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# Priority issues in the Mediterranean environment

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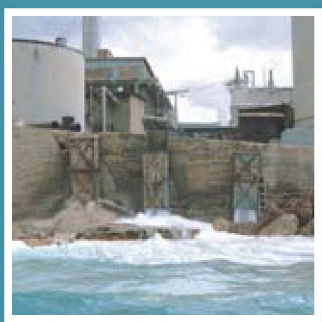

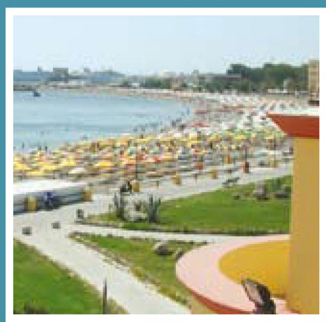

UNEP

European Environment Agency

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European Environment Agency
Kongens Nytorv 6
1050 Copenhagen K
Denmark
Tel.: +45 33 36 71 00
Fax: +45 33 36 71 99
Web: www.eea.eu.int
Enquiries: www.eea.eu.int/enquiries

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# Acknowledgements

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# Preface

In 1999, recognising the lack of timely and targeted information for action, EEA and UNEP/MAP collaborated on a joint publication: *State and pressures of the marine and coastal Mediterranean environment*. Further cooperation to provide more in-depth assessments which form the basis for global action to reverse the present trends in the region has continued and is exemplified by this joint report.

Following the principles of the European Thematic Strategy on the Protection and Conservation of the Marine Environment, the collective interest of EEA and UNEP/MAP has been developed towards a product focusing on priority pollution zones in the Mediterranean Sea and addressing emerging issues. All these issues come under the prism of an ecosystem approach. The core of this report derives from the latest (2003–2004) country National Diagnostic Analyses reports (NDA). These have been prepared within the framework of Implementation of the Strategic Action Plan (SAP) to address pollution from land-based activities in the Mediterranean Sea. Additionally, a Transboundary Diagnostic Analysis (TDA) (UNEP/MAP, 2004a), based on the UNEP/MAP MEDPOL programme, has highlighted endangered marine and coastal areas from land-based activities (i.e. pollution arising from urbanisation, population growth, tourism, wastewater, industrial activity — including the oil industry and maritime traffic — and agriculture).

The report does not attempt to give an overall analysis of the state of the Mediterranean marine environment but addresses in more detail some emerging issues in the Mediterranean region. These issues are of concern for maintaining a sustainable ecosystem and have been recognised as such in previous EEA reports (EEA, 1999; 2002). They include:

- **Biological invasions** which may cause significant changes to marine biodiversity, particularly in the eastern basin;
- **Unsustainable fisheries and aquaculture practises in certain Mediterranean countries,** which may lead to overexploitation of living resources as well as have an impact on the coastal and marine ecosystem, i.e. trawling on sea-bottom habitats and non-target species;
- **Harmful Algal Blooms** carry risks to human health across the Mediterranean Sea;
- **Natural hazards** and **ecological quality status** have also been added to the list of emerging issues given the global interest they receive.

Finally, it should be acknowledged that the core data of this report were provided by the countries to UNEP/MAP. The report can be used to focus on alternative policy options to help regional and national policy-makers develop priority policy actions that will have a positive effect on the Mediterranean marine environment.

# Executive summary

This report is a product of EEA and UNEP/MAP. It aims to identify priority pollution zones and emerging issues in the Mediterranean Sea. The report does not attempt to give an overall state of the Mediterranean marine environment. Instead it addresses specific issues which are of main concern to the sustainable development of the region and which have been recognised as such in previous EEA reports (EEA, 1999; 2002).

The Mediterranean coast hosts many human activities which constitute important causes for the degradation of the marine ecosystem. The main issues of concern are:

*Sewage and urban run-off.* From 601 coastal cities with a population of more than 10 000 inhabitants (total resident population of 58.7 million) only 69 % operate a wastewater treatment plant. However, the efficiency of the plants to remove pollutants is often rather low and inadequate. The problem is exacerbated by the rapid growth of many coastal cities and towns, especially on the southern Mediterranean coast.

*Solid waste* produced in urban centres along the Mediterranean coastline is often disposed of in dumping sites with minimal or no sanitary treatment. Discharge of fine solids from coastal industrial plants or discharge of inert material from construction activities may lead to blanketing of the sea-bed with land-based material.

*Industrial effluents including oil processing*. Most of the Mediterranean coastal areas host chemical and mining industries that produce significant amounts of **industrial wastes** (e.g. heavy metals, hazardous substances, and persistent organic pollutants (POPs) which may reach the marine environments of the Mediterranean Sea directly or indirectly (i.e. through rivers and run-offs). In addition, stockpiles of **obsolete chemicals** (such as POPs and pesticides) are considered a significant source of contaminants into the marine environment. Most of these compounds are presented during the discussion on the occurrence of POPs in the Mediterranean region. In many cases, no measures have been taken to control and treat leachates from the dumping sites which are polluting groundwater and/or the coastal marine environment with organic pollutants and heavy metals. Furthermore, accidental fires emit smoke particles, polycyclic aromatic hydrocarbons (PAHs) and dioxins, seriously affecting air quality.

*Urbanisation* of the coastline is one of the major problems in the Mediterranean region, often leading to loss of biodiversity due to habitat destruction and physical alteration. Problems related to the concretisation of the coastline are encountered through the Mediterranean. This is usually due to uncontrolled development, especially tourist infrastructure. Both wetland and salt-marsh destruction for land reclamation and mining of coastal resources (sand and rock quarrying) for construction needs are also altering irreparably the natural Mediterranean coastline.

*Eutrophication* is very common in sheltered marine water bodies such as harbours and semi-enclosed bays along the Mediterranean coast, mainly in the vicinity of coastal towns. Untreated or partly treated urban effluents contain significant loads of nutrients and suspended matter (degradable or inert). They largely contribute to the accumulation of deposits rich in organic matter and contaminated with metals and other pollutants.

*Sand erosion* is a common problem in many Mediterranean countries. Although it is rooted in natural causes, such as marine sediment transport, it can be amplified by human activities (e.g. sand quarrying). Sand erosion may have a multitude of impacts on the coastal ecosystem; destroying soil surface layers leading to groundwater pollution; degrading the dune system leading to reduction of sedimentary resources; and desertification and reduction of biological diversity.

*Marine transport* is one of the main sources of petroleum hydrocarbon (crude oil) and PAH pollution in the Mediterranean Sea. It is estimated that about 220 000 vessels of more than 100 tonnes each cross the Mediterranean annually. These vessels discharge approximately 250 000 tonnes of oil due to shipping operations such as deballasting, tank washing, dry-docking, and fuel and oil discharges. In addition, approximately 80 000 tonnes of oil have been spilled between 1990–2005 from shipping accidents. Finally, incidents at oil terminals, together with routine discharges from land-based installations, are estimated at 120 000 tonnes/year, thus leading to elevated oil concentrations in their vicinity.

All these issues served as guidelines with which to assess major environmental problems in the coastal zone of the Mediterranean countries (Table 1). Identification of hot spots and areas of major environmental concern are shown on a country-by-country basis. However, it must be stated that the country reports sometime contained conflicting data and the data availability was not identical for all the countries. Therefore pollution stress was evaluated at the national rather than pan-Mediterranean level.

In addition to land-based and shipping-related threats, a number of issues have been recognised as being of concern to the health of marine ecosystems in the Mediterranean.

*Biological invasions*. Climatic changes in conjunction with deteriorated ecosystems near ports and lagoons have resulted in significant **changes of biodiversity** due to the introduction and establishment of exotic species. The majority of exotics are found in the eastern basin (Levantine). The introduction of exotic species (more than 600 records in 2004) is a dynamic non-stop process with approximately 15 new species reported each year. It is noteworthy that **in the 21st century, 64 new species have been reported in the Mediterranean,** 23 of them recorded in 2004.

*Harmful Algal Blooms (HABs)*. In the Mediterranean, increasing appearance of HABs has led to significant public health problems caused by the consumption of seafood contaminated by toxic algae. Based on the outcome of the EU-funded research project ECOHARM, it has been estimated that the socio-economic impact of HABs for three evaluated Mediterranean countries — Italy, Greece and France — was around 329 million euro per year.

*Exploitation of marine resources. Fishing down the marine food web* has a negative impact on whole ecosystems. According to the FAO fisheries statistics, the mean trophic level of Mediterranean catches has declined by about one level during the last 50 years, e.g. there has been a significant loss of top predators from the ecosystem. Another documented impact of fishing relates to changes observed in the structure of fish populations. Demersal stocks in the Mediterranean are dominated by young fish indicative of high fishing pressure. There is a high economic interest in small fish, leading to high catches of undersized fish in some bottom trawl-fisheries. High discard rates of undersized, targeted species is also contributing to a loss of biodiversity of non-target species.

**Table 1 Major environmental problems in the coastal zone of the Mediterranean countries**

| | Urban effluents | Urban solid wastes | Industrial effluents | Oily effluents | Stockpiles of toxic chemicals | Coastal eutrophication | Coastal urbanisation |
|---|---|---|---|---|---|---|---|
| Albania | + | + | – | – | + | +/– | +/– |
| Algeria | + | + | + | + | – | +/– | + |
| Bosnia and Herzegovina | + | + | – | – | +/– | – | + |
| Croatia | + | + | – | + (expected) | – | + | + |
| Cyprus | +/– | – | + | – | – | – | +/– |
| Egypt | + | + | + | +/– | – | + | + |
| Greece | + | + | + | – | – | +/– | +/– |
| France | + | – | + | – | – | +/– | + |
| Israel | + | – | + | +/– | – | +/– | +/– |
| Italy | + | – | + | + | – | + | + |
| Lebanon | + | + | +/– | – | – | – | + |
| Libya | + | + | + | +/– | – | – | – |
| Malta | + | +/– | +/– | +/– | – | – | + |
| Monaco | – | – | – | – | – | – | + |
| Morocco | + | + | + | + | +/– | +/– | + |
| Gaza Strip | + | + | + | – | – | +/– | + |
| Spain | + | – | + | – | – | +/– | + |
| Slovenia | + | – | + | – | – | +/– | + |
| Syria | + | + | + | + | – | +/– | +/– |
| Turkey | + | + | + | +/– | – | + | + |
| Tunisia | + | + | + | – | – | +/– | + |

+ : Important problem; +/– : Medium problem; – : Small problem

*Expansion of aquaculture.* According to UNEP/MAP/MEDPOL, intensive aquaculture is 'undoubtedly a matter of concern for the Mediterranean', for a regional sea where aquaculture increased overall from 19 997 tonnes in 1970 to 339 185 in 2002. The changes in diversity (reduction in abundance, diversity and biomass of macrofauna and flora as well as in abundance and diversity of organisms living in the sediments and bottom habitats) are among the negative effects of aquaculture that have been documented. However, severe effects are generally confined to local areas, i.e. a few hundred metres at most. Recovery of the local ecosystem, albeit at slow rates, can follow if the farm operation ceases.

*Natural hazards.* The social and economic impacts of major earthquakes can be devastating, particularly in coastal urban areas. Enhanced seismicity in certain Mediterranean regions and subsequent tsunami activity intensifies the need for better coastal protection.

During the writing of this report it became apparent that only limited knowledge exists for the following subject areas:

a) levels and loads of pollutants;
b) issues of transboundary concern;
c) inventories of exotic species, specific ecosystems and hot spots;
d) trends in ecological quality status and biodiversity changes of coastal ecosystems related to human impact, e.g. urbanisation, industrial activities, shipping, fishing, aquaculture;
e) regional cooperation. Information for the south and east Mediterranean is, unlike for the northern part, generated through scattered, inconsistent and frequently unreliable investigation programmes.

## Conclusions

The main problems in southern and eastern Mediterranean countries are the inadequate treatment of urban waste and management of chemicals in contrast to northern countries where efforts should be deployed to overcome the problems raised by use of chemicals and their impacts on environment. In the northern Mediterranean region, which is the most industrialised, there are *a priori* necessary prevention mechanisms, correction technologies and the appropriate legal framework. However, there is a lack of political willingness from the countries to enforce environmental regulation. The southern Mediterranean region is, however, growing at the expense of the environment since neither the economic conditions nor the required technologies are available.

**The number one priority in environmental management in the Mediterranean region is to develop the necessary environmental legislation and to enforce it.** Ratification of protocols remains a challenge for the region. Most of the existing multilateral environmental agreements have low numbers of ratifications.

# 1 Introduction

**Box 1.1 Main characteristics of the Mediterranean Sea**

- High temperatures: (annual minimum of 12 °C, reaching up to 25 °C during summer) which induce high metabolic rates.
- High salinity: the most saline of Europe's seas. As evaporation exceeds precipitation and river run-off the sea has a freshwater deficit of about 2 500 $km^3$/year (EEA, 1999).
- Microtidal: regime with a tidal range typically less than 50 cm which, therefore, reduces the potential for dilution and dispersion of dissolved and particulate wastes.
- Oligotrophy: poor in nutrients, low primary production and low phytoplankton biomass. Oligotrophy increases from west to east. Primary production in the open sea is considered to be phosphorus limited in contrast to nitrogen limitation in most of the world's oceans.
- Rich biodiversity: the fauna and flora is one of the richest in the world particularly in the coastal zone, highly diverse and with a high rate of endemism.
- Biological invasions: high numbers of introduced alien species which are increasing in ports and lagoons. Transportation via the Suez Canal is important, hence the greater number of alien species in the eastern basin.

## 1.1 Fingerprint of the Mediterranean Sea

The main characteristics of the Mediterranean marine ecosystems (Box 1.1 and Table 1.1) are quite different from other European seas. These characteristics determine in a unique way the fate of physicochemical and biological cycles affecting all aspects of ecological processes.

## 1.2 Physical environment

The Mediterranean Sea is the largest semi-enclosed European sea, characterised by a narrow shelf, a narrow littoral zone and a small drainage basin especially in the northern part. The Sicilian Channel (150 km wide, 400 m deep), separates two distinct basins, the western and the eastern, and acts as a geographical and hydrological frontier between them.

## 1.3 Hydrography

The circulation pattern and general physiography in the Mediterranean is complex and is shown schematically in Figure 1.1.

Oxygen levels are almost saturated in the surface layer (6 ml/l in winter and 4.8 ml/l in summer). In the deep water the oxygen concentration is around 4.5 ml/l in the western and 4.2 ml/l in the eastern basin. The main rivers are the Ebro, Rhône, Po and Nile. The yearly average temperature for surface and deep waters are shown in Table 1.2.

**Table 1.2 Mean surface temperature (winter-summer) values in the surface and intermediate (200–1 000 m) layers of the Mediterranean Sea**

| Sea area | Temperature °C | |
|---|---|---|
| | Surface | Layer from 200 to 1000 m |
| Gibraltar | 15–20 | 13.5 |
| Sicily Straits | 14–23 | 13.8 |
| Straits of Crete and south Aegean | 16–24 | 14.9 |
| Levantine | 16–26 | 14.9 |

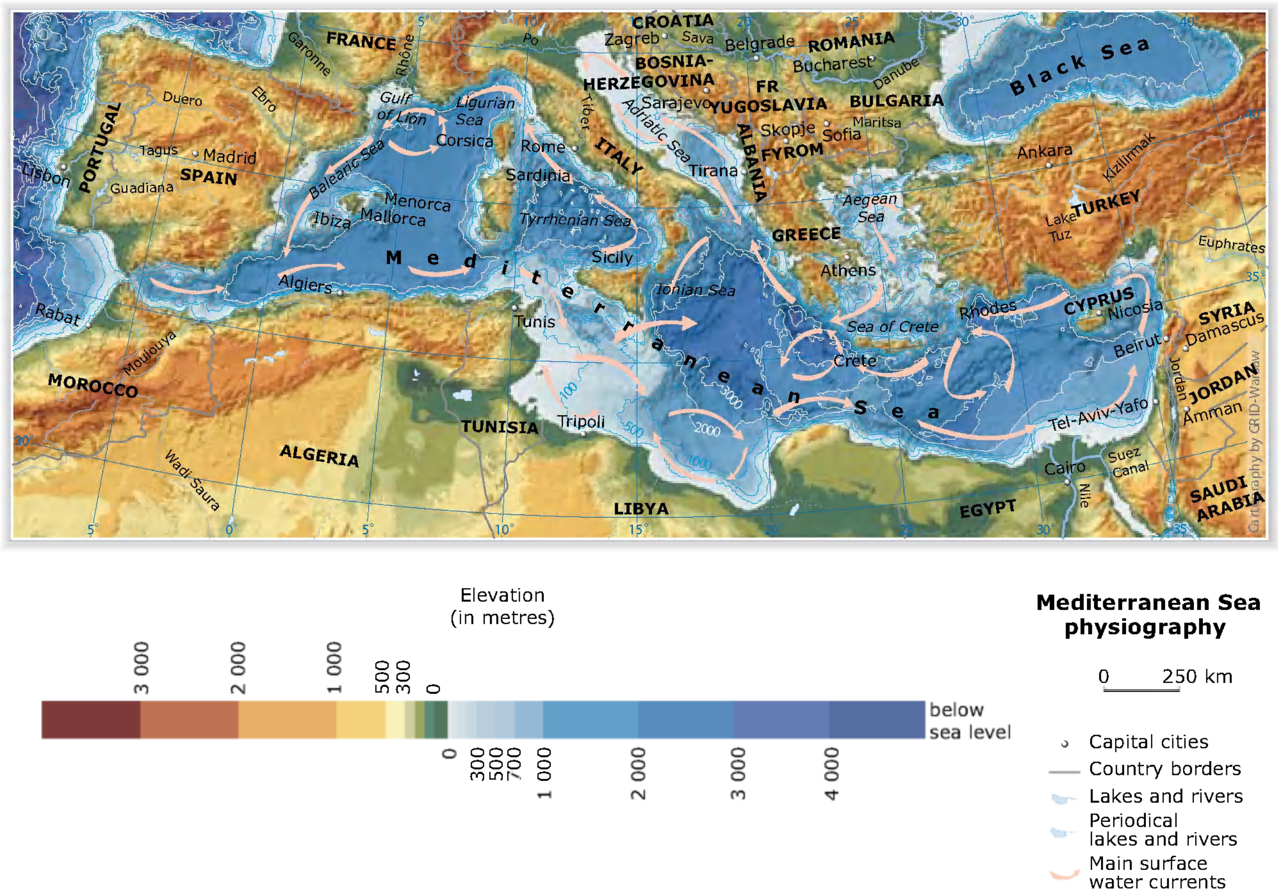
**Source:** EEA, 2002.

**Table 1.1 Statistics of the Mediterranean Sea**

| Surface $km^2$ | Coastal length km | Depth average m | Temperature average °C (W-E) | Salinity average ‰ (W-E) |
|---|---|---|---|---|
| 2.5 million | 46 000 | 1 500 | 15–21 | 36.2–39 |

**Source:** EEA, 2002.

**Figure 1.1 The Mediterranean Sea physiography (depth distribution and main currents)**




**Source:** EEA, 2002.

## 1.4 Ecosystem productivity

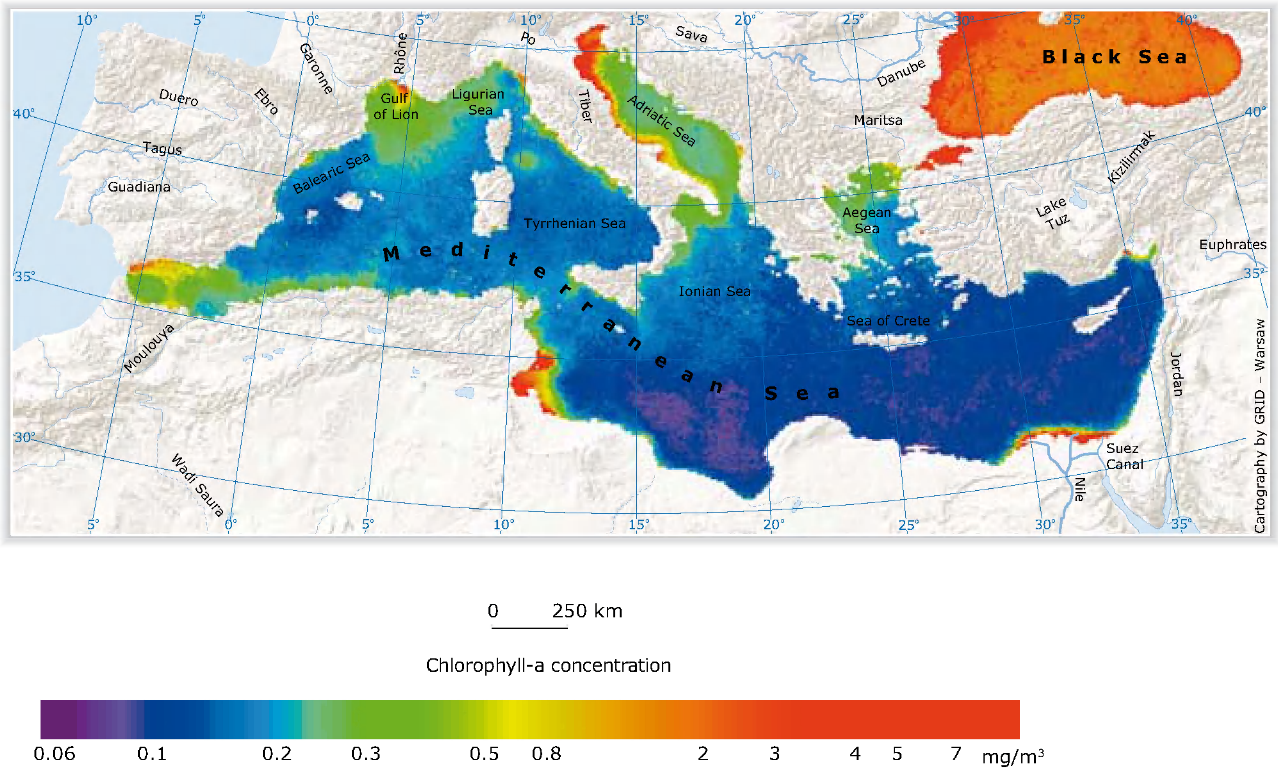
Oligotrophic conditions: low primary production (Figure 1.2) and low phytoplankton biomass characterise the Mediterranean basin. Low phytoplankton biomass means high transparency of the water and light penetration deep into the water column (Ignatiades, 1998) thus allowing photosynthesis at a greater depth. Primary production is considered to be phosphorus (P) limited as opposed to nitrogen (N) limitation in most of the world's oceans. In this context, increased primary production could be expected only when phosphorus is increased. However, recent research experiments to increase phosphorus loading in the eastern Mediterranean could not verify this statement (EU funded research project CYCLOPS). The working hypothesis has changed to one in which the eastern Mediterranean is unequivocally P limited during the winter phytoplankton bloom. It then evolves into a system in summer in which N and P are close to co-limiting.

A clear west–east gradient in chlorophyll and nutrient concentrations is present in the Mediterranean. The SeaWiFS satellite image (Figure 1.2) shows the clear, pigment-poor oligotrophic waters of the Mediterranean Sea compared to the eutrophic waters in the Black Sea, indicative of increasing oligotrophy towards the east. The main exception to the overall oligotrophic nature of the eastern Mediterranean is the highly eutrophic system of the north Adriatic Sea caused by discharges of nutrients by the northern rivers, mainly the Po River.

## 1.5 Fauna and flora: biodiversity status

The Mediterranean fauna and flora have evolved over millions of years into a unique mixture of temperate and subtropical elements, with a large proportion (28 %) of endemic species (Fredj *et al.*, 1992). The present-day variety of climatic and hydrological situations and Mediterranean-specific

**Figure 1.2 Mean surface chlorophyll-a concentrations in autumn 1998**




**Note:** A composite of all data received during September, October and November 1998 derived from the SeaWiFS ocean colour sensor.

**Source:** NASA SeaWiFS project and ORBIMAGE Inc.

biotopes account for the great species variety resulting partly from the geological history of the area. A total of 10 000 to 12 000 marine species have been recorded (with 8 500 species of macroscopic fauna and more than 1 300 plant species). This rich biodiversity represents 8 to 9 % of the total number of species in the world's seas and new species are still being recorded, especially in hitherto unexplored water depths or areas.

The general pattern of species richness in the Mediterranean Sea (Figure 1.3) matches that of primary production and chlorophyll a concentrations shown in Figure 1.2.

## 1.6 Pressures from human activities and their impacts

### *1.6.1 Nature and severity of problems on the Mediterranean coastline and coastal sea*

Many human activities are important sources of degradation to the Mediterranean marine ecosystem. Pollution is only one of the problems threatening the viability of the Mediterranean as an ecosystem. The modification and destruction of marine and coastal habitats through improper development practices and poor management are also very significant problems. Anthropogenic stress on the Mediterranean marine environment can be categorised under the following scheme:

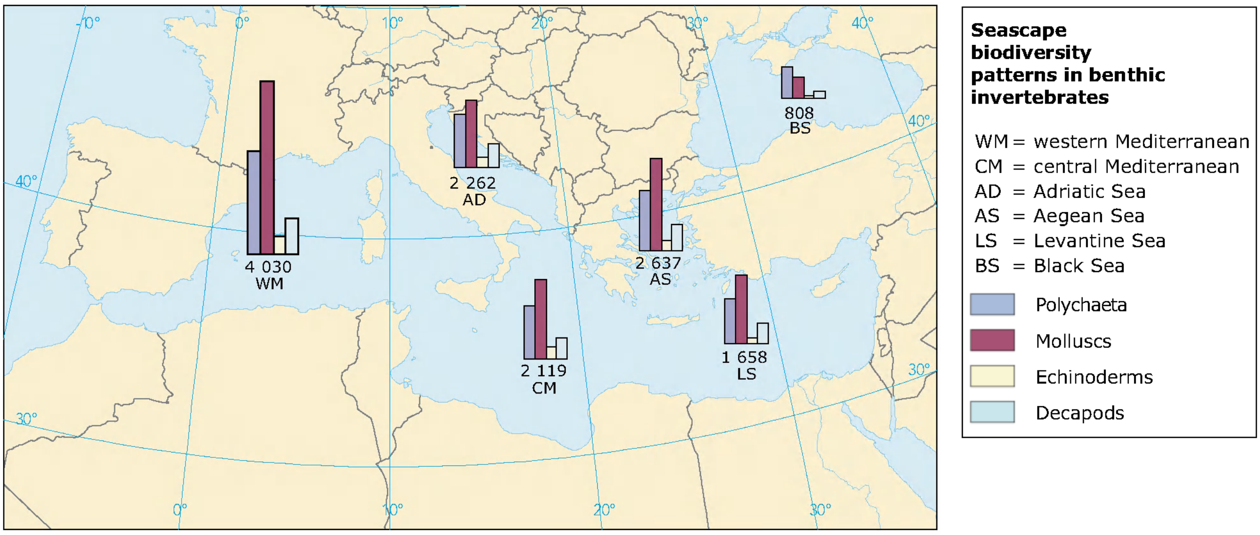
*Land-based sources of pollution*

- sewage and urban run-off
- urban solid wastes
- persistent organic pollutants (POPs)
- heavy metals
- organohalogen compounds
- radioactive substances
- nutrients
- suspended solids
- hazardous wastes.

*Habitat destruction and physical alteration*

- shoreline construction and alteration
- wetland and salt-marsh alteration
- marine waters and coastal watershed alteration.

**Figure 1.3 Patterns in species diversity of benthic invertebrates in the Mediterranean**




**Note:** Total number of benthic invertebrate species by sea area is indicated below the bar diagrams. Overall total for the Mediterranean is about 5 900 species.

**Source:** Zenetos *et al.*, 2003.

*Off shore and marine-based pollution*

- petroleum hydrocarbons from shipping activities
- marine litter.

*Emerging issues (see 1.6.3)*

- biological invasions
- overexploitation of fisheries resources
- expansion of aquaculture
- increasing appearance of Harmful Algal Blooms (HABs).

The population of the Mediterranean countries was about 450 million in 1996 and it is estimated to reach 520–570 million by 2030 (EEA, 1999). This constantly increasing population pressure is exacerbated by tourism. The mild climate and the natural and cultural heritage attract huge numbers of tourists. In fact, the figure represents about one third of the world's international tourism. Tourism is seasonally concentrated in the coastal zones, particularly on the shores of the north-western basin. The 135 million tourists visiting the area in 1996 are expected to rise to 235–300 million per year in the next 20 years.

Along the Mediterranean coastline, 131 'pollution hot spots' have been identified by the countries in the frame of the Strategic Action Programme (SAP) of UNEP (Figure 1.4 — UNEP/WHO, 2003). These hot spots are point pollution sources or polluted coastal areas which may affect human health, ecosystems, biodiversity, sustainability, or economy. Of these hot spots, 26 % are urban, 18 % industrial and 56 % mixed (urban and industrial) (UNEP/MAP, 2003a). Additionally, 59 sensitive areas (marine areas under threat of becoming pollution hot spots) have also been identified along the Mediterranean coastline. All these pressures have led to the degradation of environmental quality in certain coastal areas. The impact on the open Mediterranean Sea environment, however, is still uncertain.

### 1.6.2 *Priority issues on a country-by-country basis*

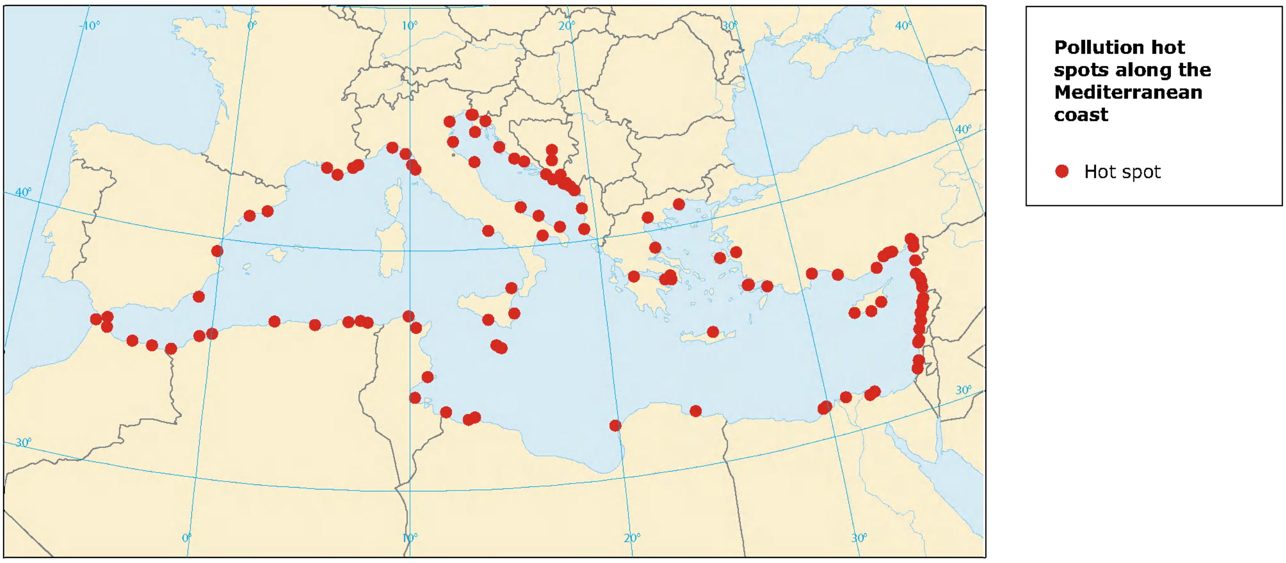
The policies addressing environmental concerns towards pollution elimination in the Mediterranean area are described in detail in Chapter 10. The main initiatives are summarised in Box 1.2.

In the NDAs, environmental issues were prioritised and ranked according to their environmental importance. Pollution hot spots and sensitive areas were included in the countries' priority lists, which also contained additional areas of concern. The major pollution issues on the Mediterranean coast are presented country by country in alphabetical order using the available information from the countries' NDAs, as well as other additional sources where NDAs are not available, i.e. Monaco, Italy and Spain.

### 1.6.3 *Emerging issues threatening ecosystems*

The following issues have been highlighted as the main future threats to the marine ecosystems in the Mediterranean (EEA, 1999; 2002):

**Figure 1.4 Pollution hot spots along the Mediterranean coast**




**Source:** HCMR based on UNEP/WHO, 2003.

- **Biological invasions**. The introduction of exotic species through ballast waters, fouling, import and invasion has resulted in the establishment of dense alien populations of species. This has sometimes led to catastrophic effects on the natural environment.
- **Over-exploitation of fisheries resources**. Unsustainable fishing practices have resulted in over-exploitation of several fish stocks in the Mediterranean. Eutrophication in some coastal areas has almost certainly resulted in an increase in catches of some pelagic fish species in the formerly low-nutrient waters of the Mediterranean Sea. By-catches and discards from trawling are considered to have a detrimental effect on the ecosystem.
- **Expansion of aquaculture**. Aquaculture takes place mainly in the coastal zone where biodiversity is high and human pressures are increasing (e.g. tourism, urban development, transport and agriculture). Therefore it exacerbates the effects of potential impacts. Habitat degradation in the vicinity of the cages and conflicts with the tourist business on the use of natural coves occur. Diseases of the fish, which could affect the wild population, as well as degradation of the benthic community under the cages, are also included in the possible impacts of aquaculture on the coastal marine environment.

**Box 1.2 Initiatives to control and eliminate pollution in the Mediterranean area**

**LBS protocol**: Protocol related to the protection of the Mediterranean Sea from Land-based Sources of Pollution adopted on 17 May 1980, entered into force on 17 June 1983 and was amended on 7 March 1996. The amended version is not yet in force.

**SAP**: The Strategic Action Programme, adopted in 1997, is an action-oriented initiative under MAP/MEDPOL that identifies the priority target categories of substances and activities to be eliminated or controlled by the Mediterranean countries. This is to be achieved through a planned timetable for the implementation of specific measures and interventions. The SAP/MED is the basis for the implementation of the LBS Protocol by the Mediterranean countries over the next 25 years, starting in the year 2001.

**NDA**: National Diagnostic Analysis is the first step in the preparation of a National Action Plan (NAP) to address LBS of pollution. It is an integrated analysis of the main issues related to LBS in coastal areas, including their environmental impacts.

- **Increasing appearance of Harmful Algal Blooms (HABs)**. Their expansion across the Mediterranean is a problem not only causing ecosystem changes but also affecting human health through the consumption of contaminated sea-food. This constitutes a socio-economic impact.
- **Natural hazards**. Although not anthropogenic, enhanced seismicity in certain Mediterranean regions and subsequent tsunami activity intensify the need for better coastal protection.

# 2 Analysis of problems

## 2.1 Land-based sources of pollution

*Sewage and urban run-off (urban wastewater)*

Sewage generation from coastal cities is one of the major pollution problems on the Mediterranean coast. Its influence on the marine coastal environment directly or indirectly affects human health, the stability of the marine ecosystem and the economy of the coastal zone (impact on tourism and fisheries).

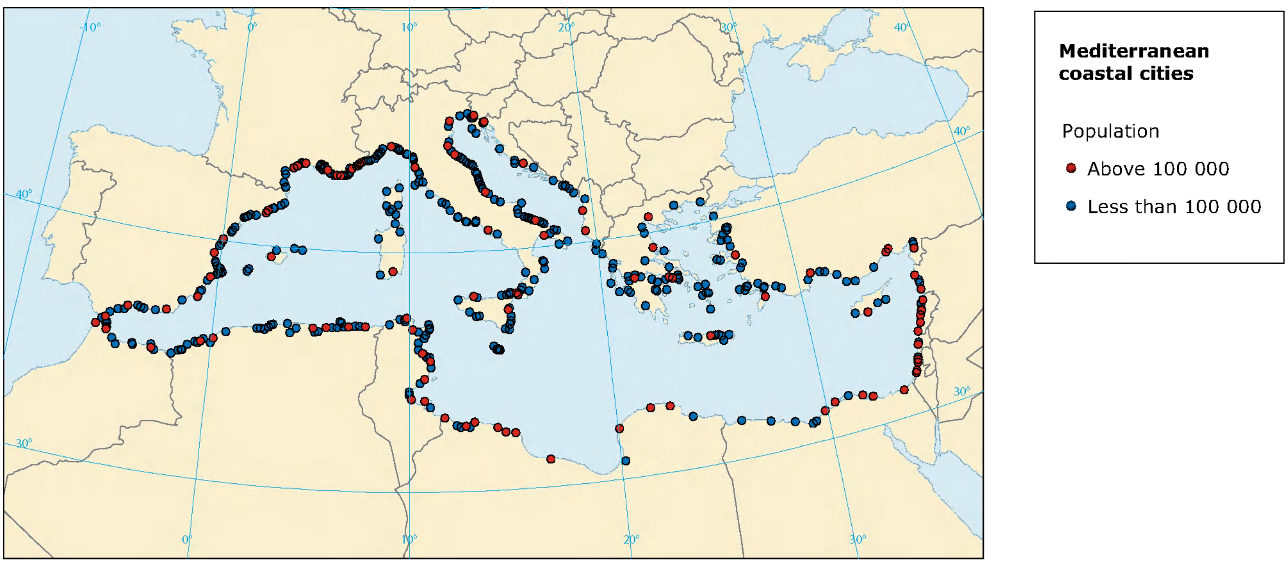
The problem is exacerbated due to the rapid growth of many coastal cities and towns, especially on the southern Mediterranean coast. The sewage collection system is often only connected to parts of the urban population, which leads to direct discharge of untreated wastewater into the sea through other outfalls. The major pollutants of municipal wastewater are: organic matter (measured as $BOD_5$ and COD), suspended solids, nutrients (nitrogen and phosphorus) and pathogenic micro-organisms. Other pollutants such as heavy metals, petroleum and chlorinated hydrocarbons are also present in the wastewater.

The permanent population on the Mediterranean coast is in the order of 150 million inhabitants. However, this figure could be doubled during the summer period as the area is one of the most frequented tourist destinations of the world. Along the Mediterranean coast, 601 cities with a population above 10 000 inhabitants were reported from 19 countries, making a resident population of 58.7 million (UNEP/MAP/MEDPOL/WHO, 2004) (Figure 2.1).

Sixtynine percent of these cities operate a wastewater treatment plant (WWTP), 21 % do not possess a WWTP while 6 % are currently constructing a plant and 4 % have a plant out of operation for various reasons (Figure 2.2a). Secondary treatment is mostly used (55 %) in Mediterranean WWTPs, while 18 % of the plants have only primary treatment (Figure 2.2b).

The distribution of treatment plants is not uniform across the Mediterranean region, the northern Mediterranean coast having a greater part of its urban population served by a WWTP than the southern coast. Also, due to increasing population in cities and failures in treatment plant operation, some WWTPs cannot produce effluent of an adequate quality as initially planned (case study: City of Nador, Morocco).

**Figure 2.1 Mediterranean coastal cities**



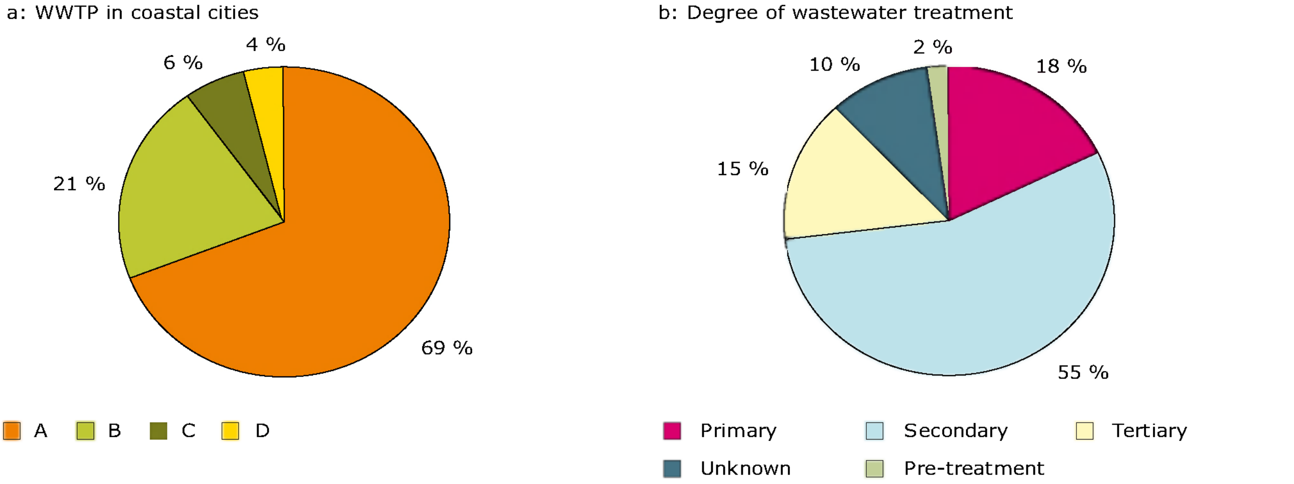

**Source:** HCMR based on UNEP/MAP/MEDPOL/WHO, 2004.

*Solid wastes*

Solid wastes produced in the urban centres along the Mediterranean coastline present a serious threat to both human health and the marine coastal environment.

In addition to uncontrolled disposal of wastes in the form of litter, in most countries solid wastes are disposed of at dumping sites with minimal or no sanitary treatment. Furthermore, these uncontrolled dumping sites are often within the town limits or literally at the waterfront. Such uncontrolled dumps

**Figure 2.2 Wastewater treatment in 601 Mediterranean coastal cities with a population > 10 000**




**Note:** A: Coastal cities served by WWTPs B: Coastal cities without WWTPs C: WWTP under construction/projected D: WWTPs under maintenance/temporarily out of operation/no information.

**Source:** UNEP/MAP/MEDPOL/WHO, 2004.

**Box 2.1 Case study — City of Nador, Morocco**

In Nador an urban wastewater treatment plant was built in 1980 to serve a population of 50 000. In 1990 its treatment capacity was enlarged to cover 100 000 people. Four wastewater polishing lagoons with a total surface of 17 hectares were constructed. However, the treatment capacity of the plant has been surpassed by the city's population which now totals almost 150 000. Furthermore, mechanical failures and abrupt further wastewater load increases during the summer months have led to only partial treatment of inflowing wastewater. To add to the difficulties, two of the four polishing lagoons have had sea-infiltration problems leaving only two of them operational. As a result, the urban wastewater of Nador reaches the coastal environment only partly treated, thus degrading the marine ecosystem.

**Box 2.2 Case study — Lebanon**

Domestic solid wastes are improperly collected in most coastal areas, often mixed with industrial solid wastes and disposed of in open dumps without proper management. The most important dumps directly on the shore are located in Tripoli (surface area 3 ha), Beirut (Borj Hammoud 15 ha), Normandy (10 ha) and Saida (Photo 2.1). These coastal dumps are sources of leachates loaded with metals and organic compounds which directly affect the coastal marine environment. It is estimated that the total BOD load leached from the dumps of Borj Hammoud, Normandy and Tripoli are respectively 36, 24 and 7.2 million tonnes per year.

Leachates continue to present a threat to the coastal environment despite the fact that the dumpsite at Borj Hammoud has been closed since 1997 and a project to remedy the Normandy dumpsite is in progress. Also, the long lifetime of drifting debris and floating waste has led to the sea-floor being covered with waste (including cans, tyres and plastic bags) in many locations in front of these dumps. This has the effect of reducing photosynthesis and suffocating the marine flora and fauna.

**Photo 2.1:** Borj Hammoud dumpsite close to the coastline (Lebanon).

**Source:** NDA Lebanon, 2003.

are sources of disease and litter to the surrounding areas. In many cases, no measures have been taken to control and treat leachates from the dumping sites which are polluting groundwater and/or the coastal marine environment with organic pollutants and heavy metals. Moreover, accidental fires emit smoke particles, Polycyclic Aromatic Hydrocarbons (PAHs) and dioxins, seriously affecting the health of neighbouring towns.

*Persistent organic pollutants — POPs*

Persistent organic pollutants include certain prohibited pesticides and industrial chemicals the manufacturing of which is also prohibited. For example, polychlorinated biphenyls (PCBs) and unwanted contaminants (hexachlorobenzene, dioxins and furans). The proposed targets agreed by the Barcelona Convention Contracting Parties in the SAP include the following:

- Phasing out the following pesticides by 2010 (DDT, aldrin, dieldrin, endrin, chlordane, heptachlor, mirex, toxaphene and hexachlorobenzene). Exceptions have been made for those used for the safeguarding of human life or when a risk/benefit analysis is very conclusive according to WHO recommendations;
- Prohibition of all existing uses of PCBs by the year 2010;
- Reduction of the emission of hexachlorobenzene, dioxins and furans.

For many Mediterranean countries, no detailed information is available on the releases of POPs from point sources (urban centres and industry). Limited studies have been carried out on the bioaccumulation of selected POPs in Mediterranean biota (Figures 2.3a and 2.3b). On the Spanish Mediterranean coast, the distribution of POP concentrations as measured in Mytilus galloprovincialis shows the highest concentrations in the area of Barcelona, both for PCBs and DDTs (BIOMEJIMED project). In general, local or national authorities do not routinely monitor most of the POPs. The main source of POPs — since most POPs have been banned in the majority of the countries of the region — is believed to be stockpiles and inventories due to former production and/or import (i.e. PCBs in transformers), as well as secondary releases from environmental reservoirs (i.e. contaminated sediments) due to previous usage and accidental spills. The contribution from industrial production is only important in those cases where some restricted usage of POPs is allowed (i.e. DDT as precursor of dicofol) and for the POPs that are generated as unwanted secondary products (i.e. PAHs and dioxins from combustion) (UNEP Chemicals, 2002).

- Organochlorine pesticides have been extensively used in the region but their production and usage is now banned in the majority of the countries. However, remaining stockpiles of these pesticides are found in many countries (Table 2.1).

**Table 2.1 Stockpiles of pesticides in the Mediterranean region**

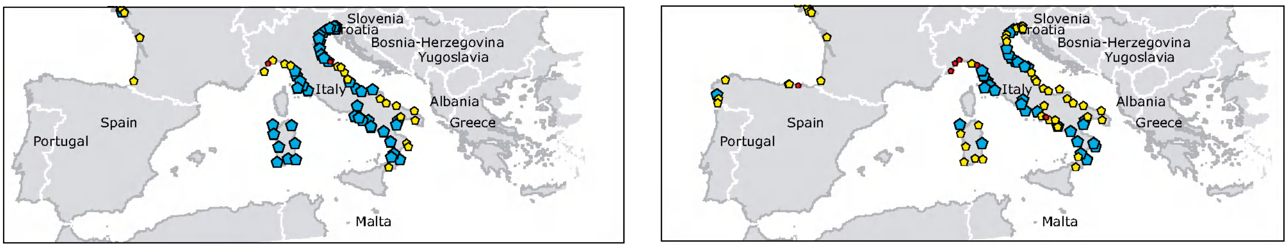
| Country | Location | Pesticide | kg |
|---|---|---|---|
| Algeria | Algiers, Tipaza | Aldrin | 345 |
| | Algiers, Ain Tremouchent, Mascara, Mustaganem, Sidi bel Abbas, Tizi Ouzou | DDT | 189 400* |
| Libya | Tripoli-Bengazi | Dieldrin | 20** |
| Morocco | | DDT | 2 062* |
| | | Dieldrin | 880 |
| | | Endrin | 2 626 |
| | | Heptachlor | 2 062 |
| Syria | Hamah | DDT | 1 500 |
| Turkey | Kirikkale | DDT | 10 930 |
| Tunisia | | Pesticides | 882 |

*For locust control **Reported

**Source:** UNEP Chemicals, 2002.

**Figure 2.3 POPs in mussels (*Mytilus edulis*), median concentration 1996–2002**

a: DDT b: PCBs



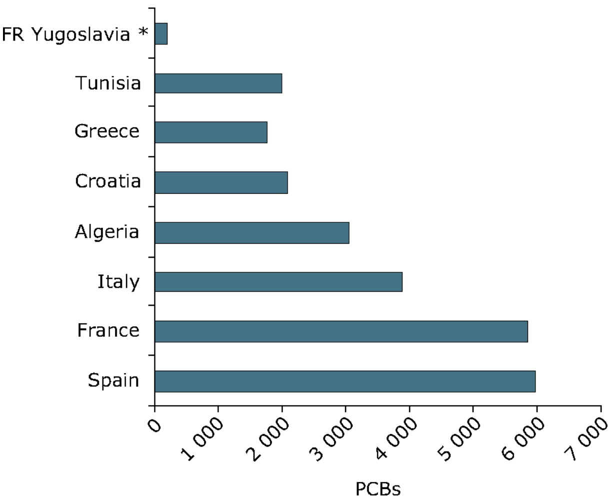

**Note:** Red for high, yellow for moderate, blue for low concentrations.

**Source:** EEA, 2004b (WHS6) Hazardous substances in marine organisms.

- Equipment containing PCBs has also been used extensively in the Mediterranean region. The total production of PCBs in France, Italy and Spain has been estimated to be about 300 000 tonnes for the period 1954–1984. Production stopped in 1985 in France and 1987 in Spain.

The main source of PCBs in the region is the disposal of equipment with PCB-containing oils. The main stockpiles are located in the northern Mediterranean countries due to their extensive use (and as a result of economic development) prior to the ban. A large number of these stockpiles have been eliminated during the past years, mainly in the Northern Mediterranean countries (i.e. France, Italy, and Spain). The stocks still remaining in the Mediterranean region are presented in Figure 2.4.

**Figure 2.4 Country contribution to the stockpiles of PCBs in the Mediterranean region during the mid-1990s**




*Serbia and Montenegro

**Source:** UNEP Chemicals, 2002.

- Dioxins and furans are largely produced during combustion of waste materials (see Solid Waste section). Unfortunately, information is mainly restricted to the EU Mediterranean countries as can be seen in Table 2.2 (EC, 2000).

*Heavy metals (arsenic, cadmium, chromium, copper, nickel, lead and mercury)*

- Urban and industrial wastewater, and run-off from metal contaminated sites (e.g. mines), constitute major land-based sources of toxic metals.

Metal enhancements in local geology may also influence sediment metal content (e.g. mercury enhancement due to the geochemical mercury anomaly of Mount Amiata). Regardless of the origin of the land-based metal source, contaminated coastal sediments constitute an important secondary non-point pollution source because they release metals into the overlying water.

As metals tend to precipitate after their introduction into the coastal marine environment they accumulate in sediments and biota (Figures 2.5a and 2.5b). This occurs especially in sheltered areas such as harbours and semi-enclosed bays in the vicinity of land-based metal sources. Increased metal concentrations have been identified in many coastal areas in the Mediterranean Sea, such as the coast of Tuscany (Tyrrhenian Sea), Kastella Bay (Adriatic Sea), Haifa Bay and the coast of Alexandria (eastern Mediterranean), and Izmir Bay and Elefsina Bay (Aegean Sea) (EEA, 1999).

Mercury is of particular concern because it is easily released from the sediments into the overlying water and consequently re-enters the food chain. High consumption of mercury-contaminated fish has been proven to result in neurological effects. The weekly intake of most people in central

**Table 2.2 Assessment of dioxin emissions in EU Mediterranean countries until 2005**

| Country | Sources | Revised for 1995 | Data from 2000 | Projections for 2005 |
|---|---|---|---|---|
| France | Total sources | 1 350–1 529 | 804–949 | 692–813 |
| | Industrial | 987–1 027 | 461 | 340 |
| | Non-industrial | 363–502 | 343–488 | 352–473 |
| Italy | Total sources | 366–967 | 370–985 | 227–628 |
| | Industrial | 271–620 | 281–648 | 153–303 |
| | Non-industrial | 95–348 | 89–336 | 74–325 |
| Spain | Total sources | 131–388 | 117–327 | 122–323 |
| | Industrial | 77–184 | 64–132 | 71–137 |
| | Non-industrial | 54–203 | 53–195 | 51–187 |
| Greece | Total sources | 89–136 | 90–135 | 91–136 |
| | Industrial | 55–58 | 56 | 58 |
| | Non-industrial | 34–79 | 34–79 | 34–78 |

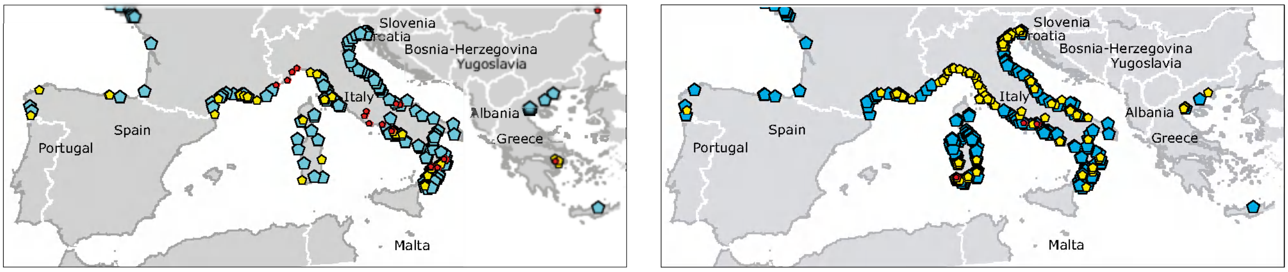
**Note:** Ranges in g I-TEQ/year (g International Toxic Equivalent/year) represent differences in emission estimations (low and high emission scenarios).

**Source:** EC, 2000.

**Figure 2.5 Heavy metals in mussels (*Mytilus edulis*), median concentration 1996–2002**

A: Lead (Pb)

b: Mercury (Hg)




**Note:** Red for high, yellow for moderate, blue for low concentrations.

**Source:** EEA, 2004b.

and northern Europe is below the international 'Provisional Tolerable Weekly Intake' (PTWI) for methylmercury (1.6 µg/kg body weight/week), and a lower US 'Reference Dose' (RfD) (0.7 µg/kg body weight/week). However, the intake of most people in coastal areas of Mediterranean countries, and around 1–5 % of the population in central and northern Europe is around the RfD. In addition, part of the Mediterranean fishing communities is above the US 'Benchmark Dose Limit' (BMDL) of 10 times the RfD — the level at which it is accepted that there are clear neurological effects (EC, 2005).

Release of pollutants from sediments has been reported in the Gulf of Trieste, in the northern Adriatic Sea off the mouth of the river Po, where a net flux has been recorded of Cd and Cu into the overlying water from the contaminated sediments (Zago *et al.*, 2000).

**Box 2.3 Case study — Alexandria area, Egypt**

Industrial wastewater from the Alexandria area is discharged into Mex Bay, Abou-Qir Bay and lake Maryut. This presents severe signs of environmental degradation (lack of oxygen, discolouration, algal blooms) (Table 2.3). Land-based heavy metal discharges are causing increased metal concentrations in coastal seawater.

On the Spanish Mediterranean coast, the distribution of heavy metal content in *Mytilus galloprovincialis* shows the highest concentrations in the area of Cartagena, especially for mercury, cadmium and lead (BIOMEJIMED project).

*Organohalogen compounds*

Hexachlorocyclohexanes (HCHs) are ubiquitous along the Mediterranean coast due to their environmental persistence although they are no longer used. The main sources of HCHs (and particularly lindane), are stockpiles and contaminated land at hot spots. This has resulted from previous manufacturing and stocking. The compounds were extensively used against pests in many Mediterranean countries. In France 1 600 tonnes/year of lindane were used in the mid–1990s, in Egypt more than 11 300 tonnes between 1952 and 1981, while in Turkey, the usage of lindane amounted in 1976 to 96.6 tonnes (UNEP Chemicals, 2002).

*Radioactive substances*

Radioactivity is not a major pollution problem in the Mediterranean Sea. Atmospheric fallout (as a result of nuclear weapon testing in the early 1960s for the total Mediterranean area and the Chernobyl accident in 1986 for the northern and eastern basins) has been the major source of $^{137}$Cs and $^{239,240}$Pu in the Mediterranean marine environment. Other sources (input from rivers, nuclear industry, exchanges through the straights) amount to no more than 10 % of the total load from fallout. Inputs deriving from nuclear industry and from accidents (other than Chernobyl) are negligible when considered in terms of contribution to the total budget. However, they might lead to local enhancement of radioactivity levels (EEA, 1999).

**Photo 2.2:** Contaminated soil containing sulphur and chromium salts at a closed chemical factory, Porto Romano (Durres, Albania).

**Source:** Michalis Angelides.

*Nutrients*

The increase of nutrients (nitrogen and phosphorus) to a marine ecosystem enhances primary production and may lead to eutrophication of the water body. This phenomenon has as side effects: proliferation of planktonic biomass, discolouration of the water, reduction of water transparency, reduction of dissolved oxygen in deeper waters and, in extreme cases, occurrence of toxic algal species. Urban wastewater discharges are important nutrient loads, especially when untreated. As a result, all coastal areas in the vicinity of large towns or cities

**Table 2.3 Quality of marine waters near Alexandria**

| Parameter | Reference station | Mex bay | Western harbour | Anfoushy area | Eastern harbour | Abu-Qir bay |
|---|---|---|---|---|---|---|
| Dissolved oxygen (DO) (ml/l) | 5.3 | 2.01 | 4.81 | 3.32 | 3.98 | 4.93 |
| $BOD_5$ (mg/l) | 0.2 | 10.6 | 8.05 | 39.3 | 22.5 | 16.2 |
| Total suspended matter (mg/l) | 1.5 | 15.6 | 154.0 | 92.3 | 54.7 | 35.5 |
| Chlorophyll-a (Chl-a) (µg/l) | 0.05 | 1.21 | 1.15 | 4.3 | 8.94 | 3.32 |
| Dissolved inorganic phosphorus (DIP) (µg/l) | 0.07 | 1.60 | 0.62 | 2.59 | 1.69 | 1.11 |
| Nitrates ($NO_3$) (µM/l) | 1.8 | 13.23 | 2.5 | 4.40 | 6.80 | 5.87 |
| Ammonium ($NH_4$) (µM/l) | 20.62 | 5.38 | 16.77 | 3.77 | 3.0 | |
| Lead (Pb) (µg/l) | 0.13 | 0.85 | 4.45 | 1.33 | 0.61 | 1.48 |
| Cadmium (Cd) (µg/l) | 0.017 | 0.83 | 0.63 | 0.31 | 0.14 | 1.15 |
| Mercury (Hg) (µg/l) | No data | 505 | 383 | 125 | 83 | 147 |

**Source:** NDA Egypt, 2003.

**Box 2.4 Case study — Durres, Albania**

One of the major lindane stockpiles on the Mediterranean coast is located at Durres, Albania, where a plant producing sodium dichromate for leather tanning and pesticides such as lindane (γ-HCH) and thiram was operational until 1991. The releases from the production process heavily contaminated the area of the former plant. The nearby dumpsite contains approximately 20 000 tonnes of toxic wastes including lindane and chromium-rich residues, and abandoned chemical storage facilities containing 370 tonnes of chemicals including lindane, methanol, carbon sulphite, sodium dichromate, and mono- and di-methylamine. Rainwater from the contaminated area flows into the sea through a pumping station which collects the sewage water from the city of Durres. High concentrations of PCBs and pesticides have been found in marine samples collected from Porto Romano Bay. Human health risk is imminent in the area since thousands of people recently arrived from other parts of Albania and are living in and around the highly contaminated area.

(Photo 2.3) which do not efficiently operate a wastewater treatment plant are receiving high loads of nutrients and may suffer the consequences. The coastal cities presented in the chapter on sewage are also sources of nutrients. Rivers are also important transporters of nutrients and suspended solids since they drain basins with agricultural activities (fertilisers) and urban centres. It has been estimated that 605 000 tonnes of $N\text{-}NO_3$ and 14 000 tonnes of $P\text{-}PO_4$ are entering annually (1995) into the Mediterranean Sea from the rivers Po, Rhône and Ebro (UNEP/MAP, 2003a). The average nutrient concentrations in various Mediterranean rivers are shown in Table 2.4.

**Table 2.4 Average nutrient concentrations in various Mediterranean rivers, sampling periods are not identical (1985–1996)**

| River | Country | $N\text{-}NO_3$ mg/l | $N\text{-}NH_4$ mg/l | $P\text{-}PO_4$ mg/l | Total P mg/l |
|---|---|---|---|---|---|
| Adige | Italy | 1.248 | 0.111 | 0.033 | 0.113 |
| Acheloos | Greece | 0.350 | 0.020 | | 0.020 |
| Aliakmon | Greece | 2.350 | 0.110 | | 0.140 |
| Argens | France | 0.740 | 0.090 | 0.110 | 0.220 |
| Arno | Italy | 3.620 | 1.347 | | 0.406 |
| Aude | France | 1.420 | 0.090 | 0.090 | 0.490 |
| Axios | Greece | 2.590 | 0.150 | | 0.880 |
| Besos | Spain | 1.900 | 31.000 | | 12.700 |
| Buyuk Menderes | Turkey | 1.440 | | 0.550 | |
| Ceyhan | Turkey | | | | 8.680 |
| Ebro | Spain | 2.323 | 0.167 | 0.115 | 0.243 |
| Evros/Meric | Greece/Turkey | 1.900 | 0.050 | 0.280 | |
| Gediz | Turkey | 1.650 | 0.050 | 0.190 | |
| Goksu | Turkey | | | | 8.870 |
| Herault | France | 0.610 | 0.060 | 0.045 | 0.220 |
| Kishon | Israel | | | | 20.000 |
| Krka | Croatia | 0.526 | 0.093 | 0.046 | |
| Llobregat | Spain | 1.900 | 3.200 | 1.200 | 1.530 |
| Neretva | Croatia | 0.269 | 0.029 | | 0.050 |
| Nestos | Greece | 0.780 | 0.040 | | 0.120 |
| Nile | Egypt | 3.000 | | | |
| Orb | France | 0.670 | 0.440 | 0.140 | 0.450 |
| Pinios | Greece | 1.890 | 0.090 | | 0.140 |
| Po | Italy | 2.192 | 0.261 | 0.084 | 0.239 |
| Rhône | France | 1.320 | 0.091 | 0.044 | 0.124 |
| Seyhan | Turkey | 0.590 | 0.310 | 0.010 | |
| Strymon | Greece | 1.100 | 0.030 | | 0.110 |
| Tet | France | 1.800 | 1.500 | 0.470 | 0.800 |
| Tiber | Italy | 1.370 | 1.038 | 0.260 | 0.355 |
| Var | France | 0.180 | 0.031 | 0.006 | 0.130 |

**Source:** UNEP/MAP, 2003a.

## 2.2 Habitat destruction and physical alteration

*Shoreline construction and alteration*

- Improperly managed coastal development due mainly to urbanisation is one of the major problems in the Mediterranean region often leading to loss of biodiversity.

The concentration of people on the coastline leads to various constructions which alter the waterfront. Concretisation problems of the coastline are encountered on many Mediterranean coasts. These problems are usually related to urbanisation and the development of tourist facilities.

As the coastal zone presents better employment opportunities in many countries (due to the presence of industry, tourism and commerce) internal migration results in higher housing needs and in the rapid growth of coastal cities and towns. For example, in Morocco the mean population density on the coast is 90 persons/km$^2$ compared to the national average density of 64 persons/km$^2$. This figure is even higher in urban centres (e.g. 108 persons/km$^2$ in Al Hoceima). From 1977 to 1994, the number of medium-sized coastal towns increased from 16 to 30, while small towns increased from two to 14 (NDA Morocco, 2003). A similar concentration of activities on the coast is also found in many other Mediterranean countries, such as Lebanon where almost half (49 %) of the coastline is built-up. Along the same lines, the built-up coastal zone of Barcelona, Spain, has increased by 10 % over the 1990s (EEA/TE, 2004) (Figure 2.6).

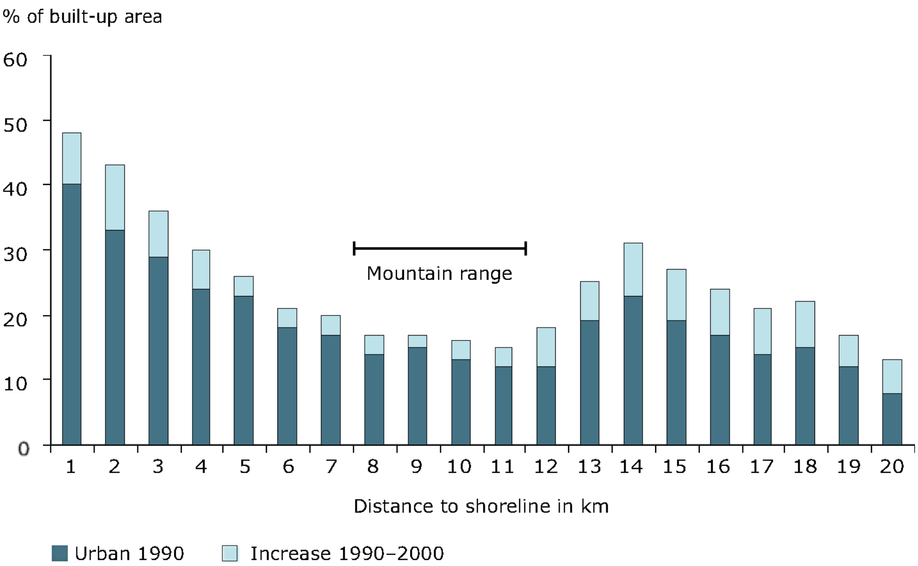
**Photo 2.3:** Industrial plant north of Batroun in northern Lebanon. Sulphuric acid being directly spilled into the sea at phosphate plant.

**Source:** Helmut Zibrowius.

*Wetland and salt marsh alteration*

Improperly managed coastal development and land reclamation for agricultural purposes have reduced the size of the Mediterranean wetlands leading to a loss of biological diversity.

**Figure 2.6 Built-up area by distance to the coast (Barcelona, Spain) in 1990 and 2000**




**Note:** In order to understand the shape of the graph, there is a mountain range behind Barcelona which is a protected area. The urban growth appears to continue landwards of the mountain range.

**Source:** ETC/TE 2004.

**Box 2.5 Case study — Croatia**

In Croatia, intense uncontrolled construction along the coastline for recreation, houses, tourist facilities, marinas and small harbours has led to serious physical alterations of the coastal zone. This is due to the dumping and depositing of inert material. The situation is highly critical in the river Zrnovnica estuary, the Tarska vala cove — river Mirna estuary, the river Neretva estuary, the river Cetina estuary and in some parts of the Pirovac Bay.

**Box 2.6 Case study — Egypt**

In Egypt, recreational constructions are confined to a narrow strip of land rarely exceeding a few hundred metres in width between the coastal highway and the coastline. Most of the tourist resorts are being built on calcareous ridges that run parallel to the coastline, and in many cases the removal of those ridges has led to the destruction of natural vegetation (olives and figs). Quarrying activities for construction needs are also exhausting the coastal limestone ridges, irreparably damaging the coastal environment. The pressure on the coastal zone is further intensified by shoreline modifications (dredging, creation of artificial lakes, etc.) for the benefit of recreational resorts. All these coastline modifications affect the coastal stability as well as the quality of coastal habitats.

Erosion is an important environmental problem on the Egyptian coast. Owing to dam construction along the Nile, the amount of sediment transported by the river is greatly reduced. As a consequence, erosion is very severe in the northern delta from Rosetta eastwards. In some places the coastline has receded one hundred metres (mouth of the Rosetta branch of the Nile). In an attempt to stop the loss of sand from beaches, erosion protection structures have been built along the coastline. However these constructions have created artificial coastline conditions and in many cases relative stagnation of the water and further degradation of the marine environment.

As an example, at the Nile Delta (Egypt) lake Maryut has been drained to only 25 % of its original size for the creation of agricultural land while lake Manzala was reduced to 1 200 $km^2$ by the year 1980 compared to its original 1 710 $km^2$. Lake Burullus has also suffered an area loss because of drainage works for agricultural land reclamation. Furthermore, many wetlands in the vicinity of cities and industrial areas are used as receptors of wastewater. Major Mediterranean endangered wetlands are shown in Table 2.5.

*Marine waters and coastal watershed alteration*

Coastal erosion is a common problem in many Mediterranean countries and may have natural causes (marine sediment transport). However it is amplified by human activities such as:

- Trapping of sediments at drainage-basin level;
- badly designed constructions on the waterfront; and
- excessive sand extraction from the beaches for construction purposes.

Erosion may have a multitude of impacts on the coastal ecosystem:

- destruction of soil surface layers leading to groundwater pollution and reduction of water resources;

**Table 2.5 Mediterranean endangered wetlands**

| Endangered wetland | Country | Source |
|---|---|---|
| Delta of river Evros/Meric | Greece/Turkey | NDA Greece, 2003 |
| Salt lake Regahaia | Algeria | NDA Algeria, 2003 |
| 23rd of July lake | Libya | NDA Libya, 2003 |
| Karavasta lagoon | Albania | NDA Albania, 2003 |
| Lake Bizerta | Tunisia | NDA Tunisia, 2003 |

**Box 2.7 Case study — Algeria**

Out of 250–300 km of sandy beaches in Algeria, 85 % are retreating and losing sand at a rate ranging from 0.30 to 10.4 m/year (NDA Algeria 2004). At Bejaia beach, the sea advanced 345 m from 1959 to 1995. Similar problems are encountered at Boumerdes, Bou Ismail, Macta and Beni Saf. Few of the sandy beaches remained stable (10 %) and only 5 % of the beaches are progressively accumulating more sand during the last decades. The main causes for this erosion are:

(i) Feeding of the littoral zone with sediment has greatly diminished recently because sedimentary material is trapped behind dams which were constructed for irrigation or other purposes along rivers and streams. It is calculated that during 1992 approximately 219 million $m^3$ of sediment were trapped behind the 39 principal Algerian dams at a rate of 9 million $m^3$/year (or 16.4 million tonnes/year).

(ii) Less sediment material is transported along the coastline because harbour infrastructure has often led to sediment entrapment. The total volume of sediment trapped in Algerian harbours is estimated to be more than 20 million $m^3$, and is mainly located in the harbours of Oran, Azrew, Bethioua, Algiers, Bejaia, Skikda and Annaba (78 % of the total sediment volume). Also, due to sediment accumulation, harbours need frequent dredging in order to maintain the necessary depth for navigation purposes.

(iii) Sand mining for construction purposes takes place at many locations along the coastline at: alluvial deposits of coastal streams (oueds), zones of recent windborne deposition, the upper parts of beaches and even at the under-water level of beaches. Although sand mining from coastal deposits is often a legal process, the excessive removal of sand destroys the coastal ecosystem. Also, illegal operations further increase sand removal rates (Photo 2.4).

- degradation of the dune system, leading to desertification and reduction of biological diversity;
- destruction of dunes with adverse effects on beach dynamics and reduction of the sedimentary resources;
- disappearance of the sandy littoral lanes which protect agricultural land against the intrusion of seawater (leading to soil and ground water salination).

**Photo 2.4:** Illegal sand extraction in Kheloufi beach (East Algiers).

**Source:** NDA Algeria, 2003.

## 2.3 Off-shore and marine based pollution

*Petroleum hydrocarbons from shipping activities*

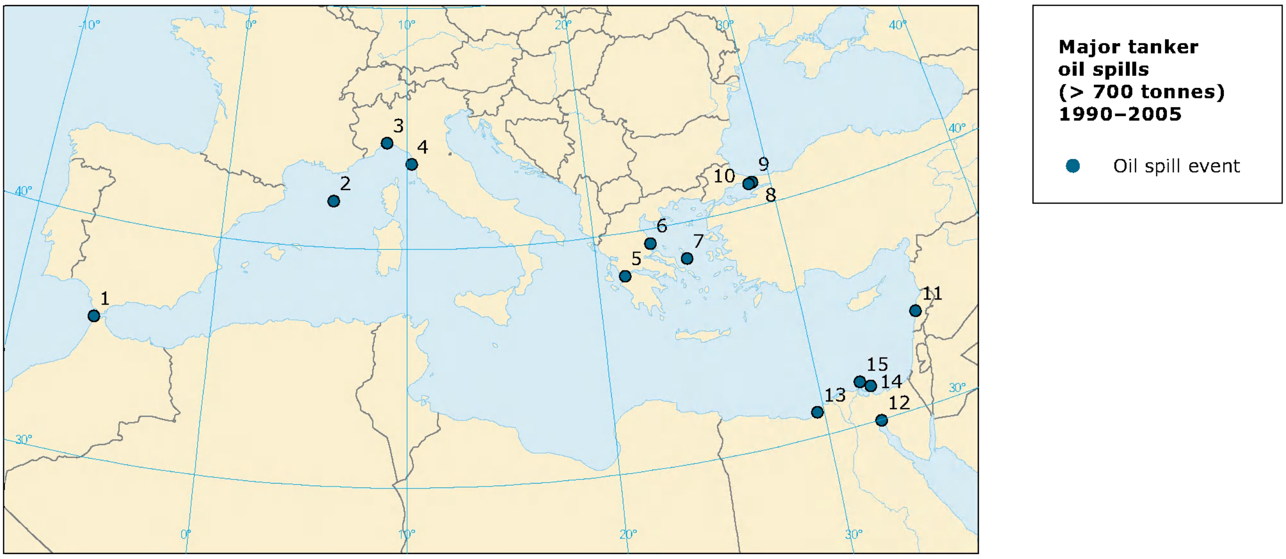
Marine transport is one of the main sources of petroleum hydrocarbon (oil) and polycyclic aromatic hydrocarbon (PAH) pollution in the Mediterranean Sea.

- *Shipping and oil slicks*

It is estimated that about 220 000 vessels of more than 100 tonnes each cross the Mediterranean each year discharging 250 000 tonnes of oil. This discharge is the result of shipping operations (such as deballasting, tank washing, dry-docking, fuel and discharge oil, etc.) and takes place in an area which since 1973 has been declared as a 'Special Sea Area' by the MARPOL 73/78 convention, i.e. where oily discharges are virtually prohibited. The PAH input varies according to the type of oil discharged and its range is estimated at between 0.3 and 1 000 tonnes annually (UNEP Chemicals, 2002).

Illicit vessel discharges can be detected through the interpretation of ERS SAR (Synthetic Aperture Radar) satellite images. In pioneering work carried out in the Mediterranean by Pavlakis *et al.*, (2001), 1 600 ERS SAR images acquired during 1999 were interpreted to reveal the degree of the

**Figure 2.7 Major tanker oil spills (> 700 tonnes) 1990–2005**




**Note:** Numbers correspond to accidents listed in Table 2.6.

**Source:** UNEP — WCMC, 2004.

problem of the deliberate oil spill discharges in the Mediterranean Sea for the first time.

- *Oil spills*

In addition, over the 1990–2005 period, about 80 000 tonnes of oil have been spilled in the Mediterranean Sea and its immediate approaches because of shipping accidents (taking into account accidents resulting in releases of more than 700 tonnes). The four major ones were responsible for 77 % of the quantity spilled. The distribution of these oil spills in the Mediterranean and its approaches according to UNEP-WCMC is shown in Figure 2.7 and Table 2.6. According to the Regional Marine Pollution Emergency Centre in the Mediterranean (REMPEC) statistics, 82 accidents involving oil spills were recorded during the period January 1990 to January 1999 and the quantity of spilt oil was 22 150 tonnes (REMPEC, 2001). Incidents at oil terminals and routine discharges from land-based installations (estimated at 120 000 tonnes/year,

**Table 2.6 Major tanker oil spills (> 700 tonnes) 1990–2005**

| Code | Date | Name | Tonnes | Cause |
|---|---|---|---|---|
| 1 | 06 August 1990 | SEA SPIRIT | 10 000 | Collision |
| 2 | 17 August 1993 | LYRIA | 2 200 | Collision |
| 3 | 11 April 1991 | HAVEN | 10 000* | Fire/explosion |
| 4 | 10 April 1991 | AGIP ABRUZZO | 2 000 | Collision |
| 5 | 30 October 1997 | SERIFOS | 900 | Grounding |
| 6 | 14 August 1990 | VASILIOS V | 1 000 | Unknown |
| 7 | 03 May 1992 | GEROI CHERNOMORYA | 1 600 | Collision |
| 8 | 29 March 1990 | JAMBUR | 1 800 | Collision |
| 9 | 13 March 1994 | NASSIA | 33 000 | Collision |
| 10 | 29 December 1999 | VOLGONEFT 248 | 1 578 | Hull failure |
| 11 | 01 November 1998 | GIOVANNA | 3 000 | Fire/explosion |
| 12 | 18 August 1990 | SILVER ENERGY | 3 200 | Grounding |
| 13 | 18 November 2004 | GOOD HOPE | 1 353 | Equipment failure |
| 14 | 14 December 2004 | AL SAMIDOON | 9 000 | Grounding |
| 15 | 04 February 2005 | GENMAR KESTREL | 1 000 | Collision |

*Based on estimate from REMPEC

**Note:** Code number refers to Figure 2.7.

**Source:** HCMR based on UNEP — WCMC, 2004.

UNEP/MAP/WHO, 1999) contribute to elevated concentrations of oil in their vicinity.

*Marine litter*

- Mediterranean coasts are becoming littered mainly with plastic debris (Photo 2.5). However, the degree of the impact has not been quantified yet. Growing evidence indicates that when dumped, lost or abandoned in the marine environment, plastic debris has an adverse impact on the environment. Not only does it become an aesthetic nuisance, it also requires costly clean-up procedures.

Environmental impacts arise from entanglement of marine animals in plastic debris and from ingestion of plastic by these organisms. Marine debris poses a threat to humans when divers, ships or boats become fouled by debris.

**Photo 2.5:** Marine debris on a coast of Attiki, Greece.

**Source:** M. Salomidi.

**Box 2.8 Case study — Algeria**

Maritime oil shipping lanes pass close to the Algerian coast transporting 150 million tonnes of oil per year (out of 500 million tonnes/year total oil transported in the Mediterranean Sea). This corresponds to the passage of 1 800 tankers annually. Also, more than 50 million tonnes of oil per year pass through oil terminals in the Algerian major harbours (Arzew, Bethioua, Bejaia and Skikda), resulting in significant operational losses into the sea (10 000 tonnes/year). Deballasting operations are also responsible for the release of an additional 12 000 tonnes of oil annually into the coastal waters. This occurs because the available ballast reception facilities cannot cope with the ballast quantities. Furthermore, oil pollution is caused by the discharge of industrial and urban wastewater, toxic sludge from oil refineries at Algiers, Oran and Skikda and natural gas production. Due to the presence of oil-related activities in Algeria, harbour and coastal sediments have high concentrations of total, as well as PAH (Table 2.7).

**Table 2.7 Concentrations of total petroleum hydrocarbons (TPH) in harbour sediments of Algeria**

| Harbours | TPH in mg/kg d.w. |
|---|---|
| Oran | 1 500–17 000 |
| Arzew | 930–8 600 |
| Bethioua | 67–940 |
| Mostaganem | 1 600–8 800 |
| Ténès | 680–990 |
| Alger | 1 900–31 000 |
| Bejaia | 140–260 |
| Jijel | 180–430 |
| Ancient port of Skikda | 450–2 000 |
| New port of Skikda | 79–120 |
| Annaba | 130–6 200 |

# 3 Pollution issues country by country

Identification of pollution hot spots and areas of major environmental concern was based on:

- UNEP/WHO data (including UNEP/MAP/WHO, 1999 and UNEP/WHO, 2003);
- 2003 country reports to UNEP/MAP (Country National Diagnostic Analysis, NDA);
- a country National Action Plan (NAP France 2005).

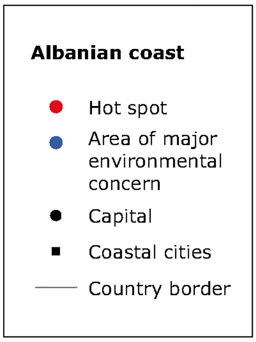
The comments received from MEDPOL National Coordinators of France, Slovenia and Spain during the revision of the final draft were included as appropriate. However, it must be stated that the NDA reports contained conflicting data in some cases, and data availability was not identical for all countries. Therefore pollution stress was evaluated at the national rather than pan-Mediterranean level. As a result, some discrepancy among countries can be expected in the appraisal of an area as a pollution hot spot or area of major environmental concern.

## 3.1 Albania

Approximately 58 % of the Albanian population live in the coastal areas along the Adriatic and the Ionian Seas (Figure 3.1). After 1991, most large Albanian industries (e.g. mineral production and processing, pesticides, fertilisers, chemicals, plastics, paper, food and textiles) were obliged to close down. This left stockpiles with obsolete hazardous substances as well as contaminated land. **The main contamination problems are stockpiles of obsolete chemicals, untreated urban wastewater and solid wastes.** Discharge of untreated urban wastewater, beach erosion and illegal construction on the coastline are witnessed at Vlora Bay, Porto Romano Bay, Durres Bay, Saranda Bay, Kune-Vaini lagoon, Drini River mouth (at the city of Lezhe), the Fieri district (on the Semani River), Karabasta lagoon and Divjaka Beach. Most LBS are located in:

- Durres district: Stockpiles of lindane and chromium VI salts, untreated urban wastewater (9 600 $m^3$/day), incorrect management of solid wastes (150–200 t/day); harbour activity.

**Figure 3.1 Albanian coast with areas of major environmental concern and pollution hot spots**

- Vlora district: Mercury contamination inland of the former chlor-alkali plant detected in an area of 20 ha around the factory at a soil depth of 1.5 m (mercury concentrations 5 000–60 000 mg/kg soil); mercury in groundwater and coastal sediments of Vlora Bay (up to 2.33 mg/kg); chlorinated hydrocarbons and other dangerous pollutants in soil.

## 3.2 Algeria

Algeria's coast hosts approximately 12.5 million people (1998), representing 45 % of the country's population. During the summer months tourists increase the permanent population. Algiers, Oran, Annaba, Ghazaouet, Mostaganem, Arzew, Bejaia and Skikda are the most important coastal cities. (Figure 3.2) (NDA Algeria, 2003). **Major pollution problems include untreated urban and industrial wastewater, petroleum hydrocarbon slicks and coastal erosion.** Most of the urban wastewater is discharged untreated directly into the sea (Photo 3.1). Although 17 treatment plants for urban wastewater have been constructed in the Algerian coastal zone, only five are in normal operation. This represents approximately 25 % of the total treatment capacity. Faecal microorganisms are present on most Algerian bathing beaches, exceeding sanitary standards. Also, petroleum hydrocarbon pollution is very common along the Algerian coastline because of maritime oil-shipping lanes that pass close to the Algerian coast. Erosion is also a major issue. Out of 250–300 km of sandy beaches in Algeria 85 % are retreating, losing sand at a rate ranging from 0.30 to 10.4 m/year.

**Photo 3.1:** Wastewater discharged directly into the sea (Algiers).

**Source:** NDA Algeria, 2003.

The areas of concern are:

- Bay of Algiers: urban and industrial wastewater, cadmium, copper, mercury, lead and zinc in sediments;
- Oran: urban and industrial wastewater (oil terminal and refinery, tanneries);
- Skikda: urban and industrial wastewater (natural gas, mercury production, oil terminal and refinery, chemical industry), heavy metals;
- Annaba: urban and industrial wastewater (fertilisers, chromium);
- Ghazaouet: urban and industrial wastewater (zinc and sulphuric acid);
- Mostaganem: urban and industrial wastewater, lead, mercury;

**Figure 3.2 Algerian coast with areas of major environmental concern and pollution hot spots**

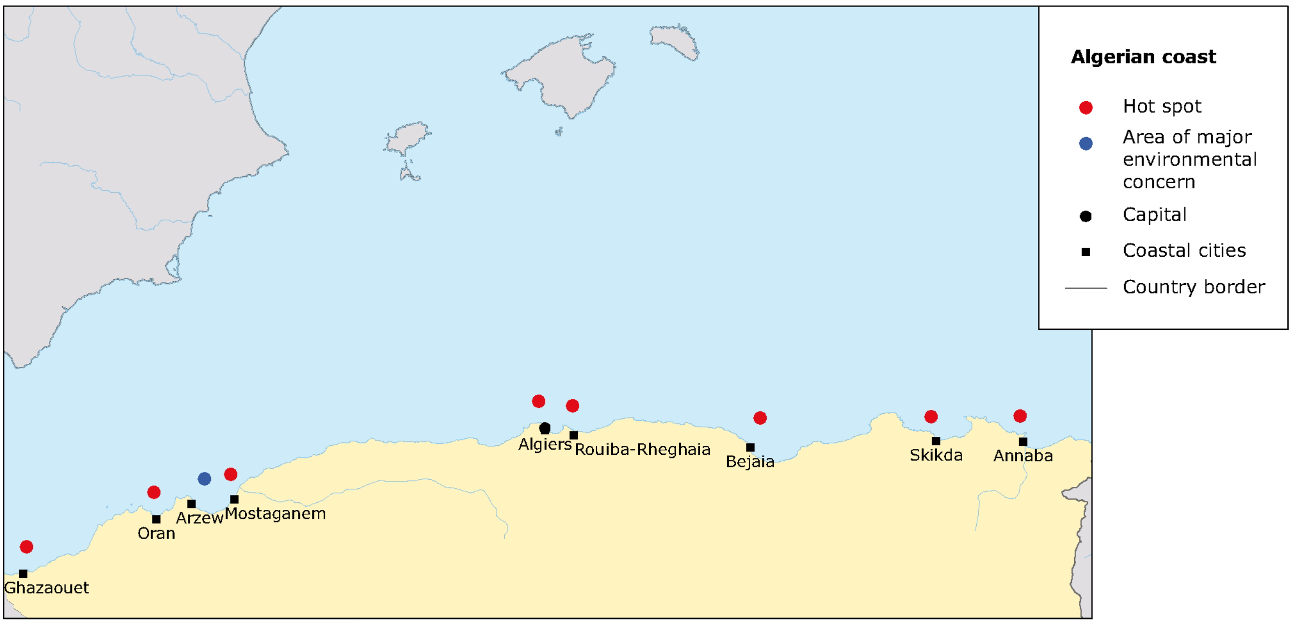


**Figure 3.3 Coastline of Bosnia and Herzegovina and Croatia with areas of major environmental concern and pollution hot spots**


- Arzew: urban and industrial wastewater, liquified gas, oil spills, fertilisers;
- Bejaia: urban and industrial wastewater (oil pipeline).

## 3.3 Bosnia and Herzegovina

The Mediterranean coast of Bosnia and Herzegovina on the Adriatic is 25 km long, hosting the town of Neum (population 4 300). The pollutants generated in the drainage basins of the major Bosnian rivers of Neretva (from the nearby towns of Konjic, Mostar, Caplinja, Ploce and Metcovic) and Trebisnjica (from the towns of Bileca and Neum) can be carried to the Adriatic Sea affecting its environment (Figure 3.3) (NDA Bosnia and Herzegovina, 2003). **The major pollution problems are untreated urban wastewater and occasional stockpiles of obsolete chemicals**. The areas of concern are:

- Mostar (population 130 000). Urban and industrial wastewater is discharged into the River Neretva without any treatment and urban solid wastes are dumped without proper management. Barrels of obsolete chemicals are left on both riverbanks. During the war (1992–1995), bombing destroyed electric power transformers leading to oil leakage and contamination of soil and water with PCBs.
- Neum (population 4 300) is the only urban centre in Bosnia and Herzegovina that discharges its primarily treated urban wastewater directly into the Adriatic Sea. The town population doubles during summer months because of tourism.

## 3.4 Croatia

Croatia has a permanent coastal population of 1 000 000 which increases considerably during the summer because of tourism. The larger coastal towns are Split (population 207 000), Rijeka (population 206 000), Zadar (population 137 000), Pula (population 85 000), Sibenik (population 85 000) and Dubrovnik (population 71 400). Ongoing physical alterations in many areas are the results of intense uncontrolled construction along the coastline (recreational buildings, tourist facilities, marinas and small harbours). This has led to dumping and depositing of inert materials. Another threat to the coastline is fish farming, which has caused habitat degradation in the vicinity of the fish cages and conflicts with the tourist business.

Major endangered coastal areas are presented in Figure 3.3 (NDA Croatia, 2003). **Major pollution problems include urban wastewater, eutrophication of coastal waters, and urbanisation and destruction of the marine coastal habitat in**:

- Kastela Bay (Split): Eutrophication and accumulation of organic matter, metals and organohalogen compounds in the sediment due to the discharge of untreated urban and industrial wastewater. Biodiversity changes due to exotic species;
- Rijeka, Zadar, Pula, Sibenik and Dubrovnik: Untreated urban and industrial wastewater;
- Primorsko-Goranska County (Omisalj/Rijeka oil terminal and refinery): The Adriatic Pipeline System is located in the area (JANAF, Plc

JAdranski NAFtovod Joint Stock Company), and an international oil transport system from the oil terminal to refineries in eastern and central Europe. The design capacity of the pipeline is 34 million tonnes of oil per year and the current installed capacity is 20 million tonnes per year. Although no major pollution has occurred so far, there is concern about future crude oil leakages. In addition, introduction of alien species by the fouling/ballast dumped by tankers is possible if the terminal is used for loading of crude oil from Russia.

## 3.5 Cyprus

The southern coastal zone of Cyprus is densely populated by about 370 000 permanent inhabitants (47 % of the total permanent population) and tourists (3 million per year). The country's industrial sector is small and therefore industrial pollution is limited. All coastal towns and tourist centres operate wastewater treatment plants. **The major environmental problems are coastline alteration, industrial mining activities and urban wastewater**, in the Bay of Limassol, the Bay of Liopetri and Ayia Napa, and the Bay of Vassilikos (NDA Cyprus, 2003) (Figure 3.4). In more detail:

- Bay of Limassol: Urban and untreated industrial wastewater. The construction of the Limassol harbour resulted in beach erosion and the rectification measures (breakwaters perpendicular to the coastline) resulted in serious degradation of water quality;
- Bay of Liopetri and Ayia Napa: Nitrogen leaching from the intense agricultural area because of over-fertilisation (150 tonnes of nitrogen per year);
- Bay of Vassilikos: Mining activity (ferrous-pyrite ore) resulted in copper, iron and zinc contamination of the marine environment. Inert material from industrial activity blanketed the bay's sediments destroying the benthic community of the area.

## 3.6 Egypt

The coastal area around Alexandria (Lake Manzala, Abu-Qir Bay and Mex Bay, Alexandrian coast) is the major area of concern in Egypt as is Port Said (Figure 3.5). **Major environmental problems are caused by untreated urban and industrial wastewater and intense urbanisation has caused coastline degradation** (NDA Egypt, 2003). Sensitive areas and pollution hot spots include:

- Alexandrian coast: a critical wastewater problem because of high population growth and rapid industrial development;
- Mex Bay and Abu-Qir Bay: total $BOD_5$ load is 219 500 tonnes/year and 91 700 tonnes/year respectively for urban and industrial wastewater. High metal concentrations in the sediments of the bays;
- Lake Maryut: receives industrial wastewater and shows severe signs of eutrophication (anaerobic conditions, hydrogen sulphide odours) as well as a significant accumulation of heavy metals (mercury, cadmium, lead, zinc) in sediments and biota;

**Figure 3.4 Coastline of Cyprus with areas of major environmental concern and pollution hot spots**

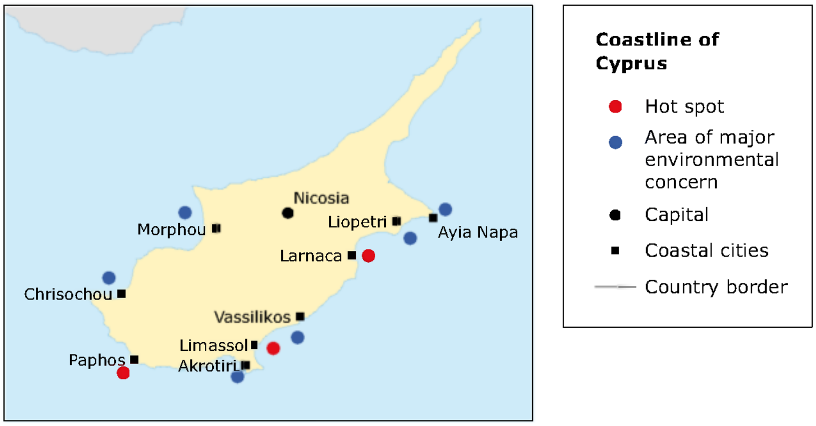
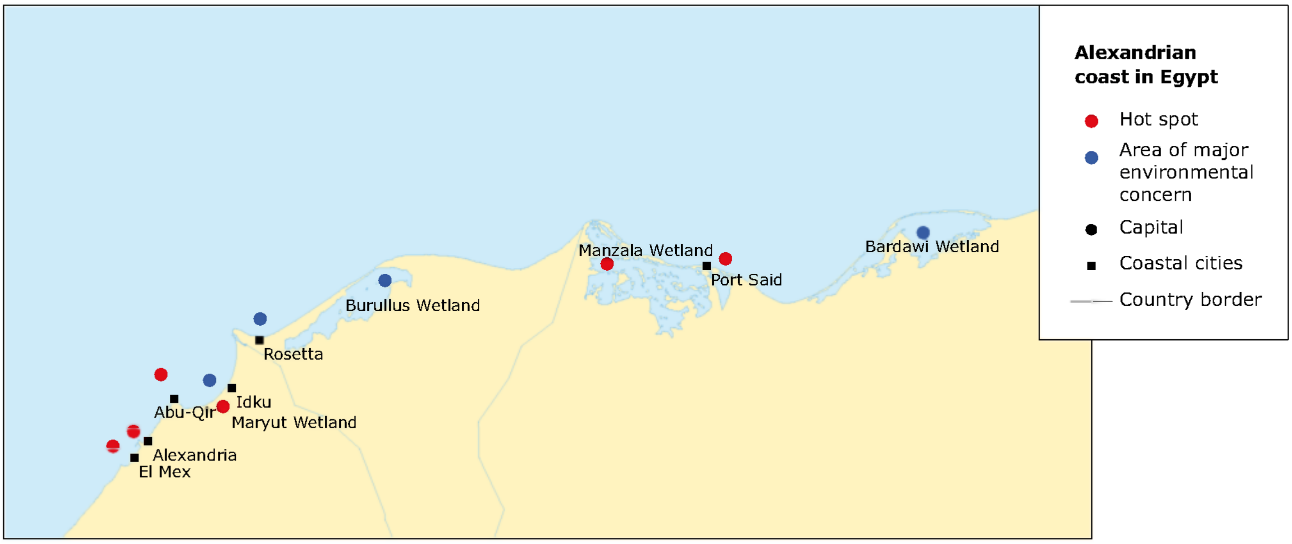


**Figure 3.5 Alexandrian coast in Egypt with areas of major environmental concern and pollution hot spots**




- Alexandria to Mers Matruh coastline: intensive urbanisation along the coastline leading to the destruction of the natural calcareous ridges;
- Rosetta branch of the River Nile: erosion;
- Wetlands of lakes Manzala, Maryut, Burullus and Idku: seriously reduced in size because of drainage for the irrigation of new agricultural land.

## 3.7 France

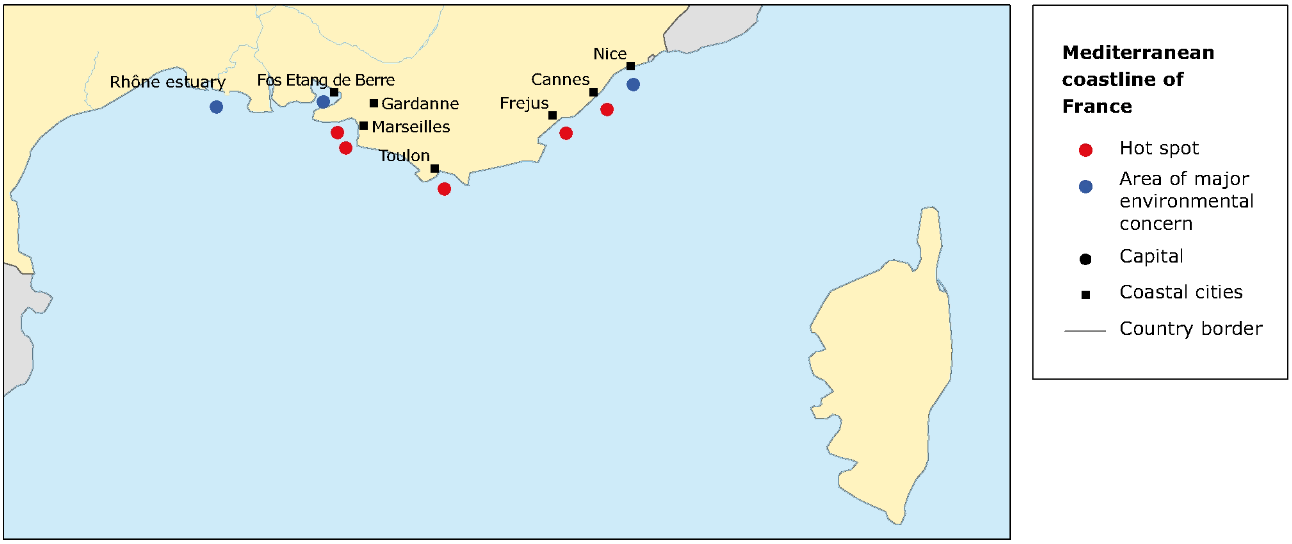
France's coastline in the Mediterranean extends for 1 960 km in the regions of Languedoc-Roussillon, Provence-Alpes-Côte d'Azur and Corsica. **Major environmental problems are caused by river-transported pollution, and treated industrial and urban wastewater. In addition, intense urbanisation along the densely populated coastline** is also a major cause for concern (IFEN, 1999). Concretisation of the coastline owing to construction of marinas alters important parts of the natural coastline. Between the towns of Martigues and Menton, 15 % of the coastal zone with depths 0 to 10 m and 17 % of the coastline (110 km) consists of concrete. Similarly, 20 % of the 120 km long coast in the Alpes-Maritimes area is occupied by small harbours, marinas and boat shelters. Areas of environmental concern are shown in Figure 3.6 while the major anthropogenic activities in them are listed below:

- Marseilles and Nice are relatively big coastal cities (density > 3 000 persons per $km^2$) discharging mostly treated urban wastewater into the sea;
- river Rhône: transports significant loads of nutrients and other pollutants (organic matter, metals) from its drainage basin;
- Fos Etang de Berre: Fos is the biggest French and the second largest European harbour hosting oil and methane terminals (natural gas is imported from Algeria), as well as a large industrial complex;
- rivers Herault, Gard and Vaucluse are considered as vectors of industrial pollution (hydroelectric and nuclear plants, petroleum processing, electronic, metal plants and chemicals);
- harbours of Marseilles, Sète, Port-la-Nouvelle, Port-Vendres, Toulon (French naval base), Nice, Bastia and Ajaccio: petroleum hydrocarbon pollution occurs because of deballasting practices and accidental oil spills.

## 3.8 Greece

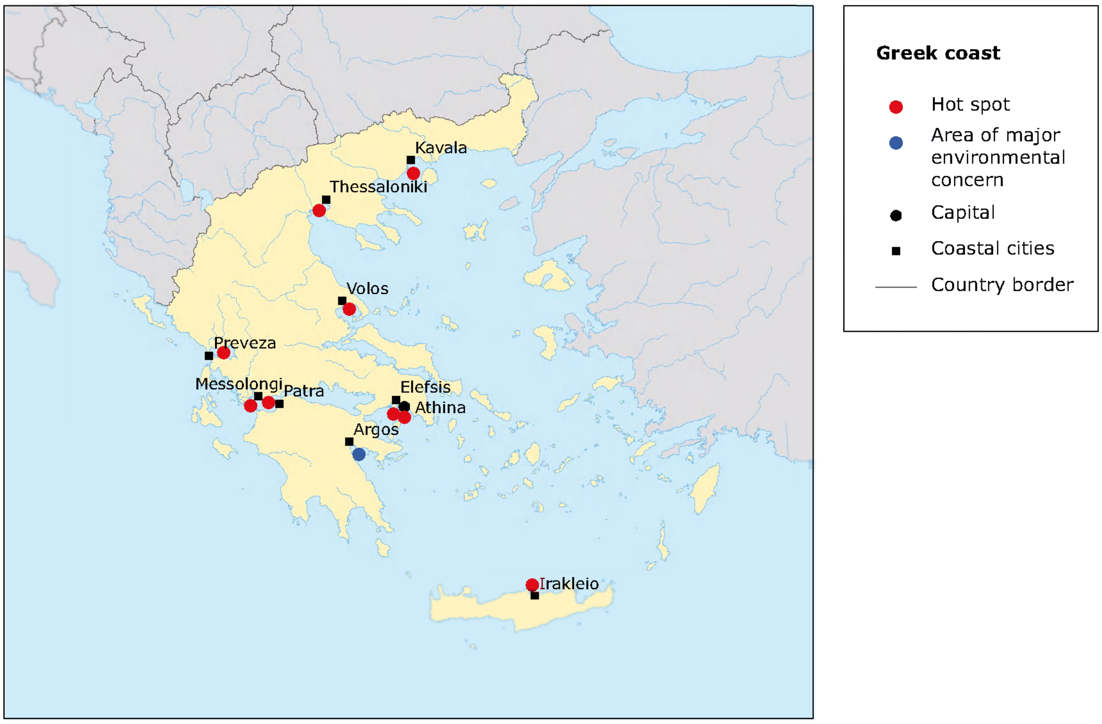
The coastline of Greece has a length of approximately 15 000 km. It hosts 50 % of the country's population and the majority of the industrial activity (NDA Greece, 2003). Most coastal cities operate wastewater treatment plants. **Localised environmental problems are caused by poorly treated urban and industrial wastewater, and run-off from agricultural areas**. The major source of nitrogen to the marine coastal areas of Greece is run-off from agricultural land, which contributes from 45 % (in the Aegean Sea islands) to 70 % (in the eastern Peloponnesus) of the total load. The endangered marine coastal areas in Greece are presented in Figure 3.7 and are as follows:

**Figure 3.6 Mediterranean coastline of France with areas of major environmental concern and pollution hot spots**




- Elefsis Bay: untreated industrial wastewater (1 000 industrial plants) including shipyards, iron and steel, petroleum refineries, cement, paper, detergents and food. Heavy metals are detected in high concentrations in water, sediment and some biota (mussels);
- Saronikos Gulf (Athina): primary treated wastewater from the capital and industrial wastewater. Occasional signs of eutrophication are present;
- Thessaloniki Gulf: treated industrial and urban wastewater from the city of Thessaloniki and the Kalohori industrial area;
- Pagasitikos Gulf (Volos): treated industrial and urban wastewater from the city of Volos and agricultural land run-off through the river Pinios;
- Amvrakikos Gulf (Preveza): treated industrial and urban wastewater as well as agricultural (nitrogen) run-off;

**Figure 3.7 Greek coast with areas of major environmental concern and pollution hot spots**



- Patra and Irakleio: urban and industrial wastewater;
- Argolikos Gulf (Argos): agricultural land run-off results in excessive nitrogen load;
- Lagoon of Messolongi: urban and agricultural land run-off.

## 3.9 Israel

Seventy percent of the population resides within 15 km of the Mediterranean coastline, where the major economic and commercial activities are concentrated. **The main pollution sources include industrial and urban wastewater,** although most of the urban wastewater is treated and recycled (Figure 3.8). The rivers Na'aman (near the city of Akko), Yarkon and Taninim are transporting nutrients from agricultural run-off. According to NDA Israel (2003), the areas of environmental concern along with the major LBS are:

- Haifa area: urban wastewater, industrial wastewater including oil refinery (directly and through the Kishon River) and harbour. Apart from Haifa, the area is also affected by discharges from the cities of Akko, Kiryat Haim and Kiryat Yam. Cadmium, mercury, lead and zinc are accumulated in the sediments of the harbour. Industrial discharges via the Na'aman River are affecting Haifa Bay;
- Hadera area: receives urban and industrial wastewater from the coast as well as run-off from agricultural land through the Hadera and Taninim streams;
- Tel Aviv — Jaffa area: industrial and urban wastewater, port facilities. Pollution vectors include the Gush Dan and Yarkon River. Tel Aviv harbour and the marinas of Tel Aviv and Jaffa are contaminated with PCBs and TBT;
- Ashod: Israel's main industrial harbour and its sediments are contaminated by heavy metals, organochlorine pesticides and TBT.

## 3.10 West Bank and Gaza

The Gaza Strip is 42 km long and 5.7–12 km wide. It hosts a 1 million population with strong growth potential as 50.2 % of the inhabitants are less than 15 years old. The area is highly urbanised, including the towns (Gaza, Khan-Yunis and Rafah) and 54 villages. **Poorly treated municipal wastewater is the main source of pollution of the coastal zone of Gaza Strip. Several small and medium industries also contribute to the pollution of the coastal area.** More than 20 individual sewage drains end either on the beach or a short distance away in the surf zone. These drains carry mainly untreated wastewater (only 40 % of the wastewater generated in the Gaza Strip is properly treated). Furthermore only 60 % of the population is served by sewerage systems. The major areas of concern are:

- Gaza city: urban and industrial wastewater (fuel, asphalt, clothing, mechanical workshops, printing, plastic, tiles);

**Figure 3.8 Coast of Israel with areas of major environmental concern and pollution hot spots**

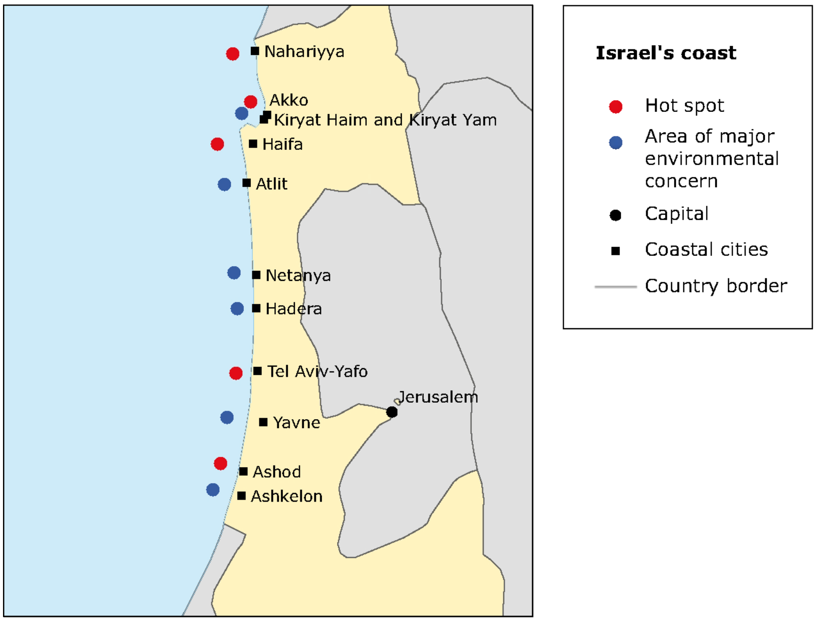
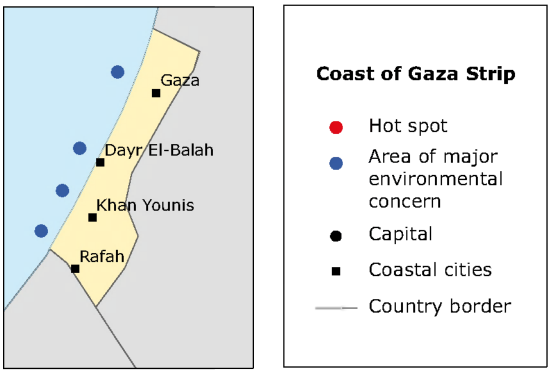


**Figure 3.9 Gaza Strip with major towns where environmental problems are encountered**



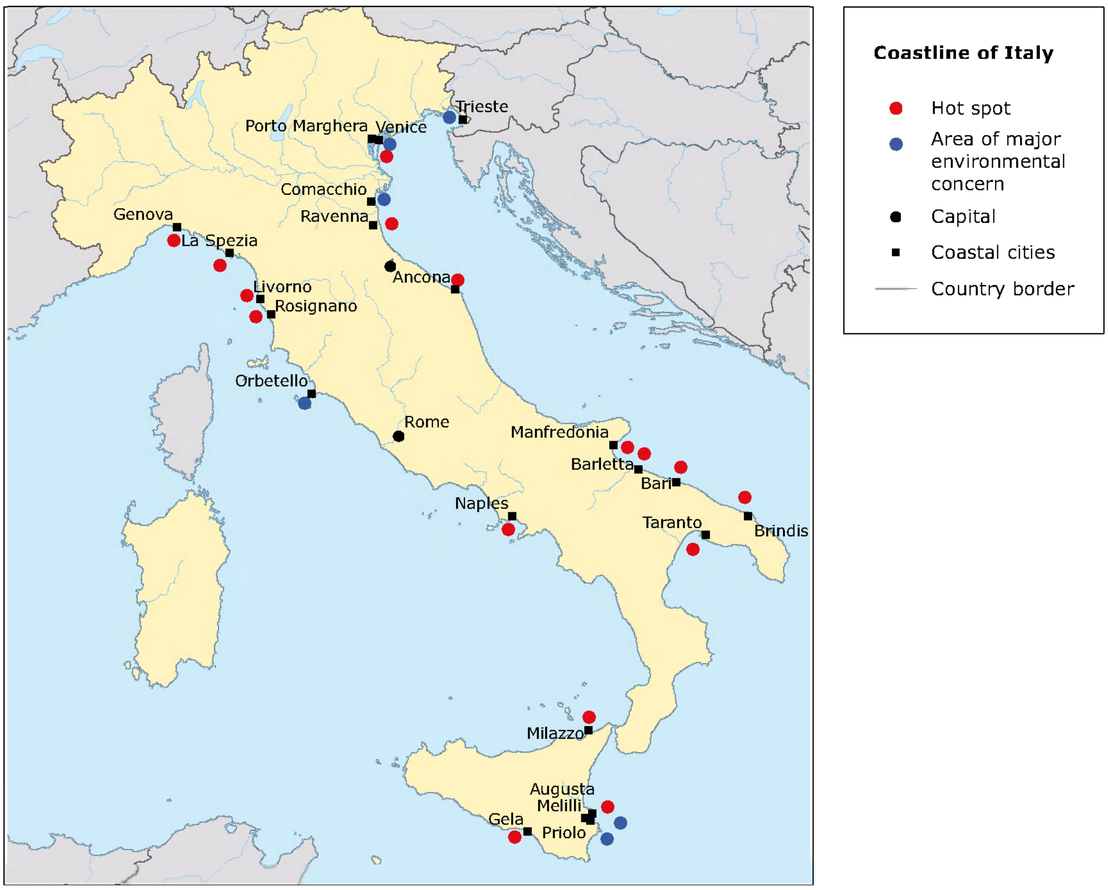

- Khan Younis town: urban and industrial wastewater (fuel, cement, food, clothing, mechanical workshops, printing, plastic);
- Rafah town: urban and industrial wastewater (fuel, cement, clothing, mechanical workshops, metal, wood);
- Dayr El-Balah town: urban wastewater.

## 3.11 Italy

Italy's coastline stretches 7 500 km and the whole territory is located in drainage basins flowing into the Mediterranean Sea. **Major environmental problems are caused by urban and industrial wastewater, agricultural run-off and shipping.** Urbanisation and concretisation of the coastline is also occurring because of tourist infrastructure development. Most cities have wastewater treatment plants, however only 63 % of the population is connected to them. Furthermore, 13 % of the existing plants have operational problems or need upgrading (OECD, 2002) (Figure 3.10). The river Po is a very important pollution vector in the area transporting urban and industrial wastewater as well as agricultural run-off from its drainage basin to the Adriatic Sea. In the mid 1990s the nitrogen load transported through the river amounted to 270 000 tonnes per year, leading to eutrophic algal blooms in the area. Areas of environmental concern are:

- Gulf of Trieste: eutrophication problems because of nutrients transported by the river Po, as well as coastal discharges;

**Figure 3.10 Coastline of Italy with areas of major environmental concern and pollution hot spots**



- lagoons of Venice, Comacchio and Orbetello are eutrophic to hypertrophic;
- the coastal areas of Liguria, Lazio and Emilia-Romagna: show eutrophication problems because of urban/industrial wastewater;
- the Tyrrhenian coast near the mouths of the rivers Arno and Tevere: show signs of eutrophication;
- harbours of Trieste, Venice, Genova, Livorno, Naples, Taranto, Brindisi, Ancona, Augusta-Priolo-Melilli, Milazzo, Ravenna and Gela: show petroleum hydrocarbon contamination because of intense maritime traffic (41 % of the Mediterranean oil transport takes place through Italian ports) and refineries' oil losses (150 oil slicks were recorded in 2000), (OECD, 2002).

### 3.12 Lebanon

It is estimated that 2.3 million people are resident in the Lebanese coastal zone. This zone is very narrow and lies between the west mountainous chain and the sea. **Major pollution problems are untreated urban wastewater, solid wastes and coastline urbanisation**. Beirut, Tripoli, Sidon, Jounieh and Tyre are the major coastal cities (Figure 3.11). Urban wastewater is discharged into the sea untreated (44 000 tonnes of $BOD_5$ per year) as no municipal WWTP is in operation in the country (NDA Lebanon, 2003). Furthermore, beachfront dumping sites of municipal and industrial solid wastes constitute an important LBS. The major factor for the physical alteration of the coastal zone is urbanisation since most of the coastal fringe (at a width of 8 to 10 km) is built-up. Areas with major environmental problems include:

- Tripoli area: urban and industrial wastewater, harbour and coastal dumpsites contaminate the coastal zone;
- Beirut area: untreated urban and industrial wastewater is discharged directly from outfalls and through the Al Ghadir River. The coastal area is also affected by leachates and litter from Burj Hammoud and Normandy dumpsites;
- Mount Lebanon area hosts industrial activities at Jbeil, Jounieh, Halat, Zouk Mosgeh, Antelias, which discharge their wastewater into the sea;
- Sidon: urban and industrial wastewater, solid waste dumping.

### 3.13 Libya

Libya's coastal zone hosts 85 % of the country's population and most of its industrial, agricultural and tourist activity (NDA Libya, 2003). There are no natural rivers in the area, only wadis (temporary dry rivers) which transport sediment, litter and pollutants from inland to the sea during storms. With the exception of the larger coastal cities, most towns have no effective sewer system. Therefore, discharge of wastewater into the sea is minimised. **Major environmental problems in Libya are oil pollution near terminal facilities as well as untreated urban and industrial wastewater from the bigger cities** (Figure 3.12). Urban solid wastes

**Figure 3.11 Lebanese coast with pollution hot spots**

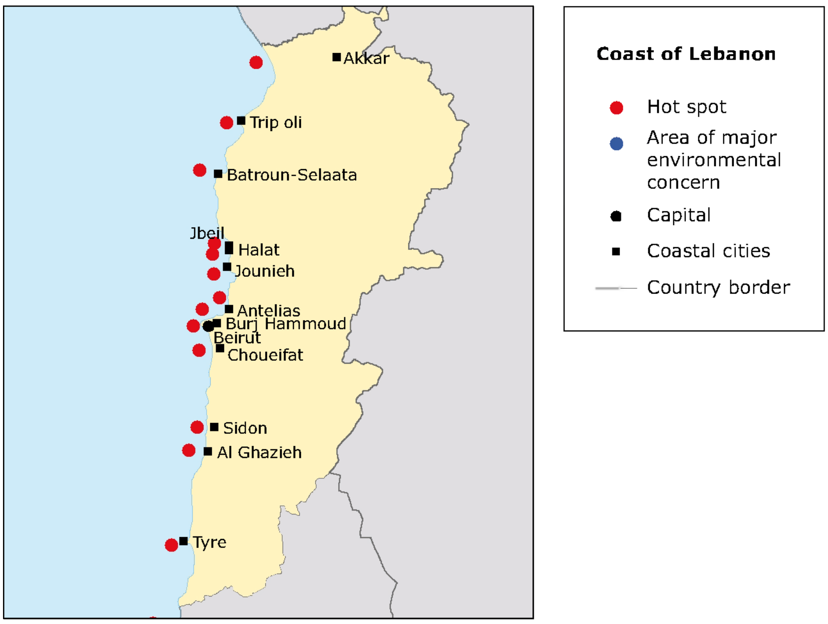
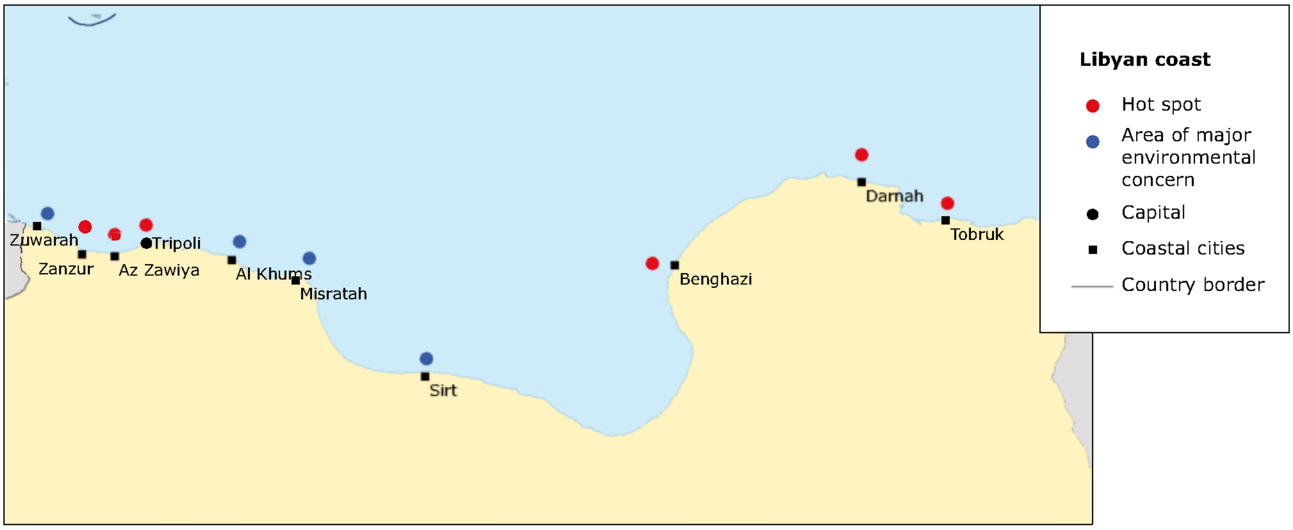


**Figure 3.12 Libyan coast with areas of major environmental concern and pollution hot spots**




are often disposed of in empty plots within the town limits, which creates serious health problems.

- Tripoli and Benghazi: urban wastewater partly treated;
- Az Zawiya: petroleum hydrocarbon contamination from the oil terminal and refinery with a production capacity of 120 000 barrels per day;
- Zuwarah: industrial wastewater (chemical industries) and urban wastewater;
- Misratah: urban, industrial (steel) and harbour facilities;
- Al Khums: power generation plant, oil terminal and cement plant;
- Sirt: urban wastewater.

Away from the cities, a significant part of the Libyan coastline is under no serious human stress because in many areas there is no paved access to the seashore.

## 3.14 Malta

Malta has a coastline of 190 km, 43 % of which is heavily utilised (the remaining 57 % being inaccessible). The built-up area comprises 24 % of the coast. This constitutes a very high population density (1 300 persons/km$^2$). **The southern part of the island of Malta is the area with the majority of human activities (cities, harbours, and tourist resorts) and the major environmental problems, i.e. urban and industrial wastewater** (Figure 3.13). On the island, 85 % of urban and industrial wastewater is disposed of untreated while solid wastes are mainly disposed of in two landfill sites (Malta Ministry of Environment, 2001; Malta National Statistics Office, 2002).

**Figure 3.13 Malta with areas of major environmental concern and pollution hot spots**

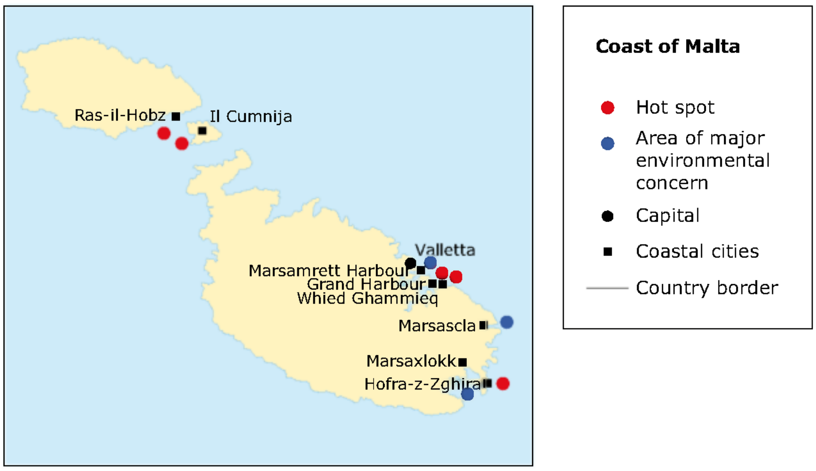
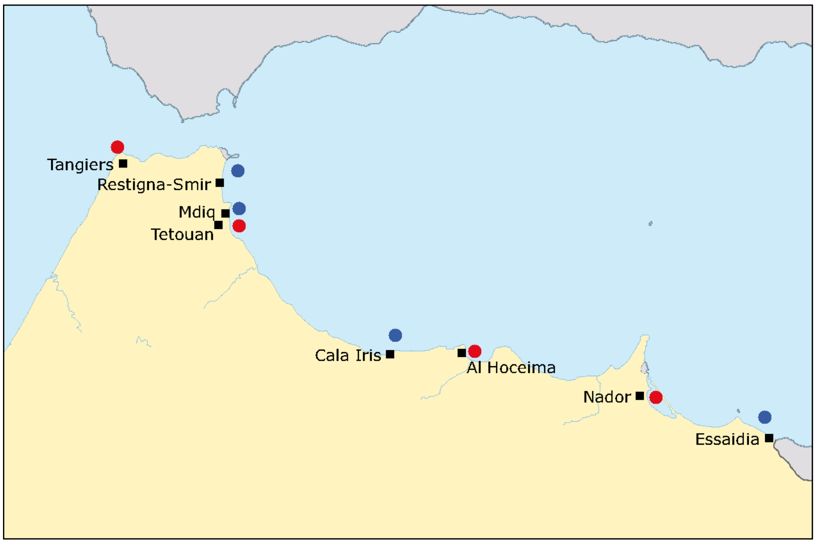


**Figure 3.14 Moroccan coast with areas of major environmental concern and pollution hot spots in the Mediterranean**




- Southern Harbour District: Mostly untreated urban and industrial wastewater discharged into the sea through submarine outfalls. Southern beaches in the vicinity of the Grand Harbour and Marsaxlokk Bay (Figure 3.13) are affected by microbial contamination. Oil pollution related to oil transport and shipping occurs in the vicinity of the Grand Harbour and Msida Yacht Marine.

## 3.15 Monaco

Monaco has a population of 33 000, and a high population density (16 500 people per km$^2$). The city wastewater (urban and industrial) is discharged into the sea through submarine outfalls after treatment. Furthermore, there is also primary treatment of storm water before it is discharged into the marine environment. Solid wastes are recycled (glass, paper, batteries, lubricating oil) or incinerated, reducing their weight by 70 % before sanitary disposal. Special industrial wastes are also treated (Principauté de Monaco, 1997). The greater part of the coastline of Monaco is urbanised (Photo 3.2).

**Photo 3.2:** Urbanisation along the coastline of Monaco.

**Source:** Helmut Zibrowius.

## 3.16 Morocco

The Mediterranean coast of Morocco has witnessed increased urbanisation over recent years. From 1977 to 1994, medium-sized coastal towns grew from 16 to 30, and small towns from 2 to 14. The major urban centres, which are also the most polluted areas on the Mediterranean coast, are: Tangiers (population 640 000), Tetouan (333 000), Nador (149 000) and Al Hoceima (65 000) (NDA Morocco, 2003) (Figure 3.14). **The main environmental problems are caused by urban and industrial wastewater, maritime traffic and coastal urbanisation**. For example, construction, sand extraction and erosion have resulted in serious stress on the beaches. This has led to the disappearance of seven out of 47 beaches in recent years. The major beaches under stress are in Tetouan, Mdiq, Restinga-Smir, Al Hoceima, Cala Iris, Nador and Essaidia. Due to bacteriological contamination, 17 % of recently surveyed beaches were not in conformity with sanitary standards for bathing. Maritime traffic is one of the major concerns for oil and hazardous compounds contamination. It is estimated that 60 000 ships pass through the straits of Gibraltar yearly, including 2 000 ships carrying chemicals, 5 000 oil tankers and 12 000 gas tankers. Major problems in the coastal areas which are also urban centres are listed below:

- Tetouan: industrial and urban wastewater, sand erosion, eutrophication and toxic algal blooms;
- Nador: urban and industrial wastewater, solid wastes, sand erosion;
- Al Hoceima: urban and industrial wastewater, solid wastes, sand erosion.

## 3.17 Serbia and Montenegro

The Mediterranean coast of Serbia and Montenegro has a population of 409 000. Four percent of the total population of the country reside in urban areas. The major towns are: Bar (population 47 000), Herceg Novi (37 000), Kotor (23 000), Ulcinj (21 500), Budva (18 000) and Tivat (15 600) (Census 2003 — including refugees) (NDA Serbia and Montenegro, 2004). The summer population of these towns increases because of tourism. Owing to the discharge of untreated urban wastewater, eutrophication problems and microbial pollution can be detected in the vicinity of coastal towns (west beaches of Bar, Herceg-Novi Bay, Kotor Bay, Port Milena [Ulcinj] and Tivat Bay). Similar problems exist at Velika Plaza and Ada at the river mouths. It is estimated that 50 % of the produced solid wastes in the coastal area are being collected and disposed of in open dumps without sanitary treatment. Quarrying of stones occurs near the town of Bar and Platamuni peninsula. This causes dust generation and alteration of the coastal morphology. Land erosion signs are detected in all the coastal areas.

**The major pollution problems are untreated urban wastewater, eutrophication of coastal waters and uncollected solid wastes.** The areas of concern (Figure 3.15) are:

- Bar: urban and industrial wastewater (food);
- Herceg Novi: urban and industrial (shipyard, harbour and food);
- Kotor: urban and industrial (metal, chemicals, petroleum storage and harbour);
- Ulcinj: urban and industrial (salt and harbour);
- Budva: urban and harbour;
- Tivat: urban and industrial (shipyard and harbour).

## 3.18 Slovenia

Slovenia possesses a short coastline on the Adriatic Sea (46.6 km). It hosts approximately 80 000 people who mainly reside in the towns of Koper, Izola and Piran (Figure 3.16). More than 80 % of the Slovenian coastline is urbanised and mostly within 1.5 km from the sea front. This leaves only 8 km (18 %) of coast in its natural state. **Major environmental problems are related to discharge of partly treated urban and industrial wastewater and run-off from agricultural land** (NDA Slovenia, 2003):

- Koper Bay: receives primary treated wastewater from the town of Koper, nutrients and heavy metals (Ni, Cr and Zn) through the rivers Rizana and Badasevica (585 tonnes of nitrogen and eight tonnes of phosphorus per year);

**Figure 3.15 Coastline of Serbia and Montenegro with areas of major environmental concern**

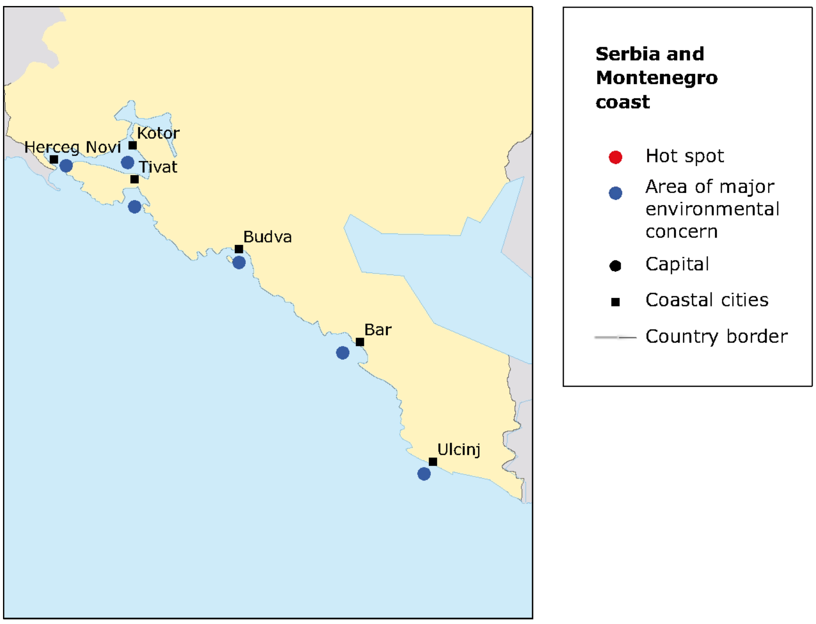
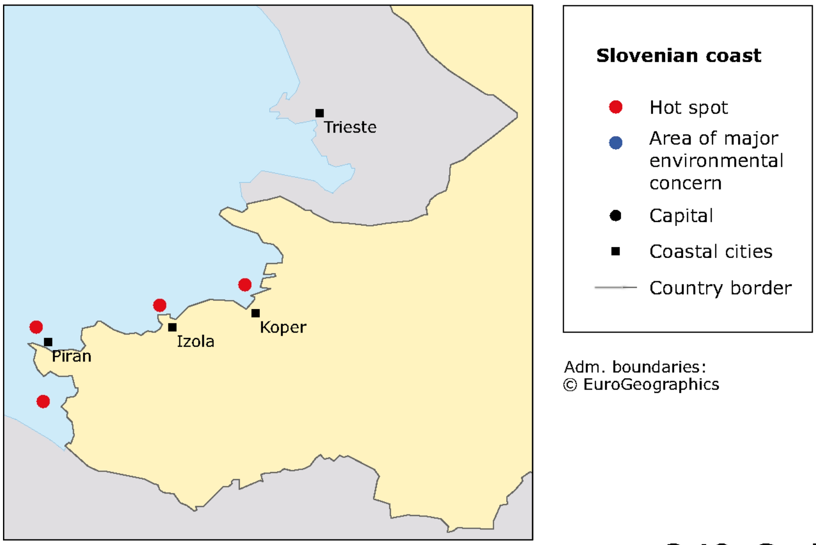


**Figure 3.16 Slovenian coast with areas of major environmental concern and pollution hot spots**




- Bay of Piran: receives primary treated wastewater from Piran and untreated wastewater from Izola, as well as nutrients and heavy metals through the rivers Dragonja and Drnica (61 tonnes of nitrogen and 1 tonne of phosphorus per year).

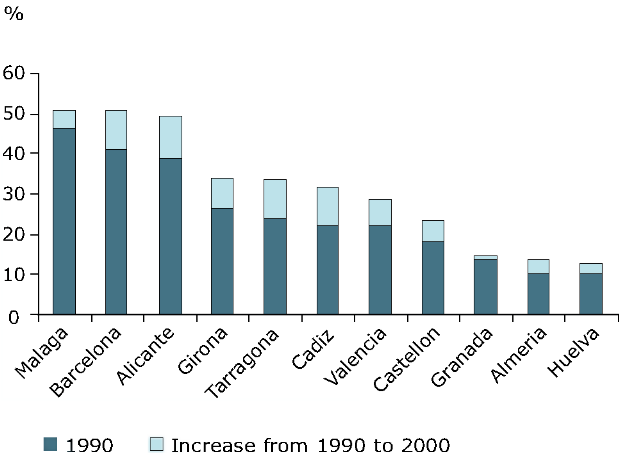
## 3.19 Spain

The Spanish Mediterranean coast has a population of 15.6 million, representing more than 39 % of the country's population. Urbanisation is very intense as 85 % of the Mediterranean coastal population lives in cities and towns of more than 10 000 people. The major cities are: Barcelona (4 million), Valencia (2.1 million), Malaga (900 000), Murcia (400 000), Palma de Mallorca (370 000), Granada (310 000), Cartagena (185 000), Benidorm (125 000), Tarragona (110 000) and Algeciras (105 000) (UNEP/Plan Bleu, 2001). Urbanisation affects the most valuable and

**Figure 3.18 Mediterranean coastline of Spain with areas of major environmental concern and pollution hot spots**

fragile coastal biotopes, such as dunes, coastal forests, wetlands and beaches. Built-up areas act as an important barrier between land and sea (the so-called 'Med wall' occupies more than 50 % of the coast). On the other hand, the proximity of these built-up areas to the sea makes the settlements extremely vulnerable during sea storms, floods and other exceptional events. Up to 6 million of the buildings are second homes that are seasonally occupied. The building rate is especially high on the Mediterranean coast (Figure 3.17) due to two major factors: tourist resorts and second homes development, and growth of urban sprawl in metropolitan areas of the major cities.

**Figure 3.17 Percentage of built-up area in the first km of the coast by province in Spain (1990 and 2000)**




**Source:** ETC/TE 2004.

The rivers Ebro, Segura and Jucar are also important routes by which urban and industrial pollution are transported to the Mediterranean Sea near the cities of Amposta, Murcia and Valencia, respectively. Although most of the coastal cities operate wastewater treatment plants, **the major pollution problems include discharge of urban and industrial wastewater. Intense urbanisation of the coastline is also a major issue.**

Figure 3.18 shows the main pollution spots on the Mediterranean coast. These are:

- Barcelona, Valencia, Cartagena, Tarragona and Algeciras: urban and industrial wastewater;
- Mouth of the River Ebro (Aragosta): urban and industrial pollutants.

## 3.20 Syria

The Syrian coastal area represents only 2 % of the country's surface but hosts 11 % of its population (i.e. 1.5 million). The major coastal cities are Lattakia, Jableh, Tartous and Banias (Figure 3.19). Coastal urbanisation, due to housing needs (local and tourist) and industrial development, (harbour facilities) has led to serious environmental problems. These problems are: **disposal of untreated urban and industrial wastewater, oil slicks from the oil refinery and the oil terminal, and the management of solid wastes** (NDA Syria, 2003). In total it is estimated that 24.8 million $m^3$ of urban wastewater, 99 % of which is untreated, is discharged into the sea. As a result, the loads of heavy metals discharged into the sea can be high, for example the maximum value of lead (Pb) measured in marine sediments has reached 358.5 mg/kg in Tartous harbour.

- Lattakia area: urban wastewater (7 364 tonnes of $BOD_5$, 1 664 tonnes of nitrogen and 377 tonnes of phosphorus), solid waste dumping site on the shore and eutrophication of the coastal zone.
- Tartous-Banias area: urban wastewater, (5 582 tonnes of $BOD_5$, 714 tonnes of nitrogen and 218 tonnes of phosphorus), industrial plants including a petroleum refinery (at Banias) and a power generation plant.

**Figure 3.19 Coastline of Syria with hot spot areas**

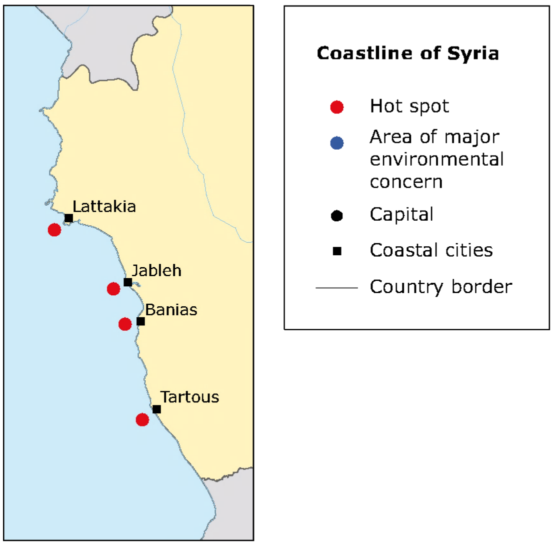
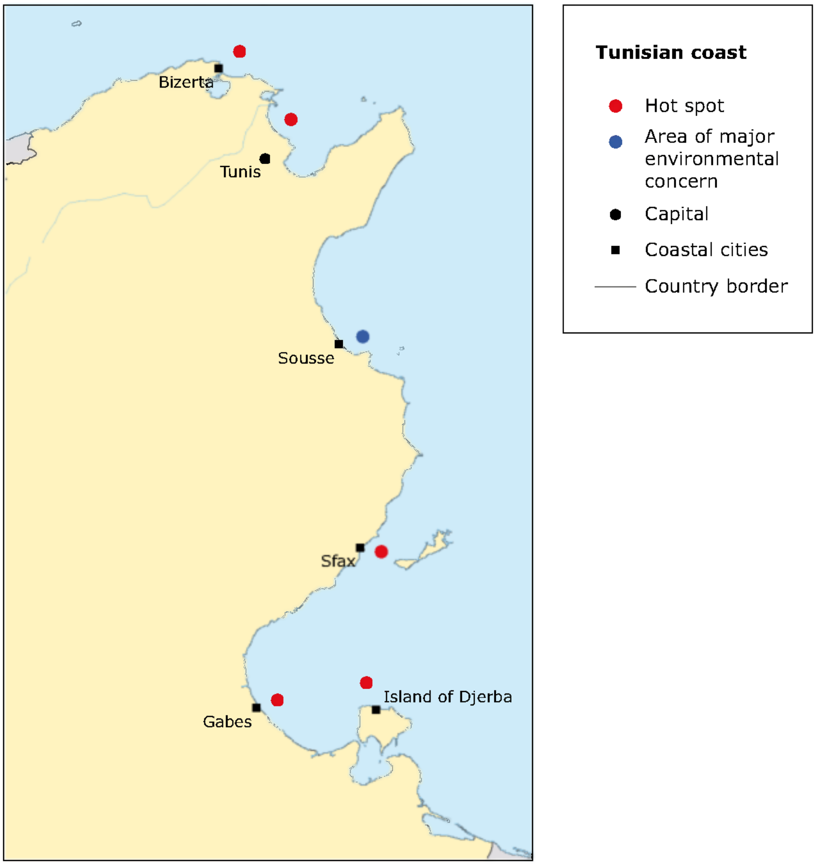


**Figure 3.20 Tunisian coast with areas of major environmental concern and pollution hot spots**




## 3.21 Tunisia

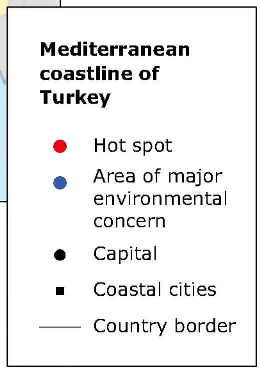
The coastal zone of Tunisia is densely populated, hosting 6.3 million (70.2 % of the country's population) in 1995. Tunis (population 1.6 million), Sfax (510 000), Sousse (185 000), Gabes (140 000) and Bizerta (130 000), are the most important cities. A major part (81 %) of the cities' wastewater is treated. **The major environmental problems are industrial and urban wastewater, industrial (phosphogypsum) and urban solid wastes, and coastal urbanisation.** The most endangered areas are shown in Figure 3.20 while LBS are presented below.

- Gulf of Gabes: phosphogypsum slurry (10 000–12 000 tonnes per year) from production of phosphoric acid and fertilisers discharged into the sea (acidity, suspended particulate matter, fluoride, phosphorus and cadmium); urban wastewater.
- Sfax coastal zone: industrial wastewater (12 000 tonnes of fluoride, 5 700 tonnes of phosphorus, 2.4 tonnes of cadmium and one tonne of mercury) and phosphogypsum wastes dumped on the seafront (19 million $m^3$ in two dumping sites); urban solid wastes; illegal dumps.
- Lake of Bizerta: urban and industrial wastewater, as well as leachates from two main solid waste dumping sites at Sabra Bay and El Fouledh.
- Island of Djerba: tourist development, sand extraction for construction purposes (building of hotels at the north-eastern side of the island) and trawling in the *Posidonia* meadows.

## 3.22 Turkey

The Turkish coast extends for 8 333 km and can be divided into the Aegean region and the eastern Mediterranean region. **Urban and industrial centres, oil terminals, agricultural and recreational facilities on the coast are the major land-based pollution sources in both regions** (NDA Turkey, 2003). Rapid urbanisation is taking place in Turkey because of recreational constructions and extensive building of second (vacation) houses on the Aegean and eastern Mediterranean coastline. This is drastically altering the landscape. **Coastal erosion** is also an important problem. Out of 110 sand dune systems recorded in the 1980s only 30 (27 %) are relatively intact today. Areas of concern (Figure 3.21) and LBS include:

**Figure 3.21 Turkish Mediterranean coast with areas of major environmental concern and pollution hot spots**


- Bay of Izmir: urban and industrial wastewater; Rivers Gediz and Bakircay drain large agricultural and urban areas transporting significant nutrient loads into the sea causing eutrophication;
- Buyuk Menderes River: untreated industrial wastewater (mercury, cadmium and chromium from leather industry);
- Aliaga and Foca regions: harbours and untreated industrial wastewater;
- Iskenderun Bay: industrial activity including petroleum pipeline terminal (oil pollution from deballasting and operational oil spills);
- Mersin: industrial and urban wastewater, heavy shipping activity;
- Bodrum: tourism and aquaculture activities.

# 4 Key issue: natural hazards

## 4.1 Seismicity

The present form of the Mediterranean Sea is the result of continuous interaction of complex geodynamic processes during the last 50–70 million years. This is addressed in detail in the *State and pressures of the marine and coastal Mediterranean Environment* (EEA, 1999).

Seismic activity in the Mediterranean region is closely related to the active geodynamic processes.

Figure 4.1 highlights the main regions of enhanced seismicity.

In the eastern Mediterranean, the earthquake epicentres are concentrated along the active Hellenic and Cypriotic arcs as well as behind them, within the deforming Aegean and western Asia Minor regions. Specific areas within this region, such as the Ionian Islands, the Gulf of Korinthos, the area along the north Anatolian fault and others are well known for their very high seismicity. The entire Italian Peninsula constitutes the second region of enhanced seismicity. Seismic activity is related to the ongoing subduction of the Ionian basin below the Calabrian arc and the associated deformation of the overriding Italian microplate.

Earthquakes of a magnitude higher than M = 6 or M = 7 occur frequently causing the death of thousands of people and extensive damage to buildings (Table 4.1).

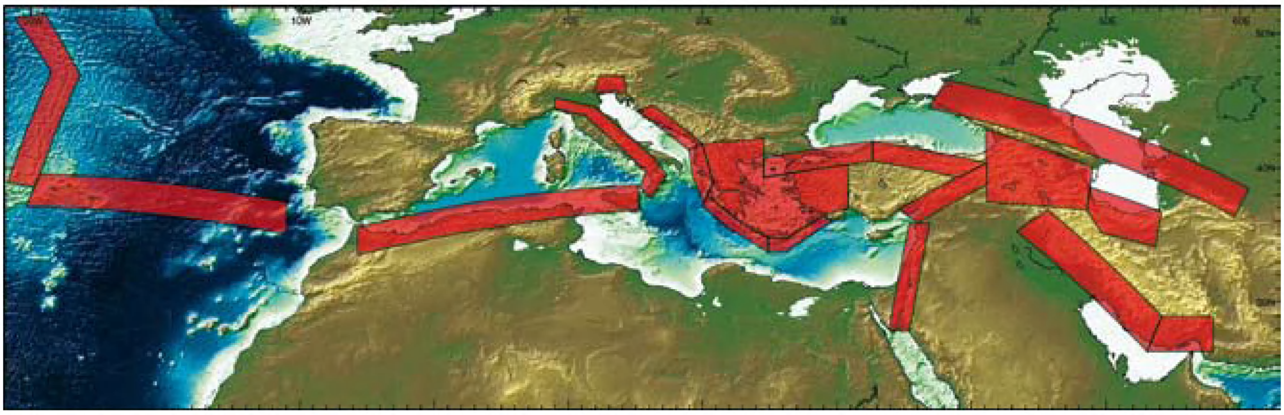
## 4.2 Volcanic activity

Active volcanoes in the Mediterranean region date back 1–2 million years and are associated with the active orogenic arcs, namely the Calabrian and the Hellenic ones.

In Italy, Etna and Vesuvius are the volcanic centres together with the volcanoes of the Aeolian islands, such as Stromboli, and these are associated with the ongoing subduction of the Ionian oceanic crust below the Calabrian arc and the opening of the Tyrrhenian back-arc basin. The spectacular and frequent lava eruptions from the top and the sides of the Etna volcano started some 700 000 years ago, while the oldest dated rock from Vesuvius is about 300 000 years old. Both volcanoes remain active, attracting tourists from all over the world, as does Stromboli, but also threaten their surrounding, densely populated areas. Historical cases of devastation of entire cities, with the best known example being the total destruction of Pompeii (Vesuvius) and adjacent cities in about 79 AD, point to the possibility of future catastrophic eruptions.

Santorini and Nisyros islands are the most famous volcanic islands of the Hellenic volcanic arc in the Aegean Sea. They are volcanically active. In addition, the lesser known volcanic centres distributed along the arc are also active. The 400 m deep caldera of Santorini, an internationally known target for tourists, was formed during the largest ever known volcanic eruption on earth in the 17th century BC, which led

**Figure 4.1 Seismic zones of the Mediterranean. Hypocenter depth < 50 km**



**Source:** Vannucci *et al.*, 2004.

**Table 4.1 Selected catastrophic earthquakes during the last decade (1995–2004)**

| Date | Area | Magnitude | Deaths | Impact |
|---|---|---|---|---|
| 14.08.2003 | Lefkas isl., Greece | M = 6.3 | None | Low impact: collapse of the summer 2003 tourist season |
| 21.05.2003 | Boumerdes, Algeria | M = 6.8 | 2 200 | Thousands of houses were demolished or seriously damaged<br>3 m high tsunami |
| 31.10.2002 | Foggia, South Italy | M = 5.9 | 29 | 70 % of houses damaged in the Campobasso area |
| 09.09.1999 | Athens, Greece | M = 5.9 | 135 | A few thousand houses were demolished or seriously damaged |
| 17.08.1999 | Izmit, NW Turkey | M = 7.4 | 18 000 | 15 400 houses were destroyed<br>Coastal zone collapsed<br>Tsunami |
| 15.06.1995 | Aigion, Greece | M = 6.5 | 31 | Collapse of numerous houses/hotels<br>Impact on tourist season<br>Coastal zone collapsed<br>3 m high tsunami |

to the fall of the Minoan civilisation. The volcano is still active 3 650 years after this event and the rising lava gives birth to new islands emerging above sea level within the caldera. Even though no destructive eruption from the Nisyros volcano has taken place during the last thousand years, the perfectly shaped craters and the numerous fumaroles within its caldera are evidence of the ongoing volcanic activity.

## 4.3 Mass movements — tsunami

Submarine slope failures and gravity-driven mass movements of various origins occur frequently in the Mediterranean region and have generated many destructive tsunamis.

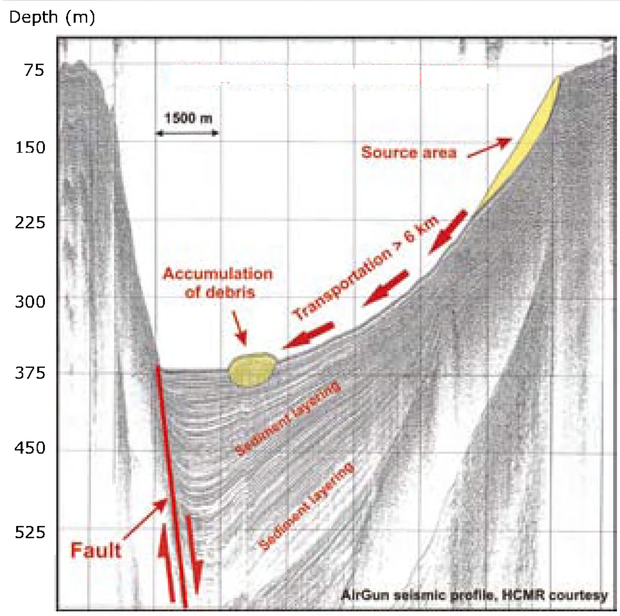
The active geotectonic processes in the Mediterranean region favour the creation of the appropriate morphological and geological conditions which may give rise to tsunamis. About 200 tsunamigenic events occurred over the last 500 years (1500–1990) around the Mediterranean (after Soloviev *et al.*, 1997). Most of the reported tsunamis occurred in the most tectonically and volcanically active regions like the Aegean, Ionian and Tyrrhenian Seas, the Sea of Marmara and subsequently along the Algerian margin and Cyprus arc, or off-delta areas.

Earthquakes are the most frequent triggering mechanism for the destabilisation of sedimentary bodies deposited on submarine slopes or for coastal collapses. Slope failure may take place right after the earthquake or may be delayed for days, weeks, or months). The most recent earthquakes, which triggered tsunamis, are those of Izmit, Boumerdes and Aigion. On 31 December 1995, about 6 months after the lethal Aigion earthquake, a 3 m high tsunami inundated many km$^2$ of coastal areas along the southern shore of the Gulf of Korinthos. Tsunamis generated by volcanic or volcanically driven processes comprise a considerable threat to coastal areas around the Aegean and Tyrrhenian Seas.

On 30 December 2002, a major instability occurred on the Sciara del Fuoco slope, on the western flank of the volcanic Stromboli island (Bosman *et al.*, 2004). The total volume of the rock mass involved in the sub-aerial submarine slide was estimated to be more than 28.5 million m$^3$. The resulting scar extended to a depth of 700 m. The tsunami induced by the landslide spread around the island and the surrounding Aeolian archipelago and was felt as far away as the coast of Sicily.

Nevertheless, tsunamigenic events occur also in areas of no or weak seismic/volcanic activity and are related to instabilities of sediments deposited on the shelf or the slope off large river mouths.

**Figure 4.2 Schematic submarine landslide (from the Gulf of Korinthos)**



The most striking example took place on 16 October 1979 in the western Mediterranean. A large slide involving at least 8 million $m^3$ occurred in shallow water during infilling operations related to the enlargement of Nice airport at the Var River mouth. Fine to medium sand from the coastal zone was transported up to more than 200 km from the fault site (Migeon *et al*, 2004). The tsunami, which followed the collapse, drowned the coastal zone of Nice and several people were killed.

Figure 4.2 illustrates a typical case of submarine landslide (from the Gulf of Korinthos), which may have triggered a large tsunami in the past.

# 5 Key issue: exotic species

## 5.1 Biological invasions: a non-stop process

Exotic species — sometimes termed alien, introduced or non-native species — are extra-Mediterranean plants and animals that have been unintentionally introduced, have invaded and/or have been imported, and are subsequently living in the wild.

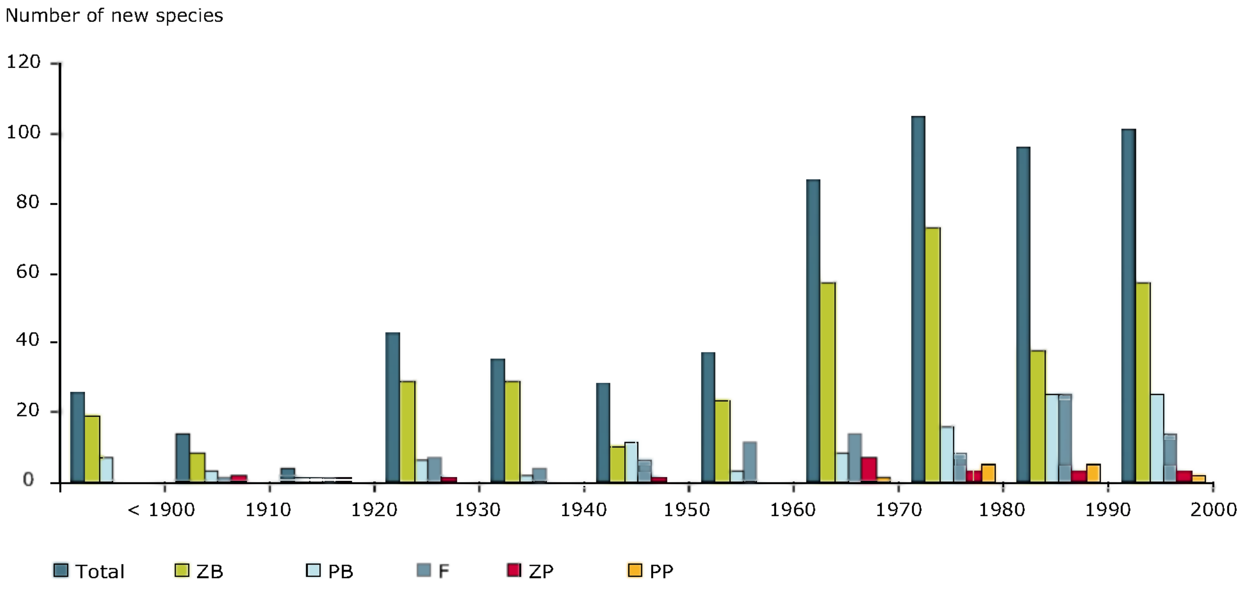
- Over 600 marine exotic species have been recorded in the Mediterranean Sea.
- The rate of introduction of exotic species in the Mediterranean Sea peaked in the 1970–1980 period, and since then has remained stable or kept increasing for most groups, especially for zoobenthos (bottom-living animals).
- An average of one introduction every four weeks has been estimated over the past five years.

The introduction of exotic species is an ongoing process. The phenomenon, which peaked in the 1970–1980 period (a total of 105 records), is continuing at a steady rate (95 and 100 species in the following two decades) but not equally for all groups (Figure 5.1). It is characteristic that **in the 21st century, 64 new species have been reported in the Mediterranean,** 23 of them recorded in 2004, which reveals the difficulties in keeping records up to date as well as calling for continuous research on this issue (Streftaris *et al*., 2005).

## 5.2 Mode of introduction and distribution of exotic species across the Mediterranean

The phenomenon of introduction of exotic species is apparent across the Mediterranean (Figure 5.2). However, it is more intensive in the eastern Mediterranean, especially in the Levantine basin. The mode of introduction is different between the two basins. Whereas in the eastern Mediterranean, penetration via the Suez Canal is the main mode of introduction, in the western Mediterranean, shipping and/or aquaculture are responsible for the great majority of exotic species. Lagoonal ecosystems in the northern Adriatic and the south of France (with 70 and 96 exotic species respectively, mostly introduced via aquaculture) are considered hot-spot areas for exotic species.

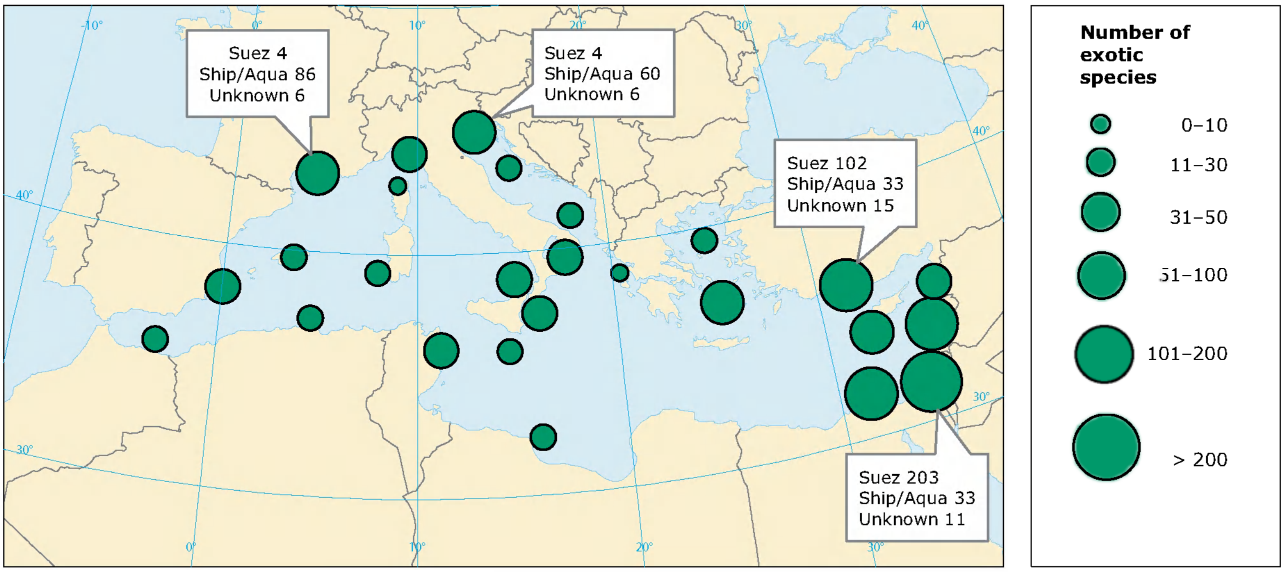
**Figure 5.1 Rate of detection of exotic species in the Mediterranean**




**Source:** UNEP/MAP, 2004b.

**Note:** ZB = zoobenthos, PB = phytobenthos, F = fish, ZP = zooplankton, PP = phytoplankton.

**Figure 5.2 Distribution of exotic species across the Mediterranean Sea and mode of introduction in selected areas. Ship/Aqua denotes transportation via shipping and/or aquaculture**




**Source:** HCMR based on various sources, UNEP/MAP, 2004b.

Migration and shipping via the Suez Canal constitute the major pathways for the introduction of new species to the Mediterranean, followed by aquaculture (deliberate and unintentional) and those cases where the mode of introduction remains undetermined.

It is argued that exotic species have increased the biodiversity of the eastern Mediterranean. Today, 12 % (68 out of 569) of the benthic biota of Israeli coasts are of Indo-Pacific origin (Fishelson, 2000). According to an updated check-list of the macroalgae of Thau lagoon (France), it was estimated that introduced species made up 23 % of the total flora (Verlague, 2001).

**Photo 5.1:** The enormous proliferation of *Anadara inaequivalvis* in the N. Adriatic (Rinaldi, 1985) has changed the physiognomy of the seashore.

**Source:** Emidio Rinaldi.

## 5.3 Impact of exotic species

Exotic species are the next biggest cause of loss of biodiversity after habitat destruction (Breithaupt, 2003) having modified all aspects of marine ecosystems. They represent a growing problem due to the unexpected and harmful impacts that they have on the environment, economy and human health.

### *A threat to biodiversity?*

The alterations of marine ecosystems due to new introductions have been scarcely studied in most areas. There are only a few well-documented cases such as that of *Caulerpa racemosa*.

Biodiversity changes, such as the dominance of certain species exhibiting an invasive character at the expense of others, has often been reported but not quantified. Typical examples are the rapid decrease in Israel of populations of the sea star *Asterina gibbosa*, the prawn *Melicertus kerathurus*, and the jelly fish *Rhizostoma pulmo.* Whereas exotic species such as *Asterina burtoni*, *Marsupenaeus* (= *Penaeus*) *japonicus* and *Rhopilema pulmo* have increased in numbers. Fish populations of red mullet (*Mullus barbatus*) and hake (*Merluccius merluccius*) have been forced to migrate to deeper waters by the exotic species *Upeneus moluccensis* and *Saurida undosquamis*, respectively (Galil and Zenetos, 2002).

**Box 5.1 Expansion of *Caulerpa racemosa* in the Mediterranean**

Recorded for the first time in the Mediterranean in the early 1990s in Libya, the invasive *Caulerpa racemosa* appeared during the same period in different parts of the basin. The species showed traits of invasiveness right from the first phase of its spread. Thirteen years on, nearly the whole Mediterranean basin is colonised and the Canary Islands have just been reached (Verlaque *et al.*, 2004).

Piazzi *et al.* (in press) reports that *Caulerpa racemosa* has been recorded along the coasts of 11 countries developing on all kinds of substrata. It has been found in both polluted and unpolluted areas between 0 and 70 m depth. At the end of 2003, the length of coastline affected by the invasion of *Caulerpa racemosa* in Spain, France (Figure 5.3), Italy and Croatia totalled 700 to 750 km.

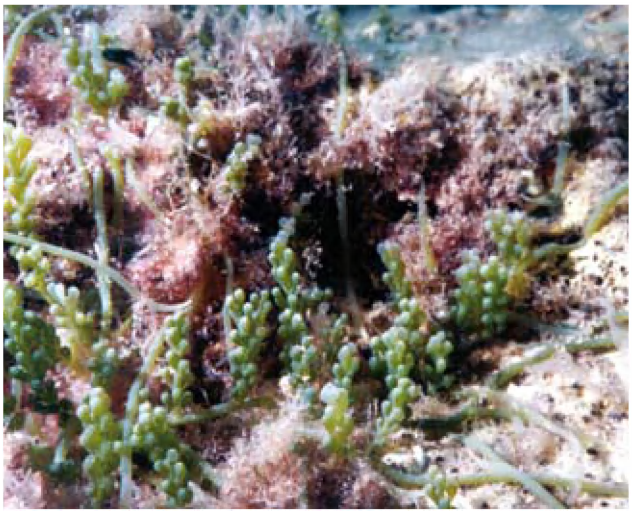
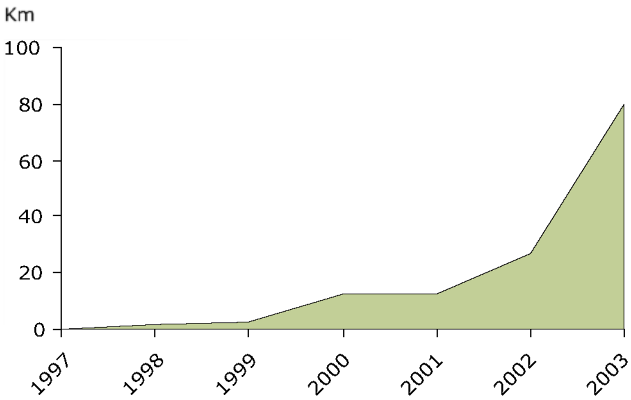


**Photo 5.2:** *Caulerpa racemosa.*

**Source:** P. Panagiotides.

**Figure 5.3 Increase in length of the French coastline affected by *Caulerpa racemosa* (from Meinesz *et al.*, 2003)**




In the Mediterranean, the Manila clam *Ruditapes philippinarum,* in addition to out-competing native species, have impacted the physical environment because their harvesting has led to increased loads of suspended material (Occhipinti Ambrogi, 2002).

Economic losses are also known to be caused by massive appearance of species such as:

- The macroalgae *Womersleyella setacea* and *Acrothamnion preissii* clog up fishing nets in France and Italy, respectively, where it is known as 'pelo' due to its impact on the fishing gear (Verlaque, 1989; Cinelli *et al.*, 1984).
- The macroalga *Codium fragile*: its removal from the coasts of Marseilles in the 1960s has led to mechanical removal of accumulated material on the beaches (Boudouresque, 1994).
- The jellyfish *Rhopilema nomadica* reported along the eastern Mediterranean coast and as far north as the southeastern coast of Turkey: impact on tourism, fisheries and clogged coastal installations (Galil and Zenetos, 2002).
- *Caulerpa taxifolia* infestations are also renowned for the negative impact on fishing, both commercial and recreational; tourism (e.g. on recreational activities such as scuba diving).

## 5.4 Exotic species as a fishery resource

A significant number of exotic species have become valuable fishery resources in the Levantine area. Those most notable are: the conch *Strombus persicus;* the prawns *Marsupenaeus japonicus, Metapenaeus monoceros* and *M. stebbingi*; the crab *Portunus pelagicus* and a few fish species, such as the mullids (*Upeneus moluccensis* and *U. pori*), the Red Sea obtuse barracuda (*Sphyranea chrysotaenia*) and clupeids (*Dussummieria acuta, Herklotsichthys punctatus*). *Strombus persicus* was first reported in Mersin Bay, Turkey in 1978 and by 1987 had colonised areas in Israel, Greece (Rhodes), Cyprus and Lebanon. In Israel densities of tens of specimens per $m^2$ have been reported and consequently it has found its way to the fishing market (Mienis, 1999). Similarly, it was discovered served in restaurants on the island of Rhodes in 2004, where recent surveys have discovered a massive proliferation of the conch.

## 5.5 Added value from studying exotic species in the Mediterranean

*Indicators of climatic changes*

Much has been written about the phenomena collectively named 'tropicalisation of the Mediterranean'. These phenomena have introduced changes in the biodiversity and biogeography of the area. Significant changes in the Adriatic's physical conditions have been recorded that may have favoured the establishment of thermophilic species. According to Bello *et al.* (2004), the tropicalisation of the Adriatic is confirmed by the occurrence and establishment of three tropical species, namely: the toxic dinoflagellates (microalgae) *Ostreopsis lenticularis, Coolia monotis* and *Prorocentrum mexicanum.*

*Indicators of disturbance*

Polluted or physically degraded environments are more prone to invasion than pristine sites. A recent study of macrofouling organisms discovered that many more species were found in a polluted than in a non-polluted marina. The cosmopolitan serpulid worm *Hydroides elegans* that dominated the fauna in the polluted marina was only infrequently found

**Photo 5.3:** *Marsupenaeus japonicus* (a prawn).

Commercially important for fisheries in the Levant where it invaded via the Suez Canal (Balss, 1927). Now in aquaculture from which wild populations have been established in the Aegean Sea, central and western Mediterranean (Galil *et al.*, 2002).

**Source:** Kosmas Kevrekides.

in the non-polluted marina (Kocak *et al.*, 1999). The mariculture introductions are mostly restricted to lagoonal or estuarine habitats and the vessel-transported exotics to polluted harbours (Zibrowius, 1992); environments that are known for their low biodiversity. **Therefore, the response of exotic species to pollution makes them good candidates for assessing Ecological Quality Status, a strategic issue for both the WFD and the forthcoming European Thematic Strategy on the Protection and Conservation of the Marine Environment.**

# 6 Key issue: Harmful Algal Blooms

## 6.1 Harmful Algal Blooms (HABs) in the Mediterranean Sea

Microscopic algae (phytoplankton) are normal components of all aquatic environments. Sudden population explosions of certain species, also called algal blooms (Photo 6.1), occur naturally. However, there is good evidence that many blooms are caused by eutrophication (especially nitrogen and phosphorus enrichment) from land-based sources (e.g. agricultural run-off, urban and industrial sewage). A study (EMEP/MSC-W, 2000) found that ship traffic contributed to more than 50 % of exceeded critical loads for nutrient nitrogen in parts of the coastline of Greece, Italy, Croatia and Spain.

When marine algae occur in significant numbers and produce biotoxins they are termed **H**armful **A**lgal **B**looms (**HAB**s). HABs are truly a global phenomenon, and evidence is mounting that the nature and extent of the problem has been increasing over the last 10–20 years. This worldwide increase of HABs has also affected the Mediterranean Sea (Smayda, 1990).

To investigate the increase of HABs several research programmes have been initiated. In 1999 a European Initiative on Harmful Algal Blooms (EUROHAB) started. Mediterranean countries such as Spain, Greece and Italy took part. EUROHAB was formulated to generate and coordinate the required research to better manage the effects of toxic/harmful marine microalgae and cyanobacteria in the marine and brackish waters of the EU (Table 6.1). To promote scientific research and cooperation between north African countries on monitoring and management of HABs a network of scientists was established.

**Photo 6.1:** Bloom of *Noctiluca scintillans* in Thessaloniki, February 2002.

**Source:** A. Soupilas.

HAB phenomena take a variety of forms and have multiple impacts which can be differentiated into the following main impact categories:

1. toxic effects on humans;
2. fish kills and contaminated seafood;
3. ecosystem changes;
4. socio-economic effects.

## 6.2 Toxic effects on humans

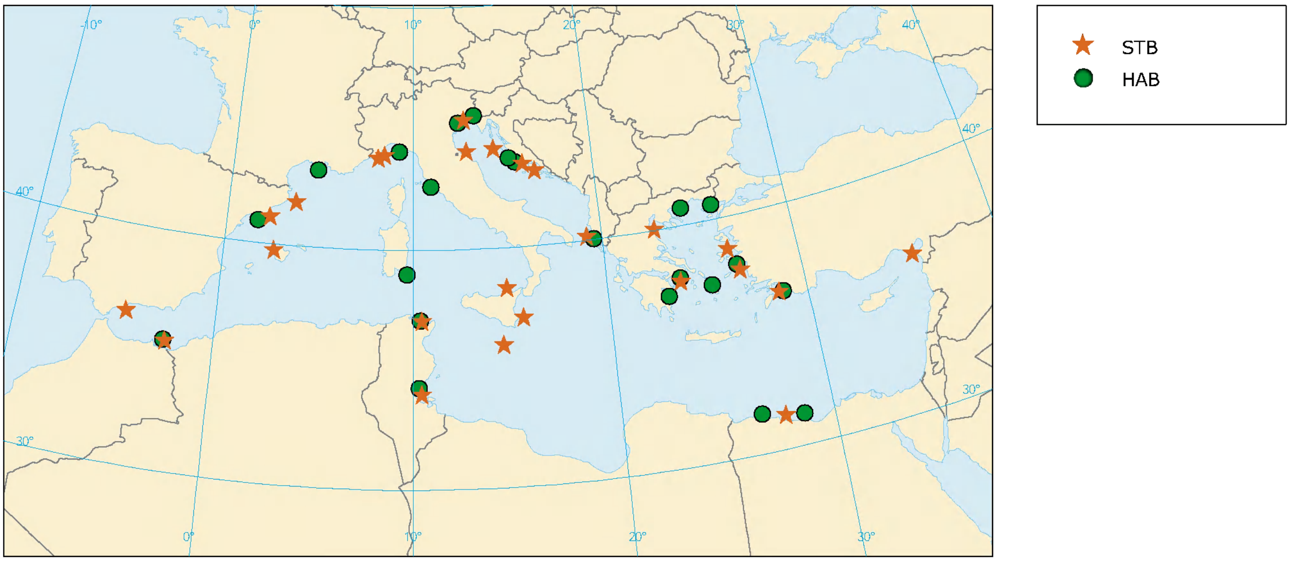
Humans are particularly vulnerable and become sick when consuming foods that have bioaccumulated microalgal toxins (filter-feeding shellfish and fish). The most significant public health problems caused by the consumption of seafood, which is contaminated by HABs, are called **S**eafood **T**oxin **B**looms (**STB**). In the Mediterranean, the

**Table 6.1 The projects of the EUROHAB initiative (Mediterranean countries)**

| |
|---|
| • **BIOHAB** (Biological control of harmful algal blooms in European coastal waters: Role of eutrophication) (**France, Spain**) http://www.nioz.nl/projects/biohab/index.html |
| • **HABES** (Harmful Algal Bloom Expert system), Harmful Introductions by Ships (Test monitoring systems for risk assessment of harmful introduction by ships to European waters) (**Spain**) http://www.habes.net/ |
| • **STRATEGY** (New strategy of monitoring and management of HABs in the Mediterranean Sea)-under negotiation (**France, Greece, Italy, Spain**) http://www.icm.csic.es/bio/projects/strategy/ |
| • **ALIENS** (Algal introductions to European shores) (**France, Italy, Spain**) http://www.uniovi.es/bos/Aliens/E-aliens.htm |
| • **FATE** (Transfer and fate of Harmful Algal Bloom toxins in European marine waters) (**Greece**) http://www.bom.hik.se/~fate/ |

**Source:** http://www.cordis.lu/eesd/ka3/cluster5.htm.

**Figure 6.1 Harmful Algal Blooms (HABs) and Seafood Toxin Blooms (STBs) in the Mediterranean Sea**




**Source:** Compiled by the HCMR based on STRATEGY, FATE, Country report of the EU-Commission and Koray, 2002.

three major symptoms of STB are **DSP** (Diarrhetic Shellfish Poisoning), **PSP** (Paralytic Shellfish Poisoning), and **ASP** (Amnesic Shellfish Poisoning) (Table 6.2). The distribution of HAB and STB blooms in the Mediterranean Sea by country is mapped in Figure 6.1.

## 6.3 Fish kills and contaminated seafood

One major type of impact is mass fish mortality, which occurs when HABs have a high level of toxicity. Accumulation of toxins in filter-feeding marine biota, threatens humans, birds and marine

**Table 6.2 Health problems caused by algal toxins in the Mediterranean**

| STB type | Causative species | Toxin produced | Symptoms | Shellfish/fish |
|---|---|---|---|---|
| **PSP** Paralytic Shellfish Poisoning | Alexandrium andersonii<br>Alexandrium catenella<br>Alexandrium minutum<br>Alexandrium tamarense<br>Gonyaulax spinifera<br>Gymnodinium catenatum<br>Pyrodinium bahamense | Saxitoxins | • Potentially fatal; death occurs within 24 hours in severe cases<br>• Numbness in the mouth and extremities, ataxia, dizziness, floating sensation, headache, respiratory distress, paralysis, death | Mussels, cockles, clams, scallops, oysters, crabs, lobsters |
| **DSP** Diarrhetic Shellfish Poisoning | Dinophysis acuminata<br>Dinophysis acuta<br>Dinophysis caudata<br>Dinophysis fortii<br>Dinophysis mitra<br>Dinophysis rotundata<br>Dinophysis sacculus<br>Dinophysis tripos<br>Dinophysis trypsos<br>Gonyaulax grindley<br>Prorocentrum cassubicum<br>Prorocentrum lima | Okadaic acid | • Diarrhoea, nausea, vomiting, abdominal cramps and chills | Mussel, cockles, oysters |
| **ASP** Amnesic Shellfish Poisoning | Pseudo-nitzschia delicatissima<br>Pseudo-nitzschia multiseries<br>Pseudo-nitzschia multistriata<br>Pseudo-nitzschia pseudodelicatissima<br>Pseudo-nitzschia pungens | Domoic acid | • Potentially fatal; within 24 hours of eating contaminated shellfish<br>• Abdominal cramps, diarrhoea, dizziness, headache, seizures, disorientation, short-term memory loss, paralysis | Oysters, clams |

**Source:** Hawkey J (ed.), 2003, EEA, 1999, www.bi.ku.dk/ioc/IOC_List.doc, Country report of the EU-Commission and Koray, 2002.

mammals feeding on them. In 2001, no HAB monitoring occurred for fish farms in Spain, Greece and Italy (Anderson *et al.*, 2001). Although there is increasing discussion on the potential role of acquaculture in HAB development, only a few studies are available which underline the relation between HAB frequency and human activities. International transport and increased interstate distribution of seafood and international travel by seafood consumers means that practically nobody is wholly free of risk from biotoxins that originate from microscopic marine algae.

## 6.4 Ecosystem changes

Until now, the impact of HAB species on the ecosystem is one of the least understood. Although the negative effects are obvious, the causes are subtle and difficult to discern. Such effects include:

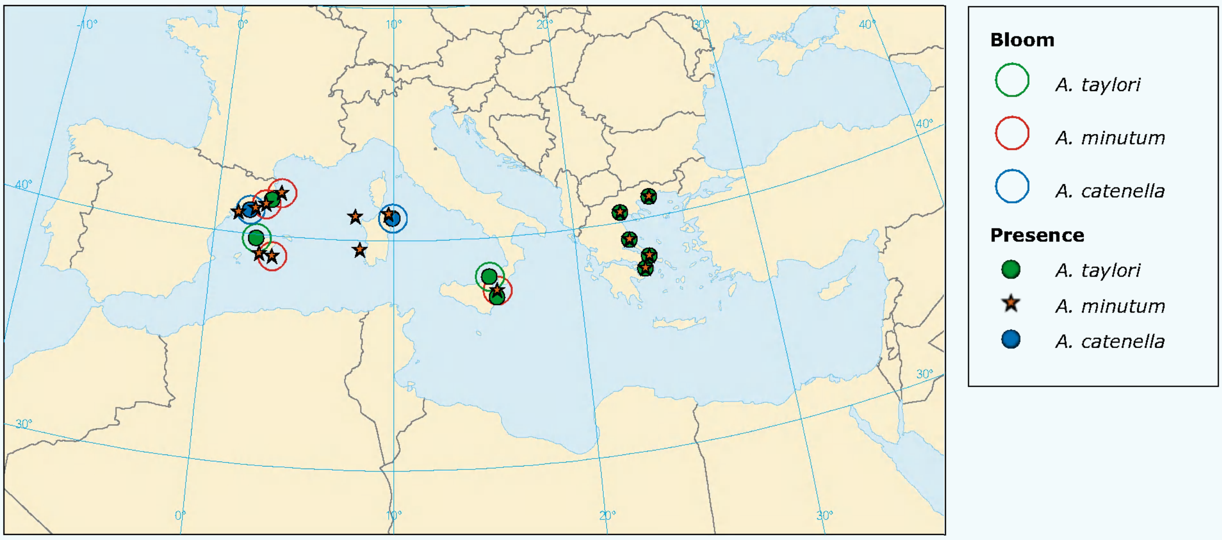
- mass mortalities of fish or marine mammals;
- accumulation of unpleasant foam and mucilage on the coast;
- discolouration of the water;
- low oxygen levels in bottom water caused by degradation of HABs.

To understand these effects, researchers are trying to describe the factors that control the dynamics of individual HAB species and to understand the physiological, behavioural and morphological characteristics of HABs and how these interact with environmental conditions. In parallel, current research is addressing the transportation of resistant cysts via ballast waters or the introduction/invasion through canals (e.g. Suez Canal) — see also NIS. The increasing threat posed by such organisms has been on the agenda of the International Maritime Organization (IMO) since 1973.

**Box 6.1 *Alexandrium* spp.- STRATEGY, an EU-funded research project**

The genus *Alexandrium* is a group of dinoflagellates which cause many HABs in the Mediterranean Sea (Garcés *et al.*, 2000). The research of STRATEGY puts emphasis on three *Alexandrium* species. *A. taylori, A. minutum and A. catenella*. From the STRATEGY study areas (Figure 6.2) only the coast of Greece was not affected by blooms. Another relevant output of STRATEGY is related to the finding of resting cysts in sediment harbours, an indication of transportation via ballast waters.

**Figure 6.2 Presence of *Alexandrium* species and areas affected by blooms during first sampling period (March–October 2002) in the Mediterranean Sea**




**Source:** STRATEGY project.

## 6.5 Socio-economic effects

**Box 6.2 Socio-economic effects of HABs — ECOHARM, an EU-funded research project**

The total expenses for medical treatment, transportation and lost wages due to illness caused by HABs are considered by Todd (1993) as a public health impact. He estimated that each reported DSP case costs 1 462 EUR and each reported PSP case 1 154 EUR. Case studies of ECOHARM, which were conducted in the summer of 2003, and mussel aquaculture data collected by the FAO from 1984 to 2001 were used to evaluate the socio-economic impact of HABs. The results for three evaluated Mediterranean countries (Greece, Italy and Spain) show that the total socio-economic impact of HABs is around 329 million euro per year based on available information on HAB events and reported cases of illness from 1989 to 1998.

**Source:** ECOHARM, http://www.bom.hik.se/ECOHARM/.

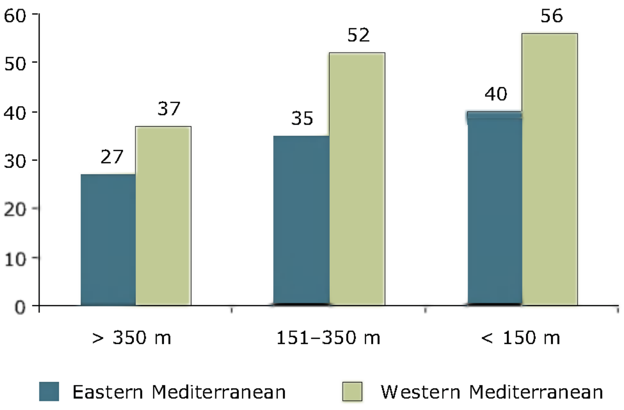
# 7 Key issue: ecosystem changes due to unsustainable fishing

## 7.1 The ecosystem approach in fisheries

Widespread interest in the environmental impact of fishing and its ecosystem effects has stimulated intense research in the last 15 years. It is not just the fish populations that need protecting but also the environment that supports them. A number of recent studies has established that intensive fishing dramatically impacts all levels of biological organisation of marine life, i.e. population, communities and the ecosystem.

Fishing in the Mediterranean has increased by about 48 % since 1970 with high exploitation of both bottom-living (demersal) and big pelagic stocks, e.g. tuna and swordfish (Figure 7.1). The overall upward catch trends for many species registered up until about a decade ago suggest that perhaps recruitment of young fish has been conserved unintentionally despite intensive fishery for demersals and a lack of quota control. However, short-term trends over the last ten years now reflect a general picture of full- to over-exploitation for most demersal and shellfish populations.

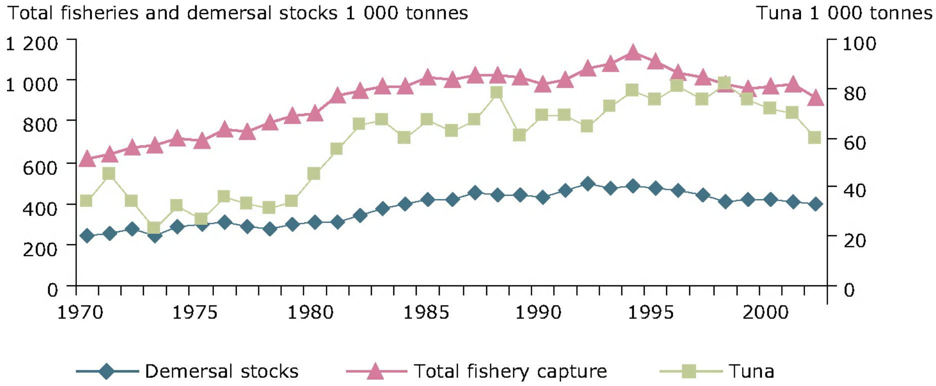
**Figure 7.2 Trend in discard rates in % (biomass discarded to total catch) with fishing depth**




**Source:** HCMR based on Vassilopoulou and Papaconstantinou, 1998; Carbonell *et al.*, 1998.

Based on the results of the MEDITS programme ([1]), Bertrand *et al.* (2002) concluded that over-exploitation has led to a serious decline in many fish stocks.

**Figure 7.1 Trends in capture fisheries production**




**Source:** HCMR based on FAO FISHSTAT PLUS, 2004a.

([1]) Funded by EU in France, Greece, Italy and Spain since 1994 to carry out regular standardised trawl surveys along the northern shelves of the Mediterranean.

## 7.2 Biodiversity loss — the problem of discards

A major impact of fishing on the marine ecosystem comes from the fact that fishing practices lead to discards.

Discard rates range with fishing depth (Figure 7.2), gear used (mesh size) and targeted species (complex of species). However, analysing discards from deep water trawling (250–750 m), D'Onghia *et al.* (2003) found that discard rates increased with total catch and depth. The species composition of discards in the Mediterranean and the number of discarded animals are different between the eastern and western parts (Figure 7.3). However, this difference may be attributed to the lack of data.

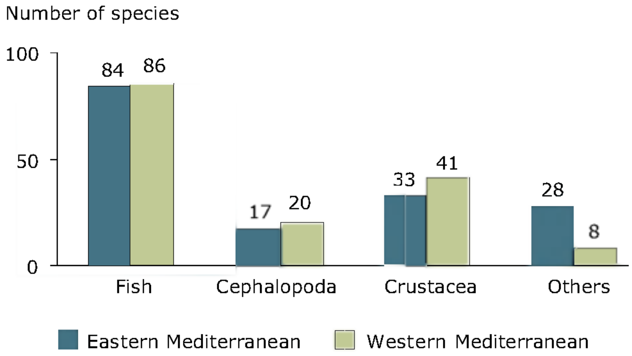
Effects on the biodiversity of non-target species and habitats caused by trawling are key issues because loss of biodiversity has been documented in many cases.

In deep fishing grounds, such as the biotopes of the Norway lobster and red shrimp, biodiversity loss is crucial (Figure 7.4). Thus, of the 162 species caught in the trawl (eastern Mediterranean), two were the target species, 34 were by-catch of variable commercial value and the remaining 126 were unwanted species (D'Onghia *et al.*, 2003). It is characteristic that among the discarded unwanted species, sensitive taxa such as stony corals (*Caryophylia smithii, Desmophyllum cristagalli*), sea pens (*Funiculina quadrangularis, Pennatula rubra, Kophobelemnon leucarti*), sea fans (*Isidella elongata*) and soft coral (*Alcyonium palmatum*) prevailed.

The physical disturbance of the sea-bed by the dragging of gear can cause long-term changes to fragile habitats and affect the number and diversity of organisms that live there. A recent report by M. Gianni for WWF, IUCN and NRDC, titled, '*High Seas Bottom Fisheries and their Impact on the Biodiversity of Vulnerable Deep-Sea Ecosystems*', stresses that '*some species, such as corals and sponges, are particularly sensitive to disturbance. Deep sea ecosystems such as cold-water coral reefs can be destroyed by a single trawl. It is time that the international community takes action before they are completely wiped out*' (Gianni, 2004).

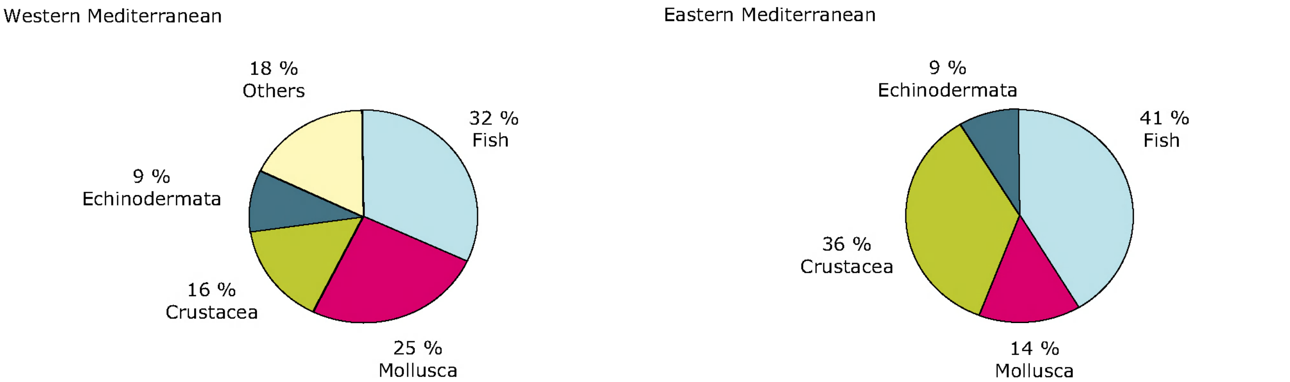
- A key issue is the frequent destruction of the *Posidonia* meadows as a result of illegal beam trawling activities in addition to otter trawling. A recent study in the western Mediterranean showed a destruction of 10 % in sea-grass cover on degraded meadows and of only 3.5 % on dense meadows (Ardizzone *et al.*, 2000; UNEP, RAC/SPA, 2003).

**Figure 7.4 Qualitative composition of hauls in the Mediterranean deep sea fisheries for lobster and shrimp**




**Source:** HCMR based on D'Onghia *et al.*, 2003 (Eastern Mediterranean) and Sartor *et al.*, 2003 (Western Mediterranean).

**Figure 7.3 Discarded species composition resulting from trawling activities at 150–400 m depth in the Mediterranean**




**Source:** HCMR based on Carbonell *et al.*, 1998 (for western Mediterranean) and Machias *et al.*, 2001; TRIBE, 1997 (for eastern Mediterranean).

- Well-preserved Mediterranean maerl grounds (Photo 7.1) are sites with a high diversity that support a high macrobenthic secondary production. These sites can be important for species of commercial interest. High trawling pressure on maerl areas may negatively affect assemblages by breaking up rhodoliths, diminishing their cover and hence affecting the associated biota. Indirectly, they may enhance siltation and turbidity (Bordehore *et al.*, 2003).

## 7.3 Changes in the structure of fish populations

Demersal stocks in the Mediterranean are dominated by juveniles, which can be indicative of high fishing pressure.

Some analyses of this phenomenon include:

- A population dynamics study of hake (*Merluccius merluccius*) exploited with two different trawl nets (i.e. the Italian traditional one and the so called 'French' net) in the north Tyrrhenian Sea revealed that the length-frequency distributions of the landings for both gears principally consisted of size classes smaller than first time spawners (Reale *et al.*, 1995).
- The dominance of young fish in the MEDITS samples of red mullet (*Mullus barbatus*) and striped red mullet (*Mullus surmuletus*) makes the stocks highly vulnerable to recruitment changes. Hence protection of spawning and nursery areas seems to be essential for their protection (Tserpes *et al.*, 2002).
- Age structure of populations of the four-spotted megrim (*Lepidorhombus boscii)* and the spotted flounder (*Citharus linguatula)* showed that the sampled populations mainly consisted of juveniles (Sartor *et al.*, 2002).

UNEP, RAC/SPA (2003) noted: '*Demersal populations are consequently overfished; shallow areas (within the 3-mile coastal limit or on bottoms less than 50 m deep, depending on the country) are illegally trawled, and small, illegal mesh sizes are used. The use of small and illegal mesh sizes in codend is certainly a common practice for many artisanal fisheries but poorly reported in the literature. Due to the traditional large interest in small fishes, massive catches of undersized fish are seasonally carried out in some bottom trawl fisheries. For example, the well-known massive harvest of undersized red mullet which are caught in shallow grounds in the autumn in the Gulf of Lions or in the Adriatic Sea*'.

**Photo 7.1:** Maerl beds.

**Source:** http://www.marlin.ac.uk/baski/image_viewer.asp?images=phycal&topic=Species.

*Fishing down marine food web*

As over-fishing reduces the populations of more valuable larger fish that are at higher trophic levels, such as piscivores (fish that feed on other fish), the landings of fish lower down the food web, such as zooplanktivores (fish, which feed on zooplankton), make up a larger proportion of the overall catch. This is generally indicative of a negative impact on the whole ecosystem caused by fishing and has been called '***fishing down marine food webs***' (Figure 7.5). This phenomenon was first demonstrated by Pauly *et al.* (1998) and is evident in many fishing areas globally.

- According to FAO fisheries statistics, the mean trophic level of Mediterranean catches declined

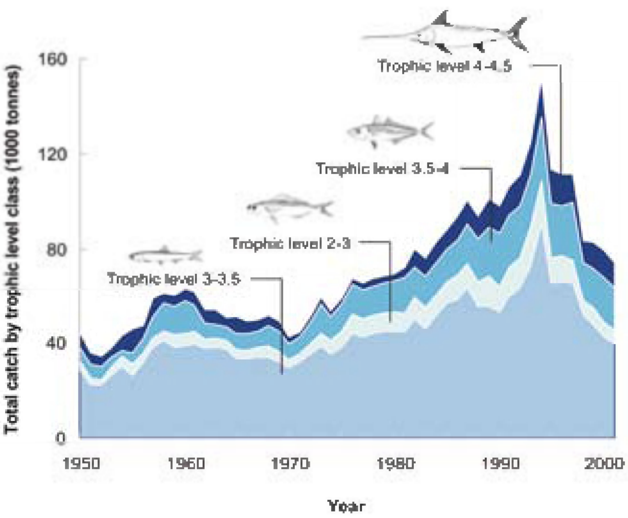
**Figure 7.5 Fishing down marine food web**


**Source:** Designed by Daniel Pauly, original by Rachel Atanaceo.

by about one trophic level during the last 50 years (Pauly *et al.*, 1998). For example, the mean trophic level of catches in Hellenic waters has decreased in the late 1990s (Figure 7.6).

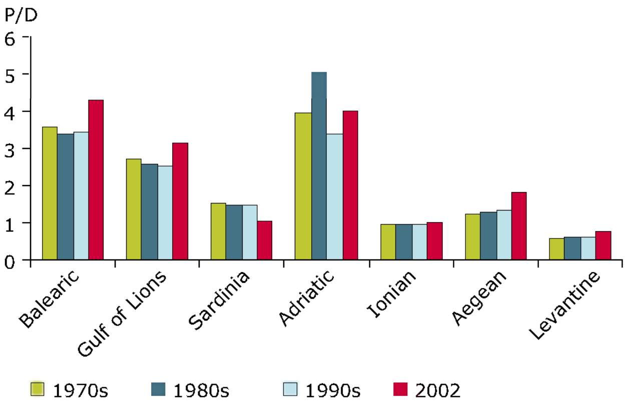
One simple indicator that can be derived from commercial statistics, as a measure of the status of the fish community, is the ratio of pelagic/demersal catches (P/D ratio). The P/D ratio for European semi-enclosed seas ranges from just over 1:1 for oligotrophic or nutrient-poor basins such as the Mediterranean. In the North Sea it is between 2:1 and 5:1 and is more than 10:1 for enclosed basins (De Leiva Moreno *et al.*, 2000). While examining the impact on fish resources over the past 30 years, a clear spatial pattern has been found from the oligotrophic eastern Mediterranean (Levantine, Ionian and Aegean Seas) to the western basin with moderate levels of nutrient availability (Gulf of Lions and Balearic Sea) (Figure 7.7).

**Figure 7.6 Long-term changes in fish catches in Hellenic waters aggregated by four trophic level classes**




**Source:** Stergiou and Koulouris, 2000.

**Figure 7.7 Trends in (average) ratio of Pelagic/Demersal fish catches in 1970–2002 across the Mediterranean**




**Note:** 70s, 80s and 90s = average values of catches for each decade.

2002 = catches value in 2002.

Catches: Fish that are caught and landed.

**Source:** HCMR based on FAO FISHSTAT Plus, 2004a and De Leiva Moreno *et al.*, 2000.

# 8 Key issue: ecosystem changes due to aquaculture development

In recent years, aquaculture has been the only segment of the fisheries industry in the European Community to experience a rise in employment. The sector accounts for approximately 60 000 full-time jobs, mostly in coastal and rural areas (Fischler, 1999). In the Mediterranean, aquaculture increased overall from 19 997 tonnes in 1970 to 339 185 in 2002 (Figure 8.1).

However, recent expansion of aquaculture has often been associated with negative publicity. The fact that aquaculture takes place mainly in the coastal zone where biodiversity is high and human pressures are increasing has aggravated the effects of potential impacts.

An integrated ecosystem approach has only seldom been applied to aquaculture. Most environmental studies have been done at local level, i.e. single farm. The effects on a local scale are thus well documented whereas the effects at an ecosystem level remain unexplored. Assessing effects at ecosystem level are hindered because there is a large difference in sensitivity and assimilation capacity of different ecosystems. Furthermore, general conclusions cannot be easily drawn since the impact of aquaculture depends on species, culture method, stocking density, feed type and hydrography of the site and aquaculture practices.

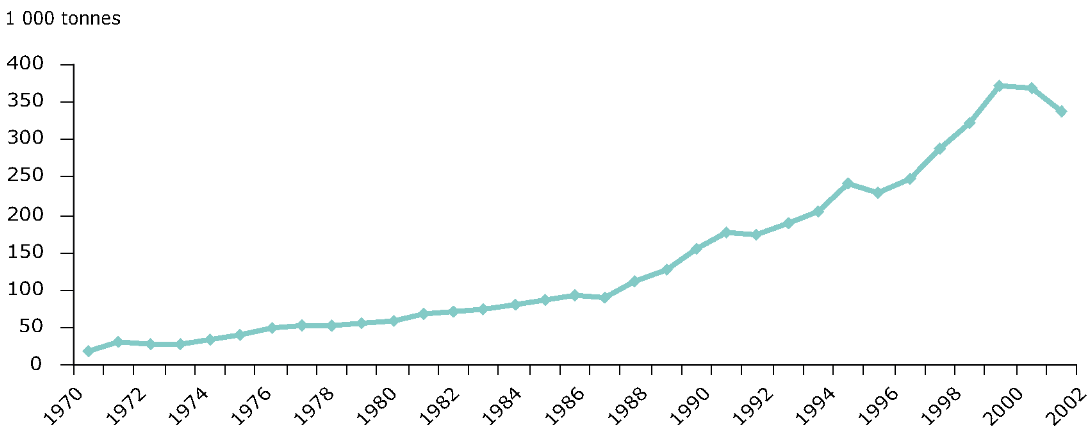
In general, farming of finfish and shellfish is regarded as a threat to the marine environment since it can induce pollution and can lead to conflicts with other users. In the Mediterranean, such threats must be regarded as potential as there is little direct evidence of aquaculture impact. However, it should be pointed out that a lack of scientific validation of a perceived impact does not reduce its potential importance (Gowen *et al.*, 1990). According to UNEP/MAP/MEDPOL, intensive aquaculture is 'undoubtedly a matter of concern for the Mediterranean' (UNEP/MAP/MEDPOL, 2004).

## 8.1 Key issues of aquaculture impact

*Eutrophication ⇒ no clear connection*

Limited studies on the issue in the Mediterranean lead to inconclusive evidence as to the threat of eutrophication. It has been argued that the quantities of nutrients (phosphorus and nitrogen) released from aquaculture are small relative to the total discharges from human activity (P and N loads into the Mediterranean from agriculture were estimated at 976 000 t/y and 1 570 000 t/y respectively, as contrasted to 394 t/y and 8 678 t/y attributed to aquaculture (Izzo, 2001)). However, discharge from intensive aquaculture often represents a localised discharge of waste into

**Figure 8.1 Aquaculture production (marine and brackish; thousand tonnes) in 1970–2002 in the Mediterranean Sea**




**Source:** HCMR based on FAO FISHSTAT PLUS, 2004b.

nutrient poor waters where such impact could be significant (UNEP/MAP/MEDPOL, 2004).

*Enrichment of sediments ⇒ impact limited spatially*

The most widely known effect of fish farming is benthic enrichment, i.e. increased organic content of the sediment beneath the fish cages. The deposition of particulate organic material, i.e. faecal material and uneaten fish feed, in the immediate vicinity of the farm leads to increased oxygen demand, a condition that often results in anaerobic metabolism and anoxia. The severity of the impact is site-specific and related to local attributes such as depth, hydrographical conditions, quality of ambient water, and geomorphology (sediment type). Impacts are in general limited both on a temporal and a spatial scale, and recovery can be swift when the operation ceases, i.e. between 3 to 10 months. Time of recovery to the initial state is 10 times quicker for marine aquaculture than for industrial and urban discharge impacts (Johnson and Frid, 1995).

Increased organic supply may encompass a positive aspect, i.e. immigration of new species. The relatively low impact of organic enrichment on the sea-bed has been attributed to the consumption of the organic matter by demersal fish and invertebrates according to data from the Mediterranean Sea (McDougall and Black, 1999). Underwater video surveys beneath fish farms in the western and eastern Mediterranean confirmed the aggregation of various species of wild fish under the fish cages during feed supply. Similar preliminary results from Israel suggest that cages can act as attractors of schooling species that feed on fouling algae and discharged organic matter.

Studies in Greece revealed that the overall abundance of the fish assemblage increased by a factor of four and the average trophic level of the fish community increased from 3.59 to 3.79 after the introduction of fish farms in oligotrophic waters (Machias *et al.*, 2004).

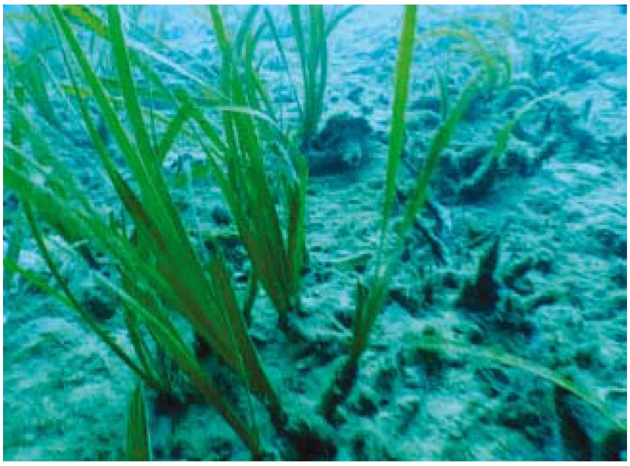


**Photo 8.1:** Sea-grass meadow.

**Source:** N. Krstulovic and G. Kuspilic, Institute of Oceanography and Fisheries, Split, Croatia, 2003.

*Changes in diversity ⇒ reduction in abundance, diversity and biomass of macrofauna and flora, as well as in abundance and diversity of meiofauna*

The mortality of large benthic fauna, the deterioration of sea-grass meadows and the changes in the trophic status of large water bodies are the main potential impacts of aquaculture on ecosystem biodiversity. However, severe effects are generally confined to the local area, i.e. a few hundred metres at most and recovery of the local ecosystem, albeit at slow rates, can follow if the farm operation ceases.

*Ecosystem health ⇒ probable deterioration*

At present, most of the scientifically documented effects of fish farming are those on macrofaunal invertebrates at a zone beneath and close to the farm cages. The documented local elimination of macrofauna is ecologically important but it is very unlikely that they will become extinct or that the population at larger spatial scales will be significantly affected.

Changes have been documented in the microbial component of the benthic community as a result of fish farming activities (Table 8.1).

**Table 8.1 Reported impacts of fish farming on meiobenthos**

| Area | Impact | Reference |
|---|---|---|
| Eastern Mediterranean | Microbial densities of the sediment near the cages was found to increase by 4–28 times | Karakassis *et al.*, 2000 |
| Tyrrhenian Sea | Density of bacterial and vibrio microbial aerobic communities rapidly increased following the deployment of a fish cage | La Rosa *et al.*, 2004 |
| Northwestern Mediterranean | Increase in bacterial abundance | La Rosa *et al.*, 2004 |

**Box 8.1 Detrimental and chronic effects on sea-grass meadows**

The close proximity of fish farms and sea-grass areas pose a serious threat to the integrity of the *Posidonia* meadows. These meadows constitute key ecosystems of the Mediterranean marine environment and play a major role in the spawning and recruitment of various marine organisms. There has been evidence that sea-grass meadows were severely affected or became totally eliminated as a consequence of fish farming in Fornells Bay, Minorca, Balearic Isles (Delgado *et al*., 1999). Here, there were no signs of recovery for at least three years after cessation of aquaculture activities.

Other documented cases in:

- *Western Mediterranean, SE Spain*
  53 % of the meadow area had decreased shoot sizes, leaves per shoot and leaf growth rate (Ruiz *et al*., 2001).
- *Western Mediterranean, Corsica*
  The meadow shoot density decreased from 466 (reference station) to 108 per $m^2$ at impacted site (Cancemi *et al*., 2003).
- *Western Mediterranean, Sardinia*
  Disappearance of the sea-grasses underneath the cages (Pergent *et al*., 1999).
- *Central Mediterranean, Malta*
  Severe changes in meadow ecosystems (Dimech *et al*., 2002).
- *Eastern Mediterranean, Croatia*
  Beds have almost disappeared beneath the cages and have regressed in the entire bay (Katavic and Antolic, 1999).

**Box 8.2 Case study — combined impacts of tuna farming**

Tuna farming (specifically the penning of bluefin tuna for fattening) is an activity that poses several threats to the marine environment and serves as an example of the range of potential aquaculture impacts. Such impacts include:

- local pollution, if the activity is not settled in offshore water;
- resource depletion (tuna farming industry currently depends on the capture of wild fish, with increasing and uncontrolled demand);
- and impact on small pelagic fish stocks which serve as food for the tuna.

Tuna cage culture has become a subject of heated debates in Croatia (NDA, Croatia, 2003). Degradation of the benthic community below the cages was recorded from all the culture sites along with some adverse effects on the water column as well as on the sediments. There is an ongoing discussion on the possible impact of removal of fry (sea bass, sea bream and *Mugilidae* spp.) to satisfy the food needs of aquaculture, particularly in Egypt. However, as the industry is more and more dependent on hatchery-raised fry, the practice is not regarded as a hazard. ICCAT (International Commission for the Conservation of Atlantic Tuna) and GFCM (General Fisheries Commission for the Mediterranean) are convening a Working Group on the bluefin tuna farming issue. They aim to develop practical guidelines on the collection of tuna spawners used for fry production, the management of the tuna farming as well as potential environmental, social and economic issues.

- Studies underneath mussel farms revealed similar results to fish farms with increased densities of microbial assemblages. However, the impact of mussel farms has proven considerably less severe than that of fish farms.
- Studies in the Adriatic suggest that mussel farms do not significantly alter the marine ecosystem when benthos, biochemical, microbial and meiofaunal parameters were investigated (Danovaro *et al.*, 2004).

*Pharmaceuticals and chemicals ⇒ no clear connection; monitoring required*

The use of a variety of organic chemicals and pharmaceuticals for disease prevention, disinfection and therapy as well as metals for anti-foulants is a common practice in fish farming. These chemicals can pose a serious threat to the environment. Currently, studies in the Mediterranean are lacking, especially on a long-term and a large spatial scale.

According to a UNEP/MAP/MEDPOL report, even 'the compilation of a complete and quantitative list of mariculture chemicals used in the Mediterranean is at present impossible'.

However, a joint ICES-CIESM effort has been put forward to address the issue on a pan-European level. These efforts are taking a precautionary approach.

*Transfer of parasites and diseases ⇒ no clear connection; monitoring required*

In the Mediterranean no such impacts have been observed so far (IUCN, 2004).

*Escapees/GMOs ⇒ no clear connection; monitoring required*

This is not an issue in the Mediterranean as no impacts have been observed in the area so far.

*Other users of the coastal area ⇒ impact on tourism*

Tourism and marine aquaculture interact negatively with each other as illustrated by cases from Cyprus and Croatia. An integrated approach in planning coastal zone management is strongly advised to mitigate the problem. In both countries the implementation of ICZM has minimised the impact of ill-planned aquaculture activity near areas of importance for tourism (Stephanou, 1997; NDA Croatia, 2003).

# 9 Key issue: ecological quality status in coastal areas

At their 12th meeting held in Monaco in November 2001, the contracting parties to the Barcelona Convention requested the MED POL Programme to review and develop a set of marine pollution indicators, in cooperation with Blue Plan, EEA, UNIDO-ICS and other competent bodies and organisations (UNEP/MAP, 2003b). Based on Guidelines for the Development of Ecological Status and Stress Reduction Indicators (UNEP/MAP, 2003c) and the outcome of the relevant Marine Pollution Indicators (MPI) Workshop (UNEP/MAP, 2005), the proposed biological indicators of the core set of MPIs, adopting the DPSIR framework, includes the following:

- number of exotic species (all taxa) (see Chapter 5) (state impact);
- presence and coverage of benthic macrophytes (sensitive/opportunistic) (state);
- presence/abundance of sensitive/opportunistic zoobenthic species/taxa (state);
- community diversity (zoobenthos/phytobenthos) (state);
- biotic indices;
- Ecological evaluation index based on macrophytes (EEI) — not covered in this report (state);
- Ecological quality index based on zoobenthos (BENTIX) (state).

The proposed ROAD MAP of UNEP/MAP in the short term (2004–2006) includes:

a) developing methodology sheets for each of the above indicators to correspond with existing sheets developed by related organisations;
b) undertaking a test procedure in a few Mediterranean countries. The invasion of exotic species, being a key issue in the Mediterranean, is covered separately (Chapter 5).

It has to be noted that the above-proposed system is one of the possibilities to be used as the discussion about indicators remains still open.

## 9.1 Presence and coverage of benthic macrophytes (sensitive/opportunistic)

The presence and coverage of benthic macrophytes (sensitive/opportunistic) has received much attention. A specific action plan entitled 'Mediterranean Marine Vegetation' is included in the UNEP/MAP. The sea-grasses are already used in some monitoring projects of the EU countries (e.g. France). In addition, species such as *Posidonia oceanica, Cymodocea nodosa, Zostera noltii* and the brown seaweed *Cystoseira* are described as endangered in the Barcelona Convention.

*Key messages*

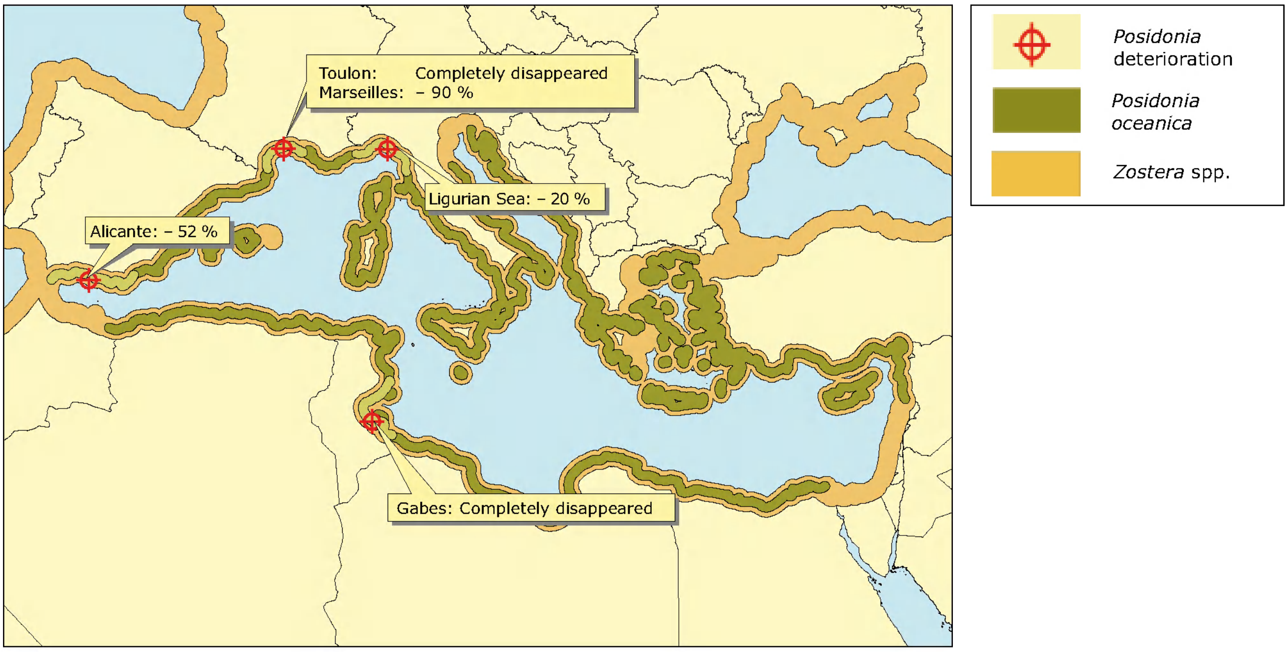
- Presence of sensitive benthic macrophytes is indicative of good ecological quality.
- Depth distribution limit and density of roots of rooted sea-grasses are successfully employed in assessing ecological quality status/changes.
- Presence of opportunistic benthic macrophytes (such as some newly introduced macroalgae) may be indicative of environmental degradation.

Benthic macrophytes are a common biological element along the Mediterranean coastline. The *Cystoseira* communities together with the *Posidonia* meadows are the main supporters of biodiversity in shallow water. Since these communities best develop between the surface and 10 m depth, they are often exposed to intertidal pollution. The most typical example is that of *Posidonia oceanica*, which is a key species for the Mediterranean region. Its population is therefore monitored as '*Populations of key species including protected ones*'. Deterioration of the *Posidonia* meadows attributed to anthropogenic impact across the Mediterranean is depicted in Figure 9.1.

There are indications that improvement of wastewater treatment along the French Mediterranean coastline and direct protection regulation of *Posidonia oceanica* (since 1988) has led to improvement of the meadows (in 1990 50 % of the sites were in regression; from 1990–1993 27 % were in regression; 46 % were stable and 27 % were in progression).

Although highly invasive, *Caulerpa racemosa* has not been the subject of large-scale research projects to describe its expansion (Table 9.1, Figure 9.2). Aranda (2004) reports the presence of *Caulerpa racemosa* in the Valencia area (Spanish coast). In 1999, about 3 $km^2$ of the bottom were occupied by *Caulerpa racemosa* at Castellon. In 2000, the species was found

**Figure 9.1 Distribution of the marine sea-grasses *Posidonia oceanica* and *Zostera* spp. in the Mediterranean**




**Source:** EEA, 2004a.

**Table 9.1 First records of *Caulerpa racemosa* in Mediterranean countries**

| | | | |
|---|---|---|---|
| Albania | 1995 | Lebanon | 1931* |
| Croatia | 2000 | Libya | 1991 |
| Cyprus | 1999 | Malta | 1999 |
| Egypt | 1950* | Gaza Strip | 1941* |
| France | 2000 | Spain | 1999 |
| Greece | 1994 | Syria | 1957* |
| Israel | 1960* | Tunisia | 1926* |
| Italy | 1993 | Turkey | 1976* |

*cited as *Caulerpa racemosa* (forma *lamourouxii*)

**Source:** HCMR based on: Piazzi *et al.*, in press, www.caulerpa.org.

in Alicante and a survey carried out in 2002 showed that 10 km$^2$ of the bottom was occupied along 18 km of coastline. In 2002, the species was also found at Sagundo (Valencia) and in 2003 at Tabarca (Marine Park) where 3 000 m$^2$ of the bottom were occupied.

## 9.2 Presence/abundance of sensitive/opportunistic zoobenthic species/taxa

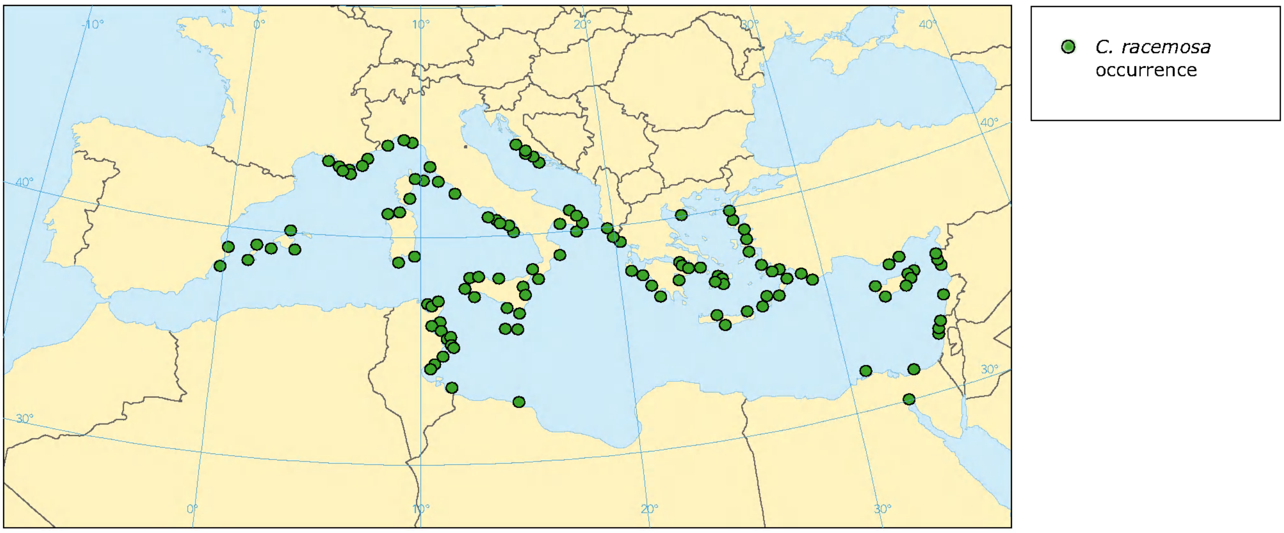
*Key messages*

- The presence of sensitive taxa is a reliable measure of ecosystem health.
- The dominance of tolerant species/taxa is proportionate to the degree of disturbance.

## 9.3 Community diversity index (H) based on zoobenthos

**The Shannon-Wiener diversity index (H)** has been widely used and tested in various environments. However, the use and interpretation of this index has been subjected to long debate. This index depends on sample size, effort and on habitat type. Ideally, it should refer to a standard sampling surface. Based on the community diversity index, five classes of community health can be found in Mediterranean

**Figure 9.2 *Caulerpa racemosa* records in the Mediterranean Sea**




**Source:** HCMR based on: Piazzi *et al.*, in press, www.caulerpa.org, UNEP/MAP, 2004a.

**Box 9.1 Mortality of key species of sponges**

The phenomenon of mass mortality of marine invertebrates is not rare in the Mediterranean. Mortality of sponges was reported in the north west Mediterranean in the summer of 1999. The area affected stretches from Elba Island in Italy to the Bay of Marseilles in France. All other north western Mediterranean regions appeared to have been spared by this event (www.biomareweb.org). However, cases of mortality have been reported in August and September 1999 in Tunisia, Greece, Morocco, Cyprus and Turkey (Perez *et al.*, 2000). The degradation of biodiversity-rich ecosystems, such as that of the marine park of the isles of Zebra in Tunisia, can be indicated by the reduced population density of sponges (Table 9.3). It is assumed that the degradation is related to the presence of *Caulerpa racemosa* and *Caulerpa taxifolia.*

**Table 9.3 Density of gorgonians (colonies/m²)**

| | Cape Bon | Eastern Zebra and Zembretta | Zone of Sidi Daoud | Southeast Zebretta | Western Zebretta | Tabarka |
|---|---|---|---|---|---|---|
| *Eunicella singularis* | 8 to 10 | 17 to 25 | 50 | 40 | 35 | 70 |
| *Eunicella cavolinii* | 2 to 3 | 3 to 5 | 25 | 15 | absent | absent |

**Source:** Ben Mustafa and Abed, 2001.

**Photo 9.1:** *Eunicella singularis* Porquerolles Island, France (13 m). This *Eunicella* has been severely affected by two mortality events which occurred in 1999 and 2003 in the northwestern Mediterranean.

**Source:** Thierry Perez.

coastal waters (Table 9.4). These apply mostly to muddy sands or sandy mud marine benthic habitats. The limits of these classes are somewhat arbitrary and they are based on literature and experience of the authors. However, it is further supported by literature from other Mediterranean areas.

## 9.4 Ecological quality status based on zoobenthos

The various tools used as indicators are often adapted to regional requirements and biological particularities. In Spain, a biotic index called AMBI was developed by Borja *et al.* (2000). This is used for the assessment of the ecological quality of European coasts and estuaries, analysing the response of soft-bottom benthic communities to natural and man-induced changes in water and sediment quality. AMBI is based on five ecological groups related to the degree of sensitivity/tolerance to an environmental stress gradient, and is now being used in the implementation of the Water Framework Directive (WFD) and inter-calibration with other countries. BENTIX (Simboura and Zenetos, 2002) is a newly developed tool (based on macrozoobenthos of soft substrata) to assess ecological quality status in accordance with the needs of the WFD. The resulting classification system (Table 9.5) includes five levels of ecological quality status (EQS) in accordance with the needs of the WFD.

AMBI and BENTIX have a lot of similarities. AMBI has been used in many locations in the Atlantic and in some locations in the Mediterranean (Borja *et al.*, 2003). The BENTIX index discriminates between only two ecological groups and is probably more appropriate and convenient for Mediterranean ecosystems with a high species richness and diversity. The results obtained are consistent with those obtained using several widely applied methods and parameters, such as species richness and community diversity.

*Key messages*

- Ecological evaluation of benthic ecosystems across the Mediterranean is feasible by using a simple tool (BENTIX), which is not community type specific or site specific (global application).
- BENTIX appears to work well for different types of stress (sewage, fishing, dumping) but is best applicable to assess effects of wastewater in coastal waters.
- AMBI has been checked under different environmental impact sources, both in coastal and estuarine waters; however, it appears to work successfully under a variety of impacts.
- Best assessment of EQS is achieved by a combination of BENTIX with H (community diversity) and S (number of species).

**Table 9.4 Classification of EQS according to range of the community diversity index (H)**

| Pollution classification | H | EQS WFD | H in physically stressed mud |
|---|---|---|---|
| Normal/pristine | H > 4.6 | High | H > 5 |
| Slightly polluted, transitional | 4 < H ≤ 4.6 | Good | 4 < H ≤ 5 |
| Moderately polluted | 3 < H ≤ 4 | Moderate | |
| Heavily polluted | 1.5 < H ≤ 3 | Poor | |
| Devoid of animal life to heavily polluted | 0 < H ≤ 1.5 | Bad | |

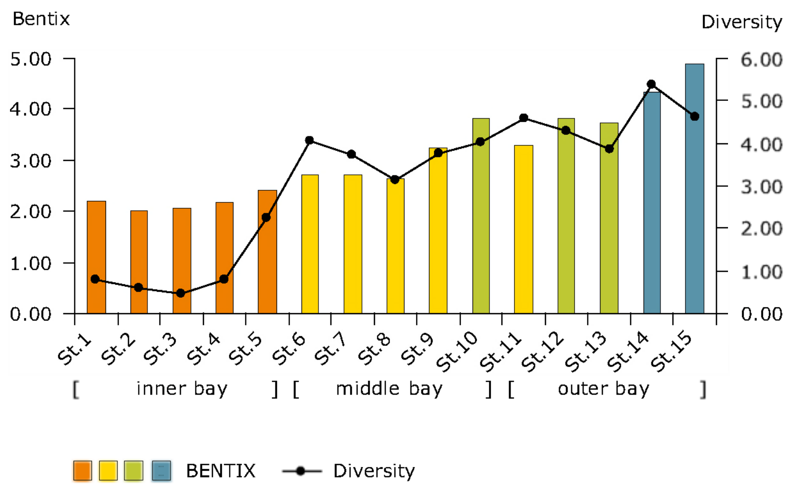
**Source:** Zenetos and Simboura, 2001; Simboura and Zenetos, 2002.

**Table 9.5 Classification of EQS according to the range of BENTIX**

| Pollution Classification | BENTIX | EQS WFD | BENTIX in physically stressed muds |
|---|---|---|---|
| Normal/Pristine | 4.5 ≤ BENTIX ≤6 | High | 4 ≤ BENTIX ≤ 6 |
| Slightly polluted, transitional | 3.5 ≤ BENTIX < 4.5 | Good | 3.0 ≤ BENTIX < 4.00 |
| Moderately polluted | 2.5 ≤ BENTIX < 3.5 | Moderate | 2.5 ≤ BENTIX < 3.00 |
| Heavily polluted | 2 ≤ BENTIX < 2.5 | Poor | |
| Devoid of animal life | BENTIX < 2 | Bad | |

**Source:** Zenetos and Simboura, 2001; Simboura and Zenetos, 2002.

**Figure 9.3 Yearly average values of BENTIX and community diversity (H) along a pollution gradient in Izmir Bay at stations 1–15**




**Source:** Dogan, 2004.

Both BENTIX and H have been tested with datasets derived from:

- various geographic areas within the Mediterranean;
- coastal areas affected by different anthropogenic activities namely fishing, tourism, sewage and chemical effluents;
- the use of different sampling methodologies (sampler, mesh size, number of replicates).

*Case study: EQS in Izmir Bay, Turkey and Saronikos Gulf, Greece*

Mean values of the BENTIX and H index are increasing from the inner towards the outer bay and so is EQS (Figure 9.3). The poor quality of the inner bay, which is subject to a combination of pollution impacts, is reflected in all parameters. This, in turn, affects the middle bay. This gradient is also evident in the chemical parameters of the water column. Based on the faunistic and hydrographical features Kocataş (1978) divided Izmir Bay into three parts i.e. the inner, middle and outer one (Figure 9.3).

The Saronikos Gulf receives the wastewater from the Metropolitan city of Athens. Although a primary WWTP started to work in 1994 the benthic communities' ecological quality status of the gulf has only been followed since 1999. As shown in recent trend analyses of all abiotic (sediment type, depth, concentration of organic carbon in sediment), and biotic parameters (including H, BENTIX, AMBI), the EQS is improving with distance from the sewage outfall (HCMR, 2005).

AMBI appears to work successfully under many environmental impacts, including drill discharges, submarine outfalls, harbour and dyke construction, heavy metal inputs, eutrophication, engineering works, diffuse pollutant inputs, recovery of polluted systems under the impact of sewerage schemes, dredging processes, mud disposal, oil spills, fish farming, etc. (Borja *et al.*, 2003).

BENTIX appears to work successfully, mostly in the eastern Mediterranean, provided that a certain taxonomic effort is exerted (specimens assigned mostly to species level). Results were independent of mesh size used, but were misleading when based on semi qualitative data from dredges. EQS should be based on a combination of indices as results may be misleading e.g. in the case of heavy metal pollution. Moreover, further development of this type of environmental tool requires the consensus of scientists in assigning species to a particular ecological group.

# 10 Legal and policy instruments

This chapter outlines the most important sub-regional, regional and global laws and policy instruments that address the major environmental concerns in the Mediterranean region.

## 10.1 The Barcelona Convention and its protocols (Barcelona system)

The Barcelona Convention on the Protection of the Mediterranean Sea against Pollution, which entered into force on 12 February 1978, is the most important regional policy instrument related to the protection of the Mediterranean Sea and its coasts ([2]). The EU and seven other countries ([3]) which are today members of the EU, are the contracting parties to the Convention and some of its protocols (Table 10.1). They provide a significant contribution to the functioning of the Barcelona system.

Since 1994, several components of the Barcelona system have undergone important changes. An ambitious revision of the Convention was concluded in 2002. The objective of the revision was to modernise the Convention to bring it into line with the principles of the Rio Declaration and the philosophy of the new UN Convention on the Law of the Sea (UNCLOS). Then it should be made into an instrument of sustainable development to mirror the progress achieved in international environmental law.

The structure of the present Barcelona legal system includes the following instruments:

- The **Convention** for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (in force since 9 July 2004);
- The **Dumping Protocol** for the Prevention and Elimination of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft or Incineration at Sea, amended in Barcelona on 10 June 1995 (the amendments are not yet in force);
- The **Emergency Protocol** concerning Cooperation in Preventing Pollution from Ships and, in Cases of Emergency, Combating Pollution of the Mediterranean Sea, signed in Valletta on 25 January 2002 (entered into force on 17 March 2004). The Emergency Protocol acknowledges in the preamble the role of the International Maritime Organization, as well as 'the contribution of the European Community to the implementation of international standards

**Table 10.1 List of EC instruments related to the Barcelona Convention for the protection of the Mediterranean Sea**

| |
|---|
| Council Decision 77/585/EEC of 25 July 1977 concluding the Convention for the protection of the Mediterranean Sea against pollution and the Protocol for the prevention of the pollution of the Mediterranean Sea by dumping from ships and aircraft. |
| Council Decision 81/420/EEC of 19 May 1981 on the conclusion of the Protocol concerning cooperation in combating pollution of the Mediterranean Sea by oil and other harmful substances in cases of emergency. |
| Council Decision 83/101/EEC of 28 February 1983 concluding the Protocol for the protection of the Mediterranean Sea against pollution from land-based sources. |
| Council Decision 84/132/EEC of 1 March 1984 on the conclusion of the Protocol concerning Mediterranean specially protected areas. |
| Council Decision 1999/800/EC of 22 October 1999 on concluding the Protocol concerning specially protected areas and biological diversity in the Mediterranean, and on accepting the annexes to that Protocol (Barcelona Convention). |
| Council Decision 1999/801/EC of 22 October 1999 on accepting the amendments to the Protocol for the protection of the Mediterranean Sea against pollution from land-based sources (Barcelona Convention). |
| Council Decision 1999/802/EC of 22 October 1999 on the acceptance of amendments to the Convention for the Protection of the Mediterranean Sea against Pollution and to the Protocol for the Prevention of Pollution by Dumping from Ships and Aircraft (Barcelona Convention). |
| Council Decision 2004/575/EC of 29 April 2004 on the conclusion, on behalf of the European Community, of the Protocol to the Barcelona Convention for the Protection of the Mediterranean Sea against Pollution, concerning cooperation in preventing pollution from ships and, in cases of emergency, combating pollution of the Mediterranean Sea. |

([2]) Contracting Parties: Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, European Community, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Morocco, Slovenia, Spain, Syria, Tunisia, Turkey, Serbia and Montenegro, see www.unepmap.org.

([3]) Cyprus, France, Greece, Italy, Malta, Slovenia and Spain.

as regards maritime safety and the prevention of pollution from ships'. In fact, the Community has enacted a number of legal instruments. The most recent ones are: Directive 2002/6, of 18 February 2002, on reporting formalities for ships arriving in and/or departing from ports of the Member States of the Community; Directive 2002/84/EC, of 5 November 2002 amending the Directives on maritime safety and the prevention of pollution from ships; and Commission Regulation 2172/2004/EC of 17 December 2004 amending Regulation 417/2002/EC of the European Parliament and of the Council on the **accelerated phasing-in of double-hull** or equivalent design requirements for single oil tankers, to include the amendments adopted by the Marine Environment Protection Committee of IMO;
- The **LBS Protocol**: see Box 1.2;
- The **SPA and Biodiversity Protocol** concerning Specially Protected Areas and Biological Diversity in the Mediterranean (in force since 12 December 1999);
- The **Offshore Protocol** concerning Pollution Resulting from Exploration and Exploitation of the Continental Shelf, the Seabed and its Subsoil, signed in Madrid on 14 October 1994, (not yet in force); and
- The **Hazardous Wastes Protocol** on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal, (not yet in force).

As concerns cooperation in the field of response to marine pollution, the Council Decision of 23 October 2001 (2001/792/EC, Euratom) has established a Community Mechanism to facilitate reinforced cooperation in civil protection assistance interventions, covering both civil protection and marine pollution. The general purpose of the Mechanism is to provide, on request, support in the event of major emergencies and to facilitate improved coordination of assistance intervention provided by the Member States and the Community.

The recent updating of the Barcelona legal framework shows that the Parties consider it to be a dynamic system capable of being subject to re-examination and improvement, if appropriate. As a result, at their last Meeting in Catania in 2003, the Contracting Parties asked the Secretariat to start developing an additional Protocol on Integrated Coastal Zone Management.

## 10.2 EU cooperation with the Mediterranean partner countries

The Euro-Mediterranean Partnership (EMP) was established in 1995 as a means to reinforce relations between the European Union and its partner countries in the southern and eastern Mediterranean. In Helsinki in 1997, the Euro-Mediterranean Environment Ministers adopted a Declaration establishing the 'Short and Medium-Term Priority Environmental Action Programme' (SMAP). This was intended to be the operational tool for the implementation of the policy adopted by Euro-Mediterranean partners in the environment area. It should also provide project financing from the Regional Environment Programme of the MEDA financing instrument. In 2002, Euro-Mediterranean Environment Ministers reaffirmed their commitment to the SMAP through the adoption of the Athens Declaration. This declaration particularly emphasized the importance of ensuring synergies between SMAP and other regional environment initiatives. MEDA financing for regional environment through three successive SMAP programmes has amounted to a total of some EUR 50 million over the past 10 years. MEDA has also provided substantial funding for regional projects in the specific sector of water.

In addition to the regional component, the EU has concluded bilateral association agreements with most of its partner countries under the framework of the EMP. These agreements set the basis for cooperation targeted to the individual needs and conditions of each country. Through these agreements, the EU and its partner countries agree to work towards legislative approximation and cooperation in a wide range of sectors, including environment. At present, such agreements are in force with Morocco, Tunisia, Egypt, Jordan, Israel, Palestinian Authority and Lebanon. The agreements with Algeria and Syria are in the process of being finalised. As the association agreements come into force, specific sub-committees are being established to promote bilateral political dialogue on the environment.

In terms of bilateral financing under the EMP, 80 % of the total MEDA budget is allocated to national programmes. Since the MEDA instrument was first launched, financing has been allocated for a substantial number of environment projects, including grants to subsidise the interest on IEB loans for environmental infrastructure. Regrettably, however, the environment has not been consistently set out as a top priority by all partner countries in the development of these national programmes.

In view of the Extraordinary 10th anniversary Conference of the EMP held in Barcelona in November 2005, this partnership is being reoriented for the future. Initial indications point to an increased focus on environment, including a high-visibility initiative to 'depollute the Mediterranean by 2020'.

The European Neighbourhood Policy (ENP) has been launched with the aim to create enhanced relationships with the EU neighbouring countries, based on shared values and common interests. It builds on existing instruments and frameworks, such as the association agreements which have been concluded with the majority of the southern neighbouring countries around the Mediterranean Sea. As its main operational tool, the ENP uses jointly agreed action plans, which cover a broad range of policy areas including environment.

## 10.3 A review of environmental concerns and their corresponding legal and policy instruments

This section surveys the policy responses adopted to address the major perceived problems and issues identified in the Mediterranean:

A. Pollution spans diverse activities including land-based activities, marine transport and sea-bed exploitation.
B. Conservation of biodiversity.
C. Sustainable exploitation of fishery resources.

Policy responses on a regional, global and EU level are presented for each type of the three above concerns, while some subregional approaches are also considered.

*10.3.1 Pollution*

*Regional agreements and policy instruments*

- The SAP/MED: Strategic Action Programme in the Mediterranean for the implementation of the LBS Protocol to the Barcelona Convention.

The SAP/MED, adopted in 1997, is an action-oriented MAP/MEDPOL initiative identifying priority target categories of substances and activities to be eliminated or controlled by the Mediterranean countries. The schedule for the implementation of specific control measures and interventions extends over 25 years.

The key land-based activities addressed in the SAP/MED are linked to the urban environment, (particularly municipal wastewater treatment and disposal, urban solid waste disposal and activities contributing to air pollution from mobile sources) and to industrial activities. These activities target those responsible for the release of toxic persistent and bio accumulative (TPB) substances into the marine environment. They give special attention to persistent organic pollutants (POPs). Also addressed are the release of harmful concentrations of nutrients into the marine environment, the storage, transportation and disposal of radioactive and hazardous wastes and activities that contribute to the destruction of the coastline and coastal habitats.

- EU Water Framework Directive (WFD)

On the EU level, the legal instrument provided to safeguard the ecological status of waters from land-based points and diffuse sources is the Water Framework Directive (2000/60/EC). This is designed to integrate a number of earlier directives tackling water pollution into a single piece of legislation. It may be considered that implementation of their obligations under the WFD the EU-Mediterranean countries would in effect be fulfilling their general obligations under the SAP/MED. Both the SAP/MED and the WFD, in its 'Strategy against pollution of water', establish a list of priority substances to which water quality standards and emission controls must be applied. Of these priority substances, certain ones will be subject to cessation or phasing out of discharges, emissions and losses within an appropriate timescale. In general, these include toxic, persistent and bio-accumulative substances, subject to phasing out at the latest around 2025 (SAP)–2027(WFD).

- HAB related policies

Recognising the importance of Harmful Algal Blooms, a number of research and monitoring efforts have been directed at their study. The aim is to protect public health, fisheries resources, ecosystem structure and function, and coastal aesthetics. However, methods, performance criteria and action levels have not been clearly established for toxin control, resulting in inconsistencies between EU countries. To harmonise this difference the EU has established a Community Reference Library (CRL) which handles the problems associated with HAB toxins in seafood and coordinates meetings with representatives from National Reference Laboratories (NRL) within the EU and associated countries (ICES). In 2002, the EU Commission adopted the Decision (2002/225/EC) concerning maximum levels of certain biotoxins in marine gastropods, tunicates, bivalve molluscs and echinoderms.

*International conventions and policy instruments*

The following multilateral environmental agreements (MEAs) interact with the existing regional and international agreements aiming to combat pollution in the Mediterranean. They are particularly relevant to reducing pollution from Persistent Toxic Substances:

- The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978, (MARPOL 73/78).
- The Stockholm Convention on Persistent Organic Pollutants (POPs).
- The Basel Convention strictly regulates the transboundary movements of hazardous wastes and provides obligations to its parties to ensure that such wastes and their disposal are managed of in an environmentally sound manner when moved across national boundaries.
- The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade.
- International Code of Conduct on the Distribution and Use of Pesticides.

### *10.3.2 Conservation of biodiversity*

***Regional agreements and policy instruments***

- The Specially Protected Areas and Biodiversity Protocol to the Convention of Barcelona (SPA).

The SPA and Biodiversity Protocol provides for the establishment of a list of specially protected areas of Mediterranean interest (the SPAMI List). The SPAMI list may include sites that 'are of importance for conserving the components of biological diversity in the Mediterranean; contain ecosystems specific to the Mediterranean area or the habitats of endangered species; are of special interest at scientific, aesthetic, cultural or educational levels'. The procedures for the establishment and listing of SPAMIs are specified in detail in the Protocol.

- The Strategic Action Programme for Biodiversity in the Mediterranean Region (SAP/BIO).

The Strategic Action Plan for Biodiversity (SAP/BIO) adopted in 2003 establishes a measurable framework of actions for the implementation of the 1995 SPA Protocol. The SAP/BIO assesses the status of marine and coastal biodiversity, evaluates the main problems affecting biodiversity and identifies concrete remedial actions at national and regional levels.

The basic objective of this Strategic Action Programme is to be used within the context of the SPA Protocol to (i) improve the management of existing and favour the creation of new Marine and Coastal Protected Areas; (ii) favour the implementation of SAP BIO NAPs and Priority Actions; (iii) enhance the protection of endangered species and habitats; (iv) contribute to the reinforcement of relevant national legislation and national and international capacity building; (v) foster the improvement of knowledge of marine and coastal biodiversity; and (vi) contribute to fundraising efforts.

*Other regional conventions,* directives and action plans for biodiversity protection in the Mediterranean Sea include:

- The Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS) was made in 1996 under the Bonn Convention.
- The Berne Convention (on the Conservation of European Wildlife and Natural Habitats) is being implemented in all the European countries.
- Action plan for the conservation of cetaceans in the Mediterranean Sea.
- Action plan for the management of the Mediterranean monk seal (*Monachus monachus*).
- Action plan for the conservation of Mediterranean marine turtles.
- Action plan for the conservation of marine vegetation in the Mediterranean Sea.

*EU legislation on biodiversity*

The legislation on specially protected areas of the Mediterranean States, which members of the European Union must conform to, is the EC Council Directive 92/43 on the conservation of natural habitats and wild fauna and flora. Its geographical scope includes the internal waters and the territorial sea along the coasts of the four EU Mediterranean countries. The Directive sets up a coherent ecological network of special areas of conservation under the title 'Natura 2000'. This network is composed of sites hosting the natural habitat types of Community interest listed in Annex I and habitats of the species listed in Annex II (species of wild fauna and flora of Community interest) whose conservation requires the designation of special areas of conservation. However, under Art. 4, para. 1 for aquatic species that range over wide areas, such sites will be proposed only where there is a clearly identifiable area representing the physical and biological factors essential to their life and reproduction.

*International conventions*

- Global Convention on the Protection of Biological Diversity (CBD).
- The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention, 1979).
- The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).
- The RAMSAR Convention on Wetlands of International Importance especially as Waterfowl Habitat (1971).

### *10.3.3 Fisheries — aquaculture*

*Regional and subregional policies*

- FAO General Fisheries Commission for the Mediterranean (GFCM) aimed at establishing management measures for fishery resources at regional level.

More specifically it aims to promote the development, conservation and management of living marine resources occurring in the Mediterranean, the Black Sea and connecting waters, both in areas under national jurisdiction and on the high seas. In order to achieve its goal, the GFCM can, by a two-thirds majority, adopt recommendations on the measures for the conservation and rational management of living marine resources.

Other FAO projects on a subregional level in the Mediterranean include ADRIAMED, fostering scientific cooperation to promote responsible fisheries in the Adriatic. FAO COPEMED, another Mediterranean Project, focuses on advice, technical support and establishment of cooperation networks to facilitate coordination to support fisheries management in the Mediterranean. COPEMED area covers the western and central subregions of the Mediterranean.

*EU Common Fisheries Policy*

- The EU Common Fisheries Policy (CFP) is the European Union's instrument for the management of fisheries and aquaculture.

The CFP, which has been in operation since 1983, recently (2002) underwent extensive changes. Among others, a plan to ensure the sustainability of fisheries in the Mediterranean was adopted in October 2002. The measures foreseen in the Action Plan include:

- a concerted approach to declaring fisheries protection zones;
- the use of fishing effort as the main instrument in fisheries management;
- improving fishing techniques so as to reduce the adverse impact on stocks and the marine ecosystem;
- promoting international cooperation.

The EU has exclusive expertise in international relations concerning fisheries. It is empowered to undertake international commitments towards third countries or international organisations in matters relating to fisheries and aquaculture. The European Commission, on behalf of the EU, negotiates fisheries agreements with third countries and participates in various regional fisheries organisations (RFOs).

*International conventions*

- ICCAT (International Convention for the Conservation of Atlantic Tunas), in force since 1969, is designed to ensure the sustainable exploitation of Atlantic tuna and tuna-like species not only in the Atlantic Ocean but in adjacent seas, such as the Mediterranean.

The Contracting Parties to the International Convention for the Conservation of Atlantic Tunas include Morocco, Libya, Croatia, Turkey, Tunisia and the EC. On the basis of scientific research ICCAT can through its International Commission make recommendations aimed at ensuring the maximum sustainable catch. These recommendations, if not objected to by a majority of Parties, are binding on all Parties, except those that register formal objections.

*Global policy framework*

- FAO Code of Conduct for Responsible Fisheries.

This Code adopted in 1995, sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources with due respect for the ecosystem and biodiversity.

# 11 Conclusions

## 11.1 Main findings

The top priority for environmental management in the region is to enforce national and international environmental legislation. However, enforcement is carried out quite differently in Mediterranean countries, reflecting different socio-economic conditions. In addition to implementation and enforcement of existing legislation, there is an increasing need to apply integrated ecosystem-based approaches for protection of the Mediterranean environment, which currently is being plagued by several pressures impacting coastal and marine habitats. The most important issues are:

- pollution related to urbanisation and industrial activities;
- unsustainable exploitation of fisheries and aquaculture resources;
- inadequate regulatory mechanisms (mainly lack of law enforcement);
- lack of knowledge and appreciation of the biological and cultural value of existing habitats.

All around the Mediterranean basin, **coastal urbanisation** implies production of wastes (untreated or poorly treated wastewater and urban run-off and solids), increase of water demand, and pollution. In many cases **habitat destruction and physical alteration** have led to biodiversity and wetland losses and environment degradation imposing a serious threat to many aquatic species.

Most of the Mediterranean coastal areas host chemical and mining industries that produce large amounts of **industrial wastes** (heavy metals, hazardous substances, and POPs) which could reach the Mediterranean Sea directly or indirectly (through rivers and run-offs). In addition, stockpiles of **obsolete chemicals** (such as POPs and pesticides) are considered as an important source of contaminants into the marine environment. On the other hand, discharge of fine solids from coastal industrial plants also has a considerable adverse impact on the marine ecosystem.

**Overexploitation of fisheries resources** has affected the marine food web and particularly trawling has impacted the ecosystem in sensitive habitats e.g. *Posidonia* beds and deep corals. In parallel, an excessive expansion of the **aquaculture** industry has added to the degradation of the marine and coastal environment (e.g. Croatia, southeast Turkey).

Climatic changes in conjunction with deteriorated ecosystems near ports and lagoons have resulted in significant **changes of biodiversity** due to the introduction and **establishment of exotic species**. Nutrient pollution (especially nitrogen and phosphorus) has favoured some of the introduced microscopic marine algae species which are toxic and has thus led to **Harmful Algal Blooms** and associated problems.

The main problems in southern and eastern Mediterranean countries are the poorer treatment of urban waste and management of chemicals than in the northern countries where considerable effort has been deployed to overcome the problems caused by pollution from wastewater and the use of chemicals and their impacts on the environment. In general, in southern Mediterranean countries, the lack of law enforcement impedes proper management of environmental issues. These countries are lacking the necessary technical, financial and human resources to comply with national and regional regulations (e.g. stockpiles of hazardous substances).

Furthermore, in the northern Mediterranean region, the most industrialised, and consequently the one bringing more pollutants into the system, there are *a priori* the necessary prevention mechanisms, correction technologies and the appropriate legal framework. However, there is a lack of political willingness from these countries to enforce the environmental regulations. Nevertheless, there is hope for self-control of the industrial contamination from this part of the region. The southern side of the Mediterranean region is, however, growing at a large expense to the environment, since neither the financial conditions nor the required technologies are available.

Taking into consideration the above-mentioned environmental, political and socio-economic issues identified throughout the report, the need for an integrated ecosystem-based approach for protection of the Mediterranean environment becomes evident. Key elements related to the implementation of such a holistic approach have already been taken into consideration by the different Mediterranean Action Plan components such as: assessment and control of pollution, ICZM, environment and development, biodiversity, marine pollution indicators, EQSs etc. Thus, the need is to adapt and integrate these elements into a proper ecosystem-based approach.

## 11.2 Steps towards better environmental management

In order to develop an integrated ecosystem-based approach to better protect the Mediterranean environment the following issues should be addressed:

- Current knowledge gaps have to be filled;
- monitoring/assessment schemes have to be improved thus allowing informed policy-making;
- Improvement of management practices;
- Increase of socio-economic capacity for environmental management;
- Strengthening of Integrated Coastal Zone Management (ICZM);
- Decentralisation of action tailored to take into account specific contexts, pressures, impacts and needs in each country.

### *11.2.1 Gaps in knowledge and further work needed*

The definition of problems of the marine environment of the Mediterranean Sea and identification of gaps is a prerequisite to all informed policy-making. In this respect, as already pointed out, the Mediterranean region exhibits important gaps of knowledge regarding more reliable data on levels and loads of pollutants, information on issues of transboundary concern, inventories of specific ecosystems and hot spots and regional cooperation. Even though the information is collected from National Diagnostic Analysis reports, in most cases it comes from case studies and research programmes rather than comprehensive national monitoring programmes. Overall the information about the environmental state, trends and pressures is rather poor in the Mediterranean as compared to the North and Baltic Seas. In particular, information for the south and east Mediterranean is generated through scattered, inconsistent and sometimes unreliable investigation programmes.

*Data on loads*

Data on transfer of loads via air-sea interaction are not well covered and when they are, the spatial coverage is very heterogeneous. For example, data on hazardous substances and nutrients in aerosols and rainwater exist for the north western Mediterranean since the late 1980s, as opposed to the south western Mediterranean where there is little information.

Data on riverine discharges are very scarce. Most rivers, even though they are very important, are not adequately monitored for loads of organic and inorganic pollutants.

As far as the urban-industrial discharges are concerned, the information so far collected is the result of an estimation programme based on emission factors in the framework of the preparation of the NDAs of the impacts of land-based sources and the National Baseline Budget of releases from land-based point sources. This implies lack of long time-series data. Nevertheless, the collection of input data from point sources is considered a breakthrough by the Mediterranean countries.

*Data on biodiversity issues: Inventories and monitoring of ecosystems*

To adequately ensure that the best management decisions are being made with the best available scientific data, changes in the functional processes of an ecosystem must be measured on the physical, biological and chemical levels using various indicators. To accomplish this, baseline studies are needed along with the archiving of the data in the form of inventories and data banks. The more sensitive coastal habitat types in the Mediterranean are defined and partly mapped (Spain, France, Italy and Greece). This could be accomplished for all Mediterranean countries if a protocol for rapid assessment surveys were developed and agreed upon. Based on the changes in habitat distribution of a few 'key species', a clear sign of environmental degradation will be discerned and quantified. Rapid assessment techniques (e.g. rapid ecological assessment or side-scan for landscape diversity) and in particular specific surveys of species considered as 'key species' for marine biodiversity are gaining increased attention.

- Countries will have to agree on common criteria or metrics for producing assessments that are comparable between countries. It is essential to initiate the process to arrive at common criteria for the interpretation of normative definitions of the high/good and the good/moderate class boundaries. This will not be achievable until countries have developed classification schemes compatible with the requirements of the Blue Plan, EEA, UNIDO-ICS or WFD.
- It is, therefore, recommended that data flows be developed between countries and UNEP/MAP

so that advanced indicators can be developed in line with work at the European level. These indicators could then be progressively developed and modified as the information required to achieve better comparability becomes available during progressive implementation of the WFD.

Increased attention should be paid to the concept of ecoregions as proposed in the EU Marine Strategy, provided that high-risk ecoregions will usually require more conservation attention (protected areas being only one of the tools) in order to maintain their biodiversity. In that sense, scientists and managers should take advantage of the methodology and results from international programmes applied in sub-regions. This effort of integration made by a network of interdisciplinary scientific groups would be an excellent opportunity for 'good science' input into to the management process.

### 11.2.2 *Pollution prevention and improved management practices*

The modification and destruction of marine and coastal habitats through improper development practices and poor management threaten the viability of the Mediterranean as an ecosystem. Both problems need to be adequately addressed in establishing a strategy of reduction of pressures especially of transboundary concern. The first issue primarily requires a combination of prevention of pollution at source and improved wastewater treatment and the second requires improved management practices.

*Pollution prevention*

Investments in technology could assist in reducing the pressures on the environment as well as in avoiding specific impacts. A recommended key action towards preventing direct urban and industrial coastal discharges should go through the integration of cleaner production and pollution prevention concepts in national environmental policy. Pollution prevention ([4]) promotes continuous improvement through operational and behavioural changes, being a shared responsibility among governments, individuals and industrial, and commercial, institutional and community sectors.

In this context, UNEP could play a catalyst role in order to enable the suitable technological transfer alongside the prevailing socio-economic conditions and to prevent further environmental deterioration of the Mediterranean basin at the expense of the industrialisation of the southern countries.

*Improved management practices*

Improved management practices are required in the area. In this context, an integrated ecosystem approach, as promoted by the upcoming EU Marine Strategy, is needed to protect and restore ecosystems together with strengthening and improving the Integrated Coastal Zone Management (ICZM; elaborated in 11.2.4). Along the same lines regional and multilateral cooperation should be encouraged to enhance the efficacy of such an approach. Such cooperation is of paramount importance particularly for the southern countries of the region, who are facing major problems with regards to pollution management capacities in terms of finances (elaborated also in 11.2.3).

The creation of marine protected areas for conservation purposes is a step in the direction of improved management practices. However, it is not always sufficient as an impact-limitation measure since many of the impacts derive from pressures that are not necessarily of local origin. The protection of the Mediterranean's biodiversity, both in terms of species and habitats, should not be based on a number of separate measures directed towards the protection of certain species or certain habitats. It should rather be an integrated ecosystem approach.

The development of a Mediterranean Regional Advisory Council ([5]) is a good example of multilateral cooperation. The enhanced role of all stakeholders envisaged in the RAC can ensure the development and implementation of a new legislative framework towards a more effective and sustainable management of the fisheries in the region. In addition, a new association, Medisamak ([6]), was set up in the Mediterranean in May 2004. Medisamak, which also includes non-EU countries, envisages working with both GFCM and ICCAT to increase stakeholder involvement under the latest decision by fisheries ministers from the Mediterranean states to revive the GFCM with a view to encouraging multilateral cooperation.

([4]) Pollution prevention is defined as the use of materials, processes or practices that reduce or eliminate the creation of pollutants or wastes at the source.

([5]) 2004/585/EC Council Decision of 19 July 2004 establishing Regional Advisory Councils (RAC) under the Common Fisheries Policy.

([6]) under EU's Action Plan for sustainable fisheries in the Mediterranean.

Coastal Area Management Programmes are also good examples of improved management practices and regional cooperation. They constitute practical MAP initiatives lasting an average of 3–4 years, aiming at the introduction of integrated coastal-area management at local or national levels and institutional strengthening and capacity building in an effort to rehabilitate areas with the heaviest load of environmental problems. In a broader sense, the improvement of the institutional capabilities of the Mediterranean countries in the sustainable management of their environment and its rational integration in development policies is a major challenge for the region.

*11.2.3 Socio-economic capacity for environmental management*

The socio-economic conditions prevailing in each country play an important role in its capacity to apply and enforce the appropriate environmental management, particularly on remedying the impact of urban and industrial pollution. Financial aid through regional and multilateral cooperation constitutes an integral part for upgrading the socio-economic capacity and capability particularly of the southern European countries.

It is obvious that the implementation of the National Action Plans (NAP) to address land-based sources of pollution in the framework of the Strategic Action Programme (SAP) cannot take place under the same conditions in all countries. Several southern, eastern and Adriatic Mediterranean countries would face major economic problems with regard to pollution management capacities and therefore require external cooperation. Treatment technologies involving costs cannot be developed as long as they are not economically integrated into production costs, and technologies for the management of urban waste and especially industrial waste that could be developed should generate a local economic activity solely based on supply and demand. National and regional action plans should, therefore, consider the following aspects:

- development of a systemic approach for the global, nationally based, management of pollution;
- extension of registers to production flows;
- the issue of environmentally rational management of hazardous industrial waste.

All environmental conventions have raised the problem of treatment of industrial wastewater generated by producers or users of dangerous substances. However, environmental conventions have been implemented according to a pattern that does not take into consideration the close interrelation between the process of combating pollution and the socio-economic conditions prevailing in different countries. It is, therefore, of primary importance to encourage in each country the adoption of an integrated approach which could cover:

- financial capacity;
- technological capacity;
- harmonisation of regulations.

The EU Marine Strategy provides the framework for fostering such strengthened cooperation between northern and southern Mediterranean countries through the Barcelona Convention. Within this framework, and particularly through its regional implementation, cooperation to protect the marine environment of the Mediterranean, taking into account the different socio-economic capacities in the area, is already underway.

The Euro-Mediterranean Partnership and the EU Neighbourhood Policy constitute a good political base necessary for the development of the required multilateral cooperation. The Mediterranean Strategy for Sustainable Development (MSSD) aims to increase the synergies between the various regional bodies, the Euro-Mediterranean Partnerships and the MAP (along with the enhancement of regional cooperation towards capacity building and fund mobilisation).

MEDPOL, through the implementation of the SAP/NAP, continues to develop national financial instruments and tools to enable the Mediterranean countries to implement their NAPs. In this respect the north/south financial responsibilities should be considered for an effective implementation of environmental conventions in the southern countries.

*11.2.4 Needs and future interventions for Integrated Coastal Zone Management (ICZM)*

In order to mitigate negative trends caused by the previously mentioned pressures affecting the Mediterranean Sea, proposed interventions must satisfy specific needs such as:

- harmonisation and strengthening of ICZM implementation at regional, national and local levels;
- securing and upgrading the application of ICZM when dealing with transboundary issues;
- upgrading specific components of ICZM (control of urbanisation and exposure to natural hazards, including climate change impacts);

- upgrading the human and institutional capacity for the implementation of transboundary related projects;
- compatibility and coherence with external relations, obligations and priorities through policies such as the European Neighbourhood Policy and the Euro-Mediterranean Partnership Process;
- sustainability of proposed measures (particularly if financial assistance is sought).

Before describing the nature of interventions needed in coastal zone management or formulating proposals for action, the following must be considered and respected:

- the need for a realistic approach, formulation of viable proposals applicable with short- and medium-term deadlines, but providing grounds for further larger and/or more extended initiatives;
- proactive context, including future or potential transboundary impacts and issues;
- harmonisation with past and ongoing relevant initiatives at all levels;
- consistence with global/national/regional/local objectives, strategies and programmes;
- provisions formulated in Agenda 21, MED Agenda 21, MAP, GPA, GEF and EU demonstration programmes;
- a requirement that proposed activities are specific, issue and target oriented, providing for practical outputs and results, intended to mitigate/control/prevent present and future transboundary sources and issues;
- adoption of a common framework of policies general or specific to a particular type of a coastal area;
- building political support.

## 11.3 Needs for adequate regulatory mechanisms

The number one priority in environmental management in the Mediterranean region is to develop the necessary environmental legislation and to enforce it. It is important that policies leading to actions be based on legal instruments that take into account regional and international processes and it should be stressed that the success of implementation would require the application of a number of other possibilities.

The regulatory status of the region mimics the socio-economic and political structure. The legislation for hazardous substances management for EU Member States and associated countries is regulated by European directives, although the degree of compliance varies within the seven Mediterranean EU Member States and their investment in prevention of pollution by hazardous substances has been slow. On the other hand, states facing low levels of organisational capacity and weak economies have serious difficulties in increasing environmental protection and fulfilling international commitments.

The control and management of pollution at national levels is dispersed among various authorities. Urban wastewater management and hazardous substances control and regulation in many of the countries of the region is quite decentralised which implies that many of the responsibilities are transferred to provincial or local authorities.

Other Mediterranean countries exhibit low commitment to relevant national and regional regulations even though they have developed a comprehensive national legal and institutional framework for implementation of national and regional regulations.

Ratification of protocols remains a challenge for the region. Most of the existing MEAs have low numbers of ratifications. For example, neither the revised Barcelona Convention nor any of the most recent Protocols (including the revised ones) have entered into force despite having been adopted in 1995 and 1996.

# Acronyms

| | |
|---|---|
| ACCOBAMS: | Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area |
| ASP: | Amnesic shellfish poisoning |
| BOD: | Biochemical oxygen demand |
| CBD: | Convention on Biological Diversity |
| CFP: | Common Fisheries Policy |
| CIESM: | International Commission for the Scientific Exploration of the Mediterranean Sea |
| CITES: | Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| COD: | Chemical oxygen demand |
| CRL: | Community Reference Library |
| DSP: | Diarrhetic shellfish poisoning |
| EEA: | European Environment Agency |
| EC: | European Commission |
| EMP: | Euro-Mediterranean Partnership |
| ENP: | European Neighbourhood Policy |
| ETC/TE: | European Topic Centre/Terrestrial Environment |
| FAO: | Food and Agriculture Organization |
| GEF: | Global Environment Facility |
| GFCM: | General Fisheries Commission for the Mediterranean |
| HABs: | Harmful Algal Blooms |
| HCH: | HexaChlorocycloHexanes |
| HCMR: | Hellenic Centre for Marine Research |
| ICCAT: | International Convention on the Conservation of the Atlantic Tunas (the International Commission has the same acronym) |
| ICES: | International Council for the Exploration of the Sea |
| ICZM: | Integrated Coastal Zone Management |
| IMO: | International Maritime Organisation |

| | |
|---|---|
| IOC: | Intergovernmental Oceanographic Commission |
| IOC- HANA: | Intergovermental Oceanographic Commission — Harmful Algae of North Africa |
| IUCN: | The World Conservation Union |
| LBS: | Land-based Sources |
| MEAs: | Multilateral environmental agreements |
| MEDA: | 'Mediterranean Assistance' programme. Financial and technical measures to accompany reforms to the economic and social structures in the Mediterranean non-EU member countries |
| MEPC: | Marine Environment Protection Committee |
| NAP: | National Action Plan |
| NDA: | National Diagnostic Analysis |
| NIS: | Non-Indigenous Species |
| NRL: | National Reference Laboratories |
| OECD: | Organisation for Economic Co-operation and Development |
| PAHs: | Polycyclic Aromatic Hydrocarbons |
| PCBs: | PolyChlorinated Biphenyls |
| P/D ratio: | Pelagic/Demersal ratio |
| POPs: | Persistent organic pollutants |
| PSP: | Paralytic shellfish poisoning |
| PTS: | Persistent toxic substances |
| REMPEC: | Regional Marine Pollution Emergency Centre in the Mediterranean |
| RFO: | Regional Fisheries Organisations |
| SAP: | Strategic Action Plan |
| SAP/BIO: | Strategic Action Programme for Biodiversity in the Mediterranean Region |
| SAP/MED: | Strategic Action Programme in the Mediterranean |
| SMAP: | Short and Medium-Term Environmental Action Programme |
| SPA: | Specially Protected Areas |
| SPAMI: | Specially Protected Areas of Mediterranean Interest |
| STB: | Seafood Toxic Blooms |
| TDA: | Transboundary Diagnostic Analysis |

| | |
|---|---|
| TL: | Trophic level |
| UNCLOS: | United Nations Convention on the Law of the Sea |
| UNEP: | United Nations Environment Programme |
| UNEP/MAP: | United Nations Environment Programme/Mediterranean Action Plan |
| UNEP/RAC/SPA: | United Nations Environment Programme/Regional Activity Centre for Specially Protected Areas |
| UNEP-WCMC: | United Nations Environment Programme — World Conservation Monitoring Centre |
| UNEP/WHO: | United Nations Environment Programme/World Health Organization |
| UNIDO-ICS: | United Nations Industrial Development Organization — International Centre for Science and High Technology |
| WFD: | Water Framework Directive |
| WWTP: | Wastewater Treatment Plant |

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