
Hurricane Joaquin
Outer Banks, NC
October 2015
Photo credit: Dianna Keen

National Assessment of Coastal Change Hazards: Science for Decision Makers

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(representing co-PIs Hilary Stockdon, Nathaniel Plant, Joe Long, and many others…)

USGS National Assessment of Coastal Change Hazards

Extreme erosion during Hurricane Irene
Rodanthe, NC

Long-term cliff erosion
Pacifica, CA

Goal: Identify, quantify, and model the vulnerability of the U.S. shorelines to coastal change hazards

Ongoing Science Tasks

- Impacts of severe storms & hurricanes
- Long-term coastal change
- Coastal vulnerability to sea level rise

USGS

Forecasting Coastal Change during Storms

- Two decades of research on storm-induced coastal change
- Development of models for forecasting future impacts
- Implementation and sharing with stakeholders

Photo credit: Mario Tama

Seaside Heights, NJ after Hurricane Sandy (2012)

Coastal response to Hurricane Isabel
Hatteras, NC

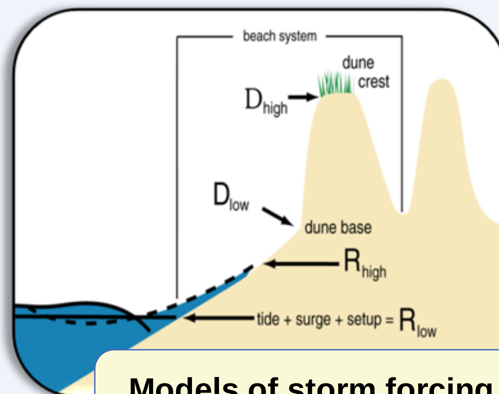
Predictions of Coastal Change during Storms

The beach response to storms is dependent, in part, on the interactions between local morphology and the offshore forcing.

These data are used by sophisticated models to simulate and predict the type/magnitude of coastal changes that may be expected during storms.

Approaching storm (waves, surge)

Beach morphology (slope, dune height)



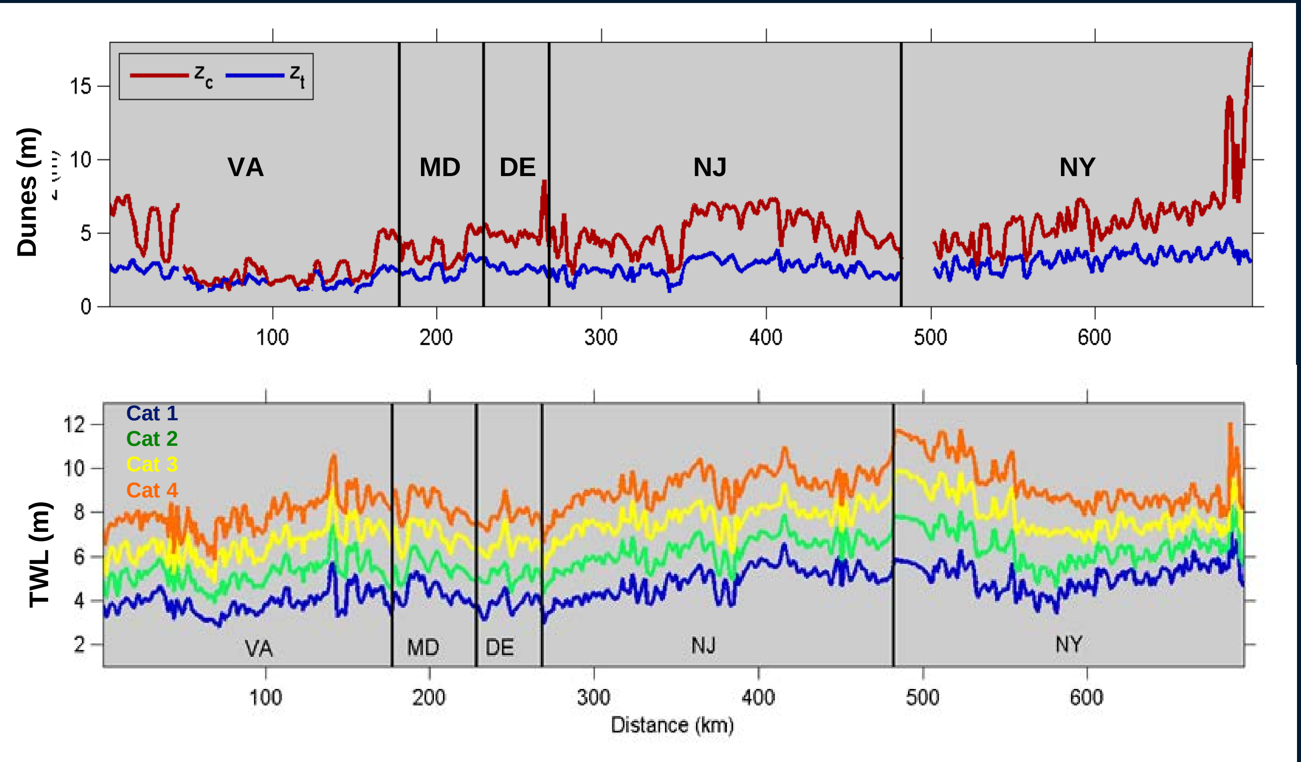
Models of storm forcing and beach response

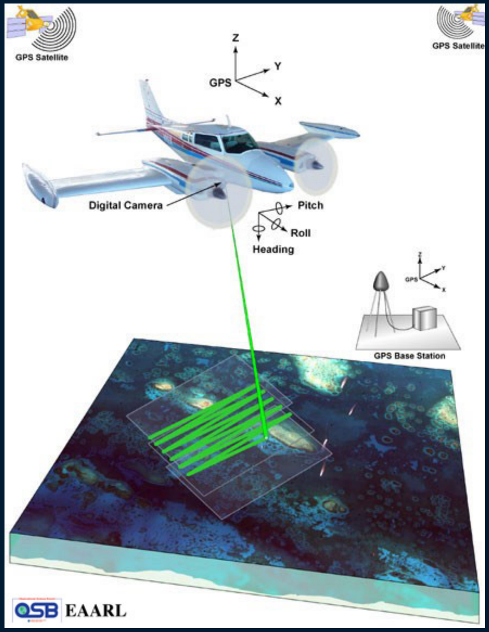
Coastal change (overwash, erosion)

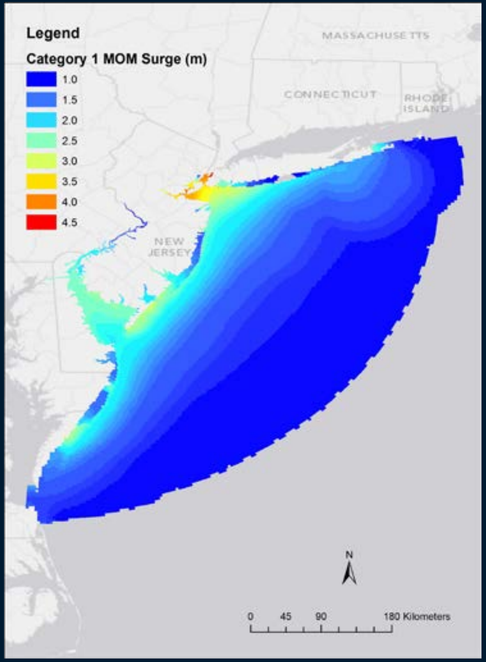
USGS

Elements of coastal change forecasts

Dune elevations - Lidar-based topography surveys (USGS, NOAA, USACE)







Total water levels - Wave and surge models (USGS, NOAA)

USGS

Probabilities of coastal change

What is the likelihood that storm-induced total water levels will exceed the elevation of the base and crest of protective sand dunes?

Collision

Waves/surge collide with the dune base, leading to erosion.

Overwash

Waves/surge overtop dune crest, moving sand landward.

Inundation

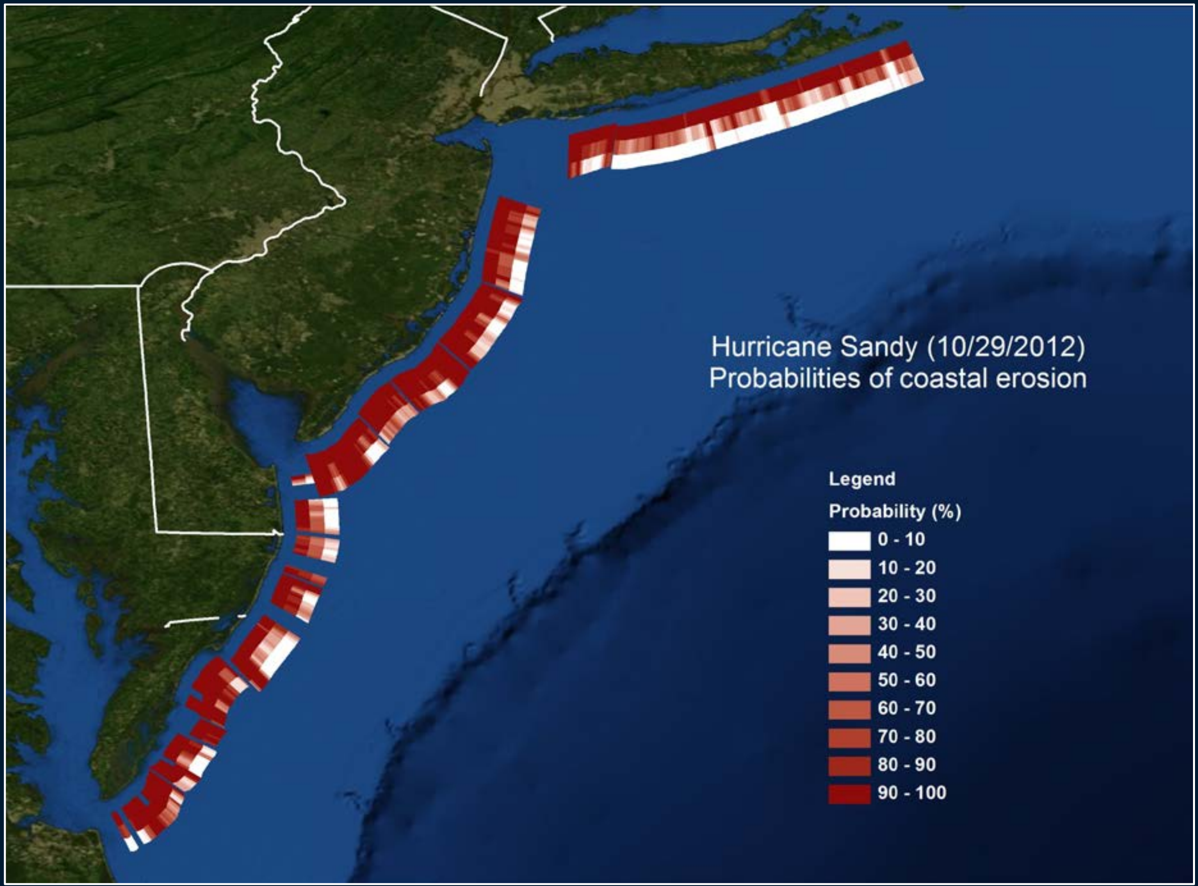
Surge is higher than dune crest, submerging beach system.

1) Real-time mode for approaching storms
2) Scenario-based approach for generalized storms

USGS

Real-time forecast of coastal erosion – Hurricane Sandy

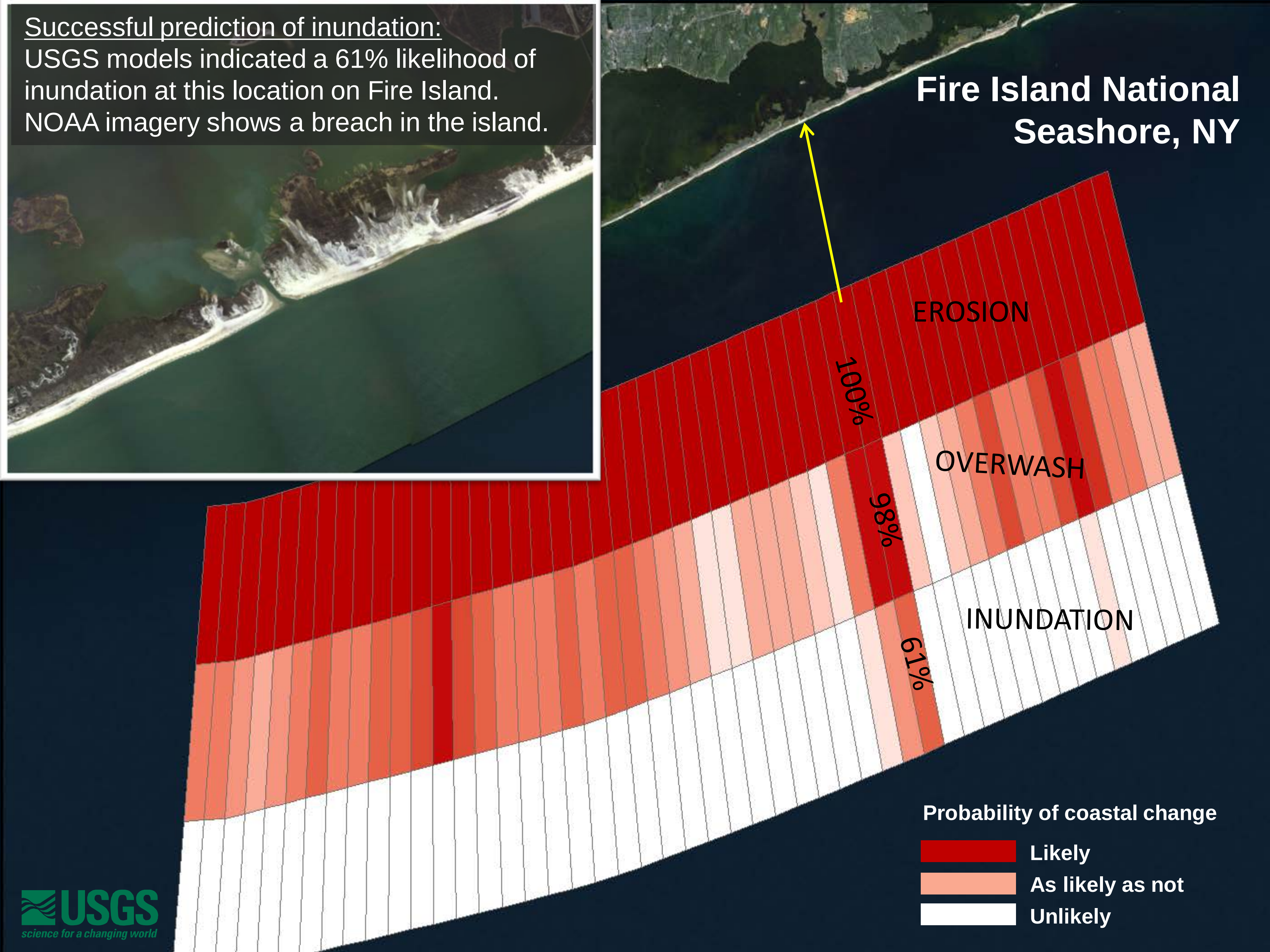
- Inputs:
  - Lidar-based shorelines, dunes (USGS, USACE)
  - Storm surge (NOAA)
  - Wave conditions (NOAA)
  - Wave runup (USGS)
- Output: Probabilities of
  - Dune erosion
  - Overwash
  - Inundation
- Assessments are posted online and updated with NHC meteorology as the storm nears landfall.



% of coast very likely to experience coastal change :

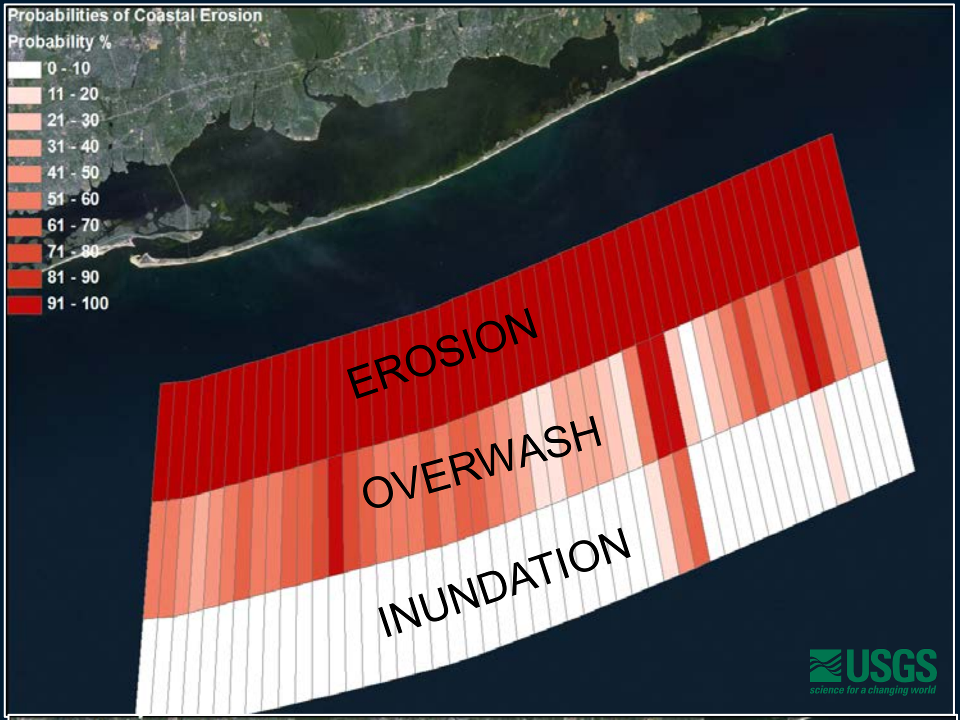
	Dune erosion (inner)	Overwash (middle)	Inundation (outer)
Long Island, NY	93	12	4
New Jersey	98	54	21
Delmarva	91	55	22

USGS

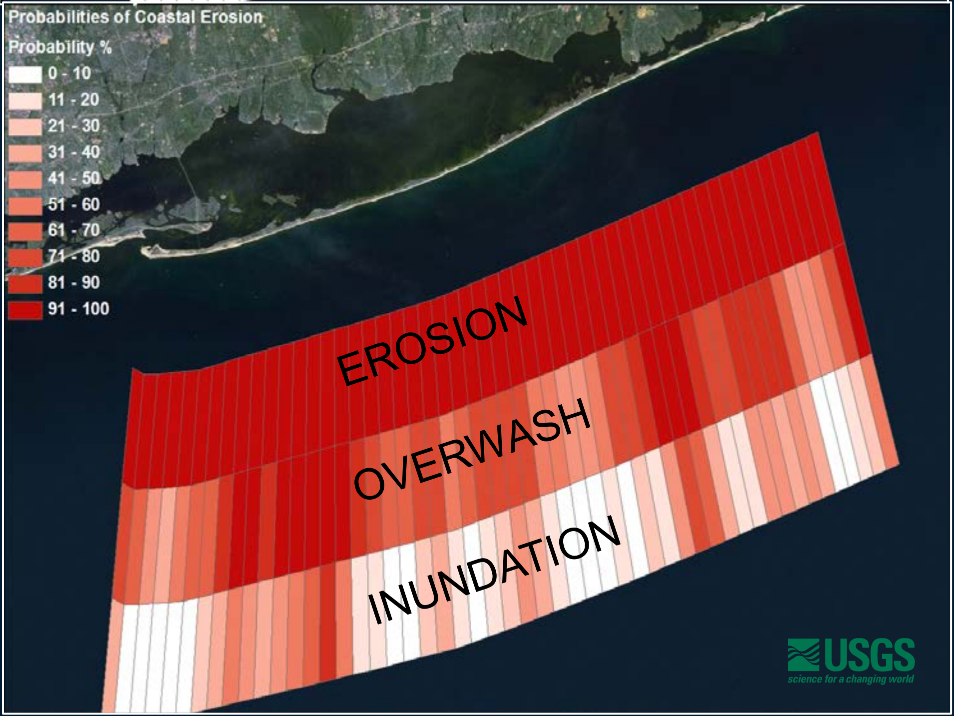


Successful prediction of inundation:
USGS models indicated a 61% likelihood of inundation at this location on Fire Island. NOAA imagery shows a breach in the island.
Fire Island National Seashore, NY
EROSION
OVERWASH
INUNDATION
100%
98%
61%
Probability of coastal change
Likely
As likely as not
Unlikely
USGS
science for a changing world

Increased vulnerability to coastal erosion during future storms



Pre-Sandy (2010) vulnerability
20% of Fire Island was likely to overwash during Hurricane Sandy.



Post-Sandy (2012) vulnerability
70% of Fire Island is likely to overwash during conditions similar to Sandy.

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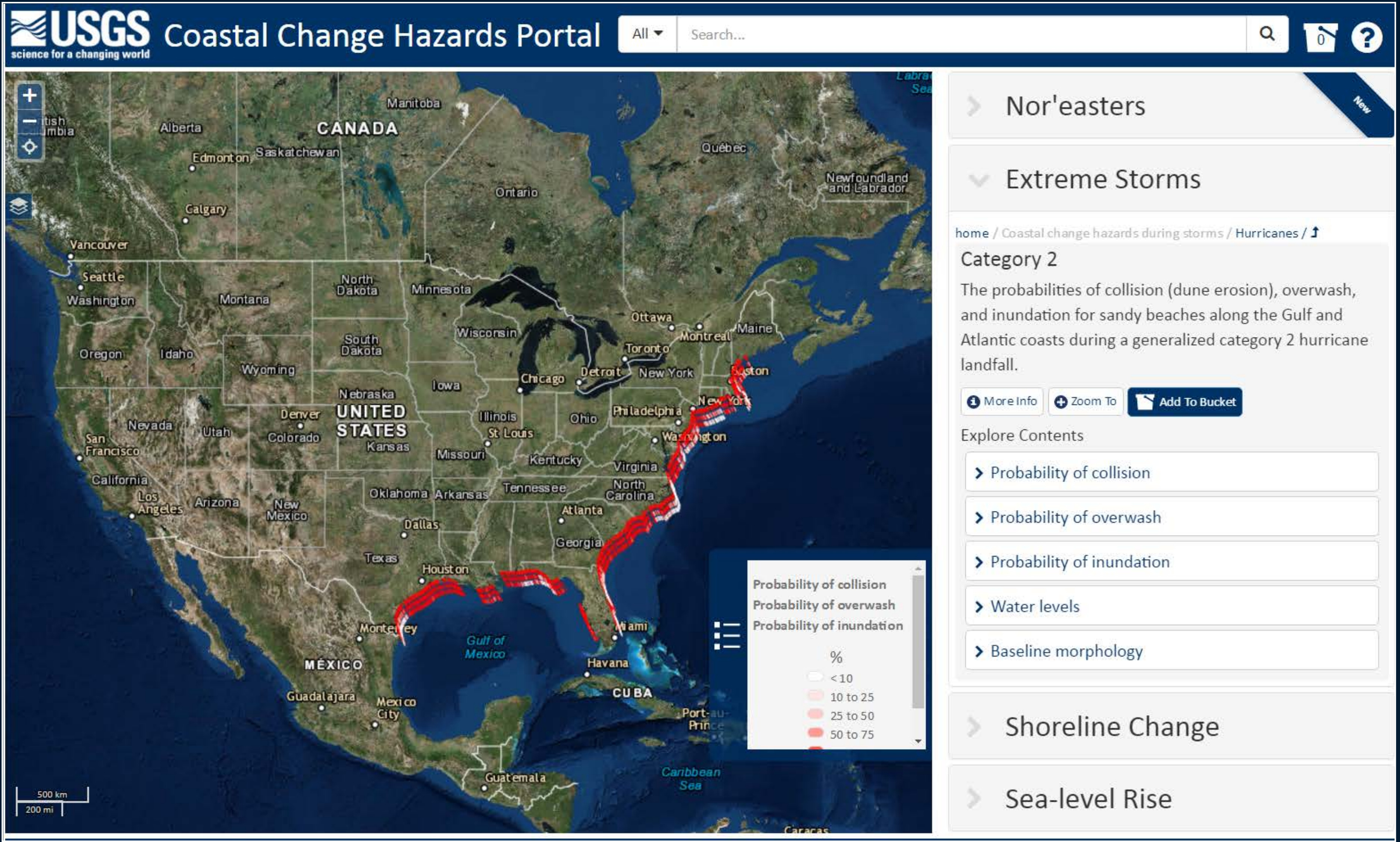
Coastal Change Hazards Portal

Scenario-based coastal change forecast: category 2 storm on post-Sandy beaches and dunes

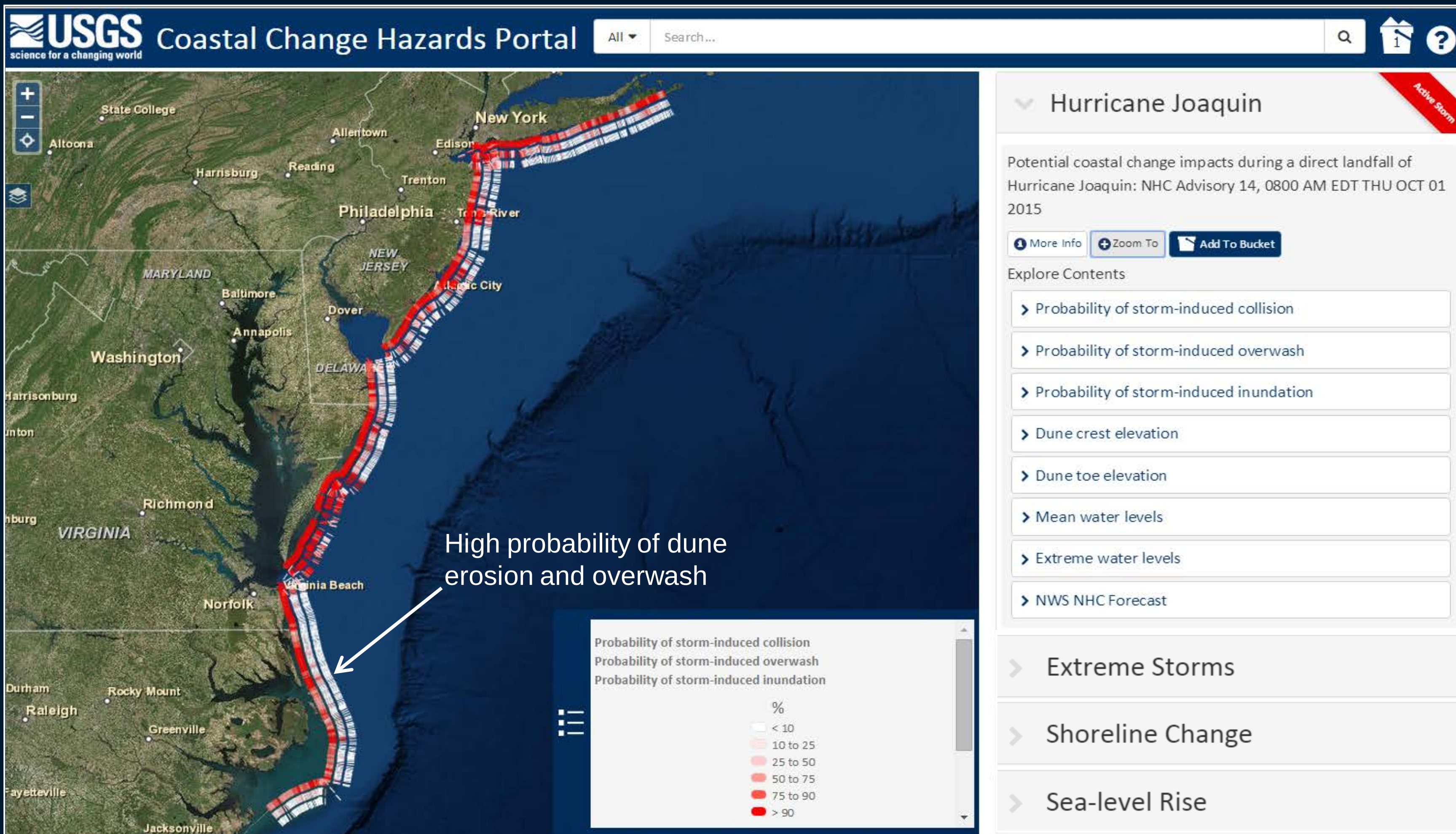


http://marine.usgs.gov/coastalchangehazardsportal/

USGS

Real-Time Coastal Change Forecast: Joaquin (2015)

- Assessments, data, and web mapping services available online for the first time
- Includes probability of collision, overwash, and inundation, as well as lidar-derived dune elevations and storm-specific total water levels



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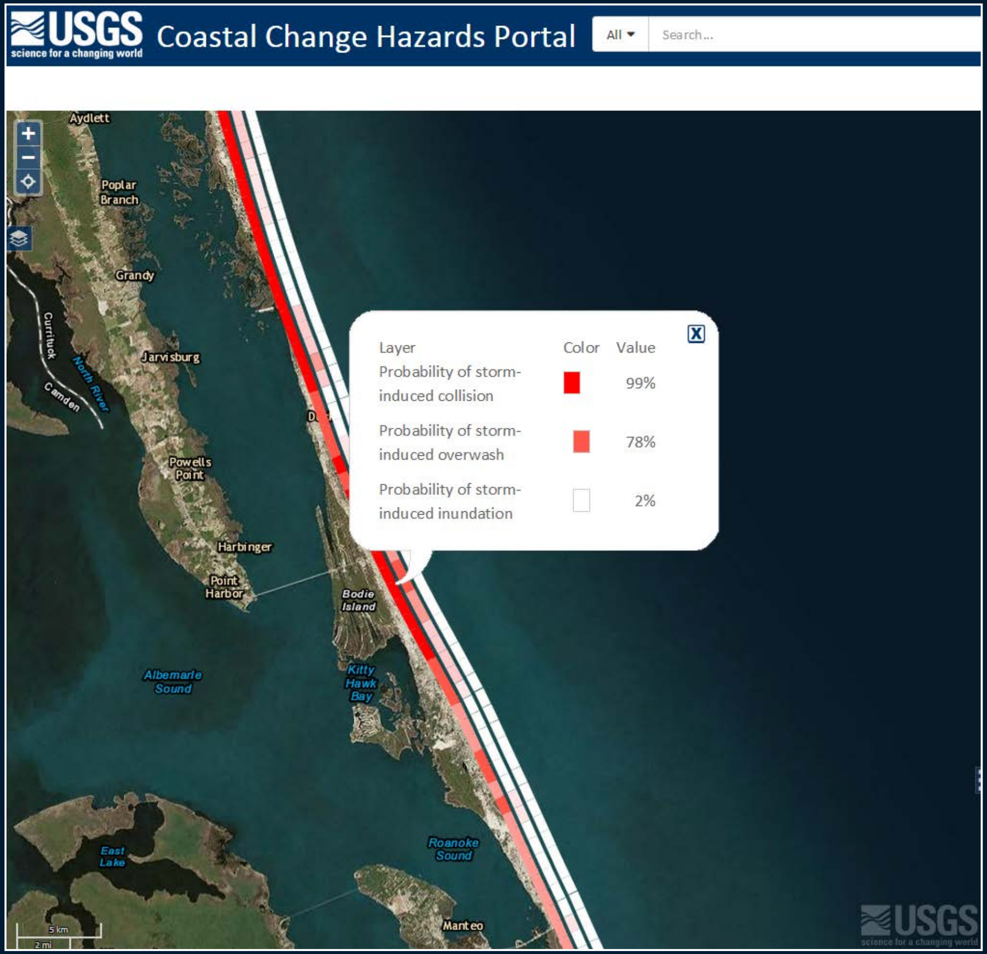

Photo credit: National Weather Service

- Overwash of Hwy 12 was observed in Kitty Hawk, NC during Joaquin. USGS models indicate the probability of overwash in this region was ~75%.
- Extensive dune erosion was also observed, consistent with model forecasts indicating that the probability of dune erosion was >95% for this entire region.

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Operational Total Water Level Model: Hurricane Joaquin (2015)

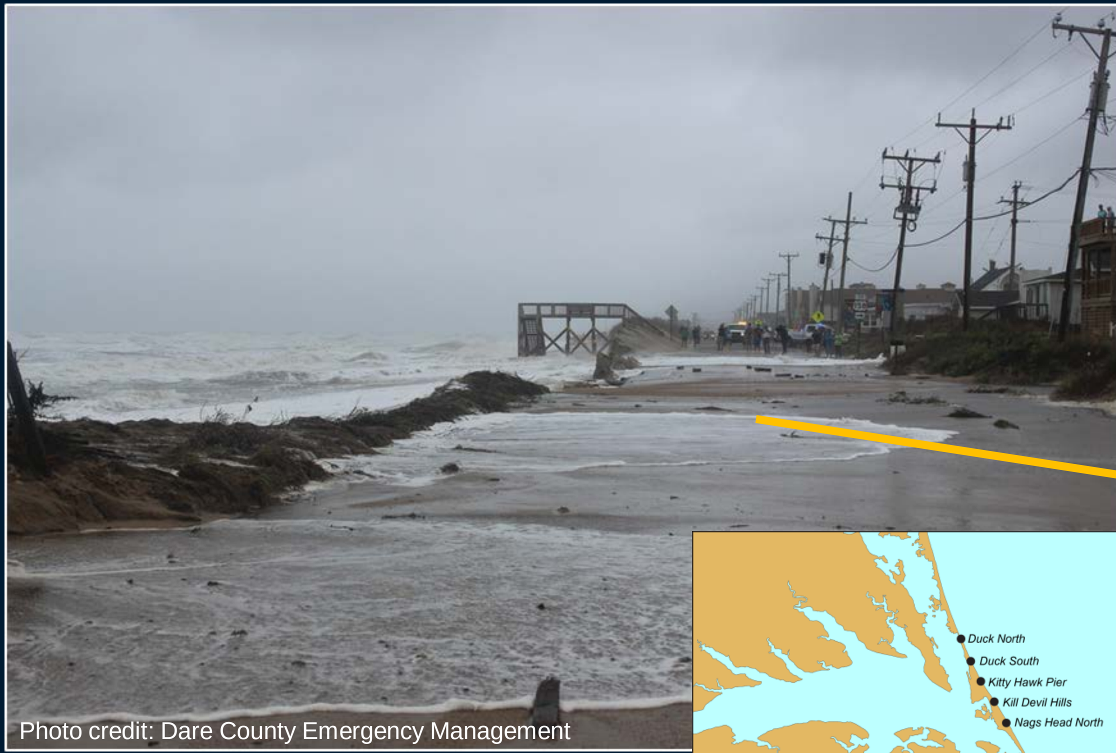
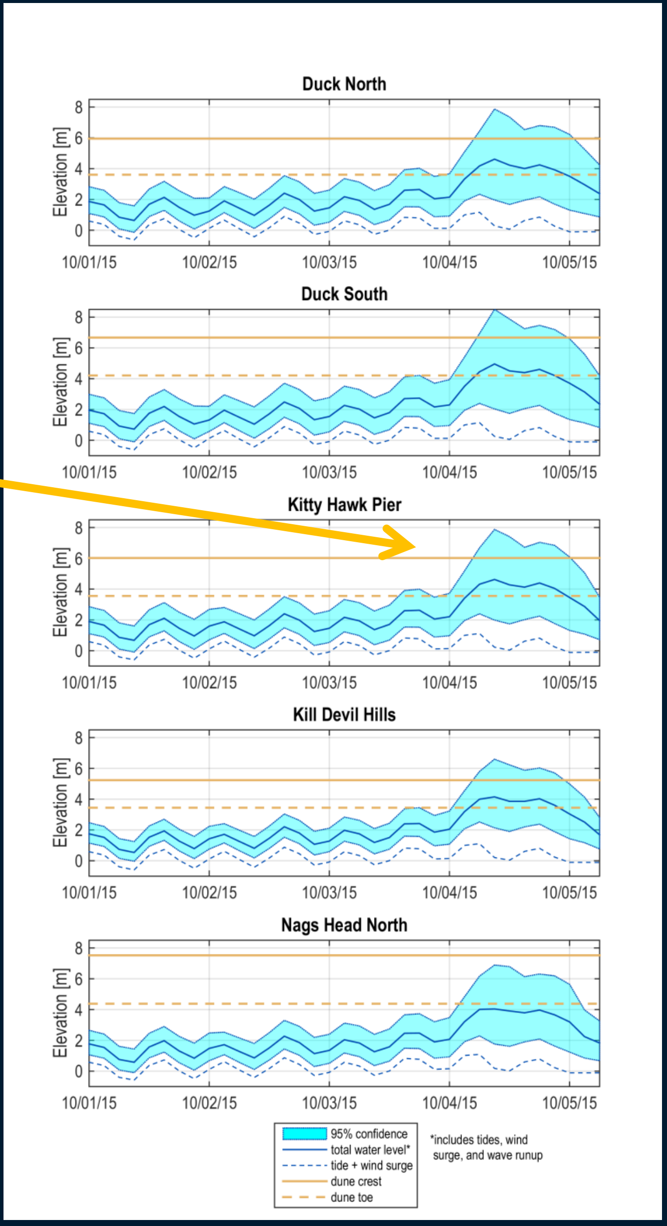


Photo credit: Dare County Emergency Management

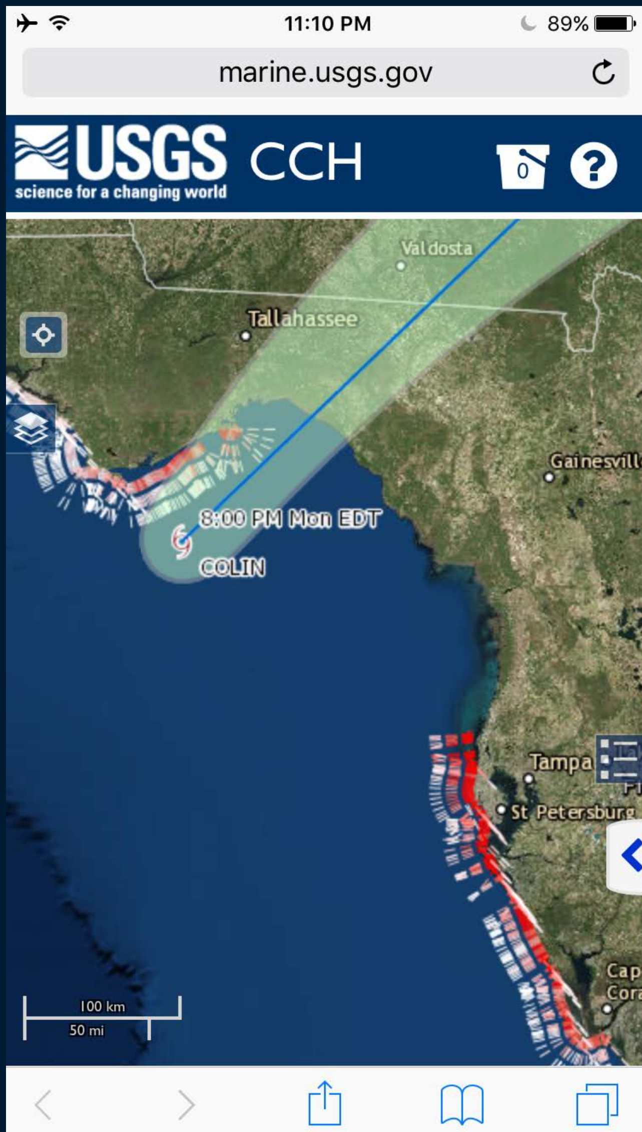


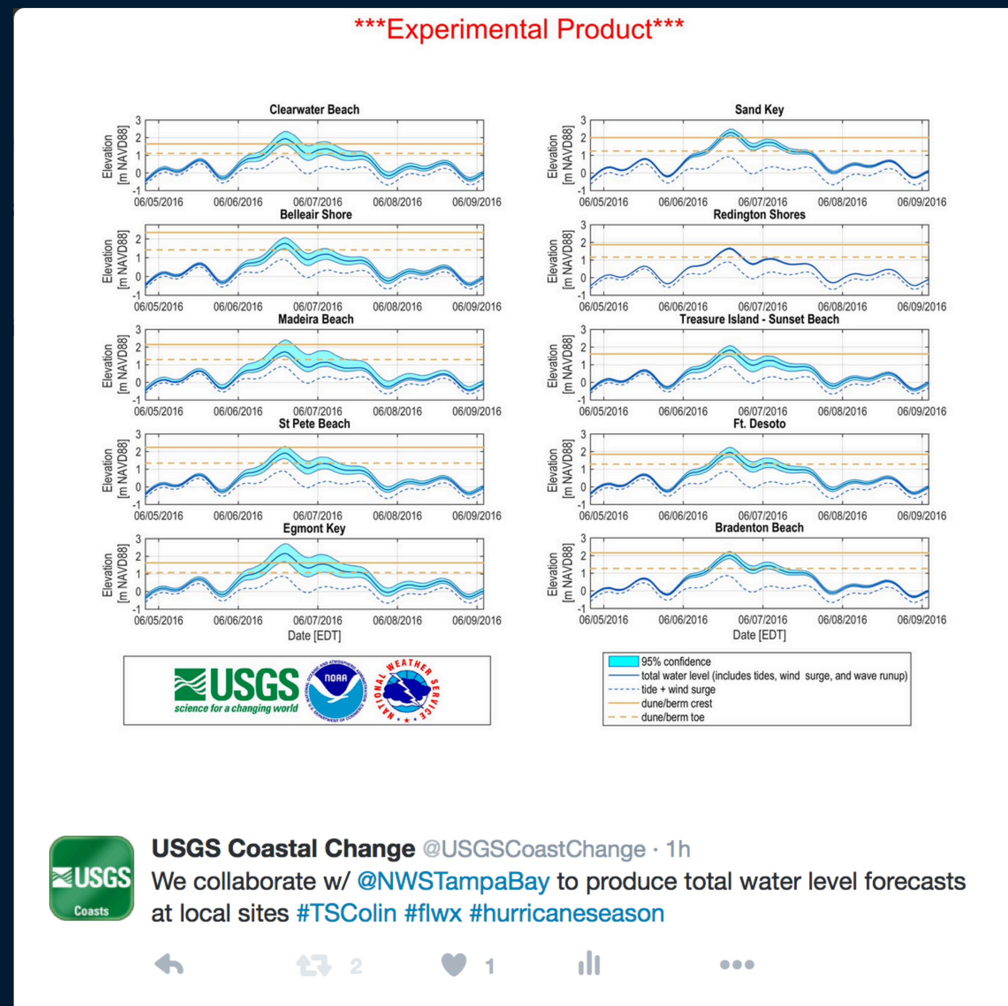
Operational forecasts of total water levels can warn local officials of potential overwash, such as that observed along Hwy 12 in Kitty Hawk.

(USGS collaboration with NOAA, NWS)

USGS

Operational Total Water Level Model: TS Colin (yesterday…)





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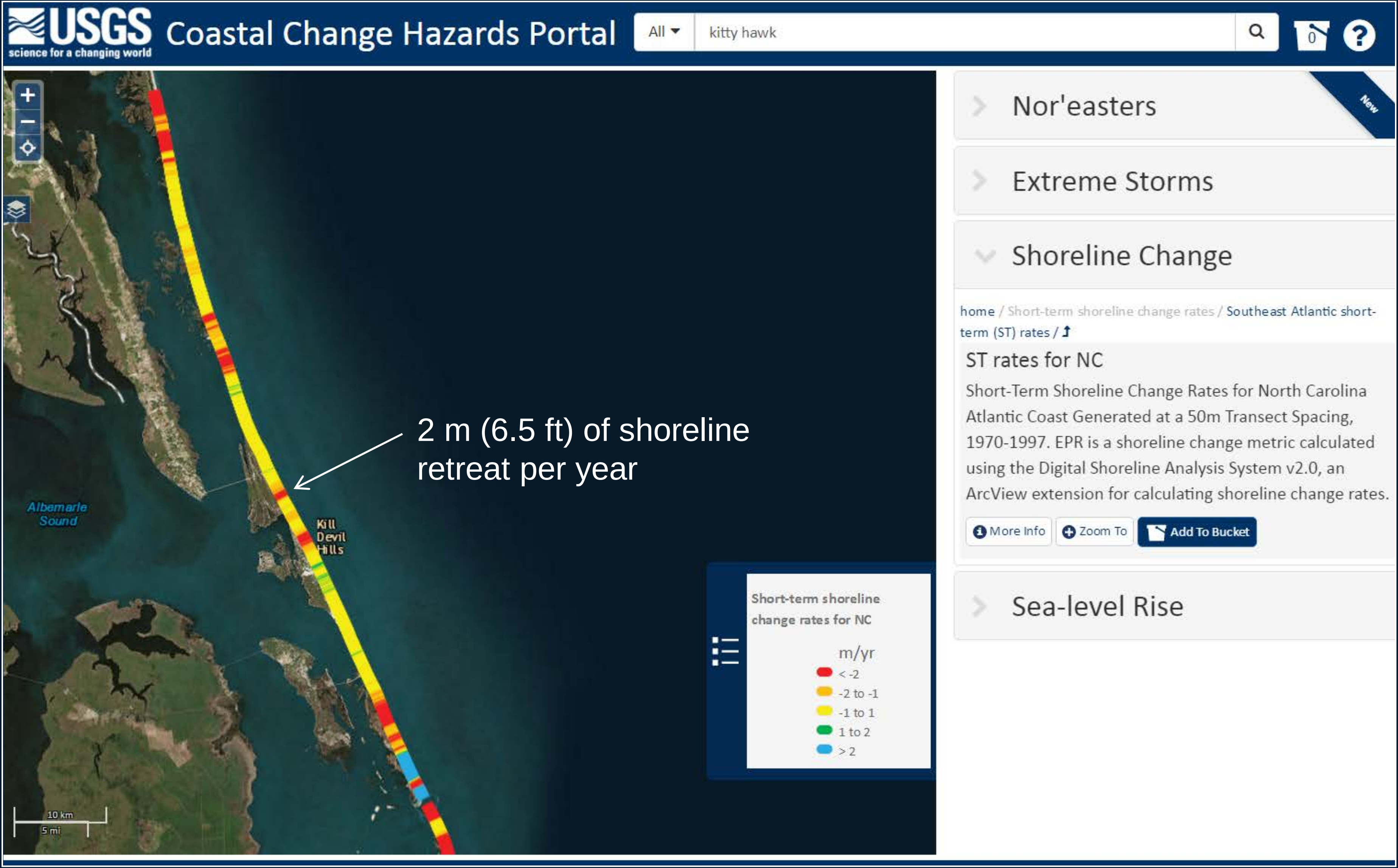
Historical shoreline change

Short-term rate based on data from 1970-1997



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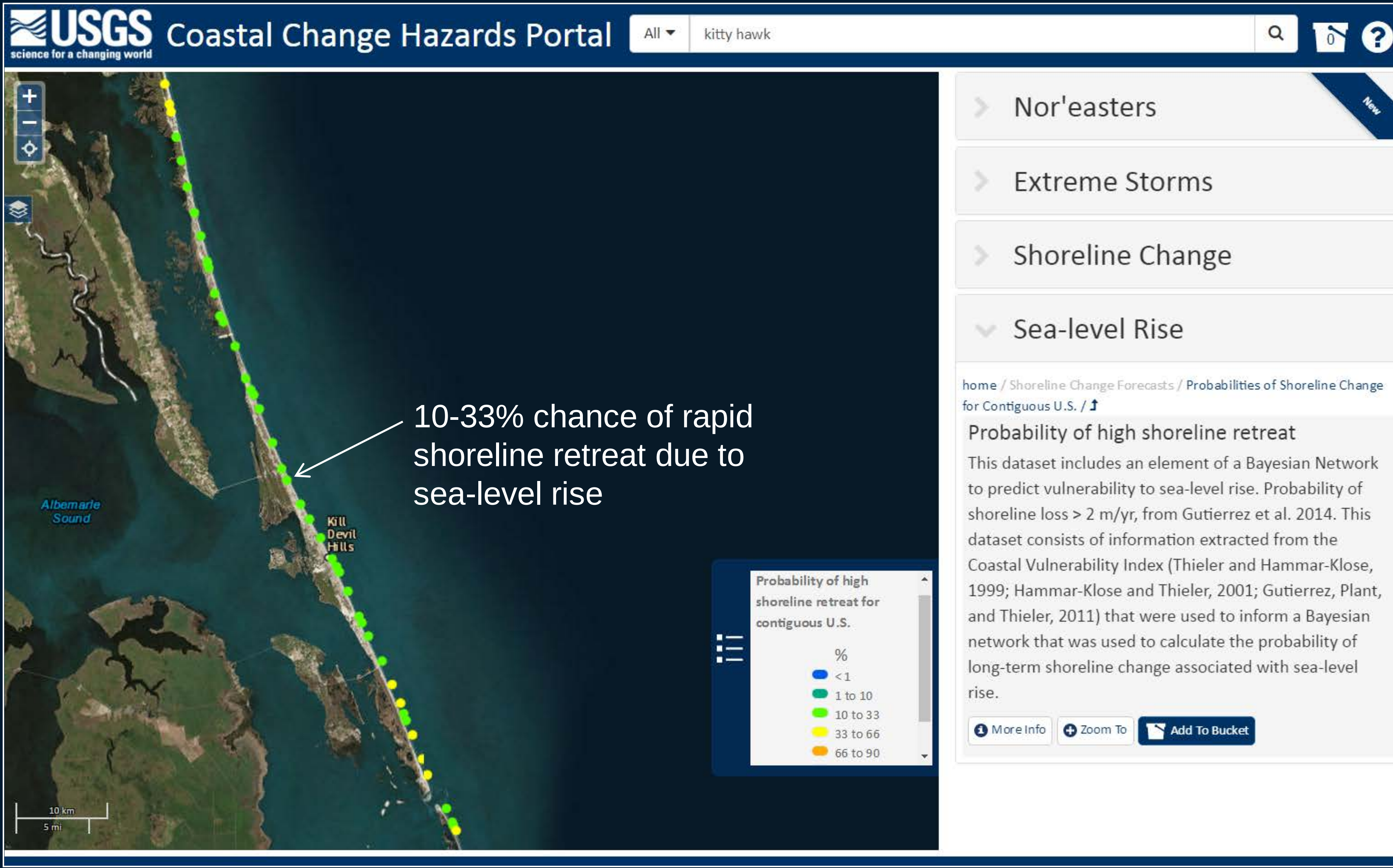
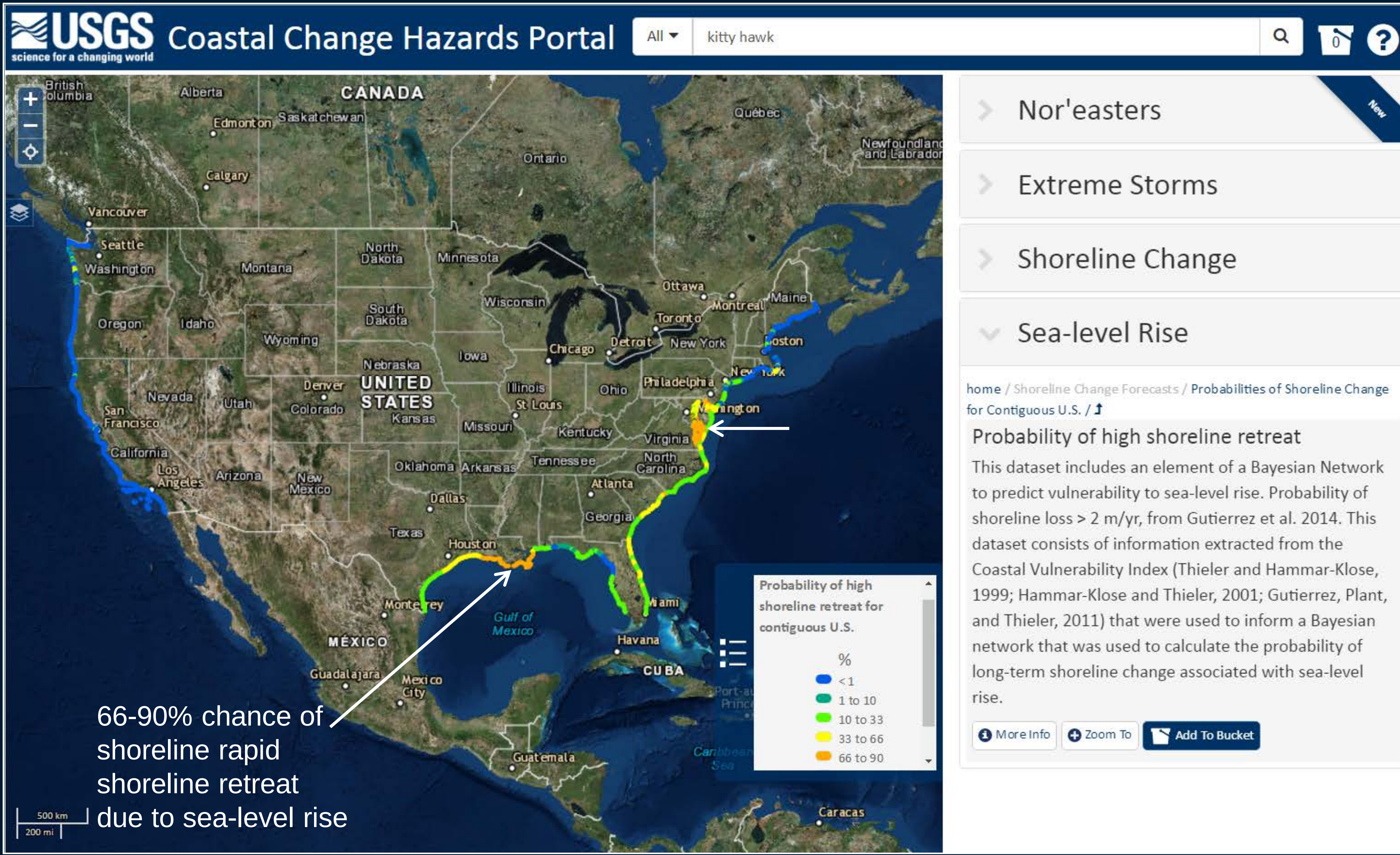
Erosion due to Sea-Level Rise

Probability of more than 2 m/yr of shoreline retreat

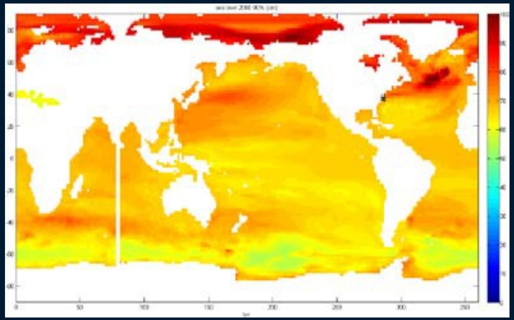


Erosion due to Sea-Level Rise

Probability of more than 2 m/yr (6.5 ft/yr) of shoreline retreat



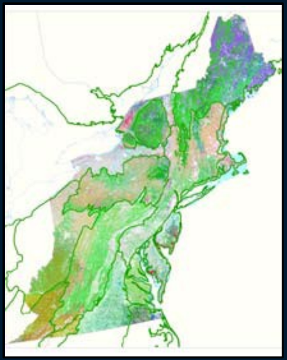
Determine probabilities of adjusted land elevation and response type given a range of sea level scenarios



Latest GCM Projections

Tide Gauge and GPS Velocities

National Elevation Dataset



TNC Ecological Systems Map

Projected Sea Level (m)	
0 to 0.25	25.0
0.25 to 0.5	25.0
0.5 to 0.75	25.0
0.75 to 2	25.0

Vertical Land Movement (m)	
-0.3 to 0	33.3
0 to 0.1	33.3
0.1 to 0.3	33.3

Elevation (m, MHW)	
-10 to -1	39.8
-1 to 0	18.7
0 to 1	17.4
1 to 5	23.5
5 to 10	0.55

Adjusted Elevation (m)	
-11.7381 to -1	40.2
-1 to 0	18.1
0 to 1	15.2
1 to 5	19.5
5 to 10.0478	6.99

Land Cover Type	
Water	57.0
Marsh	14.5
Beach	4.02
Cliff	0.24
Forest	13.5
Developed	10.7

Coastal Response Likelihood	
Dynamic	71.0
Inundate	29.0

Dynamic Response vs. Inundation

Photo Credit: Sydney Coastal Councils Group

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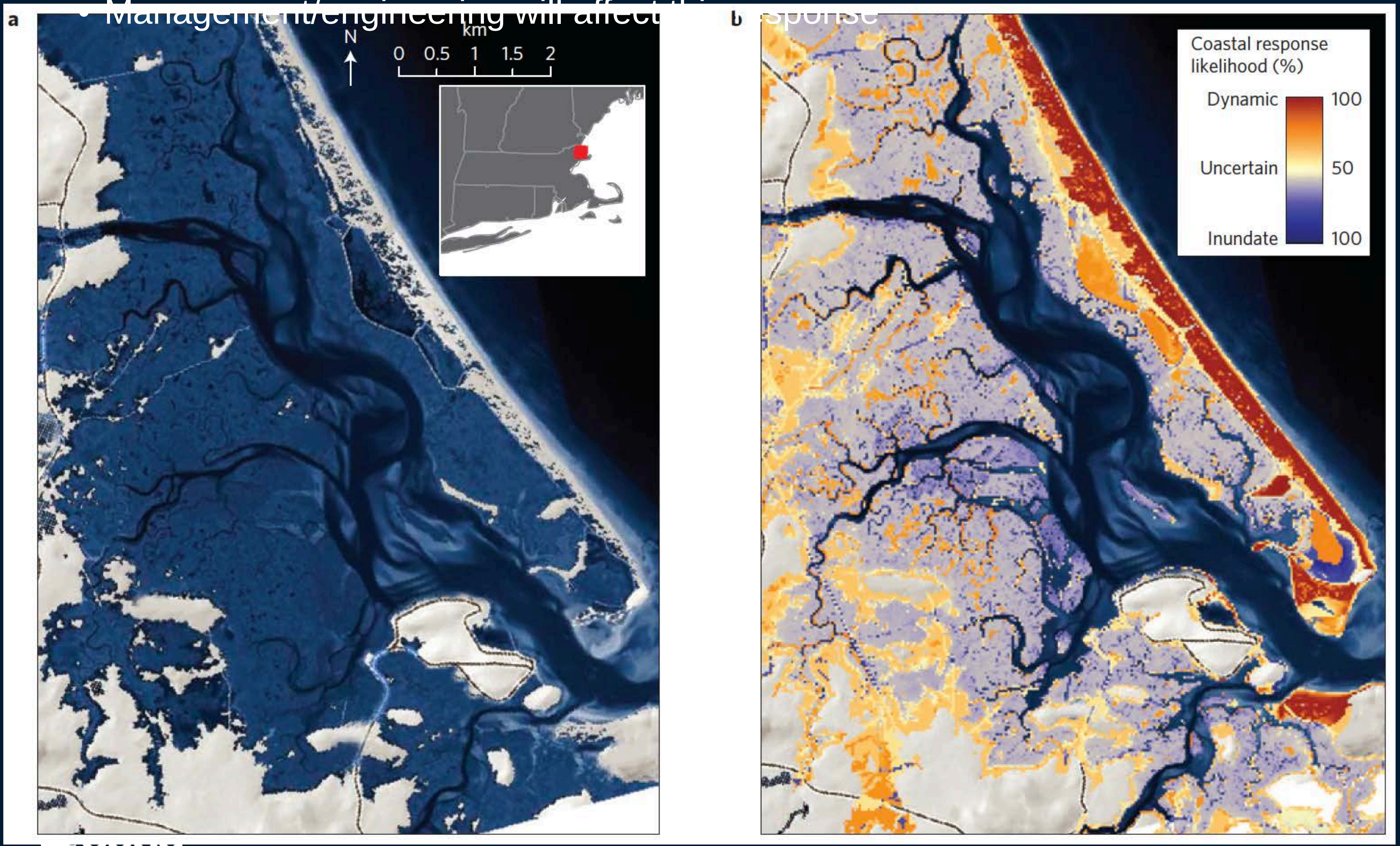
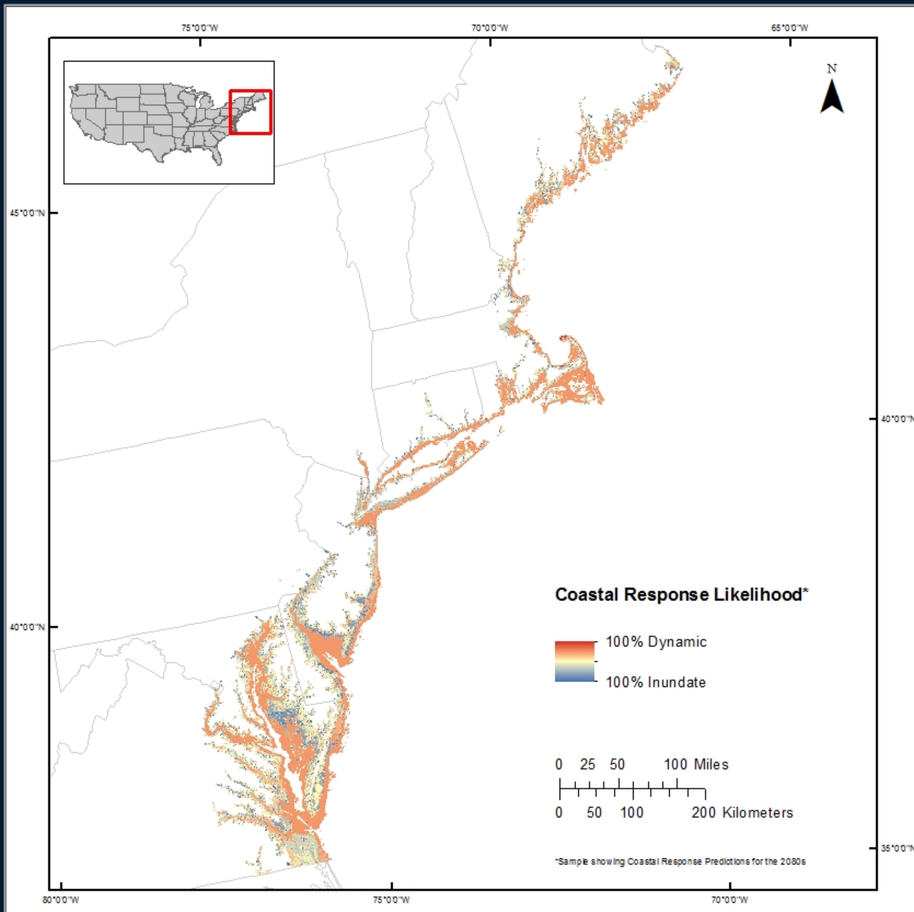
Dynamic Coastal Response to Sea-level Rise

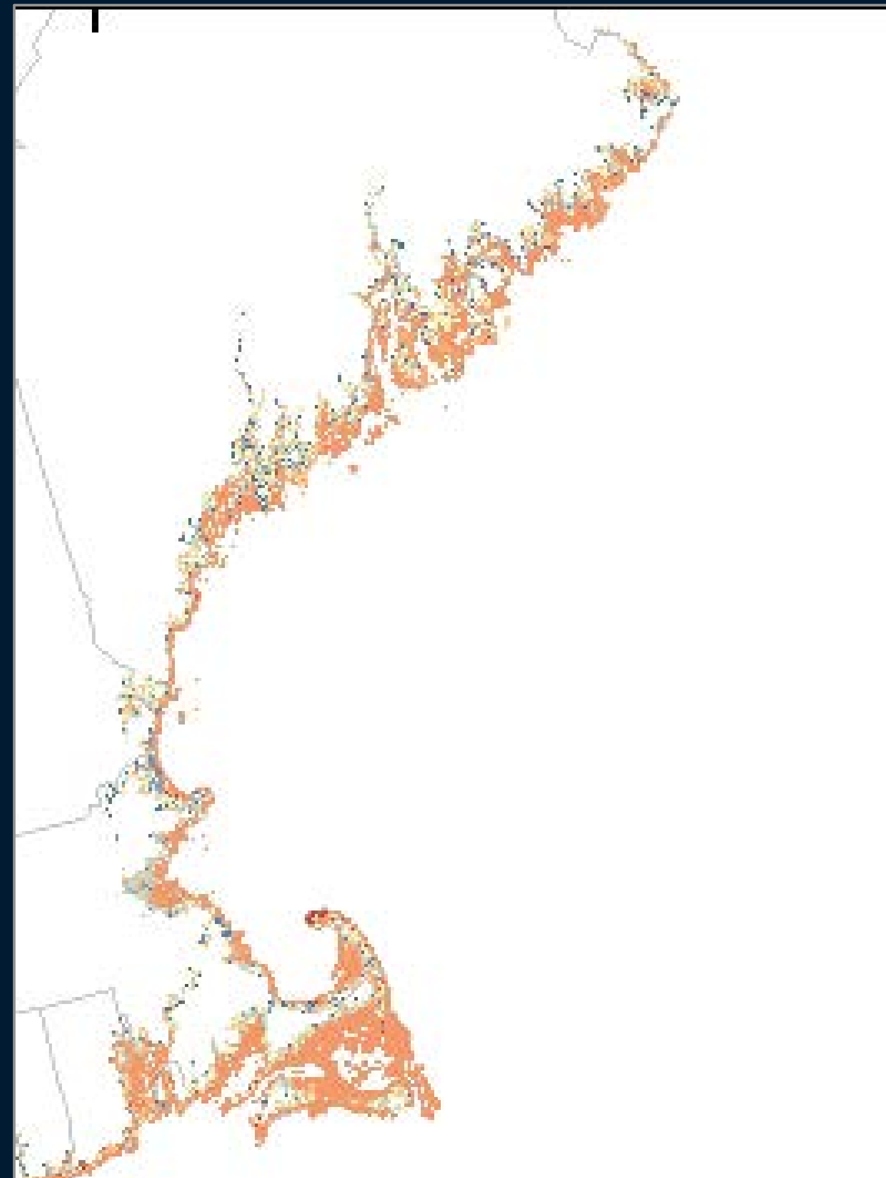
- Some places will be inundated… but some will not, and more area is likely affected
- Management/engineering will affect this response



(Lentz et al., 2016)

Coastal response to SLR predictions





http://go.usa.gov/cSJNk

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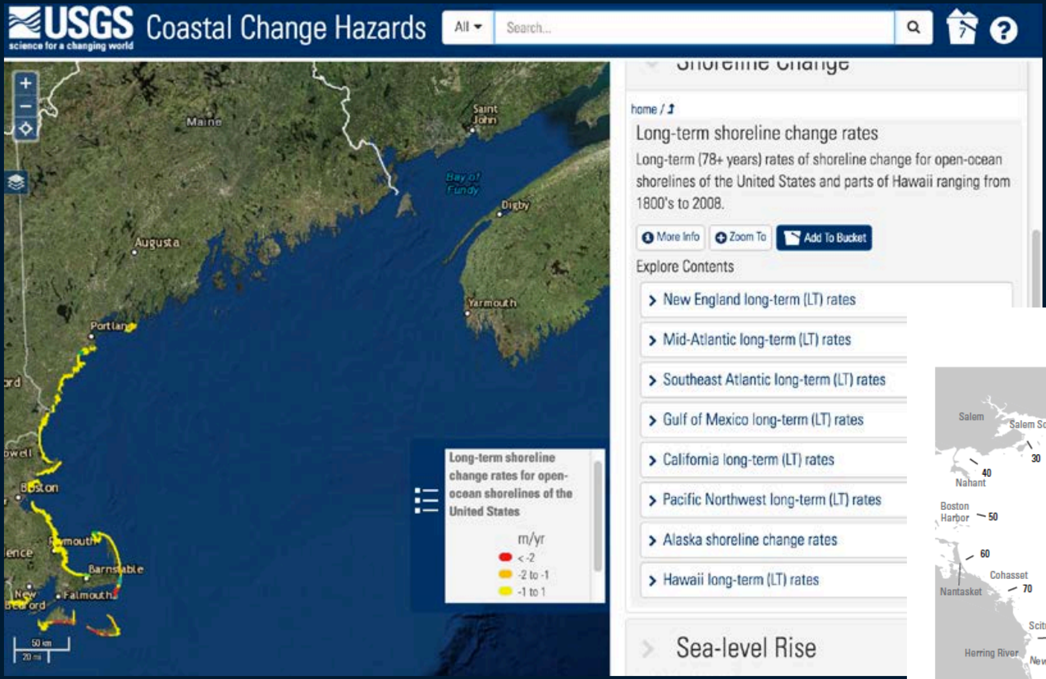
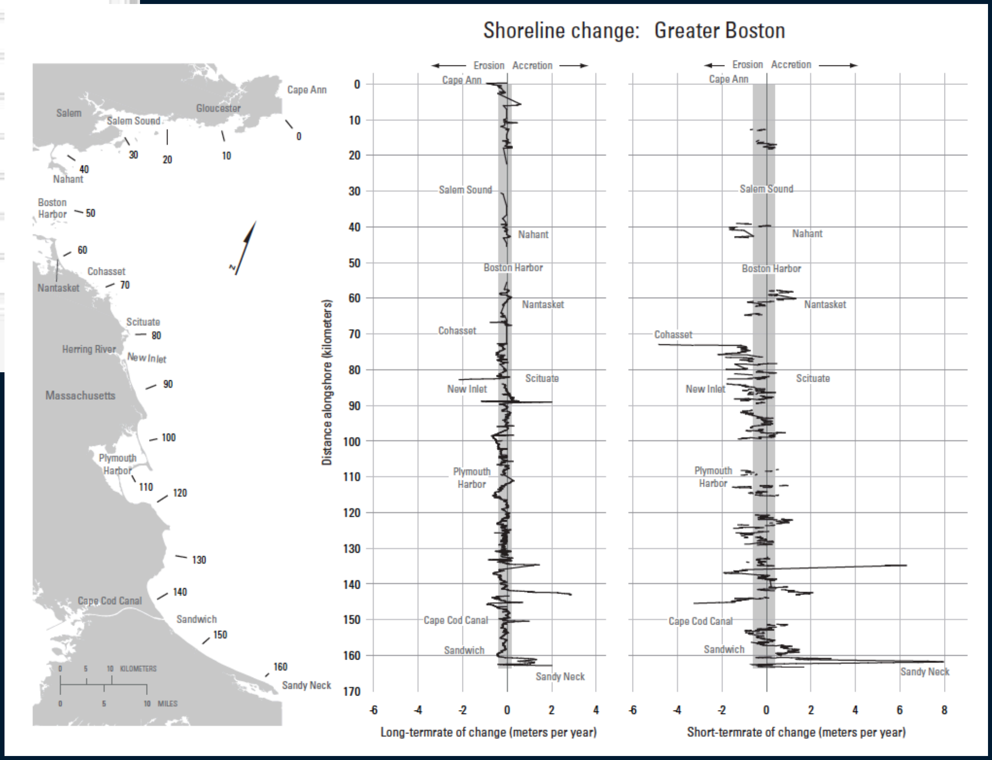
(Lentz et al., 2015; 2016)

Long-term shoreline change

- Consistent national database of shoreline positions and rates of change
- Analyses of geology and processes in change trends
- Framework for national synthesis

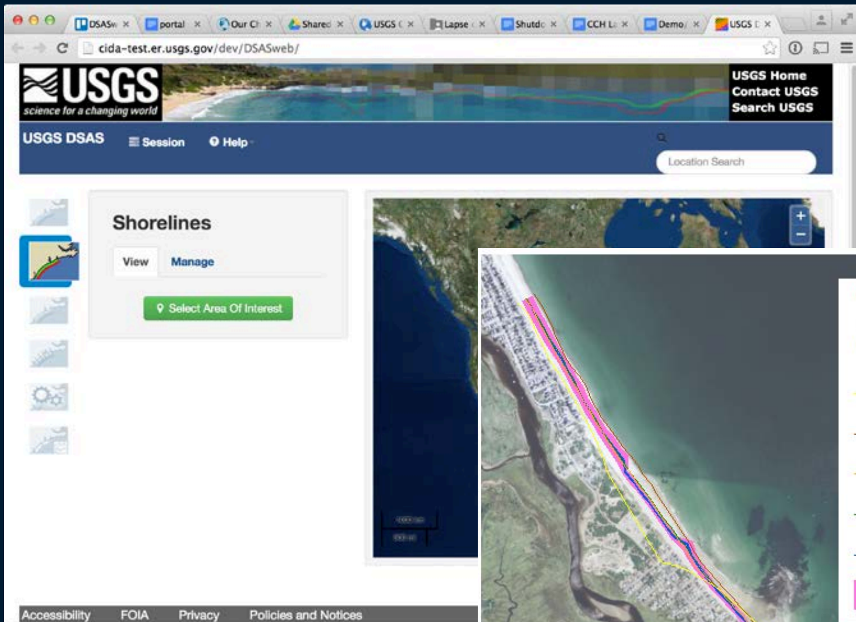
Gulf of Mexico 2004, 2016*
Southeastern U.S. 2005, 2016*
California beaches and cliffs, 2006/7
Northeastern U.S. 2010
Hawaii 2012
Pacific Northwest 2013
Alaska North Slope 2014

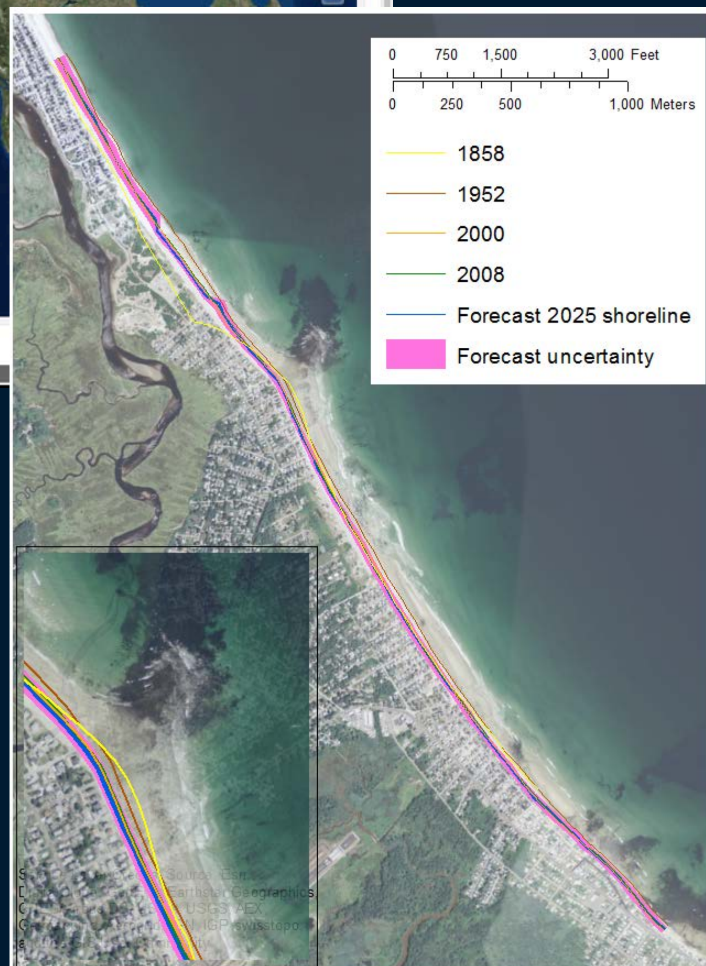


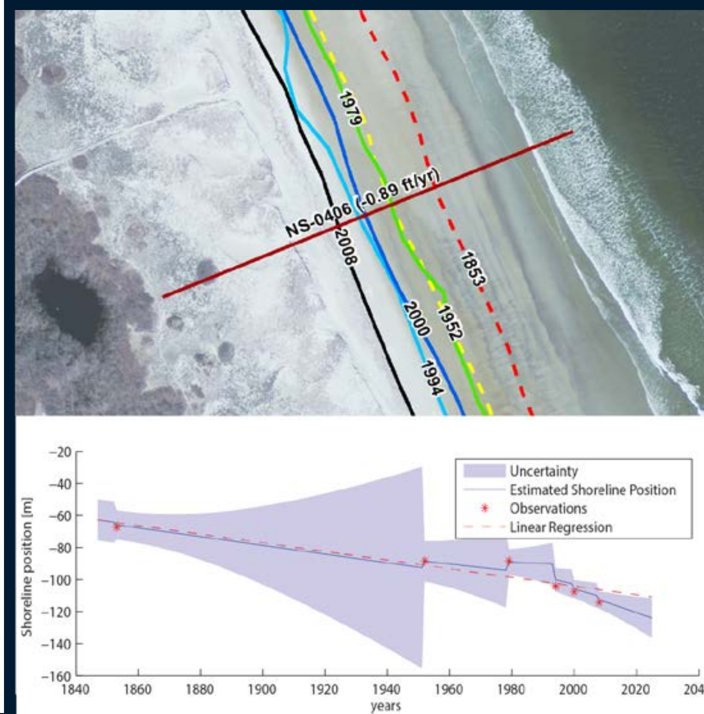


(Hapke et al., 2010)

Shoreline change forecasting



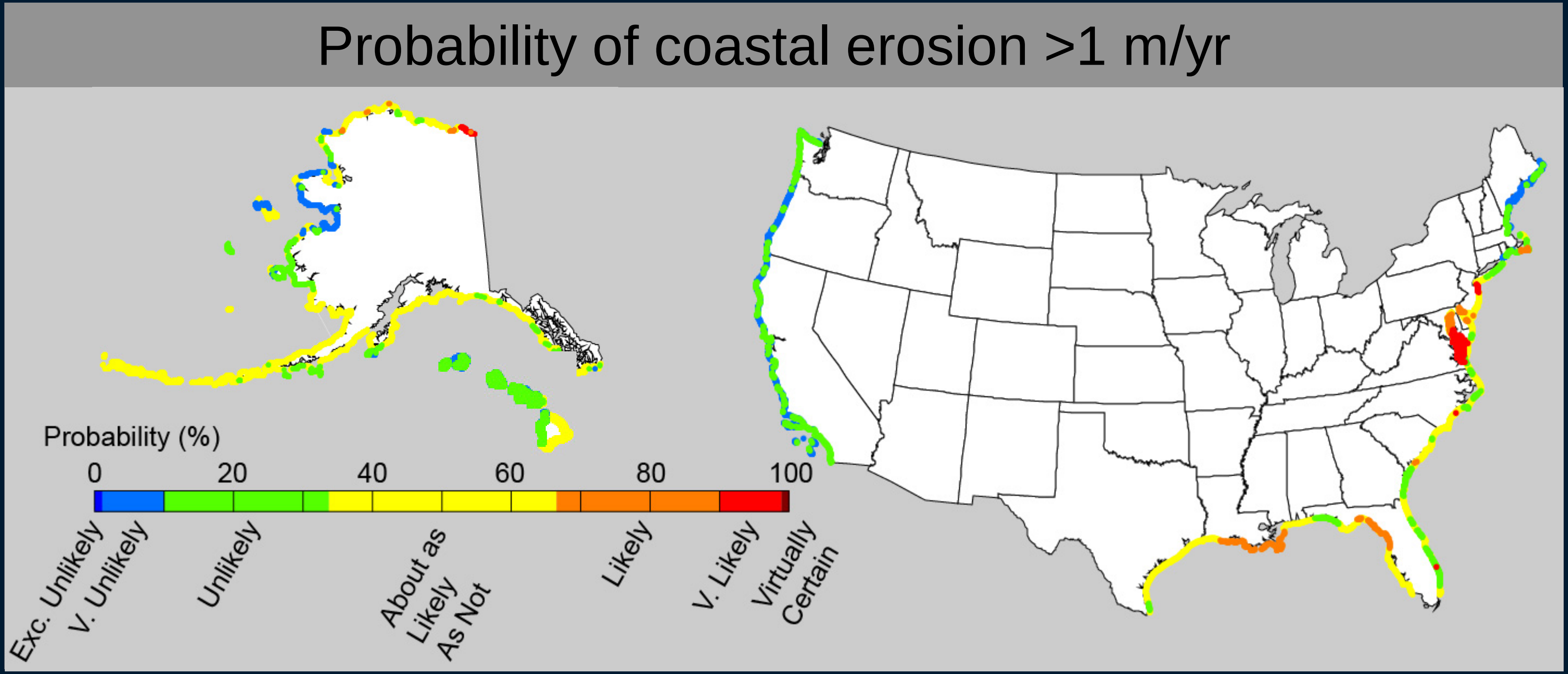




(Massachusetts Coastal Erosion Commission, 2015)

Predicting future changes

- Bayesian Network uses climate forcing and geologic constraints
- Prediction and uncertainty maps identify where better information is needed (input data, process understanding)
- Provides scientific knowledge context for decision makers
- Can use to focus research resources



(Gutierrez et al., 2011; USGCRP, 2014)

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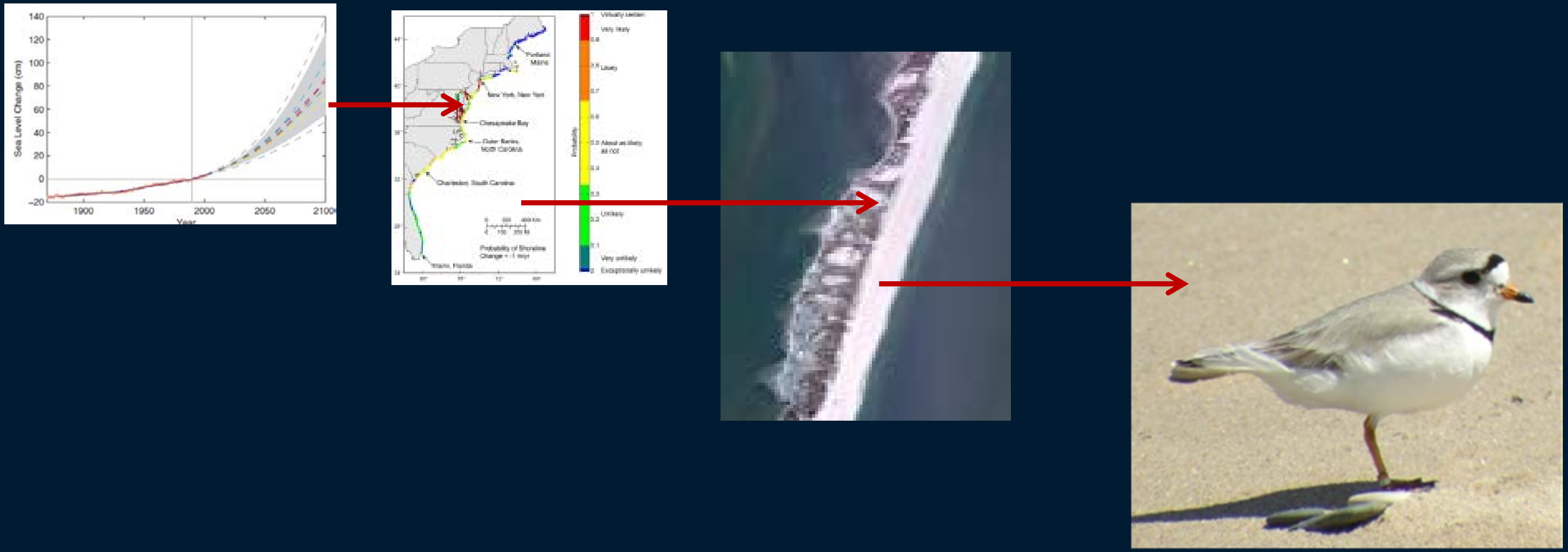
Objective: predict influence of sea-level rise ⇒ coastal morphology ⇒ plover*



- Sea-level change (and other factors) drive coastal erosion
- Erosion and sedimentation modify morphology
- Large-scale and local morphology predicts plover success (and vegetation, groundwater resources, wetland behavior, etc.)
- *The people problem is the same, minus the feathers

Informing Decisions along the Coast

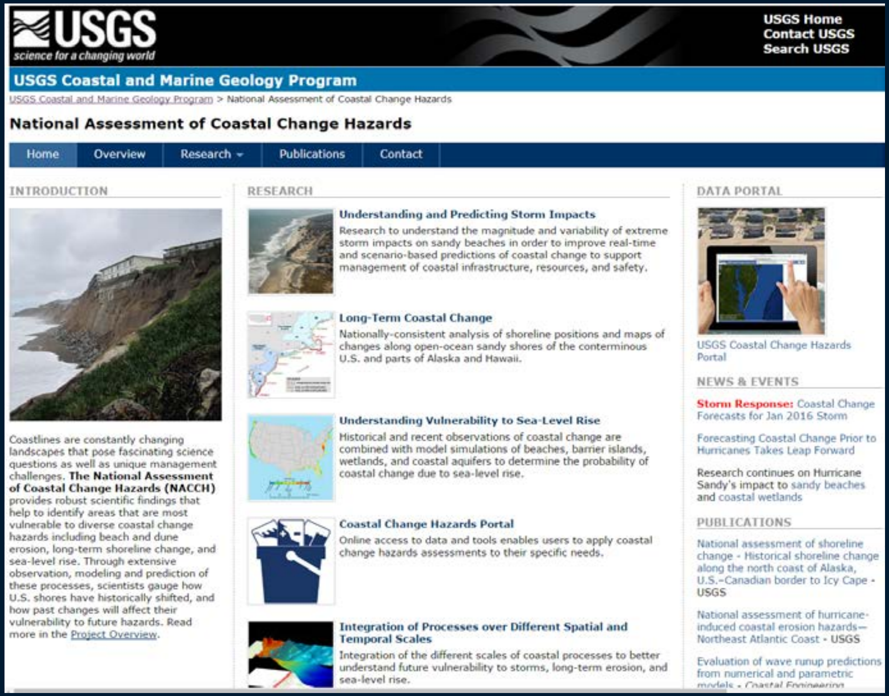
Local – Firefighters in the Rockaways, NY, requested overwash forecasts for emergency response following Hurricane Sandy.

State – Models for coastal change are part of decision support framework for barrier island and habitat restoration efforts in MS, AL, and LA; forecasting shoreline change in MA.

Regional – Methodology for large-scale coastal change forecasts was included in development of Hazards Map for the West Coast Governors' Alliance.

Federal

- NPS and FWS need to predict impacts of sea level rise on plovers and their habitat.
- NASA needs to understand long-term coastal evolution to plan for future launches - most recently, the Orion rocket.



USGS coastal change hazards science provides knowledge, data, and tools based on well-published research to decision makers who require unbiased information to make important economic, social, and ecological decisions.

For more information:

marine.usgs.gov/

marine.usgs.gov/coastalchangehazards/

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