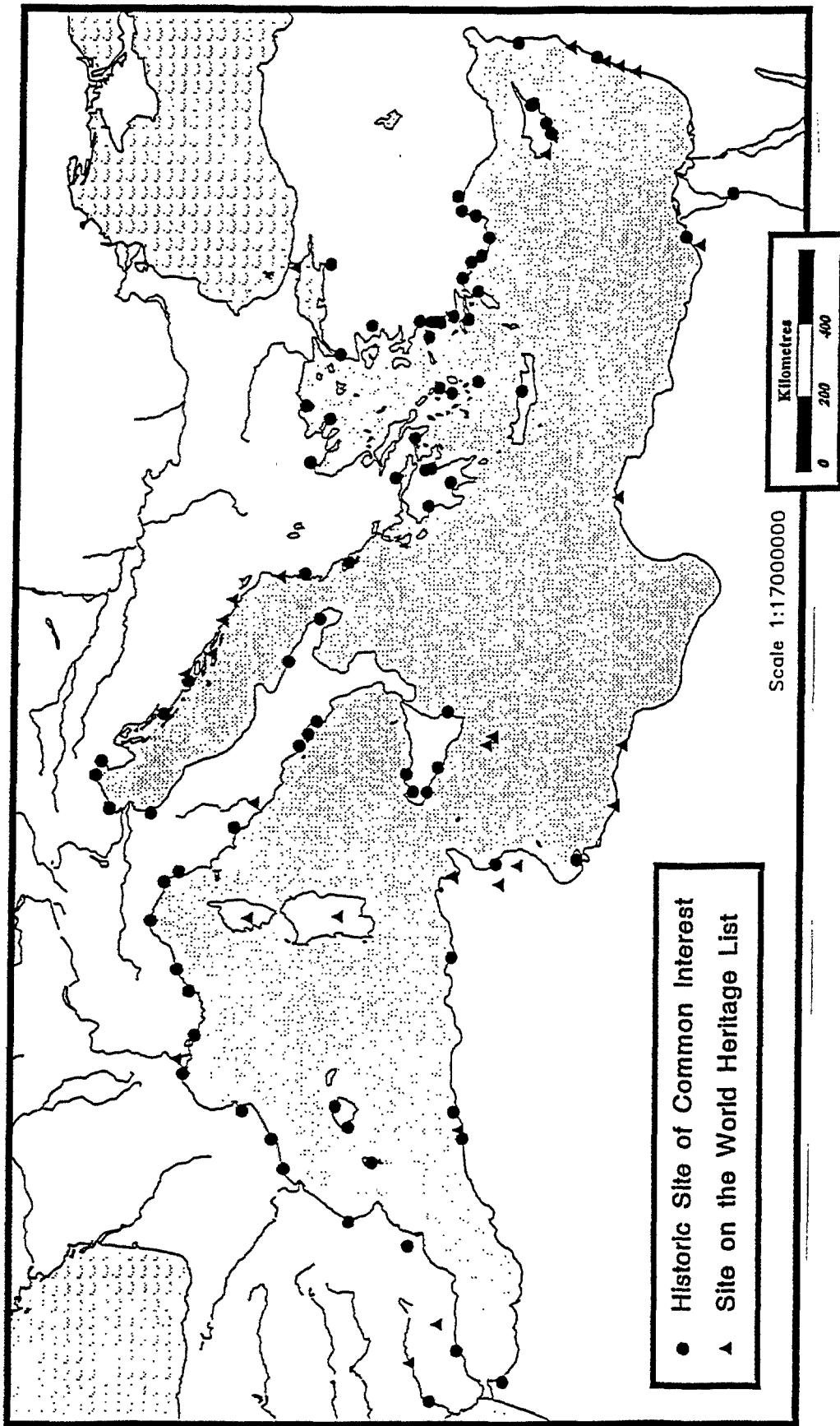


Fig. 3. Locations of Mediterranean Historic Sites

of buildings, of historical interest, such as: those dedicated to religious observance (temples, churches, mosques, synagogues, monasteries etc.); those serving military purposes (fortresses, ramparts, barracks etc.); those having civic functions (town halls and other public administration buildings, hospitals, museums, theatres and cultural centres, fountains etc.); monuments of architectural or sculptural interest and memorials to the famous; houses; shops; commercial buildings; civil infrastructure (bridges, roads, canals, waterworks, harbours etc.); and (iv) sites of a complex nature, usually combining natural and architectural interest, such as: historical and memorial parks; sites significant for their natural and historical/artistic features; gardens (if they comprise elements of historical/artistic interest).

Buildings are subject to decay or destruction due to natural phenomena or to human activities; this may occur over a long time (normal ageing) or catastrophically (by fire, floods, landslides, avalanches, earthquakes, volcanism).

Natural ageing depends on such factors as geographic location and orientation, hence on local climate (especially temperature variations and exposure to solar radiation, rainfall and humidity, wind strength and persistence), hence on the establishment of harmful organisms (e.g., moulds, algae, higher plants on walls, ceilings or floors, or insects, birds, rodents etc. within a building's structure).

Natural catastrophes are, for the most part, inevitable and unpredictable, either as to timing or extent, but not altogether unforeseeable. Damage limitation from such causes has been practised since Antiquity. Now, however, much effort is devoted to improving prediction of such events from selected environmental variables and their evolution. Even so, the necessary opposition of the rarity of occurrence, in a given place and period, and the generally considerable but localized damage that is done (notably to human structures) limits the resources devoted to achieving useful predictability.

Human causes are a result, generally, of ill-considered socio-political decisions or bad management. They may depend on local, regional or even global political forces, changes

in economic systems or even in architectural fashion, and may reflect political or ideological intolerance. The economic changes may be in the system of production or of trade, leading to a decline or a major change in such activities as agriculture, crafts, industry, fishing, mining etc. The disappearance of socio-economic activities leads, almost always, to physical decay of the buildings in which they were carried out, and even, in some cases, to the abandonment of entire towns and villages. In some cases, also, it may be only tourism that can save such buildings, villages or towns, as they are restored in the interest of tourism itself.

Economic change can also overload historic city centres with commercial, administrative and other functions for which they were never intended and not designed. Modern transport systems, heavy through-traffic and parking lots for residents' and tourists' vehicles are not easily accommodated, but somehow, accommodated they are, usually at the expense of important historic structures. The associated negative consequences for buildings, in the form of vehicle exhaust gases and other pollutants (not least in the form of acid rain), are mentioned in section 3 of the present document. Vibration (which includes noise) due to traffic (ground and air) is an additional decay factor for buildings.

The solution is proper management (including maintenance) of existing buildings, and sound planning of new buildings as to their structure, location and "cohabitability" with respect to historic buildings. Such management must incorporate disaster preparedness, and limitation of damage due to inevitable accidents and catastrophes. It cannot, however, comprise war, yet an aggressor nation may include in its war objectives the destruction of another nation's cultural heritage, and notably the buildings that are the main physical manifestation of such a heritage.

The document (UNEP, 1994d and UNEP, 1994e) goes on to provide a set of fairly detailed instructions on such matters as, *inter alia*, rehabilitation of buildings, architectural surveys and analysis of the current state of a site of interest.

Volume II provides five case studies in which the methodology proposed in the

guidelines has been applied. They are: the Plaka district of Athens, the oldest Athenian neighbourhood, at the foot of the Acropolis; (ii) Genoa's historic centre (now not so central socially speaking, as it once was); (iii) Marseilles, which has a long experience in the application of an effective methodology to the documentation and research on sites of archaeological/historical interest; (iv) Split, of which the historic centre encompasses Diocletian's palace (nearly 2,300 years ago), as well as pre-Romanesque, Romanesque, Gothic, Renaissance and Baroque buildings; and (v) the Hafsia district of Tunis, which covers the lower part of the Medina (fort), is disadvantaged by its topography and was, historically, reserved for foreign minorities; the PAP/RAC methodology has been followed in the attempt to rehabilitate this district.

The work in Marseilles has been carried out under the aegis of the Atelier du Patrimoine de la Ville de Marseille (the Marseilles Heritage Workshop), but comprises a wider range of activities. Of particular interest is the protection of the submarine archaeological heritage in the Mediterranean (UNEP, 1995b). This heritage has only been fully recognized since the introduction of the aqualung some forty years ago. The document cited reviews the state of such archaeology in Albania, France, Israel, Italy, Malta, Spain, Tunisia and Turkey. The vast majority of the sites are shipwrecks dating from 3,600 years ago up to recent historic times; the remaining submarine sites comprise ancient ports and harbours (notably in Israel and Tunisia), human settlements (notably in Albania, Malta and Tunisia), ramparts (Malta) and quarries (Albania). However, in France alone, over 600 submarine sites of historical, artistic or archaeological interest have been identified, though not all in the Mediterranean.

The main problems confronting these submarine sites are siltation (whether gradual or as a result of submarine slides), destruction of once-exposed wood by xylophagous worms (teredos), encrustation by corals, serpulid worms (calcareous tubes), etc., damage by trawl gear, and plundering by "amateur" scuba divers.

3.6 Implications of Climatic Changes

The implications of climatic changes for

the Mediterranean basin have been described in detail by Jeftic *et al.* (1992) and summarized by Jeftic *et al.* (1995).

In the long term, it is essential to assess the impacts on climatic change of the various air-sea exchanges discussed in section 3.2 (on air pollution), particularly as a result of serious modification of the air-sea exchanges and the "greenhouse" effect due to biogases in the atmosphere.

Climate changes due principally to the "greenhouse" effect can be expected to have a significant impact on, *inter alia*, the marine environment and the adjacent coastal zone in the coming decades. Some of the known and suspected biogases were discussed in section 3.2, above.

The primary "greenhouse" effect is to raise the Earth's mean temperature, particularly that of its atmosphere. The main general consequences are changes in: (i) atmospheric transport patterns (wind field, particularly at the land-sea interface); (ii) air-sea interaction (evaporation, precipitation, gas and salt exchange); (iii) the sea's volume (hence mean sea level); and (iv) its density distribution (hence circulation patterns). From these changes will flow changes in relative humidity, rainfall and wind regimes, for example, leading to ecosystem changes (in vegetation patterns, soil state, animal distribution etc.).

This impact has been assessed by a regional UNEP Task Team on the Implications of Climate Change for the Mediterranean region (Jeftic *et al.*, 1992). The Task Team was asked to examine the following possible effects: (i) of sea-level changes on coastal ecosystems (e.g., deltas, estuaries, wetlands, coastal plains, lagoons); (ii) of temperature increases on terrestrial and aquatic ecosystems, particularly with respect to economically important species; and (iii) of climatic, physiographic and ecological changes in socio-economic structures and activities. It was also asked to determine areas or systems that appear to be the most vulnerable to such changes.

The Mediterranean Task Team initially identified eight topics for which regional assessments were undertaken: (i) climate change; (ii) sea-level change; (iii) oceanography; (iv) hydrology; (v) coastal

lowlands; (vi) land degradation; (vii) vegetation; and (viii) socio-economic activities. It also carried out six site-specific case studies on: (i) the delta of the Ebro; (ii) of the Rhone; (iii) of the Po; (iv) of the Nile; (v) Thermaikos Gulf; and (vi) the Bizerta/Ichkeul Lakes. The results have been published in a book titled *Climatic Change and the Mediterranean* (Jeftic *et al.*, 1992).

Subsequently, five new site-specific studies have been undertaken on: (i) the Island of Rhodes; (ii) Kastela Bay; (iii) the Syrian Coast; (iv) Malta; and (v) the islands of Cres/Losinj. These five case studies identified and assessed possible implications of expected climatic change on the terrestrial, aquatic and marine ecosystems, populations, land-use and sea-use practices and other human activities at these sites; they also determined areas or systems that appear to be most vulnerable to the expected climate change, and identified options for the planning and design of major infrastructure and other systems.

The results were reviewed at a Meeting on Implications of Climatic Changes on Mediterranean Coastal Areas (Valletta, 1992). They indicated a number of shortcomings in the assessments: (i) an oversimplification of the processes (e.g., beach dynamics, ecosystem adaptability) that would mediate or even mitigate a given expected impact; (ii) insufficient data or insufficient exploitation of available data to allow a reliable assessment; and (iii) inadequate attention to extreme events (e.g., storm surges, wave action) through which an impact might be heightened.

Some of the variations in the conditions under which marine ecosystems exist and operate are, now and in the future, likely to be due to global climate change. Such changes will add to the natural variations all ecosystems have always been subject to. Their effects on fisheries and aquaculture are, at best, difficult to forecast.

The UNEP/WMO Intergovernmental Panel on Climate Change (IPCC) has assembled the views of the international scientific community on the magnitudes of expected global change related to the climate (IPCC, 1992), and the International Council of Scientific Unions (ICSU) has initiated an International Geosphere-Biosphere Programme

(IGBP) to assess the pace of all the major observable terrestrial changes (Williamson, 1992). Regarding the oceans, the IOC has initiated a Global Ocean Observing System (GOOS) (Kullenberg, *et al.*, 1993).

The preparatory studies to these ends suggest that carbon dioxide (a "greenhouse" gas) in the atmosphere is likely to double by 2025-2050 on a "business as usual" basis, leading to a probable increase in the global mean temperature of 1.5°-4.5°C (IPCC, 1992). This rise is expected to cause a rise in mean sea level of about 20 cm by 2030, and of about 65 cm by 2100, and to an increase in sea-surface temperature between 0.2°C and 2.5°C. Bakun (1992) projects some likely effects of such changes on coastal and shelf-sea ecosystems, referring particularly to the likely increase in the temperature differences between the land and the sea in the coastal zone, which is predicted to amplify upwelling by changing the air-pressure/wind regime (see also Bartzokas and Metaxas).

Methane (CH₄) is a "greenhouse" gas that may be produced naturally on land (agriculture, forestry), in certain industrial processes (e.g., oil extraction and refinery), in freshwater bodies and estuaries and in the sea either by methane-forming bacteria or under reducing conditions or by algal metabolism. Eutrophication can be expected to play a role in this flux of methane between the sea and the atmosphere. Some of this methane, which is relatively stable in the marine environment, is released into the marine atmosphere (Liss, 1989).

Although little is known of the biological production of methane in the sea and of its contribution to the atmospheric methane levels, results from other areas (e.g., the Arabian Sea) suggest that it is more important than hitherto suspected, at least in specific areas of the Mediterranean, including the basin depths where reducing conditions may prevail.

Besides carbon dioxide, several other gases are known or thought to be "greenhouse" gases or to be likely to play a role in climatic change. Dimethyl sulphide (DMS) is present everywhere in marine surface waters. Its main biological precursor, dimethylsulphonium propionate (DMSP), is produced by many marine algae (Holligan and Kirst, 1989) as well

as some sea grasses and salt-marsh grasses (Andreae, 1989). DMS is also formed by the methylation of sulphur by certain species of phytoplankton. Although production is variable according to region and season of sampling, eutrophication, by favouring algal growth, may favour production of DMS, which may be lost to the atmosphere where it is oxidized to such products as methane sulphonate, sulphur dioxide and sulphate. The sulphate is in the form of submicronic aerosol particles (hence not originating from sea salt) which act as condensation nuclei for atmospheric water vapour, thus affecting the atmospheric radiation balance, in the short term, and possibly the climate, in the long term.

Carbonyl sulphide (COS) is produced by the photochemical degradation of dissolved organic sulphur compounds and is transferred from the sea to the atmosphere where it is oxidized to sulphate, with similar effects to those of DMS (above).

Nitrous oxide (N_2O) is potentially a "greenhouse" gas originating from bacterial metabolism of nitrates and from industrial combustion; it can also affect the ozone layer. The marine contribution to the atmosphere is not known at present.

The global climate changes mentioned above are not expected to change overall fish production in a major way, although particular stocks may be adversely affected, and changes in rainfall and river run-off will affect life in coastal fishery and fish-nursery areas. Coastal aquaculture will also be affected. Tropical upwelling zones, which produce large amounts

of fish resources, may shift polewards and increase in intensity. The year-to-year variability of the resources they support may increase; however, increased plankton productivity may reduce oxygen levels and lead to anoxic situations.

These climatic-change impacts will, however, develop over a long period of time, allowing, to some degree, a progressive adaptation to factors that cannot be easily modified, if at all, by human intervention; they will, therefore, be of far less immediate significance for the future of the Mediterranean than the impact of most of the current, and still increasing, human activities in the Mediterranean coastal zone and its hinterland.

In the next few decades, the impact of non-climatic factors, such as population dynamics and present development plans, on the natural, social and economic systems of the Mediterranean, will most probably far exceed the direct impacts of climatic changes. Nevertheless, longer-term changes in climate may contribute quite significantly to the vulnerability of coastal communities to adverse environmental conditions and impair the sustainable development of coastal areas. The sectors of the economy most likely to be affected may well be tourism and agriculture. Traditional fisheries are already over-exploiting the productive capacity of the Mediterranean Sea, so climatic change will add little to this stress. Aquaculture may benefit from future environmental changes. Coastal wetlands, low-lying areas and deltas may suffer, with consequent effects on agriculture and migratory birds (Jeftic, 1993).

4. *The Policy and Legislative Context*

4.1 Environmental Policy

4.1.1 The Mediterranean Countries

The environmental policy of the Mediterranean countries is becoming progressively aligned with the requirements of the Barcelona Convention, its Protocols and the diverse agreed measures arising therefrom, since all the Mediterranean countries are signatories to the Barcelona Convention. This international, though regional, policy is also applicable to UNEP's Mediterranean Action Plan (see section 4.2, below).

The Barcelona Convention has been in force since 1978; its four protocols currently in force are: (i) Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft (1978); (ii) Protocol Concerning Cooperation in Combatting Pollution of the Mediterranean Sea by Oil and Other Harmful Substances in Cases of Emergency (1978); (iii) Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources (1983); and (iv) Protocol for Specially Protected Areas (1986). The Protocol for the Protection of the Mediterranean Sea against Pollution from Offshore Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil was adopted in 1994.

The Contracting Parties have also adopted thirteen common measures in respect of the Land-based Sources Protocol: Interim Environmental Quality Criteria for Bathing Waters (1985); Interim Environmental Quality Criteria for Mercury (1985); Measures to Prevent Mercury Pollution (1987); Environmental Quality Criteria for Shellfish Waters (1987); Measures for the Control of Pollution by Used Lubricating Oils (1989); Measures for the Control of Pollution by

Cadmium and Cadmium Compounds (1989); Measures for the Control of Pollution by Organotin Compounds (1989); Measures for the Control of Pollution by Organohalogen Compounds (1989); Measures for the Control of Pollution by Organophosphorus Compounds (1991); Measures for the Control of Pollution by Persistent Synthetic Materials (1991); Measures for the Control of Pollution by Radioactive Substances (1991); Measures for the Control of Pollution by Pathogenic Microorganisms (1991); Measures for Control of Pollution by Carcinogenic, Teratogenic and Mutagenic Substances (1993). Other Common Measures are being elaborated for zinc, copper and anionic detergents.

Insofar as the Contracting Parties to the Barcelona Convention have ratified the UN Convention on the Law of the Sea (United Nations, 1983), which came into force in November 1994, the 1973/1978 Convention on the Prevention of Marine Pollution from Ships (MARPOL), and the 1972 Convention on the Prevention of Marine Pollution by the Dumping of Wastes and Other Matter, their respective national legislation should also not run counter to these conventions.

Implementation is slow, however, because, for example, MARPOL calls for the establishment of costly reception facilities, and the LBS Protocol itself, since it calls for substantial action on the control and abatement of pollution from land-based sources, it also calls for far-reaching decisions on such matters as urban policy, waste-treatment plants and improved agricultural practices (Chircop, 1992). Moreover, as noted in section 4.4, below, in respect of protected areas, national policy, as expressed in national legislation, is essentially sovereign in the coastal zone and territorial waters of each country and the harmonization of national with the relevant international legislation is relatively slow, even after

ratification of the relevant international conventions.

National environmental policy is also expressed in national environmental plans and programmes. Documents describing such plans and programmes, as well as providing information on the state of the environment, have been received from 16 of the Mediterranean countries, which is a great increase over previous years. It is not possible in the present document to go into details. For some countries, their responses to a questionnaire issued by the Programme Activity Centre for the Priority Actions Programme have also been used.

The mechanisms for implementing such policy are generally complex, since responsibilities are spread amongst a relatively large number of national authorities and agencies and, in some cases, national non-governmental organizations. There is also, therefore, a general need to improve the coordination and cooperation between the various entities concerned, in most countries. It should be noted, too, that nearly always, the relevant laws were enacted without taking adequately into account the environmental protection aspects. Thus, many laws are in need of amendment in this sense. The institutional mechanisms and the main environmental issues in the individual Mediterranean countries, insofar as the information is available, are briefly described in section 4.1.3, below.

4.1.2 The Mediterranean Action Plan

Mediterranean countries and the EEC adopted in 1975 the Mediterranean Action Plan (MAP) and in 1976 the Convention for the Protection of the Mediterranean Sea against Pollution (Barcelona Convention). The main objectives of MAP were to assist the Mediterranean Governments to assess and control marine pollution, to formulate their national environment policies, to improve the ability of governments to better identify options for alternative patterns of development and to make better rational choices for allocation of resources (Jeftic, 1993a).

Although the initial focus of the MAP was on marine pollution control, the experience soon confirmed that socio-economic trends,

combined with poor management and planning of development are at the roots of most environmental problems, and that meaningful and lasting environmental protection is inseparably linked to social and economic development. Therefore, the focus of MAP was gradually shifting from a sectorial approach of pollution control to integrated coastal zone planning and management as the key tool through which solutions are being sought.

Although it is difficult to assess progress achieved, there is direct and indirect evidence that a large number of concrete actions were taken by many countries in conformity with the requirements and provisions of MAP, thus influencing the environmental policies and practices of the Mediterranean countries. MAP has been a significant instrument for change and progress concerning environmental matters in the Mediterranean. Among the achievements of particular importance are the creation of awareness concerning the significance of a healthy environment for the present and future of the Mediterranean and its people; marked change of the attitude of policy-makers towards the protection of the environment; and creating a sense of solidarity and need to act collectively towards a better future for the Mediterranean.

The environmental policy of MAP is laid down by the Contracting Parties to the Barcelona Convention and its protocols, as described in section 4.1.1, above.

Environmental policy under MAP is also kept consistent with the UN Convention on the Law of the Sea, the 1973/1978 Convention on the Prevention of Marine Pollution from Ships (MARPOL), and the 1972 Convention on the Prevention of Marine Pollution by the Dumping of Wastes and Other Matter.

4.1.3 Institutional Aspects

The Coordinating Unit of MAP

In order to coordinate activities in the framework of MAP, the Coordinating Unit for MAP was established and has been, since 1982, located in Athens, Greece. This unit performs such secretariat functions in the name of UNEP as provided for in the Convention. It prepares meetings with their necessary documentation, transmits notifications,

considers inquiries, performs functions assigned to it by the protocols and "such other functions as may be assigned to it by the Contracting Parties", which include above all, the coordination of all activities of MAP.

The Coordinating Unit coordinates and supervises the work of the following Regional Activity Centres of MAP:

- Blue Plan Regional Activity Centre (BP/RAC), Sophia Antipolis, France;
- Priority Actions Programme Regional Activity Centre (PAP/RAC), Split, Croatia;
- Regional Marine Pollution Emergency Response Centre for the Mediterranean (REMPEC), Manoel Island, Malta;
- Specially Protected Areas Regional Activity Centre (SPA/RAC), Tunis, Tunisia;
- Environment Remote Sensing Regional Activity Centre (ERS/RAC), Palermo, Italy; and
- Secretariat for the Protection of Coastal Historic Sites, Marseille, France.

Regional Activity Centres

The Regional Activity Centres are responsible for the implementation of respective components of the Mediterranean Action Plan. RACs (except REMPEC) are considered to be national centres carrying out regional functions on behalf of the Mediterranean community. This regional function is financed through the Mediterranean Trust Fund. They perform tasks under the guidance and supervision of the Coordinating Unit and in accordance with the decisions of the meetings of the Contracting Parties.

Blue Plan Regional Activity Centre (BP/RAC) has progressively clarified its main purpose of forecasting developments in the Mediterranean basin on the basis of several probable hypotheses as to growth in such parameters as human population (resident and tourist), urbanization, industry, agriculture, forestry, trade, and so on, including the related demands for water, energy, transport and communications, and as to possible climatic changes. All these changes are being actively pursued by the Mediterranean Observatory for

Environment and Development with a view to updating the prospective scenarios developed by the BP/RAC (UNEP, 1994f).

Priority Actions Programme Regional Activity Centre (PAP/RAC) attempts to address immediate problems, of a developmental nature, and effects of stress on coastal environments and resources, at specific sites, with a view to inducing sound environmental management practices required for sustainable socio-economic development. A major tool used is integrated coastal and marine area management. Projects are being carried out in selected coastal areas, such as Albania, Fuka-Matruh (Egypt), Izmir (Turkey), Rhodes Island (Greece), Syria etc. Other fields of activity include aquaculture, rehabilitation and reconstruction of historic sites, water-resource management for islands and isolated coastal areas, solid- and liquid-waste management, and land-use planning in earthquake zones.

Regional Marine Pollution Emergency Response Centre for the Mediterranean (REMPEC) (previously called ROCC) has played, since the adoption of the Emergency Protocol, a fundamental coordinating role in the implementation of that protocol by the Mediterranean countries. In addition, the Centre's role was expanded from its initial task to deal with accidental oil pollution, to deal with accidental pollution by hazardous substances. REMPEC is working on the development of a Regional Information System, of National Systems for Preparedness and Response to accidental marine pollution, and on the preparation and launching of sub-regional contingency plans. REMPEC has also assisted extensively developing countries of the Mediterranean by organising important programmes of regional and national training on the scientific and managerial aspects of accidental marine pollution.

Specially Protected Areas Regional Activity Centre (SPA/RAC) has played an essential role in the implementation of the Protocol concerning Specially Protected Areas in the Mediterranean. The Centre has assisted several countries by giving the necessary training and advice on the creation and management of protected areas and has successfully worked for the formulation and implementation of specific action plans for the protection of endangered species such as the

monk seal, the marine turtle *Caretta caretta* and the Mediterranean cetaceans. The Centre is expected to play an important coordinated role for the activities related to the preservation of biodiversity in the Mediterranean.

Environment Remote Sensing Regional Activity Centre (ERS/RAC) has introduced the application of remote sensing techniques in the Mediterranean Action Plan. Such techniques successfully supplement the field data gathered by the various activities with satellite data which can provide information on the dynamics of the changes of the coastal regions of the Mediterranean. The Centre has been specially active in a number of Coastal Areas Management Programmes (CAMPs) by providing time series images showing the changes in the coastline. This will represent an important tool in the management of the coastal areas specially in relation to the problem of desertification, soil erosion, urbanisation, management of protected areas, etc.

The Secretariat for the Protection of Coastal Historic Sites (100 Coastal Historic Sites) attempts to protect the coastal historic sites of common Mediterranean interest already identified by the Contracting Parties on the basis of approved selection criteria. The programme concentrates its work on the identification and assessment activities for the protection and conservation of sites on the list of 100 Historic Sites in various Mediterranean coastal states. Training programmes and workshops are used as tools and methods for historic sites management. The main priority fields are stone degradation of historic sites and underwater archaeological sites including shipwrecks.

Mediterranean Countries

The institutional arrangements that have been made in the countries of the Mediterranean region and the main environmental issues they must address may be summarized, based on the information available, as follows.

In Albania, the principal government entity is the Committee of Environmental Preservation and Protection, of the Ministry of Health and Environmental Protection (Albania, 1993). The Committee defines government

strategy, coordinates the relevant monitoring functions of ministries, other central institutions and local authorities. It organizes the monitoring of pollution at the national level and proposes specific steps for the protection of air, water and soil purity and the national biodiversity. It determines the basic policies and defines priorities for investment in environmental protection. It also sets the admissible limits for gaseous, liquid, solid and radioactive pollutant substances in water, air and soil, and the levels of harmful and toxic substances in hazardous wastes and substances. It is assisted scientifically and technically in these fields by the Institute of Hydrometeorology (of the Academy of Sciences), the Committee of Science and Technology, the Institute of Hygiene and Epidemiology, the Research Institute of Chemical Technology, and the University of Tirana.

The main environmental issues in Albania are: deforestation; soil erosion; contamination of surface waters by uncontrolled discharges of industrial and domestic waste waters; sewage treatment, which is entirely lacking; and air pollution from thermal power and industrial plants.

In Algeria, the department concerned with the environment is part of the office of the Secretary of State for Scientific Research (Secrétariat d'Etat à la Recherche) which sets the regulations governing the prevention and combatting of all forms of pollution and environmental nuisance; it discharges these responsibilities through the Head Office for the Environment (Direction Générale de l'Environnement) and, for research, a National Environmental Protection Agency (Agence Nationale pour la Protection de l'Environnement). The department concerned with agriculture is part of the Ministry of Agriculture (Ministère de l'Agriculture) which sets the regulations governing the prevention and combatting of all forms of degradation of forests and natural areas in the coastal zone; it discharges these responsibilities through the National Forestry Agency (Agence Nationale des Forêts), the National Agency for Nature Conservation (Agence Nationale de la Conservation de la Nature), and the National Forest Research Institute (Agence Nationale de Recherche Forestière). The department concerned with water resources is part of the

Ministry of Equipment (Ministère de l'Équipement) which sets the regulations governing the water supply and the coastal area; it discharges these responsibilities through the National Water Resources Agency (Agence Nationale des Ressources Hydrauliques). The department concerned with tourism is part of the Ministry of the Interior (Ministère de l'Intérieur) which is charged with promoting the development of tourist areas; it discharges these responsibilities through the National Tourist Office (Office National du Tourisme). The department concerned with public works is part of the Ministry of Equipment (Ministère de l'Équipement) which is charged with developing port infrastructure and maritime traffic control; it discharges these responsibilities through the central directorate and local offices. The National Coast Guard Service is part of the Ministry of Defence (Ministère de la Défense); it is charged with ensuring compliance with maritime laws and regulations. The National Planning Council sets the regulations governing land development, especially in coastal areas; it discharges these responsibilities through the National Land Development Agency (Agence Nationale d'Aménagement du Territoire).

The main environmental issues in Algeria concern fisheries, tourism, water use for industrial and urban purposes, and ports. All these activities are strongly and adversely affected by pollutants and solid wastes, whether originating on land or at sea; sea-water desalination is particularly badly affected by this pollution, and ports suffer from siltation through waste-water discharge or coastal erosion.

In Croatia, although some ten ministries have specific environmental concerns and responsibilities, the key governmental body is the recently established State Directorate for Environment. Besides the aforementioned ministries, some 20 governmental quasi-governmental or non-governmental institutions are occupied with one or another aspect of the environment.

The main environmental issues in Croatia are: harmful algal blooms in the northern Adriatic, causing though less problem than on the western side; severe pollution problems in several coastal bays (Bakar, Sibenik and Kastela) and ports with large local

populations (Pula, Rijeka, Zadar, Sibenik, Split and Dubrovnik), mainly due to the discharge of unprocessed urban and industrial waste waters (Croatia, 1993 and 1993a).

In Egypt, the Egyptian Environmental Affairs Agency, under the Presidency of the Council of Ministers, is responsible for drawing up national policy on the welfare of the environment and the natural resources; it endorses executive plans and programmes, promulgates and follows up relevant legislation. It operates through environment enhancement departments in each governorate. The Academy of Scientific Research and Technology draws up the national programme of environmental research on the relationship between the society and its environment. Several non-governmental and voluntary environmental societies are concerned with public orientation and information, legislation and enhancement of the output of environmental systems. Under this relatively simple structure, a rather complex programme of action has been elaborated.

The main environmental issues are: urban encroachment on valuable agricultural land, in spite of the rapidly rising demand for agricultural products; disregard of environmental considerations in the siting of some industrial installations which, with related urban growth, has exposed the Nile river to pollution from industrial liquid, solid and gaseous wastes; failure to use, treat and re-use agricultural waste waters; critical pollution levels in Lake Mariut and in the air over large cities; growth in the use of agricultural chemicals; pollution of irrigation and drainage networks, as well as of the Nile itself; oil pollution of the sea water and the nearby shoreline due to the dense maritime traffic (Suez canal); growing shortage of traditional energy sources; accumulation of large volumes of solid and liquid wastes combined with inadequate handling and management, re-use and re-cycling; the need to protect several rare Egyptian species; pollution and environmental degradation of numerous pharaonic, christian and islamic archaeological sites and some tourist sites; need to increase public awareness through education and the media (Egypt, 1992).

In France, as a relatively large, well developed country, the governmental structure is also relatively complex and not least in the

environment field (IFEN, 1994).

At the central government level, the Ministry of the Environment (Ministère de l'Environnement) now has four major departments: Water Department (Direction de l'Eau), Department of Pollution Prevention and Hazards (Direction de la Prévention des Pollutions et des Risques); Head Department for Administration and Development (Direction Générale de l'Administration et du Développement); and Department of Nature and Landscapes (Direction de la Nature et des Paysages). There are also two public bodies: the Environment and Energy Supply Agency (Agence de l'Environnement et de la Maîtrise de l'Energie) and the French Institute for the Environment (Institut Français de l'Environnement). The control of energy consumption helps to improve air quality, hence to help modernize industry and reduce industrial wastes. The Institute is essentially the statistical and information arm of the Ministry of the Environment.

At the regional level, there are the Regional Offices for the Environment (Directions Régionales de l'Environnement); the Regions are specific French socio-political entities. The roles of each Regional Office are defined by national regulatory dispositions, but a law fixing the division of responsibilities between the State and the sub-national communities is awaited.

The main environmental issues in France, at the national level, at least, are: the rehabilitation of polluted areas; the restoration of water courses and protection against flooding; the management and protection of nature; the fight against noise; the construction of waste-water treatment plants. At the local level and in the Mediterranean basin, the main issues are: excessive and sometimes uncontrolled coastal development for tourism, recreation and secondary residences; coastal pollution; coastal erosion (in some areas); marine and coastal protected areas.

In Greece, the National Council for Physical Planning and the Environment is responsible for environmental policy and the approval and supervision of all urban/regional plans and programmes for environmental protection (Greece, 1995). The Ministry of the Environment, Physical Planning and Public

Works is responsible for the development of policies for physical planning and the environment and for the coordination and supervision of their implementation; it is supported by regional and prefectural services. The Ministry of National Economy draws up general guidelines for economic planning and development policies, but the various ministries elaborate and implement sectorial policies within their respective fields of competence; the main ministries involved, in respect of environmental matters, besides the aforementioned Ministries of the National Economy and Environment are Agriculture, Health, Merchant Marine and Interior. Several other national entities are also involved with specific aspects of the environmental question: the Greek National Tourism Organization, the Public Power Corporation, the General Secretariat for Research and Technology, and other National Research Centres.

The main environmental and coastal management issues in Greece are: water resource management (made difficult by the broken terrain and uneven population distribution); air pollution over and around the large Greek cities (Athens-Piræus, Thessaloniki, Patras and Volos) and the marine pollution in the gulfs associated with these cities (Saronikos, Thermaikos, Patraikos and Pagassitikos, respectively); soil erosion (in which deforestation/fires and overgrazing are the main factors); agricultural pesticide and fertilizer residues in run-off and river water; impact of extensive open-cast mining (notably for lignite, bauxite, magnesite, limestone/marble) on agricultural and forest land.

In Israel, responsibility is invested in the Ministry of the Environment which replaced and absorbed the pre-existing Environmental Protection Service and has since taken over certain environmental functions from the Ministries of Defence, Industry, Commerce, Interior, Agriculture and Health; these ministries, however, retain responsibility for the handling of hazardous substances specific to their respective fields of action (Gabbay, 1994). The goals of the Ministry are to formulate a comprehensive national environmental policy and to develop the tools for implementing this policy, based on the principle of incorporating environmental considerations fully into planning and decision-making. It aims also at:

implementing pollution control, monitoring and research programmes; developing and updating environmental legislation and standards; ensuring effective enforcement and supervision; promoting environmental education and public awareness; and advancing regional and global cooperation in this field.

The main environmental issues in Israel are: water resource management, particularly with respect to irrigation and the water quality of the coastal aquifer; waste-water treatment and recycling; air pollution, mainly over the large cities but also due to an unfavourable meteorological situation; disposal of solid waste, given the small land area and the relatively high level of industrial, commercial and urban activity; the occupation and use of the coastal area and the competing claims of industry, tourism/recreation and agriculture (on the country's most fertile land).

In Italy, coastal-area management is organized at four levels: ministerial, regional, provincial and municipal (Italy, 1993). The Ministry of Defence manages all coastal areas under military jurisdiction and runs the Maritime Hydrographic Service, which is charged with marine bathymetry and safety at sea. The Ministry of the Merchant Marine manages State property, including use permits, regulates navigation in territorial waters, fishery, and a permanent coastal-water monitoring network. Through its Harbour Offices, it collaborates with the Ministry of Defence in all matters concerning State property, port activity, fishing, maritime traffic, pleasure boating, port tariffs, sea rescue and coast guard, and cooperates in the elaboration of marine maps; it collaborates with regional authorities in matters of tourism. The Ministry of the Environment has a coordinating function in coastal affairs and sets relevant standards; in collaboration with the Ministry of the Merchant Marine, it defines and creates natural reserves, defines minimum acceptable values for water microbiological parameters, and authorizes industrial waste dumping. The functions of the very recently established National Agency for Environment Protection are still to be defined. The Ministry of Public Works is responsible for the construction and maintenance of major harbours, and the construction of coastal protection works. Its executive arm is the Water Authority which is responsible for internal water management, including coastal lagoons. The

Ministry of Health, through the Higher Institute of Health, monitors industrial discharges and bathing water quality. Its Local Health Authorities undertake routine and emergency water sampling and control urban discharge. The Ministry of Cultural Wealth is the competent authority in respect of coastal area landscape and issues permits for underwater archaeological activities. The Ministry of Industry, among other things, issues permits for oil exploration and exploitation.

The regions are responsible for planning and development and, in coastal areas, they are delegated to manage state property used for tourism and recreation; they are responsible for small harbours, the coordination of environmental protection and monitoring of waste waters, and drawing up regional water-resource rehabilitation plans.

The provinces carry out waste-water surveys, whereas the municipalities are responsible for the maintenance of coastal protection structures, controlling waste waters, managing aqueducts, sewers, depuration plants, issuing permits for building construction and waste-water discharge, and collecting environmental taxes and charges.

The most important coastal environmental issues in Italy are: the impact of tourism and recreation facilities (including unregulated construction of secondary homes); maritime transport of hazardous substances (oil and chemicals); development of commercial, industrial and leisure port facilities, increasing erosion, pollution and landscape degradation; technical and political difficulties in controlling urban and industrial waste (strict law, low compliance) and the correct siting of heavy industrial plants; impact of military uses (loss of fishery and tourist space, effects of explosives); marine parks and reserves (population often still hostile), eutrophication and the production of mucilage by algae (notably northern Adriatic, adversely affecting tourism and fishery); and coastal erosion, mostly due to human activities (dams, inland irrigation systems, inshore structures modifying wave action).

In Libya, the principal governmental entity is the Technical Centre for Environment Protection of the Secretariat of Public Utility and Housing. The centre defines government strategy, coordinates the relevant monitoring

functions of other secretariats and other national institutions.

The centre organises and conducts the relevant monitoring of pollution at national level and proposes specific steps for the protection of air, water and soil purity and national biodiversity. It is assisted, scientifically and technically in this field by the Marine Biology Research Centre, Industrial Research Centre and the Petroleum Research Centre.

The main environmental issues in Libya are: contamination of surface waters by uncontrolled discharges of industrial and domestic waste waters, sewage treatment, desertification and soil erosion and management and protection of nature.

Regarding Lebanon, Fawaz *et al.* (1992), in a report for UNDP, Beirut, indicate that the governmental structure dealing with environmental problems is beginning to emerge in the period of post-war reconstruction that started in 1991 following the prolonged strife from 1975 to 1990; responsibility is still, however, dispersed among several ministries (as in many other countries of the region). Paradoxically, the same reconstruction is in many ways a solution to a catastrophic environmental situation due to the long period of strife in the country. The lead in the development of an environmental policy falls to the State Ministry for the Environment. Fawaz *et al.* (1992) have proposed a work programme for 1993-1998 and a framework programme to enable Lebanon to respond to Agenda 21 of UNCED.

In Malta, as a small island with a comparatively simple government structure, most environmental concerns are dealt with by governmental Departments (Malta, 1995). The Drainage Department is responsible for sewage and is aiming for total tertiary treatment by the year 2000, with total recycling for re-use in irrigation and zero marine discharge in summer. The Public Health Department and the Environment Protection Department are jointly responsible for health monitoring of bathing beaches. The Planning Authority is responsible for the urban environment, especially near the coast (nearly all the coastline is owned by the government which strictly controls development there). The University of Malta undertakes the required environmental research in support of

the government Departments concerned.

The main environmental issues in Malta are: soil erosion; water resource management (including desalination); and the impact of tourism and the related coastal development (including secondary summer residences).

In some respects, Monaco is similar to Malta in having a simple governmental structure (Monaco, 1992). The Environment Service (Service de l'Environnement) is charged with: the elaboration, supervision and implementation of the environmental regulations; the promotion of environmental protection and public information; and monitoring of environmental quality and pollution sources. It is under the Department of Public Works and Social Affairs (Département des Travaux Publiques et des Affaires Sociales).

The main environmental issues in Monaco are: water resources; impact of tourism; and marine pollution.

In Morocco, many ministries have responsibility over environmental issues such as the Ministries of Public Works, Agriculture and Agrarian Reform, Public Health, Energy and Mines, Fisheries, etc. However, one special department for the environment created in 1972 and since 1985 attached to the Ministry of Interior is responsible for coordinating all the activities. In 1995 this ministerial department became autonomous. At the regional level there exist services responsible for land development and the environment (Morocco, 1994).

A National Council for the Environment presided by the Minister in charge of the Environment (presently the Minister of Interior) was created in 1980 to advise the government on big development projects and to prepare an annual report on the state of the environment.

The main environmental concern in Morocco are human settlements, the management of water resources, soil and desertification, management of toxic wastes, health protection, etc.

In Slovenia, the Nature Protection Administration of the Ministry of Environment and Regional Planning is the principal

governmental entity responsible for environmental matters (Slovenia, 1995).

The main environmental issues in Slovenia are: harmful algal blooms in the northern Adriatic, causing the production of massive amounts of mucilage in the sea water and benthic fish kills due to very low oxygen levels in the bottom water; forest fires; water resources; impact of tourism; and, sometimes, air pollution over the main cities.

Regarding Spain, the national report on the environment (Spain, 1992) stresses that all the public administration entities have a greater or lesser competence in environmental matters, which renders their integration into a coherent framework very difficult. Responsibility is set at three main levels: the State, the Autonomous Communities, and the Local (Local Corporations and Municipalities). At the State level, after three decades of evolution after 1960, the central body is the office of the Secretary of State for Water Policy and the Environment (with responsibility for: environmental standards; coordination with relevant ministerial departments, with the Autonomous Communities, with the European Union and other international organizations in this field; environmental impact assessments at the national level; conduct of water resources policy; protection and management of State property in the maritime-terrestrial public domain; climatology; and cartography). At the Autonomous Community level, certain Communities are empowered with the right to undertake environmental legislation in conformity with their respective Statutes of Autonomy, though always in conformity with basic State criteria, and certain executive powers; for other Communities only the power to execute State laws is granted. At the local level the Local Corporations have specific standard-setting powers, and the Municipalities have significant competencies regarding disturbing, unhealthy, harmful and dangerous activities. Spanish environmental policy is strongly influenced by the environmental directives issued by the European Union.

The main environmental issues in Spain are: erosion and desertification (efforts at reforestation, rehabilitation of degraded floral biotopes and hydraulic works notwithstanding); water resource management; industrial waste waters and sludges, as well as atmospheric

emissions; urban waste disposal.

In Syria, several ministries and departments are concerned with one or another aspect of coastal resources management and environmental protection (Syria, 1995).

The Ministry of Transport's General Directorate of Ports is responsible for the protection of the marine environment and public property in the coastal strip, overseeing commercial maritime navigation and coastal ports and territorial waters. The Ministry of Agriculture is concerned with forests as well as agriculture (including agricultural settlement zones). The Ministry of Culture and its General Directorate of Antiquities and Museums are responsible for archaeological sites and historic monuments. The Ministry of Local Administration is mainly responsible for town and country planning, ordinance survey and public utilities. The Ministry of Environment is responsible for environmental cleanliness and combatting all sources of pollution; to this effect recently a new laboratory was created in Damascus to deal with chemical pollution. The Ministry cooperates with other bodies, especially in Tartus and Lattakia, concerned with the coastal area.

The University of Tishrine, in Lattakia, operates the marine research centre.

The most important issues in the coastal area are: management of land use, particularly for agriculture, housing, tourism/recreation, ports, warehouses, roads, railways, silos, industrial plants and construction in general; urban population increase (although no overall population policy has yet been developed); sand extraction from dunes; illegal fishing methods (e.g., use of dynamite); contamination of sea water by oil spills, sewage discharge and industrial and agricultural liquid and solid wastes; location of heavy industry (oil refinery, cement manufacture, hydroelectric power generation; environmental protection of forests and smaller wooded areas, river estuaries and some special ecosystems; strengthening the role of the Ministry of Environment in the supervision and enforcement of regulations, international standards and conventions.

In Tunisia, coordination of the various ministries involved is effected at the Prime

Ministerial level, normally through a council of ministers (Tunisia, 1992). The use of sea resources concerns the Maritime Ports Office (Office des Ports Maritimes), for the supervision and proper operation of ports. The Regional Fisheries Office (Commissariat Régional des Pêches) is charged with safeguarding the sea bed and reporting on infractions by fishermen; if necessary, to this end, it can call on: the navy (Service de la Marine Nationale), the National Environmental Protection Agency (Agence Nationale de Protection de l'Environnement) and even a regional laboratory for controlling and analysing illegal discharges; and on the Ministry of the Economy (Ministère de l'Economie) for the issuance of sea-bed research permits. Regarding urban development, the Ministry of Equipment and Housing (Ministère de l'Équipement et de l'Habitat) plans the distribution of industrial, commercial and urban areas; however, the Housing Development Agency (Agence Foncière de l'Habitat) is responsible for the development of new urban areas. The Tourism Development Agency (Agence Foncière Touristique) is similarly responsible for the development of new tourist areas. For certain zones that require twofold management, for marine and terrestrial components, involving more than one ministry, coordination is entrusted to a regional development council.

The main environmental issues in Tunisia are: uncontrolled industrial development and a related, but also uncontrolled, urban development often preceding the necessary urban infrastructure; over-exploitation of marine resources (especially fish and shellfish stocks), hence the need for protection of the sea-bed resources; agricultural residues and wastes are causing significant environmental degradation; some tourist areas still require some infrastructural attention (transport).

In Turkey, the principal government entity is the Ministry of Environment (Turkey, 1993). Several other bodies are attached to this Ministry, but their functions are not yet fully defined: the Supreme Environmental Board and the Local Environmental Boards. An Authority for Specially Protected Areas has recently been so attached. The Ministry itself is designed to implement policies for the protection and conservation of the environment and for the sustainable development and management of natural resources. The Ministry of Public Works

and Settlement has a General Directorate of State Hydraulic Works which is charged with developing water resources for irrigation and hydro-electric power generation and with preventing damage to surface and ground waters as well as ensuring their quality. The Bank of Provinces, also attached to this Ministry, is responsible for planning sewerage and waste-water treatment plants in small cities (<100,000 inhabitants). The Ministry of Energy and Natural Resources is responsible for the production, use and control of these "commodities". The Ministry of Industry and Trade is responsible for industrial policy development, in the light of potential environmental impacts. The General Directorate of Protection and Control, of the Ministry of Agriculture and Rural Works, and the General Directorate of Rural Services, of the Prime Ministry, also conduct environmental management projects on sewage and irrigation systems. The General Directorate of Forestry, of the Ministry of Forestry, conducts projects on: water-pollution control; identification, protection and management of national parks, nature reserves etc. The Environmental Service of the Ministry of Health is responsible for health networks, the monitoring of air and bathing water quality.

The main environmental issues in Turkey are: degradation of forests by illegal settlements, tourism, agriculture, fire and pests; the drying up of wetlands for other purposes (Turkey is an important route for migratory waterfowl); protection of marine turtle nesting beaches and of monk seal habitats; the degradation of valuable archaeological and architectural sites from air pollution, urban encroachment, smuggling of antique artifacts etc.; water pollution; solid-waste disposal in the coastal area (in particular); air pollution due to the burning of lignite and high-sulphur coal; and soil erosion.

UN Cooperating Agencies

Several UN agencies competent in the marine environmental field have cooperated closely with the MAP Coordinating Unit in the implementation of MAP, each according to its specific mandate and competence.

Food and Agriculture Organization of the United Nations (FAO)

FAO has four major departments focused on resources and environment: Agriculture; Forestry, Fisheries and Sustainable Development.

In the Fisheries Department, the focus being on the rational use of fishery resources, increased consideration is given to the relationship of a resource with its environment, its response to fishing, the demand for fish and fish products, the socio-economic role of the fishery and the legal and administrative constraints on fishing, fish processing and marketing.

To bring the Department's experience, knowledge and information to bear on regional fishery problems, FAO has created several regional subsidiary bodies; for the Mediterranean, the relevant body is the General Fisheries Council for the Mediterranean (created in 1952).

The Fisheries Department has, therefore, cooperated principally in the MED POL programme on the effects of pollution on marine organisms. FAO has also been involved in related questions of human food quality.

FAO was the lead agency for a number of pollutant assessments; notably, on the state of pollution of the Mediterranean Sea by mercury; cadmium; copper and zinc; organohalogenes; organotin; organophosphorus compounds; and eutrophication.

FAO has also collaborated with the UN Environment Programme in the development of a Marine Mammal Action Plan, though not in the framework of MAP.

Intergovernmental Oceanographic Commission (IOC)

The Intergovernmental Oceanographic Commission (of UNESCO) is playing a key role in defining the physical, chemical and biological factors underlying marine resource use, and in promoting international cooperative investigation and data collection on marine resources and environment. It also provides a context for improving understanding of the links between the oceans and climate, and between

the oceanic environment and the biological components supporting food chains leading to fisheries. IOC's Global Investigation of Pollution in the Marine Environment (GIPME), in which UNEP, IMO, and IAEA also participate, concentrates on chemical pollution, but is nevertheless relevant to the work of MAP, because of the effects of pollutants on marine organisms.

The IOC has also participated in a number of pollution assessments conducted under MAP, notably on: applicability of remote sensing for the survey of water quality parameters; petroleum hydrocarbons; persistent synthetic materials; and organohalogen compounds.

International Maritime Organization (IMO)

The IMO is concerned mainly with shipping: safety of navigation; safety (of seamen and others) at sea; protection of the marine environment from discharges of wastes, pollutants and hazardous substances from ships (including garbage-dumping vessels).

IMO is the depository and secretariat of the global London Convention which regulates the dumping of wastes into the sea and of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78).

IMO has, through the work of the Marine Environment Protection Committee, also focused on the definition of Sensitive Sea Areas.

It has collaborated closely with MAP, mainly through its support and supervision of the Regional Marine Pollution Emergency Response Centre.

World Meteorological Organization (WMO)

The relation of WMO to marine environmental pollution monitoring and research is mainly through its Global Atmosphere Watch. The routine monitoring programme includes measurements of key parameters and chemical species in precipitation and in the air itself.

WMO, through the WMO/ICSU/IOC World Climate Research Programme (WCRP), is concerned directly with global climate change

and this provides a basis for evaluating possible long-term changes in the marine and coastal environment. UNEP also participates directly in the WCRP.

United Nations Educational, Scientific and Cultural Organization

UNESCO promotes marine science in general (notably, but not exclusively, through IOC). The UNESCO Man and the Biosphere (MAB) programme, among other activities of much wider scope, seeks to reveal whole ecosystem linkages and to promote the creation of marine as well as terrestrial biosphere reserves.

UNESCO has cooperated with MAP particularly in the organization of a major Scientific Workshop on Eutrophication in the Mediterranean: Receiving Capacity and Monitoring Long-term Effects, held in Bologna in 1987, which FAO also cosponsored.

World Health Organization (WHO)

WHO works closely with UNEP on the overall planning, implementation and evaluation of health-related aspects of the Mediterranean Action Plan. Through MAP, it participates in the establishment and/or progressive development of health-related aspects of national marine pollution monitoring programmes (pollution sources, coastal recreational and shellfish areas) including identification of requirements, development of standardized sampling and analytical methods, organization of individual and group training, quality control of microbiological data, evaluation of country data and analysis of trends.

WHO coordinates the research projects implemented by Mediterranean Institutions within the MED POL Phase II programme, including technical assessment of proposals, identification of requirements, formulation of intercountry projects and development of networks, progress in monitoring and evaluation of results in the broad field of environmental pollution-related health risks.

WHO also participates in the organization of the preparation of guidelines on various aspects of waste treatment and disposal in terms of the Protocol for the Protection of the Mediterranean Sea against

Pollution from Land-Based Sources, and has participated as well in the preparation of health-related aspects of overall regional assessments of the state of pollution of the Mediterranean Sea by specific substances, including proposed prevention and control measures for adoption by Governments.

International Atomic Energy Agency (IAEA)

IAEA is particularly concerned with, *inter alia*, the contamination of the marine environment and organisms by radioactive substances in the sea, but in the last decade, through its Marine Environment Laboratory in Monaco, has engaged in the analysis of specific non-radioactive compounds in the marine environment. It has been particularly active in preparing and providing standard reference samples (of sediments and marine organism tissues) for the analysis of key contaminants, and in the conduct of intercalibration exercises, many specifically within the MAP context.

IAEA(MEL) has collaborated in several MAP assessments on: radioactive substances; organotins; organohalogens; and organophosphorus compounds.

Besides the examples of inter-agency cooperation already given in the foregoing sections, there is a mechanism for more general inter-agency cooperation which provides useful scientific and technical input to MAP. It is the IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP), which produces, *inter alia*, overview reports on the state of the marine environment.

World Bank for Reconstruction and Development

The World Bank-European Investment Bank Programme for the Mediterranean was initiated in 1988 to address the environmental policy, institutional and investment needs of the region (WB/EIB, 1990). The aim is to influence the formulation of economic policies and investment projects. Phase II, following a diagnostic Phase I, was initiated in 1990 and comprises the Mediterranean Technical Assistance Programme (METAP) specifically to identify projects, assist in their preparation,

strengthen national environmental management institutions and advise on policy and legislation (Kudat *et al.*, 1994). The main priority fields are: water resources management; management of solid and hazardous wastes; prevention and control of marine pollution from oil and chemicals; and coastal-zone management. Phase II will consist of implementation proper. Cooperation with MAP has been formalized, as well.

International Non-Governmental Organizations

Non-governmental organizations (NGOs) have played a key role in developing environmental awareness with respect to marine resources and environmental issues. They are too numerous to deal with individually. However, they should be recognised as partners in promoting the concept of sustainable development and in the implementation of Agenda MED 21 through their expertise, experience and capacity in their particular fields.

4.1.4 Legislation and its Enforcement

For the most part, international legislation does not apply to coastal terrestrial development and the question of implementation and compliance does not arise. This also holds essentially true for territorial seas. Exceptions arise where activities in these national domains have effects outside them in the international domain.

The status of signature and ratification of the Barcelona Convention and its Protocols is given in Table X. The main international instruments governing the marine and coastal environment in the Mediterranean region were summarized in section 4.3 below.

Since environmental policy under MAP takes into account the UN Convention on the Law of the Sea, the 1973/1978 Convention on the Prevention of Marine Pollution from Ships (MARPOL), and the 1972 Convention for the Prevention of Pollution by Dumping of Wastes and Other Matter, it is worth noting that the following Mediterranean countries have not yet ratified these conventions: Albania, Bosnia-Herzegovina, Croatia, Israel, Lebanon, Libya, Malta, Morocco, Slovenia, Spain, Syria, Turkey and the European Union (MARPOL); Albania,

Algeria, Bosnia-Herzegovina, Israel, Lebanon, Syria, Turkey and the European Union (Dumping); and Albania, Croatia, France, Greece, Israel, Italy, Lebanon, Libya, Monaco, Morocco, Slovenia, Spain, Syria, Turkey and the European Union (Law of the Sea).

The two main areas in which international legislation is widely applicable are sea-bed mining and fisheries.

Sea-bed Mining: In the Mediterranean, this covers mainly the extraction of oil and gas, and of sand and gravel. Most of this activity is conducted in territorial seas and, in itself, is governed only by national legislation. The relevant international legislation is the Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Sea-bed and its Sub-soil, adopted in 1994, as is, and in certain cases (ships engaged in mining operations) the Barcelona Convention (1976) and the Dumping Protocol (1976).

Fisheries: The UN Convention on the Law of the Sea, by stipulating the rights and obligations of coastal States in extending their jurisdiction over fisheries, removed the condition of free and open access which the distant-water fleets formerly operated under on most continental shelves within 200 miles of the coast. Subsequently, many coastal States internalized the problem of effort control, allowing an increase in fishing effort under the free and open-access conditions prevailing within national maritime jurisdictions (e.g., EEZs). This occurred because no specific rights were assigned to national harvesters and, in many cases, through excessive use of inappropriate subsidy schemes, this led to excessive fishing effort and further deterioration of the national resource base. One possible solution is that specific geographical rights to specified fishery areas, referred to as TURFs (Territorial User Rights of Fishermen), be granted in a Mediterranean regional framework.

In the Mediterranean Sea itself, no State has established an Exclusive Economic Zone, although Malta has established a small exclusive fishing zone, so, in effect, almost all fishing activity, except that within territorial seas, is conducted under an open-access regime. Since most fish stocks, and not least the highly migratory resources, lie across

Table X: Status of Signature and Ratification of the Barcelona Convention and its Protocols (UNEP, 1995c)

	Convention for the Protection of the Mediterranean Sea against pollution	Protocol for the prevention of pollution of the Mediterranean Sea by Dumping from Ships and Aircraft	Protocol concerning cooperation in combating pollution of the Mediterranean Sea by Oil and Other Harmful Substances in Cases of Emergency	Protocol for the Protection of the Mediterranean Sea against Land-Based Sources	Protocol concerning Mediterranean Specially Protected Areas	Protocol for the Protection of the Mediterranean Sea against pollution resulting from Exploration and Exploitation of the Continental Shelf and the Sea-bed and its Sub-soil
Place/Date Adoption	Barcelona 16. 2. 1976	Barcelona 16. 2. 1976	Barcelona 16. 2. 1976	Athens 17. 5. 1980	Geneva 3. 4. 1982	Madrid 14. 10. 1994
Entry into force	12. 02. 1978	12. 2. 1978	12. 2. 1978	17. 6. 1983	23. 3. 1986	
Albania	30. 05. 1990(AC)	30. 5. 1990(AC)	30. 5. 1990(AC)	30. 5. 1990(AC)	30. 5. 1990(AC)	
Algeria	16. 02. 1981(AC)	16. 3. 1981(AC)	16. 3. 1981(AC)	2. 5. 1983(AC)	16. 5. 1985(AC)	
Bosnia-Herzegovina	22. 10. 1994(AC)*	22. 10. 1994(AC)*	22. 10. 1994(AC)*	22. 10. 1994(AC)*	22. 10. 1994(AC)*	
Croatia	12. 10. 1993(AC)*	12. 10. 1993(AC)*	12. 10. 1993(AC)*	12. 10. 1993(AC)*	12. 10. 1993(AC)*	14. 10. 1994 (S)
Cyprus	19. 11. 1979 (R)	19. 11. 1979 (R)	19. 11. 1979 (R)	28. 6. 1988(AC)	28. 6. 1988(AC)	14. 10. 1994 (S)
European Community	16. 3. 1978(AP)	16. 3. 1978(AP)	12. 8. 1981(AP)	7. 10. 1983(AP)	30. 6. 1984(AP)	
Egypt	24. 8. 1978(AP)	24. 8. 1978(AP)	24. 8. 1978(AP)	18. 5. 1983(AC)	8. 7. 1983 (R)	
France	11. 3. 1978(AP)	11. 3. 1978(AP)	11. 3. 1978(AP)	13. 7. 1982(AP)	2. 9. 1986(AP)	
Greece	3. 1. 1979 (R)	3. 1. 1979 (R)	3. 1. 1979 (R)	26. 1. 1987 (R)	26. 1. 1987 (R)	14. 10. 1994 (S)
Israel	3. 3. 1978 (R)	1. 3. 1984 (R)	3. 3. 1978 (R)	21. 2. 1991 (R)	28. 10. 1987 (R)	14. 10. 1994 (S)
Italy	3. 2. 1979 (R)	3. 2. 1979 (R)	3. 2. 1979 (R)	4. 7. 1985 (R)	4. 7. 1985 (R)	14. 10. 1994 (S)
Lebanon	8. 11. 1977(AC)	8. 11. 1977(AC)	8. 11. 1977(AC)	1994 (AC)*	1994 (AC)*	
Libya	31. 1. 1979 (R)	31. 1. 1979 (R)	31. 1. 1979 (R)	6. 6. 1989(AP)	6. 6. 1989(AP)	
Malta	30. 12. 1977 (R)	30. 12. 1977 (R)	30. 12. 1977 (R)	2. 3. 1989 (R)	11. 1. 1988 (R)	14. 10. 1994 (S)
Monaco	20. 9. 1977 (R)	20. 9. 1977 (R)	20. 9. 1977 (R)	12. 1. 1983 (R)	29. 5. 1989 (R)	14. 10. 1994 (S)
Morocco	15. 1. 1980 (R)	15. 1. 1980 (R)	15. 1. 1980 (R)	9. 2. 1987 (R)	22. 6. 1990 (R)	
Slovenia	15. 3. 1994 (AC)	15. 3. 1994 (AC)	15. 3. 1994 (AC)	15. 3. 1994 (AC)	15. 3. 1994 (AC)	
Spain	17. 12. 1976 (R)	17. 12. 1976 (R)	17. 12. 1976 (R)	6. 6. 1984 (R)	22. 12. 1987 (R)	14. 10. 1994 (S)
Syria	26. 12. 1978(AC)	26. 12. 1978(AC)	26. 12. 1978(AC)	1. 12. 1993 (AC)	11. 9. 1992 (AC)	
Tunisia	30. 7. 1977 (R)	30. 7. 1977 (R)	30. 7. 1977 (R)	29. 10. 1981 (R)	26. 5. 1983 (R)	14. 10. 1994 (S)
Turkey	6. 4. 1981 (R)	6. 4. 1981 (R)	6. 4. 1981 (R)	21. 2. 1983(AC)	6. 11. 1986(AC)	

S = Signature R = Ratification AC = Accession AP = Approval * pending confirmation from the Depository State (Spain)

national maritime boundaries or between territorial seas and international waters, the prospects for joint management of the stock are particularly problematical, given that a unitstock must be managed in a coordinated fashion based on information on catches throughout its range.

Under the UN Convention on the Law of the Sea, jurisdiction over shelf resources lies with the coastal States, except for limited areas of shelf beyond 200 miles, and States are charged with cooperating to ensure sustainable management of shared marine resources, to use an existing fishery commission, or to set up such a body for this purpose.

This definition of a semi-enclosed sea incorporates several key ideas: (i) the potential effect of land on the marine system; (ii) the direct involvement of two or more States; (iii) a connection with another sea or ocean through a strait; and (iv) the division of the sea area into territorial seas and/or Exclusive Economic Zones, in theory at least. However, in the Mediterranean, no formal EEZ claims have yet been made.

The Convention definition excludes seas that are wholly national, such as the Sea of Marmara, even though, as for archipelagic seas and straits in general, the unhindered passage of marine resources from one jurisdiction to another through such wholly national waters is internationally recognized and accepted. This imposes a special obligation on the concerned States for conservation of international migratory resources while they are traversing straits and national seas.

4.1.5 Public Awareness and Participation

In spite of the fact that the general public, and notably the tourist population in the Mediterranean region, is becoming more and more aware of the marine and coastal environment, not the least evidence being the increasing demand for so-called eco-tourism and eco-recreation (see section 3.2.7), it appears that MAP is still lacking a popular constituency in the resident and tourist populations. This is partly because it has always been addressed to national and international decision-makers. Tourists may be willing to pay an "environmental protection" tax,

especially as the aforementioned eco-tourism expands and aesthetic insults such as tarred and littered beaches, for example as well as transport difficulties (i.e., coastal road traffic jams) become more frequent and possibly influence tourist quality. However, tourists would need to be much better informed of what MAP is and what it is doing to improve the environment in the way that tourists and resident populations seek.

Such a tax implies a need to cost resource utilization more realistically than at present (Chircop, 1992). The possibility that such a tax could be paid into the Mediterranean Trust Fund for MAP should not be excluded.

4.2 Prevention and Control of Marine Pollution

Various definitions of marine pollution need to be taken into consideration in assessing the effects of human activities on marine resources.

The basic definition was provided by GESAMP: "the introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of sea water, and reduction of amenities".

The UN Convention on the Law of the Sea, in 1982, in Article 1, paragraph 1(4), largely followed the GESAMP definition, by describing marine pollution as "...the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities;"

Under Article 1 of the London Dumping Convention, contracting parties pledge to "take all practicable steps to prevent the pollution of the sea by the dumping of waste and other matter that is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea".

The slight modification affected to the GESAMP definition as it appears in the UN Convention on the Law of the Sea is very significant as it introduces the precautionary principle. For this reason, this modified definition has been proposed for the purposes of the Barcelona Convention. It should be noted that the introduction of the same substances into the marine environment that do not cause the above-mentioned negative effects would not be considered pollution.

The prevention and control of marine pollution is the primary responsibility of the Contracting Parties; these act principally through the Mediterranean Coordinating Unit in the framework of the Mediterranean Pollution Monitoring and Research Programme (MED POL). The policy guidance springs, primarily, from the Protocols (i)-(iii) and (v) mentioned above in section 4.1.1 and from the Common Measures adopted under the Land-based Sources Protocol. A detailed evaluation of MED POL was carried out by a group of experts and is reported in UNEP (1993a). With the benefit of hindsight, it draws attention to a number of policy and implementation weaknesses in Phases I (1976-1980) and II (1982-1995) of MED POL which should be progressively corrected in Phase III (1996-2005).

Scientific research in marine pollution problems is seen as a means to reduce present uncertainties for facing management decisions and to secure links between inputs, concentrations and effects of contaminants and other stresses. That is scientifically based hazard assessment of contaminants is essential to correct management decisions (Jeftic, 1992).

4.3 Protected Areas and Endangered Species

There are 75 Specially Protected Areas (SPAs) under MAP, but only 23 cover marine spaces, either exclusively (8) or as part of a mixed (land + sea) space (15). The remainder are purely terrestrial, having their boundary far from the coast or at high-tide level, that is, coastal/terrestrial.

The national legislation of the Contracting Parties in respect of protected areas, which include national parks and wildlife reserves, as well SPAs, has been reviewed and

summarized by de Klemm (1994); her conclusions are, succinctly, as follows.

For the most part, there is a widespread separation of regulatory powers between governmental entities responsible for the land and those responsible for the sea, which make it very difficult to establish protected areas in the coastal zone (i.e., land + sea regimes). In some countries there is also potential legal opposition between national and regional governments, the former generally having responsibility for national parks, the territorial seas and other entities of national stature, the latter generally having responsibility for the actual territory occupied by a protected area and for the management of such areas.

There is, moreover, very little legislation allowing or governing the creation of marine protected areas, *de novo*; most marine protected areas established have been by extending the domain of coastal/terrestrial protected areas.

These two major difficulties have been overcome, to some extent, by using laws designed for quite other purposes (e.g., restriction on hunting of wildlife or on fishing). There are some examples in which laws in more than one legal domain (e.g., fishery law + navigation law + wildlife protection law) have been applied to achieve, *de facto*, a protected area. Of all the Contracting Parties, only Italy at present has a specific law governing the creation of marine protected areas.

A major problem is that protected areas established under non-specific laws cannot also have their regulation fixed under such laws; hence they only afford limited protection of such areas, usually against only certain specific activities but not others. Also, as a rule, the legislation governing national parks and reserves is often the only legislation applicable, but often ill-adapted, to special coastal areas such as wetlands and salt marshes.

Regarding specific activities in protected areas, the following constraints generally apply:

- (i) fishing may be totally prohibited or only allowed under special, and restricted, licence;
- (ii) cropping of sea-food species is

- generally governed likewise;
- (iii) hunting is widely banned, with occasional derogations under specific circumstances;
- (iv) navigation is subject to a wide variety of restrictions as to vessel track, speed and mooring, but total prohibition is rare;
- (v) swimming and diving is generally restricted and regulated, especially to exclude hunting (use of harpoons etc.);
- (vi) removal of rocks and minerals is also generally restricted and regulated, especially to prevent disturbance of the substrate (sea bed);
- (vii) introduction of exotic species is generally restricted or banned, but regulation sometimes applies only to flora; and
- (viii) discharge of pollutants is generally restricted or banned, but sometimes is limited to specific sites and/or types of pollutant.

The general prohibition of any action likely to disturb or modify the flora, fauna, water or substrate is widespread in the legislation at the national level. A zonation of protected areas is often adopted to allow accommodation of locally long-established rights of exploitation in, or in the immediate vicinity of a protected area.

The management of marine protected areas is not usually based on the law under which they were created. Regulations are often established by a local entity under specific statutes, or are not established at all. *Ad hoc* management committees are sometimes set up; they may or may not be effective in the management of the protected area. Sometimes *ad hoc* arrangements are made between interested parties and may prove workable.

Declassification criteria (for the disestablishment of a protected area) are rarely more severe than those for establishment, so that the duration of, a protected area is only weakly assured.

UNEP, through its Specially Protected Areas Regional Activity Centre, and with the collaboration of the International Union for the Conservation of Nature and Natural Resources (IUCN), has prepared a directory of marine and coastal protected areas of the Mediterranean

region (UNEP, 1994c), which lists, in Part 1, 233 sites of biological and ecological value, all under some degree of protection. IUCN has also compiled a directory of the world's protected areas (IUCN, 1990), of a much wider scope than that prepared by UNEP (1994c) and not limited to the coastal zone, however.

Protected areas, including SPAs, are all established, so far, in areas under national jurisdiction, and there are, therefore, few international legal instruments governing their establishment, regulation and management; the SPA Protocol to the Barcelona Convention is the principal one in the Mediterranean.

A number of international conventions are applicable in the Mediterranean region, insofar as the coastal States are signatories to, or have ratified, them. These have been summarized by de Klemm (1993). They are with place and date of signature in parenthesis (UNEP, 1995c):

- The African Convention for the Conservation of Nature and Natural Resources (Algiers, 1968). The species in Class A (in Annex) must be fully protected by the contracting States against hunting, slaughtering, capture or collection. The marine species of main concern in this priority Class, as well as in the Mediterranean context (see section 3.3.1), are the monk seal, all marine turtles, storks, cranes, flamingoes and pelicans. In the Mediterranean, Algeria, Egypt, Morocco and Tunisia are signatories.
- The Convention on the Conservation of Migratory Species of Wild Animals (Bonn, 1979). The species in Annex I (total protection) of actual or possible concern in the Mediterranean are the blue whale (*Balaenoptera musculus*), the monk seal (also in Annex II, which requires signatories to make every effort to establish agreements amongst themselves to protect and manage the resources of the animals listed), all marine turtles (in both Annexes), the white pelican, Audouin's sea gull, and two other bird species: white-tailed eagle (*Haliaeetus albicilla*) and billed curlew (*Numenius tenuirostris*). The coastal States signatories to this Convention in the basin are Spain,

France, Monaco, Italy, Israel, Egypt, Tunisia and Morocco, as well as the European Union.

The Convention on the Conservation of European Wildlife and the Natural Habitats (Bern, 1979). The species in Annex II (total protection) of actual or possible concern in the Mediterranean are the blue whale (*Balænoptera musculus*), the killer whale (*Orcinus orca*), the false killer whale (*Pseudorca crassidens*), Risso's dolphin (*Grampus griseus*), the pilot whale (*Globicephalus melæna*), the common dolphin (*Delphinus delphis*), the bottlenosed dolphin (*Tursiops truncatus*), the rough-toothed dolphin (*Steno bredanensis*), the striped dolphin (*Stenella coeruleoalba*), the harbour porpoise (*Phocoena phocoena*), the dense-beaked whale (*Mesoplodon densirostris*), Cuvier's beaked whale (*Ziphius cavirostris*), the bottle-nosed whale (*Hyperoodon rostratus*) (all other cetaceans are included in Annex III - protection and management), the monk seal, the green turtle, the loggerhead turtle, the hawksbill turtle, Kemp's ridley turtle (*Lepidochelys kempi*), the leatherback turtle (*Dermochelys c. coriacea*), and the vast majority of birds. The coastal States signatories to this Convention in the basin are Spain, France, Monaco, Italy, Malta, Greece, Cyprus and Turkey, as well as the European Union.

The International Convention for the Regulation of Whale Hunting (Washington, DC, 1946). The species of whales that are the object of this Convention and are likely to be found in the Mediterranean are the blue whale, the fin whale (*Balænoptera physalus*), the sei whale (*B. borealis*), the minke whale (*B. acutorostrata*) and the sperm whale (*Physeter macrocephalus*). All are protected species or are the subject of a whaling moratorium. The coastal States signatories to this Convention in the basin are Spain, France and Monaco.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington, DC, 1973). This Convention is relevant to the protection of species mainly in the

sense that it prohibits or controls the supply (of native species)-demand (for non-native species) loop, but it thereby favours the creation of protected areas. The coastal States signatories to this Convention in the basin are Spain, France, Monaco, Israel, Italy, Malta, Greece, Cyprus, Egypt, Tunisia, Algeria and Morocco.

The Council of the European Union has also adopted two directives which apply only to EU Member States and in the Mediterranean, to Spain, France, Italy and Greece, at present, which have the protection of endangered species as their principal objective: 79/409 on the conservation of wild birds; 92/43 on the conservation of natural habitats and wild fauna and flora.

De Klemm (1994) also reviews the national legislation relating to the protection of marine and coastal species.

UNEP (1993b) organized an expert meeting on environmental legislation related to specially protected areas and endangered species in the Mediterranean. It reviewed the state of development of national legislation in this field and, in particular, submitted a proposal to the Contracting Parties to modify the title of the SPA Protocol, essentially to add the notion of "wildlife", and the related revision of the text that might be necessary.

The Contracting Parties, through the Genoa Declaration (1985), also adopted ten objectives to be attained by 1995. Among these objectives were the protection of endangered marine species, such as the monk seal and marine turtles, and the creation of a Mediterranean network of some fifty protected areas.

Eight Mediterranean coastal States have established 31 biosphere reserves set up under UNESCO's Man and the Biosphere Programme. These reserves are designed to conserve genetic resources (see section 3.4.2, above) and representative ecosystems, while allowing the sustainable development of the neighbouring human populations. These reserves are unconventional and are adapted to local ecological and socio-economic circumstances; they comprise a central zone of strict protection, surrounded by a buffer zone

with strict limitations on human activities in turn, surrounded by a transition zone where human activities are carried out under certain restrictions.

The protection of specific natural areas, insofar as it is effective, also protects endangered species, although it is not always necessary to set up such areas to ensure protection of many species.

* The Contracting Parties have adopted Action Plans for the Management of the Mediterranean Monk Seal (1987), the Conservation of Mediterranean Marine Turtles (1989), and the Conservation of Mediterranean Cetaceans (1991). It may also be noted that UNEP adopted a Global Action Plan for the Conservation of Marine Mammals (1984).

A Meeting of Experts on the Evaluation of the Action Plan for the Management of the Mediterranean Monk Seal (Rabat, October 1994) reviewed progress in this field since 1987, making a number of recommendations aimed at generalising the application of the Action Plan by the Contracting Parties (UNEP, 1994b).

4.4 Protection and Development of the Coastal Zone

Ever since MAP was established it has been aware of the need to apply the integrated management of coastal areas, and integrated planning, to the protection of the Mediterranean environment. During the first decade of MAP, activity concentrated on monitoring the state of the Sea and on intervention to improve the state of the natural system. In doing so, it became increasingly clear that 80% of the marine pollution problem had a source on the land, and that it was necessary to harmonize development, globally and regionally, with the receiving capacity of the environment. This requires a continuing process of integrated planning and rational management of the region's limited resources, with particular emphasis on the interface between the land, as the main source, and the sea as the main recipient - the coastal zone.

The policies for environmental and resource management and for coastal area development, as a major contributor to the land-based sources of pollution, must therefore

be based on complementary objectives and be applied using instruments that are compatible and efficient that is, cost-effective.

The objectives of an integrated coastal-area management scheme in a given place, time and socio-economic context are multiple and often conflicting; therefore, these objectives must be clear-cut and related to the political, ecological and socio-economic objectives of the responsible government and local authorities in such a way as to maximize the common good. The public perception of this good may not be constant, but it must also be related to the time scale on which human societal development proceeds: that is, decadal. This common good must, in the current climate of social thinking, have sustainable development as its main objective.

The reduction of user conflict would generally demand the assignation of a value (expressed as some form of rent for use) to the coastal zone which would require a restriction on access, either through the economic cost of the rent or through socially established limits, and necessitate zonation whereby different uses are, as far as possible and, indeed, convenient, kept physically separate, so as to avoid adverse impacts on other users and uses and, perhaps above all, on the environment and the natural resources.

It is not normally possible for all these uses to co-exist in the same coastal area. Coastal habitation, tourism and recreation, on the one hand, and industry and marine mining, on the other, tend to be mutually exclusive, if the coastal area under consideration is relatively small; and all these uses tend to prejudice the pursuit of fishing (perhaps even sport fishing) and marine aquaculture. The choice of an integrated coastal-area management scheme is therefore important mainly because ecological criteria of choice in terms of space and objectives are unlikely to correspond to political criteria, in terms of jurisdiction and economics. Controlling coastal development and protecting habitats will require improved planning procedures, and will often involve painful social and political choices.

With these considerations in mind, MAP has worked to identify appropriate institutional, technical or policy mechanisms to make environmental and coastal-zone

development policies mutually supporting and-reinforcing, to evaluate the effectiveness of such mechanisms and to assist in their establishment.

In the majority of Mediterranean countries the concept of integrated coastal-area planning has not yet been fully applied and modern tools for such planning have not yet been introduced. Even those plans that have been drawn up do not take into account the atmosphere, nor the nearshore and offshore areas relevant to the plans, nor the role of natural processes and human activities in the hinterland.

The major form of assistance provided to the Contracting Parties by MAP in this field are the Coastal Area Management Programmes (CAMPs). They represent a new form of cooperation between MAP and the relevant national institutions and experts. The sum of MAPs knowledge and experience is now being applied to the development and execution of CAMPs. The details of this action are given by Brachya *et al.* (1994) and summarized by Jeftic (1993b).

The main objectives of CAMPs are to introduce or develop the process of integrated planning and management of Mediterranean coastal zones and to contribute to a sustainable development and environmental protection.

Each CAMP contains the following components:

- implementation of legal instruments (LBS Protocol, monitoring, survey of pollution, common control measures, Emergency Protocol, Dumping Protocol, MARPOL Convention);
- resource evaluation, protection and management (water, soil, forests, coastline, marine ecosystems, protected areas);
- activities (evaluation and trends);
- natural hazards and phenomena (seismic risk, implications of climatic changes);
- planning and management tools (database, geographical information system (GIS), Environmental Impact Assessment (EIA), carrying capacity);
- development-environment scenarios;

- and
- integrated planning and management (integrated planning studies, resources protection and management plans).

CAMPs are a new form of cooperation of MAP with national and local institutions and experts aiming primarily to create suitable conditions for the process of Integrated Management of Coastal and Marine Areas to be introduced and developed in Mediterranean coastal areas. That is an area-specific activity carried out in comparatively small selected areas of the region and based on the integration of knowledge and experience obtained by all MAP components (Jeftic, 1993a).

In order to assist such activities the "Guidelines for Integrated Management of Coastal and Marine Areas" (UNEP, 1994g) were prepared.

So far, CAMPs have been established for the Bay of Izmir (completed in 1993), the Syrian coast (completed in 1994), the Island of Rhodes (in progress), Kastela Bay (Croatia, completed in 1994), the Albanian coast (in progress), Fuka-Matruh (Egypt, in progress) and Sfax (Tunisia, in progress). Other CAMPs Israel and Lebanon (Figure 4).

4.5 Sustainable Development

4.5.1 Objectives

The concept of sustainable development was at the core of the debate at the UN Conference on Environment and Development, held in Rio de Janeiro in June 1992. The need for sustaining improvements in human well-being, while pursuing policies compatible with the capacity of the global environment to sustain such improvements over the long term, has led in recent years to the ideal of sustainable development. This concept embodies the idea of "progress", the motive force for technologically driven changes since the middle of the last century, and the idea of "stability", the ability of mankind to extract a constant level of benefits from an ecosystem over an indefinite period. The more notion of exploitation or harvesting of natural resources, but such exploitation must be constrained by the capacity of the exploited resource and its natural environment to resist

FINALIZED (3)
 ONGOING (4)
 TO BE INITIATED (2)
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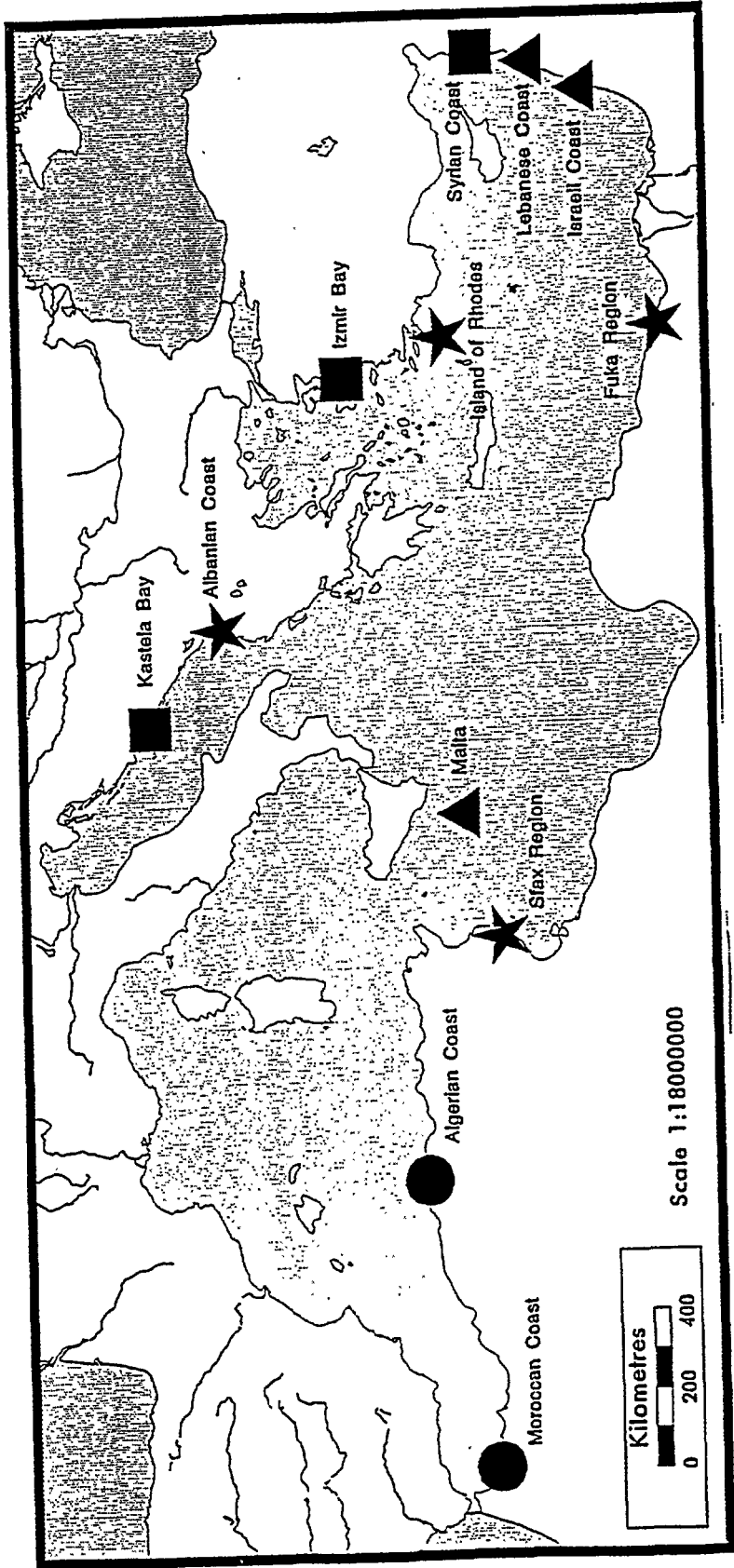


Fig. 4. Coastal Areas Management Programme of MAP

the impact of exploitation, if such development is to be sustainable. The pursuit of "progress" without restrictions has had negative effects on marine, as well as terrestrial, environments (WB/EIB, 1989).

The definition of sustainable development adopted by the World Commission on Environment and Development in 1987 (the Brundtland Report) is perhaps the simplest:

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

This definition recognizes that the value systems of society are continuously changing, as will the relative value currently assigned to a particular living resource. A more explicit definition for aquatic and terrestrial systems was adopted by the FAO Council in 1988:

"Sustainable development is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such development conserves land, water, plant and genetic resources, is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable."

The main objectives for the achievement of sustainable development in the Mediterranean context are outlined in the Action Plan for MAP Phase II (UNEP, 1995d) and in CEC (1993) for all the major areas of socio-economic activity. They may be summarized as follows.

Regarding economic activities, the main areas of concern are agriculture, industry, energy production and consumption, tourism, transport and fisheries.

Agricultural production is expected to increase, particularly in the countries on the southern and eastern borders of the Mediterranean Sea. The continued or increased use of inefficient irrigation systems will increase the negative impact on soil, through changes in its composition, nutrient content and texture, and on water quality, since the volume of

discharged water will be reduced and have to carry a higher load of excess chemicals (including salt), fertilizers and pesticides. This reduced free-water volume will also facilitate soil erosion which is a factor in desertification.

The main objectives in the sustainable development of agriculture should include:

- adoption of farming practices that are well adapted to the physical and ecological conditions, especially with respect to soil and water-resource conservation;
- adoption of environmentally friendly techniques to increase agricultural productivity and production and to conserve biodiversity;
- adoption of much more efficient systems of irrigation and water drainage;
- greater control and more limited use of chemicals that pollute soil and water; and
- increased use of natural fertilizers.

Regarding industry, a principal problem is the persistence of old-established industries in which the industrial processes used were designed when there was not much concern with the environmental impact of the wastes they produced; nor was there enough demand to force a much greater exploitation of those wastes, by recycling or the manufacture of secondary products based on them. The main objectives, among others, of sustainable development of industry should include:

- the promotion of the use of "clean" industrial procedures and techniques, and the transfer, adaptation and control of this technology between Mediterranean countries;
- the reduction of industrial wastes and their improved management and control, so as to minimize the environmental impact of these wastes, or, as far as possible, the incorporation of processes to exploit them.

Regarding energy production and consumption, the growth of the demand and the supply, mainly of fossil fuels, is a main factor in environmental pollution and other forms of environmental degradation. The

objectives of sustainable development should include:

- increased use of new (i.e., currently non-conventional) and renewable energy sources that are more environmentally friendly than the burning of fossil fuels, in domestic, industrial, private and public uses;
- development and application of techniques, especially insulation and ventilation, for better controlling and energy-saving;
- modernization of existing power stations in the Mediterranean basin and the environmentally friendly design of any new power stations to be installed there.

Tourism, though having a generally positive impact on the economies of "tourist-importing" countries, has a generally adverse effect on the environment in which it takes place, through pressure on land (for accommodation and other facilities), on food resources, on transport facilities, on coastal seas, on historical and natural sites, and, culturally, on the resident population.

The main objectives of the sustainable development of tourism include:

- improved assessment of the tourist carrying capacity of each tourist area;
- increased cooperation between the "tourist-exporting" and the "tourist-importing" countries, so as to improve public awareness of the environmental factor and the cost, *sensu lato*, of minimizing environmental impact;
- regular monitoring of the natural, cultural and human tourist resources and the regular assessment of the response of each tourist site to the tourist impact;
- promotion of tourism based on the natural, unspoiled environment and, as far as possible, at off-season periods of the year.

Transport is an infrastructural economic activity. Air and land transport will continue to grow and to have an increasing impact on resources, notably land and fuel, through the increased number and size of roads (hence vehicles) and airports (hence aircraft).

The main objectives for the achievement of sustainable development in this respect, are:

- to develop new forms of transport that, while providing all necessary comfort for individuals and efficiency for goods, decrease the amount of fuel and space used for each individual or unit product transported;
- improve the systems of transport for persons and goods, by facilitating the use of mixed modes of transport for different purposes;
- harmonize, at least on a regional basis, the systems of transport that are best suited to the Mediterranean basin.

Fisheries have probably reached a plateau in terms of what can be taken from the sea without driving the stocks to economic extinction, which normally precedes biological extinction unless the public willingness to pay the cost of capture remains directly proportional to the availability of the catch. In some cases, this is regrettably the case (e.g., bluefin tuna), and sustainable development is severely compromised.

The main objectives for the achievement of such development are:

- control of fleet size, technical advances in gear, vessels and navigational and fish-finding equipment, so as to adjust fishing effort rapidly to changes in stock size and biological yield;
- development of a much improved information base to allow accurate assessment of the state of the stocks and the optimum biological yield therefrom;
- rational and equitable allocation of fishing areas and resources, so as to place responsibility for stock maintenance in the hands of those to whom the resources have been so allocated;
- the special protection of estuaries and associated nearshore areas from use prejudicial to the fishery resources, because of the biological importance of these land-water interfaces which are nursery areas for many valuable species, areas where coastal marine systems are fertilized from the land,

- and on which marine resources harvested farther offshore depend;
- the rehabilitation of coastal ecosystems in which fishery resources once prospered;
- the development of legal, management and conservation mechanisms required for the management of the freshwater-seawater interface and the related resources;
- the implementation of the FAO Code of Conduct for Responsible Fishing, the Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas, and in due course, the relevant decisions expected to emerge from the UN Conference on Straddling Fish Stocks and Highly Migratory Species.

Marine aquaculture and habitat enhancement measures such as the construction of artificial reefs, are centred on coastal waters, estuaries and lagoons. The allocation of exclusive rights to users over the area of operation, the promotion of environmentally friendly aquaculture, and the protection of aquacultural standing crops against the harmful effects of other users of the environment are essential to the sustained development of marine aquaculture.

There are several socio-economic activities that need to be developed so as to contribute effectively to the achievement of sustainable development in the Mediterranean basin. They are: urban management, the management of natural resources, whether exploited or not, the conservation of natural landscape and natural sites of special ecological, social or cultural interest. In terms of the particularly complex coastal area, the aforementioned activities may be dealt with under the concept of integrated coastal-area management.

Urban management - increased analysis of the urban environment and the application of the results thereof to urban planning or redevelopment, taking environmental issues into account; the creation and development, where necessary, of a policy for urban management and an institutional and financial framework for such management; the development of the required professional and

institutional capabilities; increased regional cooperation, possibly through a "twin-cities scheme", to promote exchange of experience in urban management throughout the Mediterranean basin.

Management of natural resources - this covers four main areas: water resources; soil; forests and other natural vegetation; living marine resources.

The actions directly relevant to the sustainable development of water resources are: improved monitoring of water demand and of the supply to meet such demand; the preparation of national water-resources plans, on a drainage-basin basis, and the application of respective management programmes derived from such plans, with particular attention to the special problems of the coastal area and of small islands; increased and improved re-use of waste waters; increased regional and international cooperation to ensure adequate exchange of experience between countries in this field.

The actions directly relevant to the soil and its sustainable development are: increased and improved monitoring of soil state and mapping of soil types, preferably on a drainage-basin basis; development and application of policies and programmes to combat and, if possible, prevent soil degradation (down to desertification) and loss; the application, as appropriate, of the Convention to Combat Desertification.

The actions directly relevant to the sustainable development of forests and other natural vegetation may be derived conveniently from the FAO Mediterranean Forest Action Programme which requires: an assessment of the state of the forests in each country and the identification of problems to be given priority attention; the preparation and eventual application of Forest Directory Plans for each country for the protection, sustainable development of forests and their multi-purpose use; and increased cooperation between countries of the region in the exchange of information and experience.

The actions directly relevant to the sustainable development of the living marine resources, other than those discussed above under fisheries, are: improvement of the

information base (e.g., biological data, biogeographical data and human consumption data) required to determine the state of stocks of fishery or not, because of the importance of inter-specific relations (predation, competition for ecological niches, food supply etc.), and to determine the effects of environmental degradation and fishery pressure on the natural stocks (even of species not directly subject to fishery); the development of regional resource management policies and mechanisms inspired by the "precautionary principle".

Conservation of natural landscape and natural sites of special ecological, social or cultural interest - this conservation is an essential part of sustainable development because of the very heavy pressure exerted on these resources by uncontrolled urban, industrial and touristic development and the wastes they produce and discharge into the natural environment. Not only is land space increasingly denied to other uses, and historical sites destroyed, at worst, or seriously marred, at best, but typical ecosystems and unique species assemblages are also degraded or permanently modified, if not destroyed. The UN Conference on Environment and Development established a basis for the promotion of sustainable development known as Agenda 21 (UNCED, 1992), and for the conservation of the Earth's biodiversity by the adoption of the Convention on Biodiversity. The main actions called for are: periodic assessment of the state of the natural resources; the development and application of legal measures to protect them; improved management of natural resources; promotion of improved public awareness thereof; and the international exchange of experience in the conservation of natural resources and their biodiversity.

The very first principle of the Rio Declaration, however, states that "Human beings are at the centre of concern for sustainable development. They are entitled to

a healthy and productive life in harmony with nature". As a "cross-cutting" issue, health is well represented throughout Agenda 21 in the chapter on "promotion and protection of human health", where one of the five priority areas consists of reducing health risks from environmental pollution and hazards. Other chapters, most notably those on toxic chemicals, hazardous and solid wastes, fresh water and human settlements are very much human-health oriented.

4.5.2 Planned and Ongoing Activities

The achievement of sustainable development (EEC, 1993; UNEP, 1995e) is an ideal, though an essential one for human success and perhaps even survival, and only a very small beginning has been made. Many of the underlying concepts and possible mechanisms for such development were crystallized, but not "invented" at UNCED. Nevertheless, a number of activities have been carried out or are planned for the coming decade or more that, if pursued diligently, will help to promote the achievement of sustainable development. In the Mediterranean region, MED POL and the Regional Activity Centres have, for many years, been identifying and analysing many of the impediments to such an achievement and applying new as well as old and reliable methods to this end. FAO and its GFCM have, likewise, always made sustainable development the keystone of fishery management without so naming it. The removal, and especially the prevention, of disease in human beings, which has been the basis of WHO's work for many decades, is also essential to sustainable development. Similar remarks could be made of all the collaborating UN agencies (see section 4.1.3, above) and of many NGOs. The latter play an important role, sometimes supporting, sometimes stimulating. MAP cooperation with NGOs is outlined in UNEP (1995f).

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List of Acronyms and Abbreviations

BP	Blue Plan
CAMP	Coastal Areas Management Programme
CEC	Commission of the European Communities
COS	Carbonyl Sulphide
DBT	Dibutyltin
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
DMS	Dimethyl Sulphide
DMSP	Dimethylsulphonium Propionate
DYFAMED	Dynamique et Flux Atmosphériques en Méditerranée occidentale
ECE	Economic Commission for Europe
EEC	European Economic Community
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EROS	European River-Ocean System
ERS	Environment Remote Sensing
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
GAW	Global Atmospheric Watch
GESAMP	Group of Experts on the Scientific Aspects of Marine Pollution
GFCM	General Fisheries Council for the Mediterranean
GIPME	Global Investigation of Pollution in the Marine Environment
GIS	Geographical Information System
GOOS	Global Ocean Observing System
GRT	Gross Registered Tons
HCB	Hexachlorobenzene
HCM	Hexachlorohexane
HOC	Hydrophobic Organic Chemicals
IAEA	International Atomic Energy Agency
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
IFEN	Institut français de l'environnement
IGPB	International Geosphere-Biosphere Programme
IMO	International Maritime Organisation
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IPCC	Intergovernmental Panel on Climatic Change
IPSU	International Council of Scientific Unions
IUCN	International Union for the Conservation of Nature and Natural Resources
LBS	Land-based sources
MAB	Man and the Biosphere Programme (of UNESCO)
MAP	Mediterranean Action Plan

MARPOL	Convention on the Prevention of Marine Pollution from ships
MAU	Mediterranean Assistance Unit
MBT	Monobutyltin
MED 21	Agenda 21 for the Mediterranean
MED POL	Mediterranean Pollution Monitoring and Research Programme
MEL	Marine Environment Laboratory
METAP	Mediterranean Technical Assistance Programme
NGO	Non-Governmental Organization
NW	North West
OECD	Organisation for Economic Cooperation and Development
OP	Organophosphorus
PAH	Polycyclic Aromatic Hydrocarbons
PAP	Priority Actions Programme
PCB	Polychlorinated biphenyls
PH	Petroleum Hydrocarbons
PVC	Polyvinylchloride
RAC	Regional Activity Centre
REMPEC	Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea
ROCC	Regional Oil Combating Centre
SPA	Specially Protected Areas
TAC	Total Allowable Catch
TBT	Tributyltin
TPE	Terms of Oil Equivalents
TPT	Triphenyltin
TURF	Territorial User Rights of Fishermen
UN	United Nations
UNCED	United Nations Conference on the Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organisation
WB	World Bank for Reconstruction and Development
WCRP	World Climate Research Programme
WHO	World Health Organisation
WMO	World Meteorological Organization
WW	Waste Water