Fluxes and Inventories of Blue Carbon in Texas Wetlands; Measuring Ecological Shifts from Coastal Salt Marsh to Mangrove Dominated Wetlands

Norwood, M.J[1]., Louchouarn, P[1],[2]., Armitage, A.R[2]., White, N[2]., Highfield, W[2]., and Brody, S[2].

1Texas A&M University, College Station, Texas 77840, United States
2Texas A&M University at Galveston, Galveston, Texas 77550, United States

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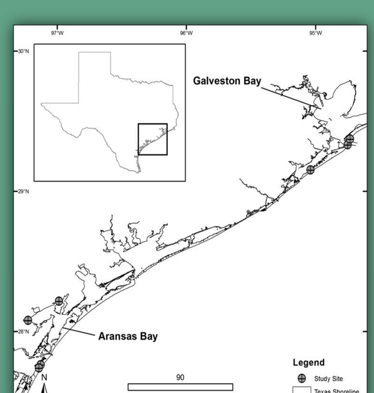
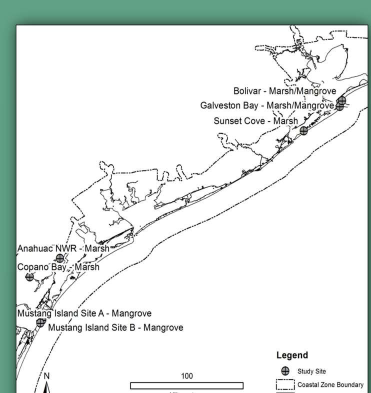
Introduction

Researchers have coined the term "Blue Carbon" to reintroduce a topic that has been studied since the early '60s (Teal, 1962).This form of carbon is linked to wetland systems where high rates of inundation leads to large quantities of carbon storage. Despite their relatively small area (203 x 10^3 km^2 , which represent only 0.1% of the Earth's surface), tidal estuarine wetlands may have an important role in the global carbon (C) budget due both to exceptional burial fluxes and negligible CH_4 and N_2O emissions (DeLaune et al., 1990). The substantial emissions of CH_4 (and N_2O) from inland wetlands (bogs and peatlands) limit their potential to moderate global warming (Pearce and Clymo, 2001). In contrast, the large-scale C sequestration potential of estuarine coastal wetlands (~41 Tg/yr; Chmura et al., 2003), suggests these systems could act as measurable sinks for atmospheric CO_2. This potential may be increased by rising sea level, which in gentle slope areas may cause landward expansion of low marsh areas (Choi et al., 2001), or by ecosystem shifts from salt marshes to mangroves (Montagna et al., 2007) in a process similar to terrestrial "woody plant encroachment" (the colonization of grasslands by woody plants; Archer et al., 2001). In-situ storage of organic carbon (OC) as plant biomass in wetlands is controlled by the coastal environment which has highly reducing anoxic mineral soils with a relatively thin oxidized sediment layer (0-15cm). Plant tissue from salt marsh plants and mangroves contain 10-45% lignin within its structure along with hemicelluloses. The lignin molecule being aromatic in structure is considered recalcitrant in anoxic soils and can act as a sink for organic carbon storage in wetlands.

Texas coastal wetlands are made up of a dynamic tidal zone that has historically been dominated by salt marshes. Due to global climate change, this region has experienced warmer winters with fewer freezes, allowing the black mangrove (Avicennia germinans) to encroach on salt marsh plants changing the ecologic structure of theses wetlands. Present OC inventories from sediment cores, retrieved from four sites; East Galveston Island salt marsh, West Galveston Island, Copano Bay, East Galveston mangrove, and Mustang Island indicate OC fluxes of ≈ 46.7 g/m^2•yr, 24.4 g/m^2•yr, 40.7 g/m^2•yr, 35.6 g/m^2•yr, and 28.0 g/m^2•yr respectively. Organic carbon inventories for these sites are 479.4 g/m^2, 250.0 g/m^2, 441.8 g/m^2, 216 g/m^2, and 170 g/m^2, respectively. Comparing the differences in OC fluxes and inventories among sites develops the story among the different wetland plant type (salt marsh vs. mangrove).

Sampling Site and Methods





Sediment Core Extraction
Sediment Core Preparation
(Sectioning and Freeze Drying)

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Porosity and Dry Weight Calculated

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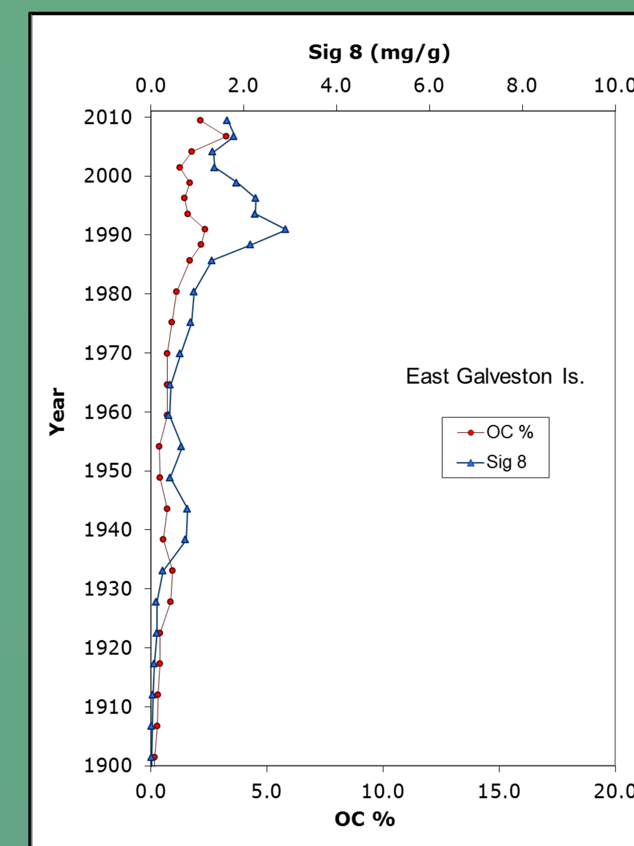
- Delta C-13 Isotope analysis
- Lignin Oxidation Product (LOP) → GC-MS Quantification of LOP
- Elemental analysis (CHN)

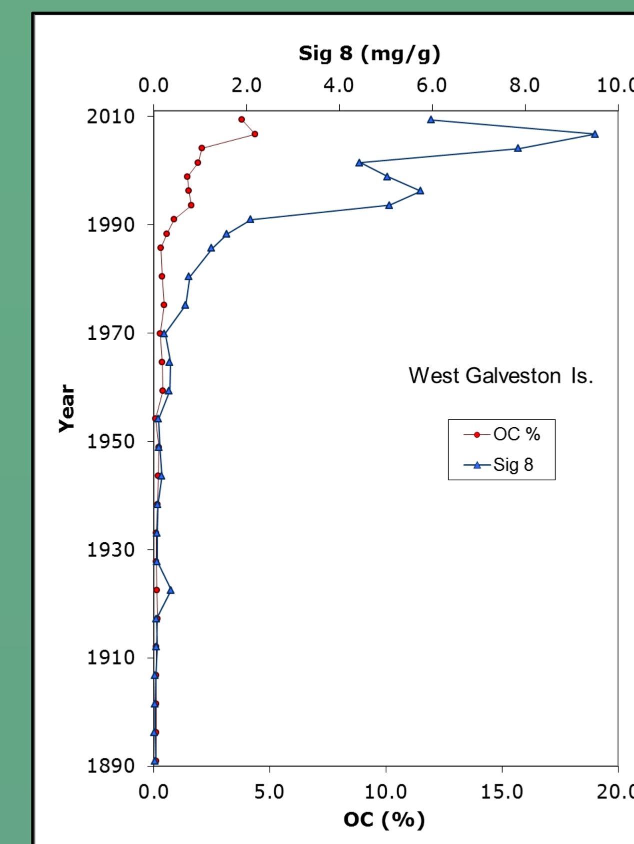
- Sampling occurred during the winter and summer of 2012.
- High, mid, and low tide soil cores were retrieved from the field sites but only mid tide soil data is presented.
- Sedimentation rates assumed via Ravens et al., 2009.

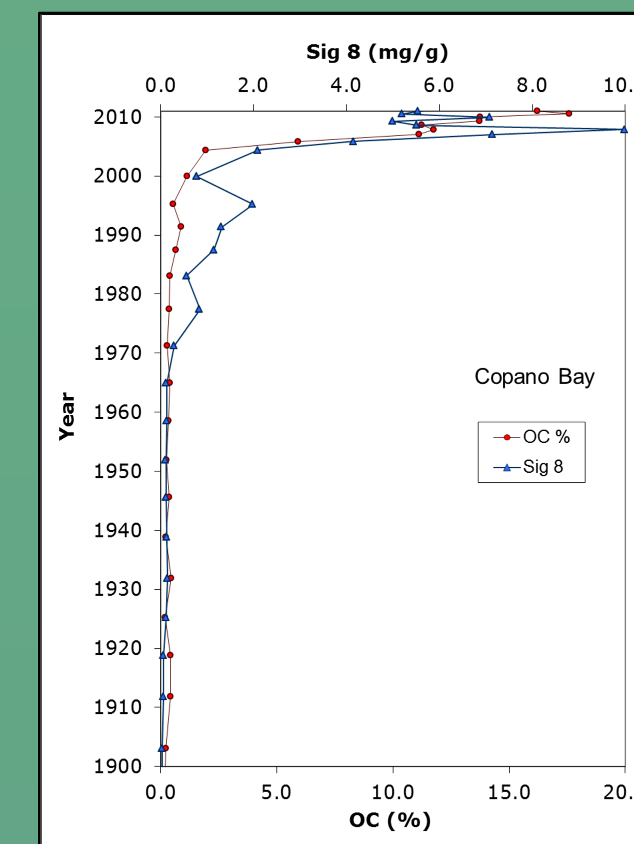
Results

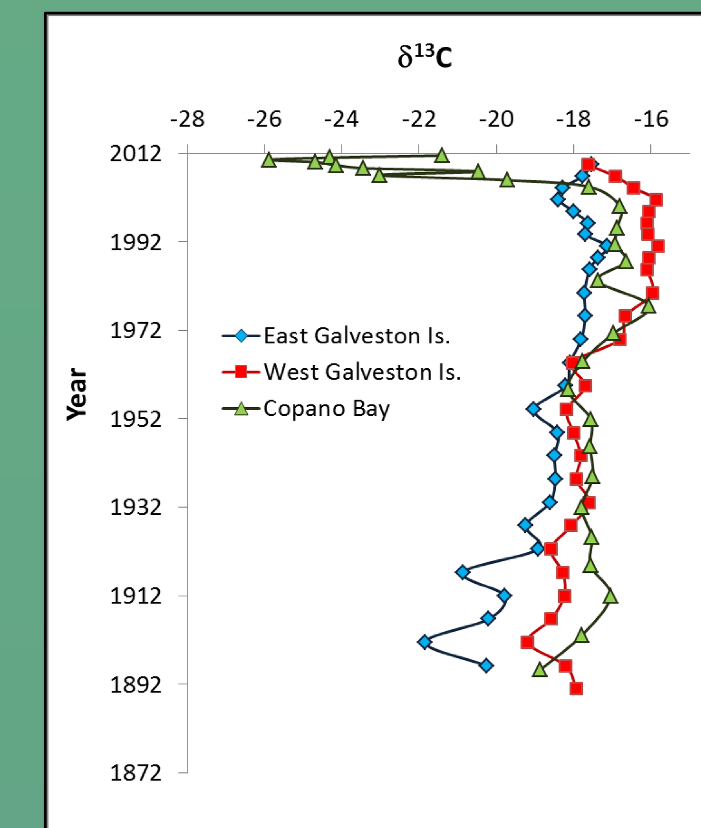
Salt Marsh Sites

- Within the last 10 years, salt marshes have received an increase in organic carbon storage.
- The signature of this OC is primarily lignin derived.
- Isotopic analysis of salt marshes indicate a grass signature for all three sites, although the Copano Bay site shows a shift towards a woody plant signature.



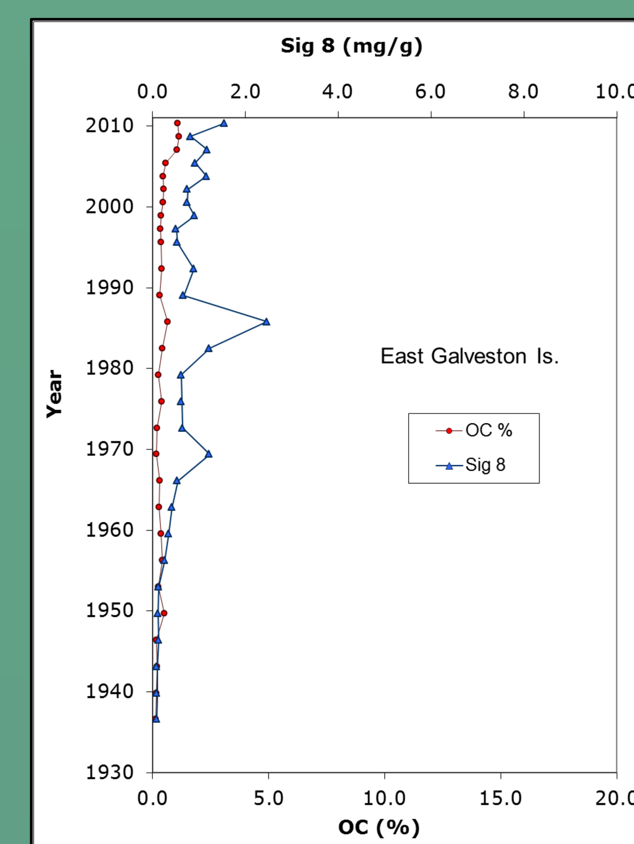


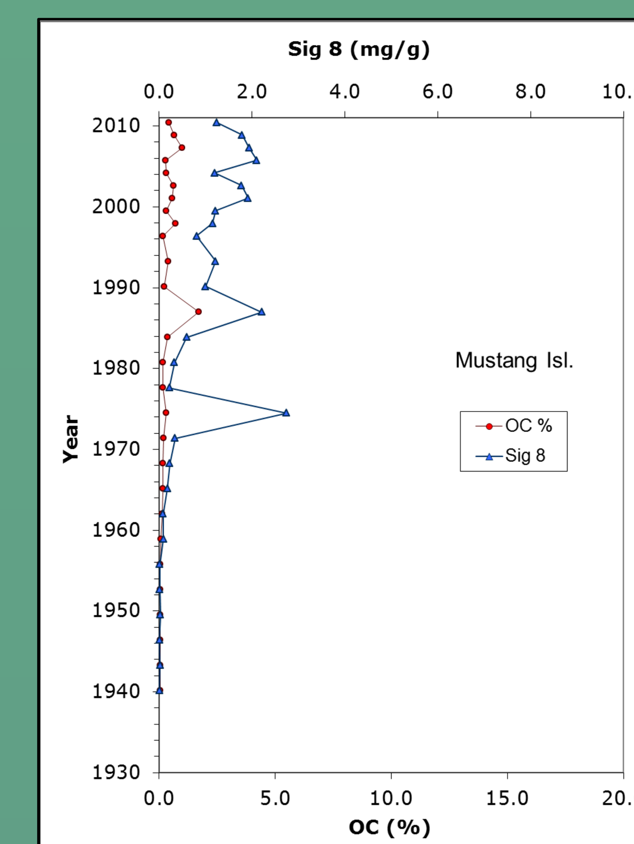


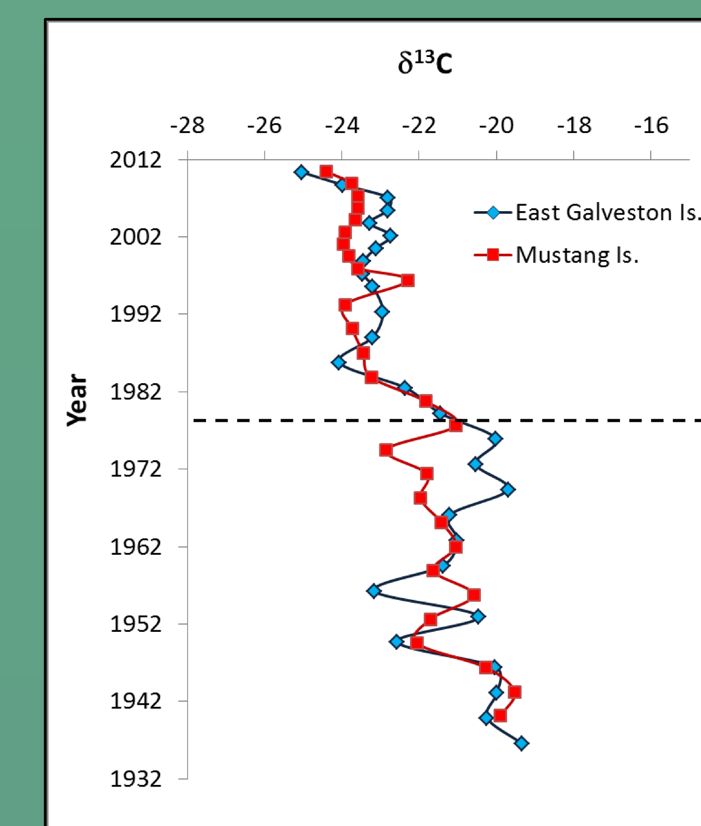


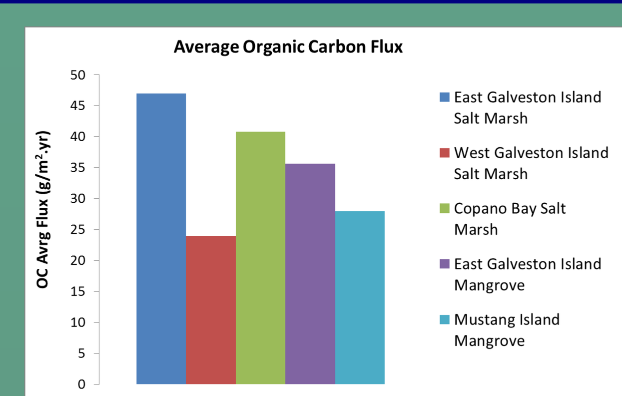
Mangrove Sites

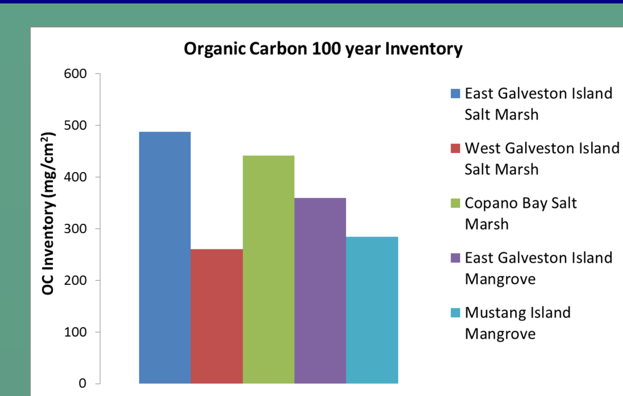
- Lignin and OC stocks between sites are similar although isotopic signatures indicate ecological shifts over the past 60 years.
- The mangrove sites indicate an isotopic shift from salt marshes to a mangrove isotopic signature in the late 1970's.

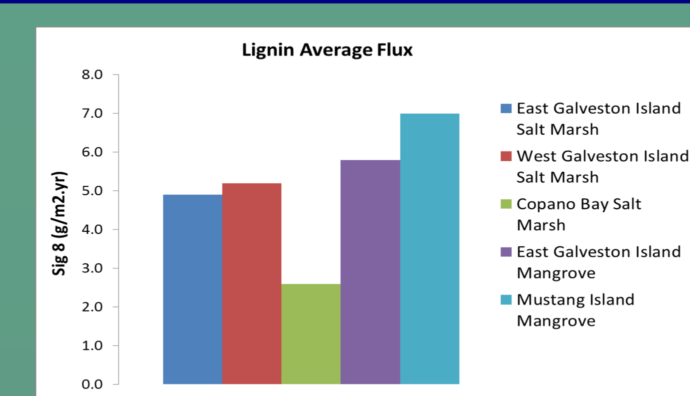












- The average OC flux for the salt marsh and mangrove sites are 37.33±12 and 32.0±5 g/m^2·yr, respectively.
- Over the 100 year OC inventory for salt marsh sites and mangrove sites , we calculated that the two distinct marshes sequester 391±120 and 322±54 mg/cm^2, respectively.
- The average flux of lignin (sig 8) for the salt marsh and mangrove sites are 4.2±1.4 and 6.4±0.85 g/m^2.yr, respectively.

Conclusions

According to our calculations of organic matter inventories for salt marshes and mangroves, the salt marsh wetland has accumulated similar amounts of OC on average (391±120 *vs.* 322±54 mg cm^{-2}, respectively) suggesting that there is no difference in the amount od OC sequestered in saltmarsh vs. mangrove wetland soils. The average flux of OC is similar between salt marshes and mangrove dominated wetlands (37.33±12 and 32.0 ± 5 g/m^2·yr, respectively). Mechanisms for OC storage within the wetlands takes place due to the anoxic soil conditions and the lignocellulose plant biomass deposition. We calculated that the average flux of lignin in the salt marsh sites and mangrove sites are, 4.2 ±1.4 and 6.4 ±0.85 g/m^2.yr, respectively. The preliminary results indicate that salt marshes and mangrove dominated wetlands sequester similar loads of OC, potentially due to the mechanisms in OC storage such as lignin rich organic material within anoxic soils.

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