Using Landlab and Mesa to Simulate Oyster Ecohydraulic Feedbacks

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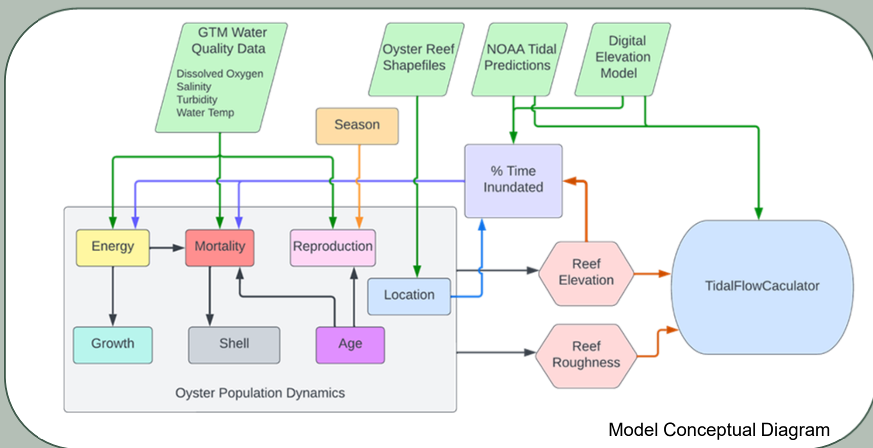


Model Conceptual Diagram

Purpose

Eastern Oysters (*Crassostrea virginica*) are reef building organisms that occupy tidal and subtidal zones along the eastern coasts of the Americas. They provide key ecosystem services by improving water quality, creating habitat, adding to local economies, and protecting shorelines from erosion by attenuating waves. Eastern Oyster populations are declining. At the same time, climate change is causing more frequent and intense storms and rising sea levels, leading to unprecedented degradation of coastal habitats. Reef restoration can boost oyster populations and help create protective barriers for vulnerable coastlines. However, there is little research on how oyster population dynamics influence reef structure–and in turn how reef structure influences hydrodynamics. This modeling effort is a first step in addressing this gap. Our model simulates oyster population dynamics and reef structure using an agent-based model (ABM), which is coupled with the Landlab TidalFlowCalculator component and a simple inundation model to simulate how reef structures affect tidal velocity and water surface elevation.

Methods

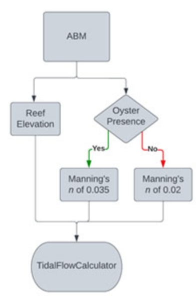
Agent-Based Model

We adapted an ABM developed by Kjellend et al.[1], which was built using data from and assumptions based in the Chesapeake Bay. Because our study site had much higher salinity, we reduced salinity's impact on mortality and energy. Since oysters in southern waters tend to grow intertidally, we added the effect of tidal inundation. We also integrated a reef accretion component from Walles et al.[2] to model elevation changes on the oyster reef.

We used the Mesa and Mesa-Geo python libraries to code our agent-based model.

Integrating with Landlab

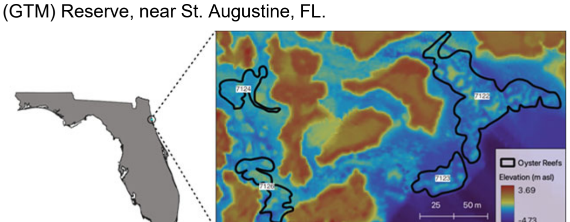
We ran the ABM for five years, and derived the resulting reef elevation and oyster presence/absence. Areas with oysters/shells were assigned a Manning's *n* of 0.035 and areas without oysters/shells were assigned a Manning's *n* of 0.03. We fed these inputs, as well as tidal range and tidal period data from the closest NOAA gage site at Mayport, FL, into Landlab's TidalFlowCalculator to determine how oyster reefs influence tidal velocity.



Study Site

Exposed Oyster Reef near St. Augustine, Florida. Photo by Candice Piercy.

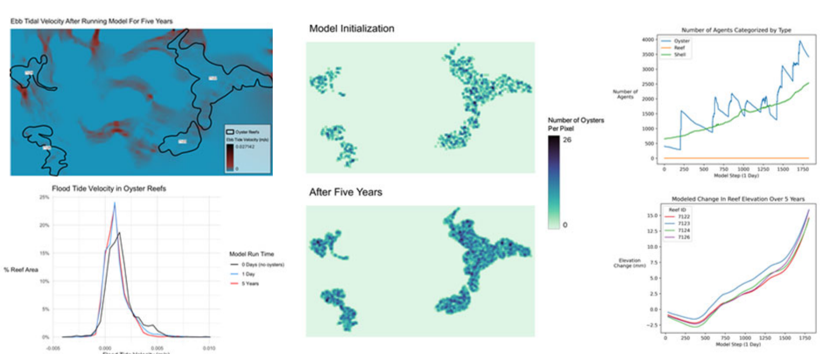
We centered our modeling efforts around four intertidal oyster reefs in the Guana Tolomato Matanzas National Estuarine Research (GTM) Reserve, near St. Augustine, FL.



Elevation of Reefs at Study Site. Digital Elevation data from the 2016 USACE National Coastal Mapping Program Topobathy Lidar. Reef vector data from St. Johns River Water Management District.

Results

Our model produced relatively slow-growing reefs that do not significantly impact tidal velocity.



Future Directions

This model represents the first phase of a larger research effort, which aims to model how oyster population dynamics impact reef structures and in turn how reef structures impact wave attenuation. We plan to assess the use of other dynamic energy budget models that better capture the system dynamics of oysters outside of the Chesapeake Bay.

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References

1. Kjelland, M. E., Piercy, C. D., Lackey, T. & Swannack, T. M. An integrated modeling approach for elucidating the effects of different management strategies on Chesapeake Bay oyster metapopulation dynamics. *Ecol. Model.* **308**, 45–62 (2015).
2. Walles, B. *et al.* Demography of the ecosystem engineer Crassostrea gigas, related to vertical reef accretion and reef persistence. *Estuar. Coast. Shelf Sci.* **154**, 224–233 (2015).