**Project Title: Carrot Island oyster reef and marsh restoration from 2018-05-11 to 2020-08-18**

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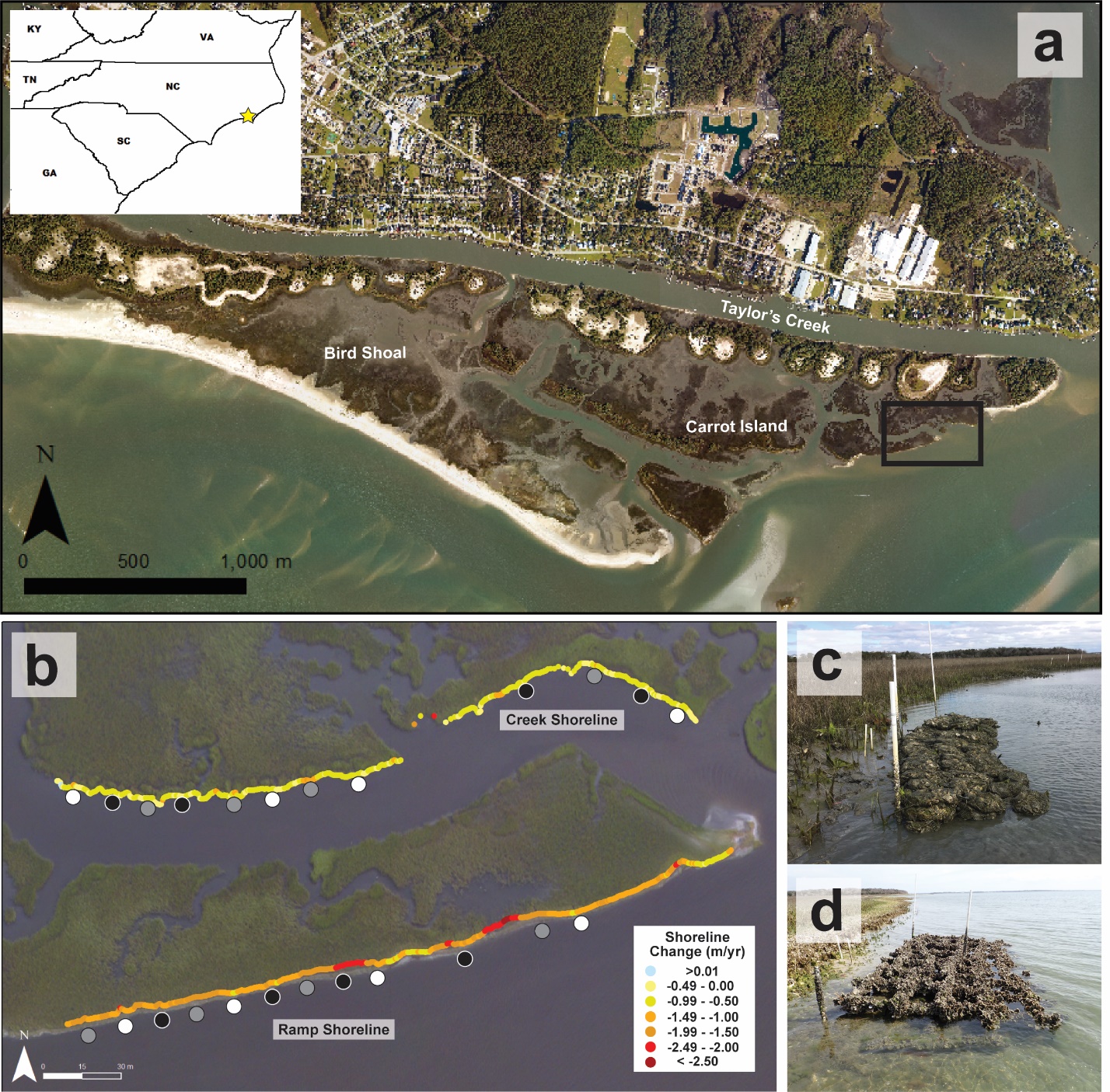
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Purpose: Included in this document is metadata related to Carrot\_Island\_Oyster\_Marsh\_Restoration.zip, which contains spatial data accompanying the submission “Carrot Island oyster reef and marsh restoration from 2018-05-11 to 2020-08-18.” This project was funded by the North Carolina Division of Environmental Quality, NOAA, U.S. Fish and Wildlife Service, and the North Carolina Policy Collaboratory. This project focused on restoration of intertidal oyster reefs along eroding salt marsh shorelines in Eastern North Carolina. Reefs were built from two substrates, oyster shell bags (SB) and Oystercatcher™ (OC), and replicated along a low-energy tidal creek shoreline (creek) and an exposed, high-energy shoreline (ramp). In 2018 and 2020, we used an R10 Trimble Real Time Kinematic GNSS unit (hereafter, RTK) to map the waterward extent of salt marsh on both shorelines, representing the shoreline position. Additionally, in 2018 we used the RTK to map the footprints, and therefore, area, of all restoration sites. Shoreline position data were used to assess shoreline change both at the site level and along each entire shoreline, with the latter analysis employing the AMBUR (Analyzing Moving Boundaries Using R) program. The analyses of shoreline change and reef performance which incorporated these spatial data have been published by Wellman et al. (2021) in the journal *Ecological Applications*.



*Figure 1: A) Map of study area near Beaufort, NC, USA in the Rachel Carson National Estuarine Research Reserve, with black polygon denoting study area. B) Reefs were constructed along two shorelines at Carrot Island: a sheltered tidal creek shoreline and an exposed “ramp” shoreline. Annual shoreline change rates over the study period were calculated with the AMBUR program (Jackson et al. 2012). Polygon color denotes experimental treatment: control (grey), SB (black), and OC (white). Photographs show intact C) SB and D) OC reefs in March 2019.*

**Field Data Collection Methods:** This restoration project took place in the Rachel Carson National Estuarine Research Reserve, located in Beaufort, NC. Specifically, all restoration was carried out in the eastern portion of the Reserve, in a marsh complex called Carrot Island. In May 2018, we sited four experimental blocks along a high-energy ramp and low-energy creek shoreline. Within each block we constructed one SB and one OC reef (2 m × 4 m; Fig. 1), for a total of 16 reefs (n=8 per shoreline). Four control sites (no reef) were also established along each shoreline (n=8). In September 2018 and August 2020, we collected positional data along the creek and ramp shorelines using a backpack-mounted RTK, delineating the marsh shoreline based on the waterward extent of emergent *Spartina alterniflora* vegetation. These data were collected before Hurricane Florence on September 10, 2018, and after Hurricane Isaias on August 18, 2020. Additionally, we mapped the footprint of each experimental site, again by walking its perimeter with a backpack-mounted RTK, on September 26 and 27, 2018 (post-Florence).

GPS data were uploaded into ESRI ArcMap 10.7.1 as shapefiles, with positional data converted to line files and reef footprints converted to polygons. The spatial dataset is composed of four line files, two point files, and two shapefiles, for a total of eight map elements (“Carrot\_Island\_Reef\_Marsh\_Restoration.zip”). The 2018 and 2020 line files for each shoreline were used as model inputs for AMBUR analysis. The AMBUR program casts shore-perpendicular transects between two baselines (i.e. measurements of shoreline positions) and calculates change over time using the end-point rate (EPR) method (Dolan et al. 1991). AMBUR was therefore employed to calculate shoreline change along both the creek and ramp during the study period.

**Description of information contained within of the spatial dataset:**

*Carrot\_Island\_Ramp\_VegLine\_20180910*

* ‘ObjectID\*’: Discrete identifier for each polyline in the spatial dataset.
* ‘Shape\*’: Geometry type of the spatial data (polyline).
* ‘Shape\_Length’: Length of the polyline (meters).
* ‘Shoreline’: Identifier of experimental shoreline (ramp or creek).
* ‘Date’: Date of spatial data collection.

*Carrot\_Island\_Ramp\_VegLine\_20200818*

* ‘ObjectID\*’: Discrete identifier for each polyline in the spatial dataset.
* ‘Shape\*’: Geometry type of the spatial data (polyline).
* ‘Shape\_Length’: Length of the polyline (meters).
* ‘Shoreline’: Identifier of experimental shoreline (ramp or creek).
* ‘Date’: Date of spatial data collection.

*Carrot\_Island\_Creek\_VegLine\_20180910*

* ‘ObjectID\*’: Discrete identifier for each polyline in the spatial dataset.
* ‘Shape\*’: Geometry type of the spatial data (polyline).
* ‘Shape\_Length’: Length of the polyline (meters).
* ‘Shoreline’: Identifier of experimental shoreline (ramp or creek).
* ‘Date’: Date of spatial data collection.

*Carrot\_Island\_Creek\_VegLine\_20200818*

* ‘ObjectID\*’: Discrete identifier for each polyline in the spatial dataset.
* ‘Shape\*’: Geometry type of the spatial data (polyline).
* ‘Shape\_Length’: Length of the polyline (meters).
* ‘Shoreline’: Identifier of experimental shoreline (ramp or creek).
* ‘Date’: Date of spatial data collection.

*Creek\_ReefFootprints\_20180927*

* ‘ObjectID\*’: Discrete identifier for each polyline in the spatial dataset.
* ‘SHAPE\*’: Geometry type of the spatial data (polygon).
* ‘SHAPE\_Length’: Length of the polygon perimeter (meters).
* ‘SHAPE\_Area’: Area of the polygon (m2)
* ‘Treatment’: Experimental treatment assigned to plot.
  + CTRL: Control, unrestored salt marsh shoreline.
    - Note: Control “footprints” were mapped to approximate the area of restored reefs (8 m2).
  + OC: Oystercatcher restored reef.
  + SB: Shell bag restored reef.
* ‘Block’: Experimental block within which the plot was located, synonymous with “replicate.” Blocks are numbered 1 through 4 in ascending order from east to west along each shoreline.
* ‘Shoreline’: Identifier of experimental shoreline (ramp or creek).

*Ramp\_ReefFootprints\_20180926*

* ‘ObjectID\*’: Discrete identifier for each polyline in the spatial dataset.
* ‘SHAPE\*’: Geometry type of the spatial data (polygon).
* ‘SHAPE\_Length’: Length of the polygon perimeter (meters).
* ‘SHAPE\_Area’: Area of the polygon (m2)
* ‘Treatment’: Experimental treatment assigned to plot.
  + CTRL: Control, unrestored salt marsh shoreline.
    - Note: Control “footprints” were mapped to approximate the area of restored reefs (8 m2).
  + OC: Oystercatcher restored reef.
  + SB: Shell bag restored reef.
* ‘Block’: Experimental block within which the plot was located, synonymous with “replicate.” Blocks are numbered 1 through 4 in ascending order from east to west along each shoreline.
* ‘Shoreline’: Identifier of experimental shoreline (ramp or creek).

*Ramp\_AMBUR\_Results*

* ‘FID’: Discrete identifier for each point in the spatial dataset.
* ‘Shape\*’: Geometry type of the spatial data (point).
* ‘Transect’: Discrete identifier for each transect cast by AMBUR.
* ‘Tran\_Spac’: Distance between shore-perpendicular transects (meters).
* ‘Tran\_Dist’: Length of the shore-perpendicular transect, i.e. distance between the two specified baselines (meters).
* ‘Num\_Dates’: Number of dates between which shoreline change is being calculated.
* ‘Min\_Date’: Date of the oldest shoreline data.
* ‘Max\_Date’: Date of the newest shoreline data.
* ‘Elp\_Years’: Years elapsed between the oldest and newest shoreline positional measurements.
* ‘EPR’: End-point shoreline change rate between the oldest and newest shoreline positions (meters per year).

*Creek\_AMBUR\_Results*

* ‘FID’: Discrete identifier for each point in the spatial dataset.
* ‘Shape\*’: Geometry type of the spatial data (point).
* ‘Transect’: Discrete identifier for each transect cast by AMBUR.
* ‘Tran\_Spac’: Distance between shore-perpendicular transects (meters).
* ‘Tran\_Dist’: Length of the shore-perpendicular transect, i.e. distance between the two specified baselines (meters).
* ‘Num\_Dates’: Number of dates between which shoreline change is being calculated.
* ‘Min\_Date’: Date of the oldest shoreline data.
* ‘Max\_Date’: Date of the newest shoreline data.
* ‘Elp\_Years’: Years elapsed between the oldest and newest shoreline positional measurements.
* ‘EPR’: End-point shoreline change rate between the oldest and newest shoreline positions (meters per year).

**References**

Dolan, R., M. Fenster, and S. Holme. 1991. Temporal analysis of shoreline recession and accretion. *Journal of Coastal Research* 7: 723–744.

Jackson, C. W., C. R. Alexander, and D. M. Bush. 2012. Application of the AMBUR R package

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Wellman, E. H., C. J. Baillie, B. J. Puckett, S. E. Donaher, S. N. Trackenberg, and R. K. Gittman. 2021. Reef design and site hydrodynamics mediate oyster restoration and marsh stabilization outcomes. *Ecological Applications*, in press.