

Draft Report

**Priority issues in the
Mediterranean Environment**

EEA

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PREFACE

In 1999, recognising the lack of timely and targeted information for action, EEA and UNEP/MAP collaborated towards a joint publication on the *State and pressures of the marine and coastal Mediterranean Environment* which was to be used as a knowledge base. 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 upcoming European Marine Strategy, 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 and all these under the prism of an ecosystem approach. The core of this report is the latest (2003-2004) country National Diagnostic Analyses reports (NDA) which 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), based on the UNEP/MAP MEDPOL programme, has highlighted endangered marine and coastal areas from land-based activities [pollution arising from urbanisation, population growth, tourism, sewage effluents, industrial activity (including the oil industry and maritime traffic) and agriculture].

The report does not attempt to give an overall state of the Mediterranean marine environment but addresses in more detail some emerging issues in the Mediterranean region, which are of main concern to the sustainable ecosystem approach and have been recognised as such in previous EEA reports (EEA, 1999, 2002). These are: **Biological Invasions** which may cause significant changes to marine biodiversity, particularly in the eastern basin; **Fisheries and Aquaculture** which may lead to overexploitation of living resources as well as having an impact on the coastal and marine ecosystem i.e. trawling on sea bottom habitats and animals; **Harmful Algal Blooms** whose expansion across the Mediterranean carries risks to human health and is under investigation. **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 are provided by the countries to UNEP/MAP, and the report could be used to focus on alternative policy options to help regional and national policy makers to develop priority policy actions that would have a positive effect on the Mediterranean marine environment.

Chapter 1: Introduction

1.1 Fingerprint of the Mediterranean Sea

The main characteristics of the Mediterranean marine ecosystems (Box 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.

Box 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 European seas. As evaporation exceeds precipitation and river runoff the sea has a freshwater deficit of about 2 500 km³ / 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 biota in the eastern basin.

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 (Figure 1.1).

Table 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

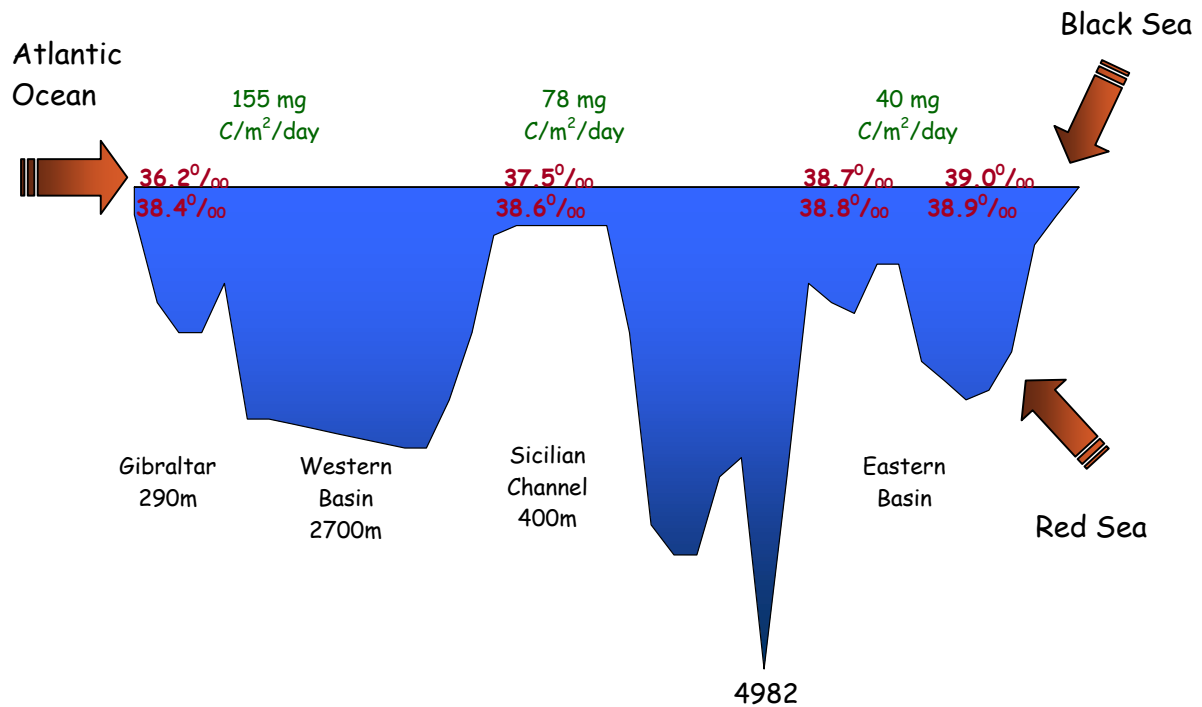


Figure 1.1: A west-east profile of the Mediterranean Sea showing salinity gradient (surface and depth) and primary production (mg C/m²/day).

Source: EEA, , 2002

1.3 Hydrography

The circulation pattern and general physiography in the Mediterranean is complex and is shown schematically in Figure 1.2.

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, Rhone, Po and Nile. The yearly average temperature and salinity for surface and deep waters are shown in Table 1.2.



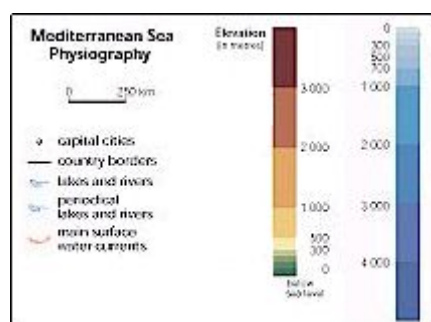


Figure 1.2: The Mediterranean Sea physiography (depth distribution and main currents)

Source: EEA. UNEP/GRID Warsaw

Table 1.2: Mean surface temperature (winter–summer) and salinity values in the surface and intermediate (200 - 1 000 m) layers of the Mediterranean Sea (source: EEA, 2002)

Sea area	Temperature °C	
	Surface	Layer at 200-1 000 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

1.4 Ecosystem productivity

Oligotrophic conditions: low primary production (Figure 1.1) 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 limited as opposed to nitrogen limitation in most of the world's oceans. In this context, increased primary production could be expected only when phosphate is increased. However, recent research experiments to increase phosphorus loading in the eastern Mediterranean could not verify this statement (CYCLOPS project, DG Research). 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 1.3) 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.

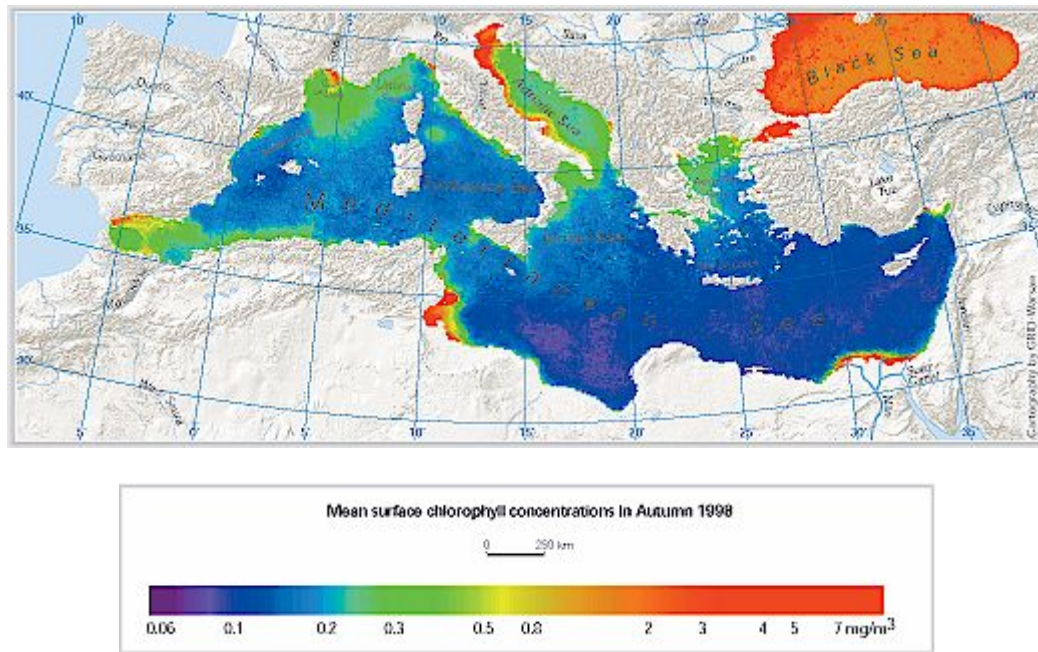


Figure 1.3: Mean Chl-a concentrations in autumn 1998

Source: NASA SeaWiFS Project and ORBIMAGE Inc

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

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 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 1.4) coincides with that of primary production and chlorophyll a concentration shown in Figure 1.1 and 1.3.

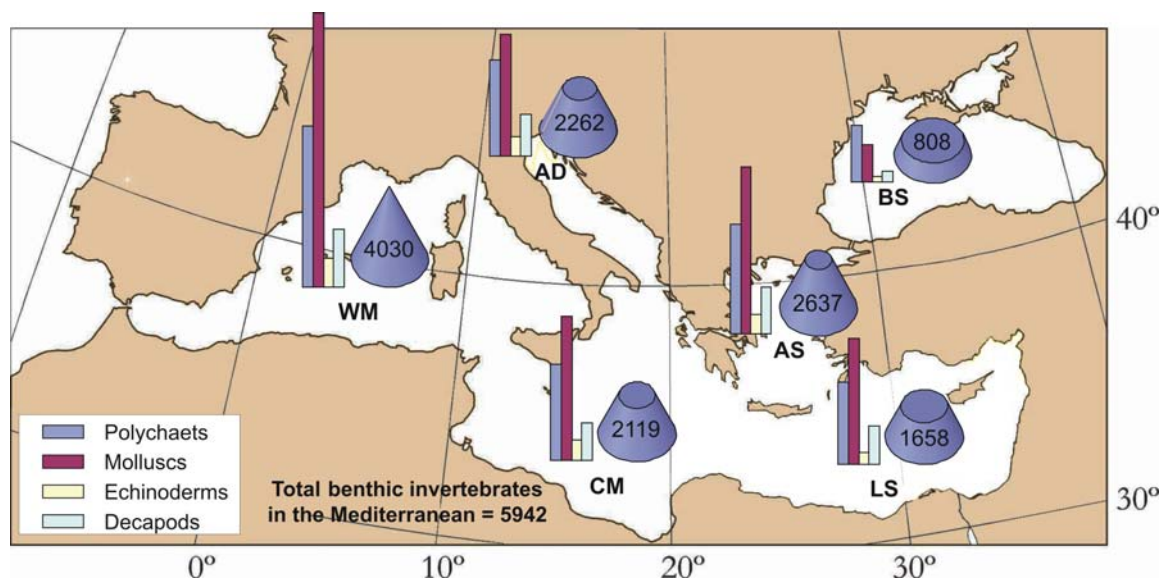


Figure 1.4. Patterns in diversity (species variety) of benthic invertebrates in the Mediterranean
 WM=west Mediterranean, CM=central Mediterranean, AD=Adriatic Sea, AS=Aegean Sea,
 LS=Levantine Sea, BS=Black Sea
 Source: Zenetos *et al.*, 2003

1.6 Impact of Human activities

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

Along the Mediterranean coast many human activities constitute important causes of degradation of the Mediterranean marine ecosystem. Such human impacts on the Mediterranean marine environment can be categorised under the following sources and contaminants scheme:

1. 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

2. Habitat destruction and physical alteration

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

3. Off shore and marine-based pollution

- ❖ petroleum hydrocarbons from shipping activities
- ❖ marine litter

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 because of tourism. The mild climate and the natural and cultural heritage attract huge numbers – about one third of the world’s international tourism – 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 1.5. - 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, 2003). Additionally, 59 sensitive areas (marine areas under threat to become 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, while the impact on the open Mediterranean Sea environment is still uncertain.



Figure 1.5: Pollution hot spots along the Mediterranean coast
Source: HCMR based on UNEP/WHO, 2003

1.6.2 Analysis of problems country by country

In the frame of the Strategic Action Plan (SAP), almost all Mediterranean countries prepared National Diagnostic Analyses (NDA), presenting the most important pollution problems in their coastal areas. 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. France, Monaco, Italy, Spain.

1.6.3. Emerging Issues threatening ecosystems

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

- ❖ **Biological invasions.** The introduction of Non Indigenous Species (NIS) through ballast waters, fouling, import and invasion has resulted in the establishment of dense alien populations of species, resulting sometimes in catastrophic effects on the natural environment.
- ❖ **Overexploitation of fisheries resources.** Fishing has resulted in overexploitation of several fish stocks in the Mediterranean. Eutrophication in some coastal areas has almost certainly resulted in an increase in fish 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, nature reserves 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.
- ❖ **Increasing appearance of Harmful Algal Blooms (HABs).** Their expansion across the Mediterranean is a problem causing not only ecosystem changes but affecting humans through the consumption of contaminated sea-food and thus having a socioeconomic impact.
- ❖ **Natural hazards.** Enhanced seismicity in certain Mediterranean regions and subsequent tsunami activity intensifies the need for better coastal protection.

1.6.4. Quality Status in coastal areas

Human impact has resulted in degradation of coastal ecosystems and biodiversity loss. An effort to assess ecological quality status and quantify the changes at ecosystem level by applying successful tools has been a challenge for marine scientists who have devoted significant efforts over the last decade, and a must for policy makers, who have channelled significant funds towards the development and implementation of them.

Chapter 2: Analysis of problems

2. 1 Land based sources of pollution

Sewage and Urban run-off (Urban effluents)

Sewage generation from coastal cities is one of the major pollution problems on the Mediterranean coast. Their 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 since due to the rapid growth of many coastal cities and towns, especially on the southern Mediterranean coast, the sewage collection system is not connected to the whole of the urban population, leading to direct discharge of untreated effluents into the sea through other outfalls – urban run off. The major pollutants of municipal effluents are: organic matter (measured as BOD₅ and COD), suspended solids, nutrients (nitrogen and phosphorus) and pathogenic micro-organisms, while other pollutants such as heavy metals and petroleum and chlorinated hydrocarbons, are also present in the effluents.

The permanent population on the Mediterranean coast is in the order of 150 million inhabitants, but it 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, having a resident population of 58.7 million (Figure 2.1) (UNEP/MAP/MEDPOL/WHO, 2004).

Of these cities, 69 % operate a wastewater treatment plant (WWTP), 21 % do not possess a WWTP, while 6 % are actually 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 identical in the different Mediterranean areas, 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 the treatment plants' 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

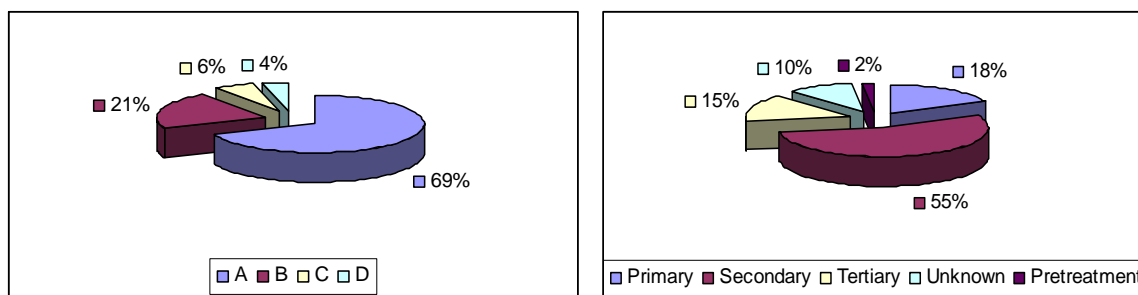


Figure 2: a): WWTP in coastal cities, b): Degree of wastewater treatment

Source: UNEP/MAP/MEDPOL/WHO, 2004

Notes: A: Number of coastal cities served by WWTPs, B: Number of coastal cities without WWTPs
C: WWTP Under Construction/Projected, D: WWTPs Under maintenance / Temporarily out of Operation/No information

Box 2.2: Case study - City of Nador, Morocco

In Nador an urban wastewater treatment plant was built in 1980 to serve a population of 50 000 and was extended in 1990 to a treatment capacity of 100 000 persons, with the addition of four wastewater polishing lagoons with a total surface of 17 hectares. However, the treatment capacity of the plant has actually been surpassed as the city's population is almost 150 000. Furthermore, mechanical failures and abrupt further wastewater load increases during the summer months have led to only partial treatment of inflowing effluents. To add to the difficulties, two of the four polishing lagoons had sea-infiltration problems leaving only two of them operational. As a result, the urban effluents of Nador reach the coastal environment partly treated, thus degrading the marine ecosystem.

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 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 ground water 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.

Box 2.3: Case study - Lebanon

Domestic solid wastes are improperly collected in most coastal areas (except in Beirut), 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] and Normandy [10 ha] dumps) 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, because drifting debris and floating waste have been present for a long time in the area, the sea floor at many locations in front of these dumps is covered with waste (including cans, tyres and plastic bags), reducing photosynthesis and suffocating the marine flora and fauna.



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

Source: NDA Lebanon, 2003

Persistent Organic Pollutants – POPs

Persistent Organic Pollutants include certain pesticides, the use of which has been prohibited, in the Mediterranean region, industrial chemicals whose manufacturing is prohibited, such as (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 by 2010 the following pesticides (DDT, Aldrin, Dieldrin, Endrin, Chlordane, Heptachlor, Mirex, Toxaphene and Hexachlorobenzene), except those used for the safeguard of human life when the latter is in danger 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 (Fig. 2.3a and 2.3b).

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. Polycyclic Aromatic Hydrocarbons (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 Source: UNEP Chemicals, 2002

COUNTRY	Location	Pesticide	Kg
Algeria	Algiers, Tipaza Algiers, Ain Tremouchent, Mascara, Mustaganem, Sidi bel Abbas, Tizi Ouzou	Aldrin	345
		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

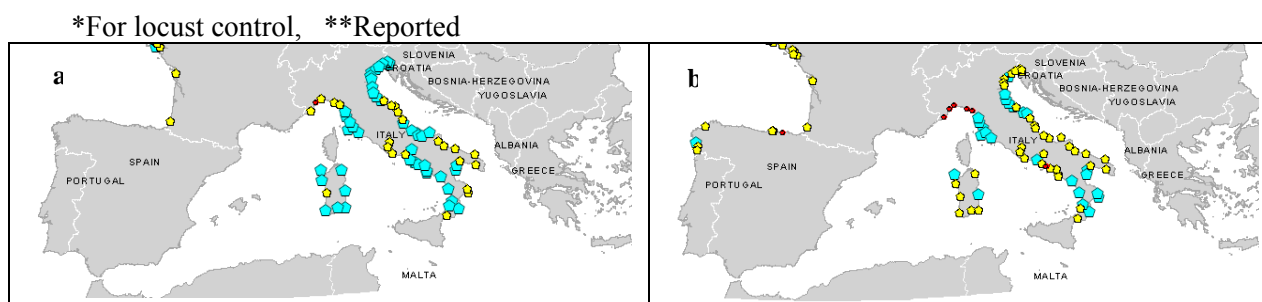


Figure 2.3: POPs in mussels (*Mytilus edulis*), median concentration 1996-2002.a: DDT , b: PCB

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

Source: EEA (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, with the main stockpiles located in the northern Mediterranean countries due to their extensive use (as result of economic development) prior to the ban. A large number of these stockpiles has 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.

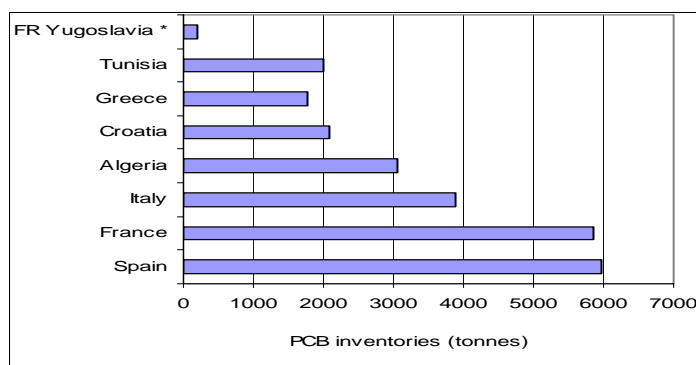


Figure 2.4: Relative country contribution to the cumulative stockpiles of PCBs in the Mediterranean region during the mid-1990s

Note: * 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 (E.C., 2000).

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

Source: E.C., 2000

Country	Sources	Revised for 1995	Data 2000	Projections 2005
France	Total sources	1350-1529	804-949	692-813
	Industrial	987-1027	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)

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

- ❖ Urban and industrial effluents, and runoff 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 because of 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, through benthic flux.

Because metals tend to precipitate after their introduction into the coastal marine environment, they accumulate in sediments and biota (Fig. 2.5a,b), 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 along the Mediterranean Sea, such as the coast of Tuscany (Tyrrhenian Sea), Kastella Bay (Adriatic Sea), Haifa Bay and the coast of Alexandria (eastern Mediterranean), Izmir Bay and Elefsina Bay (Aegean Sea) (EEA, 1999).

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).

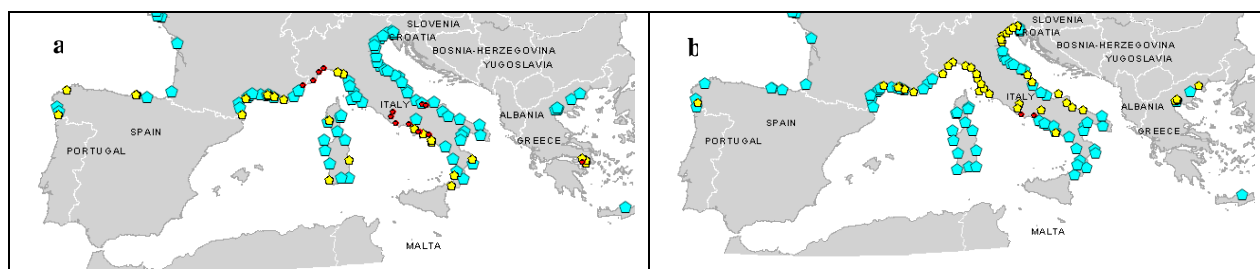


Figure 2.5: Heavy metals in mussels (*Mytilus edulis*), median concentration 1996-2002.a: Lead (Pb)
b: Mercury (Hg)

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

Source: EEA, 2004

Box 2.3: Case study: Alexandria area, Egypt

Industrial effluents from the Alexandria area are discharged into Mex Bay, Abou-Qir Bay and lake Maryut, which present 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 (Figure 2.6 a,b).

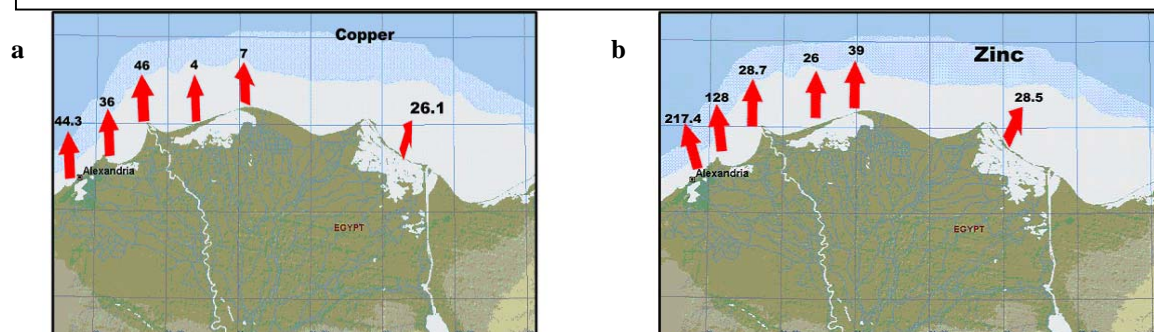


Figure 2.6: Heavy metal loads discharged from land-based sources in Egypt into the Mediterranean
a: Copper (Cu) b: Zinc (Zn) *Source: NDA. Egypt, 2003*

Table 2.3: Quality of marine waters near Alexandria. *Source: NDA Egypt, 2003*

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 (TSM) (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) (µM/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

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, as a result of previous manufacturing and stocking (they 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)).

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 have 370 tonnes of chemicals including lindane, methanol, carbon sulphite, sodium dichromate, 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, are living in and around the highly contaminated area.



Photo 2.2: Durres – Chemical storage warehouse
Source: Photo Gallery - 2000 Environmental Assessment in Albania, UNEP, Post-Conflict Assessment Unit.

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 $^{239,240}\text{Pu}$ in the Mediterranean marine environment. Other sources (input from rivers, nuclear industry, exchanges through the straits) 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, but might lead to local enhancement of radioactivity levels (EEA, 1999).

Nutrients

The increase of nutrients (nitrogen and phosphorus) to a marine ecosystem enhances primary production and may lead to eutrophication of the water body, a phenomenon having 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 effluents are important nutrient loads, especially when untreated. As a result, all coastal areas in the vicinity of large towns or cities, which do not efficiently operate a wastewater treatment plant, are receiving important 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-NO_3 and 14 000 tonnes of P-PO_4 are entering annually (1995) into the Mediterranean Sea from the rivers Po, Rhone and Ebro (UNEP/MAP, 2003). 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) *Source: UNEP/MAP, 2003*

River	Country	N-NO ₃ mg/l	N-NH ₄ mg/l	P-PO ₄ mg/l	Tot 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
Rhone	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

2.2 Habitat destruction and physical alteration

Shoreline construction and alteration

- ❖ Urbanisation of the coastline 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. Problems related to the concretisation of the coastline are encountered on many Mediterranean coasts, usually related to urbanisation and the development of tourist facilities.

Because the coastal zone presents better employment possibilities in many countries (industry, tourism, commerce), internal migration results in higher housing needs and in the rapid growth of coastal cities and towns. As an example, in Morocco the mean population density on the coast is 90 persons/km² compared to the national average density of 64 persons/km², and is even higher in urban centres (e.g. 108 persons/km² in Al Hoceima). From 1977 to 1994, the

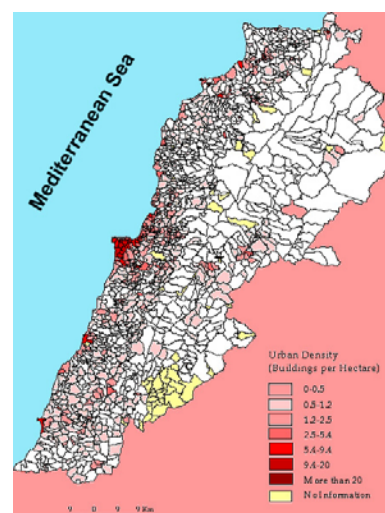


Figure 2.7: Built-up areas in Lebanese coastal area

Source: NDA Lebanon. 2003

number of coastal medium-sized 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 (Figure 2.7). Along the same lines, the built-up coastal zone of Barcelona, Spain, has been increased by 10% over the 1990s (EEA, 2004) (Figure 2.8).

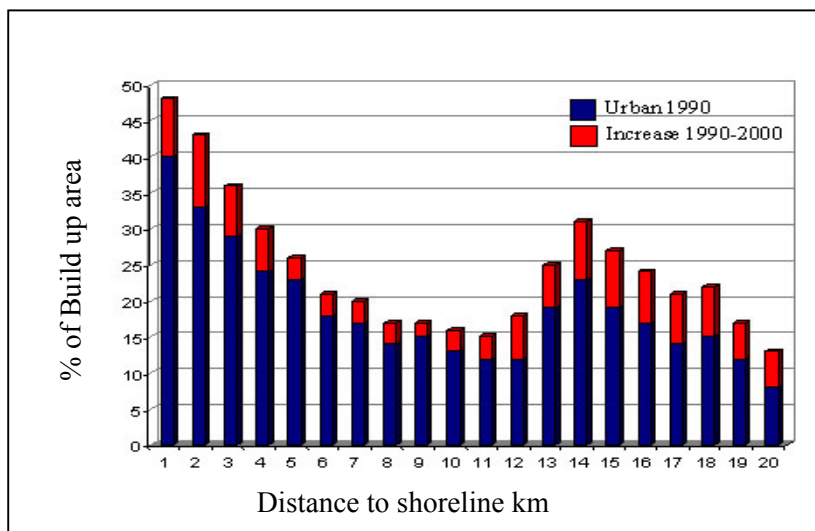


Figure 2.8 Built-up area by distance to the coast (Barcelona, Spain) in 1990 and 2000

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 everywhere behind the mountain.

Source: ETC/TE 2004.

Box 2.5: Case study - Croatia

In Croatia, intense uncontrolled construction along the coastline (recreation, houses, tourist facilities, marinas and small harbours) has led to serious physical alterations of the coastal zone because of 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. In addition, 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.

Wetland and salt marsh alteration

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

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 km² by the year

1980, compared to its original 1 710 km². 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 effluents. Major Mediterranean endangered wetlands are shown in Table 2.5.

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
23 rd of July lake	Libya	NDA Libya, 2003
Karavasta lagoon	Albania	NDA Albania, 2003
Lake Bizerta	Tunisia	NDA Tunisia, 2003

Marine waters and coastal watershed alteration

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

- (i) Trapping of sediments at drainage basin level;
- (ii) Badly designed constructions on the waterfront;
- (iii) 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 ground water pollution and reduction of water resources.
- 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 are protecting agricultural land against the intrusion of seawater (leading to soil and ground water salination).

Box 2.7: Case study – Egypt

Erosion is an important environmental problem on the Egyptian coast. Because of 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, where in some places the coastline has receded one hundred metres landward (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

Box 2.8: Case study - Algeria

On 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 (NDA Algeria 2004). At Bejaia beach, the sea advanced 345 m from 1959 to 1995. Similar problems are encountered at Boumerdes, Bou Ismail, Macta, 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 m³ of sediment were trapped behind the 39 principal Algerian dams at a rate of 9 million m³/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 m³, and is mainly located in the harbours of Oran, Azrew, Bethioua, Algiers, Bejaia, Skikda and Annaba (78 % of the total sediment volume). Also, because of 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), at zones of recent windborne deposition, at the upper parts of beaches or 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 2.3).



Photo 2.3: 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 due to shipping operations (such as deballasting, tank washing, dry-docking, fuel and discharge oil, etc.) in the area which has been declared, since 1973 by the MARPOL 73/78 convention, as a "Special Sea Area", i.e. where oily discharges are virtually prohibited. The PAH input varies according to the type of oil discharged and its range is estimated to be between 0.3 and 1 000 tonnes annually (UNEP Chemicals 2002).

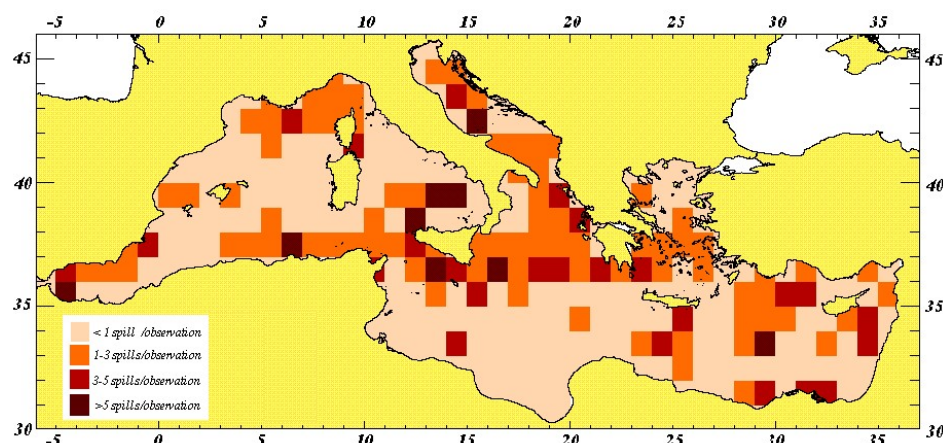


Figure 2.9 Statistical assessment of oil spilling in the Mediterranean in 1999.

Source: Pavlakis et al., 2001

Illicit vessel discharges, can be detected through the interpretation of ERS SAR (Synthetic Aperture Radar) satellite images. In a pioneer work carried out in Mediterranean by Pavlakis et al (2001), 1600 ERS SAR images acquired during 1999 were interpreted revealing for the first time the degree of the problem of the deliberate oil spill discharges in the Mediterranean Sea, (Figure 2.9).

- Oil spills

In addition, over the last 15 years, about 55 000 tonnes of oil have been spilled in the Mediterranean Sea because of shipping accidents; the three major ones being responsible for 75 % of the quantity spilled. The picture of oil spills in the Mediterranean according to UNEP-WCMC is shown in Figure 2.10 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, while the quantity of spilt oil was 22 150 tonnes (REMPEC, 2001). Incidents at oil terminals, together with routine discharges from land-based installations (estimated to be 120 000 tonnes/year (UNEP/MAP/WHO, 1999), contribute to elevated concentrations of oil in their vicinity.



Photo 2.4: Tanker ablaze in the Mediterranean

Source: REMPEC, 2003

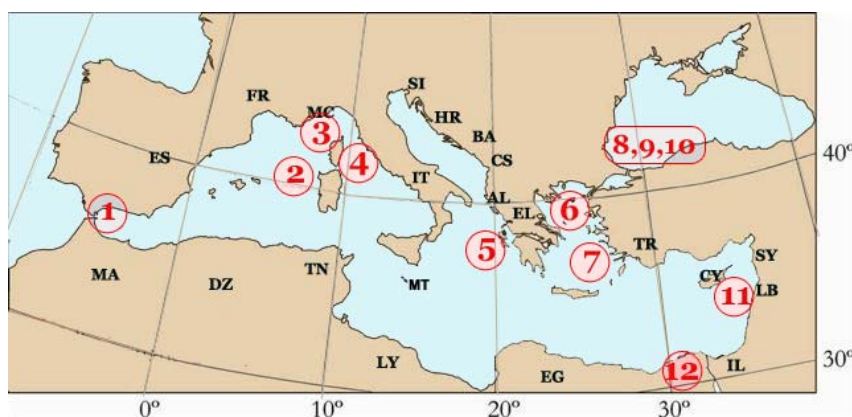


Figure 2.10: Major Tanker oil spills (> 700 tonnes) 1990-2003

Note: Numbers correspond to accidents listed in Table 2.6

Source: adopted by UNEP –WCMC, 2004

Table 2.6: Major Tanker oil spills (> 700 tonnes) 1990-2003

Source: HCMR based on UNEP –WCMC, 2004

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	1 November 1998	GIOVANNA	3 000	FIRE/EXPLOSION
12	18 August 1990	SILVER ENERGY	3 200	GROUNDING

*Based on estimate from REMPEC

Box 2.9: 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), corresponding 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). De-ballasting operations are also responsible for the release of an additional 12 000 tonnes of oil annually into the coastal waters, because the available ballast reception facilities cannot cope with the ballast quantities. Furthermore, oil pollution is caused by the discharge of industrial and urban effluents, toxic sludge from oil refineries at Algiers, Oran and Skikda and natural gas production. Because of 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
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

Marine litter

- ❖ Mediterranean coasts are becoming littered mainly with plastic debris (Photo 2.5). However the degree of their 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, becoming an aesthetic nuisance and imposing 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

Chapter 3: Pollution issues country by country

3.1 Albania

Approximately 58 % of the Albanian population is living in the coastal areas along the Adriatic and the Ionian Seas (Figure 3.1). After 1991, most of the large Albanian industries (such as mineral production and processing, pesticides, fertilisers, chemicals, plastics, paper, food and textiles) were obliged to close down leaving stockpiles with obsolete hazardous substances as well as contaminated land. **The main contamination problems along the Albanian coast are stockpiles of obsolete chemicals, untreated urban wastewater and solid wastes.** Discharge of untreated urban effluents, 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, 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 effluents (9 600 m³/day), incorrect management of solid wastes (150-200 t/day); harbour activity.
- 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 ground water and coastal sediments of Vlora Bay (up to 2.33 mg/kg); chlorinated hydrocarbons and other dangerous pollutants in soil.



Figure 3.1: Albanian coast with areas of major environmental concern (blue dots) and hot spots (red dots)

3.2 Algeria

Algeria's coast hosts approximately 12.5 million people (1998) representing 45 % of the country's population, while during the summer months tourists increase the permanent population. Algiers, Oran, Annaba, Ghazaouet, Mostaganem, Arzew, Bejaia, Skikda are the most important coastal cities. (Figure 3.2) (NDA Algeria, 2003). **Major pollution problems in the country include untreated urban and industrial effluents, petroleum hydrocarbon slicks and coastal erosion.** Most of the urban effluents are discharged untreated directly into the sea (Photo 3.1). Although 17 treatment plants for urban effluents have been constructed in the Algerian coastal zone, only five are in normal operation representing approximately 25 % of the total treatment capacity. Faecal microorganisms are present on most Algerian bathing beaches, which are not in accordance with the necessary sanitary standards. Also, petroleum hydrocarbon pollution is very common along the Algerian coastline (Photo 3.2) because of maritime oil shipping lanes that pass close to the Algerian coast. Erosion is also a major issue, since on 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. The areas of concern are:

- Bay of Algiers: urban and industrial effluents, cadmium, copper, mercury, lead and zinc in sediments;
- Oran: urban and industrial effluents (oil terminal and refinery, tanneries);
- Skikda: urban and industrial effluents (natural gas, mercury production, oil terminal and refinery, chemical industry), heavy metals;

- Annaba: urban and industrial effluents (fertilisers, chromium);
- Ghazaouet: urban and industrial effluents (zinc and sulphuric acid);
- Mostaganem: urban and industrial effluents, lead, mercury;
- Arzew: urban and industrial effluents, liquefied gas, oil spills, fertilisers;



Photo 3.1: Effluents discharged directly into the sea (Algiers)

Source: NDA Algeria, 2003



Photo 3.2: Petroleum pollution on the beach of Palm Beach, east of Algiers, January 2003

Source: NDA Algeria, 2003

- Bejaia: urban and industrial effluents (oil pipeline).



Figure 3.2: Algerian coast with areas of major environmental concern (blue dots) and hot spots (red dots)

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). However, pollutants generated in the drainage basins of the major Bosnian rivers (Neretva and Trebisnjica), 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 effluents and occasional stockpiles of obsolete chemicals.** The areas of concern are:

- **Mostar:** (population 130 000), Urban and industrial effluents are 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, 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 effluents directly into the Adriatic Sea. The town population doubles during summer months because of tourism.



Figure 3.3: Coastline of Bosnia and Herzegovina and Croatia with areas of major environmental concern (blue dots) and hot spots (red dots)

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 (pop. 207 000), Rijeka (pop. 206 000), Zadar (pop. 137 000), Pula (pop. 85 000), Sibenik (pop. 85 000) and Dubrovnik (pop. 71 400). The results of intense uncontrolled construction along the coastline (recreational buildings, tourist facilities, marinas and small harbours) - because of dumping and depositing of inert materials - are the ongoing physical alterations in many areas. Another threat along the coastline is fish farming, which has caused habitat degradation in the vicinity of the fish cages and the conflicts with the tourist business.

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

- **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 effluents. Biodiversity changes due to exotic species.
 - **Rijeka, Zadar, Pula, Sibenik and Dubrovnik:** Untreated urban and industrial effluents
- Primorsko-Goranska County (Omislj oil terminal):** The Adriatic Pipeline System is located in the area (JANAF, Plc JAdranski NAFtovod Joint Stock Company), (Photo 3.3) and an international oil transport system from the oil terminal to local and foreign refineries in the Eastern and Central Europe. The design capacity of the pipeline is 34 million tonnes of oil per year and the already installed capacity is 20 million tonnes per year. Although no major pollution has occurred so far, there is concern about future crude oil leakages as well as the possible introduction of alien species by the fouling/ballast dumped by tankers if the terminal is used for loading of crude oil from Russia.

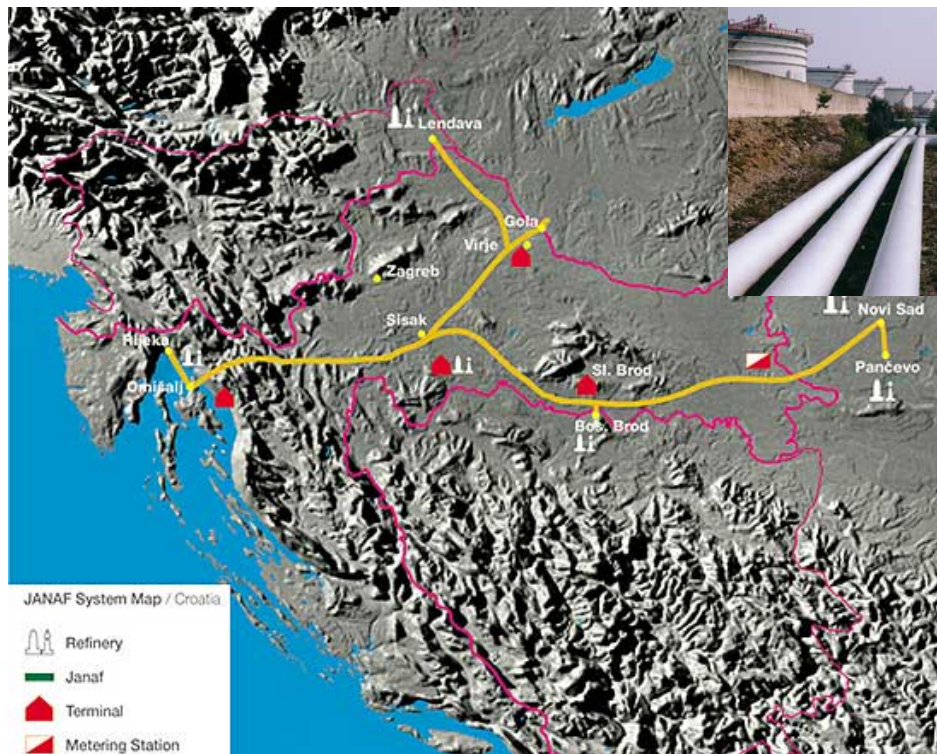


Photo 3.3: System of Oil Pipelines in Croatia

Source: http://www.janaf.hr/e_sustav.htm

3.5 Cyprus

The southern coastal zone of Cyprus is highly populated by permanent inhabitants ci 370 000 (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, while all coastal towns and tourist centres operate wastewater treatment plants. **The major environmental problems are coastline alteration, industrial mining activities and urban effluents**, 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 effluents. The construction of the Limassol harbour resulted in beach erosion and the rectification measures (breakwaters perpendicular to the coastline) resulted in serious degradation of the 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 the industrial activity blanketed the bay's sediments destroying the benthic community of the area.



Figure 3.4: Coastline of Cyprus with areas of major environmental concern (blue dots) and hot spots (red dots)

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, along with Port Said (Figure 3.5). **Major environmental problems are caused by untreated urban and industrial effluents, while 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 BOD5 load is 219 500 tonnes/year and 91 700 tonnes/year respectively from urban and industrial effluents. High metal concentrations in the sediments of the bays;
- Lake Maryut: receives industrial effluents 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;
- 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.



Photo 3.4: Hotels along the Alexandrian coast

Source: <http://luckytegypt.com/abouteg.htm>

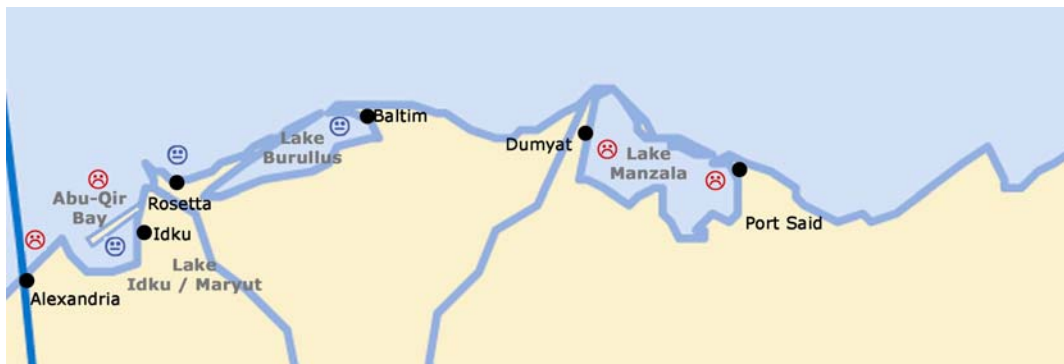


Figure 3.5: Alexandrian coast in Egypt with areas of major environmental concern (blue dots) and Hot Spots (red dots)

3.7 France

France's coastline in the Mediterranean extends for 1 960 km in the regions of Languedoc-Roussillon, Provence-Alpes-Cote d'Azur and Corsica. **Major environmental problems are caused by river transported pollution, treated industrial and urban effluents, as well as intense urbanisation along the densely populated coastline** IFEN (1999). Concretisation of the coastline because of 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) are concrete. In a similar way, 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:

- Marseille and Nice: are relatively big coastal cities (density 136 persons per km²) discharging mostly treated urban effluents into the sea;

- River Rhone: including the rivers Aude and Herault, transport significant loads of nutrients and other pollutants (organic matter, metals) from their drainage basins;
- Fos - Etang de Berre: Fos is the biggest French and the second largest European harbour hosting oil and methane terminals (the 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 Marseille, Sete, Port-la-Nouvelle, Port-Vendres, Toulon (French Navy base), Nice, Bastia and Ajaccio : petroleum hydrocarbons' pollution occurs because of deballasting practices and accidental oil spills.



Figure 3.6: Mediterranean coastline of France with areas of major environmental concern (blue dots) and hot spots (red faces)

3.8 Greece

The coastline of Greece has a length of approximately 15 000 km and hosts 50 % of the country's population and the majority of the industrial activity (NDA Greece, 2003). Although most coastal cities operate wastewater treatment plants. However, **localised environmental problems are caused by poorly treated urban and industrial effluents, as well as runoff from agricultural areas.** The major source of nitrogen to the marine coastal areas of Greece is runoff 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:

- Elefsis Bay: untreated industrial effluents (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 effluents from the capital and industrial effluents. Occasional signs of eutrophication are present;
- Thessaloniki Gulf: treated industrial and urban effluents from the city of Thessaloniki and the Kalohori industrial area.
- Pagasetikos Gulf (Volos): treated industrial and urban effluents from the city of Volos and agricultural land runoff through the river Pinios;
- Amvrakikos Gulf (Preveza): treated industrial and urban effluents as well as agricultural (nitrogen) runoff;

- Patra and Iraklion: urban and industrial effluents;
- Argolikos Gulf (Argos): agricultural land runoff results in excessive nitrogen load.



Figure 3.7: Greek coast with areas of major environmental concern (blue dots) and hot spots (red dots)

3.9 Israel

In Israel, about 70 % 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 effluents**, although most of the urban effluents are treated and recycled (Figure 3.8). The Rivers Na'aman, Yarkon and Taninim are transporting nutrients from agricultural land runoff. According to NDA Israel (2003), the areas of environmental concern along with the major LBS are:

- Haifa area: Urban effluents, industrial effluents including oil refinery (directly and through the Kishon River), 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.
- Hadera area: Receives urban and industrial effluent from the coast, as well as runoff from agricultural land through the Hadera and Taninim streams.
- Tel Aviv – Jaffa area: Industrial and urban effluents, 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.

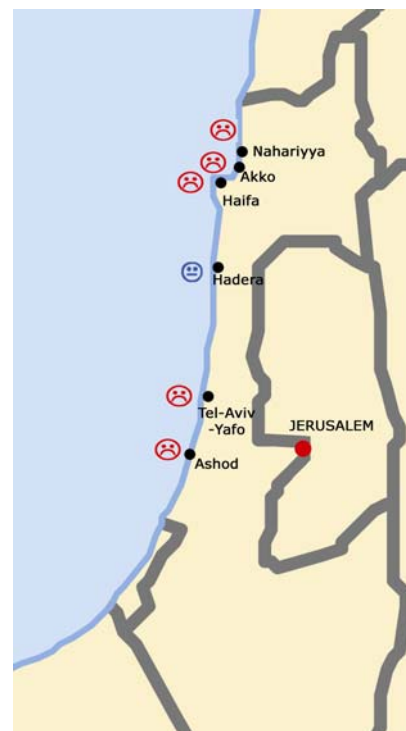


Figure 3.8: Israel's coast with areas of major environmental concern (blue dots) and hot spots (red dots)

- Ashod: Israel's main industrial harbour and its sediments are contaminated by heavy metals, organochlorine pesticides and TBT.

3.10 Gaza Strip

Gaza Strip has a length of 42 km with a width of 5.7 – 12 km and hosts a population of 1 million with strong growth potential since 50.2 % of the inhabitants are less than 15 years old. The area is highly urbanized and includes three towns (Gaza, Khan-Yunis and Majdal) as well as 54 villages. **Poorly treated municipal effluents are the main source of pollution of the coastal zone of Gaza Strip, but 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, carrying mainly untreated effluents, since only 40 % of the effluents generated in the Gaza Strip are properly treated. Furthermore only 60 % of the population is served by sewerage systems. The major areas of concern are:

Gaza city: Urban and industrial effluents (fuel, asphalt, clothing, mechanical workshop, printing, plastic, tiles)

Khan Younis town: Urban and industrial effluents (fuel, cement, food, clothing, mechanical workshop, printing, plastic)

Rafah town: Urban and industrial effluents (fuel, cement, clothing, mechanical workshop, metal, wood)

Dayr El-Balah town: Urban effluents



Figure 3.9. Gaza strip with major towns where environmental problems are encountered

3.11 Italy

- Italy has a coastline of 7 500 km and the whole of its territory is located in drainage basins flowing into the Mediterranean Sea. **Major environmental problems are caused by urban and industrial effluents, agricultural runoff and shipping.** Urbanisation and concretisation of the coastline is also occurring, because of tourist infrastructure development. Most cities have wastewater treatment plants (WWTP), however only 63 % of the population is connected to them. Furthermore, 13 % of the existing WWTPs have operational problems or need up-grading (OECD, 2002) (Figure 3.10). The river Po is a very important pollution vector in the area transporting urban and industrial effluents, as well as agricultural land runoff from its drainage basin. 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:



Figure 3.10: Coastline of Italy with areas of major environmental concern (blue dots) and hot spots (red dots)

- Gulf of Trieste: eutrophication problems because of nutrients transported by the river Po, as well as coastal discharges;
- 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 effluents;
- 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, which is very narrow and lies between the west mountainous chain and the sea. **Major pollution problems are untreated urban effluents, solid wastes, and coastline urbanisation.** Beirut, Tripoli, Sidon, Jounieh and Tyre are the major coastal cities (Figure 3.11). Urban effluents are discharged into the sea untreated (44 000 tonnes of BOD5 per year) since no municipal WWTP is in operation in the country (Photo 3.5) (NDA Lebanon, 2003), while beachfront



Photo 3.5: Direct discharge of untreated urban effluents in south Beirut, Lebanon
Source: NDA Lebanon, 2003

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

Figure 3.11: Lebanese coasts with areas of major environmental concern (blue dots). Oval shaded area identifies Mount Labanon including Beirut.

3.13 Libya

Libya's coastal zone hosts 85 % of the country's population, as well as most of the industrial, agricultural and tourist activity (NDA Libya, 2003). There are no natural rivers in the area, but 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, there is no effective drainage system in most towns, thus minimising the drainage of urban wastewater into the sea. **Major environmental problems in Libya are oil pollution near terminal facilities, as well as untreated urban and industrial effluents from the bigger cities** (Figure 3.12). Urban solid wastes are often disposed in empty plots within the town limits, therefore, creating serious health problems.

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

A significant part of the Libyan coastline away from cities is not under serious human stress because in many areas there are no paved roads that lead to the seashore.



Figure 3.12: Libyan coast with areas of major environmental concern (blue dots) and hot spots (red dots)

3.14 Malta

Malta has a coastline of 190 km, of which 43 % is heavily utilised (the remaining 57 % being inaccessible). The built-up area is 24 % of the coast leading to a very high population density (1 300 persons/km²). **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 effluents (Figure 3.13). On the island, 85 % of urban and industrial effluents are disposed of untreated, while solid wastes are mainly disposed of in two landfill sites (Malta Ministry of Environment, 2001; Malta Environment Statistics, 2002).

- **Southern Harbour District:** Mostly untreated urban and industrial effluents 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.

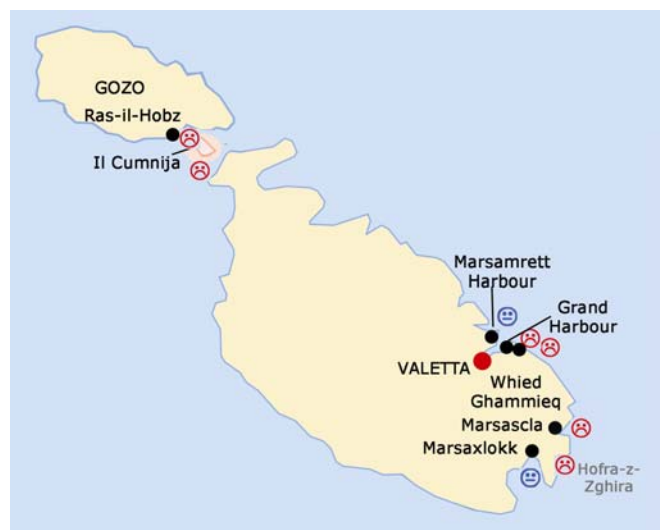


Figure 3.13: Southern part of Malta with polluted Harbour district (red dots) and areas of environmental concern (blue dots)

3.15 Monaco



Monaco has a population of 33 000, with a high population density (16 500 people per km²). The city effluents (urban and industrial) are discharged into the sea through submarine outfalls after complete treatment. Furthermore, storm water is also primarily treated before being 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 (Principaute de Monaco (1997). The greater part of the coastline of Monaco is urbanised (Photo 3.6).

Photo 3.6: Urbanisation along the coastline of Monaco.

Source: www.wasserkuppe.com/bild/urlaub-monaco-stadt.jpg

3.16 Morocco

The Mediterranean coast of Morocco has witnessed an increased urbanisation during recent years. From 1977 to 1994, medium-sized coastal towns increased from 16 to 30, while small towns from two to 14. The major urban centres, which are also the most polluted areas on the Mediterranean coast are: Tangiers (pop. 640 000), Tetouan (pop. 333 000), Nador (pop. 149 000) and Al Hoceima (pop. 65 000) (NDA Morocco, 2003) (Figure 3.14). **The main environmental problems are caused by urban and industrial effluents, maritime traffic and coastal urbanisation.** For example, construction, sand extraction and erosion have resulted in serious stress on the beaches, leading 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. Because of 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 because 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 effluents, sand erosion, eutrophication and toxic algal blooms;
- Nador: urban and industrial effluents, solid wastes, sand erosion;
- Al Hoceima: urban and industrial effluent, solid wastes, sand erosion.

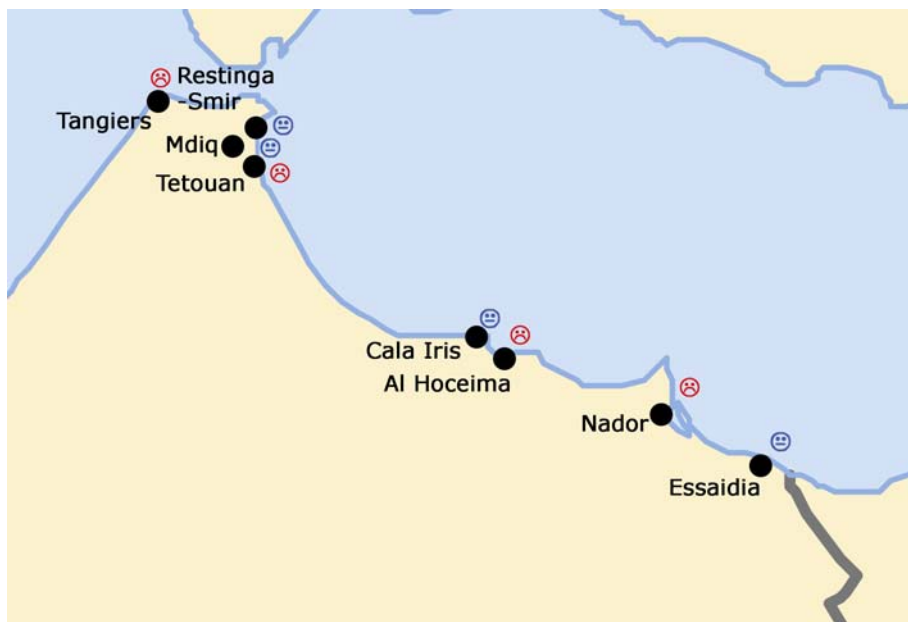


Figure 3.14: Moroccan coast with areas of major environmental concern (blue dots) and hot spots (red dots) in the Mediterranean

3.17 Serbia-Montenegro

The Mediterranean coast of Serbia-Montenegro has a population of 409 000, 4 % of the total population of the Federation, mostly residing 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-Montenegro, 2004). The summer population of these towns increases because of tourism. Because of the discharge of untreated urban effluents eutrophication problems, as well as microbial pollution is detected in the vicinity of coastal towns (west beaches of Bar, Herceg-Novi Bay, Kotor Bay, Port Milena [Ulcinj] and Tivat Bay). Similar problems are occurring 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 in open dumps without sanitary treatment. Quarrying of stones occurs near the town of Bar and Platamuni peninsula, causing dust generation and alteration of the coastal morphology. Land erosion signs are detected in all the coastal areas.

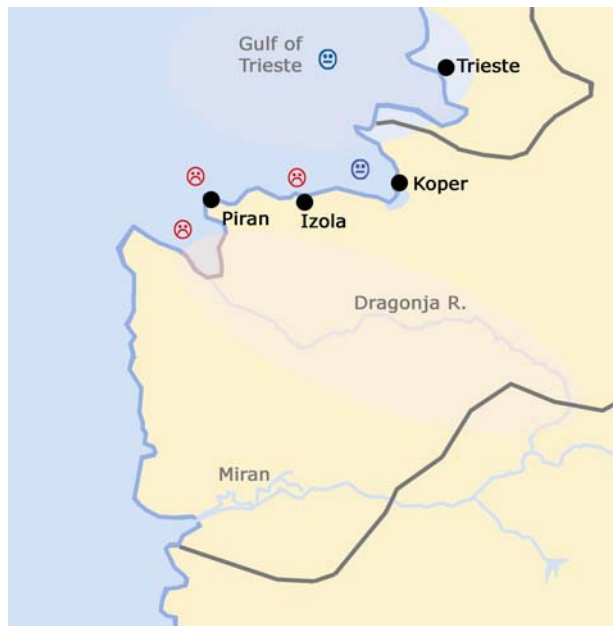
The major pollution problems are untreated urban effluents, eutrophication of coastal waters and uncollected solid wastes. The areas of concern (Figure 3.15) are:

- Bar: urban and industrial effluents (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)

Figure 3.15: Serbia-Montenegro coasts with hot spot areas (red dots)



3.18 Slovenia



Slovenia has a short coastline on the Adriatic Sea (46.6 km) hosting approximately 80 000 people, mainly in the towns of Koper, Izola and Piran (Figure 3.16). More than 80 % of the Slovenian coastline is urbanised mostly within 1.5 km from the sea front, leaving only 8 km (18 %) of coast in its natural state. **Major environmental problems are partly treated urban effluents, runoff from former mining activity and intense coastal urbanisation** (NDA Slovenia, 2003)

Figure 3.16: Slovenian coast with areas of major environmental concern (blue faces) and hot spots (red faces)

- Gulf of Trieste: is contaminated by Hg and Pb transported from the closed mines of Idrja (Hg) and Predil (Pb) by the river Soa. Contaminated sediments act as secondary pollution sources and are responsible for 26 % of the total mercury (of which up to 25 % is in methylated form) in the gulf's waters (Covelli *et al.*, 1999).
- Koper Bay: receives primary treated effluents from the town of Koper, as well as 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).
- Bay of Piran: receives primary treated effluents from Piran and untreated effluents from Isola, 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 Mediterranean coast of Spain has a population of 15.6 million, more than 39 % of the country's population. Urbanisation is very intense, since 85 % of the Mediterranean coastal population lives in cities and towns with a population of more than 10 000. 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), Algeciras (105 000) (UNEP/Plan Bleu, 2001). Urbanisation affects the most valuable and 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 gives an extreme vulnerability to the settlements during sea storms, floods and other exceptional events. Up to 6 million of the buildings are second homes that are not often used.. 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.

The River Ebro is also an important route by which urban and industrial pollution is transported to the Mediterranean Sea. Although most of the coastal cities operate Municipal treatment plants, **the major pollution problems include urban effluents and industrial wastewater, as well as intense urbanisation of the coastline.**

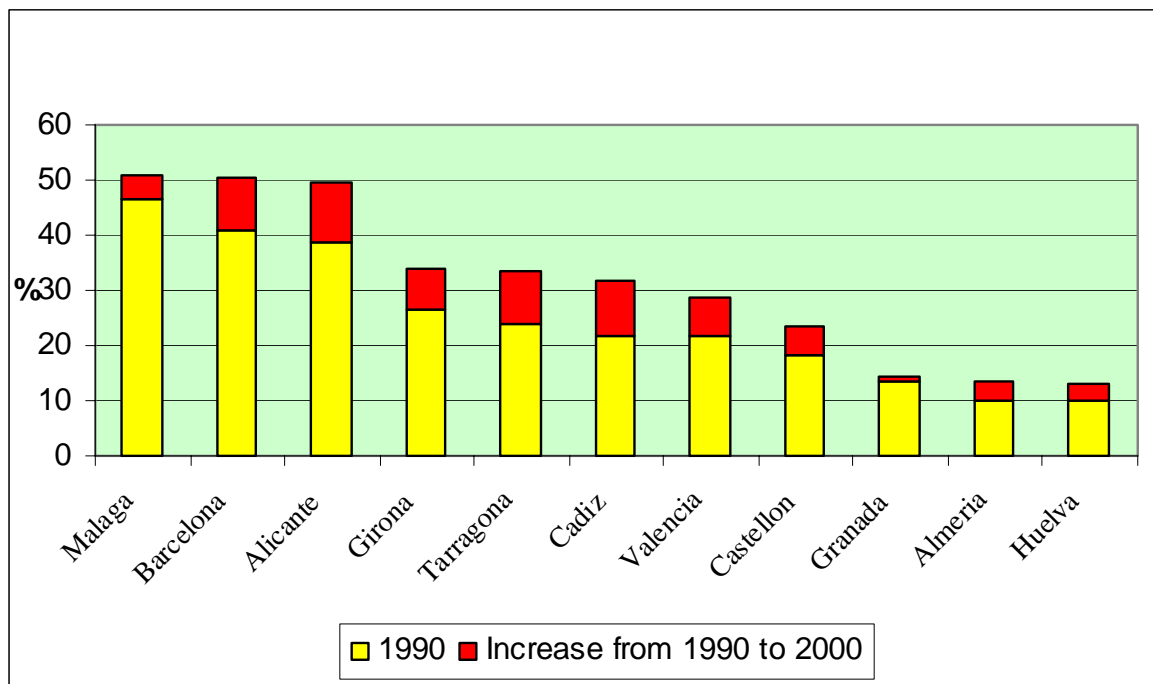


Figure 3.17 Percentage of built-up area in the first km of the coast by NUTS 3 (province) in Spain (1990 & 2000), ETC/TE 2004

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

- Barcelona: urban and industrial effluents
- Valencia: urban effluents
- Cartagena: urban effluents
- Tarragona: urban effluents
- Algeciras: untreated urban effluents
- Mouth of the river Ebro: urban and industrial pollutants



Figure 3.18: Mediterranean coastline of Spain with areas of major environmental concern (blue dots) and hot spots (red dots)

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, because of housing needs (local and tourist) as well as industrial development (harbour facilities), leads to serious environmental problems.

These are: disposal of untreated urban and industrial effluents, oil slicks from the oil refinery and the oil terminal, and management of solid wastes (NDA Syria, 2003). In total it is estimated that 24.8 million m³ of urban effluents are discharged into the sea, of which 99 % are untreated. 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: urban effluents (7 364 tonnes of BOD5, 1 664 tonnes of nitrogen and 377 tonnes of phosphorus), solid waste dumping site on the shore, eutrophication of the coastal zone;
- Tartous-Banias area: urban effluents, (5 582 tonnes of BOD5, 714 tonnes of nitrogen and 218 tonnes of phosphorus), industrial plants including a petroleum refinery (at Banias) and a power generation plant.

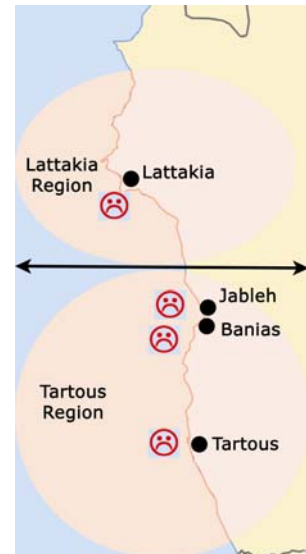


Figure 3.19: Coastline of Syria with hot spot areas (red dots)

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 (pop. 1.6 million), Sfax (pop. 510 000), Sousse (pop. 185 000), Gabes (pop. 140 000) and Bizerta (pop. 130 000), are the most important cities. A major part (81 %) of the cities' effluents is treated. **The major environmental problems are industrial and urban effluents, 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 effluents.
- Sfax coastal zone: Industrial effluents (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 m³ in two dumping sites); urban solid wastes; illegal dumps.
- Lake of Bizerta: Urban and industrial effluents, 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.

Figure 3.20: Tunisian coast with areas of major environmental concern (blue dots) and hot spots (red dots)

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 (summer) houses on the Aegean and eastern Mediterranean coastline, which drastically alter the landscape. Coastal erosion is also an important problem, because out of 110 sand dune systems recorded in the 1980s only 30 (27 %) have stayed relatively intact today. Areas of concern (Figure 3.21) and LBS include:

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



Figure 3.21: Turkish coast with areas of major environmental concern (blue dots) and hot spots (red dots) in the Mediterranean

Chapter 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. The development of the present geodynamic regime 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 concentrate along the active Hellenic and Cypriot arcs as well as behind them, within the deforming Aegean and western Asia Minor regions. Specific areas within this region, like 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.

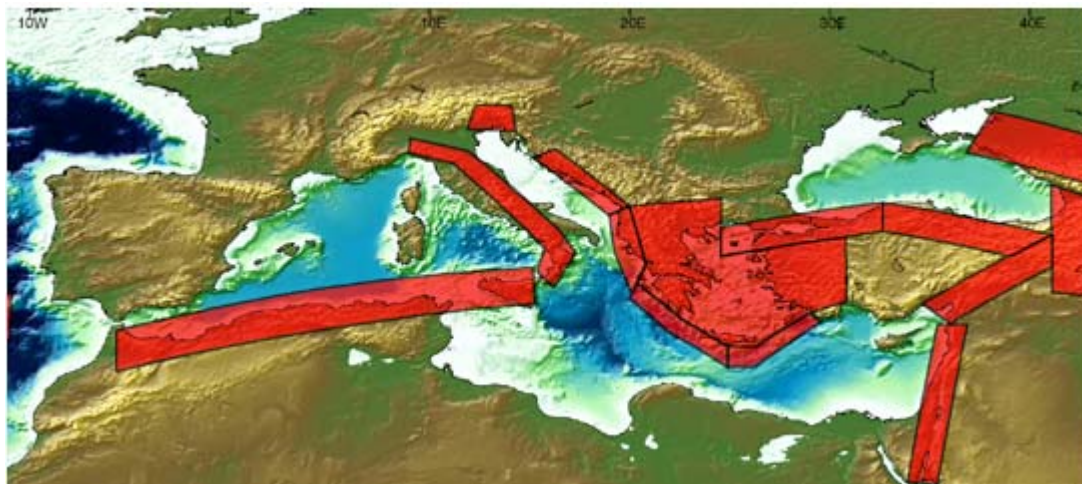


Figure 4.1: Seismic zones of the Mediterranean, Hypocenter depth < 50 km
Source: Vannucci et al, 2004

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).

Table 4.1: Selected catastrophic earthquakes during the last decade (1995-2004)

Date	Area	Magnitude	Death	Impact
14.8.2003	Lefkas isl., Greece	M=6.3	None	Low impact: Collapse of the summer 2003 tourist season.
21.5.2003	Boumerdes, Algeria	M=6.8	2200	Thousands of houses were demolished or seriously damaged 3 m high tsunami
31.10.2002	Foggia, South Italy	M=5.9	29	70 % of houses damaged in the Campobasso area.
9.9.1999	Athens, Greece	M=5.9	135	A few thousands of houses were demolished or seriously damaged
17.8.1999	Izmit, NW	M=7.4	18000	15 400 houses were destroyed

	Turkey			Coastal zone collapsed Tsunami
15.6.1995	Aigion, Greece	M=6.5	31	Collapse of numerous houses/hotels Impact on tourist season Coastal zone collapsed 3 m high tsunami

4.3. 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, like 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 the 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 volcano) and adjacent cities in about 79 AD, point to the possibility of future catastrophic eruptions.



Photo 4.1: Eruption of lava from the Etna volcano, Italy, in July 2001

Source: taken from: National Geographic, February 2002, photo: Peter Carsten

Santorini and Nisyros islands are the most famous volcanic islands of the Hellenic volcanic arc in the Aegean Sea. Both of them, together with other, less known volcanic centres distributed along the arc, are active. The 400 m deep caldera of Santorini, an internationally known target for tourists, was formed during the largest ever known volcanic eruption on the earth in the 17th century BC, which led to the fall 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 has taken place during the last one thousand years from the Nisyros volcano, the perfectly shaped craters and the numerous fumaroles within its caldera are evidence of the ongoing volcanic activity.

4.4. 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. The map, shown in

Fig.4.2, displays about 200 tsunamigenic events 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 31st December 1995, about 6 months after the lethal Aigion earthquake, a 3 m high tsunami inundated many km³ 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.

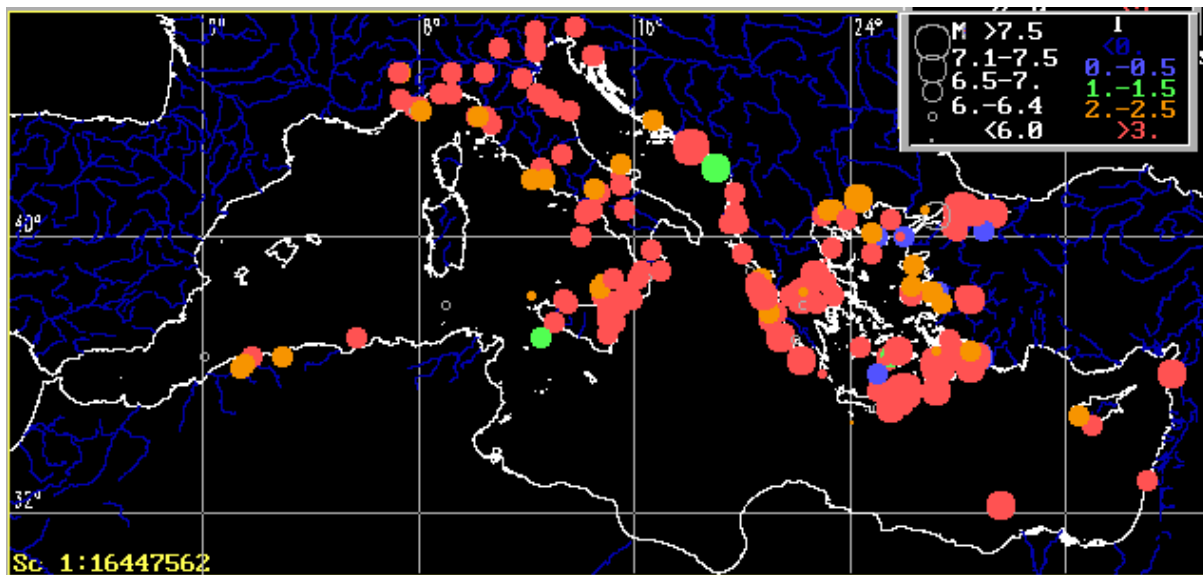


Figure 4.2: Historical tsunamigenic events in the Mediterranean region.

Source: <http://omzg.sccc.ru/tsulab/med.html>

Note: The size of the circle is proportional to the magnitude (M) of the event. The preliminary version of the regional tsunami catalogue (Soloviev *et al.*, 1997) covers the period from 1500 to 1990 and contains 297 events. However, not all events are presented on this map, because the source coordinates of 91 events are lacking.

On 30th 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 m³. 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. The most striking example took place on October 16, 1979, in Western Mediterranean. A large slide, involving at least 8 million m³, 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 two people were killed.

Chapter 5: Key Issue: Non Indigenous Species

5.1 Biological invasions: A non-stop process

Non Indigenous Species, NIS (also known as alien, exotics, introduced, invasive, or non-native), are extra-Mediterranean plants and animals that have been unintentionally introduced or have invaded and/or imported species that are subsequently living in the wild.

- ✓ Over 600 marine NIS species have been recorded in the Mediterranean Sea.
- ✓ The rate of introduction of NIS 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.

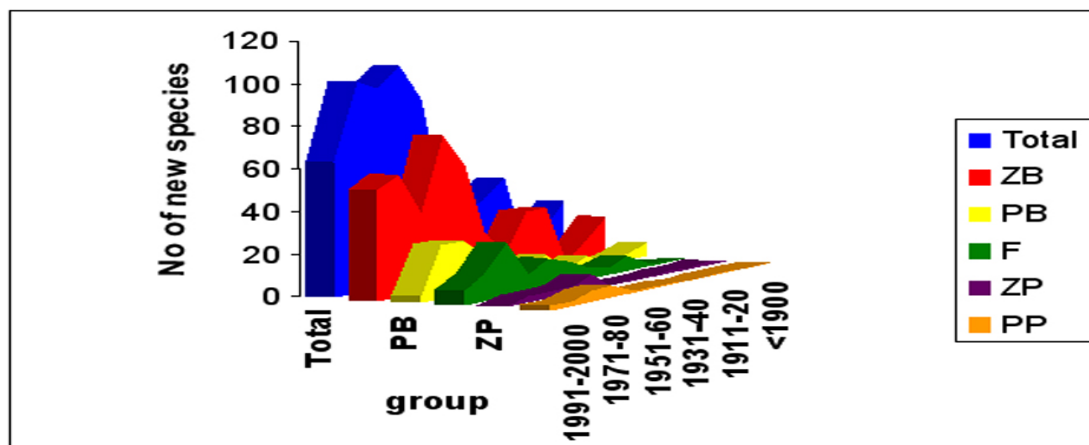


Figure 5.1: Rate of detection of NIS across the Mediterranean.

Source: UNEP/MAP, 2004

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

The introduction of NIS is a dynamic non-stop process with a new species reported each day. The phenomenon, which peaked in the 1970-80 period (a total of 105 records), continues at a steady rate (95 and 100 species in the following two decades) but not equally for all groups. 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 NIS across the Mediterranean

The phenomenon of introduction of alien species is apparent across the Mediterranean (Figure 5.2). However, it is more intensive in the eastern Mediterranean and especially in the Levantine basin and 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 alien 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 NIS.

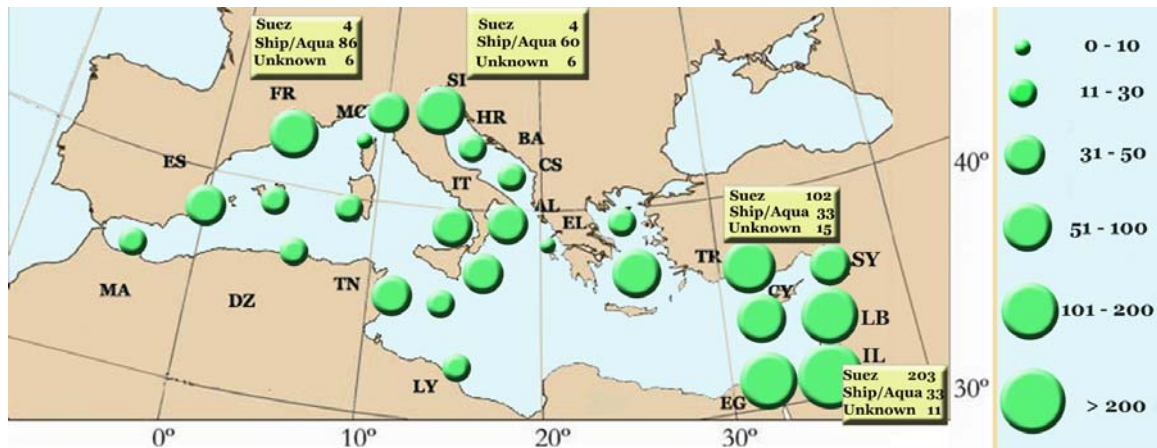


Figure 5.2: Distribution of NIS across the Mediterranean Sea and mode of their introduction in selected areas. Ship/Aqua denotes transportation via shipping and/or aquaculture.

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

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

It is argued that NIS 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).

5.3 Impact of Non Indigenous Species

NIS 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 enormous proliferation of *Anadara inaequalis* in N Adriatic (Rinaldi 1985) has changed the physiognomy of the seashore
Photo 6.1: E. Rinaldi

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

Box: 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 later, nearly

the whole Mediterranean basin is colonised and the Canary Islands have just been reached (Verlaque *et al.*, 2004).

Piazzini *et al.* (in press) reports that *Caulerpa racemosa* has been recorded along the coasts of 11 nations, developing on all kinds of substrata, both in polluted and in 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, Italy and Croatia ranged from 700 to 750 km (Figure 5.3)



Photo 5.2: Expansion of *Caulerpa racemosa*

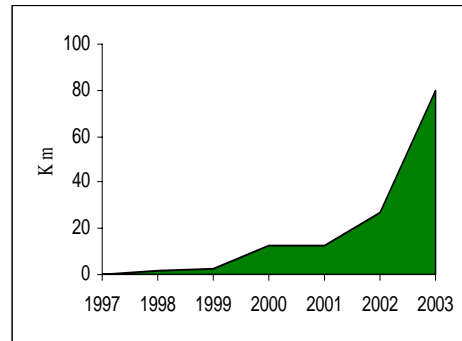


Figure 5.3: Increase in length of the French coastline affected by *Caulerpa racemosa* (from Meinesz *et al.*, 2003).

Biodiversity changes such as the dominance of certain species exhibiting an invasive character at the expense of others has been often reported but not quantified.

Typical examples are the rapid decreases on the coasts of Israel of populations of the sea star *Asterina gibbosa*, the prawn *Melicerus kerathurus*, and the jelly fish *Rhizostoma pulmo*, as those of *Asterina burtoni*, *Marsupenaeus* (= *Penaeus*) *japonicus* and *Rhopilema pulmo* increased in numbers. Fish populations of red mullet (*Mullus barbatus*) and hake (*Merluccius merluccius*) have been forced to migrate to deeper waters by the exotics *Upeneus moluccensis* and *Saurida undosquamis*, respectively (Galil & Zenetos 2002).

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 blooms of species such as:

- The macroalga *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 Marseille 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 (Levantine) coast and as far north as the SE coast of Turkey: impact on tourism, fisheries and clogged coastal installations (Galil & Zenetos 2002).
- *Caulerpa taxifolia* infestations are also renowned for the negative impact on fishing, both commercial and recreational (Figure 5.4); tourism (e.g. on recreational activities such as SCUBA diving).

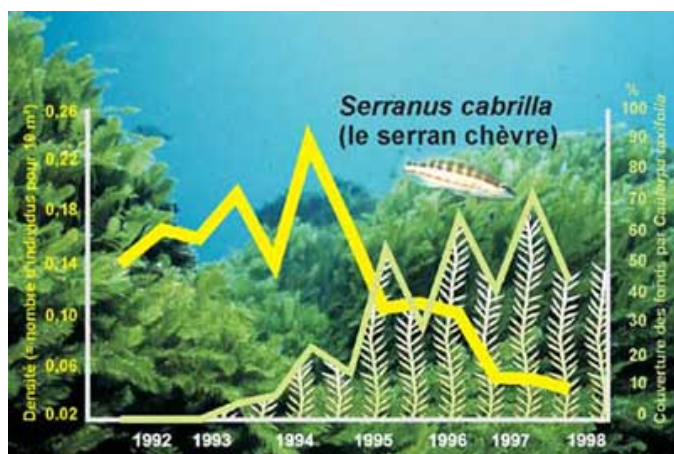


Figure 5.4. Impact of *Caulerpa taxifolia* on fish stocks of comber (*Serranus cabrilla*) in France
Source_Vincent Gravez (vincent@AquaticEcology.org)

5.4 Positive impact

A significant number of NIS species have become valuable fishery assets in the Levantine area. The ones worth mentioning are: the gastropod *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 (*Dussummiera 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 m² 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 (2004) where recent surveys have discovered a massive proliferation of the conch (gastropod mollusk).



Marsupenaeus japonicus

Commercially important for fisheries in the Levant where it invaded via the Suez Canal (Balss, 1927). Cultured + wild population from aquaculture in the Aegean Sea, central and western Mediterranean (Galil *et al.*, 2002).

Photo 5.3: Leonardo Innocenti

5.5 Added value from studying NIS in the Mediterranean

Indicators of climatic changes

Much has been written about the phenomena collectively named “tropicalisation of the Mediterranean” that 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 nonpolluted marina and that the cosmopolitan serpulid worm *Hydroides elegans* that comprised 65 % of the population in the polluted marina was only infrequently found 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 NIS to pollution makes them good candidates for assessing EQS, a strategic issue for both the WFD and the Marine Strategy**

Chapter 6: Key Issue: Harmful Algal Blooms

6.1 Harmful Algal Blooms (HABs) in the Mediterranean Sea

Microscopic marine algae (Phytoplankton) are normal components of all aquatic environments. Sudden population explosions of certain species, also called algal blooms (Photo 6.1) occur naturally, but there is good evidence that many are caused by eutrophication (especially nitrogen and phosphorus enrichment) of waterways by agricultural runoff, human sewage, and animal waste.

When algae blooms are in significant numbers and they produce biotoxins then these events are termed **Harmful Algal Blooms (HABs)**. HABs are truly global phenomena, and evidence is mounting that the nature and extent of the problem has been expanding over the last 10 – 20 years. This worldwide increase of HABs has also affected the Mediterranean Sea (Smayda, 1990).



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

To investigate the increase of HABs several research programmes were initiated. In 1999 a European Initiative on Harmful Algal Blooms (EUROHAB) started, where Mediterranean countries like Spain, Greece and Italy take part. EUROHAB is 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). The IOC established for the north African Mediterranean countries (Tunisia, Morocco and Egypt) the IOC-HANA (Harmful Algae of North Africa) network to promote scientific research and cooperation between the countries concerning monitoring and management of the problem of HAB.

Table 6.1: The projects of the EUROHAB Initiative (**Mediterranean Countries**)

<ul style="list-style-type: none">• BIOHAB (Biological control of harmful algal blooms in European coastal waters: Role of eutrophication) (France, Spain) http://www.nioz.nl/projects/biohab/index.html
<ul style="list-style-type: none">• 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/
<ul style="list-style-type: none">• 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/
<ul style="list-style-type: none">• ALIENS (Algal introductions to European shores) (France, Italy, Spain) http://www.uniovi.es/bos/Aliens/E-aliens.htm
<ul style="list-style-type: none">• 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>

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, at the top of the food chain, 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 **Seafood Toxin Blooms (STB)**. In the Mediterranean, the three major syndromes of STB are **DSP** (**Diarrhetic Shellfish Poisoning**), **PSP** (**Paralytic Shellfish Poisoning**), and **ASP** (**Amnesic Shellfish Poisoning**) (Table 6.2). The distribution of PSP, DSP and ASP blooms in the Mediterranean Sea by country is mapped in Figure 6.1.

Table 7.2: Toxic syndromes of algal toxin origin in the Mediterranean Sea

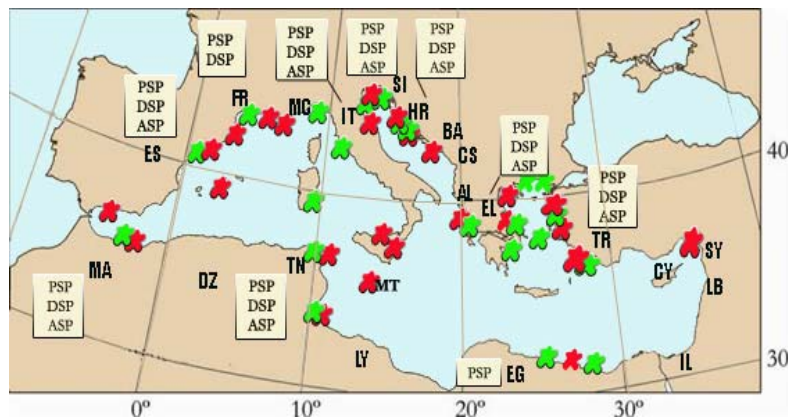


Figure 6.1: Location of reported HABs including STBs (in red) in the Mediterranean Sea

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

Note: others: include algae blooms, which are non-toxic and other effects like fauna or flora mortality through toxic algae species

Table 6.2: Toxic syndromes of algal toxin origin in the Mediterranean Sea

STB type	Causative species	Toxin produced	Symptoms	Shellfish / fish
PSP Paralytic Shellfish Poisoning	<i>Alexandrium andersonii</i> <i>Alexandrium catenella</i> <i>Alexandrium minutum</i> <i>Alexandrium tamarense</i> <i>Gyrodinium aureolum</i> <i>Gyrodinium aureolum</i> <i>Pyrodinium bahamense</i>	saxitoxins	<ul style="list-style-type: none"> Potentially fatal; death occurs within 24 hours in severe cases. 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	<i>Dinophysis acuminata</i> <i>Dinophysis acuta</i> <i>Dinophysis caudata</i> <i>Dinophysis fortii</i> <i>Dinophysis mitra</i> <i>Dinophysis rotundata</i> <i>Dinophysis sacculus</i> <i>Dinophysis tripos</i> <i>Dinophysis trypanos</i> <i>Gyrodinium aureolum</i> <i>Prorocentrum cassubicum</i> <i>Prorocentrum lima</i>	okadaic acid	<ul style="list-style-type: none"> Diarrhoea, nausea, vomiting, abdominal cramps and chills. 	Mussel, cockles, oysters
ASP Amnesic Shellfish Poisoning	<i>Pseudo-nitzschia delicatissima</i> <i>Pseudo-nitzschia multiseriata</i> <i>Pseudo-nitzschia multistriata</i> <i>Pseudo-nitzschia pseudodelicatissima</i> <i>Pseudo-nitzschia purgens</i>	domoic acid	<ul style="list-style-type: none"> Potentially fatal; within 24 hours of eating contaminated shellfish. 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

6.3 Fish kills and contaminated seafood

One major category of impact occurs when HABs with a high level of toxicity cause mass fish mortality. Accumulation of toxins in filter-feeding marine biota, threaten, besides humans, birds and marine 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 mariculture and aquaculture in HAB development, only a few studies are available which underline the relating HAB frequency to human activities. The 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 originated 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 non-toxic algae.

To understand these effects, researchers are trying to describe the factors that control the dynamics of individual HAB species, 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 – and hence the increasing threat posed by such organisms has been on the agenda of the International Maritime Organisation (IMO) since 1973.

Box 6.1: *Alexandrium* spp.- EU-Project STRATEGY

The genus *Alexandrium* is the group of dinoflagellates, which cause many HABs, in the Mediterranean Sea (Garcés *et al.*, 2000.) The research of EU-project STRATEGY puts emphasis on three *Alexandrium* species (Photo 6.2): *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 the STRATEGY is related to the finding of resting cysts in sediment harbours, an indication of transportation via ballast waters.

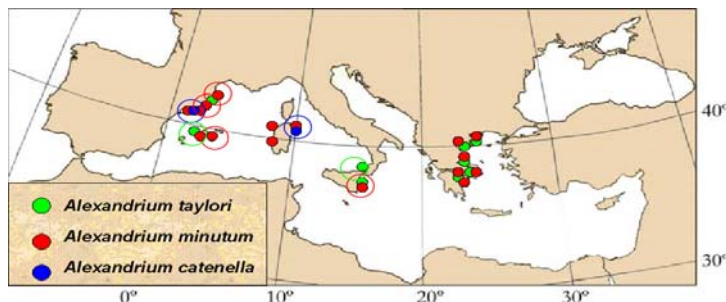


Figure 6.2: Presence of *Alexandrium* species (bullets) and areas affected by blooms (circles) during first sampling period (March - October 2002) in the Mediterranean Sea

Source: STRATEGY project

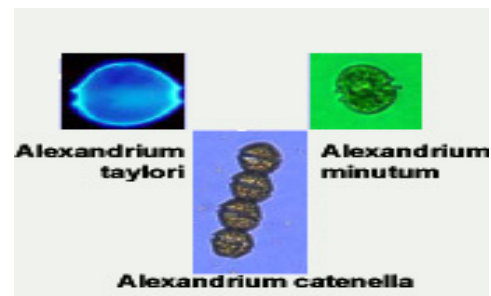


Photo 6.2: *Alexandrium* species

Source: STRATEGY project

6.5 Socio-economic effects

Box 6.2: Socio-economic effects of HABs – EU-Project ECOHARM

The total expenses for medical treatment, transportation and lost wages due to illness 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 are summarised in Table 6.3 which shows that the total socio-economic impact of HABs is around 329 million EUR per year based on available information on HAB events and reported cases of illness from 1989 to 1998.

Table 6.3: The Socio-Economic Impact of HABs in three countries in the Mediterranean basin – Yearly Average in million EUR

Country	Public Health	Commercial Fishery point estimate	Recreation and Tourism point estimate for 2000	Monitoring and Management costs
Greece		0.25	- 33.98	- 2.71
Italy		- 6.32	- 106.85	- 1.73
Spain	- 0.01	- 52.84	- 124.28	- 0.92

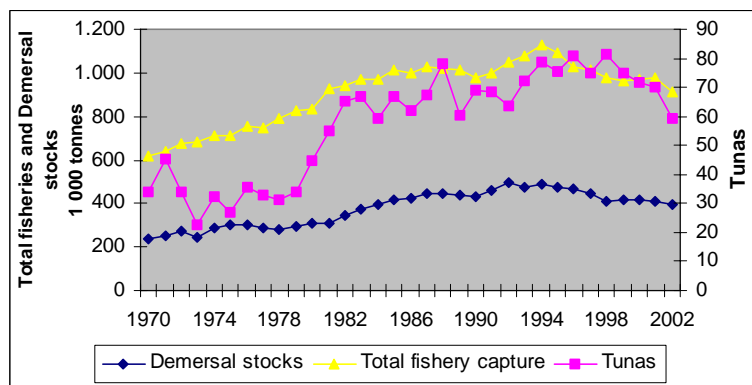
Source: ECOHARM, <http://www.bom.hik.se/ECOHARM/>

Chapter 7. Key Issue: Ecosystem changes due to fishing

7.1. The ecosystem approach in fisheries

Widespread interest in the environmental impact of fishing and more recently in the ecosystem effects of fishing has stimulated intense research in the last 15 years. It has been understood that it is not just the fish populations that need protecting but also the environment that supports them. A number of recent studies have 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 over the long term until about a decade ago were surprising, but suggested that perhaps recruitment of young fish has been conserved unintentionally despite the 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.

On describing the fisheries assessment in the Mediterranean, based on the results of MEDITS programme¹, Bertrand *et al.* (2002) concluded that over-exploitation has led to a serious decline of many fish stocks.

Figure 7.1: Trends in capture fisheries production.

Source: HCMR based on FAO FISHSTAT PLUS,

7.2 Biodiversity Loss – The Problem of Discards

A major impact of fishing on the marine ecosystem comes from the fact that fishing kills many more fish than are landed and registered. The term “discards” is used here for marine fauna brought on to the deck of a fishing vessel and subsequently returned to the sea. The effects of the trawling gear on benthic communities is the subject of heated debate, but the generality of trawl effects at the ecosystem level in respect to gear and habitat types is poorly understood. Discard rates range with depth (Figure 7.2), gear used (mesh size) and targeted species (complex

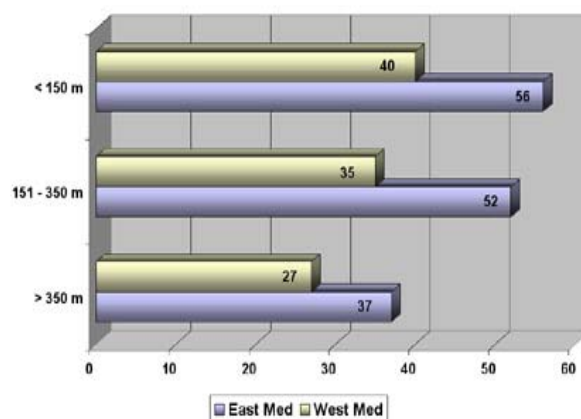


Figure 7.2: Trend in discard rates in % (biomass discarded to total catch) with depth

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

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

of species). Analysing discards from deep water trawling (250-750 m), D'Onchia *et al.* (2003) calculated that discard rates increased with total catch and depth. However, an opposite pattern, similar for the eastern and western Mediterranean, is revealed on examining discard rates derived from fishing with normal commercial trawlers (>350 m depth; Figure 7.2). When examining the discards in the Mediterranean, in terms of species composition and the numbers of discarded animals, a difference has been observed between the eastern and western parts (Figure 7.3). It appears that while the marketable fraction is equal across the two parts of the Mediterranean, the discarded fraction in the western part exceeds by far that in the eastern. However, this can be attributed to the lack of data in the eastern Mediterranean as, up to the present, few studies have been aimed at the estimation of biodiversity loss in the benthic ecosystem due to trawling. Some studies have been conducted on fish, cephalopods and crustaceans.

It is remarkable that the discarded fraction is higher than the marketable one in both the western and eastern Mediterranean.

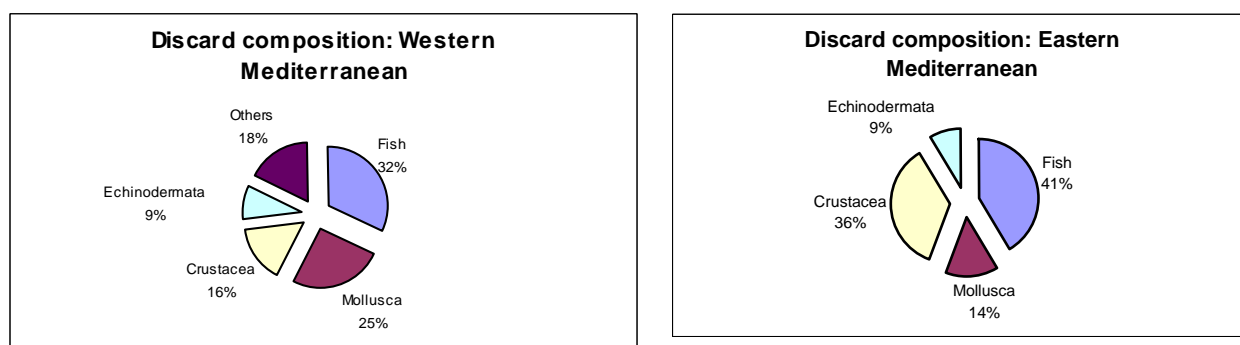


Figure 7.3: Discarded species composition resulting from trawling activities at 150-400 m depth in the Mediterranean

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

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 shrimps, 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'Onchia *et al.*, 2003). It is characteristic that among the discarded unwanted species, sensitive taxa such as stony corals (*Cayophylia smithi*, *Desmophyllum cristagalli*), sea pens (*Funiculina quadrangularis*, *Pennatula rubra*, *Kophobelemnion leucarti*), sea fans (*Isidella elongate*) and soft coral (*Alcyonium palmatum*) prevailed.

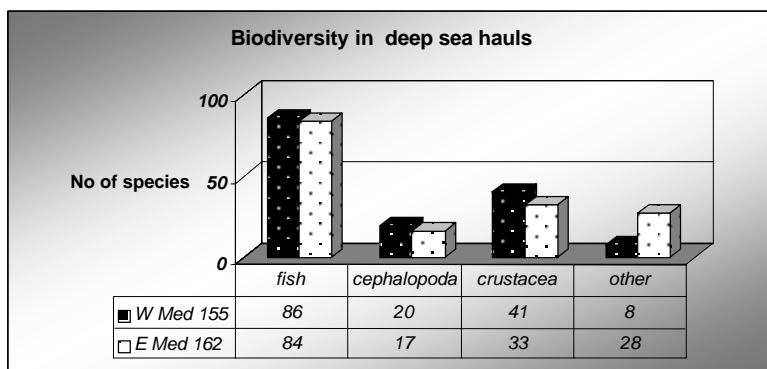


Figure 7.4: Qualitative composition of hauls in the Mediterranean deep sea fisheries for lobster and shrimps.

Source: HCMR based on D'Onchia *et al.*, 2003 (E.Med) and Sartor *et al.*, 2003 (W. Med)

The physical disturbance of the seabed by the dragging of the 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 like 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. Length and weight of the ground rope and weight and contact surface of the otter boards, considered in relation to the towing speed, are the most critical parameters of the friction forces of trawl on the sea bed. These elements can be worked on to reduce the potential damage to sea grass beds, for instance, the use of plastic bobbins on the ground rope may mitigate the impact of heavy components towed on the meadows (Ardizzone, *et al*, 2000; UNEP, RAC/SPA, 2003).
- ❖ Well-preserved Mediterranean maerl grounds (Photo 7.1) are sites with a high diversity that support a high macrobenthic secondary production which may 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 and indirectly by enhancing siltation and turbidity (Bordehore *et al.*, 2003).



Photo 7.1: Maerl beds

Source:

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

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. This is also the result of high economic interest in small fish (i.e. massive catches of undersized fish are seasonally carried out in some bottom trawl fisheries) and high discard rates of undersized, targeted species.

Here are some records on the phenomenon.

- ✓ 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 (*Mulus barbatus*) and striped red mullet (*Mulus 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 consisted of mainly 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. Because of the traditional large interest for small fishes, massive catches of undersized fish are seasonally carried out in some bottom trawl fisheries as, 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”.

“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 it is evident in many fishing areas globally.

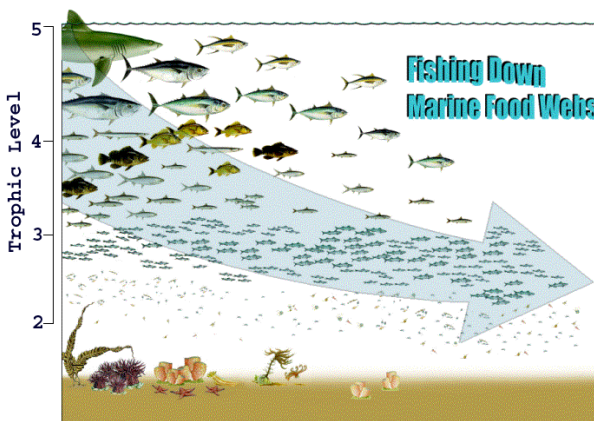


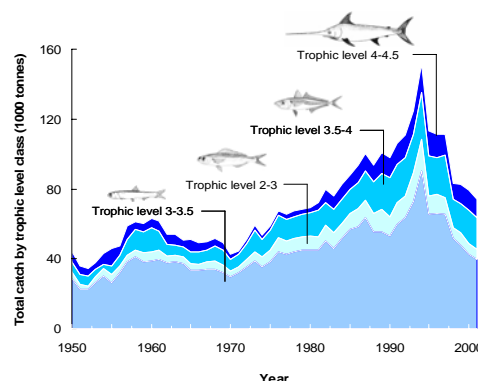
Figure 7.5: Fishing down marine food web

Source: Designed by Daniel Pauly, original by Rachel Atanaceo

- ❖ According to FAO fisheries statistics, the mean trophic level of Mediterranean catches declined by about 1 trophic level during the last 50 years (Pauly *et al.*, 1998). For example, the mean trophic level of catches in Hellenic waters has decreased during the last five years (Figure 7.6).

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

Source: Stergiou and Karpouzi, 2005



One simple indicator that can be derived from commercial statistics, as a measure of the multispecies status of the fish community, is the ratio of pelagic/demersal catches (P/D ratio). The logic behind this indicator is that a decline in the P/D ratio will tend to measure the degree of stress the fish fauna as a

whole is exposed to. 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 trend 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) (Figure 7.7). A significant finding is the increased values of the P/D ratio across all the Mediterranean in the year 2002 and the persisting peak observed in the Adriatic, which can be attributed to excessive nutrient concentration.

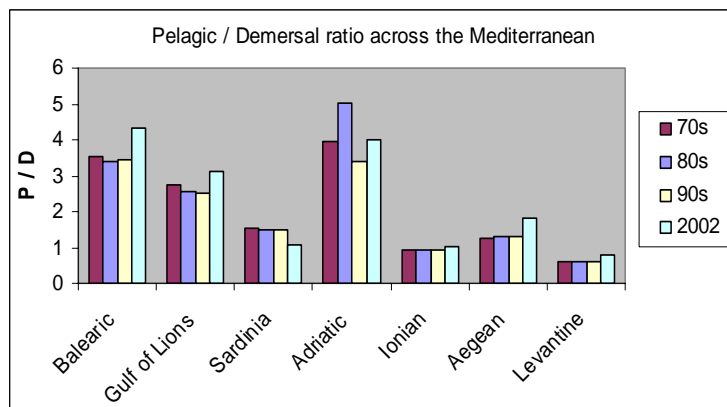


Figure 7.7: Trends in (average) ratio of Pelagic / Demersal fish catches over the 1970-2002 period across the Mediterranean.

Note: 70s, 80 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

Chapter 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 and 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).

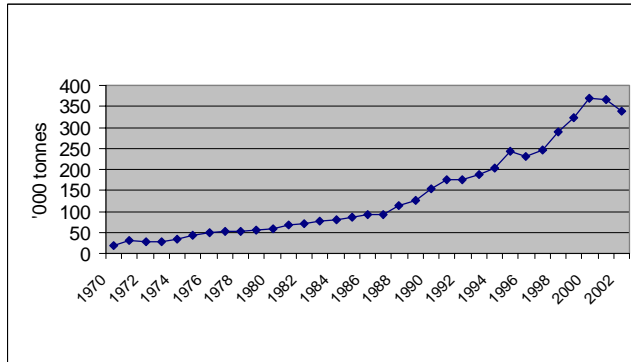


Figure 8.1: Aquaculture production (marine and brackish) 1970-2002 in thousand tonnes in the Mediterranean Sea

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 i.e. single farm level. The effects on a local scale are thus well documented whereas the effects at an ecosystem level remain unexplored, hindered by the fact that 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 husbandry practices.

In general, farming of finfish and shellfish is regarded as a threat since it can induce pollution in the marine environment in various aspects and forms and can lead to conflicts with other users. In the Mediterranean, where in many cases there is little direct evidence of aquaculture impact, such threats must be regarded as potential. 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, opposed 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 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 e.g. 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 (McDougall & 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: Fish (mullet) aggregated under a fish cage
Source: *MERAMED News letter*

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.

8.2 Deterioration of ecosystem health

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.



Photos 8.2: Dead flora (left) and fauna (right) beneath fish farm cages

Source:

Left: N. Krstulovic & G. Kuspilic, Institute of Oceanography and Fisheries, Split, Croatia, 2003

Right: MERAMED website

Changes have been documented in the microbial component of the benthic community as a result of fish farming activities (Table 9.1).

Table 8.1. Reported impacts of fish farming on meiobenthos.

Area	Impact	Reference
E Mediterranean	Microbial content of the sediment near the cages was found to increase by 4-28 times.	Karakassis <i>et al.</i> , 2000
Tyrrhenian Sea	Density of bacterial and vibrio microbial aerobic communities rapidly increased following the deployment of a fish cage.	La Rosa <i>et al.</i> , 2004
NW Mediterranean	Increase in bacterial abundance.	La Rosa <i>et al.</i> , 2004

- ❖ Studies underneath mussel farms revealed similar results to fish farms with increased densities of microbial assemblages. However, the impact of mussel farms was proven considerably less severe than 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).

8.3 Effects on sea grass meadows ⇒ can be detrimental and chronic

The close proximity of fish farms and sea grass areas pose a serious threat to the integrity of the *Posidonia* meadows which are key ecosystems of the Mediterranean marine environment playing 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) There were no signs of recovery for at least 3 years after the cessation of aquaculture activities.



Photo 8.3: Sea grass meadows

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

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 m² (Cancemi *et al.*, 2003).

- ✓ *Western Mediterranean, Sardinia*
Disappearance of the sea grasses underneath the cages as well as the localised extent of the impact (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).



Photo 8.4: Dead fish under tuna cages in Croatia.

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

8.4 Case Study – Combined impacts of tuna farming

Tuna farming (specifically the on-growing of bluefin tuna) is an activity that poses several threats to the marine environment and serves as a good example of the range of potential aquaculture impacts. Such impacts include: local pollution, if the activity is not settled in offshore water; resource depletion (the 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 continuing discussion on the possible impact of removal of fry (sea bass, sea bream and

Mugilidae spp.) to satisfy aquaculture needs, 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 in order 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.

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 antifoulants is a common practice in fish farming that can pose a serious threat to the environment. Studies on these issues are lacking in the Mediterranean, 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’.

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

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).

Chapter 9: Ecological Quality Status in Coastal Areas

The Contracting Parties to the Barcelona Convention at their 12th Meeting held in Monaco in November 2001 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, 2003a). Based on Guidelines for the Development of Ecological Status and Stress Reduction Indicators (UNEP/MAP, 2003b) and the outcome of the relevant Workshop, the proposed core set of biological indicators to assess the state of ecosystem Stress includes the following:

- Number of non indigenous species (all taxa) (see chapter 5)
- Presence and coverage of benthic macrophytes (sensitive/opportunistic)
- Presence/abundance of sensitive/opportunistic zoobenthic species/taxa
- Community diversity (zoobenthos/phytobenthos)
- Biotic indices:
 - Ecological evaluation index based on macrophytes (EEI) - not covered in this report
 - Ecological quality index based on zoobenthos (BENTIX)

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 be in line with existing sheets developed by related organisations and 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).

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 marine Angiosperms (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 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 (marine Angiosperms and macroalgae) are a common biological element along the Mediterranean coastline. The *Cystoseira* communities together with the *Posidonia* meadows are the main supporters of biodiversity in the infralittoral zone¹. Since these communities are best developed between the surface and 10 m depth, they are often exposed to marine pollution. The most typical example is that of *Posidonia oceanica*, which is a key species for the Mediterranean region and 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.

¹ **Infralittoral** zone: Beyond the reef-edge into deeper water

There are indications that improvement of sewage treatment along the French Mediterranean coastline and direct protection regulation of *Posidonia oceanica* (since 1988), has led to improvement of the meadows (up to 1990 50 % of the sites were in regression; from 1990-93 27 % were in regression; 46 % were stable and 27 % were in progression).

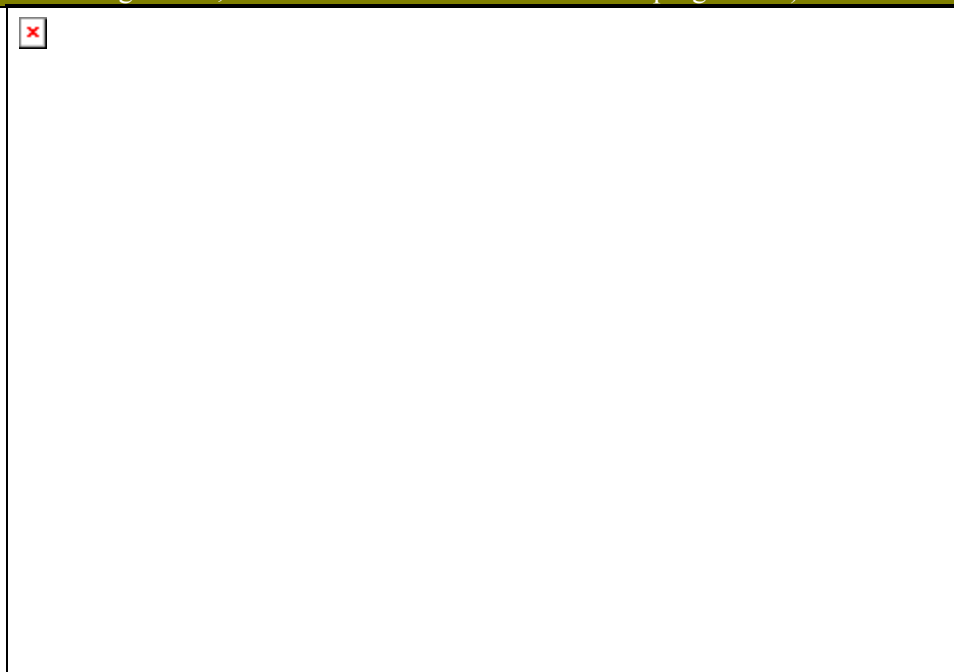


Figure 9.1: Distribution of the marine angiosperms *Posidonia oceanica* and *Zostera* spp. in the Mediterranean.

Source: EEA, 2004

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 km² of the bottom were occupied by *Caulerpa racemosa* at Castellon. In 2000, the species was found in Alicante and a survey carried out in 2002 showed that 10 km² of the bottom were occupied along 18 km of coastline. In 2002, the species was also found at Sagunto (Valencia) and in 2003 at Tabarca (Marine Park) where 3.000 m² of the bottom were occupied.

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

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

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

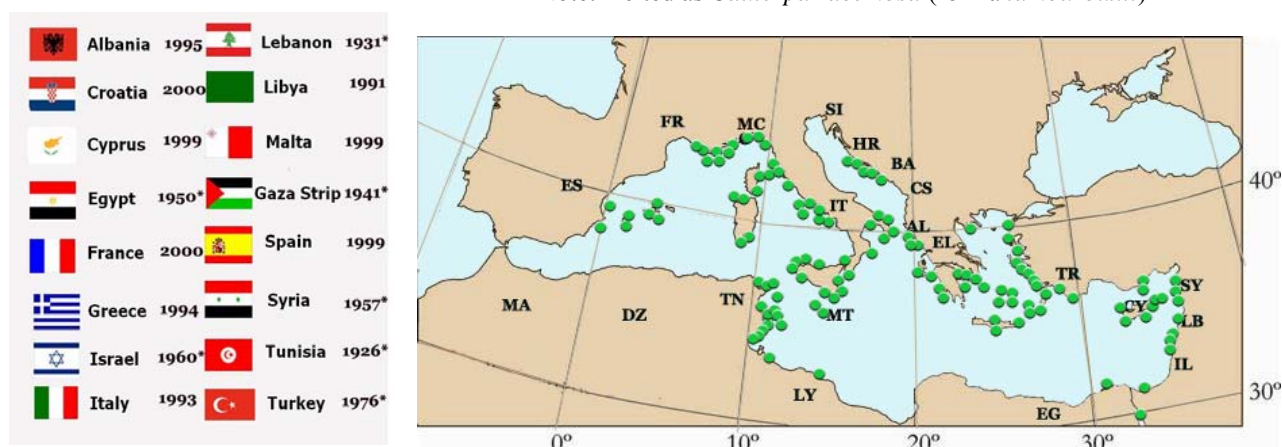


Figure 9.2: *Caulerpa racemosa* records in the Mediterranean Sea

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

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.

Box 9.1: Dominance of a species tolerant to pollution in Oued Laou, Morocco



Photo 9.1: *Ampelisca* sp.

Source: <http://www.nhm.org/guana/bvi-invt/bvi-surv/images/pera-i03/h1052am.jpg>

Percentage of prevalence of the amphipod *Ampelisca brevicornis*, a species tolerant to pollution, is increasing (Table 9.2) as community diversity (H) decreases, i.e the poorer the ecological quality becomes.

Table 9.2 Trend in macrobenthic parameters (including percentage of contribution of a tolerant species) along a pollution gradient

Depth m	H	Dominance of <i>Ampelisca brevicornis</i>
5.1	1.56	78 %
5.7	2.04	62 %
5	2.25	48 %
5	3.81	20 %

Increased pollution

Data source: Bayed et al., 2004

Box 9.2: Mortality of key species of sponges



Photo 9.2:
Eunicella_singularis has
been severely affected.

Source:

[www.aiam.info/pic/wsj/
Eunicella_singularis.jpg](http://www.aiam.info/pic/wsj/Eunicella_singularis.jpg)

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, Tunisia is clearly evidenced by the distribution, measured as 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	E Zebra & Zembretta	Zone of Sidi Daoud	SE Zebretta	W Zebretta	Tabarka
<i>Eunicella singularis</i>	8 to 10	17 to 25	50	40	35	70
<i>Eunicella cavolinii</i>	2 to 3	3 to 5	25	15	absent	absent

Source: Ben Mustafa & A.El Abed, 2001

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 and ideally should refer to a standard sampling surface.

Based on the community diversity index, 5 classes of community health can be found in Mediterranean 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 Greek literature and experience of the authors. However, it is further supported by literature from other Mediterranean areas.

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	
Azoic to heavily polluted	0<H≤1.5	Bad:	

Source: Zenetos & Simboura, 2001; Simboura & Zenetos, 2002

9.4 Ecological quality index based on zoobenthos

The various tools used as indicators are often adapted to regional requirements and biological particularities. BENTIX (Simboura & Zenetos, 2002) is a newly developed tool (based on macrozoobenthos of soft substrata) in assessing ecological quality status in accordance with the needs of the Water Framework Directive (WFD). A classification system (Table 9.5) appears as a function of BENTIX. Including five levels of ecological quality status (EQS) in accordance with the needs of the WFD.

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

Pollution Classification	BENTIX	EQS WFD	BENTIX in physically stressed muds
Normal/Pristine	$4.5 \leq \text{BENTIX} \leq 6$	High	$4 \leq \text{BENTIX} \leq 6$
Slightly polluted, transitional	$3.5 \leq \text{BENTIX} < 4.5$	Good	$3.0 \leq \text{BENTIX} < 4.00$
Moderately polluted	$2.5 \leq \text{BENTIX} < 3.5$	Moderate	$2.5 \leq \text{BENTIX} < 3.00$
Heavily polluted	$2 \leq \text{BENTIX} < 2.5$	Poor	
Azoic	$\text{BENTIX} < 2$	Bad	

The BENTIX index discriminating between only two ecological groups 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 sewage effluent in coastal waters.
- ❖ Best assessment of EQS is achieved by a combination of BENTIX with H (community diversity) and S (number of species).

Both BENTIX and H have been tested with data sets 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

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 sources is reflected in all parameters and 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 3 parts i.e. the inner, middle and outer one (Figure 5.3).

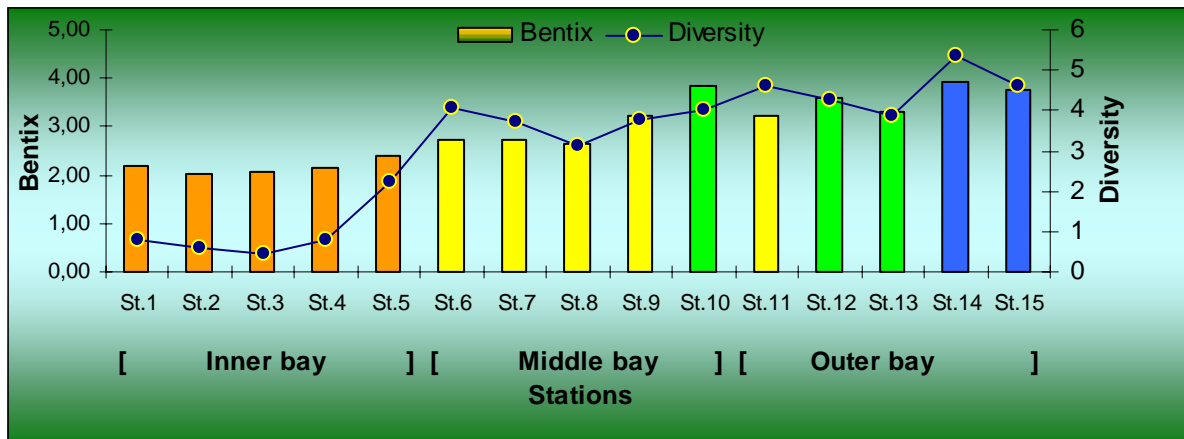


Figure 9.3.: Yearly average values of BENTIX and community diversity (H) along a pollution gradient in Izmir Bay. Colours correspond to EQS classes as defined by BENTIX in accordance with WFD

Source: Dogan, 2004

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. In any case, EQS should be based on a combination of indices, as the 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 (Zenetos *et al.*, 2004).

Case Study : EQS in Saronikos Gulf, Greece

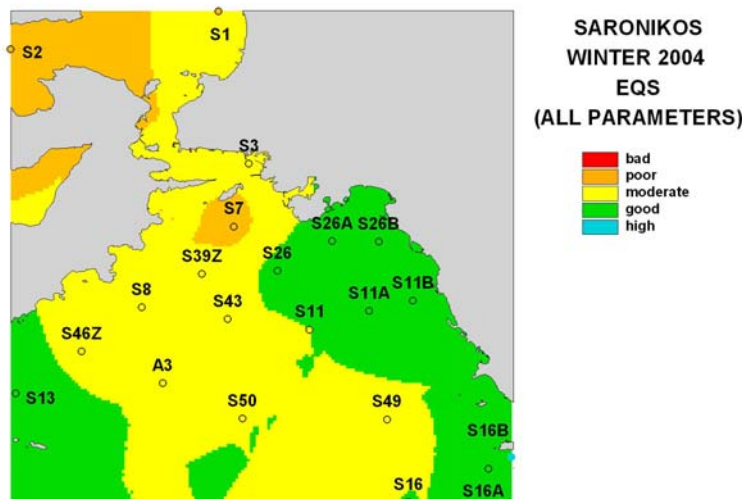


Figure 9.4: EQS in Saronikos Gulf considering all benthic parameters

Source: HCMR, 2005

In **Saronikos** Gulf, receiving the sewage effluents of the Metropolitan city of Athens a Primary WWTP started working in 1994. The benthic communities' ecological quality status is followed the years 1999 to 2004. As shown by recent trend analyses considering all abiotic (sediment type, depth, concentration of Organic Carbon in sediment), and biotic parameters (including H, BENTIX) the EQS is improving with the distance from the sewage outfall (station S7: poor quality). A reference "high" quality status zone is limited in the more coastal areas (S16B: high quality) (HCMR, 2005).

Chapter 10: Policies

The following sections outline the most important of the many subregional, regional and global laws and policies that address the priority environmental concerns in the Mediterranean region.

10.1 The 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 coasts¹. The European Community is a Contracting Party to the Convention and some of its protocols (Table 10.1), together with seven States², which are today members of the European Community and provides a significant contribution to the functioning of the Barcelona system.

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.

Since 1994, several components of the Barcelona system have undergone important changes. Starting in 1995 an ambitious revision of the Convention began which concluded in 2002. The

¹ 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, FR (Serbia and Montenegro as from November 2003) see - www.unepmap.org

² Cyprus, France, Greece, Italy, Malta, Slovenia and Spain

objective of the revision was to modernise the Convention to bring it in line with the principles of the Rio Declaration, the philosophy of the new UN Convention on the Law of the Sea (UNCLOS) and the progress achieved in international environmental law in order to make it an instrument of sustainable development.

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, (not yet in force); The Emergency Protocol acknowledges in the preamble the role of IMO, as well as “the contribution of the European. 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 (EC) N° 2172/2004 of 17 December 2004 **amending** Regulation (EC) N° 417/2002 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 (MEPC° of IMO.
- The **LBS Protocol** for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities (the amendments are not yet in force);
- 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).

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 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, i.e.

- A. Pollution: spans diverse activities causing pollution 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.

10.2.1 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/MED POL initiative identifying priority target categories of substances and activities to be eliminated or controlled by the Mediterranean countries. The timetabled 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 effluents treatment and disposal, urban solid waste disposal and activities contributing to air pollution from mobile sources) and to industrial activities, targeting those responsible for the release of toxic persistent and bio accumulative (TPB) substances into the marine environment, giving 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) (WFD) designed to integrate a number of earlier directives tackling water pollution into a single piece of legislation. The SAP/MED and the WFD are similar in their approach so that it may be considered that in implementing 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 timetable. 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, research and monitoring efforts based on EU Directives have been directed to their study so as 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 Union and associated countries (ICES). In 2002, the EU Commission issued a new Directive (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. The following are particularly relevant to reducing pollution from PTS:

- 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 are managed and disposed 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.

10.2.2 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 improving of knowledge of marine and coastal biodiversity; and (vi) contribute to fund raising efforts.

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

- The 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 and the EU birds and habitats directives are implemented in the EU 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 Community Legislation on Biodiversity

The legislation on specially protected areas of the Mediterranean States that members of the European Community must conform to EC Council Directive No. 92/43 of 21 May 1992 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 EC 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)

10.2.3 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 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 Community 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 to the Community, 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 and, therefore, in the Mediterranean too.

Among the Contracting Parties to the International Convention for the Conservation of Atlantic Tunas are France, Morocco, Libya, Croatia, Tunisia and the EU. On the basis of scientific research ICCAT can, through its International Commission, make recommendations aiming 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.

CHAPTER 11. CONCLUSIONS AND RECOMMENDATIONS

11.1. Conclusions

Several problems are plaguing conservation measures to protect Mediterranean coastal and marine habitats with the most important being urbanisation, pollution, lack of law enforcement and lack of knowledge of the biological and cultural value of existing habitats.

All around the Mediterranean basin, **coastal urbanisation** is interrelated with biodiversity losses, unsustainable increase of water demand, as well as of wastes and thus pollution. Wetland losses and environment degradation have imposed a serious threat to many aquatic species.

Most of the Mediterranean coastal areas do not host chemical industries that produce important amounts of hazardous wastes. The majority of these substances come from **stockpiles of obsolete chemicals**, such as banned pesticides and PCBs which are presented in this report. The occurrence of POPs in the Mediterranean region is also discussed. With regard to discharge of fine solids from **coastal industrial plants** or discharge of inert material from construction activities, it may lead to blanketing of the sediments with land-based material and to serious degradation of the benthic community. Industrial induced blanketing is found in the vicinity of industrial plants such as aluminum production (e.g. Korinthos Gulf, Greece), cement (e.g. Bassilikos Bay, Cyprus), or in areas of intense construction (river Zrnovnica estuary, the Tarska vala cove – river Mirna estuary, the river Neretva estuary, the river Cetina estuary in Croatia), and solid waste dumping sites (Beirut area, Lebanon).

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 rise of the **aquaculture** industry has added to the degradation of the marine and coastal environment (e.g. Croatia and 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 enrichment, especially with nitrogen and phosphorus, has favoured some of the introduced microscopic marine algal species which are toxic and has led to **Harmful Algal Blooms** phenomena.

In general, south Mediterranean countries are lacking the necessary technical, financial and human resources to comply with national and regional regulations (e.g. stockpiles of pollutants).

11.2 Gaps in knowledge – further work needed

The definition of problems of the marine environment of the Mediterranean Sea and identification of **gaps** is a prerequisite to find the proper management solutions. In this respect, as already pointed out, the Mediterranean region exhibits important gaps of knowledge regarding levels and loads of pollutants, statistics of elements of transboundary concern, inventories of specific ecosystems and hot spots. In fact, the information collected through the process of the preparation of this document, in most cases comes from case studies and does not cover by any means the whole Mediterranean region. Unlike the northern part of the Mediterranean, information is generated through scattered, inconsistent and frequently unreliable investigation programmes in the south and east of the Mediterranean.

11.2.1 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 rain water exist for the northwestern Mediterranean since the late 1980s, as opposed to the southwestern Mediterranean where there is little information.

Data on riverine discharges is also very scarce. Most rivers, even though they are very important sources of water supply 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 indicates that most of the data are not from monitoring programmes but estimated through the preparation of the National Diagnostic Analysis (NDA) of the impacts of LBS and the National Baseline Budget of releases from point LBS sources. This implies a lack of long-term time series data.

Up to now, the efforts carried out in quality control/quality assurance (QC/QA) in monitoring programmes at regional level are not reflected in the existence of adequate data banks. Lack of measurement data is a very serious drawback for environmental assessments and also for modelling transfer processes of pollutants and particularly, transboundary transport within the region.

Moreover, for comparative reasons, further standardisation (or at least, increased data compatibility) of research and assessment methodologies and reporting requirements is needed. Therefore, any attempt to increase database measurements through comprehensive monitoring networks should be encouraged.

11.2.2 Data on biodiversity issue: 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 easily accomplished for ALL Mediterranean countries if a protocol for rapid assessment surveys is developed and agreed upon. Based on the changes in habitat distribution of a few “key species”, a clear sign of environmental degradation will be easily 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 should agree on common criteria or metrics for producing assessments that are comparable within countries. It is essential to initiate the process to arrive at common criteria for the interpretation of the 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 Blue Plan, EEA, UNIDO-ICS or WFD.

It is, therefore, recommended that data flows be developed between countries and the UNEP/MAP so that advanced indicators can be developed in line with work at a European level. These indicators could then be progressively developed and modified as the information required to achieve better comparability becomes available during the progressive implementation of the WFD.

Increased attention should be paid to the concept of eco-regions as proposed by ICES in the preparation of the EU Marine Strategy (ICES, 2004), in the knowledge that higher-risk eco-regions 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 subregions. This effort of integration from a network of interdisciplinary scientific groups should be used as an excellent opportunity for “good science” input to the management process.

11.3 Reduction of pressures

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. Both problems need to be adequately addressed in establishing a strategy of reduction of pressures of transboundary concern, the first primarily requiring technological interventions and the second improved management practices.

11.3.1 Technological interventions

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 promotes continuous improvement through operational and behavioural changes. Pollution prevention is a shared responsibility among governments and individuals, industrial, commercial, institutional and community sectors.

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 the 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 cost to the environment, since neither the economic conditions nor the required technologies are available. In this context, UNEP should play a catalyst role in order to make possible the socioeconomic conditions and the technological transfer to prevent further environmental deterioration of the Mediterranean basin at the expense of the industrialisation of the southern countries.

11.3.2 Proper development practices for the ecosystem

The creation of marine protected areas for conservation purposes is often not sufficient as an impact-limitation measure, since many of the impacts derive from pressures that are not necessarily of local origin.

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

On 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.

Coastal Area Management Programmes, for instance, are 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.

11.4 Identification of needs for regional cooperation

11.4.1 Land Based Sources

It is obvious that the development of management structures and the implementation of Strategic Action Programme (SAP) and National Action Plans (NAP) to address land-based sources of pollution cannot take place under the same conditions in all countries. The southern countries of the region are those facing major problems with regards to pollution management capacities and therefore, those primarily requiring external cooperation. The main problem is the treatment of organohalogen wastes, which have no recycling value and require major investments.

The conclusion, which may be drawn from this point, is that technologies for the management of industrial waste that could be developed are those generating a local economic activity solely based on supply and demand. Treatment technologies involving costs cannot be developed as long as they are not economically integrated into production costs. It is, therefore, evident that any national action plan should be preceded by the establishment of a pollutant release and transfer register. National and regional action plans should, therefore, consider the following aspects:

- Development of a systemic approach for the global, national-based management of pollution.
- Enlargement of the permit system related to point sources discharges as well as the compliance and enforcement of regulations.
- Extension of registers to production flows.

- The issue of environmentally rational management of hazardous industrial waste.

All environmental conventions have raised the problem of the treatment of industrial effluents generated by producers or users of dangerous substances. There are three aspects, which are indivisibly linked to this issue and which are often overlooked during the implementation of conventions: the Technology/Regulation links, the Technology/Financing links and the Financing/Regulation links.

The search for solutions should, therefore, aim at a global, national-based approach, which would integrate these three parameters. Today, however, environmental conventions have been implemented according to a pattern that does not take into consideration the close interrelation between them. It is, therefore, of primary importance to encourage in each country the creation of working groups bringing together the national operators of the different conventions, in order to integrate all the aspects of the problem in a global manner:

- Financial capacity
- Technological capacity
- Harmonisation of regulations

SAP/NAPs should take into account, as a key element, each country's economic situation. In this respect, the north/south financial responsibilities should be considered for an effective implementation of environmental conventions in the southern countries.

11.4.2 Fisheries and Aquaculture

The development of a Mediterranean Advisory Council¹ (RAC) is another step in the direction 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**², has been set up in the Mediterranean in May 2004. Medisamak, which also includes non-EU countries, envisages working with both GFCM and ICCAT driving to increase stakeholders' involvement under the latest decision by fisheries ministers from the Mediterranean states to revive the GFCM with a view to encouraging multilateral cooperation.

The aquaculture industry has to improve itself on specific issues towards sustainability. To do that it should focus on improving its image and the environmental local situation and impact monitoring, working on the issue of sustainable feeding and promoting coastal zone integration (IUCN, 2004). It is widely accepted that impacts can be minimised or negated if culture procedures and environmental safeguards (regulatory, control and monitoring) are adopted.

11.5 Needs and future interventions for ICZM

In order to mitigate negative trends caused by the previously mentioned related issues affecting the Mediterranean Sea, proposed interventions should satisfy specific needs/areas for intervention:

- Harmonisation and strengthening of ICZM implementation at local, national and regional levels; .
- Securing and upgrading the application of ICZM when dealing with transboundary issues by upgrading the human and institutional capacity for the implementation of related projects.
- Upgrading specific components of ICZM (coastal urban – sea level rise - seismicity). [The social and economic impacts of major earthquakes can be devastating, particularly in urban areas. A proper building code that sets standards for construction and maintenance should be based on knowledge of both seismicity and local ground conditions].

However, before describing the nature of interventions needed in coastal zone management and planning and before 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/ more extended initiatives.

¹ 2004/585/EC Council Decision of 19 July 2004 establishing Regional Advisory Councils (RAC) under the Common Fisheries Policy

² under the EU Action Plan for sustainable fisheries in the Mediterranean

- Proactive context, including future/ potential transboundary impacts and issues.
- Harmonisation with past and ongoing relevant initiatives at all levels.
- Consistence with global/ regional/ national/ 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.

11.6 *Solutions-management and regulatory mechanisms*

The number one priority in environmental management in the Mediterranean region is to develop the necessary environmental legislation and to enforce it.

The regulatory status of the Region mimics the socioeconomic and political structure. The legislation for hazardous substances management in EU Member States and the associated countries is regulated by the European directives, although the degree of compliance is varying within the Member States and their investment in regional hazardous substances issues 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. The control and regulation of hazardous substances in many of the countries of the Region and environmental control and regulation is quite decentralised which implies that many of the responsibilities are transferred to regional, provincial or local authorities.

Other Mediterranean countries exhibit low commitments 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. As an example, none of the most recent Protocols (including the revised ones), has entered into force, despite having been adopted in 1995 and 1996.

11.7. The way forward

Development of regional environmental legislation and enforcement of it seems to be the only route to a real improvement of the environmental conditions in the region and should be done at both national and regional levels.

At the same time, networking among the environmental scientists including engineers and interaction with stakeholders in the region is considered the only way forward. Implementation of these collaborations can be achieved through three main channels which include:

- multilateral assistance programmes such as those sponsored by MAP bodies, UNEP, the GEF and multilateral development banks;
- state-driven domestic implementation efforts; and
- EU-driven efforts for EU candidate states and non European countries through the Euro-Mediterranean partnership.

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Acronyms

ACCOBAMS: Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area

ASP: Amnesic Shellfish Poisoning

BOD: Biological 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

EQS: Ecological Quality Status

EEA: European Environment Agency

EC: European Commission

EQS: Ecological Quality Status

ETC/TE: European Topic Centre/Terrestrial Environment

FAO: Food and Agriculture Organisation

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: Intergovernmental Oceanographic Commission – Harmful Algae of North Africa

IUCN: The World Conservation Union

LBS: Land-Based Sources

MEAs: Multilateral Environmental Agreements

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 Cooperation and Development
PAHs: Polycyclic Aromatic Hydrocarbons
PCBs: Poly Chlorinated Biphenyls
P/D ratio: Pelagic / Demersal ratio
POPs: Persistent Organic Pollutants
PSP: Paralytic Shellfish Poisoning
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
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 Organisation
UNIDO-ICS: United Nations Industrial Development Organisation -International Centre for Science and High Technology
WFD: Water Framework Directive
WWTP: Waste Water Treatment Plant