Bulletin de la Société Royale de Liège, 57e année, 4-5, 1988, pp. 441 à 452

EROSION CAUSES OF CALVI BEACH

A. LEJEUNE [1], S. GRILLI [2], D. BAY[3] et A. OZER[4]

(1) Head of the Civil Engineering Department,
University of Liège, Belgium
(2) Visiting professor, Department of Civil Engineering,
University of Delaware, Newark, USA
(3) Director of the Oceanographic Station STARESO in Calvi, France
(4) Docent, Geomorphological Laboratory, Faculty of Sciences,
University of Liège

Key-words : *Beach, erosion, wave, environmental behaviours.*
Mots-clefs : *Baies, érosion, vague, comportements environnementaux*

SUMMARY. The erosion of the Beach of Calvi Bay in Corsica (France) started already in 1960, but the problem began to be severe four years ago. The impact of new constructions (harbour, hotels, coffee-houses on the beach) will be presented in this paper through four different studies (sedimentological, currents, wave propagation and geomorphological studies). Findings show that the erosion process is due to the rise of relative sea level, with as a catalyst, the tourist behaviour and the implementation of new constructions.

Causes d'érosion de la plage de Calvi.

RESUME. L'érosion de la plage de la Baie de Calvi en Corse, (France) a débuté en 1960, mais le problème est devenu critique il y a quatre ans. L'impact des nouvelles constructions (port, hôtels, cafétarias construites sur la plage) sera présenté dans cette communication au travers de quatre études différentes (sédimentologique, courantométrique, propagation de la houle, géomorphologique). Les conclusions montrent que l'érosion est due au surélèvement du niveau de la mer, avec comme catalyseur, le développement touristique et la construction du port et d'immeubles sur la plage.

1. BACKGROUND

Due to the presence of the Oceanographic Station of the University of Liège (Belgium), located in the Peninsula of the Revelata near Calvi, in Corsica (France), the University of Liège was very much involved in the study of the erosion process of the Calvi Beach (Fig. 1).

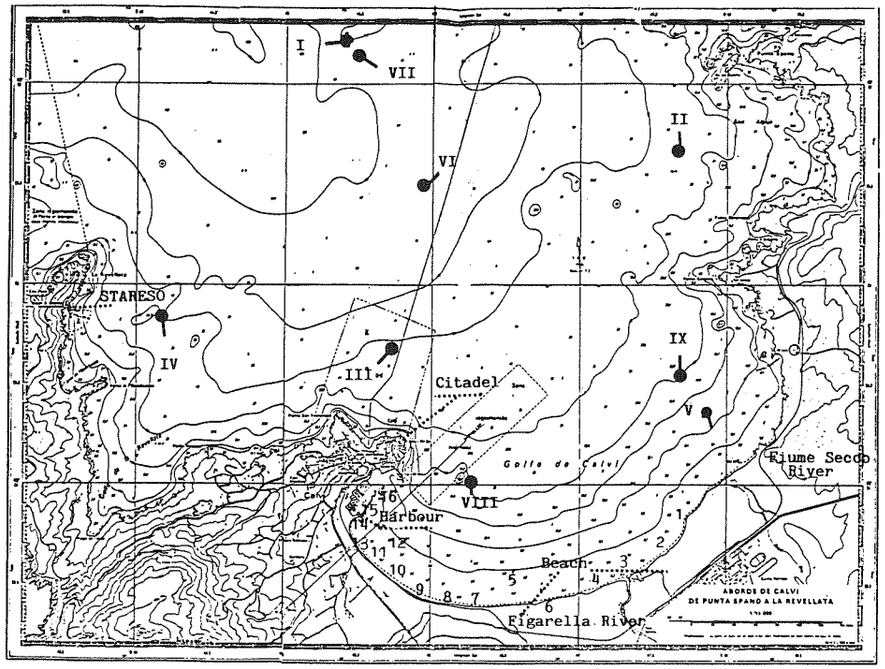

Fig. 1. General map of Calvi Bay
I- IX positions of the currentmeters
1-16 : positions of samplings

This paper will describe the results of a complete two years study on the site, from February 86 to December 87.

The erosion of the beach of Calvi started already in 1960, but the problem began to be very severe four years ago, after the implementation of a new harbour in 1982 and buildings, hotels and restaurants on the beach. To consider the impact of those constructions and other factors like waves, currents, geomorphological aspects, the studies were divided in four parts : sedimentological, currents, wave propagation and geomorphological studies.

2. SEDIMENTOLOGICAL STUDY

Temperature of the water surface shows rather great seasonal fluctuations. In winter it is 13°C and in summer it could be rised up to 25°C (from July to September). The maximum amplitude of the thermocline is 10°C, and it starts at a depth of 20 meters in May to reach nearly 50 meters in September. Salinity of Bay water varies from 37.5 °/₀₀ in winter to 38.1°/₀₀ in summer, but keeps a constant value in the open sea i.c. 37.4°/₀₀.

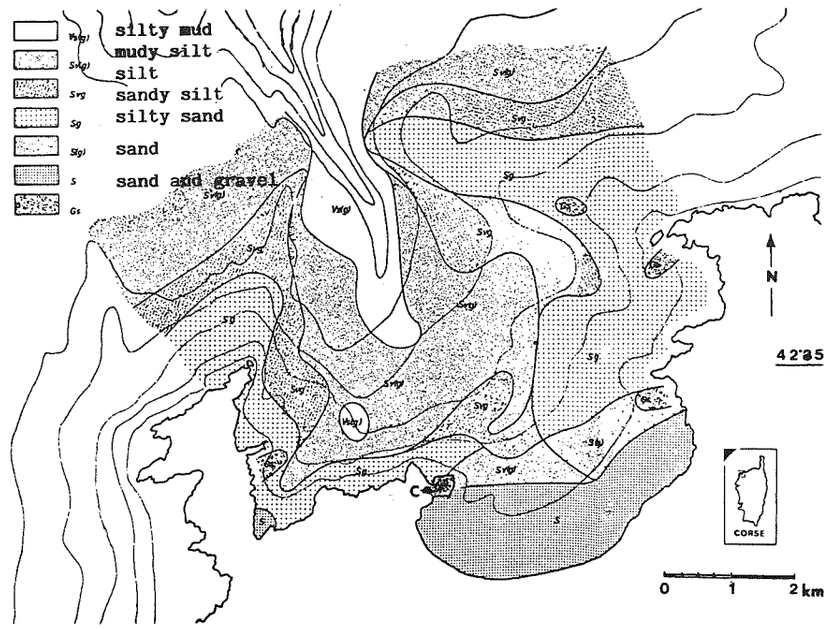

Fig. 2. Sedimentary facies

The sediments met on the bottom of the Calvi Bay are given in the figure 2. Sedimentological analysis and diving visual inspection of the beach show three different sedimentary zones :

East zone is rocks and gravel beach.

Centre zone is fine sand with a median diameter of sediment particles of 250 microns.

West zone, near the new harbour and the city of Calvi is very fine sand, and silt with a median diameter of sediment particles of 125 microns. Sieve analysis results of beach samples are given in figure 3.

The numbers start from East zone to West zone (see figure 1).

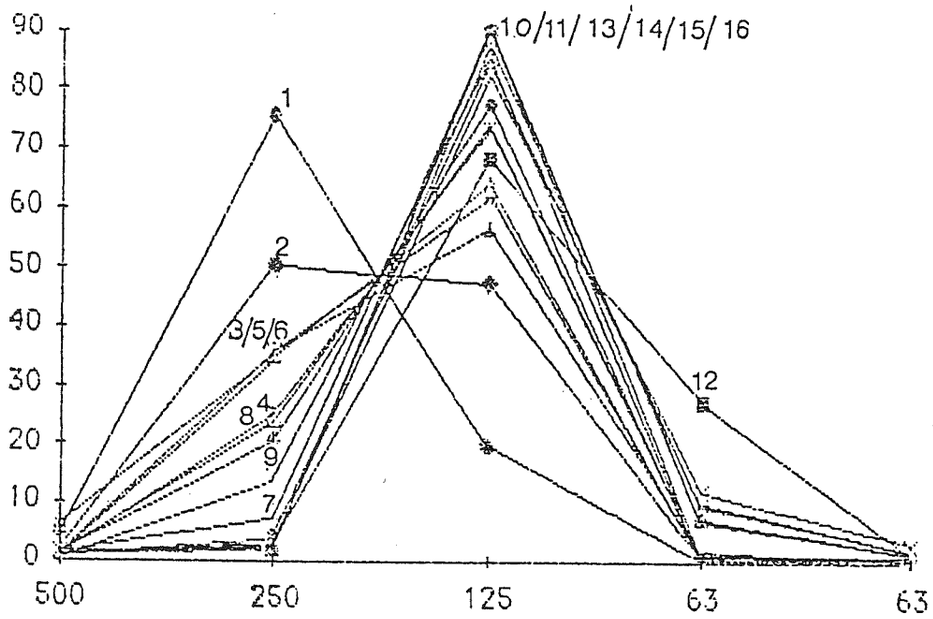

Fig. 3. Summary of sieves investigations

3. CURRENT STUDY

From 1981 to 1983, STARESO studied the flow pattern of Calvi Bay with the anchoring of currentmeters at seven successive positions (number I to VII in figure 1). Moreover in 1986 two currentmeters were anchored from February to October at the positions VIII and IX.

For each record, velocity, direction and duration of the current were analysed. Figure 4 shows one example of the current recording data for Augustus 1986. Findings of the current study are the following ones :

a) flow pattern of Calvi Bay is rather complex, very unsteady in function of the meteorological conditions (wind, storm, duration, direction and intensity).

b) values of product (cm/s x %) are maximum for nearly constant directions (West at the currentmeter VIII and North East or South at the currentmeter IX).

This phenomenon is shown by the figure 5 and indicates the general direction of the sediments transport.

To long term, those currents could be the cause of the sediments deposit at the entrance of the harbour.

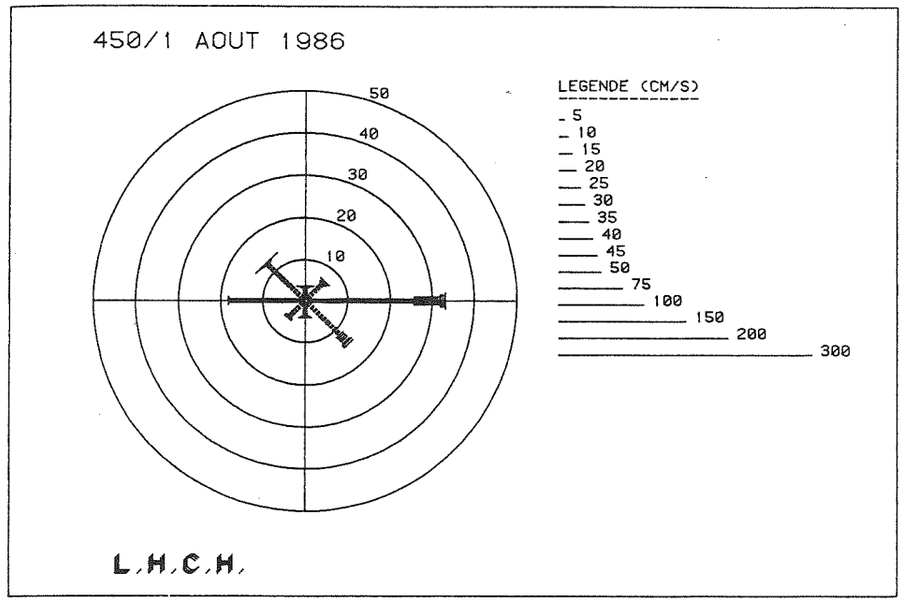

Fig. 4. Currents Record

This flow pattern is observed only during February, March, April, May and June, with a probability of more than 25 %, and agrees with the most active current of sediments transport.

c) West East currents, shown at the figure 6, meet the lowest values of the product (cm/s x %) with a probability of about 5 %, and could not be the cause of beach erosion and sediments transport. The diffraction current around the Calvi citadel could be also the cause of the sediments deposit at the entrance of the harbour.

4. WAVE PROPAGATION STUDY

One of the causes of the beach erosion could be also the wave action. As everybody knows the energy contained in the waves is very large, and is able to transport the sediments on rather long distances.

In the first part of this study, the waves in the Calvi Bay have been measured using wave recorders and analysed. One example of the wave analysis is given in the figure 7 and the associated periods are shown by the figure 8.

Fig. 5. General pattern in winter

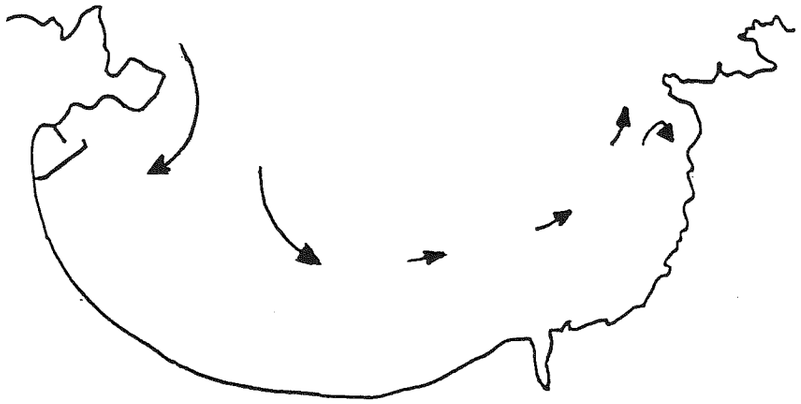

Fig. 6. Flow pattern in summer

The second part was involved with the wave propagation study. For that purpose, finite elements models, using Berkhoff method, set up with the following parameters (wave period, wave length, storm direction, rise of the relative sea level, harbour construction).

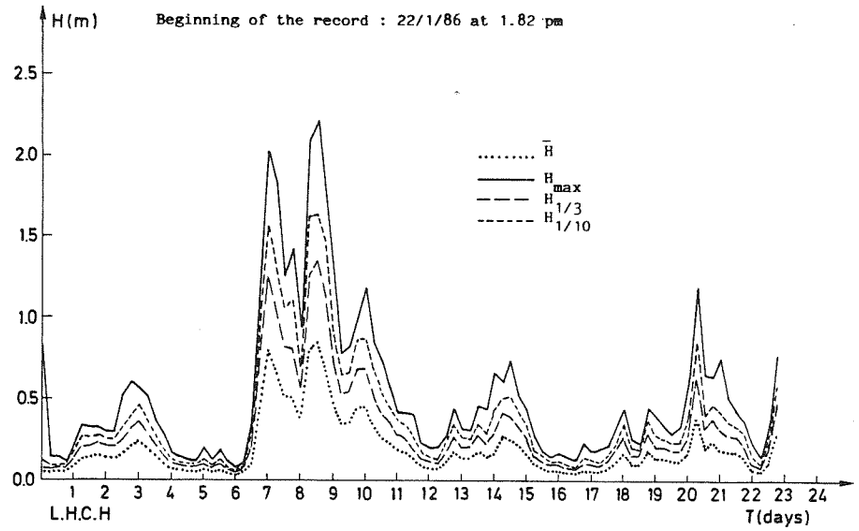

Fig. 7. Wave height analysis

The summary of the computer analysis is given in the table I and one example of the wave amplification pattern is given by the figure 9.

The findings of the wave propagation are the following ones :

a) the roughness of the bay is the greatest one with waves of 9 seconds period. For waves of 7 seconds period, the bay is rather quiet and for waves of 12 seconds period, the roughness is greater with the harbour construction than without.

b) the storms coming from East, are the most active ones with an effect of resonance.

The roughness is rather great near the harbour, and near the shore.

c) there is no general conclusion about the construction of the new harbour. For the waves of a period of 7 seconds, the harbour has an effect of damping, but for the periods of 9 to 12 seconds, which are the most frequent ones, the harbour produces a rather great roughness.

d) there is also no general conclusion about the change of the relative sea level (RSL).

The rise of RLS has a damping effect with waves of period from 7 to 9 seconds, but for the same condition, the roughness is increased with waves of 12 seconds period.

TITLE	Orientation	Period	Long the wave	SWL=0,00	SWL=0,50	HARBOUR with	HARBOUR without	$\bar{X}_A$	max A	Comments
CALVI 1	N.	7	76,40	x		x		1,34	1,56	A rather small, increasing slowly to the open sea.
CALVI 2	N.	9	123,90	x		x		3,09	7,21	A very hight
CALVI 3	N.	12	198,80	x		x		2,02	2,97	A "normal", shore peaks
CALVI 5	N-O	9	123,90	x		x		2,58	3,55	A rather small, quiet on the shore
CALVI 6	N-O	12	198,80	x		x		1,69	2,33	A medium, small peaks
CALVI 8	N-E	9	123,90	x		x		1,73	3,45	A very small
CALVI 9	N-E	12	198,90	x		x		1,49	2,19	A very small
CALVI 11	N.	7	76,40	x			x	2,08	2,36	A small, increasing slowly to the open sea
CALVI 12	N.	9	123,90	x			x	3,62	8,17	A maximum, important peaks in the shore
CALVI 13	N.	12	198,80	x			x	5,03	11,42	Most important value of the study
CALVI 16	N-E	9	123,90	x			x	1,61	2,32	A very quiet
CALVI 19	N-E	12	198,80	x			x	1,22	4,12	A very important and especially on the shore
CALVI 22	N.	9	127,90		x	x		1,97	2,68	A important, same peaks on the shore
CALVI 25	N-O	12	198,80		x	x		3,50	6,10	A very important near the harbour
CALVI 28	N-E	9	123,90		x	x		1,44	1,91	A "normal" peaks in the open sea
CALVI 29	N-E	12	198,80		x	x		1,95	3,69	A important, strong roughness near the harbour and the open sea

max A = maximum of the amplification
$\bar{X}_A$ = mean of the amplification

Table I

5. GEOMORPHOLOGICAL STUDY

From field survey and interpretation of aerial photographies taken in 1960, 1973, 1975, 1980 to 1985, the findings of the geomorphological study are the following ones :

a) Shore sediments of Calvi Bay come from two sources

- initial source : sediments settled by the sea 5-6000 years ago (initial stock).
- fluviatile source : alluvial deposits from the Fiume Secco River and Figarella River (Fig. 1). The alluvial deposits have been distributed along the bay by a drift current from East to West.

This drift current is shown by :

- the storage of sediments in the West part of the bay.

At the East of the mouth of the Fiume Secco River, rocks are sitting directly in the sea, instead to the West, the Santa Catherine abandoned cliff is parted from the sea by a lowland of 150 meters wide.

- the spit at the mouth of the Figarella River turned to the West in 1960.

b) At the present day, only the Fiume Secco is still active in the sediments transport, as it could be observed from the lithotypes distribution and the delta form. On the contrary, the Figarella River is most of the time closed by an offshore bar of the sediments coming from the Fiume Secco River. In its lowest part, the river is a swamp and there is no sediment transport until the sea shore.

c) between 1960 and 1985, it was a general erosion of the beach (figure 10), but at various degrees in function of the area :

- area A-B : Sediments accumulation near the jetty of the harbour due to the stop of the East-West drift current.
- area B-C : In this area located at South-East of the harbour, some erosion was observed from 1975 to 1980, probably due to the harbour construction. But during the 1960-1975 period, the shore was rather limited.
  On the other hand, from 1980 to 1985, few shore advance is noted but under the 1960 situation.
- area C-D : This part of the beach is rather stable, but on the field, some thinning is observed.
- area D-E : In this area, a very important erosion is noted, but it is developped only from 1980 to 1985. The shore retreat is due to the construction of buildings on the beach (restaurants, coffee houses, etc...) or on the dune-sea face.

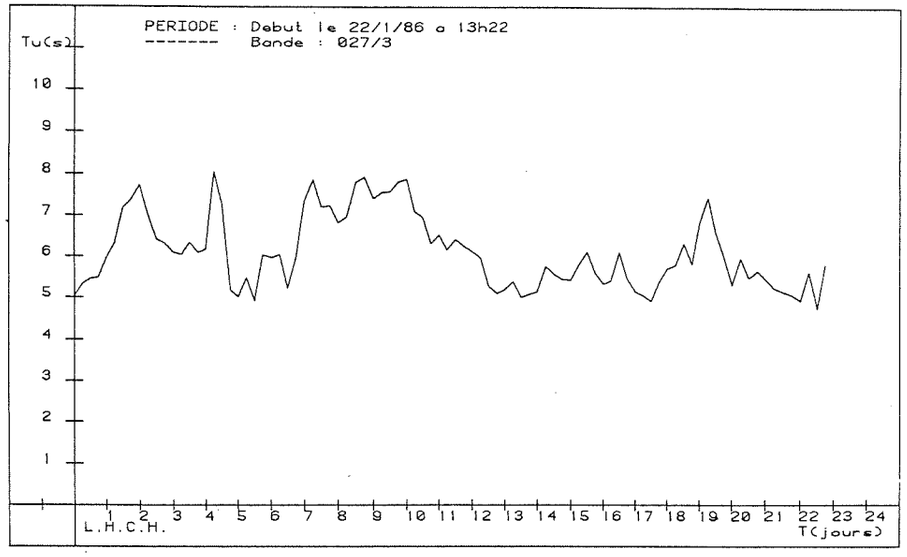

Fig. 8. Wave period analysis

- area E-F : This part of the beach is extended along a camping implanted since about 1960. From this time and until now a important retreat of the shore line is observed (= 1,5 meter/year). This erosion is due to the pebbles extraction from the beach in view to give a "Sandy Beach" at the tourist season. The erosion is also helped by *Posidonia* leaves cleaning. Moreover, the construction of a jetty on the eastern part of the mouth of Figarella River has stopped the drift sediment transport to the West and could also explain the important erosion in this area.

6. FINDINGS

The main cause of the erosion process is the rise of relative sea level (1,3 mm/year) with as a catalyst, the tourist behaviour and the implementation of buildings (hotels, coffee-houses, etc...) on the beach. Following the Bruun

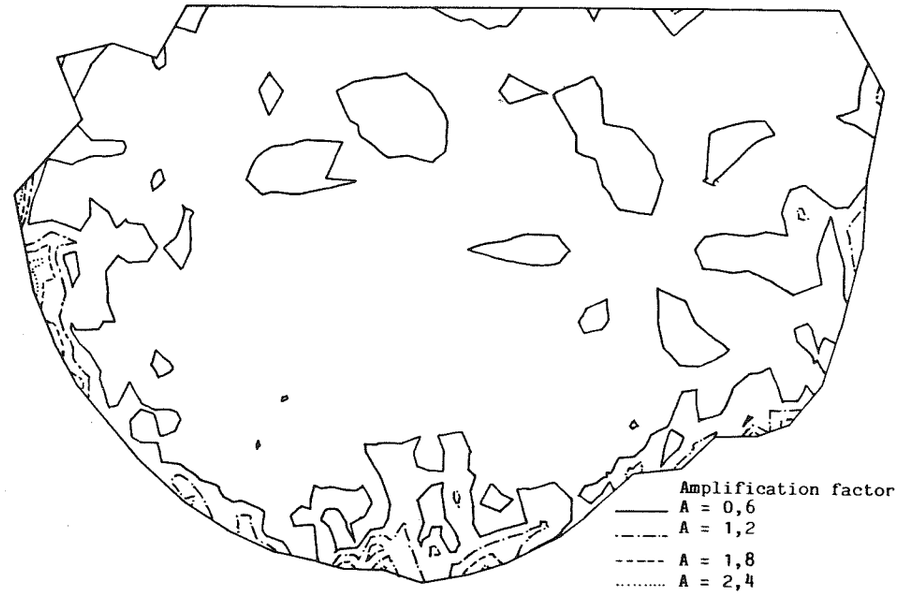

Fig. 9. Wave amplification pattern

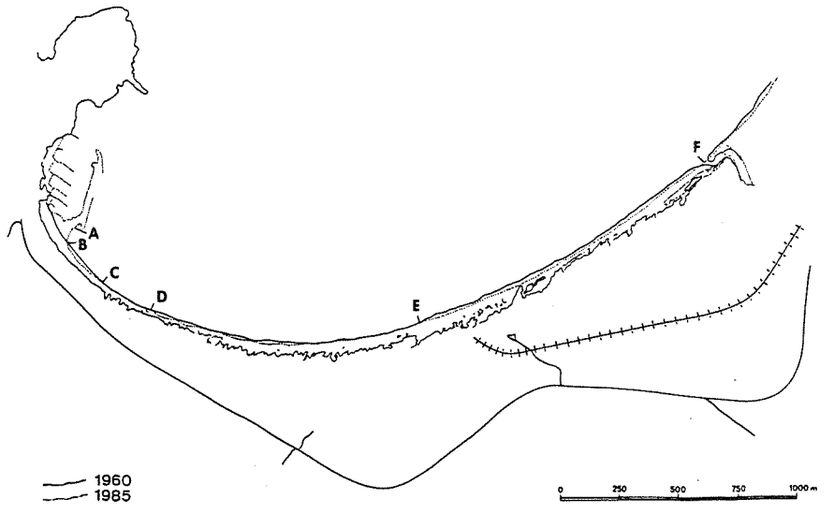

Fig. 10. General evolution of the beach between 1960 and 1985. Aerial photographies study

principle, the retreat of the beach will be in the future, of about one meter/year if the conditions remained constant. In the case of the Calvi Bay, the influence of the construction of the new harbour is rather limited, if the erosion process is taken into account.