North Atlantic coast of the USA – sea level change vulnerability and adaptation measures

Presentation to iGLASS on US North Atlantic coast SLC issues

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**Title:** North Atlantic coast of the USA - sea level change vulnerability and adaptation measures

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**Abstract**

The report focuses on the North Atlantic coast of the USA, examining the vulnerability to sea level change and the potential adaptation measures that could be taken. The study likely involves an analysis of coastal and riparian areas, considering the impacts of rising sea levels on infrastructure, ecosystems, and human communities. It might include a review of current and proposed strategies to mitigate the effects of climate change-related sea-level rise, addressing both physical and socioeconomic aspects. The report would be of interest to policymakers, coastal managers, and stakeholders in the region, offering insights into how best to prepare for and adapt to future environmental changes.
Contents

- Progress in evaluating the 7 sites
  - Land profile analysis
  - Submergence analysis and impact of sea level change
  - SLOSH analysis and how to evaluate impact of SLC on this
  - Comments on Blackwater National refuge

- Discussion on selecting measures and the approach to their evaluation
General issues for barrier islands

- Barrier islands naturally migrate in response to sediment supply, prevailing wind conditions, tidal currents and severe storm actions.

- Migration is defence against sea level rise, as they can naturally reshape in response to the coastal process changes.

- Addition of permanent infrastructure and expecting infrastructure to be defended is counter-productive cfd. resilience of holistic coastline communities
Assateague Island - submergence

MHW Changes

Submergence due to Sea Level Rise

- Area submerged (%)
- Sea level rise (ft)
- Year
- Sea Level Rise Scenarios
- USACE Low
- USACE Intermediate
- USACE High
- NOAA High

1 ft
3 feet

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A ‘tale of two halves’

- breach channel in front of Ocean City formed during 1933 hurricane.
- breach channel maintained by jetties and dredging, in order to provide navigational access to Ocean City.
- longshore sediment drift during normal weather conditions disrupted
- Hence, migration of north and south parts of Assateague very different

Strategies

- beach replenishment on seaward face, and sediment bypassing around the jetties, has allowed the two halves to be maintained as coastal defences.
- encouraging the natural vegetation to continue to act as dune or marsh stabilisation is also a priority method of maintenance.
- restricting the development of human infrastructure or encouraging relocation of existing infrastructure would be beneficial if the barrier islands are to continue as an effective coastal defence for the mainland as sea levels rise.
Submergence due to Sea Level Rise

- 1 ft
- 3 feet

Sea Level Rise Scenarios

- USACE Low
- USACE Intermediate
- USACE High
- NOAA High

Height above MSL (ft)
- <0
- 0-1
- 1-2
- 2-3
- 3-4
- 4-5
- 5-6
- 6-7
- 7-8
- >8

Long Beach, NY
Long Beach Island, NJ
Long Beach Island, NJ – cross sections

[Graphs showing level relative to MSL for Transect ID: 656, 682, 673, 664]
Long Beach Island, New Jersey

MHW Changes

Submergence due to Sea Level Rise

Sea Level Rise Scenarios

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Long Beach Island NJ - SLOSH zones

SLOSH Category
- Zone 1
- Zone 2
- Zone 3
- Zone 4

SLOSH Category
- Zone 1
- Zone 2
- Zone 3
- Zone 4
a. Use of Saffir-Simpson scale to convert (approximately) storm categories to surge levels

b. Approx return periods from ERDC StormSim analysis
### Expected Annual Flooded Parcels

<table>
<thead>
<tr>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Zone 5</th>
<th>TOTAL</th>
<th>Parcels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1041</td>
<td>300</td>
<td>59</td>
<td>3</td>
<td>4</td>
<td>1407</td>
<td>7.0%</td>
</tr>
</tbody>
</table>

### Expected Annual Flooded Area

<table>
<thead>
<tr>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
<th>Zone 5</th>
<th>TOTAL</th>
<th>Area (sq m)</th>
<th>Area (sq ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1372230</td>
<td>347574</td>
<td>67469</td>
<td>3102</td>
<td>4654</td>
<td>1795030</td>
<td>7.7%</td>
<td>19321547</td>
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<tr>
<td>14770564</td>
<td>3741261</td>
<td>726235</td>
<td>33395</td>
<td>50092</td>
<td>19321547</td>
<td>7.7%</td>
<td></td>
</tr>
</tbody>
</table>

c. Expected annual flooded area / no of parcels = 7% of total for present day conditions
Barrier Island measures

‘Pathway’ measures

- Atlantic freeboard: Maintain beach schemes (need for backing walls?)
- Backshore of islands – solution of protecting by flood walls or levees
- Back bay frontage – dunes and walls
- Alternative: protect both backshore of islands and back bay using Venice style barriers between barrier islands

‘Receptor’ measures

- Building elevation - short term effectiveness due to submergence of access
- Others??
Max water level rise:

- 0m: Existing system
- 1m: Over-rotate Thames Barrier and restore interim defences
- 2m: Flood storage, improve Thames Barrier, raise u/s & d/s defences
- 3m: Flood storage, over-rotate Thames Barrier, raise u/s & d/s defences
- 4m: New barrage

TE 2100 final plan: combination of approaches

Latest climate change results for TE2100 H++
Decision pathways for inhabited barrier island

Sea level rise

Seaward shoreline protection
- Beach recharge
- Add groins, detached breakwaters, sills
- Add levees, revetments or floodwalls

Landward /back-bay shoreline protection
- Unprotected shoreline
- Add levees or floodwalls
- Wave protect flood walls by natural features
- Surge barriers

Non-structural measures
- Flood warning and occasional evacuation
- Flood-proofing properties
- Elevating properties
- Community relocation

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Morphological issues on Atlantic freeboard (approach modified over last month)

- Decision to focus (given limited time) primarily on cross-shore response rather than long shore response
- Long Island NJ focus – best data available

Steps to evaluate dune-beach systems

1. Overview existing morphological data using review of literature and results of comprehensive studies.
Geomorphological review and characterisation

- Protection Areas
- Beaches
- Backshore
- Offshore Transport Rates
- Erosion and Accretion
- Sediment Budget
- Flood Risk Areas
- Engineering Works
- Historical Data
- Response to Extreme Events
Morphological issues on Atlantic freeboard (approach modified over last month)

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Steps to evaluate dune-beach systems
1. Overview existing morphological data using review of literature and results of comprehensive studies
2. Validate a dune erosion rule using Stockton CMC measured profiles.
Methodology

- Stockton CRC (2013) survey data on Long Beach Island (NJ) on the NJ Beach Profile Network
  - Fall 2012
  - November 2012
Utilise data in order to validate dune erosion rule by comparing Stockton CMC profiles during
- normal SL and elevated SL
- during Hurricane Sandy

Various dune erosion rules available

DUNERULE model (van Rijn, 2013):

Based on sensitivity tests to the CROSMOR model

It gives Dune erosion area \( A \) above storm surge level \( S \) as a function of peak period \( T \), offshore significant wave height \( H \), median bed material diameter \( d_{50} \), slope gradient \( \tan \beta \), offshore wave incidence angle \( \Theta \)

\[
A_{d,t=S} = A_{d,ref} \left( \frac{d_{50,ref}}{d_{50}} \right)^{\alpha_1} \left( \frac{S}{S_{ref}} \right)^{\alpha_2} \left( \frac{H_{s,o}}{H_{s,o,ref}} \right)^{\alpha_3} \left( \frac{T_p}{T_{p,ref}} \right)^{\alpha_4} \left( \frac{\tan \beta}{\tan \beta_{ref}} \right)^{\alpha_5} \left( 1 + \frac{\Theta}{100} \right)^{\alpha_6}
\]
Morphological issues on Atlantic freeboard (approach modified over last month)

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Steps to evaluate dune-beach systems

1. Overview existing morphological data using review of literature and results of comprehensive studies
2. Validate a dune erosion rule using Stockton CMC measured profiles.
3. Predict dune erosion for different sea level rise scenarios
4. Calculate overtopping rates for different sea level rise scenarios to input into inundation models
Propose to look at the following policy options for both beach-dune systems (following general approach adopted during Thames Estuary 2100 study) and assess the following alternative policies:

- P1 – walk away
- P3 – maintain defences at 2014 crest level and structural condition
- P4 – raise defences in line with sea level change and maintain condition

Whether defences breach as well as overtop will depend on condition.

For each case, examine impact of policy options via:

- Submergence studies for barrier islands and other low-lying areas (normal conditions)
- Assessments of flood risk in populated areas by examining a range of extreme conditions
Sensitivity of seaward design armour for rubble-mound structure

Source: John Headland, Moffatt & Nichol
Recession of Calvert Cliffs near Cove Point

T = wave pressure
S = cohesive strength
Inundation extensive with very little increase in sea level

The wider area is gradually being lost as well
Straight cut drainage ditches as example of extensive anthropogenic modification
Blackwater National Nature Reserve - measures

- Existing study of potential measures fairly comprehensive
- Encouraging migration of wetlands most effective, but barriers to such require identification and addressing
- Trickle charging with sediment might be useful, rather than direct placement?
- Reshaping of straight cuts
  - Use a more dendritic drainage pattern rather than infilling, or leaving as is
  - Slowing the straight cut drainage erosion by strategic brushwood check dams
- Ensuring propagule supply and distribution rather than a deliberate planting scheme

Engineered dendritic ditches in managed realignment site, UK
Marsh erosion and loss of extent through coastal squeeze.

Trickle charging using sediments from navigational dredgings.

Trickle charging ‘tuned’
  • to the location
  • to reduce siltation in undesirable areas and
  • to optimise the flow of sediment by reducing the speed of discharge into the water column.

Monitoring conclusions so far:
  • few areas of erosion
  • more accretion areas
  • trickle charging potentially useful
Similarities to barrier islands

- Narrow strip of properties protected by beach nourishment.
- No protection of ‘back’ side which is floodable due to tidal river and marsh areas behind

Similarities to Blackwater National Nature reserve

- Low lying marsh areas being progressively drowned by sea level rise
- Marsh areas may well not accrete due to (a) insufficient sediment and (b) regular land drainage pattern
The more severe SLC scenarios are (potentially) controversial in USA. However they can be useful:

1. In defining the extent of the project area
2. In representing (through the SLR rate curve) the earliest by which a problem may need to be addressed (including lead times)
   - e.g. tipping point in barrier island submergence
Tipping points: thresholds, lead times and decision points

- **Indicator value** (e.g. sea level rise)
- **Threshold value of indicator when intervention is needed**
- **Lead time** for planning and construction
- **Decision point** based on best estimate
- **Predicted values of indicator based on rate of change**
- **Recorded values of indicator**
- **Date of review**

Source: United Kingdom TE 2100
The more severe SLC scenarios are (potentially) controversial in USA. However they can be useful:

1. In defining the extent of the project area
2. In representing (through the SLR rate curve) the earliest by which a problem may need to be addressed (including lead times)
   - e.g. tipping point in barrier island submergence
3. In helping to identify realistic decision pathways, maybe discouraging use of some options that might otherwise have been considered
   - illustrated via barrier island studies
4. In assessing a maximum rate for increased coastal erosion processes
   - e.g. Calvert Cliffs illustration
5. In situations “where there is little tolerance for risk (e.g. new infrastructure with a long anticipated life cycle such as a power plant)” (NOAA, 2012).
   - e.g. possibly ‘overdesigning’ armor size for an exposed location like Point Judith
Proposed next steps for HR Wallingford team

Write up thinking to date on all sites

Illustrate value of thinking about a range of sea level change scenarios

Focus further analysis on Long Beach Island NJ

- Investigation of implementation of policy options, including long-term effectiveness of beach nourishment projects and identification of tipping points at which various options become viable / non-viable

- Determination of realistic decision pathways
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