

CHAPTER 310

NOURISHED BEACH CONTROL BETWEEN BALIS AND ARENYS HARBOURS (SPAIN)

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ABSTRACT

A description of the monitoring works carried out in the Maresme beaches between Arenys de Mar and Balis Harbour after the completion of the regeneration works consisting on the demolition of the existing groins and the execution of an artificial nourishment is presented.

INTRODUCTION

Maresme beaches are located close to the city of Barcelona (40 km in the northwest) and because of this they are frequently visited all year round.

The zone was suffering an important regression that couldn't be restrained by any attempts of stabilization. So in February of 1992, a regeneration project of this coastal zone was carried out as a part of the works that the Spanish Public Works Ministry has been doing on the Catalan Coast.

The nourishment works began in August 1993 and the first phase of the regeneration was finished in October of the same year, in March of 1994 the second phase ended.

Because of the high investment dedicated to this work, an accurate monitoring of the beaches was planned in order to obtain a better understanding of the beach behaviour with respect to the littoral processes and thus to implement appropriate coastal management strategies.

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The monitoring has been divided in two different parts:

- A field systematic monitoring of the beaches
- A shoreline evolution analysis using a numerical model of simulation

Following the predicted evolution, the possible actions will be analyzed in order to guarantee the adequate maintenance of the desired stability conditions and quality.

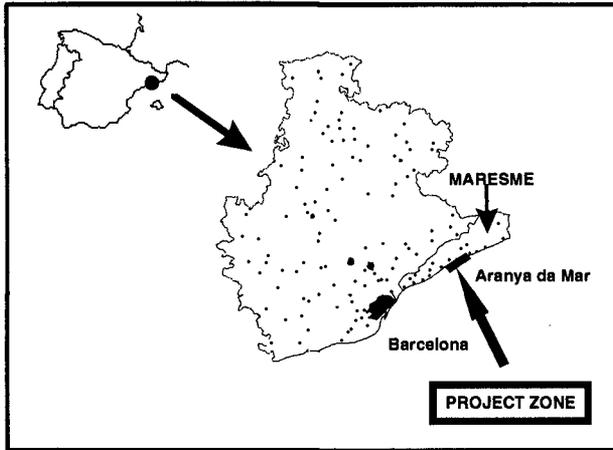


Figure 1: Project location

HISTORY

Maresme littoral is a fisiographic unit which is spread out between Tordera River mouth and Barcelona Harbour.

From the littoral dynamics point of view the working scheme of the stretch, is simple: This area has a NE-SW orientation with a net littoral transport from east to west, and net rates around 40.000 and 100.000 m³/year.

After Arenys Harbour was built in the late forties, littoral dynamics of the beaches in the southwest of the Harbour were strongly modified suffering a regression that could not be restrained by any of the attempts of stabilization carried out. Mainly seawalls and transversal groins.

In the closest zone to Arenys Harbour, a seawall about 2 km long was built to protect the railway line, and far away to the south, for 2.5 km, a set of eleven transversal groins were constructed.

The nourishment project was designed with the double objective of:

- obtaining a great stable beach area
- establishing an important nourishment source for the Maresme beaches in the southwest of Arenys Harbour as far as Barcelona.

The total length of the regeneration was 4.5 km, with a beach width of 70 to 110 m and an elevation of 2.5 m. The mean slope was 1/10.

The total volume of sand was 3.8 million cubic meter. Ten of the eleven transversal groins were demolished.

MONITORING WORKS

Monitoring program consists in bathymetric and topographic works which are performed every six months with the purpose of identifying areas where accretion and erosion occur.

Bathymetric surveys of the whole area were carried out just after the works were completed.

The field data available for this study were those carried out in:

- July 1993 (before regeneration works)
- October 1993 (at the end of the first phase)
- November 1993 (specific survey for the mouth of Arenys Harbour)
- January 1994 (also in the mouth)
- March 1994 (at the end of the second phase)

- February 1995 (first survey)
- July 1995 (second survey)

With these data and employing a digital terrain model, comparative shoreline and isopach planes, and comparative diagrams of control profiles are obtained.

Some of the results of these works are shown in figure 2 where shorelines corresponding to every bathymetric survey are drawn.

Since the nourishment ends until the february of 1995's monitoring survey, shoreline stepped back around 30 meters along all the study zone except the both ends, westward Balis Harbour and eastward Arenys Harbour. It has been a sediment accumulation which means a shoreline advance, in some points a very significant advance (70 meters close to Arenys Harbour counterdike).

It has also been a shoreline advance in the central part of the stretch, downstream of the Hotel Colon groin.

From February to July 1995, shoreline position has hardly modified what indicates a relative tendency to stabilization. A light tilting takes place at westward beach of Arenys Harbour with an important accretion in the counterdike due to wave diffraction effect.

The control profile analysis also indicates (fig. 3) the local advance and receed of the shoreline. Different studied profiles show how the shoreline has receed 30 meter in profile 82 or has advanced in the other points. It can be seen in any profile that July 95's shoreline tilt around February 95 position with 3 meters variation.

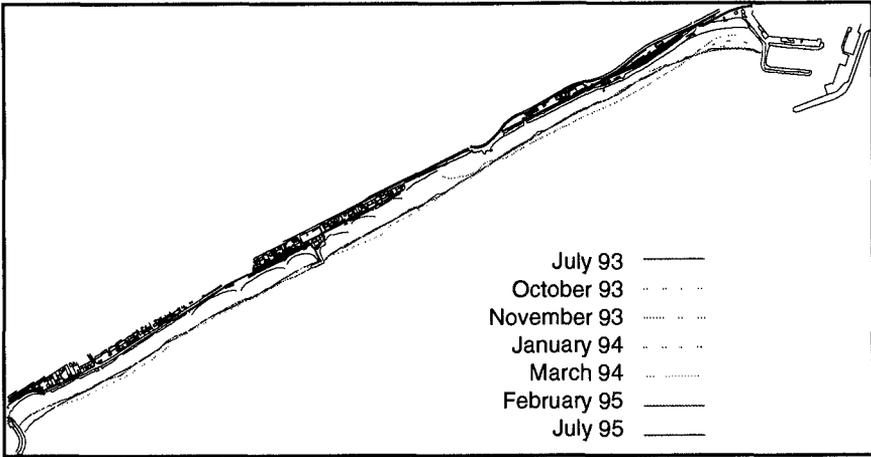


Figure 2: Shoreline evolution

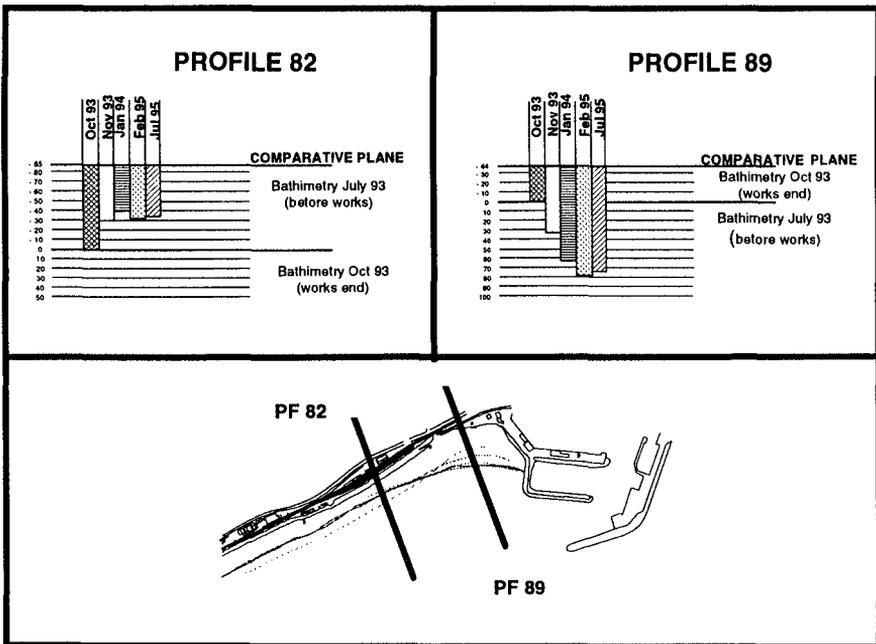


Figure 3: Control profiles evolution

NET SEDIMENT TRANSPORT

A sedimentary budget was done with the purpose of estimating sand volume mobilized by wave action since the completion of the works until July 1995.

Analysing the volumes in the considered cells, the sand quantity lost in this area through the SW extreme during this period was 46,923 m³.

Finally, from these volumes, estimate longshore transport calculations were made.(Figure 4). At this figure two zones can be clearly distinguished:

- In the first zone, from Balis Harbour, and for a length of 3,000 meters, the net sand transport has the NE-SW direction with a maximum value of 89,307 m³/year.
- In the second zone, from this point to Arenys Harbour, the net sand transport has the SW-NE direction with a maximum value of 81,190 m³/year.

In the first zone a relative minimum exists as a consequence of the sand accumulation due to the Hotel Colon groin that acts as a partial barrier.

SHORELINE EVOLUTION NUMERICAL MODELIZATION

Parallel to the monitoring work performed taking account of the field data, a shoreline numerical modelization was executed.

This study was structured in two different parts:

- calibration of numerical model employing the first survey data
In order to obtain good transport coefficients necessary for long term coastal evolution prediction, a calibration was carried out. Then a verification of the obtained coefficients was done.
- simulation of the shoreline behaviour in a 10 year term

The numerical model used for the simulation was GENESIS by CERC.

The main variables involved in one-line shoreline evolution model are wave climate, sediment characteristics, closure depth, coastal structures and boundary conditions.

In this work, different sets of wave data were used. Height and period of wave data proceeded from Tordera escalar buoy, and directions were obtained from visual data of routing ships registered in this sector. With both set of data a continuous register for a year was built up.

The selected boundary conditions were:

- null longitudinal transport in the Arenys Harbour breakwater which means that it acts as a total barrier
- permeable transversal groin in the Balis Harbour breakwater

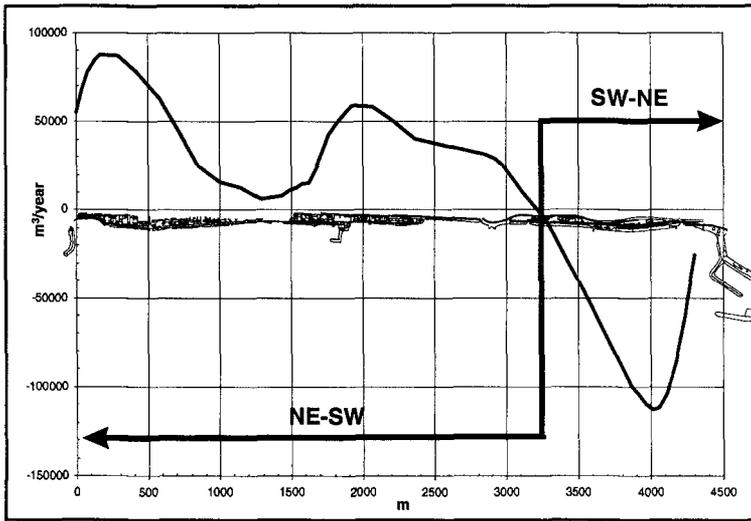


Figure 4: Measured net transport

Some simulations for the period end of the works - February of 1995 period were made, by varying transport parameters k_1 and k_2 , in order to obtain a proper adjustment between the numerical values of the longitudinal transport and shoreline evolution in comparison with the measured values. Values found to agree more accurately were $k_1=0,8$ and $k_2=0,5$.

The net longshore transport distribution along shoreline is shown in figure 5, which can be compared with that obtained from measured values: Both distributions present similar global behaviour with identical peaks of transport.

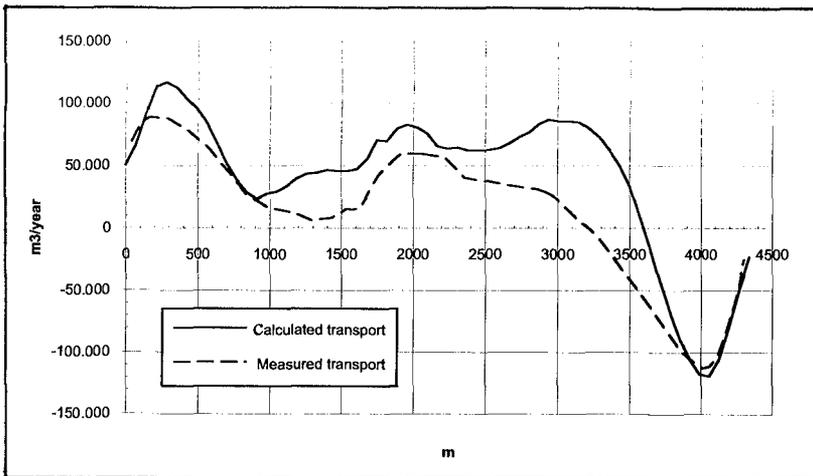


Figure 5: Net transport comparison

The obtained prediction of shoreline evolution is shown in figure 6. A reasonable agreement between measured and predicted shoreline positions can be observed. Both lines present identical accumulation and erosion areas. There is a sediment accumulation close to Balis Harbour and to Arenys Harbour, and sediment erosion in the rest of the stretch, specially downstream of Arenys Harbour.

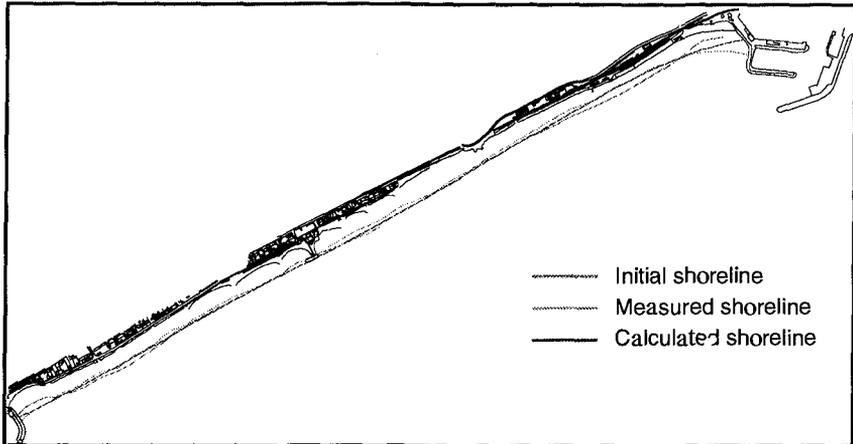


Figure 6: Shoreline prediction

10 YEAR SHORELINE MODELIZATION

Afterwards, with parameters obtained previously, a long term simulation was made in order to find out the beach evolutive trend for the next ten years. In this case a mean climate obtained from visual data is used. Shoreline from July of 1995 is employed as initial position.

Boundary conditions are the same. The existence of a seawall which represents the edge of urbanized area, that can not be overpassed by the shoreline regression, is considered as well.

Figure 7 shows the result. It can be observed that since the 7th year, shoreline has receded, in some points, reaching the edge of the urbanized area. The other points remain rather stable.

Points where regression is maximum are situated downstream of Arenys River Mouth. This zone has been traditionally protected by seawalls.

The most important observations are:

- Westward of Arenys Harbour, shoreline tends to stability but downstream a strong erosion takes place, so after the 6th year less than 10 m of the beach width remains. Points where regression is maximum are situated downstream of Arenys stream outlet. This zone has been traditionally protected by seawalls.

- Hotel Colon Groin doesn't represent, a total barrier to longshore transport and its presence has no influence in the beach behaviour.
- But in the long term, erosive trend of the coast situated downstream of the Arenys stream outlet could move downstream, causing the beach to lie in the Hotel Colon groin.

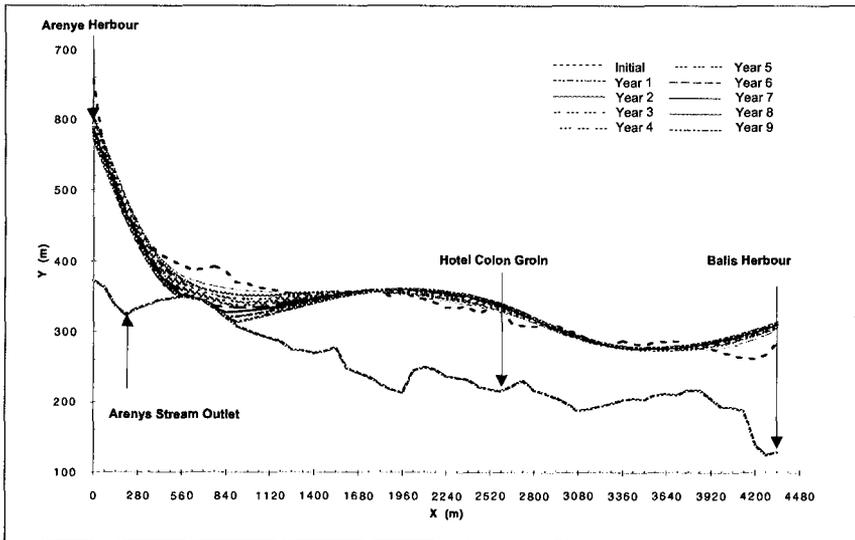


Figure 7: 10 year shoreline evolution

ACTIONS

To restrain the erosive trend of the stretch, two possible actions have been suggested and studied:

- A periodical beach fill, upstream of the stretch (westward of Arenys Harbour)
- Construction of a detached breakwater

Figure 8 shows the first action modelization. As it can be seen in the diagram, an annual beach fill of 40,000 m³ of sand, after the third year, produces stability of the entire beach.

Secondly, with a detached breakwater a salient is generated (figure 9), what means an important increment in the beach surface in this area.

Since there is a possibility of an erosion later on in this point, beach fills are also studied (figure 10). Subsequently the beach would be totally stabilized.

Both solutions satisfy the stabilization objective of the regenerated beach.

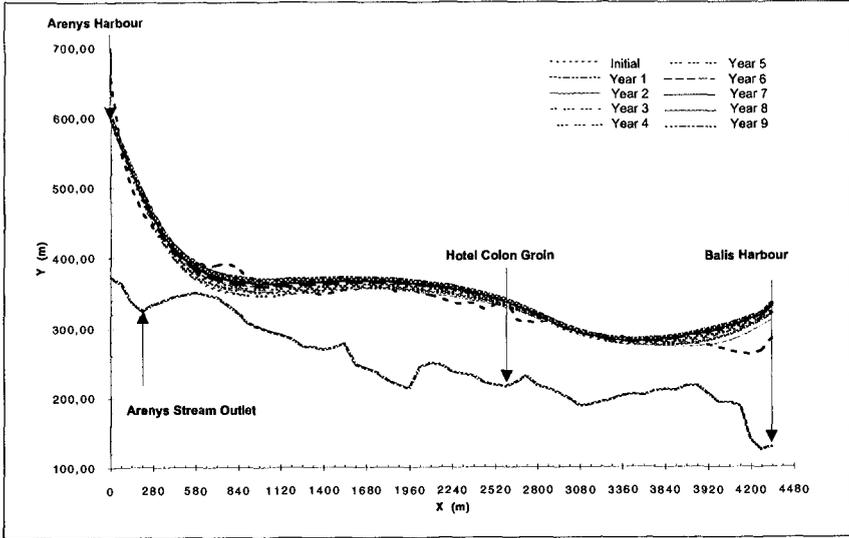


Figure 8: Periodical beach fill modelization

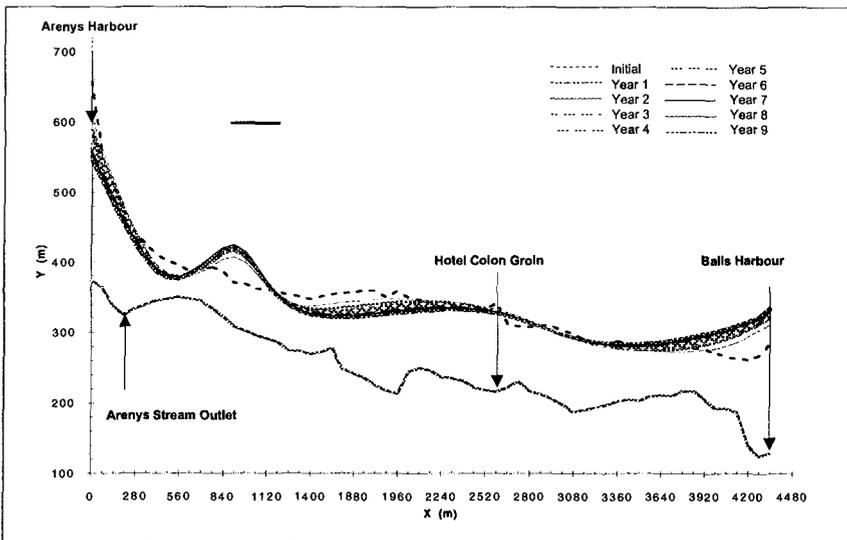


Figure 9: Detached breakwater modelization

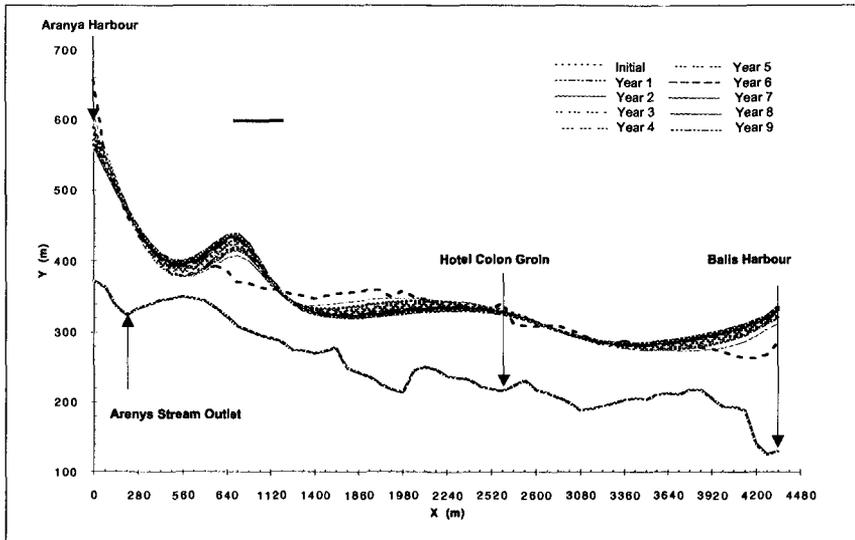


Figure 10: Detached breakwater with periodical beach fill modelization

CONCLUSIONS

- To guarantee extensive coastal zone regeneration, it is very important to carry out monitoring of the shoreline evolution.
- The monitoring and control processes should be completed with simulation models in order to:
 - improve the understanding of littoral processes
 - predict the evolutive trends
 - the necessary actions, their evolution and quantification could therefore be analyzed
- Monitoring continuity will allow the feed back of the calibration of the model and a better adjustment of both, the regenerated beach evolution simulation and the effect of the suggested actions.