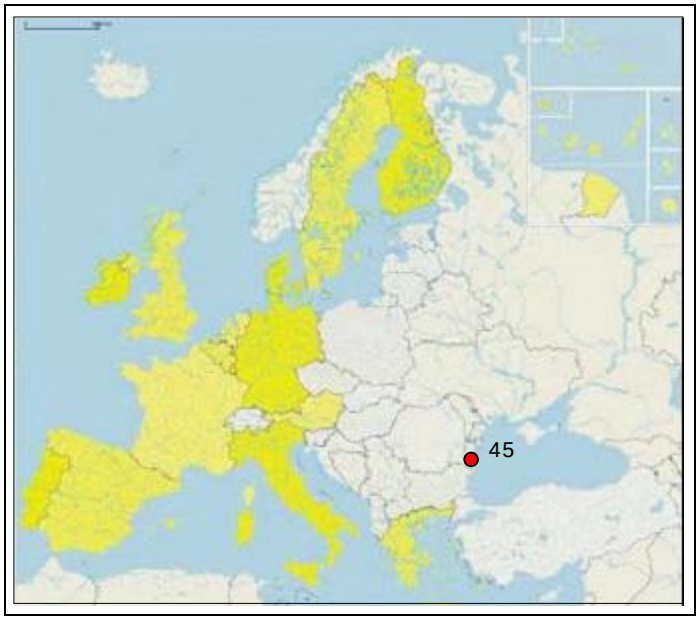
MAMAIA
(ROMANIA)



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1. GENERAL DESCRIPTION OF THE AREA

The Romanian Black Sea shore has a length of 244 Km, extending from the Chilia branch on the Danube delta, in the north, to Vama Veche, (Bulgarian border) in the south. It is divided into two major units: the Northern unit (between the Chilia branch and Midia Cape) and the Southern unit (between Cape Midia and Vama Veche). The Southern unit is primarily characterized as an erosive coast, with active cliffs, interrupted by small sand bars and barrier beaches. The Southern unit of the Romanian Shore is divided in three sectors, each of them with different shore protection solutions: 1) **Mamaia** sector; 2) Cape Signol – Eforie Sud; 3) Eforie Sud – Vama Veche.

The Mamaia sector from Cape Midia to Cape Singol is transitional and characterised by the occurence of the first promontories with active, high cliffs separated by the larges zones with accumulative beaches. The beaches are in certain places backed by littoral lakes

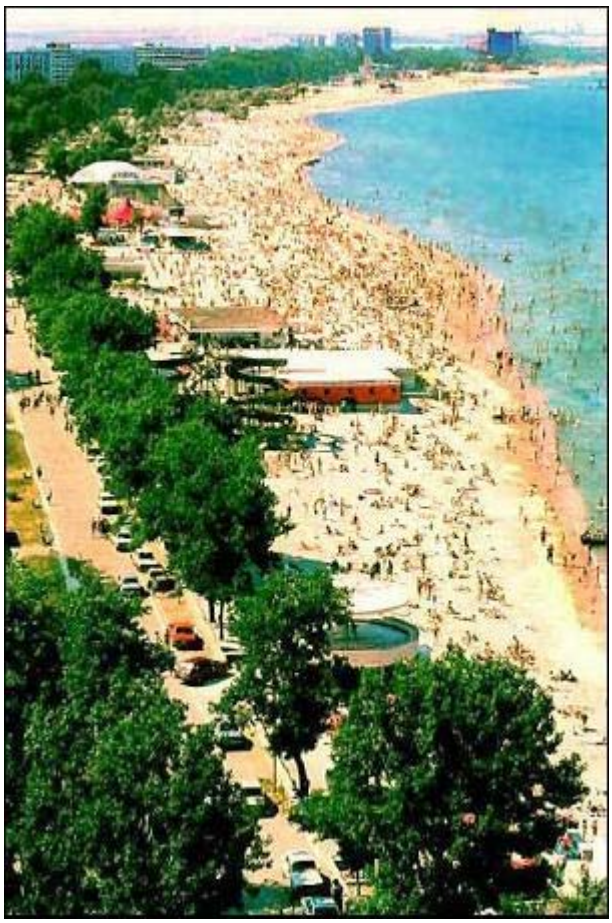

Fig. 1: Mamaia beach (summer period).

Mamaia beach is situated in the southeastern extremity of Romania, near Constanta city, on a narrow sand bar, 250 – 350 m wide, between the Black Sea and Siutghiol Lake. Mamaia is the largest touristic seaside resort of Romania, stretching 8 Km from north to south (Photo 1). An important concentration of settlements, industrial and harbour activities are located north and south of Mamaia resort.

1.1 Physical processes

1.1.1 Classification

- General: sand barrier
- CORINE: beaches
- Coastal guide: coastal plain

The Romanian shore has an almost linear configuration with the exception of build-up areas such as commercial harbours (Constanta, Mangalia and Midia), marinas and coastal protection works in the southern area (groins, breakwaters, etc), particularly in Mamaia beach.

Mamaia beach is one of the most famous beaches of the Romanian Black Sea. It is located close to Constanta city, on a narrow sand bar, 250 – 350 m wide. It is formed by sandy material that originates from the Danube. Between Siutghiol Lake (in the west) and the sea (in the east) (see Fig 2), a highway is connecting Mamaia resort with the Constanta city. In the past Siutghiol Lake was a marine lagoon, which became in time a fresh water lake. Mamaia beach is facing east and is a natural low sandy beach characterised by gentle sloping underwater profile down to - 6 m. The beach consists of alluvial sediments (brought into the Black Sea by the Danube and transported to the beaches by combined wave action and the north to south flowing current along the Romanian coast) and biogenic shells sediments (especially shells of Mytilus and Mia arenaria). The sand is fine and has a grey light colour.

Fig. 2: Map of Mamaia Beach.

1.1.2 Geology

The Romanian littoral was formed during the Upper Pleistocene high-stands and in the Holocene. Its present day geomorphology expresses the interaction of the river (sediment and water discharges) and the sea (waves and littoral currents, sea level changes). Beach sediments consist of terrigenous, organogenous and calcareous sand. Terrigenous sand, from the Danube is predominantly found in the northern sector, and makes up to 87% on the beach and up to 95% in the nearshore zone. Organogenous and calcareous sand are found in the southern zone and make up to 98% of the beach sediments and up to 80% of the nearshore sediments. . Shells of Corbula, Cardium, Mya in the northern zone, and Mytilus in the southern zone, are the sources for organogenous sand.

The grain size of the beach and nearshore sediments ranges from predominantly fine to very fine sand, including shell fragments and clay. Along the shore the grain size varies parallel tot the shores. The foreshore zone predominantly contains shell fragments, coarse and very coarse sand. Small quantities of fine sand occur predominantly from 0.5 m to 10.0 m depth. On the whole, the medium diameter of the grains decreases seaward (0.15 - 0.10 mm.). Nowadays, the contribution from different sand sources is decreasing due to a number of factors. The anthropogenic impact can be considered the worst factor, with negative influence on coastal evolution in the last decades.

1.1.3 Morphology of the coast

In the last decades erosion has affected the entire beach of Mamaia, where important beach losses were registered. Erosion processes are more intense during winter, when storms are more frequent and stronger. Storms have induced deficits of beaches sediments and damaged the tourist facilities. During the summer, storms are less frequent and their intensity is weaker, however, the beaches do not restore completely and consequently the sedimentary budget remains negative.

More then a half part of the beach is protected by “hard” works consisting of 6 breakwaters parallel to the shoreline and a groin in the southern part (see Figure 3). The shoreline evolution of Mamaia beach is strongly influenced by the Midia harbour dikes. The sand supply of the longshore drift is trapped upstream of the Midia harbour dikes, causing sediment starvation of the Mamaia beach and the remainder of the Romanian southern coast, where the other touristic beaches are located.

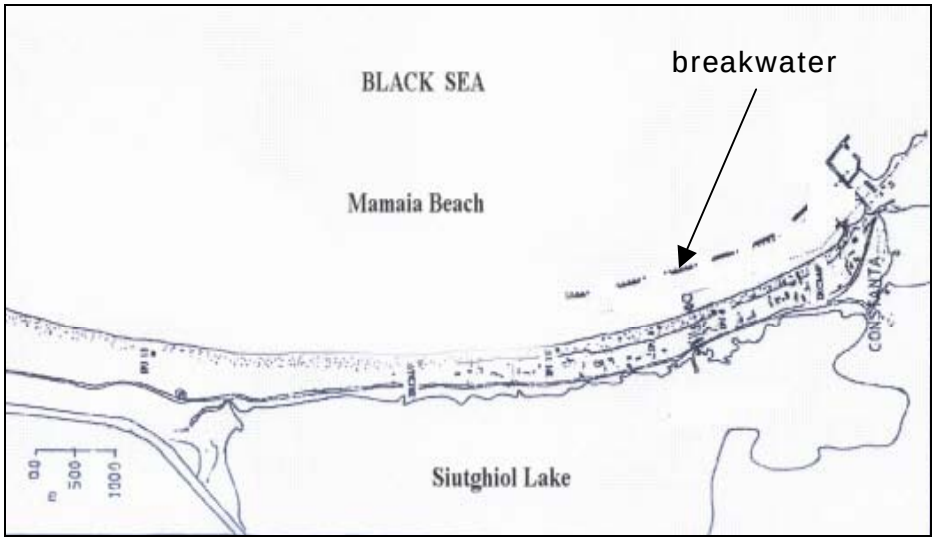

Fig. 3: “ Hard” Coastal protection – breakwaters.

1.1.4 Physical processes

Mamaia is acting as a coastal cell due to its position between Cape Midia in the north and Cape Singol in the south. The natural driving forces wind, waves and currents) combined with anthropogenic impact on the coast, result in increased erosion of the beach. The waves and currents during severe storms damaged the beach touristic facilities in Mamaia. In

addition temporary sea level rise, due to wind set up, contributes to the erosion process mainly in winter.

The predominant wind direction is from North, and 80% of the storms belong to this direction in 20 years (1974-1993) along the Romanian shore. Statistic tests of wind direction indicate also a high value of the coefficient of stability during storm situations with strong winds (Diaconu, 1994). Mean duration (about 30 hours) and maximal duration of storms (more than 130 hours) are recorded for wind from the North.

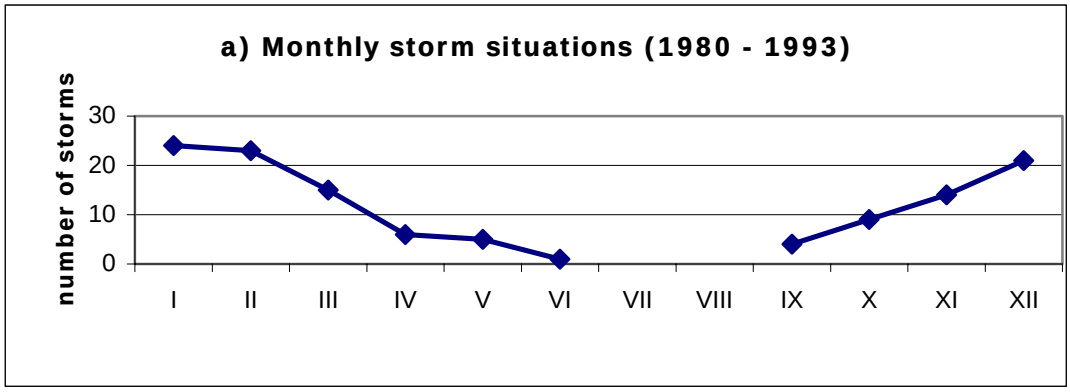

Fig. 4a: Monthly storms' situations (1980-1993).

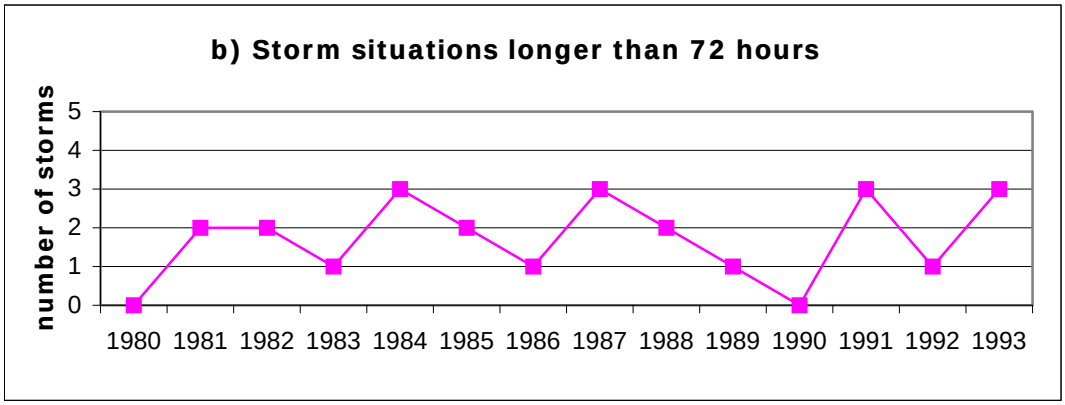

Fig. 4b: Storm situations longer than 72 hours (1980-1993).

Waves characteristics

Maximum wind speed is about 40 m/s. Maximum wave height during these storms is about 9.5 m and about 8 m near the shore (Chertic et al., 1992).
The North-South orientation of the Romanian shore the bathymetric contours determine the asymmetry of wave propagation. Winds from West have a confined fetch and wave crests run parallel to the shoreline because a refraction in the shallow water near the shore. The highest values of the average wave parameters are recorded for waves from the East direction, perpendicular to the shore: length (Lm) is about 34 m, height (Hm) about 1.2 m and the period (Tm) about 5 sec (see fig.5).

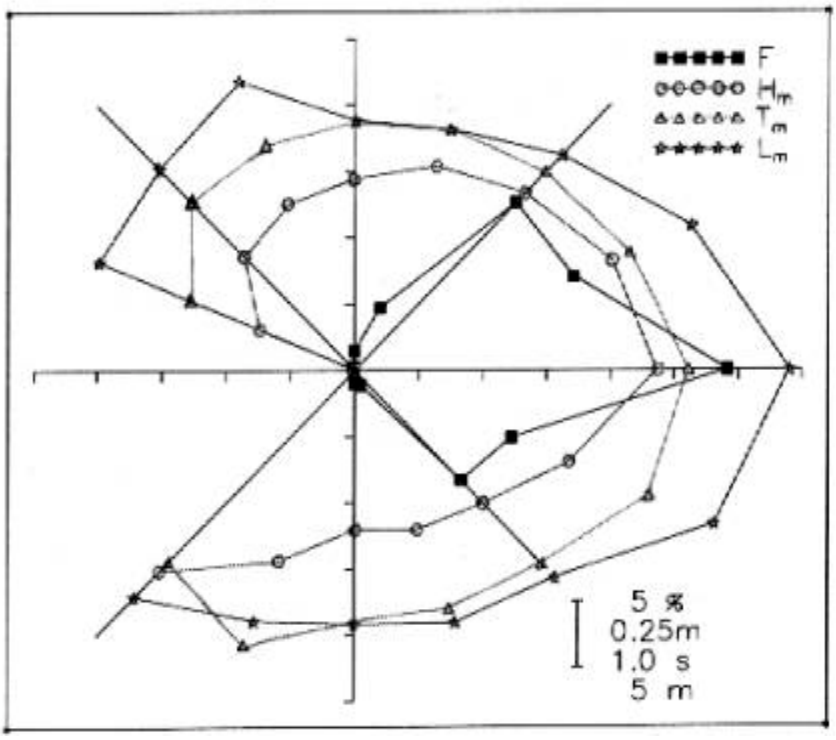

Fig. 5: Waves' parameters distribution depending on waves' direction (Diaconu, 1994).

The calculation of wave energy during storms longer than 3 days over a 9 year period, showed that the storms in January 1981 and February 1986 had the highest values (figure 6). Maximum wave heights have been recorded during these storms too.

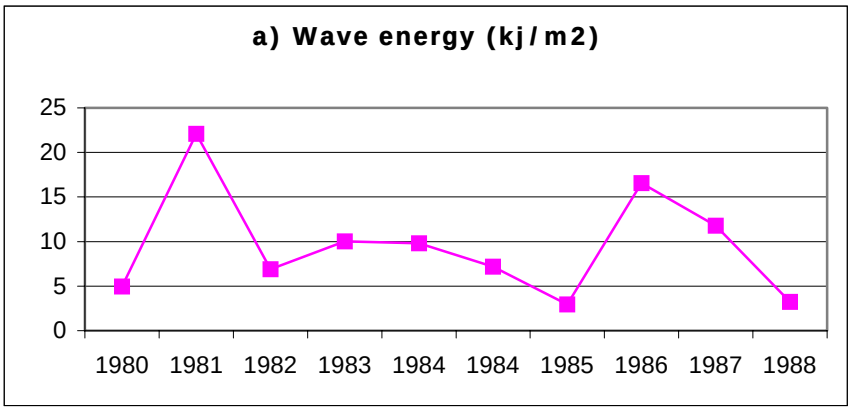

Fig. 6a: Waves energy during the most violent storms (1980-1988).

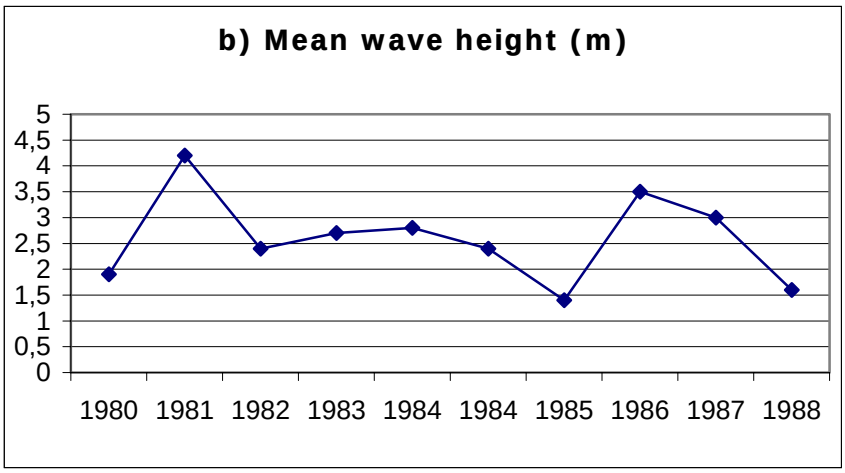

Fig. 6b: Mean height during the most violent storms (1980-1988).

The longshore current is oriented parallel along the Romanian coast, from north to south. The longshore current is interrupted by the Midia harbour dike north of Mamaia beach.

1.1.5 Erosion

Coastal erosion is a particular problem at Mamaia, due to the Midia harbour extension dikes (5 Km long) . The dike deflects the longshore sediment drift offshore, to the south-east, bypassing Mamaia beach. The coastal cell of Mamaia beach was transformed in a bay, which almost totally lacks a natural sediment supply. The general decreasing of the sediment supply into the Black Sea as a result of Danube River damming adds to the problem.

Erosion Causes

Hydrotechnical works on the Danube and its tributaries have resulted in serious decrease of Danube sediment load, imposing negative consequences on the littoral sediment balance. In addition, hydrotechnical and harbour works intercept the longshore drift, leading to a decrease of the littoral sediment budget and acute erosion. Different types of protection works have been built in the southern part of the coast, which was the most affected by erosion.

Causes and effects

- The rectification of Sulina branch of the Danube delta and extension of jetties 8 km seaward determined a constant migration of sediment discharging points to areas of a larger depths (> 15 m). However, this sediment load has a big role in replenishing coastal sand bars from the southern part of the coast, from Mamaia to Vama Veche.

- The seaward extension of the jetties for navigation purposes, created a sediment trap for the sediments discharged through Chilia branch. These sediments contribute to a secondary delta of Chilia branch north of Sulina in Musura Ba.

- The Sahalin Island, a naturally formed littoral sand bar and Midia, Constanta South - Agigea, Mangalia harbour dikes disturbed the natural direction of the longshore

drift, having negative effects both on the littoral sediment budget and the shoreline.

- Sea level rise and intensification of hydrodynamic factors contribute to the erosion phenomenon.

Table 1: Summarising causes and effects of erosion.

Causes	Effects
Sulina jetties extension seaward - Sulina Branch (the middle branch of the Danube river).	Discharge point of alluvial sediments is far away from the longshore current. Interception of the sediment outflow from Chilia Branch.
Hydro-technical works on Danube and its tributaries.	Decrease with circa 50% of sediments supplied by the Danube, with negative consequences on Romanian beach sediments balance.
Extension and modernization of Midia-Constanta and Mangalia harbour.	Deviation of the longshore drift offshore, limiting the sediments supply of southern littoral beaches.
The rate of reduction of marine shells stocks with circa 50%.	Reduction of organic sediments supply.
The average trend of sea level rise with 0.15 mm/yr.	Shoreline retreat inland.
The high frequency of severe storms periods.	Beach flooding and modification of wave front attack.
The illegal exploitations of littoral sediments.	Negative impact on sediment balance. Natural landscape deterioration.
Human pressure on the beach.	Degradation of natural landscape. Levelling the beach. Distruction of the dunes and dune vegetation.

1.2 Socio –economical aspects

1.2.1 Population rate

1.2.2 Major function of the coastal zone

- **Tourism and recreation:** Mamaia, the oldest resort on the Romanian Black Sea coast, is particularly suitable for families on account of it's safe, 8 km long, 250 - 350 m wide beach, fringed by wild pear trees, and renowned for its fine, soft sand. Mamaia resort has an accommodation capacity of 21,737 places in 61 hotels (1 to 5 stars), 14 villas and 3 campsites in 2002. It was founded in 1906, when the first balneal building was built. After 1919, a Casino and residential villas of Ferdinand King were built and then, in the second stage, at the beginning of sixties the first hotels have been built.

Table 2: Accommodation facilities in Mamaia.

Mamaia	1999	2000	2001
No of accommodation units	85	83	83
Accommodation capacity	26458	26283	26474

Table 3: Tourist numbers for all the seaside resorts from the southern part of the Romanian coast including Mamaia.

Tourist fluxes	1997	1998	1999	2000	2001
Overseas no tourist	72452	61998	48275	43817	58025
Native no tourists	782084	844056	720648	713927	687479
Total no tourists	854536	906054	768923	757789	745504

1.1.3 Assessment of capital risk

Erosion risk exists in Mamaia beach because it is a narrow sand bar, exposed to waves and sea level changes from the Black Sea and lacking sediment supply. Coastal protection measures have been carried under the communist regime, when Mamaia was severally affected by erosion. The infrastructure and the touristic activities were damaged and a large area surface of the beach and the promenade disappeared. If the erosion processes will continue and no action is undertaken to protect the beach, there is a potential risk for the beach and resort to disappear in the future.

2. PROBLEM DESCRIPTION

2.1 Description of the eroding sites

After the extension of the Midia harbour dike, Mamaia beach recorded accretion in the northern part and erosion in the south. In winter 1988, the southern part of the beach was severely destroyed by erosion. Beach shoreline retreated up to 59 m, among 1966 and 1988 and the beach surface eroded was 88900 sq m (see photo 4). Urgent protection measures that consisted of 6 longshore breakwaters and artificial nourishment were designed. After the implementation of the coastal protection scheme, shoreline retreated continued with rates up to 35 m and limited accumulation with maximum value of 15 m between 1978 – 1995.

Fig. 7a: The southern part of Mamaia Beach in 1961 before the Midia harbour construction.

Fig.7b: The southern part of Mamaia Beach in 1986 – after the Midia harbour construction.

2.2 Impact

Severe storms in 1981, 1986 and 1988 have aggravated the erosion process, particularly in the southern part of Mamaia beach. Over the period 1966 –1988 the shoreline retreated with 59 m and 88,900m^2 beach surface has vanished. Simultaneously with erosion, degradation has been reported under the form of biological changes and declining biodiversity. Significant damages have occurred to beach developments and some hotels have been endangered.

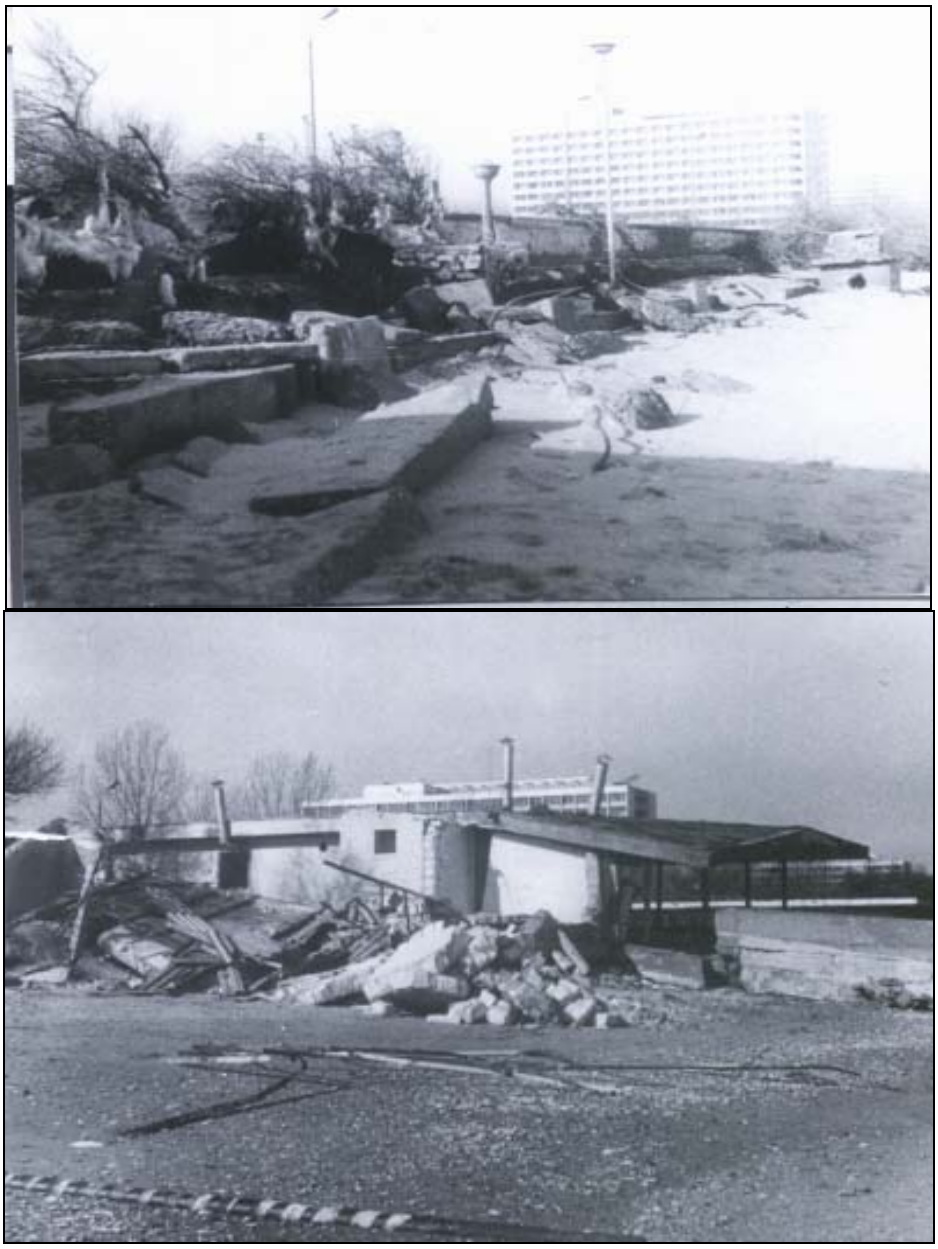

Fig. 8: Storms impact on the beach 1988.

In the winter season the combined action of hydrodynamic and aerodynamics forces results in high waves which remove a large quantity of sand from the beach and destroy the beach facilities.

The wind, a driving dynamic force, has the most influence on the Romanian shore dynamics and frequently changes in wind direction and force induce changes in waves and current regime and significant changes in the Mamaia beach profile.

Fig. 9: Storm damages on Mamaia beach 1986.

3. SOLUTIONS / MEASURES

3.1 Policy options

Hold the line.

3.2 Strategy

For the moment, there is no strategy for coastal protection in Romania. A monitoring programme to control the coastal erosion is carried out by the National Institute for Marine Research and Development “Grigore Antipa”.

The strategy adopted before 1990 was to solve the problem of coastal erosion locally. “Hard and soft” coastal protection measures were developed to reduce the effects of wave attack on the beach in the stormy weather. The soft solution -nourishment- was not effective, because the relatively fine sand that was dredged from the lake was washed away seaward in a short time.

The defence structures in the southern part of Mamaia beach have the objective to limit the disastrous effects of storm surges, which induce erosion on this beach. The main problem of this sector of the Romanian Black Sea shore is the lack of sediment supply.

Lack of funding reduced coastal protection efforts since 1990. No new coastal protection works have been carried out till the present. There is an urgent need of beach protection and maintenance of coastal defence structures (breakwaters) in order to be effective for the future.

3.3 Technical measures

In the last three decades, almost the entire southern shore of Romania was affected by erosion, requiring urgent implementation of coastal protection measures. The problem of Mamaia beach protection was taken into account by the specialist in 1975 (*Tanase et al., 1992*), when the stability of the Parc Hotel was endangered as the shoreline retreated up to the hotel. In 1977–1978 the first coastal protection structure was built, a groin with the shape of a hockey stick was combined with artificial nourishment. The sand was removed from the Tabacarie Lake (cca. 27,000 mc of sand). The erosion stopped in this area for a short period but eventually continued and extended northward.

In 1988 6 breakwaters were build parallel to the shore down to a depth of 5 m, running from the south to the centre of Mamaia beach. The main role of these “hard” protection works is to dissipate the wave energy and reduce the wave attack on the beach. In addition, artificial nourishment on the beach (1.5 km length) behind the breakwaters (see figure 10) was undertaken with sand taken from Siutghiol Lake.

Fig. 10: Artificial nourishment in the southern part of Mamaia Beach.

The nourishment works started in February 1989 and ended in June 1990. During this period the sedimentary budget increased with about 500 000 cubic meters sand. The total beach surface renewed from the beach nourishment was 64 000 m^2. The sandy material combined with mud was taken from the Siutghiol Lake and hydraulic pumped on the beach (see figure 11). The sediment had a fine texture and a dark grey colour that totally differed from the beach sand colour.

Fig. 11: Pumping sand from Siutghiol Lake - artificial nourishment.

The artificial nourishment was stopped in 1991 because of the hydro-geologic and ecological equilibrium of the lake was endangered. The sand was washed away in short time and the erosion rate increased in the area (see figure 12).

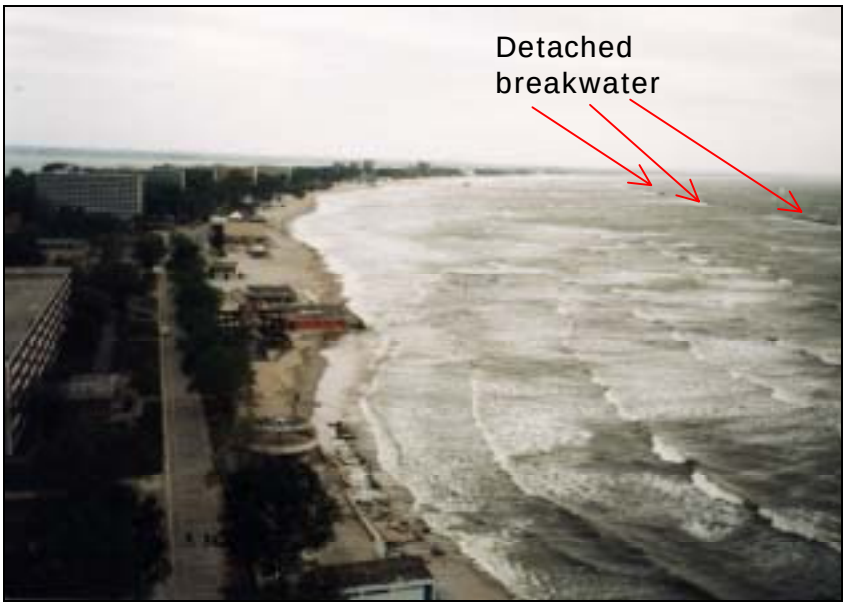

Fig. 12: Mamaia beach- the shoreline in 1998.

The beach area protected by breakwaters represent about 30 % of the total length of beach cell (12.5 km). Shoreline retreat was stopped directly in front of the breakwaters for a short period of time, but erosion rates nevertheless increased in the protected area and northward of the protected area. The beach survey carried out every year indicates a very slow trend of "tombolo" formation in front of the protected beach behind the detached breakwaters. The development level of these geomorphologic forms is different from one breakwater to another.

3.4 Costs

The expenses for the coastal protection of Mamaia beach have been supported by the state in the communism regime. There is no information about the costs of coastal protection.

4. EFFECTS AND LESSON LEARNT

4.1 Effects related to erosion

Beach nourishment is being increasingly used as a more acceptable 'soft' management option as opposed to the 'harder' engineered breakwaters and groins. The advantages of beach nourishment as a management option include the **positive aesthetic results**, which often enhance recreational value and the minimal probability of causing down-drift erosion. Dis-advantages on the other hand include high monitoring and maintenance costs, potential for changing local sediment characteristics and problems with identifying a suitable sediment source.

Beach nourishment at Mamaia was applied to re-charge the eroded beach with a appropriate sand material Basic guidelines include the principle that as much as possible, the material used for replenishment must correspond in form and size to the local beach material. Unfortunately the sand material used was too fine in the case of Mamaia beach. The nourishment resulted in local turbidity and water retention problems.

The effects of the breakwaters is moderately positive, dissipating the energy of incoming waves and reduce the waves force. As a consequence, the southern part of Mamaia beach is partially protected against erosion in shadow of the breakwaters which allow the beach to restore. The underwater profiles in the shallow water in the protected area of Mamaia beach reveals the modification of the isobaths (-1 up to – 4) position seaward in the back of the breakwaters.

Negative aspects of the breakwaters could be mentioned as well:

- Unattractive view of the detached breakwaters
- Breakwaters extremities fall down due to erosion process
- Changes in current direction induce beach erosion between breakwaters
- Erosion process extended in the unprotected beach area

4.2 Effects related to socio- economic aspects

Other then tourism industrial activity along the Romanian Black Sea coast is rather limited. The Romanian coastline is under the effect of considerable erosionfor approximate 70-80% of its the length . Coastal erosion south of Cape Midia, including Mamaia Beach which is the major beach area and tourist resort, has been considerable.

In the south of Cape Midia, the Mamaia Beach has the highest concentration of tourism activity and have been experiencing severe erosion. Mamaia resort has the largest tourism capacity along the Romanian shoreline representing 26 474 beds. Mamaia's beach surface has diminished with about 65% from 135 600 sq m to 46 700 sq. m between 1966 –1988. With a figure of 8 sq. m of beach area per tourist, the total decrease of beach surface can be expressed as a loss of capacity of about 11 000 tourist over 22 years, or roughly 500 beds per year . In addition to adverse effects on tourism activity, coastal erosion also threatened certain segments of the road between Constanta and Mangalia.
As natural resources, fish is the only natural resources along the Romanian coastline.

4.3 Effects in neighbouring countries

There are no side-effects visible in the area.

4.4 Relation with ICZM

In the southern part of the Romanian coast, the manager of the touristic beaches is the National Administration " Romanian Waters " – Directorate Dobrogea Litoral" - NARW (ex. National Company " Romanian Waters " - DDL) since 1999 is a governmental authority under the authority of Ministry of Waters and Environmental Protection. Some of the responsibilities of NARW as a manager of the touristic beaches are mentioned below:

- Elaboration of impact studies on the beach erosion phenomena
- Beach protection works in the off-season period
- Maintenance and cleaning beaches in the bathing season and extra season period

In the winter reed fences are installed at Mamaia beach in order to maintain the sand on the beach. The small dunes formed are destroyed and the beach is levelled at the beginning of the tourist season.

The beach surface losses are important arguments to stress the need for coastline preservation. The problems require a reconsideration of the national strategy for environmental protection, to include coastline management as primary objective. The coastline conservation strategy should consider the following:

- Number of km with touristic beaches eroded to be protected
- Natural areas that are endangered
- The costs of shoreline maintenance
- The cost of coastal defence maintenance
- The cost of artificial nourishment

Recently, the **environmental fund** was established in the Governmental Programme for 2001 –2004 as an important tool to support the priority projects included in the National Action Plan for Environmental Protection. Coastal erosion should be considered as a threat and funds should be allocated for coastal protection.

The Coastal zone law has been approved by the Romanian government at the end of 2002 (December 29th). The ICZM plan will be developed and include the strategy for coastal protection against erosion and environmental rehabilitation of the coastal zone.

4.5 Conclusions

Effectiveness

"Hard" coastal protection - partially effective.
"Soft" coastal protection - less effective cause of limited experience and knowledge about artificial nourishment.

Undesirable effects

- Changes of longshore current regime
- Important changes in beach profile
- Decrease the sediment transport
- Bathing water quality in summer season
- Relocation of the tetrapods from the breakwaters

Gaps in information

- Adequate current measurements
- Natural mechanisms of beach rehabilitation "working with nature", as a recommended solution to ensure beach equilibrium
- Evaluation of the “hard” works efficiency
- Costs of the breakwaters maintenance
- Costs of artificial nourishments
- Potential sand sources for artificial nourishments
- Knowledge of the coastal defence problems
- Updating the tools beach measurements
- Database of beach erosion
- No information about beach regulation

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