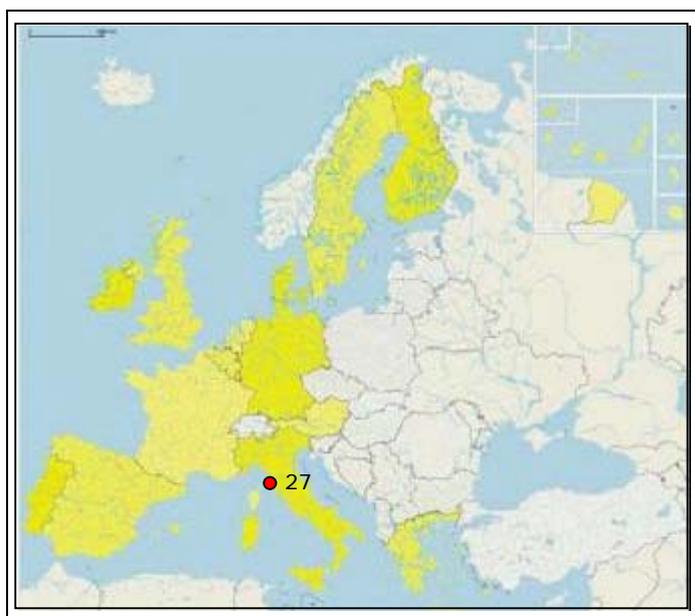

MARINA DI MASSA-MARINA DI PISA TOSCANA (ITALY)



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1. GENERAL DESCRIPTION OF THE AREA

Marina di Massa is located in the northern Tuscany. The studied area is part of a larger physiographic unit that sweeps from Sarzana to Livorno towns for about 63km. The zone is divided in two areas: one area that extends from about 6,7km south of the Marina di Carrara harbour and the other extends southwards (see Figure 1).

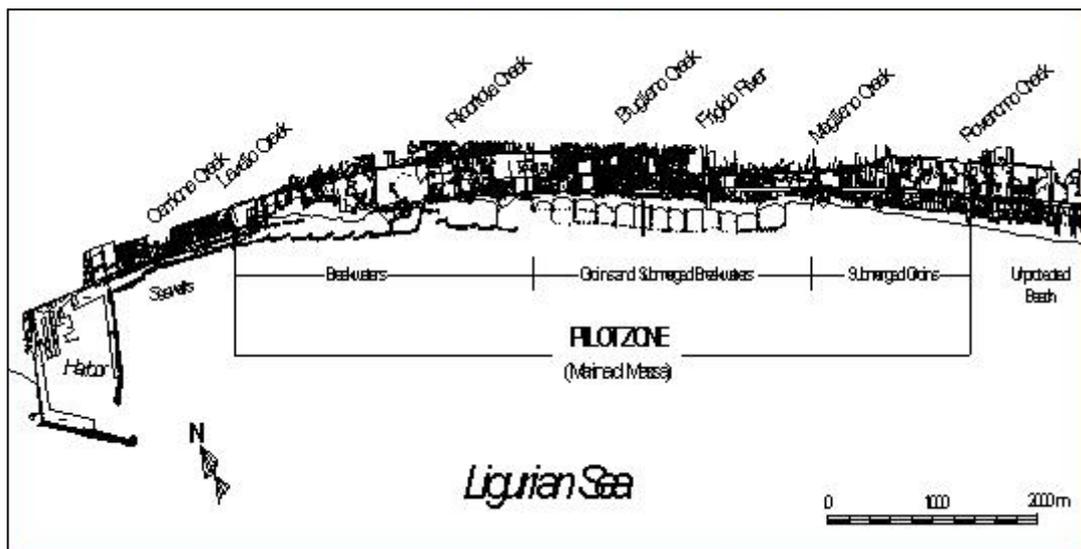


Fig. 1: Map of the studied zone – Marina di Massa.

1.1 Physical process level

1.1.1 Classification

- General: beaches.
- CORINE: beaches, artificial coast.
- Coastal guide: coastal plain, recent sedimentary.

This lowland plain facing the Tyrrhenian sea to the NE is bounded by the Apuan Alps which are part of the Appennine chain, the major orographic feature of the Italian peninsula. Until the XIX sec. the lowland was largely swampy and after human intervention the most part of it has been reclaimed by artificial draining.

1.1.2 Geology

The Appennine chain consists of a series of nappes which override each other from West to East. Those nappes are either sedimentary and ophiolitic (Ligurian Nappe) or exclusively made up of sedimentary formations (Tuscan Nappe) while the Apuan Alps, together with Mount Pisani, constitute the low grade metamorphic basement over which, at place, the nappes have been tectonically emplaced.

The sand which constitutes the beaches of the area under consideration is almost entirely the result of the "Macigno" (Oligocene sandstone formation) erosion, transport and sedimentation of this river. This kind of sand is characterized by the presence of quartz, feldspars, mica and chlorites (see Figure 2 below). In this type of sediments the content of carbonates is quite sparse (Gandolfi and Paganelli, 1975).



Fig. 2: Sediment characteristics.

1.1.3 Morphology

The study area consists on a quite small beach that extends for about 265m. The continental shelf bounding this lowland to the West reaches a 200m depth at about 30km from the coast. One remarkable feature of this continental shelf is its undisturbed morphology being not cut by any transversal canyon. The sea bottom in the area of study has a transversal concave profile (Figure 3), with an average slope of 1.61% between shoreline and 5m depth, of 0.71% between 5 and 10m isobatic and 0.94% from shoreline and 10m isobatic.

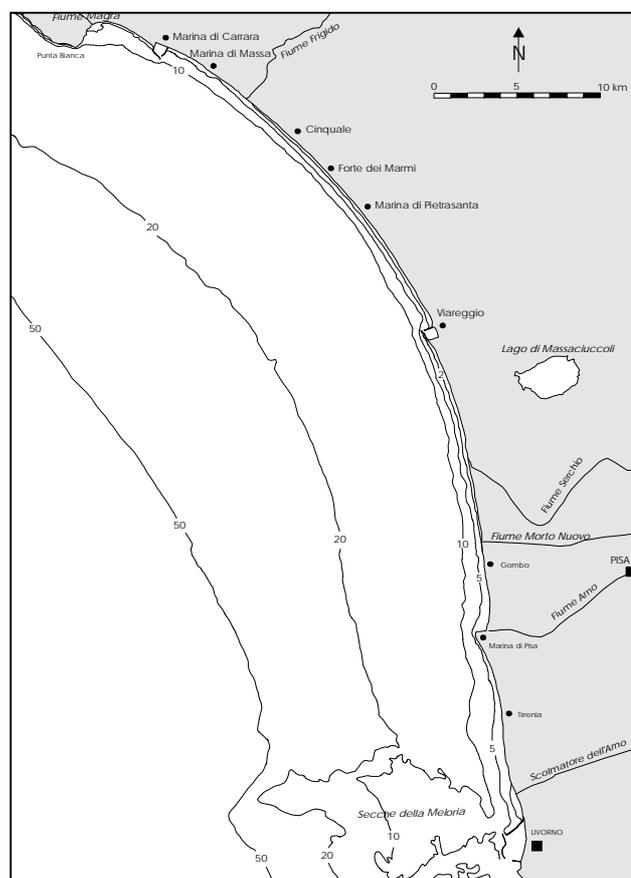


Fig. 3: Bathymetrical map of the physiographical unit which Marina di Massa belongs.

1.1.4 Physical processes

The prevailing winds blow from W and SW during spring and summer time, while in autumn and winter NNE winds progressively increase their frequency. All the data agree about the direction of the wave motion and put in evidence that most part of the storms come from the SW. The main cause of coastal erosion along the beach at Marina di Massa, is the reduction in sediment input from the Magra River essentially due to a change in land use and to anthropic interventions like river bed sediments dredging for construction, building of dams and modification of natural course of the river.

1.1.5 Erosion

Erosion type

The construction of the industrial harbor at Marina di Carrara in the early 1920's caused the interception of the southward longshore drift, inducing rapid progradation in the updrift beach and erosion downdrift.

Marina di Carrara beach has undergone shoreline progradation for approximately 300m since the harbor construction, even though in recent years (1985-1998) the trend has changed and the shoreline has retreated due to a strong reduction in the Magra River sediment load.

In particular, Marina di Carrara harbour has been producing 106m downdrift erosion and 44m updrift accretion for the period between 1938 and 1998 (see Figure 5).

Marina di Massa, which is located downdrift, has instead experienced severe erosion since the early 1930's, even though in those years the harbor updrift jetty was 400m long against the present time 900m (see Figure 4).

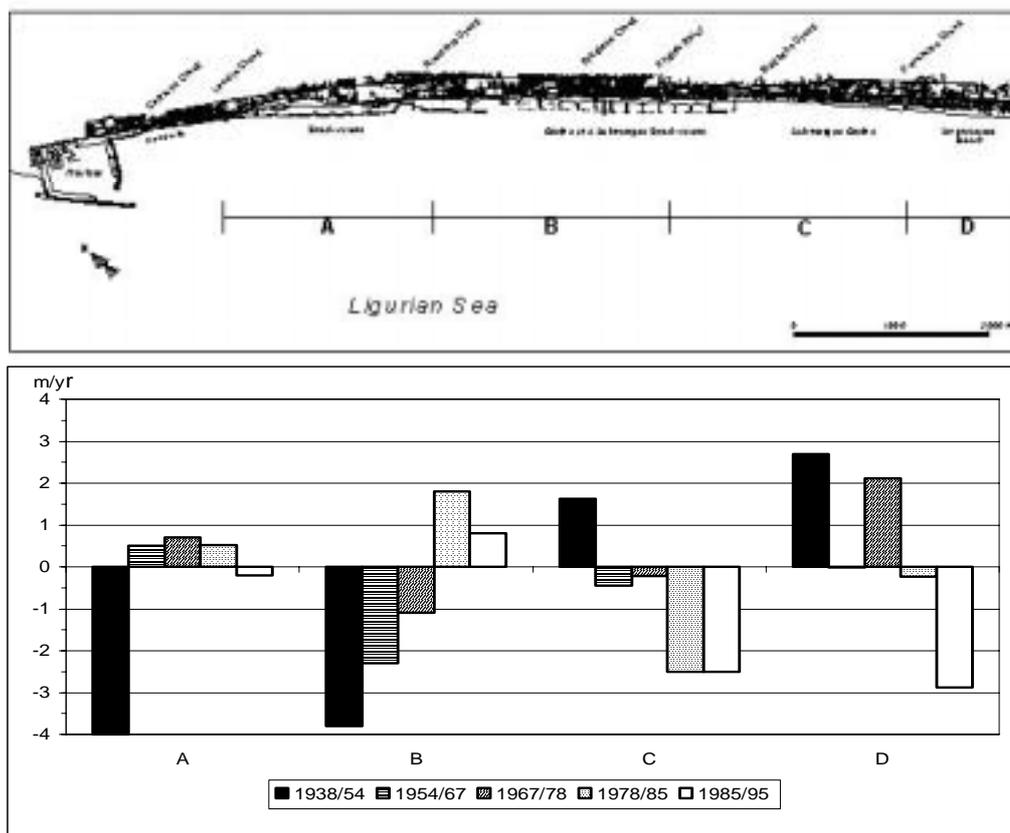


Fig. 4: Mean shoreline evolution at Marina di Massa between 1938 and 1995.



Fig. 5: Aerial view of the harbour at Marina di Carrara.

The potential net longshore sediment transport has been estimated in terms of volume of sediments and direction of drift and it is estimated to be directed southwards for approximately 150,000m³/yr (see Figure 6).

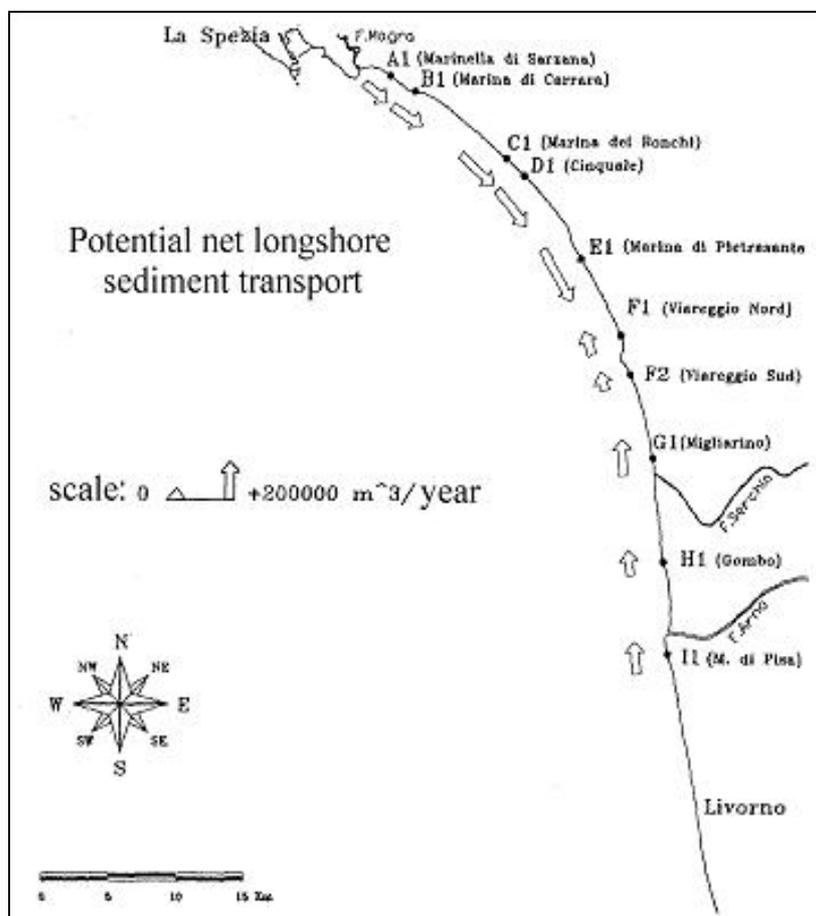


Fig. 6: Average annual trend of the net potential solid transport.

Erosion cause

The main reasons of this problem are due to both natural and artificial factors, such as modification of the lower courses of some rivers present in this area with the purpose to reduce the risk of floods and to the reduction of the soil erosion with stabilisation of the slopes.

1.2 Socio-economic aspects

1.2.1 Population rate

Municipality of Massa, with 66,097 habitants, represent 33% of provincial population (197,411 habitants). Coastal zone is the highest populated area: the three coastal municipalities of the Province of Massa Carrara (Massa, Carrara and Montignoso), with theirs



141,685 habitants, represent 72% of provincial population. The population density is approximately of 500 inh/km².

1.2.2 Major functions of the coastal zone

- **Agriculture:** agricultural activities are only the 1% of economic activities in Massa. The main agricultural activities at provincial level are the production of vegetables and potatoes, while in the coastal zone are important the production of wine and olive oil. In the years from 1980 to 1999 interest in these activities went down causing an abandonment of the inland municipalities that now begin to be populated again, this trend is connected with the increasing number of agritouristic activities founded in the last year.
- **Industry:** the most important industrial activity is building industry with 56%. Iron industrial activity is the second important in the municipality of Massa because of the presence of one of the most important Italian industry placed in the "Industrial district". Thanks to the presence of the near marble quarries of Carrara, stone industry, with 5%, is the third industrial activity. Presence of a commercial port in the near Carrara represent an important development possibility for stone and iron industries.
- **Tourism and recreation:** the Municipality of Massa is the most important touristic destination in the Province of Massa Carrara. Tourism visits in the Municipality of Massa represent the 80% of the provincial tourism visits. The nearness of expensive Versilia, one of the most popular Italian beach, give to this zone a big number of tourists that can go to the famous Versilian discoteques and beaches sleeping in the cheaper Massa.

1.2.3 Land use

Massa's coast is strongly affected by presence of coastal defence structures. As we seen before those structures has been built from 1930 to protect the coast from erosion. Municipality perform a "*Sandy shore plan*" to plan the urbanization system between the boulevard and the coastline. In this area every construction can't be higher than two flats and must be built in wood with the possibility to be moved (without any foundation). The area placed inland the boulevard is a residential zone for a length of 2-3km; on the inside of this residential zone is placed the *Industrial district*.

1.2.4 Assessment of capital at risk

Every winter hard structures suffers many demaging caused by energy of waves, but maintenance interventions aren't so fast. In 1999 some bathing establishments was damaged by waves for the last time. Now many demaging on the breakwaters and a little loss of sand on the depth in front of the submerged groins are registered but there aren't any important effects on the emerged beach and on the structures placed on the seafront. The situation is under control today.

2. PROBLEM DESCRIPTION

2.1 Eroding sites



Fig. 7: Erosion trend map of the Tuscany coast.

As said before, all the shoreline of Marina di Massa south of Marina di Carrara harbour is put under severe erosion processes since 1850. This is why the government constructed the whole part of the coastal defence structures which characterize the coastal front of the town.

2.2 Impact

In Marina di Massa there was an important loss of surface that induced beach concession holders to move inland bathing establishments and replacing parking areas. Those changes caused many impacts on users functions:

- Loss of parking areas.
- Accesses to the beach placed on the coastal road.
- Width reduction of the sidewalk.
- Increase of sound and smell of engine due to the nearness of the streets.

3. SOLUTIONS/MEASURES

3.1 Policy options

Hold the line.

3.2 Strategy

3.2.1 Approach related to the problem

Both hard and soft structure were adopted, even if the purpose is to evaluate the possibility of gradually modifying the northern hard structures into softer ones. Hard structures such as: breakwaters (see Figure 8), groins and seawalls, had a strong impact on the stretch of coast to the south of Marina di Carrara harbour and has influenced longshore sediment transport inducing many negative effects.



Fig. 8: Detached breakwaters at Marina di Massa.



Fig. 9: Beach renourished with marble gravels.

Every year before the beginning of the summer season, occasional beach replenishment works with small amounts of sand that are undertaken in order to stabilise the shoreline. Frequently beach nourishments are made using marble gravel (see Figure 9).

3.3 Technical measures

3.3.1 Historical measures

Until 1850 the beach of Marina di Massa was in *equilibrium*, however after this date the erosion process became a severe problem that induced shoreline retreat for approximately 500 meters. At the beginning of the 20th Century the adopted defence action was the construction of 9.3km of hard structures like detached breakwaters, seawalls and groins (see Table 1). This kind of structures were useful to protect the stretch of coast immediately in front of them, but at the same time, interrupting sediment transport along the coast, they exported the erosion action southward implying the construction of new defence structures.

In the past, small amounts of sand, dredged from the Marina di Carrara harbour, were discharged along the nearshore of the protected area of Marina di Massa, but these interventions did not resolve the erosion problem because the grain size of the used sand was too fine to be stable on the beach (Iannotta, 1998).

Table 1: Historic measures in Marina di Massa.

Marina di Massa	Seawall	1930
	Battery of breakwaters	1957
	Seawalls, breakwaters, groins Submerged breakwaters	1960
	Sand by-pass system	1970

3.3.2 Type / Technical details

- **Breakwaters, groins and seawalls:** these structures had a strong impact on the stretch of coast to the south of Marina di Carrara harbour and has influenced longshore sediment transport inducing many negative effects. For instance, wave energy scour seawards at the toe of the detached breakwaters inducing instability of the structures themselves and deepening the nearshore profile. Moreover the particular disposition of these kind of coastal defences has determined the worsening of sea-water and beach quality due to a reduced water circulation.

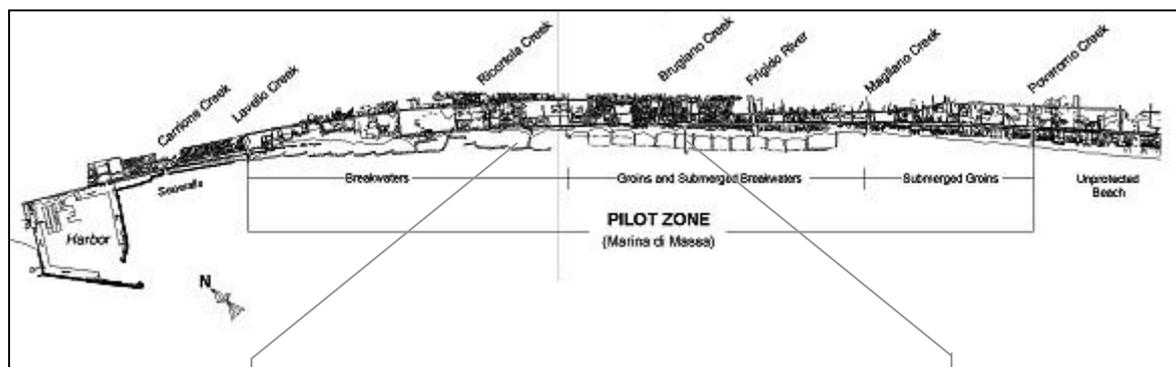
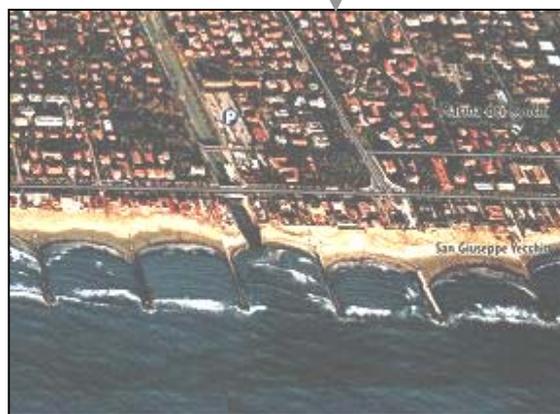


Fig. 10: Location map of the hard structures.



Figs. 11 & 12: Aerial views of the detached breakwaters and the battery of groins in Marina di Massa.

- **Beach renourishment:** every year, before the beginning of the summer season, occasional beach replenishment works with small amounts of sand are undertaken by the Municipality of Massa in cooperation with the private sectors (bathing facilities' owners and their associations) in order to stabilize the shoreline. The sand used for nourishments is usually dredged from the nearshore or from Marina di Carrara harbor entrance channel. Lately gravel from maintenance dredging of the nearby rivers is used as well as beach nourishment material in the unprotected part of the beach. Thanks to the detached breakwaters and to the groins, which decrease the energy level of incoming waves, it is possible to have a quite wide beach during the summer even if a very limited volume of sand is dumped on the beach every year.

At Marina di Ronchi, three experimental submerged groins were built during the last three years. In this area, located southward of the last hard defence of Marina di Massa, mean shoreline retreat rate was approximately 4m/yr between 1985 and 1999. After the construction of the groin field together with a nourishment of 35.000m³ of coarse sand and gravel, data collected during a detailed monitoring project, show that this stretch of coastline is now experiencing a stability phase, with a local expansion of approximately 10m since 1999. The groins run from the body of the backshore to the -3m isobath, thus they are completely covered by sand and water. They are made of polypropylene bags of 3x1.8m size (see Figures 13, 14 & 15) containing a volume of approximately 1.5m³ of sand for a mean weight of 3.7Tons. Sand bags were disposed making a 2, 3 or 4 layers structure. Right

position of sand bags in the foreshore was enabled by the help of divers, while in the backshore they were positioned inside a trench and covered with sand.



Figs. 13, 14 & 15: Sand bags and construction works of experimental submerged groins.

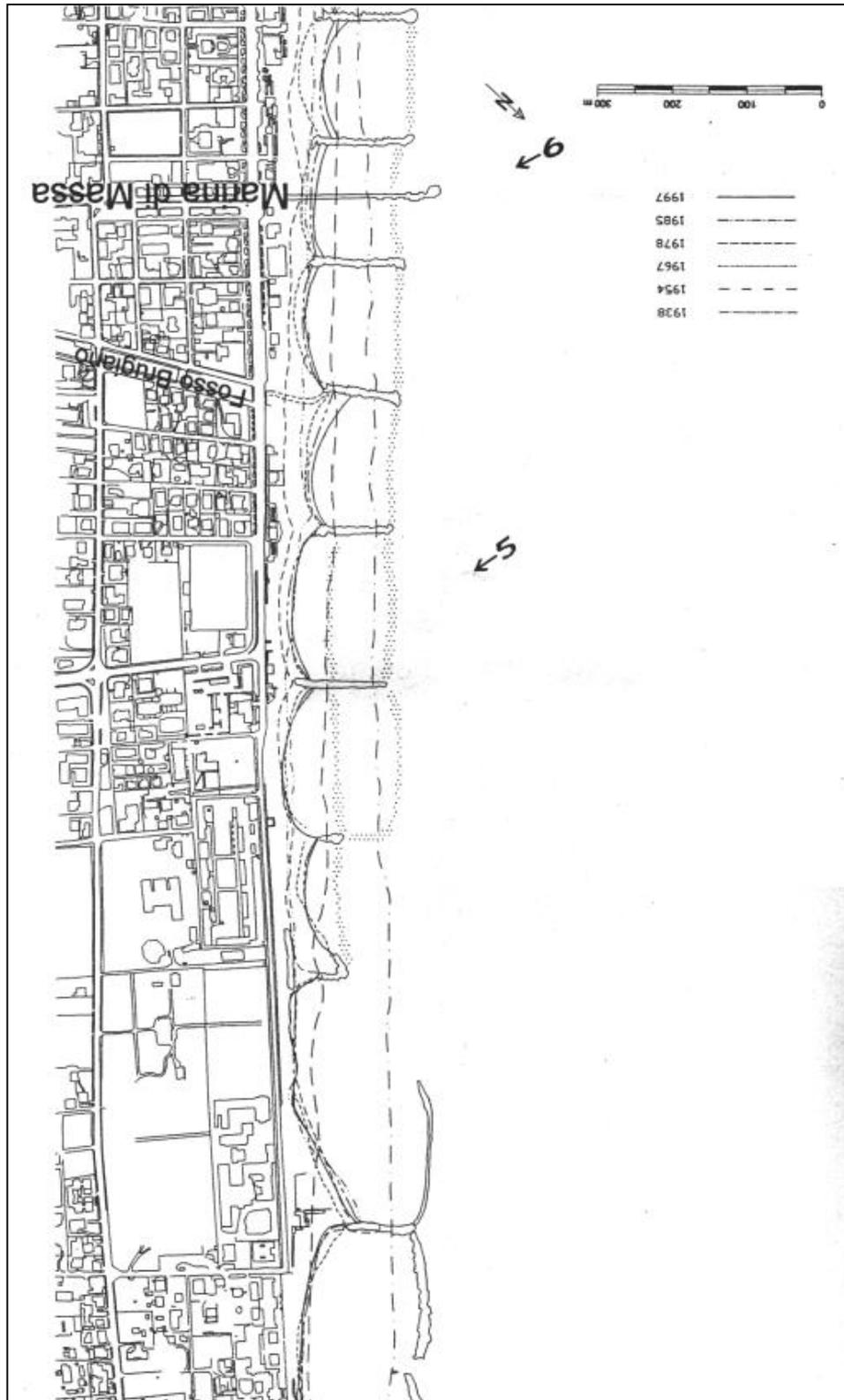


Fig. 16: Scheme of the southern part of Marina di Massa.

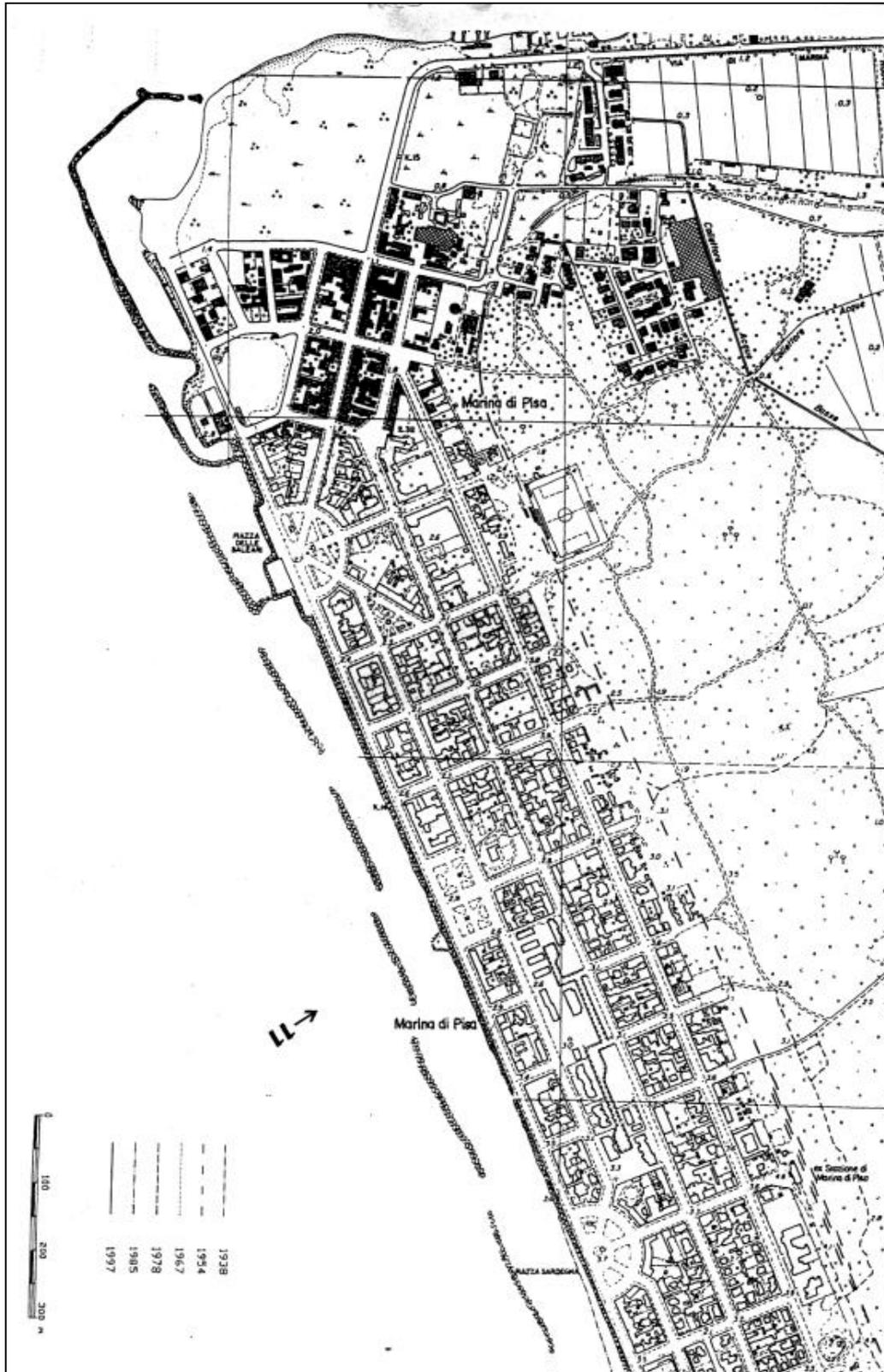


Fig. 17: Scheme of the northern part of Marina di Massa.



3.3.3 Costs

Detached breakwaters built in Marina di Massa in 2002 had a cost of approximately 1,150,000€/km. If we consider that hard defences at Marina di Massa have a linear extension of approximately 9.7km, we obtain a total cost for the entire structures of 11,155,000€. Between 1995 and 2001 the Municipality of Massa has obtained 7,400,000€ for coastal defence. These were used for the following works:

- Maintenance of existing structures: 2,071,800€
- Beach nourishment: 3,882,200€
- Submerged groins in polypropylene bags filled with sand: 973,500€
- Beach cleaning after flooding or storms: 309,900€
- Interventions at river mouth: 180,800€



4. EFFECTS AND LESSONS LEARNT

4.1 Effects related to erosion

The construction of hard structures had a high impact on along the stretch of coast south of the harbour of Marina di Carrara and has influenced longshore sediment transport inducing many negative effects. These effects can be identify in local accretion or erosion, especially downdrift the several structures, and modification of the natural feature of the submerged beach . Moreover the particular disposition of these kind of coastal defences has determined the worsening of water and beach quality.

4.2 Effects related to socio-economic aspects

The presence of a severe coastal erosion induced important changes in beach use over all on the beaches protected by groins and submerged breakwaters made with blocks. In this way there was been an important loss of surface that induced beach concession holders to move inland bathing establishment replacing parking; those changes caused many impacts on users functions:

- Loss of parking areas.
- Accesses to the beach placed on the coastal road.
- Width reduction of the sidewalk.
- Increase of sound and smell of engine due to the nearness of the streets.

Reduction of beach surface of all Massa beaches cause, first of all, a strong reduction of play and sport areas on the beach replaced by deckchairs and sunshades.

4.3 Effects in neighbouring regions

The kind of structure adopted were useful to protect the stretch of coast immediately in front of them, but at the same time, interrupting sediment transport along the coast, they exported the erosion action southward implying the construction of new defence structure.

4.4 Relations with ICZM

Regione Toscana is working at the formation of a Regional Plan for Integrated Coastal Zone Management in cooperation with the local Authorities (Provincial and Municipal Administrations). The Regional Plan follows the European Parliament and Council Recommendation concerning the implementation of Integrated Coastal Zone Management in Europe (COM(2001)533; published on the G.U.C.E. L 148 on 6 June 2002), in particular concerning the respect of natural processes. In addition to this the Regional Plan was proposed to the European Commission to be considered as a potential case to be found through the "Patti Tripartiti" which are agreements among the European Commission, member States, and Regional Administrations.



4.5 Conclusions

Effectiveness

The coastal structures built have not had the expected results. The position of the hard structures prevent water circulation inside them, inducing to a strong worsening of sea water quality especially during the summer. Groins and detached breakwaters have interrupted littoral transport and have exported southward the erosion effects which have been, lately, limited by the construction of the submerged groins.

Possible undesirable effects

The construction of these hard structures caused the destruction of most part of the *habitats* like dunes system and of a wide extension of coastal vegetation represented by *Mediterranean flora*.

Gaps in information

All the data are given free of charge to any individual (public or private) who request them, but most of the potential users are not aware of the existence of these data.

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