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Soft Management of Beach-Dune Systems as a Tool for their Sustainability

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ABSTRACT

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In this paper, we present a review of soft beach management alternatives that are described and analyzed as effective tools for a more sustainable coastal management. The coastal management policies taken by the Administration in the Balearic Islands (Spain) in the last decades have been conceived only by its economic interest: administration of beach services and artificial creation, stabilization and growth of beaches. There was a lack of sustainable management and therefore, the quality of the natural spaces and their geo-ecologic conservation has been obviated. The economic interests have prevailed over the environmental ones, generating serious environmental impacts.

ADITIONAL INDEX WORDS: *Coastal management; Geo-ecological conservation; environmental impacts*

INTRODUCTION

In the Balearic Islands due to the high seasonal occupation of beach users, sandy coastline has suffered many changes in their natural processes. These changes occur either by interruptions of natural defense mechanisms that impede the smooth functioning of coastal ecosystems (BROWN and MCLACHLAN, 1990) or by generating new spaces of sandy beaches due to artificial stabilization or expansion of existing operations, linked to the nearest service offerings. These processes have changed dramatically the traditional landscape, giving rise to important changes in their natural characteristics.

The management techniques used on these sandy coastlines have relied almost exclusively on providing services, including cleaning mechanics, which have worsened in the last decades, but continued, the erosive effects. In other cases there has been an increased dependence on the beaches with artificial beach nourishment (RODRÍGUEZ-PEREA et al., 2000; SERVERA, 1997). These efforts were justified as socio-economic interests and too often they have allowed the degradation of the precious and fragile natural systems, as in the case of beach-dune systems of the Balearic Islands. On numerous occasions the authorities tend to alter the beach to accommodate a tourist economy, as opposed to natural resource (NORDSTROM et al., 2002). In many occasions, the management is dealt with a local perspective, ignoring the influence of agents and forces involved in the coastal zone. As a result, some problems can be solved locally, while others are accentuated.

The present paper describes and analyzes the so called soft management for beaches and dunes: the one that help the natural recovery of dune morphologies and associated plant communities in contrast with the management based on artificial regeneration of beaches by replenishment of sand from outside of the system.

THE USE OF SOFT SKILLS OR NATURAL MANAGEMENT SYSTEMS IN SANDY COASTLINES

The soft coastal management techniques outlined in this paper are conditioned by the natural agents that act on the beach (sediment availability, wind regime, wave climate, etc.). Those techniques work slowly than the hard ones such as artificial beach regeneration, breakwaters, groins, etc., but they are much more sustainable. Furthermore, these methods can only be applied in areas retaining a minimum of environmental quality and morphology of the beach-dune system, as opposed to the methods of artificial regeneration, which allows the creation of new spaces in non sandy beaches or expanding the areas and volumes of the sandy beaches.

Some of the techniques used in soft management of beaches and dunes tested on the islands of Menorca and Mallorca are presented below, with an assessment of their ecological impacts.

Restrictions on the mechanical cleaning of the beach.

The mechanical cleaning has been one of the factors that accelerated the erosion processes at the beach-dune systems (ROIG, 2004). This technique consists of a daily superficial plough of the beach using heavy machinery in high season, which spreads out from the swash zone to the dune toe. Restrictions on mechanical cleaning, both in frequency and in the areas of performance, are an important factor in the natural restoration of the first dune ridges, in particular, are crucial to the recovery of new beach morphologies and vegetation, and for the recovery of foredune perimeter. The cleaning reduction over five years at four beach-dune systems in Menorca resulted in the recovery of a surface of 12,207 m^2 (ROIG et al., 2007), with an average

Figure 1. Accumulation of remnants of *Posidonia oceanica* mixed with sediment after a beach cleaning (Alcúdia Bay, Mallorca).

accumulation of 0.36 m in height. With time, new dune forms have been developeded and growth to stabilize eroded slopes and giving further a natural beach profile. The cleanup is limited to the area of sun bathers, avoiding action on the entire surface. This fact facilitates the development of vegetation cover and allows the sediment accumulation in the already recovered new morphologies.

Using remnants of *Posidonia oceanica* on the emerged beach

The withdrawal of *Posidonia oceanica* remains accumulated in the foreshore is one of the most important tasks of cleaning beaches. These withdrawals made without technical criteria have generated significant erosion processes along the Balearic coast, either by the methods used (heavy machinery) either by the high frequency (almost daily in high season). This withdrawal produce a significant loss of sediment, as the material accumulated contains a great amount of sand which is usually transported outside the beach-dune environment. It means an important output in the sedimentary budget (ROIG and MARTIN, 2005).

ASENSI and SERVERA (2004) in a work in Alcúdia Bay (N, Mallorca) quantified the sand content of such removed materials. They obtained up to 23% of sand in withdrawal accumulations located at the rear of the beach. In Menorca, ROIG et al. (2004) quantified the sediment content loss of the vegetal berms of *Posidonia oceanica* located in the foreshore. They obtained sediment losses closed to 4%. Such disparity of values is linked with the residence time of those accumulations on the beach. The proximity to the shoreline in the case of Mallorca and the soft methods used in their withdrawal, in the case of Minorca, are important factors too.

In the Figure 1, we can clearly see the volume of sediment removed in a withdrawal of berms accumulated on a beach in Alcúdia Bay (N, Mallorca). This indiscriminate and massive cleaning method using heavy machinery is widely used throughout the Mallorca coastline. This removed sediment never again return to the system since it is carried out beyond the system, giving place to continuous erosion of the beaches.

When these withdrawals are apply with the criteria described by ROIG (2002), or with techniques for levelling the surface of the beach towards the accumulated berms, according to their thickness, such accumulations of sediment remains on the beach. In the absence of dune morphology, this technique involves levelling the natural beach profile toward the accumulated berms. Thus, no impact is generated with its withdrawal (loss of volume and sedimentary structure of the swash profile) other than increasing the surface of the beach. Sand overlapping remnants of *Posidonia* allows the temporary gain of beach surface (approximately 2 m per meter accumulated of *Posidonia oceanica*) accelerates the natural sedimentation processes and it helps the attachment of submerged bars on the foreshore.

Use of remnants of *Posidonia oceanica* as interference wind barriers

The withdrawal of accumulated berms and the subsequent accumulation on the system can be used as a technique for wind interference in erosive morphologies. They have been used as wind screens in wind discontinuities of dune areas, like deflation

Figure 2. Using remnants of mechanical cleaning as wind screen in a blowout; accumulations can be seen in the deflation channel (N, Menorca).

Figure 3. Using deterrent cords can be sufficient to protect the dune vegetation from beach users.

channels between foredunes or in stabilized longitudinal dunes (Figure 2). This technique brings to the system large amount of organic matter and sediment interspersed, just depending on the maturity of the removed berm and its sediment content. Moreover, this technique promotes rapid plant colonization. In this way, and based on the morpho-ecologic classification of HESP (2002), have succeeded in moving foredunes from 5-4 stadiums to 2 stadium in some beach-dune systems. In the beach-dune system of es Grau (north of Menorca) a total of 3.582 m^2 were recovered by this method with an average thickness of 1.23 m.

Using remnants of *Posidonia oceanica* in urban beaches

In urban beaches or coastal systems without dune morphologies, *Posidonia oceanica* remnants are booked in areas close to the beach in order to be reverted later to the swash zone. Once finished the tourist season, the return of the remains of *Posidonia oceanica* to the swash zone, speeds artificially the creation of natural berms. It lets to the protection and rowing of emerged beach and brings back to the beach the interspersed sediment taken from its withdrawal.

Deterrent cords for the dune protection

Simply placing stakes linked by ropes to prevent the passage of visitors into the interior of the dune systems has resulted in a slow and gradual recovery of dune morphologies and vegetation. It helps the colonization of natural vegetation of the small and indiscriminate trails on the dune system and seals blowouts (Figures 3 and 4). This restriction was respected by beach users around 98%, according to ROIG et al. (2007). The volumetric gain thickness is 0.30 m in average, nevertheless it is very important because helps and accelerates plant colonization and the creation of associated morphologies.

Transfer of submerged bar on the beach

For urban beaches, especially in pocket ones that are systems influenced by mixed processes both coastal and torrential, the recovery of summer profile does not occur in a timely manner or is not sufficient for tourism recreation. On these occasions, transfers can be made from submerged sand bars attached to the swash area towards the emerged beach. Doing so, we artificially accelerate its accretion to the beach, and later, we proceed, through a levelling process, to extend the surface accumulations on the beach

Wind interference barriers

These barriers are made of different porous materials that reduce wind speed and accumulate the sediment carried by wind. In beach-dune systems it was chosen the use of vegetable materials that are buried (reeds or spartina grass), or reusable shingles that are installed annually. In some discontinuities, like blowouts or deflation channels, reed fences were used with porosity close to 50%. It developed a deposition at distances between 5 and 10 times the height of the trap. On the frontal parts of the systems it was used spartina grass with a porosity of 10% to create the first forms of retention (Figure 5). In the same way branches of variable porosity was used in some deflation channels and blowouts

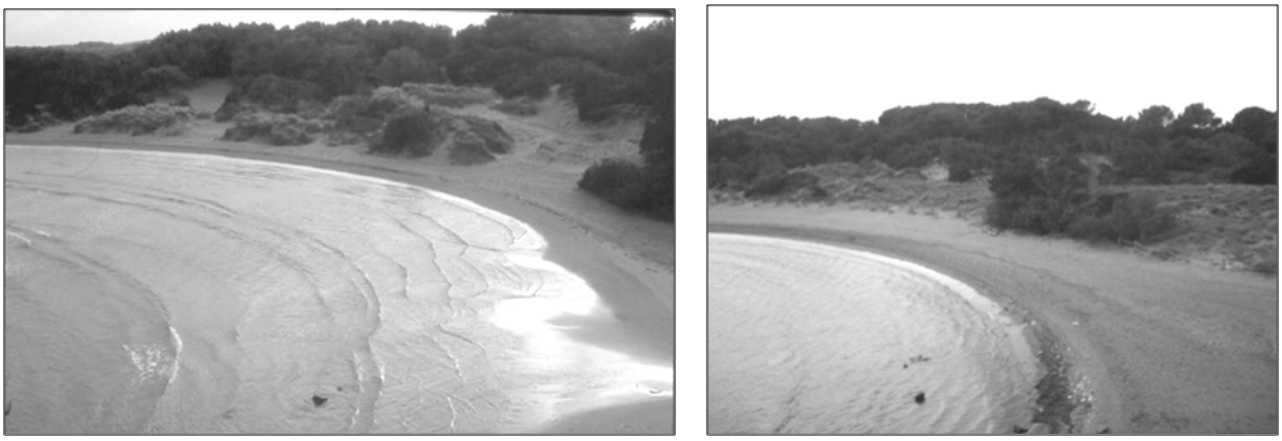

Figure 4. Comparison between 1995 (left) and 2005 (right) of a beach of North Menorca, before and after the installation of deterrent cords.

Figure 5. The use of spartina grass as sediment trap.

Figure 6 Wind interference traps in an urban beach .

In urban beaches, slatted wooden screens of a porosity of 50% were also used. They have the advantage that they can be reusable for each winter period (Figure 6). Once these facilities are withdrawn, a process of levelling the beach is made. Nevertheless, in some beaches with significant volume gains, captured sediment serves as reservoir of sediment for the nearest beaches. It ensures the quality in the provided sediment, without associated environmental impacts.

Artificial beach nourishment

The artificial regeneration of beaches is the replenishment of sand providing from another area on a sand-lacking beach. It should be carried out according to the coastal processes and always using sediment obtained outside the natural beach environment: sandy submerged banks of the near shore or emerged sand dunes. Artificial beach nourishment has raised great controversy and expectation over the past few years. The generated interest is given by his attempt to make a positive contribution both to stabilize beaches allowing their use for recreation, as to recover their ecologic values, although in practice only gets the first point and on a temporary basis.

This technique could be successful if: 1) is made in a safe measure; 2) is profitable; 3) is durable in time and 4) provides opportunities for other potential uses of the coast. However, these requirements are not met and usually the artificial beach nourishment is made with a limited knowledge of coastal dynamics, and there are abundant negative experiences all around. In cases where the availability of suitable sediment is not guaranteed, sand extraction causes irreversible damage to grasslands seabed, especially in the *Posidonia oceanica* meadow. This artificial refund of sand does not resolve the erosion causes, only acts on its effects. The origin of the problem continues to exist and will not be solved until there were radical changes in the mechanisms governing coastal management. After each erosive episode, municipalities require replacement of the sand with a "stranger" schedule that does not match natural processes. Tourism industry needs the beach at their firstborn state that does not agree the natural ecosystems state. For this purpose millions of euros are invested in recovering the beaches and leave them in place for the enjoyment of visitors.

Another problem associated with the extraction of sand in the platform, is the large amount of sludge that contains the extracted sediment. This sludge is lost, both incidentally, or by overflow during transport to their destination, resulting in their deposition on the meadow or in an increase of the turbidity of the water column. Sometimes, as in the case of submerged sand deposit in Ibiza (Sa Talaia), it happens that the percentage of the sludge is so high that exceeds 10% of the total scheduled volume of a removal amount of three million of cubic meters. The second risk associated with this technique, occurs when the new sand on the beach is reworked by the waves and that muddy portion is put in suspension. The fine content from the new sediment have negative consequences for the upper limit of *Posidonia* meadows as they can be buried by that mud stifling the plant that began a process of putrefaction, resulting in high environmental consequences.

From another point of view, the alocthonous sediment added to the beach is quite different from the original. In this regard, numerous complaints were made by neighbours and users of the reclaimed beaches in the sense of having different texture and colour and a significant increase in water turbidity.

CONCLUSIONS

Beach management in the Balearic Islands was characterized by the application of rigid and static measures, similar to those applied in urban areas, without considering the different geomorphologic and environmental peculiarities of the coastal ecosystems. Lack of knowledge of littoral processes has led to the progressive deterioration of beach and dune ecosystems. Actually, due to the lack of good results in the management of these spaces, a new methodology has been taken in practical. Along the last six years soft and passive management techniques have been applied to this space. They work sustainable, with the nature, but they do more slowly than the hard technologies. These soft methodologies consist basically in:

Regulation of withdrawals from accumulated vegetal berms of *Posidonia oceanica* leaves: Criteria is established to minimize the erosive impact of the indiscriminate withdrawal of *Posidonia* dead leaves remnants deposited on the beach by using heavy machinery. A schedule has been developed along the year together with the use of appropriate machinery adapted to avoid the loss of sediment inserted among the leaves (ROIG, 2002, ROIG et al., 2004, ROIG and MARTIN, 2005).

Regulation of mechanical cleaning across the beach and foredune system: Traditional methods of beach cleaning have affected the beach dune systems to a worrying extent. By this reason, sectors of mechanical cleaning are established just in the

zone of the more intense beach use. The swash zones and the foredune toe are avoided and in this way, the stability of the system is favored. This methodology does not interrupt the natural processes (ROIG, 2004).

Regulation of beach users in dune systems: the surrounding area next to the dune toe is protected with a cord line. This technique avoids the recreational use behind this point and also prevents walking and trampling processes over the foredune vegetation (NORDSTROM et al., 2002).

Use of mixed techniques of sediment retention: The use of wind-screen fences constructed with splints, *spartina* grass, wattles and rests of pruning, and other natural materials protects the dune front and recover the internal lobules from deflation, favouring the natural colonization of the system.

Sand levelling: In the sub-aerial beach, some amounts of sand are used to level on top of the accumulated berms of *Posidonia oceanica*. In this way, beach erosion is avoided and it accelerates recovering of sedimentary processes, specially the accretion of submerges sand bars to the foreshore.

Use of accumulations of *Posidonia oceanica* in the dune fronts: The use of *Posidonia oceanica* remnants as wind-screen in blowouts and other dune scars gives the dune system not only sand, but it also recover the depositional structure of the dune and increases the organic content for plant feeding.

All of these soft techniques have allowed the recovery of the beach dune ecosystem, the stabilization of erosive morphologies and the neo-colonization of psammophilous species characteristic of the dune front. The present work takes into account different methods of beach management as well as their ecologic and economic values. These methods have resulted in the recovery of the dune front of the several beach-dune systems of the Balearic Islands, especially in Menorca. It also shows than both from the economical and ecological point of view, the social and environmental profit is greater than the damage could have taken. In conclusion these soft techniques are basically inexpensive, help with the erosive problems, work with the natural processes and finally, do not have collateral impacts on the ecosystem.

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