CHAPTER 258

PROJECTS, WORKS AND MONITORING AT BARCELONA COAST

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0. INTRODUCCION

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.

Just at the sea-front of the city is the port of Barcelona, the most important in Spain. The coast of the province of Barcelona is divided in two at this point. The northern part of Barcelona's coast runs from this port up to the mouth of the Tordera river, which is the border between the provinces of Barcelona and Girona.

These are 47 kms of the spanish coast whicharc very heavily degradated in some parts.

In its natural state it was a continuous and broad sandy beach 47 km. long and is some points two or three hundred meters wide, mantained by the sediments transported to the coast by Tordera and other small rivers.

Fig. 1[2] shows the situation of Barcelona in Spain and on the Mediterranean sea.

Fig. 2 shows the distribution of wave height all along the different directions focusing on the Barcelona coast. Data of this distribution comes from the well known visual data provided by ships.

Just a look at this fig. 2 shows that there is a potential sand transport capacity from north to south. This sand transport capacity has been evaluated by means of the CERC formula in about 89.000 m^3/year near Barcelona city.

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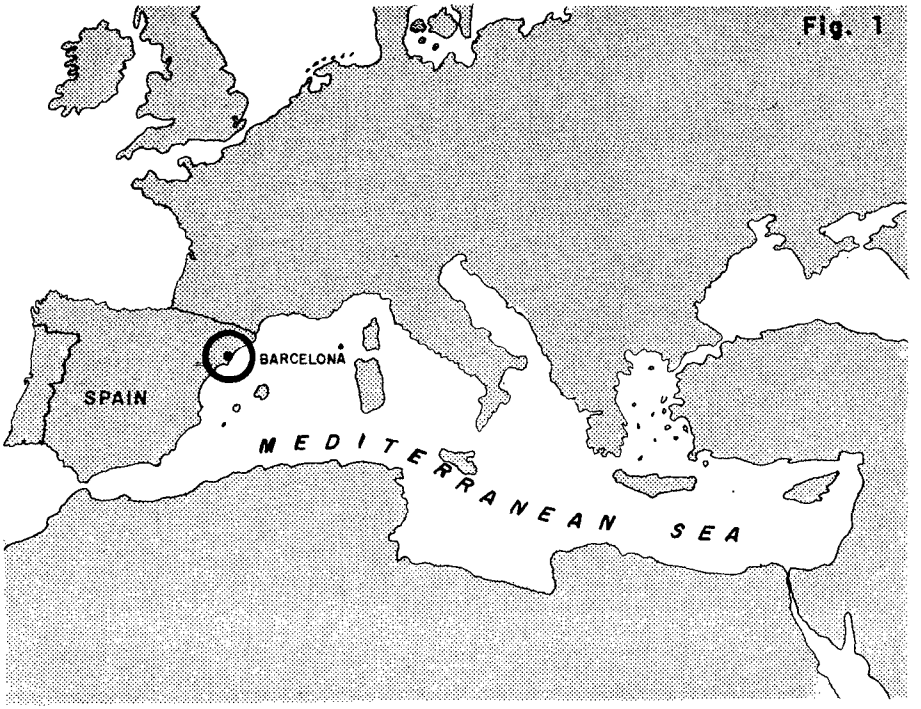
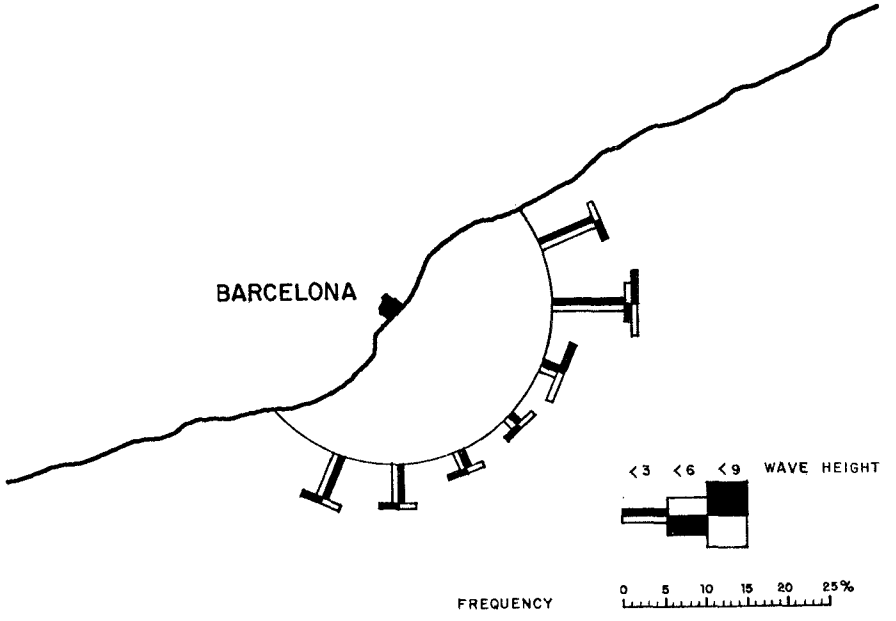


WAVE HEIGHT DISTRIBUTION (1950 – 1983) Fig. 2



Let's have now a brief description of the whole sector (from Barcelona's port up to the Tordera delta) in its actual state.

In order to do so, the whole sector has been divided in three different segments.(Fig. 3).

1. FIRST SEGMENT (Tordera river - Arenys de Mar)

The first segment goes from the mouth of the Tordera river up to the port of Arenys de Mar. Although the coastal zone has been heavily developed all along these 22,4 kms., the beaches remain in their natural state since the Tordera river delta maintains its enormous capacity to nourish them with coarse sand. Only in a few points some restoring works and mourishments were needed due to small and inadequate artificial works. As a whole we can say that the beach (not the coastal zone) keeps its natural dynamics and its existence is not threatened by a short-fall in sand.

The sand transportation capacity evaluated by the CERC formula is about 66.000 m3/year whith the visual wave heights data as input in the formula.

So, the target here is to mantain and improve the natural sediments dynamics, since the Tordera river and its delta are still capable of providing the amount of sediment needed to mantain all the beaches of this segment.

Actual planning is limited to some located sand nourishments, to remove or cut down some small groins and to prevent the beach being occupied.

2. SECOND SEGMENT (Arenys de Mar - Besos river)

The second segment runs from to the port of Arenys de Mar up to the mouth of the Besos river. It is the most heavily degradated.

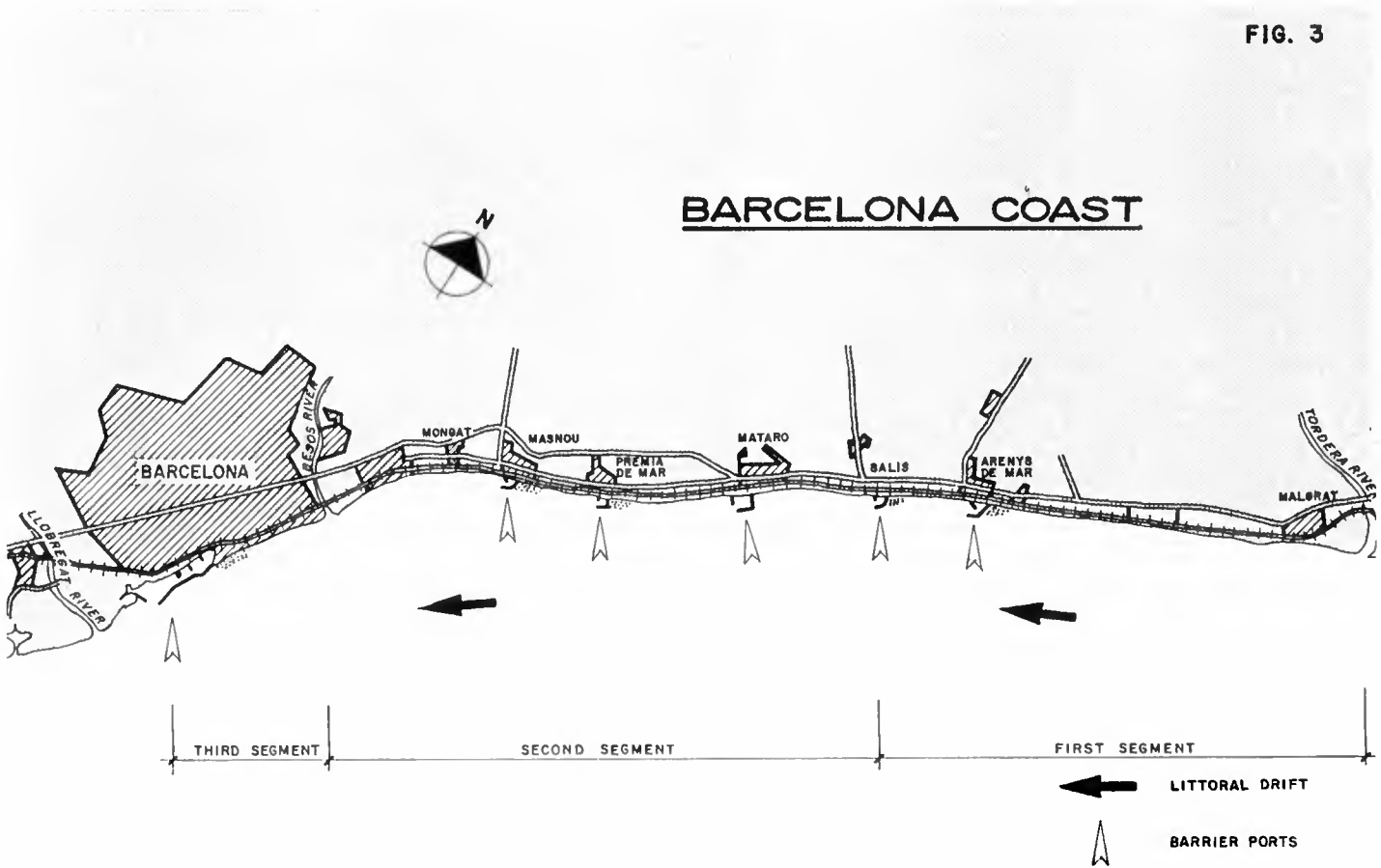
2.1. HISTORY (induced erosion and countermesures)

The first outer attack came from the construction in 1850 of the first Spanish railway. It was built in the easiest way and on the flatest land: the beach.

After this, five marinas or leisure ports were built up. The first one was Arenys de Mar in 1907, at the middle of the whole sector and, as a consequence, a very hard and continued erosion began at the southern part of the port for many kilometres. After Arenys de Mar four other ports were constructed: El Balis in 1972, El Masnou in 1972 Premiá de Mar in 1971 and the last one Mataró in 1989 (see fig. 3)

Since all these ports are total barriers to longshore drift of sediments, the inmediate consequence was always the same: a small triangular beach at the northern breakwater of the port and a hard erosion at the south up to next port.

FIG. 3


BARCELONA COAST
N
BARCELONA
BESOS RIVER
MONGAT
MASNOU
PREMIA DE MAR
MATARO
SALIS
ARENYS DE MAR
TORDERA RIVER
MALGRAT
LLOBREGAT RIVER
THIRD SEGMENT
SECOND SEGMENT
FIRST SEGMENT
LITTORAL DRIFT
BARRIER PORTS

The first counter-measure to halt erosion was taken by the railway company. A long line of quarrystones showed up all along many kilometers in order to prevent the railway collapsing. As the beach disappeared quite quickly, some attempts to recover the beach were made. Eleven groins were constructed between the ports of Arenys de Mar and El Balis but they failed in recovering the beach and the only result was a further degradation in the coast landscape. Other small groins were constructed but generally speaking the beach was progressively disappearing; the environment, from the landscape point of view was going from bad to worse, the railway was at the sea-land border and this limit was (and still is) just a long line of quarrystones.

2.2. BEACH REPLENISHMENT AND STRATEGY

The situation from Arenys de Mar up to the south was a few years ago untenable and in 1985, the Spanish Public Works Ministry planned the recovery of all this part of the mediterranean coast. The first step was the replenishment of the beach with 2.228.888 m^3 of coarse sand (0.4 mm) between the groin of Mongat and the port of Premiá de Mar with the port of Masnou at the middle (Fig. 4). There are 4,9 kms. of the coast recovered by means of simple sand replenishment as a first step. The second and necessary step is to by-pass all the ports in order to restore the litoral drift of sediments. The third step will be the replenishment of the remaining parts of the eroded coast and the forth and last step will be the periodical sand nourishment at the beginning of the whole segment: the southern point of the port of Arenys de Mar. So, if the four ports do by-pass the sand from north to south at the rate of sand transport capacity and at the same rate sand is nourished at the beginning of this sector, littoral drift will be restored and the beach all along 22,9 kms. will be recovered.

Theoretically, since sand transport capacity is evaluated by CERC formula in about 90.000 m3/year this will be the volume to nourish every year and the same amount must be by-passed by the ports.

2.3. MONITORING

The subsector replenished at the first step (groin of Mongat - Port of Premia) has been monitored by CEPYC (Spanish Official Maritime Research Center[3]) in order to confirm these hypotheses.

Profiles of the beach have been monitored twice a year in 1987 and 1988 and once a year in 1990 and 1991 (Fig. 5).

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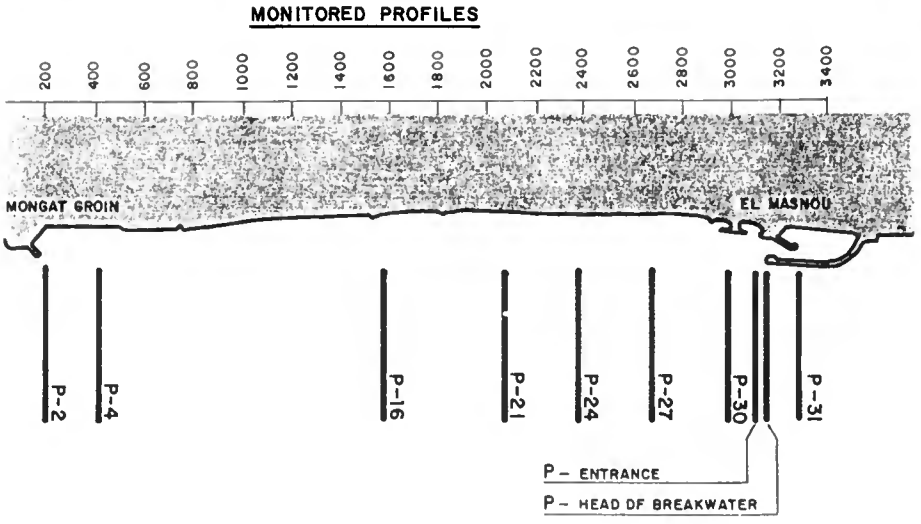
FIG. 4

FIG. 5


MONITORED PROFILES
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
MONGAT GROIN
EL MASNOU
P-2
P-4
P-16
P-21
P-24
P-27
P-30
P-31
P- ENTRANCE
P- HEAD OF BREAKWATER

If we focus our attention between the groin of Mongat and the port of Masnou, (see fig. 3) we have 33 profiles of the beach (see fig. 5), each of them taken at May and Octuber 87, May and October 88, May 89, September 90 and November 91. In addition to this, two sand nourishments have been carried out in this period of time. The first one betwen May 88 and October 88 (the amount was 245.000 m^3) the second one was between september 90 and November 91 (the amount was 160.000 m^3).

Figures 6 up to 15 show the result of this monitoring. Let us make a few comments to these profiles.

Fig. 6 shows the profiles outside the breakwater of the port of Masnou. The sea bottom is growing up because of the sand drifted from the north.

Fig. 7 shows the profiles at the mouth of the port. Here too, sea bottom is coming up except for the profile measured in 1988 because it was dredged before.

Fig. 8 shows the profiles about 100 m. from the mouth of the port. We can see that they remain very stable because the port is a total barrier to littoral drift.

Figs.9 and 10 show the profiles at the points of sand nourishments in 1988 an 1991.These are also the points of most rapid erosion because of the proximity of the port. This is why these profiles move very quickly.

Fig.11 & 12 show the profiles 20 and 24 at the middle of the stretch.

Fig.13 and 14 show the profiles near the groin of Mongat. The beach has been quite stabilized.

Fig.15 shows the profile nº 1 just besides the groing of Mongat where the beach line only retreats under the effect of storms.

The rate at which sand is lost (i.e., drifted to the south) has been measured.

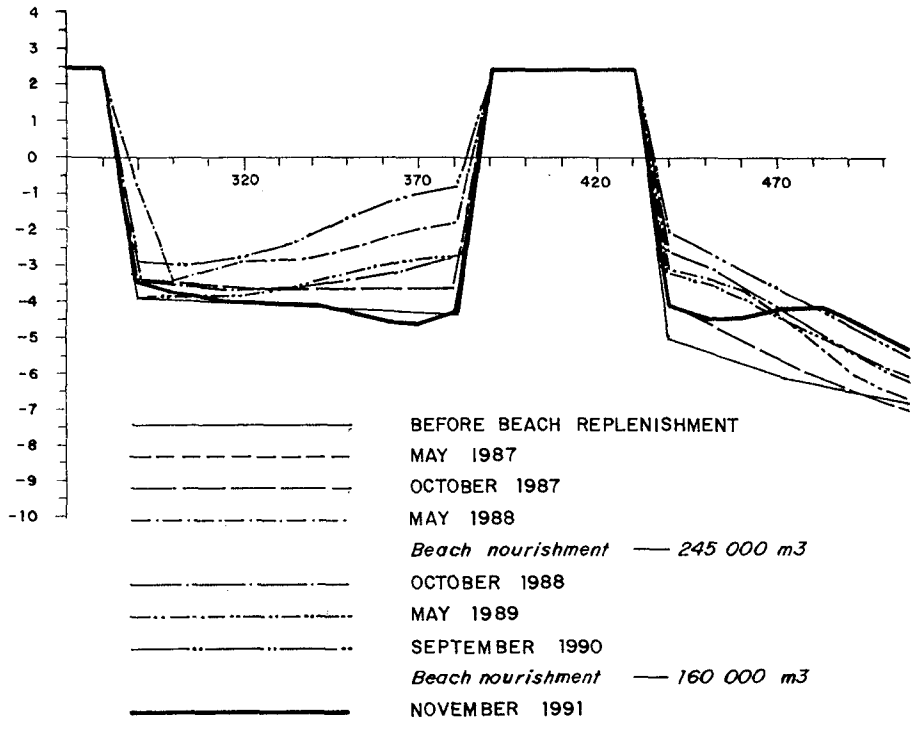
Between May - 87 and May 88..... 110.000 m^3
Between May - 88 and May 89..... 55.000 m^3

Unfortunately profiles were no longer mesured in the month of May.

Between October 87 and October 88..... 160.000 m^3
Between October 88 and September 90..... 180.000 m^3 (2 years)
Between September 90 and November 91.... 120.000 m^3

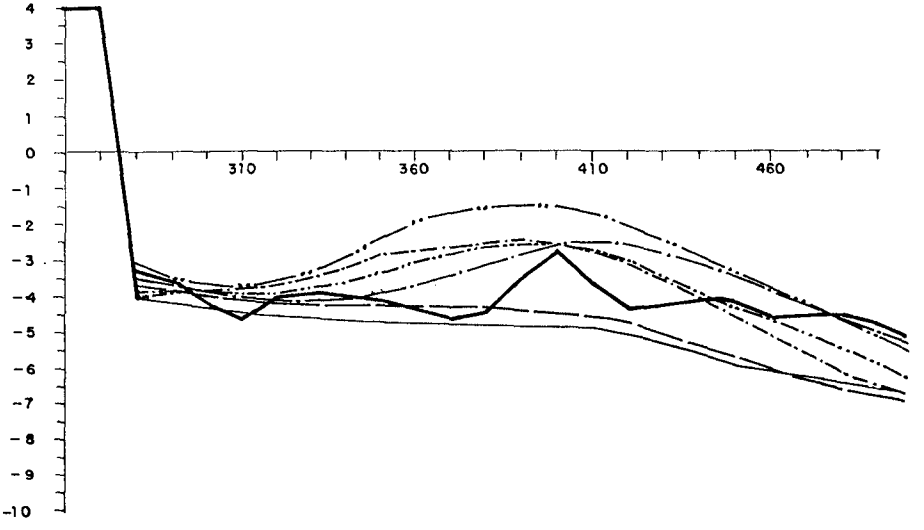
P - HEAD OF BREAKWATER

FIG. 6



P - ENTRANCE

FIG. 7



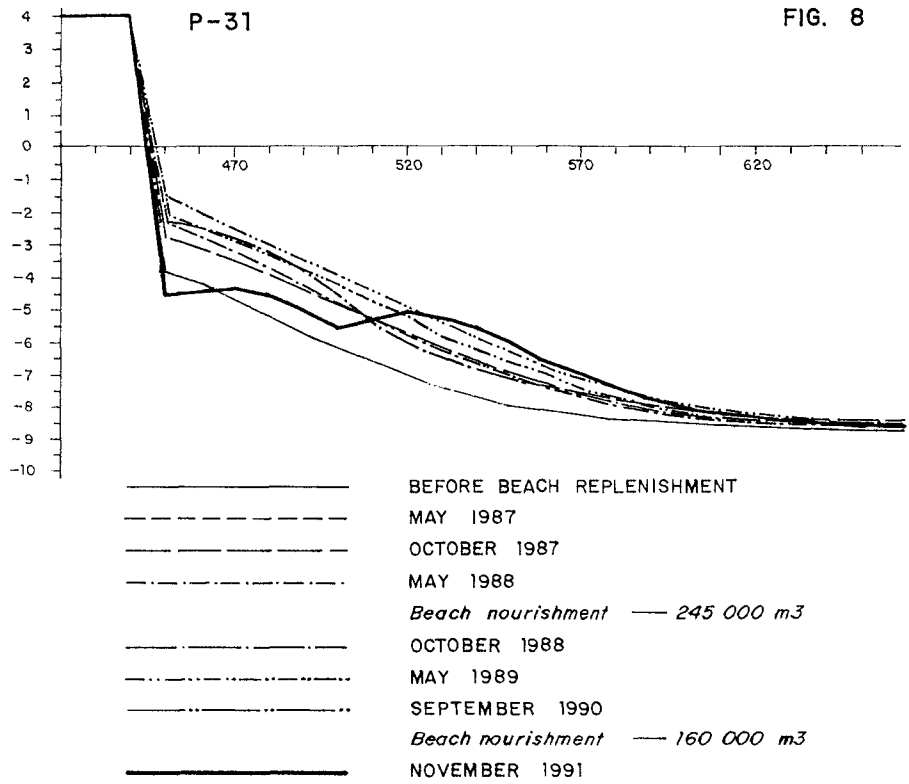

P-31
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
470
520
570
620
BEFORE BEACH REPLENISHMENT
MAY 1987
OCTOBER 1987
MAY 1988
Beach nourishment — 245 000 m3
OCTOBER 1988
MAY 1989
SEPTEMBER 1990
Beach nourishment — 160 000 m3
NOVEMBER 1991

FIG. 8

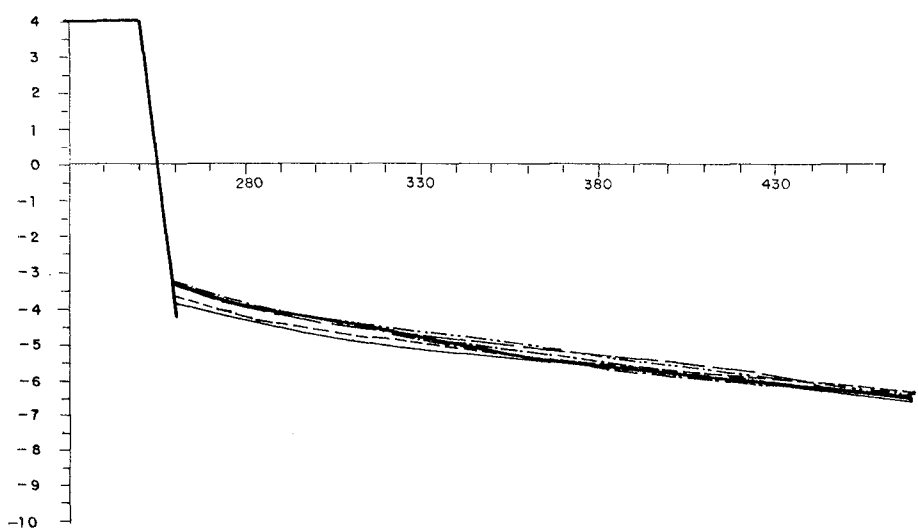

P-30
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
280
330
380
430

FIG. 9

FIG. 10

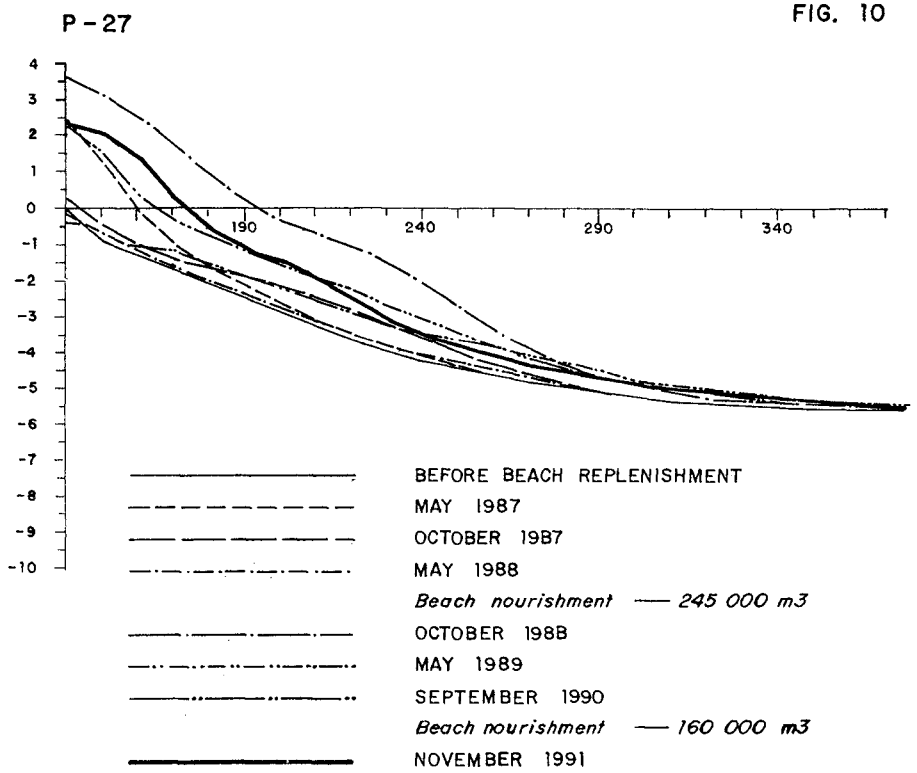

P - 27
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
190
240
290
340
BEFORE BEACH REPLENISHMENT
MAY 1987
OCTOBER 1987
MAY 1988
Beach nourishment — 245 000 m3
OCTOBER 1988
MAY 1989
SEPTEMBER 1990
Beach nourishment — 160 000 m3
NOVEMBER 1991

FIG. 11

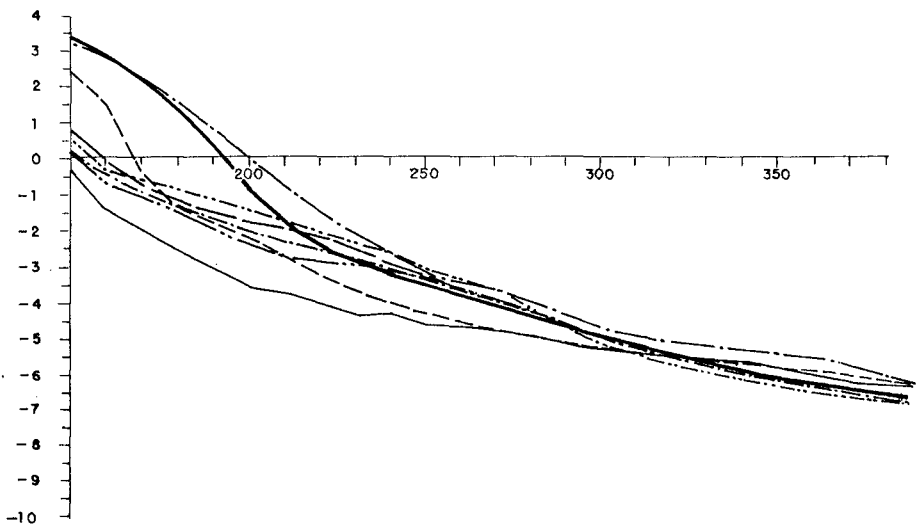

P - 24
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
200
250
300
350

FIG. 12

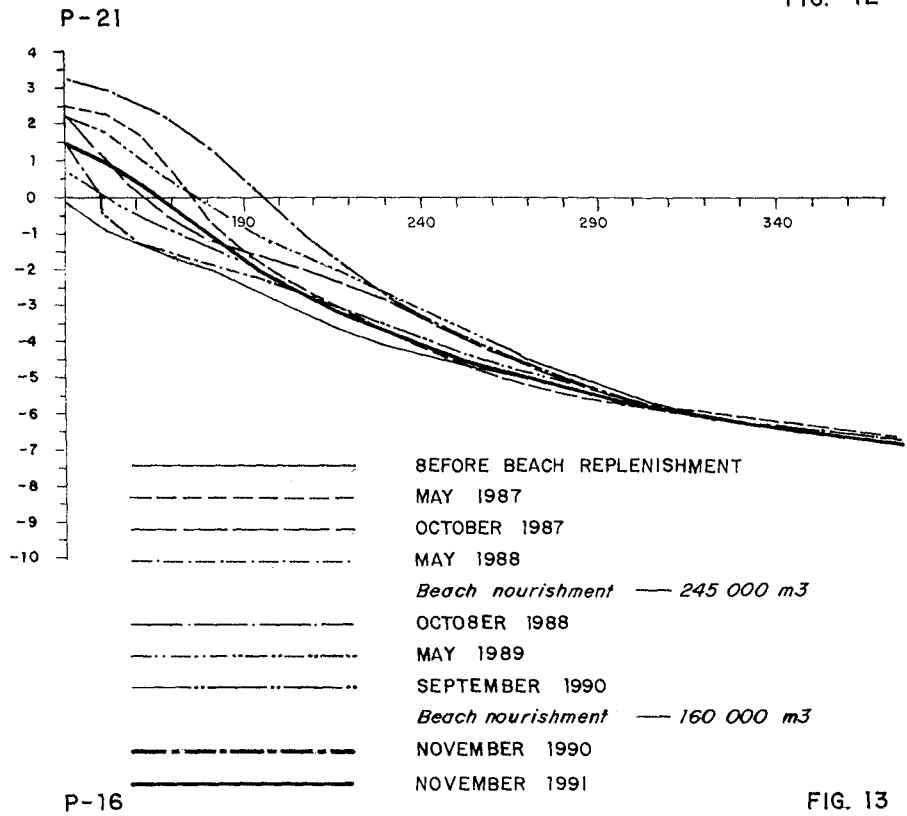

P-21
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
190
240
290
340
BEFORE BEACH REPLENISHMENT
MAY 1987
OCTOBER 1987
MAY 1988
Beach nourishment — 245 000 m3
OCTOBER 1988
MAY 1989
SEPTEMBER 1990
Beach nourishment — 160 000 m3
NOVEMBER 1990
NOVEMBER 1991

FIG. 13

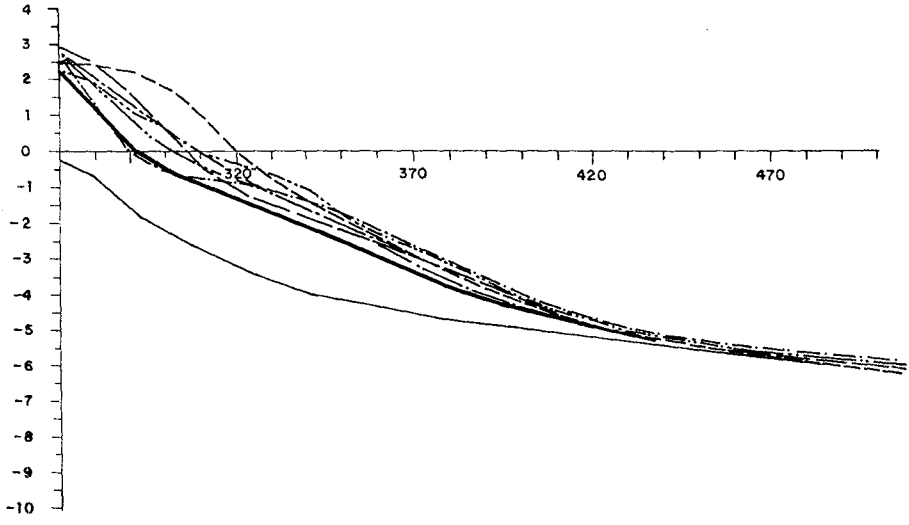

P-16
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
320
370
420
470

FIG. 14

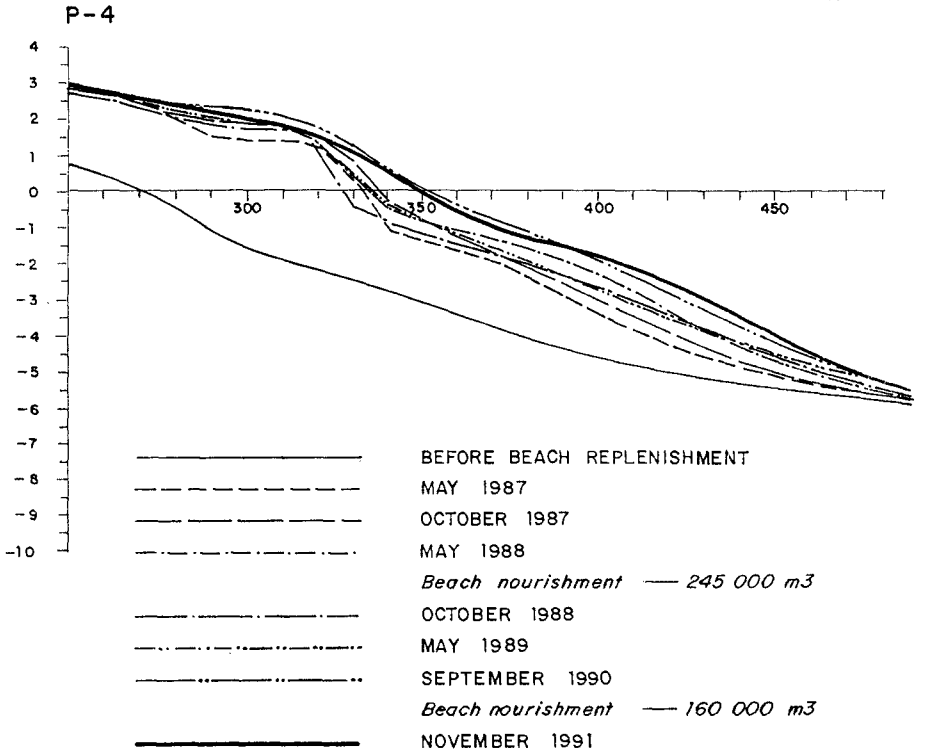
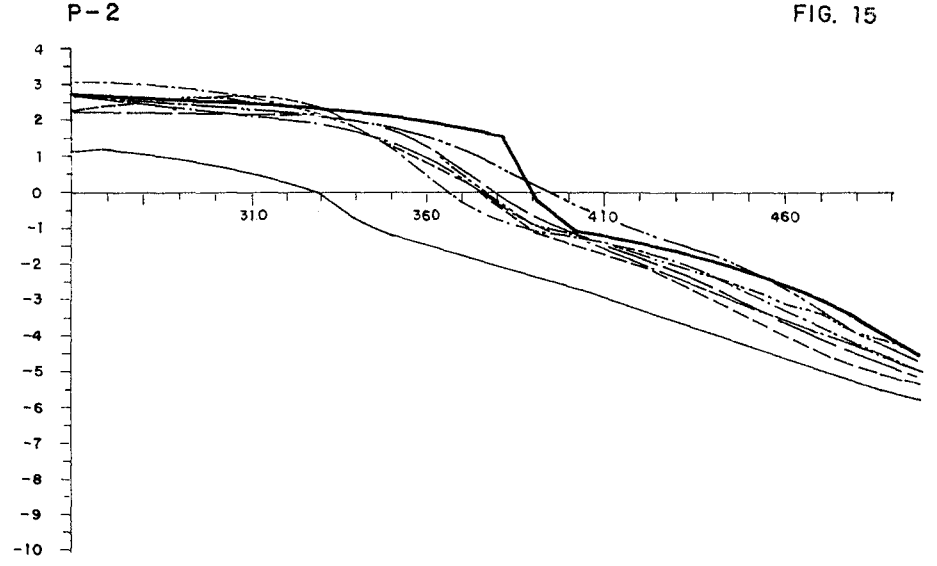

P-4
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
300
350
400
450
BEFORE BEACH REPLENISHMENT
MAY 1987
OCTOBER 1987
MAY 1988
Beach nourishment — 245 000 m3
OCTOBER 1988
MAY 1989
SEPTEMBER 1990
Beach nourishment — 160 000 m3
NOVEMBER 1991

FIG. 15


P-2
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
310
360
410
460

Between October 87 and November 9..... 460.000 m^3 (4 years)

These results have not yet been checked and compared with the wave-height-visual-data of the same period, but as an average we can provisionally conclude that for this kind of coarse sand (0.5 mm.) CERC formula minimizes longshore transport capacity in about 20%. Differences would probably be greater with finer sand.

3. THIRD SEGMENT (Barcelona city sea front)

This is the third of the three segments of the figure 3. It runs from the mouth of the Besos River up to the port of Barcelona. Works in this segment have been completed just before the Olympic Games, last summer (1992).

A few years ago it was the ugliest and most degraded part of Barcelona's coast. Everybody considered most of the sea-front side of Barcelona as the rubbish dump where everything could be thrown.

In addition to this, there was some groins constructed to assure the discharge of Barcelona seawage draining system (now there are only rain water discharges there).

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.

A schematic plan of the whole segment can be seen in fig. 16.

The whole segment is being monitored once or twice a year, but as the works have just been completed a few months ago, only the first bathimetry has been carried out and no conclusions are available.

We hope that in next Coastal Engineering Conference in Kobe more conclusions and results can be discussed.

FIG. 16

BARCELONA CITY SEA-SIDE WORKS