Characterization of bottom sediments in the Río de la Plata estuary

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Introduction and aim:

Draining the second largest basin of South America, the Río de la Plata (RdP) is one of the largest and most turbid estuaries of the world (Figure 1). The sediments' load that reach the system mainly come from the Paraná river (in its two main branches, Paraná de las Palmas and Paraná Guazú), and has been estimated between 80 and 160 Mtonsy^{-1} (Urien 1972, Menéndez and Sarubbi, 2007). From that total, 10% correspond to bedload (sand and silt) and 90% to suspended matter (clay).

The deposits go from sand on the upper estuary and silts in the intermediate estuary, to clay and silts in its exterior part. In the area of the salt wedge the flocculation of suspended sediments occur and, therefore, a zone of maximum turbidity occur. Turbulence over the bottom, due to tidal currents, winds and/or waves, can be strong enough to mix and homogenize the water column, and re-suspend the sediments.

The aim of this work is to characterize the bottom surficial sediments mean distribution and to study their composition including the organic matter and water contents, to obtain a qualitative description of the mean transports.

Figure 1. True color MODIS image of the Río de la Plata. Red dots indicate the sampling sites.

Data and Methods:

1. *In situ* observations from the FREPLATA/FFEM Experiment: During 2009 and 2010, six oceanographic synoptic cruises were done every approximately 2 months. During each cruise CTD, turbidity profiles and water and bottom sediment samples were gathered during a period of 2-3 days at the 26 sites shown as red dots in Figure 1.
2. Grain size analyzes were performed for the samples collected in cruises 2 to 6. A grain size analyzer using a laser diffraction optical system integrated with a charge-coupled device (CCD) camera (CILAS 1180) was used. We computed the mean and standard deviation among samples, and for every sample, the mean grain size, μ, standard deviation, σ, and skewness, *Sk*, were calculated using the statistic moment method (McManus, 1988). The sediments were classified according to Shepard (1954). We applied the Principal Components Analysis (PCA, Preisendorfer, 1988) to analyze the large number (5×26=130) of different CILAS grain size histograms obtained from the 5 different samples collected at each of the 26 stations. We applied grain size trend analysis to study possible sediment transport paths in the RdP.

Mean distribution of bottom sediments and water and organic matter contents:

The mean percentage and standard deviation between samples of sand (grain sizes between 62.5 and 250 µm), silt (grain sizes between 3.9 and 62.5 µm) and clay (grain sizes less than 3.9 µm, in the Wentworth scale classification), are shown in Figure 2. Figure 3 shows the mean percentage concentration and standard deviation between samples of the water contents and organic matter contents.

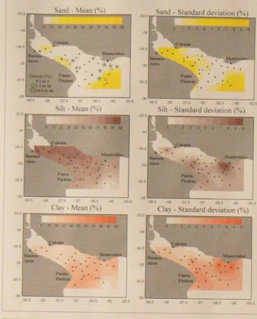


Figure 2. Mean (left panel) and standard deviation between samples (right panel) of the percentage concentration of sand (upper panel), silt (middle panel) and clay (lower panel), estimated from the bottom sediments samples. Stars in the upper left panel represent the mean percentage of gravel.

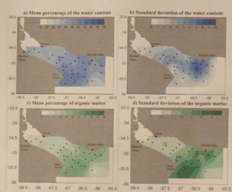


Figure 3. Mean percentage and standard deviation between samples of the water content (panels a and b), organic matter (panels c and d), computed from the bottom sediments samples.

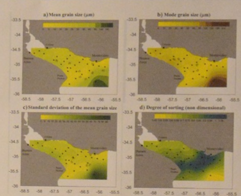


Figure 4. Mean (a) and mode grain size (b), standard deviation (c), and degree of sorting (d) of the bottom sediments size, computed from the bottom sediments samples.

Sediment's distribution according to Shepard:

Figure 5 shows a schematic distribution map for the different types of bottom sediments, according to the Shepard classification scheme.

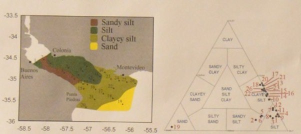


Figure 5: Schematic distribution of the characteristic bottom sediments (left) according to the Shepard (1954) classification scheme (right).

Principal components analysis of the bottom sediments distribution:

PCA was applied to the 5×26=130 histograms obtained of the CILAS grain size analysis (cruises 2 to 6, 26 stations).

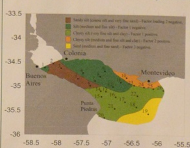


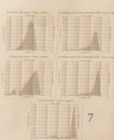
Figure 6: Schematic distribution of the areas where data well correlate to the different factors derived of the PCA analyzes.

The first PC (or Factor 1) accounts for 70% of the total variance of the histograms.

The second PC (or Factor 2) accounts for 20% of the total variance.

The third PC (or Factor 3) accounts for 5% of the total variance.

The characteristic grain size distributions for the five regions identified from the PCA:



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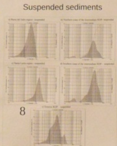
Bottom sediments

a) Factor 1 positive, light green in Figure 6; b) Factor 1 negative, dark green in Figure 6; c) Factor 2 positive orange in Figure 6; d) Factor 2 negative, dark brown in Figure 6; and e) Factor 3 negativeyellow in Figure 6.

a) "Barra del Indio region" (light green), b) "Northern coast of the intermediate RDP" (dark green), c) "Santa Lucía region" (orange), d) "Southern coast of the Intermediate RDP" (brown), and e) "Exterior RDP" (yellow).

Suspended sediments



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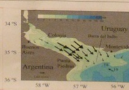
Net sediment transport pathways:

The data set of computed grain-size parameters was used in a trend analysis to determine statistically possible net sediment transport pathways.

McLaren (1981) and McLaren and Bowles (1985).



Conclusions:

- Bottom sediments have a gradational arrangement of textures as they are transported seawards, from sand at the head, silt in the intermediate estuary and clayey silt and clay at its mouth.
- The distributions of water and organic matter contents resemble those of the clay, suggesting that they could reflect in some extent the degree of compaction of bottom sediments.
- Coarse deposits (carbonated shell) are more abundant in the northern sector of the exterior estuary.
- The distribution patterns inferred for the textures seem to be strongly related to the geometry and what is known about the hydrodynamics in the estuary. Along the Northern coast of the intermediate RdP, medium and fine silt predominates, whereas in the Southern coast, coarser and silt prevails. This could be due to differences in tidal currents and/or to differences in the riverine water pathways along both coasts depending on their source.
- Around Barra del Indio shoal, clay prevails over silt and sand, and the water and organic matter contents reach a maximum. Physicochemical flocculation processes probably become important there, and the width and the depth of the estuary also largely increase, producing a significant reduction of the currents.
- Immediately seawards the salt wedge, coarser sand dominates. This sand is much coarser than the sediment transported by the RdP tributaries, suggesting that it comes from the adjacent shelf.
- Between the Santa Lucía River mouth and Montevideo, a different type of sediment is observed consisting fine silt and clay; they seem to be relict sediments.

This work is a summary of a complete paper recently published.Moreira, D., Simionato, C.G., Dragani, W.C., Cayocca, F., and Luz Clara Tejedor, M. (2016): Characterization of bottom sediments in the Río de la Plata estuary. Journal of Coastal Research, JCOASTRES-D-15-00078. Edited by The Coastal Education and Research Foundation [CERF]. Volume 32, Issue 6: pp. 1473 – 1494.

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