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I A S O N

Deliverable to WP4

AN ASSESSMENT OF THE MEDITERRANEAN EROSION STATE, PRESSURES AND HAZARDS

by Dov S. Rosen and Sigal Calderon

IOLR Report H66/2006, May 2006

דו"חות חיא"ל

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National Institute of Oceanography
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An assessment of the Mediterranean Erosion State, Pressures and Hazards

by

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Contents

Contents - continued

Contents - continued

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

1. STATE OF THE ENVIRONMENT IN THE MEDITERRANEAN SEA

1.1 Mediterranean characteristics in short[1]

- The total length of the Mediterranean coastline is 46,000 km, of which 19,000 km represent island coastlines. About 54% of the Mediterranean coastline is rocky; the rest consists of low sedimentary shores.
- The specific geology results in the creation of a specific marine and coastal environment:
  - almost enclosed sea is characterised by a slow replacement of the seawater from the Atlantic. The turnover period is estimated to be from 80 to 90 years;
  - small drainage basin creating limited natural fresh water supply, a very narrow littoral zone and steep slopes directly into the sea, a certain isolation of coastal populations;
  - great basin depth is an obstacle in the exploitation of the resources and a 'good' place to dump;
  - many islands create a problem for communications and trade but offer good opportunities for tourism;
  - high volcanic and seismic activity represent a certain level of risk; and
  - specific wind regime characterised by strong seasonal winds.
- The climate is 'Mediterranean', 250 sunny days a year, hot and dry summers, mild winters, seasonal rainfall pattern, disparity north/south in occurrence and amounts of precipitation, uneven water cycle.
- Major rivers are Ebro (Spain), Rhone (France), Po (Italy) and Nile (Egypt).
- Agricultural resources are limited, farming in coastal areas, typically Mediterranean, in many areas in decline, soil erosion processes (rainfall induced, wind induced). Forests in decline, covering only 5% of the region. Forest fires are very common during the summer.
- Industry in the region represents 16% of the world industry, characterised by decline of primary production in the north, and by transfer of technologies to east and south.
- Maritime transport: 200 million tons of oil per year, 200-250 large oil tankers permanently in navigation, 60 large ship accidents per year.
- International tourism: 33% of the world international tourism, around 200 million international visitors. Today, the whole of the Mediterranean countries constitute the most tourist region in the world and is at present the destination for nearly 200 million international visitors.
- Coastal areas are unique, attractive, habitats of specific flora and fauna, natural parks, fragile ecosystems, specific biodiversity, many rare and endemic species, many endangered and disappearing species. More than 4 hundred sites of the UNESCO world cultural heritage.

[1] Marko PREM (2004)

1.2 Emerging issues in the Mediterranean region[2]

The following issues are of concern for maintaining a sustainable ecosystem and have been recognised as such in European Environment Agency (EEA) reports:

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

1.3 Causes of the Mediterranean degradation

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

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

1.3.2 Solid waste

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

1.3.3 Industrial effluents including oil processing.

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

1.3.4 Urbanisation and tourism[3]

The 150 million people living along the Mediterranean coast produce 3.8 billion cubic metres of wastewater each year. A further 2.5 million cubic metres are produced by the 220 million tourists visiting the Mediterranean region every year. The above figures are a rapidly increasing trend.

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[2] European Environment Agency Report (2006)

[3] WWF-World Wide Fund for Nature(2006)

Urbanization[4] of the coastline is one of the major problems in the Mediterranean region, often leading to loss of biodiversity due to habitat destruction and physical alteration. Problems related to the concretisation of the coastline are encountered

through the Mediterranean. This is usually due to uncontrolled development, especially tourist infrastructure. Both wetland and salt-marsh destruction for land reclamation and mining of coastal resources (sand and rock quarrying) for construction needs are also altering irreparably the natural Mediterranean coastline.

1.3.5 Eutrophication

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

1.3.6 Sand erosion

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

1.3.7 Marine transport

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

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

***1.3.8 Biological invasions*.**

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

1.3.9 Harmful Algal Blooms (HABs).

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

[4] Source: European Environment Agency Report (2006)

1.3.10 Exploitation of marine resources[5].

Fishing down the marine food web has a negative impact on whole ecosystems. According to the FAO fisheries statistics, the mean trophic level of Mediterranean catches has declined by about one level during the last 50 years, e.g. there has been a significant loss of top predators from the ecosystem. Another documented impact of fishing relates to changes observed in the structure of fish populations. Demersal stocks in the Mediterranean are dominated by young fish indicative of high fishing pressure. There is a high economic interest in small fish, leading to high catches of undersized fish in some bottom trawl-fisheries. High discard rates of undersized; targeted species is also contributing to a loss of biodiversity of non-target species. ***Overfishing***[6] - Around 1.5 million tonnes of fish are caught in the Mediterranean each year. Destructive and often illegal fishing methods, including bottom trawlers, dynamite, long lines, and drift nets have depleted fish stocks. Uses of drift nets are also responsible for the accidental deaths and for incidental catches of flagship species such as cetaceans and marine turtles. Depleted fish stocks are also reflected in the undersized catch. 83% of all blue-fin tuna and swordfish caught in the Mediterranean sea are undersized.

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

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

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

[5] Source: European Environment Agency Report (2006)
[6]WWF-World Wide Fund for Nature(2006)

1.4 Mediterranean Sea hotspots[7] (overview)

Along the Mediterranean coastline, 131 'pollution hot spots' have been identified by the countries in the frame of the Strategic Action Programme (SAP) of UNEP (Figure 1.4 — UNEP/WHO, 2003). These hot spots are point pollution sources or polluted coastal areas which may affect human health, ecosystems, biodiversity, sustainability, or economy.

Of these hot spots, 26 % are urban, 18 % industrial and 56 % mixed (urban and industrial) (UNEP/MAP, 2003a). Additionally, 59 sensitive areas (marine areas under threat of becoming pollution hot spots) have also been identified along the Mediterranean coastline. All these pressures have led to the degradation of environmental quality in certain coastal areas. The impact on the open Mediterranean Sea environment, however, is still uncertain.

Identification of hot spots and areas of major environmental concern are shown on a country-by country basis. However, it must be stated that the country reports sometime contained conflicting data and the data availability was not identical for all the countries. Therefore pollution stress was evaluated at the national rather than pan-Mediterranean level.

Figure 1 - Pollution hot spots along the Mediterranean coast[8]

Source: HCMR based on UNEP/WHO, 2003.

1.5 Point sources[9]

Over the past three decades, much of the attention in dealing with ocean and coastal environmental problems focused on point sources of pollutants, including oil from tankers, sewage from municipal and hotel pipes and even radioactivity from nuclear power stations. More recently marine scientists have begun to look at more diffuse sources of contamination, including sources that deliver a broad range of pollutants and contaminants. Agriculture, forestry, extractive industry, urban development and many other sources all contribute large quantities of solid waste, sediments, nutrients and toxic pollutants. Rivers and streams are a major transport route for these materials to the oceans, but atmospheric deposition is also playing a role, making clear the linkages between human and ecosystem health on land, in the air and at sea[10].

1.5.1 Sewage and urban run-off (urban wastewater)

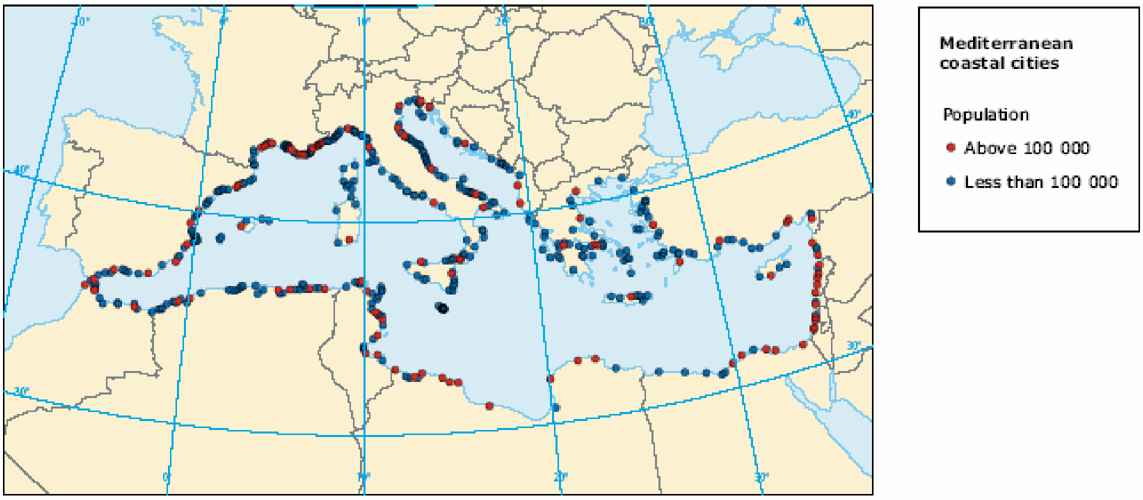
Sewage generation influence on the marine coastal environment directly or indirectly affects human health, the stability of the marine ecosystem and the economy of the coastal zone (impact on tourism and fisheries).

The problem is exacerbated due to the rapid growth of many coastal cities and towns, especially on the southern Mediterranean coast. The sewage collection system is often only connected to parts of the urban population, which leads to direct discharge of untreated wastewater into the

[7] Source: European Environment Agency Report (2006).
[8] Source: European Environment Agency Report (2006).
[9] Source: European Environment Agency Report (2006).
[10] UNEP – WCMC (2002)

sea through other outfalls. The major pollutants of municipal wastewater are: organic matter (measured as BOD5 and COD), suspended solids, nutrients (nitrogen and phosphorus) and pathogenic micro-organisms.
Other pollutants such as heavy metals, petroleum and chlorinated hydrocarbons are also present in the wastewater.
The permanent population on the Mediterranean coast is in the order of 150 million inhabitants. However, this figure could be doubled during the summer period as the area is one of the most frequented tourist destinations of the world. Along the Mediterranean coast, 601 cities with a population above 10 000 inhabitants were reported from 19 countries, making a resident population of 58.7 million[11].

Figure 2 - Mediterranean coastal cities[12]



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

Sixty nine percent of these cities operate a wastewater treatment plant (WWTP), 21 % do not possess a WWTP while 6 % are currently constructing a plant and 4 % have a plant out of operation for various reasons. Secondary treatment is mostly used (55 %) in Mediterranean WWTPs, while 18 % of the plants have only primary treatment. The distribution of treatment plants is not uniform across the Mediterranean region, the northern Mediterranean coast having a greater part of its urban population served by a WWTP than the southern coast. Also, due to increasing population in cities and failures in treatment plant operation, some WWTPs cannot produce effluent of an adequate quality as initially planned.

1.5.2 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 groundwater and/or the coastal marine environment with organic pollutants and heavy metals. Moreover, accidental fires emit smoke particles, Polycyclic Aromatic Hydrocarbons (PAHs) and dioxins, seriously affecting the health of neighboring towns[13].

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[11] Source: European Environment Agency Report (2006).
[12] Source: European Environment Agency Report (2006).
[13] Source: European Environment Agency Report (2006).

1.5.3 Persistent organic pollutants — POPs

Persistent organic pollutants include certain prohibited pesticides and industrial chemicals the manufacturing of which is also prohibited. For example, polychlorinated biphenyls (PCBs) and unwanted contaminants (hexachlorobenzene, dioxins and furans).

The proposed targets agreed by the Barcelona Convention Contracting Parties in the SAP include the following:

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

For many Mediterranean countries, no detailed information is available on the releases of POPs from point sources (urban centres and industry). Limited studies have been carried out on the bioaccumulation of selected POPs in Mediterranean biota (Figures 2.3a and 2.3b).

On the Spanish Mediterranean coast, the distribution of POP concentrations as measured in Mytilus galloprovincialis shows the highest concentrations in the area of Barcelona, both for PCBs and DDTs (BIOMEJIMED project). In general, local or national authorities do not routinely monitor most of the POPs.

The main source of POPs — since most POPs have been banned in the majority of the countries of the region — is believed to be stockpiles and inventories due to former production and/or import (i.e. PCBs in transformers), as well as secondary releases from environmental reservoirs (i.e. contaminated sediments) due to previous usage and accidental spills.

The contribution from industrial production is only important in those cases where some restricted usage of POPs is allowed (i.e. DDT as precursor of dicofol) and for the POPs that are generated as unwanted secondary products (i.e. PAHs and dioxins from combustion)

- 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[14].

- 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.

[14] Source: European Environment Agency Report (2006).

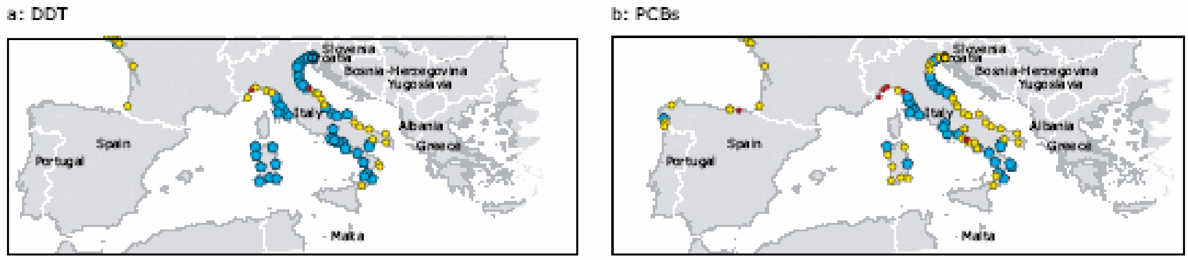
Table 2 - Stockpiles of pesticides in the Mediterranean region[15]

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

*For locust control **Reported

Source: UNEP Chemicals, 2002.

Figure 3 - POPs in mussels (*Mytilus edulis*), median concentration 1996–2002[16]



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

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

The main source of PCBs in the region is the disposal of equipment with PCB-containing oils.

The main stockpiles are located in the northern Mediterranean countries due to their extensive use (and as a result of economic development) prior to the ban.

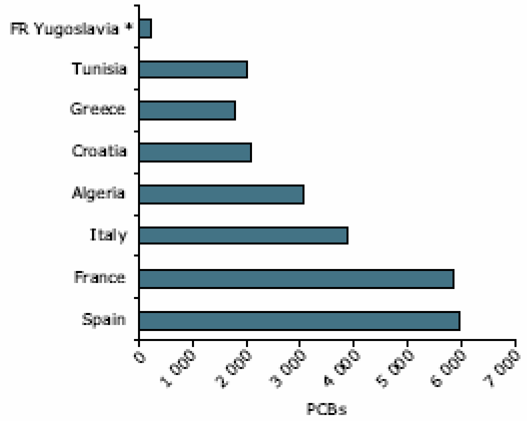
A large number of these stockpiles have been eliminated during the past years, mainly in the Northern Mediterranean countries (i.e. France, Italy, and Spain).

[15] Source: European Environment Agency Report (2006).

[16] Source: European Environment Agency Report (2006).

The stocks still remaining in the Mediterranean region are presented in the following figure[17].

Table 3 - Country contribution to the stockpiles of PCBs in the Mediterranean region during the mid-1990s[18]



*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 below:

Table 4 - Assessment of dioxin emissions in EU Mediterranean countries until 2005[19]

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

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

Source: EC, 2000.

1.5.4 Heavy metals (arsenic, cadmium, chromium, copper, nickel, lead and mercury) [20]

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

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

As metals tend to precipitate after their introduction into the coastal marine environment they accumulate in sediments and biota. This occurs especially in sheltered areas such as harbours and semi-enclosed bays in the vicinity of land-based metal sources. Increased metal concentrations have been identified in many coastal areas in the Mediterranean Sea, such as the coast of

[17] Source: European Environment Agency Report (2006).
[18] Source: European Environment Agency Report (2006).
[19] Source: European Environment Agency Report (2006).
[20] Source: European Environment Agency Report (2006).

Tuscany (Tyrrhenian Sea), Kastella Bay (Adriatic Sea), Haifa Bay and the coast of Alexandria (eastern Mediterranean), and Izmir Bay and Elefsina Bay (Aegean Sea).
Mercury is of particular concern because it is easily released from the sediments into the overlying water and consequently re-enters the food chain. High consumption of mercury-contaminated fish has been proven to result in neurological effects. The weekly intake of most people in central and northern Europe is below the international 'Provisional Tolerable Weekly Intake' (PTWI) for methylmercury (1.6 µg/kg body weight/week), and a lower US 'Reference Dose' (RfD) (0.7 µg/kg body weight/week). However, the intake of most people in coastal areas of Mediterranean countries, and around 1–5 % of the population in central and northern Europe is around the RfD. In addition, part of the Mediterranean fishing communities is above the US 'Benchmark Dose Limit' (BMDL) of 10 times the RfD — the level at which it is accepted that there are clear neurological effects (EC, 2005). Release of pollutants from sediments has been reported in the Gulf of Trieste, in the northern Adriatic Sea off the mouth of the river Po, where a net flux has been recorded of Cd and Cu into the overlying water from the contaminated sediments.

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

1.5.6 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 137Cs and 239,240Pu in the Mediterranean marine environment. Other sources (input from rivers, nuclear industry, exchanges through the straights) amount to no more than 10 % of the total load from fallout. Inputs deriving from nuclear industry and from accidents (other than Chernobyl) are negligible when considered in terms of contribution to the total budget. However, they might lead to local enhancement of radioactivity levels.

1.5.7 Nutrients
The increase of nutrients (nitrogen and phosphorus) to a marine ecosystem enhances primary production and may lead to eutrophication of the water body. This phenomenon has as side effects: proliferation of planktonic biomass, discolouration of the water, reduction of water transparency, reduction of dissolved oxygen in deeper waters and, in extreme cases, occurrence of toxic algal species. Urban wastewater discharges are important nutrient loads, especially when untreated. As a result, all coastal areas in the vicinity of large towns or cities which do not efficiently operate a wastewater treatment plant are receiving high loads of nutrients and may suffer the consequences.

The coastal cities presented in the chapter on sewage are also sources of nutrients. Rivers are also important transporters of nutrients and suspended solids since they drain basins with agricultural activities (fertilisers) and urban centres. It has been estimated that 605 000 tonnes of N-NO3 and 14 000 tonnes of P-PO4 are entering annually (1995) into the Mediterranean Sea from the rivers Po, Rhône and Ebro (UNEP/MAP, 2003a).

Average nutrient concentrations in various Mediterranean rivers are shown in the table below.

Table 5 - Average nutrient concentrations in various Mediterranean rivers (sampling periods are not identical (1985–1996)[21]

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

1.5.8 Rivers[22]

The river mouths and deltas, the coastal lakes, lagoons, wetlands and all types of natural fresh and brakish water discharges which act as "carriers" and bring to the coastal region anthropogenic pollutants, that have entered them at different time and place, eventually long before or in a place far away from the coast.

The contribution in pollutants of the Mediterranean rivers has not been assessed thoroughly until now. It is beyond doubt, however, that rivers draining large catchment areas with agricultural lands, such as the rivers Rhone, Po, Axios, Loudias. Aliakmon and of course the Nile, are the most important point sources of agrochemicals, mostly pesticides in the Mediterranean. Among the pesticides detected are also the "new generation" ones atrazine, simazine, alochlor, molinate and metalochlor which, however, represent only very small percentage (~ 3%) of the quantities applied to cultivated lands. Rivers carry industrial chemicals too, such as polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), solvents and heavy metals (Pb, Zn, Hg, Cu, As). The metal concentrations in Mediterranean rivers are, in general, lower than those of the majority of western European rivers. This is attributed to the result of dilution of anthropogenic heavy metal loads by high levels of suspended solids of low metal content, deriving from soil erosion. The fact that in the last few decades hundreds of reservoirs from the damming of rivers have been created alters in various ways the distribution of metals: in some cases by retaining the sediment-bound metals (so the impact in the river mouth seems diminishing), while in other cases by retaining the low metal particles that "dilute" the anthropogenic load (so the impact in the estuary becomes more visible and the concentrations in the upper layer of sediment columns increase).

[21] Source: European Environment Agency Report (2006).

[22] Source: Michael J. Scoullos.

Rivers seem to be also major carriers of the radionuclides Cesium-137 and Plutonium-239 and 240 especially in areas where the deposition from the Chernobyl accident was significant (eg. North Adriatic and Liguro-Provençal areas).
The "runoff" which is less visible but very important input to the coastal waters, includes not only distinctive freshwater discharges from torrents and streams, but all small non-point discharges entering the sea in fluxes after each rainfall. Runoff carries anthropogenic substances from all types of activities through the washout of rural lands and urban areas. Runoff is a major carrier of pesticides (including insecticides, herbicides and fungicides). Their utilization has increased significantly over the last two decades due to the expansion of intensive agriculture. The largest amounts of active ingredients were applied in the north western part of the Mediterranean (approximately 100.000 tonnes per year in Spain, France and Italy). However high consumptions are noted also in other countries (such as in Turkey, ~35000 t/y) a proportion of which is washed out and carried to the coastal regions by runoff and rivers.

1.5.9 Oil Pollution

The land-locked waters of the Mediterranean have a very low renewal rate (80 to 90 years), and so are extremely sensitive to pollution. Every year 600,000 tons of crude oil are deliberately released into the sea from shipping activities. 80% of the urban sewage produced is discharged untreated. Added to that are agricultural runoffs containing pesticides, nitrates and phosphates which contaminate the Mediterranean Sea (WWF 2006). Marine transport is one of the main sources of petroleum hydrocarbon (oil) and polycyclic aromatic hydrocarbon (PAH) pollution in the Mediterranean Sea (EEA 2006)

Shipping and oil slicks

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

Oil spills

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

1.5.10 Marine litter

Mediterranean coasts are becoming littered mainly with plastic debris. However, the degree of the impact has not been quantified yet. Growing evidence indicates that when dumped, lost or abandoned in the marine environment, plastic debris has an adverse impact on the environment. Not only does it become an aesthetic nuisance, it also requires costly clean-up procedures.
Environmental impacts arise from entanglement of marine animals in plastic debris and from ingestion of plastic by these organisms. Marine debris poses a threat to humans when divers, ships or boats become fouled by debris.

2. THE MEDITERRANEAN SEA AND COASTAL EROSION [23]

2.1 General

The Mediterranean coast was perceived as being not vulnerable to sea-level rise, but this past perception was incorrect. The Mediterranean was seen as less vulnerable because of tectonic uplift regions (Cyprus, most of Italy's east coast) and rocky and steep coastlines (Croatia, Turkey, Malta). However, this is much less so on the North-African coast of the Mediterranean and in particular on the Egyptian an Israeli coast located within the Nile littoral cell. Some countries (Spain, Italy) have experience with adaptation to problems in the coastal zone, such as erosion. However the forecasted sea level rise in the present century including the Mediterranean change the previous perception.

The expected sea-level rise due to the "greenhouse effect" for 2100, range between 0.1 m and 0.9 m. This value is a world wide average rise, while the relative regional value may differ significantly due to additional various factors, such as plate tectonics. Sea level measurements carried out at Hadera GLOSS station since 1992 as well as satellite altimetry measurements of the sea level indicate that the sea levels in the Eastern Mediterranean rose at a rate of about 1cm/year in the last 13 years, while a lowering has been measured in the Ionian sea. These changes seem to be due not only to the global warming effect but also due to fluctuations in the formation and circulation of the deep Levantine water between the Adriatic and the Aegean during this period. The figure below (Fenoglio-Marc, 2001) shows the sea level rate of change in the mentioned period over the Mediterranean.

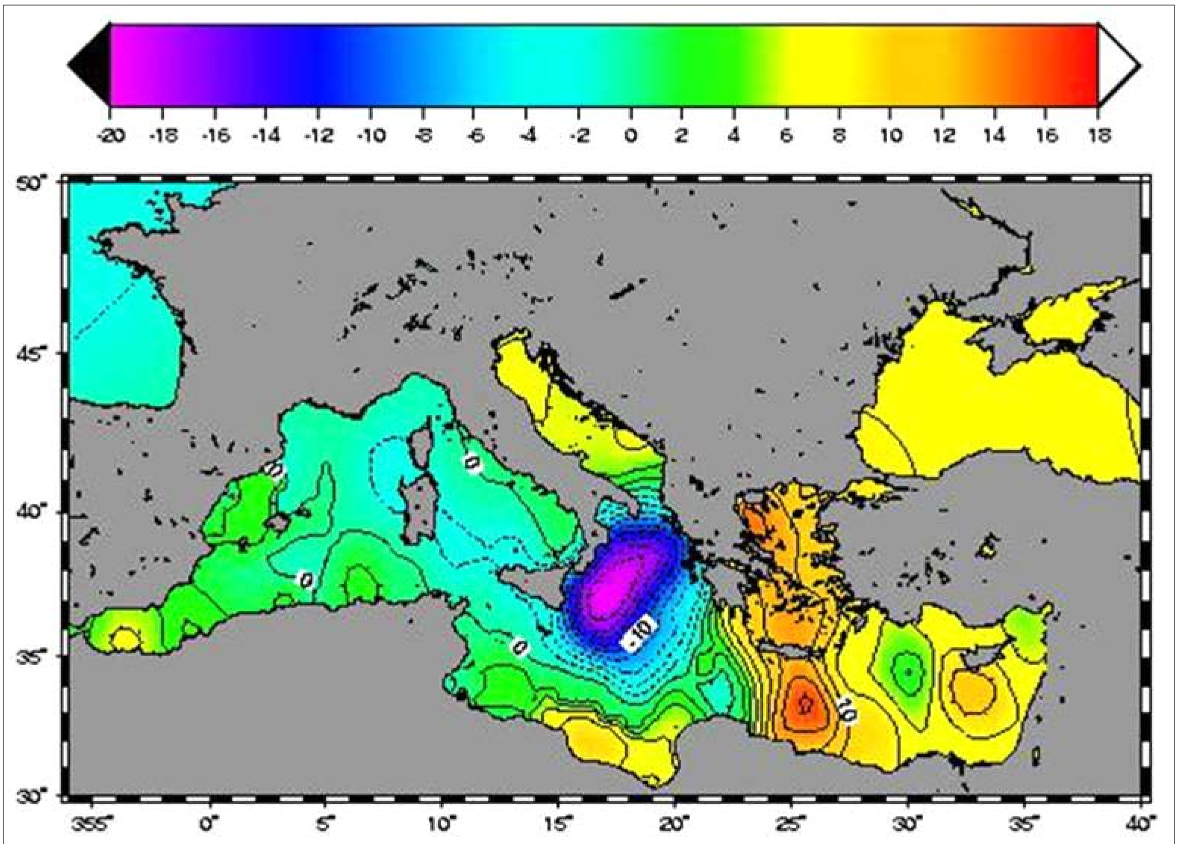
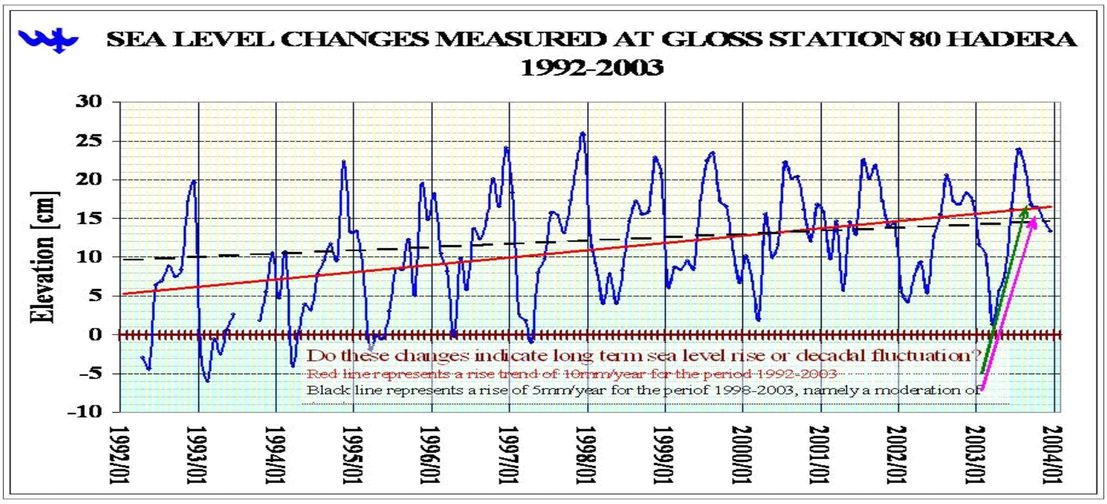


Figure 4 - Sea level changes 1992-2000 based on Topex-Poseidon satellite altimetry (Fenoglio-Marc, 2001)

[23] National Institute of Coastal and Marine Management of the Netherlands (2004), A guide to coastal erosion management practices in Europe

These sea level changes are confirmed for example by measured sea levels at the Hadera GLOSS station since 1992, shown in the figure 5 below.



The meteorological contribution to sea-level in the Mediterranean was recently assessed for the period 1958 – 2001 within the HIPOCAS project (Gomis et al, 2005) as shown in figure 6 below.

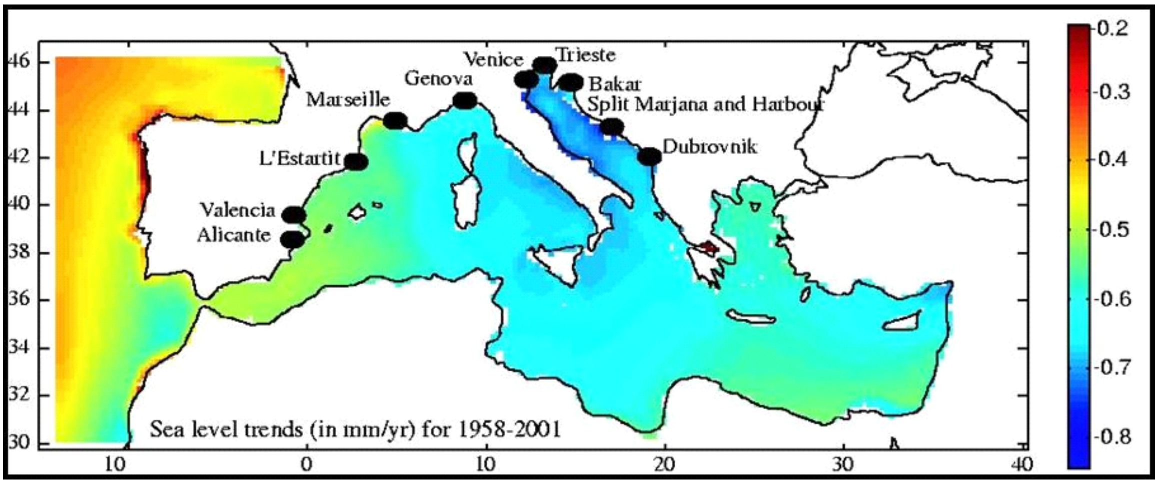


Figure 6 - meteorological contribution to sea-level in the Mediterranean during 1958 – 2001

In particular low laying coastal areas such as major river deltas are particularly sensitive to the impact of sea-level rise (e.g. the Ebro, Rhône and Nile deltas, and the historical city of Venice). Furthermore, there are many, smaller `pockets of vulnerability'. Although these do not always cover large amounts of land or substantial shares of the population, they may be important economic assets (e.g., sandy beaches) or important ecological areas (e.g. coastal wetlands).

Other issues and developments may well be as important or even more than sea-level rise (e.g impact of Aswan dam to retreat of Nile delta). These include also other aspects of climatic change (primarily changes in precipitation, temperature, wind, wave and nearshore currents climate), but also issues such as population and economic growth, and changes in the national and international political situation.

Generally, coastal zone managers in the Mediterranean did not pay a lot of attention to accelerated sea-level rise, even though long term investments are made.

This attitude is presently changing, following recent research activities on European wide extent (e.g. EUROSION project) and Mediterranean wide extent (MAMA project).

2.2 Erosion in the Mediterranean Coastal Regions

All through its history, the Mediterranean region has suffered from the fragility of its eco-systems, and more specifically in the coastal areas where most of the population has always concentrated. Agricultural activities in particular are refrained by degradation and constant risk of depletion of soil and water resources in many sub-regions, and especially in the coastal areas.

When discussing soil erosion or land degradation it is important to bear in mind the four main basic physical factors on which the rate of erosion depends: the erosivity/
agressivity of climate and rainfall, the fragility/erodibility of the soil, the topography, and the amount and density of vegetation cover. In the Mediterranean region, which is a transition zone between the arid tropics and the temperate and more humid climates of the North, most of these factors are of particular relevance:

- The Mediterranean Basin includes an enormous variety of topographic, lithologic and edaphic (predominantly fragile red Mediterranean soils) conditions and landscapes;
- The so-called Mediterranean ecosystems have as major criterion the alternation of hot, dry summer and more humid winter periods thus generating a very typical climatic feature which consists of a marked deficit of precipitation as related to evapo-transpiration during 3 to 6 months of summer period; this peculiarity is to be considered as a highly determinant parameter in the global resources degradation process and in some specific physical desertification mechanisms. Another characteristic is that most of the precipitation comes in violent downpours, which makes the erosivity of rainfall much higher than in temperate zones, when these violent rainstorms follow or coincide with the dry summer periods, thus generating severe erosion damages to the unprotected topsoil;
- The existing semi natural vegetation cover (i.e. vegetation associations such as garrigue, maquis) actually represents degraded forms of the genuine mixed Mediterranean forest. The natural vegetation had to adapt to growth conditions characterised by high summer temperatures that coincide with a severe shortage of water. During these same periods the remaining forest formations are periodically affected by bush fires. The remaining vegetation still establishes large wooded areas, but these appear rather vulnerable to further destruction by fire or illegal timber extraction.

2.3 Coastal Classification

The geology of the Mediterranean is extremely complex and subject of continuous scientific debate. The large scale evolution is dominated by the tectonic convergence of Europe and Africa. The convergence leads to large vertical (uplift and subsidence) and horizontal (displacement of landmasses and basins) movements and active volcanism (Italy Sicily, Greece). The vertical movements differ regionally and even locally, with different rates and styles (abrupt or continuous) of movement. The surface geology also differs strongly alongshore, with outcrops of various types rocks of different ages as well as a broad range of quaternary sediments. Given the complexity and variation in geology along the Mediterranean shores, this must be considered on a local or regional scale.
There are three major geomorphical settings within the Mediterranean basin; areas with stable margin characteristics, areas with unstable convergent margin characteristics, and areas with extensional margin (rifting) characteristics. Thus the Mediterranean basin is a location of an intercontinental interplate system; with compressional and extensional events occurring within close proximity. Subsidence-related and other vertical displacements are also found in compressional and extensional areas. A few notable events occurred during the Cenozoic which affected the entire Mediterranean; the Messinian "salinity crisis", when the closing off of the
Mediterranean-Atlantic seaway caused complete isolation of the Mediterranean and thus widespread evaporation; and then the Pliocene "revolution", when the channel opened back up,

causing reestablishment of marine conditions; and the Quaternary "transgressive raised terraces," of controversial geological origin; among others.
At least, six major basins can be structuraly and morphologically differentiated: Alboran, Liguro-Provençal, Tyrrhenian, Adriatic, Ionian and Levantin
The Central portion of the Mediterranean basin exemplifies the juxtaposition of compressional and extensional tectonic activity in the area. The region bordered to the west by Sicily and to the east by Turkey's west coast (encompassing the Aegean, Ionian, and Adriatic seas) exhibit a particular set of features.

The two broad categories of coastal landscapes (high cliffs and low-lying flat land) are not mutually exclusive, nor restricted to particular geographical areas.

2.4 Hard rock coast

Cliffs and more gently sloping rocky shores are often composed of various types of limestone which form the basis for the karst landscapes of the hinter-land.

2.5 Sedimentary coast

Along the micro-tidal sedimentary coasts in the European part of the Mediterranean sea sandy beaches and dunes are found, frequently with spits and lagoons in low coasts. In Spain, with the exception of some river mouths, coastal low lands are very limited in the Andalucían Mediterranean coast and from Murcia to Cataluña a group of mountains ranges bordering the sea are setting the edge of this coastline. In France, on the continental Mediterranean shore, most of the dunes stands are located in the Golfe du Lion. The beaches and deltaic coastline is evaluated at 230 km (of which 120 km are "lidos"). The latter are low-lying dunes, the main part of which has been pulled down because of urbanisation processes. In Corsica dunes are not much developed, they often show up as a sandy arrow or a coastal string, and most of them are located on the eastern part of the island. In Italy, continuous belts of sandy beaches are mostly developed on the Adriatic coast of the peninsula.

Deltas and narrow coastal plains, generally occupied by wetlands and lagoons, help to define the landscapes of the Mediterranean coasts. These are present throughout the region and are most extensive in areas backed by mountains where major eroding catchments deliver large quantities of sand and silt to the coast. Short torrents, without water during most of the year, are draining enormous volumes of water in response to heavy local rains, in very short periods. This causes floods which also enhance sedimentary processes. This process combined with the small tidal range help to create some of the largest deltas in Europe: those of the Ebro, the Rhone and the Po rivers. All of these have been modified in some way by human activity whether through changes to the cycle of deforestation in the hinterland, damming of rivers delivering the sediment or drainage and other activities in the deltas themselves. Developed deltaic coast is restricted to the Po delta, which occupies the northern Adriatic. Barrier islands coasts, with associated lagoons and coastal lakes, are characteristics of the territories north of the Po delta, and occur along a coastal stretch of 130 km.

2.6 Definition of Coastal Areas in the Mediterranean Sea[24]

The concept of coastal area, broader than the coastal zone, understands a distinct transitional system between marine and terrestrial (continental) environments. Figure below illustrates the Blue Plan – MAP definition of Mediterranean coastal areas, based on territorial/administrative

[24] Priority Actions Programme, 2000, Guidelines for erosion and desertification control management with particular reference to Mediterranean coastal areas. Split

coastal units (UNEP-BP/RAC, 1989). For a more detailed insight on definition(s) and practical understanding of the notion, references (UNEP, 1995) and (Vallega, 1999) might be consulted.

Figure 7 - The Blue Plan – MAP definition of Mediterranean coastal areas[25]

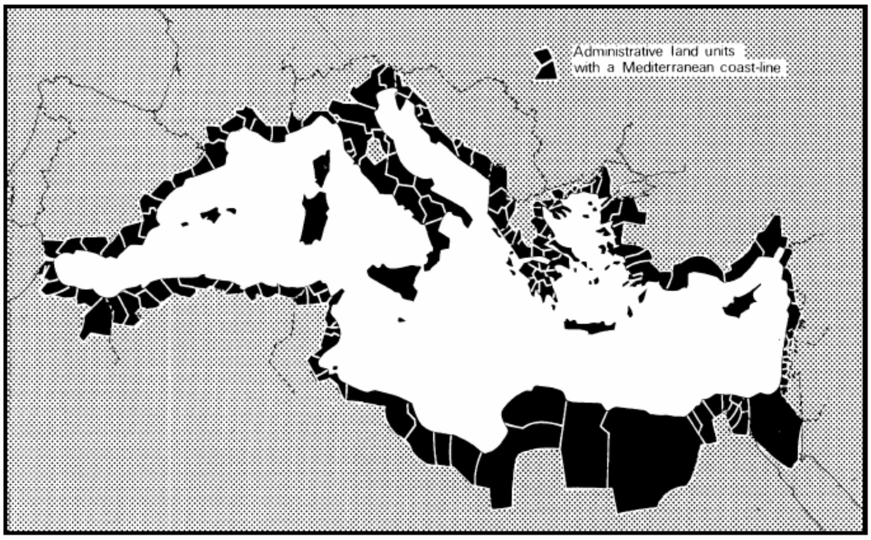
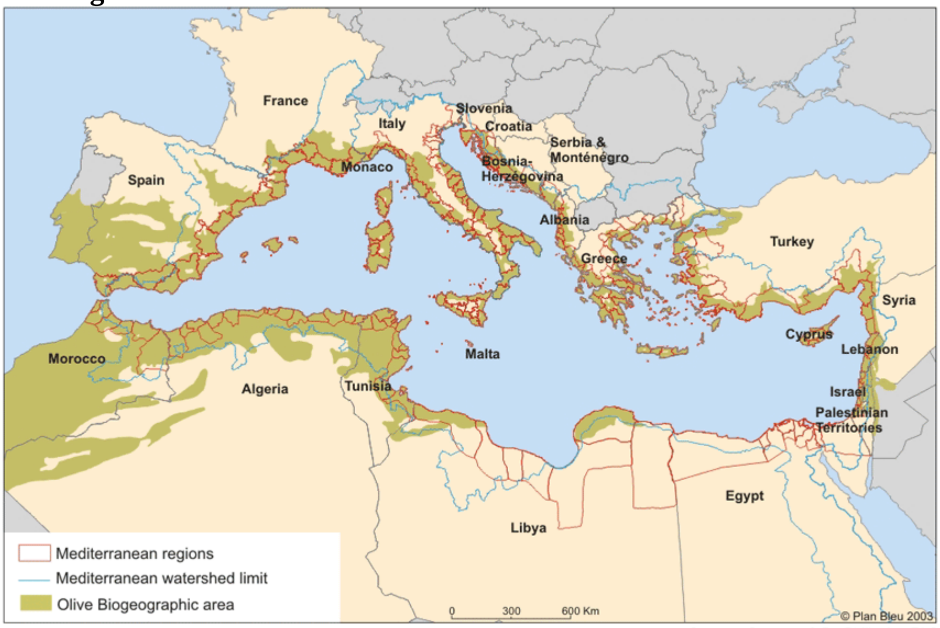


Figure 8 - Mediterranean Countries and Their Different Limits[26]



The geographical interpretation of Mediterranean watershed(s), however, must be approached in a more flexible way, in particular within the context of these Guidelines.

The following figure presents boundaries of the Mediterranean watershed, with boundaries in very arid areas to be understood as approximate ones. In practice, all relevant upstream processes and those parts of river basin areas under the influence of the Mediterranean climate and with Mediterranean specific biota should be considered as corresponding to the Convention definition. Faraway areas of large rivers, such as Ebro, Rhone, Po and Nile, are in practice excluded, but not the relevant impacts generated there.

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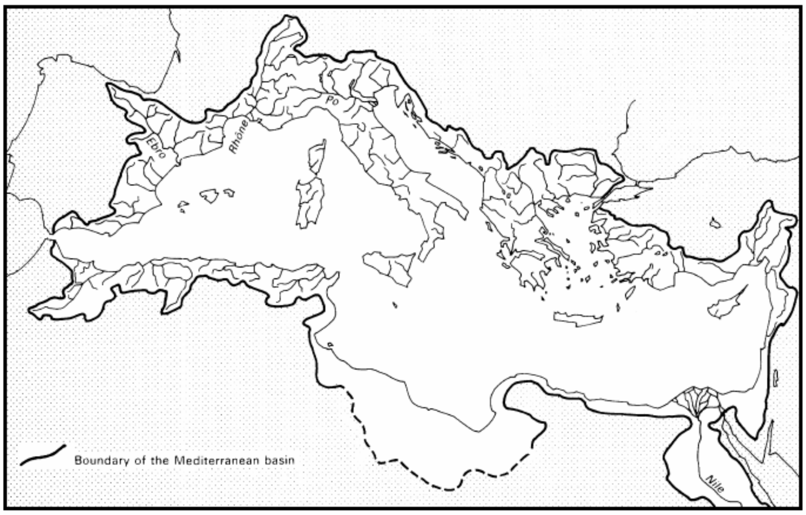
[25] Source: Priority Actions Programme, 2000, Guidelines for erosion and desertification control management with particular reference to Mediterranean coastal areas. Split

[26] Source: www.planbleu.org.

Figure 9 - Boundaries of the Mediterranean watershed[27]



Concerning erosion/desertification related phenomena the geographical context as defined above results with focus on land resources and management, including faraway upstream causes and respective impacts, as well as the adjacent marine environment affected by the resulting pollution, sediment transport and impacts on biodiversity.

2.7 Erosion

2.7.1 Physical processes

The Mediterranean Sea, as depicted in the figure below, is an enclosed basin connected to the Atlantic Ocean by the narrow Strait of Gibraltar (width ~13 km, sill depth ~300 m) and connected to the Black Sea by the Dardanelles/ Marmara Sea/ Bosphorous system. It is made up of two sub-basins, the Western (WMED) and Eastern (EMED) Mediterranean, connected by the strait of Sicily (~35 km/ ~300 m).

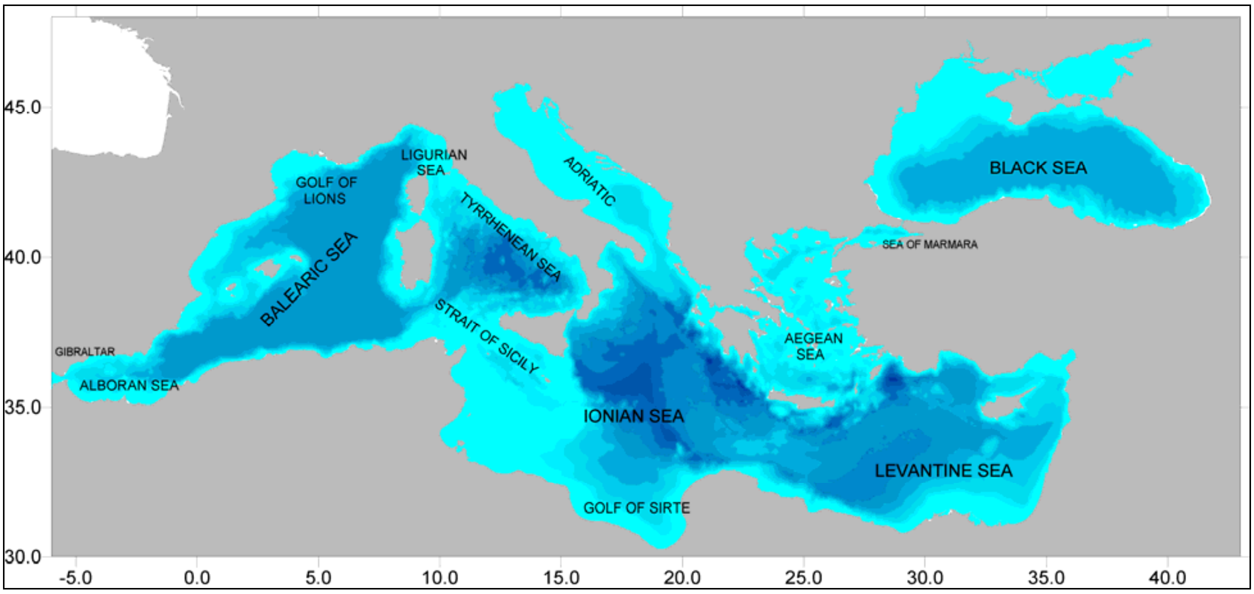


Figure 10 -The Mediterranean Sea. Geographic features

[27] Priority Actions Programme, 2000, Guidelines for erosion and desertification control management with particular reference to Mediterranean coastal areas. Split

The EMED is comprised of four sub-basins: the Ionian, the Levantine, the Adriatic, and the Aegean Seas. The most eastern, the Levantine Basin, merges with the Ionian Sea through the Cretan Passage at a depth of about 1500 m between Crete and the Libyan coast and is connected, to its north, to the Aegean Sea through three relatively shallow passages.

The MED has an annual negative water balance (due to the excess of evaporation (mainly in the EMED) as compared to precipitation, river runoff and Black Sea exchange) causing inflow of less saline Atlantic water through the Strait of Gibraltar.

The climatological circulation of the Mediterranean basin is constructed, basically, from a zonal and two meridional vertical circulation belts. The first, is an open and shallow (0-500 m) vertical circulation belt associated with the inflow of the Atlantic water at Gibraltar, which reaches the Levantine basin and is transformed there into Levantine Intermediate Water (LIW). The LIW is an important component of the flow exiting from Gibraltar into the Atlantic Ocean. The other circulation belts are meridional cells driven by deep water mass formation processes occurring in the Northern MED areas such as the Gulf of Lions or the Adriatic (Schlitzer et al., 1991), and (recently) the Aegean Sea (Roether et al., 1996) . The deep water formation in such areas which determines the abyssal waters in both the EMED and WMED basins, is affected, if not controlled, by LIW present before formation events (Wu and Haines, 1996). These cells are, thus, interconnected. The Zonal cell is thought to have a decadal timescale (Stratford and Williams, 1997), while the meridional overturning cell has a multi-decadal timescales of 70 to 120 years and ~40 years for the eastern and western basins, respectively (Stratford et al., 1998). The similarity to the North Atlantic meridional overturning circulation makes the MED an important laboratory for studying air- sea interaction and mass formation.

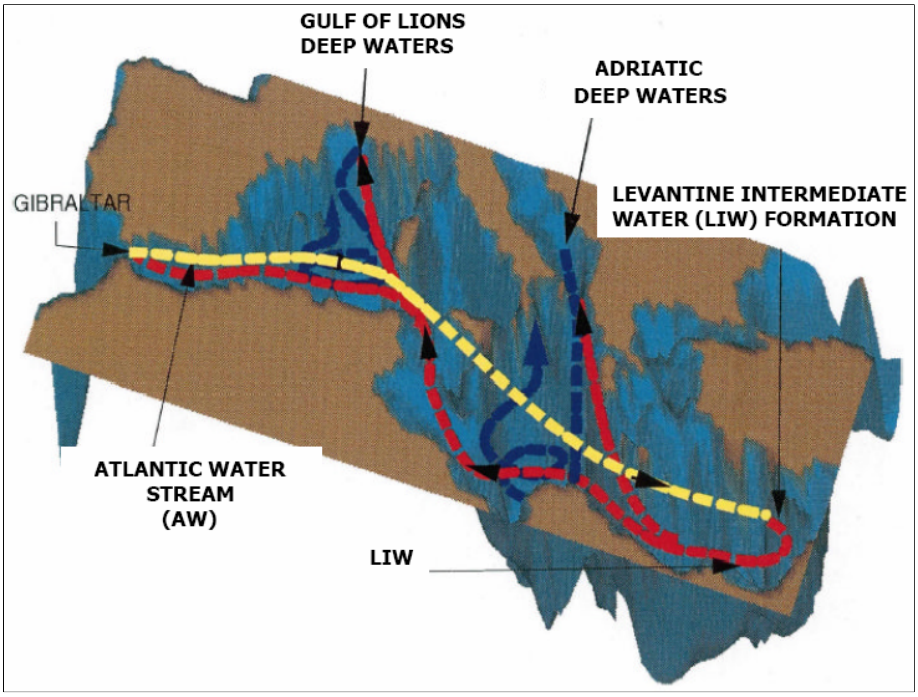


Figure 11 - Schematic of the thermohaline circulation in the Mediterranean

The figure above shows the schematic of the thermohaline circulation in the basin with the major conveyor belt systems indicated by dashed lines with different color. The yellow indicates the AW stream which is the surface manifestation of the zonal conveyor belt of the Mediterranean. The red indicates the mid-depth LIW recirculation branch of the zonal thermohaline circulation. The blue lines indicate the meridional cells induced by deep waters. LIW branching from the zonal conveyor belt connects meridional and zonal conveyor belts. Adapted from Pinardi and Masdetti (2000)

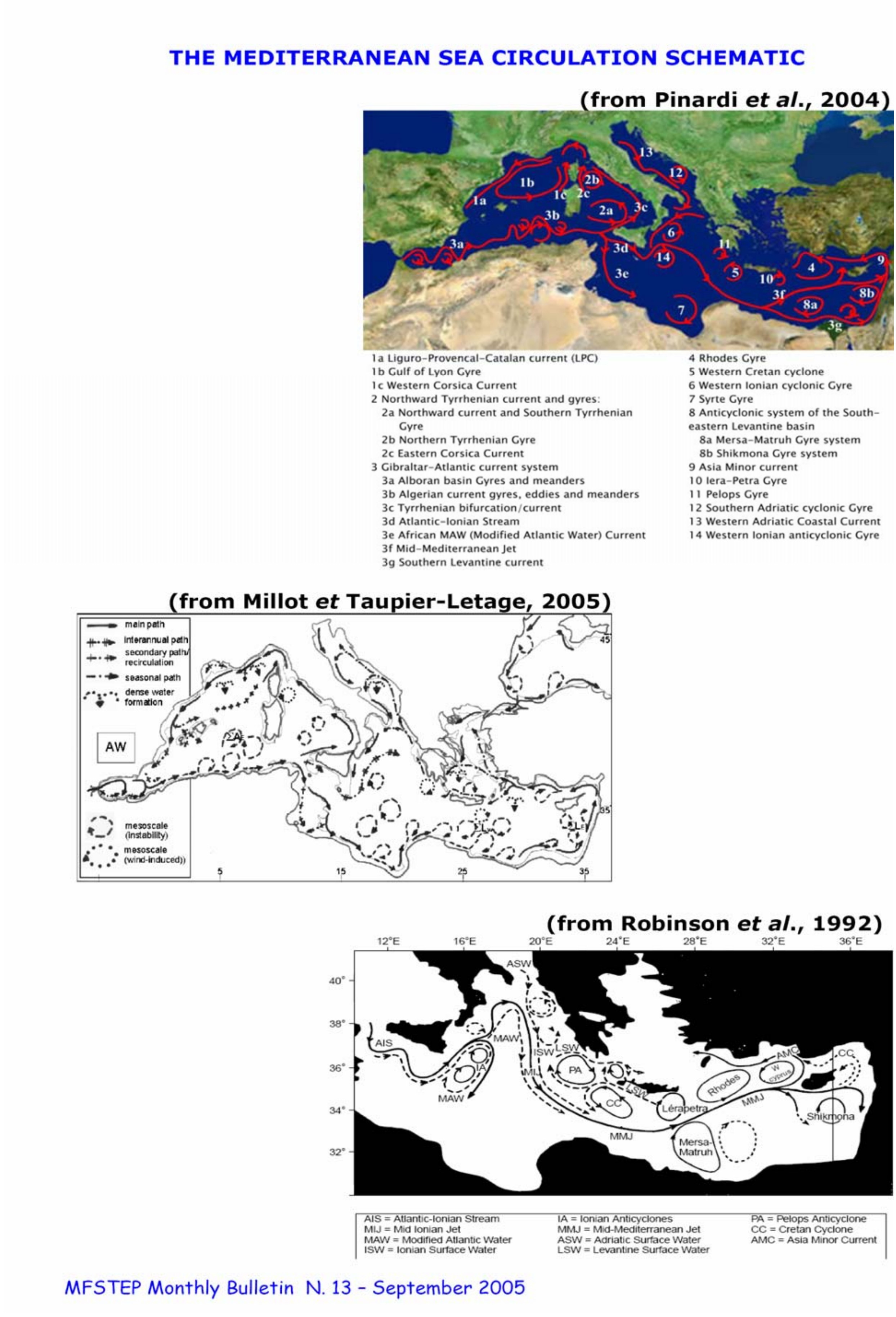


Figure 12 - The Mediterranean circulation schematic

The Mediterranean is **micro-tidal**, with small variations alongshore due to basin shape. Seas that are almost completely closed have, like lakes, only a very small tidal range, i.e. a small difference in sea level between high and low water. In the Mediterranean tides are only significant in the Gulf of Gabes (to the south-east of Tunisia) and the northern Adriatic. The general Mediterranean astronomical tidal range is about 20 centimetres. In the Adriatic it can reach about 90 centimetres. The latter sea can almost be regarded as a channel, between the straight Italian coast, and the coast of the Balkan peninsula, with many small islands, most of which run parallel to the coast. In the Adriatic Sea not only the tidal range is different: the surface currents are created primarily by the wind. They can reach a speed of three and a half knots.

Water level variations result from climatic influence in the form of atmospheric pressure changes and winds (excluding sea level rise due to the global warming, mentioned in the introduction). The complex basin geometry and the variations in weather hinder the description of one wind- and wave-climate. As to the general climate of the Med: it is windy, with mild, wet winters and relatively calm, hot, dry summers. Spring is changeable, autumn is relatively short. The flow of the air into the Med takes place through gaps in the mountain ranges. In the summer most Mediterranean winds come from the north. A number of special winds occurs. Some of these are: Levanter, Gibleh, Sirocco, Mistral (or Maestrale), Libeccio, Tramontana and Bora.

The size of **coastal cells** (i.e. coastal units with marked physical boundaries that share their sediments) along the Mediterranean varies strongly depending on the local and regional geology and sediment-transport pathways. Sediment sources vary accordingly. Sediment sources can be fluvial, cliff erosion, biogenic production and alongshore redistribution. On certain parts of the Mediterranean the input of biogenic carbonates (shells of various organisms) plays an important role in the sediment budget. The production of biogenic carbonates can be coupled to specific habitats on shoreface and slope, dominated by Posidonia Oceanica (see for instance the Mallorca case study).

The Eastern Mediterranean has been subject to a high sea level rise during the past decade at a rate up to 20 mm/yr in the Levantine basin. Sea level rise of 5-10 mm/yr was also observed in the Algerian-Provencal basin as well as in the Tyrrhenian and Adriatic seas. The north Ionian sea, on the other hand, showed an opposite trend, i.e., a sea level drop of ~-5 mm/yr. Sea surface temperature trends are highly correlated to sea level trends, which suggests that at least part of the observed sea level change has a thermal origin. The Mediterranean sea level rise observed by satellite altimetry during the last decade is possibly related to the warming trends reported from hydrographic cruises in the intermediate and deep waters of the eastern Mediterranean since the early 1990s, and of the western basin since the 1960s.

The relative sea level rise has important implications for the future of the deltas of the Mediterranean Sea as well as for the future of the sand beaches and coastal cliffs in particular when these are made of cemented sediments, as is the case for the many of southern and south-eastern coasts of the Mediterranean. However the pattern of change is complicated by tectonic movements caused by a variety of influences (e.g. volcanic activity, earthquakes).
When this is coupled with human influences which exacerbate sea level rise, significant problems of erosion, salt water intrusion and flooding can occur. These effects are especially important in the major deltas where a decrease in sediment availability and subsidence due to water pumping or the sheer weight of infrastructure may be some of the factors which give rise to substantial problems of erosion and flooding as is being experienced in several of the major Mediterranean deltas.

2.7.2 Erosion of different coastal types due to driving forces[28]

a. Hard and soft rock coasts

Rocky coasts are widespread in Mediterranean sea (Western Corsica, Riviera, Liguria, Sardinia, Puglia, Cataluña, most of Greek coastland, etc). The erosion rate is generally small and manly caused by wave attack (wave generated by boats and ships can erode unprotected shorelines or accelerate the erosion in areas already affected by natural erosional processes).

b. Microtidal Sedimentary coast

In Greece there are beaches with sand dunes and wetlands too. But the increment of tourism, majority in the small islands, and the construction of hard engineering structures along the coast modify highly the natural processes of erosion.

2.7.3 Natural Processes Combined with Man-Made Actions[29]

Driving forces of erosion processes along the Mediterranean coast are pretty similar amongst them, but a high diversity results from geo-morphologial features of each different area (Geodiversity). As a natural process of hundreds of years, erosion is mainly due to winter storms, when most of the material is extracted from beaches and transported elsewhere down the coast line, a fraction of it being lost forever under the bathymetric of –10 m/-15 m and, naturally, replaced by new material from continent shelf erosion transported by rivers.

All these forces reach to a natural equilibrium point where as much material is eroded as it is sedimented. However, the rising of sea level introduces a condition of displacement of that equilibrium which again set different acting forces to work. Lately, since most of the new material remains trapped in dams and reservoirs along Mediterranean river basins, at least one of the acting forces is not present and the equilibrium does not occur naturally. Moreover, quite a number of man-made causes are present throughout the Mediterranean Sea: obstacles to longshore drift (ports, dykes, and so on), and a weakening of the coastal material resilience due to development and urbanization processes[30].

So, a lot of erosive problems in the coastline are the evident manifestation of the coastal dynamics disturbances. It is the result of different impacts and processes that can be summarised in the next points:

- Sea level rise whose effects, however slow, can provoke an irreparable impact over the low littoral, specially when the natural adaptation possibilities are hampered by urban settlements.
- The reduction of the sediment sources, specially the ones originated in the river-basins. This reduction is often the consequence of changes related to the catchment area regulation, mainly with dams.
- Amongst direct causes of soil erosion and desertification, deforestation should certainly be considered as the most predominant and ancient. The consequences of deforestation leading to soil erosion which eventually generates the outcrop of stone pavements or soil “hard pans” thus reducing greatly the percolation of water into the soil. The remaining perennial plants can barely survive, and germination in general becomes difficult for both annuals and perennials[30].
- In the last twenty years there has been a significant increase in the frequency and magnitude of forest fires in the Mediterranean area. Various explanations have been proposed for the dramatic increase of bush fires in Spain and in Italy: (i) land abandonment

[28,29,30] National Institute of Coastal and Marine Management of the Netherlands (2004), A guide to coastal erosion management practices in Europe, Directorate General Environment European Commission and the subsequent vegetative cover changes; (ii) traditional agriculture and grazing practices which include burning to improve soil fertility; (iii) the increased change of forested land into tourist and recreational areas; and (iv) speculative initiatives to convert land for tourism, urbanisation and extensive ranging[31].

- In Morocco, Tunisia and Turkey, where pastoralism is vital, the reduction of grazing areas due to soil erosion and land use change towards cropping activities initiated a depletion spiral: less total grazing space means higher animal pressure on land which, in turn, generates more intensive land degradation and the progressive shrinking of agricultural land. In North Africa, the evidence of determinant impact of overgrazing on desertification may be inferred from the great amount of shifting sand moving from the steppe areas toward the desert (Rognon, 1999). Turkey is also facing this problem of overgrazing; extension of the grazing period from early spring to late fall results in accelerated land degradation[32].
- The increasing number of barriers to sediment transport: mainly coastal defence and harbour structures. This is often the direct cause of many accounted regressive sand beaches and coastal dunes.
- The occupation and alteration of beaches and coastal sand dunes in most of the cases due to the tourist and urban pressures. These alterations degrade the beach stability, reduce the bulk of moving sediment and increase the erosive problems over urban settlements and roads.
- Non controlled extractive activities in river basins and in coastal sand dunes that contribute to weaken the available volume of sediments. In some regions like Murcia and Almeria greenhouse crops has have a strong influence in this phenomenon for sand coming from coastal dunes has been used as a substrate.

2.8 Erosion due to human interference in the coastal zone[33]

2.8.1 General

In the Mediterranean, while sea level fluctuations in historical times seem to be largely determinated by local tectonic effects, climate change may have represented an additional factor particularly affecting the most important natural wetlands and coastal lowlands in different coastal areas. Human-induced effects maximise the problems linked to sea level rise, via the following damaging activities:

-A reduction of river sediment supply.

-The destruction of natural shoreline defences, such as sand dunes and coastal ridges, for coastal urban development relating to commercial or tourist activities.

-The excessive pumping of groundwater, which may increase subsidence due to the lowering of piezometric surfaces of confined aquifers, as well as to compaction phenomena.

2.8.2 Damming

Dams prevent natural sedimentation processes by restraining the flow of riverine fresh water, so reduce sediment supply to the coastal system and deltas.

Of the over 6000 large dams in Europe, Spain has the most (1200), followed by Turkey, France, Italy and United Kingdom whom each have more than 500 large dams.

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31 UNEP/MAP/PAP: Guidelines for erosion and desertification control management with particular reference to Mediterranean coastal areas. Split, Priority Actions Programme, 2000.

32 UNEP/MAP/PAP: Guidelines for erosion and desertification control management with particular reference to Mediterranean coastal areas. Split, Priority Actions Programme, 2000.

33 National Institute of Coastal and Marine Management of the Netherlands (2004), A guide to coastal erosion management practices in Europe, Directorate General Environment European Commission

Mediterranean regions are a very clear example of problem related to damming. In fact, the major part of rivers have a torrential regime and so the effects of dams are stronger: in this case, dams have a very short life and detain a lot of sediments that otherwise would reach the beaches. The example of the Ebro delta is highly representative: less than a 5% of the sediment carried before damming is reaching the delta (serra, 199723).

2.8.3 Gravel mining

In stream gravel mining is, together with dams, the main cause of sediment deficit in many rivers. In stream mining directly alters the channel geometry and bed elevation while disrupting the continuum of sediment downstream.
One of the most dramatic examples of wild gravel mining in the Catalan Coastal Ranges can be followed in the not regulated Tordera River (970 km^2). There, around $5 \cdot 10^6$ t of sand and gravel were extracted during the sixties and seventies until 1982, when mining was prohibited. This means ten times more the annual sediment yield of the Tordera River, including both suspended and bedload (Rovira et al., 2002). Fluvial sediments were converted to aggregated for construction in the Costa Brava area during the rapid growth of tourism during those decades.

2.8.4 Ports, port extentions and marinas

Large ports (harbours) and small ports (marinas and leisure activities) are one of the main causes of coastal erosion, especially in wave-dominated coasts with important sediment transport drift.

2.8.5 Urban and economic development

Roads, buildings, and other infrastructure can limit or affect the natural response of coastal ecosystems to sea level rise. As populations in coastal areas have grown and economic activity has intensified so a range of often inter-related and conflicting pressures have emerged in the coastal zones focused around agricultural use, industrial and port use, residential use, tourism, coastal water quality and fisheries. These in terms have caused pressure for coastal development and land reclamation around estuaries and lagoons. In France, for example, natural coastal areas are being lost at a rate of 1 per cent a year; 15 per cent have disappeared since 1976, and 90 per cent of the French Riviera is now developed.

2.9 Socio-Economics and Environment

2.9.1 Economic situation

In 1960 the total population of the countries surrounding the Mediterranean Sea was 246 million. In 1990 the population grew up to 380 million and in 2000 it is estimated at 450 million. According to the blue plan data base (see Figure 2-6) It is expected that the population shall grow to 520-570 million in 2030 and might even grow to 600 million in 2050. By the end of the 21st century, the population is believed to grow up to 700 million. A greater part of the population lives in the coastal area. In the past, the population of the countries lying in the North of the Mediterranean formed 2/3 of the total population. At present, they represent half of the population.
Tourism is presently the first source of income and contributes to about 22% of the Bruto National Product (BNP). The Mediterranean Sea areas contribute in total about 1/3 of the international financial returns from Tourism.

2.9.2 Urbanization

Migration rate to the bigger cities is high and has lead to shortages of public services in these cities. These includes water supply, roads, sewage water treatments plants and housing.

2.9.3 Tourism

The Mediterranean sea area is famous for tourism and hosts about 30% of the international tourists. According to estimates, the number of tourists in the coastal area of the Mediterranean Sea is expected to grow from 135 million in 1990 to 235-350 million in 2025. Tourism is seasonal and is concentrated in the coastal areas. Nature Conservation areas in the coastal areas are affected due to the pressure of tourism.

2.9.4 Agriculture

Agricultural activities take place in the limited lowlands lying between the rocky coastal region of the Mediterranean Sea. Almost all types of agriculture and other land-use types are considered as diffuse sources for water pollution and are therefore very difficult to be quantified. Agricultural activities are believed to facilitate soil erosion while increasing the supply of nutrient in the coastal waters of the Mediterranean Sea. Lakes found in the surrounding countries often receive high nutrient levels from the agricultural lands. The rivers Rhone and Po are often affected. The catchments that are seriously affected by high concentrations of nutrients from agricultural practices are found in the following countries: Italy, Sicily , Sardine, Greece, Turkey and Spain.

2.9.5 Fisheries

The total fish landings from the Mediterranean Sea is still higher. The total landings in the Mediterranean countries has increased from 1,1 million tons in 1984 to 1,3 milliton tons in 1995.The fishing techniques practiced have undergone very little changes in the last few years. The number of fishing boats has increased by 19.8 % between 1980 and 1992. The fishing techniques slightly shifted from the use of relatively high labor intensive equipments to capital intensive ones. Big trawlers and multifunctional boats are presently being used but the average number of trawlers has remained constant since 1982. The by-catches and the number of missing fishing nets at sea have however increased.

2.9.6 Aquaculture

Marine aqua cultural production has increased in some of the countries surrounding the Mediterranean Sea. The production has increased from 78.000 ton in 1984 to 248.500 ton in 1996. Aquaculture is a relative new activity is in the Mediterranean region and is mostly directed towards the farming of shelled animals (bivalves) and fish species including Bass and Red seabream. The effects of this activity on the environment is local and is relatively lesser when compared to the effects registered in Asia or South America.

2.9.7 Industry

Industrial activity (from mining to end production) around the Mediterranean Sea is very common. Especially in the North Western part where the hot spots are concentrated. Big industrial complexes and big sea ports are found in this region. Chemical pollution of the waters is caused by the chemical/petrochemical sector and the metal industries in the area. Other big industrial sectors in the coastal area are: sewage treatment plants and recycling of solvents, metal works, paper production, paint, plastic, textile, and printing companies.

Based on the Exports from the Mediterranean countries, three groups of countries can be classified:

1. Countries that are highly specialized and export very few items whilst the rest of the products are being imported. These are the oil producing countries e.g. Algeria, Syrie, Egypt and Libya.
2. Less specialized countries that export similar goods exported by other countries in the region. These countries often export goods even under unfavorable market conditions.

Some of these countries include: Turkey, Tunisia, Morocco, ex Jugoslavia, Cyprus en Malta. They export clothes, textile and leather. Next to these, these countries can produce specialized products for export. For example: Tunisia produces chemical products including oil and lubricants; Morocco produces chemical products including fertilizers whilst Turkey and ex Jugoslavia produce textile, wool, cotton, paper and cement.

3. Highly diversified exporters and less specialized group of countries. These include the countries of the European Union. They also form the biggest part of the petrochemical industry in the Mediterranean area.

The environmental effects of the industries can either be direct or indirect. Direct effects are found in the cases of sewage water pollution, sea ports and pollution from the industrial complexes which contribute to the formation of the hot spots. Indirect effects are related to the location of the industries. Industries call for a concentration of workers and urbanization along the coastal area. The industries also contribute to air pollution.

2.9.8 Sea transportation

Three main sea routes are known for going to and from the Mediterranean Sea area:

- Dardanellen/ Sea of Marmara/ Strait of Istanbul,
- Strait of Gibraltar and
- Suez canal

About 90 % of the oil transport is done from east to west (Egypt-Gibraltar), between Sicily and Malta and very close to the coast of Tunisia, Algeria and Morocco.
On average 60 accidents take place every year at sea and about 15 ships loose their cargo of chemicals at sea. Most of the accidents take place in the Strait of Gibraltar, Messina, The Canal of Sicily and the routes leading to the Dardanelle. At some of the ports like Genoa, Livorno, Civitavecchia, Venetia, Trieste, Piraeus, Limassol/Larnaka, Beirut and Alexandria, accidents do occur.

3. COASTAL EROSION AT BASIN SCALE[34]

3.1 General

Information, at basin scale, about the coastal zones and their use does not exist for the Mediterranean area. Aside from urban population concentrations, competing land use along the coast comes from tourism, agriculture, fisheries and aquaculture, transport, energy and industry infrastructure, causing acceleration of the modification of the morphology of the coastal system.
Coastal erosion is an environmental threat, related to a combination of human activities such as damming and coastal development, the abandonment of agriculture, and global climate change. Habitat erosion has also occurred mainly due to the competitive use of the coastal zone. Erosion data showed that the 1500 km of artificial coasts can be found in the EU marine area (Balearic Islands, Gulf of the Lion,
Sardinia,Adriatic, Ionian and Aegean) with harbours and ports contributing the major part (1250 km) (EC, 1998). Based on the CORINE coastal erosion data, about 25 % of the Italian Adriatic coast and 7.4 % of the Aegean Sea show evolutionary trends of erosion while about 50 % of the total coastline of the Euro-Mediterranean area considered to be stable.

Table 6 - Evolutionary trends of some coasts of the European part of the Mediterranean Sea for both rocky coasts and beaches as % of coasts[35]

Maritime regions	No information	Stability	Erosion	Sedimentation	Not applicable	Total (km)
Balearic Islands	0.5	68.8	19.6	2.4	8.7	2861
Gulf of Lion	4.1	46.0	14.4	7.8	27.8	1366
Sardinia	16.0	57.0	18.4	3.6	5.0	5521
Adriatic Sea	3.9	51.7	25.6	7.6	11.1	970
Ionian Sea	19.7	52.3	22.5	1.2	4.3	3890
Aegean Sea	37.5	49.5	7.4	2.9	2.6	3408

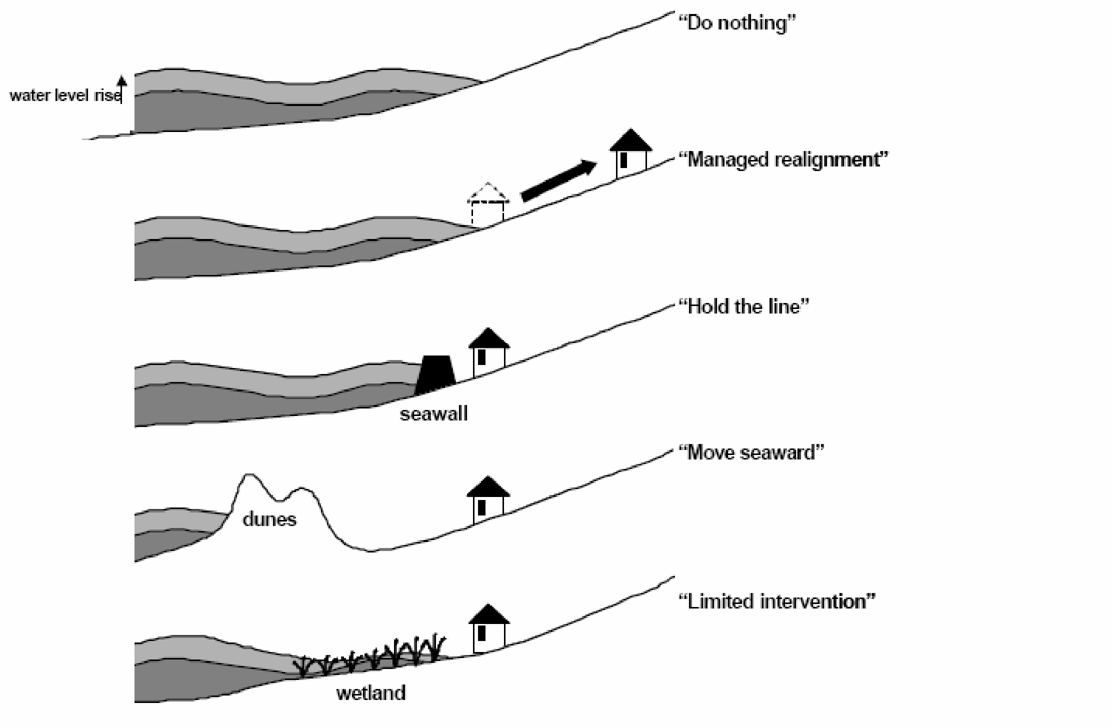
Source: EC, 1998

[34,35] EEA (1999): State and pressures of the marine and coastal Mediterranean environment, pp.44 Copenhagen

3.2 Policy Options[36]

For the purpose of the Eurosion project, the approach of generic policies as defined by the UK Department for Environment, Food and Rural Affairs (DEFRA) is adopted as shown in the following figure and explained below.

Figure 13 - The five generic policy options[37]



3.3 Policy options adopted for Eurosion project

3.3.1 Do nothing

There is no investment in coastal defence assets or operations, i.e. no shoreline management activity.

3.3.2 Hold the line

Hold the existing defence line by maintaining or changing the standard of protection. This policy covers those situations where works are undertaken in front of the existing defences to improve or maintain the standard of protection provided by the existing defence line. Policies that involve operations to the rear of existing defences should be included under this policy where they form an integral part of maintaining the current coastal defence systems.

3.3.3 Move seaward

Advance the existing defence line by constructing new defences seaward of the original defences. This use of policy is limited to those management units where significant land reclamation is considered.

3.3.4 Managed realignment

Identifying a new line of defence and, where appropriate, constructing new defences landward of the original defences.

[36,37] National Institute of Coastal and Marine Management of the Netherlands (2004), A guide to coastal erosion management practices in Europe

3.3.5 Limited intervention

Working with natural processes to reduce risks while allowing natural coastal change. This may range from measures that attempt to slow down rather than stop coastal erosion and cliff recessions (e.g. nourishments), to measures that address public safety issues (e.g. flood warning systems, dune and forest maintenance, building restriction in coastal strip).

3.4 Organization and legislation

Administrative bodies dealing with different aspects of coastal management in Southern Europe evolve from port authorities to public works and land planners (tourist administration bodies) to environmental bodies as the coastal policies gain weight.

The following table shows three major issues concerning coastal administration and management: land use planning (frequently on the hands of local authorities), coast management (which includes coastal defense when mentioned) and Integrated Coastal Zone Management.

Table 7 - Administration framework and legislation for major coastal policies throughout Southern and Eastern Europe (source: IIMA) [38]

Country	Land Use Planning	Coast Management	Legislation	ICZM	Comments
Cyprus	Ministry of Communications and Works and local authorities	Ministry of Communications and Works; Cyprus Ports Authority (pollution)	N.A.	N.A.	
France	Conservatoire du Littoral. Ministère de l'Équipement, des Transports et du Logement, la Direction du Transport Maritime, des Ports et du Littoral (DTMPL). Local authorities.	Secrétariat Général de la Mer, under Premier Minister. It coordinates the National Policy on the Sea. It promotes a *Comité Interministériel de la Mer*.	Conservatoire du Littoral/Loi no 86-2 du 3 janvier 1986 relative à láménagement, la protection et la mise en valeur du littoral (1975)	N.A.	The objective of the Conservatoire du littoral is currently to keep one third of the coast without any kind of urbanization ("tiers sauvage")
Greece	Ministry of the Environment, Physical Planning & Public Works - Directorate of Physical Planning. Local authorities	Local authorities (cleaning, restoration). Ministry of Mercantile Marine under the National Contingency Plan.	Law 2344/1940 "On the foreshore and the wasterfront" (1940)	Ministry of Environment, Physical Planning & Public Works - Directorate of Physical Planning, and Department of Nature Protection.	
Italy	Local and regional authorities	Erosion control is promoted by regional goverments and financed by national budget.	Legge 31 dicembre 1982, n. 979, Disposizioni per la difesa del mare (1982)	Not implemented although regional programmes	
Malta	N.A	N.A	Developement Protection Act (1992)	N.A	
Slovenia			In 1993 the Office for Physical Planning organised a planning workshop for the entire coastal area entitled 'Physical Planning of the Coastal Area' (1993)		
Spain	Ministery of the Environment, D.G. Costas (500 m strip) and local authorities	Ministery of the Environment, D.G. Costas	Ley 28/1969, de 26 de abril de Costas (1969)	Ministry of the Environment, D.G. Costas	ICZM has been estated as apolitical willing (April 1992). DG Costas is to lead the process.

[38] National Institute of Coastal and Marine Management of the Netherlands (2004), A guide to coastal erosion management practices in Europe, Directorate General Environment European Commission

3.5 Policy Options Implemented in the Mediterranean Sea[39]

Throughout the information in the cases of the Mediterranean Sea in 17 situations a policy option is mentioned. In most of them examples of Hold the Line are found (9). In most of these 9 situations the problem is an eroding beach that is being used for tourism. Also, Hold the Line is found where economically valuable activities/structures are found (roads, industry).

For the Mediterranean Sea situations, the Do Nothing option was found 4 times. It is found where the policy is to “preserve and improve the conditions for the natural coastline” (Cyprus – Dolos Kiti). In Malta the coastal engineering works are constructed for maritime related activities and transport services rather than for the purpose of combating erosion. That is why Malta classifies this as Do Nothing (Xemxija Bay). In the French Mediterranean Rhône Delta there is a policy for doing nothing on stable beaches in a nature reserve area.

Limited Intervention consists of mitigating measures to reduce risks while allowing natural coastal changes. In the case studies only 2 examples could be found. In Mallorca nourishments are done when a significant retreat is observed. In Ghajn Tuffieha (Xenxija – Malta) the precautionary measures of prohibition of extraction of dead posidonia oceanica leaves is classified there to be Limited Intervention.

Only in one case study the policy was classified as Move Seaward. In Lakkopotic (Greece) constructing engineering works resulted in beach width increase. A good example of moving seaward can be found in Monaco (no case study).

Managed Realignment is also a rare policy option in the Mediterranean Sea. In the Ebro Delta case study managed realignment is mentioned. There are examples of removal of infrastructure located on the shore (La Marquesa and Pal beaches).

3.6 Strategy

3.6.1 *Approach to combat erosion*

In the past (until about 1980), hard engineering options were commonly applied. These were constructed only when erosion became a serious problem. As such, a reactive strategy was adopted in general; for example:
At the beginning of the 90s the Maltese Government has started to elaborate some Structure Plan Policies in order to control and reduce the impact of the coastal areas. The principle Structure Plan Policies are the CZM1, CZM2 and CZM3 which manage and plan the use of the coastal areas taking into account the preservation of the environment. There are some more concrete Structure Plan Policies as RCO21 and RCO22 that control directly the erosion in the coastal areas of the Maltese Areas.

Nowadays (from about 1980), however, authorities are more aware of the need to develop sustainable policy plans. This anticipation on the future problems, a pro-active strategy, as in the Ebro delta (Spain):
Some measures have been directed at protection against rising sea levels and over-washing without taking erosion processes into account. These measures were taken as a consequence of the breaking of Trabucador Bar in October 1990 because of a storm. The volume eroded was about 70,000m3 (Sánchez -Arcilla et al., 199721). This event led in January 1991 to the beginning of emergency works, building a 5km dune 1.5m high, 12m at the crown and 24m at

[39] National Institute of Coastal and Marine Management of the Netherlands (2004), A guide to coastal erosion management practices in Europe, Directorate General Environment European Commission

the base, fixing it using cane stakes and dune vegetation (Amophila Arenaria, Othanthus Marítima and Elymus Factus).
This action was completed in 1992 with the "Trabucador Bar Protection Scheme", which consisted of extending the above solution along the whole bar, positioning the dune in the interior, beside the bay, with the aim of preventing overwashing by water from the open sea when high waves were produced. The fixing system consisted on one hand of constructing 10 x 10m stake "corrals" of spartina versicolor, and on the other hand of planting dune vegetation (Montoya et al., 199722). The works done on the Trabucador spit were considered two years later as a non-sustainable solution because dunes and vegetation have no dynamic stability (Serra, 1997).

3.6.2 Hard and soft measures

Until about 1980 coastal erosion used to be treated as a problem that could be stopped. There are a lot of examples of major structures built to protect property or a beach. In some cases the effect was positive (Lakkopotic – Greece), but in most of the cases the erosion continued at a somewhat lower rate, but in some cases even increased. Generally, hard measures can be successful if there is a solid understanding of the coastal system. Also due to lack of monitoring data, the level of understanding is often not enough to find the optimal solution right away.
In Marina di Massa for instance, a lot of hard measures were taken to combat erosion. At the point where the coastline was absolutely full of structures, soft measures (beach nourishment) were applied. Still now the soft measures have to be carried out periodically to combat erosion. Sometimes however, hard structures seem to be a very good solution for a densely populated area that is aimed to be protected for flooding.

3.6.3 Measures concerning safety of hinterland

Coastal defence is the general term covering all aspects of human initiated defence against coastal hazards such as flooding and erosion. Coastal defence efforts may be small scale involving relatively small structures or may involve extensive land claims, e.g. by establishing buffer zones.

The relative sea level rise can have important implications for the future of the deltas of the Mediterranean Sea. However here the pattern of change is much more complicated with tectonic movements caused by a variety of influences (e.g. volcanic activity and earthquakes). When this is coupled with human influences which exacerbate sea level rise, significant problems of erosion, salt water intrusion and flooding can occur. These effects are especially important in the major deltas where a decrease in sediment availability and subsidence due to water pumping or the sheer weight of infrastructure may be some of the factors which give rise to substantial problems of erosion and flooding as is being experienced in several of the major Mediterranean deltas.

4. COASTAL EROSION BY COUNTRIES

4.1 Albania

Albania, which lies on the west side of the Balkan peninsula, is mainly a mountainous country. The estimates indicate that in 1992 population was 3.41 million. The Albanian coastline is 470 km long, with many lagoons, sand belts and sand dunes. The Adriatic section of the coastline is under constant dynamic change due to river inputs and the seismic profile of the area, while the Ionian coast is rocky with small beaches and limited sandy areas. Due to the rugged relief of the land, rivers are torrential with a high erosive power. Albania is situated in the Mediterranean climatic belt, with a hot dry summer and a generally mild winter with abundant rainfall. The country has a rich cultural heritage and diversified archaeological sites which include prehistoric settlements, monuments and necropoles of Illyrian towns, and ruins of castels of the early Albanian Middle Ages[40].

In general, the Albanian coast, unlike some other places, is preserved more or less in its natural state. It represents, as in some parts of the North African seashore, the last remnants of marine habitats of Mediterranean Sea. But on the other hand it is a fact that the uncontrolled human activity has damaged extensively the ecological values of the coastal area Albania. Along the

[40] Source: Priority Action Plan (website), CAMP "Albania"

years, huge amounts of sand was removed for construction purposes from the coast of various places, such as Vlora (Cold Water, New Beach) Skelë ,in Golem ,Durrës, in Cape of Seman, In Shëngjin etc .Whole systems of coastal dunes, representing one of the most important elements of the nature environment of coastal zone, have been destroyed, to the detriment of ecological and tourism values. Apart from this, moving away the sand damages also extensively the profile structure of the hydromorphometric balance of the seashore, thus intensifying the erosion process[41].

Compared with other parts of the country, Albania's coast is the most important and valuable in economical terms, both for its environment and development potentialities. Economical and social liberalization of the country has caused a massive and uncontrolled migration of the people towards the coast, and hence an increase of the human pressure and demand on marine and coastal resources. Consequently, threats to marine and coastal biodiversity are evident and becoming more and more significant. Integrated Management of the Coastal Zone and the Action Plan for the Administration of the Coastal Zone should be considered a high priority for Albania in order to ensure a sustainable use of the marine and coastal natural resources, protection of biodiversity and creation of a legal and institutional base for the implementation of the sustainable development strategies.

Background Compared with other parts of the country, Albania's coast is the most important and valuable in economical terms, both for its environment and development potentialities. Economical and social liberalization of the country has caused a massive and uncontrolled migration of the people towards the coast, and hence an increase of the human pressure and demand on marine and coastal resources. Consequently, threats to marine and coastal biodiversity are evident and becoming more and more significant. Integrated Management of the Coastal Zone and the Action Plan for the Administration of the Coastal Zone should be considered a high priority for Albania in order to ensure a sustainable use of the marine and coastal natural resources, protection of biodiversity and creation of a legal and institutional base for the implementation of the sustainable development strategies[42].

Major problems and issues[43]

- Albania ranks as one of the poorest countries in Europe. Low levels of productivity and capital investments combined with shortages of skilled labour are major constraints of the growth.
- There are no restrictions on the use of chemical herbicides, pesticides and fertilisers in agriculture resulting in contamination of rivers, canals and groundwater. Damages to aquatic life and incidents of eutrophication have been reported due to the improper disposal of industrial waste into the aquatic environment and unsustainable agricultural practices.

In 2003 the Albanian authorities formally adopted the principle recommendations of the 1995 plan, which provides a useful conservation and development framework that is still pertinent today. It divides the coastline broadly into three, the northern, central, and southern 1 1995 Albania Coastal Zone Management Plan – Phase One zones, with differentiated strategies for each.2 The north, with a coastline of 54 kilometers, and a population of about 150,000, includes four river mouths and rich delta and coastal wetlands and has potential mostly for ecotourism rather than mass tourism and for improved fisheries resource management. The priorities are improved water quality management and ecosystem conservation.

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[41] Republic of Albania (2002).
[42] Source: Violeta Zuna, Eno Dodbiba(2005).
[43] Source: Priority Action Plan (website), CAMP "Albania"

The central belt, with a coastline of 207 kms, a population of 821,000 and broad stretches of sandy beaches, has greater potential for large-scale tourism and recreation, as long as the environment is well managed. Priorities include, improved water, wastewater, solid and hazardous waste management, and careful land use planning, zoning and development control to protect the region's wetlands and coastal biodiversity. The southern zone belt, with a coastline of 168 kms, a population of about 70,000 and little industrial development, is characterized, except for Butrint in the south, by steep wetlands hugging the shore, spectacular cliffs and grottos and, potential for "high-end", carefully managed tourism combined with protection of the unique scenery and cultural heritage of the area. There is also scope for development of marine tourism.
The Plan also recommends strengthening of the institutional and regulatory framework for coastal zone management and establishment of a permanent coordinating body to support an integrated approach to coastal zone management issues[44].

4.2 Algeria

Algeria's coast hosts approximately 12.5 million people (1998), representing 45 % of the country's population. During the summer months tourists increase the permanent population.

44 Albania Coastal Zone Development and Cleanup http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2004/04/13/000104615_20040414093146/Rendered/PDF/Project0Inform1ment010Concept0Stage.pdf

Algiers, Oran, Annaba, Ghazaouet, Mostaganem, Arzew, Bejaia and Skikda are the most important coastal cities.
Major pollution problems include untreated urban and industrial wastewater, petroleum hydrocarbon slicks and coastal erosion. Most of the urban wastewater is discharged untreated directly into the sea. Although 17 treatment plants for urban wastewater have been constructed in the Algerian coastal zone, only five are in normal operation. This represents approximately 25 % of the total treatment capacity.
Faecal microorganisms are present on most Algerian bathing beaches, exceeding sanitary standards. Also, petroleum hydrocarbon pollution is very common along the Algerian coastline because of maritime oil-shipping lanes that pass close to the Algerian coast.
Out of 250–300 km of sandy beaches in Algeria, 85 % are retreating and losing sand at a rate ranging from 0.30 to 10.4 m/year (NDA Algeria 2004). At Bejaia beach, the sea advanced 345 m from 1959 to 1995.
Similar problems are encountered at Boumerdes, Bou Ismail, Macta and Beni Saf. Few of the sandy beaches remained stable (10 %) and only 5 % of the beaches are progressively accumulating more sand during the last decades. The main causes for this erosion are:

(i) Feeding of the littoral zone with sediment has greatly diminished recently because sedimentary material is trapped behind dams which were constructed for irrigation or other purposes along rivers and streams. It is calculated that during 1992 approximately 219 million 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, due to sediment accumulation, harbours need frequent dredging in order to maintain the necessary depth for navigation purposes.

(iii)Sand mining for construction purposes takes place at many locations along the coastline at: alluvial deposits of coastal streams (oueds), zones of recent windborne deposition, the upper parts of beaches and even at the under-water level of beaches. Although sand mining from coastal deposits is often a legal process, the excessive removal of sand destroys the coastal ecosystem. Also, illegal operations further increase sand removal rates[45]

As a rule, Algeria's Coast may be devided to three main part:
East coast: industrial character but high tourism potential (absence of touristic structures and presence of important biotypes); surface and marine water pollution, coastal erosion, rapid urbanization, and agriculture exploitation.
Algiers' Bay: heavily urbanized and industrialized, affected by untreated wastewaters that bring to marine sediments pollution; lack of urban and industrial development planning.
West coast: tourism character; lack of land use planning and uncontrolled exploitation of sand from beaches (coastal erosion)[46].

The coastal zone of central part of Algeria face heavy erosion due to man made causes.Regulations exist but implementation of the legislation is made difficult due to the huge demand of sand and gravel to feed ambitious programme of housing and industrial development[47].

[45] European Environment Agency (2006).
[46] Source: Interdepartment Centre for Environmental Science Research(2003).
[47] Source: Y.N. Krestenitis & I.S. Androulidakis (2006).

4.3 Bosnia and Herzegovina

The Mediterranean coast of Bosnia and Herzegovina on the Adriatic is 25 km long, hosting the town of Neum (population 4 300).

The coast of the Neum gulf is very hard and stoned. There is no need for any coastal construction – protection measures, but preserve it is necessary to keep it in its natural state. The additional reasons for not having any destruction phenomenas at the coast are sheltering of the gulf Neum, without strong winds and waves.

Coastal steep slopes don't allow a forming of the gravel beaches, and the areas of stone deposits in the vicinity are very poor, for the purpose of nourishment.

Highway building, as well as the urbanization significantly reduce the possibility of small stoned material depositing towards the coast reduced, so it is the one of the reasons for inexistence of more significant erosion of the coast, and gravel beaches also[48].

The pollutants generated in the drainage basins of the major Bosnian rivers of Neretva (from the nearby towns of Konjic, Mostar, Caplinja, Ploce and Metcovic) and Trebisnjica (from the towns of Bileca and Neum) can be carried to the Adriatic Sea affecting its environment.

The major pollution problems are untreated urban wastewater and occasional stockpiles of obsolete chemicals. The areas of concern are:

- ✓ Mostar (population 130 000). Urban and industrial wastewater is discharged into the River Neretva without any treatment and urban solid wastes are dumped without proper

[48] Source: UNEP/MAP (2003)

management. Barrels of obsolete chemicals are left on both riverbanks. During the war (1992–1995), bombing destroyed electric power transformers leading to oil leakage and contamination of soil and water with PCBs.

- ✓ Neum (population 4 300) is the only urban centre in Bosnia and Herzegovina that discharges its primarily treated urban wastewater directly into the Adriatic Sea. The town population doubles during summer months because of tourism[49].

4.4 Croatia[50]

The Croatian coast is mainly rocky and very indented with few alluvial zones. Generally, the coastal strip is very narrow, and is separated from the continental part by chains of mountains. There are numerous islands, which are located in two-three groups and are lying parallel to the mainland. 67 of its 1,185 islands are inhabited. The total length of the Croatian coast is 5,835.3 km, while the length of the insular part is 4,058 km. The coefficient of indentation of the mainland coastline is 3.4. The coastal zone of Croatia (area of 1245 km2) accommodates 1,119,113 inhabitants, which represents 23% of the total Croatian population. Population density

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[49] European Environment Agency (2006)
[50] SURVAS (2000).

in the coastal zone (89.9 inhabitants/km2) is higher than in the continental part (84.5 inhabitants/km2). Historic towns, residential houses, tourist complexes and roads are often constructed in lowlying coastal areas. The main economic activities in the coastal area are marine-related, such as tourism, fisheries and aquaculture and maritime transport.
Since the coastline is mainly rocky, it is not vulnerable in terms of coastal erosion. Limited areas where erosion is present could probably be more endangered due to expected sea-level rise, but overall, this is a restricted and local problem.

4.5 Cyprus[51]

Cyprus, the third largest island in the Mediterranean Sea, has a coastline of 735 km in length: 295 km under the control of the Republic of Cyprus (40%), 370 km under Turkish occupation since 1974 and inaccessible (50,3%) and 70 km within the Sovereign British Military Bases. This paper refers to the territory under the control of the Republic of Cyprus.

There is not a single legal or planning definition of the coastal zone in Cyprus. The most "popular" definition is the one that suggests the width of the coastal strip to be 2 km inland from the coastline. According to this definition, the coastal strip covers 23% of the island's total area. 50% of the population lives and works within this strip where 95% of the tourist industry is located. Tourism is by far the most important economic activity of the island whose coastal zone is and has always been the primary destination for tourists (1999 figures show Cyprus with 2,5 million). With an official target of 3,5 million tourists by 2010 (Cyprus Tourism Organisation) i.e., a planned mean annual growth of 3,4%, it is obvious that the coastal zone is under extremely high pressure.

[51]Xenia I Loizidou (2003)

Coastal Policy framework in Cyprus

In Cyprus, as in many other countries, there is no Coastal Zone Management Policy as a separate and self contained document. Policies for the Coastal zone are included in various sectoral policies which apply to different administration areas. The main policies are:

Land use Policy: Land use planning policy in Cyprus is under the responsibility of the Town Planning and Housing Department, Ministry of Interior and it is controlled mainly by the Town and Country Planning Law, which came into force in 1991. The development in the main urban areas is controlled by the Local Plans and in the rural areas through the Policy Statement for the Countryside. The land uses and the development zones are defined through these two planning tools, which are revised every approximately 4 years.

Tourism Policy: The Cyprus Tourism Organisation (CTO), a semi- Governmental Organisation under the Ministry of Commerce Industry and Tourism is the authority responsible for the Tourism Policy. Several policies and measures for the regulation of tourism development and tourism establishments are in force on the basis of the CTO legislation. As mentioned in the introduction, in 2000 a Strategy for Tourism was prepared by the CTO containing the main strategic goals for Cyprus tourism for the decade 2000 – 2010, aiming in a 40% increase of the number of tourists.

Environmental Policy: The responsibility for the Environmental Policy lies mainly at the Environment Service of the Ministry of Agriculture, Natural Resources and Environment. At this moment, environmental policy in Cyprus is focused on the harmonization with the EU Acquis and the incorporation of EU Directives into the legislation of Cyprus. Environmental policy is expressed in sectoral policies of various natural resources (water, air, forests etc). Except from the Environment Service, more than 10 Governmental Departments and authorities from different Ministries are involved in Environment policies, creating a rather complex system.

Coastal Development in Cyprus – Land uses

The dominant trends for development in Cyprus are:

- Sub-urbanisation, i.e., rapid population growth and urban development in suburbs located at the edges of the main urban areas
- Coastal development, i.e., rapid coastal tourism development

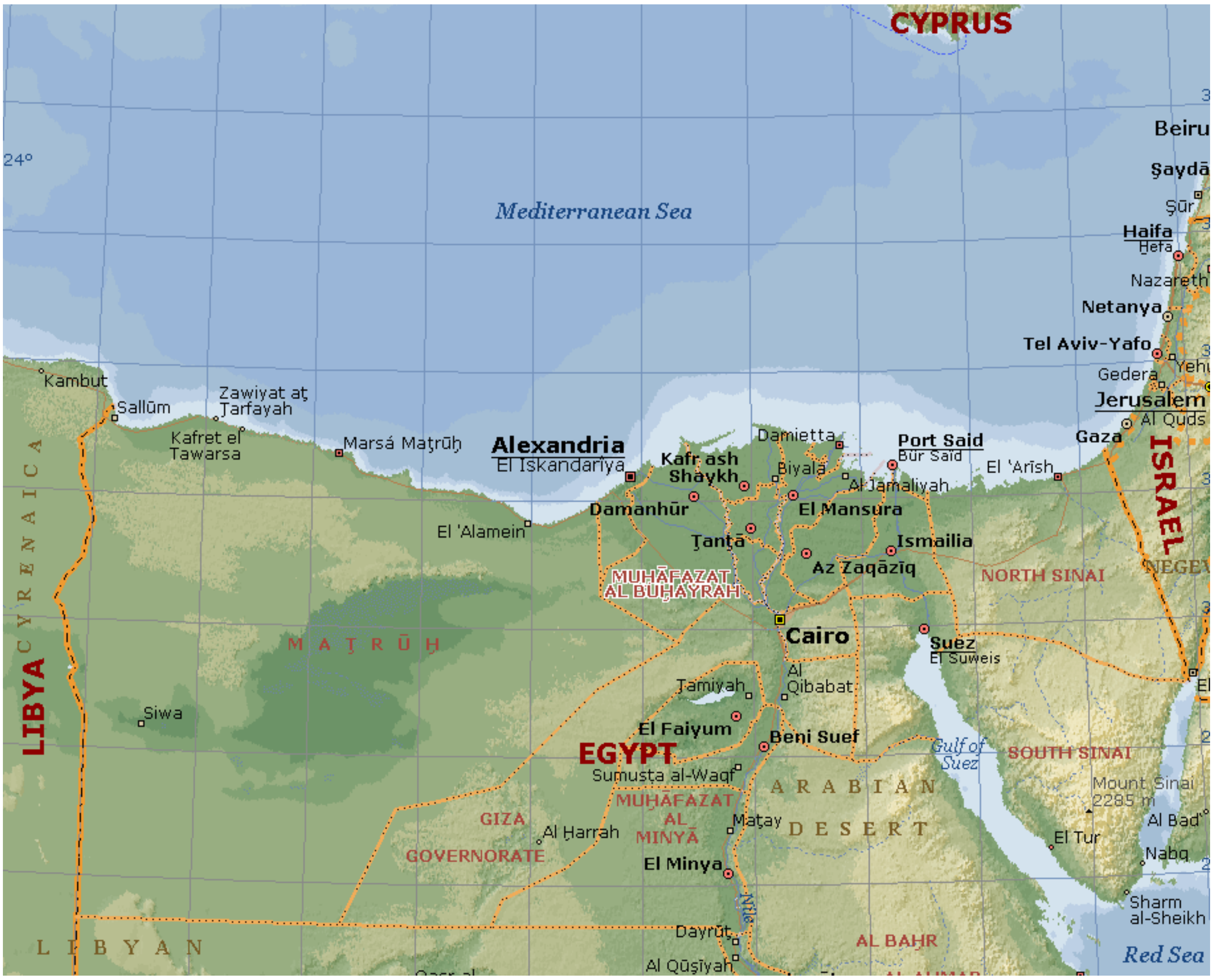
A major characteristic of the coastal development of the last two decades is that formerly agricultural and natural zones at the coastline are converted to tourist development zones after each revision of the land use planning zones every four years. The situation after the last revision of the land use planning zones in 1997-98 was as follows along the coastline:

- Tourist zones cover 105 km, i.e., 37% of the coastline (in length)
- Open areas/protected natural or archaeological areas cover 125 km, i.e., 43%
- Agricultural zones cover 36 km, i.e., 12%
- Residential zones cover 17 km, i.e., 6%
- Industrial zones cover 9 km, i.e., 3%

It is expected that he new revision of land use planning zones will be published by summer 2003 and the percentage of tourist zones along the coastline is expected to rise, with agricultural coastal zones shrinking. A long “coastal wall” of tourist development has been under construction for the last two decades, all along the coasts of the island.

As a result of the policies and the targets of the Cyprus Tourism Organization, the number of beds in the coastal areas of Cyprus has increased seven fold over the last twenty years, i.e. from 12524 beds in 1980 it became 88302 in 2001. At the same time the numbers in inland areas have increased only by 11%, i.e. from 3902 in 1980 to 4358 in 2001. No study on the carrying capacity of the island has ever been conducted.

4.6 Egypt



The coastal zone of Egypt is now under forceful stress. These persuasions are mostly due to the expansions of coastal activities during the last few years. The total coastline of Egypt is about 3700 km. Coastal areas display wide variations in the coastal related activities (e.g. agricultural, Land reclamation, Industry, Fishing, Communications and harbors, tourist activities, secondary housing, Oil and Gas exploration). Some activities are more developed in some areas than the others (e.g. tourist activities in the Red Sea; Oil and Gas in the gulf of Suez; Industry at Alexandria; Fishing in coastal lagoons) (Sammak, 1996). The lower Nile Delta part, between 0-5m elevation, harbours 12 million inhabitants and the important industrial and communication centres. It is also the vital centre of summer tourism and essential recreation outlets for the over crowded cities of the interior. Severe beach erosion is predominating along the coast and will continue and increase in future especially at the Rosetta and Damietta headlands[52].

Results from studies on various aspects of the impacts and possible responses to sea-level rise on the Egyptian coast (Broadus et al., 1986; Milliman et al., 1989; Sestini, 1989; Ante, 1990; El-Raey, 1990; El-Sayed, 1991; Khafagy et al., 1992; Stanley and Warne, 1993) indicate that a sizable proportion of the northern part of the Nile delta will be lost to a combination of inundation and erosion, with consequent loss of agricultural land and urban areas. Furthermore, agricultural land losses will occur as a result of soil salinization (El-Raey et al., 1995).

[52] Source: Y.N. Krestenitis & I.S. Androulidakis (2006)

Khafagy et al. (1992) estimate that for a 1-m sea-level rise, about 2,000 km^2 of land in coastal areas of the lower Nile delta may be lost to inundation. Substantial erosion should be expected, possibly leading to land losses of as much as 100 km^2. A very rough estimate of the agricultural land area that might become unusable is 1,000 km^2 (100,000 ha). With an average land value of US$1.5/m2, the value of land loss in the lower Nile delta as a result of flooding alone will be on the order of US$750 million (2,500 million Egyptian pounds) (Khafagy et al., 1992). Outside the delta, erosion is expected to be quite limited. If average erosion were 20 m along 50% of the remaining coast (and assuming land values on the order of 5 Egyptian pounds per m^2), the total loss would be about US$60 million (200 million Egyptian pounds).
It has been widely reported that 8 million people would be displaced in Egypt by a 1-m rise in sea level, assuming no protection and existing population levels[53].

4.7 France

The total length of coastline in mainland France is estimated at about 5,500 km including some 1,960 km of sandy beaches[54]. On the Mediterranean coast, the most vulnerable area corresponds to the deltaic plain of the Rhône River, chiefly because of human actions (*e.g.,* shortage of sediment supply as a result of dam construction; river embankments). Coastal erosion, lowland flooding, and ground water salinisation are the main impacts expected from ASLR. The

[53] Watson Robert T., Zinyowera Marufu C. , Moss Richard H. and Dokken David J (Ed.s)(1997)
[54] Source: Y.N. Krestenitis & I.S. Androulidakis (2006).

Languedoc coastal barriers will move landward faster than at present, thus jeopardising dense tourist facilities[55].

Coastal defence works are quite significant and most of them comprise the construction of groynes, seawalls and detached breakwaters but nourishment is only a marginal technique adopted to control the erosion France has a coastline bordering both the Atlantic Ocean, with extreme tidal variations in some locations, and the Mediterranean Sea with little or no tide. The French approach of beach nourishment is traditionally to couple it with hard structures as supporting measures to minimise sand losses and maintenance. In addition, in the most important nourishment projects, the nourishment option was chosen on the basis of the desire to get rid of available sand dredged to maintain navigable depths in a nearby harbour[56].

4.8 Greece[57]

Greek coastal areas are extremely valuable as they concentrate a significant part of the total population, the majority of the main urban centers, a large variety of human activities and most

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[55] Paskoff, R. (2004).

[56] Krestenitis Y.N. & Androulidakis I.S. (2006).

[57] Krestenitis Y.N. & Androulidakis I.S. (2006).

transport and communication infrastructure facilities. Additionally, coastal areas are very important and fragile from the ecological perspective as the interface between land, sea and air.

Climate changes are likely to affect both the sources of supply and the rates of loss at beach sand. The rise in sea level is likely to increase the loss of sediment from beaches through inundation or flooding, particularly where the position of the shoreline has been immobilized by heavy coastal infrastructure. Increased rain could mobilize more sediment in the river flood plains and result in an increase in sand supply. But the amount of sand replenishment may be not enough to maintain the beaches, especially because much of the sand and sediment are trapped behind dams and prevented from reaching the beaches.

The supply of sediment to both the beaches and the near shore may also be augmented by more cliff erosion. One effect of the large-scale human development in Greece has been a marked decrease in the supply of sand or sediment from existing natural sources. The construction of dams, the canalization of rivers and the intense coastal development (more than one million houses built in thirty years) have greatly reduced the supply of sediment from rivers by eliminating flows and trapping sediment behind the dams as well as reducing the ability of streams to erode their channels further (Doukakis, 2004).

Recently, an afford has been introduced by the state environmental authorities to include inside the environmental impact assessment reviews regarding maritime structures, coastal erosion modelling and monitoring especially for large coastal infrastructure. In the past, a simple description of the coastal geomorphologic state was enough and forecasting and modelling of the future changes have been implemented rarely. The problems that have been occurred in the coastal regions from this type of approach were significant, so numerical modelling is now necessary not only in future constructions but in order to describe precisely current problems and to propose possible interventions for rehabilitation.

4.9 Israel[58]

Sedimentological Processes

Coastal developments in the coast of Israel have already induced sedimentological impacts, expresses as coastal erosion, silting of marinas and other protected areas, and cliff retreat. In the last decade, the coastal region of Israel is facing mild but progressive erosion (Rosen, 2002). The majority of the sediments covering its coasts were initially transported via the Nile River to the Nile delta, as indicated by the large content of "nilotic" (quartz material) sand, versus the low content of local biogenic (carbonate material) sand, produced by shells and some local river outflows. Hence, it is obvious that any developments in the cell between Egypt's Nile Delta to Haifa Bay in the Northern part of the Israeli coast would be influenced by their predecessors upstream the longshore sediment transport flow and would be influencing the coast downstream that flow. Two major anthropological activities according to Golik et al. [1997] were defined to be the major factors responsible for the erosion:

-sand quarrying from the beaches for concrete preparation and filling of land and road developments (stopped by law in 1965)

-Man made coastal structures obstructing the net longshore sand transport brought to the Israeli coasts along the coast of the Sinai peninsula, itself fed mainly from the Nile Delta.

Due to population growth rate and to rapid industrial development, the constructions are estimated to increase soon in size and number, by port developments and expansions at the Nile Delta coast, at Gaza and Ashdod, new marinas and other coastal and marine works, including future artificial islands and/or peninsulas

In the last two decades, there has been increasing evidence that the Israeli coast faces a mild but progressive erosion. Among the facts backing this evidence, one may mention ancient (Neolithic) human skeletons discovered in perfect condition in the late 1980's as well as a few years ago on the sea bottom off Atlith, at about 6m water depth, a 2000 years old merchant wood ship found also in the late 1980's in shallow water (~2.5 m water depth) almost undamaged, with much of its goods onboard and many antiques recently discovered in the shallow water off Ashkelon. All these were found in good condition, and could not have survived the destructive power of the sea-waves and currents, would they not have been covered until recently by a protective, thick layer of sand which is no longer there.

In former studies (Golik *et al.* 1997) it was indicated that two major anthropological activities were identified to be the major factors responsible for the existing situation:

- Sand quarrying from the beaches for concrete preparation and filling of land and road developments, which fortunately was formally stopped by law in 1965;
- Man-made coastal structures obstructing the net longshore sand transport brought to the Israeli coasts along the coast of the Sinai peninsula, itself fed mainly from the Nile Delta.

Due to population growth rate and to rapid industrial development mentioned above, such constructions are estimated to increase soon in size and number, by new port developments and expansions at the Nile Delta coast, at Gaza and Ashdod, new marinas and other coastal and marine structures, including future artificial islands and/or artificial peninsulas.

According to Egyptian coastal studies (Fanos *et al.* 1997), within the period starting from the construction of the Low Aswan Dam in 1903 until 1965, when the High Aswan Dam was completed, the Nile Delta retreated some 5 km (in 60 years). However, since then and until 1995 (30 years), another 5 km of the delta coast was removed to sea by accelerated erosion (double), induced by the almost cessation of Nile quartz sediment supply to the Nile delta since 1965.

Hence, the future of the existing Nile littoral cell coast, and in particular the Israeli coast, are threatened not only by the existing erosion due to past sand mining and last century coastal constructions and by new coastal and marine developments mentioned above (if proper remediation steps will not be taken), but also by the cessation of Nile sediment supply. The impact of sediment supply by the Nile River is however estimated not to be significant in this century, because the eroding Nile delta coast is still supplying sand to the Sinai coast, that itself is still rich with sand, which may be transported by the combined natural action of wind, waves and currents to feed the northern part of the Nile cell.

Review of major coastal developments

A list of the coastal structures built along the Nile Littoral Cell starting from Bardawil lagoon on the Sinai coast and ending at Haifa is presented in this section. The listing of the construction of the major structures includes also a description of the resulting sedimentological changes in their neighborhood. The growth pattern of the coastal structures and their resulting morphological changes at the coast are expected to enable a better understanding of the past coastal processes, leading to an integrated sustainable coastal zone planning and development.

a. Historic retrospective

A number of ancient coastal developments were built in this area, of which few have been active until the last centuries, and two are still active today. Their historic presence enabled geologists and archeologists to learn about the sea-level in the last few thousand years in this region and to draw conclusions regarding the very long-term stability of the coast in respect to accretion or erosion processes. We will refer here only to the most relevant site: King Herod's Caesaria

Maritima, now Caesarea anchorage. The harbour site, 10km north of Hadera was a wisely designed and built coastal development carried out some 2,000 years ago (20 BC). It was built by Roman engineers at the site of an existing small anchorage belonging to the remnants of the previous Straton Tower city and harbour. It was skillfully made with various coastal engineering features, which even nowadays are considered by some as novel and indicative of thorough coastal engineering knowledge. Among these one may mention the construction of its breakwaters by caissons filled with sand and topped with pozzolana (an ancient version of cement), a submerged breakwater (prokumatia) in front of the main breakwater to break large waves, openings with gates in the southern part of the main breakwater for water quality maintenance, port flushing and water depth preservation against silting at the entrance. Nowadays the major part of the main breakwater as well as of the lee breakwater are sunken, at the head at about 5m water depth. (Raban 1989) assumed that the breakwaters sank into the sea due to a tectonic fault, which however left intact the land-based part of the harbour. Raban considered the sinking to have occurred gradually, while other researchers estimated a more abrupt sinking. Some later efforts were made to repair the harbour, but it did not return to its previous dimensions. According to archeological findings and historic documentation (Flavius ~78AC, Raban 1989), the harbour coast (Mart and Perecman 1996), north and near to the port was eroded, leading to damage of part of the High Level Aqueduct built by Herod's engineers. This erosion however is quite local. As a matter of fact, both the aqueduct and the port were covered by a thick layer of sand until they were uncovered at the beginning of the 1950's.

The coast at the Caesarea port appears to be at about the same location it was some 2,000 years ago, as confirmed by the aqueduct remains on the coast of Caesarea. (Flemming 1978) advocated this fact because most of the ancient coastal structures at the coast (except Caesarea's breakwaters) are found at about the elevation that one would build such constructions for the present sea-level. This fact may indicate a very long-term coast stability, which seems to have started diminishing in the last half of the 20th century. According to Flemming, the mean sea-level, for some period prior to the 3rd century BC, was higher than that of nowadays by about 1.2 to 1.3m. (Galili and Inbar 1987) estimated that the sea-level some 2000 years ago was about the same as the present one, with the rise and fall that occurred since then. However, they reached the conclusion that the sinking of the area north to Caesaria (and hence also that of the Caesaria breakwaters) must have occurred at more than 10000 BC, hence indicating that also the sinking of the Caesaria breakwaters must have been due to other reasons (e.g. destruction due to lack of maintenance).

b. Coastal engineering in the 20th century

During the 20th century the Mediterranean coast of Israel was impacted by coastal developments as well as beach sand mining forbidden by law since 1965. It is not known exactly how much sand was mined from the beaches, but (Nir 1976) as well as (Golik 1997) arrived to estimates of about 10 million cubic meters of sand for the period 1948-1965, making use mainly of the records of the Zif-Zif Committee which investigated this mining in 1964. Among the coastal developments which were carried out during the 20th century one can distinguish four major types: (a) commercial ports and fishing harbours, (b) cooling basins for power stations, marinas and anchorages, (c) offshore marine terminals, (d) detached breakwaters, groins and sea-walls.
Given the situation described above one can understand the heavy burden on the coastal zone. It should be also mentioned that about a third of the Israeli coastal length of only 197 km is occupied by various industrial, energy, transportation and military uses, leading to a high public sensitivity for the state of the beaches left for public access. The forecasted population growth combined with the world wide known desire of more than 70% of the people to live near the coast led obviously to serious considerations of land reclamation from the sea, either as seaward land expansions or as artificial islands.

A study on the management of the Israeli coastal sand resources was conducted (Golik *et al.*, 1999) which had the following major results: (a) Beach erosion started along the coastline, due to beach sand mining, long before the construction of the Ashdod port. (b) Anthropogenic activities disturbed the natural balance between the supply (Nile Delta) and removal (to coastal dunes and the open sea) of coastal sand. (c) In the last century, about 20 million m^3 of sand (equivalent to about 50 years of natural supply) were removed from the general coastal reservoir due to mining and entrapment behind coastal structures. (d) The negative coastal sand budget has already affected the near-shore area but hasn't yet cause significant general retreat of the coastline. (e) In the future the state of the coast might deteriorate further due to global climate change (sea-level rise and changes in the storm regime).

4.10 Italy[59]

Italy has 7,500 kilometres coasts of which just under half consists of low lying alluvial beds, particularly exposed to coastal erosion. An idea of the importance that Italy attaches to its problems in coastline engineering comes from the northern Adriatic beaches, holiday destination of more than 90 million tourists from Italy and northern Europe

[59] Y.N. Krestenitis & I.S. Androulidakis (2006).

Beach erosion started at the river mouths and gradually spread to more distant coastal segments, affecting now approximately 30% of the national beaches. In addition, harbours were built on sandy beaches inducing downdrift erosion (Pranzini, 2002). Seventy percent of the Italian sandy seashores show coastal erosion, which is particularly severe near the main river. The most probable cause is a reduced input of sediments by rivers, while harbour or groyne construction can be locally important, modifying the marine currents (Pranzini & Cipriani, 1999). According to the Atlas of the Italian Beaches (Fierro and Ivaldi, 2001), 27% of the Italian beaches which constitute 61% of the total Italian coastline are retreating, 70% in equilibrium, and only 3% prograding.

Almost all nourishment projects (figure bellow) comprise of a combination of sand nourishment and hard structures (Benassai et al. 1997). These different projects may be attributed to one of the following general objectives: 1. Erosion mitigation at local scale. 2. Enhanced recreation at a very small scale. 3. In southern Italy there is often the need to safeguard the coastal railway. These interventions may, almost generally, be regarded as remedial (counter-active) rather than preventive (pro-active) measures, i.e., emergency-type actions are taken as problems are identified along the coast without any long-term planning or overall strategy (Hanson, 2002).

Italy Figure. Beach nourishment sites in Italy (Hanson, 2002)

4.11 Lebanon[60]

It is estimated that 2.3 million people are resident in the Lebanese coastal zone. This zone is very narrow and lies between the west mountainous chain and the sea. Major pollution problems are untreated urban wastewater, solid wastes and coastline urbanisation. Beirut, Tripoli, Sidon, Jounieh and Tyre are the major coastal cities. Urban wastewater is discharged into the sea untreated (44 000 tonnes of BOD5 per year) as no municipal WWTP is in operation in the country. Furthermore, beachfront dumping sites of municipal and industrial solid wastes constitute an important LBS. The major factor for the physical alteration of the coastal zone is urbanization since most of the coastal fringe (at a width of 8 to 10 km) is built-up. Areas with major environmental problems include:

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

[60] European Environment Agency (2006).

4.12 Libya[61]

Libya's coastal zone hosts 85 % of the country's population and most of its industrial, agricultural and tourist activity. There are no natural rivers in the area, only wadis (temporary dry rivers) which transport sediment, litter and pollutants from inland to the sea during storms. With the exception of the larger coastal cities, most towns have no effective sewer system. Therefore, discharge of wastewater into the sea is minimised.

Major environmental problems in Libya are oil pollution near terminal facilities as well as untreated urban and industrial wastewater from the bigger cities. Urban solid wastes are often disposed of in empty plots within the town limits, which create serious health problems. Tripoli and Benghazi: urban wastewater partly treated;

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

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

[61] European Environment Agency (2006).

4.13 Malta[62]

Structurally Malta is divided into two major blocks by the Victoria Lines Fault, which down throws north and runs from the west coast at Fomm ir-Rih to the east coast at Madliena Tower. The northern block is characterised by a series of normal faults striking ENE, which divide the region into horsts, grabens and half grabens. In contrast, the southern block is characterised by less pronounced faulting striking NE. The Maltese Islands have an undulating tilt towards the northeast thus producing two types of coastline, a gently sloping rocky coast on the northeastern side and a steep cliff-dominated coastline on the southwest and west side of the Islands. Superimposed on this general dip are the effects of faulting and differential erosion. The structural properties of the various rock layers influences the rate of erosion under the action of wind, waves and rain and thus give rise to different formations that include:

- Wave cut notches or wave cut platforms at the base of the Lower Coralline Limestone cliffs (often extending below sea level).
- Smooth gently sloping coastal platforms on Globigerina limestone shores.
- Bays where clays and marls have been eroded away at a fast rate.
- Boulder screes (both on land and in the sea) where erosion of the blue clay undermines the upper coralline limestone cap above it forming the typical drum coastline.
  -Karstland.

62 Source: Krestenitis Y.N. & Androulidakis I.S. (2006).

4.14 Monaco[63]

Monaco has a population of 33 000, and a high population density (16 500 people per km2). The city wastewater (urban and industrial) is discharged into the sea through submarine outfalls after treatment.

Furthermore, there is also primary treatment of storm water before it is discharged into the marine environment. Solid wastes are recycled (glass, paper, batteries, lubricating oil) or incinerated, reducing their weight by 70 % before sanitary disposal. Special industrial wastes are also treated (Principauté de Monaco, 1997). The greater part of the coastline of Monaco is urbanised.

[63] Source: European Environment Agency Report (2006).

4.15 Morocco[64]

The Mediterranean coast of Morocco has witnessed increased urbanisation over recent years. From 1977 to 1994, medium-sized coastal towns grew from 16 to 30, and small towns from 2 to 14. The major urban centres, which are also the most polluted areas on the Mediterranean coast, are: Tangiers (population 640000), Tetouan (333000), Nador (149000) and Al Hoceima (65000). The main environmental problems are caused by urban and industrial wastewater, maritime traffic and coastal urbanisation. For example, construction, sand extraction and erosion have resulted in serious stress on the beaches. This has led to the disappearance of seven out of 47 beaches in recent years. The major beaches under stress are in Tetouan, Mdiq, Restinga-Smir, Al Hoceima, Cala Iris, Nador and Essaidia. Due to bacteriological contamination, 17 % of recently surveyed beaches were not in conformity with sanitary standards for bathing. Maritime traffic is one of the major concerns for oil and hazardous compounds contamination. It is estimated that 60 000 ships pass through the straits of Gibraltar yearly, including 2 000 ships carrying chemicals, 5 000 oil tankers and 12 000 gas tankers. Major problems in the coastal areas which are also urban centres are listed below:

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

[64] Source: European Environment Agency Report (2006).

4.16 Palestinian Authority (Gaza Strip)[65]

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

The major areas of concern are:

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

[65] European Environment Agency (2006)

4.17 Serbia and Montenegro[66]

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

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

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

[66] Source: European Environment Agency Report (2006).

4.18 Slovenia[67]

Slovenian Coast is situated at the far northern end of the Mediterranean, along the Gulf of Trieste, which is the northernmost part of the Adriatic Sea. The whole coastal area is divided into three municipalities, namely, Koper, Izola and Piran.

Slovenian Coast is highly varied, with stretches falling into several types according to coastal typology. In general there are cliffs, shingle beaches, coastal plains (lagoons, wetlands) and artificial coasts.

Most of the Slovenian Coast represents the abrasive type of coast with steep and crumbling cliffs of marl and sandstone in different phases of development, and with different erosion driving forces prevailing. Majority of cliffs are in mature form having shingle beaches at toe. The main erosion factor there is weathering with occasional landslides and toppling, wave erosion being limited only to occasional extreme storm events. Minority of almost vertical cliffs is under constant erosion action of waves, rock falls and toppling being main failure modes there. The accumulative type of coast is formed by large quantities of fine sediments, deposited by rivers: mainly by the Soca and to a smaller extent by the Rizana, the Badasevica and the Dragonja. The sediment deposition resulted in coastal plains facing a shallow sea with muddy gently shelving sea bottom. Coastal plains are mostly highly changed by human activities. Some were developed to saltpans and artificial lagoons, while in Koper area there has been extensive dredging of navigational canals combined with deposition of material to build the docks. Most of the

[67] Source: Krestenitis Y.N. & Androulidakis I.S. (2006).

coastline is protected by artificial structures. However, during extremely high tide events the stretches of low coast are flooded for some hours short periods several times a year. One of mayor problems, represents the historic centre of Piran. It is regularly flooded every time, usually in autumn, when astronomical high tide coincides with low air pressure and southerly wind storm surge.

4.19 Spain[68]

In the Mediterranean area, erosion has greatly increased as a consequence of the drastic reduction of fluvial sediment input due to the regulation and reforestation of river basins and the construction of dams. The coastal evolution of the Ebro delta clearly shows this tendency (Sanchez-Arcilla et al. 1998). Most of the areas affected by accelerated erosion are the result of the construction of ports that interrupt littoral drift, and the situation is exacerbated by urban development and the construction of infrastructures as well as by the associated coastal defence structures. In some cases, this has involved the erosion of the barriers separating coastal wetlands from the sea, such as the one between Puнol and Massalfasar, as a result of the port of Sagunto, the spit of the lagoon between Valencia and Cullera, due to the Valencia port, and the closing barrier of Santa Pola lagoon, a consequence of the Santa Pola port (Alicante).

[68] Source: Antonio Cendrero Uceda, Agustin Sanchez-Arcilla Conejo and Caridad Zazo Cardena (2005).

In other cases, the erosion of beaches and coastal plains has been radically accelerated, like in Puerto de Mazarrףn (Murcia) and Carboneras (Almeria).
The conatruction of walls or coatings in areas where retreat is now an established fact (for example, in the Manga del Mar Menor) breaks the natural summer/winter sediment balance and causes two negative effects: it inhibits the growth of the beach in summer by waterproofing the swash area, and prevents the erosion of the upper part of the beach in winter, and consequently, the formation of the sediment bar which acts as a reserve in the area of transition to the shoreface. In all these cases, the estimate of transports, both longitudinal and transversal, presents multiple uncertainties with regard to the present climate (Sבnchez-Arcilla et al. 2001), and even more for future climate scenarios.
On the northern coasts, the situation is different, as the basins flowing to these have not generally been subjected to any great regulation. On these coasts, there is evidence of appreciable increases in sediment deposits in recent times, most likely as a result of human intervention (Cendrero 2003; Remondo et al. 2004; Mיndez et al. 2004, Cendrero et al. 2004).
The retreat of beaches and dune fronts, however, is perceptible in many places, or even the accelerated erosion of "soft" cliffs (Rivas 1991; Rivas and Cendrero 1991, 1992, 1995).
Based on these data, it could be considered that a rise of around 50 cm for the end of the century is a reasonable scenario. A pessimistic hypothesis, much less likely but which cannot be ruled out, would involve a rise of 1 m, corresponding to the maximum in certain predictions and with the aforementioned levels in the past. This situation appears to be much less likely on the S and E coast than on the N.
In the case of a generalised rise in mean sea level (MSL), the most vulnerable areas would be deltas and naturally or artificially confined beaches. The part of the Spanish coast with cliffs made up of resistant rocks would present no particular problems. There is potential danger, however, regarding the stability of the coasts with cliffs consisting of non-coherent materials (not very significant). The hypothetical scenario of 0.5 m maximum possible rise could mean the disappearance of 30% of the beaches in the eastern part of the bay of Biscay, considering that no natural or artificial nourishment of sediments takes place. A relative rise in MSL by 0.5 m without an associated sediment response would give rise to the disappearance of around 50% of the Ebro delta.
These hypothetical rises in MSL could cause the flooding of coastal lowlands (deltas, coastal wetlands and agricultural and built up areas in the vicinity of deltas or on coastal alluvial plains).
On the eastern part of the Bay of Biscay, this could imply the flooding of some of the lowlands, estimated at 23.5 km2 for the above-mentioned value. In the Mediterranean and the Balearic Isles, and supposing a maximum of 0.5 m, the most threatened areas, apart from the aforementioned deltas (Ebro and Llobregat), are the Manga del Mar Menor (around 20 km), the Cabo de Gata lagoons (5 km) and, in the Gulf of Cadiz, around 10 km of the coast of Doסana and around 100 km2 of marshland. Some of these areas are occupied by buildings or infrastructures, but others are devoted to agricultural use or are part of a nature park, and could allow for the formation of new wetlands which would compensate, by displacement, for the
foreseeable loss of other wetland areas due to permanent flooding.
However, more precise estimates about the future evolution of this kind of coastal systems should also take into account changes in the height and intensity of waves and meteorological tides.
It should be pointed out that, added to the potential impacts of climate change, other factors of anthropic origin, such as changes in river sediment transport or construction on the coast, have, at least, a similar potential influence in the short-term stability of the coast.

4.20 Syria[69]

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. Coastal urbanisation, due to housing needs (local and tourist) and industrial development, (harbor facilities) has led to serious environmental problems.

These problems are: disposal of untreated urban and industrial wastewater, oil slicks from the oil refinery and the oil terminal, and the management of solid wastes. In total it is estimated that 24.8 million m3 of urban wastewater, 99 % of which is untreated, is discharged into the sea. As a result, the loads of heavy metals discharged into the sea can be high, for example the maximum value of lead (Pb) measured in marine sediments has reached 358.5 mg/kg in Tartous harbour.

- Lattakia area: urban wastewater (7 364 tonnes of BOD5, 1 664 tonnes of nitrogen and 377 tonnes of phosphorus), solid waste dumping site on the shore and eutrophication of the coastal zone.

[69] European Environment Agency (2006).

• Tartous-Banias area: urban wastewater, (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.

4.21 Tunisia

Tunisia has more than 1300 km of coastline that shows a big variety of natural landscapes. This wealth is strengthened by the existence of numerous island spaces. Unfortunately, due to the reasons listed below, a lot of beaches face critic phenomena of erosion. Those reasons are a) human activity which is concentrated on the coast area (90% of tourism activities and hotels, 90 % of industry, 46 harbours & ports, 70% of the population, etc.), and b) impact of some natural conditions, like the shortage of sediments (dams on the rivers) [70].

On the northern coast, the beaches are most often less sensitive to erosion problems and have, sometimes a rather excess sedimentary budget in the case of the beaches occupying the oueds

[70] Source: Krestenitis Y.N. & Androulidakis I.S. (2006).i

mouths. However, weakness signs, balance break threats and sometimes even preoccupying erosion problems exist in developed segments notably those belonging to important agglomerations zones[71].

In Tunisia, although there is no specific legal framework for coastal zones, there is a specialised agency, which, since 1995, has had the mission of instituting an integrated form of development.

Tunisia receives nearly 5 million tourists a year, primarily from France, Germany, the United Kingdom, Italy and countries of the Maghreb. In 1999, Tunisia put in place an action plan to develop cultural tourism[72].

4.22 Turkey[73]

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

71 Source: REPUBLIC OF TUNISIA, MINISTRY OF ENVIRONMENT, AND LAND PLANNING (2001), "Initial Communication of Tunisiaunder the United Nations Framework Convention on Climate Change"

72 WWF Mediterranean Programme Office and AMBIENTEITALIA(2004), Guidelines for sustainable tourism investments in the Mediterranean coasts,

73 Source: Krestenitis Y.N. & Androulidakis I.S. (2006).i

constructions and extensive building of second (vacation) houses on the Aegean and eastern Mediterranean coastline. This is drastically altering the landscape. Coastal erosion is also an important problem. Out of 110 sand dune systems recorded in the 1980s only 30 (27 %) are relatively intact today.

Areas of concern and LBS include:

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

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