A Multi-Hazard Evaluation of Vulnerability using GIS along Cape Hatteras National Seashore, NC

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¹East Carolina University, ²Saint Louis University

Presented by Michael Flynn¹, Coastal Resources Management PhD Student
A place to engage your senses

The sound of ocean waves, the starry night sky, or the calm of the salt marshes, you can experience it all. Shaped by the forces of water, wind, and storms these islands are ever changing. The plants, wildlife, and people who live here adapt continually. Whether you are walking on the beach, kayaking on the sound, or climbing the Cape Hatteras Lighthouse there is something for everyone to explore!
Hurricane Irene six hours before landfall on Aug 27
Hurricane Irene (2011)

Pea Island Wildlife Refuge

Rodanthe
Sea Level Rise and Coastal Flooding Impacts

Data: The data in the map do not consider natural processes such as erosion or marsh migration that will be affected by future sea level rise.

Confidence: There is not 100% confidence in the elevation data and/or mapping process. It is important not to focus on the exact extent of inundation, but rather examine the level of vulnerability.
Task Agreement No. P13AC01432

Piedmont – South Atlantic Cooperative Ecosystems Studies Unit

Task Agreement

Between

National Park Service

And

East Carolina University

To

Identify Cultural Resources Sites Affected by Sea Level Rise at Cape Hatteras National Seashore
Principal Investigators

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East Carolina University

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Department of Geography  
East Carolina University

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Department of Geology  
East Carolina University

Dr. Tom Crawford  
Center for Sustainability  
Saint Louis University
Scope of Work

“East Carolina University will work closely with NPS staff and scientists to model local sea level rise and evaluate the vulnerability of 27 Historic Structures at Cape Hatteras National Seashore.”
Project Objective

“ECU will identify the risk level of each structure and identify the estimate timelines for potential impact and alternative relocation of structures and districts.”
Cape Hatteras National Seashore

• There are 27 historic structures located within 5 areas of interest.
  • Bodie Island Coast Guard and Light Station
  • Little Kinnakeet
  • Hatteras Light Station
  • Hatteras Weather Bureau
  • Ocracoke Light Station
Bodie Island Light and Coast Guard Station

Cape Hatteras National Seashore Vulnerability Assessment
Area of Interest

Background > Objective > Study Area > Methodology > Completed Work > Future Work
Little Kinnakeet
Cape Hatteras Light Station, Ranger Station, and CCC Cabins
Cape Hatteras Light Station, Ranger Station, and CCC Cabins

© Michael Colligan
Hatteras Weather Bureau

Background > Objective > Study Area > Methodology > Completed Work > Future Work
Multi-Hazard Approach

• Coastal Erosion
  • DSAS
    • LRR
• Storm Surge
  • SLOSH
    • MOMs
• Sea Level Rise
  • Bathtub
  • Hydrodynamic
Completed Projects

• Historical Shoreline Change
• Effects of climatology on net shoreline movement
• Elevation Change Assessment following storm events
• Completed using USGS Digital Shoreline Analysis System (DSAS)
• What method and shorelines should be used to project future shoreline position?
  • Net Shoreline Movement
  • End Point Rate (NCDCM)
  • Linear Regression Rate
• 2D vs 3D considerations
• How do you account for nourishment?
• What about estuarine shorelines?
# NDBC Diamond Shoals Station 41025 Historical Data

<table>
<thead>
<tr>
<th>Year</th>
<th>WD (deg)</th>
<th>WSP (m/s)</th>
<th>D GST (m/s)</th>
<th>WVHT (m)</th>
<th>DPD (s)</th>
<th>APD (s)</th>
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<td>5.1</td>
<td>1.5</td>
<td>7.5</td>
<td>5.1</td>
</tr>
</tbody>
</table>

Std. Dev

- WD: Wind Direction
- WSP: Wind Speed Peak
- D GST: Directional Spreading
- WVHT: Wave Height
- DPD: Wave Peak Direction
- APD: Wave Peak Period
NDBC Diamond Shoals Station 41025 Historical Data

Annual Wind Analysis

- Wind Direction (Degrees)
- Wind Speed (m/s)
- GST (m/s)

Annual Wave Analysis

- Wave Period (s)
- Wave Height (m)

Background > Objective > Study Area > Methodology > Completed Work > Future Work
NDBC Diamond Shoals
Station 41025
Historical Data

Annual Wind Analysis

<table>
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<tr>
<th>Year</th>
<th>Wind Speed (m/s)</th>
<th>Wind Direction (Degrees)</th>
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</thead>
<tbody>
<tr>
<td>2003</td>
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<td>0</td>
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<td>2008</td>
<td>5.0</td>
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<tr>
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<tr>
<td>2010</td>
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<tr>
<td>2011</td>
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</table>

Annual Wave Analysis

<table>
<thead>
<tr>
<th>Year</th>
<th>Wave Period (s)</th>
<th>Wave Height (m)</th>
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</thead>
<tbody>
<tr>
<td>2003</td>
<td>0.0</td>
<td>1.3</td>
</tr>
<tr>
<td>2004</td>
<td>0.0</td>
<td>1.4</td>
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<tr>
<td>2005</td>
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<tr>
<td>2006</td>
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<td>1.6</td>
</tr>
<tr>
<td>2007</td>
<td>0.0</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Net Shoreline Movement from 2004 to 2009

Historical Data

Eur. Oceano. OEBDO, NOAA NDBC, and other contributors
NDMC Diamond Shoals
Station 41025
Historical Data

Annual Wind Analysis

Wind Speed (m/s)
0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0

Wind Direction (degrees)
0 50 100 150 200 250 300


WD (deg) - WSP (m/s) - D GST (m/s)

Annual Wave Analysis

Wave Period (s)
1.3 1.4 1.5 1.6 1.7

Wave Height (m)
1.3 1.4 1.5 1.6 1.7


WVHT (m) - APD (s) - DPD (s)

Linear (WVHT (m))
**NDBC Diamond Shoals Station 41025 Historical Data**

### Annual Wind Analysis

- **WD (deg)**
- **WSP (m/s)**
- **D GST (m/s)**

![Graph showing annual wind analysis](image)

### Annual Wave Analysis

- **WVHT (m)**
- **APD (s)**
- **DPD (s)**

![Graph showing annual wave analysis](image)

### Net Shoreline Movement from 2004 to 2012

![Map showing net shoreline movement](image)

**Legend:**
- **NSM (m):**
  - 51 - 129
  - 1 - 50
  - 0 - 49
  - 50 - 199
  - 200 - 399

**Location:**
- **Hatteras Island**
- **Diamond Shoals**
- **Raleigh Bay**
NDBC Diamond Shoals Station 41025 Historical Data

Should we pay attention to seasonal variation? What effect does it have on shoreline position?
• 2009 USACE
  • Aug 16-24
  • CHARTS
  • Grid Size: 2
  • +/- 0.75m Hor
  • +/- 0.2m Ver

• 2009 USGS
  • Nov 27, 29 Dec 1
  • EAARL
  • Grid Size: 2
  • +/- 1.0m Hor
  • +/- 0.15m Ver
• 2009 USGS
  • Nov 27, 29 Dec 1
  • EAARL
  • Grid Size: 2
  • +/- 1.0m Hor
  • +/- 0.15m Ver

• 2011 NGS
  • Aug 28-29
  • Riegl Q680i-D
  • Grid Size: 2
  • +/- 1.0m Hor
  • +/- 0.3m Ver
- **2011 NGS**
  - Aug 28-29
  - Riegl Q680i-D
  - Grid Size: 2
  - +/- 1.0m Hor
  - +/- 0.3m Ver

- **2012 USGS**
  - Nov 5-29
  - Optech Gemini
  - Grid Size: 1
  - +/- 0.194m Hor
  - +/- 0.147 – 0.075m Ver
Future Work

- Storm Surge
  - Sea, Lake, and Overland Surges from Hurricanes (SLOSH)
  - Nor’Easter – Use MOM
- Sea Level Rise
  - 20, 40, 80, 120 cm scenarios

- Future geomorphological change
  - Sea Level Affecting Marshes Model (SLAMM)
  - Inlet Opening Potential
  - Dune Hazard Analysis Tool (DHAT)
Search Hurricanes By

Location | Name/Year | Ocean Basin
----------|-----------|-------------

[Search Box]

Refine Search

Search through the storms below

[Search Box]

Results (34) | All Selected | My Storms (0)

Sort By Year (Asc.)

Historical Hurricane Tracks

[Map with hurricane tracks]

United States Department of Commerce | National Oceanic and Atmospheric Administration | National Ocean Service

Background > Objective > Study Area > Methodology > Completed Work > Future Work
• Inputs
  • National Wetlands Inventory (NWI)
  • Digital Elevation Model
  • DEM derived slope
  • Dikes derived from NWI
  • Tidal datum and SLR data from NOS/CO-OPS
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• Method
  • Simple cross-section measurements of island volume above sea level (Perkins et al., 2007, Walsh et al., submitted)
  • Plan to update using most recent LIDAR derived DEM
Deliverable

- Final report and maps documenting the hazards that threaten the 27 historic structures forecasted 30 years in 5 year increments.

- A protocol that other parks can use to perform a similar assessment.

E-mail questions/comments to flynnmi13@students.ecu.edu
“That’s all Folks!”

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