Beach Nourishment on the Florida East Coast

Past

Future

Boca Raton
Erosion is the Main Reason for Beach Nourishment

• **Past** - Erosion on the east coast was mainly caused by inlets created or modified for navigation.

  How much occurred and how well nourishment worked

  **Shed Light**

  • **Future** - Erosion will mainly be caused by sea level rise.

  How much and how well nourishment will work.
• Common argument against fighting erosion has been: “You can’t fight Mother Nature”

• The fight on the east coast has not been with Mother Nature, but with inlets modified for navigation

Inlets removed > 200 million $\text{yd}^3$ of sand from system
Past Erosion
Pre-Beach Nourishment (1800s-1970)

- Shoreline position data from 1800s

<table>
<thead>
<tr>
<th>County</th>
<th>Data Start</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nassau</td>
<td>1857</td>
</tr>
<tr>
<td>Duval</td>
<td>1853</td>
</tr>
<tr>
<td>St Johns</td>
<td>1858</td>
</tr>
<tr>
<td>Flagler</td>
<td>1872</td>
</tr>
<tr>
<td>Volusia</td>
<td>1873</td>
</tr>
<tr>
<td>Brevard</td>
<td>1874</td>
</tr>
<tr>
<td>Indian River</td>
<td>1880</td>
</tr>
<tr>
<td>St Lucie</td>
<td>1883</td>
</tr>
<tr>
<td>Martin</td>
<td>1883</td>
</tr>
<tr>
<td>Palm Beach</td>
<td>1868</td>
</tr>
<tr>
<td>Broward</td>
<td>1884</td>
</tr>
<tr>
<td>Dade</td>
<td>1866</td>
</tr>
</tbody>
</table>

Measurements about every 1000 ft (almost 2000 locations)

- Determined shoreline change rates using data at all 2000 locations
Eroding, Stable, Accreting

- Absalonsen and Dean (2011) determined shoreline change uncertainty of ± 0.5 ft/yr and defined this as stable.

- Determined whether the shoreline was eroding, stable, or accreting at each of the 2000 locations.

Example: Atlantic Beach, Duval County.
Pre-Beach Nourishment (1800s - 1970)

• 70% of shoreline was stable or accreting
• Shoreline on average advanced + 75 ft
• Beyond inlets, only 9% of shoreline eroded despite sea level rise
• Substantial onshore sand transport (Houston and Dean, 2014)
Where Has Nourishment Been Placed?

Florida DEP has published 3 volumes of Strategic Beach Management Plans (2015) for the east coast

<table>
<thead>
<tr>
<th>Date Completed</th>
<th>Volume (CY)</th>
<th>Source</th>
<th>Placement Location</th>
<th>Length (Mi.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 1980</td>
<td>2,877,200</td>
<td>Offshore borrow area</td>
<td>R31-R80</td>
<td>10.1</td>
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<tr>
<td>1985</td>
<td>1,284,400</td>
<td>Jacksonville Harbor</td>
<td>R41-R53</td>
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<tr>
<td>1986</td>
<td>308,650</td>
<td>Offshore borrow area</td>
<td>R52-R67</td>
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<tr>
<td>1987</td>
<td>849,770</td>
<td>Offshore borrow area</td>
<td>R67 to R80</td>
<td>2.5</td>
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<tr>
<td>1991</td>
<td>300,000</td>
<td>Offshore borrow area</td>
<td><strong>R44-R52.5</strong></td>
<td>1.6</td>
</tr>
<tr>
<td>November 1995</td>
<td>1,200,000</td>
<td>Offshore borrow area</td>
<td>R47-R80</td>
<td>7</td>
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<tr>
<td>2003</td>
<td>120,000</td>
<td>Jacksonville Harbor</td>
<td>R72-R80</td>
<td>1.5</td>
</tr>
<tr>
<td>August 2005</td>
<td>615,198</td>
<td>Offshore borrow area</td>
<td>R43-R53 and R57-R80</td>
<td>5.9</td>
</tr>
<tr>
<td>August 2011</td>
<td>689,015</td>
<td>Offshore borrow area</td>
<td>R43.5–R53 and R57-R80</td>
<td>5.9</td>
</tr>
</tbody>
</table>

Duval County
Beach Nourishment (1970 - 2015)

- Over 200 beach nourishment projects
- Over 120 million yd$^3$ of sand placed
- Shoreline advanced 80 ft on average
- Only 43% of nourishment placed on eroding beaches
  - Beach encroachment
  - Recognition that wide beaches protect
Recognition That Wide Beaches Protect Hurricane Sandy, New Jersey

- “Where there was a federal beach fill, there was no major damage - no homes destroyed” (Associated Press, 2012)
- “At locations without beach nourishment, the destruction was complete” (New Jersey Star-Ledge, 2012)
Encroachment and Desire for Wide Beaches for Protection

- Delray Beach dunes leveled in 1920s
- Beaches widened 80 ft from 1883 to late 1960s
- Using beach nourishment, dunes rebuilt and the shoreline advanced 250 ft

Situation in late 1960s
Improving Nourishment Placement

1970 - 2015

Accreting 34%
Stable 23%
Eroding 43%

1970 - 2005

Accreting 38%
Stable 24%
Eroding 38%

2006 - 2015

Accreting 20%
Stable 23%
Eroding 57%
Future Shoreline Change

Positives

• Inlet shoals no longer building
• Sand bypassed around many inlets
• Sand no longer disposed in ocean
• Onshore transport continues
• Setback lines limit encroachment
• Nourishment being placed on eroding beaches
Future Shoreline Change

Big Negative

Sea level rise is going to increase significantly

Sea level rise rate up a factor > 5 since 1900

Mankind is responsible

Don’t blame Mother Nature

Atmospheric CO₂

Mankind is responsible

Mother Nature
Sea Level Rise in the Future?

IPCC has the only credible sea level rise projections

- It developed CO$_2$ scenarios and temperature projections used by all
- IPCC projections were made by 71 of the world’s sea level experts

<table>
<thead>
<tr>
<th>Country</th>
<th>Number</th>
<th>Country</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>19</td>
<td>Norway</td>
<td>2</td>
</tr>
<tr>
<td>Great Britain</td>
<td>12</td>
<td>Sweden</td>
<td>2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>10</td>
<td>Austria</td>
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<tr>
<td>Australia</td>
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<td>Belgium</td>
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<td>Germany</td>
<td>5</td>
<td>Japan</td>
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<td>Canada</td>
<td>4</td>
<td>Denmark</td>
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</tr>
<tr>
<td>France</td>
<td>2</td>
<td>India</td>
<td>1</td>
</tr>
</tbody>
</table>
IPCC CO$_2$ Scenarios

- At past nourishment rates, the east coast will accrete on average except for the upper level rise of the worst scenario (Houston, 2016)
RCP 8.5 Scenario Assumes

- Gigantic world population growth that is at odds with reality

![Graph showing the rate of world population growth from 1950 to 2010, peaked in 1962 and down for 56 years.](Image 1)

![Graph showing the annual world population growth rate from 1950 to 2100.](Image 2)

![Map of Africa highlighting Nigeria.](Image 3)
RCP 8.5 Assumes

- Nigeria’s population will be 1.5 billion in 2100 – twice Tampa’s population density
- Nigeria cannot feed its current population – it imports $22 billion in food annually
RCP 8.5 Assumes

- Population increase causes energy use to triple, led by coal consumption.

### Change in coal consumption 2015 - 2016

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>China</td>
<td>Orange</td>
</tr>
<tr>
<td>2016</td>
<td>US</td>
<td>Blue</td>
</tr>
<tr>
<td></td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rest World</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vietnam</td>
<td></td>
</tr>
<tr>
<td></td>
<td>India</td>
<td></td>
</tr>
</tbody>
</table>

### 2017 Headlines

- “China and India stop construction on 100 coal electric plants”
- “Coal power is in a ‘death spiral’ in the European Union”

### China natural gas consumption 2010-2040

- Natural gas imports
- Liquefied natural gas
- Pipeline
- Natural gas production from shale gas
- Tight gas coalbed methane
- Reservoired gas

**Shale gas**

- LNG imports up 75% last 2 years
- Natural gas has 40-50% of the carbon emissions of coal
RCP 8.5 Assumes

Coal use tripling leads to carbon emissions quadrupling

- 55% of new world power generation in 2016 was from renewable energy
- U.S. retired 8 GW of coal plants in 2016
- Added 9 GW natural gas, 8.7 GW wind, 7.7 GW solar (65% renewable)
### IPCC Sea Level Rise Projections to 1990-2100

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Low (ft)</th>
<th>Most Probable (ft)</th>
<th>High (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCP 2.6</td>
<td>0.9</td>
<td>1.4</td>
<td>2.0</td>
</tr>
<tr>
<td>RCP 4.5</td>
<td>1.2</td>
<td>1.7</td>
<td>2.3</td>
</tr>
<tr>
<td>RCP 6.0</td>
<td>1.3</td>
<td>1.8</td>
<td>2.4</td>
</tr>
<tr>
<td>RCP 8.5</td>
<td>1.7</td>
<td>2.4</td>
<td>3.2</td>
</tr>
</tbody>
</table>

97.5% chance less than 3.2 ft

Extraordinarily Unlikely \( \times \) 2.5% chance = Almost Impossible

Media usually reports RCP 8.5
Future Shoreline Change for RPC 8.5

• If beach nourishment remains at past rates (Houston, 2016)
  - East coast will accrete for next 50 years for all scenarios (accreted 155 ft on average 1800s-2015)
  - Will accrete to 2100 except for RCP 8.5 upper level rise (12% increase in nourishment would offset)

• Caveats
  - Past nourishment rate must be maintained
  - Sea level rise cannot be >> IPCC projections
Past Rate Must be Maintained

East Coast Nourishments

WARNING

Long-term Average

Year

Beach Nourishment (yd³)


0 1000000 2000000 3000000 4000000 5000000 6000000 7000000 8000000 9000000 10000000
Headline – “New NOAA sea level rise projections dramatically increase to 8.2 feet” (CBS News, 2017)

NOAA report: If RCP 8.5 occurs, there is a 0.1% chance (1 chance in 1000) that sea level will rise 8.2 ft

NOAA report: If RCP 8.5 occurs, there is an 83% chance the rise will be less than the IPCC upper level rise of 3.2 ft
Summary - Shoreline Change on Average

- 1800s – 1970 Shoreline advanced 75 feet
- 1970 – 2015 Shoreline advanced 80 feet
- 2015 – 2065 Shoreline will advance for all IPCC scenarios
- 2065 – 2100 Shoreline will advance except for upper rise of scenario RCP 8.5

NOT
(If nourishment rate maintained)
Sea Level Rise - Other Problems

- Back-bay flooding
- Salinity Intrusion
- Environmental – Wetlands Drowning
Conclusions

• Less than half of beach nourishment placed on eroding beaches – we can do better

• Beach nourishment can offset IPCC sea level rise – if the rate of placement is maintained

• Nourishment is the strategy to mitigate coastal sea level rise, but strategies are needed for all rise impacts
The End