Living Shorelines

Non-structural Erosion Control Practices
Rhode Island Land & Water Summit, 2014

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United States Fish and Wildlife Service

Project Supported By:

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

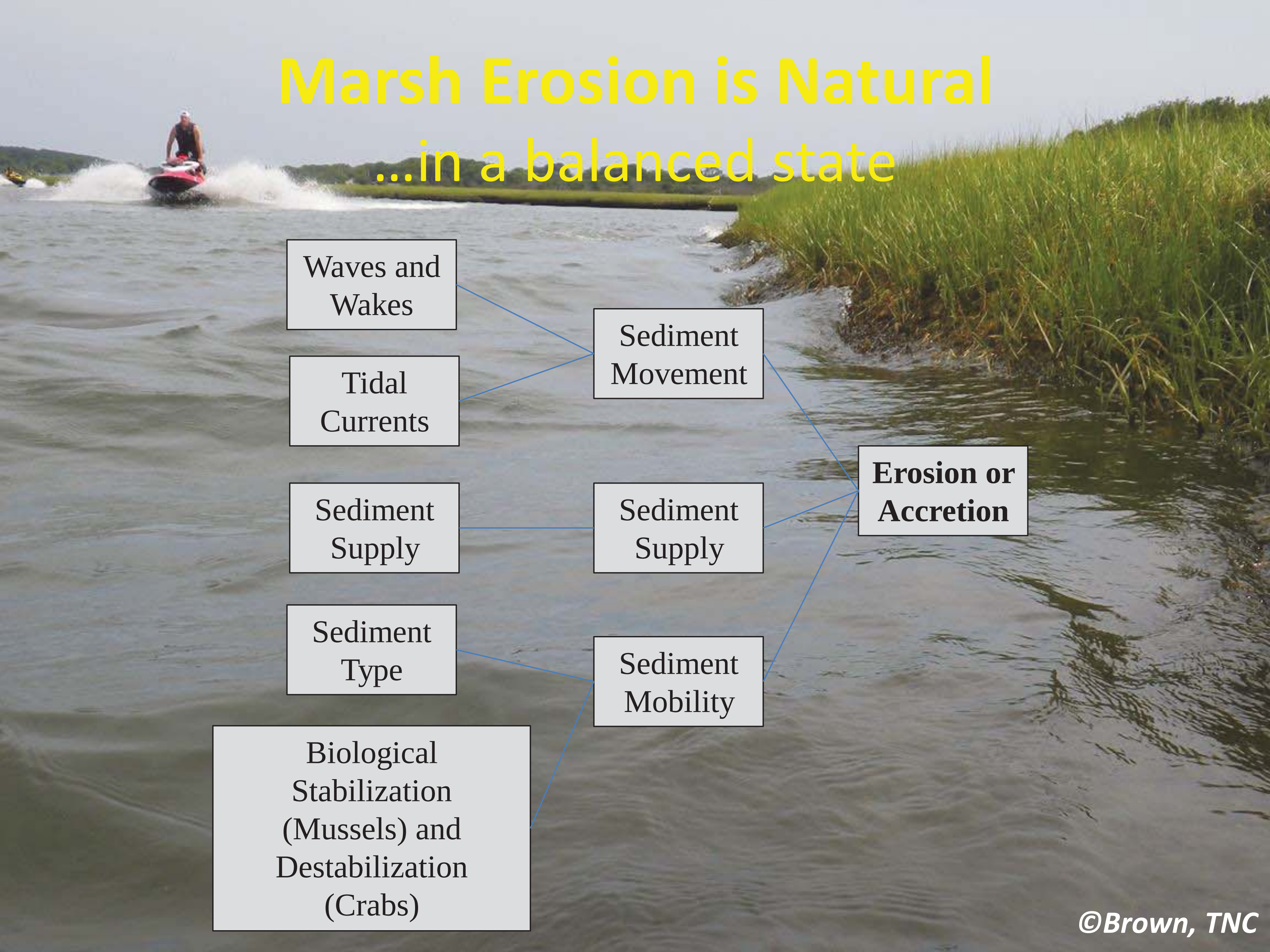
Setting the Stage

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

Image: wetland peat beneath an exposed tidal flat, evidence of sea-level rise and landward migration of the shoreline, ©Brown, TNC

Image: eroding fringe marsh and remnant peat colonized by mussels, evidence of marsh loss, ©Brown, TNC


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
©Brown, TNC

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

Wooden bulkhead, ©VIMS

Stone Riprap, ©VIMS

Rock gabion, ©UK NE

Shoreline Protection

Hard/Structural Practices

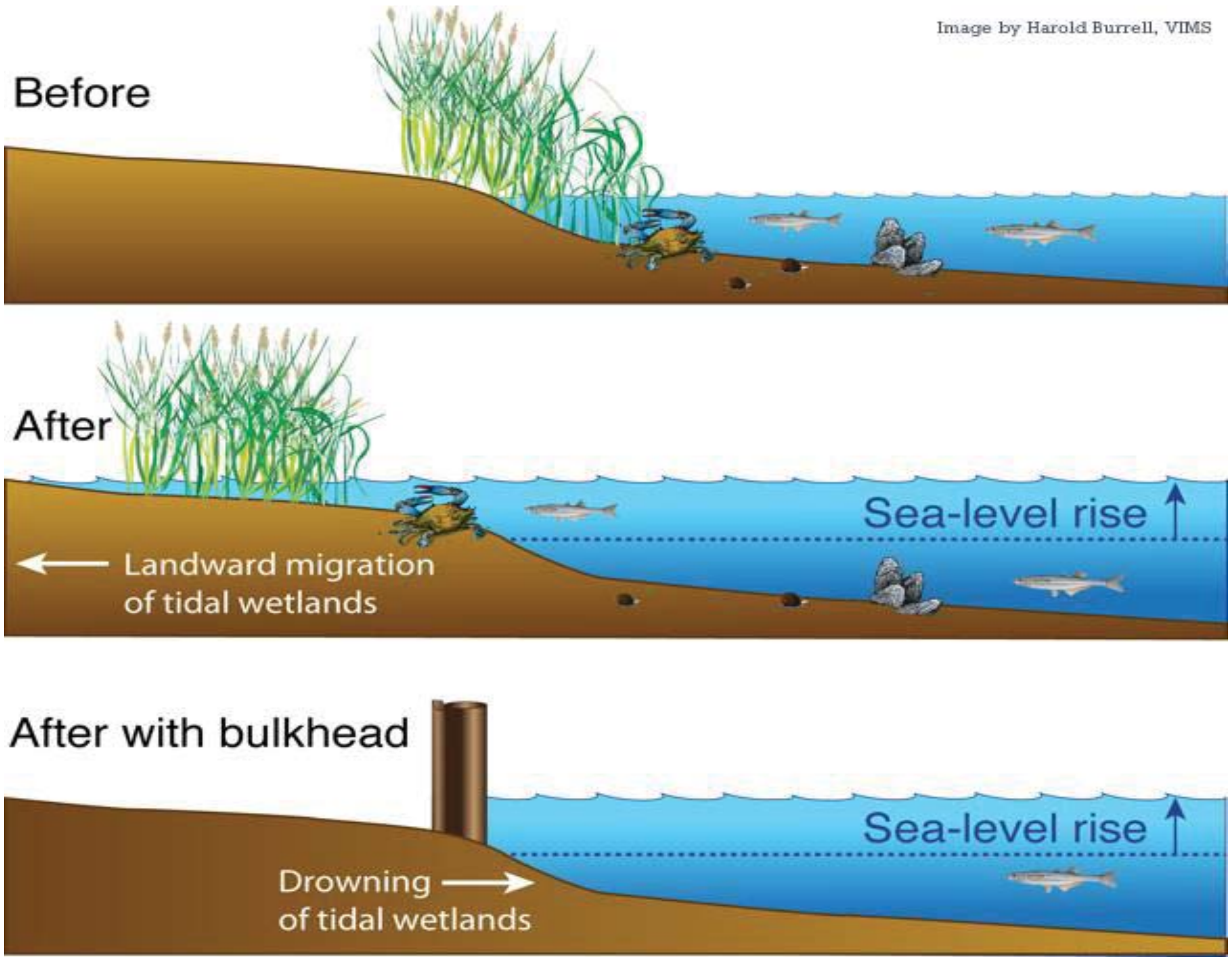
- **Potential Benefits**
  - Can slow down rates of landward erosion, particularly in high energy environments (NOAA, 2009)
- **Potential Drawbacks**
  - Often exacerbates erosion seaward of hardened structure
  - Impacts wetland and intertidal habitat
  - Interferes with coastal access
  - Diminishes coastal processes and services

Shoreline Protection

Detroit riprap

Shoreline Protection

Hard/Structural Practices



Hard structures preclude landward migration of tidal wetlands, ©Harold Burrell

Shoreline Protection

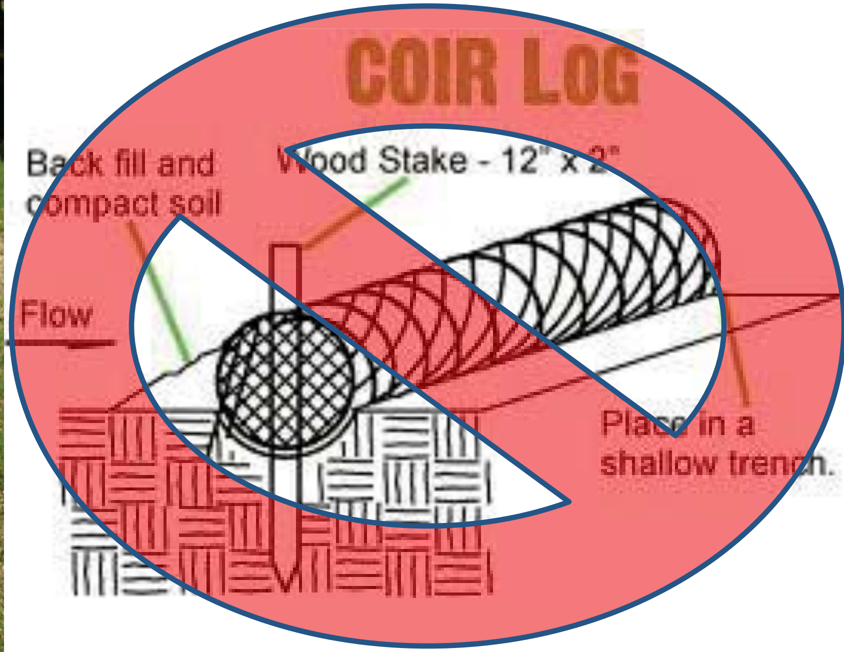
Soft/Non-structural

- **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!

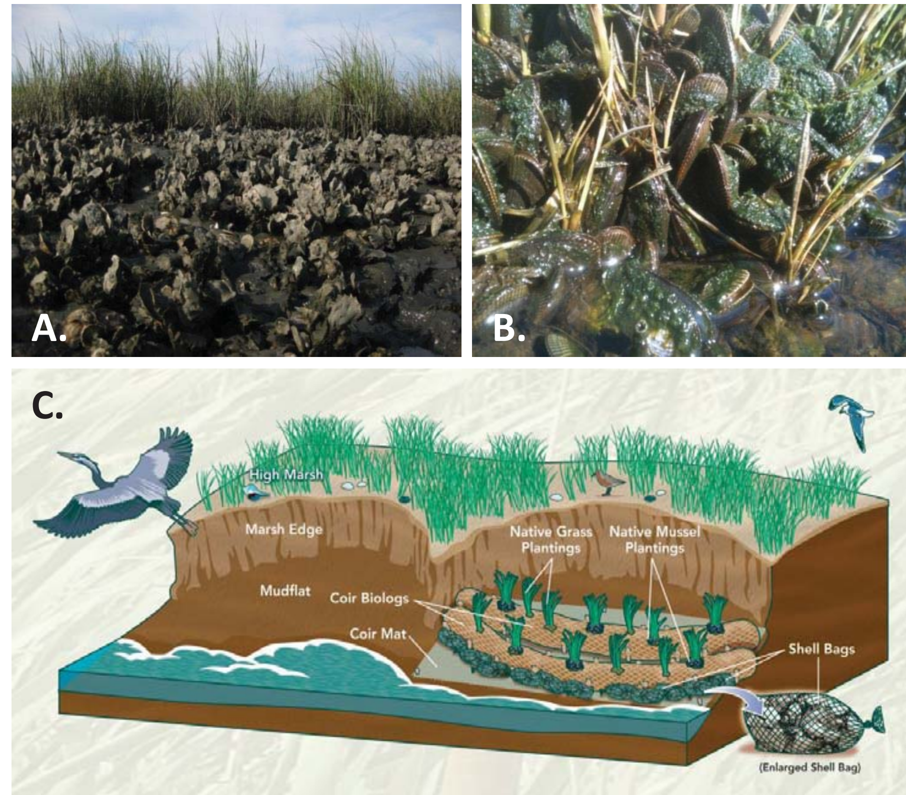
DELSI project

- **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

Materials needed for 50-ft. oyster sill, ©Brown, TNC.

- 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

Recruitment

After 18 months

After 6 months

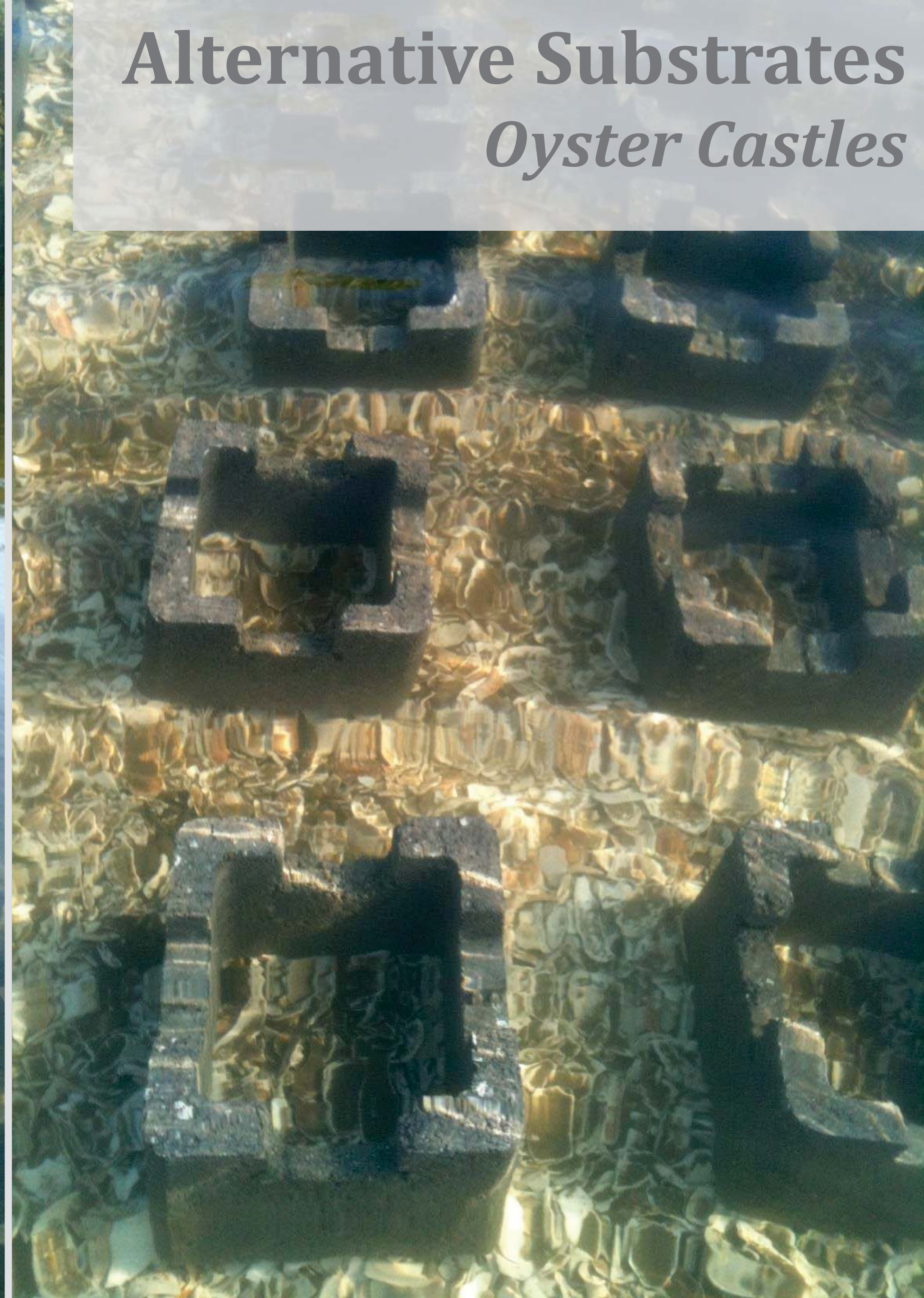

Oyster Sill
Bagged Shell
©Erika Nortemann, TNC

Oyster Sill
Bagged Shell

©Erika Nortemann, TNC

Alternative Substrates

Oyster Castles



Alternative Substrates
Oyster Castles

©Erika Nortemann, TNC

Alternative Substrates

Oyster Castles

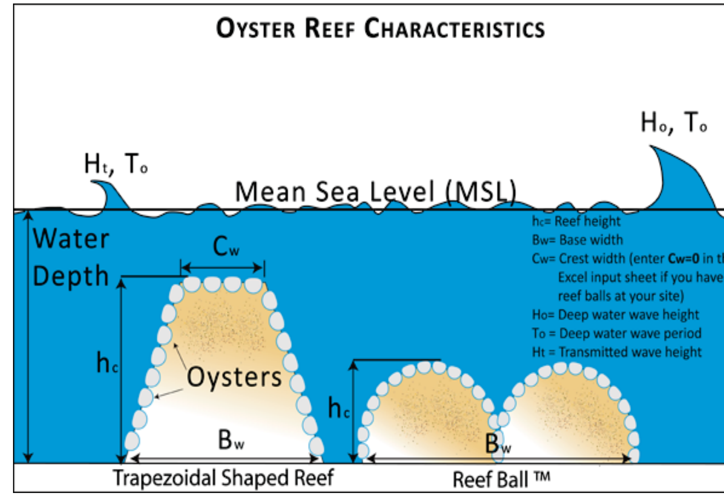
Alternative Substrates

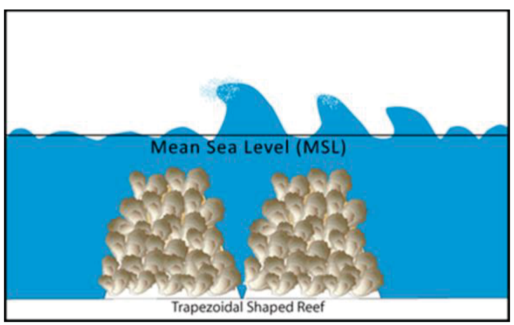
Oyster Castles

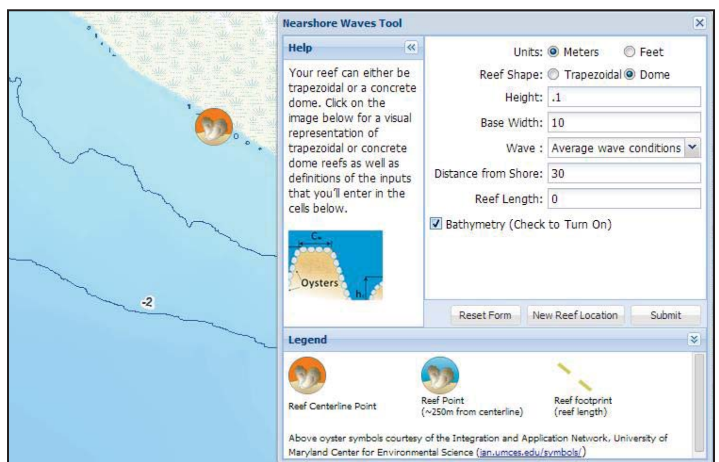
©Erika Nortemann, TNC

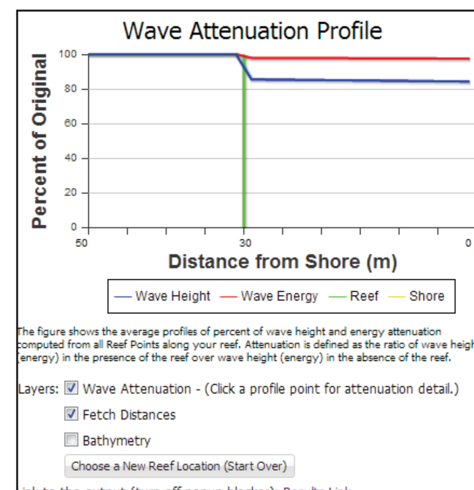
Shellfish Reef Design
Wave Attenuation

- 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









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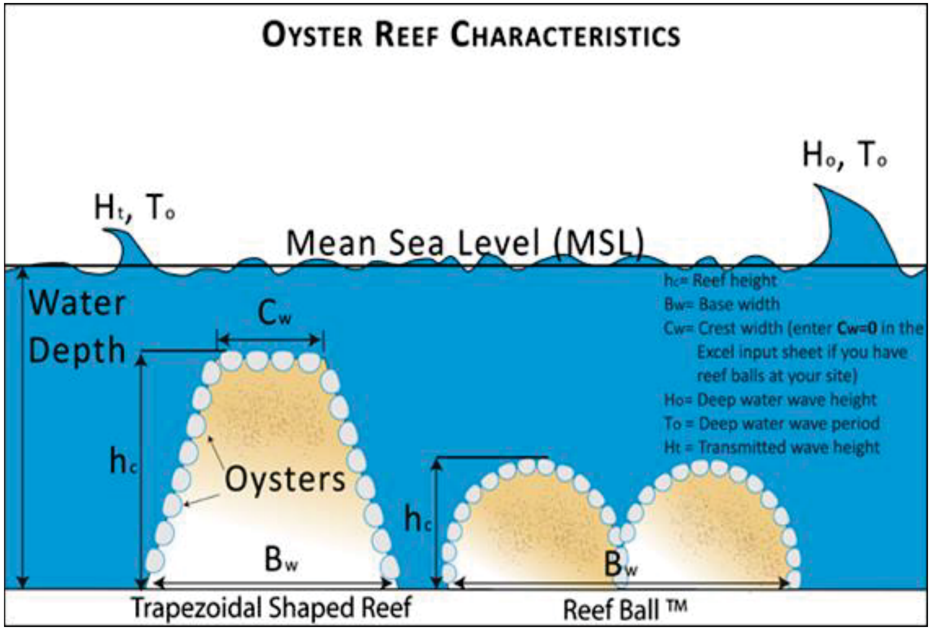
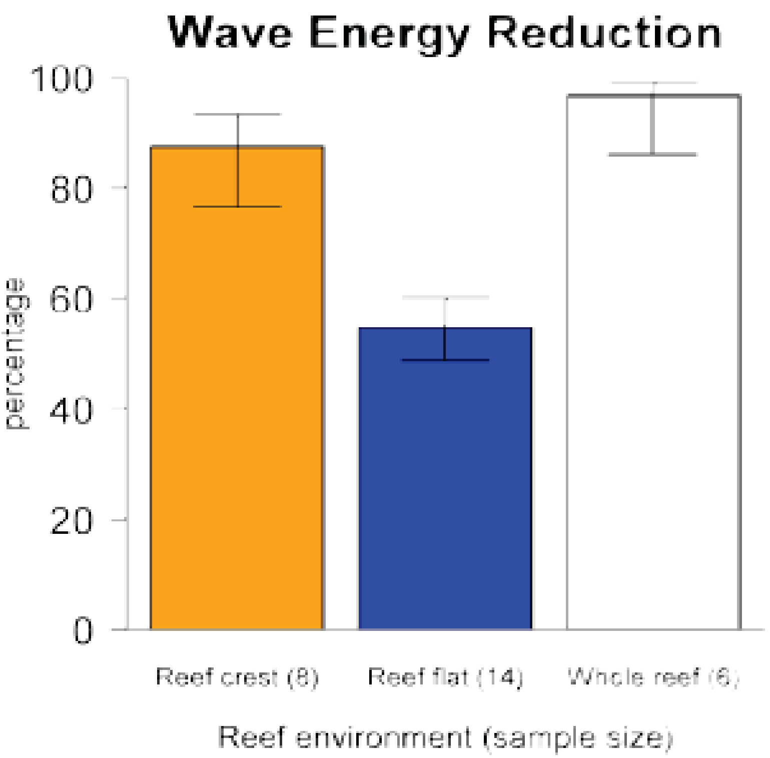
natural capital PROJECT

Shellfish Reef Design
Wave Attenuation





Greater wave dissipation associate with wider reefs and reefs higher than MSL (Beck, 2011)

Adopted from Scyphers, 2011

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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

WHICH PROJECT IS RIGHT FOR MY SITE?

(source: MD Department of Natural Resources)

Site Conditions	Low Energy (Nonstructural)	Medium Energy (Hybrid)		High Energy (Structural)
Shoreline Location	creek or cove	minor river	major tributary	mainstem Bay
Water Depth (ft/near shore)	-1.0	-1.0 to -2.0	2.0 to -4.0	-4.0 to -15.0
Fetch (mi/distance to nearest opposite shore)	0.5	1.0 to 1.5	2.0 or more	2.0 or more
Erosion Rate (ft/yr)	2 or less	2 to 4	4 to 8	8 to 20
Erosion Control Treatment Options	Nonstructural projects	Hybrid Project		Structural Projects
	beach replenishment	marsh fringe w/groins		bulkheads
	marsh fringe	marsh fringe w/sills		revetments
	marshy islands	marsh fringe w/breakwaters		stone reinforcing
	biologs, groins	beach replenishment w/breakwaters		groins and jetties
Cost per foot	$50-100	$150-300	$350-500	$500-1,200

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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** $300to $480

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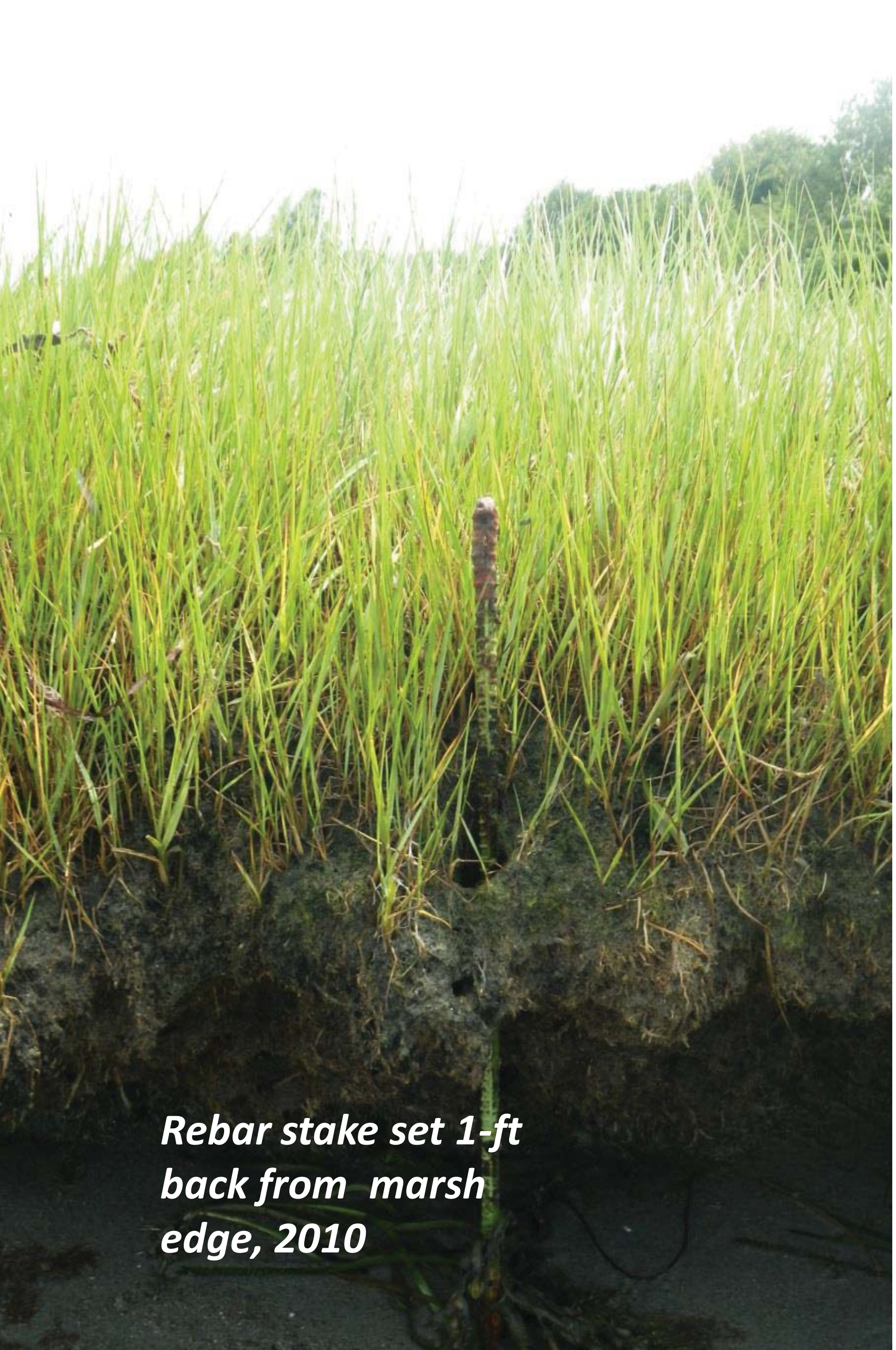
Narrow River Shoreline Protection Project

- **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)


©Brown, TNC

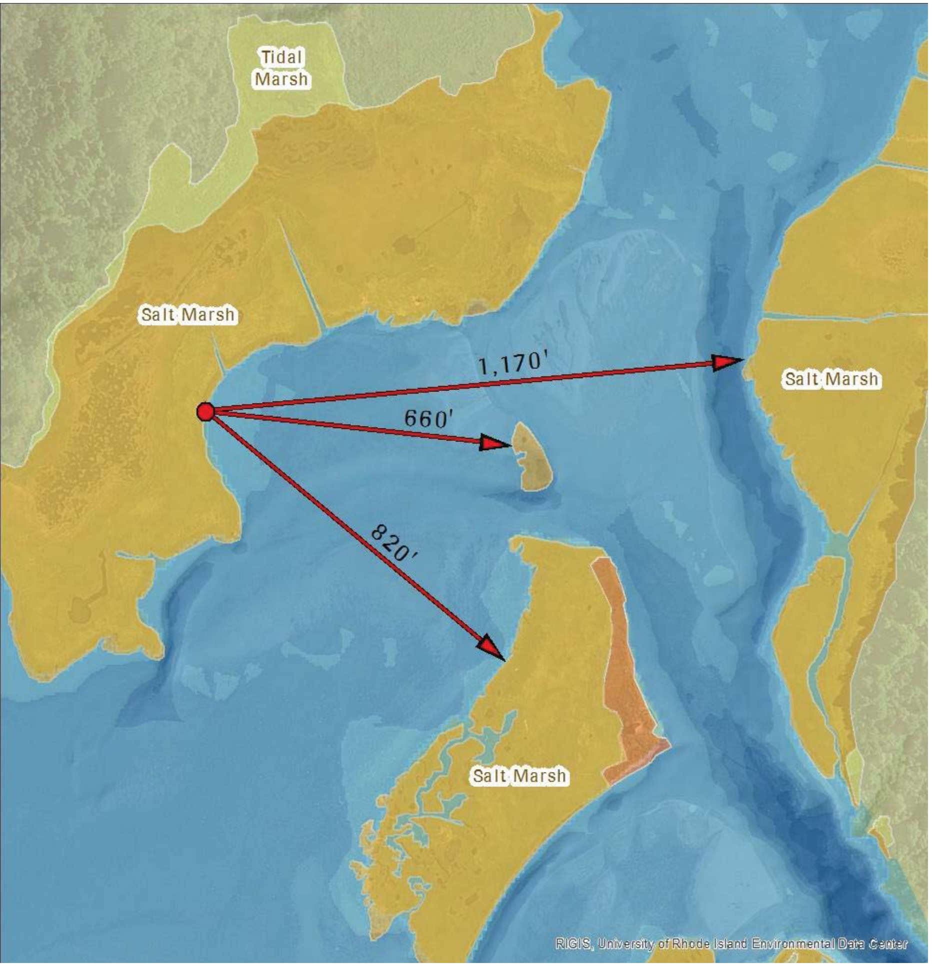

Rebar stake set 1-ft
back from marsh
edge, 2010

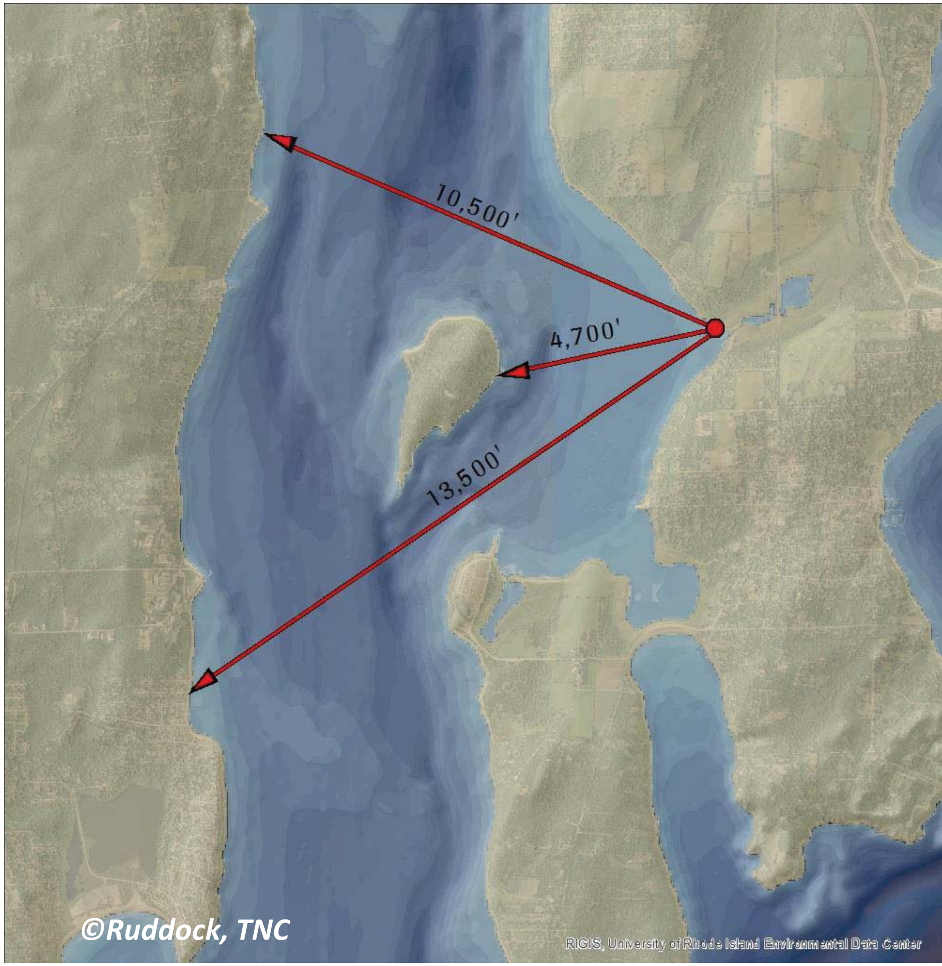

Rebar stake (marsh
loss 0.2 ft./yr.) , 2012
©Brown, TNC

Narrow River
Site Suitability

©Ruddock, TNC

Narrow River
Site Suitability

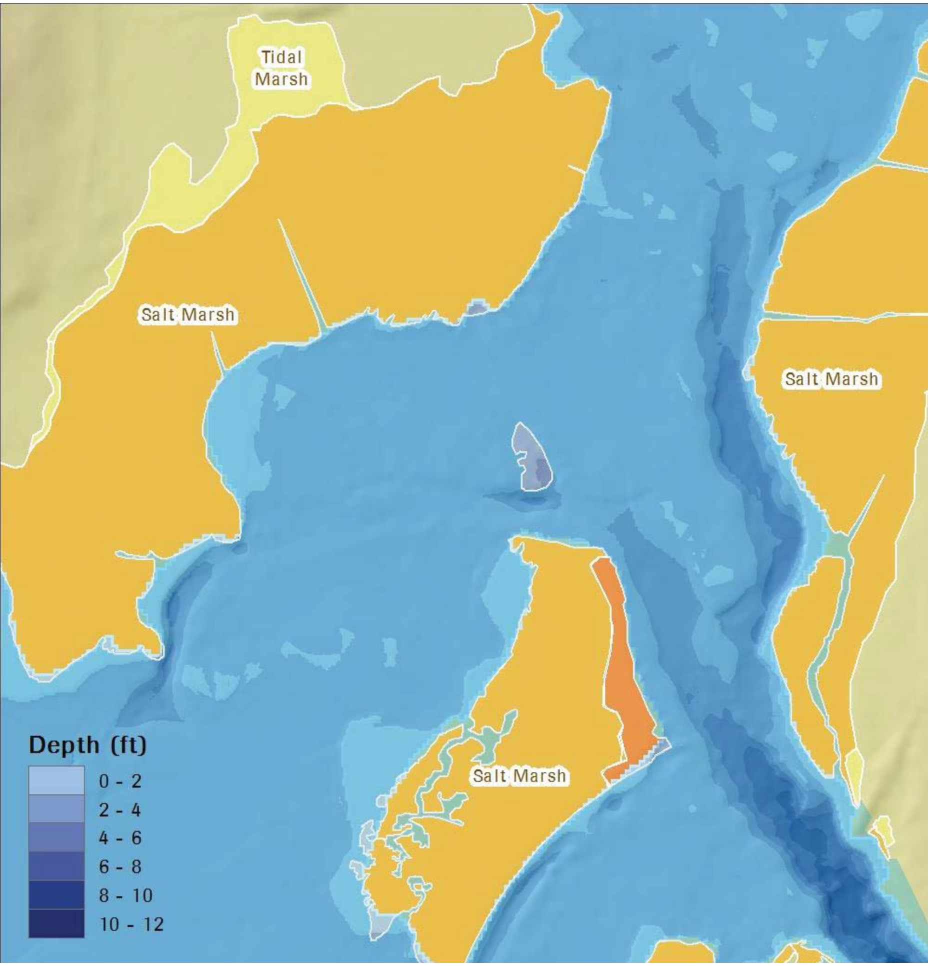


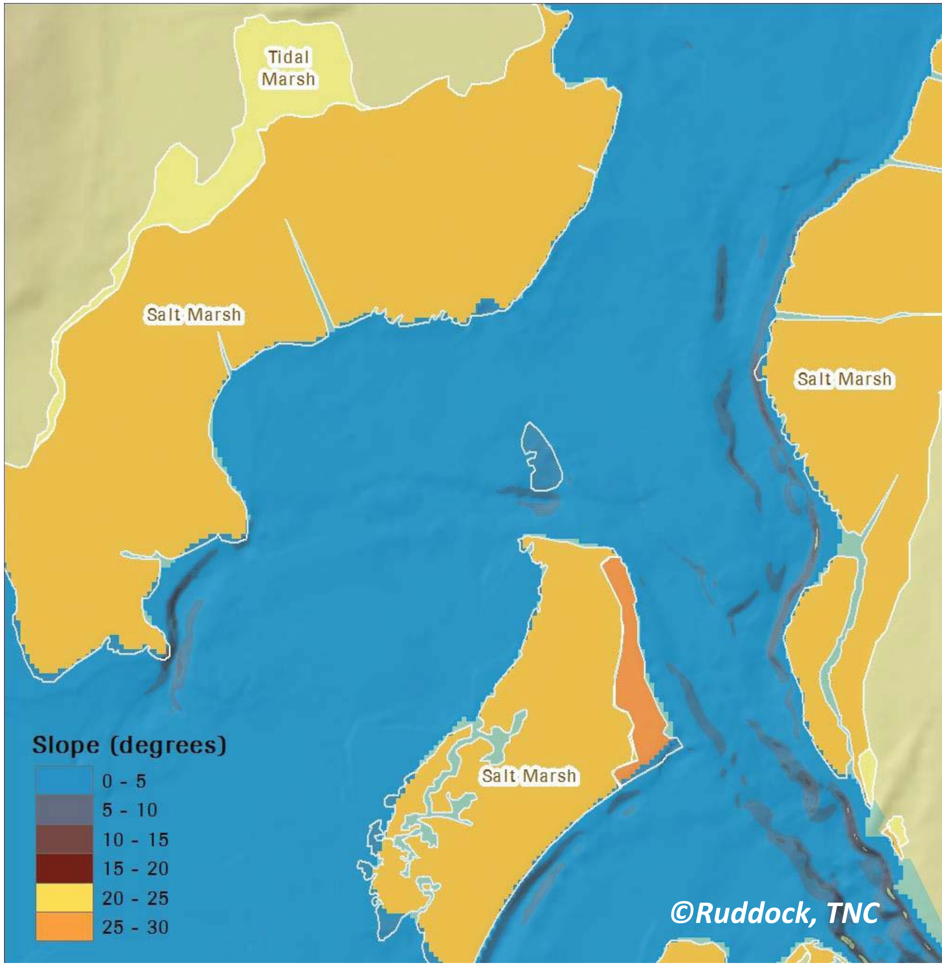


- **Suitable**
  - Fetch < 2 miles, Narrow River
- **Not Suitable**
  - Fetch < 2 miles, Narragansett Bay

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∘m^{-2} Upper Reach, 2012
    - 25.6 ind∘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

Oyster spat settlement collector, 2012.

Shellfish reef complex, 2011.

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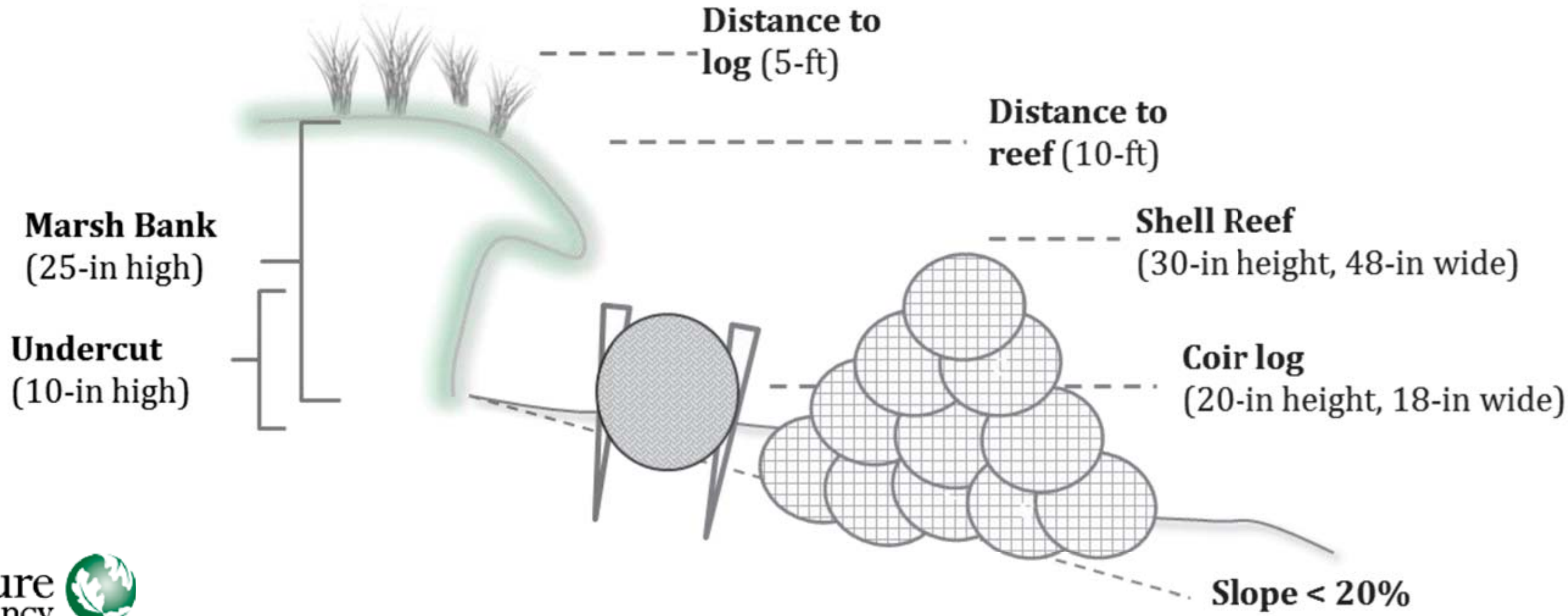
Project Design

Coir log and oyster sill, Narrow River

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



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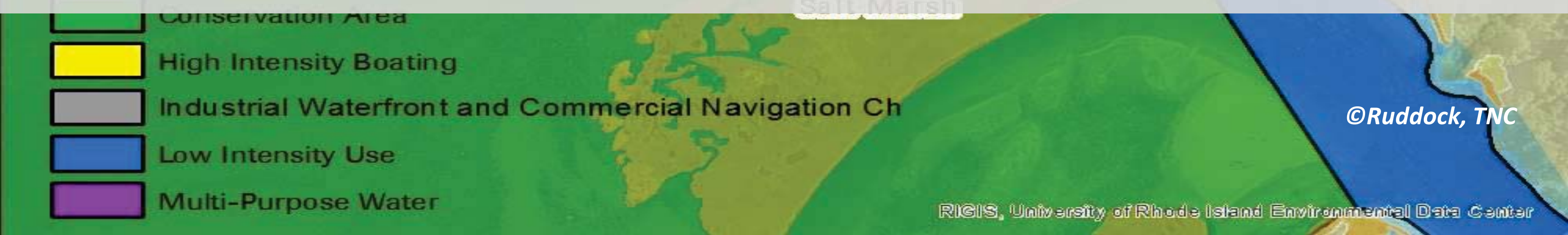
Permits & Regulations

- 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**

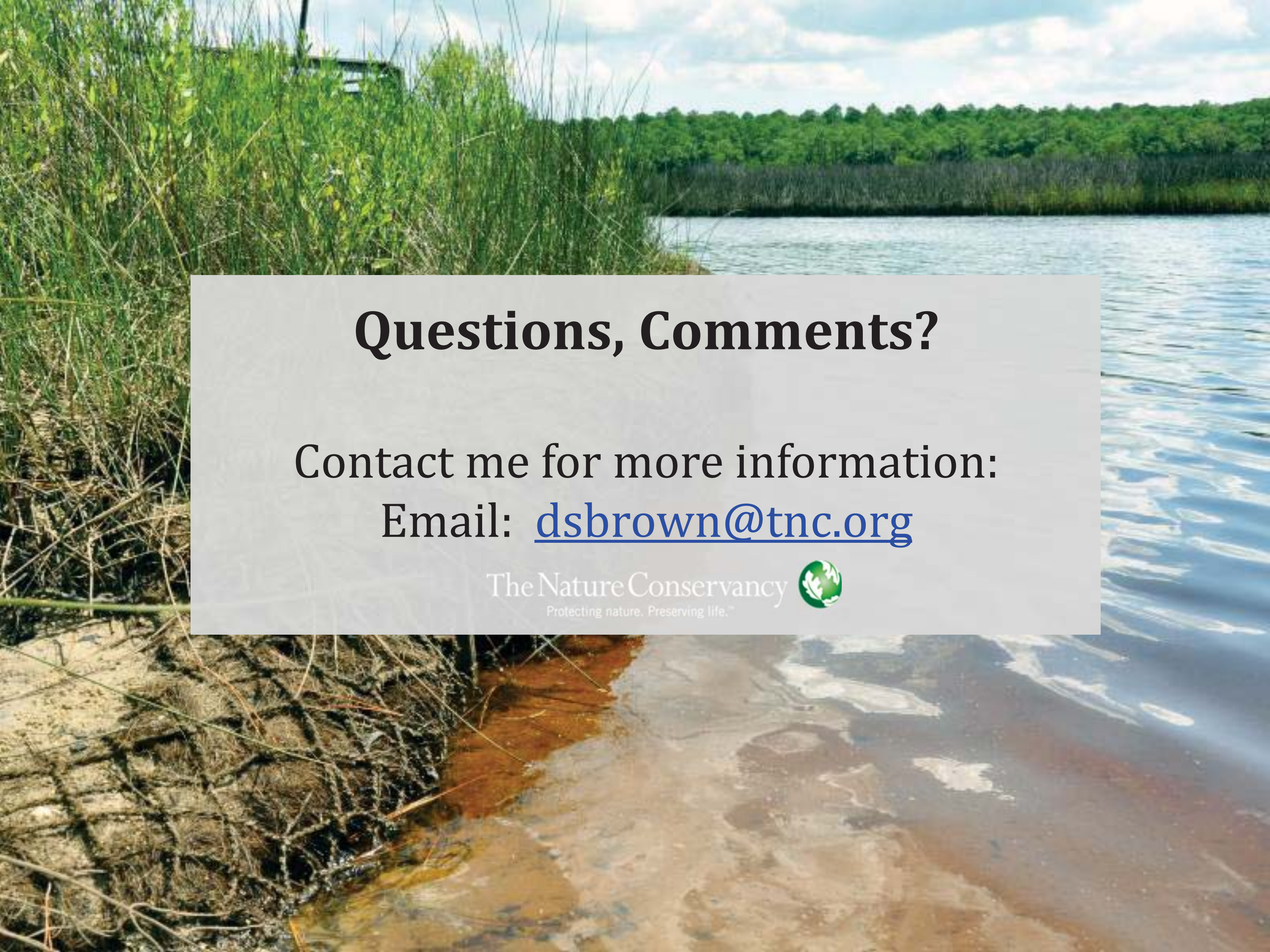
Phase II – site installation (restoration); expected date of completion is **May 2014**

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

Identify Sites

Installation

Monitor results



Questions, Comments?

Contact me for more information:
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