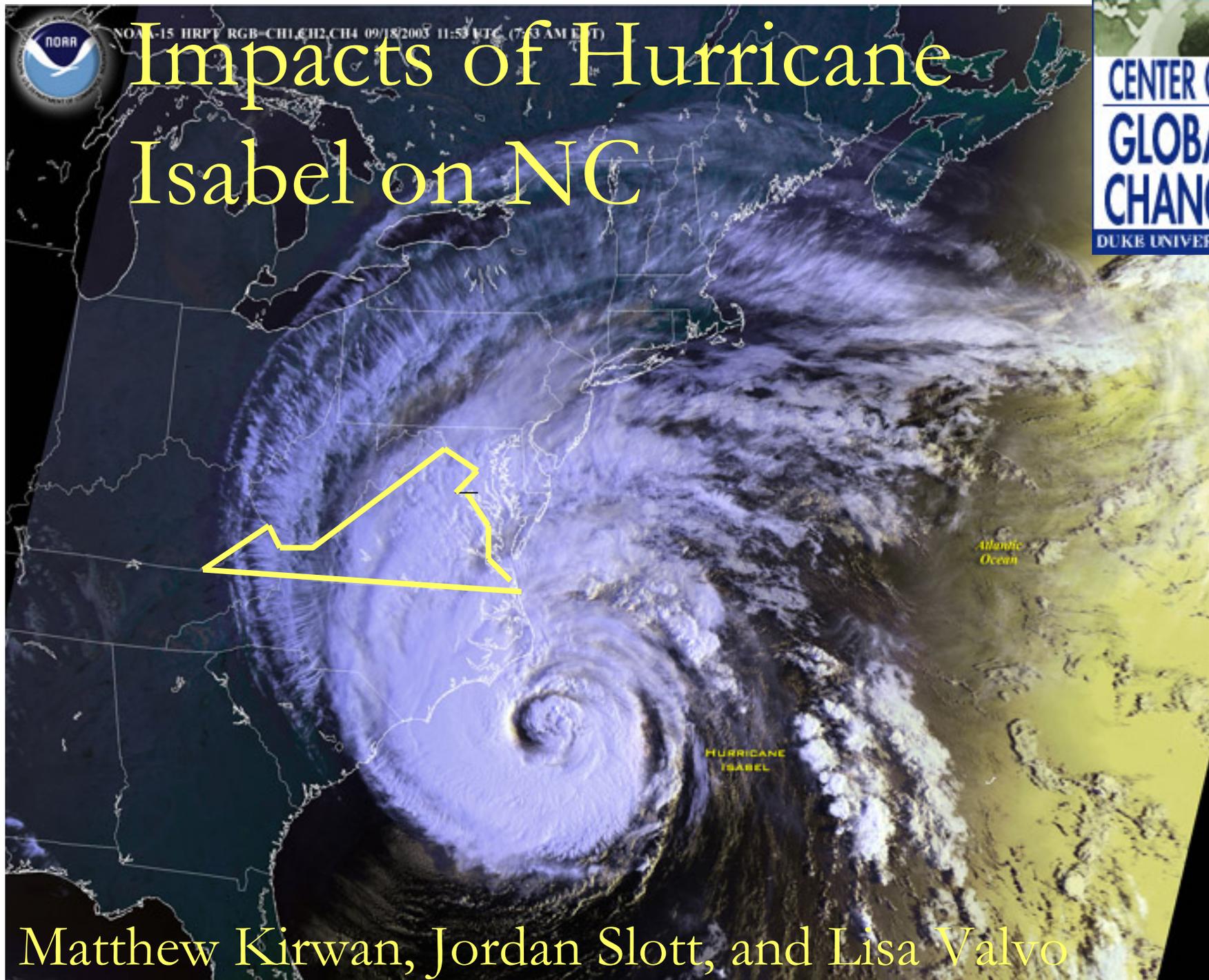




NOAA-15 HRPT RGB-CH1,CH2,CH4 09/18/2003 11:53 UTC (7:53 AM EDT)

Impacts of Hurricane Isabel on NC

CENTER ON
GLOBAL
CHANGE
DUKE UNIVERSITY

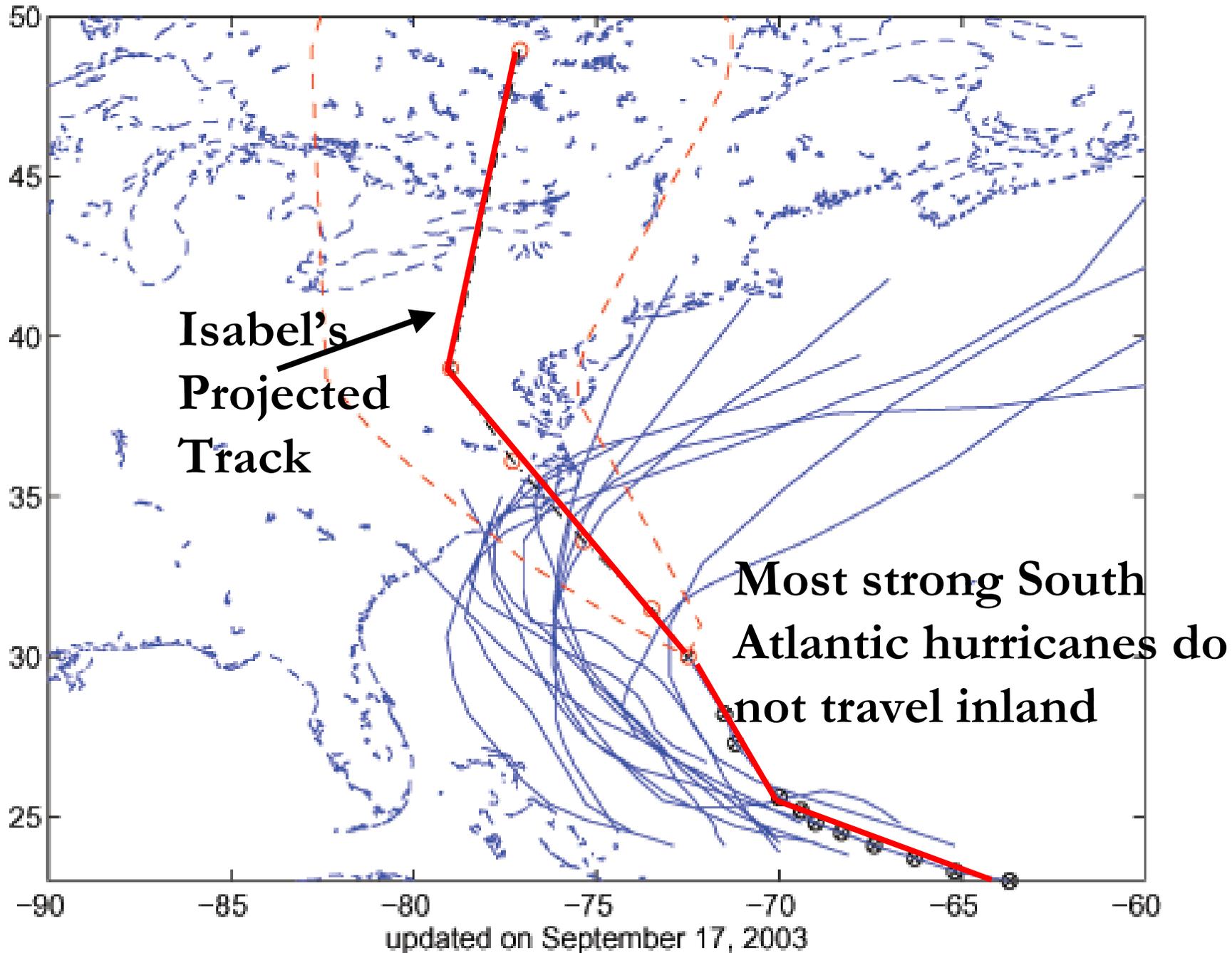


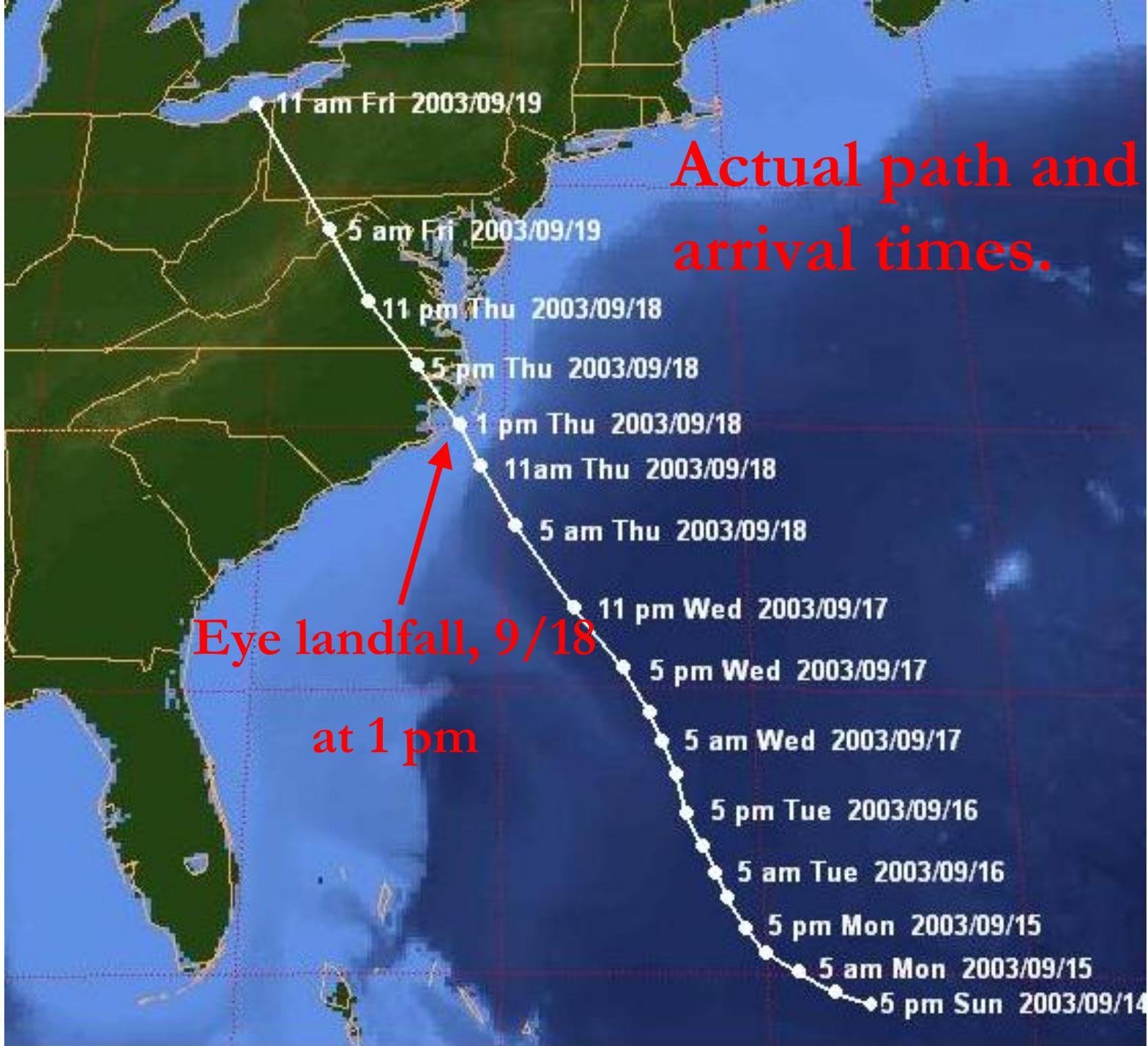
Matthew Kirwan, Jordan Slott, and Lisa Valvo

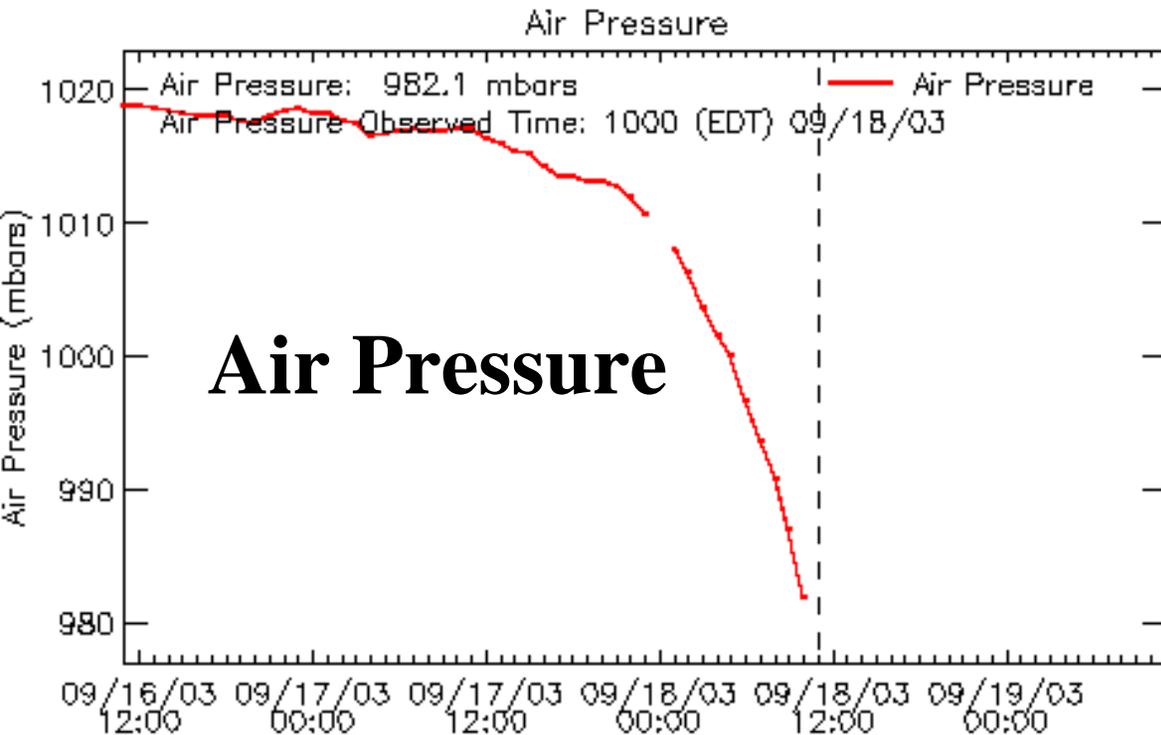
Outline:

- Overview of Hurricane Isabel
- Effects of Isabel on the Outer Banks, NC
- Natural and Unnatural Recovery

ISABEL forecast & tracks of historical similar to ISABEL

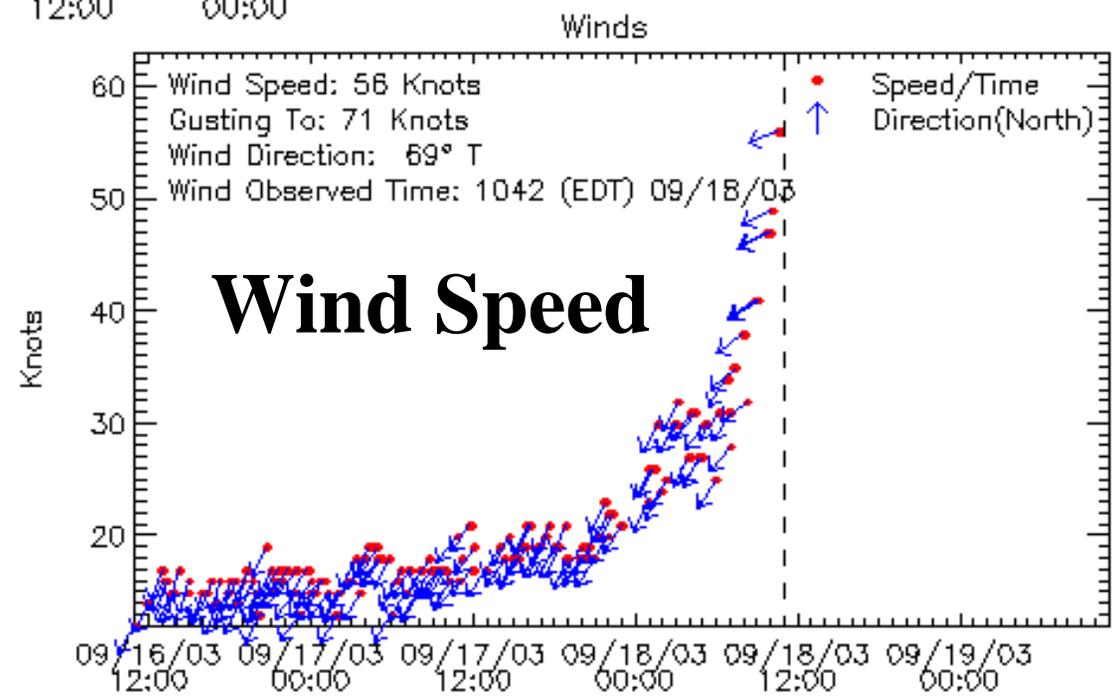






Meteorological Conditions

Hatteras Island, NC
 (Source: NOAA)



Wind Speed

Water Levels

Observed Height: 7.15 ft.

Predicted Height: 2.27 ft.

Water Level Observed Time: 1042 (EDT) 09/18/03

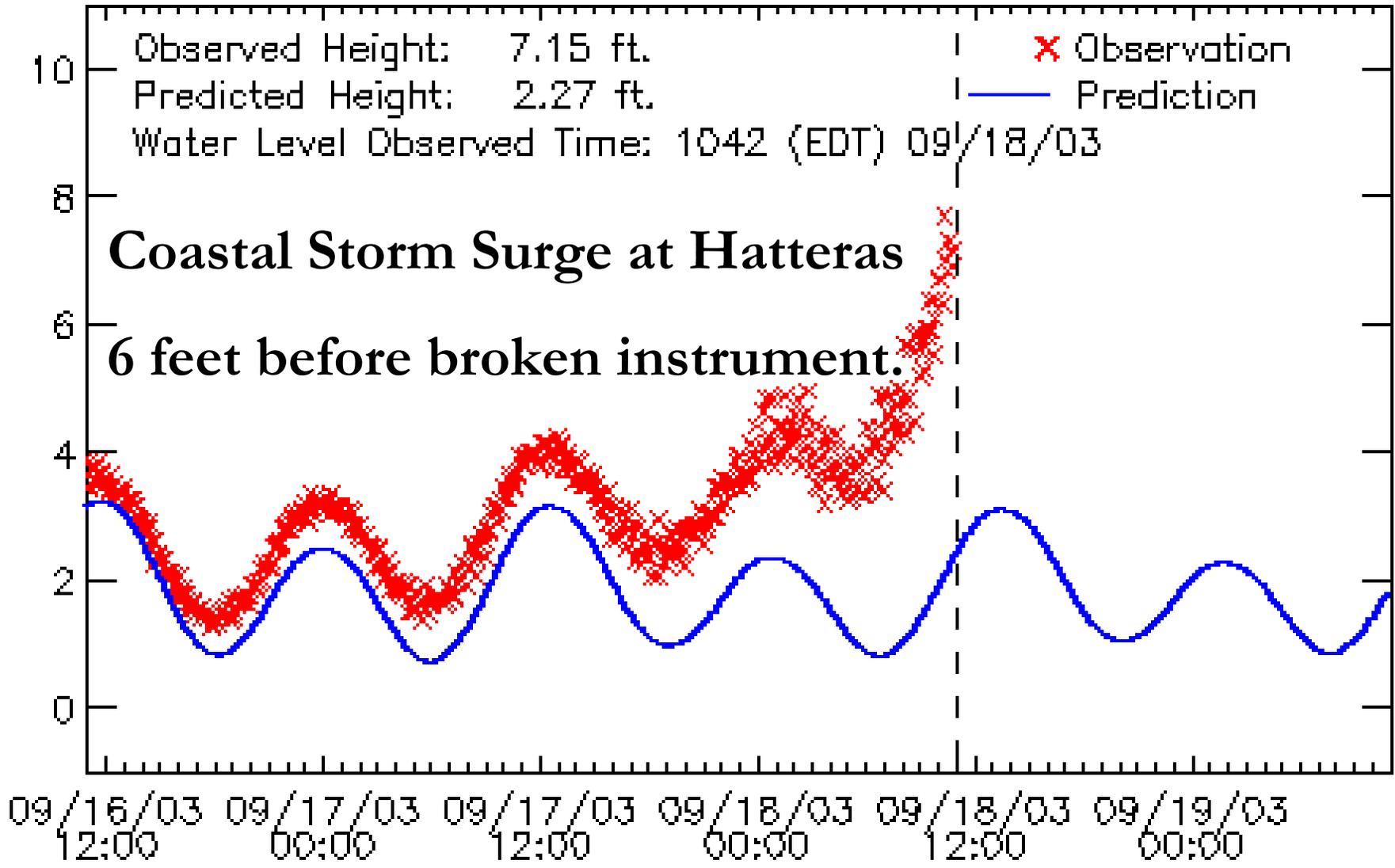
x Observation

— Prediction

Coastal Storm Surge at Hatteras

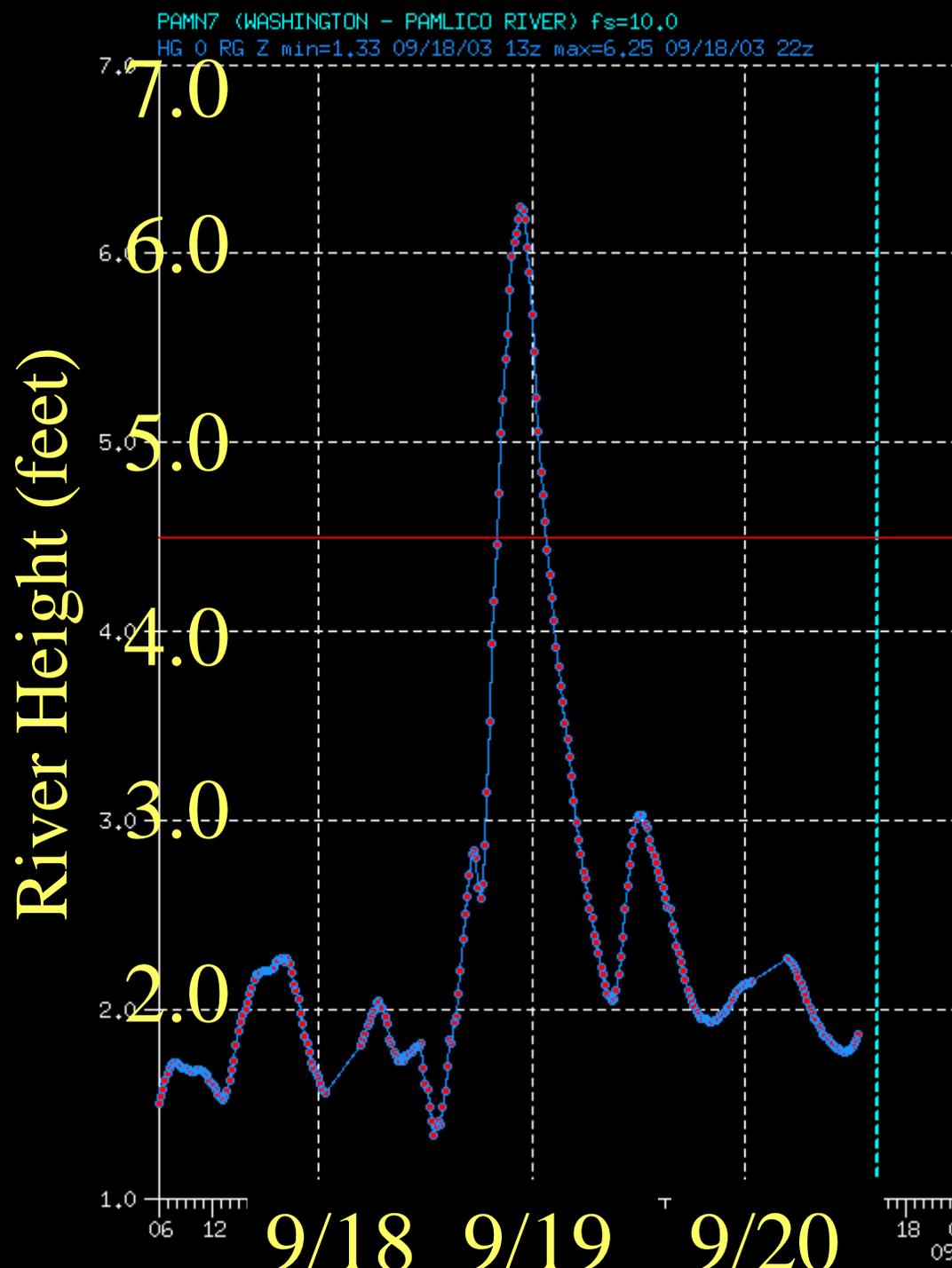
6 feet before broken instrument.

Feet Above MLLW



Tar-Pamlico River

- Washington, NC
- 25 miles upstream
- Peak 1 day after storm
- 4 ft increase



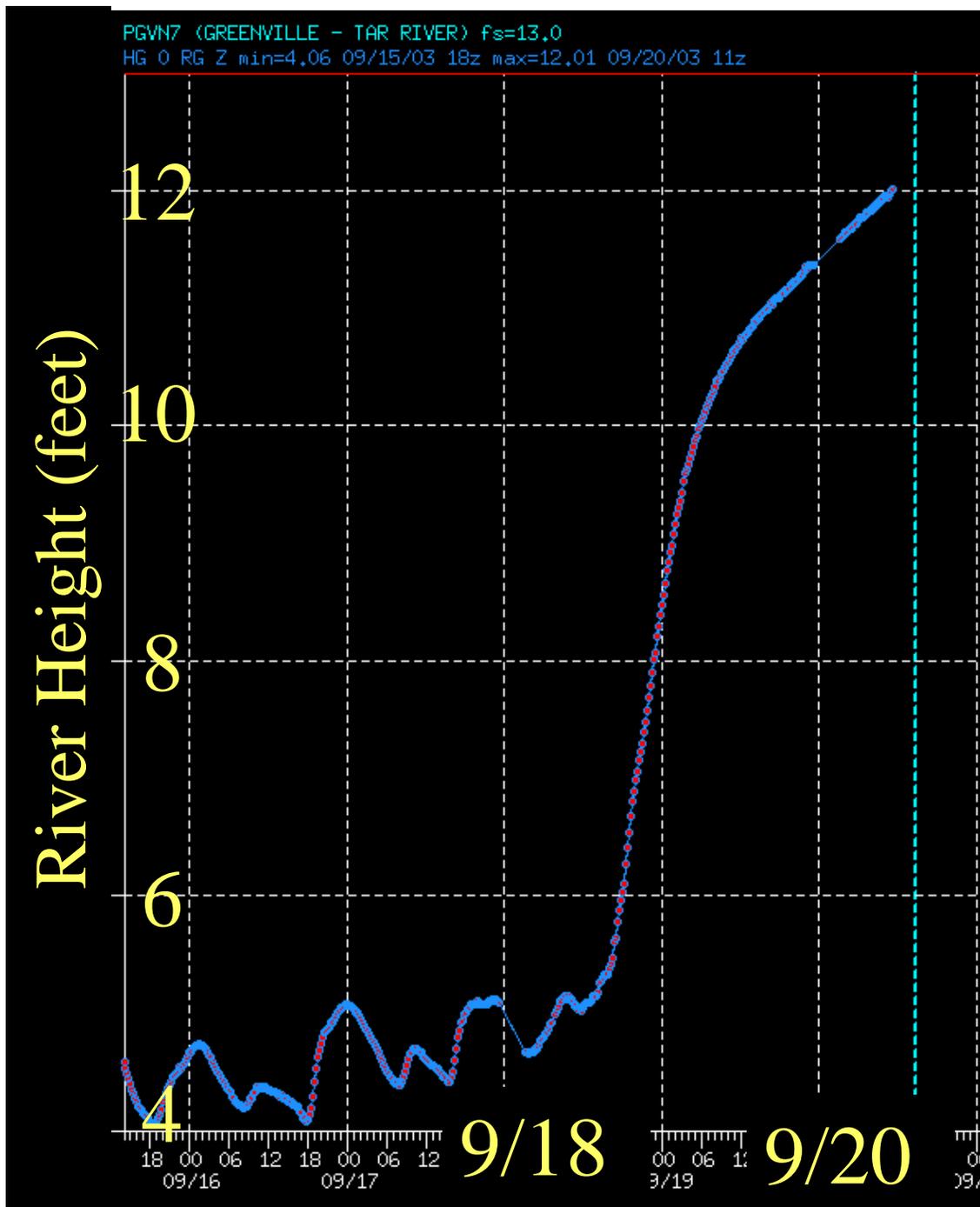
Tar-Pamlico River

- Greenville, NC

- Another 10 Miles upstream

- Peak 2 days after the storm

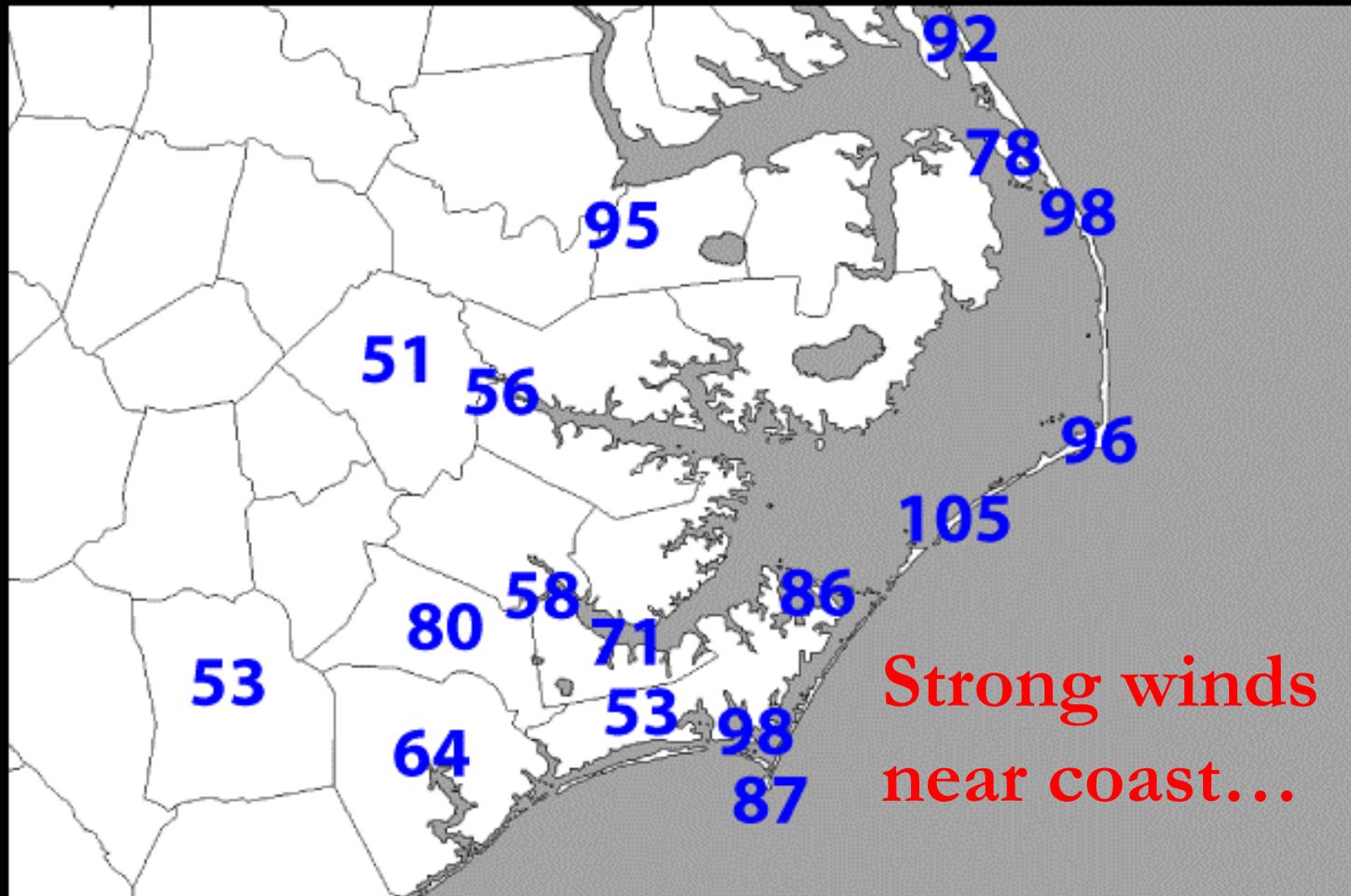
- Bigger peak





HURRICANE ISABEL

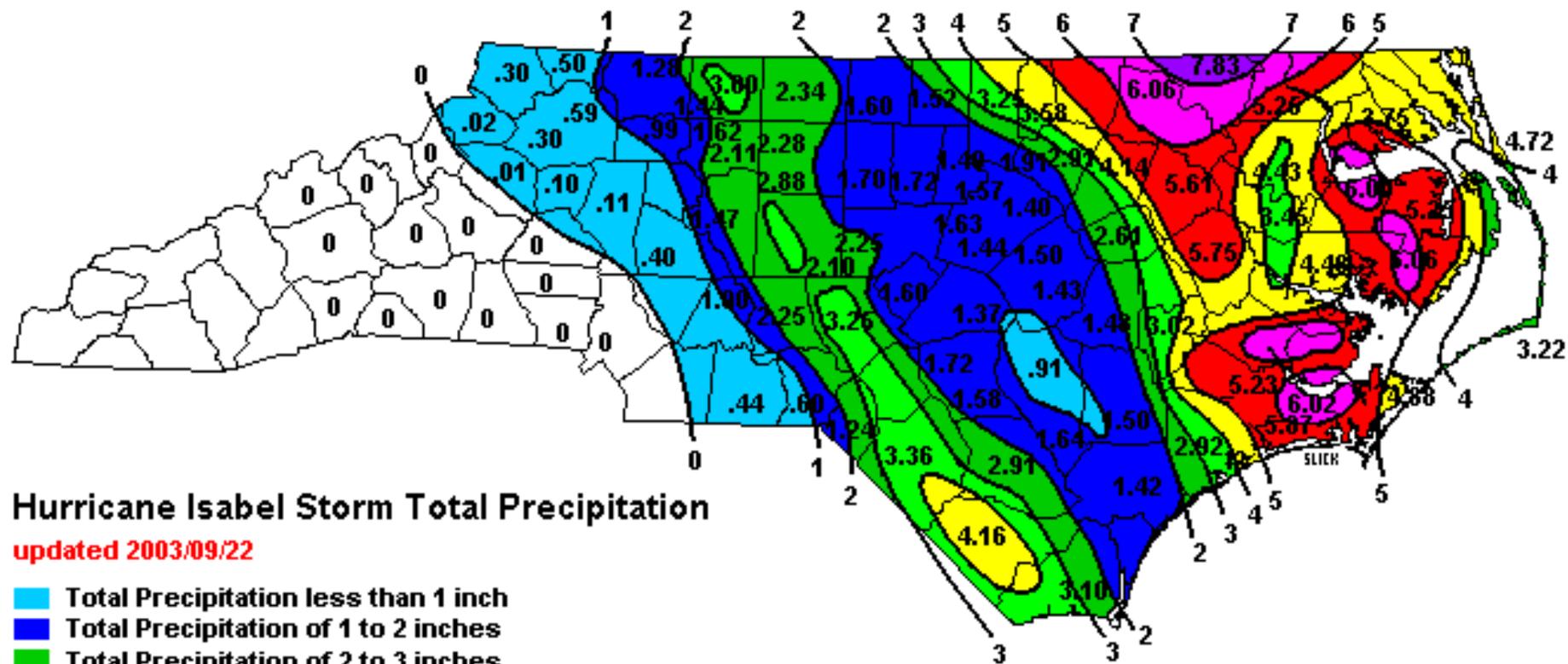
PEAK WIND GUSTS



Strong winds near coast...

Preliminary Unofficial Collection of Observed Wind Reports and Estimates in MPH

Ocracoke	105	Plymouth	95	Trenton	80	New Bern	58
Harkers Island	98	Duck COE Pier	92	Manteo	78	Washington	56
Oregon Inlet	98	Cape Lookout	87	Cherry Point	71	Kenansville	53
Cape Hatteras	96	Cedar Island	86	New River	64	Newport	53
						Greenville	51



Hurricane Isabel Storm Total Precipitation

updated 2003/09/22

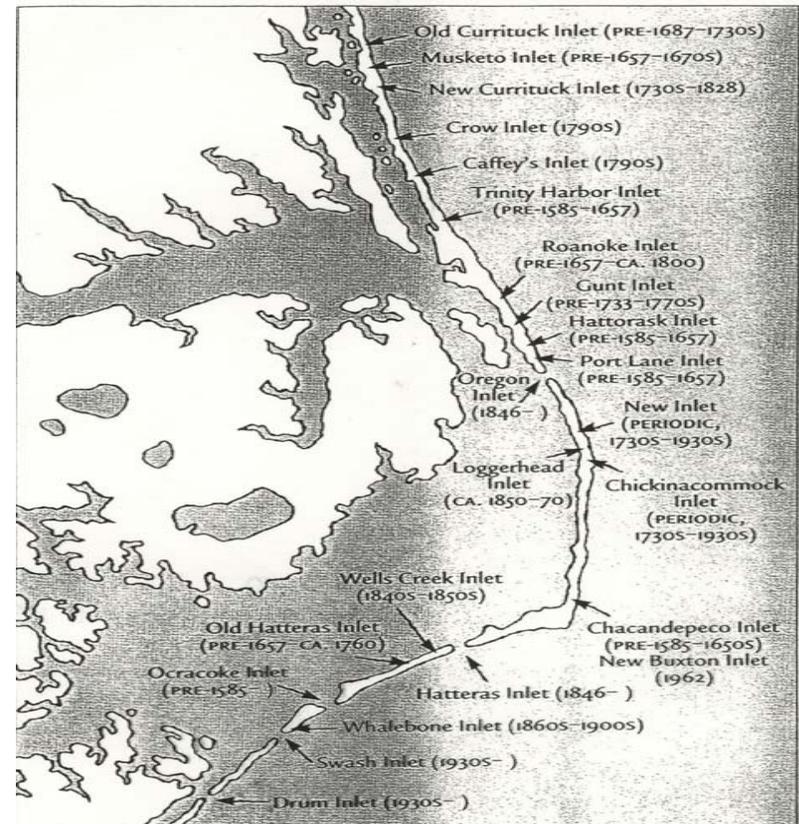
- Total Precipitation less than 1 inch
- Total Precipitation of 1 to 2 inches
- Total Precipitation of 2 to 3 inches
- Total Precipitation of 3 to 4 inches
- Total Precipitation of 4 to 5 inches
- Total Precipitation of 5 to 6 inches
- Total Precipitation of 6 to 7 inches
- Total Precipitation greater than 7 inches

Data analysis - Phillip Badgett
 Graphic - Jonathan Blaes
 NWS Raleigh, NC
www.erh.noaa.gov/rah

But precipitation greatest away from coast.

Inlets Happen

- Inlets are natural parts of barrier islands
- They form and close naturally
- Outer banks:
Maximum of 8,
Minimum of 5,
Currently 5 (+ Isabel)



Frankenberg, Dirk. "The Nature of the Outer Banks: Environmental Processes, Field Sites, and Development Issues, Corolla to Ocracoke." University of North Carolina Press, 1995.

How New Inlets Form

- After a major storm event
- Erosion from the landward force of the storm waters.
- Water from the lagoonal side breaks through and flows towards sea (storm surge rebound and lots of water in the system)

Where Inlet Formed & Isabel



- West of Cape Hatteras and Frisco, East of Hatteras Village
- North of the eye, where the winds were strongest

Isabel Inlet



Andy Coburn, Program for the Study of Developed Shorelines, Duke University

- Sunday September 21, 2003 – 1700 - 2000 ft wide

Isabel Inlet (continued)



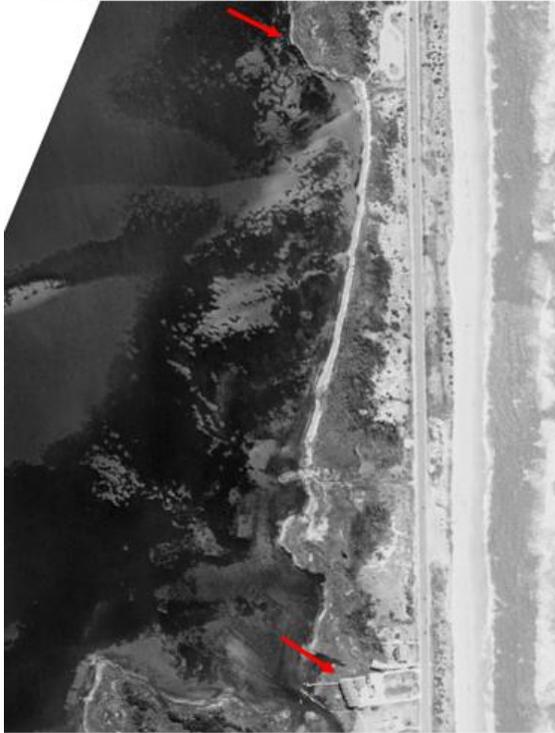
Andy Coburn, Program for the Study of Developed Shorelines, Duke University

- Friday September 26, 2003 (visible seaward current and delta forming)

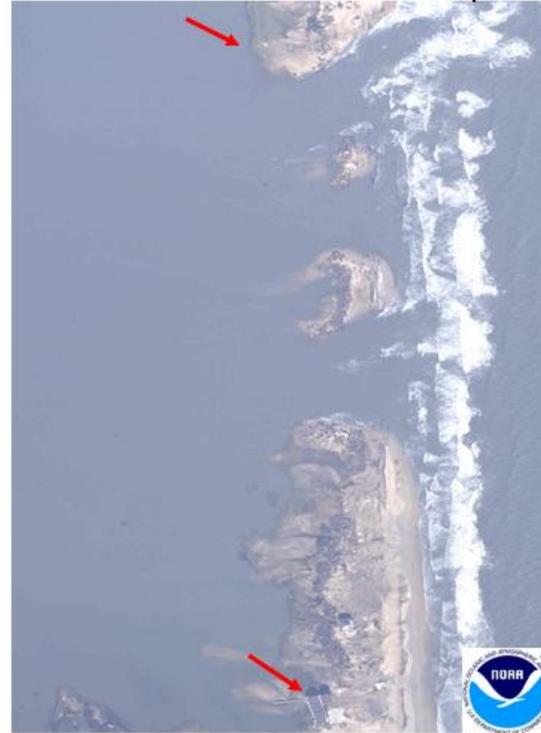
Isabel Inlet (continued)

Hurricane Isabel Damage Assessment

1998



19 Sept 2003



Cape Hatteras National Seashore, North of Hatteras Village, NC.

Source: NOAA (<http://www.noaa.gov>)

Hurricane Damage- Wind/Waves



Nags Head, building partially destroyed.

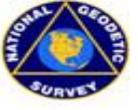
Rodanthe, house moved off its foundation



Hatteras Village Damage



Hurricane Isabel Damage Assessment



Hatteras Village, North Carolina

1998

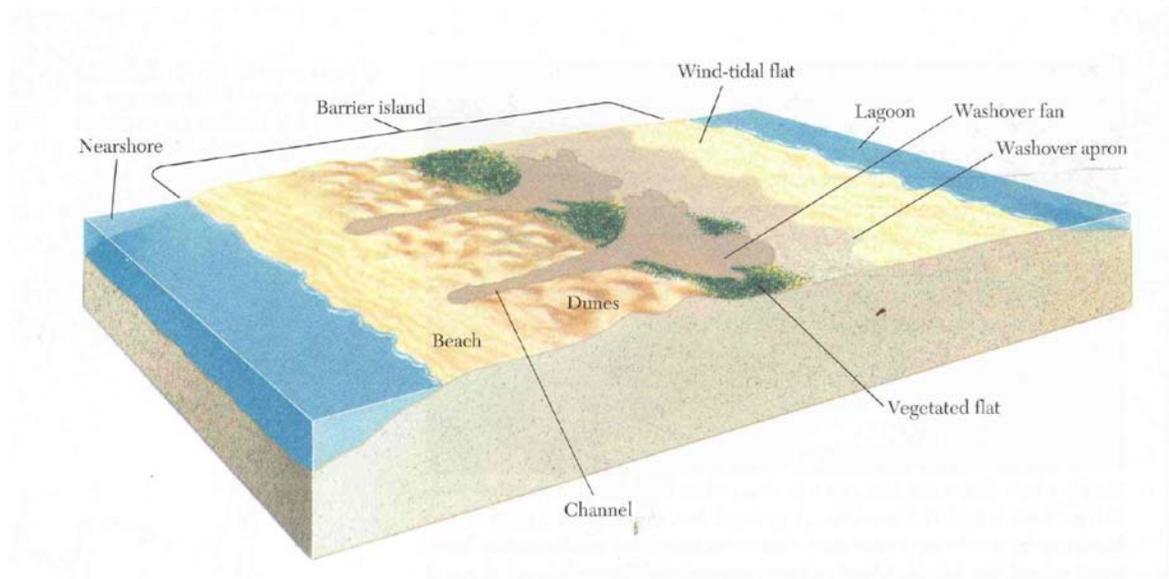


September 19, 2003



Source: NOAA (<http://www.noaa.gov>)

Overwash



“The Evolving Coast” Richard A. Davis. Scientific American Library, 1997.

- Sediment is carried onto and over barrier island
- Natural way for barrier island to build itself up and move itself back in face of storms/sea-level rise

Overwash (continued)

- Overwash entire island at National Wildlife Refuge
- Overwash much of the island at Rodanthe (houses and Highway 12)



Overwash (continued)



Lisa Valvo, Department of Earth and Ocean Sciences, Duke University.

- Sand carried to the far side of Highway 12

Post Isabel:

Recovery of the Coastal System

- Natural recovery
- Human related recovery

Natural Recovery

Storm erosion = temporary erosion

During Storm:

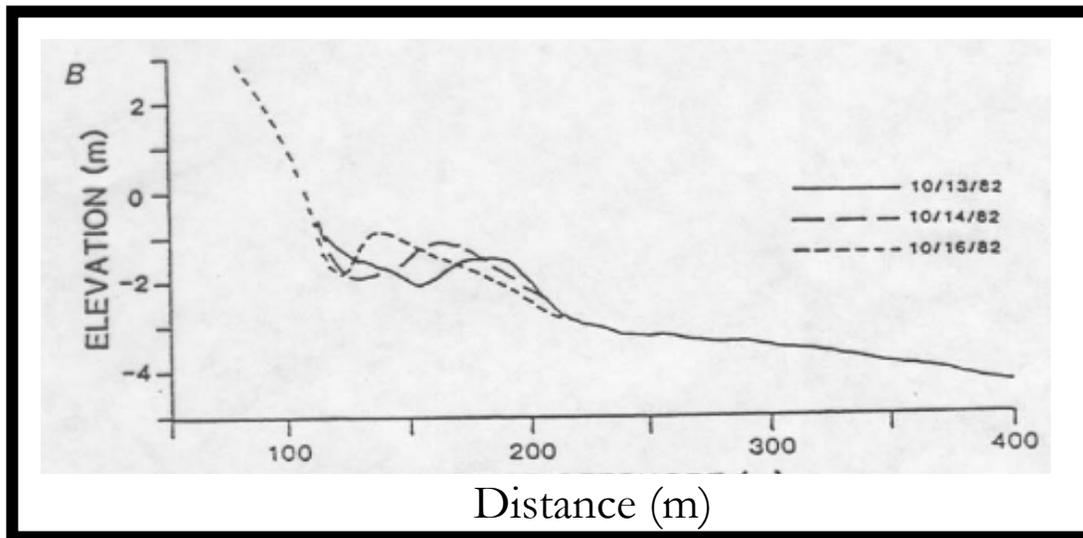
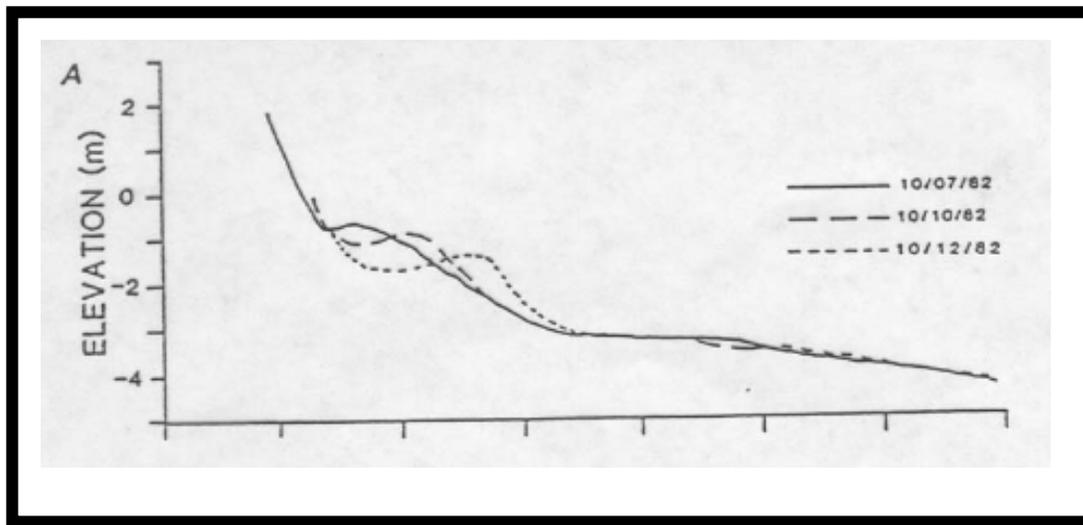
- Larger waves → break farther out
- Outer part of profile becomes too steep → sand moves offshore
- Profile remains the same, but moves out → erosion of the beach

Natural Recovery

Storm erosion = temporary erosion

After Storm:

- Smaller waves → break closer to shore
- Slope too low → sand moves onshore
- Profile moves back → accretion and a big wide beach



Beach profiles measured by the towed sled during Duck – 82. Upper panel shows the erosive response to a storm which took place from 10-12 October, while the lower panel shows the equally rapid post-storm recovery. (after Sallenger et al., 1985)

Natural Recovery: 1 week



- As the system recovers, the equilibrium profile is maintained
- The profile moves back toward shore → big, wide beach

Human Recovery and Cleaning Up



- Bulldozers worked around the clock to clean up overwashed sand and rebuild the dune

Human Recovery and Cleaning Up



Tilted house

Septic tank

- In Rodanthe, many homes and businesses are uninhabitable due to hurricane damage

The Inlet

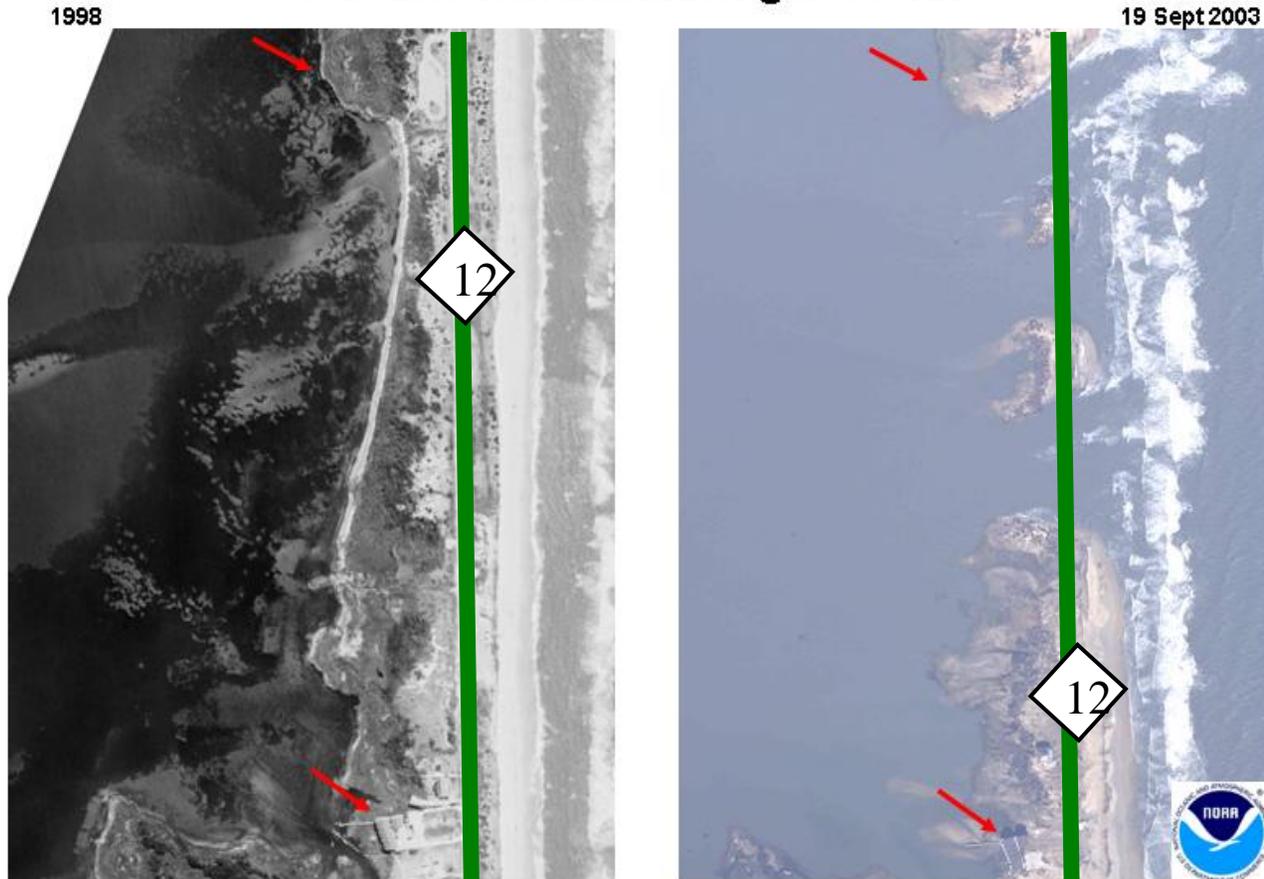


AKA the “breach”

- Inlet opened in same place in 1933 → closed naturally
- 1,700 ft. wide and growing
- 28 ft. deep
- 400,000 cubic yards of sand
- The plan: plug by Oct. 28
- Dredge from Pamlico sound
- “This would be a permanent solution until the next big storm comes” –David Allsbrook, NCDOT

The Inlet and Highway 12

Hurricane Isabel Damage Assessment



Cape Hatteras National Seashore, North of Hatteras Village, NC.

<http://www.noanews.noaa.gov/stories/s2091.htm>

- The inlet eliminated a portion of Highway 12
- The highway is essential for residents, businesses, and tourism

Highway 12

- NC spends **4 times** as much per mile to maintain Highway 12
- Since 1987, NCDOT has spent **\$32,000,000** maintaining Highway 12

1987	Gloria	\$12,000
1991	Grace	\$827,000
1993	Emily	\$1,032,000
1994	Gordon	\$353,000
1995	Felix	\$103,000
1996	Bertha	\$19,000
1996	Fran	\$55,000
1998	Nor'easters	\$1,327,000
1998	Bonnie	\$98,000
1999	Dennis	\$1,145,000
1999	Floyd/Irene	\$50,000
2003	Isabel	\$5,000,000



Summary

- Isabel hit the Outer Banks with winds up to 105 MPH.
- Created a 1700 ft wide inlet, to be closed by the U.S. Army Core of Engineers.
- Widespread damage in some coastal towns (e.g. Rodanthe).
- Repairs to Highway 12 estimated at \$5M.