

# Trends in turbidity in the fluvial section of a highly turbid macrotidal estuary, the Gironde in SW France, based on continuous in-situ monitoring Isabel Jalón Rojas, Sabine Schmidt, and Aldo Sottolichio



• With its 625 km<sup>2</sup>, the Gironde estuary (SW France) is the largest estuary of the European Atlantic coast (Fig. 1). The upper estuary consists of two narrow tidal rivers (Garonne and Dordogne) whose watersheds (71,000 km<sup>2</sup>) undergo a significant land use (hydropower dams, agriculture).



Figure 2. SSC in surface water at low tide under low (a) and moderate (b) river discharges.



Figure 1. Gironde fluvio-estuarine system: location, uppermost limits of tidal influence and continuous monitoring network.

- The tidal asymmetry toward upstream and subsequent tidal pumping develop a pronounced **turbidity maximum** zone, TMZ, (Allen *et al.* 1980) resulting in suspended sediment concentration (SSC) over  $1 \text{ gL}^{-1}$  at surface.
- Tidal cycles (semidiurnal and springneap) and freshwater inflow (Fig. 2) cause spatial and temporal TMZ variations (Castaing et al., 1981; Sottolichio et *al.,* 2001).
- The tidal rivers are still poorly investigated.
- This is crucial for a better evaluation of the estuarine processes and the water quality, and for a more sustainable landscape management.
- In this work we present 9 years of continuous record of turbidity for analysis and discussion of trends in this upper area at all representative scales.



As a part of the MAGEST (MArel Gironde ESTuary) network (Etcheber et al., 2011), a real-time continuous system (Fig. 3) records turbidity every 10 minutes at 3 upper stations and at one lower stations (Fig. 1) of the estuary:

	Station	Operating time	Operating
Tidal rivers	Bordeaux	Apr2005 - present	71%
	Libourne	Apr 2005 - present	74%
	Portets	Apr 2005 - Jan 2012	70%
Central	Pauillac	Apr 2005 - present	57%

The turbidity sensor (Fig 4.) measures values between **0** and **9999** NTU ( $0 - 8 \text{ gL}^{-1}$ ).

http://www.magest.u-bordeaux1.fr





Figure 3. MAGEST station. Water is pumping 1 m below the surface and circulates through a measuring cell.



Endress & Hauser, CUS31-W2A.



Typical deposition-resuspension patterns related to tidal cycles: SSC peaks at mid-flood and mid-ebb due to resuspension by tidal current, and deposition during flood and ebb slacks.







Figure 8. Tide-averaged turbidity as a function of 3-day-averaged river flow.

## Conclusions

The TMZ is often associated with the limit of freshwater influence (LFI). The increasing persistence of the TMZ in the tidal rivers in the last years suggests a progressive upstream shift of the LFI, with consequent reinforcement of the estuarine behavior of the tidal rivers.



- rivers during neap tides.
- concentrated TMZ with a presence in tidal rivers up to 70% of time.

estuary, showing high sensitivity to changes in hydrological conditions, especially river flow.

• Hysteresis patterns of turbidity values versus river flow reveal the local or remote location of the sediment source, suggesting high deposition flux of mud remaining after the passage of the TMZ. • Hysteresis patterns of turbidity vs tidal range suggest consolidation of settled mud in the tidal

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• Long drought periods and scarce flood events during dry periods leaded to a strongly

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