

CHAPTER 257

PROJECT, WORKS AND MONITORING AT BARCELONA OLYMPIC BEACHES

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1.- INTRODUCTION.

Barcelona is the second city in Spain(2.3 million inhabitants) after Madrid (4 million) and is also the city that held the last Olympic Games in July 1992.

It is the third segment of a physiographic unit beginning at Tordera River Delta and ending at the port of Barcelona.(A description of the whole physiographic unit can be found in ref. 1 by Carlos Peña 1992).

But in the last decades it became one of the ugliest and most degraded part of the coast of Spain. Everybody considered most of the sea-front side as the rubbish dump where everybody could get rid of everything.

In addition to this, there was some groins constructed to assure the discharge of Barcelona sewage draining system.(Nowadays there are still from time to time, rain water discharges there).

2.- THE SCHEME.

The first important decision to be taken when the recovery of this part of the city was decided was to choose between the simple sand nourishment or the stabilization of the coast line with rigid structures.

The previously existing groins have conditioned the solution to recover the beaches of Barcelona sea-front. If these groins were not there as an unavoidable condition the solution probably was a simple and periodic sand nourishment since in the vicinity of Barcelona many millions cubic meters of coarse sand are available at less than 30 m. depth water.

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But since it was necessary to keep and improve the discharge capacity of the draining system of Barcelona, the solution finally adopted was to rigidize the coast and to build pocket beaches between every couple of groins.

A schematic plan of the whole project in front of the Olympic Village can be seen in fig.1 and a part of it in fig.2.

3.- THE WORKS

The landscape has deeply changed; a marina has been constructed as part of the Olympic Games infrastructure, beaches can be found instead of previous rubbish tips, and the groins have been rebuilt in order to assure the stability of the beaches.

Fig.13 shows an aerial view of the whole area in 1993 after the works have been completed.

As a whole, 1,485,476 m³ of sand have been pumped to the beaches and most of the groins have a submerged part in order to stabilize the sand without horizon visual intrusion, supporting the submerged part of the sand profiles at the southern part of every pocket beach of this project.

As we can see later this part of the project only partially did work properly.

An important element is the submerged groin of fig.3a and fig.3b. It was designed with a double purpose: The first one is to act on the incident waves in order to make them refract in the same way as an emerged breakwater would do. The second one is to support the submerged profile of the Somorrostro Beach.

It was built with the crown at mean sea water level in order to keep the horizon line free of visual intrusion as much as possible.

In order to precisely design this part of the project so that to keep the energy transmission coefficient below 0.1 and to test its stability, a lot of experiments were carried out at the Centro de Estudios y Experimentación de Puertos y Costas (CEPYC-CEDEX, ref.2). As a result, the groin has the crown 34 m. wide at mean sea water level.

The coast line was predicted using only very simple numerical models (logarithmic spiral of Carlos Garau - ref.3 - and the theory of pocket beaches of Silvester - ref.4 -), and available visual wave data records. We all were well aware that, since these visual wave data are not very accurate, some errors could be done in the project as a whole.

Works have been completed just before the Olympic Games (July-1992), and since then the whole project is being monitored.

4.- THE MONITORING

The monitoring has been focussed and divided in three different parts:

a) Topography

The cartography and drawing of the sea-land line has been done in June and February of 1993 and April and June of 1994.

Some of the results of this topographic work are shown in fig. 4 and 7, where also the coast line of 1987 previous to the project and the so called theoretical line have been drawn. This last line has been obtained by means of Garau logarithmic spiral theory and proves to be good enough to predict future coast lines when complete, accurate and reliable wave climate are not available.

b) Bathimetric surveys

Bathimetric surveys of the whole area have been carried out just after the works have been completed in June 1992 and September 1993.

The lower part of fig.10 shows the measured profiles obtained at the key plan of the same fig.10. The profile of July 87 previous to the works is also included.

It is clear that these three profiles should fit below 7 or 8 m. depth but it can be seen that they do not fit even below 10 or 12 m. depth. Therefore some error (systematic or not) must have been introduced. This kind of trouble is very common in making bathimetries all over the world and as a matter of fact, this kind of surveys are useless for scientific purposes. Further investigations, research and experimentation should be done in order to improve bathimetric technic. Anyway, if we correct all the profiles forcing them to fit below 10 m. depth, (upper part of fig. 10) we can draw the map of erosion and deposition areas, and we can find out a slight trend in the sand to move to the South, except in Nova Icaria Beach which is fully stabilized by the submerged groin (fig.8) and Somorrostro Beach which shows a trend to tilt towards the Port's mouth (fig. 5).

c) Tracers

The very same sand of the beach colored with rhodamine, uvitex and auramine was used to trace the movements of the sand. Two hundred points were sampled twice in 1993 to find out the movements of six different tracers. The results of two of them are shown in figures 6 and 9 showing the same general trend found out in the bathymetric surveys but with another very important conclusion: The submerged breakwaters and groins are not impermeable to movements of sand grains although we are not able to quantify the amount of sand that traversed them.

5.- CONCLUSIONS

1) The logarithmic spiral theory of Carlos Garau and Silvester is a very useful tool to predict the coast line changes.

2) Further research should be carried out to make available better bathimetric technic.

3) Tracers are a very useful tool to find out the general trends of sand movements.

4) As far as Barcelona beaches is concerned we can conclude that the project as a whole is working well but a few small corrections should be introduced because:

a)The equilibrium shape of the pocket beaches seem to be slightly tilting to the south.

b)The submerged breakwaters and groins are not completely impermeable to sand movements.

c)The Somorrostro Beach is slightly tilting to the Port's mouth.

REFERENCES

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3)Garau C. - Conditions for Beach Stability - Revista de Obras Publicas.January 1981 (in Spanish)

4)Silvester R. - Coastal Engineering,2 - Chapter 2 (Elsevier Scientific Publishing Company 1974).

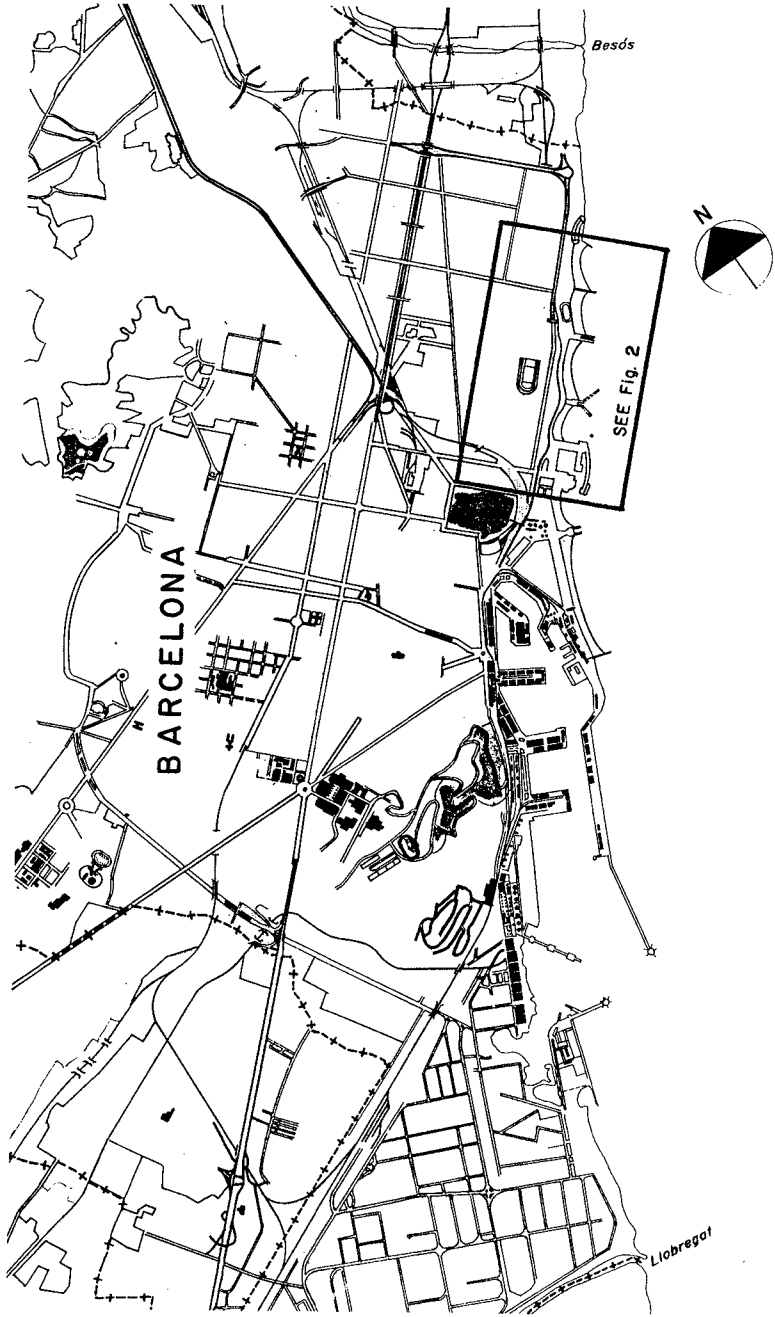


Fig. 1 GENERAL PLAN OF BARCELONA SEA-FRONT RECOVERY PROJECT.

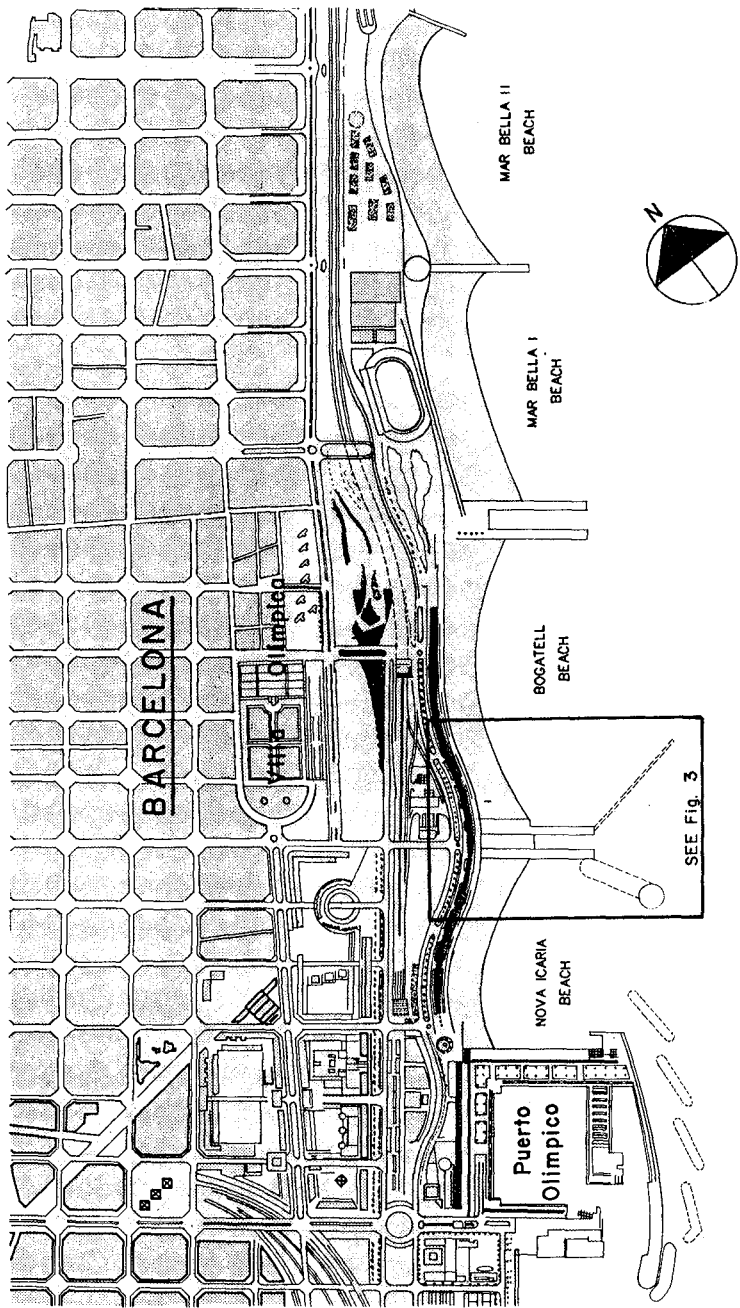


Fig. 2 PARTIAL PLAN OF THE BEACHES.

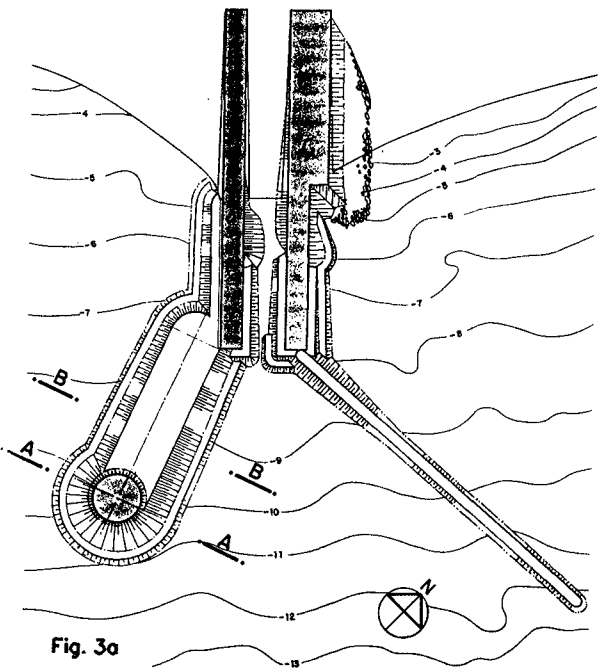
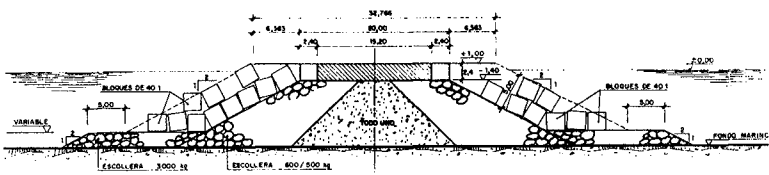
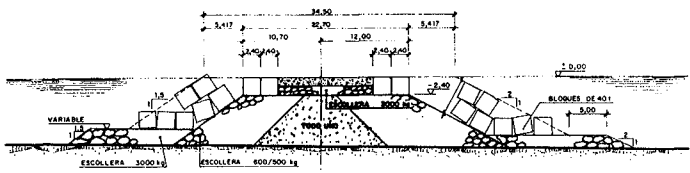


Fig. 3a



SECCION A-A



SECCION B-B

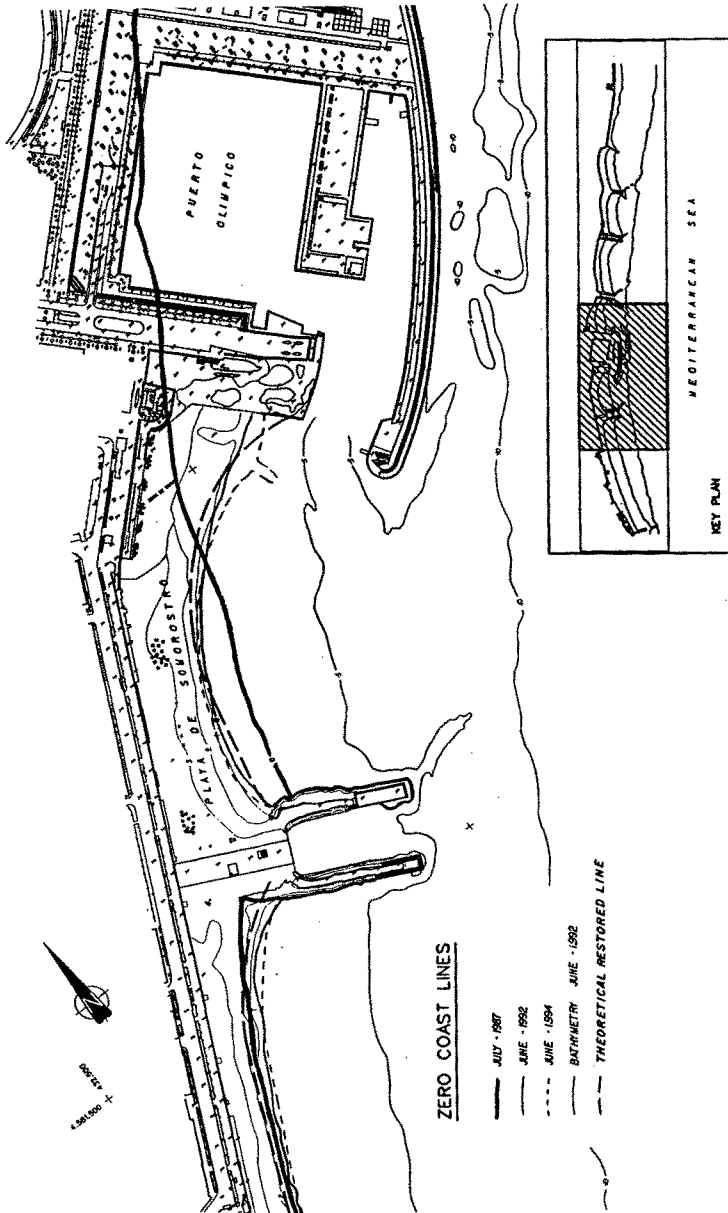


Fig. 4. THE SHORELINE OF BEACH (Playa de Somorrostro) HAS EXPERIENCED VERY BIG CHANGES SINCE JULY 1987. THE SO CALLED THEORETICAL LINE IS OBTAINED WITH CARLOS GARAU'S SPIRAL.

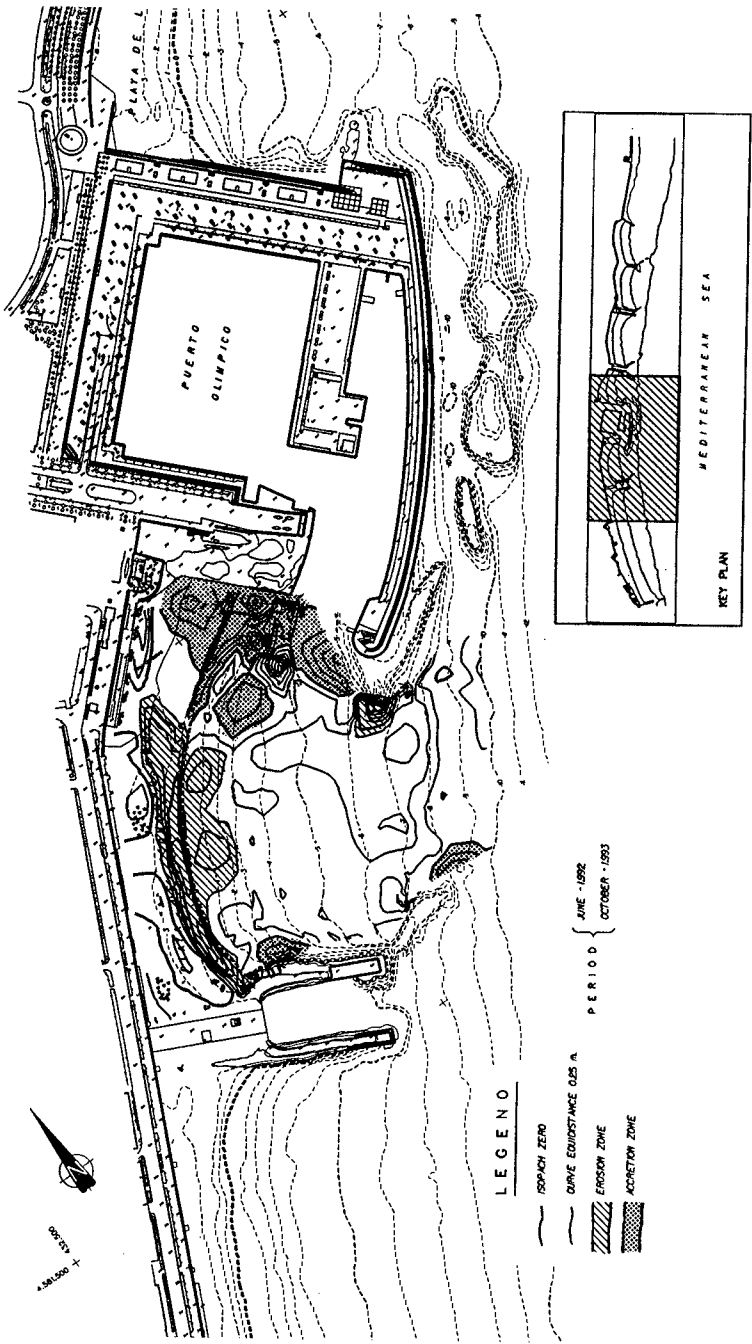


Fig. 5 THIS FIGURE SHOWS THE AREAS OF SEIMENTATION AND EROSION IN SOMORROSTRO BEACH.

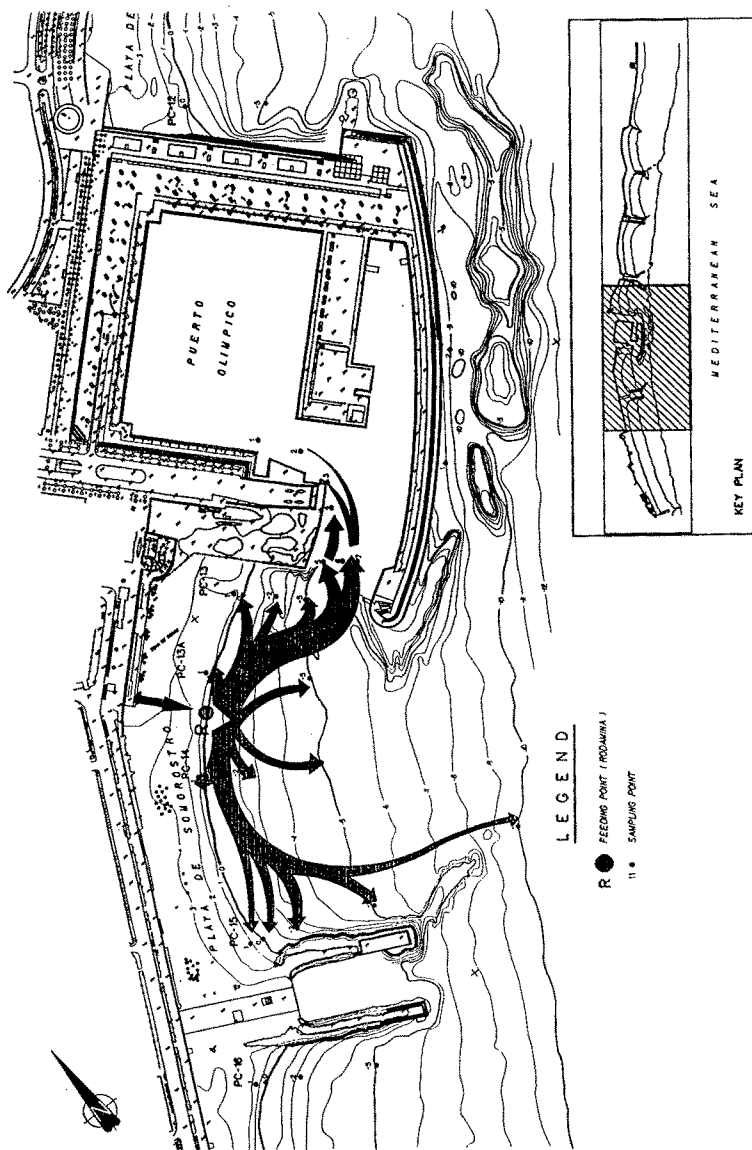


Fig. 6 TRACERS FEEDED IN R AND SAMPLED IN MANY POINTS SHOW THEY TEND TO MOVE MAINLY TOWARDS THE PORT-MOUTH.

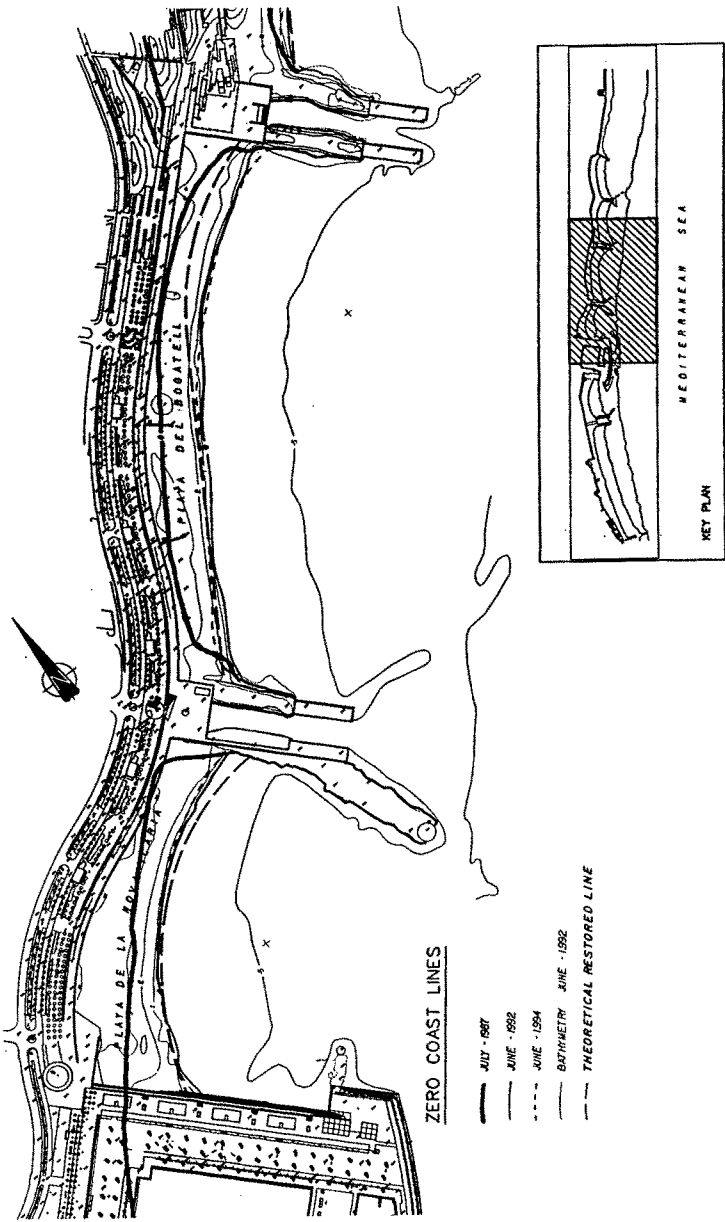


Fig. 7 AT THE NORTHERN PART OF THE PORT THE COASTAL LINE ADVANCED ABOUT TWENTY METERS AFTER THE WORKS.

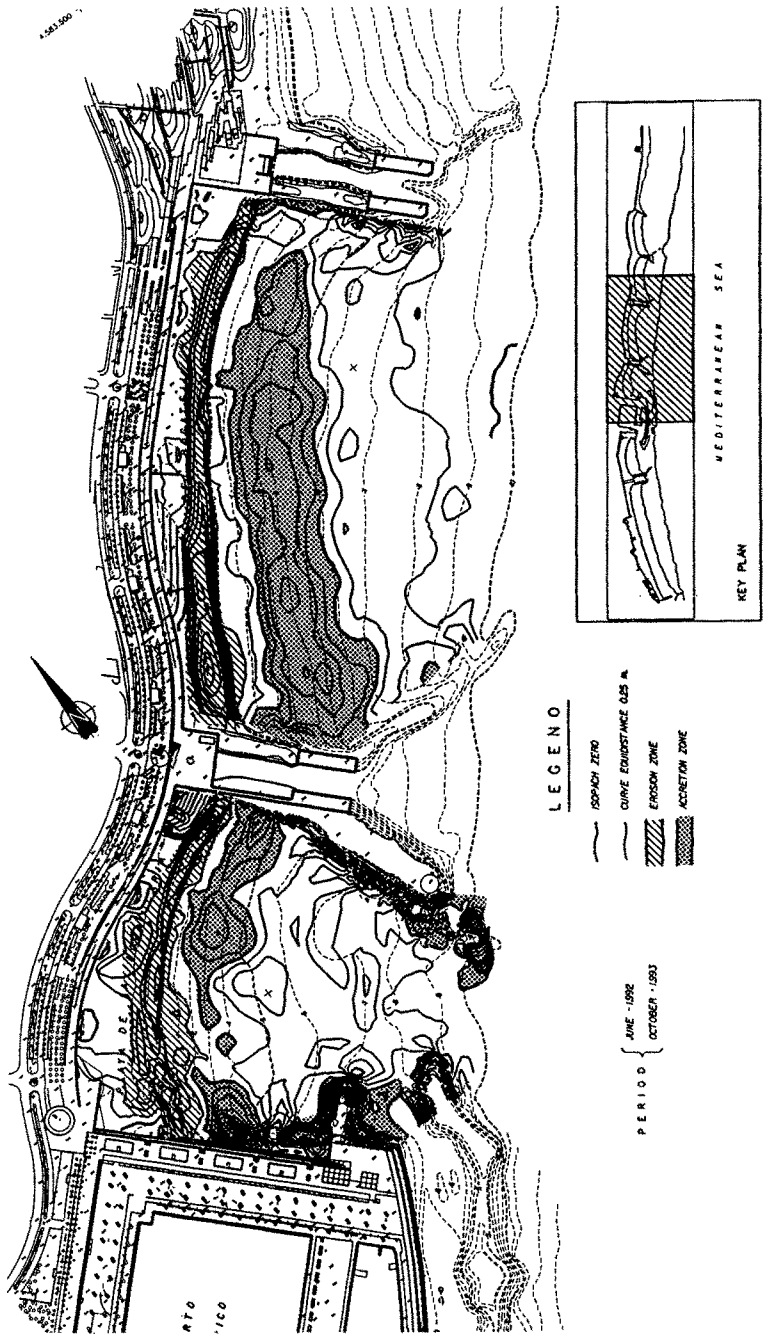


Fig. 8 DARK ZONES ARE DEPOSITION AREAS SINCE JUNE 1992. THEY SHOW A GENERAL TENDENCY TO MOVE SLITLY TO THE SOUTH.

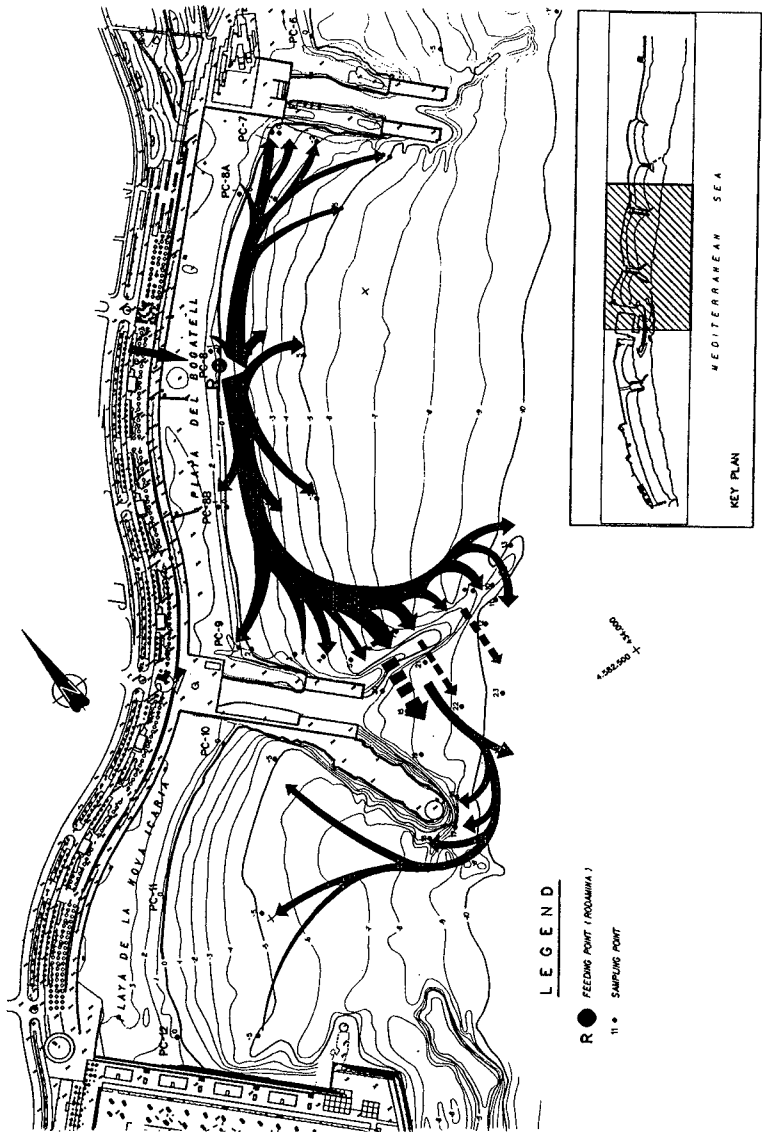


Fig. 9 TRACERS SAMPLES SHOW CLEARLY THE SAND TENDENCY TO MOVE TO THE SOUTH, THROUGH OR SURROUNDING THE SUBMERGED GROINS.

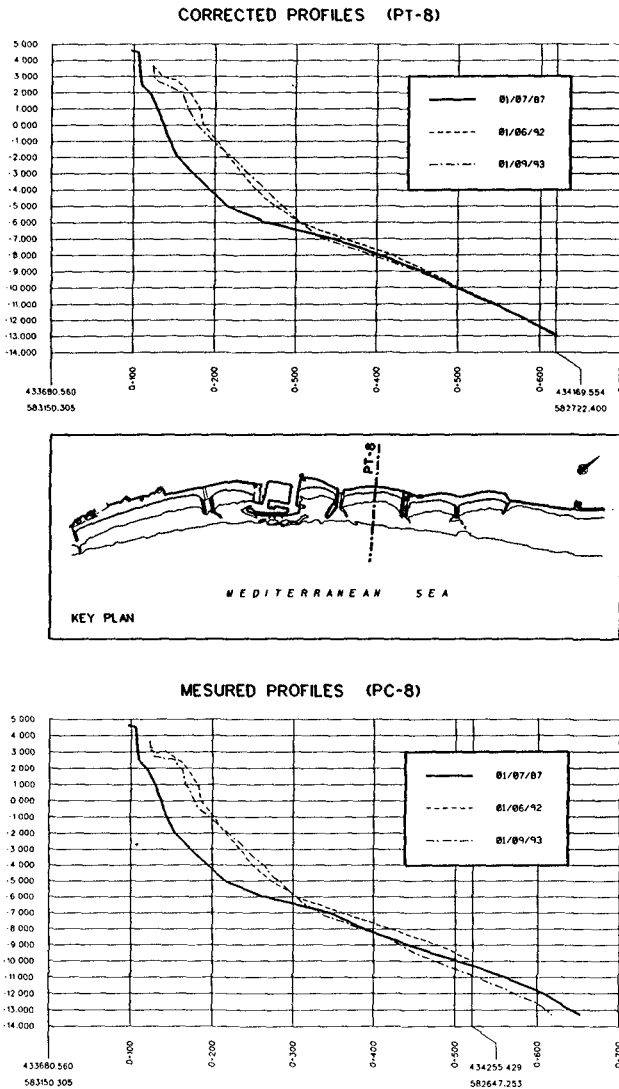


Fig. 10 THE LOWER FIGURE SHOWS MEASURED PROFILES IN 87, 92 AND 93 BATHIMETRIES. THEY DO NOT FIT EVEN BELOW 10 METERS DEPTH. THE UPPER PROFILES SHOW THE CORRECTED ONE'S.



Fig. 11 A GENERAL AERIAL VIEW OF BARCELONA'S OLYMPIC BEACHES. FROM THE LOWER PART OF THE PHOTO TO THE END WE CAN SEE SOMORROSTRO BEACH, THE OLYMPIC MARINA, NOVA ICARIA BEACH, BOGATELL BEACH, MAR BELLA I AND MAR BELLA II BEACH.