

Fluid mud transport from Patos Lagoon to Rio Grande Port, RS, Brazil

Marroig Patrícia and Susana Vinzon

Oceanic Engineering Program, Federal University of Rio de Janeiro (UFRJ), Rio de Janeiro, RJ, Brazil
E-mail: pmarroig@oceanica.ufrj.br; susana@oceanica.ufrj.br

Fluid mud is frequently observed in navigational channels. This work aims to contribute to the understanding of the source and transport of fine sediments in the Patos Lagoon system, which may contribute to the silting of Rio Grande Port, southern Brazil. The Patos lagoon receives the contribution of flow and sediments of continental source, which are storage in this large and shallow fresh water body, according to previous studies. On the other hand, huge amounts of fine sediments are dredged annually in the Port channels and basins, which are located in an estuarine portion of the system. This study aims the characterization and mapping of the muddy areas, in the transition from the Lagoon to the mouth, and the main hydrodynamic characteristics of the System. Measurements with OBS, DensiTune, ADCP, AQUADOPP and sampling were carried out in order to obtain the characteristics of the sediment, and the local hydrodynamic in a single campaign. The driving forces responsible for the exchanging of sediments between those two compartments were addressed with the help of a 3D hydrodynamic model.

Keywords

Fluid mud; Patos Lagoon; Port of Rio Grande.

Introduction

The Patos Lagoon system, located in the southern part of Brazil, receives contributions from a continental drainage basin of about 200,000km², with approximately 4.5 million tonnes of suspended particulate matter forming layers of fluid mud in the Lagoon (Hartmann and Schettini, 1996). Baisch (1998) found that only 25% of the total sediment that arrive in the lagoon reach the estuary, the remaining being deposited in the lagoon, where the coarse sediment will be found in the shallow areas exposed to wave action, while silt and clay prevail in the deep channels and in the protected areas from wave action (Toldo *et al.*, 2007). Fluid mud is a high concentration aqueous of well-mixed flocculated suspension of fine-grained sediment. It is frequently related with a sudden change in sediment concentration with depth (lutocline), and typically occurs in near-bottom layers in lakes and estuaries, but also in places that receive plenty fine-sediment supply and have periods of low intensity flow (Wells and Coleman, 1981; Metha *et al.*, 2014). This study presents a first characterization of the bottom composition in the transition from the lagoon to the estuary (Fig. 1). The hydrodynamics of the system is mainly governed by the wind, which is responsible by the set-up and set-down. Vinzon *et al.* (2009) observed that the remote wind have the most influence in the water exchange through the Lagoon's mouth. For example the local NE wind will cause a set-up inside the Lagoon towards the entrance, whereas the NE remote wind will cause a set-down on the Shelf near the Lagoon's mouth by Ekman dynamics. In order to assess the main driven mechanisms which may carry the fine sediments from the lagoon to the navigation channels, a 3D hydrodynamic model was set up and compared with measured data.

Field survey

One survey was conducted in February 2014 aboard R/V Larus to evaluate mud in Patos Lagoon. Profiles of density, suspended sediment concentration, salinity and currents were measured, and bottom sediment samples were collected to determine sediment rheology, shear strength, and grain size, including a box-core. Fig. 1. shows the location of the samplings.

Results and discussion

The distribution of bottom sediments in Patos Lagoon follows the energy gradients and bathymetry, with presence of mud on deeper central regions, and sand banks in the margins. From the analysis of the bottom sediment it was observed that the points are mainly composed by silt (mean of 78%) and clay (mean of 16%), while 3 sampling locations showed a higher percentage of fine sand: 1a, 7a and 9c (91%, 10% and 11%) as shown in Fig. 6. Fig. 2 shows an example of the density profiles, indicating the existence of mud layers, with lutocline height varying from 0.1 to 0.5m. The mean current velocity observed during the period of data collection was 0.4m.s⁻¹, with a maximum of ~1.5m.s⁻¹. The hydrodynamic model was calibrated with a series of 5 months of water levels. Using this tool, and during this period, the series of occurred meteorological events were tested assessing the importance of them for the transport of fine sediments from the Lagoon to the estuarine area.

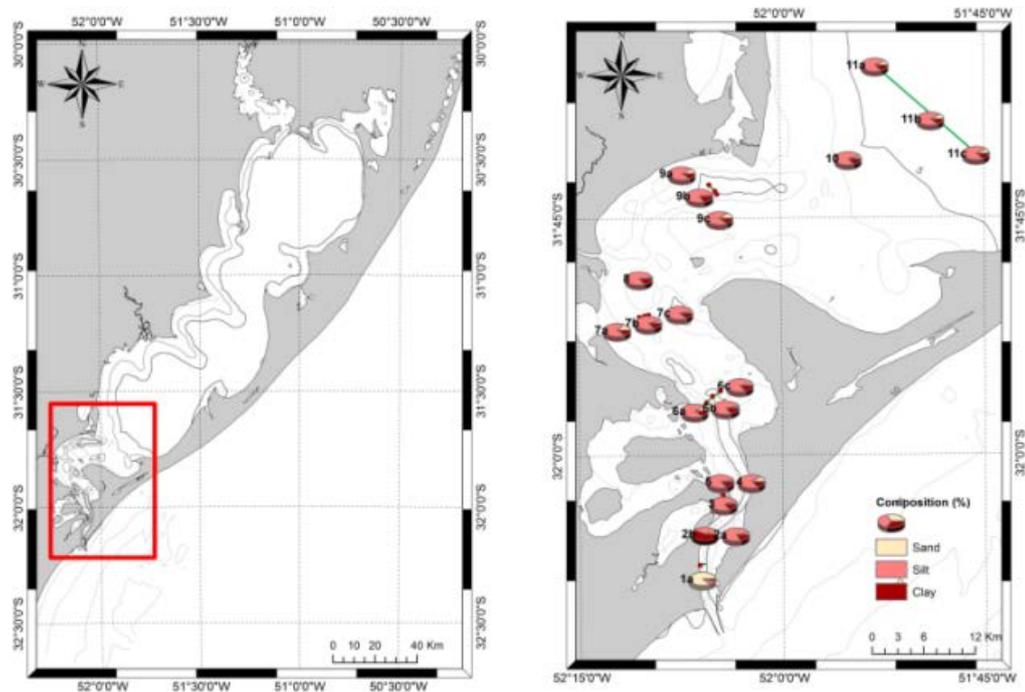


Fig. 6. Patos lagoon and estuary. Port of Rio Grande is located at the entrance, in the estuarine portion of the system. Right panel: % of sand, silt and clay of bottom sediments at sampling points.

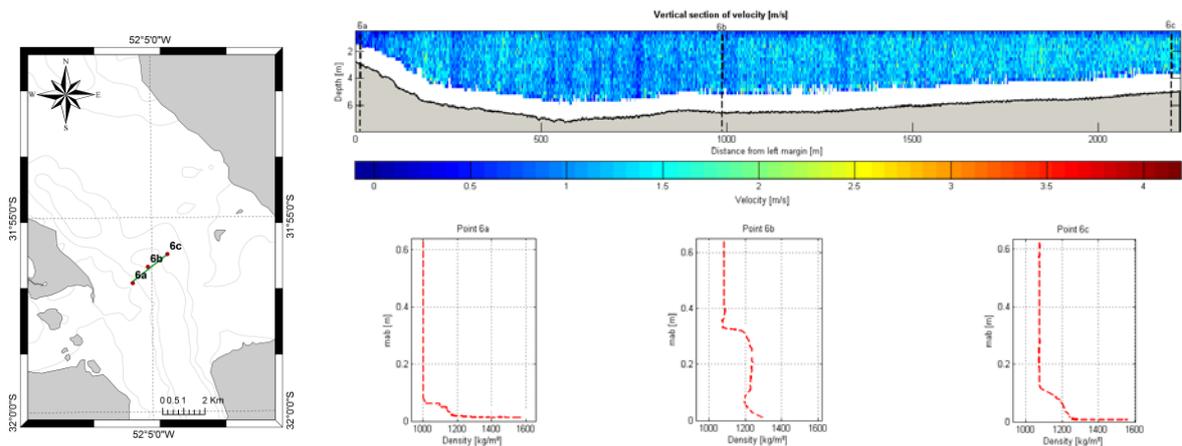


Fig. 7. Vertical section of velocity (m/s), in the transect 6 (left map and also Fig. 1.). During the survey, the velocity direction was leaving the Patos Lagoon. The lines represent the locations of the observed profiles using Densitune, which are depicted below.

References

- Baisch P.R. and J.C. Wasserman. 1998. Chemistry and distribution of trace elements in the Patos Lagoon, South Brazil. p.97-126. In: Environmental geochemistry in the tropics. Springer Berlin Heidelberg.
- Calliari I., N.S. Sperranski, M. Torronteguy and M.B. Oliveira. 2000. The mud banks of Cassino beach, southern Brazil: characteristics, processes and effects. Journal of Coastal Research v. ICS 2000 Proceedings: 318-325.
- Hartmann C. and C. Schettini. 1996. Cronologia sobre o estudo do material em suspensão no sistema lagunar Patos - Mirim e plataforma continental adjacente, RS, Brasil. Technical Notes 9:12-20. LOG/DEGEO/FURG.
- Metha A.J, F. Samsami, Y. Khare and C. Smith. 2014. Fluid mud properties in nautical depth estimation. Journal Waterway, Port. Coastal, Ocean Eng. 140(2):210-222.
- Toldo Jr. E., S. Dillenburg, I. Corrêa, L. Almeida, J. Weschenfelder and N. Gruber. 2007. Sedimentação de Longo e Curto Período na Lagoa dos Patos, Sul do Brasil. Pesquisas em Geociências 33(2):79-86.

- Vinzon S.B., J.C. Winterwerp, R. Nogueira and G.J. de Boer. 2009. Mud deposit formation on the open coast of the larger Patos Lagoon Cassino beach system. *Continental Shelf Research* 29:572-588.
- Wells J.T. and J.M. Coleman. 1981. Physical processes and fine-grained sediment dynamics, coast of Surinam, South America. *Journal of Sedimentary Research* 51(4):1053-1068.