

Changing use of the estuarine system of the Ria de Aveiro, Portugal, and resultant impact on tidal flat sediments

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Abstract: Changes in use of the Ria de Aveiro, Portugal, have impacted on the sediments of the lower intertidal areas. Loss of seagrasses, due to increased tidal flows, exacerbated by increased recreational activities, has been accompanied by a change from fine cohesive sediments to coarser, mobile sediments with reduced biological activity.

Key words: Ria de Aveiro, boating, leisure, sediments, seagrasses

INTRODUCTION

The Ria de Aveiro (41°N, 9°W) of northern Portugal is a complex, multiuse, estuary-shallow coastal lagoon system, with a recent origin and rapid natural evolution. It is relatively small; the area enclosed by the high water line is c.120 km², yet its ecosystem provides all of the 17 categories considered by COSTANZA ET AL. (1997) in the assessment of world ecosystem services and functions. Man has harnessed several of these services in the ria, since remote times, controlling its natural evolution. Works carried out in the inlet channel, which has been gradually improved for navigation purposes have, since the early 19th Century, progressively reversed the naturally choked condition of the lagoon. The hydrographic and sedimentary conditions have, in consequence, adjusted to the increased tidal flows transmitted by the improved channel (SILVA AND DUCK, 2001).

Other important forcing factors were the construction of saltpans, the collection of aquatic plants and the digging of canals for boating and drainage of inner areas of the lagoon. These traditional activities were regulated by the state and, until 1960, contributed to sustain a diverse and productive ecosystem. Until that time, the saltpans isolated an area of c.17 km² from tidal oscillation and the collection of submerged vegetation, for use in agriculture, prevented the rapid accumulation of sediment on the extensive tidal flats (low intertidal areas). After the 1960s, traditional activities declined and new pressures were created due to harbour development and the growth of leisure activities. The steady increase in tidal action has resulted in a major ecosystem change, resulting in the almost complete disappearance of seagrasses (*Zostera*, *Ruppia*, *Potamogeton*) which formerly covered large tidal flat areas, leaving unstable sediment that is easily mobilised by

the stronger tidal currents and colonised by macroalgae only (for full details see SILVA ET AL., 2004). This positive feedback mechanism between submerged plant loss and sediment mobilisation has been exacerbated by activities related to the recreational use of the lagoon, in particular increased motor boating and collection of invertebrates from the tidal flats.

METHODS

Since most of the activities in the ria require the use of boats, the recent changes in use of the lagoon may be characterised by the changes in the numbers and types used. This analysis was based on the numbers of the various types of vessels with a navigation licence. The boats registered in the Capitania do Porto de Aveiro are classified into recreational boats (registration plate AV) and professional boats which are sub-divided into:

- Auxiliary boats (registration plate AL) used for collecting seaweed and marsh plants (for agriculture) and to be used in salt production and transport;
- Boats with the registration plate L are used for professional fishing.

Characterisation of surface sediment was carried out on samples hand collected at 10 points located in the major intertidal areas. The sampling programme extended from

September 2002 until September 2004 and included campaigns in various hydrological conditions. Samples were analysed to determine grain size distributions (Beckman Coulter Laser Granulometer LS230), organic matter content (combustion at 550 °C), Fe and Ca (acid digestion and atomic absorption spectrometry).

RESULTS AND DISCUSSION

The Ria de Aveiro has always been of major importance to the regional economy. The region was served by a large number of small quays used for transportation of goods such as aquatic vegetation, fisheries products, sea salt, wood and agricultural products. Seaweed collection and saltpan construction had a direct impact on the sedimentary balance of the lagoon. However, in spite of the large number of small boats used, their impact on the ecosystem was minimal, as they traditionally had a small draft and were sail- or oar-propelled. After the 1960s, the traditional activities declined while commercial navigation and recreation increased dramatically. The data presented in Table 1 show the changes in the number of small boats in use in the Ria de Aveiro since 1985 according to category of use.

The new boats, coming into use in the ria, are generally equipped with outboard engines

Table 1. New boats registered for use in the Ria de Aveiro (SILVA AND CATARINO, 2004).

Years	Plate AL	Plate L	Plate AV
1985-89	247	c. 900 (total)	1180
1990-94	110		1674
1995-99	29		1675
2000-	13	c. 600 (total)	>1800

and have a high potential for disturbing the sediment of the shallow tidal flats, particularly the areas covered with seagrasses. The collection of bait for recreational fishing, by digging in the intertidal areas, also disturbs the sediment.

Sediment samples collected from intertidal areas covered by *Zostera noltii* and from areas with only macroalgae reveal important differences in grain size distribution and organic content. The presence of seagrasses clearly favours the retention of fine sediment particles and organic matter. The mean grain size of the sediment in the seagrass areas is c. 85 μm , the silt and clay fractions contributing c.43 % of the mass. However, this cohesive sediment becomes depleted in fine particles after losing the coverage of the seagrasses, giving rise to a mobile sediment characterised by dunes, in which only macroalgae are growing. In this type of sediment fine sand predominates, the mean grain size is c. 230 μm and the finer fractions contribute only c.13 % of the mass. The reduction in organic matter, associated with the reduction in fine particles, corresponds to a decrease in the mean organic content from 8 % to 3 %. The fine particles lost are enriched in Fe, as coatings, while in the coarser fraction shell fragments are present causing enrichment in Ca. The mean Fe content decreases by 50 % while the mean Ca content increases by 150 %, comparing sediment from seagrass beds with sediment from areas with macroalgae only.

CONCLUSIONS

The change in use of this estuarine ecosystem has been from a situation in which the inhabitants of the area depended on the resources obtained from it, but in so doing preserved its biological productivity, to one in which the use is now mainly recreational but with a potentially significant environmental impact. The change occurring in the sediments of the extensive tidal flat areas, from finer cohesive sediment supporting a very intense biological and chemical activity to coarser mobile sediment with a reduced biological activity, corresponds to a reduction in importance of the benthic compartment of the lagoon ecosystem. Since this compartment has an important role in filtering the pollutants reaching the lagoon, it is anticipated that the ecosystem will become more susceptible to the impacts of pollutant loads, potentially further reducing its biological productivity.

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