An example of Integrated Coastal Management in Punta Candor (Co. Rota, Spain)

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ABSTRACT

The Northwestern coast of Cadiz (Spain) presents a variety of coastal engineering and coastal management problems whose solution is not an easy task due to the complexity of parameters involved. Punta Candor beach, a very popular recreational point in Rota Co., experiments one of the highest dune erosion rates, more than 1 m/yr. In order to solve this coastal degradation, the Atlantic Andalusian Coastal District has performed beach and dune restoration planning, as an example of sustainable coastal management tool.

KEY WORDS: Dune and restoration, coastal management, erosion rate, reef protected beaches, Punta Candor, Spain.

INTRODUCTION

Beach erosion and the corresponding shoreline retreat cause unacceptable economic and environmental risks in numerous coastal areas.
In Spain, littoral sand dune management have been studied by several authors: Bonnet Fernández-Trujillo (1989), Sanjaume and Pardo (1992), Van Der Meulen and Salman (1995), Ramírez and Ley (1998,1999), Gómez-Pina (1999), Colmenar (2001), Osorio et al. (2001), Muñoz-Pérez et al. (2001).

The northern coastline of Cadiz has been in recession for at least the last century. Erosion is caused by a negative sediment budget, due to the instability of eroded coastal cliff sediments (Anfuso and Gracia, 2005; Muñoz-Pérez et al., 2007), the lack of sediment supply from Guadalquivir river and the action of the rocky platform, preventing the arrival of sediments to the beach from the nearshore zone (Muñoz-Pérez and Enríquez, 1998). Therefore, this sector has almost no sedimentary input. Furthermore, the complexity of boundaries of the different authorities involved in coastal zone management policy (State Government, Provincial Government, Municipality and Military) makes difficult to get an integrated coastal management (Gómez-Pina et al., 2002). According to Medina et al., (2006) shore protection structures as groins and detached breakwaters, beach nourishment or the combination of structures and sediment addition are the most common response to the risk caused by persistent beach erosion.
The main objective of this paper is to show the different projects carried out in Punta Candor dunes by the Atlantic Andalusian Coastal District (Spanish National Coastal Authority, Ministry of Environmental Protection). These projects should be regarded as a good example of environmental coastal protection, opposite to the traditional sea wall reparations.

STUDY AREA

The study area is located in the SW Spanish littoral, in the south of the Guadalquivir estuary and in the north of the Gulf of Cádiz. Punta Candor is placed between villages of Chipiona and Rota (Fig. 1).

Fig 1. Location of the study area.

The coast is represented by straight beaches backed by

cliffs on resistant rocks. (Del Río et al., 2002). The sector from Punta Candor headland to Rota village, has a broad WNW-ESE direction and is formed by beaches with well-developed dune ridges at their back.

Sediments are moderately well sorted, with a medium and fine granulometry (Anfuso and Del Río, 2003). The tidal range, with semidiurnal periodicity, varies between 3,72 m (spring tides) and 1,10 m (neap tides), classifying the coast as a low mesotidal environment.

The littoral is mainly affected by winds and waves (both ''sea'' and ''swell'' wave conditions) approaching from the SW to WNW (Fig.2). Atlantic winds blowing from the W and WSW are responsible of the most important winter storms in the area.
Waves approach the coast mainly from the west (45% of annual frequency), with an average height of less than 1 m, and a significant wave height associated with storms of 3 m (Reyes et al, 1996).
The highest wave height values are recorded during the winter months (November-January), followed by the spring period (April-May). According to Anfuso and del Río (2003), the wave period is different from January-March (with values of 10-12s), November-December (6-8s) and the summer months, which are characterized by low periods (5-6 s).

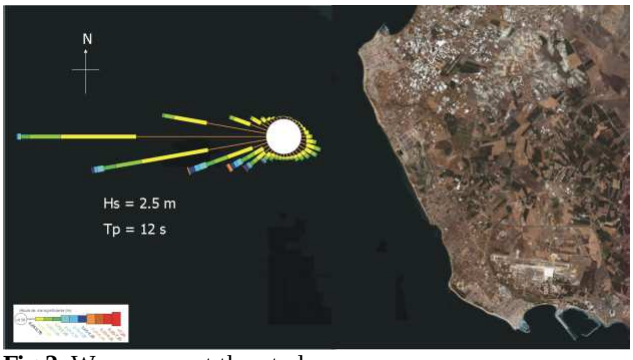

Fig 2. Wave rose at the study area.

Because of the coastline orientation, prevailing littoral drift currents in the zone flow to the SE. A secondary, opposite drift is also occasionally recorded, associated with wind-driven waves generated by strong winds blowing from the S and SE (Anfuso and Gracia, 2005).
In Fig. 3, the dominant sediment transport drift annual tendency (NW-SE) can be observed, increasing its value in the same direction, with an average net volume of 25-30.000 m^3 per year.
As a result, the study area and the dune system located in its north present very high erosion rates, with a retreat of 40 m in the last 30 years (Muñoz-Pérez and Enríquez, 1998).

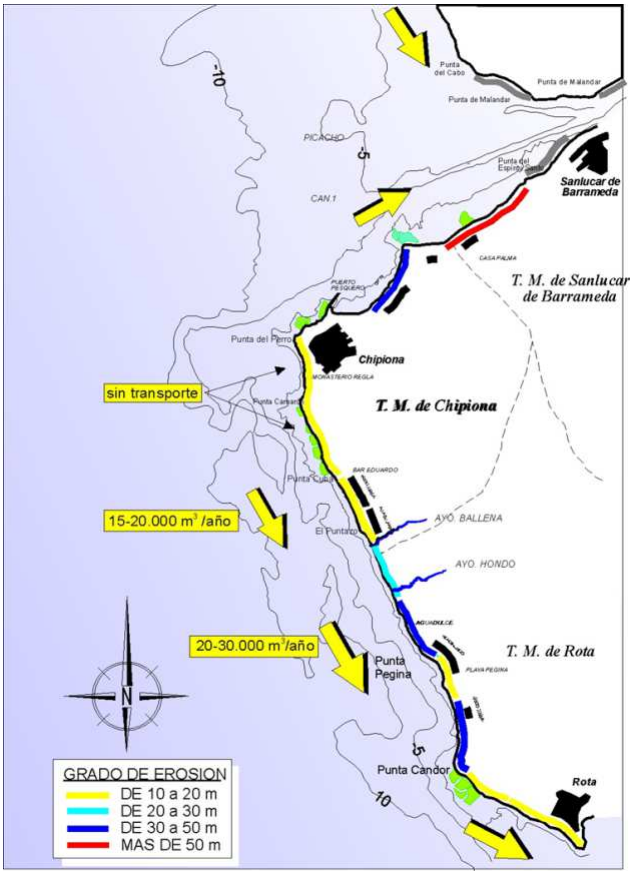

Fig. 3. Sediment transport and erosion rates in the coastline (from Muñoz-Perez and Enriquez, 1998).

In this study area, several coastal engineering and coastal management problems are taken into account, whose complex solution is not an easy task to find out. Some of these problems are:

-The presence of reef areas, conditioning beach morphodymamics, as they prevent the connexion between the beach and the sediment below the rocky platform.
-High dune erosion rates (0,5-1 m retreat per year) due to the nature of beach and cliff sediment (Fig. 4).
-Existence of environmental rich rocky areas to be preserved from beach nourishment projects.
-Location of still preserved dunes under natural geological erosion.
-Urbanization and dune occupation prior to the Spanish Shore Act approval in 1988.
-High turist development under an eroded coastline.
-The almost null possibility at present of using the only known high quality sand borrowed area, due to the radical opposition of local fishermen;
-Impressive presence of the "corrales", a kind of stoned man-made ponds, built from the Roman times, acting as a fishing pond as well as a protective semi-submerged

breakwater under a 3,5 m tidal range (Muñoz-Pérez et al., 2007).
-The existence of endangered species linked to the littoral ecosystems.

Fig. 4. Coastline retreat within a 30 year period.

Moreover, the continuous retreat of the coastline provokes other problems, as the Public Dominium limit.

METHODOLOGY

In order to reach a sustainable beach and dune restoration project, some design aspects must be taken into account. Technical, economical, environmental, constructive, aesthetics, recreational and safety elements are necessary to achieve a correct management of the system. This allows a good use for all the public sectors.
Several projects in this coastline have been successfully performed. One of the most important restoration works were applied in Punta Candor, where erosion destructed of a protruding paved area in 2004 (Fig. 5). Wave processes have been analysed in order to understand local negative effects.


Fig. 5. Destruction of Punta Candor protruding paved area after the storm of December, 2004.

The location of these concrete structures at the shoreface of the beaches creates a wave reflection on the wall, generating a sum of the reflected wave (1) with the incident wave (2). This new wave produced by the contact of both waves, turns out to be more erosive than the first one (Fig. 6.a.). When the incident wave is oblique to the wall, it produces lateral erosion, as it is confirmed in Fig 6.b. Storm waves can cause this material to be swept out to sea by rip currents, to be transported downcoast by the oblique reflection of swell waves from these structures (Silvester and Hsu, 1997).

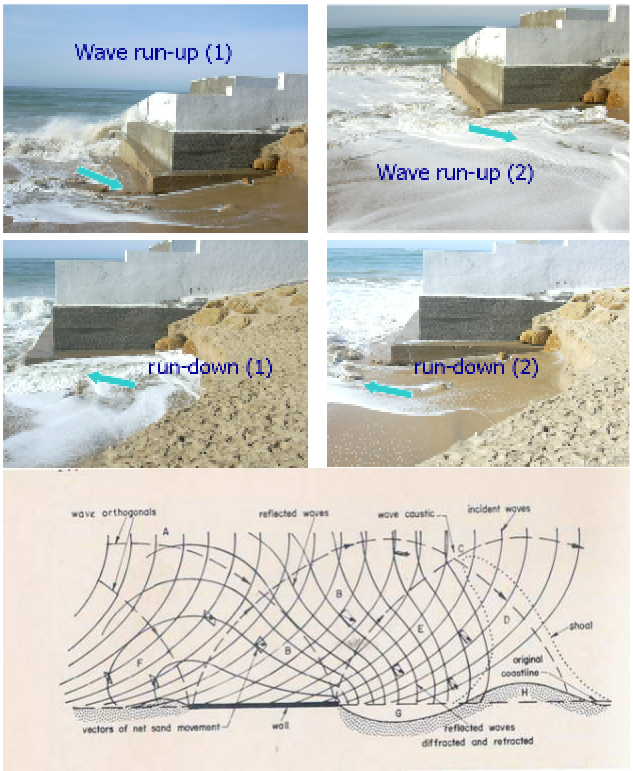

Fig. 6. a) Reflection process on a protruded paved wall. b) Schematic reflection wave behaviour by Silvester.

The Coastal Engineering Manual (CEM, 2002), displays five alternative ways to mitigate the damage of coastal storms, namely, accommodation, protection, beach nourishment, retreat and of course, the do-nothing alternative. In many locations, elevated structures combined with some type of armoring or shoreline stabilization structure together with beach nourishment are employed for shore protection.

In the other hand, Punta Candor Beach had several deficiencies:
-Lack of free zones for parking use.
-Fenced space and location of concrete structures.
-Weaponry bases.
-Difficulty access for physical disabled.
-Existence of invading plants (*Carpobrotus edulis*).

In order to solve these problems, the Atlantic Andalusian Coastal District performed a joint of actuations driven to beach and dune restoration. Chronologically, these works were the following:

-Demolition of the old paved prone area "protected" by a vertical wall (finished in 2003).
-Dune restoration, Phase I (finished in March 2007).
-Dune and surrounding area restoration, Phase II (starting May 2007).

RESULTS AND DISCUSSION

The first phase of Punta Candor restoration was quickly finished in a 6 months period, as there were policy interests due to the closeness of local Town Hall elections (Fig. 7). The new Punta Candor finally achieved the EU blue flag thanks to this restoration project.
However, dune restoration works began in spring of 2007, with dune replenishment from a sandpit, longitudinal willow fencing and cross walks settle (Fig. 8). New sand supply had different color from the natural Punta Candor dune sand, although this feature changed after 3 months, recovering its natural color. To prevent an ecological problem linked to the existence of chameleon nests, willow sand fences were carried out by hand. All these actuations allowed better accesses from the created parking area to the beach, dune protection and stabilization as well as a sustainable use of the ecosystem.

Fig. 7. Comparison between pre (2004) and post-restoration works (2005).

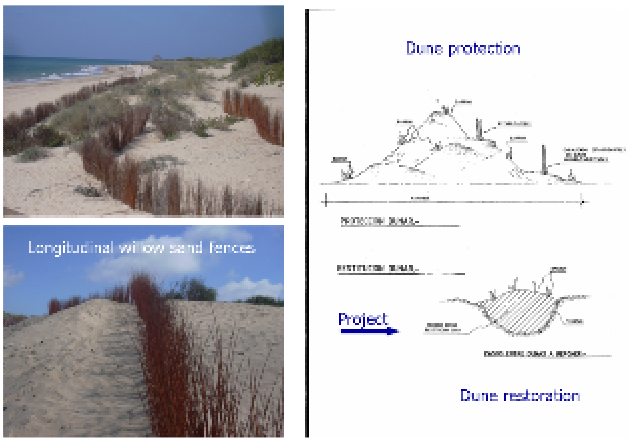

Fig. 8. Dune restoration works in Punta Candor.

Furthermore, demolition works of a typical II War bunker and Punta Candor Military Headquarters were performed within the proximities of the beach, although nowadays there are still some old military buildings to be demolished.

CONCLUSIONS

The existence of protruded paved walls at the shoreface produces grave negative effects, not only on beach but also on dune equilibrium. This aspect turns out even worse in the case of the study area, whose erosion rate is near to 1m/year.

On one hand, restoration works seemed very "brave", as there were not a previously known solution to solve the initial problem. However, this application example of coastal integrated management can be very useful for other locations, as the same problem appears in many parts of the world. Furthermore, dune restoration experiences based in other dune systems of Cadiz allowed to apply the best available techniques to control and stabilize the dune system.

Nevertheless, solutions for other "minor" problems, as the refreshment stand new location, chameleon problems, the initial sand replenishment color, etc., were a complex task.

As a result of all these works, people involved within the project were finally satisfied with the resolution of the problems.

Although the project has been a good example of an Integrated Environmental Dune Restoration, erosion problems in Punta Candor remain still unsolved due to the continuous retreat of the coastline. Therefore, it will be necessary to carry out seasonal sand replenishments periodically in order to maintain this successful situation.

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