Response of Intertidal Oyster Reefs to Increasing Rates of Sea-Level Rise

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Living Shorelines

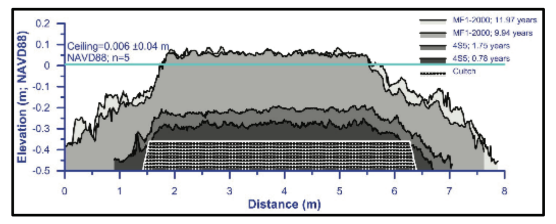
Oysters are ecosystem engineers that provide valuable ecosystem services to estuaries. Oyster reefs filter water, provide nesting and feeding habitat for fish and crustaceans, and provide refuge from predation.[1]

Applications in Living Shorelines

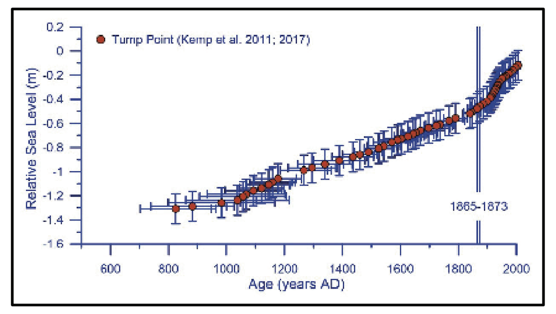
Traditional living shorelines include a nearshore sill or breakwater with native vegetation positioned along the upland to mitigate coastal erosion. Most living shorelines along the eastern coast of the US consist of salt marshes. Because of their hard carbonate structure and the ecosystem services they provide, oyster reefs are being explored as options for living shorelines.[4,5] Their addition into living shoreline systems can have a synergistic effect because they naturally attenuate wave energy, improve water quality, stabilize sediments and mitigate the inland retreat of marshes.[7,8]

Uncertain Response to Sea-Level Rise

The rate of sea-level rise increased between 1865 and 1873.[2] Previous research on oyster reef growth rates has focused on restored reefs and measured on yearly to decadal time scales. We know that restored intertidal reefs can grow up to 10 cm yr^{-1}, but we don't know how natural reefs will respond to increases in the rate of sea-level rise over longer periods of time.[6]



Above: decadal growth of restored reef.
Below: NC sea-level curve.

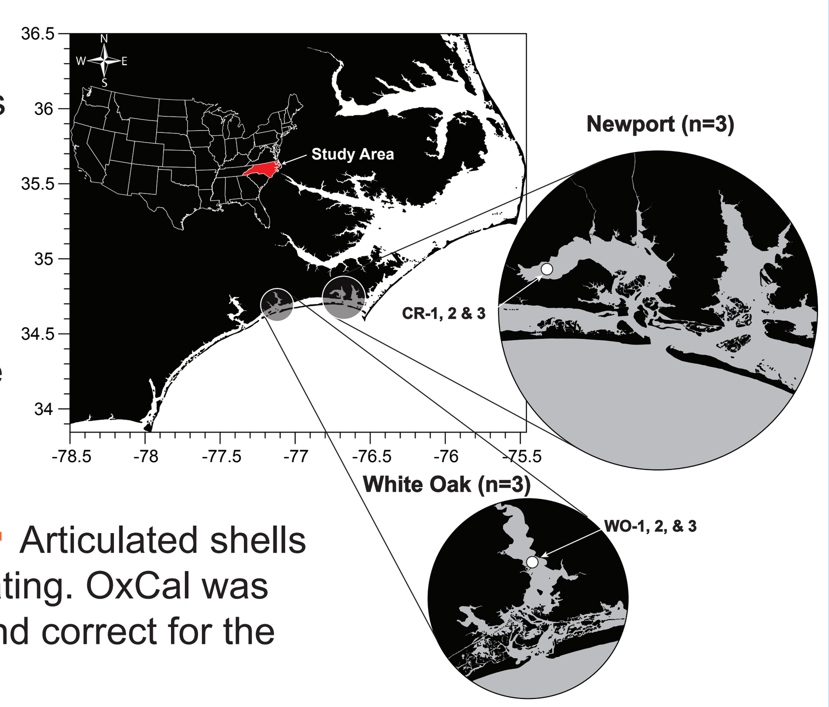


The purpose of this study is to examine the responses of intertidal oyster reefs to the late holocene increase in sea-level rise. This study will help determine if oyster reefs are viable options for long term use in living shorelines under conditions of accelerated sea-level rise.

Research Objectives

1. Develop an **age-depth model** for an oyster reef from the Newport (CR-3) and from the White Oak (WO-2) estuaries through radiocarbon dating to find **vertical accretion rates** and reef response time to changes in sea-level rise.
2. Investigate composition through **grain-size analysis** and **% shell** to see how oyster reefs record changes in estuaries.
3. Examine reef **morphology** by constructing a cross section of a reef to see how the relief has changed over time.

Methods



Core Collection - Three reefs in each estuary were selected for coring. A 4.6 meter core was collected from the crest of each reef and the coordinates were surveyed with a Trimble R8 Real Time Kinematic GPS receiver.

Core Processing - Cores were divided into 5 cm subsections. The shells and fine grains were separated, dried and weighed. Grain size was measured with a CILAS particle size analyzer.

Geochronology Development - Articulated shells from CR-3 and WO-2 were selected for radiocarbon dating. OxCal was used to convert radiocarbon years to calendar years and correct for the marine reservoir effect (ΔR=-184 +/- 51; 2SD)

Results - Reef Composition

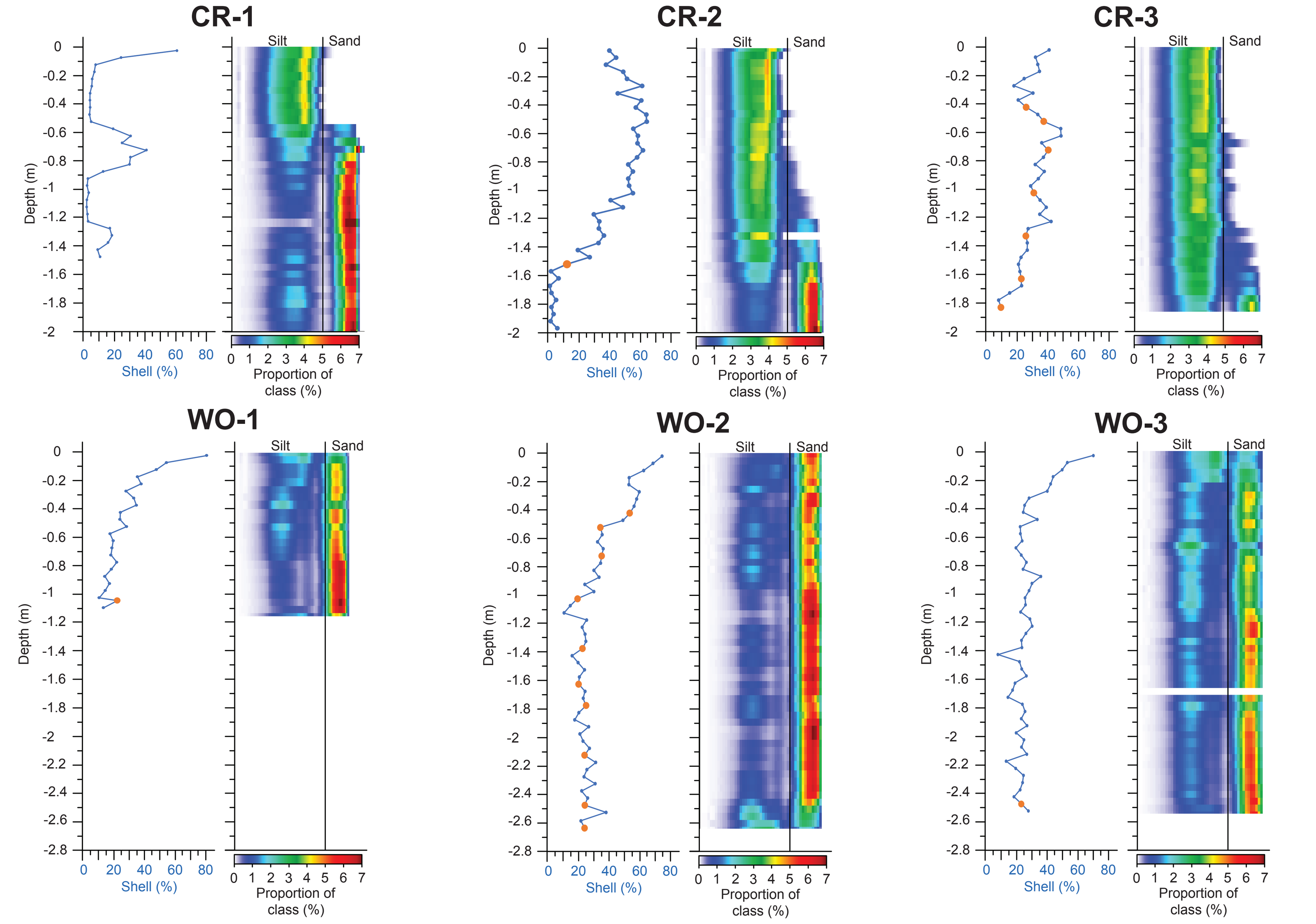


Figure I: CR reefs show transition from sand dominant to silt-dominant sediments traceable to 1964 watershed land-use change.[3] WO reefs are sand-dominant and show more stable % shell. Depths that have a radiocarbon date are shown in orange.

Results - Cross Section

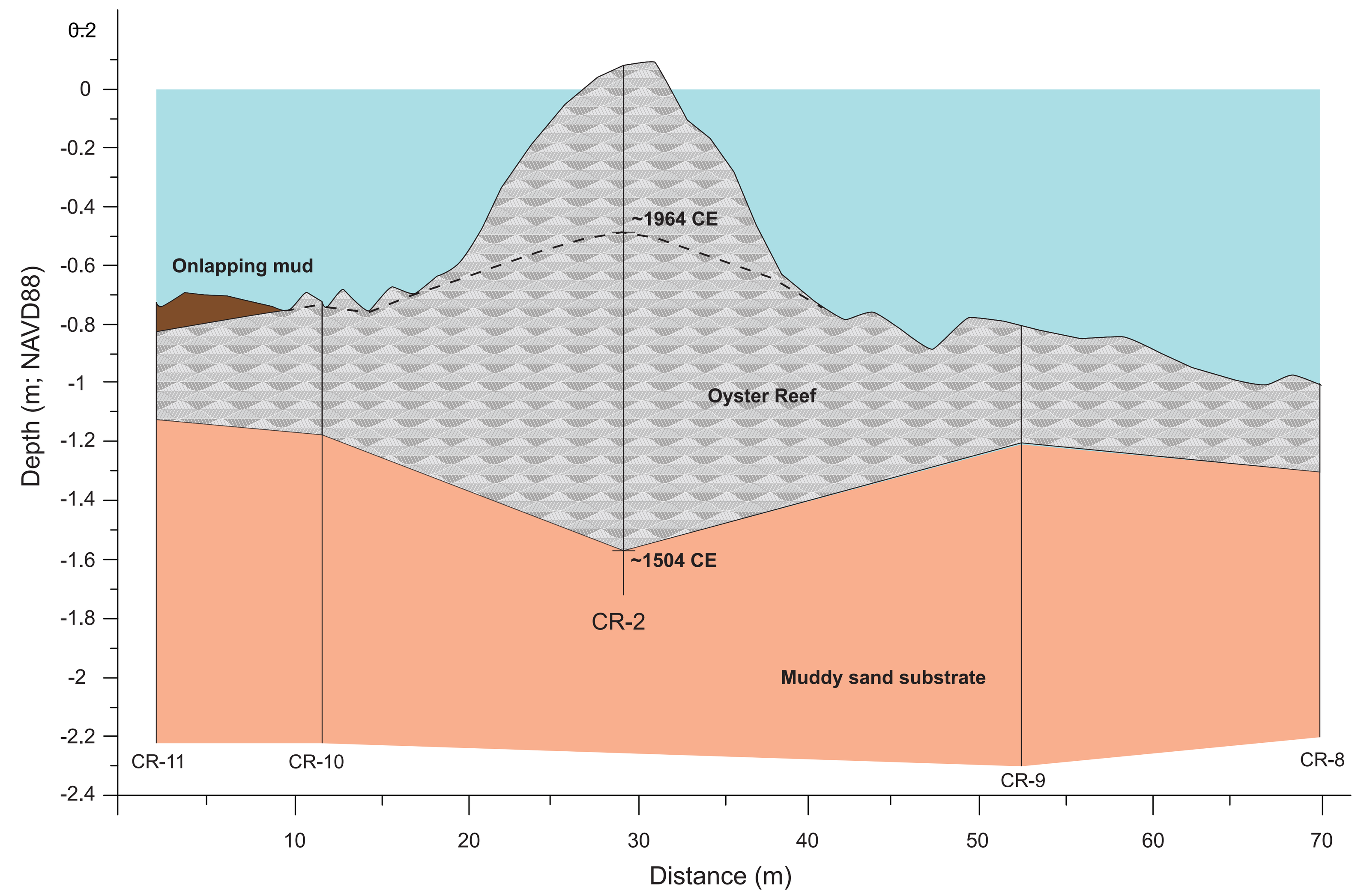


Figure 2: CR-2 colonized the substrate in 1504 and maintained a low relief for roughly 500 years. The vertical relief became more pronounced after 1964.

Results - Geochronologies

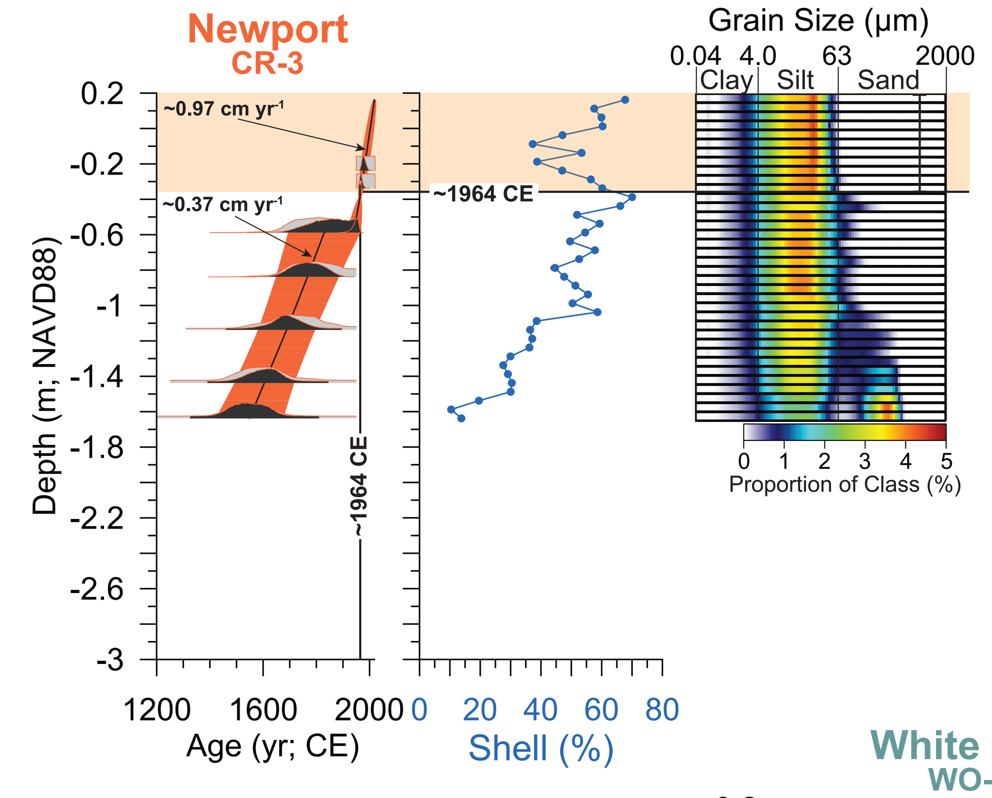


Figure 3: The age-depth model of CR-3 shows an increase in accretion rate from 0.37 cm yr^{-1} to 0.97 cm yr^{-1}. The top two shells we radiocarbon dated returned dates younger than 1950, and their depths were factored into the model with an error of +/- 10 years. The depth of the year 1964 was determined from grain size data and included in the model.

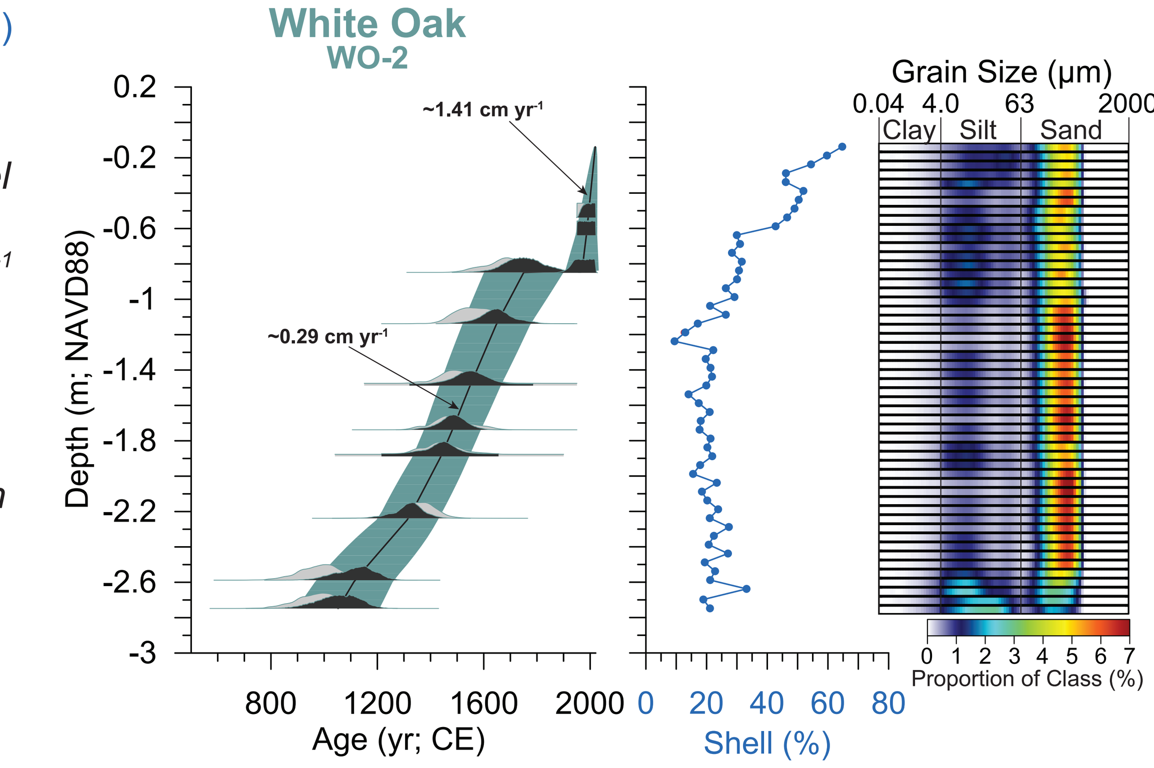


Figure 4: The age-depth model of WO-2 shows an increase in accretion rate from 0.29 cm yr^{-1} to 1.41 cm yr^{-1}. The top two shells we radiocarbon dated returned dates younger than 1950, and their depths were factored into the model with an error of +/- 10 years.

Conclusions

1. **Oyster reefs are modulated by the rate of sea-level rise.** The reefs in this study consistently outpaced sea-level rise, but still responded to the acceleration in sea-level rise in 1865, implying they will be able to maintain shoreline stabilization into the future.
2. **Oyster reefs are resilient to changes in sediment loading.** They can withstand changes to estuaries that will be brought on by continued coastal development.
3. **The vertical relief of oyster reefs has increased since the acceleration of sea-level rise.** The increase in rugose surface area creates more habitat for fish and crustaceans, and leads directly to an increase in the stock of economically important fisheries.

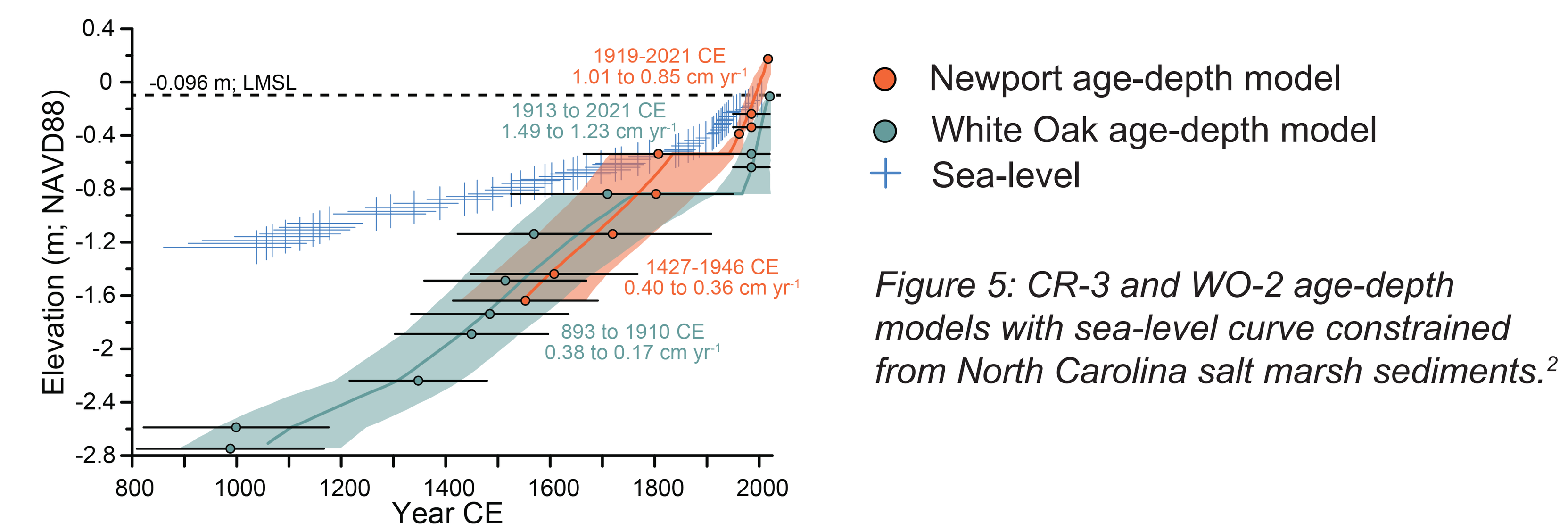


Figure 5: CR-3 and WO-2 age-depth models with sea-level curve constrained from North Carolina salt marsh sediments.[2]