The Social Costs of Lost Carbon Sequestration Potential in the Delaware Estuary

Porter Hoagland[a], Edward Carr[b], Yosef Shirazi[b], George Parsons[b], Kelly Heber-Dunning[c], Andrew Beet[a]

[a] Marine Policy Center, Woods Hole Oceanographic Institute, Woods Hole, MA 02543
[b] School of Marine Science and Policy, University of Delaware, Newark, DE 19712
[c] Environmental Policy and Planning, Massachusetts Institute of Technology, Cambridge, MA 02139

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1. Background

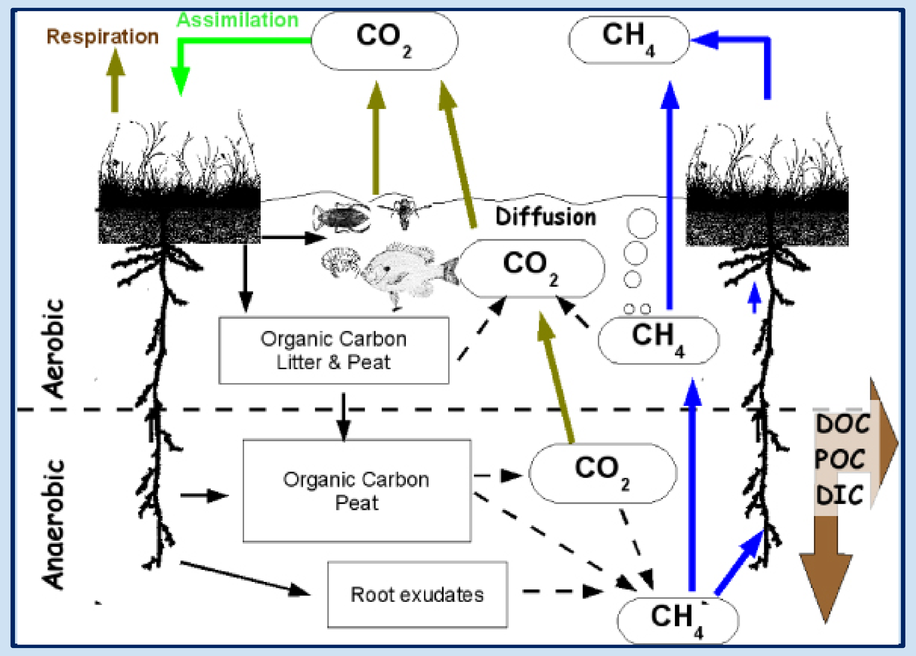
Port facilities located in the major estuaries along the US East and Gulf coasts are preparing to handle the larger "***New Panamax***" class container ships which are set to arrive when the Panama Canal's new third set of longer, wider, and deeper locks opens in 2016.

New Panamax vessels have drafts of up to 50 feet, requiring channel deepening at US East coast estuaries through ongoing public-private dredging projects.

The scales of these projects are unprecedented, and the potential effects on estuarine environments, including flows of ***ecosystem services*** (ESs), are only beginning to be explored. ES value changes may also be affected by human actions to manage water, wetland, and beach resources in both the coastal zones and the relevant water basins.

2. Purpose

One salient hypothesis is that ***channel deepening*** could lead to physical changes in wave interactions with the shore, leading to ***accelerated erosion*** of an estuary's salt marsh. We report on early results of a multidisciplinary research effort to investigate declining economic benefits due to losses of emergent (non-forested) marshes in the Delaware Bay resulting in reduced carbon sequestration. When coupled with models of estuarine physical dynamics, these values can inform both land-use and channel deepening decisions.



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3. Methodology

1. **Identify Emergent Wetland Areas in the Delaware Estuary Coastal Zone**
   - Wetland areas within USGS hydrologic units (HUC10) connected to the estuary
   - Pre-1970 - Hand-delineated from USGS historical topographic maps using GIS
   - 1970 onwards - Identified from National Land Cover Dataset raster files
2. **Measure Historical Change in Wetland Area**
   - We calculated a time series of areal change for identified wetlands using GIS
3. **Apply Carbon Sequestration Rates**
   - We used annual CO_2 sequestration rates for wetlands from the Chesapeake Bay (287 $gC.m^{-2}.yr^{-1}$; Chmura, 2003) to estimate annual carbon sequestration in identified wetlands
4. **Determine Total Area and Average Annual Rate of Wetland Loss**
   - Based on lost wetlands, we estimated the total area lost historically and the average annual rate of wetland loss, which we converted to reduced carbon sequestration rates
5. **Apply Social Cost of Carbon**
   - We evaluated the cost to society, going forward, from historical wetland loss and associated additional atmospheric carbon.

Port of Wilmington, DE. Credit: WHYY/Newsworks

Gandy's Beach, NJ. Credit: Katie Conrad/USFWS

4. Change in Wetland Area

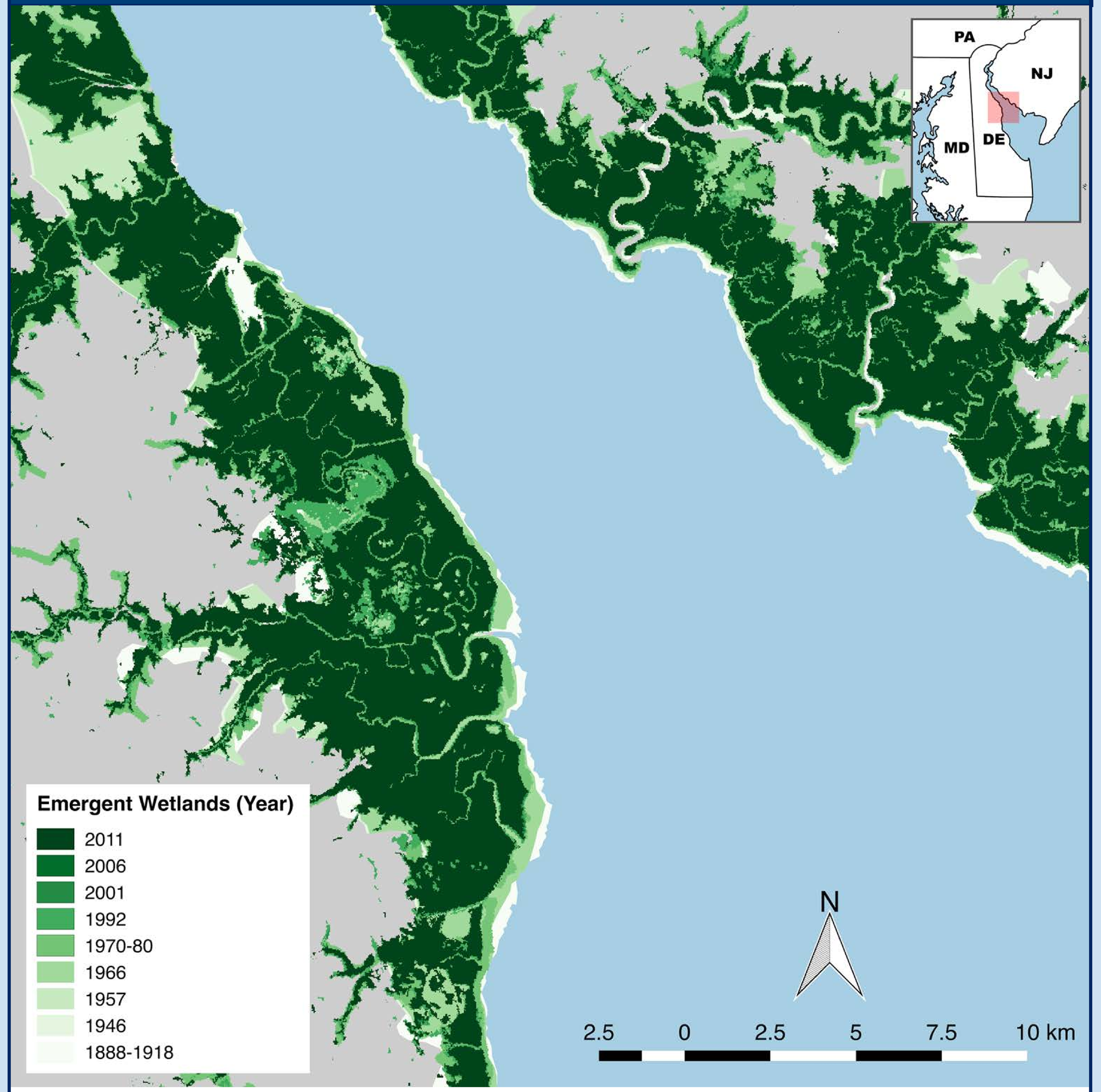


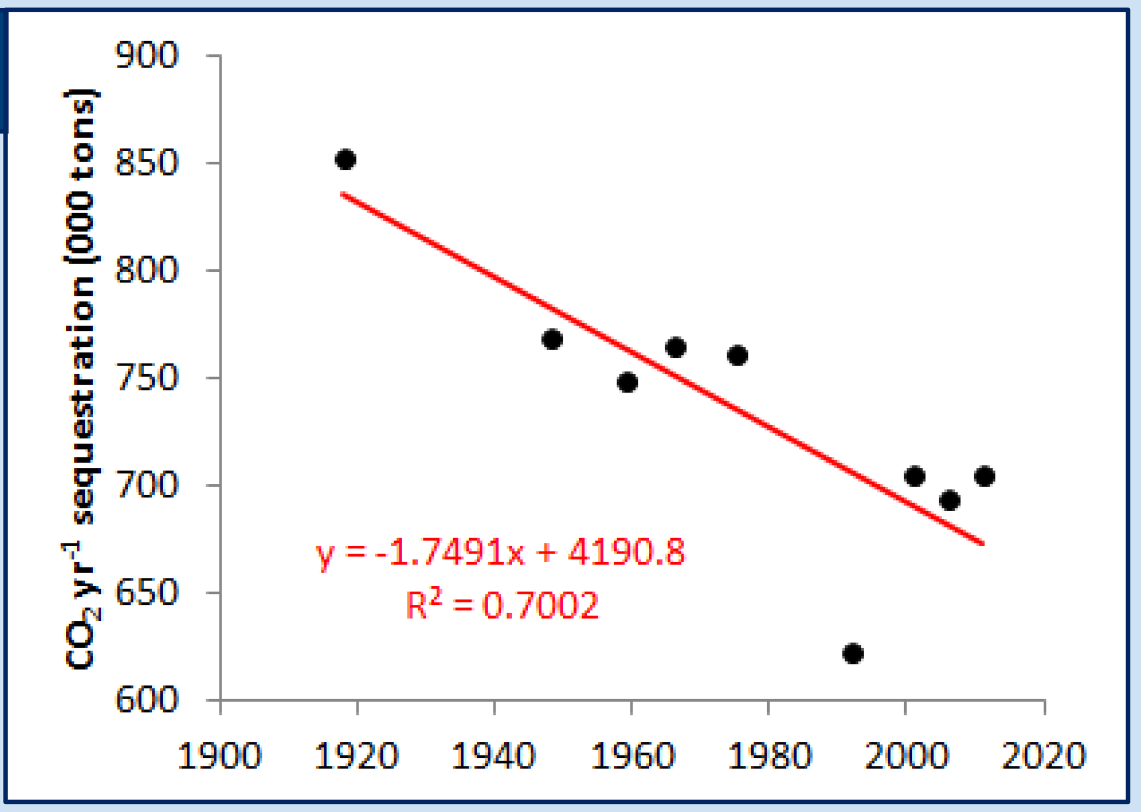
Figure 1: Change in emergent wetland area due to shoreline retreat and coastal squeeze from land use change is clearly visible in the Delaware Bay at Bombay Hook National Wildlife Refuge. Lighter shades show areas where wetlands previously existed. Pre-1918 wetlands were compiled from a mosaic of available USGS topographic maps from between 1888 and 1918.

5. Social Cost of Carbon

The social cost of carbon (SCC) is the cost to society, going forward, from an additional ton of CO_2 released into the atmosphere. SCC estimates vary widely, largely driven by future uncertainty and differing discount rates. A widely-cited meta-analysis by Tol (2009) found mean estimates of $50, a 33rd percentile of $20 and a 99th percentile of $270 (weighted, 3% discount rate, 1995 dollars). The following estimates comprise a policy-relevant range of SCC (in 2015 dollars):

- Lower Bound: $31.60/ton (3% Discount rate; 33rd %ile from Tol, 2009)
- Central Estimate: $40/ton (3% Discount rate; U.S. Government, 2013)
- Upper Bound: $177/ton (3% Discount rate; 90th %ile from Tol, 2009)

6a. Results



6b. Results

- Since 1918, ***Delaware Estuary*** wetland area decreased by 17%, yielding a reduction in sequestration ability. (Compare this to a ~50% wetland loss ***worldwide*** since 1900 [Davidson 2014].)
- Delaware Estuary carbon sequestration was estimated at 898,000 tons CO_2 yr^{-1} in 1918, falling to 741,000 CO_2 yr^{-1} in 2011.
- Historical trends (Section 6a) suggest that annual sequestration falls by 1,749 (± 866; 95% c.i.) tons CO_2 yr^{-1}
- This trend is driven by both shoreline retreat and coastal squeeze due to land use change.
- Satellite imagery and the classification used in 1992 created patchier wetlands compared with the same area in earlier and more recent years.
- At a carbon price of $40 per ton, the reduced ability of the Delaware Estuary wetlands to sequester carbon relative to 1918 incurs social costs of $6.28 million per year, a rate which increases by $0.07 ± $0.03 million per year.
- Calculating the historic rate of wetland loss (Section 6a) and the resulting cumulative loss of sequestration ability over this period, we estimate total additional CO_2 released as 8.3 ± 4.1 million tons, representing social costs of $333 ± $165 million.

7. Related and Ongoing

Topic	Research question	Methodology
Flooding/ Coastal Inundation	What value do people place on flood risk reduction? What are the prefered types of defense?	Stated preference survey among homeowners in high risk flood areas
Salt Migration Upstream	How will users of DE river water respond to increases in salinity? What are the associated costs?	Cost accounting, defensive action, averting behavior
Fishing habitat/water quality	Value changes in fishing experiences as a function of fish abundance	Combined Stated/Revealed preference survey among DE anglers

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