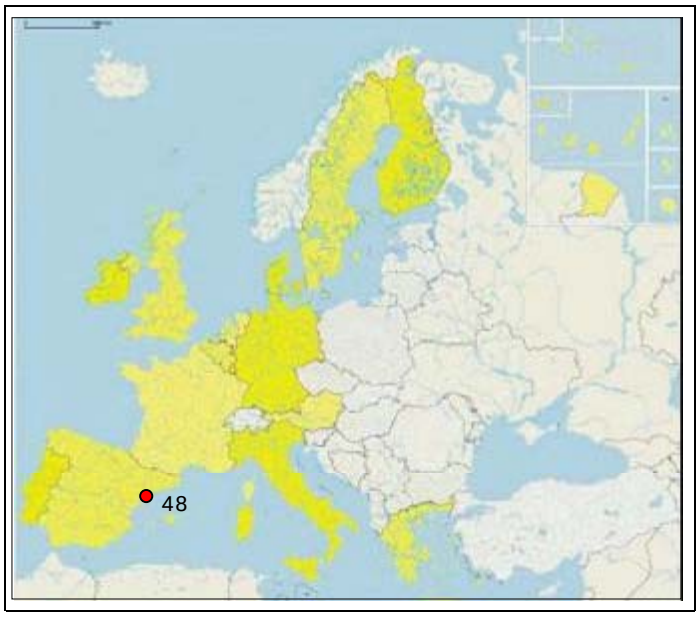
CASTELLÓN
(SPAIN)



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1. GENERAL DESCRIPTION OF THE AREA

The area under study (Figure 1) is in the province of Castellón, in the municipality of Almazora. It is situated on the Mediterranean coast in what is known as the "Valencian Oval", including the section from the port of Castellón to the mouth of the River Mijares.

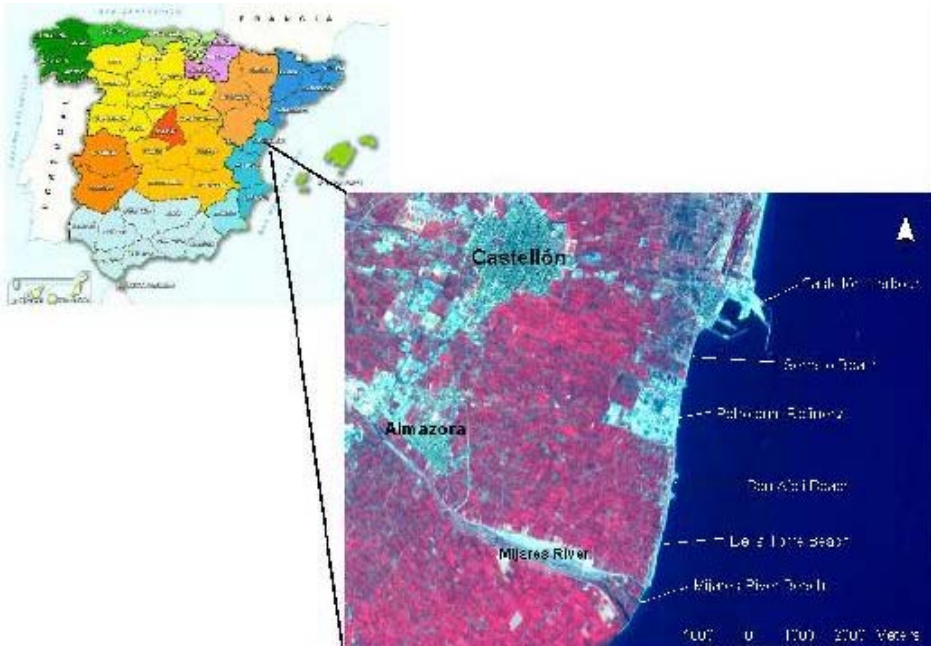

Fig. 1: Position of the study area.

The study area includes the beaches of Serrallo beach, Ben Afeli beach and La Torre be as observed from North to south respectively (see Figure 2a and 2b)-Source: Geoplaneta.com.

Fig. 2a: Port of Castellón, Serrallo beach and Ben Afeli beach.

Fig. 2b: Ben Afeli beach, De la Torre beach and River Mijares mouth.

1.1 Physical processes

1.1.1 Classification

- General: pocket beaches
- CORINE: beaches
- Coastal Guide: coastal plain, recent sedimentary

1.1.2 Geology

The study area is based on Quaternary materials generated by the activities of torrents from the inland massifs ("Maestrazgo" Range and tributaries from the "Sierra de Espadán" Range), which have formed lagoons moving closer to the sea. This process is reported to have started at the end of the Tertiary period, as the Pliocene became the Pleistocene era, favouring a climate suitable for the activities of torrents (Díez, J., 1996).

Eustatic variations have led to an unusually strong presence of Pleistocene sediments and a young coast that has been closed by a succession of coastal bars and spits, forming lagoons and marshes along the coastal strip. Some examples of these still remain on the coast of Castellón, which has been filled in and blocked up in very recent times due to natural causes or human activity.

At the Nothern end of the study area at Serrallo beach, there is no dry beach.The submerged beach in the area ispoor in condition. Southwards from this area dry beach is found and is believed to be formed exclusively by gravel (Figure 3) with a base of fine material. Due to human intervention in the coastal processes like construction of coastal defences or the direct contribution of gravel or sand, some stretches of the coast have a greater quantity of snady material..

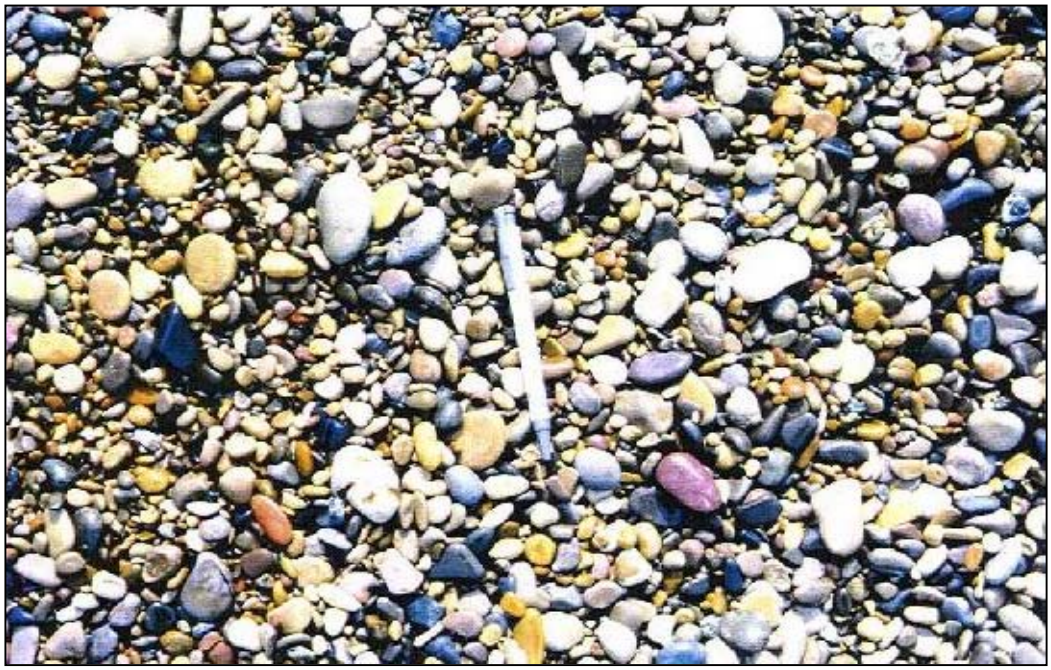

Fig. 3: Granulometric sample from Ben Afeli beach (CEDEX, 1996).

As for the granulometric distribution of the sediments in relation to depth, it can be said that The size of grains of sediments decrease with the depth of water in which they are found, with deposits of sandy gravels in the inshore platform changing to mud in the midshore and offshore platforms (see bathymetric map in the next section – Figure 5).

Sources of sediment

The main source of sediment is the River Mijares. The supply of sediments has reduced in the last few years because of regulation in of the course of the river. There is apparently no other source of sediment of any significance in the study area.

1.1.3 Morphology of the coast

The northern end of the study area begins with the leeside of the port of Castellón, with a stretch which follows a general alignment of 8ºN and includes Serrallo beach, with longitudinal rockfill defence, followed by Ben Afeli beach and La Torre beach. Further south are the specific feature formed by the delta of the River Mijares which is currently inactive. Beyond the Mijares delta, the coast line turns in the direction of 39ºN.

The stretch is regressive because of the conjunction of factors affecting the materials feeding it. Firstly, the section is down drift from the port of Castellón, which causes strong erosion on neighbouring beaches characteristic of the dominant southward coastal transport. Other factors involved in this situation are the regulation of the River Mijares and urban pressure on the beaches. To mitigate this erosion, the coast has been protected with various maritime works that have changed the original orientation of the coast, as shown in Table 1 and Figure 4.

Table 1: Variation in orientation of beaches due to coastal protection works.

Beach	General orientation	Initial orientation	Final orientation
Ben Afeli			
1st and 2nd cell	8ºN	11ºN	11ºN
La Torre			
1st to 7th cell	8ºN	15ºN	12ºN
8th cell	8ºN	15ºN	10ºN

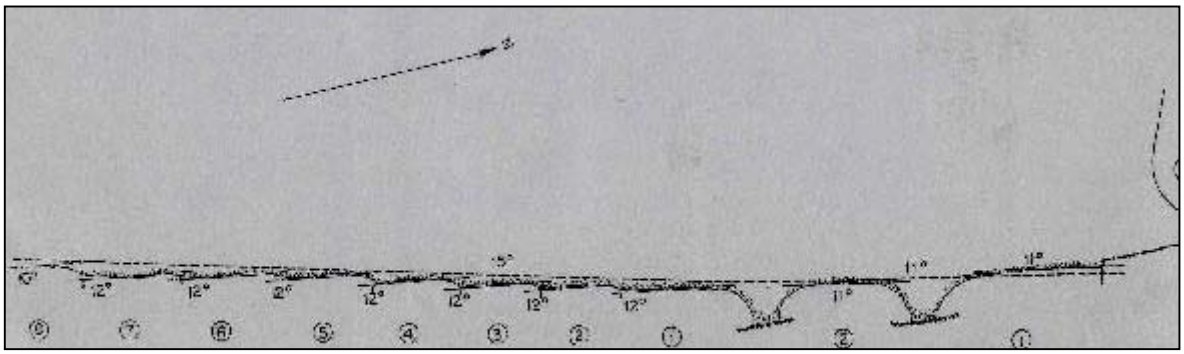

Fig. 4: Orientation of beaches after the works (CEDEX, 1996)

River network

The River Mijares has a large delta extending along the whole beach Of Mijares, with a delta front of around 1,000 metres. The blunt shape of its mouth, together with the gravel that forms its beaches, shows that it is in open regression dueto the regulation, canalisation and the exploitation of its bed.

However, the river can carry material during floods but to a much lesser degree than it could some years ago. Because of material accumulating against the

wall of the northern harbourt of Burriana (situated further south), which had to build a sea wall to retain the sand, indicates that the sources supplying the material upstream are still active and are limited to a minimum level as compared to the past.

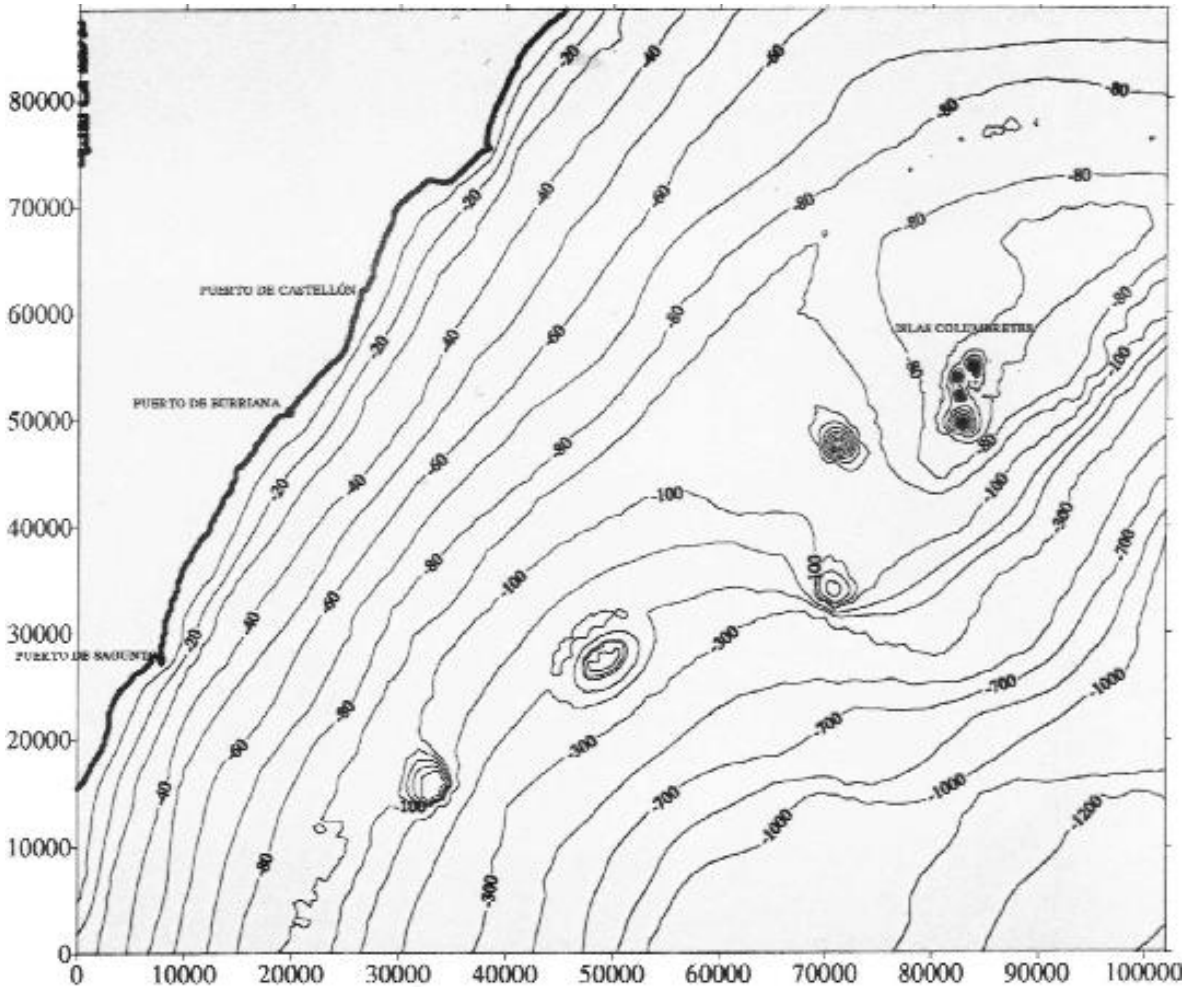

Fig. 5: Bathymetry of the surroundings of the study area.

1.1.4 Physical processes

Wave and wind climate

On the Castellón coast, the main agent for erosion is is wave action, and this is therefore responsible for the coastal dynamic and the development of the coast (CEDEX, 1996). In SEA type wave systems, those from the NE predominate, followed by WS. The predominant period is 5s or less. For SWELL type save systems there is a predominance from the first quadrant, EN, E and NE, and, as for SEA wave systems, the predominant period is 5s or less, followed by wave systems with periods between 6 and 7 seconds. In general, the wind direction is uniformly distributed. The main direction is NE, followed by SW.

Variations in sea level

This is an important phenomenon on the Castellón coast because, in the pre-littoral area in the La Plana region, there are large zones close to sea level. This is because they were formed from coastal bars and filled in former marshes. Any variation in sea level can therefore have an effect on the future development of the coast and if any variation in sea

level coincides with a big storm, the risk of the sea invading the low-lying coastal areas behind the beach is increased (see Table 2 for data).

Table 2: Variation in sea level (CEDEX, 1996)

VARIATIONS IN SEA LEVEL	
ASTRONOMICAL TIDE	15cm
VARIATIONS IN PRESSURE	30cm
HIGH WINDS	15cm
HIGH SEAS	
For H_0 = 2.6	35cm
For H_{0max} = 3.3	45cm
TOTAL HEIGHT	
For H_0 = 2.6	**95cm**
For H_{0max} = 3.3	**105cm**

Currents

The general current affecting the study area is the General Mediterranean Current, which, on entering the Strait of Gibraltar, runs along the penibetic and eastern Spanish coast, turning at Cape Palos to head for the North African coast. Its influence is felt near the coast with low speeds generally less than one knot (sea mile).

Local currents caused by the wind show NNE and SW directions. At times of strong wind, the normal current increases. For winds with a S component, the current heads NE and for winds of a N component, SW (see Figure 6).

1.1.5 Erosion

Coastal erosion problems in the study area are caused by the existence of the port of Castellón and this started since 1961, when the last extension of its sheltering harbour wall was carried out. The wall forms a barrier against the passage of sediments. The effects generated by a barrier of this kind are the massive accumulation of sediment on the up drift side of the barrier (with respect to the direction of transport), which leads to a loss of materials down drift of the wall. On the downdrift side of the wall, the coastal dynamic retains its transport capacity, eroding the whole coast and causing the coastline to recede.

The impact of coastal alignment through human intervention (an average of 2º) supersedes that created by wave action. There is therefore little solid transport in this area. The rigid fixing of Serrallo beach and the barrier provided by the port of Castellón, have significantly reduced the level of solid transport. The average value of transport estimated for Ben Afeli beach is 12,500m^3/yr and on La Torre beach 27,000m^3/yr (CEDEX, 1996).

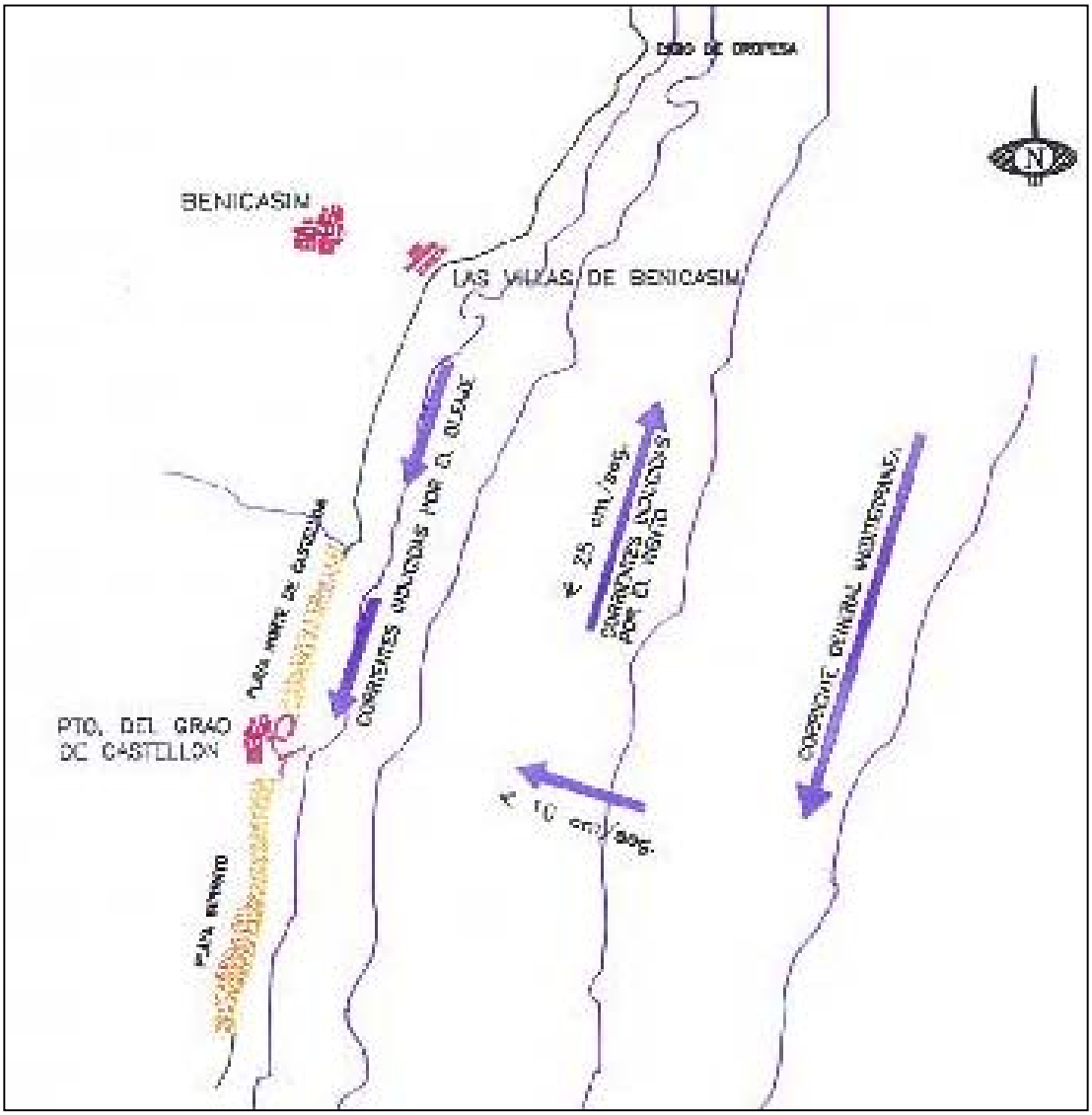

Fig. 6: Predominant currents at the Port of Castellón (CEDEX, 1996)

The development of the coast is entirely dependent on daming effect of the wall of the port of Castellón, because of its ability to retain all the sedimentary material coming from the North and heading southwards. Erosion down drift of the port is generated by the dune cordon disappearing and thereby exposing the low-lying land to continuous sea flooding.

Table 3: Linear regression of the coastline between 1957 and 1981 (Value obtained from CEDEX restoration of the coast).

BEACH	REGRESSION (m)
Serrallo	40
Ben Afeli	40
La Torre	25
Mouth of the River Mijares	33

1.2 Socio-economic aspects

1.2.1 Population rate

The municipality of Almazora covers 33km^2 and has a population of 16,500 (average population density of 500 inhabitants/km^2). It is estimated that during the summer months the population of the coastal area is close to 7,000 inhabitants.

1.2.2 Main functions of the coastal zone

The ceramic industry of floor and wall tiles and a wide sector of services for the ceramic industry forms the main economic activity. Next to this industry is the construction sector followed by there finery on the coast at Serrallo beach.

Agricultur in the area was once very important, with the cultivation of citrus fruit (oranges) and other fruit trees as well as olives. From the urban centre towards the coastal area, many villas and apartment blocks are being built for tourism.

2. PROBLEM DESCRIPTION

2.1. Eroding sites

Where are the hot spots? Not all the beach is a problem area.This chapter needs further attention. The hot spots in the study area have to be shown.

Description of the studied beaches (Note: the order of the photographs is from north to south).

Serrallo beach

Serrallo beach is 1,400m long. Situated next to the Port of Castellón it has only a submerged beach with the coastline consisting of a longitudinal protective sea wall. At the end of it there is a small jetty providing service to the refinery at the end of the beach.

Fig. 7: Serrallo beach, next to the port of Castellón.

Fig. 8: Oil refinery on Serrallo beach.

Ben Afeli beach

This is a short beach (450m long and an average of 40m wide) of an urban nature with deficient beach services. It has two detached breakwaters forming a gravel pocket beach, a morphology typically known as a "shell-shaped beach". Bathing conditions show moderate waves and the degree of tourist occupation is average because it is necessary to have a vehicle to reach it.

Fig. 9: Beginning of Ben Afeli beach.

Fig. 10: First detached breakwater.

Fig. 11: Second detached breakwater.

La Torre beach

An urban beach, situated to the north of the mouth of the River Mijares. It has a set of eight breakwaters, which make its width vary between 45m and 15m. It is 2,200m long and made up of gravels. Bathing conditions show moderate waves and the degree of tourist occupation is average. As with Ben Afeli beach, it is necessary to have a vehicle to reach it. It does not have beach services.

Figs. 12, 13 & 14: Different views of the set of groins built on La Torre beach.

Figs. 15 & 16: Final groins and the beginning of the River Mijares mouth.

2.2. Impacts

The port of Castellón acts as a barrier to sediments coming from up drift.. This prevents the replacement of sediments in the wave eroded areas on the coast. The disappearance of the sediment from the coast through wave action causes a regression of the coastline inland.

The elimination of the dune cordon from the beaches does not only encourage coastal erosion, it also allows seawater to get in behind the beach during storms.

This problem is more acute in the Castellón area because the average height of the land is close to sea level, so the area covered by seawater during storm is large and comes as far to human settlements..

3. SOLUTIONS / MEASURES

3.1. Policy options

Hold the line.

3.2. Strategy

In the study areaonly an engineering solution can be feasible. In some places, as on Serrallo beach, coastal defences in the form of longitudinal sea wall have been built. These walls stop erosion in their immediate area and they also serve asprotection against flooding during storms. On Ben Afeli beach and La Torre beach, the works carried out have been aimed not only to fight erosion, but also to create pocket beaches by means of detached breakwaters and small groynes.

3.3. Technical measures

3.3.1 Type

A longitudinal sea wall has been built as a defence on Serrallo beach along the entire coast starting at the end of the port of Castellón, rigidly fixing the entire coast, which means there is no dry beach and the submerged beach is in poor condition.

On Ben Afeli beach, two detached breakwaters have been built with symmetrical accumulation of sediments around both of them, forming a “shell-shaped beach”. This is because the results of wave action are head on to the general orientation of the beach and there is a lack of sediment up drift, as Serrallo beach is rigidly fixed and the port of Castellón does not allow the southward passage of sediments.

On La Torre beach, a set of eight short groynes has been built so that each one generates a beach beside it. To the north of each of these groynes there are accumulations of material depending on their length and the distance between them and the availability of material, while to the south there is a step down because of the erosion caused by the net solid coastal transport southwards.

3.3.2 Technical and financial details

The Environment Ministry plans to carry out new defence works to reinforce those beaches already described for Ben Afeli and La Torre.

Title: BEACH PROTECTION AT LA TORRE BEACH, ALMAZORA (CASTELLÓN).
Municipality: ALMAZORA.
Amount: €1,201,303.00.
Date: June 1999
Description: The work mainly consists of constructing a 203m breakwater, supported on an existing 83m one, with a rockfill trapezoid section of various sizes and a crown reaching a level of +1.00m, running from –4.00m to water level. Afterwards a layer of sand from the port of Castellón will be distributed. In addition, the water from the fields, which flows out in the centre of the cell, will be channelled and finally seven oases will be formed. The cell

being regenerated and the next one will also be protected by constructing a semi-submerged rockfill defence to a level of 0.50m to the south of the freestanding breakwater.

Title: EMERGENCY WORKS IN THE SECTIONS NEXT TO THE MOUTH OF THE RIVER MIJARES.
Municipality: ALMAZORA.
Amount: €721,214.53
Start date: 7-05-2002. **Finishing date:** 15-11-2002.
Description: This consists of building a groyne 97m long with two types of trapezoid section, one of them consisting of a stretch 60m long, at a level of +1.00m. This section is formed of a nucleus of 2 to 3 tonnes of material and an outer layer of 4 tonnes of rockfill, with a width at the crown of 6.69m and sloping banks of 3m horizontally and 2m vertically. The other section is 37m long, formed by a trapezoid section with a nucleus of between 2 and 3 tonnes of material and an outer layer of 4 tonnes of rockfill, at the level of + 0.29m and a surface width at the crown of 8.97m. The banks are 3m horizontally and 2m vertically. To the north of this groyne, the cell has been filled with granular material, to a level of 0.00m.

Title: ALMAZORA BEACH REGENERATION PROJECT – PHASE 1.
Municipality: ALMAZORA.
Amount: €742,657.31
Date: November 2001.
Description: In the first place, a first rockfill breakwater is planned. It is straight and 170m long; extending the breakwater built by the General Directorate for Coasts situated more to the south. The breakwater consists of two sections, the first 70m long reaching depths between – 3.80 and – 5.50m and is crowned to +1.50m above the LWM. It is made up of a single nucleus and two layers of between 5 and 6 tonnes of rockfill. The second, 100m long, reaching depths between – 5.5 and – 7.0m and is crowned to +1.5m below the LWM. It is made up of between 2 and 3 tonnes of rockfill. In the second place, a second rockfill breakwater is planned, this one 60m long and straight, situated 700m north of the first breakwater. The breakwater reaches depth of –3m below the LWM and is crowned up to 1.50m above the LWM. It is made up of between 2 and 3 tonnes of rockfill. Thirdly, the regeneration of the beach is planned, with the provision of 100,000m^3 of quarried sand. Before the sand is brought work will have to be carried out to level the current beach to leave all the dry beach at the same level and to clean up rocks weighing more than 3kg. Fourthly, to make the beach compatible with its traditional use, the construction of filter zones has been planned at the mouths of the streams so that however much rain falls it will drain away properly.

4. EFFECTS AND LESSONS LEARNT

Complete barriers to the passage of sediments, such as the port of Castellón means that the beaches down drift of the obstacle have to be maintained by means of artificial hard engineering works. While the port of Castellón remains, the erosion problem down drift caused by wave action increases, requiring continual investment in projects leading to the provision of sand, as well as new defence work to maintain the coastline.

5. REFERENCES

CEDEX (1996). *Estudio evolutivo de la costa de Castellón (Puerto de Castellón al Puerto de Sagunto)*. Centro de Estudios de Puertos y Costas, Ministerio de Obras Públicas, Transporte y Medio Ambiente.

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Environment Ministry (*www.mma.es*)