Living Shorelines

Non-structural Erosion Control Practices
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Project Supported By:

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Outline

• Setting the Stage
• Traditional Protection Strategies
  – Structural vs. non-structural
• Evolving Shoreline Practices
  – Concepts and techniques
• Narrow River Pilot Project
  – Site suitability
  – Permits and regulations
  – Project Timeline
Setting the Stage
Rhode Island’s changing coastline

• **Historical habitat loss**
  – 50% decrease in saltmarsh habitat, 4,000 acres (Bertness 2006)
  – 91% loss of shellfish reef habitat, 750 acres (Brown 2013)

• **New challenges**
  – Sea level rise
    • Wetlands can keep pace with up to 2.5 mm of sea-level rise per year
  – Coastal erosion
    • Accelerated by storm surge, wave energy, and chronic human-use impacts such as boat wakes
Marsh Erosion is Natural
...in a balanced state

- Waves and Wakes
- Tidal Currents
- Sediment Supply
- Sediment Type
- Biological Stabilization (Mussels) and Destabilization (Crabs)
- Sediment Movement
- Sediment Supply
- Sediment Mobility
- Erosion or Accretion

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Shoreline Protection

**Hard/Structural Practices**

- **Definition**
  - Erosion control practices using hard structures that armor and stabilize the shoreline

- **Examples**
  - Bulkheads, concrete seawalls, rip-rap, groins, breakwaters, stone reinforcement

- **30% of RI’s shoreline is armored** (Hehre, 2007; Freedman, 2012)
  - 30% of Narragansett Bay
  - 20% of South County and Washington County
Shoreline Protection

Hard/Structural Practices

• Potential Benefits
  – Can slow down rates of landward erosion, particularly in high energy environments (NOAA, 2009)

• Potential Drawbacks
  – Often exacerbates erosion seaward of hardened structure
  – Impacts wetland and intertidal habitat
  – Interferes with coastal access
  – Diminishes coastal processes and services
Shoreline Protection
Detroit riprap

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Shoreline Protection

*Hard/Structural Practices*

*Before*

*After*

Landward migration of tidal wetlands

*After with bulkhead*

Drowning of tidal wetlands

Hard structures preclude landward migration of tidal wetlands,
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Soft/Non-structural

• Definition
  – Shoreline erosion control and restoration practices using only plantings and organic materials to restore, protect or enhance the natural shoreline environment

• Examples
  – Vegetation plantings (marsh, submerged aquatic vegetation, dune grasses), coir fiber logs and matting, coir wattle, oyster shell substrate, live oysters and ribbed mussels
Shoreline Protection

*Soft/Non-structural*

- **Potential Benefits**
  - Reduce bank erosion and property loss
  - Provide an attractive natural appearance
  - Improve marine habitat & spawning areas
  - Improve water quality and clarity

- **Potential Drawbacks**
  - Not suitable for high energy environments
  - Requires ongoing maintenance
  - Typically requires trained contractors who may be less familiar with soft stabilization techniques
Coir Log Warning!

- Use only premium coir logs
- Re-wrap logs in high fiber matting
- Don’t spear the logs, double stake on either side
- Secure stakes with nylon not fiber rope
- Don’t place logs directly in front of marsh banks, must be set at least 2-ft from bank
Protection Strategies

Soft/Non-structural

What not to do!
What to do!

**DELSI project**

- **Goal**: develop strategies for Delaware Bay that incorporate local native vegetation and shellfish
- **Design**: installed multiple configurations of coir log and mat
- **Results**: vegetative treatments attenuated waves, reduced erosion, trapped sediments, produced micro-phytobenthos, attracted ribbed mussels
- **Optimal Configuration**: two rows of logs over mat with shell bags in front
Coir logs
DELSI design
Shellfish Reefs

- Natural integration into saltmarsh habitat
- Enhance sedimentation
- Sedimentation is a factor of sediment supply and reef design (height, width)
- Reduces re-suspension and improves water clarity
- Not the solution to shoreline protection but can protect marsh habitat and enhance ecosystem services (e.g., fish production, denitrification)

A. Oyster reef and B. ribbed mussel reef complex associate with saltmarsh habitat (©Brown, TNC). C. Conceptual plan for living shoreline practices (©DELSI).
Shellfish Reefs

Ecosystem Services

- **Habitat enhancement** – complexity and vertical structure provides food and refuge, stimulates abundance and diversity
  - $1,669 to $14,170 acre-year (Grabowski & Peterson 2007)
- **Nutrient removal** – assimilation, denitrification, burial – eutrophication mitigation
  - $560 to $2,719 acre-year (Kellog 2011)
- **Benthic stabilization** – erosion prevention, sediment enhancement and deposition, nutrient deposition
  - $14,574 to $34,817 acre-year (Kroeger and Guannel 2013)
  - Wave height reduced by 51-90°
  - Wave energy reduced by 76-99°
Vertically Complex Reefs

Sedimentation rates

- High relief reef attenuated waves and enhanced sedimentation landward of reefs
- High relief reefs (50 cm): 56 to 122 g m$^{-2}$/week
- Low relief reefs (15 cm): 22 to 36 g m$^{-2}$/week
- Varies by sedimentary landscape
- Oyster settlement and survival was a magnitude higher on high relief versus low

Materials needed for 50-ft. oyster sill, ©Brown, TNC.
Alternative Substrates
Oyster Castles
Shellfish Reef Design

Wave Attenuation

- Nearshore Waves Tool
- Attenuation is a function of the incident wave height, reef physical characteristics (height, crest and base width), as well as its location along the 1D profile.
- Reefs close to the water surface can be quite efficient breakwaters and transmit 3% of the incident wave height.
Greater wave dissipation associate with wider reefs and reefs higher than MSL (Beck, 2011)

Adopted from Scyphers, 2011
Shoreline Strategies
Tradeoffs between Structural and Non-Structural

- Trade-offs
  - Wave characteristics
  - Prevailing tides
  - Distance to shore
  - Slope
  - Bathymetry
- Numerous site selection tools available
  - DELSI model
  - SCDNR model
  - VIMS site checklist

©VIMS, 2010
Project Costs
*Includes fabrication, transport, and installation*

- **DELSI Living Shoreline** *(coir logs, plugs, shell bags)*
  - Estimated $50 to $100 per linear ft.

- **Shellfish Reef**
  - Estimated $5 to $150 per linear ft.
    - Reef Ball $54 per linear ft.
    - Oyster Castle $45 per linear ft.
    - Oyster Breaks $112 per linear ft.
    - Oyster Shell Bags $5 per linear ft.

- **Marsh Stone Sill** $300 to $480
Narrow River
Shoreline Protection Project

• **Problem** – incremental loss of low marsh
• USFWS and TNC erosion study documented:
  – Accelerated lateral erosion near navigational channels
  – Mechanical weakening of marsh bank (loss of surface vegetation, undercutting of supporting sediments, bank collapse)
  – Multiple stressors compounded by Sea Level Rise (SLR)
• **Objective** – identify and implement non-structural erosion control practices that protects marsh banks and enhances services (fish production, nitrogen removal)
Rebar stake (marsh loss 0.2 ft./yr.) , 2012

Rebar stake set 1-ft back from marsh edge, 2010

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Narrow River
Site Suitability

• Suitable
  – Fetch < 2 miles, Narrow River

• Not Suitable
  – Fetch < 2 miles, Narragansett Bay
Narrow River

Site Suitability

- **Bathymetry**
  - Suitable: ≤2 feet MLW

- **Slope**
  - Suitable: ≤20%
Narrow River
Site Suitability

• Habitat suitability, field surveys, and population monitoring shows promise
• Shellfish settlement
  • 58.4 ind\(\cdot\)m\(^{-2}\) Upper Reach, 2012
  • 25.6 ind\(\cdot\)m\(^{-2}\) Sedge Island, 2012
• Shellfish reefs will improve fishery resources
• Shellfish reefs are sustainable
  • Sediment burial is unlikely if well-engineered and vertically complex

Shellfish reef complex, 2011.

Oyster spat settlement collector, 2012.
Site Conditions
- Slope must be less than 20%
- Height of oyster sill must be equal to or greater than mean high water
- Maximum wave height ($H_{max}$) ranged from 5.47 to 11.62 cm
- Tidal range is 7-12 inches, 7-in at middle bridge and 11-in at Sprague bridge
- Factor in 12-in for tidal range
Permits & Regulations

• Construction of new hardened structures in **Type 1 (Conservation Areas)** waters is prohibited

• When structural shoreline protection is proposed, the owner exhaust all reasonable and practical alternatives (Section 300.7.E.1).

• **Erosion Control Permits**
  - RI DEM Water Quality Permit
  - RI CRMC Assent
  - ACOE Category 1 “fill”
Narrow River Evaluation Project Timeline

**Phase I** – establish baseline information on salt marsh and shellfish populations; permit application and coordination with partners; expected date of completion **January 2014**

**Phase II** – site installation (restoration); expected date of completion is **May 2014**

**Phase III** – post-restoration monitoring for two years; expected date of completion is **January 2016**
Questions, Comments?

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