Anticipated Impacts of Sea Level Rise

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Adapted from presentations by
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Goals of today’s presentation

- What is the science telling us about sea level rise?
- What are the general effects of sea level rise in Florida?
- How will manmade systems likely be affected by sea level rise?
- How will coastal habitats likely be affected by sea level rise to 2100?
- How can we mitigate for and adapt to sea level rise?
What is the science telling us about sea level rise?
Florida’s Coastline

- The gray shows the dry land 1.8 million years ago...
- The dotted line shows the shoreline 10,000 years ago.
Causes of Sea Level Rise

What causes the sea level to change?

- Terrestrial water storage, extraction of groundwater, building of reservoirs, changes in runoff, and seepage into aquifers
- Surface and deep ocean circulation changes, storm surges
- Subsidence in river delta region, land movements, and tectonic displacements
- Exchange of water stored on land by glaciers and ice sheets with ocean water

As the ocean warms, the water expands.
The map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an arrow to access additional information about that station.

**Sea Level Trends**

<table>
<thead>
<tr>
<th>mmyr (feet/century)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 to 12 (3 to 4)</td>
</tr>
<tr>
<td>6 to 9 (2 to 3)</td>
</tr>
<tr>
<td>3 to 6 (1 to 2)</td>
</tr>
<tr>
<td>0 to 3 (0 to 1)</td>
</tr>
<tr>
<td>-3 to -6 (-1 to 0)</td>
</tr>
<tr>
<td>-6 to -9 (-2 to -1)</td>
</tr>
<tr>
<td>-12 to -15 (-4 to -3)</td>
</tr>
<tr>
<td>-15 to -18 (-6 to -5)</td>
</tr>
</tbody>
</table>
The map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an arrow to access additional information about that station.
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Global Mean Sea Level Rise Scenarios

About 3 mm per year...

About the thickness of a Kraft Single each year

9 inches in Key West in the past 100 years

Beever 2011
Big Pine Key Model

“Initial Estimates of the Ecological and Economic Consequences of Sea Level Rise on the Florida Keys through the Year 2100”

- Sea level rise modeling focused on Big Pine Key using fine scale elevation data
- Sea level rise modeling on the entire Keys using coarse scale elevation data
- Resilience and adaption responses
BIG PINE KEY: 2007 sea level

2008 Value Data
$1,561,809,86

16,235 acres
BIG PINE KEY SCENARIO 1: +18 cm (7 in.) 2100
BEST OF THE BEST CASE IPCC SCENARIO (B1)
+18 cm (7 in.) TO +38 cm (15 in.)

-$40,000,000
-1840 acres
**Big Pine Key Scenario 2:**

+35 cm (13.7 in.) 2100 Mid Range IPCC Scenario (A1B)
+21 cm (8.3 in.) to +48 cm (19 in.)

- $75,000,000
- 2530 acres
Big Pine Key Scenario 3: +59 cm (23.2 in.) 2100
Worst of the Worst IPCC Scenario (A1F1)
+26 cm (10 in.) to +59 cm (23.2 in.)

$239,000,000

3410 acres
Big Pine Key Scenario 4: +100 cm (39.3 in) 2100 Mid Range Rahmstorf et al. 2007 +50 cm (19.7 in.) to +140 cm (55 in.)

- $993,000,000
- 4980 acres
Big Pine Key Scenario 5: +140 cm (55 in) 2100
High End Rahmstorf et al. 2007
+50 cm (19.7 in.) to +140 cm (55 in.)

- $1,620,000,000
- 5950 acres
What does the modeling show for SWFL?

- Modeling shows tidal inundation reaching inland between the red and yellow zones in Southwest Florida.

- Different regions of Florida will have different results...
What are the general effects of sea level rise in Florida?
What is the situation in Florida?

- 2.4 million people in Florida live below an elevation of 4 feet; 840,000 below 3 feet.
- In Miami-Dade county, over 250,000 residential structures valued over $50 billion are vulnerable to storm surge.
- Florida has 30 energy facilities less than 5 feet above local high tide.
What are the general effects of sea level rise?

- Increased vulnerability to coastal flooding and storm surge
- Increased shoreline erosion
- Salt water intrusion into fresh water sources
- Changes to tides and tidal regimes
- Increased inundation
- Deterioration of coastal infrastructure

Projected impacts for FL

- A 0.49 foot rise in sea level will result in flooding in SE coastal FL leading to water use cutbacks and the need for additional freshwater deliveries from other areas (SFWMD)
- A 1-foot rise in sea level will erode most FL beaches by at least 100-200 feet unless mitigation measures are used (US EPA)
Projected impacts for FL

- A 15-inch rise in sea level
  - Loss of about 50% of saltmarshes
  - Loss of 84% of tidal flats
  - About 30% of ocean beaches and 67% of estuarine beaches will disappear. (NWF)
### Economic impacts

<table>
<thead>
<tr>
<th>County</th>
<th>Variable</th>
<th>0.16 feet</th>
<th>0.33 feet</th>
<th>0.49 feet</th>
<th>0.98 feet</th>
<th>2.13 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dade</td>
<td>Value of land at risk</td>
<td>$1.05 B</td>
<td>$1.4 B</td>
<td>$2.33 B</td>
<td>$4.81 B</td>
<td>$12.3 B</td>
</tr>
<tr>
<td></td>
<td>Area at risk b</td>
<td>5,486</td>
<td>5,861</td>
<td>7,903</td>
<td>11,627</td>
<td>26,467</td>
</tr>
<tr>
<td></td>
<td>Per-acre value</td>
<td>$0.19 M</td>
<td>$0.24 M</td>
<td>$0.29 M</td>
<td>$0.41 M</td>
<td>$0.47 M</td>
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<tr>
<td>Duval</td>
<td>Value of land at risk</td>
<td>$10.4 M</td>
<td>$13.7 M</td>
<td>$19.6 M</td>
<td>$344 M</td>
<td>$572 M</td>
</tr>
<tr>
<td></td>
<td>Area at risk b</td>
<td>1,855</td>
<td>1,868</td>
<td>1,878</td>
<td>10,635</td>
<td>18,734</td>
</tr>
<tr>
<td></td>
<td>Per-acre value</td>
<td>$5,624</td>
<td>$7,354</td>
<td>$10,462</td>
<td>$32,384</td>
<td>$30,508</td>
</tr>
<tr>
<td>Escambia</td>
<td>Value of land at risk</td>
<td>$126 M</td>
<td>$136 M</td>
<td>$148 M</td>
<td>$194 M</td>
<td>$499 M</td>
</tr>
<tr>
<td></td>
<td>Area at risk b</td>
<td>798</td>
<td>899</td>
<td>962</td>
<td>1,863</td>
<td>5,209</td>
</tr>
<tr>
<td></td>
<td>Per-acre value</td>
<td>$0.16 M</td>
<td>$0.15 M</td>
<td>$0.15 M</td>
<td>$0.10 M</td>
<td>$95,760</td>
</tr>
</tbody>
</table>

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a. Values calculated for years 2030 and 2080. However, the overlap between the mid-2030 scenario and the low 2080 scenario (both 0.33 ft, or 0.1 m) is redundant, and since property value changes over time are not considered, the years are not shown here.

b. Unit: acres.
How will manmade systems likely be affected by sea level rise?
Increased coastal flooding

- Inability of stormwater systems to drain
- Saturation of road beds leading to collapse

Photo credits: St Augustine Record
Saltwater intrusion

Animation courtesy of South Florida Water Management District
South Florida

- 90% of south Florida residents get water from groundwater
- 6 out of 8 wells supplying Hallandale Beach have been shut down because of saltwater intrusion
Options for dealing with saltwater intrusion

- **Drill new wells**
  - Approx. $435,000/well, plus $50 million for a nanofiltration plant to remove organics

- **Desalination of brackish wellwater**
  - Approx. $80 million for desal plant plus $5.5 million per well for deep injection wells (brine)

- **Desalination of ocean water**
  - Approx. $115 million for desal plant plus $5.5 million per well for deep injection wells (brine)

  Plus operating & maintenance costs of $6-15 million/year...
Facilities Using Brackish Groundwater and Seawater in South Florida

Number of Facilities:
- Operating 35
- Under construction 7

Total Capacity (MGD):
- Operating 245
- Under Construction 36.5
How will coastal habitats likely be affected by sea level rise to 2100?
What are the effects of sea level rise on coastal habitats in Florida?

- Increased vulnerability to flooding/storm surge
- Increased inundation
- Salt water intrusion into fresh water sources
- Changes to tides and tidal regimes
- Increased shoreline erosion

- Habitat damage/destruction
- Habitat loss/migration
- Changes to plant and animal communities
- Changes to plant and animal communities
- Habitat loss/migration
Coastal ecosystems...so what?

- Value of wetlands
  - Flood storage capacity
  - Storm surge buffering
  - Erosion control
  - Water quality maintenance
  - Fish & wildlife habitat
What are some of our coastal ecosystems?

- Submerged habitats
  - Seagrass beds
  - Oyster reefs

- Emergent habitats
  - Salt marsh
  - Mangroves
Sea level rise is expected to cause migration of seagrass beds landward.

Where natural shoreline exists, seagrass beds are expected to migrate into appropriate depths.

Where opportunities for landward migration is blocked the seagrass beds will be reduced and may disappear.

Vulnerable Species: *Argopectin irradians*

Beever et al. 2009

http://www.tbep.org/portrait/featured_creature_12.html
Oysters

Sea level rise will change salinity regimes for oysters

Reefs may shift upstream to narrow portions of estuaries and rivers

Reefs will be less productive and prolific

Possible alteration of estuarine ecology

Oyster restoration used as protection for the shoreline against SLR

http://www.dep.state.fl.us/northwest/ecosys/section/restorationoyster.htm

Savarese and Volety, 2001
Mangroves

Can migrate landward

Sediment surface elevations are not keeping pace with current rate of SLR (Gilman et al. 2008)

Because mangroves may replace other species, overall coverage may increase
If no accretion of sediment, seaward portions of the salt marsh flood, marsh grass drowns and marsh soils erode.

If sea level rise rates are slow enough, marshes may migrate up-gradient until they encounter an obstacle.

Potentially 89% loss of salt marsh acreage in Charlotte Harbor by 2100, but a 372% gain in Hernando County.
Salt Marsh Migration

1953

2010

SWFRPC 2011
How can we mitigate for and adapt to sea level rise?
Adaptation strategies

- Municipalities are starting to look at longer-scale planning efforts (30-40 years)
- Need to assess critical infrastructure within potential flood/erosion areas and plan to relocate

Photo credit: NPS
Mitigation strategies

- Taking steps to reduce greenhouse gas emissions
- Energy reduction is part of many municipal comprehensive plans
How can we preserve coastal ecosystems?

- Identify and maintain places where ecosystems can move upland
  - Planning/Zoning
  - Natural Resource Adaptation Action Areas (Comprehensive Plan)
  - Removal of abandoned infrastructure

- Restore degraded habitats
  - Seagrass/oyster reef restoration
  - Exotic species removal
  - Living shorelines
References

Unless otherwise noted, all photos were taken by the author.


Beever, Lisa. 2011. PowerPoint slide


Mitchum, Gary T. Sea Level Changes in the Southeastern United States. Florida Climate Institute, 2011.

Noss, Reed. Impacts Of Climate Change and Sea Level Rise in Peninsular Florida – Can We Adapt? Presentation to FRRP. May 10-12, 2011.

Ott, Judith. Seagrass Changes Maps. 2010


Thank You!

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