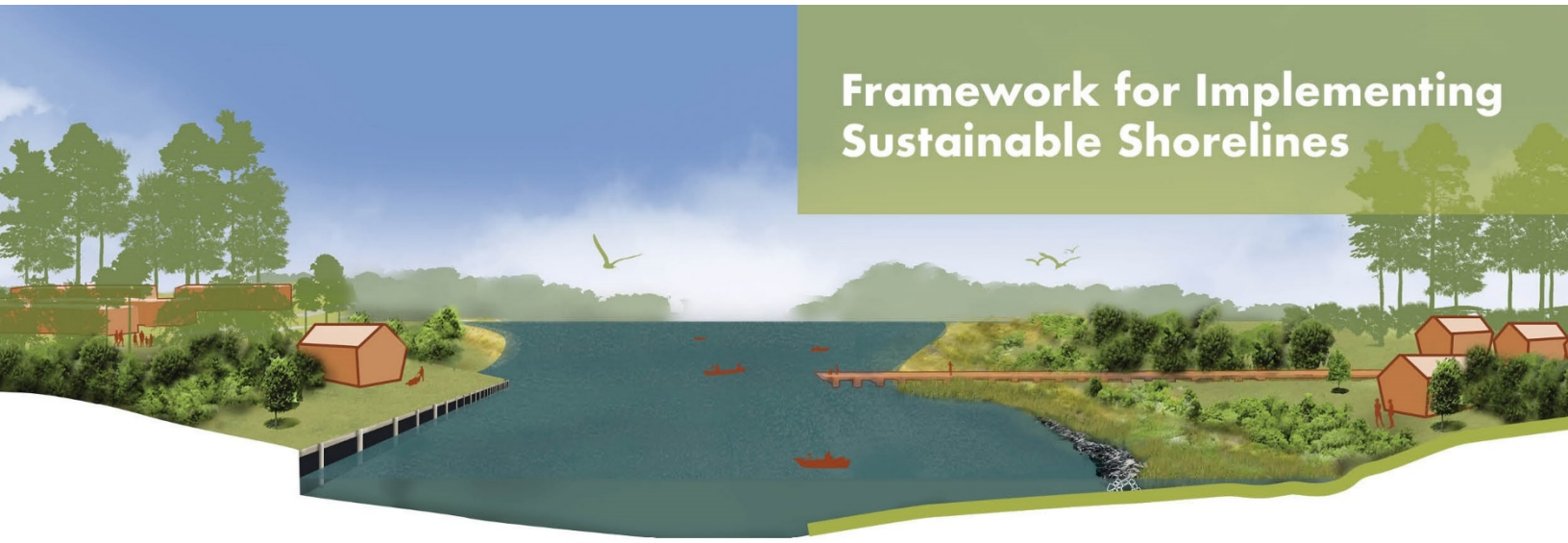


Summary of Natural Science Investigations:

Modeling Tidal Marsh Evolution (TMM)

Project Activity: Development of the Tidal Marsh Model (TMM)

Objective: Develop a dynamic high-resolution model by integrating the physical and human components needed to simulate and assess the evolution and persistence of tidal marshes under different sea-level rise scenarios.

The Tidal Marsh Model advances the state of the science by building a better foundation/ framework to model marsh evolution. TMM has the capacity to overcome many limitations that current marsh models have. TMM is a cross-scale model, so it can model marshes in large areas, but with the kind of spatially explicit resolution currently only available from site-specific marsh evolution studies. In addition, TMM has the capacity for a much more dynamic simulation (i.e. rates vary in space and time as determined by changes in the hydrodynamic conditions of the system). Finally, TMM includes hardened shoreline structure in the simulations, which allows it to highly resolve marsh transgression.

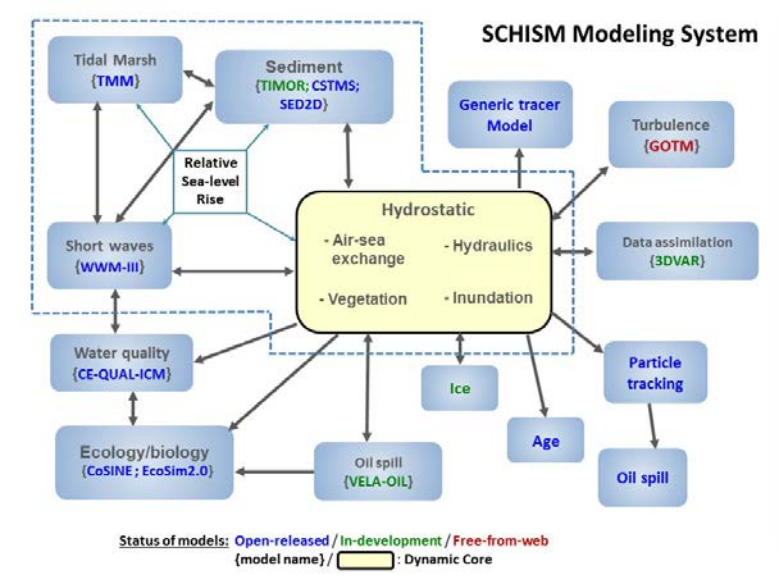
Methods: TMM is based on the SCHISM modeling system (schism.wiki). The Tidal Marsh Model consists of four major components: the hydrodynamic core that serves as the foundation of the SCHISM modeling system, the wind wave model (WWM-III), the 3D sediment transport model (CSTMS), and a newly developed TMM-migration module. Sea-level rise is explicitly accounted for in all models. The TMM accounts for shoreline bank erosion, marsh accretion through mineral sediment deposition, upland erosion inputs at the marsh edge, and marsh transgression under a changing sea level. The development of the TMM was focused on two areas within the York River system: Taskinas Creek and Carter Creek. Even though TMM was developed and applied in these areas, it can be exportable to other systems.

Major datasets used for TMM and the supporting models:

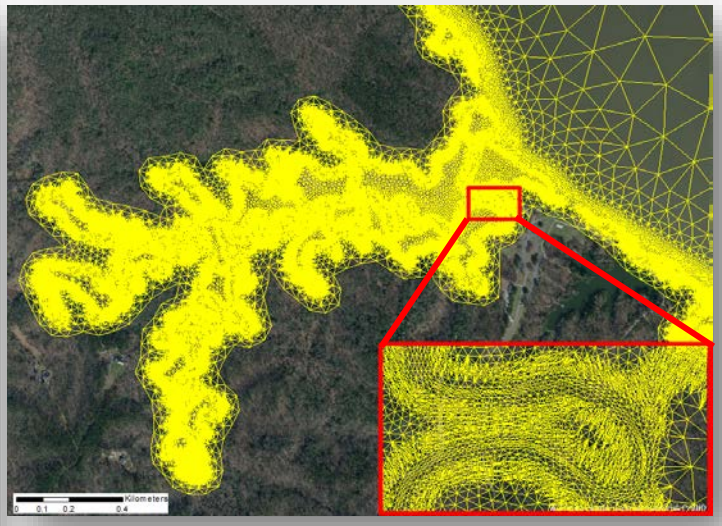
Dataset	Source
Tidal Marshes (Scale: 1:1,000)	Tidal Marsh Inventory – CCRM, VIMS
Shoreline Structures	Shoreline Inventory Program – CCRM, VIMS
Bank Condition	Shoreline Inventory Program – CCRM, VIMS
Riparian Land use (distance: 100 ft.)	Shoreline Inventory Program – CCRM, VIMS
LIDAR data	Virginia Geographic Information Network (VGIN)
Bathymetry	NOAA / CBNERR, CCRM - VIMS
Bottom Type (grain sizes)	VIMS / Maryland Geological Survey (MGS)
River Input (average daily values)	United State Geological Survey (USGS)
Atmospheric Forcing	North American Regional Reanalysis (NARR)
Tides	US East Coast Tidal Database

Progress to date: Project completed.
Article: Nunez, K., Zhang, Y.J., Herman, J., Reay, W., Hershner, C. (2020) A multi-scale approach for simulating tidal marsh evolution. Ocean Dynamics. https://doi.org/10.1007/s10236-020-01380-6
Full text: https://rdcu.be/b5j0C
The Tidal Marsh Module (TMM) is freely accessible for users at
http://ccrm.vims.edu/schismweb/

Visuals:



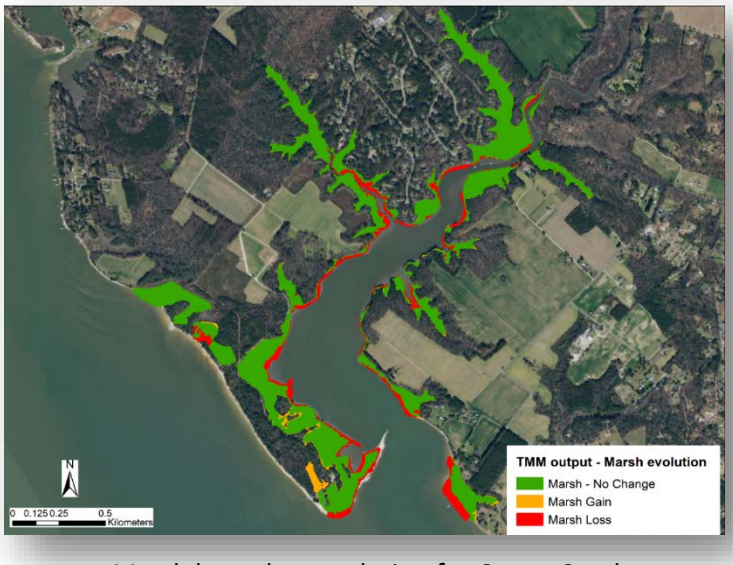
SCHISM modeling system as of July 2021



Unstructured TMM grid used for Taskinas Creek marsh evolution simulations

Findings:

- The TMM was successfully calibrated and verified against historic data and field observations (overall accuracy: 78-81%).
- Marsh migration into open areas was well captured, as well as the negative effect of hardened shoreline structures and development on the natural capacity of marshes to migrate inland as sea-level rises.
- The model was further improved with the addition of a new vegetation algorithm to evaluate the effects of *Spartina alterniflora* on sedimentation and currents (enhanced model accuracy in both the vertical and horizontal dimensions).



Marsh boundary evolution for Carter Creek
Hindcast output: changes in marsh boundary (past 40 years) with a sea-level rise of 4 mm/yr.

The new TMM functionality and an example of its application are presented in:
Nunez, K., Zhang, Y., Bilkovic, D.M., Hershner, C. (in review). Coastal Setting Determines Tidal Marsh Sustainability with Accelerating Sea-level Rise. Ocean and Coastal Management.

Coastal managers and decision-makers can use these highly resolved model outputs to improve the long-term effectiveness of conservation strategies by maximizing the amount of marsh habitat in high-sediment regions, prioritizing sediment allocation, and identifying key upland transitional sites.