Designing and utilizing modular wire structures to recruit oysters (*Crassostrea virginica*) for habitat enhancement and shoreline stabilization in coastal South Carolina.

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Project Background

Oysters in South Carolina

- Eastern oyster (*Crassostrea virginica*) populations in South Carolina (SC) occur primarily as extensive intertidal reefs (Fig. 1).
- SC oyster larval production is plentiful, but suitable attachment substrate is limited.
- This limitation has allowed for the exploration of alternate substrate supplementation as a means of restoration.

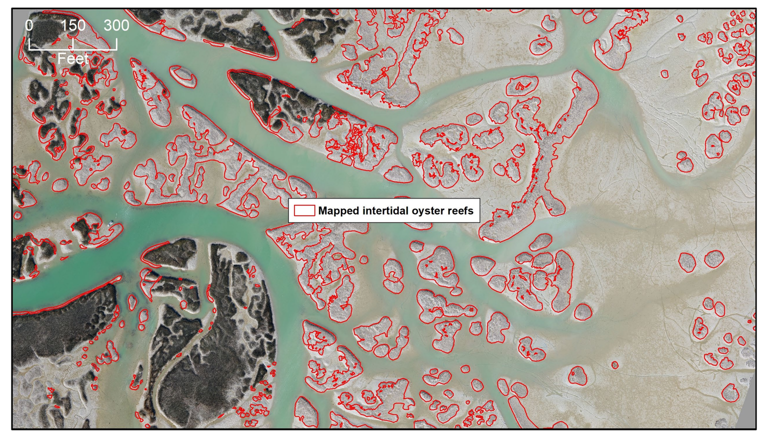


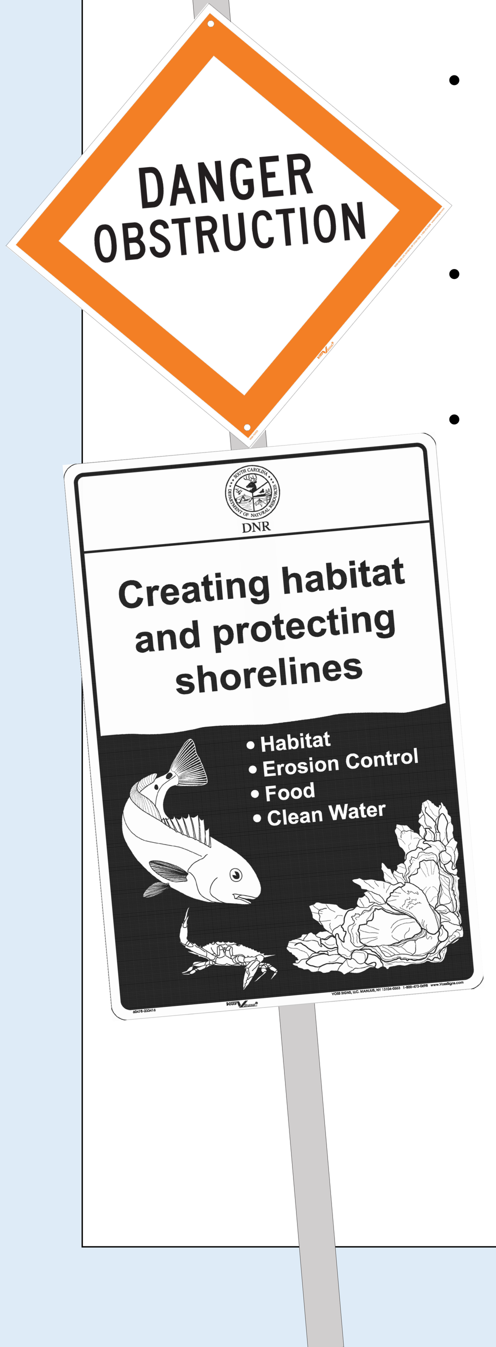
Figure 1: Mapped intertidal oyster reefs exposed at low tide in Mark Bay, South Carolina (SC).

Repurposed Crab Traps (RCTs)

- Derelict crab traps are a prevalent form of marine debris in SC estuaries that support high levels of oyster recruitment when abandoned in the intertidal zone.
- Since 2011, the SCDNR's Shellfish Research Section (SRS) has repurposed derelict and donated crab traps as oyster reef substrate (Fig. 2), installing 47 RCT reefs in SC estuaries (Fig. 3).

Figure 2: Derelict traps are removed from the environment (A), modified to prevent "ghost fishing", coated with a thin layer of cement (B), and deployed in the intertidal zone, where they recruit and sustain oyster growth (C).

Modified Wire Reefs (MWRs)



- Building on the success of RCT reefs, in 2016 SRS researchers began using purpose-built plastic-free wire structures for oyster restoration.
- Goal: To design and evaluate a modular unit that is easy to construct, meets simple regulatory guidelines, and efficiently recruits oysters.
- To date, the SRS has installed 22 MWR reefs at 16 sites (Fig. 3).

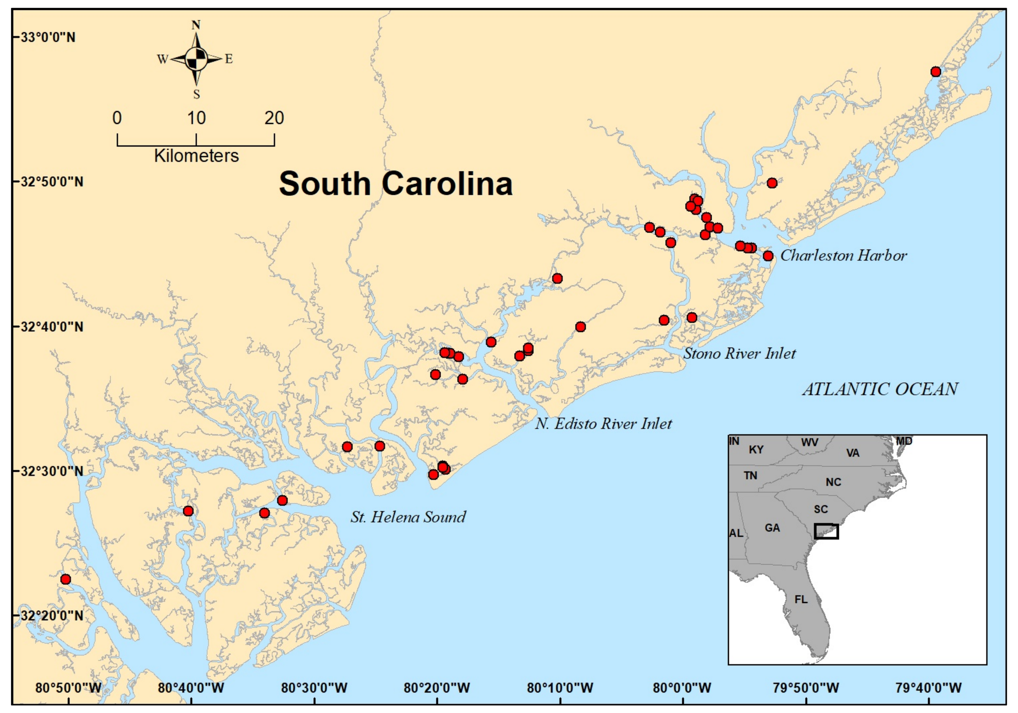


Figure 3: All sites in coastal South Carolina, USA, where wire-based living shorelines have been installed by the Shellfish Research Section of the South Carolina Department of Natural Resources (SCDNR).

Development & Construction

Design Exploration

SRS researchers have explored designs (Fig. 4) with multiple variations in:

- Overall shape & structure
- Mesh size
- Wire gauge
- Internal structure design
- Vinyl vs. non-vinyl coated materials

Figure 4: (left) example version 1: vinyl-coated, 1.5-inch mesh, peaked design, vertical internal pillars, cement coated; (right) example version 2, no vinyl-coating, 1-inch mesh, peaked design, horizontal internal panel, cement coated.

Current MWR design (Fig. 5) incorporates:

- Simple, un-peaked box
- No vinyl coating
- 12.5-gauge galvanized wire
- 1.5-inch mesh size
- 2 vertical internal panels
- 48" long x 22.5" wide x 15" high
- Coated or uncoated

Figure 5: Most current MWR design created by the SRS: a plastic-free, easy to handle, modular wire structure for recruiting oysters.

Construction

Figure 6: MWR construction includes the use of pneumatic wire cutters, mechanical wire bender, and pneumatic hog-ringing tool. If coating in cement, the use of thin-set mortar tile mix as well as a cement mixer and sprayer are utilized. To build each structure, wire panels are cut to size, sections are bent into shape (A), panels are hog-ringed together (B), and the surface is coated with a thin layer of cement (C).

Installation

- Current design was first deployed in June 2020 and has been installed at 5 locations.
- Curved rebar stakes are utilized to secure structures in intertidal zone (Fig. 7).
- MWRs have been deployed adjacent to highly developed urban areas as a means for both oyster reef restoration and shoreline stabilization (Fig 8).

Figure 7: MWR reef immediately after installation on Fort Johnson shoreline, Charleston Harbor, SC, utilizing current design and secured with curved rebar stakes.

Figure 8: Combined MWR and RCT reef, covering a total footprint of 150 linear feet installed on Charleston, SC peninsula shoreline in the Charleston Harbor in 2021.

Reef Performance Results

Oyster Recruitment

- MWRs are effective at quickly recruiting oysters, typically occurring on internal panels before external surfaces (Fig. 9).
- Preliminary results suggest cement coated MWRs recruit oysters more rapidly than uncoated MWRs.

Figure 9: MWRs installed on the Fort Johnson shoreline of the Charleston Harbor, 3 months post-installation (left), September 2020 and 11 months post-installation (right) in May 2021.

Figure 10: Oyster quadrat photos taken 1 year after installation (A) and 5 years after installation (B) on MWRs installed at Big Bay Creek near Edisto Beach, SC.

Reef Longevity

- MWRs can support oyster reef growth for multiple years (≥ 5 years) post-installation (Fig. 10).

Marsh Edge Stabilization: A Case Study

- Marsh edge changes were analyzed using unmanned aerial vehicle (UAV) data.
- Over a 2-year period, the MWR treatment site gained marsh while the negative control site continued to lose marsh (Fig. 11).

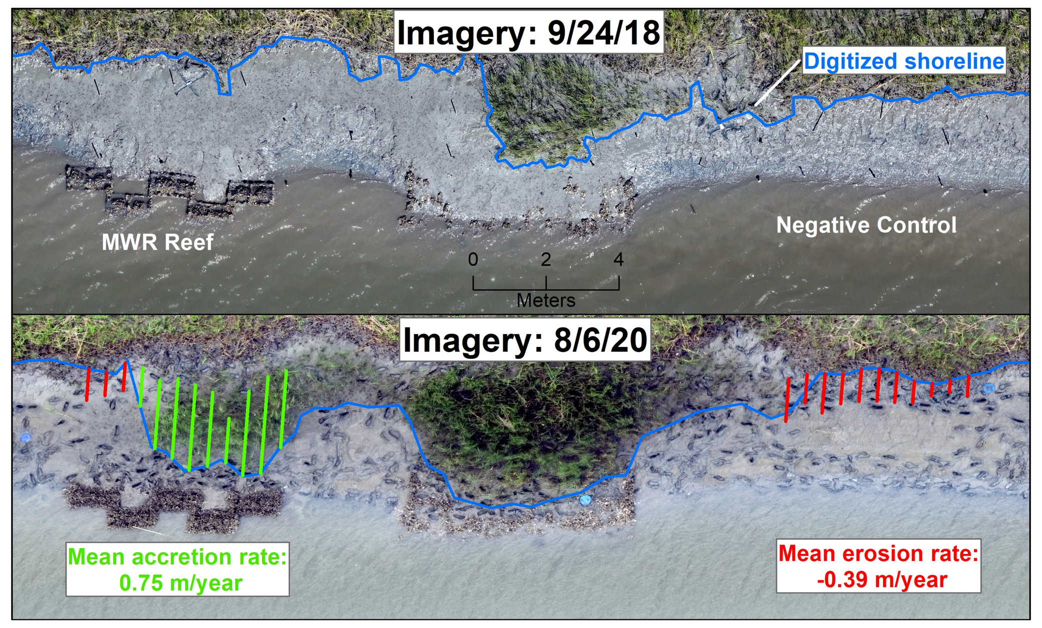


Figure 11: UAV-based imagery of Big Bay Creek living shoreline experimental site showing changes in marsh vegetation edge over time analyzed using AMBUR (Analyzing Moving Boundaries Using R) software (Jackson, Georgia Southern University). Blue lines indicate marsh edge position at the time of imagery, green lines indicate transects with an expanding marsh edge, and red lines indicate transects with receding marsh edge.

Take Home Messages

- Plastic-free wire reef structures can be effectively deployed as successful living shorelines in substrate-limited intertidal habitats of South Carolina estuaries.
- The modular nature of MWRs make them suitable for application at multiple scales.
- Cement coated MWRs recruit oysters more rapidly than uncoated MWRs.
- Wire-based reef substrate has been shown to persist in estuarine environments for multiple years (≥ 5 years).
- Future work includes studying the longer-term performance of current designs.