Time-varying rates of organic and inorganic mass accumulation in Louisiana marshes and relation to sea-level change

It is well-recognized that both organic and inorganic sediment must provide a continuous input to build wetland soils both vertically and horizontally to keep it in equilibrium with water level change due to *i)* tidal and wave energy, and *ii)* sea level variations (Redfield and Rubin, 1962; Redfield, 1972; Schwimmer, 2001; Morris et al, 2002; Turner et al., 2002; Temmerman et al., 2004; Nyman et al., 2006; Kirwan and Guntenspergen, 2010; Wilson et al., 2014; Morris et al., 2016). Studies in Louisiana show that, in many of our sediment-starved marshes, the accumulation of organic material is vital to increasing soil volume and ensuring the sustainability of marsh surface elevation (e.g., Nyman et al., 1990; Turner et al., 2002; Day et al., 2011). Marsh soil is composed of live and dead root and rhizome structures (collectively termed ‘belowground biomass’) within an inorganic sediment matrix. When plants die, their roots lose turgor pressure and dewater, decreasing pore space and volume; however autocompaction and decreased decomposition under loading and reducing conditions, respectively, forms peaty substrates composed predominantly of plant lignin (Kaye and Barghoorn, 1964; Niering and Warren, 1980; Benner et al., 1991; Mitsch and Gossellink, 2003). For all marsh substrates, consolidation of the soil and reduction in porosity occurs with depth and over time, which results in a loss in elevation capital relative to rising water levels (Tornqvist et al., 2008; Brain, 2016). However, it can take decades to centuries to accomplish this loss in volume, and new material (organic and inorganic) can infill this accommodation space if available (Tornqvist et al., 2008; Brain, 2016; Cahoon et al., 2019)

Recent research shows that Louisiana water levels are a function of not only eustatic and relative sea-level rise (eustatic + subsidence), but also nearshore sea-level anomalies brought about by mesoscale remote and local atmospheric perturbations that show strong correlation with global climate teleconnection indices. These interannual-to-decadal timescale anomalies are expressed as “higher/lower than normal” coastal water levels with peak-to-trough ranges exceeding 10 cm, (see Fig 1a) and are strongly correlated with inundation durations in Louisiana coastal wetlands (Fig 1b, Snedden et al., *in prep*). Flooding and waterlogging experienced by the marsh platform negatively affects both above- and belowground biomass production, particularly the accumulation of organic matter for soil formation: greater inundation stresses plants, resulting in lower below-ground biomass production (see Fig 1c, *from* Snedden et al., 2015; Kirwan and Guntenspergen, 2012). With this reasoning, there may be evidence

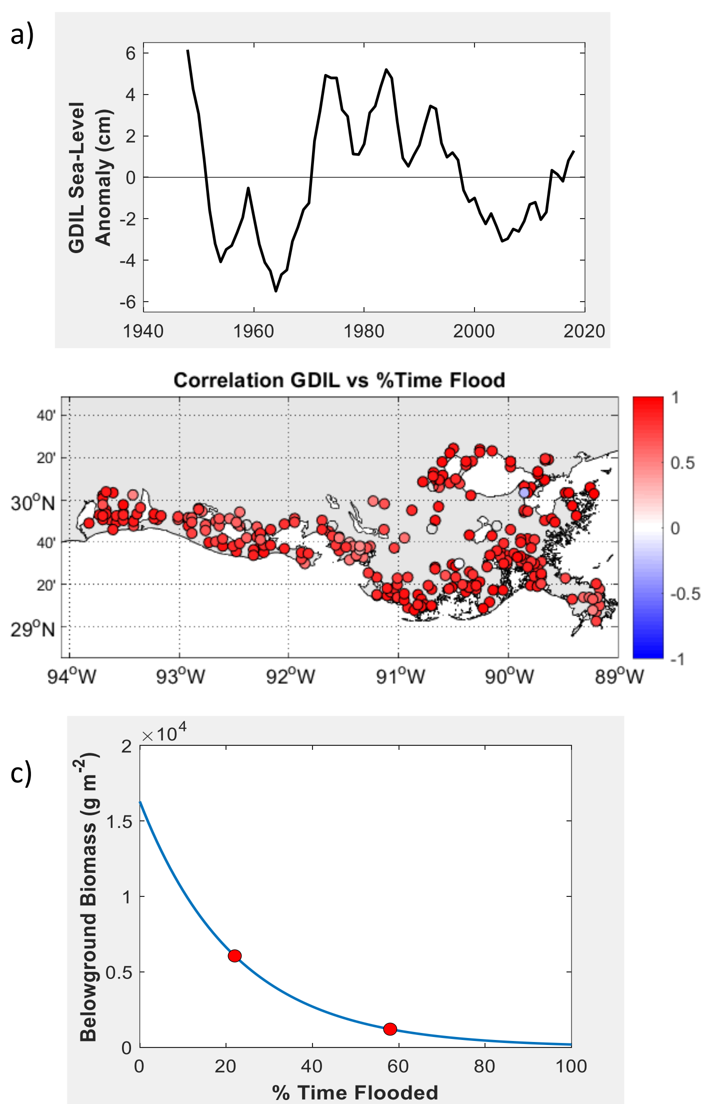

Figure 1. (a) Coastal sea-level anomaly measured at Grand Isle, LA, is linked to inundation time at CRMS marshes (b); (c) Inundation impacts belowground productivity in *Spartina patens* and *Spartina alterniflora* in Louisiana (from Snedden et al., 2015; Snedden et al., *in prep*).

of time-varying rates of organic mass accumulation in Louisiana marshes related to this sea-level fluctuation. A preliminary analysis of the Coastwide Reference Monitoring System (CRMS) sites show that >70% exhibited a strong ($r > 0.8$) correlation with the sea level anomaly and marsh hydroperiod (Figure 1; Snedden et al., *in prep*).

Objectives: We propose to test the hypothesis that organic mass accumulation rates in Louisiana marshes are related to sea-level fluctuations in Louisiana. We will accomplish this by quantifying both organic and inorganic mass accumulation rates over time from radiochemically-dated cores extracted in key marsh locations of Barataria Bay. For this project, we will focus on brackish and saltmarshes (dominated by *Spartina patens* and *Spartina alterniflora*) located near the proposed Mid-Barataria Sediment Diversion, as this information will be particularly useful for understanding how these marshes may respond to increased inundations and sediment delivery expected during spillway operation.

Data and Analysis: Cores (~1 m length) will be extracted using gouge and Russian peat augers to minimize compaction of the marsh substrate. Geotechnical properties will be measured (bulk density, water content, porosity, organic content, grain size) and samples will be processed for long-term vertical accretion using ^{137}Cs and ^{210}Pb chronology. The Constant Rate of Supply (CRS) model for ^{210}Pb accumulation allows for the calculation of how vertical accretion rates change over time, and has been employed in many wetland settings but few in Louisiana (Kolker et al., 2012; Corbettt and Walsh, 2015). This information will be compared to local water surface elevations, particularly the coastal sea-level anomalies recorded at Grand Isle over the past 50 years (Snedden et al, in prep). Furthermore, we propose to assemble time series of organic and inorganic accumulation rates over the past several decades, a relatively new approach for wetland chronology in Louisiana (Shrull, 2018; Wilson et al., 2019). These mass accumulation time series will then be examined for correlation with sea-level anomalies as measured at Grand Isle.

The proposed research activities will provide a student with key training across a broad range of topics, including oceanography and climatology at the global scale, coastal physical oceanography at the regional scale, and wetland ecology and geomorphology at the local scale, as well as data analysis and critical thinking skills. This will be a collaborative project and joint venture under PI Wilson and Gregg Snedden at the USGS, who will serve on the student's committee. USGS will fund the core collection, and cores will be processed in PI Wilson's lab.

RELEVANCE OF FINDINGS TO LOUISIANA COASTAL MASTER PLAN

Processes that contribute to subsurface expansion and elevation gain in wetlands is of critical importance for wetland sustainability, particularly in the face of rising sea-levels (Morris et al., 2016; Cahoon et al., 2019). Parsing how much organic and inorganic accumulation has occurred and how these rates are affected by interannual-to-decadal timescale inundation anomalies is of particular interest to wetland scientists today, and Louisiana as a whole as it is dedicated to spend billions towards restoring the coast (2017 Master Plan). CPRA routinely performs restoration projects in Louisiana marshes, through new marsh creation or shoreline stabilization. Our analyses will provide key information how brackish and saltmarshes in Barataria Basin have maintained elevations over the past 50 years, specifically by quantifying the time-varying organic and inorganic accumulation and vertical accretion rates. Additionally, this research will directly inform how the marshes in the receiving basin of the Mid-Barataria Sediment Diversion may respond to increased inundations and sediment delivery expected during spillway operation.