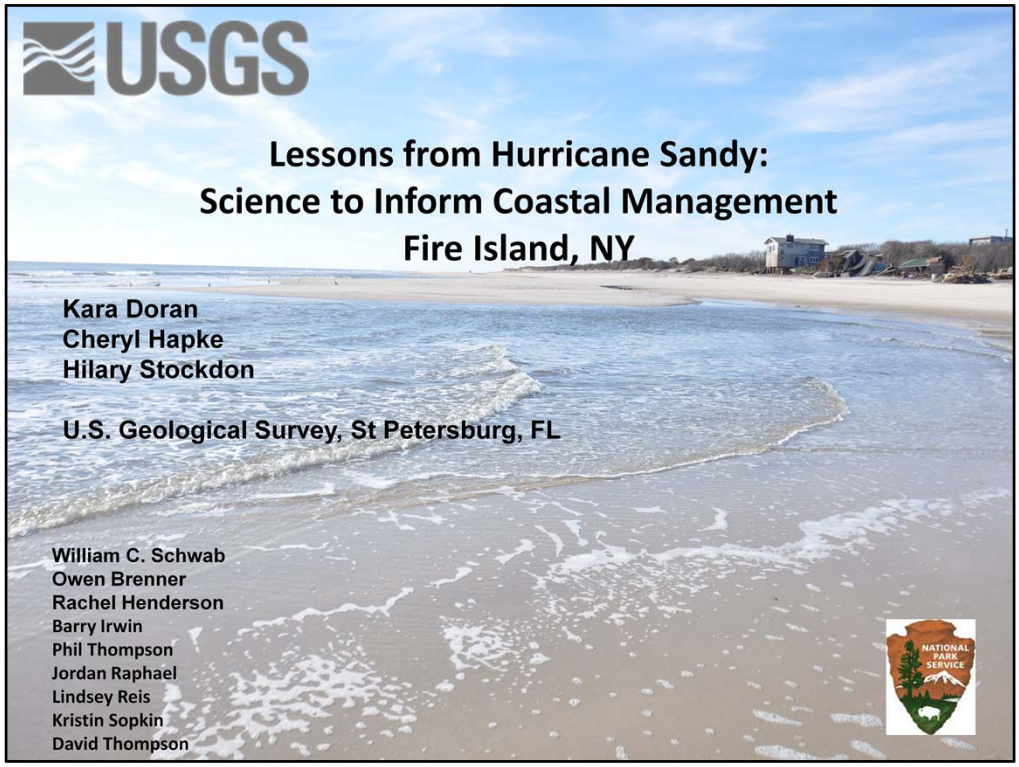
USGS
Lessons from Hurricane Sandy:
Science to Inform Coastal Management
Fire Island, NY
Kara Doran
Cheryl Hapke
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U.S. Geological Survey, St Petersburg, FL
William C. Schwab
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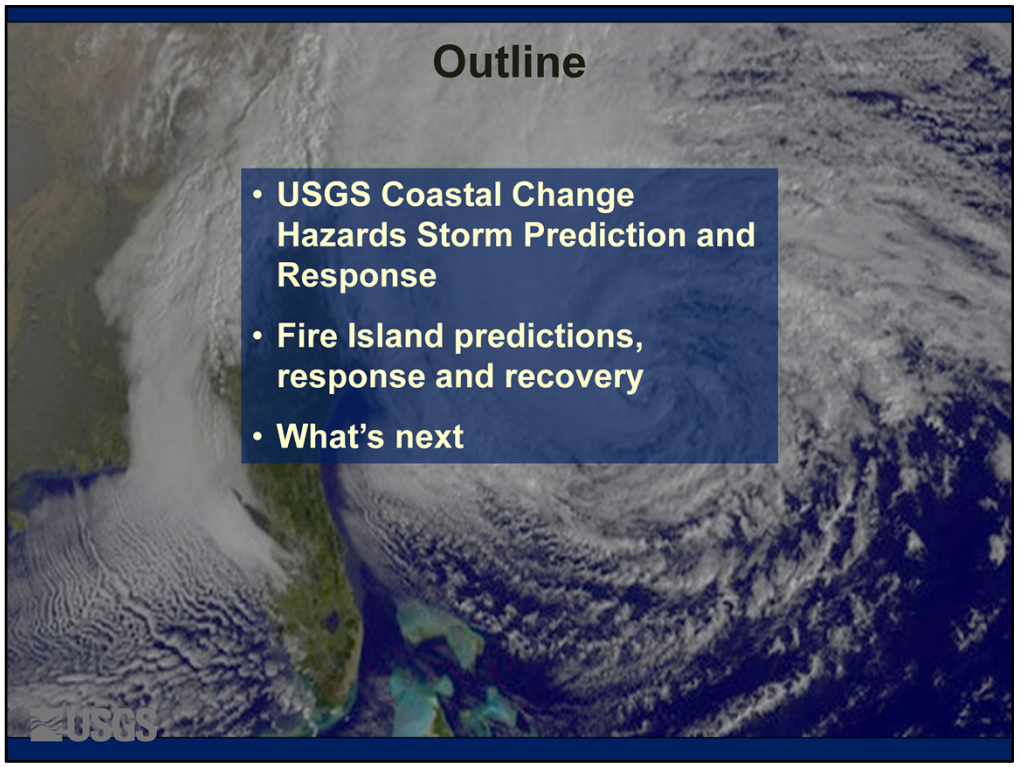
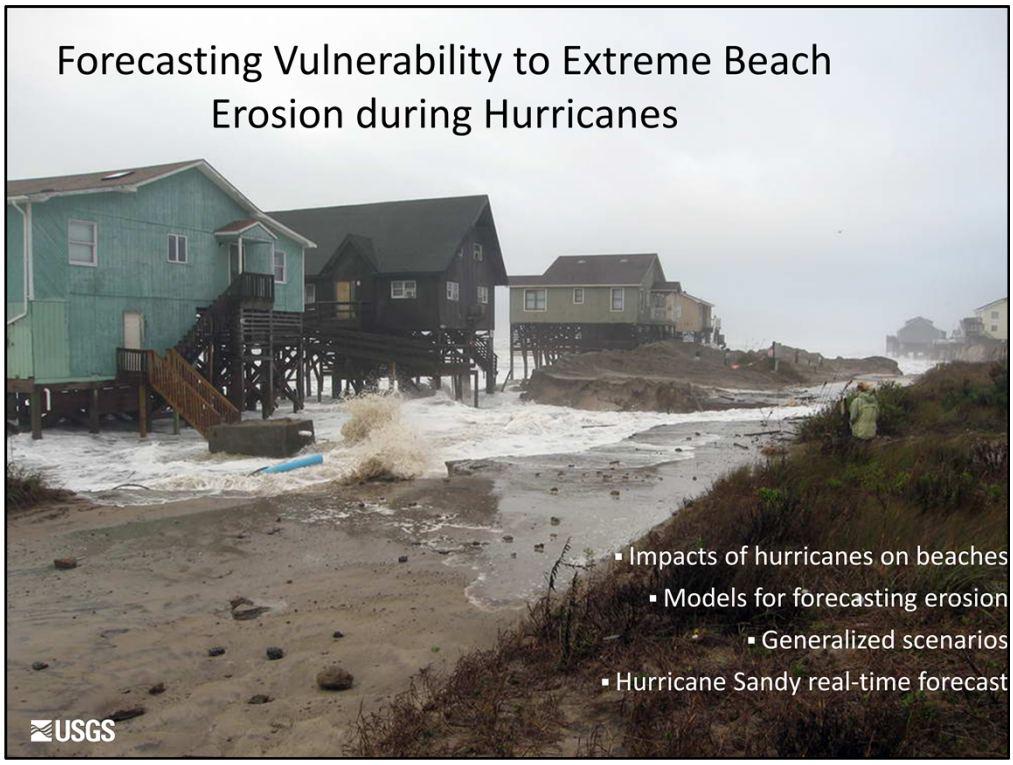
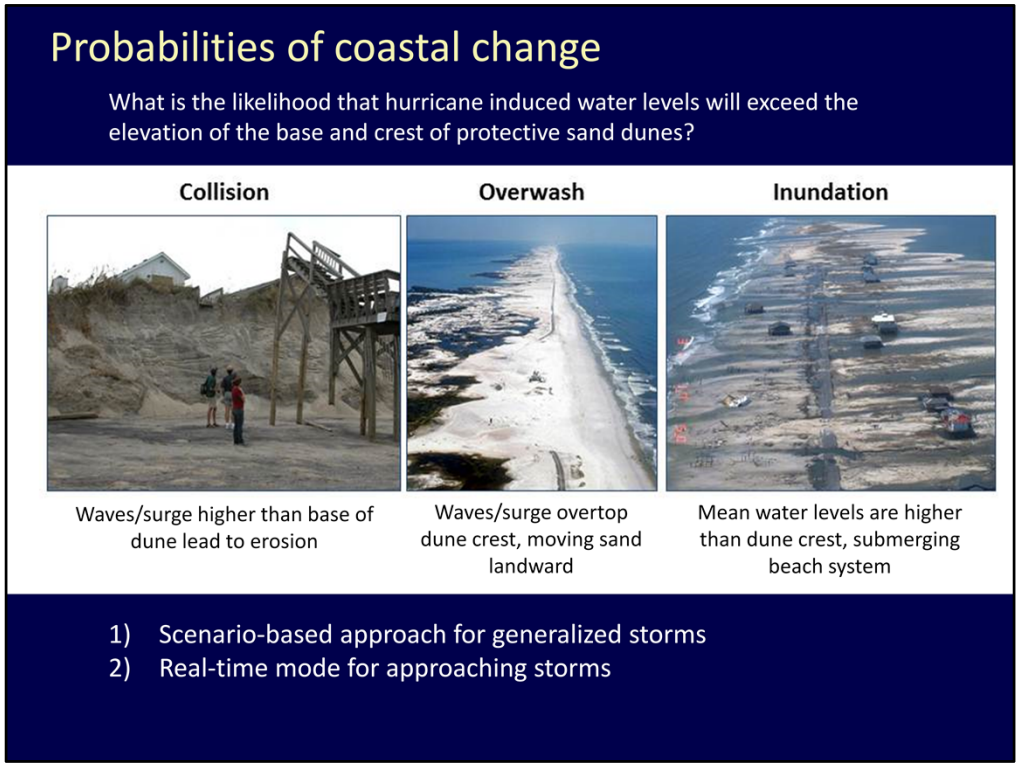
Rachel Henderson
Barry Irwin
Phil Thompson
Jordan Raphael
Lindsey Reis
Kristin Sopkin
David Thompson
NATIONAL PARK SERVICE


Outline
• USGS Coastal Change Hazards Storm Prediction and Response
• Fire Island predictions, response and recovery
• What's next
USGS

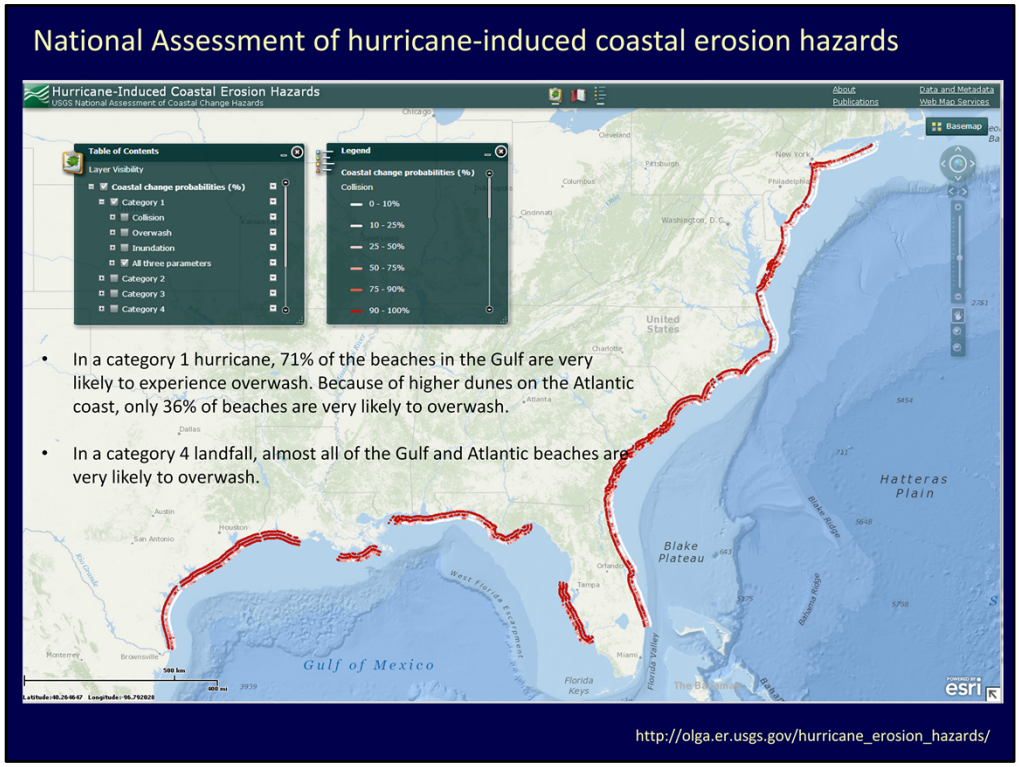

Forecasting Vulnerability to Extreme Beach Erosion during Hurricanes
▪ Impacts of hurricanes on beaches
▪ Models for forecasting erosion
▪ Generalized scenarios
▪ Hurricane Sandy real-time forecast
USGS

Example – Isabel, 2003, Hatteras NC. Within 5 km
Dune erosion
Overwash
Island breaching



Coastal Processes

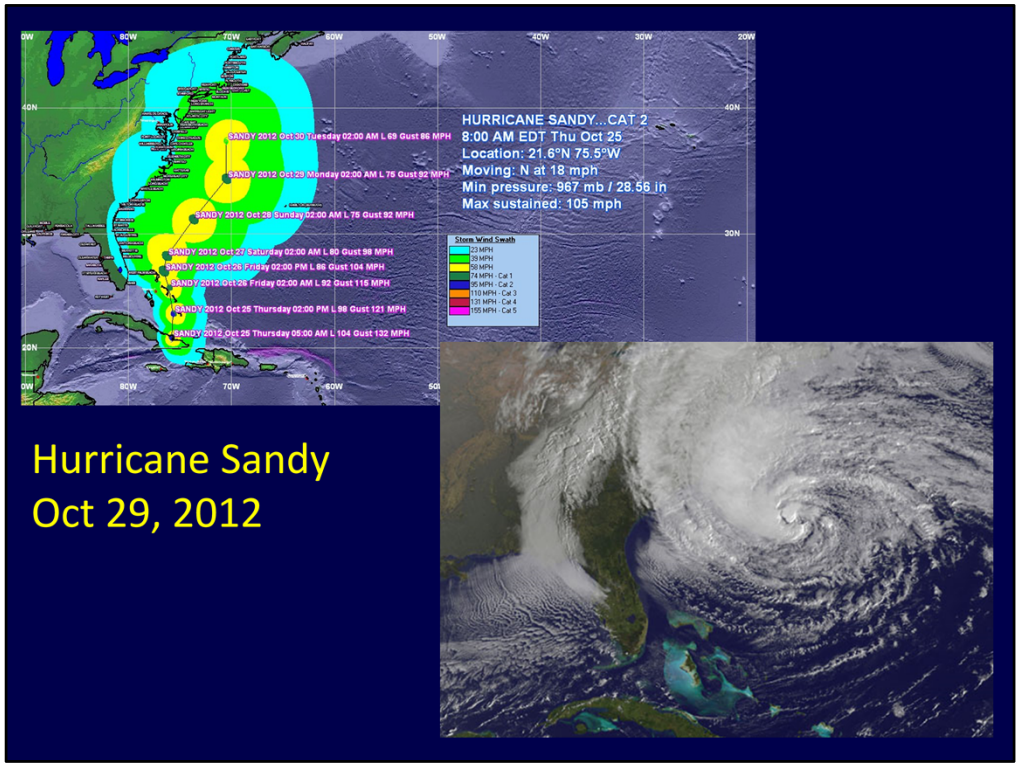
In collaboration with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Army Corps of Engineers (USACE), the USGS is predicting the likely interactions between storm forcing (for example, surge and waves) and coastal topography (beaches, berms, and dunes) during hurricanes in near-real-time. This information provides a powerful short-term tool to emergency responders and communities to identify areas of greatest likely damage.



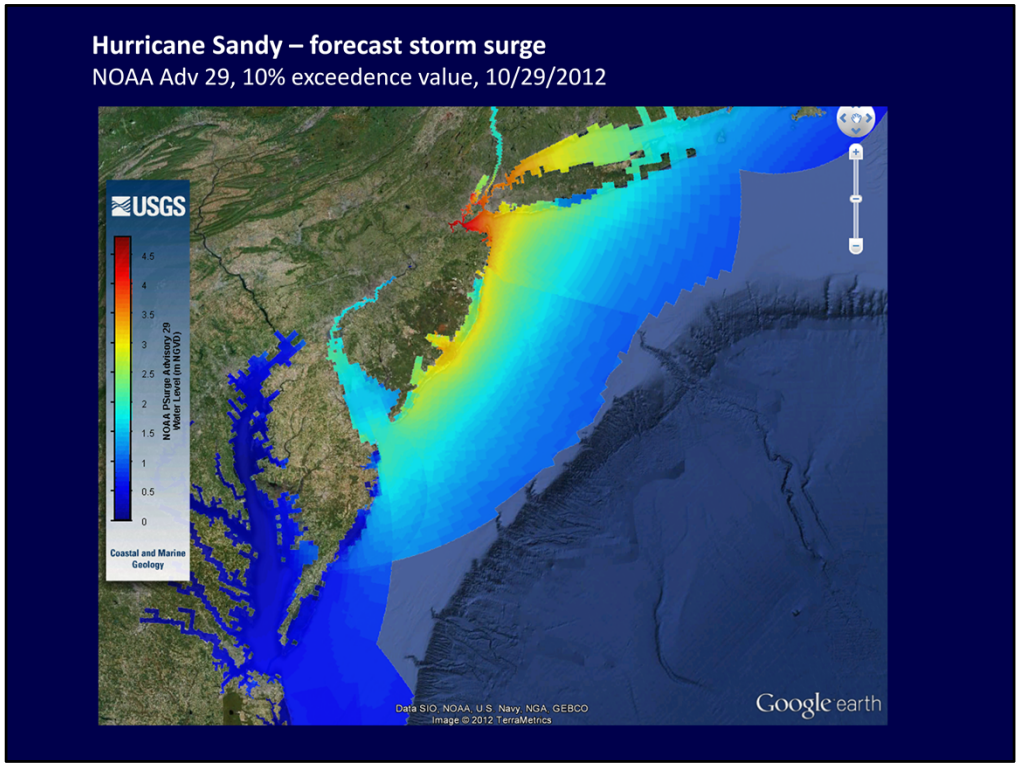
In general, lower dune elevations along the Gulf of Mexico and southeast Atlantic coasts make these regions more vulnerable to erosion hazards during hurricanes. Average dune elevations along the shores of the Gulf of Mexico are just 2.4 m high, making approximately 71% of these beaches very likely to experience extreme erosion due to overwash in the direct landfall of a category 1 storm. By contrast, dunes along the mid-Atlantic coast are, on average, over 2 m higher and, therefore, less likely to overwash or inundate. In the mid-Atlantic, only 25% of the beaches are very likely to experience overwash in the direct landfall of a category 1 storm. However, this area also has the most variability in dune size and shape. This leads to a corresponding variability in the vulnerability of the beaches, placing areas highly likely to erode adjacent to more stable locations. Another regional difference is found in the relative role of waves and storms surge in increasing coastal erosion vulnerability during low category hurricanes. In the Gulf of Mexico and southeast Atlantic regions, waves play a larger role in elevating shoreline water levels than they do in the mid-Atlantic. During a category 1 hurricane in the Gulf of Mexico or southeast Atlantic, the contribution of waves to storm-induced extreme water levels is nearly twice that of surge.

Build tools for specific concerns (habitat, transportation infrastructure etc.)

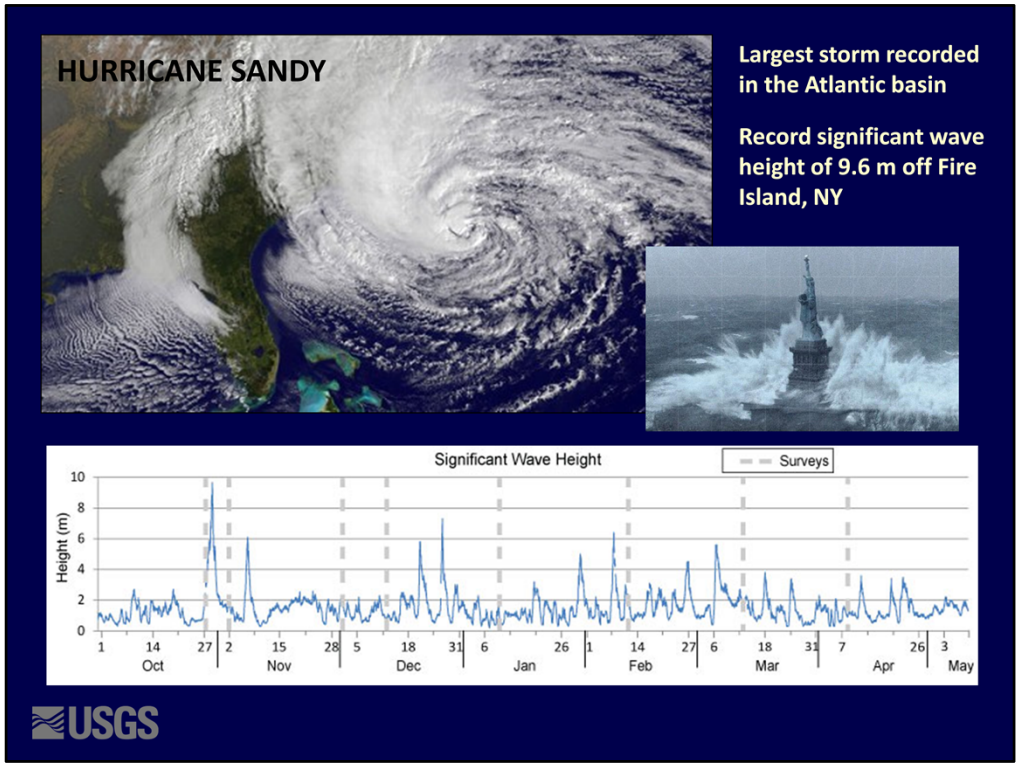
- **requiring tools for overwash/inundation extent, catastrophic impacts (breaching)**
- **Move towards risk (including social/economic dimensions) – (Supplemental)**



Hurricane Sandy
Oct 29, 2012



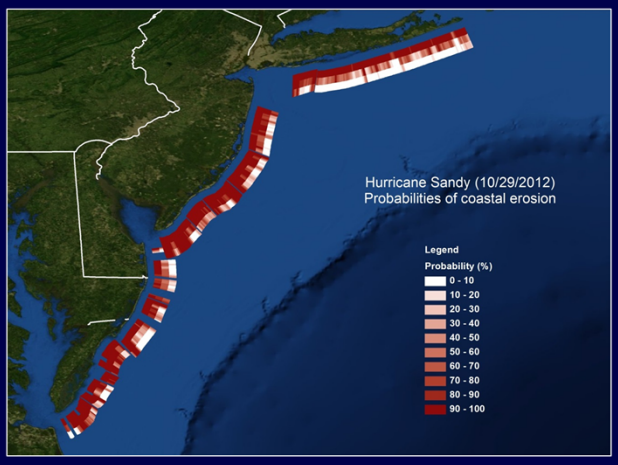
Fire island – 3 m surge + high tide = 4.3 m water level



9.6 m waves, 4.3 m water level

Real-time forecast of coastal erosion – Hurricane Sandy

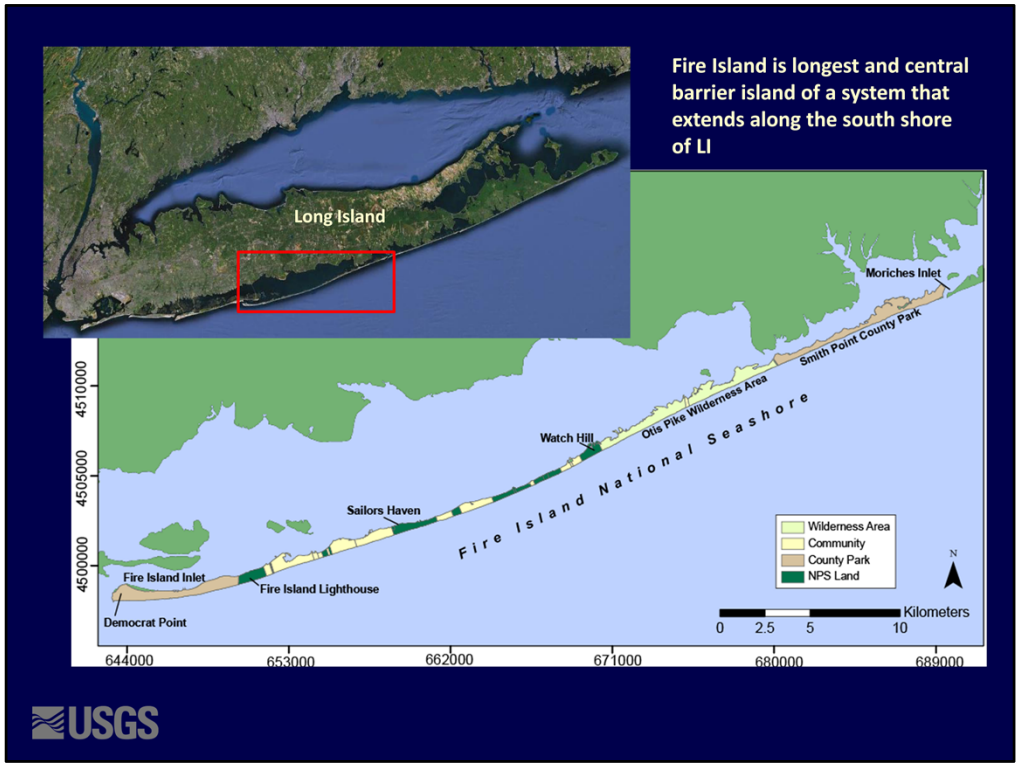
- Inputs:
  - Lidar-based shorelines, dunes (USGS, USACE)
  - Storm surge (NOAA)
  - Wave conditions (NOAA)
  - Wave runup (USGS)
- Output: Probabilities of
  - Dune erosion
  - Overwash
  - Inundation
- Assessments are posted online and updated with current NHC meteorology as the storm approaches landfall.



% of coast very likely to experience coastal change :			
	Dune erosion (inner)	**Overwash (middle)**	**Inundation (outer)**
Long Island, NY	93	12	4
New Jersey	98	54	21
Delmarva	91	55	22

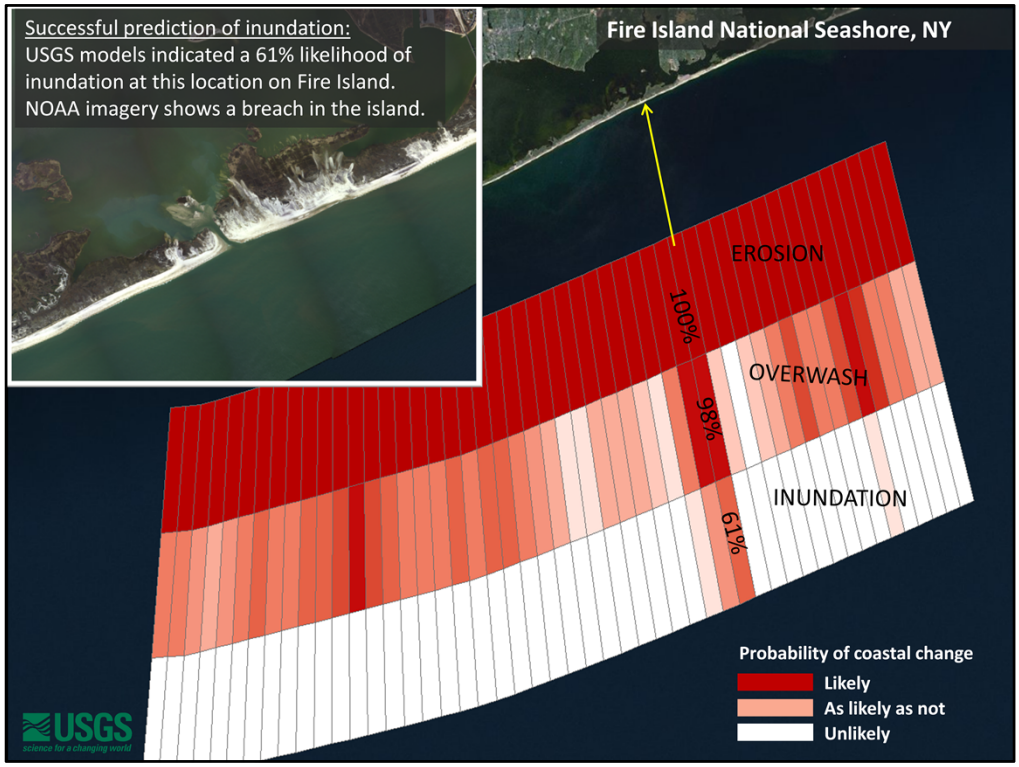
10-29-2012, 1100 EDT (National Hurricane Center Forecast Advisory 29)

Prior to landfall, USGS scientists used modeled storm surge (psurge) and wave conditions (wavewatch3) and observations (lidar) of beach and dune elevations to determine what types of coastal change might be expected during landfall.



Management challenges include developed communities, county, state and federal jurisdictions

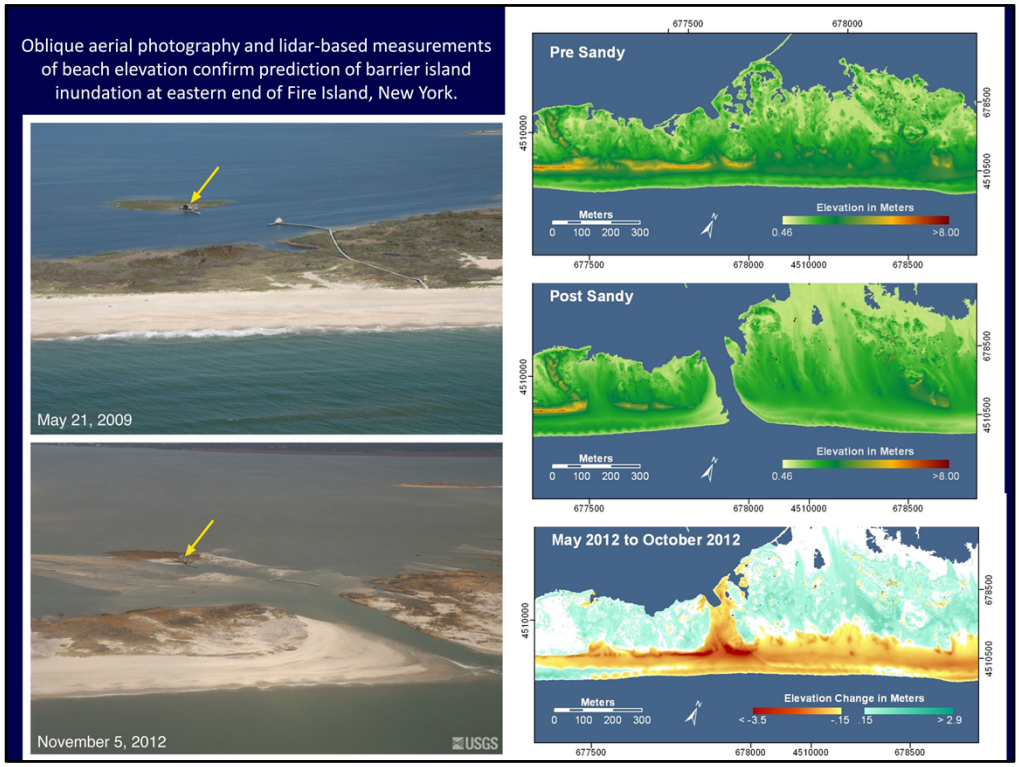
Storm impacts from nor-easters and of course Hurricanes (recently Irene, Sandy)



Because we know how barrier island respond to storms, we can forecast coastal erosion expected during future storms and identify more vulnerable areas.

During Sandy, we forecast the probability of erosion, overwash, and inundation based on the elevations of the seaward most dune and expected water levels at the shoreline due to both surge and waves.

Predictions for FIIS during Sandy. Red indicates a higher probability of coastal change. Entire island expected to experience dune erosion. (Yes, this happened). Variability due to difference in dune elevation. Higher elevation areas are less likely to overwash, while low area more likely. Yellow arrow indicates lowest elevation along island. Models indicate 61% likelihood for storm surge to inundate the area. This , in fact, did happen, as shown by NOAA photography and USGS data (next slide)

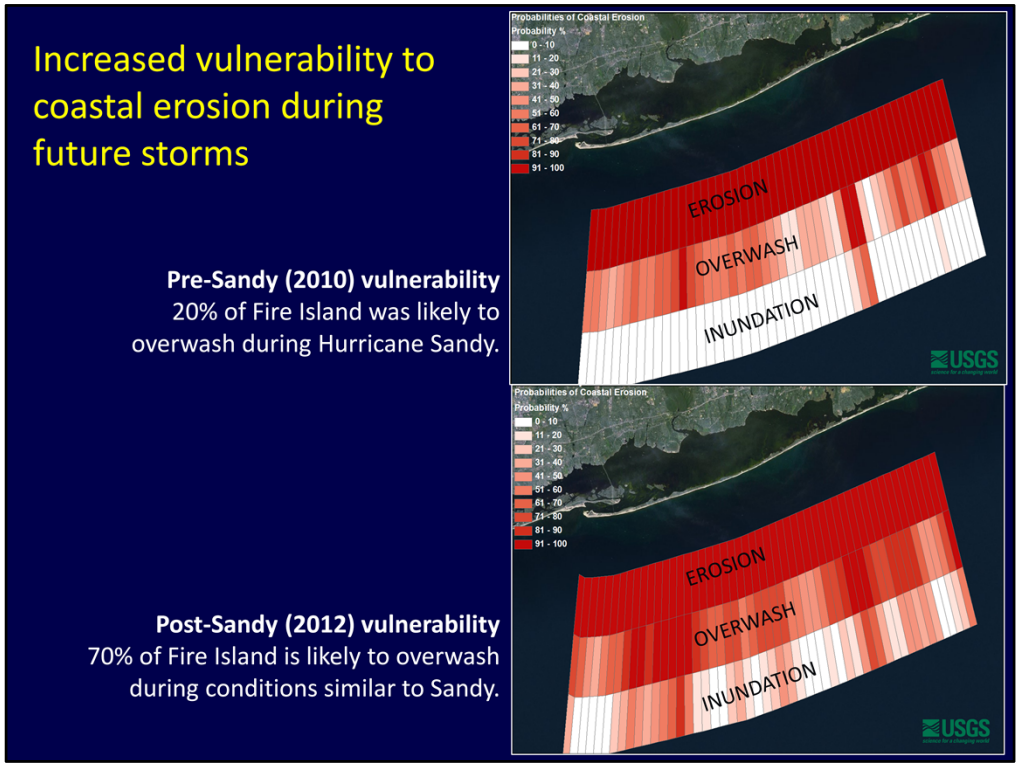


Oblique aerial photography and lidar-based measurements of beach elevation confirm prediction of barrier island inundation at eastern end of Fire Island, New York. (Explain pre, post, difference images.)

When beach is narrow and becomes inundated, connects ocean to sound allowing currents to flow and increased erosion. This inlet became tidal and is currently monitored by USGS water offices (Chris S).

Some key findings of the field data collection effort in Fire Island indicate that:
- 50% of the dunes on Fire Island were overwashed during the storm, carrying large volumes of material to the interior portion of the island
- In locations where the dunes remained intact, they retreated an average of 20 m
- Dune elevation losses were as high as 5m and the berm of the beach was lowered by as much as 3m

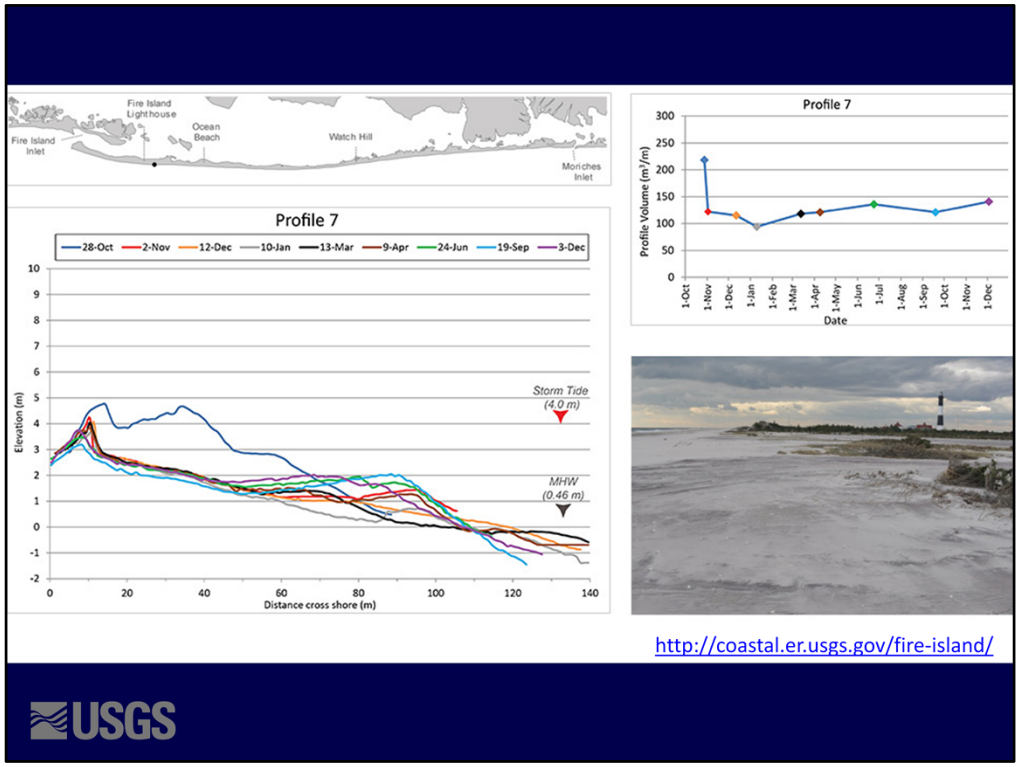
Oblique aerial photographs of Pelican Island and Fire Island, New York. (Wilderness Inlet) The view is looking northwest across Fire Island towards Great South Bay. This location is within Fire Island National Seashore near Old Inlet—a very narrow portion of the island that has experienced breaching in previous large storms. The island breached during Sandy, creating a new inlet. Despite the breach, the fishing shack (yellow arrow) remained standing.



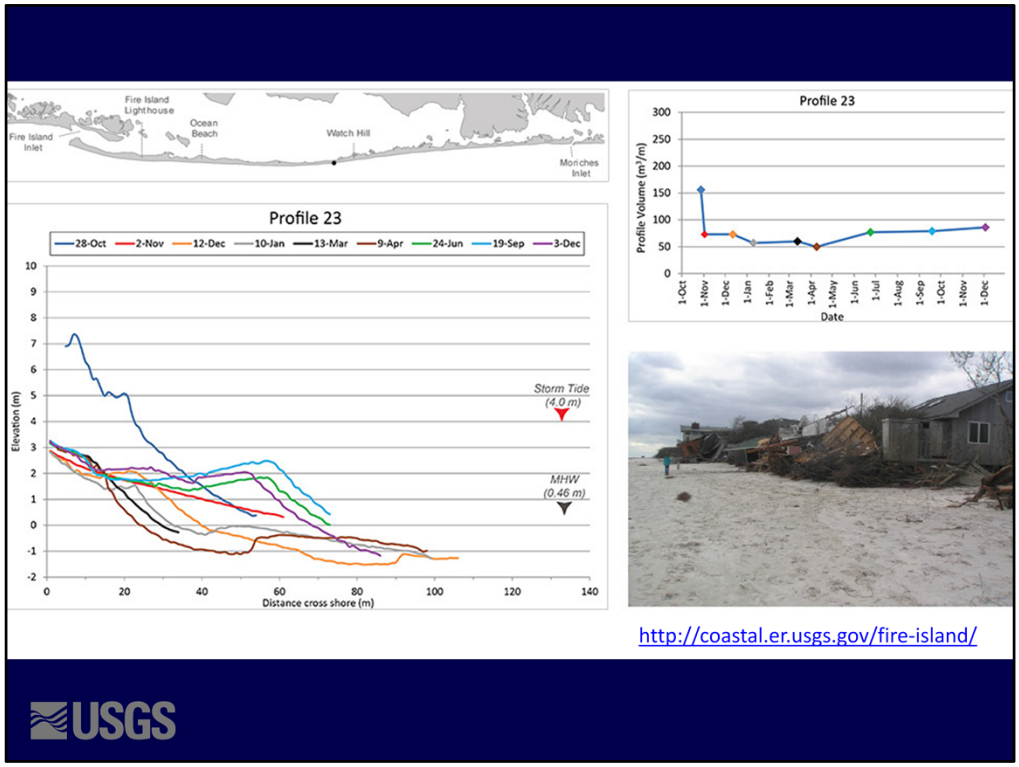
Because of lower elevations, barrier island is more vulnerable to erosion during future storms.

Prediction using pre-sandy lidar morphology. 20% likely to overwash. (50% actually did. Why the difference? Likely due to duration of the storm. Dunes eroded for several tide cycles. Becomes more vulnerable during the course of the storm.)

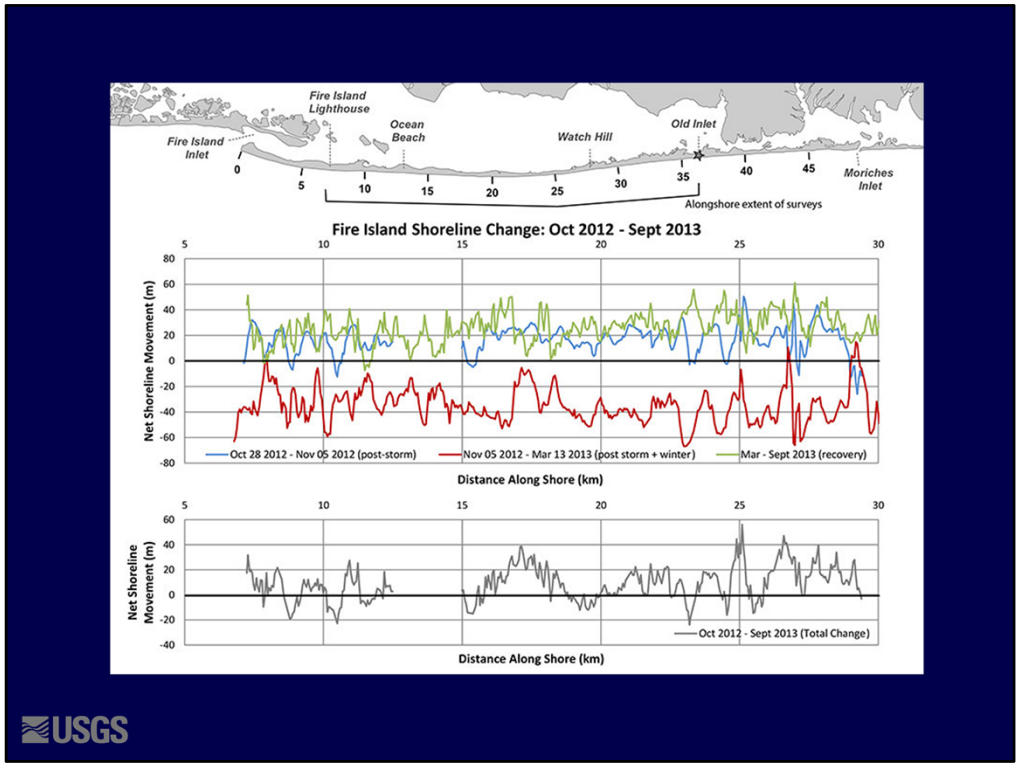
Prediction using post-sandy lidar morphology. 70% of island likely to overwash.
The USGS has continued to monitor FIIS for recovery.



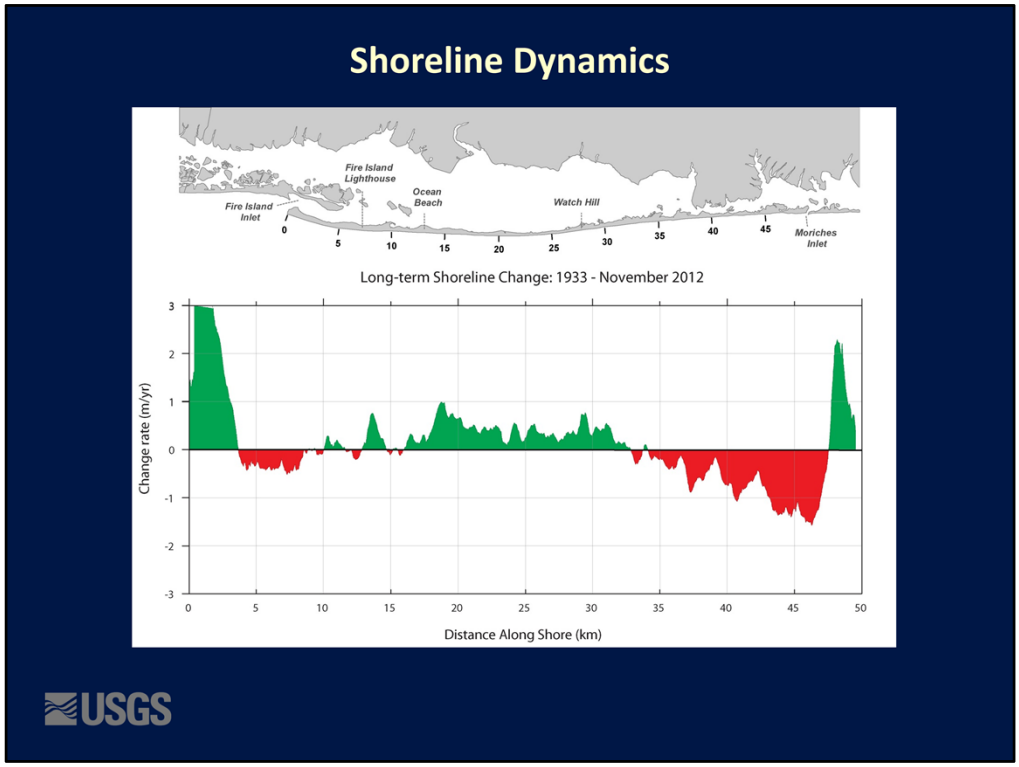
Pre- and post-storm surveys along western Fire Island. The inverted triangle was water level in the center of the island near these sites. Dunes were completely overwashed near the lighthouse (W7)



The central portion of Fire Island is overall much less developed and modified by humans than the western portion. However, beach/dune loss was much greater within the communities at Fire Island than in the natural areas. The communities alter the profile of the beach through beach scraping.



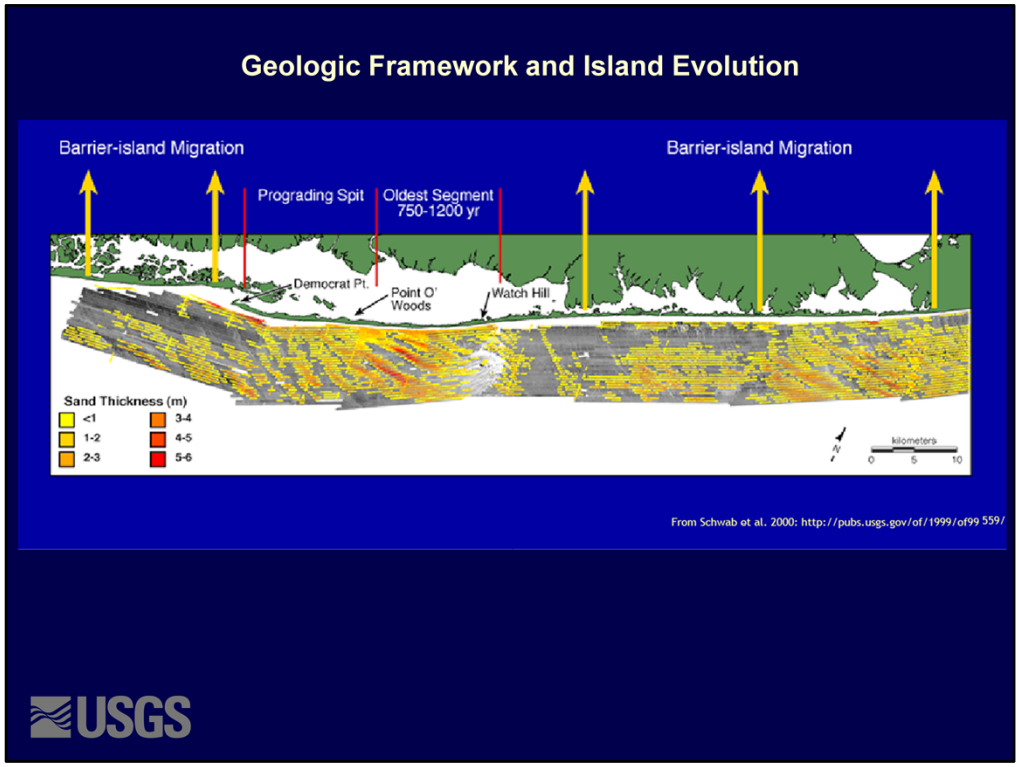
Rhythmic (~1-km length-scale)storm/recovery response, primarily accretional – related to welding of swash bar back onto beachface.
Shoreline continued to erode through winter. Noisier but broad patterns repeating, length-scale increasing.



An updated shoreline change analysis (1933 – 2011) shows three distinct zones of long-term shoreline behavior at Fire Island:

- strong erosional trend along eastern Fire Island (except for the area immediately adjacent to Moriches inlet where the large accretional signal is the result of jetty by-passing)
- progradational signal in central Fire Island
- Stable in western Fire Island (erosion rate of -0.12 is lower than the uncertainty of 0.2)

The zones of varying shoreline response correspond to mapped variations of features on the inner shelf implying that there is some geologic control on the long-term behavior of the shoreline.



Remember to mention USACE wants to mine the ridges for nourishment.
And Nearshore data gap.

Ongoing field research: Breach, closing nearshore data gap with waverunner surveys


Lessons learned and future research
Need for scenario-based assessments that can inform coastal management and planning decisions
Need for real-time forecasts of coastal erosion, especially overwash.
Results from field studies at Fire Island will feed back into USGS scenario-based and storm-specific predictive model
Geologic and societal influence on coastal resiliency
http://coastal.er.usgs.gov/hurricanes/
USGS


Questions?
USGS