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THE ALENTEJO AND ALGARVE COASTS IN THE PORTUGUESE FRAMEWORK

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Abstract

In the Portuguese coast the cliff systems prevails with several estuaries where are settle the most important harbours and towns. Nevertheless they are some sandy systems both on West and Southern coasts. The West coast is exposed to the Atlantic wave climate while the Southern coast is a sheltered one. Near the coast leaves more than half of the Portuguese population and therefore it is submitted to a strong pressure. The main conflict situation are of two kinds: coastal sections in erosion and at the same time, the infilling of the small estuaries and coastal lagoons, promoting their eutrophism and risking the local aquaculture communities. They are both the result of different human interventions on the coast or inland.

Key words: coastal dynamic, cliff coast, beach, spit, barrier-island, coastal lagoon, human pressure, coastal land-use, coastal erosion, infilled lagoon.

1. DYNAMICS AND COASTAL SYSTEMS

The Portuguese coast is about 900 km long. It is scarcely trimmed and has two fronts with distinct exposure to the dominant NW wave climate (over 80 % of the year). The Western coast is directly exposed to waves with an average height of 2-2.5 m and 8-9 seconds period. Thus it has of a more active morphogenesis. The Southern Algarve coast is a shelterd front, where the wave heigh is lower than 1m, in 70 % of the year. The alluvial deposits are the main origin of beach sediments, being more abundant in the Western coast and particularly, North of Nazaré. As a matter of fact, it is in the Northern half of Portugal that the drainage stream network density is higher, and sediments are more abundant in the contiguous continental shelf.

Broadly speaking, the longshore drift sediments circulation is from N to S on the Western coast, and eastwards on the Southern coast. The first tests held on the Western coast in normal conditions (with NW waves, with 3 m significant heigh and 8 seconds period) point to a longshore drift of 1 000 m/day and a maximum speed of 2 300 m/day (*Dias et al*., 1992). Others experiments with 3 m significant breaker height has show a mean longshore current of 0,5m/s and a total transport rate of about 1.9×10^4 m^3/year (*Taborda et al*, 1994).

The cliff systems prevails in the Portuguese coast. Although they can present narrow summer beaches (Fig. 1). There are numerous estuaries of very diversified dimensions. From North to South, the most important estuaries are: the estuary of River Douro, near Oporto; the one of River Mondego, on the right bank of which lies the city of Figueira da Foz; the one of River Tagus near Lisbon; and the one of River Sado partly closed by the spit of Tróia where it is located the city of Setúbal, (Fig. 1). The small-sized estuaries are submitted to a strong infilling (tendency which is known since the XVIth century), and some are completely closed by a sand ridge, allowing the formation of small-sized coastal lagoons.

Although the cliff coast prevails, there are some sand systems that are worth mentioning, both because of their extension and because of the unbalance situation and the environmental vulnerability.

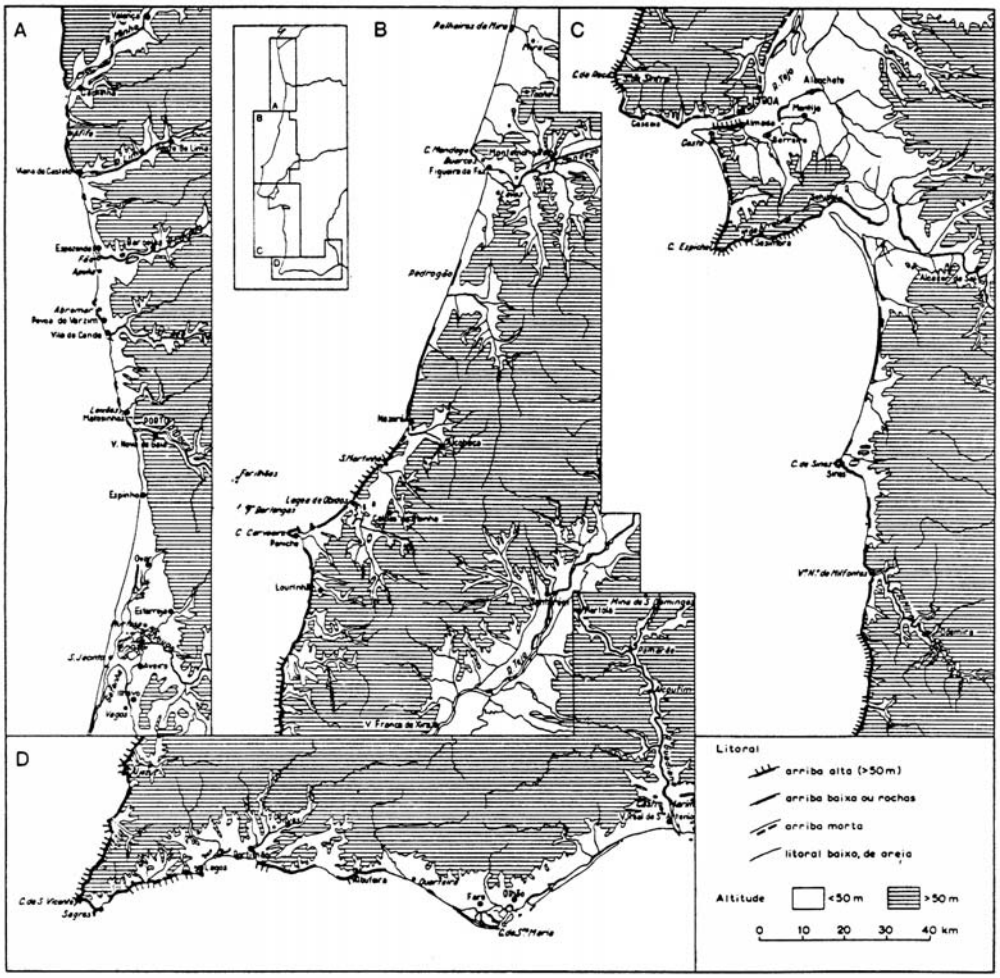

Fig. 1 – The Portuguese coastline. Legend: a) coastline: 1 – cliff higher than 50 m; 2 – cliff smaller than 50 m or reefs; 3 – inactive cliff; 4 – sandy coast; b) altitude (Ribeiro *et al*, 1987).

On the Western coast it should be mentioned the 80 km length sandy coast between Espinho and Cape Mondego. It is made up of two spits and a narrow outlet between, (which now is man-made), that almost close the so called Ria de Aveiro. It is a coastal lagoon with a 500 km^2 water body in an accelerated infilling situation, by means of alluvial sediments of the rivers that flow into it, and of sediments from beaches and dune ridges of the spits caused by frequent overwashes.

The barrier-island system of Algarve is also worth-mentioning. It is on the maximum limit of its existence conditions, since it is a mesotidal zone (4 m on the Western coast North of Lisbon and slightly inferior on the Southern coast). It is made up of 5 islands surrounded by two spits in a 70 km coastline length with a general dynamics from W to E. It is probably an Holocene system, that has been migrating towards the coast, keeping the pace with the sea level rise.

2. HUMAN PRESSURE ON THE COAST

The coastal areas are the most populated areas in the country, reaching in its two main metropolitan areas (Lisbon and Oporto) values higher than 1 000 inhabit/km^2 in 1991 (*Pereira*, 1992). The Northern half of the West coast has a density above to 50 inhabit/km2 (North of the mouth of River Sado, Fig. 1 and 2), and in most of the areas, above 100 inhabit/km^2. The rest of the Western coast (except for the industrial district of Sines and part of the Algarve coast), has a density below 50 inhabit/km^2. This uneven

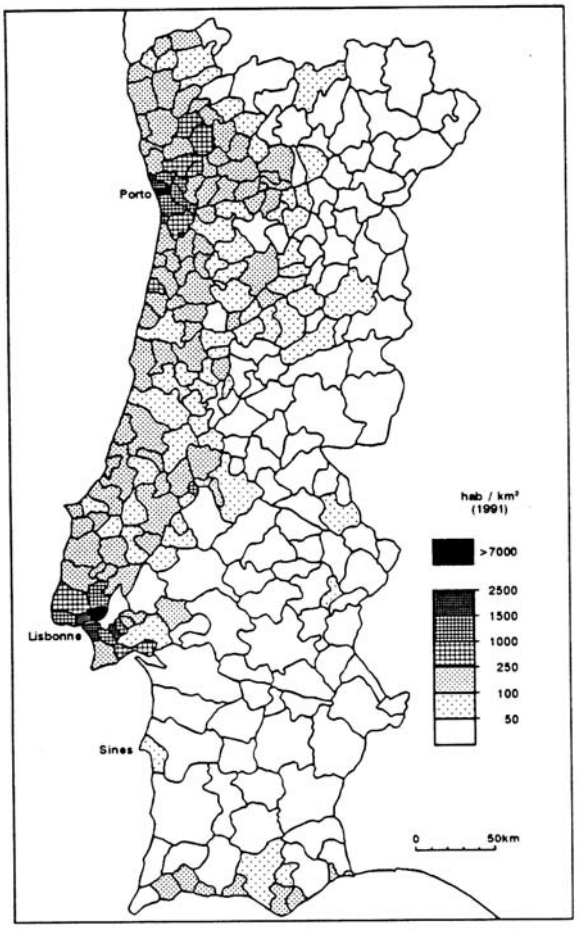

Fig. 2 – Population density in 1991 (*Pereira*, 1992).

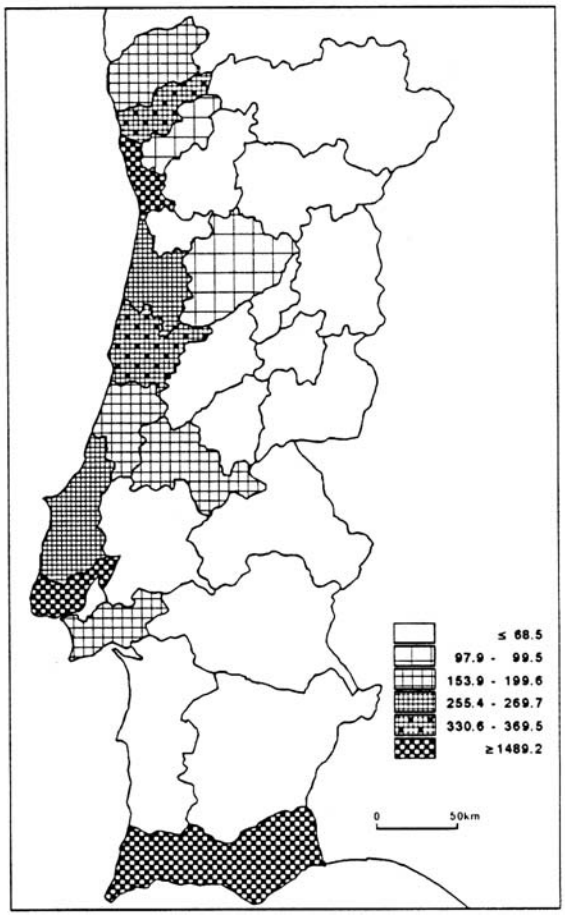

Fig. 3 – Hotel rooms density/100 km^2 in 1991 (*Henriques*, 1994).

distribution of the population along the coast foresee different pressures. On the other hand, the coastal areas are also submitted seasonally to the pressure of the holiday-makers, which also reveals strong regional contrasts. The amount of hotel rooms supply (Fig. 3) shows, clearly, the tourist appeal of the coast. The percentage of overnight shows, in turn, the interest of tourists on the coast and, particularly, on Algarve´s (Fig. 4). It should be noted that the coast of Alentejo, although offering a low lodging capacity, it is a place with growing appeal (Fig. 3 and 4). Algarve is the place with greater lodging capacity and also the most sought after by tourists. Nevertheless, Algarve has several contrasts with special reference to the Southern coast, particularly, central Algarve, where the human pressure is also stronger.

In Portugal, as in many other places, there is a coincidence between the higher populated areas and those where the main problems and heavy and soft coastal protections exist.

3. PROBLEMS AND INTERVENTIONS

As in other coasts, the existing problems are mainly the consequence of the dynamic character of the coastal systems and the management and land-use. As a matter of fact, the coastal systems are dynamic and the coastline is in motion in different time scales. For example, if we consider a beach, it has several positions according to the seasons, namely, in a reflective or in a dissipative profile. On a wider time scale, e.g. during the Holocene, the coastline migrated globally inland. The main problem of the coast lies exactly in the attempt to settle it and making a permanent occupation of a mobile section, both in time and space. The splitted knowledge of the coastal

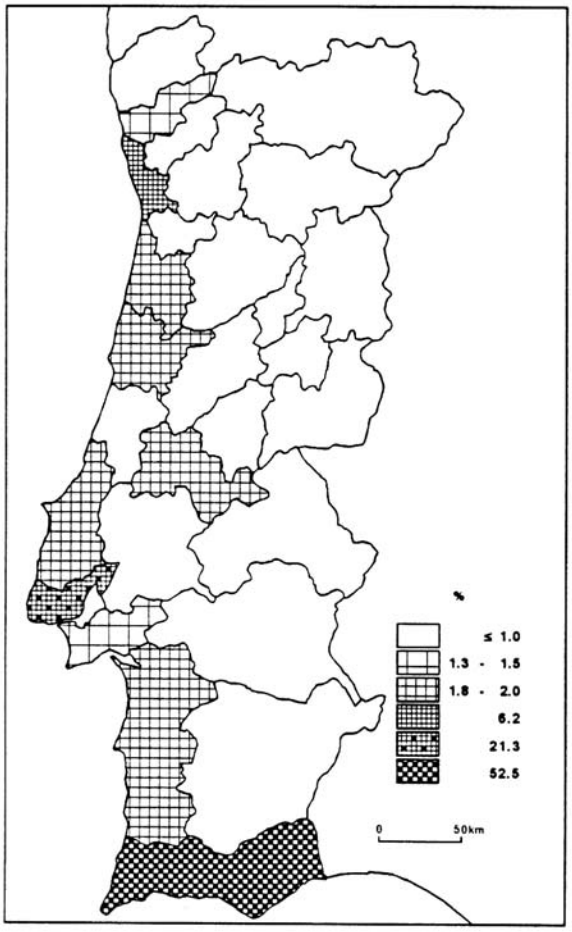

Fig. 4 – Overnights in 1991 (*Henriques*, 1994).

dynamics has contributed to trigger several conflict situations, along with several interventions whose results are to change the natural dynamics, namely, as a consequence of the decrease in the discharge of sediments on the coast.

The main conflict situations are of two kinds: coastal sections in more or less accentuated erosion and which goes public when it occurs in areas highly populated, or where the tourist investments are endangered, and at the same time, the infilling of small estuaries and coastal lagoons, promoting their eutrophism and risking the local aquaculture communities.

Coastal erosion problems in Portugal are not a present-day phenomenon. Since the past century that this problem started to be discussed. The area of Espinho (Fig. 1 and 5) is a good example of it. Reports of sea "progression" which damaged Espinho date back namely from 1869, 1871, 1874, 1885 and 1889, with an average coastline retreat of about 8 m/year (*Oliveira et al* 1982; *Valle*, 1989). The first coastal protection works in Portugal took place at Espinho, where seawalls were built in 1908 (destroyed by the sea in 1911) and 3 waterbreakers between 1911 and 1918. Between 1954 and 1990, the evaluated land loss was 2 100 100 m^2 in 10 km coastline lenght (*Ângelo*, 1991). In 1989, in the Espinho-Cortegaça section, there were an average of about 1,8 waterbreakers/km of coast and more than 325 m of longshore structures.

3.1 The causes of erosion

There are several causes for coastal erosion but the most important are the result of human actions directly over the coast and also from others interventions, which, although separated by several kilometres, have repercussions on the coastal dynamics.

3.1.1 The deficit of sediments available for the coast nourishment

This deficit has several causes. The first one is, most probably, the construction of dams whose increase took place in the 70´s. It should be mentioned as an example, the river Douro. In natural regime it would transport a bedload sediment of about $1.8x10^6$ m^3/year, and this value is estimated to have been reduced to 0.25×10^6 m^3/year (*Oliveira et al*, 1982). This decrease is not only caused by the sediments retention upstream. The dams, when decreasing the frequency and magnitude of the floods, prevent sediments coming from the downstream areas to reach the coast. Forestations and the regularisation of the stream beds also contribute to this deficit. The numerous drags that take place in the estuaries, as well as the extraction of deposits remove enormous amounts of sediments which never reach the coastline. It should be noted as an example, that downstream of river Douro alone, the volume of dragged sediments between 1982 and 1986 was of 3×10^6 m^3, that is an amount slightly above the estimated one for the volume of sediments in transit by the

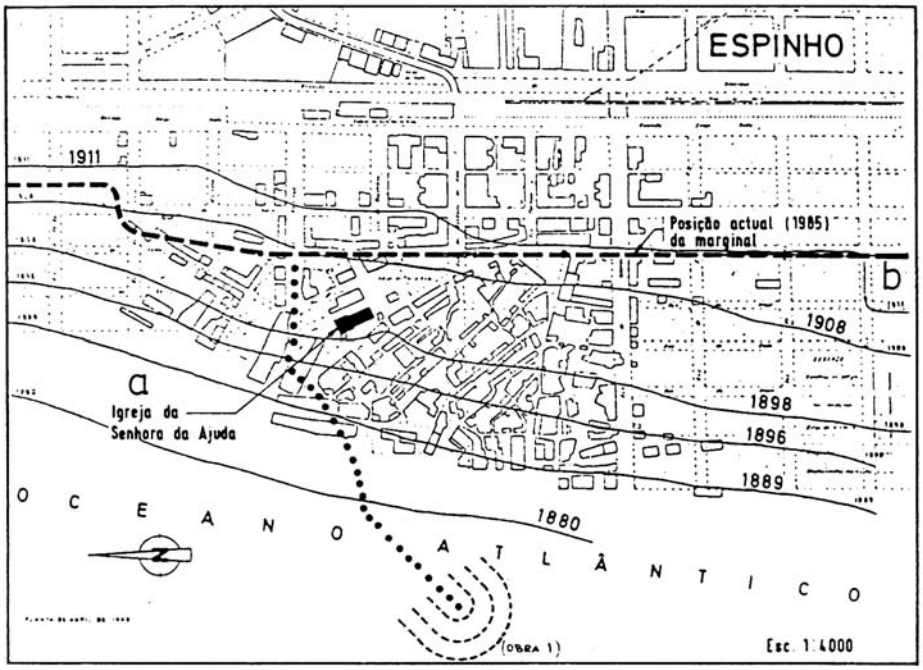

Fig. 5 – The coastline evolution at Espinho, from 1880 to 1885 (*Valle*, 1985). Legend: a) church of Sra. da Ajuda; b) longshore road.

longshore drift, which is estimated to be 1×10^6 to 2×10^6 m^3/year, as mentioned before. Between 1990 and 1994, there is an estimate that about 6×10^6 m^3 of sediments were dragged on the Portuguese coast (*Rego & Cid*, 1995). To this values it must be added the illegal extraction of deposits, which, in some places of the Portuguese coast seem to reach surprising values.

3.1.2 The partial or total destruction of the coastal systems

This phenomenon takes place after the built of structures (houses and communication ways) up to the top of the cliff or over the primary dunes. These structures destroy the natural systems, preventing, namely, the transversal exchange of sediments. The randomly treading of the dune ridges and the sand extraction, as well as the road construction contribute also to this unbalance.

3.1.3 The prevention of the free longshore bypassing of sediments

The obstacle to the longshore drift results on the construction of heavy structures to regularise the harbours entrance and transversal structures to defend the coast against erosion.

The soil impermeabilization and the deforestation could put an end to this deficit of sediments. However, the larger volume of sediments is kept in the dams and this phenomenon only matters in the small hydrographic basins without dams.

The sedimentary deficit and the direct anthropogenic intervention weaken the natural systems, namely beaches and dunes which operate as protection systems from the wave attack, being more frequently subject to overwashes, with an increase in coastal erosion and coastline retreat.

3.1.4 The sea level rise

The study of sea level rise at Cascais, concerning a period of one hundred years (*Taborda & Dias*, 1988, *Dias & Taborda*, 1989, 1991) shows an average sea level rise of about 1.5 mm/year. However, it is possible to define two distinct periods: one until 1920 where there was a slight decrease in the sea level and another up today, with a sea level rise of 1.7 mm/year. This phenomenon cannot be overlooked in the management and land-use of the coast.

Nevertheless, estimates held by *Ferreira* (1993) and *Ferreira et al* (1990) on the weight of the present sea level rise on the coastline retreat, for the Aveiro-Cape Mondego section, reveal that it could justify directly only 10 % of the retreat. Identical conclusions can be made from the works of *Andrade* (1990) for the Algarve coast and of *Teixeira* (1990) for the the Peninsula of Tróia.

Nowadays, on the Portuguese coast prevail the sections under erosion with retreat rates from a few millimetres over a dozen metres. The most critical areas, in which those values range from 1 to 14 m/year, are located on the South of the harbours of Viana do Castelo, Douro and Leixões, Aveiro, Figueira da Foz and Lisbon, and also in the Algarve.

3.1.5 The storm surge

Storm surge effects have been repported by several authors. Some data based on the analysis of the differences from the recorded and the predicted tidal levels at each station are now available for the seven Portuguese tide gauges (Viana do Castelo, Aveiro, Cascais, Lisboa, Tróia, Sines on the West coast, and Lagos on the Southwest coast). The several periods studied has shown a maximum level of 1.10 m at Viana do Castelo during the 14th-16th October 1987 storm (Gama *et al*, 1994).

The Portuguese coast is not submitted to a real storm since 1989. With the human pressure and buildings that have been settled near the coast since then, it is predictable that a real disaster may happen. The Winter of 1995-96 had heavy rainfalls and some problems occurred, but the EWIN (wave energy sensor, which was installed in the West coast South of Sines) has shown that the wave energy recorded was never a storm one.

3.2 The infilling causes

The infilling affects mainly the estuaries of the small streams whose flow was not regularised by dams (the infilling in the large estuaries is compensated by drags). In their hydrographic basins, the deforestation has contributed to the increase of the sediments discharge into the coast. Due to the sea level rise, these sediments are not carried away off the estuaries. The sediments on transit by the longshore drift flow into these estuaries accelerating the infilling. The smaller estuaries are already completely infilled or in a stage of a quick infilling process, reason why they have been submitted to intervention to compensate this tendency and fix their outlets.

4. SOUTHWEST AND ALGARVE COASTS

The coast of the Southern half of Portugal illustrates quite well the coastal systems and their problems in the Portuguese coast.

The Southwest coast between Sines and Boca do Rio (West of Lagos) illustrates several kinds of cliff coast, with narrow beaches on the base and rare pocket beaches. There, along with a low population density there is still low Summer human pressure, although in a growing phase. It has a length of 176 km of protected coast (Natural Park), corresponding to about 20 % of the Portuguese mainland coast.

In this long coastal section, the erosion has not been arising major problems, although it has been recorded a retreat of 2 m in a cliff coastal section (E of Sagres) during January 1996. The infilling tendency of the small-sized estuaries has, in turn, caused some problems in the aquaculture exploitation's.

On the Southern coast the conflicts between coastal dynamics and human pressure start to get more and more serious from the East of Lagos to the Central Algarve.

The Bay of Lagos and Alvor lagoon illustrates the progressive infilling of the coastal lagoons, as well as the erosion created by the settlement of its inlets/outlets, endangering and damaging the tourist structures.

The Praia da Rocha and Vale do Lobo coastal sections are examples of quick erosion of cliff-beach systems whose retreat is risking several buildings. At Vale do Lobo the cliff retreat is endangering a luxury tourist urbanisation (house, swimming-pool, golf field and its own beach).

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