

On the sediment mobility and recent morphological changes in a mesotidal system: the Arcachon lagoon

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INTRODUCTION

The Arcachon lagoon is a mesotidal embayment in the south coast of the bay of Biscay (Fig. 1). Its total surface is about 174 km² at high tide, where 65% is formed of tidal flats.



Fig. 1: Location maps of the study area

Bathymetric changes were analyzed by L'Yavanc (1995) for a period of 126 years (1864 – 1993). The most recent observations made by end-users of the lagoon, suggest relative infilling of the channels (Allard *et al.*, 2009) and relative increase of turbidity in the inner waters.

This suggests that a mobile stock of surficial fine sediment is available in the lagoon, which is able to be exchanged between the tidal flats and the channels, depending on the hydrodynamic conditions, reinforced by the recent loss of vegetation. For example, Fig. 1a and 1b shows a significant accretion of mud occurred in areas occupied previously by sand or by seagrass.

The aim of this study is to estimate the stock of mobile surficial sediment available in the different compartments of the lagoon, transported under natural and anthropogenic forcings. This study is mainly based on information provided by bathymetric and topographic available data.

MATERIALS & METHODS

Bathymetric charts: they were obtained in 1992, 2001, 2005 and 2012 (Fig. 3). For the 2005 situation, only the area scanned at low tide, i.e. the eastern lagoon, is suitable for the analysis.

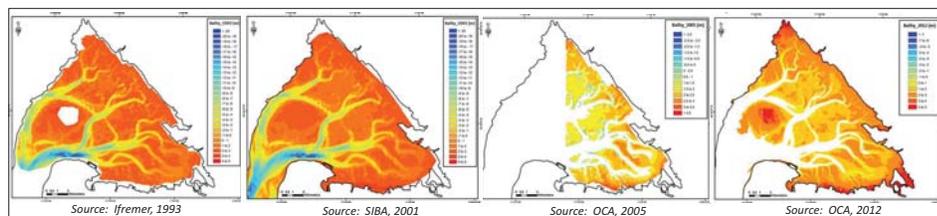


Fig. 3: Bathymetric maps of the Arcachon lagoon

Estimation of changes on bathymetry. The DMS were built with ArcGIS 10.2 software, for the periods 2001-1993 (following L'Yavanc limits and our limits based on morphological criteria), 2005-2001, 2012-2005 and 2012-1993 (Fig. 4)

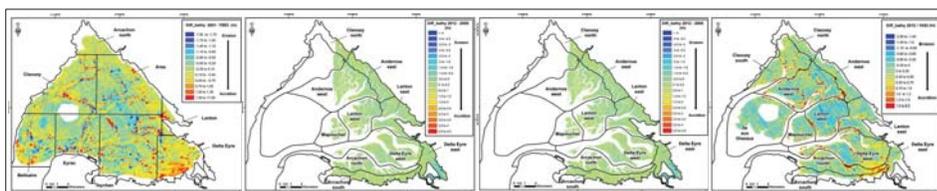


Fig. 4: Differential bathymetric at different periods

The results for the period 2001/1993 are compared with the limits proposed by L'Yavanc (1995), then bathymetric changes are discussed with the new limits based on morphological criteria. These latter limits are used for the analysis of later periods.

RESULTS

Sedimentary budget related to the depth and general morphology:

Fig. 6 shows the relationship between bathymetry of the oldest year (x axis) and the variation relative to the bathymetry with the most recent year (y axis). Fig. 6a shows the bathymetric variation of the years 2001/1993, while the Fig. 6b shows the bathymetric variation of the years 2012/2005.

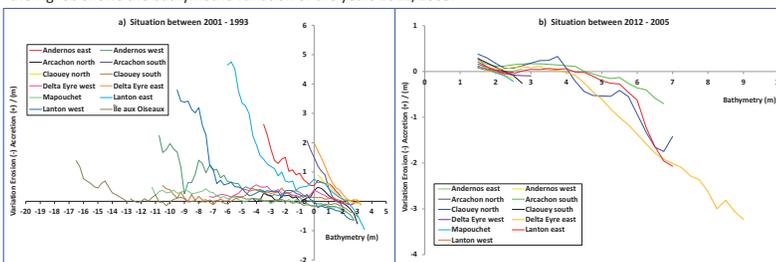


Fig. 6: Variation accretion/erosion as a function of class of depth at each morphological zone

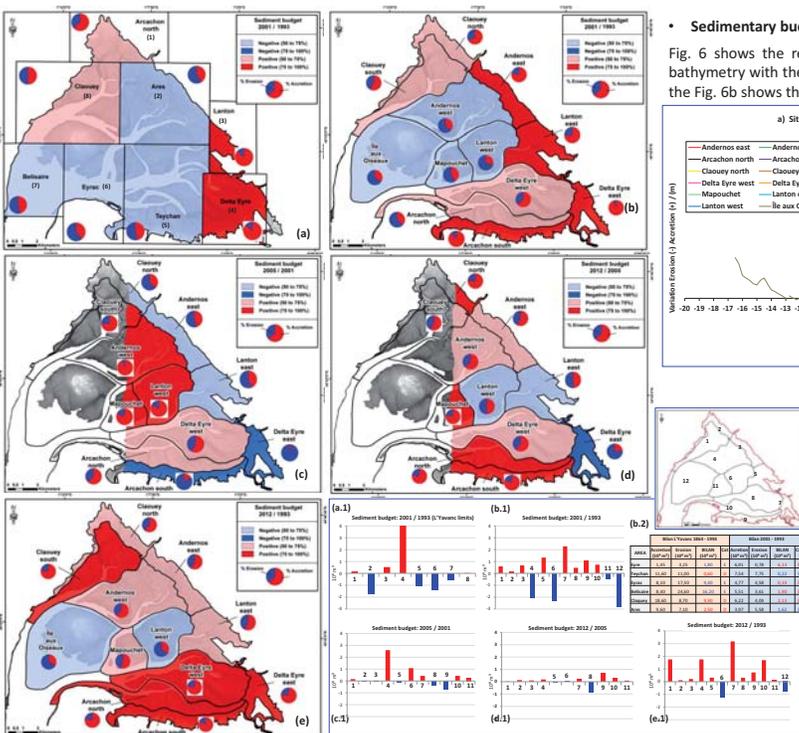


Fig. 4: Sedimentary budget over the period : (a-a.1) 2001-1993, L'Yavanc limits; (b-b.1-b.2) 2001-1993, geomorphological criteria, (c-c.1) 2005-2001; (d-d.1) 2012-2005; (e-e.1) 2012-1993

Bathymetric variations in the different periods analyzed.

- Compared with results from L'Yavanc (1995), sedimentary budget of the period 2001/1993 shows opposite trends (Fig. 4a and 4b.2), except at Clauouey area.
- With the new limits based on morphological criteria, we can clearly distinguish a pattern that tends to accretion in nearshore and a tends to erosion in the inner part (Fig. 4b), where the sedimentary budget is $-0,36 \cdot 10^6 \text{ m}^3$. This situation is reversed in the period 2005-2001 (Fig. 4c), with a sedimentary budget of $3,65 \cdot 10^6 \text{ m}^3$, while in the period 2012-2005 the pattern is less clear from a spatial point of view (Fig. 4d); however, the sedimentary budget is similar to the previous period: $2,57 \cdot 10^6 \text{ m}^3$. In these last two periods (2005-2001 and 2012-2005) we can see the trend of erosion of the delta of Eyre, as opposed to previous reporting period (2001-1993).
- Finally, the sediment budget between all the analyzed period (2012-1993) shows a general trend of accretion (with a sedimentary budget of $8,20 \cdot 10^6 \text{ m}^3$) especially in the southern part of lagoon; while Lanton West and Île aux Oiseaux have a tendency to erosion (Fig. 4e).

- In general, the accretion rate decreases as the depth decreases; and conversely, the rate of erosion increases as the depth decreases. Accretion occurs mainly in the channels, and decreases regularly towards the shallower areas; erosion occurs in the zones upper to 1 m.
- Although the general trend is the decline of the curves, the variation is less pronounced in the lower depths (< 0 m) at Île aux Oiseaux, Mapouchet, Clauouey south, Delta Eyre west and Arcachon north areas (Fig. 6a). When comparing the situation of the years 2001/1993 and 2012/2005 (Fig. 6b) the same trend is observed in almost all areas, except at Clauouey north, east and west Delta Eyre Lanton.

CONCLUSIONS & PERSPECTIVES

- This analysis suggests efficient mobility of sediment in the Arcachon lagoon. The system experienced significant changes due to accretion and erosion in the recent period covering the last 20 years. Differential dynamics between the inner zone of the lagoon and the nearest shore areas are not observed in the zoning proposed by L'Yavanc (1995), but becomes visible when considering morphology-based zones. Thus, one can see a cyclical pattern of erosion / accretion in some areas at different periods analyzed (eg: in Andernos east, west Lanton and Eyre Delta areas).
- From the spatial point of view, comparing the periods 2005/2001 and 2012/2005 shows a shift in the sedimentary trend for almost all areas (except Lanton east, Mapouchet and Delta Eyre east areas). However, from the point of view of sediment volume the variation is not as significant, which could be explained by a mobilization of sediments from the inner part of the coast and vice versa in these periods analyzed.
- Many factors can explain the changes observed. Among them, wind waves, which can develop at high tide over the entire surface of the lagoon (eg: A model exercise performed by Parisot *et al.*, 2008). This effect is maybe reinforced by the decrease of the vegetation coverage (Ganthy, 2011). These factor are under investigation.

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