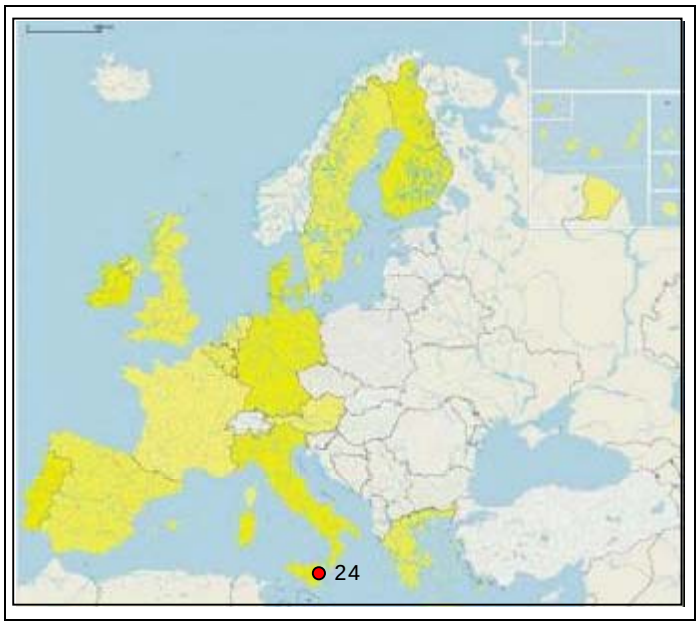
GIARDINI-NAXOS
ISLE OF SICILY
(ITALY)



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1. GENERAL DESCRIPTION OF THE AREA

The bay of Giardini is situated in the northern sector of the Ionian coast of Sicily. The study area stretches for about 5 km, from Capo Taormina in the north of the bay to Capo Schisò in the south (Figures 1 & 2).

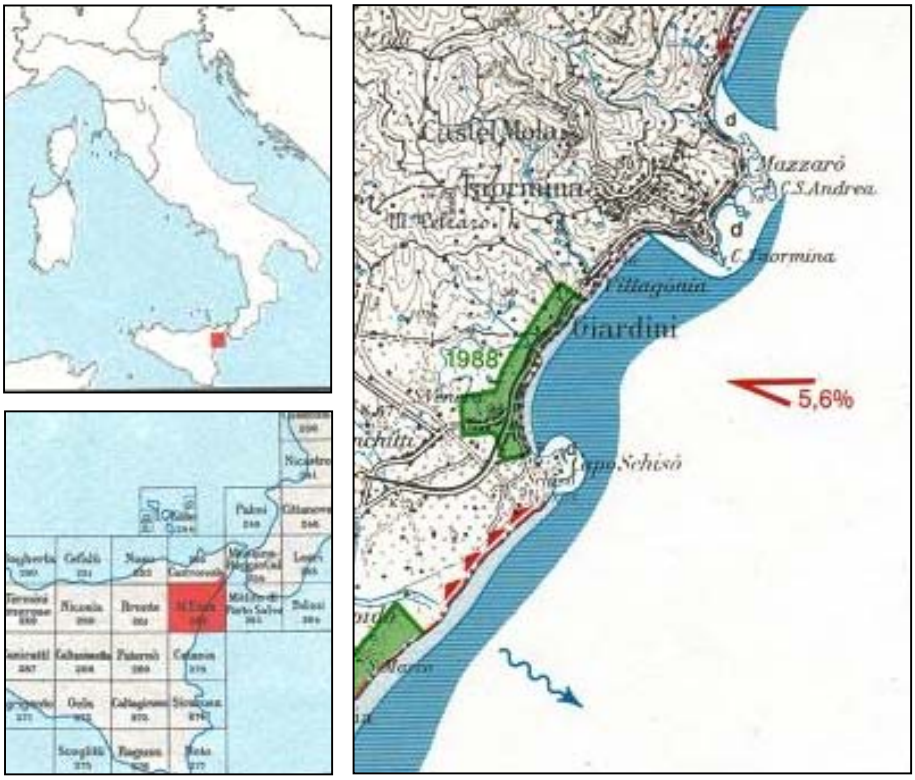

Fig. 1: Location map of the studied zone.

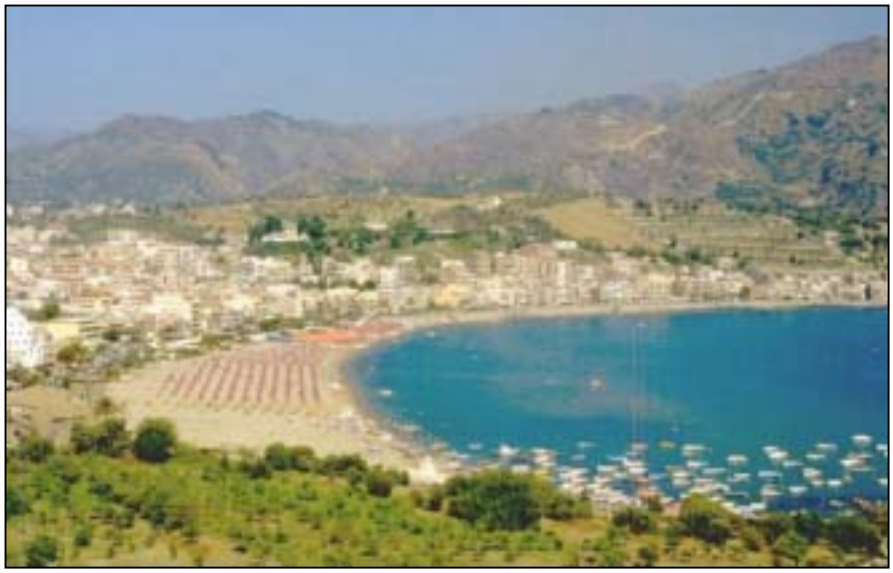

Fig. 2: View of the Giardini-Naxos bay from Capo Schisò.

1.1 Physical process level

1.1.1 Classification

- General: recent sedimentary pocket beach.
- CORINE: beaches.
- Coastal guide: coastal plain.

The beach enclosed by the bay of Giardini-Naxos may be considered a “relict” beach. It may be divided into several parts characterised by the presence of a number of man-made structures. Immediately to the south of the rocky promontory of Schisò there is a stretch of sandy beach.

1.1.2 Geology

Until a few thousand years ago the Bay of Giardini, as we know it today, did not exist, and the shoreline along which the built-up area stretches today represented the northernmost tip of the Alcantara river mouth, bounded to the North by the projection of Capo Taormina. The Etna lava flow from the Holocene period (Mojo lava flow) interrupted this continuity, creating the promontory of Capo Schisò between the mouth of the river and the extreme limits of the delta. The lava rocks, reaching out into the sea for a few dozen metres with respect to the former shoreline, has created a lithoid promontory of strong consistency which has effectively at least partially enclosed the bay system to the South.

In historic times, when the river was in flood, the left-side tributaries nearest to the coast probably “overflowed” their sediments all along the southern strip of the paleo-bay, transporting and depositing large amounts of poorly sorted material which certainly continued to contribute, probably until the last century, to the progradation of the Bay of Giardini.

At the northwestern edge of the Alcantara basin there are outcropping cretacean-eocenic soils. In the shoreline sediments, from Capo Schisò to Riposto, elements of all these lithotypes may be found, as well as metamorphic and sedimentary ones. In the more southerly areas there are outcropping of carbonatic formations of the meso-cenozoic period. Between Schiso’ harbour and the Alcantara river mouth, lies the area of Recanati, which is characterised to the North by important lava outcropping, first projecting directly into the sea, then limiting the narrow strips of sand.

The sediments on which most of the southern sector of residential Giardini-Naxos is built were formed by old flood deposits, and it is also probable that a part of the sediments (the coarser ones) still circulating within the Bay of Giardini are directly linked with the collapse of ground cut off to the north by the lava flow. Sediments have a heterogeneous distribution (see Figure 3). The zoning of sediment types makes it possible to identify two areas: in the southern sector medium sands are present, while externally the sands are finer; in the northern sector the medium sands disappear, while coarse sands are present. Classing increases in the direction of transport, while average diameter decreases.

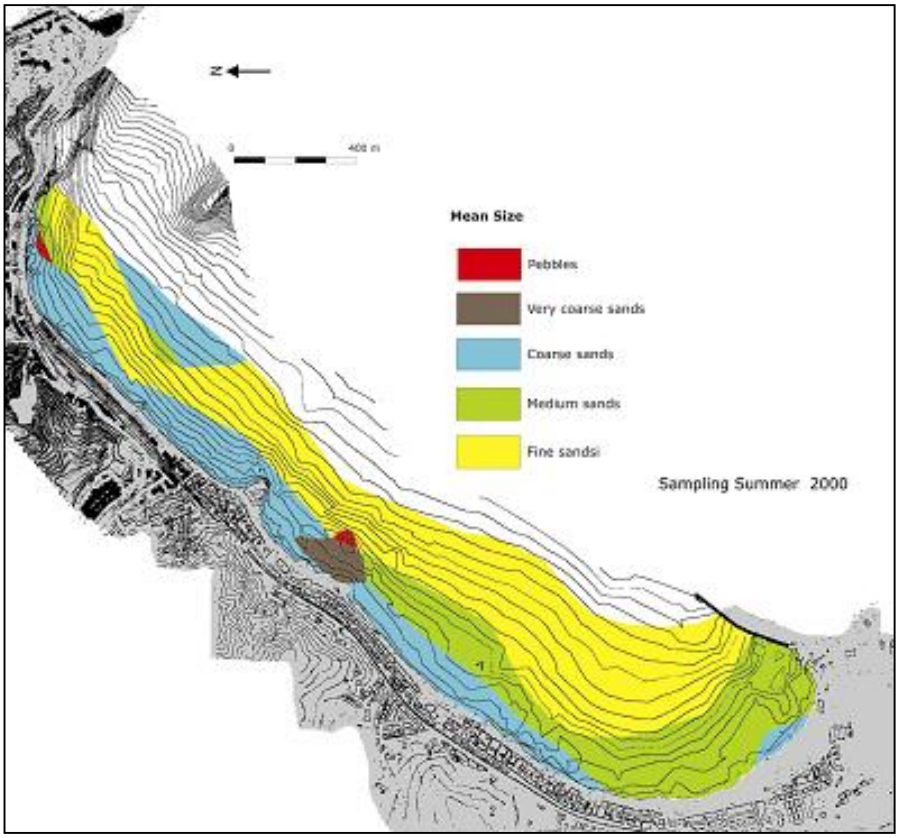

Fig. 3: Sea-bottom sediment distribution in Giardini-Naxos bay.

1.1.3 Morphology

The continental area under study is hilly. The hills increase gradually in height as one moves inland and form, as a whole, the range of the Peloritan Mountains. In general it is interesting to observe how the entire bay system is at present dominated by Schisò harbour which has upset the system of deposits within the bay, while on the other hand it continues to exercise considerable influence on it.

Beyond the isobaths closest to the coast (-1 and –2), a general distension may be noted, that is an increase in the interdistances between isobaths present at depths between –2 and –14m. Locally, especially in the areas closest to the shoreline, anomalies may be noted due to the protections along the coast. Proceeding in a North-South direction it is possible to note, opposite the sandy beach interspersed with lava outcroppings, a gently sloping seabed reaching a depth of – 15m at a distance of 300-400m from the shoreline (see Figure 4).

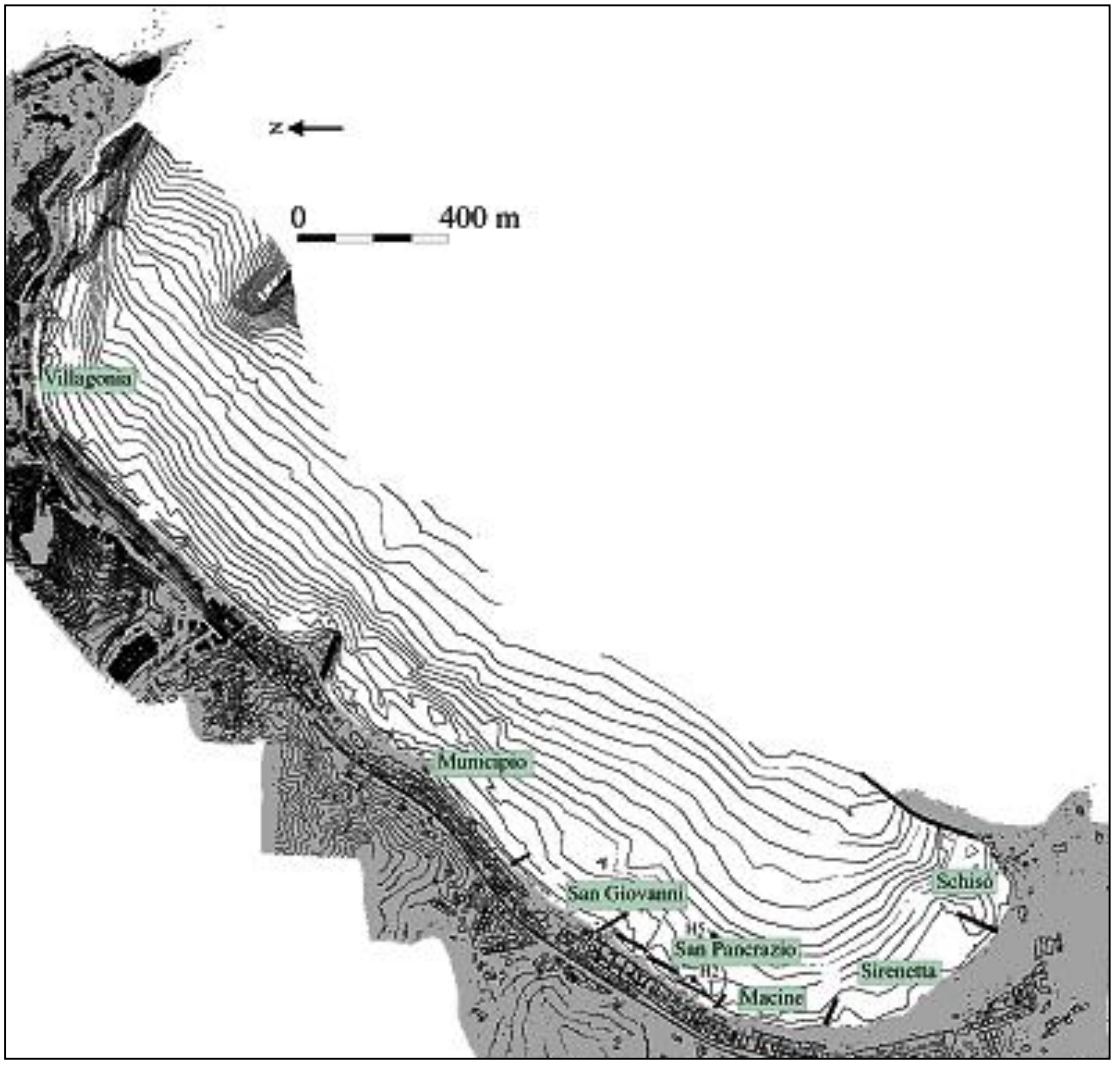

Fig. 4: Bathymetry map of the Bay of Giardini. The main interesting points of the bay are shown too.

1.1.4 Physical processes

The most frequently occurring wind phenomena are those within the NE, E and SW sectors, and that the directions NE and E present the highest wind speeds. Considering the orientation of the coastline between Capo Taormina and Capo Schisò, which is about 45° N, the dominant East and North-East winds tend to generate Southward littoral currents within the bay, while the South-Westerly winds, dominating to a lesser degree, generate Northward currents (see Figure 5).

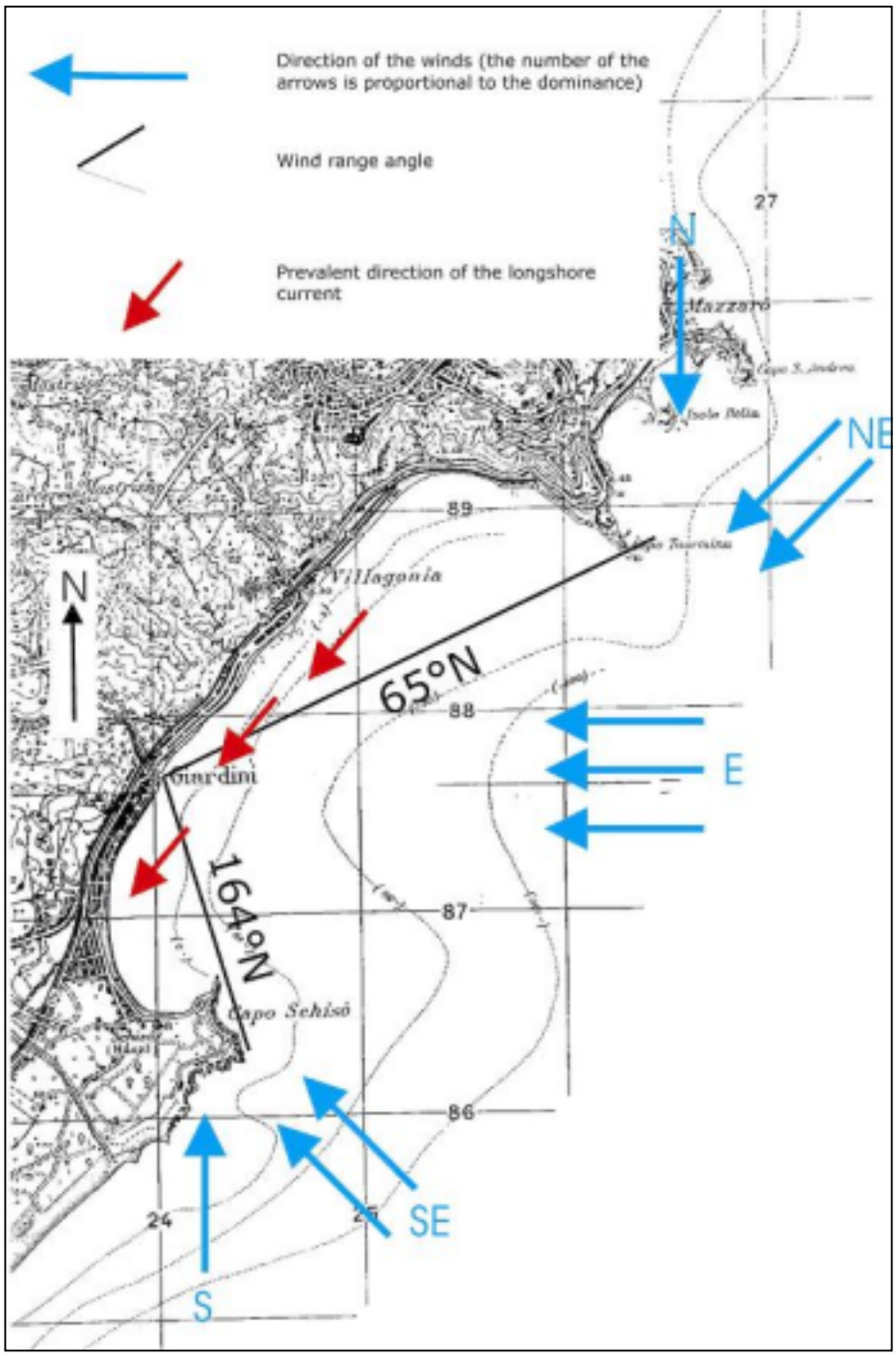

Fig. 5: Wind regime and longshore drift pattern of the bay.

The transport of sediment along the shoreline is prevalently northward oriented. The only sediments entering the bay at present are absent any solid deposits originating in the North, while those coming from the south are linked only to the solid load of the river Alcantara. In the bay it is possible to define three main circulation system, which are closely connected to the dynamics of the waters:

- In the southern area a sort of circulation movement may be noted with a tendency both to dispersion towards the open sea and to a North-West coastal drift.
- In the San Giovanni sector, besides the evident dispersion towards the open sea, there is also a divergent lateral dispersion, with Northward and Southward transport of sediments.
- In Villagonia there is evident transport landward and sub parallel to the coast.

In relation with sea level rise, the entire coastline of Sicily is considered a patchwork of pieces which show a differential movement related to the local tectonic activity, so it is not a relevant factor for erosion for this case.

1.1.5 Erosion

Erosion type

There is evidence of the most violent erosion in the central sector, while the eroded material is transported towards the south with a result that a large quantity of sediments is deposited in Schisò harbour. In the whole part of the Northern sector of this first area, a narrowing of the beach by about 5m per year was registered between 1967 and 1972. Since 1964 the delta has been going through a destructive phase, leading to a loss of emerged surface area of more than 100,000m^2, with linear withdrawals of 90m and more and an average annual withdrawal rate of 2.9 m per year.

Erosion cause

The erosion of the coastline is due to the construction of the pier of the port of Schisò. In the northern sector, it is caused by the increase in urbanisation, the building of a promenade and the erection of rigid protection structures. The erosive process is also favoured by a general reduction in transported solid load, due to a series of factors such as: river damming, destruction of the dune barriers, removal of inert material from river beds and sandy shores.

In conclusion, along the shores subject to erosion, there is a deficit in the sedimentary budget because the material removed from the coastal circulation system is no longer replaced by naturally or artificially transported fresh material.

1.2 Socio-economic aspects

1.2.1 Population rate

Population density: 1678 inhabitants/km^2

1.2.2 Major functions of the coastal zone

- **Tourism and recreation***:* this is the most incoming source. There are 4883 beds in the 34 hotels, and there are also 46 restaurants. In the last ten years there has been a continuous positive trend of presences of tourist or in the hotel structures or in extra hotel structures. In the middle of the bay, in the area of Sirina, just north

of the town hall, there is a kind of pier where there is a strong concentration of small boats in summer.

- **Urbanisation**: the whole available area (60%) is urbanised. The remaining area is constituted by marginal lands (slopes of hills and drains) where an urban development is difficult.

- **Agriculture and forestry***:* the agriculture is almost absent, only some little cultivation of gardens for a very limited production of vegetables is still present.

- **Fisheries and aquaculture**: the fishery fleet is constituted by less than hundred little boats used for local fishing, above all in the spring – summer time. In the area of Capo Schisò, there is a protected area which is the official harbour of the bay. From the technical point of the view the harbour does not give enough protection for fall – winter storage.

- **Industry, transport and energy**: the industry is completely absent. The way to reach the bay of Giardini-Naxos is a motorway and railway.

1.2.3 Land use

As said before almost the whole available area of Giardini – Naxos is urbanised.

1.2.4 Assessment of capital at risk

Erosion problem involves almost the entire resident population (about 9,000) as well as all the various categories not living but working in the area on a regular basis, and seasonal workers who, at peak season, can be as many as about three thousand. It is not possible to make a rough estimation of the capital at risk (see Figure 6).

Fig. 6: Touristic interests under severe erosion risks.

2. PROBLEM DESCRIPTION

2.1 Eroding sites

The areas subject to erosion at present are those situated in the central and southern sectors of the bay, between the Church of San Pancrazio and the Sirenetta lido (see Figure 4 for locations). In the southern area there is infilling of the harbour and the accretion of the nearest beaches (500m). In the central area there is heavy erosion with disappearing of the beach. In the north sector the beach is stable.

The increase in urbanisation near the Schisò harbour, the building of a seafront and the erection of rigid protection structures, have together led to the erosion of the Northern sector (San Pancrazio) and the progressive advancement of the beach in the area protected by the harbour structure. More precisely, in the whole of the Northern sector of this first area, a narrowing of the beach by about 5m per year was registered between 1967 and 1972.

In the more northern part, the seawall erected to protect the railway line initially led to a severe erosive phenomenon and later stabilising naturally, probably because of the characteristics of the seabed. In fact the beach at first found a new balance along the direction of the foot of the roadbed supporting the railway line, but then it became more stable thanks to the presence of natural rocks which created more protected areas.

The Recanati area cannot be excluded from the most complex system of evolution of the Alcantara river mouth, which occupies the shoreline for a stretch of a little less than 2km. Since 1964 the delta has been going through a destructive phase, leading to a loss of emerged surface area of more than 100,000m^3, with linear withdrawals of 90m and more and an average annual withdrawal rate of 2.9m/yr. In the Recanati area there is no doubt that the erosive phenomenon has been determined by the excavation of large quantities of sand, illegally removed from the beaches and the dunes behind them and used for the building of holiday homes and hotels right on the very edge of the beaches themselves.

2.2 Impacts

Erosion is a threat for the urbanised area. Actually, along the promenade, there is a long sequence of hotels and private buildings threatened. From an observation of the evolution of some rigid constructions, it has been observed that these have often transferred downdrift the erosive effects of waves and currents. Some rigid structures have favoured the formation of protected areas of the coast which have been exploited as natural seasonal harbours for small boats. Others, where the protective measures have given the desired results, have registered a clear increase in the number of tourists with a positive effect on local industry.

3. SOLUTIONS / MEASURES

3.1 Policy options

The policy adopted is to ***hold the line***. In some areas the policy is the removal of the causes of deterioration and erosion, by means of the restoration of the natural conditions, which led to the formation of the shoreline, with specific reference also to a rationalisation of the building process 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.

3.2 Strategy

3.2.1 Approach related to the problem

From the 1970 until 1990, the only defence works to be planned were of a rigid nature, consisting of structures emergent and rarely at a sufficient distance from the coast. At the present, the interventions within the bay consist of "rigid" and "soft" constructions, which live together, specifically replenishment protected by a detached supported barrier.

3.3 Technical measures

3.3.1 Historic measures

In the past, the individual local administrations have adopted their own solutions (see Table 1), using funds gathered by means of their personal political strength.

Table 1: Historic coastal defence measures in Giardini-Naxos bay.

Schiso'	Harbour	1958
San Giovanni	3 sub-parallel breakwater	1984
	Promenade	Late '70
Tyndaros	5 sub-perpendicular groins	Late '70
Saia	Quay	Late '60

3.3.2 Type

Existing protection measures can be divided in two categories: the first consists of "rigid" constructions (divided into an "active" type, such as detached barriers and groynes, and a "passive" type, such as attached defence structures – Figure 7, 8 & 9); the second consists of "soft" interventions (replenishment with granular sandy and/or gravelly material – Figure 10). The two categories, as we know, frequently live together (in "mixed" structures), as in the case of protected replenishment.

Fig. 7: Groin structure in San Pancrazio.

Fig. 8: Oblique detached breakwater (San Giovanni).

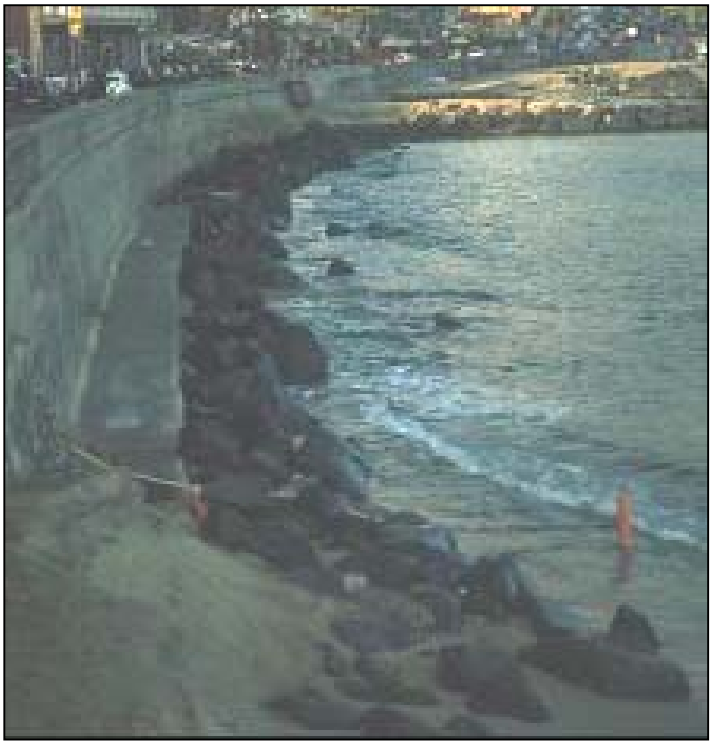

Fig. 9: Seawall structure (Macine).

Fig. 10: Renourishment works in San Giovanni.

3.3.3 Technical details

The proposal for intervention within the bay consists of a "mixed" structure, specifically replenishment protected by a detached supported barrier: a combination of the "soft" intervention of replenishment and the "rigid" structure of a supported barrier.

The supported barrier, consisting of lava rocks, has a 100m long linear development. Its berm, at a depth of –50m from the water surface, will be 15m wide with a slope of 3/1 on the seaward side and 2/1 on the landward side. The positioning of this barrier, sunk to an average depth of 50cm, will take place after a geotextile material of a density of 365g/m^3 has been laid. The "reef-breakwater" makes it possible to obtain a selective dissipation of the breaking wave motion by concentrating most of the breaking no longer at a distance of 50-70m from the shore, but on the barrier about 150-170m out.

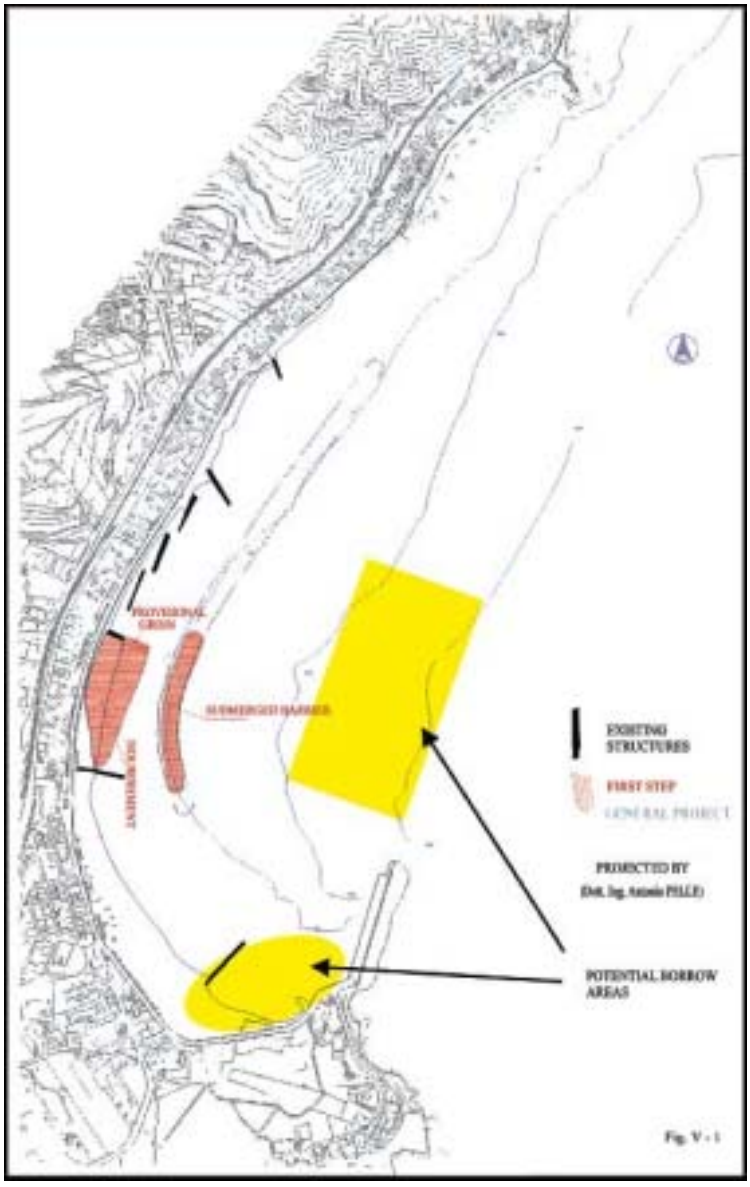

Fig. 11: Scheme of the projected "reef-breakwater" for the Bay of Giardini.

4. EFFECTS AND LESSONS LEARNT

4.1 Effects related to erosion

Along all the shores subject to erosion there is a deficit in the sedimentary budget because the material removed from the coastal circulation system is no longer replaced by naturally or artificially transported fresh material. Moreover, artificially transported material finds it difficult to remain in a stable situation, since it is deposited in areas which are already undermined by the lack of balance and without further protection. At the present time the problem of a variation in the shoreline balance is felt most strongly in those areas where structures have been erected without sufficient planning: lidos, seafronts, piers, tourist harbours, breakwaters and groynes.

4.2 Effects related to socio-economic aspects

There are no detailed studies taking into consideration the effects of these protective systems on human activities. Some rigid structures have favoured the formation of protected areas of the coast which have been exploited as natural seasonal harbours for small boats. Some areas, where the protective measures have given the desired results, have registered a clear increase in the number of tourists with a positive effect on local industry.

4.3 Effects in neighbouring regions

From an observation of the evolution of some rigid constructions, it has been observed that these have often transferred downdrift the erosive effects of waves and currents, creating a chain process consisting of transfer of the problem, request for protective measures, political pressure, concession of protective measures, further transfer of the problem.

4.4 Relation with ICZM

ICZM is entrusted to the Environmental Impact Association (EIA), which in reality proves to be the only truly effective system of control in the management and planning of interventions on the coast.

4.5 Conclusions

Efectiveness

Along shorelines which have even a temporary natural tendency to erosion, the unbalancing of the system has always been aggravated by anthropic interventions, which have usually had the effect of creating or accentuating erosive phenomena in the areas downdrift from the barriers: harbour structures planned for the mooring and protection of embarkations are often destined to be submerged by sediment; and breakwater barriers which were planned in order to defend stretches of the coast, have led to the deterioration of these stretches from a hygienic and aesthetic point of view, and to the chain-reaction of further breakwater barriers, chasing the erosive process down the coast.

Possible undesirable effects

The parties and economic categories involved are therefore prepared to put defence mechanisms into effect as soon as their personal property and interests are threatened, without taking into account the possible effects of these defence mechanisms in other neighbouring sectors of the coast.

Gaps in information

It is difficult to permit the information obtained to reach the “public” are due more to a disinterest of the latter than to a lack of the former.

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