Coastal wetlands experience fluctuating productivity when subjected to various stressors. One of the most impactful stressors is sea level rise (SLR) associated with global warming. Research has shown that under SLR, salt marshes may not have time to establish an equilibrium with sea level and may migrate landward or become open water. Salt marsh systems play an important role in the coastal ecosystem by providing intertidal habitats and food for birds, fish, crabs, mussels, and other animals. They also protect shorelines by dissipating flow and damping wave energy through an increase in drag forces. Due to the serious consequences of losing coastal wetlands, evaluating the potential future changes in their structure and distribution is necessary in order for coastal resource managers to make informed decisions. The objective of this study was to develop a spatially-explicit model by connecting a hydrodynamic model and a parametric marsh model and using it to assess the dynamic effects of SLR on salt marsh systems within three National Estuarine Research Reserves (NERRs) in the Northern Gulf of Mexico.

Coastal salt marsh systems are an excellent example of complex interrelations between physics and biology, and the resulting benefits to humanity. In order to investigate salt marsh productivity under projected SLR scenarios, a depth integrated hydrodynamic model was coupled to a parametric marsh model to capture the dynamic feedback loop between physics and biology. The hydrodynamic model calculates mean high water (MHW) and mean low water (MLW) within the river and tidal creeks by harmonic analysis of computed tidal constituents. The responses of MHW and MLW to SLR are nonlinear due to localized changes in the salt marsh platform elevation and biomass productivity (which influences bottom friction). Spatially-varying MHW and MLW are utilized in a two-dimensional application of the parametric Marsh Equilibrium Model to capture the effects of the hydrodynamics on biomass productivity and salt marsh accretion, where accretion rates are dependent on the spatial distribution of sediment deposition in the marsh. This model accounts both organic (decomposition of in-situ biomass) and inorganic (allochthonous) marsh platform accretion and the effects of spatial and temporal biomass density changes on tidal flows. The coupled hydro-marsh model, herein referred to as HYDRO-MEM, leverages an optimized coupling time step at which the two models exchange information and update the solution to capture the system's response to projected linear and non-linear SLR rates.

Including accurate marsh table elevations into the model is crucial to obtain meaningful biomass productivity projections. A lidar-derived Digital Elevation Model (DEM) was corrected by incorporating Real Time Kinematic (RTK) surveying elevation data. Additionally, salt marshes continually adapt in an effort to reach an equilibrium within the ideal range of relative SLR and depth of inundation. The inputs to the model, specifically topography and bottom roughness coefficient, are updated using the biomass productivity results at each coupling time step to capture the interaction between the marsh and hydrodynamic models.

The coupled model was tested and validated in the Timucuan marsh system, located in northeastern Florida by computing projected biomass productivity and marsh platform elevation under two SLR scenarios. The HYDRO-MEM model coupling protocol was assessed using a sensitivity study of the influence of coupling time step on the biomass productivity results with a comparison to results generated using the MEM approach only. Subsequently, the dynamic effects of SLR were investigated on salt marsh productivity within the three National Estuarine Research Reserves (NERRs) (Apalachicola, FL, Grand Bay, MS, and Weeks Bay, AL) in the Northern Gulf of Mexico (NGOM). These three NERRS are fluvial, marine and mixed estuarine systems, respectively. Each NERR has its own unique characteristics that influence the salt marsh ecosystems.

The HYDRO-MEM model was used to assess the effects of four projections of low (0.2 m), intermediate-low (0.5 m), intermediate-high (1.2 m) and high (2.0 m) SLR on salt marsh productivity for the year 2100 for the fluvial dominated Apalachicola estuary, the marine dominated Grand Bay estuary, and the mixed Weeks Bay estuary. The results showed increased productivity under the low SLR scenario and decreased productivity under the intermediate-low, intermediate-high, and high SLR. In the intermediate-high and high SLR scenarios, most of the salt marshes drowned (converted to open water) or migrated to higher topography.
These research presented herein advanced the spatial modeling and understanding of dynamic SLR effects on coastal wetland vulnerability. This tool can be used in any estuarine system to project salt marsh productivity and accretion under sea level change scenarios to better predict possible responses to projected SLR scenarios. The findings are not only beneficial to the scientific community, but also are useful to restoration, planning, and monitoring activities in the NERRs. Finally, the research outcomes can help policy makers and coastal managers to choose suitable approaches to meet the specific needs and address the vulnerabilities of these three estuaries, as well as other wetland systems in the NGOM and marsh systems anywhere in the world.

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The public is welcome to attend.