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Assessment of Hazards and Threats on the Coastal Zone, arising either from Global Change or from Regional Variability due to either Natural or Anthropogenic Forcing(WP4)

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Assessment of Hazards and Threats on the Coastal Zone, arising either from Global Change or from Regional Variability due to either Natural or Anthropogenic Forcing

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GENERAL INTRODUCTION

The Deliverable D 4.2 – "Assessment of hazards and threats on the coastal zone, arising either from Global Change or from regional variability due to either natural or anthropogenic forcing" belongs to the WP 4: "Pressures on the Coastal Zones of the Mediterranean and Black Seas".

The report gatheres the information from a large number of old and recent studies that have dealt with the impact of the Global Change and anthropogenic forcing on the state of the Coastal Zone of the Mediterranean and the Black seas. The studies showed that the combination of global changes, sea-level rising and contamination could produce unpredictable, dramatic and ireversible environmental modifications including catastrophic coastline erosions, changes in coastal sea ecosystem structure and functioning, land loos, socio-economic negative effects etc.

Increasing frequency of extreme events have also dramatic effects on the Coastal Zone:

- the recent decade was marked by both record floods and droughts in tributary river systems that question earlier premises about the climatic controls on the system;
- continuously increasing wind and wave energy, extreme storms, catastrophic events as earthquakes, tsunamis, land or sediment slides and slumps, sudden and masive green-house gas escapes from the sediments etc.

The report reviews the current knowledge on immediate and long-term threats to the coastal zone and the role of science in identifying hazards. Efforts have been done for determining the knowledge gaps that require additional research in the future.

The Black Sea Coastal Zone and the Mediterranean one are presented separately; however it is obviuos that the effects of the global changes and anthropogenic forcing are similar in both seas, and the conclusions point on a clear and urgent need for complex, continuous and detailed research and observation systems on these combined stresses and on limits of resilience of coastal zone ecosystems.

Objectives of the workpackage WP 4, deliverable D 4.2

The WP 4, task 4.3 (deliverable D 4.2), is focused on assessing the current state of the Mediterranean and Black seas Coastal Zone, the impact on it of the Global Change (erosion, sea-level rise) and the anthropogenic forcing as well as the potential hazards and threats to coastal sea and littoral zone. The synergetic effects of all impacting factors are taken into consideration. The gaps of the present-day state of knowledge about pressures on the Coastal Zone are highlighted.

The conclusions of the report point on a clear and urgent need for:

- a very complex, multidisciplinary approach;
- continuous and detailed research programmes in the most endangered areas or regions;
- implementing continuous observation systems to improve the knowledge on the impact of combined stresses and on limits of resilience of coastal zone ecosystems.

A. THE BLACK SEA COASTAL ZONE

1. Present day State of Erosion

1.1. Introduction, general setting

The Black Sea is one of the largest enclosed seas in the world, covering an area of about 4.2 x 10^5 km^2; the maximum depth of the sea is 2,212 m and the total volume of the water - 534,000 km^3. Most of this water (the 423,000 km^3 that lies below a depth of 150-200 m) is anoxic and contaminated with H_2S. The Black Sea drainage basin covers more than 2 million km^2; more than 160 million people live in this area. The largest rivers flowing into the sea are the Danube, the Dniester, the Dnieper and the Don. The River Danube is the most important European waterway flowing 2,857 km across the continent from the Schwarzwald Massif in Germany down to the Black Sea. Its water discharge into the Black Sea is about 200 km^3 of water/year. The Danube drainage basin extends on 817,000 km^2, more than 15 countries sharing this catchment area.

1.2. The Black Sea coastline

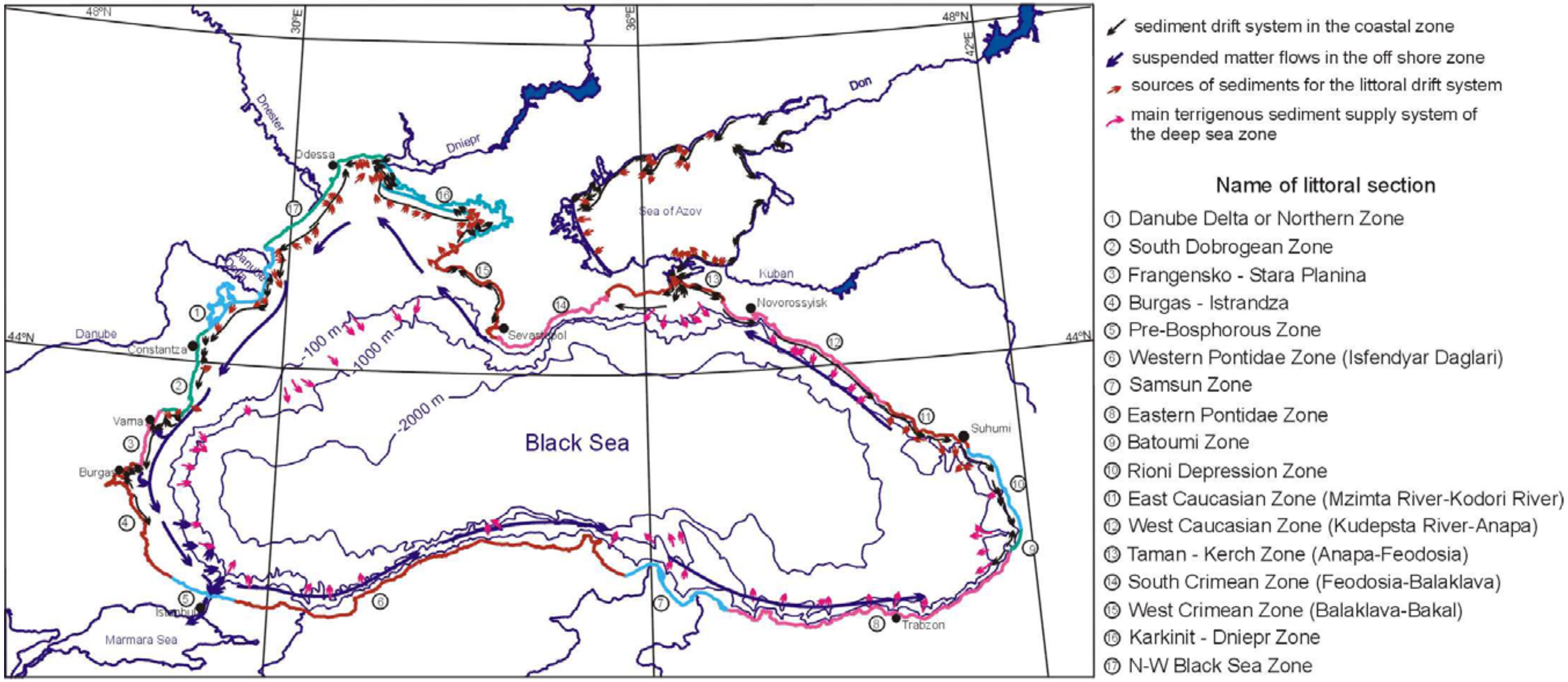
The total length of the Black Sea coastline is over 4 400 km and belongs to 6 states: Bulgaria, Turkey, Georgia, Russian Federation, Ukraine and Romania. The large variety of geomorphologic types of these coasts corresponds to different geological environments surrounding the Black Sea.

The Black Sea coastal zone can be divided in 17 main zones characterised by different geology and morphology, as well as specific littoral water circulation, sediment drift systems and sedimentary budget (Fig.1, Table 2).

In a more general approach the Black Sea coast zone could be subdivided into three main morphodynamic categories, with very specific characteristics and behaviour:

1. ***Low, accumulative coasts*** mostly related to the main rivers mouth zones. This type of littoral zone consists of sandy complex barrier beaches with strong longshore sediment drift systems; these zones are generally characterised by isostatic adjustments of overloading by rapid accumulation of sediments (subsidence).

ZONATION OF THE BLACK SEA COASTAL ZONE
Sediment movement systems



After: N. Panin, E. Ion, G. Ion

To this type belongs, first of all, the Danube Delta with a very exposed to erosion littoral of about 240 Km; then within this type must be considered partly the unit River Dnieper liman - Karkinit Bay (total length of about 618 Km) , specifically the Kinburn spit - Dolgyi Island section (~ 20 Km) and Tendra spit - Dzharylgatch Island section (~137 Km). The Taman - Anapa section of about 200 Km long (of which 66 Km are the Anapa spit) represents mainly an accumulation of sediments brought by the River Cuban few hundred years ago, and could be allocate to the same first type of coasts. Further to the South, the mentioned type is present within the Kolkhida (Rioni) Lowland where the rivers Chobi, Rioni, Inguri and Supsa have built up their deltas. On the Turkish coast there are the deltas of Kizilirmak, Yesilirmak and Sakaraya rivers, and finally, in Bulgaria, sandy accumulative beaches are related mainly to the rivers Diavolska, Kamchya, Provadyiska and Batova, summing about 100 Km.

The accumulative coasts of Anapa section, Kolkhida Depression, the deltaic sections on Turkish and Bulgarian coasts are located within or nearby zones of high relief energy, relatively strong sediment nourishment and general uplifting tendency, so their equilibrium state is not yet very strongly affected.

2. ***Erosive coasts within lowstanding plateaux and plains***, with active cliffs in lœss and lœss-like deposits, sometimes underlyed by older deposits as Pontian limestones, Meotian clays and Sarmatian lumachelles, with very narrow beaches in front of the cliffs.

To this type of coasts could be distributed the north-western unit of the Ukrainian coast zone. This unit extends from the northern limit of the Danube Delta (of the Kilia secondary delta) to the town of Ochakov (western limit of the Dnieper liman), summing 232 Km.

The Southern unit of the Romanian coastal zone (Cape Midia - Vama Veche at the Bulgarian border - about 75 Km long), as well as the Northern part of the Bulgarian coast, from the Romanian border to Caliacra Cape (about 50 Km long) belong to the same type of littoral.

3. ***Mountainous coasts***, with cliffs, marine terraces, land slides, sometimes with sandy or gravely beaches. This type of coasts is generally subject of isostatic and orogenic uplift.

To this type are belonging the coasts of Crimea, Caucasus, Pontides, Strandza and Staro Planina Mountains, as well as of Frangensko and Avrensko plateaux.

1.3. Coastal erosion in the Black Sea. Factors controlling the erosional process

The coastal erosion in the Black Sea represents one of the main environmental concerns of the riparian countries. The erosion is controlled by:

- ***Global and natural factors.*** The Black Sea coastlines erosion is strengthened as everywhere in the World Ocean by the global changes and the general sea level rise. The coast erosion will depend on synergetic effect of factors controlling the littoral processes (meteorological regime, wave energy regime, water circulation, sediment supply and drift etc.), global changes and the consequent modification of the energetic level of the coastal sea, general sea level rise and regional characteristics as shoreline morphology, elevation and geologic constitution, subsidence or/ and neotectonic regime.
- ***Anthropogenic factors.*** The coast zone erosion and the state of the coastal sea ecosystems are strongly affected by the anthropic activities, the effect of which is added to the impact of natural factors. The anthropogenic changes of large rivers hydrologic characteristics (water and especially sediment supply, regularisation of floods etc.), men-made littoral structures as breakwaters, dykes, groins, harbours etc. which are modifying the littoral circulation cells, the uncontrolled use of beach sand, dredging of sand too close to the beaches or within the river mouth bars and many other activities are causing an enhancement of coastal erosion and endangering of the coastal ecosystems.

The first category of coasts described in the Chapter 1.2 (Low, accumulative coasts) is the most influenced by the global changes, specifically by the sea level changes and by the changes in the river sediment inputs. The decreasing of sediment supply and changes in littoral sediment drift due to anthropic activities (river damming, hydro-technical regularisation, littoral structures etc.), especially when the sandy beaches are low, added to the rising of the sea level and the increasing of littoral sea energy could determine in certain conditions a very active and almost continuous recession of the beach line (up to 20 m/y, as it happens in some sections within the Danube Delta littoral). This process is causing land losses, environmental changes and economic degradation of the coastal zone. If the region represents the coastal zone of an important delta which plays essential role in the normal structuring and functioning of ecosystems, any changes of delta/sea interaction zone environments could be fatal and irreparable.

The second category of coasts described above *(Erosive coasts within lowstanding plateaux and plains)* could be also affected by erosional processes but the rates of coastline regression do not reach the same values as within the first category (only 1-2 m/y). In this case the erosion affects mostly the narrow beaches in front of the cliffs. The environmental transformations are not so important and consequently the economic losses are much lower.

The third type of coasts *(Mountainous coasts)* is the least affected and transformed by the erosional processes. Generally, the littoral of this type is constituted of consolidated rocks, resistant to the eroding process. In front of such rocky littoral there are no beaches or they are very narrow and coarse grained (coarse-grained sand and pebbles). If the development of tourism is intended one have to build up artificial beaches and pertaining protection structures as wavebrakers, groins etc. In this case one could affirm that the only economic concern is the maintenance of these artificial beaches.

2. Threats to the Coastal Zone generated by Global Changes and Anthropogenic Pressure

Taking into consideration the above mentioned observations, it clearly appears that the most vulnerable sections of the Black Sea Coastal Zone belong to the first type *(Low, accumulative coasts)* described in the chapter 1.2. Among the coast zone sections referred to this type the Danube Delta is the most significant and important.

The Danube Delta is located in the north-western part of the Black Sea, between 44° 25' and 45° 30' N and between 28° 45' and 29° 46' E. The delta plain covers an area of about 5,800 km^2 of which the lower, marine delta plain represents ca. 1,800 km^2. The Danube Delta shoreline is about 240 km long, of which about 75 km represents the coastline of Kilia Delta and belongs to Ukraine and 165 km is on Romanian territory.

The marine delta plain is a very low area with marshes, lakes and numerous old beach-ridges (very elongated, narrow and extremely low altitude sand bodies), which in certain zones generate, by juxtaposition, accumulative littoral bodies (the main of them are Letea, Caraorman and Sărăturile) with limited dune fields and the highest altitudes within the delta territory (+12.4 m in the Letea Formation, and +7 m in the Caraorman Formation). About 20.5 % of the Danube delta-plain represents areas with negative relief, i.e. with an average level below the Black Sea - Sulina reference system, about 54.5 % of the Danube delta plain consists of areas having altitudes between 0 and 1 m above the sea-level, and 18 % with altitudes between 1 and 2 m.

In front of the Danube Delta, the north-western Black Sea continental shelf is very large (over 100 km width). This part of the sea receives the discharge of largest rivers from the Central and Eastern Europe – the Danube with a water discharge of about 200 km^3/yr. and the Ukrainian rivers (Dnieper, Southern Bug and Dniester) contributing about 66 km^3/yr.

The present-day longshore sediment drift system off the Danube Delta area is directed toward the south (see Table 2, fig.2). It is induced by the predominant winds, which are from the north and northeast and the most frequent wind waves recorded also from NE corresponding to the prevailing wind direction. The mean maximum heights of wind waves in front of the Danube Delta reach 7.0 m. The energy of storm waves reaches important values (to 12,242 kWh/m, recorded on February 17, 1979), but generally the energy value is about 2 000 kWh/m (Spãtaru, 1984). The storm surges from N, NE, E and SE direction induce water level rises to 1.2 – 1.5 m. The tide in the Black Sea has an average period of 12h 25' and amplitudes of only 7 – 11 cm (Bondar *et al.*, 1973; Sorokin, 1982). The general relative sea-level rise in the delta-front area (at Sulina gauge) is estimated at 3.7 mm/a, of which subsidence accounts for 1.5 – 1.8 mm/a (Bondar, 1989).

In such natural conditions, for the Danube Delta the main factors of risk are the river flooding and the littoral beach barrier flooding by the sea. The climate changes and the related sea level rise represent also elements of risk.

2.1. River Flooding

Flooding events in the Danube Delta occur when the water discharges of the Danube River are over 10,000 $m^3.s^{-1}$. According to existent records, catastrophic floodings in the Lower Danube section took place in 1845, 1853, 1888, 1895, 1897, 1907, 1914, 1919, 1924, 1932, 1940, 1941, 1944, 1947, 1954, 1955, 1956, 1958, 1962, 1965, 1970, 1970, 1975, 1980, 1981, 1988, 2005. Statistic analysis of the data set for 161 years (1840 – 2000), concerning the mean annual water discharges of the Danube River, shows that, at the delta apex, were recorded over 89 flooding events. According to the existing data-sets, the flooding events with discharges of 10,000 – 11,000 $m^3.s^{-1}$ along the Lower Danube section have a mean repeatability of occurrence of two years.

For an easier assessment of the river water level and its influence on the delta territory a special measure unit, named *hydro-degree*, has been defined: a hydro-degree represents one tenth of the highest water level at a given point. The table below demonstrates the impact of flooding on the Danube Delta territory by showing the non-flooded areas at different stages of rising of the Danube water level.

Table No.1 – Non-flooded areas of the Danube Delta at different water levels of the Danube River

Geomorphological categories	**Non flooded area (ha)**			
	Lowest waters *3 hydro-degrees*	Low waters *4 hydro-degrees*	Ordinary waters *5-6 hydro-degrees*	Highest waters *10 hydro-degrees*
Natural fluvial levees	19,757	15,343	9,850	-
Lacustrine spits	3,005	2,607	2,210	30
Present day barrier beach	2,400	2,390	2,380	1,800
Old littoral accumulative bodies, of which:	26,215	23,811	21,410	10,000
- Letea (altitude max.+12.6 m)	12,710	12,185	11,660	7,915
- Caraorman (altitude max. +6.5 m)	5,540	4,565	3,590	165
- Saraturile	5,465	4,990	4,515	2,000
TOTAL	72,542	62,131	51,045	13,775

2.2. Littoral Beach Barrier Flooding by the Sea

The present sandy beach barrier along the Danube Delta Front is very low (+0.7 to +1.5 m) (Fig. 1a). The lowest sections are: Girla Imputita-Cisla Vadanei (about 15 Km long, corresponding to the inter-beach ridge depression Rosu-Lumina), Ciotic-Perisor (20 Km long, corresponding to the Zatoane Depression) and Portita-Periboina (about 20 km, the present-day beach barrier bordering the lagoon complex Razim-Sinoie). These sections represent the most vulnerable zones of the delta coastline to the flooding by the sea.

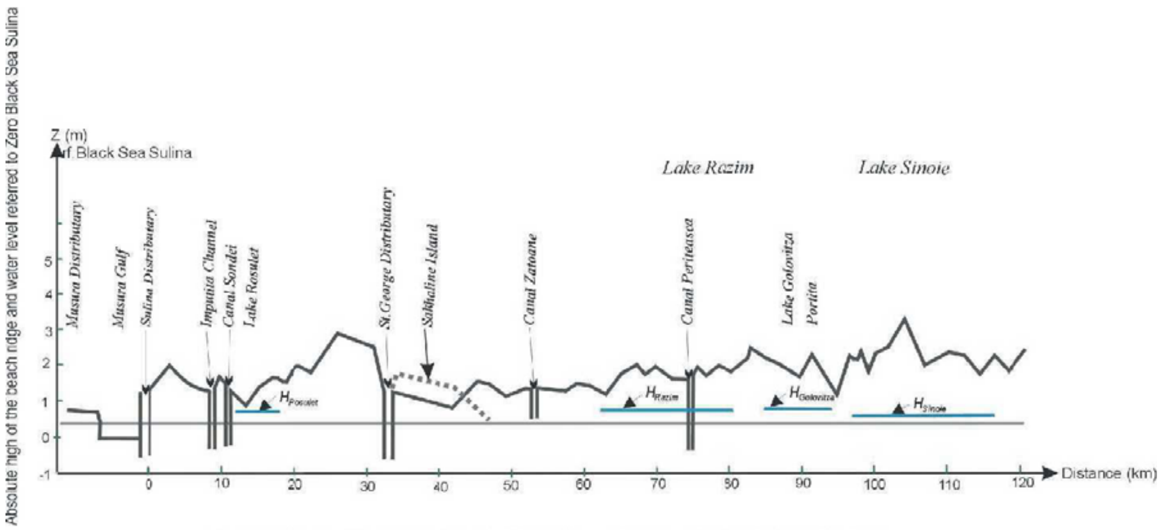


Fig.1a - The profile of the beach ridge along the Danube Delta front between the Ukraine - Romanian border (Musura distributary mouth) and Cape Midia

To the natural high degree of risk the anthropogenic pressure is added. In the last 20-25 years the River Danube sediment supply diminished severely as the Iron Gates I and II barrages have been constructed: measurements and computations show that the present day sediment discharge dropped by almost 40 % and the real sediment load brought now-a-day by the Danube into the Black Sea is not larger than 40 million t/y, of which not more than 10-12 % is sandy material taking part at the littoral budget of the delta front zone. The effects of this misbalance added to the impact of other anthropogenic structures and to the rise of the sea level and the increased energy of the coastal sea bring about a very active erosional process of delta-front beaches.

2.3. Risks and Impacts of Climate Change and Sea Level Rise

2.3.1. Impacts on rainfall and water flow and water resources

In accordance with the generally accepted models the most important changes in the climate would be the northward shift of climate zones, the lengthening of summer at the expense of other seasons, the changes of winter cyclonic patterns etc.

The models show that the increase of the mean temperature by 1.5ºC in these conditions will determine a decline with at least 10% of the river flow. This decline combined with a decrease of water energy by the rising of the base level would substantially lower the fresh water input into the sea.

Lesser and more erratic precipitation will reduce the groundwater recharge and will misbalance the fresh versus marine water equilibrium. Despite an increased need for irrigation water, the average storage in the reservoirs will fall as a consequence of decreased river flow and precipitation and of increased evapo-transpiration. Reduction of rainfall during the hot summer period might cause deficiency in soil moisture, thus degrading soil structure and fertility and finally affecting the agricultural production.

2.3.2. Impacts of Global Changes and Sea Level Rise on the Danube Delta Territory and on the Coastal Zone.

In response to the forecasted for 2020-2030 SL rise with 20-30 cm, the regression of beaches will, obviously, continue all along the north-western and western Black Sea

coast. Despite a not critical value of SL rise, the impact on the shore zone will be strong enough because of cumulated effect of the SL rising, wind set-up, the shortage of beach feeding by decreased river-borne sediment input (especially of the River Danube) and, of course the anthropic pressure on the coast area. According to Bruun theory and formulas and using the specific data for Romanian beaches we can find average values for coast recession of 3-5 m/yr.

The change of the base energy level will diminish significantly the water and the sediment discharge of the Danube River. A very rough model of the SL rise impact on the Danube water and sediment discharges shows (Panin, 1992):

- a rise of 20 cm of SL will produce a decrease of water discharge by 10% at a free water table slope of 1.143 cm/km and by 26% at a slope of 0.54 cm/km (at the lowest water level), the current velocity will decrease by 12% and respectively 28,6 % and, correspondingly its sediment transport capacity will decline;
- a rise by 30 cm of SL will produce a decrease of the water discharge by 16% for a slope of 1.143 cm/km and by 47% for that of 0.57 cm/km. The mean current velocity will decrease by 19% and respectively 50%.

The reduced fresh water input would influence the general salinity of the Black Sea especially when the general SL will rise continuously. This would involve a greater supply of saline Mediterranean water by the bottom Bosporous current and a decrease of the thickness of the less saline superficial layer of the Black Sea.

At the Danube distributaries mouth zone the penetration of the salt wedge deeper upstream into their course will create a significant disturbance in the processes of transfer of bed-load to the mouth bar and further to the littoral zone. The diminished sediment input would induce a greater deficit in the sedimentary budget of the littoral zone.

As regards the deltaic shore, a rise of SL by 20-30 cm corresponds to an equivalent river water rise with of at least 3-4 hydro-degrees. This means that very extended area of the delta nearby the shore zone would be flooded and also greater flood risks on the entire delta territory will occur (Panin, 1992).

The deltaic coast will be reshaped by marine processes, but in the more vulnerable sections as Gârla Imputita - Câsla Vãdanei, Ciotic-Perisor and Portita-Periboina conditions will be gathered to transform the corresponding intradeltaic depression or lagoon areas into bays. Such risk is greater in the Gârla Imputita - Câsla Vãdanei section which corresponds to the Rosu-Lumina interdistributary depression, in the Ciotic - Perisor section and in the Portita-Periboina zone (corresponding to the lagoon complex Razim-Sinoie), even if here the beach barrier is at present protected by a setback line of embankments limiting losses of beach material by over-washing.

Table 2 – The BLACK SEA COASTS ZONING AND DESCRIPTION

Zone	Section	Length Km	Characteristics, description	Observations on sediment feeding and littoral drift system
1	**2**	**3**	**4**	**5**
I. Danube Delta or Northern Zone of Romanian Coastal Zone	**~240.0** km long General description: Low, accumulative, mainly sandy coast. Two sub-zones: 1. Coastal zone between the main distributaries of the Danube Delta: Kilia, Sulina and St.George 2. Coastal zone of Danube Delta lagoon system			The River Danube is the main source of sediments for the littoral drift system. After the damming of the Danube River at the Iron Gates (Iron Gates 1 in 1970 and Iron Gates 2 in 1983) the sandy supply of the beaches by the river dropped by ~40%.
	1. Kilia (Chilia) Delta	75.0	Progradational trend near the main distributaries of the Kilia Delta. The Kilia distributary sediment discharge represents almost 50 % of the total sediment discharge of the Danube River. The natural lengthening of the Kilia distributary and anthropic changes occurred along the Danube River and within the delta territory the Kilia sediment supply dropped and the Kilia Delta shape is slowly changing from a lobate to a cuspate-like delta (in the neighbourhood of the main distributaries.	The sediment drift oriented to the south.
	2. Baia de Nord (Baia Musura) - Musura Bay	12.0	At the beginning of our era - strong erosion; At present: the erosion is stopped, tendency of clogging and transformation in a lagoon by forming of a spit at the entrance into the bay.	The sediment drift oriented to the south at the mouth of the bay. The spit closing the Musura Bay is formed of sandy sediment load of the Stary Stambul distributary of the Kilia Delta.

	3. Sulina beach	6.0	Before nineties accumulation of sediments; At present the accumulation is slacked under anthropic impact.	Local, eddy-like northward sediment drift, due to the Sulina 8 Km long jetties.
	4. South Sulina - Gârla Imputita - Câsla Vãdanei	16.0	Present-day strong erosion (up to 15-20 m/yr); During the last 2 K.yr. erosion of Sulina Delta - the retreatment of the coast line was over 10-15 Km.	Southward Danube borne sediment drift
	5. Câsla Vãdanei - Sf.Gheorghe distributary mouth	15.0	Present-day strong to moderate erosion; At the southern end of the section, nearby the distributary mouth weak erosion or stationary state; The section corresponds to the littoral accumulative formation Sãrãturile, formed by juxtaposition of numerous old beach ridges.	Southward littoral drift of sediments.
	6. Sakhalin island	18.0	An arcuate lateral bar, extending to SW by 300-600 m/y, migrating also westward by over-washing.	Very strong south-westward drift of Danube borne sediments
	7. Secondary delta of St.George distributary - Ciotic	~12.0	The secondary St.George delta has three distributaries: St.George (Kedrilez) – the continuation of the main course of the distributary, the Seredne arm, the smallest, almost clogged and the Gârla Turcului arm. Active progradation as result of accumulation of sediments supplied by the distributaries of the St.George secondary delta in the shadowed by Sakhalin island area	The Gârla Turcului and the Seredne distributaries mouth zones are characterised by homopicknal flows into shadowed by Sakhalin island are.
	8. Ciotic – Perisor	18.0	Strong coastal erosion; significant lack of terrigenous material, the beaches are formed predominantly by organogenic detritus (mainly hashed shells).	Southward unsaturated drift of sediments
	9. Perisor – Peritesca	12.0	The section corresponds to the littoral accumulative formation Perisor; almost stationary state of the coastline.	Southward active littoral drift of sediments

	10. Periteasca – Chituc Nord	30.0	The section represents a beach barrier limiting the Danube Delta lagoons Razim and Sinoie to the sea; this section is characterised by a strong erosion and a very active sediment transfer.	Active southward littoral drift of sediments
	11. Chituc	26.0	The section corresponds to the littoral accumulative formation Chituc; strong to moderate erosion and active sediment transfer.	Strong southward drift of sediments

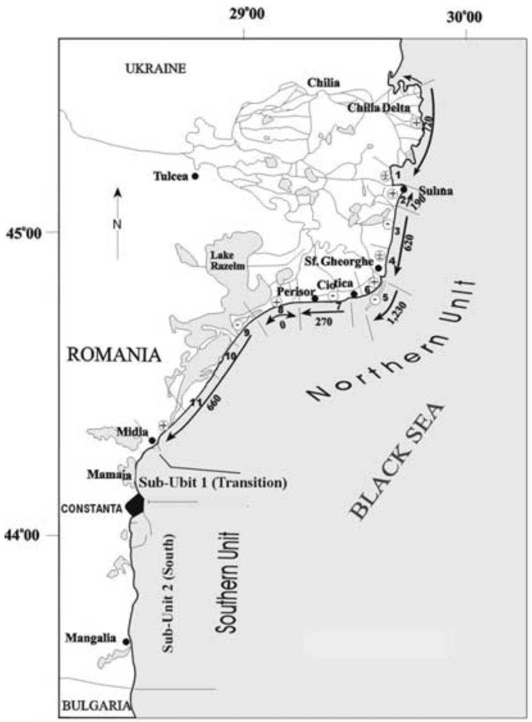


Fig.1 - Romanian Black Sea coast and the longshore sediment transport model (for the Danube Delta coast zone - Northern Unit)

Sediment drift (arrows) and transport rates in thousand of cubic meters per year (figures by the arrows). Circled + and - represent advancing and retreating sections respectively (after Giosan et al., 1997)

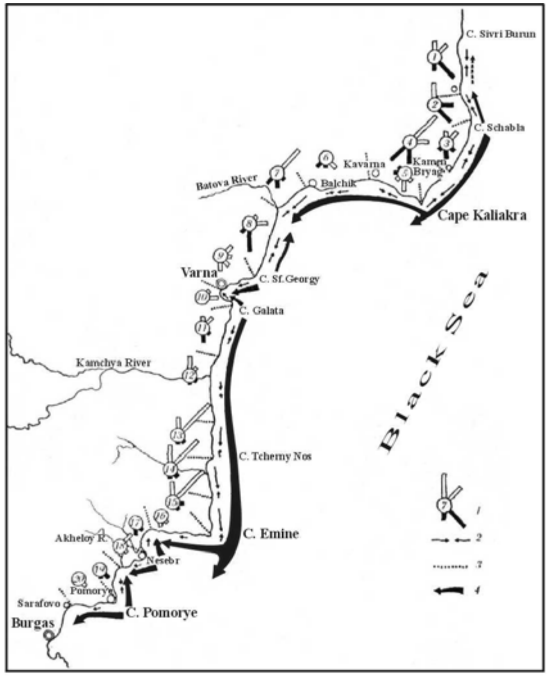


Fig. 3 - Schematic representation of the littoral drift system of sediments on the Bulgarian section of the Black Sea Coast (after Aksenov et al., 1979)
Legend: 1 - rosette diagram of the energy components in different sections; 2 - alongshore components of the energy fluxes; 3 - limits of computation sections; 4 - resultant of the alongshore energy fluxes and littoral sediment drift.

II. South Dobro-gean Zone	~ **175** km total length. General description: Erosional coast, with active cliffs and narrow beaches at the feet of cliffs or small beach barriers separating lagoons from the sea			Negative sedimentary budget, local littoral cells
	1. Cape Midia - Cape Singol	~ 22 km	The section represents a transition from the northern accumulative zone to the southern Dobrogean sensu stricto zone, characterised by predominantly active cliffs; the section is characterised by large littoral beach barriers located in front of fossil cliffs, limiting lagoons or littoral lakes.	Local littoral cells of sediment circulation; general drift system remains oriented to the South; strong anthropogene impact – the Midia harbour wave brakers disturb the littoral drift system.
	2. Cape Singol - Vama Veche (Romanian-Bulgarian border)	~ 60 km	Active cliffs with barrier beaches limiting lagoons. The cliffs are formed of loess formation laying on Sarmatian lumachelles.	Local littoral cells of sediment circulation; General sediment drift system remains oriented to the South. The beaches are formed mainly of organogenic material – shell debris.
	3. Vama Veche - Cape Kaliakra	~ 50 km	Same characteristics as the previous section - active cliffs with barrier beaches at the Black Sea tributary rivers mouth. Two subsections: (1) Cape Sivri (Sivri Burun) – Cape Shabla (Šabla) with low cliffs mainly in loess formation, small lagoons at the mouth of rivers and sandy beaches; (2) Cape Shabla – Cape Kaliakra, the cliffs become higher towards the Cape Kaliakra (up to 60 m highth), the cliffs are formed of limestone.	Local littoral cells of sediment dynamics; from Cape Shabla northward to Cape Sivri the drift is oriented to the north, with local convergent or divergent cells. From Cape Shabla to the Cape Kaliakra the general sediment drift system remains oriented to the South. Local differently oriented cells are evidenced.

	4. Cape Kaliakra - Balcic	~30 km	Almost the same characteristics as the previous section, but without beaches - active cliffs and massive landslides. The coastal relief is higher (up to 120 m at Kavarna and 220 m north of Batova river). Accumulative beaches of sandy sediments only at the mouth of Batova River (the sand is supplied by the Batova river)	The general littoral drift is oriented westward, parallel to the coast, with local littoral cels. The first subsection Cape Kaliakra-Kavarna is characterised by weaker drift, while the Kavarna-Balcic subsection has a stronger westward drift. The lack of sediments doesn't allow beaches to form.
	5. Ekrene	~ 10 km	The Batova River represents the limit between Dobrogean Plateau and Frangensko Plateau. The altitude of the relief in the coastal zone is higher, up to 290 m. Massive landslides. There are sandy beaches in the northern part of the section.	Along the Frangensko Plateau a northward oriented weak drift of sediments with local differently oriented cells. The beaches of Albena resort are formed by convergent supply from the Batova River and from the material resulted from the erosion of Frangensko Plateau coast.
III. Frangensko - Stara Planina	1. Frangensko Pla-teau coast	~ 10 km	Abrasive coast with marine terraces and massive landslides. Very small, mainly artificial beaches.	Northward oriented weak drift of sediments with local differently oriented cells.
	2. Varna bay	~ 10 km	The Varna bay is located at the mouth of Provadyiska River that represents the limit between Frangensko and Avrensko plateaus. The section is limited by the Cape St.George (Sv.Georgi) at the North and the Cape Galata at the South.	The littoral drift is convergent from the limiting capes (St.George and Galata) to the centre of the section. The drift is supplying enough material for creating a positive trend of coastline evolution – the advancement of the coastline goes up to 1 m/yr.

	3. Lower Kamchia	~ 18 km	Between the Cape Galata and the mouth zone of the Kamchia river the coastal zone relief has altitudes of 100-130 m; marine terraces and landslides occure.	The general drift system has a southward direction, with differently oriented local cells. The Kamchia River sediment supply is almost equally distributed to the north and to the south.
	4. River Kamchia-Cape Emine. Two subsections: (1) Kamchia-Cape Tcherny, (2) Stara Planina Mountains coast Cape Tcherny-Cape Emine	~ 40 km	South of the Kamchia River until the Cape Tcherny (first subsection) are located the largest beaches on Bulgarian coastal zone. In the second subsection, between Cape Tcherny and Cape Emine, the coast is characterised by land slides, terraces and small beaches. Within this second subsection starts the Stara Planina Mountains	The general drift system has a well expressed southward direction. The beaches are formed of the Kamchia River sediment supply as well as of the sediments brought by small permanent or temporary streems.
IV. Burgas-Istrandza	1. Nesebar section	~ 40 km	The Nesebar section extends from the Cape Emine to the Cape Nesebar. The Stara Planina Mountains coast continues along this section. The capes are formed of hard Neogene rocks.	The littoral sediment drift is oriented westward. The Cape Emine protects this section and large beaches could be formed: Sunny Coast beach with coastal dunes up to 11 m high, Nesebar gulf

	2. Burgas bay. Two subsections: (1) Cape Nesebar-Cape Pomorye, (2)Cape Pomorye-Cape Sozopol	~ 115 km	Coasts cut in ancient metamorphic complexes, Jurassic and Cretaceous rocks, Paleogene and Quaternary deposits. The subsection C.Nesebar-C.Pomorye is characterised by strong abrasion with small accumulative beaches within small gulfs. The subsection C.Pomorye-C.Sozopol corresponds to the Burgas bay sensu stricto and is influenced by negative neotectonic movements of the Burgas synclinorium. This is expressed by the occurrence of lagoons – Atanasovsko, Burgas, Mandrensko.	The littoral drift system is influenced by the high sinuosity of the coastline. The system in the C.Nesebar-C.Pomorye subsection is convergent to the middle of the gulf. In the C.Pomorye-C.Sozopol subsection similar convergent to the center of Burgas bay drift system is reported.
	3. Mednoridsky plateau coast	~ 60 km	This section is limited to the north by the River Tchukalya and to the south by the River Dyavolska. The coastline is very sinuous with small promontories and gulfs where small beaches are formed. Some terraces are also present.	The general drift system is oriented southward. Local cells generated manly by the coastline shape.
	4. Istrandza Mountains coast	~ 85 km	Coasts in Mesozoic-Cenozoic rocks, mainly granites, diorits, syenits. The section starts at the Dyavolska River, includes the Bulgarian-Turkish border on the Rezovska River and continues until Karacaköy. The costline is parallel to the axe of the Istrandza synclinorium. The section is characterised by rocky capes and small gulfs with limited beaches. More than 75% of the length of the section is cliffy.	The general drift system is oriented southeast-ward. Local cells generated manly by the coastline shape (small bays and capes).
V. Pre-Bosphorous zone	1. Karacaköy - Bosphorous (European side - Rumeli)	~ 45 km	Coasts formed in Cenozoic sedimentary rock complexes that are easily eroded and supply sandy sediments to beaches and littoral dunes (ex. Karaburun dunes). The coastline is almost strait.	The general drift system oriented to the ESE.

	2. Bosphorous - Sile (Asian side - Anadolu)	~ 40 km	West Pontian synclinorum. The shelf has an average width of 19 km.	
VI. Western Pontidae zone (Isfendyar Daglari)	1. Sile - Cape Kefken	~ 60 km	Mesozoic and Quaternary deposits	
	2. Sakaraya River mouth (Cape Kefeken- Cape Baba)	~ 115 km	Coasts formed of Quaternary (alluvial, terraces), Paleogene, Mesozoic and Paleozoic deposits.	
	3. Zonguldak section (Cape Baba – Cape Kerempe)	~ 160 km	Cretaceous-Eocene flysch and volcanic rocks. Very narrow and steep shelf (average width of 7 km)	
	3. Hosalay section (Cape Kerempe – Sinop)	~ 130 km		
VII. Samsun zone	1. Kizilirmak River Delta section (Sinop– Samsun)	~ 150 km		
	2. Yesilirmak River Delta section (Samsun-Unye)	~ 120 km		
VIII. Eastern Pontidae zone	1. Ünye - Cape Yasun	~ 45 km		
	2. Cape Yasun - Harasit River - Cape Fener	~ 175 km		
	3. Trabzon section (Cape Fener - Kemalpasa)	~ 230 km		

IX. Batoumi zone		**41.0**		
	1. Chorokh River Delta – Kakhaber Plaine	19.0	Sediment supply to the coastal zone from the Chorokh River	Littoral drift of sediments directed to the SW; The sediment discharge of the Chorokh River is partly discharged into the deep sea zone trough three main canyons situated in front of the river delta
	2. Batoumi - Kobuleti	22.0	Section of marine abrasion	Sediment littoral drift towards the North till Supsa River mouth.

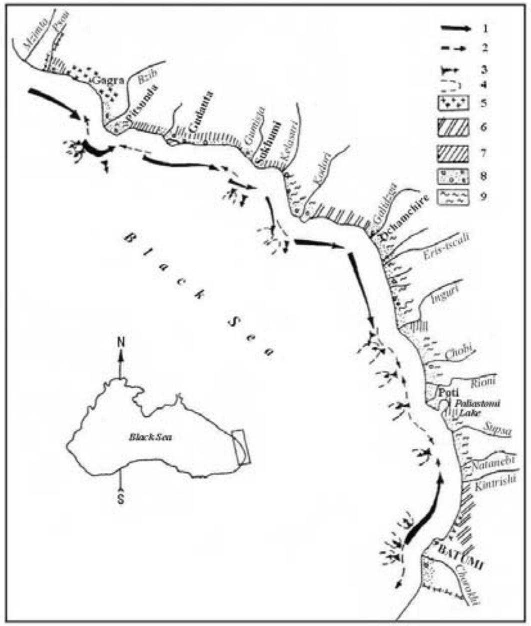


Fig. 4 - Schematic map of the littoral sediment drift system in the Black Sea Coastal Zone of Georgia (after Kiknadze, 1993).
Legend: 1 - Longshore sediment drift direction and relative capacity; 2 - Direction of fine grained sediments migration; 3 - Partial loss of sediments towards the deep sea through canyons; 4 - Canyon heads; 5 - Cliffs in hard rocks (metamorphic and eruptive); 6 - Cliffs in conglomerates, sandstones, marls, schists; 7 - Soft rocks and flat relief; 8 - Non-consolideted deposits (pebbles, gravels, sands) forming beaches, terraces, coastal dunes; 9 - Lacustrine and lagoon deposits.

X. Rioni Depression zone		**115.0**	Low, straight coast, with important input of sediments from the rivers debouching in this zone	Littoral drift of sediments with variable directions; Numerous canyons capturing a part of sediments.
	1 Kobuleti - Supsa River	10.0	Very narrow shelf	Northward littoral drift; in front of Supsa River there is a very active canyon.
	2. Supsa River - Poti (Inguri River Delta)	24.0	Accumulative sandy coast	Southward littoral drift; there is a canyon in front of the southern distributary of the Inguri River Delta.
	3. Poti - Chobi River mouth	19.0	Accumulative sandy coast	Northward littoral drift.
	4. Chobi River - Inguri River Delta	23.0	Accumulative sandy coast	Southward littoral drift; a canyon in front of Inguri River mouth
	5. Inguri River-Ochamchire	39.0	Accumulative sandy coast	Strong Southward littoral drift.
XI. East Caucasian zone (Mzimta River - Kodori River)	**186.0** km long. General description: Erosional coast with deltaic progradational sections at the river mouths			Southward littoral drift; fine sandy material migrates inversely to the north.
	1. Skurdza gulf – Ochamchire	24.0	Erosional coast	South-eastward littoral drift
	2. Kodori River Delta	15.0	Accumulative coast, sandy and gravely beach material	South-eastward littoral drift of sediments, partly captured by a very active canyon located in front of Kodori River

	3. Sukhumi bay	19.0	Low clayey coast, Kelasuri River supplies a limited amount of sediments	South-eastward littoral drift
	4. Gumista River Delta	10.0	Accumulative coast, sandy and gravely beaches	South-eastward littoral drift; a canyon in front of Gumista river mouth.
	5. Gudauta section	50.0	Erosional predominantly clayey coast with slumps	Strong south-eastward littoral drift.
	6. Bzyb River Delta and Pitsunda Cape	24.0	Sandy-gravely beaches affected by strong erosion especially within the Pitsunda Cape	Strong south-eastward drift of mostly coarse-grained sediments The Bzyb River sediment supply is predominantly discharged towards the deep sea zone through the Acula Canyon located at a few hundred meters offshore the Bzyb River mouth.
	7. Gagra section	21.0	Erosional coast with cliffs	South-eastward littoral drift
	8. Psou and Mzimta deltas	23.0	Accumulative sandy-gravely beaches	South-eastward littoral drift
XII. West Caucasian zone (Kudepsta River - Anapa)	**286.0** km in length. General description: Bay-like in the North, aligned abrasive coast composed of relatively resistant rocks (flysch series) in the South.			South-eastward littoral drift
	1. Kudepsta River - Matzesta River	11.0	Abrasive coast	South-eastward littoral drift
	2. Sochi section	13.0	Abrasive coast with significant anthropic impact	South-eastward littoral drift
	3. Mamayka River - Loo River	12.0	Curved abrasive coastal line with sudden beach width variations	South-eastward littoral drift;

	4. Loo River - Ashe River	43.0	Almost straight abrasive coastline	South-eastward littoral drift; the littoral drift starts at Ashe River Mouth
	5. Ashe River - Tuapse	23.0	Abrasive coast, sediment deficit	Section with deficit of sediments
	6. Tuapse - Aderba River section, subdivided into : 6.1. Kodosh Cape – Gryaznov Bay; 6.2. Gryaznov Bay – Guavga Cape; 6.3. Sandy Bay 6.4. Dzhubga Bay - Chugovkopas Cape 6.5. Chugovkopas Cape – Idokopas Cape 6.6. Idokopas Cape – Aderba River	87.0	Mostly abrasive curved but stable costline; The subsection Gryaznov Bay - Guavga Cape is a bay; The subsection Sandy Bay is an accumulative one; Ancient terraces are commonly present.	No littoral drift in this section.

	7. Aderba River - Myskhako Mountain section, sub-divided in: 7.1. Aderba River -Cape Thick 7.2. Gelendzhik Bay 7.3. Cape Thin-Doob Cape 7.4. Novorossiysk Bay	66.0	Abrasive coast formed by relatively resistant rocks (flysch series), with two major bays of structural origin; In certain sections there are hanging valleys.	Variable littoral drift.
	8. Sudzhuk Spit -Anapa section subdivided in: 8.1. Myskhako Mountain - Cape Utrish 8.2. Cape Utrish- Anapa	30.0	Ancient landslides coast; abrasive coast in flysch series rocks	
XIII. Taman-Kerch zone (Anapa - Feodosia)	**210.0** km in length. Straighten , abrasive coast composed of loose rocks, in certain sections lagoons with barrier beaches			
	1. Taman section, sub-divided into : 1.1. Anapa spit 1.2. Salty Lagoon - Zhelezny Rog Cape 1.3. Zhelezny Rog Cape - Panagia Cape	66.0	Accumulative coast in the eastern part and abrasive in the western one	Westward drift in front of the Panagia Cape; Eastward drift in front of lagoons and of the Anapa spit.

	2. Kerch strait and peninsula, subdivided into: 2.1. Kerch strait 2.2. Cape Takil - Opuk Mountain 2.3. Opuk Mountain – Chauda Cape 2.4. Feodosia Bay	144.0	Straighten complex coast in Cape Takil-Cape Chauda subsections; Alternating erosional and accumulative zones within the Feodosia Bay	Northward drift in the Kerch strait; Westward drift from the Cape Takil to the Feodosia
XIV. South Crimean Zone (Feodosia - Balaklava)	**221.0** km in length. General description: mountainous, abrasive coast with gulfs			
	1. Feodosia - Cape Voron, subdivided in: 1.1. Feodosia - Cape Kiik Atlama 1.2. Koktebel Bay 1.3. Karadag subsection 1.4. Meganom Penins. 1.5. Sudak Bay 1.6. Sudak Bay - Cape Voron	79.0	Very complex erosional coast, consisting of rocks with different resistance (for ex. the subsection Karadag is formed by volcanic rocks); The beaches are small and formed mainly by pebbly and gravely material.	

	2. Cape Voron - Castel Mountain, Subdivided in: 2.1. Cape Voron - Cape Tchaban Kale 2.2. Cape Tchaban Kale - Kuru-Uzen River 2.3. Kuru-Uzen River - Castel Mountain	43.0	Straighten abrasive coast in rocks of the Tavrik Formation	
	3. Castel Mountain - Balaklava Bay, subdivided in: 3.1. Castel Mountain - Cape Ayu Dag 3.2. Gurzuf Bay 3.3. Yalta Bay 3.4. Cape Ay-Todor - Kuchuk Koy 3.5. Kuchuk Koy – BatiLagoon 3.6. BatiLagoon- Balaklava	99.0	Eosional coast with landslides (Castel Mounts - Kuchuk Koy sections), olistolithes and accumulations of blocks (Kuchuk Koy - BatiLagoon) and nonabrasive cliffs and slopes	

XV. West Crimean zone (Balaklava - Bakal)	**283.0** km in length. General description: abrasive coasts in Neogene formations. Straighten and complex coast in tectonic depressions, in the south-eastern section with gulfs			
	1. Balaklava - Sevastopol section, subdivided in: 1.1. Balaklava Gulf - Kersones Cape; 1.2. Kersones Cape - Sevastopol	42.0	Abrasive and ingrssive coast in resistant rocks	
	2. Sevastopol - Evpa-toria section,subdiv in: 2.1. Bay of Sevastopol- Lukull Cape 2.2. Cape Lukull-KizilYar 2.3. Kizil Yar - Evpatoria	78.0	Straighten, abrasive coast in the southern part of the section; Straighten, complex coast in the northern part; Coast with lagoons in Kizil Yar - Evpatoria subsection	Eastward littoral drift, only in the E, close to the Sevastopol gulf.

	3. Tarkhankut Peninsula section subdivided in: (1) Donuzlavskoye Lake (2) Donuzlavskoye Lake - Tarkhankut Cape (3) Karadzhinskaya Bay (4) Tchernomorskaya Bay (5) Yarylgatchskaya Bay (6) Cape Karamrun- Bakal	163.0	Abrasive coast, with accumulative low sections and sometimes ingressive gulfs * Subsection 3.1. Evpatoria-Donuzlavskoye Lake - low, accumulative, with lagoons; * Subsections 3.2. and 3.6. (the two capes) - abrasive; * Subsections 3.3 and 3.4 - ingressive, with submerged valleys and spits at their mouths	Eastward littoral drift in front of eastern coast of Tarkhankut Peninsula, especially in the subsection 3.2. Tarkhankut Cape - Donuzlavskoye Lake

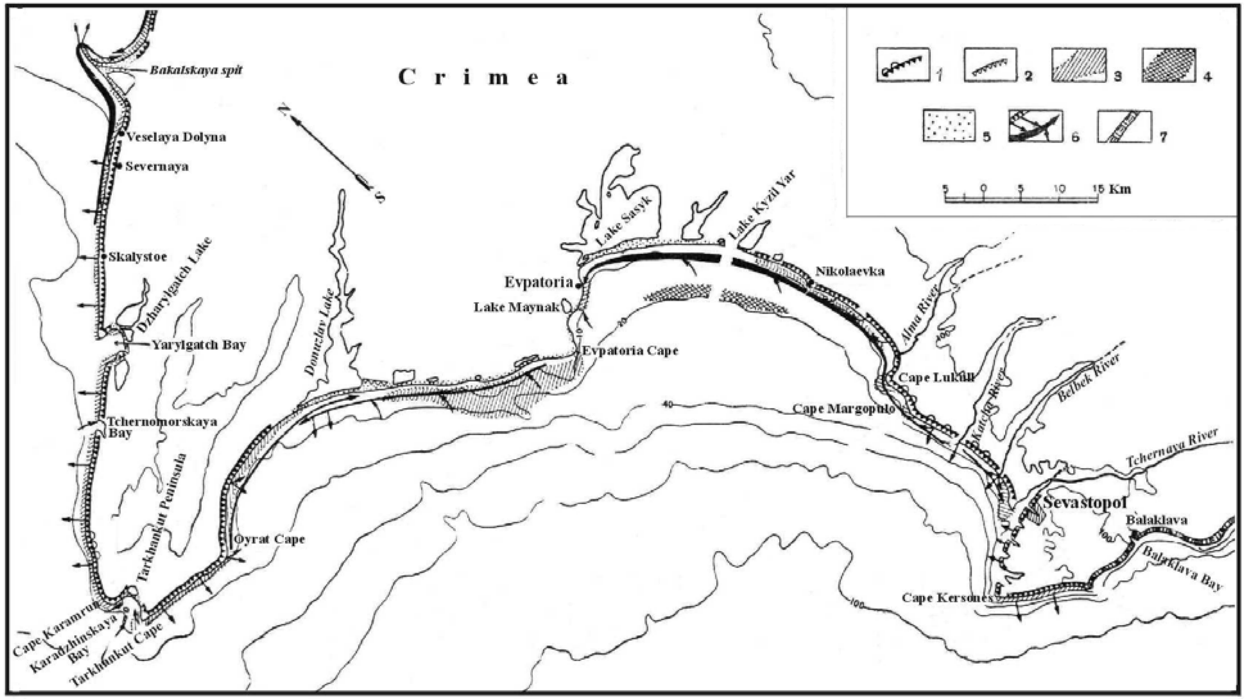


Fig. 5 - Coastal zone morphology and sediment dynamics in the Western Crimea region (after Zenkovich, 1960).
Legend: 1 - active cliff and landslides; 2 - fossil cliff; 3 - bench (outcrops of older deposits in the nearshore zone); 4 - lithified deposits; 5 - accumulative littoral bodies; 6 - littoral sediment drift system and its feeding by erosion of coast or of the bottom (the thickness of the arrow corresponds to the intensity of the drift); 7 - non-abrasive cliffs and slopes.

XVI. Karkinit - Dniepr zone	**618.0** km in length. General description: Abrasive and, in certain sections accumulative coast, with large gulfs or lobate-shaped contour			
	1. Karkinit Bay section, subdivided in: 1.1. Bakal Spit 1.2. Crimean side of the Karkinit Bay 1.3. The landward end of Karkinit Bay 1.4. Dzharylgatch Bay	312.0	Abrasive coast in clayey formations - accumulative coast in the 3.1. subsection	Northward littoral drift in the Bakal spit subsection (3.1) Southward and then northward drift in front of subsection 1.2
	2. Dzharylgatch – Tendra section subdivided in: 2.1. Dzharylgatch spit 2.2. Novo-Alekseevka - Zeleznyi village 2.3. Tendra spit (seaward side)	134.0	A system consisting of two long spits, separated by an abrasive subsection	Strong westward littoral drift in front of Tendra spit; Eastward drift from Zeleznyi village to the end of the Dzharylgatch spit
	3. Tendra Bay – Kinburnskaya Spit, subdivided in: 3.1. Tendra Bay 3.2. Egorlytzkyi Kut Peninsula 3.3. Egorlytzkyi Bay 3.4. Island Dolgyi 3.5. Kinburnskaya Spit and Peninsula	172.0	Predominantly accumulative coast with large gulfs and long spits: * 3.3. subsection - accumulative coast; * 3.4. subsection - “independent”, separated, accumulative spit; * 3.5. subsection - a long spit and an erosive zone	Westward littoral drift in front of Kinburnskaya spit; Eastward drift in front of Island Dolgyi

XVII. Northwestern Black Sea zone	**233.0** km in length. General description: from Otchakov to Zhibrieny - straighten, complex coast, with lagoons			
	1. Otchakov - Odessa Bay section, subdivided in: (1) Otchakov - Cape Adzhyask (2) Cape Adzhyask - Cape North-Odessa (3) Odessa Bay	77.0	Accumulative coast with lagoons and landslides: Subsection (1) - complex abrasive and accumulative coast; Subsection (2) - abrasive coast with landslides; Subsection (3) - accumulative coast from the Cape Odessa North to the port of Odessa (~7.5 km in length); it is a large barrier beach limiting the lagoons Kuyalnitsk and Hadjybay, concave in shape.	North-eastward drift in the western part of the section and south-eastward drift in its central part; in the Cape Adzhyask -Otchakov subsection eastward drift
	2. Odessa town section (Cape Bolshoy Fontan Cape – Odessa Port)	12.0	Abrasive coast with cliffs and large landslides. The landslides affect all the succession of deposits constituting the cliffs: Pontian limestones, Meotian marls and Quaternary loess formation. The relief of the coastal zone present three to five terraces formed by sliding of large blocks of deposits mentioned above.	North-eastward drift. The drifted material is brought by the littoral drift system from the coastal section placed to the south. This material is represented by fine to medium sands.

	3. Bolchoy Fontan Cape - Dniestr Lagoon, subdivided in: (1) Bolshoy Fontan Cape – Sukhoy Lagoon subsection (2) Sukhoy Lagoon – Dniestr Lagoon subsection	44.0	Abrasive coast with cliffs and lagoons: The subsection 1 - cliffs in Pontian limestones, Meotian clays and Quaternary loess deposits. Sometimes important landslides affecting all the succession of deposits occur. The subsection 2 is formed of cliffs in loess deposits (sometimes with land slides and incisions cut by temporary torrents) at its northern part and of a spit limiting the Dniestr lagoon at its southern end. The spit can be divided in three parts: the northern part (~4 km long and 0.7 km wide), the middle part (~4 km long) and the southern segment (~2.5 km long). Between the central and southern parts lies the only inlet into the lagoon (Tzaregradskyi inlet, water depth about 5 m).	Strong north-eastward littoral drift; the sedimentary budget is supplied by the erosion of ancient onshore and near-shore and cliff deposits. The drifted material is represented by medium to coarse sand and small pebbles supplied by the bottom and littoral erosion of older deposits.
	4. Dniestr Lagoon – Zhebriany section, subdivided in three subsections: (1) Dniestr Lagoon – Budaki village; (2) Budaki – Cape Burnas (3) Cape Burnas – Zhebriany village	~ 100 km	Straight coastline oriented to SWS. The coast is formed by loess deposits, gently deeping to the south. The section is characterised by the existence of abrasive cliffs and large lagoons. The three subsections mentioned in the column 2 can be described as follows: Subsection (1) – spit limiting the Dniestr and Budaki lagoons; Subsection (2) - abrasive coast with cliffs in loess deposits; Subsection (3) – sandy spit limiting large salty lagoons Burnas, Alibei, Shagany, Kunduk. The southern end of the subsection is formed of juxtaposed littoral bars constituting an accumulative formation.	Strong south-westward littoral drift supplied by the erosion of ancient nearshore deposits and by the abrasion of cliffs.

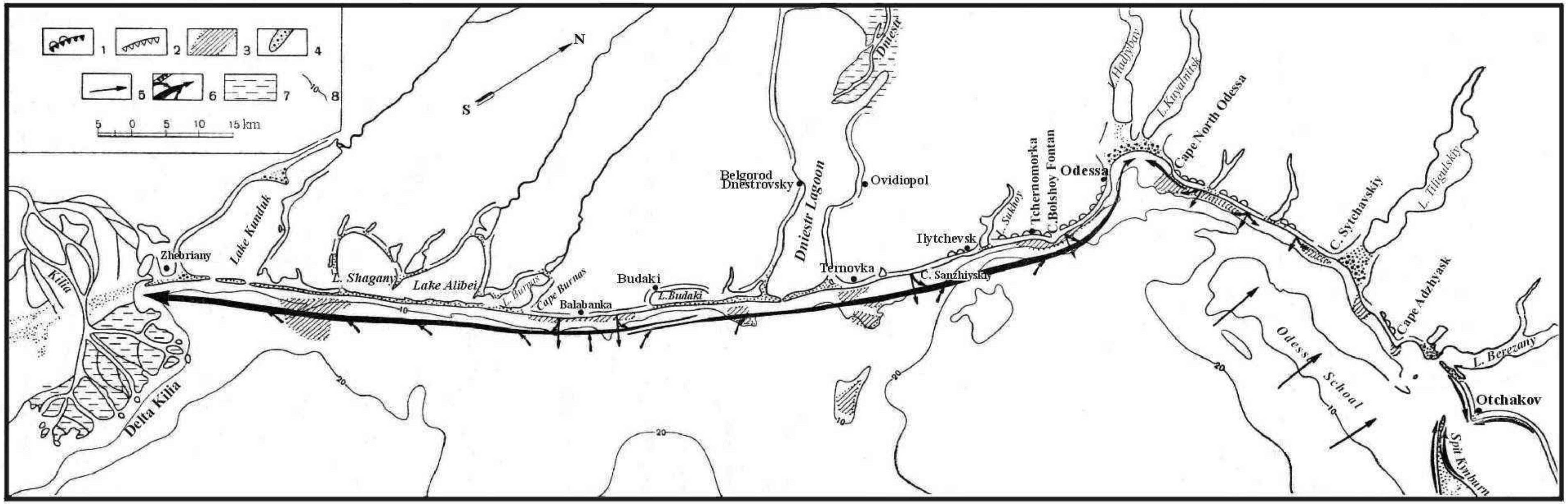


Fig.7 - Coastal Zone Morphology and Sediment Dynamics within the Dnieper mouth zone - the Danube Delta section (after Zenkovich, 1960)
Legend: 1- active cliff and landslides; 2 - fossil cliff; 3 - bench (outcrops of older deposits in the nearshore zone); 4 - accumulative littoral bpdies and beach ridges; 5 - supply system of material eroded from the bottom to underwater accumulative ridges; 6 - littoral sediment drift system and its feeding by erosion of the coast or the bottom (the thickness of the arrow corresponds to the intensity of the drift); 7 - delta area; 8 - contour lines in m.

Executive Summary

The Black Sea Coastal Zone.

State of Erosion, Hazards and Risk assessment and

Problems to be Solved

1. General Description

The total length of the Black Sea coastline is over 4 400 km and belongs to 6 states: Bulgaria, Turkey, Georgia, Russian Federation, Ukraine and Romania. The large variety of geomorphologic types of these coasts corresponds to different geological environments surrounding the Black Sea.

The Black Sea coastal zone can be divided in 17 main zones characterised by different geology and morphology, as well as by specific littoral water circulation, sediment drift systems and sedimentary budget.

In a more general approach the Black Sea coast zone could be subdivided into three main morphodynamic categories, with very specific characteristics and behaviour:

1. Low, accumulative coasts mostly related to the main rivers mouth zones. This type of littoral zone consists of sandy complex barrier beaches with strong longshore sediment drift systems; these zones are generally characterised by isostatic adjustments of overloading by rapid accumulation of sediments (subsidence):

- the Danube Delta with a very exposed to erosion littoral of about 240 Km.
- the unit River Dnieper liman - Karkinit Bay (total length of about 618 Km). specifically the Kinburn spit - Dolgyi Island section (~ 20 Km) and Tendra spit - Dzharylgatch Island section (~137 Km).
- the Taman - Anapa section of about 200 Km long (of which 66 Km are the Anapa spit).
- the Kolkhida (Rioni) Lowland where the rivers Chobi, Rioni, Inguri and Supsa have built up their deltas.
- on the Turkish coast: the deltas of Kizilirmak, Yesilirmak and Sakaraya rivers.
- in Bulgaria, sandy accumulative beaches related to the rivers Diavolska, Kamchya, Provadyiska and Batova, summing about 100 Km.

The accumulative coasts of Anapa section, Kolkhida Depression, the deltaic sections on Turkish and Bulgarian coasts are located within or nearby zones of high relief energy, relatively strong sediment nourishment and general uplifting tendency, so their equilibrium state is not yet very strongly affected.

2. Erosive coasts within lowstanding plateaux and plains, with active cliffs in lœss and lœss-like deposits, sometimes underlyed by older deposits as Pontian limestones, Meotian clays and Sarmatian lumachelles, with very narrow beaches in front of the cliffs:

- the north-western unit of the Ukrainian coast zone (from the northern limit of the Danube Delta to the town of Ochakov (western limit of the Dnieper liman), summing 232 Km.
- the Southern unit of the Romanian coastal zone (Cape Midia - Vama Veche at the Bulgarian border - about 75 Km long), and the Northern part of the Bulgarian coast, from the Romanian border to Caliacra Cape (about 50 Km long).

3. Mountainous coasts, with cliffs, marine terraces, land slides, sometimes with small sandy or gravely beaches. This type of coasts is generally subject of isostatic and orogenic uplift. To this type belong the coast of Crimea, Caucasus, Pontides, Strandza and Staro Planina Mountains, as well as of Frangensko and Avrensko plateaux.

2. Coastal erosion in the Black Sea. Factors controlling the erosional process

The erosion is controlled by:

- ***Global and natural factors.*** The Black Sea coastlines erosion is strengthened as everywhere in the World Ocean by the global changes and the general sea level rise. The coast erosion will depend on synergetic effect of factors controlling the littoral processes (meteorological regime, wave energy regime, water circulation, sediment supply and drift etc.), global changes and the consequent modification of the energetic level of the coastal sea, general sea level rise and regional characteristics as shoreline morphology, elevation and geologic constitution, subsidence or/ and uplifting neotectonic regime.

- ***Anthropogenic factors.*** The coast zone erosion and the state of the coastal sea ecosystems are strongly affected by the anthropic activities, the effect of which is added to the impact of natural factors. The anthropogenic changes of large rivers hydrologic characteristics (water and especially sediment supply, regularisation of floods etc.), men-made littoral structures as breakwaters, dykes, groins, harbours etc. which are modifying the littoral circulation cells, the uncontrolled use of beach sand, dredging of sand too close to the beaches or within the river mouth bars and many other activities are causing an enhancement of coastal erosion and endangering of the coastal ecosystems.

The first category of coasts described in Chapter 1 (*Low, accumulative coasts*) is the most influenced by the global changes, specifically by the sea level changes and by the changes in the river sediment inputs. The decreasing of sediment supply and changes in littoral sediment drift due to anthropic activities (river damming, hydrotechnical regularisation, littoral structures etc.), especially when the sandy beaches are low, added to the rising of the sea level and the increasing of littoral sea energy could determine in certain conditions a very active and almost continuous recession of the beach line (up to 20 m/y, as it happens in some sections within the Danube Delta littoral). This process is causing land losses, environmental changes and economic degradation of the coastal zone.

The second category of coasts described above (*Erosive coasts within lowstanding plateaux*) could be also affected by erosional processes but the rates of coastline regression do not reach the same values as within the first category (only 1-2 m/y). In this case the erosion affects mostly the narrow beaches in front of the cliffs and activates land-sliding processes. The environmental transformations are less important and consequently the economic losses are lower.

The third type of coasts (*Mountainous coasts*) is the least affected and transformed by the erosional processes. Generally, the littoral of this type is constituted of consolidated rocks, resistant to the eroding process. In front of such rocky littoral there are no beaches or they are very narrow and coarse grained (coarse-grained sand and pebbles). If the development of tourism is intended, artificial beaches and pertaining protection structures as brake-waters, groins etc. must be built. In this case the only economic concern is the maintenance of these artificial beaches.

3. Hazards and Risk assessment

Taking into consideration the above mentioned observations, it clearly appears that the most vulnerable section within the Black Sea coastal zone is the Danube Delta region (almost 240 km long, of which about 75 km represent the coastline of Kilia Delta and belong to Ukraine and 165 km is on Romanian territory).

For the Danube Delta the main factors of risk are the river flooding and the littoral beach barrier flooding by the sea. The climate changes and the related sea level rise represent also elements of risk.

In the last 20-25 years the River Danube sediment input diminished severely as the Iron Gates I and II dams have been constructed: measurements and computations show that the present day sediment discharge dropped by almost 40 % and the real sediment load brought by the Danube into the Black Sea is less than 40 million t/y, of which about 10-12 % is sandy material taking part at the littoral budget of the delta front zone. The effects of this misbalance added to the impact of other anthropogenic structures and to the rise of the sea level and the increased energy of the coastal sea bring about a very active erosional process of delta-front beaches.

4. Priority issues to be developed by future EC research programmes

- Development of a coherent, systematic and sound monitoring system to survey hydrodynamic, geological, sedimentological and geomorphological aspects of coastal dynamics, using modern, comparable and compatible methodology around the entire Black Sea coast. Enhancing the Global Ocean Observing System, Earth Observing System and GEOSS by improving the technical facilities at sea-level and waves measurement stations adding equipment for the measurement of earth vertical movement (CGPS);
- Development of scientific co-operation in all the Black Sea countries and with the Mediterranean science community by creating a research network of excellence regarding coastal erosion, processes, factors, dynamics and coastal protection;
- Creation of a freely accessible common data-base comprising the factors controlling the coastal dynamics coastal erosion and the state of coastal erosion for the entire Black Sea. The database should be permanently updated and upgraded each time when commonly considered necessary;
- Detailed identification of coastal processes mechanisms affecting the critical areas, in order to offer the scientific background for ICZM development.

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B. THE MEDITERRANEAN SEA COASTAL ZONE

1. Introduction

The Mediterranean region comprised of countries such as Turkey, Cyprus, Lebanon, Syria, Israel, Palestinian Authority, Egypt, Albania, Yugoslavia, Slovenia, Croatia, Bosnia Herzegovina. FYROM, Italy, France, Libya, Algeria, Tunisia, Morocco, Spain, Greece, Malta. There are 969,100 sq. mile body of water is approximately 2,300 miles in length, and has a maximum depth of 16,896 ft. The resident population of the Mediterranean coastal states almost doubled over the last 40 years, exceeding today 450 millions compared to 246 millions in 1960. In the 1950s the countries of the European coast represented approximately ⅔ of the total population, while today only ½ of it and, if the current trends continue, only ⅓ by the year 2025 and ¼ in 2050. Apparently, more than 50% (around 25000 km) of its coastline is heavily urbanised, occupied already by concrete and buildings.

Coastal erosion is one of the most important socio-economical problems that challenge the capabilities of states and local authorities. Whether it is due to natural or anthropogenic reasons, coastal erosion causes significant economical losses, social problems, and ecological damages. The problem of erosion may extend its influence hundreds of kilometres alongshore in the case of large deltaic areas, and may have transboundary implications. In the case of pocket beaches on the other hand, it could be a very local phenomenon affecting only the residents of a nearby town and/or the tourism industry (Ozhan, 2001).

In the Mediterranean, coastal erosion has been a longstanding, large-scale issue around the deltaic areas, such as the deltas of the Nile and Po Rivers, and the smaller deltas like those of the Albanian rivers. It has also been a major issue at smaller scales, especially in the municipal or tourist resort beaches along the relatively more densely developed northern coast, following the flux of people from inland areas to the coast and the boom of the tourism industry (Ozhan, 2001). More than 40 % of beaches in France, Italy and Spain was found to be confronting erosion in the EU project CORINE completed in 1990.

The natural and anthropogenic causes of coastal erosion in the Mediterranean as described by Ozhan [2001] are listed below.

The natural causes of long term coastal erosion are the followings:

a. Sea level rise
b. Coastal subsidence due to tectonic events
c. Climatic changes

d. Increased vegetation cover over the river watersheds due to climatic changes (causing decreased soil erosion and sediment supplied to the coast);
e. Sediment sinks (presence of offshore canyons, movement to great depths at steep slopes, wind transport of sand to inland areas)
f. Changing of river courses and mouths in deltas

Anthropogenic causes of long term coastal erosion are:

a. Decreasing sediment supply by rivers to the coastal physiographic unit (cutting of the sediment transport by damming the rivers, sand and gravel mining along the river beds, decreasing the sediment transport efficiency by lowering water discharges due to increased fresh water use or due to river works such as bank and bed erosion control)
b. Erosion control works and afforestation in coastal and riverine watersheds
c. Decreasing the volume of sand in the physiographic unit (sand mining from the beach and dunes, offshore sand mining)
d. Alteration of the usual pattern of coastal currents and the associated sediment transport along and across the shoreline, due to man-made coastal structures and urban development too close to the shoreline
e. Anthropogenic changes made to river courses and mouths in deltas
f. Maintenance dredging of approach channels and estuarine inlets;
g. Land subsidence due to anthropogenic effects

Coastal infrastructures, usually lacking an adequate environmental assessment, intersect littoral drift causing important erosive problems and sedimentary imbalances (Liquete et al., 2004). To avoid the ensuing financial losses, beach refilling is a common practice in the touristic Mediterranean seashores. In some countries, such as Greece, this kind of beach nourishment is not common. Nevertheless, in other areas it is a frequently adopted solution. For instance, Italy started filling beaches in 1962 and since then 12 x 106 m^3 of sediments have been used; however, the major intervention has taken place in Spain—since 1983 110 x 106 m^3 have been added to the seashore, predominantly in the Mediterranean region.

This review considers examples of coasts with “problems” and possible interventions for rehabilitation.

2. The Mediterranean Sea and Coastal Erosion [1]

2.1 General information

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.

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

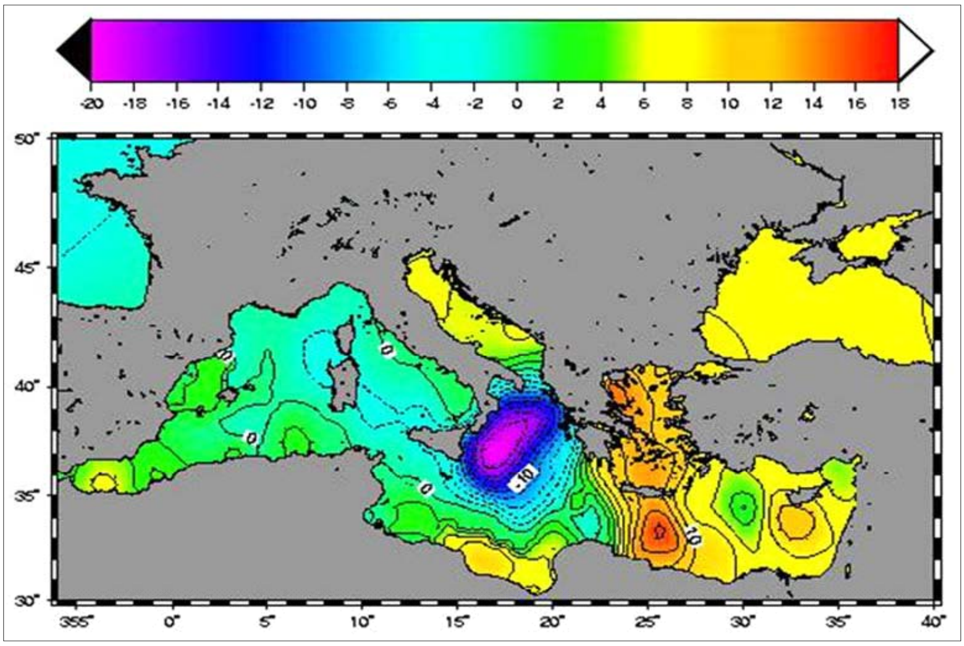
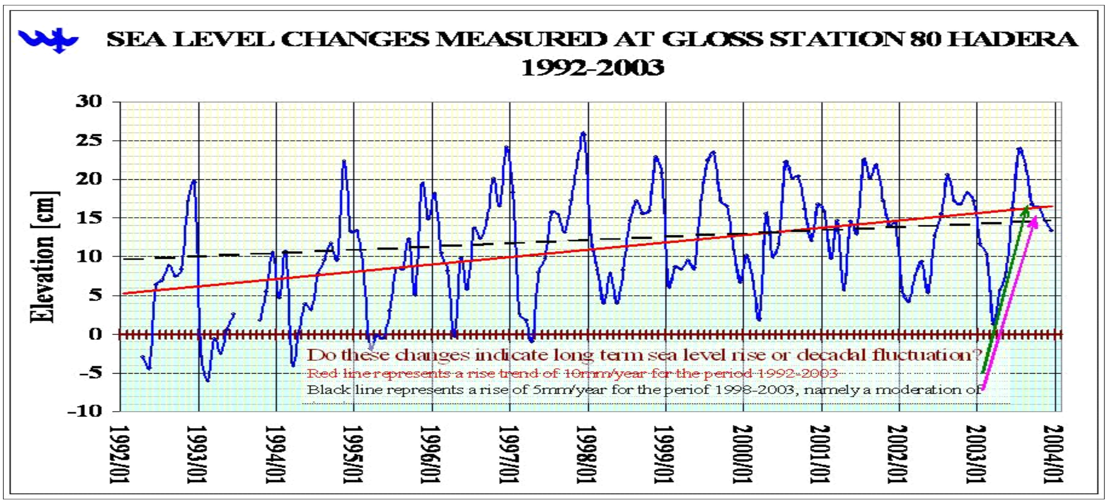


Figure 4 - Sea level changes 1992-2000 based on Topex-Poseidon satellite altimetry (Fenoglio-Marc, 2001)

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.

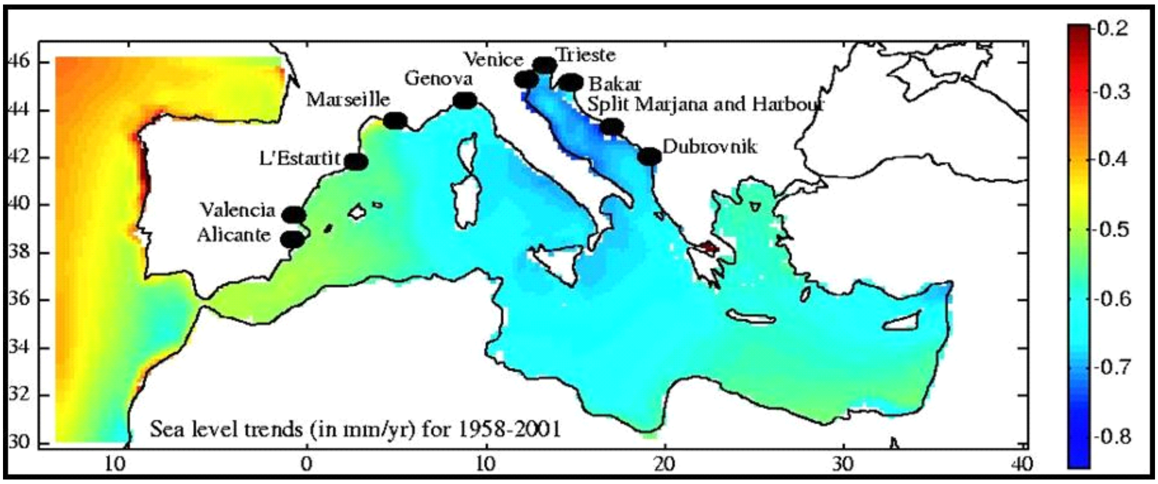


Figure 6 - meteorological contribution to sea-level in the Mediterranean during 1958 – 2001

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[2]

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 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.

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

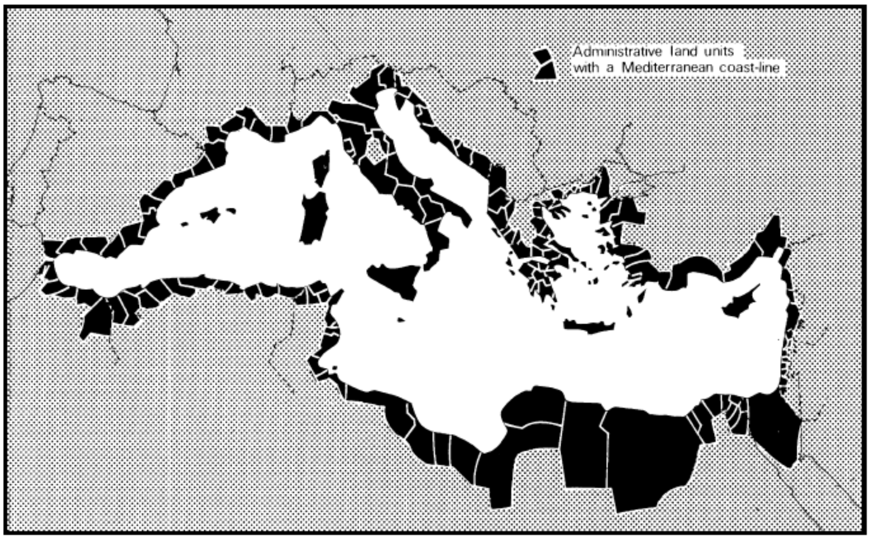


Figure 7 - The Blue Plan – MAP definition of Mediterranean coastal areas[3]

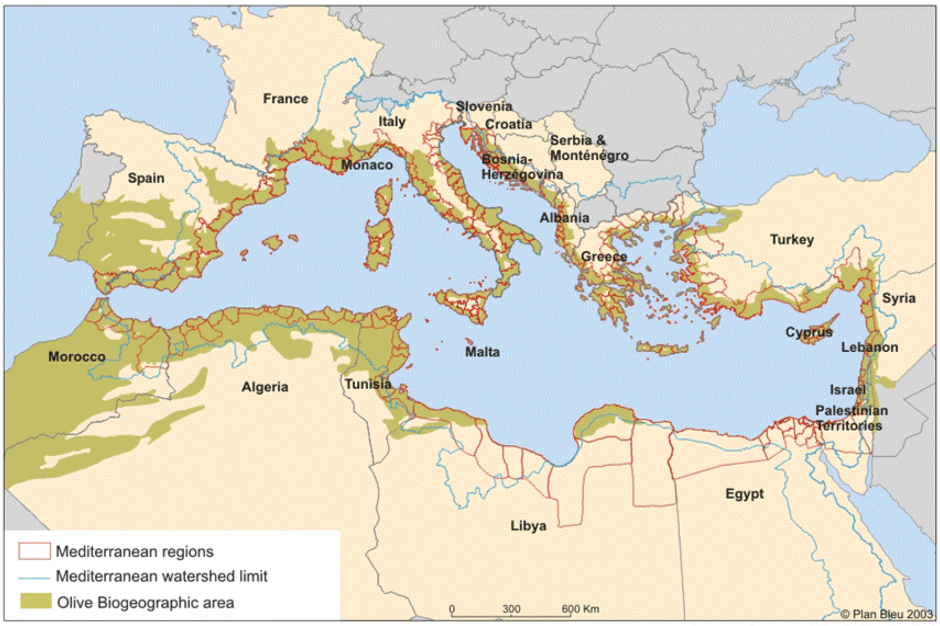


Figure 8 - Mediterranean Countries and Their Different Limits[4]

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

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

[4] Source: www.planbleu.org.

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.

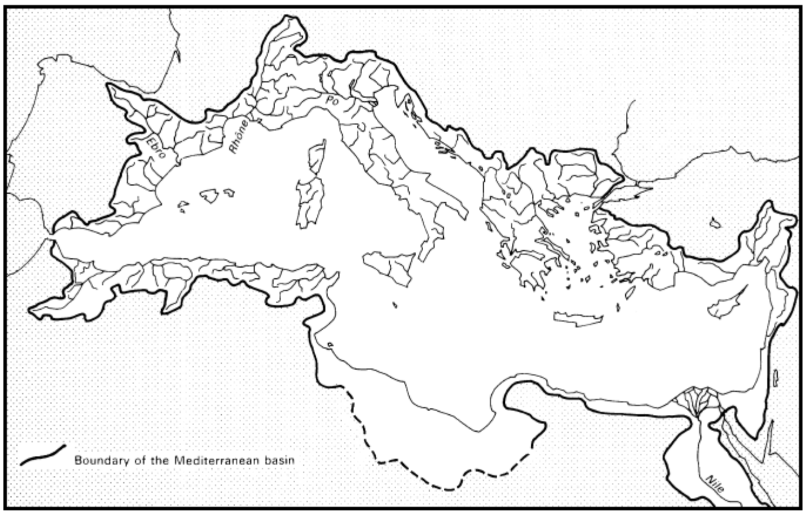


Figure 9 - Boundaries of the Mediterranean watershed[5]

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).

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

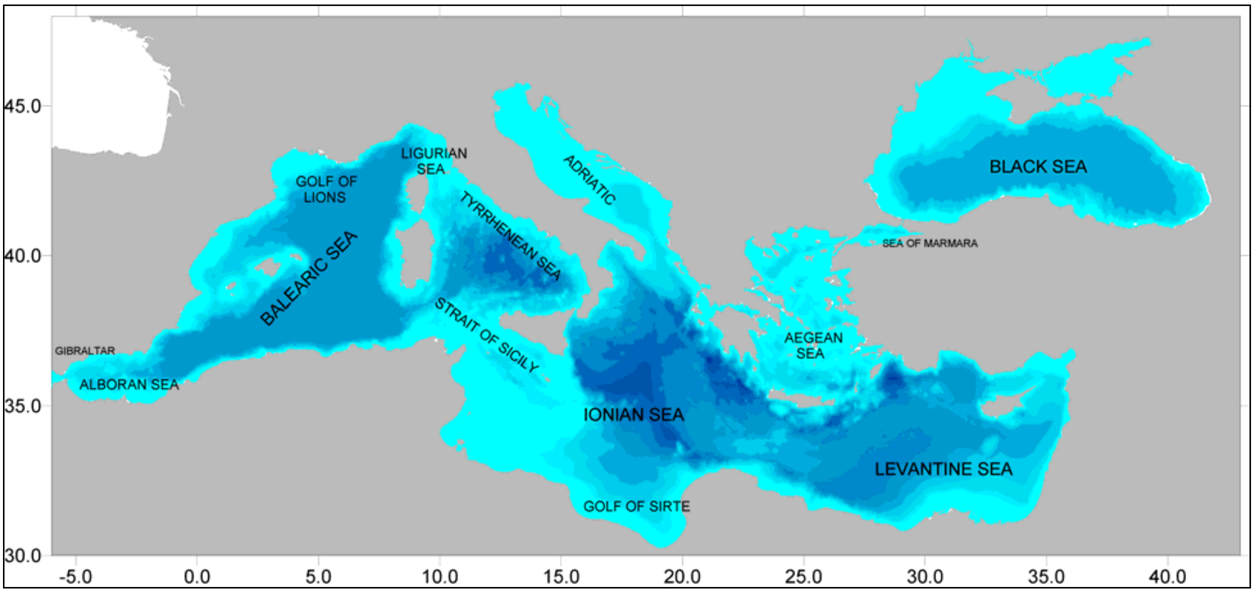


Figure 10 -The Mediterranean Sea. Geographic features

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.

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.

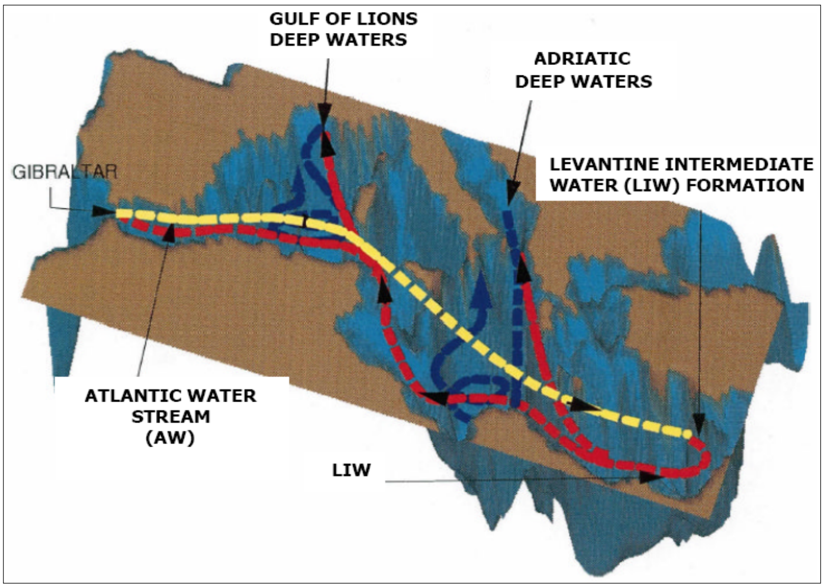


Figure 11 - Schematic of the thermohaline circulation in the Mediterranean

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).

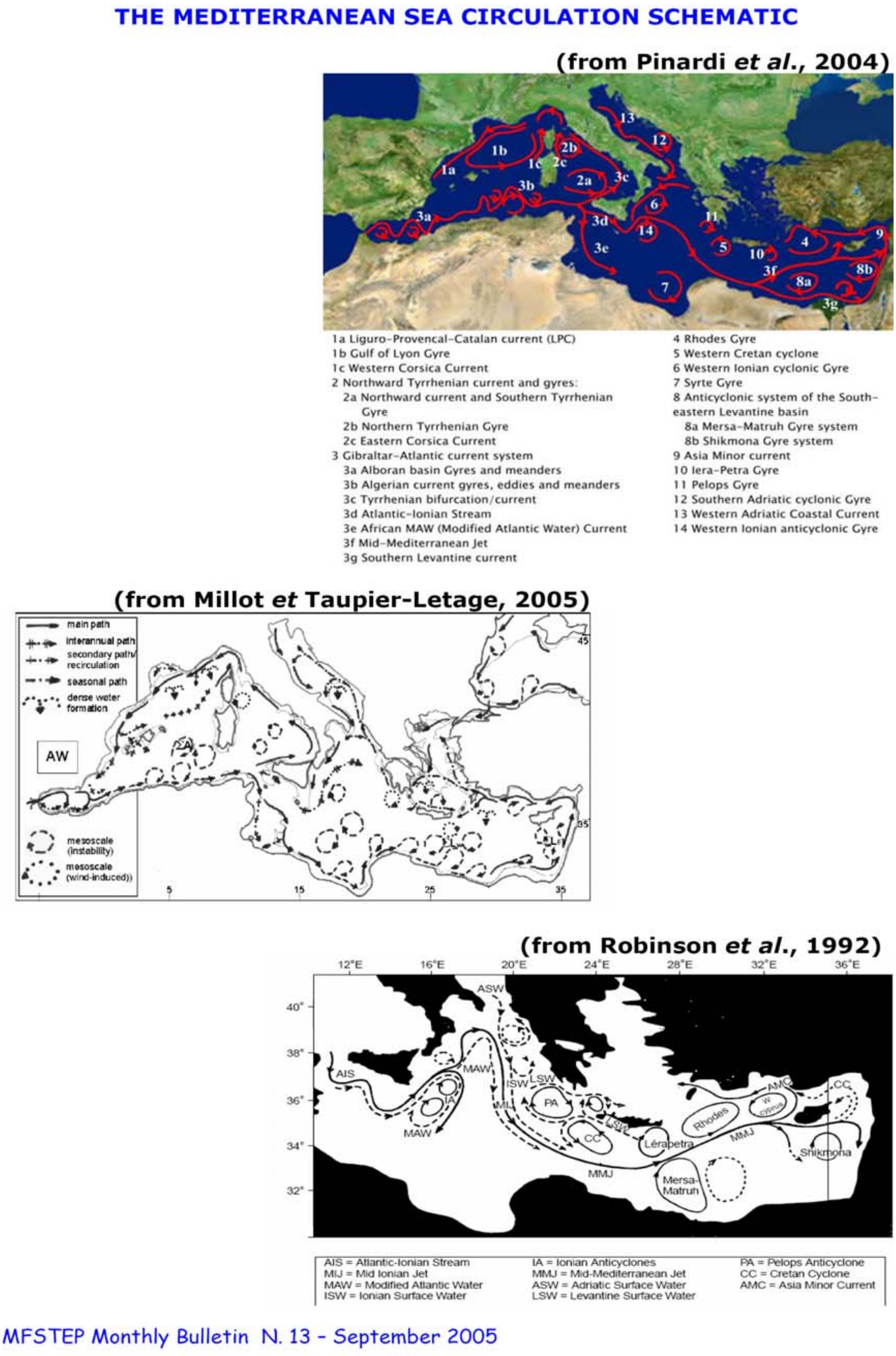


Figure 12 - The Mediterranean circulation schematic

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[6]

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.

[6,29,30] 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

2.7.3 Natural Processes Combined with Man-Made Actions[7]

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[8].
- 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 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[9].

- 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[10].
- 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.

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

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

2.8 Erosion due to human interference in the coastal zone[11]

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.

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

[11] 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

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[12]

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[13]

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

[34,13] EEA (1999): State and pressures of the marine and coastal Mediterranean environment, pp.44 Copenhagen

3.2 Policy Options[14]

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.

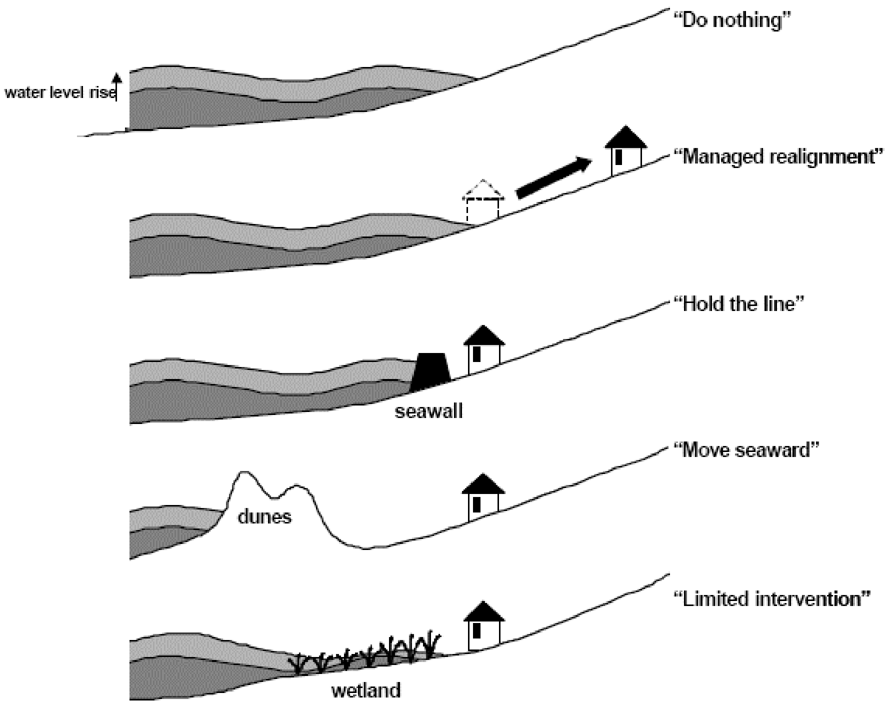


Figure 13 - The five generic policy options[15]

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

[36,15] National Institute of Coastal and Marine Management of the Netherlands (2004), A guide to coastal erosion management practices in Europe

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.

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) [16]

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	Local authorities (cleaning, restoration). Ministry of Mercantile Marine under the	Law 2344/1940 "On the foreshore and the wasterfront" (1940)	Ministry of Environment, Physical Planning & Public Works - Directorate	

16 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

	Physical Planning. Local authorities	National Contingency Plan.		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.

3.5 Policy Options Implemented in the Mediterranean Sea[17]

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).

[17] 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

3.6 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 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[18].

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 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[19].

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

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

[19] Republic of Albania (2002).

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[20].

Major problems and issues[21]

- 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.

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

[20] Source: Violeta Zuna, Eno Dodbiba(2005).
[21] Source: Priority Action Plan (website), CAMP "Albania"

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[22].

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

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. 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[23]

As a rule, Algeria's Coast may be devided to three main part:

<u>East coast</u>: 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.

<u>Algiers' Bay</u>: heavily urbanized and industrialized, affected by untreated wastewaters that bring to marine sediments pollution; lack of urban and industrial development planning.

[23] European Environment Agency (2006).

West coast: tourism character; lack of land use planning and uncontrolled exploitation of sand from beaches (coastal erosion)[24].

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[25].

[24] Source: Interdepartment Centre for Environmental Science Research(2003).
[25] 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[26].

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 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[27].

[26] Source: UNEP/MAP (2003)
[27] European Environment Agency (2006)

4.4 Croatia[28]

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 in the coastal zone (89.9 inhabitants/km2) is higher than in the continental part (84.5

[28] SURVAS (2000).

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[29]

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

[29]Xenia I Loizidou (2003)

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.

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

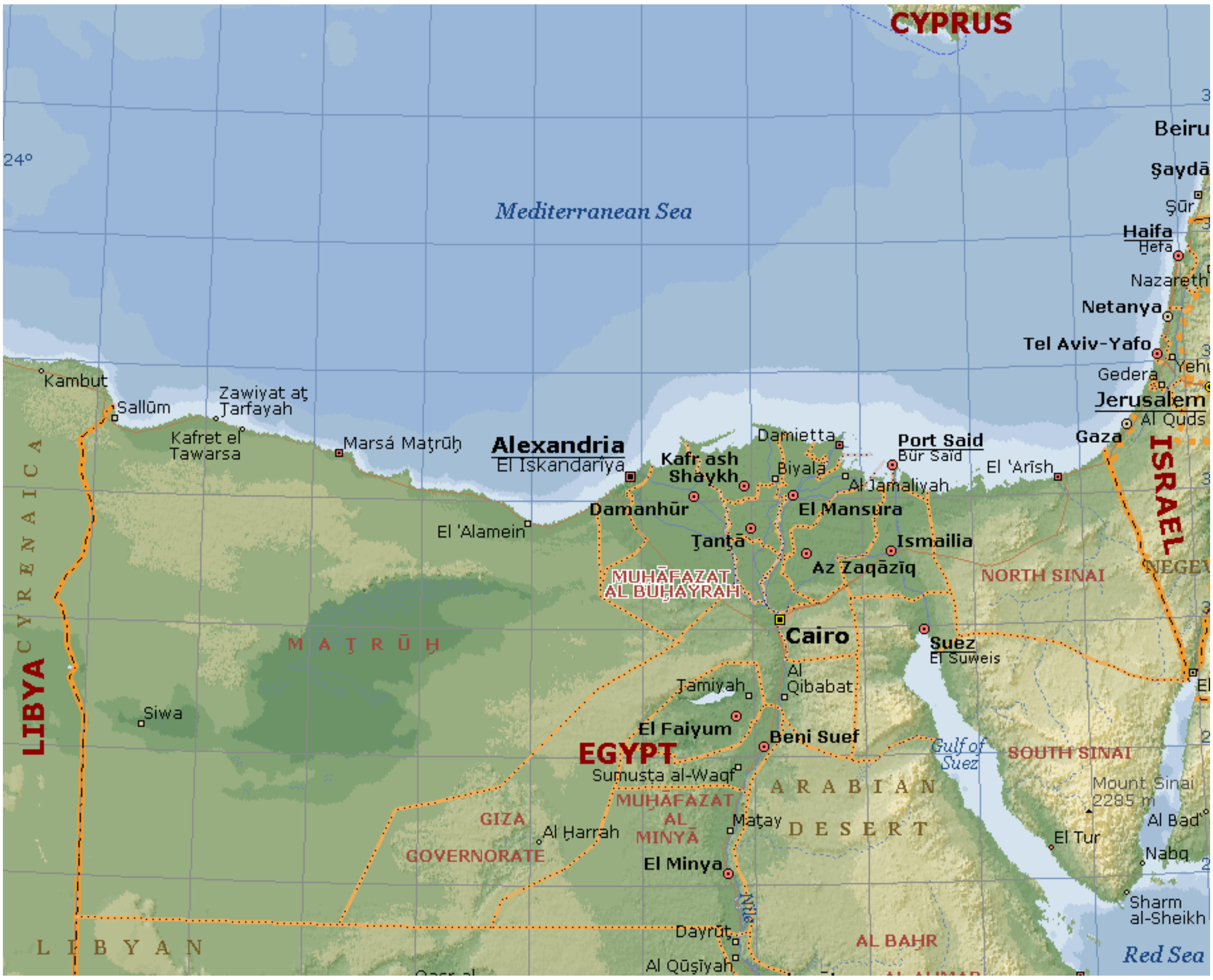
A major characteristic of the coastal development of the last two decades is that formerly agricultural and natural zones at the coastline are converted to tourist development zones after each revision of the land use planning zones every four years. The situation after the last revision of the land 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[30].

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).

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[31].

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

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[32]. 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 Languedoc coastal barriers will move landward faster than at present, thus jeopardising dense tourist facilities[33].

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

[32] Source: Y.N. Krestenitis & I.S. Androulidakis (2006).
[33] Paskoff, R. (2004).

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[34].

4.8 Greece[35]

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 transport and communication infrastructure facilities. Additionally, coastal areas are

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

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[36]

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.

<u>a. Historic retrospective</u>

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[37]

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

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

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

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[38]

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:

[38] European Environment Agency (2006).

- ✓ 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.

4.12 Libya[39]

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;

[39] European Environment Agency (2006).

- ✓ 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.

4.13 Malta[40]

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

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

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.

4.14 Monaco[41]

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

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

are also treated (Principauté de Monaco, 1997). The greater part of the coastline of Monaco is urbanised.

4.15 Morocco[42]

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

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

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.

4.16 Palestinian Authority (Gaza Strip)[43]

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.

[43] European Environment Agency (2006)

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.

4.17 Serbia and Montenegro[44]

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).

4.18 Slovenia[45]

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

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

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 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[46]

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 Puпol and Massalfasar, as a result of the port of Sagunto, the spit of the lagoon between Valencia and Cullera, due to the Valencia

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

port, and the closing barrier of Santa Pola lagoon, a consequence of the Santa Pola port (Alicante).

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 Doʊ ana 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[47]

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

[47] European Environment Agency (2006).

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.
- 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) [48].

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

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 mouths. However, weakness signs, balance break threats and sometimes even preoccupying erosion problems exist in developed segments notably those belonging to important agglomerations zones[49].

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[50.]

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

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

4.22 Turkey[51]

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

Areas of concern and LBS include:

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

- 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.

Table 8 – The MEDITERRANEAN SEA COASTAL ZONING AND DESCRIPTION

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
Albania	Durres	***Lalzi bay** with the **Erzeni river mouth***[52]	The coastline of the Rodoni-Bishti i Palles Capes, of which 35 % are cliffs exposed to mild erosion stretching along both capes. The remaining parts of this unit are alluvial beaches (actually, the Lalzi bay) of which 18 % is exposed to erosion and 47 % to deposition.	The area of Porto Romano and Lalzi bay is a narrow, reclaimed part of the coastal plain. There are some natural habitats left along the coastline, such as a belt of pine trees, temporary marshes, roadbeds and salt marshes.	The loss of large wetland parts by land reclamation, the quality of natural environment of that area continues to deteriorate due to the input of the polluted Erzeni river (contaminated mainly by sewage disposed upstream), direct discharge of	Recognizing the importance of these issues, the government of Albania has embarked on implementing a water sector strategy (Rural Water Supply and Sanitation Strategy, recently endorsed by the government) focussing on both urgent system repairs and sector reforms. The government also adopted a Biodiversity Strategy and Action Plan in 2000 that include the Kune Vain marshland as one of the priority areas in the network of protected areas and identifies lack of

[52] Intergrated Water & EcoSystems Management GEF(2003),http://www.iwlearn.net/publications/prd/pb/File_112866892247

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
					untreated urban and industrial wastewater in the Porto Romano bay, excessive felling of trees for fuel, and uncontrolled hunting and fishing	adequate management capacity as a key issue for stustainability. The government recently approve a law on protected areas that supports a more advanced management concept based on long-term sustainability[53]. The proposed project fits with and supports the government strategy on water and biodiversity by introducing new approaches to integrating wastewter management into an overall ecosystem management.
Albania	cape of Palla (Durresi)	***Porto Romano***[54]	The Porto Romano bay is a section attacked by erosion. direct discharge of	*Posidonia oceanica* and very well developed marine communities are found	The city itself is a concentration of environmental problems, because of	The Durrës area is the biggest "hot spot" on the Albanian coast, and is the most obvious example of what might happen if non-sustainable coastal

[53] Integrated Water and Ecosystems Management Project (blended with IDA Municipal Water and Wastewater Project)(2003), http://www.gefweb.org/Documents/Council_Documents/GEF_C21/Multi_Focal_Area_-_Albania_-_Executive_Summary.pdf

[54]Republic of Albania(2002), http://nfp-al.eionet.eu.int:8180/convention/other_conv/1075458781

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			untreated urban and industrial wastewater with the presence of pathogens is the potential contamination of seafood, particularly shellfish, which are are commercially very important for Albanian fishery.	along Porto Romano bay. A narrow, reclaimed part of the coastal plain. There are some natural habitats left along the coastline, such as a belt of pine trees, temporary marshes, roadbeds and salt marshes[55].	the near-total lack of environmental services. flawed implementation of industrial (Porto Romano) or tourism (Lalëzit Bay) policies, may disappear very soon.	development takes place. The central open channel is now the final receptor of all sewage waters of the Durres District, whose discharge at sea can provoke pollution effects and damages to the marine environment in the area of Porto Romano.
Albania		***Karavasta Lagoon*** system together with ***Shkumbini***	The Semani River has changed the position of its mouth on several	Karavasta Lagoon is separated from the sea by the spit stretching	Economical and social liberalization of the country has caused a	As a contracting Party to many international conventions, such as Barcelona Convention, Ramsar Convention, Biodiversity

[55] Intergrated Water & EcoSystems Management GEF(2003),http://www.iwlearn.net/publications/prd/pb/File_112866892247

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
		and Semani River mouths[56]	occasions in historical times, at least six times in the last 100 years along a corridor 25 km long. in the 1950s a new outlet became the main river mouth at the southern edge of Karavasta, building up a small delta complex whose eroded sediment is currently creating the new spit.	southward from the Shkumbini Delta , it has maximum length of 10 km, width of 4.5km and water depth of 1.5m.) It can be described as a system with low wave energy, predominant longshore sand transport, limited overwash processes and widely spaced tidal channels	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[57].	Convention, and Bern Convention, Albania is committed to create an effective system for the administration of its coast. An important part of this system is the preparation of management plans for areas of particular conservation concern58.
Albania	Otranto Strait	***Vlora Bay - Narta Lagoon - Vjosa River Mouth***[59]	The Narta Lagoon is one of the most important lagoons of Albania. The	**Narta Lagoon** is situated in the northern part of the Vlora Bay, about 3 km	The soil industry is extracting water from the **lagoon** without a	Anthropogenic activities have a great impact on Vjosa River Mouth- Narta

[56] Source: Y.N. Krestenitis & I.S. Androulidakis (2006)
[57] Source: Vjose-Narta Landscape Protected Area Administration 2005, http://www.medwetcoast.com/IMG/Narta_Vjosa_MPanglishtja.pdf
[58] See prev. note.
[59] Pano.N, Frasheri.A, Lazaridou.M (2002)

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
			lagoons of Albania. The southward shift of the Vjosa River mouth during the XX century has created serious erosion problems in the northern coast of the Narta lagoon. The sediments input to the old delta ceased, the latter has almost been completely eroded and the sediment was removed to create a spit, which formed an accumulative zone in the southern part of the Vjosa River old mouth. This spit tends to vide of the littoral cordon	Vlora Bay, about 3 km from Vlora City. Two islands are located in the south part of the lagoon, with an approximate surface of 7 ha. The bigger of the two is covered with cypress. The famous Monastery of St. Mary, built in XIV century is situated in this island. The total Vjosa River sediment discharge in the Adriatic Sea is W_T=7.5x10^6 tons/year. About 20% of total	the **lagoon** without a preliminary study. In the surrounding area of the **lagoon**, oil is drilled and gas is extracted from deep wells. But intensive agricultural and industrial activities, as well as the development of tourism, without being based on a management plan, may provoke serious problems to the lake in the future. The most important danger that the lagoon confronts is the	Lagoon- Vlora Bay water system. Both Albania and Greece do not have a regional or international program for pollution monitoring in Vjosa-Aoos River System.

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
			of the Narta Lagoon in the west direction.	sediment load equivalent to $W_F=5.6x10^6$ tons are the bottom-load, and about 80% equivalent to $W_P=1.9x10^6$ tons are the sediment load. This river discharge is the main source of coastal sediments in Vlora Bay (Pano N., 1984). The dynamics of solid deposits along the coastal zone and the accumulation intensity of sand are closely tied up with the warning process and particularly with the maximum wave effect.	imminent isolation from the sea. In the **Narta Lagoon** are observed intensive solid deposits of the **Vjosa River** on the coastal area tending to stop the active water exchange between the lagoon and the sea resulting in lack of fresh water in the lagoon. Dirty untreated urban water flow also exists in the lagoon. **Vlora bay**: flow of the dirty untreated urban and industrial water in the sea, exploitation of the	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
					sand and gravel from beaches for constructive materials, deposition of the solid industrial waters (Cu, mercury, clay etc) in the onshore and offshore coastline.	
Algeria	Wilaya of Alger[60]		The coastal zone of central part of Algeria face heavy erosion due to man made causes. The site is threatened by water pollution (organic, chemical and physical pollution), bad agricultural practices leading to destruction of the natural vegetation,		heavily urbanized and industrialized, affected by untreated wastewaters One of these causes is sand mining on beaches and dunes. huge demand of sand and gravel to feed ambitious programme of housing and industrial	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. lack of urban and industrial development planning.

[60] A. Abdelbaki and M. Boudouma (1995)

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			erosion, bad water management (irrational water pumping), destabilisation of the shore which leads to destruction of the dunes and modification in the food chains. Habitat destruction is caused by bad ploughing, overgrazing, and the cutting of *Typha latifolia* and *Tamarix africana*.		development.	
Croatia	Dalmatia, East Adriatic Dalmatia:	**County of Split-Dalmatia, County of Šibenik-Knin, County of Zadar and County of**	coast, wetland, estuary, coastal forest, rocky coast, lakes/rivers, bay, island, peninsula, sandy beach;	water pollution, sediment movement, coastal erosion, endangered species, habitat loss,	tourism/recreation, over-fishing,	overall policy, pollution control, development control, resource managment,institutional strengthening, biodiversity conservation, planning, capacity building, education/awareness,

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
		Dubrovnik-Neretva [61]				monitoring, networking; Integrated Coastal Zone Management at the national, regional/county, local and sectoral level, sustainability and biodiversity conservation, integrated ecosystem approach
Croatia		**Kaštela Bay**[62]	intensive degradation		uncontrolled industrial development and urban sprawl, and fast growth of surrounding villages and the town of Split. This area became, in the mid eighties, one of the largest and most widely known pollution	total absence of adequate measures for the reduction of urban and industrial pollution.

[61] Source: Priority Action Plan (website), Mediterranean ICAM Clearinghouse, http://www.pap-medclearinghouse.org/eng/page001b.asp?zemljaID=20&shortID=91&start=start

[62]Source: Priority Action Plan (website), Mediterranean ICAM Clearinghouse http://www.pap-medclearinghouse.org/eng/page_frameset.asp?Page=KastelaDugi.htm&IDLong=13&IDShort=84

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
					"hot spot" areas in the Mediterranean region.	
Croatia, Bosnia and Herzegovina	Split-Dalmatia and Šibenik	**River Cetina**[63]	river basin and the adjacent coastal area (approx. 1,200 km2) Coastal degradation is caused by coastal erosion. After construction of hydro power plants and storage reservoirs in the watershed and riverbed, the dynamics of sediment creation and transportation were completely transformed, triggering great changes to the sediment dynamics of the	water shortage, sediment movement, coastal erosion, endangered species, habitat loss. The coastal area of the Cetina River watershed is characterised by narrow coastal flysh strip bordered by steep mountainous hinterland.	urban expansion, water pollution, air pollution, soil pollution, population growth, tourism/recreation, mineral extraction, over-fishing, transport congestion, The development of tourism and industry on the coast, has been responsible for the current higher population density in the coastal strip	The greatest problems occur with conflicting demands for land-use for housing, tourism, and economic development in the most attractive part of the watershed (fertile fields and coastline). Uncontrolled immigration and building directly threaten the natural resources, which are the basis of development and survival in the area. This refers to both the river basin and the coastal area. The coastline has been completely built up so that open access to the sea is almost impossible, and its use for recreation and other sea-related activities proves very difficult.Uncontrolled, construction of

[63] Source: Priority Action Plan (website), Mediterranean ICAM Clearinghouse http://www.pap-medclearinghouse.org/eng/page001b.asp?zemljaID=20&shortID=91&start=start

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			coastal area. The sediment is constantly being reduced by the action of waves and sea currents, while the sediment transported by the river is considerably reduced, causing the sediment deficit in the river mouth area.		nearly 64,000 people occupying the coastal area and the islands have been supplied with water from the Cetina River. The immediate hinterland is devastated by intensive uncontrolled building in continuum.	houses and tourist structures. The river mouth area is used for several, often conflicting purposes, such as settlement growth (Omiš) and the development of industry and tourism, despite the fact that the protection of the unique natural characteristic of the Cetina River canyon and mouth is a priority The process was initiated by PAP/RAC. The first step taken was the preparation of the "Conceptual Framework and Planning Guidelines for Integrated Coastal Area and River Basin Management".
Cyprus	from Cape Kiti to Zigi	**Dolos-Kiti**[64]	The 30% of the total coastline of the island suffer from erosion (in some areas reaches about	Type of coast: Shingle beaches Tidal regime: microtidal Range of waves :	Socio-economic activities: Agriculture, Industry (cement), fisheries, and tourism.	Engineering techniques: Harbour breakwaters, groynes, detached breakwater, revetment. Policy options: Limited intervention, Do

[64] Source: Eurosion (website), Shoreline Management Guide http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			0.5m/yr). Erosion of the coastline due to natural but mainly to manmade causes, coupled with shortage of fine sandy beaches became a serious problem of growing concern the last 20 years. At the same time the growing pressure for utilisation and exploitation of the coastal zone was making the whole picture worse.	dominant sea, Hs up to 1,5 m high, H max about 5m. The total length of the coastline is 36km. The coast is generally relatively low and flat, and it is mainly characterised by accumulations of gravel and pebble and few tiny poor sandy beaches	There are 10 villages in the coastal area, with a total population of 9,173 and several conflicting uses. The land uses of the coastal area have been mainly agricultural until recently, when by a reform of the Town Planning regime most of the agricultural areas have been characterised as tourist or development areas.	nothing. Since late 1980s, Cyprus Government has realised that coastal zone is a natural resource for the island which was under the threat of extinction due to the over pressure resulting from intensive tourist development. The problem of erosion still exists in several coastlines of the island, although there have been efforts to implement Integrated Coastal Zone Management. Eventually the problem of beach quality became very important and efforts started to combat erosion, some using legal and some illegal methods.
Egypt		**Nile Delta**[65]	coast, rocky coast, bay,	sediment movement,	preparatory activities,	

[65] Source: Priority Action Plan (website), Mediterranean ICAM Clearinghouse http://www.pap-medclearinghouse.org/eng/page001b.asp?zemljaID=3&shortID=25#25

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			sandy beach	coastal erosion	institutional strengthening, planning, capacity building; the shore protection Master Plan was the result of a comprehensive study and contains detailed plan for 13 selected sites on the delta.	
Egypt		The ***Rosetta*** waterway[66]	One of the two main branches of the Nile River in Egypt and it is located on the eastern side of Abu Quir Bay coast and at about 60 km to the east of Alexandria city. The[67] impact of climate change including SLR and	During the period from 1500 to 1900 the eastern and western parts of the promontory were extended by about 11 and 8.5 km into the sea due to the large amount of sediments brought by Rosetta branch.	It is considered the life artery for fishermen who live at the Rosetta district in Egypt. The closure of the Rosetta estuary caused by sedimentation will not only affect their livelihood but also	The typical engineering solution to defend a mouth from a progressive sediment accumulation implies two jetties to either totally or partially block the littoral drift. This solution had negative impacts on the adjacent beaches.

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			salt-water intrusion is also another threat to the region land[68] based pollution to water resources and international water, urban encroachment in agricultural land		endangers the people live upstream of the mouth due to releasing a probable emergency flood.	shortage[69] of urban and environmental planning
Egypt	Located in the central northern part of the Nile delta between Rosetta and Damietta branches.	***Burullus*** headland[70]	It was built up by the sediments brought by the very active Sebennetic old Nile branch. This hump has been eroded from more than 1000 years when the feeding branch seems to have ceased its importance and died out		fishery	The dynamic processes and environmental forces affecting the coastal changes along Burullus area have been monitored for about 25 years. These measurements include the collection of wave data, daily measurements of longshore currents,

[67] Source: "SMART: Sustainable Management of Scarce Resources in the Coastal Zone", http://www.ess.co.at/SMART/b5.html
[68] Source: "SMART: Sustainable Management of Scarce Resources in the Coastal Zone", http://www.ess.co.at/SMART/b5.html
[69] Source: "SMART: Sustainable Management of Scarce Resources in the Coastal Zone", http://www.ess.co.at/SMART/b5.html
[70] Source: Y.N. Krestenitis & I.S. Androulidakis (2006).

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			importance and died out. The problems of the area vary from serious erosion on both sides of the lake outlet to siltation and shoaling of the outlet itself which is important for fish and fry.			beach profiles and bottom sediment samples. Water level variations and discharge through Burullus outlet are also being measured. Longshore sediment transport rates have been evaluated using standard formulae. The accumulated data, account for the processes responsible for the recession of Burullus hump, have been used in the design of shore protection structures and to improve the existing ones.
Egypt		***Port Said*** headland & ***Bardawil*** lagoon [71]	the shoreline has shifted southward (retreated) at the northern Sinai coast of Egypt.	Increasing numbers of engineering protective structures along the Nile delta coast, which		The change in the coastline along the northern Sinai coast probably results from the increasing numbers

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			Prior to the construction of these structures, sediment continuously nourished the entire coast of Sinai. In the absence of significant Nile sediment input, driving forces (waves and currents) actively erode the protruded coat of Sinai. beach erosion has been substantially increased in the downdrift sides of these protective systems, being -20 m/year at Baltim and -9 m/year	blocked sediment transport to the east and thus decreased sand supply to the Sinai beach. In addition, the delta coast has been substantially modified as a result of controlling the Nile flow by two dams at Aswan.		of engineering protective structures along the Nile delta coast. large numbers of coastal structures have been built to protect the beach and stabilize the lagoon inlets. The last decade, there were constructed two large-scale detached breakwater systems on the Nile delta coast of Egypt at ***Baltim*** and ***Ras El Bar*** beaches (~18.3 km shoreline length). The two protective systems were installed in a water depth of between 3 and 4 m and consist of 17 units in total (each ~250 m long). The preconstruction beach erosion at Baltim (-5 m/year) and at Ras El Bar (-6 m/year) has been replaced

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
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			at Ras El Bar. Further seaward, the two protective systems at Baltim and Ras El Bar have accumulated seabed sand at maximum rates of 30 and 20 cm/year and associated with downdrift erosion of -45 and -20 cm/year, respectively			(-6 m/year) has been replaced, respectively, by the formation of sand tombolo (35 m/year) and salient (9 m/year).
Egypt		***Alexandria coast***[72]	The major headlands occurring along the shore of Alexandria extend into the surf zone and confine the beach sands to littoral-cell embayments and pocket beaches, with little or no bypassing. This, in	Characterized by high wave energies particularly in winter. Waves induce opposing SW and NE longshore currents (Frihy et al., 2004). The higher proportion of SW	For the Governorate of Alexandria, two main economic areas appear most vulnerable: the Alexandria lowlands and the Alexandria beaches (El-Raey et al., 1995). The Alexandria	

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			effect, makes the Alexandria resort cell area an extended pocket beach and implies that the long-term net littoral drift is close to zero. sand accumulation patterns adjacent to the groins constructed along the Alexandria coast, where sand is being deposited both to the immediate east and west of the groins. The seasonal reversal in the direction of sand transport along the beach is predominantly northeast	currents is attributed to the large angle between the incident waves and the average shoreline orientation and geometry, as well as to the irregularity of the seabed and the undulating coastline. This situation differs from that recorded at the Nile delta and indicates that southwesterly littoral currents at Alexandria are strong enough to transport sediment along the coast. By contrast, easterly littoral currents	lowlands-on which the city of Alexandria originally developed-are vulnerable to inundation, waterlogging, increased flooding, and salinization under accelerated sea-level rise. The two surviving Alexandria beaches (Gleam and El Chatby) will be lost even with a 0.5-m rise in sea level. Based on the 0.5-m scenario, estimated losses of land, installations, and	

[73]Source: Watson Robert T., Zinyowera Marufu C. , Moss Richard H. and Dokken David J. (Ed.s)(1997).

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
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			during the winter and summer months, and southwest during autumn and spring, but with a zero net littoral drift when averaged over several years.	are more dominant along most of the Nile delta coastline, with only occasional reversals to the west	tourism will exceed US$32.5 billion. An average business loss is estimated at US$127 million/yr because most tourist facilities such as hotels, camps, and youth hotels are located within 200-300 m of the shoreline[73].	
Egypt	west of the Nile delta	**Abu Kir Bay**[74]	It includes important Abu Kir is located overlooking the western side of historic Abu Kir Bay. It is also close to Lake Idku and historic	It includes a large lagoon (Lake Idku) as one of the less polluted lakes of the five northern lakes of Egypt, nourished by the Rosetta branch of the	Recently, the region has attracted attention for development because of recent discoveries of sunken historic ships and cities.	The Governorate of Alexandria has recently decided to upgrade environmental and tourist conditions along the coast. Extensive waterfront developments have been introduced only recently. Integrated upgrading of both marine

[74] Source: SMART: Sustainable Management of Scarce Resources in the Coastal Zone Project Work Plan. http://www.ess.co.at/SMART/b5.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			sites of Rosetta city and Rosetta region, which includes Lake Idku and associated wetland. Lake Idku is situated about 30 km east of Alexandria. It is a shallow (1.0-1.5 m depth) brackish water lake with one connection to the Mediterranean at El Meadia. It has an area of about 125 km2. Rosetta region has been suffering from various aspects of mis-management, neglect and deterioration in the past. Problems of coastal erosion, land based	River Nile (average flow of about 4-5 billion m3 per year) The lake receives water from three drains along the southern and eastern sides. Seawater is primarily affecting the western side of the lake near the outlet. After construction of the Aswan High Dam, the annual drainage in the lake has increased. This has caused an increase of the level of the lake and induced flow from the lake into the sea and the lake became less influenced by salt water from the sea.	Resources in the region include beautiful and scenic view of the Bay, Lake Idku, Lake Burullus and coasts, historic tourism in Rosetta city, Alexandria city and in the Bay, ecotourism in lake Idku and adjacent area, religious tourism for Islamic area in Rosetta and Near by Alexandria, diving, snorkeling and yachting in the bay, with a unique mixture of urban, rural and marine culture	resources through conservation of biodiversity in the bay, better monitoring and assessment of international water dumped in the region as well as planning and development of urban coastal area will render this area into a highly desired area for tourism.

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
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			pollution to water resources and international water, urban encroachment in agricultural land, vulnerability to sea level rise (e.g. El Raey et al, 1997,1998,1999) and shortage of urban and environmental planning. Loss of marine biodiversity due to increased load of dumped waste in the bay and loss of agricultural and bird biodiversity due to deterioration of soil conditions and water quality in the region. The	from the sea. Historic cities such as Rosetta, Abu Kir and Idku.		

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			impact of climate change including SLR and salt-water intrusion is also another threat to the region. Losses of resources in the region have caused large-scale deterioration of socioeconomic conditions.			
France		**Mediterranean and Corsica Region**[75]	urban expansion, water pollution, coastal erosion, tourism/recreation, over-fishing, endangered species	Coast, river basin and the adjacent coastal area, lakes/rivers; mountains.		pollution control, resource management, institutional strengthening, biodiversity conservation, planning, monitoring, networking; water management/rehabilitation/information system

[75] Source: Priority Action Plan (website), Mediterranean ICAM Clearinghouse http://www.pap-medclearinghouse.org/eng/page001b.asp?zemljaID=11&shortID=66&start=start

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
France	Régions Provence-Alpes-Côte d'Azur and Languedoc-Roussillon	**Rhône[76] delta**	The coastline of the Rhone delta (90km long) is subjected to predominant coastal erosion (on average, 4m/yr over the last 60 years) arising from structural reasons (sedimentary deficit, very fine sands, energy of the swell). The spatial distribution of the sectors in erosion/accumulation can be divided into four coastal units	Coastal characteristics Study area: 90 km ; Sedimentary cell: 4 km Type of coast: delta and beaches (with fine sand; D50 =0.2 mm) Tidal regime: micro tidal (0,3 m) Range of waves : mean Hsig =0,8 m and T = 4,5 s ; annual storms Hsig= 3m and , T :7 s	This stretch of coast is greatly influenced by economic, industrial, harbour and touristic activities, which are sometimes in conflict with the protection of the landscape and natural heritage. Major public works are effective and justified on sectors with high economic value, where such structures are necessary to block coastal erosion. However, their	Engineering techniques: Groyne, seawall, breakwater, revetment, nourishment, wind trap sand ripping Policy options: Hold the line, limited intervention, do nothing. The management choices are thus very different according to human and economic requirements: either to stabilise the position of the coastline or to accept a moderate retreat.

[76] Source: Eurosion (website), Shoreline Management Guide http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
					effectiveness is limited in time and they can produce negative effects. The choice of less-costly techniques (ganivelles) is effective provided that sedimentary input is sufficient. A number of innovative techniques (rebuilding up of beaches, sedimentary bypassing on river courses…) have not yet been put into application.	
France	***Corsica***	***Calvi Bay***[77]	a reduction of gravel and		Two main causes	

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
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			sand delivery from the Figarella and Fiume Seccu coastal streams. Recent assessment of bedload transport during a 1 in 2 year flood and stream bed changes evaluated from aerial photographs and field measurements (cross-sections, long profiles, sediment size analysis) show these streams deliver less and less sediment to the beach, thereby explaining its erosion.		explain this trend: (1) in-channel gravel-mining has been operated on these streams since the 1970's and (2) significant land-use changes have taken place in their watershed since the end of the 19th century.	
Greece	western part of	***Pieria***[78]		This coastal area is	During the second half	During the end of the 1980s and at the

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
	the Thermaikos Gulf (NW Aegean)			characterised by extended sandy beaches, with a length of 15 to 20 km, which have been formed as a result of the interaction of small rivers and tributaries' discharges and the dominant waves, from SE direction.	of the 20th century, the coastal area was progressively developed as a tourist resort area. The man-made constructions have led to the erosion of the most important part of the beach of this area.	beginning of the 1990s, measures were undertaken along the coastal area to protect it from erosion. Five groins were constructed using natural stones. These constructions prevented erosion in the parts of the coastline lying between them, but not the degradation of the beaches. The erosion continued in the non-protected coastline areas. New groins were constructed (up to 10 groins) without a positive result. The erosion continued to affect the non-protected areas (Anagnostou, 2005).
Greece	Mesollogi West Greece	**Mesollogi[79] Lagoon area**	The barrier islets separate the Messologi lagoon in Western Greece from the Patraikos gulf. The	Coastal characteristics: Study area: 15 km; Sedimentary cell: 30 km Type of coast: beaches	Socio-economic activities: Fishery activities	Policy options: Hold the line

[79] Source: Eurosion (website), Shoreline Management Guide http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			erosion of the sandy barrier islets due to significant changes in the sediment balance of the coastline was introducing risk of ecological disaster for the Lagoon, which is protected by the Ramsar convention. The rehabilitation measures consisted of a groin system the engineering design of which is presented. Engineering techniques: Groynes	(with medium sand, D50 = 0,2 – 0,6 mm), saltmarsh. Tidal regime: micro tidal (0,18 m) Range of waves : 2.25-3.20m		

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
Greece	Peloponese, Achaia Province NW edge of Peloponese 10km east from the physical entrance of Patras Gulf	**Lakkopetra**[80]	Engineering techniques: Detached breakwaters	Coastal characteristics: Study area: 150m (+future extension of 140m) Type of coast: beaches (with fine-medium sand) Tidal regime: micro tidal (mean range 0.18m) Range of waves : 1.5-2.5m	Socio-economic activities: Tourism	Policy options: Limited intervention
Greece	northwest Peloponnisos	***Kato Achaia***[81]	At the end of the 1970s a small port was constructed. It has resulted rapid accumulation of beach sediments to the east of the construction.	Sandy beaches were formed by the sediment supply of the river Peiros.	fisheries' activities, Tuorism	To avoid the accumulation of sediments in the port basin, new constructions were undertaken in the 1980s, extending the former wave walls, which solved the problem of sediment accumulation for a short time. New constructions and

[80] Source: Eurosion (website), Shoreline Management Guide http://www.eurosion.org/shoreline/index.html

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
			The fine sediments bypassed the wave wall and were deposited in the basin of the small port, creating problems for the fishermens' boats. At the same time erosion started westerly of the construction, creating some serious problems to a relatively large hotel in the area.			installation of groins during the 1990s formed the modern type of man-made constructions in the area. To avoid erosion in front of a big hotel in the area large rocks were placed there, changing the physiognomy of this area
Greece	Cyclades Archipelago, Region of Southern Aegean	**islands of Anafi, Donousa, Thira (Community of Oia), Ios, Kimolos, Koufonissia, Milos, Paros,**	A group of islands in Greece located in the center of the Aegean Archipelago, consisting of 24 inhabited small and medium size islands and a significant number of	These islands are characterised by small surface area, limited natural resources, Tourism development poses pressure to existing traditional, in decline,	Population decline in some of these islands, major population's fluctuation. Rich cultural heritage, a natural and built environment of unique	limited administrative and organizational capacity, major deficiencies in respect to technical infrastructure and services, weak access to technological applications and innovation. Several of the islands host areas, which it has been suggested to be included in the

Country	**Area**	**Name**	**Coast and Erosion Description**	**Physical Characterization**	**Anthropogenic Characterization**	
					Social –Economic Facts	**Policy & Management**
		Serifos and Sifnos[82]	uninhabited small islands and islets. The total surface is approximately 2,528 km2 while the total population increased from 94,005 in 1991 to 111,181 in 2001. Intense tourism development which threatens the fragile balance between economy, society and environment. Variety of ecosystems such as small wetlands, coastal forest,	activities like agriculture due to increased demand for land and manpower. Land speculation and fragmentation of agricultural land into small plots are some of the problems resulting from tourism development. Conflicts between recent tourism development and mining activities are gradually emerging along with conflicts	value, domestic and international During the past decades there were economic recession and population decline. Recently, tourism development contributed for a regional development, providing opportunities for employment. Agriculture is gradually declining, completely abandoned in	Natura 2000 network. The main problems are: pollution problems, the salinization of underground water resources, illegal building, significant deterioration of build and natural environment and of landscape quality and to the loss of agricultural land, loss of habitats and overgrazing, loss of vegetation, soil erosion and desertification. Soil erosion has also resulted from the abandonment of agricultural activities in terraces.

[82] Source: Priority Action Plan (website), Mediterranean ICAM Clearinghouse http://www.pap-medclearinghouse.org/eng/page001b.asp?zemljaID=12&shortID=65#65

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			rocky coast, sandy beaches, grass and rangeland, cropland with significant ecological features.	between development and conservation goals.	cultivation in terraces. Tourism development poses additional pressure mainly due to the increased demand for land and manpower. Land speculation and fragmentation of agricultural land into smaller plots. As the main economic activity is tourism, there is a high dependance on the use of the coasts. Tourism is mainly seasonal. Most of the tourist infrastructure are located along the coast.	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
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Greece		**The Island of Rhodes**[83]	The island of Rhodes with its 220 km of coastline is situated at the northeastern corner of the Dodecanese Archipelago in the Aegean Sea. geographic concentration of tourism development along the north and east coasts; The coasts of Rhodes are exploited by mass tourism leading to an important urbanization and local degradation of areas such as in the northern part of the island and to a lesser	It is 80 km long and covers an area of 1400 km2. The central mountains are relatively high (1215 m at Mount Attaviros), surrounded by plains northwards and southward. The plains are boarded by sandy beaches. The continental shelf is narrow and depth increases rapidly close to the coasts. There are four main marine habitats: near shore sandy bottoms, forests of cystoseira	The economy is caught up in a saturated mass tourism market, environmental resources are stretched and the hinterland rural communities are marginalized. over-dependence of the economy on coastal tourism, geographic concentration of tourism development along the north and east coasts;	weak enforcement of planning and environmental controls. The existing planning laws are particularly important for environmental policy: the Framework Planning Law (Ekistics Law) for physical planning, and the Environment Law for environmental planning and control. Both are elaborate pieces of legislation but several limitations result in poor enforcement: • lack of an integrated planning process (no framework for regional planning and consideration of socio-economic issues); • Planning Law is not enforced as a whole but selectively, occasionally and reluctantly;

[83]Source: Priority Actions Programme, Regional Activity Centre(1996).

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
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			extent on the east coast. There is a gradual deterioration of the quality of the beaches (beach erosion and coastal reshaping) in the city of Rhodes, the bay of Ixia, parts of the coastal strips along the Kremasti-Theologos-Soroni-Kamiros-Skala area.	generally on shallow rocky substrate, seagrass meadows at a greater depth, and then coraline algae concretions in poor light conditions between 20 and 80 metres depth.		• land property plays an important role in society and family solidarity. Planning controls affecting development rights are generally resented and often actively resisted seen as a state threat to individual rights. Land use planning as a centrally administered governmental responsibility is poorly enforced.
Israel	area from Rosh Hanikra on the Lebanese	**Mediterranean coastline of Israel**[84]	The Mediterranean coastline of Israel extends about 190 km from Rosh	The coastline can be divided into four morphological sections	Roughly 70% of Israel's population, which reached 5,5 million in	Linear development along the coastline has been restricted. Much of the coastline is designated for various types of public open

[84] Source: Priority Action Plan (website), Mediterranean ICAM Clearinghouse http://www.pap-medclearinghouse.org/eng/page001b.asp?zemljaID=12&shortID=65#65

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
	Lebanese border to Zikim on the border with the Gaza Strip		about 190 km from Rosh Hanikra on the Lebanese border to Zikim on the border with the Gaza Strip. KEY ISSUES: Development pressure in the coastal zone. - Impact of marine structures on the shoreline. - Public access to the coast. - Beach and cliff protection. - Pollution prevention. Main conflicts arise	morphological sections according to physical characteristics and sedimentological properties: · Rosh Hanikra to Acco - a sedimentologically isolated region with abraded rocky platforms and narrow beaches; · Haifa Bay - bounded by the Acco promontory on the north and the Carmel mountain range on the south; · The Carmel coastal plane - between Cesarea and Haifa, consisting of three low parallel ridges	reached 5,5 million in 1995, lives within 15 km of the Mediterranean coastline. Intensive settlement along the coastal strip over the last 50 years now dominates the land-use pattern of the area, particularly the two major population centres of Tel Aviv and Haifa. The narrow coastal strip is the focus of the country's economic and commercial activity. The coastal strip also	designated for various types of public open space. Areas of particularly high natural value, mainly river mouths and rocky shores, have been designated as Nature Reserves. Beaches of high value for recreation in natural surroundings and sites of archaeological interest for visitors have been designated as Nature Parks. Marine reserves have been designated or are in the process of designation. They include offshore rocky areas rich in marine flora and fauna, and offshore rocks and sections of sandy shores important for sea turtles.

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
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			mainly from population pressure, urbanization and land-use conflicts on the coastal zone.	three low parallel ridges of calcareous sandstone, parts onshore and parts offshore with relatively narrow sandy beaches; and · South of Cesarea - here, sandy beaches are occasionally interrupted by sections of calcareous sandstone cliffs up to 40 m high.	The coastal strip also contains the most fertile agricultural land of Israel, especially for citrus production. The coastal strip encompasses several nature reserves (mainly river mouths and rocky shores), national parks (beaches of high value for recreation in natural surroundings and sites of archaeological interest) and marine reserves.	
Israel	some 50 km north of Tel-	***Hadera river***[85]	During mid 1978 to mid 1980 the cooling basin of			

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
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	Aviv		the Orot Rabin electric power station was built on the northern bank of the Hadera river. Since the construction of its breakwaters significant changes were detected on the beaches south to the cooling basin, but a significant accretion occurred on the beach north to the lee breakwater for a distance of about 1.5 km, and erosion some 2 to 2.5 km further north. The accretion has been attributed mainly to special local conditions which are predominant			

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			there (closed sedimentary cell), while the erosion was attributed to local coastal developments lacking coastal engineering involvement.			
		Herzliya coast[86]	A very large marina was constructed between 1991 and spring 1992 at Herzliya coast 4km south of the ancient Apollonia harbour site. Following the completion of the marina and of the detached breakwaters, beach erosion of up to 25m occurred north to them along about 3km of			

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
			coast.			
Israel		***Tel-Aviv Marina***[87]	Construction of the Tel-Aviv Marina was performed between September 1970 and fall 1972. Its entrance is at –5m water depth			Since its construction it requires periodic dredging of its entrance, almost every year.
Israel	30 km south of Tel-Aviv	***Ashdod***[88]	During 30 years of operation the port induced trapping of about 4.5 million m^3 of sand at its upstream coast side but no erosion was detected on the near downstream rocky coast, as it has been eroded by sand mining prior to the port construction.		The largest coastal structure built on the coast of Israel has been modern deep water port at ***Ashdod***.	

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
Israel	south to Ashdod port	***Ashdod marina***[89]	Ashdod marina was built with its main breakwater head at –5m water depth. It already trapped a significant amount of sand south to the marina, and is encountering significant sedimentation in its entrance.			Requiring frequent dredging operations.
Israel	south to Ashdod	***Ashkelon***[90]	Marinas as well as 3 new detached breakwaters to the north of it were built at Ashkelon, north to the Dlila beach, where 3 detached breakwaters were built in the late 1980's.			

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
			It resulted in sedimentation behind the detached breakwaters and significant erosion on about 3km of coast north to them.			
Israel	10km south to Ashkelon	***Zikim***[91]	Between fall 1973 and summer 1974 a small service anchorage was built at ***Zikim*** for the Eilat-Ashkelon oil pipe-line, with its entrance in 3m water depth. Sedimentological changes at the beach resulted almost immediately. The erosion to the north was so significant that the			To protect it against silting, two groins were built, one north of the harbour, only 80m long, in 1974, and another one 160m long to the south, in 1975. to prevent further beach erosion a rubble mound low coverage was placed there.

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			beach rock was exposed			
Italy	Regione Campania, Province of Napoli, Isle of Procida	**Cirqaccio - Ciracciello**[92]	A sandy beach of reduced extension. From the land side, the shoreline appears like a thin strip of sand bordered by a cliff on the back-beach, whose height decrease slightly going from Punta Serra to the far South of the beach. The violent sea-storms provoked both the coastal erosion and cliff damages with consequent slides whose results are still evident on the beach. The coastal erosion has	Coastal characteristics: • Study area: 1km (850m of BMS); Sedimentary cell: 1km • Type of coast: sandy beach (fine to medium sand) • Tidal regime: microtidal (0.3m) • Range of waves: màx. 4m The south Tirreno weather conditions are strongly connected, as for the rest of Mediterraneo sea, to the Azores	Socio-economic activities: Tourism The most important economical activity in the island is the fishing. Because of the nearness of the island to Napoli a lot of Procida inhabitants work in Napoli and travel daily. The second economical activity is the tourism, connected with the very nice beaches of the island.	Engineering techniques: Beach drainage system, breakwater Policy options: Hold the line In Procida island, except for few breakwater, there is not a beach protection policy, but the public administration wants to avoid the use of severe protection works and for this reason they are testing the BMS solution. A complete monitoring program is performing in the beach interested by BMS. The program includes morfological and hydraulics (i.e. water table level) measures. These measures, at the moment partially available, have to be processed in next months.

[92] Source: Eurosion (website), Shoreline Management Guide http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			significantly cut down the beach and the sea attack has already reached the foot of the cliff, threatening its integrity. The erosion reasons are due partly to natural phenomena and partly to man actions. Causes are: • lack or reduction in sedimentary contributions coming from progressive dismantling of cliffs neighbouring to the site • lack or reduction in sedimentary contributions coming	anticyclone position. During the summer this high pressure system is situated to the northern part of its annual cycle protecting the dock from the influence of Atlantic depression systems. During the winters the Azores anticyclone moves southward failing its protecting effect, so the Mediterraneo sea is interested to the transition of Atlantic depression crossing the dock during few days. Coastal characteristics: • Study area: 5 km		

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
			from the mainland (not due to the human presence); • a sand withdrawal in the submarine beach happened some years ago • making of human structures close to the emerged and back beach.	; Sedimentary cell: 5 km • Type of coast: Sandy beach • Tidal regime: microtidal • Predominant wave direction: E or SE		
Italy	Sicilia, Province of Messina, municipalities of Taormina	**Giardini – Naxos**[93]	The bay of Giardini Naxos is situated in the Northern sector of the Ionian coast of Sicily (Italy), between the towns of Messina and		Socio-economic activities: Tourism The town of Giardini Naxos has about 10,000 inhabitants and it is	Policy options: Hold the line Engineering techniques: Breakwaters, groynes, beach nourishment, seawall, detached breakwater.

[93] Source: Eurosion (website), Shoreline Management Guide http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
	and Giardini		Catania. Over recent years several stretches of the coast of Giardini have been victims of an intense erosive activity, caused and aggravated by a series of man-made constructions: within the hydrographic basin (check dams); along the coast (subparallel breakwater barriers); or directly at sea (harbour quays).		characterized by a strong tourism with plus than 1 million tourists per year.	In the 1970s and 1980s and until the early 1990s, the only projects for erosion prevention were for a rigid type of barrier, consisting of structures oriented in various directions with respect to the shoreline. These structures were always emergent and were rarely placed at a sufficient distance from the shore to b#337199e effective, in consequence of that they had a limited efficacy causing further erosion problems downdrift. On the basis of these observations the Regional Department of the Environment (ARTA) under the pressing of the EU, published a public announcement, within the project for public works from 2000 to 2006, which contained the guidelines for the definition of priority areas to be protected and the type of projects to be adopted, as well as the

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
						various stages. The aim of the announcement was “removal of the causes of deterioration and/or erosion in the coastal areas, by means of the restoration of the natural conditions which led originally to the formation of the shoreline, with particular reference also to building activities inland, to the recovery and restitution to their natural state of the wet and dry river courses and the restoration of the solid littoral transport; particular attention is to be paid also to the effects on an increase in tourist potential, the recovery of state property and the protection of private and public goods from sea storms”.
Italy	Sicily	***San Vito lo Capo***[94]	Consistent erosion along the east portion of the	Sea cliffs and inlets, stony beaches, coastal	Human activities include arable and	A gradual extension of harbor breakwaters.

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			beach has been observed over the last decades. The extension of the harbour is largely responsible for the erosion taking place along the San Vito Lo Capo beach. A removal of a previous harbour extension would, for the major portion of the beach, result in an accretion	sand dunes and sand beaches, sclerophyllous scrub, garigue and maquis95.	stock-farming, fishing, hunting, tourism and leisure96.	
Italy	Po delta	**Goro mouth**[97]	The examined area is	Coastal characteristics:	The most important	Engineering techniques: Nourishment,

[95] Source: United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC)(website), http://ims.wcmc.org.uk/ipieca/species/iba/ITALY.html

[96] Source: United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC)(website), http://ims.wcmc.org.uk/ipieca/species/iba/ITALY.html

[97] Source: Eurosion (website), Shoreline Management Guide, http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			located in the right side of the Goro Po mouth. This is a deltaic littoral area, mainly characterized by bars sometimes related to wide spits evolution, that edge large inner land lagoons with high anthropic pressure. Nowadays, in Goro Po area, a sandy beach edged by coastal dunes ridges and submerged bars on the bottom are present. In the last tens years 8 million m3 of sediments have nourished the sea bottom in front of Goro spit, but great part of these	• Study area: 6km • Type of coast: delta and beaches (with fine- medium sand) • Tidal regime: micro tidal • Other: Land subsidence The physical processes induce a longshore transport connected to Sirocco and Levanter winds; The sedimentary supply for the Goro spit are mainly due to Goro Po river contribute and, partially, comes from reworked sediments	activities of this area are referred to fishery that, from '80 years, became the main profit for the inhabitants, after the introduction of breeding of clams (*Tapes philipinarum*) inside the lagoon, and of mussels in the in front sea.	groyne, revetment, dune rebuilding Policy options: Limited intervention, hold the line Many policies concur to sustain the maintenance of this area: the regional policy (Environment Councillorship- Soil and coasts Defense) aims to safe the areas, when populated or industrial activities could be damaged by natural hazards. Po Delta Natural Regional Park policy is to keep relevant natural areas and, when possible, to restore the natural value of damaged areas, mainly trough eco-compatible actions. The Goro Municipality and the Ferrara Province policies aim to safe the economic activities and the natural value of this land.

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
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			counterbalance the local natural and human induced subsidence.	coming from northern beaches with a transportation average about of 180 millions m3 every year.		
Italy	La Liccia, Regione Autonoma della Sardegna, Province of Sassari, Comune di Aglientu	**Lu Litarroni**[98]	The distribution of the dike set strongly affects coastal morphology by creating natural barriers to longitudinal transport, defining physiographic entities and creating tombolos and isolated rocks. La Liccia, Rena Majori and Bureddaggia are highly exposed	Coastal characteristics: • Study area: 20km; sedimentary cell: 5km + 5km • Type of coast : hard rock coast, beaches (from fine sand to coarse sand, pebbles, cobbles) and dunes • Tidal regime:	Socio-economic activities: Tourism, camping, agriculture, nature conservation Tourism represents one of the predominant sectors of the local economic systems and has influenced all other	Engineering techniques: No Actions Policy options: Do Nothing Of fundamental importance is the analysis of “progettualità” deriving from the socio-economic energies used for planning, programming (in particular of the local development programs, the instruments for urban development) and from those which regard actions in the area of the Quadro Comunitario di Sostegno also with the recent instrument of “Progettatione

[98] Source: Eurosion (website), Shoreline Management Guide http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			beaches, liable to very intense swell with modest SW-NE net energy flow. Naracu Nieddu and Lu Litarroni beaches are poorly exposed, liable to intense swell with mild SW-NE net energy flow.	microtidal • Range of waves: maximun h =11 meters, 1 s period The coast under study has been subdivided into 5 physiographical units. The physiographic area includes about 22 km of coastline, 10 of which of sandy beach, 5 of low rocky coast and 7 of cliffy coast. The outcropping rocks are those related to the Hercynian cycle, with the typical sequence of intrusive events represented by tonalites,	forms of the use of those parts of coast and sea, who have oriented themselves towards an organisation suitable for the needs of tourism. Tourist activities include various compartments of quality of the agricultural nutrition sector (to think about wine, cheese, bread and so on) and furthermore traditional and artistic trade or craft (fabrication of baskets, carpets, ceramics, knives, leather, wooden	Integrata Territoriale" (PIT). With these reports it will be possible to verify a new scheme of territorial order, which directly originates from knowledge about the intentions of the local administration and the economic world in relation to the two principal objectives of development: • Strengthening and re-establishing entrepreneurship by productive investments in principally tourism-related activities, • Realisation, alignment and completion of infrastructural devices to be provided by the public (water pipes, the net of sewers, recycling…) and services

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
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				granodiorites and leucogranitic plutons. The studied area includes includes only the sectors B and C. The wave-cut (cliff) stretches of coast, oriented according to these lineations are considerably fractured and crossed by tectonic lines perpendicular to the coast, on which processes of linear erosion and deep valleys have evolved. All physiographical units under study present maximum exposure to the winds and waves from west and north-west. The	objects etc.).	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
				morphology of the submerged beaches of north western Gallura is strongly affected by the outcropping of the crystalline basement that determines its geomorphological arrangement		
Italy	Toscana	**Marina di Pisa, Marina di Massa**[99]	Approximately 7km of beaches at Marina di Massa are experiencing severe erosion as a consequence of the construction of an industrial harbor at	Coastal characteristics: • Study area: 8.5 km (Massa), 4 km (Pisa); sedimentary cell: 65 km • Type of coast: beach (fine to medium sand),	Socio-economic activities: Tourism	Engineering techniques: Seawalls, detached breakwaters, submerged breakwaters, groynes, beach nourishment, submerged nourishment, geotextiles Policy options: Hold the line The new structure intercepts the southward longshore sediment transport, inducing a

[99] Source: Eurosion (website), Shoreline Management Guide,http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			Marina di Carrara in the early 1920s. The new structure intercepts the southward longshore sediment transport, inducing a sedimentary deficit to downdrift beaches.	artificial coast • Tidal regime: microtidal • Range of waves: Hs =5.5 m and Ts=10 s with recurrence time of 20-30 yr.		sedimentary deficit to downdrift beaches. Different types of hard structures, such as seawalls, breakwaters and groins, were built in the study area in order to protect the seaside resort and the coastal highway from shoreline retreat. Nevertheless, beach erosion proceeded and tourist industry is now suffering from this retreat.
Italy	northern Adriatic Sea	***Comacchio coast***[100]	Sandy coast between Porto Garibaldi and Porto Corsini. The main problem in the area is beach erosion. This is due to the evolution of the delta of the Reno River, and to the effects of past anthropogenic impacts that modified the	the study area can be divided into three physiographic sub-unities, extending from the southern jetty of Porto Garibaldi and the Reno River mouth, to the Casal Borsetti, and from this latter to the northern jetty of Porto Corsini.	Tourism, fishery	In 1990 local defences with Tubi Longard and artificial nourishment (40,000m^3 of sand) were used to protect the coastline, but this management was insufficient. The eroded sediment was transported northward accumulating south of the Porto Garibaldi jetty, where an average beach accretion of 50-70m (with peaks of 120m) was detected from 1978 to 1993. The unit from the Reno River mouth to Casal Borsetti is heavily

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			sediment transport dynamics of the beach. An important factor affecting the morphological evolution of the site is land subsidence. This caused an important modification of the relative elevation of the ground at sea level, increasing the beach erosion. From the start of the 1980s the first unit of beach was affected by severe erosion, because of the migration of the Reno River mouth 2km south, causing significant coastal			armoured with beach revetments, which were installed in the 1980s. The unprotected beaches in this area are affected by strong erosion, 80m in the last 15 years (figure 11). The third physiographic unit is characterised by a southward littoral drift, which has experienced accretion of about 4 m/year in the last decade or relative stability. This is due to the drift of the artificial nourishment which was put in place at the end of the 1980s and also because of other protection works. In the last 30 years, because of coastal erosion, the littoral strip that separates these lagoons from the sea became narrower, and was artificially defended. In the same time the Canale Gobbino mouth closure took place, reducing even more water exchange between the lagoon and the open sea

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
			modifications. In the 1978-1983 period, the beach eroded 120m.			
Italy	Lido Adriano, Regione Emilia Romagna, Provincia di Ravenna, Comune di Ravenna	**Marina di Ravenna**[101]	During the last century, the entire coastline has been strongly influenced by two main factors: the building and progressive extending of Ravenna Port jetties (whose present length is about 2800 m) and the lack of sediment supply, formerly coming from the river consider all the negative effects caused by subsidence and the high anthropic impact	Coastal characteristics: • Study area:10,5 km • Type of coast: beaches (with fine sands) • Tidal regime: micro tidal • Range of waves : Hs=1.5-2m (Ts=5-6 s.); Hmax=4m • Other: land subsidence The coast is characterised by sand-beaches covering	Socio-economic activities: Tourism and recreation The major function of the coastal area is tourism and recreation.	Engineering techniques: Seawalls, submerged, non submerged breakwaters, groynes, jetty and nourishments. Policy options: Hold the line The actual beach management strategy, according to the present knowledge, began in 1997, with the design of a new coastal semi- submerged protection structures required because the previous submerged breakwater and groins made of sand bags resulted ineffective.

[101] Source: Eurosion (website), Shoreline Management Guide, http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			due to beach-tourism management. The coast have experienced a subsidence grater than 1 m in the last 40-50 years; natural rates of 2-3 mm/y of magnitude have been in fact greatly accelerated in the last half century by fluid (water and gas) extractions from the underground. At present, along the coastal areas, the subsiding rates are, on average, 5- 6 mm/y, with peaks of 9- 10 mm/y. The coastline experienced a huge erosion rate in the	muddy-clayey materials derived from more ancient swampy and alluvial deposits. This area is the result of the interaction between river-delta and marine coastal processes. The seawater level rising in the North Adriatic Sea is also due to an intense wind action coming from south-east, the Sirocco wind, associates to depressional fields, which move towards the East. The prevailing sea is from the		

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			southern part (from the Fiumi Uniti river mouth to about Punta Marina) and a significant accretion in the northern part (close to the jetty). In Marina di Ravenna the emerged beach shows a marked accretion (about 140-150 m in the last 50 years) while, where water depth exceeds 3-4m, a slight negative altimetric budget can be observed. More than 100 bathhouses are located on the 10.5 km of beaches. These structures damaged and destroyed the dune bar	SE (influenced by Sirocco wind) close to the shoreline, and from the NE (influenced by Bora wind) where water depth is higher than 3 m.		

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			and, because of an uncontrolled use of the beach, they caused heavy and continuous impacts on the existing residual dune bars and on the pinewood.			
Italy	Genoa	The beach of ***Vesima***[102]	Has been subject to a strong erosive trend. On the contrary, in the 1970s there was a period of temporary and limited progradation of the beach due to the beginning of new dumping, which was carried out for the building of a new railway and a motorway. During the 1980s and 1990s, the		The construction of a coastal road, the main railway line, and some breakwaters, to protect fragile coastal areas, has changed the coastal dynamics and the equilibrium of this stretch of the coast. from 1800 to 1960, there was increasing erosion along the entire	After the nourishment work in March 2000, the width of the dry beach was stable; the estimate of nourishment material (20,000m^3) and of the material left on the dry beach after 2 years (4800m^3) indicates that a remarkable quantity of sediment was taken from the shoreface to form the nearshore zone.

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			beach showed a new and greater erosional trend, essentially because of reduced contributions made by the local watercourses and littoral drift		shoreline, due to the quarrying of sandy sediments from the rivers and the beaches. This process culminated in the 1950s and 1960s with the additional impact of demand for beachside housing and holiday structures.	
Italy	Regione Liguria, Province of La Spezia – Municipality of Sarzana	**Marinella di Sarzana**[103]	The pilot zone of Marinella di Sarzana is characterized by a sandy beach with a total length of approximately 2.7 km, which extends from the Magra River mouth -on	Coastal characteristics: • Study area: 2,5 km ; Sedimentary cell: 70 km • Type of coast: beaches (with fine sand) • Tidal regime: micro tidal	Socio-economic activities: Tourism	Engineering techniques: Groynes, detached breakwater, jetty, artificial island, nourishment Policy options: Hold the line Currently, the beach of Marinella di Sarzana is protected by different kinds of hard structures like groins, breakwaters and

[103] Source: Eurosion http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			the northwest- to the Parmignola Creek mouth to the southeast. The study area constitutes the northern part of the physiographic unit that extends from the Magra River mouth to Livorno, and the Magra River is the only source of sediments for the beach. The beach at Marinella di Sarzana experienced severe erosion since the end of the XIX Century as a consequence of the strong reduction of the Magra River's sediment load due both to changes in land	• Wave climate: storm waves coming from WSW (240°)		circular artificial islands made of rocky stones around a concrete ring. This hard engineering stopped shoreline retreat but induced heavy impact on the coastal zone. The Administrations of Regione Liguria and Regione Toscana recently co-financed an innovative project aimed at reducing these impacts and increasing the beach surface in order to re-launch tourist activity in the area.

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			use and, later, to human action in the river basin, with intense sand and gravel dredging from the river bed. Being a deltaic area, erosion started in proximity to the river mouth and moved gradually downdrift toward the southern limit of the study area. In the meantime, the southern neighboring beach at Marina di Carrara experienced accretion because of the construction of the Marina di Carrara harbor which			

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			begun in the 1930's. The construction of the harbor created a physiographic sub-unit between the Magra River mouth and the harbor itself.			
Italy	located on the shore of the Ligurian Sea, in Tuscany, located 4.5 km north of the of the Arno River outlet	the shoreline south of ***Gombo***[104]	Particularly, from the mid-19th century to 1954, retreated continuously. Extreme retreat occurred north of the Arno outlet and gradually decreased northwards. In the period 1938–1954, Gombo enjoyed some sand supply from the eroding beaches located to its south and became an			In order to protect the coastal segment in front of the presidential villa at Gombo, a pair of detached breakwaters, were built in 1962, two other segments were completed in 1966 and the fifth segment was built in 1968 further north. The three southernmost tombolos facing the longshore current became the main sediment trap, causing a lee-side erosional effect to emerge within the protection scheme of the segmented detached breakwaters. The oblique incident waves

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			inversion point, i.e., north of the site the shoreline started to prograde. During the 1954–1967 period, shoreline retreat continued to the north and included the Gombo area up to Serchio river.			enter through the gaps and maintain in the inshore the depleted longshore drift, causing the shoreline configuration in the lee of the northern breakwaters to develop into a prograding log-spiral bay.
Italy	located in central Italy	***Cecina River*** mouth[105]	experienced severe erosion. The main cause of beach erosion is river bed quarrying carried on up to 1978 along the Cecina River.	Surveys conducted before, during and after project completion indicate that the shoreline prograded for approximately 5.65 meters along the northern beach, and for approximately 5.50 meters along the southern	Reducing the recreational use which contributes a large part to the economy of the area.	Beach stabilization conducted from 1987 to 1992, has included a stretch of coast approximately 1.7 kilometers north and 1.1 kilometers south of the River mouth. Emerged and submerged groins were constructed, and approximately 92,500 cubic meters of sediment were used to nourish the beach during the period under study. In addition, a submerged breakwater was placed at the 2 meter isobath on the

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
				beach. Bathymetric surveys show a sediment surplus of 140,000 cubic meters in the northern area, and of 220,000 cubic meters in the southern area		southern beach and on a very limited area of the northern beach. In addition, a submerged breakwater was placed at the 2meter isobath on the southern beach and on a very limited area of the northern beach.
Italy	Regione Lazio, Provincia di Roma, Lido di Ostia	**Vecchia Pineta**[106]	Coastal band of the examined site is constituted by a sandy beach of reduced extension. From the land side the beach is bordered by a string of dunes slightly decreasing going towards the shore. The coastal girgle is constituted by a low	Coastal characteristics: • Study area: 400 m • Type of coast: beaches (with fine and coarse sand) • Tidal regime: micro tidal (0,4 m) • Wave climate : Direction of waves = 3rd quadrant	Socio-economic activities: Tourism Tourism is the main socio-economic activity of this place. Thus, hinterland and beach, in spite of its remarkable tourist interest, appear barely built with the exception of the	Engineering techniques: Historical: submerged breakwaters, nourishments. Present: beach drainage system. Policy options: Hold the Line The Regione Lazio carried out a lot of intervention firstly aimed to hold the line and to a subsequently its advancing. In order to guarantee a long stability, every non-protected action must be combined

[106] Source: Eurosion http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			constituted by a low extension sandy beach, of approx 40 m and weak gradient nearly 1:40. On the sea side the sounding-depth outline shows a system of one or two longitudinal bars. The shore erosion forecasts pointed out a global mass of approx. 220.000 m3/year, shared in 100.000 m3/year toward North and 120.000 m3/year South direction, with a net difference of 20.000 m3/year in favour of the south side. During the previous decades this	The main wave motion, as far as intensity and frequency, is from S and SW event though there is a significant frequency from W and NW. The sea currents are mainly a wind result, therefore strongly conditioned by the weather variability and, near the cost, by the structure of the bathymetric lines. The wind climate shows a strong frequency predominance from NNE and NE. The greater intensity events seem to be due to the areas	restaurant and the cabins over the wharves which do not weightily interfere with the shore-line morpho-dynamic.	with a suitable maintenance service. In this contest, it has been carried out the installation of a new system of erosion maintenance and coast resetting, BMS (Beach Management System). This new system has a double aim: • shore-line stabilisation and consequently maintenance low-costs • get a further advancement During the previous years a lot of passive protection interventions have been performed, but this actions allowed the erosion phenomena to shift southward.

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			was compensated by Tevere contributions but today, thanks to the works of river regimentation and ground stabilisation, they are decreased helping to trigger erosion phenomena along the entire shoreline.	between SE and SW also showing a good frequency.		
Italy	Liguria	**Ligurian coastal area**[107]	coastal erosion, habitat loss	coast, river basin and the adjacent coastal area, rocky coast, lakes/rivers, island, peninsula, sandy beach	urban expansion, population growth, tourism/recreation, transport congestion,	overall policy, pollution control, development control, infrastructure development, planning, monitoring

[107] Source: Priority Action Plan http://www.pap-medclearinghouse.org/eng/page001b.asp?zemljaID=12&shortID=65#65

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
Italy	Abruzzo	**Pescara**[108]	sediment movement, coastal erosion, Funding of the Structural Funds has part-financed coastal protection works, which have contributed to beach and dune erosion further along the coast, necessitating further expenditure on yet more coastal protection with similar effects[109].	coast, river basin and the adjacent coastal area, rocky coast, grass and rangeland, lakes/rivers, sandy beach	urban expansion, water pollution, tourism/recreation	
Lebanon		**Tyre Beach**[110]	The site is situated along	The area consists of	No information is	

[108] Source: Priority Action Plan http://www.pap-medclearinghouse.org/eng/page001b.asp?zemljaID=12&shortID=65#65

[109] Source: Coastal Guide ICZM Information System, http://www.coastalguide.org/icm/abruzzi.pdf

[110] A Directory of Wetlands of International Importance (1996).

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			the Mediterranean coastline of southern Lebanon near the town of Tyre. Seawater at the site is polluted by organic (sewage) and inorganic waste. The latter is caused by illegal disposal of oil, and by heavy metals, detergents, etc. Dumping and littering are a problem too. Urbanisation from the Tyre area has been going on for over a century. Coastal erosion by storms and illegal sand mining also threaten the site. Disturbance of wildlife is	sandy stretches, at some places interspersed with pebble areas and rocky shelves with pools. The beach and sand dune area are made up of a mixture of quartz and carbonate sands which have locally been compressed and transformed into rocks. Cretaceous limestones underneath form an aquifer that provides the major part of the region's water, and overlaying impermeable layers have allowed the development of artesian wells from cracks and faults.	available about the ownership of the site. Parts of the area are irrigated for the cultivation of vegetables. Palm and citrus plantations occur further back. Stabilised dunes are used for grazing by small herds of cattle, which are also led to freshwater sources on or near the beach. In summer, the area is visited by a large number of tourists and at that time, some fishing also takes place. At Ras el Ain there are	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			a problem during the tourist season.		three artesian wells of which the walls were built by the Phoenicians	
Malta	Island of Malta (NUTS level 3), San Pawl il-Bahar Local Council Mgarr Local Council	**Xemxija - Ghajn Tuffieha**[111]	The case study areas of Xemxija and Ghajn Tuffieha are located within the Pwales graben, which is defined by two faults. The beach material comprises sand with a varying admixture of silt and some clay. The sea bed in Ghajn Tuffieha is relatively shallow in the embayment. In contrast to Ghajn Tuffieha Bay, the seabed in Xemxija is	The Maltese Islands are almost entirely made up of sedimentary rock deposited in a marine environment during the Oligo-Miocene period. These limestones and clays form a series of stratigraphic layers of varying composition and hardness. **Xemxija** Coastal characteristics:	With a total land area of 316 km2 and a total population of 378,132 (Census, 1995) the Maltese Islands have one of the highest population densities in the world. Due to its small size the economy depends heavily of foreign trade and the Islands rely substantially on imports for energy, industrial	Evidence from aerial photography suggests that the sandy beach at Xemxija Bay (although relatively small) has eroded in a period of almost 4 decades, as a result of measures to artificially realign the coastline. An afforestation project was carried out along the clay slopes at Ghajn Tuffieha, in the late 1960s. It is assumed that such a project was undertaken to stabilise the slopes. It is evident that throughout the development of Xemxija and provision of infrastructure, no consideration has been given to coastal erosion issues. In the

[111] Source: Eurosion http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			marked by a gentle slope where depths reach 25m at the mouth of St. Paul's Bay. The sandy beach at Ghajn Tuffieha occupies half of the bayhead in the form of a wedge-shaped belt, approximately 150m long and 25m wide, tapering gradually towards the south where it turns into a narrow, 100m long sand/cobble beach. Geological formation of the Xemxija area in the absence of significant clay exposures, suggests limited material availability.	• Study area: 3,6 km • Type of coast: beaches (with fine sand) • Tidal regime: micro tidal **Ghajn Tuffieha** Coastal characteristics: • Study area:1,3 km • Type of coast: beaches (with fine sand) and soft rock coast (with limestone cobbles) • Tidal regime: micro tidal	supplies and consumer goods. Tourism is a significant contributor to the local economy. Southern coast, dominated by cliffs has been dominated by agriculture development. **Xemxija** Socio-economic activities: Tourism and recreation, fishing berths **Ghajn Tuffieha** Socio-economic activities:	absence of any policy measure, the shoreline has been subjected to considerable changes that have led to the loss of the sandy beach and the saline marshland behind it as well. The legal protection afforded to Ghajn Tuffieha has slowed down the process if not eradicated completely the source of coastal erosion. **Xemxija** Engineering techniques: Revegetation. Policy options: Do Nothing **Ghajn Tuffieha** Engineering techniques: Revegetation. Policy options: Limited intervention

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
			The aerial photos indicate that erosion is predominant in the areas where human intervention took place, primarily on the clay slopes with more debris accumulating at the base of the cliff.		Nature Conservation, cultural heritage; tourism and recreation	
Malta	Northwest area of the Maltese Islands	**from Wied iz-Zurrieq to Salini Bay**[112]	water pollution, air pollution, soil pollution, water shortage, coastal erosion, habitat loss	coast, river basin and the adjacent coastal area, wetland, rocky coast, grass and rangeland, lakes/rivers, bay, island/peninsula, sandy beach	population growth, tourism/recreation, over-fishing,	overall policy, preparatory activities, pollution control, development control, resource management, institutional strengthening, infrastructure development, biodiversity conservation, urgent measures development, planning, education/awareness, monitoring, networking
Morocco		***Moulouya River***[113]	Before the construction	The largest river in		

[112] Source: Priority Action Plan http://www.pap-medclearinghouse.org/eng/page001b.asp?zemljaID=12&shortID=65#65

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			the lower Moulouya River pattern was sinuous to meandering and the river's mouth was much wider than it is today (figure 20). The fluvial load was significant enough to lead to the progradation of deltaic deposits in the eastern part of the river's mouth. After construction of the Mohamed V dam, the river's mouth and the coastline reacted with remarkable adjustments. Indeed, given the weak fluvial hydraulic power, the marine influences	Morocco, draining approximately 53,500 km^2 in the eastern Morocco. The upper basin is separated from the lower floodplain by the large Mohamed V reservoir which traps most of the sediment delivered from the upstream region Sediment trapping by the dam's reservoir affected the morphological evolution of the coastline		

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			have been reinforced, leading to the reworking of the shoreline sediments, narrowing of the mouth area, and the accumulation of mouth bars. The most effective waves and the induced sand transport are directed westwards. The net littoral transport was estimated at approximately 165,000 m^3 $year^{-1}$. The sand transported was responsible for the accretion of the west coast, whereas the east coast retreated because it was not fed by fluvial			

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			inputs.			
The Palestinian Authority		***Gaza coast***[114]	During 1997, a fishing port was built off ***Gaza coast***, extending with its breakwater head to a water depth of 5.5m. Significant sedimentation resulted to the south of the harbour and correspondingly erosion on the coast downstream to the harbour occurred.			
Slovenia	Municipality of Piran and Municipality of Izola	**Slovenian coast**[115]	Slovenian coast is a shallow marine basin, with maximum depths in its central part 20-25 m and average depth of 17	Coastal characteristics: • Study area: 10 km • Type of coast: hard and soft rock	Socio-economic activities: Nature conservation, tourism	Engineering techniques: Seawall, submerged breakwater, dyke Policy options: Hold the line, limited intervention, move seaward

[114] Source: Y.N. Krestenitis & I.S. Androulidakis (2006).i
[115] Source: Eurosion http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			m, situated at the junction of the Dinaric Alps and the Alps. Sea erosion of rock coastline through the waves and tide, is of low intensity due to small driving forces. It is comparable to erosion due to weathering on slopes inland. Shifting of coasline inlands due to sea erosion is pronounced only in uninhabitated areas and nature reserves, while the majority of inhabitated coastline is erosion protected by artificial structures. However, during extremely high tide events	coast, saltmarshes, beaches (with shingle), artificial coastline. • Tidal regime: micro tidal	Tourism development in Piran, and other parts of the coast, sprawls outside the city creating needs for new infrastructure, is excessive beyond the carrying capacity of the coast and the road network. The urbanisation of the coastal strip together with the increasing employment opportunities led to intensive migration of inhabitants from hinterland to the coast.	These parts of the coast are protected by various artificial structures ranging from seawalls and rip rap breakwaters to rock dikes. Cliffs in inhabited areas are protected by wire mesh, in exceptional cases also by concrete sills, stone walls and concrete walls. Areas of the coastal plains are protected by seawalls and submerged rip rap breakwaters. The most important policy option that was chosen and adopted is “hold the line”, which is implemented in most parts of the coastal zone, that are urbanised or occupied by intensive uses. Only the parts of the coast, that are either nature reserves or uninhabitaded areas are subject to natural processes, and are left to natural dynamics, with the soft policy option of “limited

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
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			extremely high tide events the stretches of low coast are flooded for some hours short periods several times a year. The major changes in the narrow coastal strip in the last decades (abandoning of salt production in Luclja, the construction of tourist facilities including yachtmarinas, the development of the port of Koper, infrastructure) resulted in a serious loss of natural coastline and degradation of the coastal ecosystems. There is less than 20 % of natural			intervention". In the area of the Port of Koper, the policy option is to "move seawardIn general, the approach to solving erosion problems of the coastline is local, using proper technical solutions and appropriate land use. Only the problem of filling up the Gulf of Trieste with sediment transported by rivers, is delt with regionally and internationally, trying to retain the sediments inland.

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			coastline left. Salt extraction used to be one of the important economic activities in the area.			
Slovenia		***Gulf of Trieste***[116]	Shifting of coastline inlands of the Gulf of Trieste due to sea erosion is pronounced only in uninhabited areas and nature reserves, while the majority of inhabited coastline is erosion protected by artificial structures. The highest erosion progress is to be 6 cm per year, deduced from skeleton washing away from the grave cut		Because the Gulf of Trieste is shallow, sedimentation of the eroded material to the bottom of the sea poses serious problem to navigation of transoceanic ships.	several technical solutions were introduced into the river systems to retain the eroded material inland. In the last decades, the process of natural reforestation of agricultural land is also taking place due to abandonment of agricultural production. This results in a trend that shows decline of sedimentation in the sea.

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			in the cliff about 900 years ago. All other available published sources are citing lower erosion rates. Historical data of cliff erosion next to protection wall of Piran Sv. Jurij church show erosion progress of 1 cm a year. Measurements at other sites gave values between 1 cm and 2 cm. In general, it could be taken that average speed of cliff shift at Slovenian Coast is in the range from several mm to several cm a year. Inland landslides,			

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
			torrential erosion and riverbank erosion are the most hazardous phenomena in Slovenia. Inland Erosion endangers about 44% of Slovenian territory and causes an annual loss of 2,5 million m^3 of soils			
Spain	Illes Balears (Isle of Mallorca), Alcúdia	**Can Picafort**[117]	Mallorca Island, located at the western Mediterranean Sea (Balearic Sea), is the greatest of the Balearic Islands. The area of interest is located at the north-western sector of the Alcudia Bay (Can Picafort beach). Alcudia	Coastal characteristics: • Study area: around 4 km ; Sedimentary cell: around 10 km • Type of coast: beaches (with fine-medium sand bioclasthic origin)	Socio-economic activities: Tourism, Nature conservation The major function of the coastal zone is tourism and recreation. If the beach disappears	Engineering techniques: Nourishment Policy options: Limited intervention The biological activity is strongly related to the Posidonia Oceanica. Almost all the beings that form the sediment of the beaches live around or depend on that plant. For that reason when we reduce the Posidonia Oceanica prairies we kill the sediment factory of the Mallorca beaches.

[117] Source: Eurosion http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			Picafort beach). Alcudia Bay has a structural origin, as it is limited by NE-SW Neogene normal faults at its margins, where Mesozoic materials outcrop. At the subsiding sector a sand beach system with a wet zone onshore is present (Albufera d'Alcudia). On the other hand, at the stable sector sand beaches and gently rocky coast (Plio-Pleistocene eolianites) appears alternatively. The studied sector of coast consists on 5 km long	bioclasthic origin) • Tidal regime: micro tidal • Range of waves : max H = 4 m The origin of the sediments is mainly Bioclastic (89%), being the lithoclastic fraction very low (11%). The grain size of the Alcudia bay sand has a 60 % of medium sand (between 0.25 and 0.5 mm), a 25 % of coarse sand (between 0.5 and 1 mm) and a 15 % of fine sand (between 0.125 and 0.25 mm).	the economic engine of the area will also disappear. For that reason the impacts of the beach retreat in this area will affect the inhabitants residing inland, not also those who has a house near the beach.	sediment factory of the Mallorca beaches. As there is not any external supply when the Posidonia Oceanica prairies are destroyed we are inducing a beach retreat. The adopted policy options in this area have been a limited intervention: sand renourishment of the most affected beach, the Can Picafort beach.

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			beach (from Can Picafort to S'Oberta) with a NW-SE orientation and opened to the NE. The studied shore shows erosion and accretion at different places. The distribution of the erosion and accretion sites is mainly controlled by human constructions (dikes and harbours) together with the longshore transport and storms. The type of erosion observed at Alcudia Bay is a gradual sediment loss due to the S-N longshore transport.	Tidal processes are almost imperceptible and height wave do not overpasses the 4 m in the open sea. The bathymetry of the Alcudia bay is also gentle. Two independent sedimentary cells can be defined in the Alcudia Bay, a northern cell (studied area) and a southern one. Wave induced longshore transport can be considered as the most important process along the Alcudia Bay, which at the studied sector has a main SE-NW direction.		

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
				Aeolian transport has also a great importance but in this case the sand dunes evolve from North to South (Servera, 1997). Thus in the studied zone the longshore sea transport has a S-N direction and the eolian one has an N–S direction.		
Spain	Valencia Autonomous Community, Castellón Province, Almazora	**Castellón**[118]	The study zone is known the Valencian Oval, from the Port of Castellón to the mouth of the Mijares River, including the beaches of the Serrallo, Ben Afeli and De la Torre.	Coastal characteristics: • Study area: 3,05 km • Type of coast: beaches (with pebbles, gravel and sand) • Tidal regime:	Socio-economic activities: Industry, agriculture and tourism	Engineering techniques: Serrallo Beach: groyne Ben Afeli Beach: detached breakwater and artificial nourishment De la Torre Beach: short breakwaters and artificial nourishment

[118] Source: Eurosion http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			The section is regressive by the concurrence of factors that affect their feeding. On the one hand, the section is leeward (downdrift) of the Castellón Harbour and on the other hand, the regulation of the Mijares River and the city-planning pressure on beaches. This causes an important erosion of adjacent beaches, characteristic of a dominant coastal transport towards the south, causing the disappearance of the dunes, exposing to low	micro tidal (around 1m) • Wave climate: predominant wave direction= NE		Policy options: Hold the line The main functions of the coastal zone are related to the industry and agriculture (orange trees). The problems of erosion have been tried to mitigate with hard works of engineering, that have made vary the alignment of the coast (2º in average value), being faced the resultant of the surge and a net coastal solid transport in this insignificant zone: • Serrallo beach: 1,400m long, located after the Port of Castellón, only has submerged beach, being the coastline a great longitudinal revetment made to restrain the erosion and to protect of the marine invasion. • Ben Afeli beach: 450m long and 40m of average width, present two detached breakwaters that form a gravel beach.

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			territories to continuous floods. The variation of the sea level next to 1m, is crucial because in the precoastal area, great zones with level next to the sea level exist, since they are formed by coastal barriers and old saltmarshes, reason why any variation of the same one can have influence in the future evolution of the coast.			beach. • De la Torre beach: 8 groins cause its width variation between 45m and 15m. Its length is of 2,200m and is composed by gravel. In these beaches the works have been oriented nonsingle to the fight against erosion but also to beach creation. The total barriers to the sediment passage, as in this case are the Port of Castellón, suppose the maintenance by means of artificial works of hard engineering of the beaches that are to leeward of the obstacle. Of this form, while the obstacle stays, the erosive problems of the adjacent coastal zone waters down will be more and more severe, needing continuously to invest in projects of regeneration and sand contribution, as well as in new defensive installations that maintain the coast and

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
						avoid the backward movement of the coastline. In fact, in the coast section, the Ministry of Environment has projected new engineer installations that will reinforce the existing ones already.
Spain	Catalunya Autonoumous Community, Tarragona province, Amposta	**Ebro Delta**[119]	The Ebro Delta is located in the northeast coast of Spain, in the province of Tarragona. It represents the main coastal delta of the Iberian Peninsula and one of most important of the Mediterranean. Morphologically it presents a deltaic front, in which locates the present mouth of the Ebro River	Coastal characteristics: • Study area: 50 km • Type of coast: delta, beaches (with fine - medium sand) and dunes • Tidal regime: micro tidal (0,25 m) • Range of waves : mean Hsig = 0,7m and T = 4s ;	Socio-economic activities: Natural park, agriculture, fishery, aquiculture, hunting, industry (salt), tourism At the moment, the performances in the deltaic coast are marked by the presence of the Natural Park of the Ebro Delta.	Engineering techniques: Dune nourishment, wind traps, revegetation, beach drainage Policy options: Hold the line, Do nothing, managed realignment The actions of coastal engineering have gone fundamentally to the preservation and recovery of the environment, trying to palliate and/or to diminish the impacts of hard engineering measures. The performances will have to be directed to the integration of the natural and human

[119] Source: Eurosion http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
			and two spits that partially close the Fangar and Alfacs lagoons, located north and south respectively. The spit of El Trabucador, that shows an approximated width of 250m and 6km long, is closing the bay of Els Alfacs in the south. The coast length is of about 50km and presents an emerged area of 325km2. The predominant wave directions are North, South and East, which produce sediment transport towards the northern and southern	Predominant wave directions: N, E, S.		aspects, using criteria of sustainable development, that allows to make compatible the different uses of the delta (fishing, agriculture, extraction of salt, tourism) with natural and unique ecosystems from biodiversity (flora and fauna).

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			hemideltas. The morphologic configuration of the Ebro Delta causes the existence of zones with different behavior with respect to coastal dynamics, alternating beaches with erosive character (river mouth, Marques and Pal beaches and Trabucador Spit) with beaches whose tendency is accretion (Fangar Spit, Alfacs Spit and Eucalyptuses Beach). Other factor that affect their erosion is the river damming. The Ebro Delta presents exceptional			

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			values of natural heritage. Represents the second more important aquatic habitat of the western Mediterranean, after the French Camarga. Its low altitude causes a high vulnerability to erosion putting in danger all these values of difficult economic assessment.			
Spain	Autonomous com. of Murcia, San Pedro del Pinatar – San Javier-	**Mar Menor**[120]	The Mar Menor is a hypersaline coastal lagoon of 135 Km2 in surface area, located at the SE of the Iberian Peninsula, between the parallels 37º	Coastal characteristics: • Study area: 25 km ; Sedimentary cell: 50 km • Type of coast: beaches (with sand)	Socio-economic activities: Tourism and urban In relation to human occupation, the Mar Menor has experienced	Engineering techniques: Nourishment and groynes Engineering techniques: Nourishment and groynes Policy options: Hold the line, limited intervention

[120] Source: Eurosion http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
	Cartagena		38' and 37º 50' North latitude and the meridians 0º 43' and 0º 57' West longitude. The mean depth is 3 to 4 m, and the maximum depth is over 6 m. Such characteristics made the Mare Menor one of the bigger coastal lagoons from Europe and the Mediterranean. A sandy bar, called La Manga with 22 km of long, acts as a barrier between the lagoon and the Mediterranean Sea. It is crossed by five, more or less functional, channels or "golas". (Perez-Ruzafa,	• Tidal regime: micro tidal • Range of waves : mean Hsig =< 1m	varying changes over the last 40 years. From being a practically uninhabited place, with only a few families of fishermen living permanently on its shores, there is now a large human presence, above all in the months of summer. The human activities developed close to the lagoon include: salt mining, agriculture, fishery, industry, tourism and recreation, urbanisation and military uses. This	There is no a real, active policy concerning coastal erosion. Regarding the few interventions performed (beach nourishment and construction of groins), the main policy option has been to "Hold the Line", as promoted by public administration, commonly on a national level. It is important to point out that most of the nourishment performed on the continental shore of the Mar Menor is aimed at the creation of new beaches in a place where there was originally no morphology of sandy beaches. The main goal of these interventions was to try to attract more tourism.

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			1996). Erosion factors include mainly natural driving forces - winds, storms, waves and a rise in sea level. La Manga was created by marine currents and the effect of the wind and waves. The wind is the main factor influencing sediment transport in this area. Prevailing winds in the area are from the East component. The modification of the sea level will lead to important consequences for low coasts such as the		conjunction of many interests and uses made the Mar Menor the target of all type of aggressions during its recent history (land reclamation, the opening or deepening and extending channels, mining, urban and agricultural wastes, urban development, building sporting harbours, artificial beaches creation, etc) (Pérez-Ruzafa, 1996).	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			Mar Menor, in which the backward movement of the coast is ranked at around a meter per centimetre of rise in sea level. (Mas, 1994). The Mar Menor lagoon is an accumulation coast dominated by sedimentation rather than erosion, although in some specific places erosive phenomena are quite evident, emphasizing the full exterior of La Manga. The main erosion causes are land urbanization on dune system, updrift construction of the San			

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
			Pedro del Pinatar Port (1954) and enlargement of the El Estacio channel for the construction of a harbour.			
Spain	Catalonia autonomous community, Barcelona province, Garraf	**Sitges**[121]	The town of Sitges is located on the Mediterranean coast, 40km south of Barcelona. It has a coastal area of 18.840km long, which is made of cliffs and sandy beaches. There are 18 pocket beaches in the municipality's coastal area, 10 of which are in	Coastal characteristics: • Study area: 16 km. • Type of coast: beaches (fine to medium sand, shingle) and soft rock coast • Tidal regime: microtidal • Range of waves: dominant SEA <1 m	Socio-economic activities: Tourism, industry, marinas. Sitges economy depend enormously on tourism (basically the summer tourism), so the loss of beach is the main worry for all the stakeholders involved. Quarries and	Engineering techniques: Detached breakwaters, T-shaped breakwaters, groynes, artificial islands, beach nourishment Policy options: Hold the line To face erosion, the policy adopted by the government is hold the line. The measures adopted are both hard measures, such as groynes, detached breakwaters, T-shaped breakwaters, artificial islands and seawalls,

[121] Source: Eurosion http://www.eurosion.org/shoreline/index.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			front of the urban area. Beach and bottom sediments are sands of siliciclasthic origin, of light gold colour and fine to medium grain size. The driving forces that cause erosion in the coast are mainly the lack of sediment transport by the southwestwards longshore drift, and the east storms, combined with the effect of numerous groins and breakwaters, and marina docks, which retain sediments in their leeside. The major impact of the erosion is the loss of	high, H max about 4 m.	recreational ports are other economic sectors of the municipality.	and soft measures (beach renourishment). The numerous groynes retain the sediments that circulate in a NE-SW longshore drift, avoiding the feeding of the southwest beaches, which are the most affected by erosion, and worsening the problem of erosion. The marina docks northly, deviate to the offshore a huge part of the sediment load carried by longshore drift.

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
			beach surface.			
SPAIN	Catalonia	**Barcelona**[122]	The study area in the case of Barcelona is a coastal area in between the rivers Besos and Llobregat. The coast front of the Metropolitan area is 40,8 km long, 12 km of which in the city alone. The type of coast varies in relation to the geological nature of the region. There are numerous protected areas and they cover almost all the coast. urban expansion, water pollution, air pollution, soil pollution, coastal	coast, grass and rangeland; landscape/ports	Ancient history and great cultural identity and an economy historically linked to maritime activities, and with an increased dependence of the economy on the use of the coasts. The coast front of the Metropolitan area in the case of Barcelona has 3,8 million inhabitants. The commercial port of Barcelona is in economic terms the	pollution control, resource management, institutional strengthening, infrastructure development, biodiversity conservation, education/awareness

[122] Source: Priority Action Plan http://www.pap-medclearinghouse.org/eng/page001b.asp?zemljaID=12&shortID=65#65

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			soil pollution, coastal erosion, tourism/recreation, transport congestion, endangered species, habitat loss, Environmental risks (volcanic, geological, hydro-geological) and demand for protection of environmental sites, Abandonment and deterioration of the natural and cultural heritage.		principal Spanish port although it does not house any refineries and heavy industries. The principal sources of pollution of the coast are urban and industrial. The Llobregat river has no depurator at its mouth and the water of the Besos river are purified in the city's waste treatment plant.	
SPAIN	Tarragona	***Montroig***[123]	erosion due to up-drift barriers.	Morphodynamic “problems” in free-transport beaches are		

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
				normally associated to larger-scale modifications of the transport pattern. the resulting morphodynamic evolution depends on the selected timescale and cross- plus long- shore transport processes		
Spain	Catalonia	***Cape Tortosa***[124]	the area has suffered most erosion in recent years because it is the area of the delta that absorbs most wave energy (Serra, 1997). It is estimated that the linear regression has been close to 1,600m in 40 years (figure 13),			

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			which corresponds to a velocity of 39m/yr.			
Spain	Valencia	***Castellon***[125]	have faced extensive eroding problems caused by the existence of the port of Castellón and this has increased since 1961, when the last extension of its sheltering harbour wall was carried out. The result of preventive policy (see column)has been dramatic coastal erosion on Almassora beaches.	Southward littoral drift along this coast is interrupted by the Port of Castellon and the Serrallo industrial estate.		Local management actions carried out during the last thirty years, such as beach fill and dike construction, managed to prevent erosion and even to double beach area. However, seaside quality has considerably decreased and the nearby Mijares delta is now experiencing noteworthy erosion (Liquete et al., 2004).
Spain	Mallorca	***Alcudia Bay***[126]	A classical sandy beach	The type of erosion	Human activities can be	The first human construction that has

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
	Island		and dune that shows erosion and accretion at different places. The distribution of the erosion and accretion sites is mainly controlled by human constructions (dikes and harbor) together with the longshore transport and storms. It can be considered that there is a continuous or gradual erosion process related to the longshore transport, and intermittent erosion related to storm episodes. These two processes cause redistribution of the	observed at Alcudia Bay is a gradual sediment loss due to the S-N longshore transport. During storm events acute erosion is observed. Probably, the subsidence related to the sediment compaction must be greater than the tectonic one, but data on this aspect are not available. above the sediment of the area has mainly a bioclastic origin (more than 80%). The longshore currents do not supply additional sediment to the Alcudia Bay zone. A	divided in two main actions: Housing near or on the foredune and dune field (anthropic pressure), and sea activities. Housing on the foredune implies that the de dune system is no longer part of the coastal zone. This makes the coastal zone (dune/beach and foreshore) more vulnerable for acute erosion. On the other hand, the sea activities, especially in summer, cause a retreat of the Posidonia Oceanica	influenced the studied area was the dikes of the “S’Oberta” channel (end of the XIXth century) at the northernmost sector of the studied zone. Those dikes provoke a rupture of the longshore sediment transport that has induced a division of the northern sedimentary cell in two independent sedimentary cells

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			sediment. In some places of the studied zone the retreat has resulted in the destruction of the foredune, and at present waves are eroding the sand dune field. On the other hand, some places have undergone a sediment increase and the foredune is preserved. Causes of erosion are mainly related to the human activities in combination with restricted sediment supply. Moreover, it must be noticed that the fact	unique sediment supply that is independent from the sea are sediments transported by the small creeks, which can be considered almost negligible, and those sediments coming from the erosion of the sea cliffs located at the extremes of the Alcudia Bay. The sedimentary cell of the Alcudia bay is nourished mainly by the biological activity that takes place in the sea. The biological activity is strongly related to the Posidonia Oceanica.	prairie is one of the most important organisms of the beach system.	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			that the zone is located within a subsiding area (Muro - Sa Pobla Basin) more intense erosion process associated with the relative sea level rise cannot be discarded. Nevertheless, taking into account the seismic activity of the area, we could not expect velocities higher than 0.1 mm/year of tectonic subsidence.	Almost all the organisms that form the sediment of the beaches live around or depend on that plant. So, when we reduce the Posidonia Oceanica prairies we kill the sediment factory of the Mallorca beaches. As there is not any external supply when the Posidonia Oceanica prairies are destroyed we are inducing a beach retreat. Another important aspect related to the Posidonia Oceanica is that during storms, dead parts are		

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
				deposited on the beach. Those fragments form a little wall reducing the wave energy, diminishing the effects of the storms on the beach system.		
Tunisia		**northern coast**[127]	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 mouths			
Tunisia	25 km from the established	***Zouaraa***[128]	Serious erosion of the beach near the river mouth	A linear beach, approximately 17 km	A dam plays an important role in the	

[127] Source: REPUBLIC OF TUNISIA, MINISTRY OF ENVIRONMENT, AND LAND PLANNING (2001).

[128] Source: REPUBLIC OF TUNISIA, MINISTRY OF ENVIRONMENT, AND LAND PLANNING (2001).

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
	resort of Tabarka near the Tunisian border with Algeria		by up to two metres had been experienced within two years of the dam initiation.	long, behind which is an extensive dune system that has been largely afforested.	strategic development of the area through the provision of irrigation and potable water.	
Tunisia		**Gulf of Tunis**[129]	the coasts configuration, and the importance of the lower level areas make different sectors of this zone very vulnerable to ASLR	The coast of the Gulf of Tunis, shows many forms of weakness caused by natural factors	it hosts the most important urban and industrial concentration of the country	The coast of the Gulf of Tunis, shows many forms of weakness caused by the conjunction of numerous anthropogenic interventions throughout a relatively long history.
Tunisia	north-eastern part of Tunisia	**Cape of Bon**[130]	coast, river basin and the adjacent coastal area, estuary, coastal forest, swamps/floodplains, rocky coast, grass and	1.1. The Dar Chichou forests: 6,041 hectares. This is a group of forests which fix expanses of dune, which were first	Human needs related to these natural systems (lagoon, forests, archipelago, oueds and estuary) are quite	The national policy is the coastal protection policy implemented by the APAL. Project's aims: overall policy, preparatory activities, development control, resource management, institutional strengthening,

[129] Source: REPUBLIC OF TUNISIA, MINISTRY OF ENVIRONMENT, AND LAND PLANNING (2001).
[130] Source: Priority Action Plan http://www.pap-medclearinghouse.org/eng/page001b.asp?zemljaID=20&shortID=91&start=start

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			rangeland, island, lagoon, peninsula; dunes and dune massifs; lagoons, barriers This project covered: 1- The Dar Chichou forests and the Oued Labid estuary: 11,991 hectares 2- The western Cap Bon lagoons: 450 hectares 3- El Haouaria mountain and the Zembra archipelago: 1,362 hectares The five sites studied contain a wealth of interesting biodiversity (around 35% of the endangered species on the Tunisian coasts).	undertaken under measures to prevent crop fields from being swallowed up by the sand. In the upstream stretch they include a complex of dunes made up of mobile, fixed and fossil dunes. 1.2. Oued Labid estuary: the coastal site linking the Port aux Princes site to the Oued Labid, covering 5,950 hectares. The Oued Labid is the area's main watercourse, transporting around 7 million m3/year. Its estuary communicates with the sea on an almost	varied. In the case of the lagoons, they are used for discharging industrial and urban waste; for the forests, apart from the illegal and improper hunting which goes on, the supply of wood and its by-products is used, and additional land created to serve the needs of growing urbanisation; for their part, the oueds, estuaries and the archipelago face threats more related to human pressure and farming	infrastructure development, biodiversity conservation, capacity building, education/awareness, monitoring, networking

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			The following points were noted: - Degradation of biodiversity in the wetlands and coastal areas. The main cause of degradation is the growing pressure of economic activity on the coastline. - The presence of some biodiversity of international importance, requiring particular protection and a management method for specific sites. - A lack of consultation between the population and the users on the one	constant basis. 2. The eastern Cap Bon lagoons: on the eastern side of Cap Bon. Comprises a string of lagoons stretching over 50 km, with an average length of 200m. They are separated from the sea by two low-lying dune systems. They communicate with the sea, but with the exception of Korba lagoon they dry up almost completely during the dry season. 3.1. El Haouaria mountain: the site covers	practices (creation of areas for intensive irrigated crops, over-grazing), unregulated hunting, tourist projects, and particularly the dam built on the Oued Labid, which will obviously change the parametres of the surroundings. We have also noted other environmental dysfunctions in the Dar Chichou forest, linked to intensive irrigated farming practices, use of chemical products,	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			hand, and local administrations and the associations on the other.	970 hectares, embracing virtually the entire tip of Cap Bon and including the entire area of the coastal djebel. 3.2. Zembra archipelago: made up of two islands in the North-Eastern part of the Gulf of Tunis, the natural extension of Cap Bon. The largest of the two, Zembra, lies 115 km off the peninsula and is flanked by two rocks- the Entorche to the North and the Cathedrale to the West.	and over-exploitation of the aquifer.	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
Tunisia		**Gulf of Hammamet**[131,132]	the coastal segment is anthropic. In this way, the sea sector erosion problems are raised in the tourist sector of Hammamet where some hotels have even lost an important part of their sandy beaches. faced with the threats caused by the accelerated sea level rise (ASLR), Tunisia is at risk to be more exposed and thus more vulnerable The Tunisian coast line	It is understood that, due to its geographical location and its climatic characteristics, Tunisia will certainly be very sensitive to the direct adverse effect of Climate Change	Over the last two decades, a major shift of population growth, urbanization, industrialization and tourism towards the coastal zone could be observed. The emerging problems involve a combination of rapid land use change, population growth driven to a migration from inland agricultural areas. The aesthetics and extent of the	depletion of water resources often accompanied by overexploitation of groundwater resources and consequent salt water intrusion in the immediate coastal zone, and pollution from unchecked economic development and insufficient waste and waste water management. These development conflict with the parallel development of tourism, which depends on the same resource basis but also on a clean and attractive environment, inland and coastal areas. Tourism, which is among the main strategic lines of the development of Tunisia, could suffer as a consequence of ASLR.

[131] Source: REPUBLIC OF TUNISIA, MINISTRY OF ENVIRONMENT, AND LAND PLANNING (2001).

[132] Source: SMART: Sustainable Management of Scarce Resources in the Coastal Zone Project Work Plan http://www.ess.co.at/SMART/b5.html

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			concentrates 2/3 of the total population, more than 70% of the economic activities, 90% of the tourists accommodation total capacity, and a great part of the irrigated agriculture.		beaches could be highly affected by ASLR. In addition, the infrastructures, notably those very close to the coast, will be threatened[133].	
Tunisia	Sfax South south-eastern region	**Sfax[134]**	coast, river basin and the adjacent coastal area, wetland, swamps/floodplains, grass and rangeland, island, sandy beach; Water Desalinisation Plan - Coastal erosion: Chaffar	- Water shortage: rainfall has been decreasing for several years (less than 200 mm/year), whilst the population is growing, largely due to people abandoning rural areas. The ground water	production of salt at saltworks Disorderly urbanisation and illegal land use, - Pollution of continental and seawater (from land-based sources),	Project's aims:overall policy, preparatory activities, pollution control, development control, resource management, infrastructure development, biodiversity conservation, urgent measures development, planning, monitoring, networking

[133] **Source: SMART: Sustainable Management of Scarce Resources in the Coastal Zone Project Work Plan http://www.ess.co.at/SMART/b5.html**

[134] Source: Priority Action Plan http://www.pap-medclearinghouse.org/eng/page001b.asp?zemljaID=20&shortID=91&start=start

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			beach is undergoing intensive erosion, visible year on year, Threatened species and loss of habitats: land-based sources of pollution have contributed to the loss of the Posidonia meadows, and some marine species have become endangered. The project site is part of the Sfax region in Southern Tunisia. This area is seen as the gateway to the desert, and the crossroads of routes between the Northern and Southern coasts. The relief	aquifers have become salinated. Drinking water is tapped from the aquifers in the north of the country, - Sediment movement: the oued Chaffar and the other watercourses transport various sediments into their estuaries, - The "red tide" phenomenon (algal blooms at sea) which persists from year to year,	- Air pollution from the SIAPE plant (Industrial Phosphoric Acid and Fertiliser Company) and other plants in the adjoining industrial zone, - Soil pollution caused by the storing of phospho-gypsum, the public rubbish dump, and the former vegetable water disposal points, - Population growth: 2.1%/year (from 1984 - 1994), Tourism/leisure: no	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			of the area is relatively flat and monotonous, with a semi-arid to arid climate, and with rainfall levels barely exceeding 200 mm per year. The prevailing wind is from the North East. The area is shaped like a mini gulf, stretching from the new fishing port to Gargour village and then the village of Chaffar, over almost 20 km. The sea is calm with quite a pronounced tidal range, which can reach 1.8 m.		tourism whatsoever in the area under study. The only tourism is in transit towards the South and vice versa. Recreational possibilities of minor import: bathing is officially banned on certain beaches. Recreational areas have been forgotten in many cases; they are currently starting to be rediscovered, - Excessive fishing: the marine fishing fleet makes up more than 40% of the national	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
					fleet, - Traffic congestion both on land and at sea: traffic in the town has eased somewhat since 2002, but when the study was conducted land traffic had reached saturation point. Sea traffic is also congested by the passage of fishing vessels (trawlers, etc.), cargo ships (phosphates, sulphur, salt, etc.), and oil tankers, - Intensive oil exploitation: oil and gas, and the passage of	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
					several pipelines both on land and at sea, Over recent decades, Sfax has undergone undeniable socio-economic development, allowing it to retain its position as second town after the capital. However, in spite of having 400,000 inhabitants in 1994, its population growth (2.1%/year between 1984 and 1994) is below the average for the country as a whole (2.3%), and also the national urban average	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
					(3.8%). This bears witness to the limited attraction which the town exercises over the out-lying areas in the immediate vicinity and further afield. The relatively low rate of population growth is compensated for by an employment rate of 32% in 1989 (compared with 31.4% for Tunisia as a whole), corresponding to an unemployment rate of 11.3% compared with 15.3% at national level. Sfax is also a leading	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
					producer of oil, poultry, fish and dairy produce, and many other products such as almonds and other dried fruits. It goes without saying that, as far as industry is concerned, Sfax often acts as an important magnet, attracting large numbers of investors as well as consumers and middlemen, all of whom contribute to its enhanced economic development.	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
Tunisia		**From El Kantaoui port, to Sousse**[135],	Beach erosion		tourism	
Turkey		***Bay of Izmir***[136]	The Bay of Izmir is one of the largest bays in the Aegean coast of Turkey, and extends about 24 km in east-west direction, with an average width of about 5 km. it consis of three sections according to the topography and hydrology: the Inner Bay, the Middle	The water depth in the bay ranges from 10 m in the Inner to 60 meters in the Outer Bay.. On the south shores of the Bay , much of the land is covered by high hills with steep slopes and there is a narrow alluvial plain along the shoreline. In contrast to	The existing population of approximately 2 million will, according to some estimates, double in the next 30 years. Izmir, together with a number of "satellite" cities in its vicinity, is a major industrial area. In addition to large	

[135] Source: REPUBLIC OF TUNISIA, MINISTRY OF ENVIRONMENT, AND LAND PLANNING (2001).

[136]Source: Priority Actions Programme, Regional Activity Centre(1996).

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			Bay, and the Outer Bay. The Inner and Middle Bays do not have appropriate capacities for water exchange and autopurification	the south shore, the north shore is characterized by low, flat river deltas. However, along the eastern side of the north shore, there is an area which is covered by fairly high hills. Similar to the south shore, the north shoreline is also characterized by a narrow alluvial plain. At the east end of the bay, there is a valley known as the Bornova plain. This alluvial valley is about 5 km wide, and slopes gradually to elevations about 80-90	industrial establishments, a large number of small- and medium-scale enterprises have flourished in and around the city. Environmental control over these establishments does not seem to be very efficient. Their residues are discharged untreated into numerous streams running into the Inner Bay of Izmir, adding to its already high level of pollution. The continuing	

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
				meters at its eastern end. This area is used both for agricultural and industrial purposes.	industrialization of the area has been the response to an ever-increasing demand for new jobs. Some of the industries are located in watershed areas which are of vital importance for the water supply of the city.	
Turkey	Western Turkey	***Edremit Bay***[137]	There exists a significant decrease in the amount of sediment at the coast. In the last decade, the Altinova coastline has suffered from intense	Madra River, located between Altinova and Dikili, is the main sediment source of the coastline. Bathymetric	Urban development, reflecting high population growth, Urban waste waters are one of the major sources of	The dam located on the Madra River, erosion-control works in the Kozak region, sand taken from the Madra River bed The system of resources management in the area is split between four administrative and decision

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
			chronic and permanent erosion, and thus, the shoreline has retreated approximately 600 m during the last two decades and 18– 20 m in the last year Loss of cultivated land to residential purposes on the one hand, and increasing demands for agricultural produce on the other, have reduced the nature conservation areas, decreased the level of flood protection, and increased soil erosion.	measurements in Altinova and the vicinity of the Madra River mouth reveal the existence of a deep pit, which prevents the feedback of sand removed from the region through storms and accelerates the erosion rate at the coast, because the sand input through the Madra River has decreased dramatically. This deep pit is a dominant morphologic factor causing coastal erosion	pollution of the bay Wastes discharged by the industries situated around the bay port facilities in the eastern part of the bay, and navigating vessels, present a constant threat to the bay ecosystem.	making levels, namely, the central government, the Governorate of Izmir, the metropolitan, and the district level. The existing mechanisms of decision making require much better coordination among these levels. There is no single authority entrusted with the environmental management of the entire area.

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	**Policy & Management**
Turkey		***Seyhan, Ceyhan and Goksu*** deltas[138]	The Seyhan, Ceyhan and Goksu deltas are where the most active shoreline changes have been occurring in the northeastern Mediterranean.			
		Seyhan	on the mouth of the Seyhan River, progradation summed up to about 98,437,625 m^2 with a rate of 28,304 m^2 /yr until 1954. Construction of a dam on the river in 1954 greatly reduced sedimentation in the delta and erosion		dam	

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

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			started at a rate of 24,696 m^2 /yr. As a result, from 1954 to 1995, an area of about 1,012,536 m^2 has been lost due to coastal erosion, and the delta became retrogradational.			
		Ceyhan	On the mouth of the Ceyhan River, however, the total amount of progradation from 1947 to 1995 is about 3,097,745 m^2. About 90 percent of this progradation occurred with a rate of 74,977 m^2 /yr before the construction of a dam on the river in 1984. The rate of progradation after 1984			

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			reduced to about 29,418 m^2 /yr, and only 323,597 m^2 prograding occurred from 1984 to 1995. To the northeast, an area of 835,779 m^2 was eroded by the sea due to no sediment influx on the abandoned Ceyhan River channel in Yumurtalik Bay between 1948 and 1995. The total amount of progradation, from 1956 to 1995,			
		Goksu	on the mouth of the Goksu River is 398,445 m^2. To the southwest, due to coastal erosion at a rate of 4,548 m^2 /yr from 1951 to			

Country	Area	Name	Coast and Erosion Description	Physical Characterization	Anthropogenic Characterization	
					Social –Economic Facts	Policy & Management
			1995, the lighthouse at Cape Incekum is now lying under the sea. The total amount of retrogradation here is about 200,125 m^2			

Executive Summary.

The Mediteranean Sea Coastal Zone

State of Erosion, Hazards and Risk assessment and

Problems to be Solved

1. Status of Climate Change Induced Sea Level Rise in the Mediterranean

Sea level rise due to greenhouse effect forecasted for the Mediterranean has been confirmed from recent studies conducted within the ESEAS-RI EC project as well as by other groups.

The present rate assessed is about 0.5cm/year during the last 14 years. To this decadal fluctuations of between -1.5 and +1.5cm/year have been measured, the cumulative effect being of about -1.5cm/year in the Ionian Sea region, about 2cm/year in the Eastern Mediterranean region surrounding Crete and only about 1cm/year at the coasts of Egypt, and Israel. The decadal fluctuations appear to be related to the Southern Atlantic Oscillation (El Nino – La Nina) via the monsoons penetration in the Eastern Mediterranean. The long term sea level rise due to greenhouse effect assuming the business as usual (BAU) scenario are: for 2025: +3cm to +14cm; for 2050: +5cm to +35cm and for 2100: +9cm to +88cm.

2. Status of Coastal Erosion in the Mediterranean due to Anthropogenic Impact

Anthropogenic impact on coastal erosion is an important factor which has imposed the present state of a significant number of beaches on the coasts of the Mediterranean. This is expressed mainly by construction of coastal structures, blocking most of the longshore sand impact occurred at the Nile delta coast, following the cessation of sand arrival to the sea from the Nile river after the construction of the Aswan dams. Additional erosion impact has been encountered due to local sand mining (e.g. Israeli and Lebanese coasts) or sand dredging. The last erosion contribution is due to the lack of beaches maintenance over most of Mediterranean coasts, which should have been done primarily via sand by-passing or artificial sand nourishment. Future development of coastal structures is estimated to further increase anthropogenic induced coastal erosion, unless active routine actions including especially sand by-passing and artificial san nourishment will be done.

3. Forecasts of Coastal Erosion due to Climate Change and Anthropogenic Causes.

The forecasted sea level rise and blocking of longshore sand transport are estimated to further increase and accelerate coastal beaches and cliffs erosion, impacting local residents, tourism, recreation and business. Given the fact that more than 70% of the world population lives now close to the coasts, and given the fact that about the same rate of European population uses the Mediterranean coasts for recreation, this impact will reduce the availability and quality of Mediterranean beaches for recreation, tourism and residence. Consequently active actions need to be taken to reduce the erosion as soon as possible.

4. Forecasted Impact of Coastal Erosion due to Tsunami Events in the Mediterranean

The Indian Ocean tsunami event in December 2004 accelerated the awareness to tsunami potential encounter and damage, in particular in the Mediterranean. Last November, following UN assembly decision, the 1st session of the Intergovernmental Coordination Group for the North-Eastern Atlantic, the Mediterranean and connected seas Tsunami early Warning System (ICG NEAMTWS) was held in Rome under the UNESCO umbrella. The meeting UN member states participants decided unanimously that the group will immediately start the development of the early warning system and implement it within two years, because of the relatively high risk for tsunami events, in particular in the Mediterranean. Among the various items which will be addressed, tsunami modelling of development, propagation, run-up and flooding have been also included. There is a clear potential impact of severe coastal erosion of coasts impacted by tsunamis, as well as the need for protective means such as submerged artificial reefs to reduce focusing and run-up in particularly sensitive coastal sectors. It is however estimated that these will be investigated within the ICG-NEAMTWS activity.

C. Review on the available coastal erosion models implemented in Mediterranean and Black Sea

1. Introduction

The construction of marine structures in coastal environments introduces a variety of changes in the morphology of the sea bottom and the coast itself. In the Mediterranean coasts an increasing number of maritime works affect significantly the morphology of coastline and coastal seabed. Additionally with the anthropogenic causes, the nature causes of coastal erosion produces periodical changes in sandy coasts, dunes, deltas etc. creating environmental and social problems, in all the Mediterranean countries. In the last decades, 1-D, 2-D, 3-D numerical simulations is a common aspect in forecasting and monitoring these alterations in order to provide to the designers a better view about the problems that could revealed after a construction. Additionally, models can play a fundamental role in the decision phase of the appropriate measurement method that it should be used in its erosion case. For example, planning nourishment in the context of a multi-years management strategy requires more significant prediction skills than available in the past and an awareness of dealing with uncertainty.

The adoption of simulation models represents a technique to answer ''what-if'' type of questions (Capobianco et al., 2002). The fundamental role of models is that of reducing as much as possible ''surprises''. Surprises that might be expressed in terms of failures and in terms of costs. The need that is clearly connected to such exigencies is that of handling and properly communicating uncertainties, as well as the need to properly assess the economic and environmental implications of modelling failures.

Some of the most common models are listed below followed with specific implementations in the Mediterranean region.

2. Delft3D Model

2.1 Model description

The integrated modelling system Delft3D was designed to deal with many different physical, chemical and biological processes in estuaries and coastal seas. The system can be used for the following areas of application. The system can be used for the following areas of application:

- hydrodynamics,
- waves,
- sediment transport in the water column as well as at the bottom,
- morphological evolution of the bottom,
- water quality,
- particle tracking for water quality and
- ecology.

All processes can be simulated in a two- as well as three-dimensional way, which means that vertical differences within the water column are either resolved (3d) or not (2D). Beyond simulation of the above mentioned processes, the integrated modelling system Delft3D does also provide methods for grid and bathymetry generation, graphic display, data analysis as well as data extraction. Some components are already integrated with GIS.

2.2 Model implementations

Israel Coast

In 2000, following a cooperative agreement between Israel and The Netherlands, a joint has been carried out for the sedimentological impact assessment of artificial islands on the Israeli coast. The study combined extensive field meteo-marine data gathering and analyses (waves, sea-level, currents, wind, sediments, geo-morphology, fill material sources survey, etc.) by the IOLR, sedimentological modelling (2-D Delft3D). Of varius island shapes, two were selected as the most appropriate: a tear-drop shape for residential, industrial or environment uses and a rectangular shore parallel shape for an offshore airport. The modelling included investigation of relatively long term affects(30 years and extreme storm conditions impacts on the central coast of Israel from Palmachim to Bet Yanai.

Egypt Coast

Numerical simulations were performed using DELFT3D to investigate erosion and sedimentation problems at Rosetta promontory and to propose alternative countermeasures to mitigate the coastline erosion at the southwest coastline of Rosetta (Ahmed et al 2004). The other objective of this study was to maintain the eastern and western embankments that were con-structed in 1991 around the Rosetta waterway outlet at a foundation level of -6m. The grid size of the modeled area was 25 x 50 m2 at the nearshore region of the southwestern coatsline of the Rosetta promontory while it was 25 x 40 m2 at the Rosetta waterway. Input data for the four modules, wave, current, sediment and bottom modules were prescribed and the model was executed to predict the bottom evolution after one year starting from September 2001. Figure 1 shows the 2DH morphological evolution for groins at left panel and detached breakwaters at the right panel.

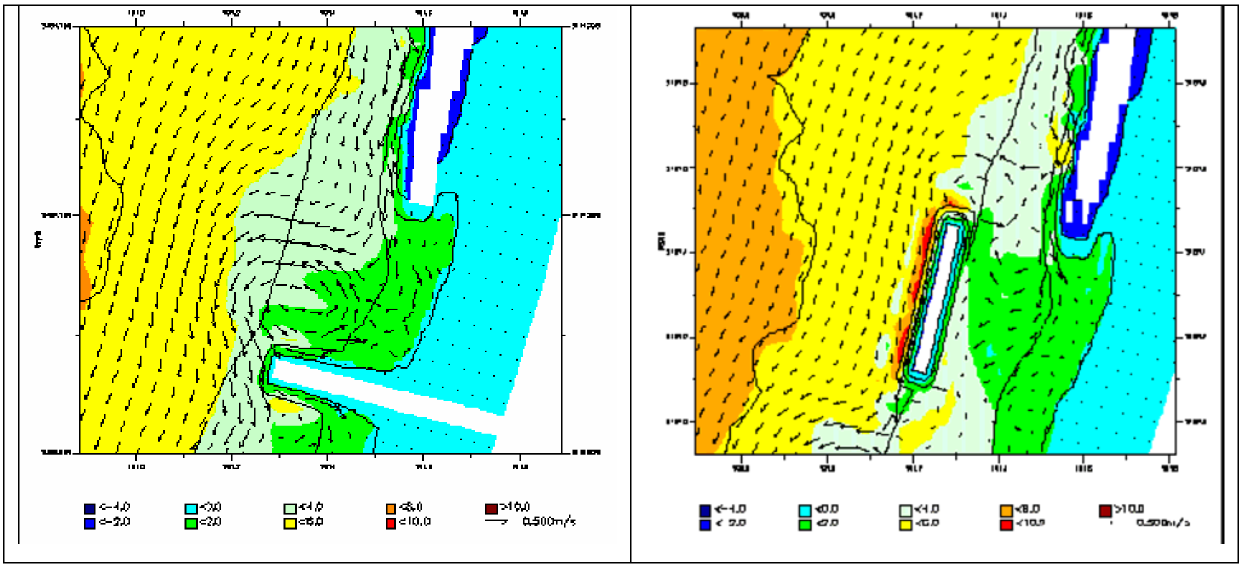

Figure 1. Prediction of the morphological evolution for groins (left panel) and detached breakwaters (right panel) immediately southwest of the western embankment (Ahmed, 2004)

3. Generalized Model for simulating shoreline Change (Genesis)

3.1 Model description

In its original version, the GENESIS shoreline-response model (Hanson 1989) allows calculation of shoreline response for a wide variety of coastal features and engineering activities, under the assumption that wave-generated currents dominate the longshore sediment (typically sand or sand-sized particles) transport. These features and activities include protective measures such as groins, jetties, seawall, beach fills, bypassing operations, and linear or point sources and sinks of sediment. Coastal structures and beach fill can be introduced in almost arbitrary numbers, locations, and combinations. Other processes included are wave transmission through structures, sediment passing through or by groins and jetties, wave diffraction from multiple structures and headlands, and multiple wave trains (e.g. wind waves and swell from different directions). However, the original GENESIS model also has limitations, of which a significant one is the lack of capability to represent tombolos.

3.2 Model implementations

Black Sea

In 2004, a study that presented a methodology for quantifying impacts of dredging on shoreline change, was based at GENESIS model (Demir et al., 2004). A combination of both analytical and numerical modeling techniques was employed, and the method could be applied to any site for which appropriate input data are available. Direct and indirect impacts of the dredged pit on sediment transport were considered. The direct impact leads to a loss of sediment from the dry beach via infilling of the dredged pit. The secondary impact results from modification of the nearshore wave conditions via the modified bathymetry. The presence of the dredged pit may lead to changes in the location of wave breaking and to modification of the wave field through refraction and, to a lesser degree, diffraction. These changes lead to modified longshore sediment transport patterns that alter the shoreline planform. Note also that while dredging for beach nourishment generally does not result in a net loss of sand from the littoral system, dredging for construction aggregate does, and therefore is a more severe concern. The impact assessment methodology was applied to a site on the Turkish Black Sea coast near Istanbul, where marine aggregate is used to meet construction demand, and where regulations regarding marine dredging are not well established.

Egypt Coast

In 1997, numerical modeling was utilized for the first time to estimate the shoreline changes during the planning of a private pleasure marina in the Gulf of Suez (Abul-Azm & Rakha, 1997**)**. This study was made to compliment an environmental impact assessment study (EIA) requested by the Egyptian Environmental Affairs Agency (EEAA). The impact of the marina on the sediment budget was investigated using GENESIS program. One of the main reasons of the study was to confirm the choice of the marina location to ensure minimum erosion to the shoreline. In the model, the sediment transport calibration constants were determined using the results of the two surveys and based on the sediment transport rate. Two locations of the marina was tested against minimum erosion in the down drift side of the marina.

4. SBEACH model

4.1 Model description

SBEACH (Larson & Kraus, 1989), is a numerical simulation model for predicting beach, berm, and dune erosion due to storm waves and water levels . Assumed in application of the model is that beach profile change during a storm event is dominated by cross-shore processes, and longshore transport effects on profile change are negligible. Application of the model is presently limited to profiles with noncohesive sediments, with no exposed reefs or bedrock. The model does not account for variations in profile response due to localized longshore effects (e.g., in the vicinity of a groin) or interactions with tidal currents. SBEACH was developed and tested based on analysis of laboratory experiments conducted with prototype-scale wave heights and periods, together with physical considerations of profile evolution and coastal processes.

4.2 Model implementations

French coast

In 2002, Sabatier et al. investigated beach change from dune to the closure depth, along the Rhône delta shoreline (Mediterranean sea), in the microtidal environment of a dissipativebarred beach. The survey was based on 38 profiles recovered during one year in order to describe the beach morphology in relation to wave, wind and sea level. A bi-variate analysis is used to find the relationships between the beach morphology (dune, berm and bars) and wave, wind and sea level characteristics. The results show that onshore-offshore bar movement is in relation with wave intensity, but not clearly correlated with the beach volume change. SBEACH, was used on the data. After several tests, the better results over-predicted the beach change during erosional conditions and did not simulate satisfying accretional events during fair-weather conditions. This numerical model was inappropriate for, at least, the investigated beaches change. One piece of explanation could be that the model was built for long wave conditions and not for short wave ones as encountered in the Mediterranean sea. In situ measurements and modelling results are presented in figure 2.

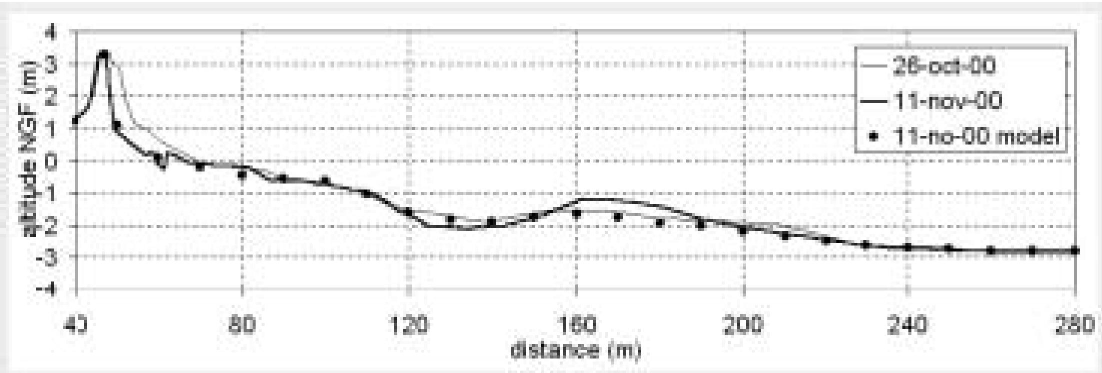

Figure 2. Modelling results and in-situ measurements featuring coastline changes (Sabatier et al. 2002)

5. UNIform BEach Sediment Transport (UNIBEST)

5.1 Model description

UNIBEST (UNIform Beach Sediment Transport) is a generic term for a software package that computes sediment transport along a uniform sandy coast and the coastal behaviour during human interference or storm. The software package UNIBEST (Delft Hydraulics 1994) consists of four separate modules; UNIBEST-LT, -CL, -TC, and -DE. UNIBEST-LT (littoral transport) can be used for the computation of net sand transport in longshore direction and its cross-shore distribution. UNIBEST-LT supplies the boundary conditions for UNIBEST-CL (coastline behaviour), which can be used to assess coastline changes due to human influence (e.g. breakwaters, groynes). UNIBEST-TC (transport cross-shore) can be used to assess coastal profile developments due to wave action. UNIBEST-DE can be used to compute dune erosion, and is quite similar with the TC module, but is especially intended to compute the effects of stormy episodes.

5.2 Model implementations

Egypt coast

The model was used in the study of the shore line changes at Sidi Krir touristic village by Mohamed & Saad of the Hydraulics Research Institute, Egypt .It is located at the Northern coast of Egypt along the Mediterranean sea. A seawall has been built along the village to protect it against the wave attack. An artificial lake has been constructed in the village for recreation purposes. A shore parallel breakwater was constructed in front of the village at about 390 m from the shore line to create a water basin behind it. It was planned that the water is delivered to the artificial lake in the village through an intake pipe, which takes the water from the water basin behind the breakwater. Three culverts were made in the body of the shore parallel breakwater for water refreshment in the basin. Figure 3 shows the general layout of the site. An outlet pipe has been constructed to take the water out from the lake to the sea. It was found that the seawall at about 450 m east of the breakwater has collapsed and the water basin behind the breakwater was filled up with sand. Consequently, the intake pipe, which delivers water to the artificial lake is blocked with sand. The prediction of the morphological changes of the shore line was carried out for 10 years. The shoreline in !996 and the predicted one in 2005 are presented in figure 4.

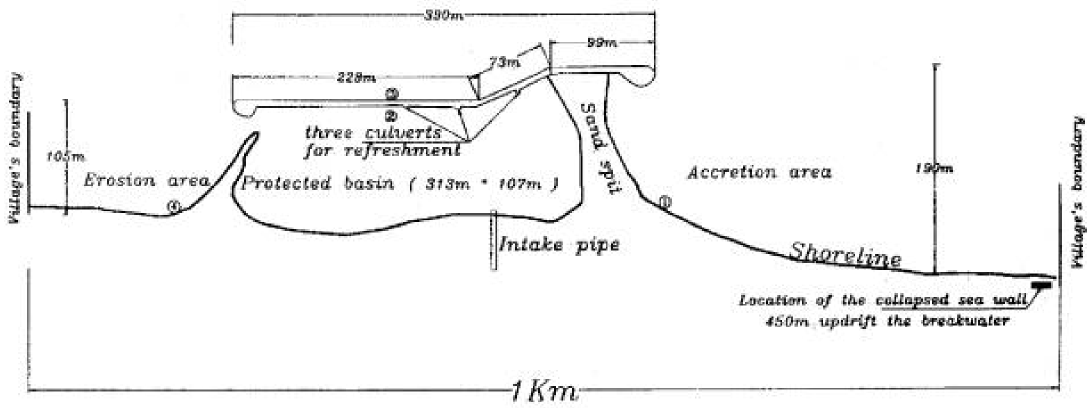

Figure 3. General layout of the project site

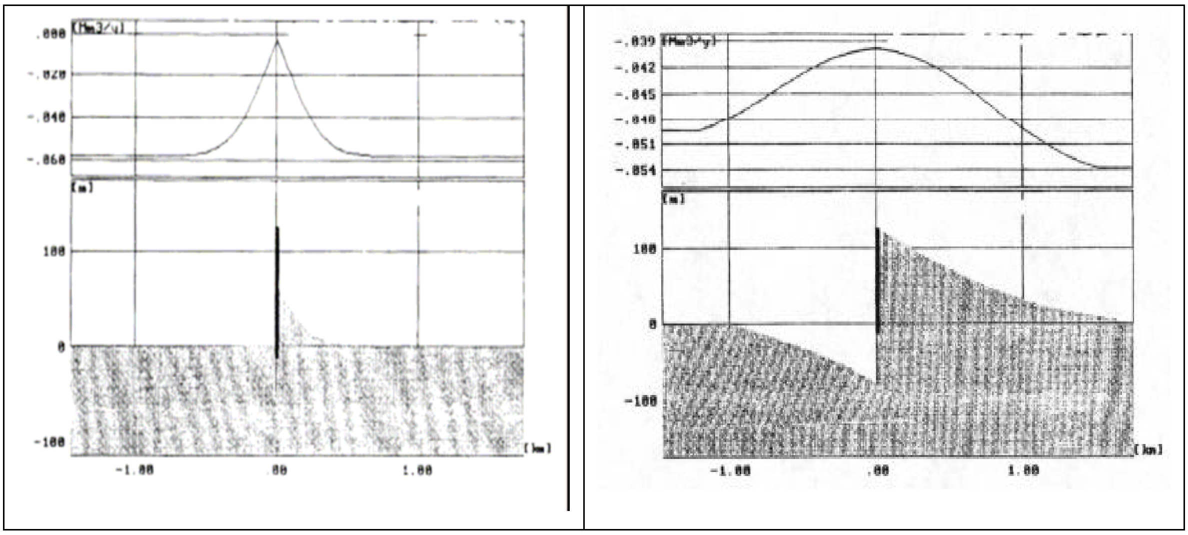

Figure 4. The shore line in 1996 (left) and the predicted in 2005 (right)

Black Sea

In 2002, numerical simulations were carried out using the UNIBEST-TC module of the UNIBEST package to study the cross-shore profile evolution in Yesil Irmak River (figure 5) after the construction of a pipeline project from a gas station in the southern Russia across the Black Sea to Ankara, Turkey (Chen et al. 2002). The simulation has been carried out for 5 years. The results show that the averaged cross-shore profile remain approximately the same. This confirms that the present crossshore profile is close to its dynamic equilibrium. The project site is located at a distance of about 5 km from the mouth of the Yesil Irmak River.

The coast at the project site is relatively straight and its orientation is about -5° with respect to the horizontal line which runs East-West.

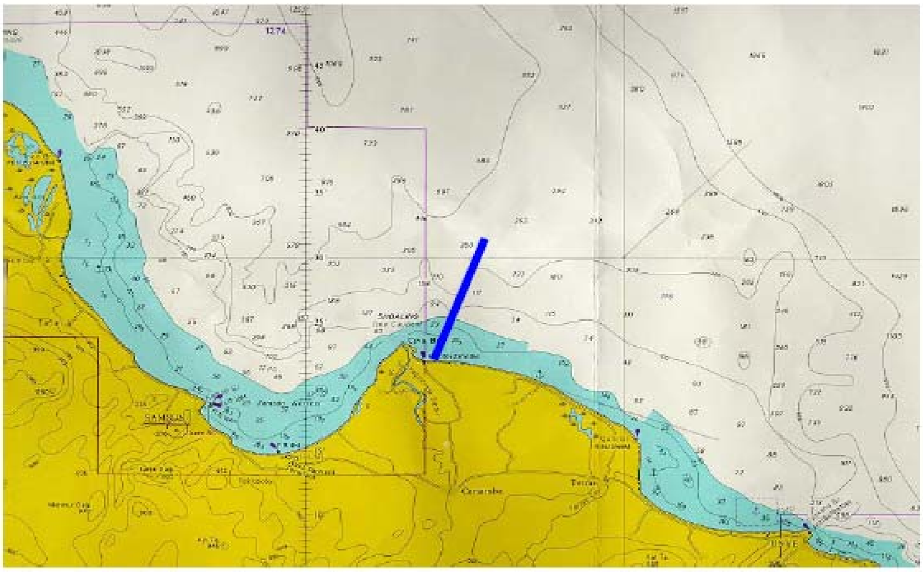

Figure 5. Landfall location at Turkish coast

6. Other numerical simulations

Black Sea

In summer of 2001, a research project was initiated to quantify the effect of sand mining on nearshore waves and currents, assess the magnitude of any mining-related erosion, and establish guidelines for acceptable mining rates and locations. For the experimental component of the project, a coastal research station is established on the Black Sea coast of Istanbul (figure 6) to measure shoreline position, beach profiles, waves, currents, and sediment characteristics. The theoretical component of the project is based on numerical model results, with validation of some aspects of the modelling via field data. Project outcome is site-specific, but the methodology can be applied at any coastal site that features primarily non-cohesive sediments. Two wave models are used throughout the study. These are ***REF/DIF-1*** (Kirby and Dalrymple, 1983) and ***SWAN*** (Booij et al. 1999). REF/DIF-1 is a 2-dimensional finite difference model which solves the mild slope equation with the parabolic approximation to compute the wave height and the wave number distribution over a mildly sloping bathymetry. SWAN is a finite difference model which solves the conservation of action density equation in a 2-dimensional water surface. It can simulate refraction and reflection of spectral waves but not wave diffraction. It can input wind conditions over model grid as an extra source term to the spectral energy and generate directional wave spectrum. Wave parameters obtained by REF/DIF-1 and SWAN are used to compute the shoreline evolution using a one-line model (Demir, 2002).

Figure 6. Coastline deformation due to mining operations on the Black Sea coast of Istanbul. (Courtesy of Istanbul Sand Miners Association, 1999)

Egypt Coast

The Nile Delta coastal zone exhibits a low-lying backshore which lies between+3 and –1m. from the mean sea level and is therefore vulnerable to a small rise in sea level. The three main Nile Delta promontories are the most exposed parts against direct wave attack in conjunction with the summer and autumn high tides. The cross-shore patterns of erosion and accretion versus texture of bottom sediment across a beach profiles have been studied for testing the ***Bruun model*** (Lofty & Frihy, 1995). This model assumes that the grain sizes must be uniform across the zones of beach profile erosion versus deposition. Results reveal that nearshore is composed of awide varieties of sand sizes, with sand becoming usually finer in the offshore direction. The eroded sand on the upper beach face is coarser and better sorted (average, MZ=2.63 φ and σ1=0.62 φ) than the accreted shallow offshore ones (average, MZ=3.1 φ and σ1=0.79 φ). Bruun model ignores the cross-shore sediment transport processes due to the hydrodynamic sorting that takes place across a beach profiles.

Italy coast

Bruun Rule and its more recent formulations, a modified model to predict shoreline retreat as a consequence of sea level rise was was applied to predict shoreline retreat along the Tuscany coast. Offshore ramp and inland morphology are here considered to improve the accuracy of the prediction. Polynomial equations have been used to fit beach profiles and a dedicated software was created to simulate beach evolution under different models and scenarios (Pranzini and Rossi, 1995)

Israeli Coast

A sedimentological impact study was carried out by IOLR in cooperation with Danish Hydraulics and Environment in order to investigate impacts of Hailfa's port breakwater expansion. To derive input data for the calibration and verification of the sedimentological models run at ***DHI (1-line LITPACK and 2-D MIKE 21)*** a series of field studies were carried out by IOLR. They included comparison of waterline position changes during 1945-1997, differential bathymetric maps, sand granulometric analyses and meteomarine data gathering and analyses (waves, currents, sea-level, wind). The major outcome of the field study resulted from the differential maps of the surroundings of the port. It showed that during 69 years since the port construction, about 5.3 million m^3 of sand have accumulated in the bay near the existing main breakwater, while another 0.7 million m3 have bypassed the breakwater (based on the model results) and fed the beaches of the bay. The study also showed that the majority of the sand is of Nilotic source, being of quartz type. This would correspond to an average net yearly transport of about 87,000m^3. Such an yearly averaged value misleads proper understanding of the coastal processes, as a major part of the above 6 million m^3 of sand were transported in a small number of rare strong Wly storm events (Rosen, 2002).

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