CHAPTER 258

SANTA CRISTINA BEACH NOURISHMENT WORKS AND MONITORING PROGRAM

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ABSTRACT

The purpose of this paper is to analyze the suitability of the solution adopted to restore Santa Cristina beach in La Coruña (Spain). The solution, which did not include any structures such as groins, consisted of adding 450.000 M3. of sand dredged from the sea bottom.

Also, a monitoring program was carried out for two years in order to implement appropriate coastal management strategies.

1.- INTRODUCTION

1.1 Morphological Description and Historic Evolution.

Santa Cristina beach lies at the southern end of the La Coruña estuary ("Ría"), approximately 6 Kilometers from the estuary's entrance, forming a classic spit configuration which includes in its interior the Burgo Estuary as well.

The beach has a semi-circular shape and is approximately 1.000 meters in length.

Santa Cristina and Bastiagueiro Grande beach, which is located to the East of Santa Cristina beach and separated from it by Fiaiteira Point, comprise the bottom of the La Coruña Estuary.

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From East to West, the beach is bounded landward by:
- a pier abutting agains a vertical wall 80 meters long
- a vertical wall, approximately 150 meters long, built upon rocks (where "Casa Sara" was formely located)
- rubble-mound protection, 700 meters in length, cotgα=1.5 and above the Highest Tidal Level (HTL)
- beach and dune, 300 meters in length.
- El Burgo Estuary rivermouth, bordered on its Western end by a cliff and Oza Point, known as the "El Pasaje" zone.

Urban development of the spit, in addition to the effect of the coastal defense works and sand mining in the past, caused the near destruction of almost tone Kilometer of dry beach.

Santa Cristina Beach before urban development of the spit (see figure 1 and 2)

FIG. 1 SANTA CRISTINA BEACH. 1.940 (PHOTO: BLANCO)

FIG.2 SANTA CRISTINA BEACH. 1.950 (PHOTO: BLANCO)

1.2 Previous Analysis

Two preliminary studies were performed to evaluate the feasibility of the nourishment project: one by the CEPYC, and the second by Professor Losada, University of Cantabria.

The studies treated the variations of the tidal prims or river flow of the El Burgo Estuary, incident waves variations, changes to the terms of the global balance of sediments equations, and the deterioration of the land areas adjoining the beach.
The following conclusions were reached:

- During the period studied, the beach would have lost approximately one million cubic meters (600.000 M3 between the highest high tide and lowest low tide, and 400.000 M3 between the lowest low tide and the bathymetric 5, which would not have undergone any significant changes in its position.

- The loss would occur in the Eastern zone of the beach.

- The tidal shoal was shifted approximately 100 meters to the West, but keeping its morphology.

- The principal cause of the changes was sand mining carried out during the last century.

- Construction of the Barrié de la Maza Dike has not caused important changes to the beach's contour.

- Construction of the Paseo Marítimo protective breakwater has caused the dismantling of 400 meters of dry beach, although the volume of sand affected by this disappearance is small, approximately 150.000 M3.

Figures 3, 4, 5 and 6, illustrates the shoreline evolution.

FIG. 3 LA CORUÑA ESTUARY 17 TH CENTURY

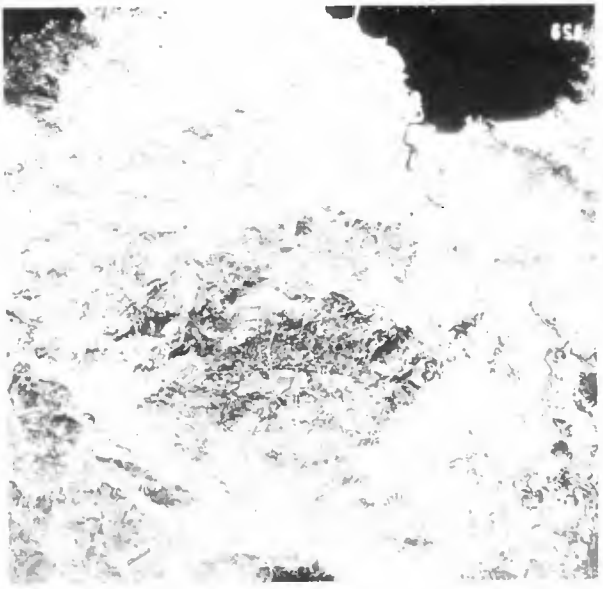

FIG.4 LA CORUÑA ESTUARY - AERIAL PHOTO 1.945

FIG. 5 SANTA CRISTINA BEACH BEFORE NOURISHMENT WORKS. AERIAL PHOTO 1.990

After studying the effect of the newly constructed Oza Dock on Santa Cristina beach, it was concluded that it would be feasible to restore the spit to its original position, by means of adding approximately 450.000 M3 of sand dredged from the sea bottom. This figure is similar to the one reached by the CEPYC.(See fig. 7 and 8)

FIG. 6 SANTA CRISTINA BEACH BEFORE NOURISHMENT WORKS

2. HYDRODINAMIC CONDITIONS

- Wave regime

- Return Period (years)	Hs (m)
15	9,5
50	10,7
100	11,3
150	12,1

- Tidal range, 4M
- Wave diffraction effect (outer breakwater and the new inner quay of Oza)
- Effect of tide currents
- Annual maximum discharge (instantaneous) 15,9 M3/sg
- Annual average discharge 1,8 M3/sg

FIG. 7 SANTA CRISTINA BEACH BEFORE NOURISHMENT WORKS

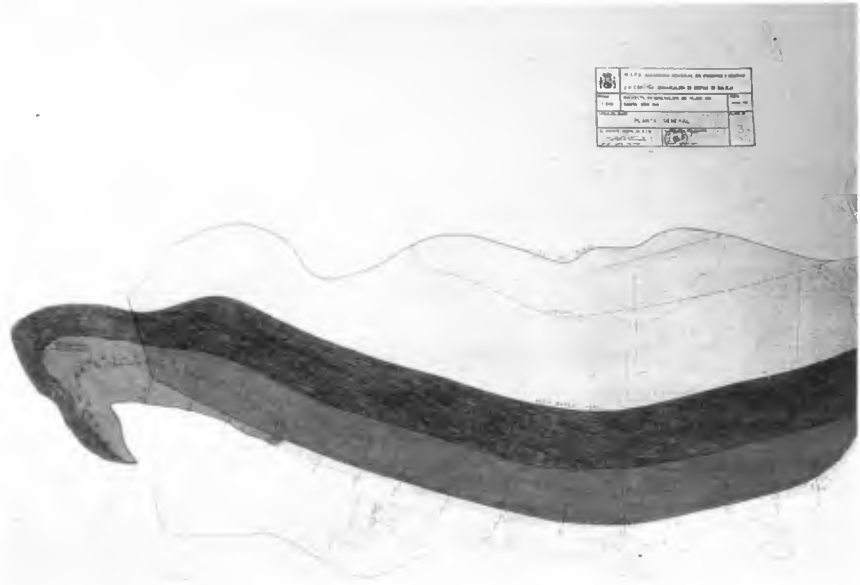

FIG. 8 SANTA CRISTINA BEACH AFTER NOURISHMENT WORKS FORECAST.

3. SEDIMENTOLOGICAL CHARACTERISTICS

- NATIVE SAND
D50= 0,18 mm at -1.0 meter water depth
D50= 0,15 mm at -5.0 meter water depth

BORROWED SAND

450.000 m3 of sand from the sea bottom was added which is D50 = 0,45 mm at -5.0 meter water depth.(FIG.9)

Furthermore, the rubble mound defending the sea front was modified to satisfy aesthetic and social considerations. The city's population can now enjoy sitting on the stepped sea front which has become a popular meeting point at night for the city's teenagers.

FIG. 9 SANTA CRISTINA BEACH AFTER NORISHMENT WORKS

4. MONITORING

4.1 Bathymetric Procedure Utilized

To eliminate possible errors in the oceanographic devices normally used, as well as the influence of the tides, it was decided to gather data as if trating a classic leveling situation on land, that is to say, obviating the sea.

Once the data information was known, it was analyzed by computer to obtain level curves, volumes, etc.

Presently, bathymetric and granulometric works are performed every three months to monitor its evolution for the purpose of identifying areas where accretion and erosion occur.(Fig. 10)

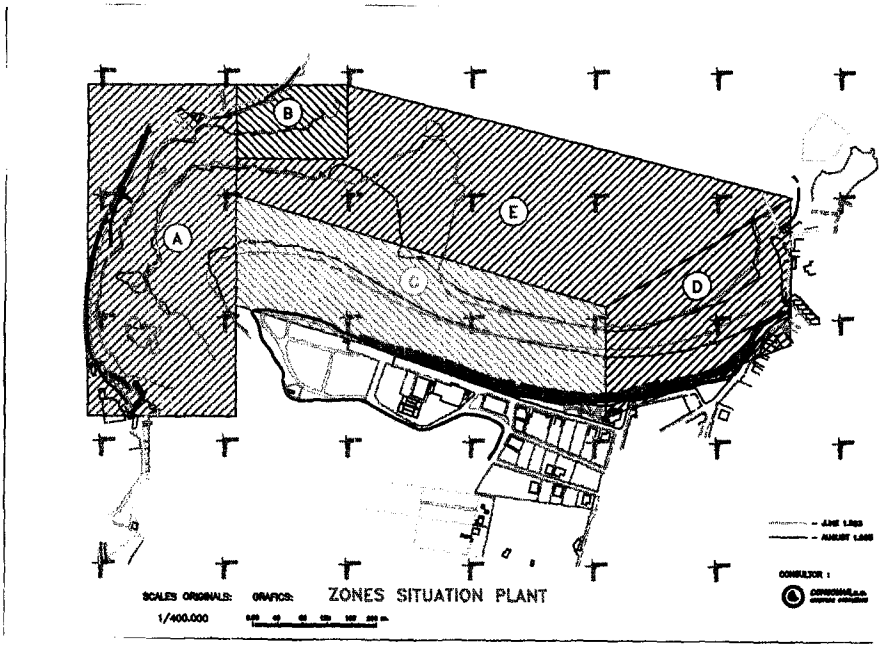

FIG. 10 ZONES SITUATION PLANT

4.2 Elements Studied

The following elements have been studied:

- evolution of the beach's high and low tide lines
- beach transects and channel
- comparison between the areas of erosion and accretion
- volumetric changes of the eroded and accreted areas

5. BEACH EVOLUTION/DEVELOPMENT

The beach has a 900 m.l. coastline which is exposed directly to waves.(See figure 11)
The eroded area (600 meters in length) is situated between the transversal outlines 1 and 4 in the East zone and reflects a typical spiral form due to the difraction process. In this area, the beach is at 30º angle with respect to the alignment of the spit, as indicated in the outlines 5,6 and 7, whose bathymetrics are noticeably parralel to the Paseo Marítimo and have experienced no changes during the entire process. Therefore, we can emphasize that this alignment corresponds to the beach's geomorphological equilibrium position.

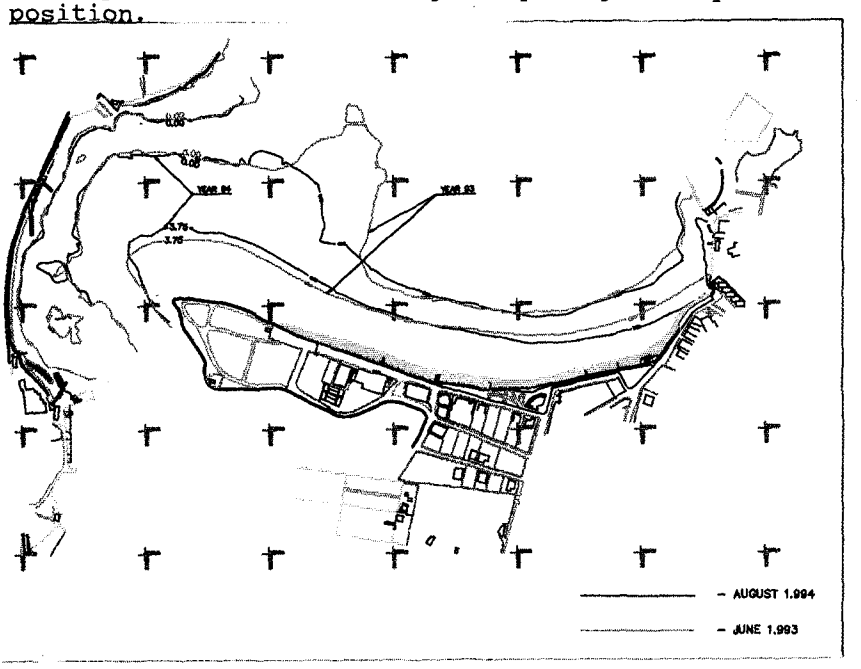

FIG. 11 BEACH EVOLUTION/DEVELOPMENT JUNE 1.993-AUGUST 1.994.

Figure 12 shows the isopaches curves in the period june 1.993 - august 1.994

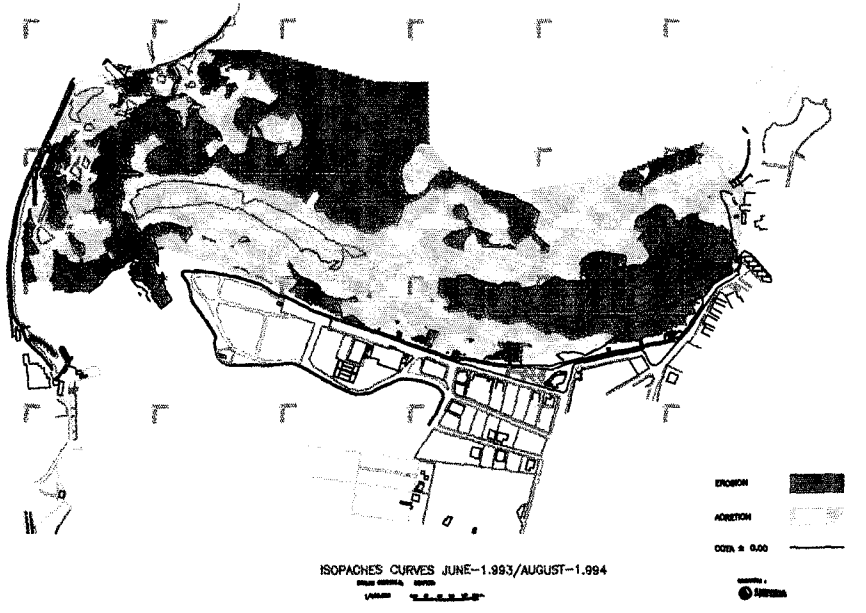

FIG. 12 ISOPACHES CURVES JUNE 1.993 - AUGUST 1.994

The sediment drift movements are showed in figures 13 and 14.

The sand eroded at the beach's Eastern zone is carried and deposited to the Western zone (spit) where significant growth is noted both in surface and elevation as a result of receiving 52.000 M3 continuously in two years (actual monitoring period).

The beach area submerged under the low tide has lost 17.000 M3 due to erosion in the last year. This sand has sihifted to the spit's mouth (extreme West) and to the left bank of the river mouth.

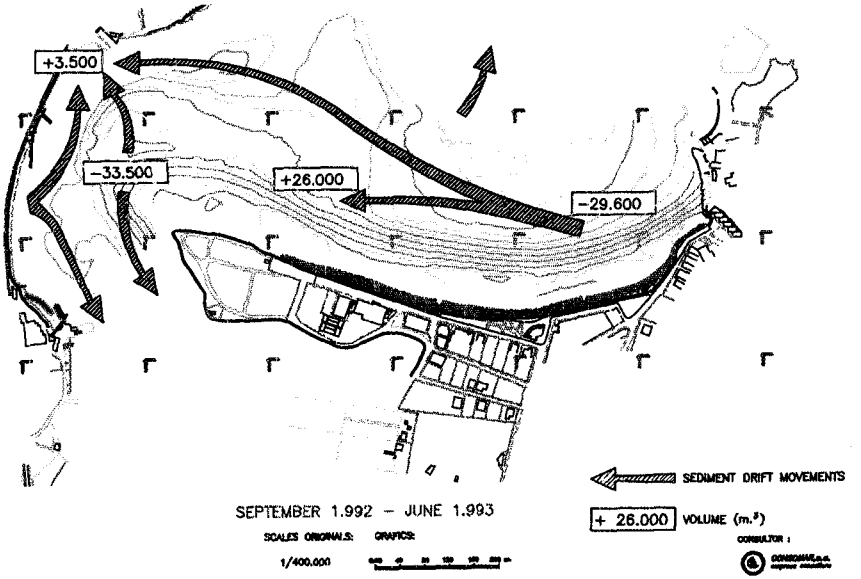

FIG. 13 SEDIMENT DRIFT MOVEMENTS SEPTEMBER 1.992 - JUNE 1.993

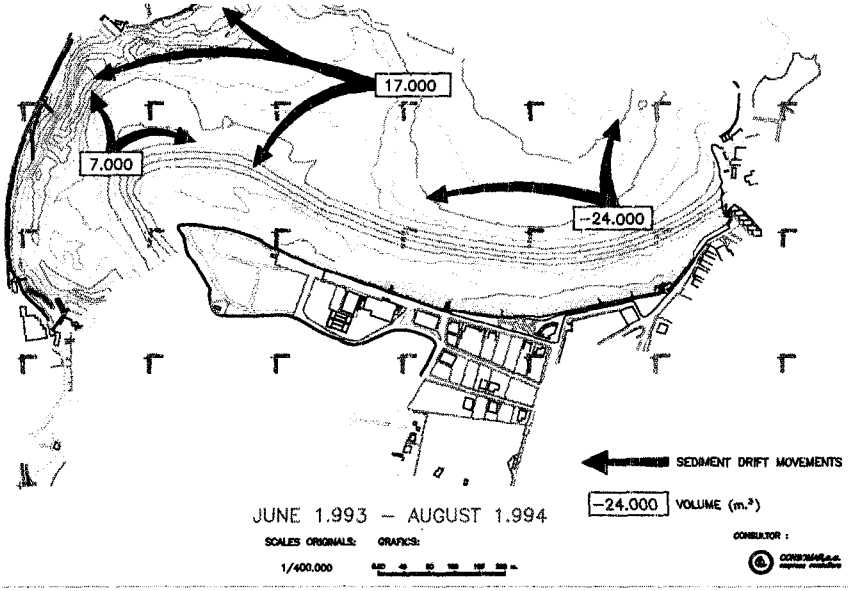

FIG 14 SEDIMENT DRIFT MOVEMENTS JUNE 1.993 - AUGUST 1.994

One of the causes of this phenomenon could be the diffractive effect produced by the new Oza breakwater, witch was constructed after the beach's nourishment works had been completed, and whose effects (already predicted in the previously mentioned studies) were as follows:

1. Wave height will be reduced at every point on the beach: approximately 50% reduction in the Western half of the beach and 20% reduction in the Eastern half.

No significant change to the wave's transversal gradient will be noted, except in the beach's extreme Western sector.

2. The wave's angle of incidence will not change in the Eastern half of the beach and in the Western half, will be modified approximately 15º, reaching maximum values of 30º in the extreme Western sector of the beach.

Based on data gathered during the monitoring period, the following points can be made:

a) Coastline retreat (outline 2) "East zone" has been:

	Elevation +0,00	Elevation +3,75
Período Sept. 92 to June 93:	-28,00	-28,00
Período June 93 to Aug.94:	-10,00	-21,00
TOTAL	-38,00	-49,00

b) Coastline advancement (outline 8)"West zone" has been:

	Elevation +0,00	Elevation +3,75
Período Sept. 92 to June 93:	-2,00	+36,00
Período June 93 to Aug.94:	+13,00	+18,00
TOTAL	+11,00	+54,00

The resultats of the profiles evolution are showed in figures 15 and 16.

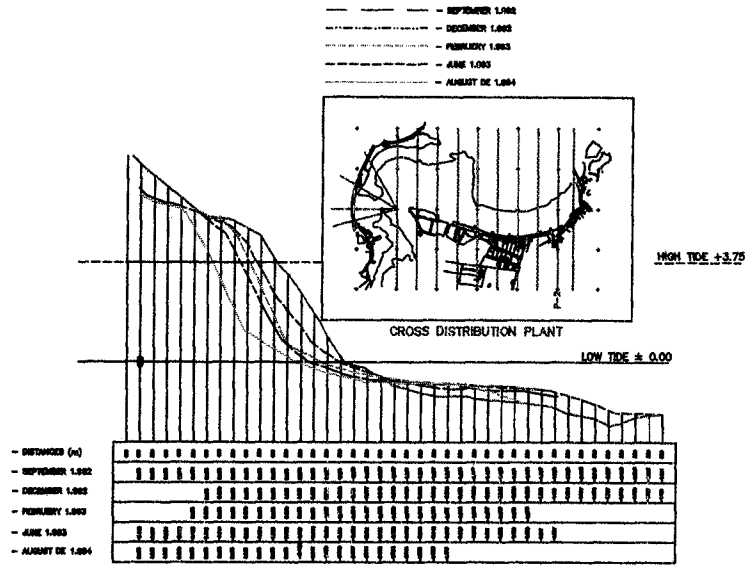

FIG. 15 PROFILE - 2

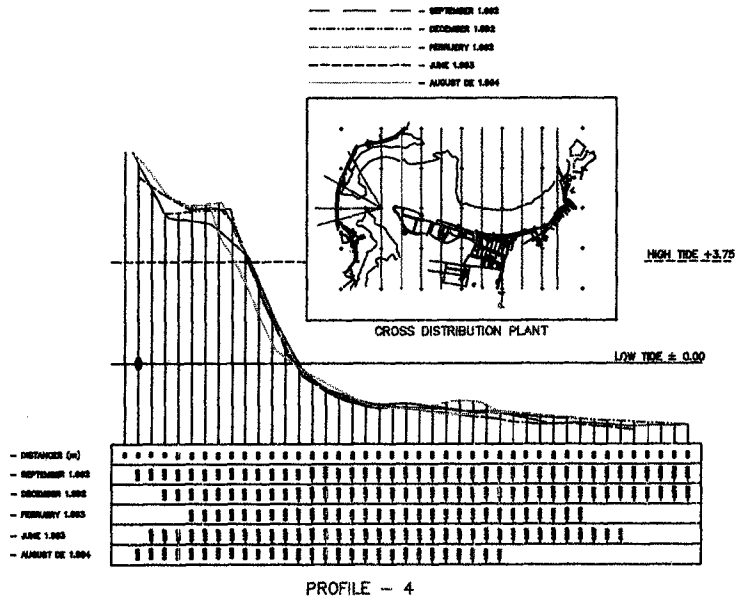

FIG. 16 PROFILE - 4

6. CONCLUSIONS

1ª The evolution of the beach in the two annual periods studied are similar.

2ª The east side is being wearing away continually.
The semi-circular shape of the beach is identical to an spiral. Tipical shape of beaches that are resting on by the balancing diffration's surge.

3ª The central area remains in balance and there-is no significant change.

4ª The west side (arrow) wins an amount of sediments. Coming mainly from the east side.
The arrow go forward parallel to itself and in the direction of the flow of the mouth of the Mero river, being more noticeable the advance in the high tide than in the low tide.

5ª The element of control studied shows and equilibrate sedimentary balance between erosion and accretion.