Natural and Nature-Based Features in the USACE North Atlantic Coast Comprehensive Study

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Hurricane Sandy

Storm Impacts and Damages:

► Human

- 286 people killed (159 in the US)
- 500,000 people affected by mandatory evacuations
- 20,000 people required temporary shelter
- Extensive community dislocations – continuing today in some areas

► Economic

- $65B in damages in the U.S.
- 26 states affected (10 states and D.C are in the NACCS study area)
- 650,000 houses damaged or destroyed
In the Context of Coastal Resilience...

- What opportunities are there for achieving better alignment of natural and engineered systems?
  - Can improved alignment reduce risks to life and property?
  - What additional services can be produced?
  - What are the science and engineering needs in order to achieve better alignment?

Sustainable Solutions Vision: “Contribute to the strength of the Nation through innovative and environmentally sustainable solutions to the Nation’s water resources challenges.”
Evaluating Opportunities for Natural Systems

Key Factors, the 4 Ps

► Processes
  • Physics, geology, biology…
  • Foundation of “coastal engineering Jujitsu”

► Programmatic context
  • Planning, engineering, constructing, operating, or regulating

► Project scale
  • Individual property owner to an entire coastal system

► Performance
  • Configuring the system
  • Quantifying the benefits
Systems: Coastal Risk Reduction and Resilience

“The USACE planning approach supports an integrated approach to reducing coastal risks and increasing human and ecosystem community resilience through a combination of natural, nature-based, non-structural and structural measures. This approach considers the engineering attributes of the component features and the dependencies and interactions among these features over both the short- and long-term. It also considers the full range of environmental and social benefits produced by the component features.”
NACCS Natural and Nature-Based Features: Multi-Disciplinary Team

Project Leaders:
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Natural and Nature-Based Infrastructure at a Glance

GENERAL COASTAL RISK REDUCTION PERFORMANCE FACTORS:
STORM INTENSITY, TRACK, AND FORWARD SPEED, AND SURROUNDING LOCAL BATHYMETRY AND TOPOGRAPHY

**Dunes and Beaches**
- Benefits/Processes
  - Break offshore waves
  - Attenuate wave energy
  - Slow inland water transfer
- Performance Factors
  - Berm height and width
  - Beach slope
  - Sediment grain size and supply
  - Dune height, crest, width
  - Presence of vegetation

**Vegetated Features:**
- Salt Marshes, Wetlands, Submerged Aquatic Vegetation (SAV)
- Benefits/Processes
  - Break offshore waves
  - Attenuate wave energy
  - Slow inland water transfer
- Performance Factors
  - Reef width, elevation and roughness

**Oyster and Coral Reefs**
- Benefits/Processes
  - Break offshore waves
  - Attenuate wave energy
  - Slow inland water transfer
- Performance Factors
  - Dune height, crest, width

**Barrier Islands**
- Benefits/Processes
  - Wave attenuation and/or dissipation
  - Sediment stabilization
- Performance Factors
  - Island elevation, length, and width
  - Land cover
  - Breach susceptibility

**Maritime Forests/Shrub Communities**
- Benefits/Processes
  - Wave attenuation and/or dissipation
  - Shoreline erosion stabilization
  - Soil retention
- Performance Factors
  - Vegetation height and density
  - Forest dimension
  - Sediment composition
  - Platform elevation
Natural and Nature-Based Features Evaluation and Implementation Framework

1. Identify and Organize Stakeholders, Partners and Authorities
2. Define Physical and Geomorphic Setting
3. Assess Vulnerability and Resilience
4. Identify NNBF Opportunities
   - Formalize NNBF Objectives
   - Identify NNBF Alternatives
   - Define NNBF Performance Metrics
5. Evaluate NNBF Alternatives
   - Tier 1
   - Tier 2
   - Tier 3
6. Select NNBF Alternatives
7. Design Implementation Plan: Elaborate Operational and Engineering Practices
8. Implement NNBF Alternative
9. Monitor for Performance and Assess Ecosystem Goods and Services

Feedback

Iterate as Needed
Innovative solutions for a safer, better world

UNCLASSIFIED / FOUO
Authorities

Coastal Zone Management Act

Fish and Wildlife Conservation Act

Clean Water Act

Water Resources Development Acts

National Historic Preservation Acts

Marine Protection, Research and Sanctuaries Act

Sustainable Fisheries Act

Endangered Species Act

Etc., Etc., Etc.
Vulnerability

Vulnerability wrt Nature-Based Features in the Coastal Zone

Relative vulnerability of coastal landscapes; how nature-based features affect vulnerability

Vulnerability: Degree to which a system is susceptible to, and unable to cope with, adverse effects from a hazard; vulnerability is a function of the character and magnitude of a hazard to which a system is exposed, its sensitivity, and its adaptive capacity.

Wamsley et al. 2013 (in review)
Resilience

The ability of a system to resist, recover and/or adapt to the stresses of adverse events

- **Engineering**: resist damage, or return to a prior relatively stable state following a disturbance.

- **Ecological**: resist damage, or self-organize into a new configuration after disturbance.

- **Community/Social**: learn and adapt to avoid loss in functionality; develop new functions in response to disturbance.

*Schultz et al. (2012)*
Resilience

Framework to quantify resilience for Integrated Coastal Systems (ICS)

- Focus on functional performance of engineered projects.
- Incorporates multiple projects in the ICS.
- Develops a quantified measure of resilience based on speed and magnitude of restoring functionality or service following a disturbance.
- Functionality/service can be restored via natural processes and/or human maintenance.
- Not limited by mission area.
Identifying Opportunities

Manasquan Inlet, NJ
System Performance Evaluation

- **Level 1** – Qualitative characterization of performance
- **Level 2** – Semi-quantitative characterization of performance
- **Level 3** – Quantitative characterization of performance

72 individual performance metrics identified for NNBF
Example: Wave Dampening by Wetlands

• What are the engineering benefits of wetlands with respect to waves?
• Flume studies being performed in the 10 ft flume
  • Complemented by examination of sediment processes and field studies
• Wave attenuation was found to:
  • increase with stem density
  • increase with submergence ratio
  • slight increase with incident wave height
• Results used to update STWAVE
Assessing vulnerability and resilience over the long term: performance metrics

Inundated under 1 ft of RSLR

Dune height, crest, width
Presence of vegetation

Performance Factors

Vegetated Features:
Salt Marshes, Wetlands, Submerged Aquatic Vegetation (SAV)

Benefits/Processes
Break offshore waves
Attenuate wave energy
Slow inland water transfer
Increase infiltration

Performance Factors
Berm height and width
Beach Slope
Sediment grain size and supply

Dunes and Beaches
Benefits/Processes
Break offshore waves
Attenuate wave energy
Slow inland water transfer
D2M2: Dredged Material Management Decisions
Performance Evaluation Case Studies

- **Proof of concept analysis**
  - Quantify benefits of environmental restoration projects using an ecosystem goods and services (EGS) analysis framework

- **Hurricane Sandy case study**
  - Use extreme event to improve understanding of restoration effectiveness & benefits

- **Focused on two general types of services:**
  - Flood damage Reduction
  - Wildlife Habitat (emphasis on T&E species)

- **3 Study Sites**
  - Jamaica Bay
  - Cape May Meadows
  - Cape Charles South
Moving Forward.

- Organize and expand science and engineering related to natural processes and features
  - Reduce uncertainties regarding design and performance of NNBF
  - Understand dynamic performance of NNBF
  - How to effectively integrate NNBF with other measures

- Integrating expertise across disciplines and organizations
  - Planning, designing, constructing, operating, monitoring, and maintaining integrated systems