MACWA Marsh Futures:
Assessment and Mapping of Salt Marsh
Vulnerabilities to Guide Restoration at the Local Scale

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Partnership for the Delaware Estuary
Martha Maxwell Doyle & Erin Reilly
Barnegat Bay Partnership
Coastal Wetlands

Abundant
Diverse

Benefits:
Flood Protection
Water Quality
Fish and Wildlife
Natural Areas
Carbon Capture
Coastal Marsh Declines

- Losing ~1 acre per day in the Delaware Estuary
- Losses due to various stressors
The Mid-Atlantic Coastal Wetland Assessment

Integrated monitoring of tidal wetlands for water quality, habitat management, and climate/restoration planning

Remote Sensing

Ground-Truthing

Intensive Studies

Station Monitoring
Tier 1 – Landscape Census

- NWI, NVCS etc.
- Land Use – Land Cover
- Aerial imagery
PDE/BBP/DNREC has assessed the condition of >400 points since 2010 (Mid-TRAM)
Stressor-response relationships vary widely, with lots of interactions

- Hydrology alterations
- Mosquito ditching
- Nutrient loadings
- Fill, Point sources
- Marine debris

Tier 2 – Rapid Assessments

Substrate Softness

Watershed
- Barnegat Bay North
- Barnegat Bay South
- Broadkill
- Christina
- Crosswicks
- Maurice
- Mispillion
- PA Tidal
Tier 3 – Intensive Studies

- Vulnerability assessments
- Ecosystem service studies
- Restoration tactic R&D
- Restoration targeting
Tier 4 – Station Monitoring

- 11 Stations installed
- Physical, chemical, biological

Christina Marsh SSIM Station

- Tidal Wetlands
- SSIM Station 2010
- SSIM Station 2011
- SSIM Station 2012
- SSIM Station 2014
- DNERR Station
Interesting Patterns

Are nutrient loadings affecting ability to keep pace with SLR?

Tidal Creek Nutrients

BG:AG Ratio

AG & BG Biomass

Nitrate-nitrite-N (mg/L)
Erosion vs. Accretion

Majority of marshes are net eroding from Tier 2 rapid assessments, shoreline metric.
Two Decline Patterns

Edge Erosion (Horizontal)  Interior Drowning (Vertical)

> 1 m per year edge loss

White = new open water

Source: Riter and Kearney 2009
Most Salt Marshes Cannot Survive When Sea Levels Rise >1 cm Per Year
MACWA Reference Data

10 cm difference in elevation

Happy, Healthy Plants on Living Shoreline

Unhappy Plants on Nearby Living Shoreline
Will Tidal Wetlands Keep Pace with SLR?
Will Tidal Wetlands Keep Pace with SLR?

Primary Productivity

Sediment Supply

Energy, Erosion

Nutrients

Elevation Capitol

Sea Level
Drowning (Vertical Loss)

• Plants Have Optimal Growth Ranges

Approximate Growth Range

S. alterniflora

MHW
MW
MLW

Slide adapted from James Morris
Drowning (Vertical Loss)

When rate of SLR > rate of (net) accretion ……

Approximate Growth Range
S. alterniflora

MHW
MW
MLW
... plants can grow taller at first....

Slide adapted from James Morris
But eventually succumb
Elevation Capitol

- Mean Sea Level
- Marsh Platform

Gaining Elevation

Drowning

Time

Elevation Change
Coastal Resilience

→ Coastal Wetland Projects

Hurricane Sandy (NASA)
Post-Sandy Lessons

Flooding and storm damage was lower adjacent to protective coastal wetlands and dunes

PDE-Rutgers Living Shoreline undamaged

Nearby destruction with hard infrastructure
# Habitat Benefits

## Army Corps Study


<table>
<thead>
<tr>
<th>Aggregated Measure Type</th>
<th>Category</th>
<th>Coastal Storm Risk Management Function</th>
<th>Multi-Benefits</th>
<th>Resilience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deployable floodwalls</td>
<td>STR</td>
<td>Medium</td>
<td>None</td>
<td>None</td>
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<tr>
<td>Floodwalls and levees</td>
<td>STR</td>
<td>High</td>
<td>Low</td>
<td>None</td>
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<tr>
<td>Shoreline stabilization (seawalls, revetments, bulkheads)</td>
<td>STR</td>
<td>Low</td>
<td>High</td>
<td>High</td>
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<tr>
<td>Living shorelines</td>
<td>STR/NNBF</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
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<tr>
<td>Overwash fans (e.g., back bay tidal flats/fans)</td>
<td>NNBF</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
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<tr>
<td>Reefs</td>
<td>NNBF</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
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<tr>
<td>Submerged aquatic vegetation</td>
<td>NNBF</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

| Wetlands | NNBF | Low | Medium | Medium | High |

Enhanced flood warning and evacuation planning leaves

Storm surge warnings

Enhancement Tactics

Oyster/Rock Breakwaters

Living Shorelines

Sediment Placement

What Tactics? Where Best? Successful?
Sediments are a Critical Feature of the Delaware Estuary
Beneficial Use

Why Needed?

Marshes need sediments

More sediment is removed from the system by dredging than is replaced via river inputs

Sediment deficits can lead to marsh drowning
Restoration and Beneficial Use

CONFINED DISPOSAL FACILITY

BENEFICIAL USE

CONSTRUCTION
BROWNFIELDS
LANDFILL USES
RESTORATION

DEPOSITION

SALT MARSH

SEDIMENT INPUT FROM THE WATERSHED

MAINTENANCE
DREDGING

ESTUARY

SHIPPING CHANNEL

Peppers Creek, DE 9/25/13

Slide from Burke 2010
Investment in Delaware Valley Lags

Despite Tough Times,…

High Potential for Beneficial Outcomes from Natural Infrastructure Investment

Fig. 8.8. Comparison of US EPA federal spending in FY2010 on environmental management and restoration in nine major water bodies in the United States (from Strackbein and Dawson 2011)

http://delawareestuary.org/science_programs_state_of_the_estuary_treb.asp
Hierarchical Analysis

Landscape Planning >> Local Project Designs
Planning - Hierarchical Analysis

1. Regional Prioritization
   Regional Restoration Initiative

2. Remote Sensing Analyses, Models

3. On-the-Ground Assessment

4. Project Concepts > Project Plans

5. Monitoring

6. Implementation
# Planning - Hierarchical Analysis

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
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</table>
| 1. | Regional Prioritization  
Regional Restoration Initiative |
| 2. | Remote Sensing Analyses, Models  
Locate Opportunities |
| 3. | On-the-Ground Assessment |
| 4. | Project Concepts > Project Plans |
| 5. | Monitoring |
| 6. | Implementation |

- Dredging Layer
- Eco Needs Layer
How to Judge Marsh Impairment?

Observations

• Wetland impairment can stem from diverse causes

• Pools, pannes, and short vegetation occur in healthy marshes

• Deficits in Elevation Capital (vertical vulnerability) are not always caused by lack of sediments

• Sediment application (TL) can help or harm a marsh

• Sediment impairment and TL opportunities should be identified with care using ecological reference datasets
# Planning - Hierarchical Analysis

1. **Regional Prioritization**  
   Regional Restoration Initiative

2. **Remote Sensing Analyses, Models**  
   Restoration Explorer Tool

3. **On-the-Ground Assessment**  
   Marsh Futures

4. **Project Concepts > Project Plans**

5. **Monitoring**

6. **Implementation**
Goal: Develop a field-based rapid assessment method to guide suitable projects that enhance salt marsh integrity

Outcomes:

• Vulnerability Maps
  - reflect horizontal/vertical processes

• Project Guidance Maps
  - reflect temporal/spatial needs
1. Select Marshes of Interest
2. Desktop Analyses

Elevation Data

- Potential Area of Interest
- Contours (6" interval)
- Elevation at low tide:
  - < 0ft
  - 0ft - 0.5ft
  - 0.5ft - 1ft
  - 1ft - 1.5ft
  - 1.5ft - 2ft

Analysis by Natural Lands Trust
2. Desktop Analyses

Shoreline Change Analysis

Natural Lands Trust Analysis using USGS Digital Shoreline Analysis System
3. Rapid Field Assessments

**Physical** – elevation, slope, erosion, substrate firmness

**Biological** – blade height, light penetration
4. Vulnerability Mapping

Use anomalies as weights to adjust elevation scores

Elevation Capital Mapping
Weighted measures are unitless
4. Vulnerability Mapping

Drowning Risk

Erosion Risk

Shoreline Retreat Rates
5. Project Guidance Mapping

Where will various investments yield greatest outcomes?

What should be the sequence of interventions?
Results – Vulnerability Maps

Edge Erosion Risk
Maurice >> Fortescue > Money Island

Interior Drowning Risk
Fortescue > Money Island > Maurice

Hydrological Impairment
Money Island > Fortescue > Maurice
Results – BMP Maps

Maurice:
  Living Shorelines (aggressive mix needed)

Fortescue
  Thin Layer Sediment (in low spots)
  High Marsh Containment
  Living Shorelines (to maintain)

Money Island
  Hydrological Connectivity? (more study needed)
  High Marsh Containment
Planning - Hierarchical Analysis

1. Regional Prioritization
   Regional Restoration Initiative

2. Remote Sensing Analyses, Models
   Restoration Explorer Tool

3. On-the-Ground Assessment
   Marsh Futures

4. Project Concepts > Project Plans
   Detailed Field Surveys, Ecology + Engineering

5. Monitoring

6. Implementation

Side View

Top View

3. On-the-Ground Assessment
   Marsh Futures

4. Project Concepts > Project Plans
   Detailed Field Surveys, Ecology + Engineering

5. Monitoring

6. Implementation

Side View

Top View
Delaware Estuary Living Shoreline Initiative
Recent Living shorelines

Money Island

Nantuxent Hybrid

Lewes Canal

Mispillion Hybrid
Project Monitoring Linked to MACWA

1. Regional Prioritization
   Regional Restoration Initiative

2. Remote Sensing Analyses, Models
   Restoration Explorer Tool

3. On-the-Ground Assessment
   Marsh Futures

4. Project Concepts > Project Plans
   Detailed Field Surveys, Ecology + Engineering

5. Monitoring

6. Implementation
   Apply Monitoring Framework, Pre and Post
Maurice River, NJ

“Failed” living shoreline installed in 2008-2010

Untreated Area

Treated Area - COIR logs gone but still some protection
Living shoreline Monitoring Framework

Goal-based
## Mispillion LS Monitoring

<table>
<thead>
<tr>
<th>Metric Type</th>
<th>Attribute</th>
<th>Goal</th>
<th>Metric</th>
<th>Methods</th>
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<tbody>
<tr>
<td>Core</td>
<td>Physical</td>
<td>Shoreline Stabilization</td>
<td>Elevation Change</td>
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<tr>
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<td>Supplemental</td>
<td>Physical</td>
<td>Shoreline Stabilization</td>
<td>Bearing Capacity</td>
<td>Slide Hammer</td>
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<td>Supplemental</td>
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<td>Feldspar Marker Horizon</td>
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<td>Vegetation Robustness</td>
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<td>Extent of Bivalve Communities</td>
<td>Lip Counts Oyster Reef Extent</td>
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<tr>
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<td>Inhibition of “Critter” Movement</td>
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<td>Prevailing Environmental Conditions</td>
<td>Temperature</td>
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<td>Coir Logs</td>
<td>Observation</td>
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<tr>
<td>Core</td>
<td>Other</td>
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<td>Core</td>
<td>Other</td>
<td>Photo Documentation</td>
<td></td>
<td>Camera</td>
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</table>
Statistical Approach = BACIR

Before – After - Control – Indicator - Reference

Marsh Treatments

Oyster Breakwater

Controls

Reference = nearest MACWA station
Did Sediment Collect?

Yes

Treated areas gained elevation

Untreated areas continued to lose elevation

Mean Elevation Above MLW (-0.8m)
Mispillion LS Results - Biological

Did Plants Survive?
Yes

August, 12, 2015

February 2, 2016
Did Shellfish Colonize Structures?

Yes

Good oyster recruitment in 2014, better in 2015

Mussel data still being analyzed

![Oyster Spat Density Chart]

- Lower: 2014 (gray) and 2015 (black)
- Upper: 2014 (gray) and 2015 (black)
Next Steps for Marsh Futures

• Refine Metrics to reflect different types of vulnerabilities

• Streamline field efforts to more rapidly assess sites or expand to larger areas
Conclusions

• Tidal wetlands are vital for coastal resilience in the Delaware Estuary region, but are in decline

• Well-designed restoration projects are needed and should address specific ecological impairments

• Marsh Futures is an example method for providing project guidance using ecological datasets

• Beneficial use of dredged sediments can help address certain types of marsh impairment if carefully deduced and matched to ecological needs; but there is risk of harm

• Most tidal wetland decline is due to edge erosion, and restoration of lost and degraded marsh edges may offer greater bang for buck compared to platform elevation
For More Info