Living Shorelines: Science, Efficacy, and Ecosystem Services
Carolyn Currin
NOAA NOS, Beaufort, NC
Living Shorelines – what’s in a name?
Living Shoreline Science, Efficacy, and Ecosystem Services

This Presentation
• Wave energy attenuation and role in habitat distribution
• Sediment trapping / Elevation Change
• Vegetation
• Sea Level Rise and Coastal Squeeze

Important, For Later
• Carbon sequestration (Davis et al. 2015)
• Nutrient removal/Denitrification
• Faunal Utilization
• Storm resiliency
• Cumulative Impacts Shoreline Hardening

Upcoming Estuaries & Coasts Special Issue
Salt marshes effectively attenuate wave energy and reduce erosion

- 50% of wave energy reduced within 5 m (15’) of marsh edge; >90% over 25 m of marsh (*S. alterniflora*)

- Belowground biomass binds sediments

- Wave energy reduction increases with plant biomass

- Wave energy reduction decreases as inundation depth exceeds canopy height

- Linear Relationship between wave energy or wave power and marsh erosion over large scales, other factors important locally and regionally

Research reviewed in Currin et al. 2017 *Response of salt marshes to wave energy provides guidance for successful living shoreline implementation*. In CRC Press The Science and Management of Nature-based Coastal Protection
Shoreline Change Rate by Shoreline Type

- Sediment banks exhibit highest erosion rates.
- Narrow fringe marsh significantly reduced bank erosion.
- Bank erosion is a source of sediment to NRE.
- $18,600 \text{ m}^3 / \text{yr}$ sediment eroded vs. $12,000 \text{ m}^3 / \text{yr}$ needed for NRE marshes to keep up w/ SLR.
Natural Fringing Marsh Width vs. Wave Energy

- Wave energy calculated using Fetch, wind speed and direction, nearshore bathymetry (WEMo)
- Fringing marsh width determined across wave energy ranges

Width of natural fringing marshes is markedly decreased at RWE > 300

WEMo
Malhotra and Fonseca 2007

Meyer et al 1997 Oysters
Intertidal Oyster Reef Presence / Absence vs. Representative Wave Energy (J/m)

Theuerkauf, SJ et al 2016b EsCo
At low wave energy sites, marshes are narrower when exposed to Boat Wakes.
Living Shoreline Explorer App

http://maps.coastalresilience.org/northcarolina/

Factors Driving Final Score:

1. Representative Wave Energy (WEMo)
2. Estimates Boat Wave Energy
3. Proximity of existing Marsh
Living Shoreline Habitats: resilience ..... and vulnerability to sea level rise

Worldwide 58% of salt marshes were adding elevation at rate > local SLR (Cahoon 2015)

**Sediment supply is crucial parameter**

Rodriguez et al (2014) showed NC oyster reefs grow >1 cm yr$^{-1}$
‘Hybrid’ Living Shoreline Research & Monitoring

4 paired Natural and Sill marsh sites
- Sills built between 2002 - 2004
- Sill heights < MSL, length 20 – 125 m
SETs established at Lower and Upper edge of S. alterniflora
Annual measures of marsh vegetation in permanent plots

NOAA/NERRS Partnership
SET Results Fringing Salt Marshes  Carteret County, NC

Surface elevation change mm / year

<table>
<thead>
<tr>
<th>Marsh</th>
<th>Elevation</th>
<th>mm/yr</th>
<th>n (SETS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nat</td>
<td>Lower</td>
<td>-6.0*</td>
<td>4</td>
</tr>
<tr>
<td>Nat</td>
<td>Upper</td>
<td>-0.1</td>
<td>4</td>
</tr>
<tr>
<td>Sill</td>
<td>Lower</td>
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<tr>
<td>Sill</td>
<td>Upper</td>
<td>3.2*</td>
<td>4</td>
</tr>
</tbody>
</table>

Dynamic process
Long-term monitoring
Vulnerable low marsh

Currin et al. In Press, CRC
SETs as Reference Mark to Measure marsh elevation change Sites

• Surface elevation increase greater in Sill marshes than Natural at both upper and lower edges
• Surface elevation change in Natural marshes significantly different at Upper marsh than Lower marsh edge

Digital Elevation Models
PKS, PI and NCMM Mean Live Stem Density

**PLOT -1 m**

**PLOT 0 m**

**PLOT 5 m**

**Live Stems m²**

**Sampling Date**

**Treatment**
- Nat
- Sill

**Image:** Coastal scene with a scale indicating distances from 0 to 20 m.
Sill sediment accretion resulted in increased *Spartina* biomass at lower edge, loss of low marsh habitat at upper edge. This illustrates **habitats tradeoffs**.
Using Living Shorelines to protect property and Infrastructure

A longer view...

(a) Landward migration

(b) Coastal squeeze

(c) Delayed squeeze
THANKS to J. Davis, J. Fear, B. Puckett, R. Gittman, P. Delano, A. Hilting, M. Greene, M. Piehler, L. Weaver and many others!

Living shorelines support resilient communities.

Living shorelines use plants or other natural elements - sometimes in combination with harder shoreline structures - to stabilize estuarine coasts, bays, and tributaries.

**One square mile** of salt marsh stores the carbon equivalent of **76,000 gal of gas** annually.

Marshes trap sediments from tidal waters, allowing them to grow in elevation as sea level rises. Living shorelines improve **water quality**, provide fisheries **habitat**, increase **biodiversity**, and promote **recreation**.

Marshes and oyster reefs act as **natural barriers to waves**. **15 ft of marsh can absorb 50% of incoming wave energy**.

Living shorelines are **more resilient** against storms than bulkheads.

33% of shorelines in the U.S. will be **hardened by 2100**, decreasing fisheries **habitat and biodiversity**.

Hard shoreline structures like **bulkheads** prevent natural marsh migration and may create **seaward erosion**.

The National Centers for Coastal Ocean Science | coastalscience.noaa.gov