Mud settling velocity in Barataria Bay: a crucial (yet neglected) parameter for marsh evolution

Mud is the most abundant sediment class in the marshes and bay bottom of Barataria Bay as well as in the water of the Mississippi River. Thus, mud should be considered a primary resource for marsh resilience.

Mud settling velocity strongly affects the transport and deposition of mud. Settling velocity determines: 1) how much sediment remains in suspension while being advected away from the source (e.g., a river diversion), and 2) how much sediment settles on the marsh platform, which ultimately affects the marsh elevation gain. Mud settling velocity is a critical parameter in both simplified models (the Integrated Compartment Model) as well as in detailed hydrodynamics models (the Integrated Biophysical Model) used by CPRA and WIG to predict marsh evolution under different sediment diversion scenarios.

A large fraction of the mud in Barataria Bay is made of smectite (a type of clay). Because of flocculation (i.e., the aggregation of clay particles into flocs), mud settling velocity could be highly variable: it could range from 0.01 mm/s (unflocculated clay particles) to 10 mm/s (very large flocs). Thus, there is a large uncertainty on mud settling velocity and where mud from proposed river diversions will deposit.

Salinity is the major driver of flocculation. Salinity varies drastically within Barataria Bay, from 0 at the landward end to ~25 PSU at the tidal inlets. Furthermore, salinity is zero at the outlet of river diversions (even if located in mid bay) and slowly increases away from them. Starting from freshwater, the diverted sediment will eventually enter higher salinities where flocculation will occur. Thus, considering how flocculation will vary along the trajectory of the diverted water should be a primary concern. Determining at what salinity flocculation will occur and what values the settling velocity will attain after flocculation would be highly relevant to understand where mud will settle, **especially how much mud will settle on the marsh platform** (a process that existing CPRA models are aimed to predict).

Despite settling velocity being a cardinal parameter, it has (surprisingly) received little consideration in Louisiana. Calculations used in the 2017 coastal master plan (Attachment C3-1: Sediment Distribution section 2.1.1) are solely based on literature values of study outside of Louisiana. Thus, the modeling predictions based on these values could be highly uncertain.

The purpose of this project is to produce information that can be directly used in the next iteration of the Coastal Master Plan, specifically the ICM and the IBM models. We aim to directly **measure mud settling velocity** (i.e., we will not measure flocculation *per se* but rather its effect on settling velocity).

We will frame our study into the more general objective of **determining the spatio-temporal patterns of Total Suspended Sediment (TSS) in Barataria Bay and their relationship to salinity**. Barataria Bay has a natural gradient of salinity along its main axis. In addition, a further variability is associated with the presence of an outlet of the Gulf Intracoastal Waterway (GIWW) in the west portion of mid Barataria (Fig. 1). Previous USGS studies have identified that during the high river flow period, the GIWW discharges about 50 m^3/s of water into Mid Barataria, with peaks up to 300 m^3/s. Despite the water in the GIWW flowing relatively slow and thus not carrying sand, it can still transport mud (as well as nutrients), and thus shares some of the sediment dynamics of engineered river diversions. As such, the GIWW outlet in Barataria Bay could be considered a proxy for a river diversion. Noticeably, the location of the GIWW outlet (in terms of distance along the estuary axis) is similar to the position of planned Mid-Barataria diversion. Contrary to the Davis Pond diversion, some of the water (and sediments) associated with these diversions could enter the brackish (and possibly also the saline) region.

A preliminary analysis of suspended sediment in Barataria Bay shows a large spatial and temporal variability. Noticeably, the highest TSS is found in the intermediate salinity regime (0.01-1 PSU) between January and April (when the river discharge is largest). This high TSS is not present during the same period in the saline area (even though it has largest fetch and thus more ability to resuspended sediment), and thus it is hypothesized to originate from the GIWW (**Hp 1**).

The TSS south of the GIWW remains relatively high until it reaches salinities of about 1 psu. At this point salinity-driven flocculation is hypothesized to cause a fast reduction in suspended sediment (**Hp 2**) According to this interpretation, mud from river diversions could travel ~30 km with minimal settling, but suddenly deposit within a few km when flocculation takes place. **Identifying the location of this depocenter could greatly increase our ability to predict accretion on the marsh platform.**

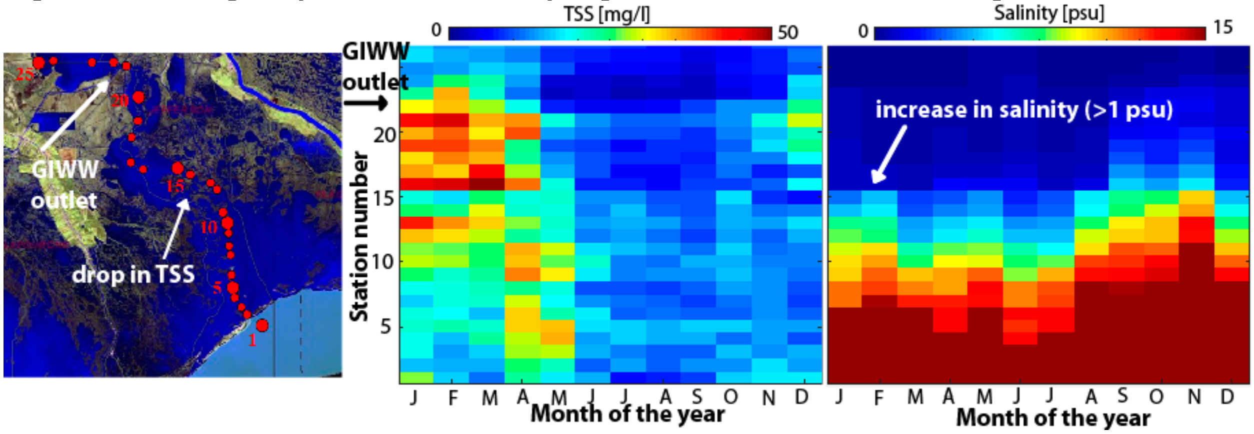

Figure 1. Results from Turner's "Barataria transect" (overaged over 22 years from 1994 to 2015).

The proposed work will have two parts, field measurements and analysis of existing datasets, both of which can be conducted by a graduate student under the PI supervision.

Task 1: **Targeted field measurements**. We will deploy up two ADVs (Nortek) and up to eight wave-turbidity sensors (RBR duo) already owned by the PI. They will be deployed along the Turner's Barataria transect (station 10 to 20 in Fig. 1), with two deployments lasting each two months (Oct-Nov) and (Feb-March). Salinity will not be measured because there are three USGS stations in the study area. Settling velocity will be estimated using three different methods. 1) TSS versus bed shear stress relationship (assuming constant erodibility). This will allow to detect relative changes in settling velocity from site to site and from season to season. 2) Eddy covariance ($w_s\bar{C} = \overline{w'C'}$), which will be obtained from the ADVs 3) Water clearing method at slack tide (i.e., fitting an exponential decay of TSS with time over 1-3 hours).

Task 2: **Analyze existing data** to identify spatio-temporal trends and to calculate settling velocity as a function of salinity.

-Barataria Bay transect collected by Dr. Turner (showed in Fig. 1), which includes TSS and well as water quality parameters (such a NO_3, possibly a clue of river water). These data will be correlated to USGS measurements of the GIWW discharge. We will also collaborate with Chris Swarzenski from USGS, who led the recent report on the hydrology of the GIWW.

-USACE "Davis Pond Monitoring Data", which collected TSS and turbidity at different height a 23 stations in Barataria (Fig. 2, publically available but not yet published). This will constitute an independent method to estimate settling velocity from vertical variability in TSS (a method not pursued in Task 1).

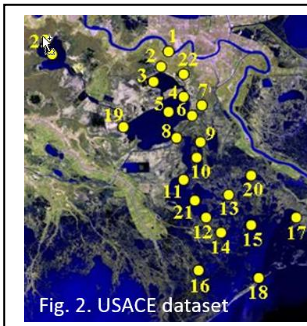

Fig. 2. USACE dataset

-Any data that CPRA will to share (possibly during the internship period).

The project is anticipated to last up to three years. The proposed methods are robust and mastered by the PI. The hypotheses are strongly supported by existing data. The project will 1) provide a novel perspective of the sediment dynamics in Barataria Bay and the GIWW, 2) deliver a well-defined product (i.e., the mud settling velocity values for different salinities). Depending on the skills and interest of the graduate student, the project could be further expanded by including some remote sensing analysis, for example by using the red band of MODIS-Terra analyzed with GoogleEarthEngine developer.