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Adaptive Management Strategies for Resilient Coastlines: A Case Study on the Ft. Pierce, FL Breakwater Project

USACE Workshop
November 21st, 2013

By: Jenna Phillips

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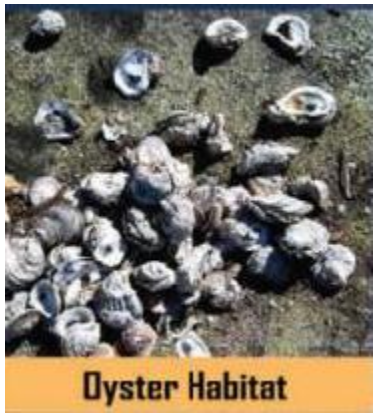
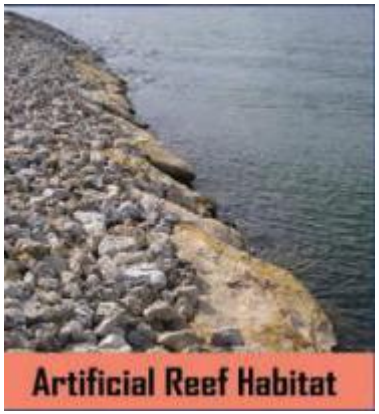
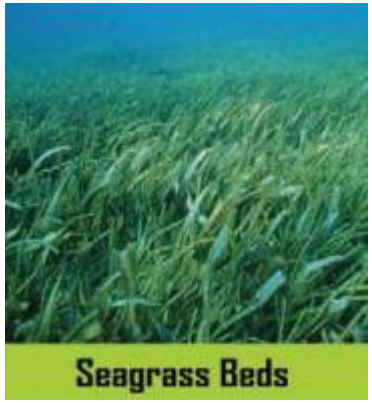
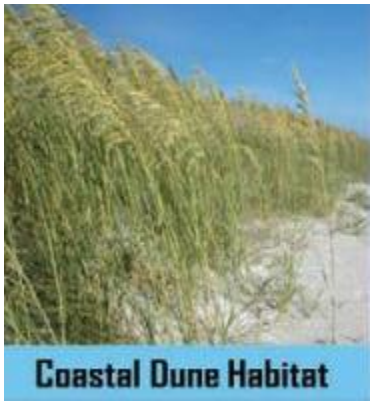
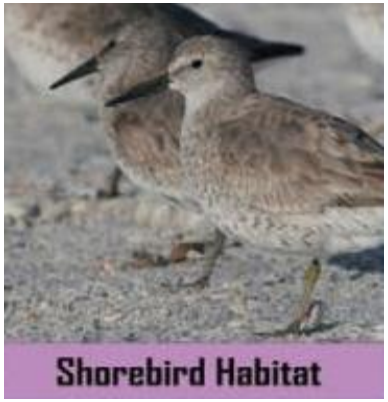
Emphasis on “Green” or “Nature-Based” Engineering Solutions for Resiliency

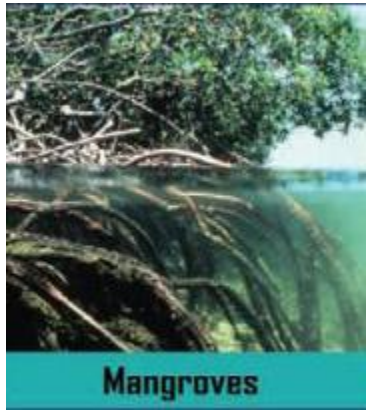












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OUTLINE

- Background & Project Goals
- Construction
  - Materials
  - Tolerances
  - Site Conditions
  - Installation
- Lessons Learned

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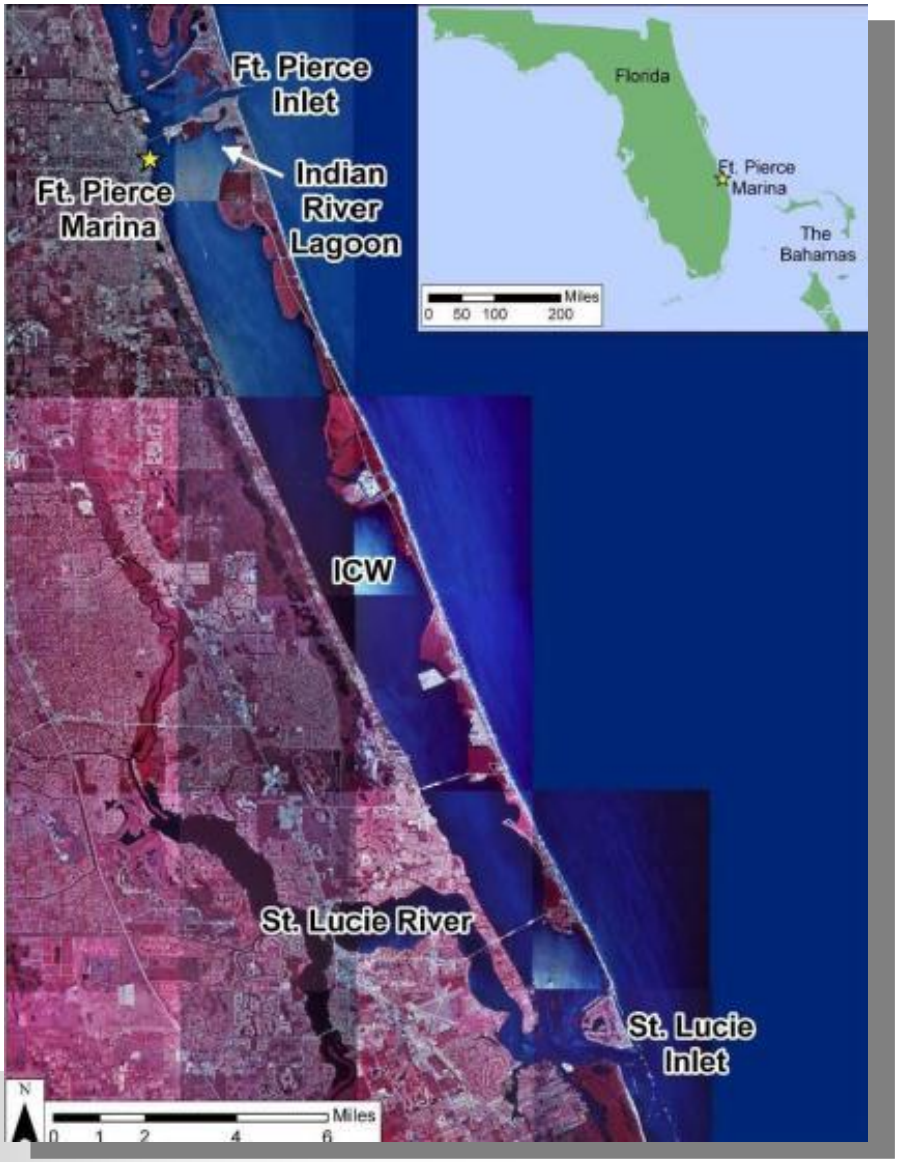
Project Location



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Project Location

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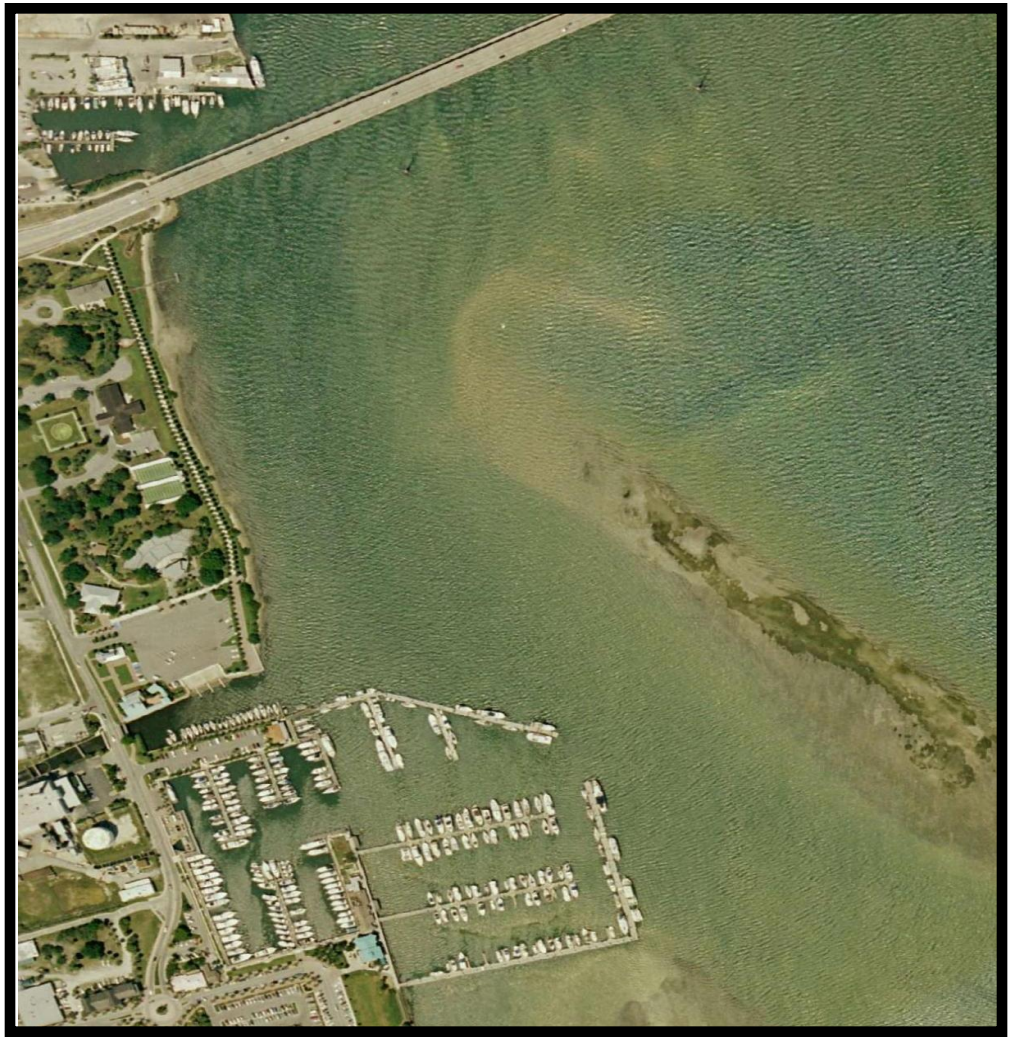
Original Marina Layout



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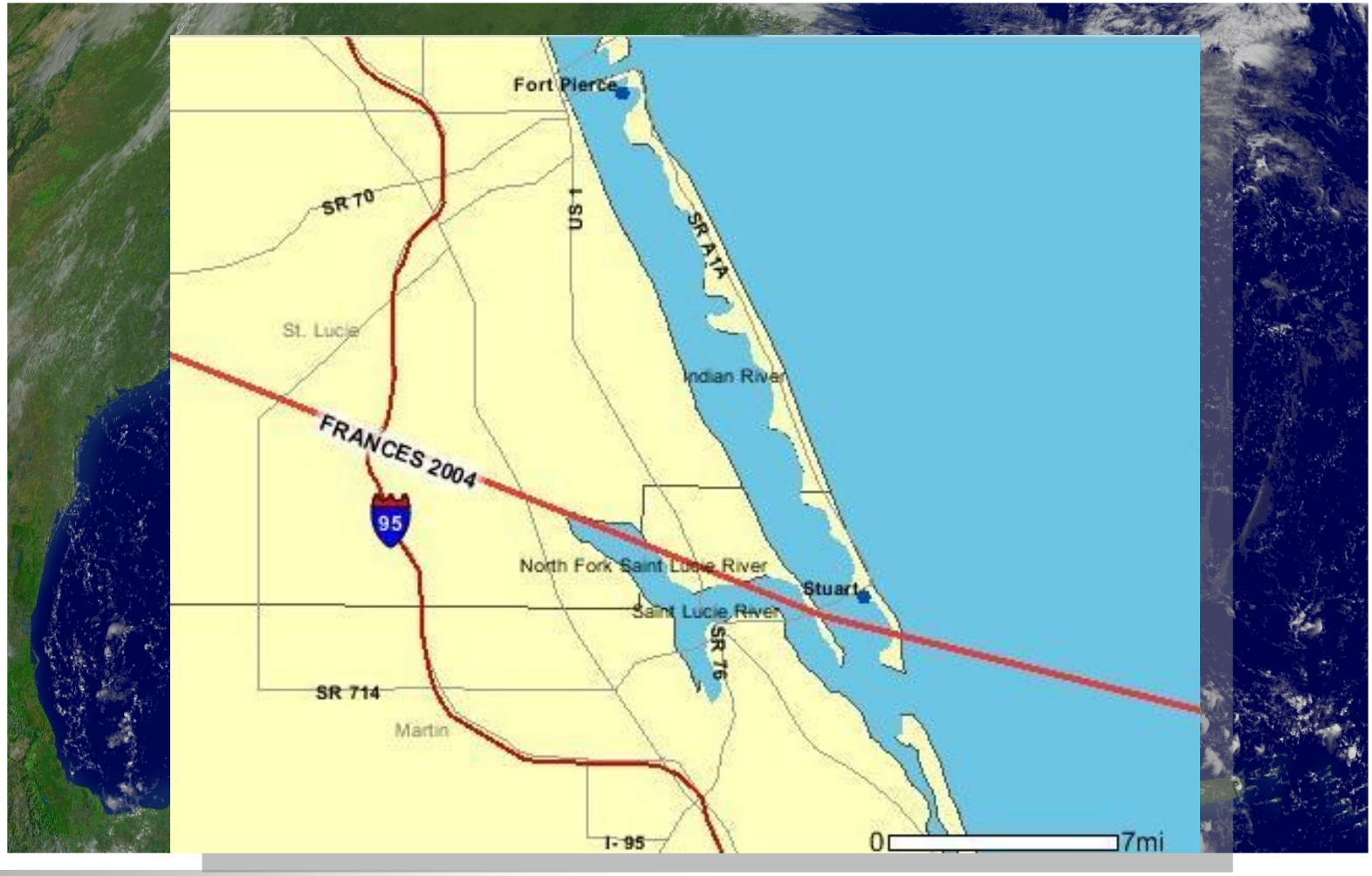
2004 Hurricane Frances



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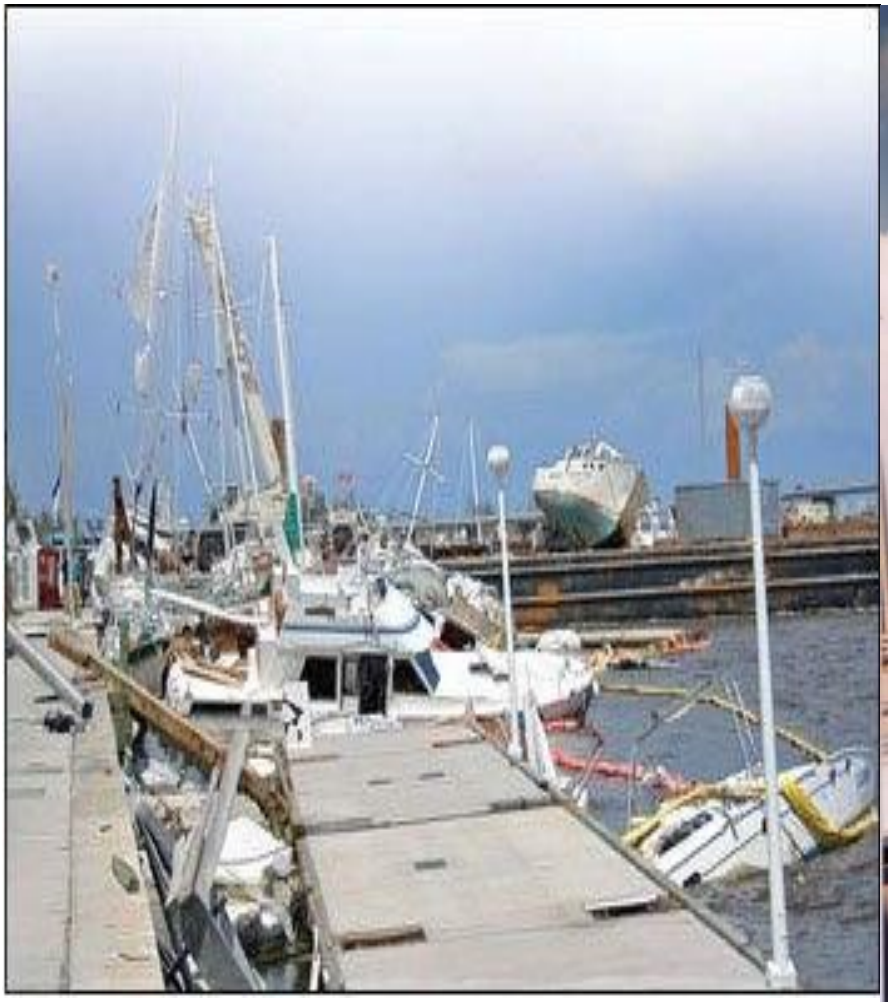
2004 Hurricane Season



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Project Funding

- City applied for FEMA public funding assistance for the amount exceeding the City's insurance coverage

- FEMA's Hazard Damage Mitigation program provides funding for improvements that reduce the magnitude and cost of damages from future storms

- According to FEMA, Hurricane Frances had a recurrence interval of approx. 9 years
  - Low recurrence interval was key in showing that substantial island construction could be economically justified

- Hurricane Frances was just one of four damaging storms to hit FL which helped to shift the political landscape to allow more robust solutions

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Project Evolution & Timeline

- September 2004 – Hurricanes Frances
- Feb 2005 – Plans for restoration begin
- Nov 2006 – Numerical modeling work beings
- Feb 2007 – Physical model testing at Queens University in Canada
- August 2009 – project went before FL Governor & Cabinet for final approval. Board set moratorium on subsequent large filling projects until 2 years post-construction monitoring
- Dec 2010 – US Army Corps issues permit with special conditions
- Late 2011 – Project went to bid
- Feb 2012 – NTP issued

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Project Purpose

- Project Goals
  - 100-Yr Storm Protection
  - Positive Environmental Impact
  - Eco-Tourism/ Aesthetically Pleasing

Physical Model – Queens University

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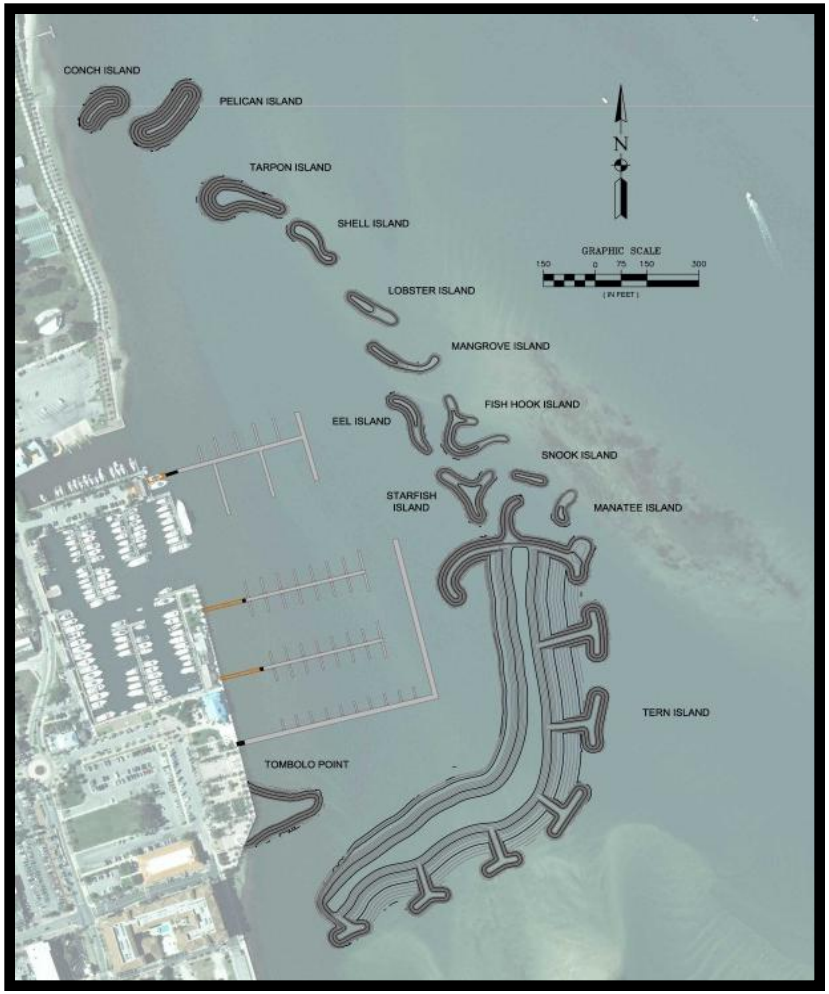
Project Layout

- 12 Island Breakwaters & 1 Peninsular Structure
  - Total of 14.66 Acres
- Ecological Enhancements
  - Oyster Recruitment – 1.28 Acres
  - Mangrove Habitat – 1.54 Acres
  - Juvenile Fish & Shorebird Habitat
  - Native Plantings
- $18.9 Million Construction Cost
  - NTP Issued February 2012
  - Construction Finished End of July 2013 – Phase I
  - Phase II replacement of dock structures



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Design Criteria

100 Yr Storm Event:

- Fetch Length: 22 km
- Water Depth: 12 to 18 ft
- Design Wave Ht: 6.2 ft
- Wave Period: 5.1 sec
- Surge Elev: +10.5’ NGVD

For 50 Yr Event:

- Limit interior wave ht to < 1.15 ft
- Promote water quality/flushing within marina basin

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Tern Island

- Island Geometry
  - 10.5 Acres
  - 1,500 lf x 300 ft
- 7 Groin Structures
- Sand Backfill in Interior
- Ecological Enhancements
  - Living Shoreline
  - Natural Limestone Reefs
  - Roosting Areas

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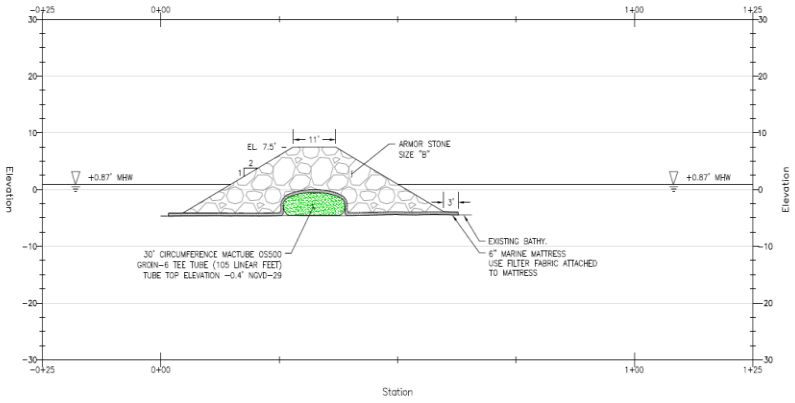
Construction Components

- Geotextile Tubes – 10,700 lf
  - Perimeter Dike for Island Creation
  - Structural Core of Groins
  - Bench for Living Shoreline
- Marine Mattress – 250,000 sf
  - Foundation for Stone Placement & Scour Apron
  - Geotextile Tube Protection
  - Matrix for Oyster Recruitment & Mangrove Plantings



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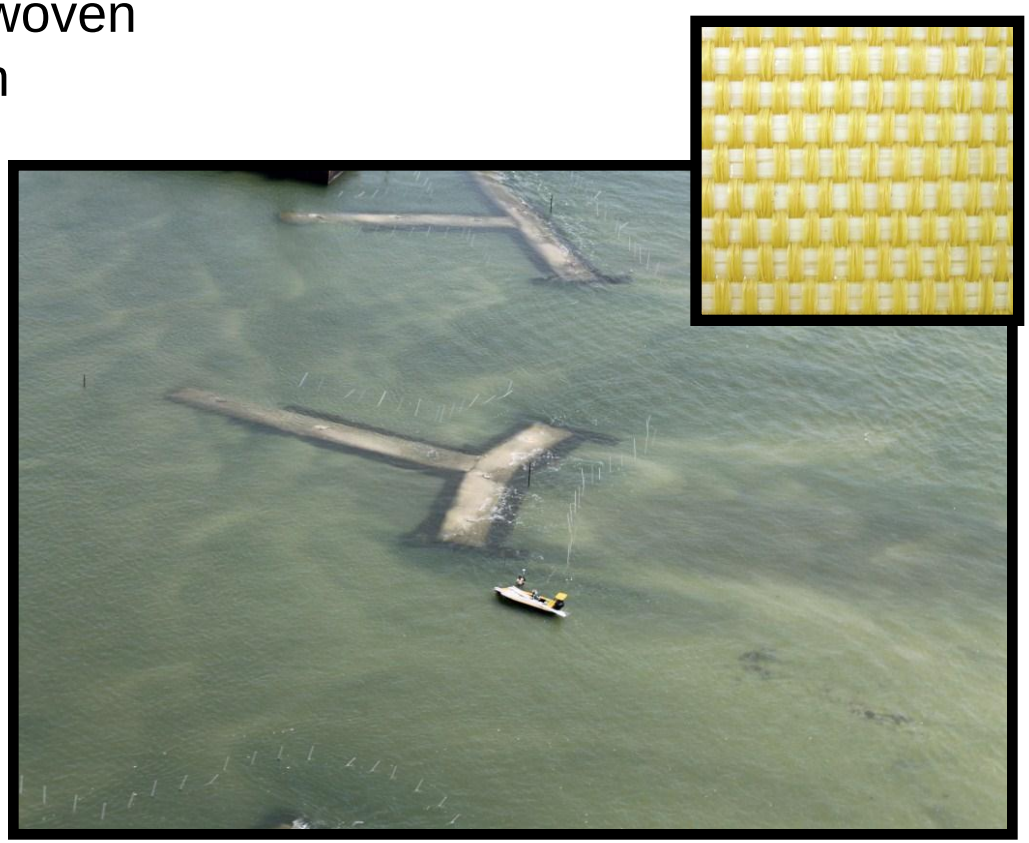
Geotextile Tubes

- High strength polypropylene, woven geotextile with UV stabilization

- MacTube OS500
  - Approx 500 ppi

- Tube Sizes:
  - 45’ circumference
  - 30’ circumference
  - Custom lengths



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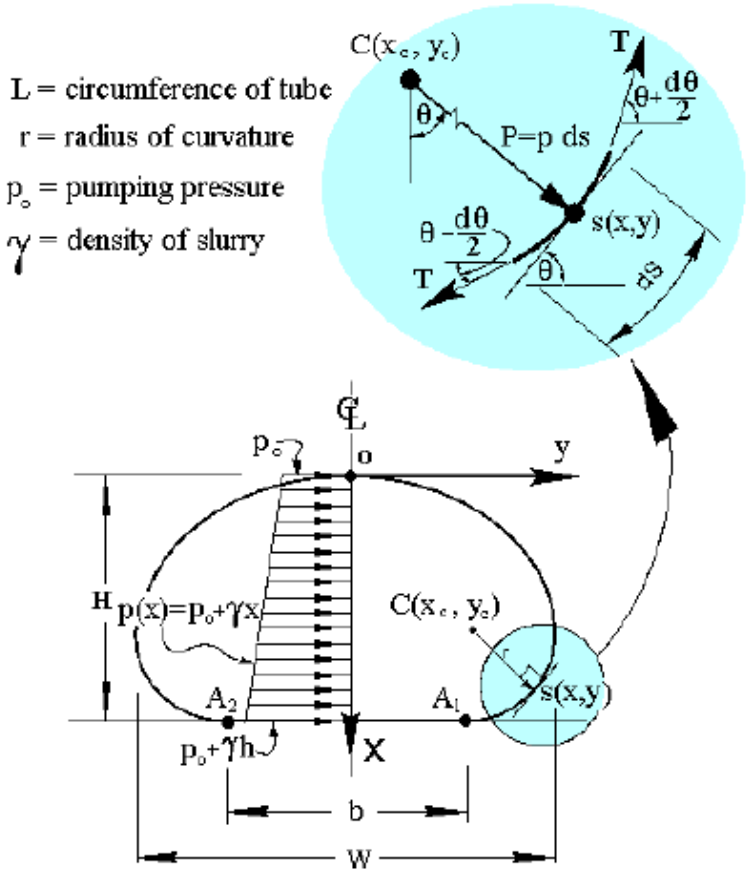
Geotextile Tubes

MacTube Design Considerations:

- Tube Geometry – GEOCOPS
  - Fabric & Seam Strength (Factor of Safety)
  - Pumping pressures
  - Sediment characteristics of fill material (upland borrow site)
- External Stability Calcs



(Courtesy of Prof. Leschinsky)

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Marine Mattress

Compartmental structures composed of high density, flexible, UV stabilized, polypropylene geogrid.

- Dual Project Purpose:
  - Protective Cushion Layer for 2.5 to 5 ton Limestone Boulders
  - Tube Foundation/Scour Protection

- Mattress Types:
  - BX EG 027 – 6” Thickness
  - UX EG115 – 12” Thickness

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Marine Mattress

- Mattress Dimensions:
  - Lengths = 10’, 15’, 20’, & 25’
  - Width = 5’ & 6.5’
- Stone Fill:
  - Ranges from 2” to 6” in diameter
- Approx. Weight = 110 pcf (12” x 20’ mat weights ~5.5 Tons)

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Marine Mattress: Bi-Axial

Onsite Preparation

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Marine Mattress: Uni-Axial

Onsite Preparation

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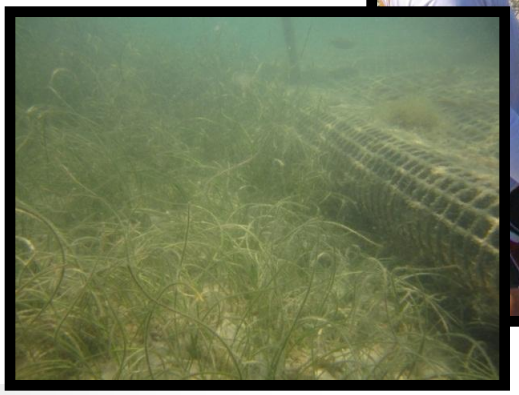
Construction Tolerances

- Geotextile Tubes
  - Horizontal +/- 12”
  - Vertical varied based on application

- Marine Mattresses
  - Varied based on application.
    - Tube coverage = 3”
    - Perimeter = 0”
    - Interior = 8”-12”



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Site Conditions

- Water Depths
  - No Impact on mattress and tube installations.
- Water Clarity
  - Impacted marine mattress installations.
- Currents
  - Impacted tube installations; V = 2 m/s

Geotextile Tube Installation

- Production Rates
  - 450 CY in approximately 4 hours
  - Corresponds to ~100 LF of 45’ Circ. Tube

- Installation Methodology
  1. Install scour protection.
  2. Deploy tube at slack tide.
  3. Anchor tube in place.
  4. Fill until design elevation achieved.

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Marine Mattress Installation

- Peak Production Rates
  - 70 Top Cover Mats
  - 30 to 40 Perimeter Mats

- Installation Methodology
  1. PVC stakes guide installations.
  2. Crane and lifting bar for rough placement.
  3. Guide and divers make final adjustments.

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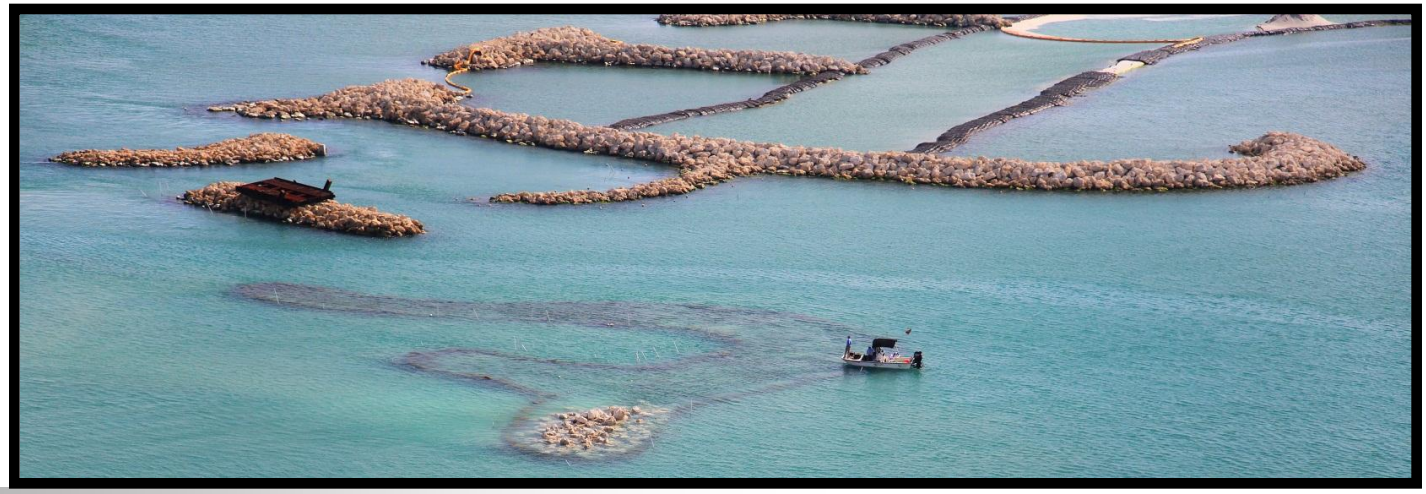
Lessons Learned

- Scour protection b/w tube installations.
- Incorporate straps into bag designs.
- Site conditions will dictate installation rates.
- Perform periodic inspections.
- Experience a must for tube/mattress installations in adverse conditions with tight tolerances.



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Project Benefits

- 100-yr Storm Protection
- Ecological Benefits
  - Living Shorelines
  - Natural Limestone Armor Reefs
  - Roosting Areas
- Increase in Revenue
  - Marina Capacity
  - Eco-tourism

- Serves as “pilot study” for future projects

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July 2013 – Substantial Completion

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July 2013 – Substantial Completion

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Thank You

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