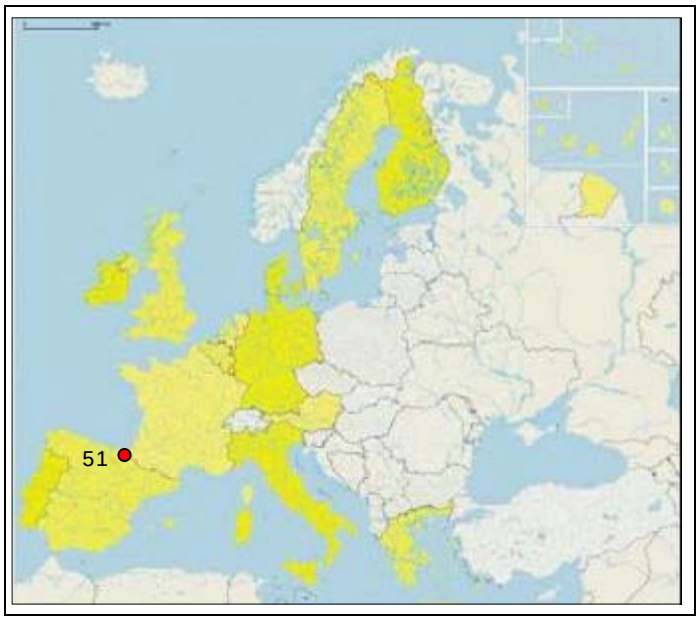
GROSS BEACH
ZURRIOLA COVE
(SPAIN)



Contact:

Inmaculada RODRÍGUEZ SANTALLA

Universidad Rey Juan Carlos

Escuela Superior de Ciencias Experimentales y Tecnología

C/ Tulipán, s/n 28933 Móstoles
Madrid (Spain)

Tel: +34 91 488 70 17
Fax: +34 91 488 74 90

e-mail: i.rodriguez@escet.urjc.es

1. GENERAL DESCRIPTION OF THE AREA

Gross Beach, in Zurriola Cove, is situated in the locality of San Sebastian on the Cantabrian coast (province of Gipuzkoa), in the northern part of the Iberian peninsula, 20 km from the French border. Situated to the east of the Urumea River estuary, it is one of the three beaches located on this city's coastline.

Fig. 1. Gross Beach and its environment. Source: Aerial View of the Coast (geoplaneta.com).

1.1. Physical process level

1.1.1 Classification

- General: Barrier beach
- CORINE: Beach
- Coastal Guide: Coastal Plain

1.1.2 Geology

The Cantabrian coast is characterised by an abundance of cliffs, many with sheer drops down to the sea. The two rocky massifs which enclose Gross Beach join beneath the sea in what was formerly the bed of the Urumea River, and which nowadays constitutes a rigid floor covered by sand.

1.1.3 Morphology of the coast

Gross Beach is a relatively open beach with a strong swell, and is located on a sandy substratum formed by fluvial contribution, supporting itself on the rocky basement found between the two mountains which flank the beach: Mount Ulía and Mompás Point. The average dimensions of the beach are: 800 m in length, 110 m in width and a surface area of 88,000 m^2.

1.1.4 Physical processes

The fluvial network

The fluvial network which drains this part of the coast is almost exclusively composed of the Urumea River. Its bed, like most of those which drain this part of the Spanish coast, is very short and torrential, constituting one of the more important sources of nourishment for Gross Beach, in addition to constructing the tombolo which joins Mount Urgull to the Donostarrian Coast. The nine dams which were built along the length of its bed, retaining and accumulating the sediments transported by the river, thereby impeded their reaching the beach (Palomar, 2001), with the usual consequences.

Maritime climate

The Cantabrian Sea is a sea which is open to the ocean, meaning that the swirls which reach the coast do so with a large fetch. The most significant storms to reach Gross Beach come from the NW, at their maximum in October and minimum in March.

The elevations in sea level due to the tide are very significant, reaching values of above 4.5 m in SHT, which, if we include that caused by the surf-beat, can produce total elevations of over 5.5 m during strong storms with significant wave heights of 4 m and over 6.5 m during strong storms with significant wave heights of 6 m.

The strongest currents are southeasterly, northerly, easterly and westerly, and those which statistically reach higher speeds come from a southeasterly direction.

Coastal dynamics

Gross Beach is bound between two rocky massifs, comprising of a sandy floor with a constant slope near the coast, and a lower rocky floor with a more pronounced slope. These floors present the risk of sediment loss due to the rising of the water. The beach has a straight and parallel bathymetry. Initially the coast and the district of Gross were separated by a wide beach where dunes were to be found in summer, protecting the beach during large storms and maintaining the balanced profile.

In 1876 there began the construction of a dam wall on the left bank of the Urumea River. The objective of this was to avoid the accumulation of sediments and possible flooding which would affect the building located at the west end of the beach, known as the Great Kursaal Casino.

At the beginning of the 20th century, the urban growth of the Gross district gave rise to the construction of the coastal wall from 1915 to 1920, which is a prolongation of the one built in 1876 on the river bed with a change in direction to make it run parallel to the coast. This is what produced the occupation of the natural dunes on Gross Beach, provoking a reduction in volume of material and interference in the seasonal profile change mechanism, thus damaging the beach.

The fluvial network brings a barely appreciable volume of sediment to the general coast dynamic. In addition, there is an absence of a coastal platform along most of the Guipuzcoan coast, it being mainly composed of rocky cliffs with sheer drops to the sea. All these issues mean that coastal transport is generally scarce and that the beaches, trapped and isolated,

have a reduced source of nourishment. Therefore, Gross Beach has been moulded by the activity of the swell, which arrives from the dominant quadrant (NW) without impediment, this being the fundamental agent in the coastal dynamic of the beach (CEDEX, 1992).

1.1.5 Erosion

The main cause for the erosion of Gross Beach is the gradual human invasion of the beach throughout the 20th century. Figure 2a demonstrates the appearance of the beach at the end of the 19th century, with a wide sand platform which was occupied by the city from 1900 to 1947, Figure 2b, due to the construction of the Gross district. In both photographs a point of reference has been located in order to attempt to estimate the change which has taken place.

The wall serving as a boundary for the esplanade and the breakwater for the Great Kursaal Casino area at the west the end of the beach were both causes of erosion and sand loss, provoking movement perpendicular to the shore. The breakwater had a pernicious effect by provoking the refraction of incidental swell, mainly at high tide.

Fig. 2a: Gross Beach in 1898. (Source: Santás et al, 1999).

Fig. 2b: Gross Beach in 1947 (Source: Santás et al, 1999).

1.2. Socio-economic aspects

1.2.1 Population rate

Inhabitants: Total 1991: 171,439

0 to 19 years old: 40,645 (23.7%)
20 to 65 years old: 104,481 (60.9%)
Over 65 years old: 26,313 (15.3%)

Inhabitants/km^2 : 343 aprox.

Rates of population:

Birth rate: 7.9/1,000
Mortality rate: 9.1/1,000

1.2.2 Major functions of the coastal zone

San Sebastian was originally a fishing village which later became an obligatory route towards France, England and Flanders, its port taking on a very important role. From this point onwards the city started to take shape and was recognised as such in 1662. In the 19th century, tourism boomed in Europe with the beach taking on new significance as a place for rest and leisure. This meant that the city took on a new look and esplanades were built along its three beaches.

Tourism and recreation are the area's main economic activities. Due to the strong swell, swimmers hardly ever visit the beach, preferring the traditional La Concha Beach. For precisely this reason, however, the beach is preferred by surfers. Therefore the largest labour sector in the province of Gipuzkoa is the service industry, accounting for almost 70 % of all activities, followed by construction with 5.6%. Industry accounts for approximately 23% and agriculture barely reaches 1.5%. The fishing industry is hardly relevant in this area nowadays, the port's small dock now a refuge for sports boats.

1.2.3 Land use

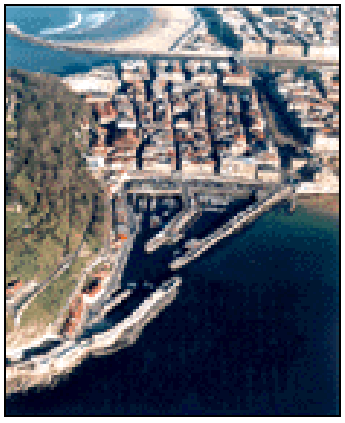


Fig. 3 : Donostia port.

Donostia - San Sebastian port was originally a small fishing port, but has, given current circumstances, been reorientating its activities, now also serving as a shelter for recreational boats.

Gross Beach has a camping area (campsite, picnic area, spa area, restaurants), security (security guards, warning alarm, local police, Red Cross post) and other services (parking, showers, changing rooms, toilets, telephones, beach cleaning service, waste paper bins, sunshades, nautical equipment rental). It also has various infrastructures which make the beach a popular place to visit (sports port, buses, train).

Fig. 4: Actual view of Gross Beach.

2. PROBLEM DESCRIPTION

2.1 Eroding sites

Gross Beach can be considered an isolated unit, in the sense that it receives very few solid contributions from the general coast dynamic of the Cantabrian coast, mainly due to the characteristics of this coastline. It is a typical Cantabrian barrier beach formed by the Urumea River and Mount Urgull.

The following were the main reasons for the disturbance of the natural balance and stability of the beach (Palomar, 2001):

- Loss of the main source of nourishment for the beach: sediment transported by the Urumea River.
- Construction on the dunes of the beach and the building of a sea wall to protect the esplanade, impeding net cross transportation towards the beach.

In the historical photograph in Figure 5a we can see how, at the beginning of the 20th century, the beach even had the typical spiral shape in the shelter of the right-hand dike of the Urumea. As this area became occupied, it interfered with the seasonal profile change mechanism, thus damaging the beach. The breakwater in the Kursaal area had an additional damaging effect on the sand at its foot, due to the refractive effect of the swell, the beach thereby losing its dissipative character.

Figure 5 shows a collection of historical photographs of Gross Beach, which allow us a graphic idea of the evolution of the coastline. From the date of the first information available (year 1900), we can see how Gross Beach has suffered a veritable invasion due to construction. In fact, during the early years of the 20th century the shoreline was close to Columbus Walk (paseo de Colón). This invasion has contributed to the regression of the beach (CEDEX, 1992).

Fig. 5a: Gross Beach in 1900.

Fig. 5b: Gross Beach in 1924.

Fig. 5c: Gross Beach in 1924.

Fig. 5d: Gross Beach in 1945.

Fig. 5e: Gross Beach in 1989.

Fig. 5f: Gross Beach in 1992.

Fig. 5: Historical photographs of Gross Beach.

3. SOLUTIONS / MEASURES

3.1. Policy options

The situation of instability in which Gross Beach found itself and the risk of the beach being submerged made the Ministry for Public Works and Transport (MOPT), in 1992, commission a study by the Centre for Study and Experimentation of Public Works (CEDEX), an autonomous organism of the MOPT, with the aim of analysing the coastal dynamic of Gross Beach and possible solutions for the effective defence of the beach after its regeneration. Later, in 1993, the MOPT instigated the Gross Beach Regeneration Project.

3.2. Technical measures

Different alternatives were studied for carrying out the regeneration project. Finally, the measures which were taken were mixed, on the one hand a dike being designed to support the beach, and on the other its regeneration through the addition of sand.

In 1993, the Regeneration Project was compiled, with the following main objectives (Palomar, 2001):

To recuperate the balanced profile The formation of new dunes	⇨	Addition of sand to widen the beach
To avoid swell refraction on the Kurssal breakwater	⇨	Beach formation and energy dissipation
To extend the slope of the beach, decreasing its morphology as a sloping beach	⇨	The addition of sand which is coarser than the natural sand of the beach
To avoid the formation of sandstorms and material deposits on terraces	⇨	Extend the slope of the beach
Avoid the loss of material due to wind currents	⇨	Make the whole beach dissipative
To create an emerged beach in the Kurssal area	⇨	Decrease the angle of the impact through diffraction of the swell

SAND REPLENISHMENT
+
BREAKWATER TO PROVOKE DIFFRACTION

Starting from these premises, the regeneration of the beach began in 1994 by supporting it against a curved wall of the Urumea River bed (Figure 6), following various criteria:

- Technical: designing a curved dike with a submerged foot perpendicular to the two main wavefronts.

- Aesthetic: designing the lowest possible crest levels for the dike, always adjusted according to technical criteria, so that visual impact is avoided and the dike is in harmony with its surroundings.

- Environmental: Analysing the biological conditions of the area in order to minimise environmental stress after renourishment.

- Surfers: The characteristics of the added sand should guarantee the continuity of surfing at the beach. To achieve this, swell breakage must be maintained in the form of spilling and, in some areas, plunging (areas of tube formation); this implies that regeneration should not provoke a very large increase in the slope of the floor which would in turn change the type of breakage to collapsing breakage.

The planform was designed in accordance with Sylvester's logarithmic spiral method, with the condition that the beach have a minimum width of 50 m at high tide, thereby defining a logarithmic spiral in the western part of the beach followed by a straight section towards the right. The breakwater is 1,100 m in length, with dimensions as shown in Figure 6.

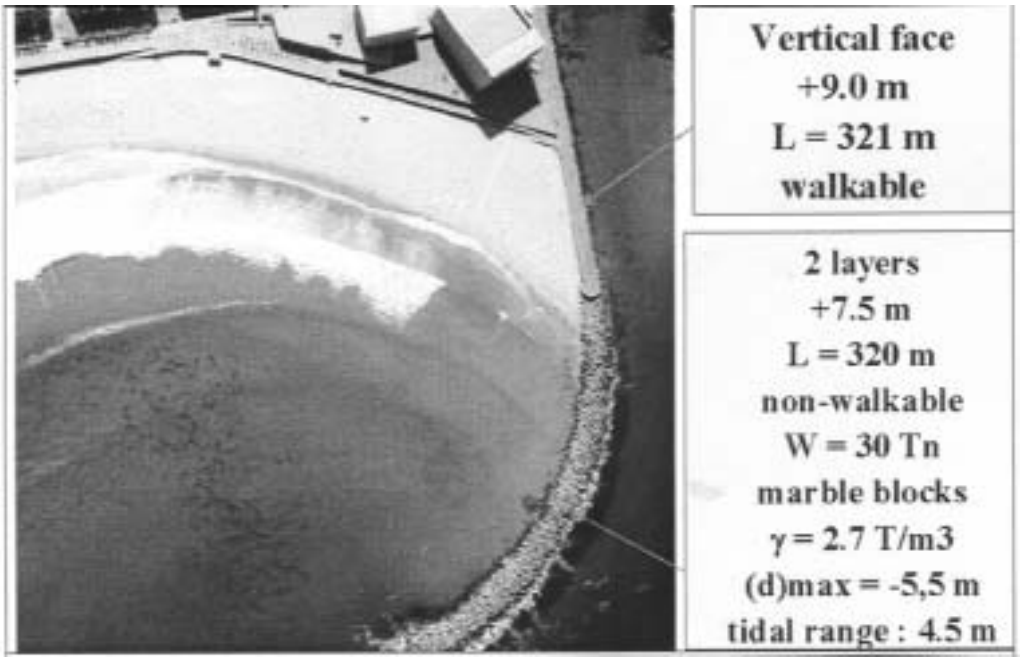


Fig. 6: View of Gross Beach after regeneration and dike dimensions (Source: Gómez-Pina et al, 2002).

In order to set the dimensions of the dike, the Goda formula was used for swell breakage. The volume of sand added was estimated by applying the Vellinga ratios, obtaining a result of 1,100,000 m^3 added sand, with a grain size of 0.33 mm.

Fig. 7. Gross Beach after regeneration (1995) (Source: Santás et al., 1999).

Another aspect relevant to the beach regeneration project was the strategy of monitoring the effects of the actions, with a continuous observation programme being drawn up and the recording of relevant data such as the direction of the swell, currents and level of the tide, monthly data related to the topography and bathymetry of the beach and visual images of the dry beach collected hourly by remote-control TV cameras (ARGUS system).

3.2.1 Costs

The funding of the regeneration project was compiled globally, integrating under the same estimated figure the cost of construction of the dike and the corresponding adding of sand.

The global estimate for the projected activity amounted to 7.829.683,60 € for material, with the amount increasing to 11.075.087,47 € with contracted work (which adds an initial amount of 17% for General Costs, 6% for Commercial Profits and 15% V.A.T.)

Costs corresponding to the continuous observation and control programme must be added to the aforementioned, although we do not have the data for the former as they are integrated into the global financial programme of the centre responsible for said programme (CEDEX).

4. EFFECTS AND LESSONS LEARNT

The effects observed are detailed below, and have been taken from the analysis and projection for the evolution of certain parameters which take into account the dynamic of the beach based on the actions taken.

4.1. Effects related to socio-economic aspects

The integration of the beach regeneration project in urban planning is of crucial importance, especially in cities of great natural and architectural beauty such as San Sebastian.

The engineering efforts aimed at renovating the aesthetic value of Gross Beach have been compensated by a large social acceptance, incorporating the new beach as another part of the urban coastal landscape.

Fig. 8: General view of Gross Beach. Source: Beach Guide (Ministry for the Environment).

The actions realised have been the basis on which an ambitious restoration plan for the district of Gross has been drawn up (also known as the Zurriola), which integrates the expansion of services aimed at the use and enjoyment of the beach, carried out in conjunction with the regeneration project.

Additionally, the municipality of San Sebastian has constructed the Kursaal Convention Centre, located at the same spot as the old Kursaal Casino.

This modern and revolutionary building, designed by the internationally renowned Spanish architect Rafael Moneo, together with the new restored beach of Zurriola, represent the new icons of a modern city at the dawn of the 21st century.

4.2. Conclusions

If we consider the data regarding the width of the Beach and the loss/gain of sediments obtained during the monitoring that has been carried out, we can deduce that Gross Beach behaves, on occasion, irregularly and unpredictably due to the simultaneous participation of various factors: climate, current, dike, etc.

The regeneration that has been carried out, however, satisfies the idea which led to the promotion of the original project, incorporating a new leisure space and economic zone related to the sectors which boost the economic development of the area. In addition, the environmental aspect as regards the surroundings of the beach has changed, its influence being notable in the city as a whole.

The project must be considered effective and a success, as it has combined an appropriate solution from a technical viewpoint with a work which has had little visual impact and preserves the natural beauty of this area.

The monitoring campaigns carried out by CEDEX reveal stable behaviour on the part of Gross Beach, which, subject to strong storms, generally tends to have a certain erosive character, although net losses in sediments can be considered acceptable.

The upper wave limits used to decide the dimensions of the dike are occasionally overcome by the strong storms that the beach is subject to. This has provoked deformation in the sections crossing the dike, due to the blocks falling to the sides.

Nevertheless, the dike has remained stable, fulfilling its function of diffracting the wavefronts, although regular small repairs have had to be made in the heavier block deposit.

Finally, the importance that the project has had in its projection and integration with the general planning of the city clearly justifies the actions taken, actions which have been valuable not only from a technical viewpoint as far as the chosen alternatives were concerned, but also aesthetically, environmentally and socio-economically, it having been completely integrated within San Sebastian's development strategies.

5. REFERENCES

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