Student Reading
Activity 4: Extreme Weather in an Estuary

Usually, when extreme weather occurs, the damage caused by it is categorized in dollars and lives lost. However, the tremendous damage on animal and plant species is rarely addressed. Estuaries are places of transition, a zone of constant change in which physical and chemical properties of water constantly shift and move in response to tides, daily cycles, and seasonal variations. Storm events have the power to alter conditions in an estuary in a dramatic and sometimes catastrophic way that threatens the survival of thousands of organisms that live there.

Estuaries are in one sense resilient. After a major storm, water in estuaries can act as a buffer, absorbing large quantities of excess precipitation and floodwater brought in by streams and rivers. However, toxins such as fertilizers, animal and human wastes, and other chemical products washed into the estuary during and after a storm can make water quality such that numerous animal and plant species face destruction.

After a major storm event, water quality slowly returns to normal. As sediment settles to the bottom, plant growth is renewed, dissolved oxygen rises, and the pH of the water returns to normal levels. The time required to return to normalcy is dependent on the amount of toxic materials carried into the estuary by the floodwaters produced by the storm.

The focus of this activity is the North Carolina National Estuarine Research Reserve (NCNERR). North Carolina's estuarine system is the third largest in the country, encompassing more the two million acres. This system is of prime economic importance to the coastal area—90 percent of the commercial seafood species caught in the state spend at least part of their lives in an estuary. The North Carolina NERR was established to preserve these fragile natural areas and the variety of life they support.

In this activity, you will investigate the features of the North Carolina NERR, and then study the effect of severe weather on NERRS sites. Then, you will investigate what happened to this estuarine area as a hurricane approached, struck the coast with 100 mph winds, and then moved into the Atlantic Ocean.

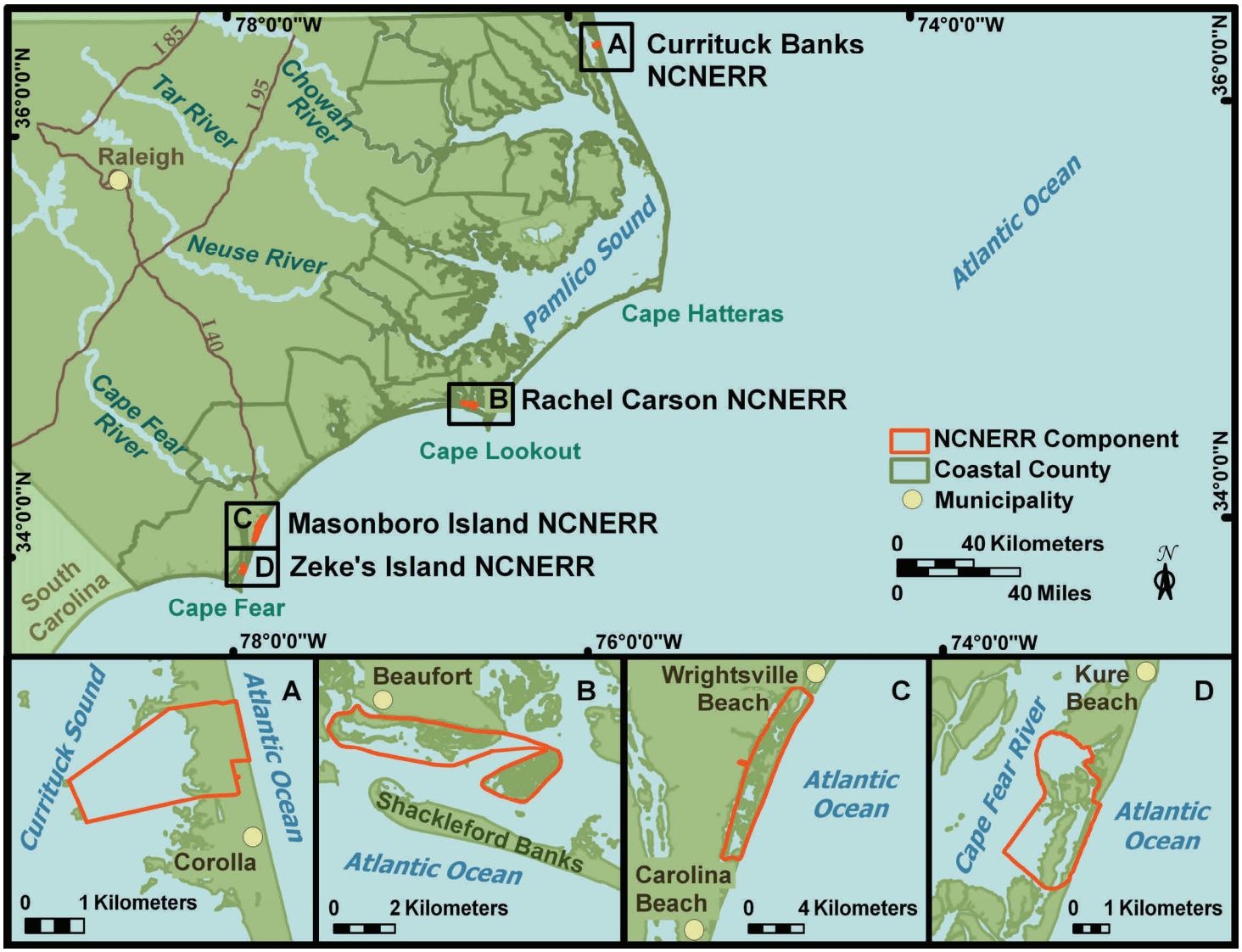


Figure 1. The four major portions of the North Carolina NERR

Student Worksheet
Activity 4: Extreme Weather in an Estuary

Student Name:_____

Part 1 — Investigating an Estuary

The North Carolina NERR consists of four different regions; in this activity, we will focus on just one of them—Zeke's Island.

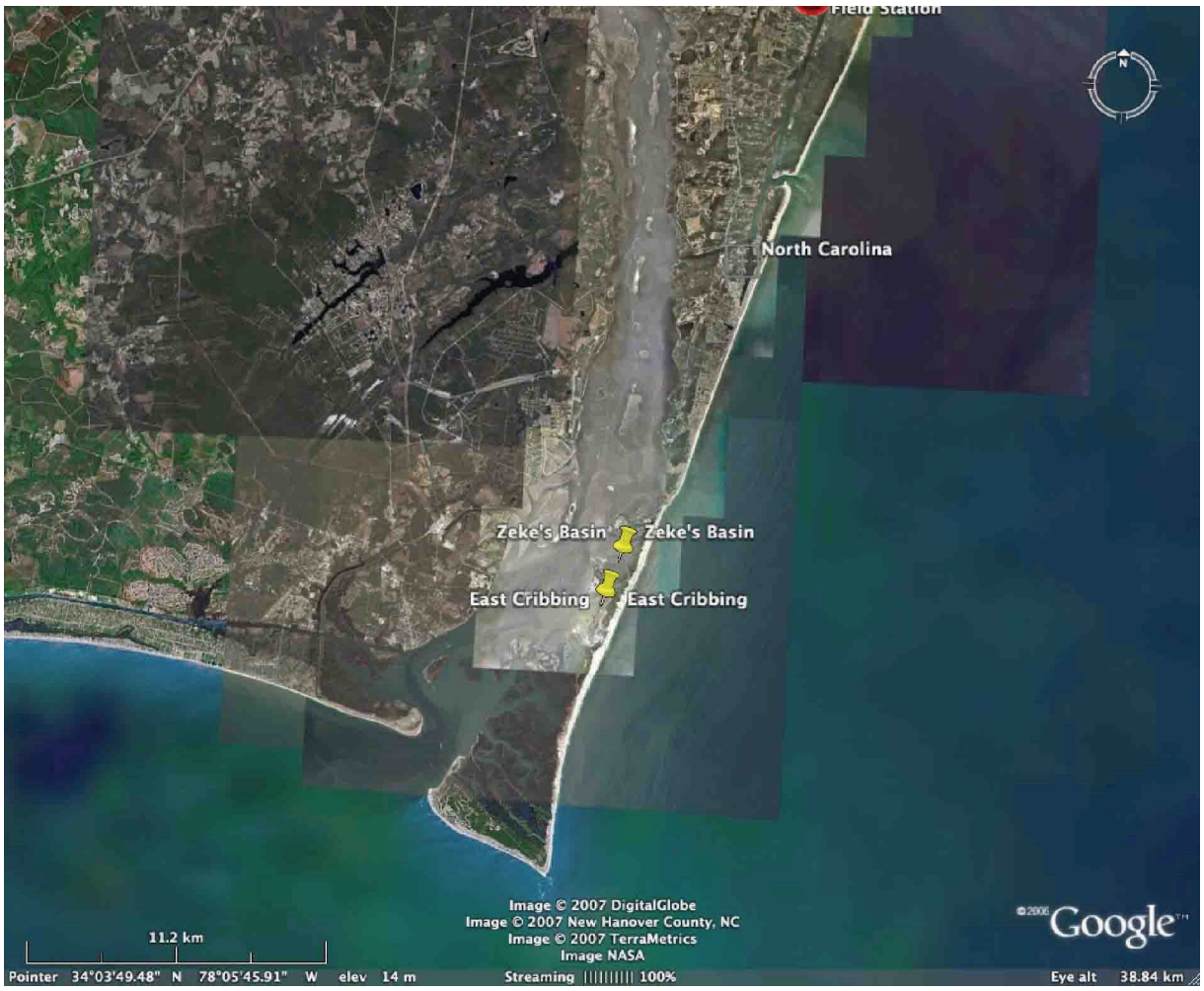


Figure 2. Region between the North Carolina NERR and Cape Fear (bottom of page) showing several monitoring stations.

Use Google Earth to investigate the North Carolina NERR. Open the Google Earth program and insert the coordinates for Zeke's Island into the "Fly To" box (33° 56' 43.19", 77° 56' 45.82").

1a.Adjust your Eye altitude to 3 km to get a good bird's-eye view of the island. Describe the estuary and features of landforms around the island.

1b."Fly" slowly down the coast and explore the region from Zeke's Island to Cape Fear. Can you identify any of the following estuary and coastal features in the region? Write the name and/or the coordinates of any features you find.

salt marshes _____

a headland _____

a bay _____

inlets _____

a slough _____

barrier beaches _____

sediment plumes _____

a lagoon _____

sand bars _____

tidal flats _____

1c. Predict which areas in the region might be most liable to be damaged during a severe storm event. Explain your reasoning.

1d. Which areas in the region do think are protected somewhat from high winds and higher than normal tides? Explain your reasoning.

Part 2 — Which NERRs Are Affected by Hurricanes?

You will find a chart of all hurricanes and major tropical storm events that occurred during 2005 in the Atlantic Ocean on *Student Data Sheet 1 — Which NERRs Are Affected by Hurricanes?*. To get an idea of how these major storms traveled through the Atlantic, your teacher will show you an animation. Or, open up http://www.nasa.gov/vision/earth/lookingatearth/2005hurricane_recap.html and click on the small map on the right side of the home page.

Which NERRS sites were affected by these storms and to what degree? To answer this question, refer to the charts and images on your data sheet and fill out the Impact on Estuaries table. Predict the severity of the impact of each storm on each estuary by considering the extent of the average major storm. Winds are highest near the center of hurricanes while bands of rain may extend a hundred miles from the center of a large storm.

2a. Which NERRS site or sites were hardest hit by a hurricane(s) in 2005?

2b. Which NERRS sites had more than one major weather event impact them in 2005?

Part 3 — Impact of Extreme Weather on an Estuary

Severe weather has profound effects on coastal areas, tearing down trees, and washing beaches and houses away. Estuaries are particularly sensitive to severe weather since the organisms that live in them are already in a delicately balanced environment of a salt and fresh water transition zone.

You will investigate the effect of a large storm on the North Carolina Estuarine Research Reserve. Hurricane Bonnie formed off the coast of western Africa on August 14th, 1998.

Although slow to develop, Bonnie grew in intensity and became a tropical storm with winds of about 40 mph a week later. While moving more quickly, Bonnie achieved hurricane status with winds over 60 mph as the storm passes north of Puerto Rico on August 22nd.

On August 26th, Hurricane Bonnie weakens a little before she strikes the coast just east of Cape Fear near midnight with winds around 110 mph.

Bonnie was the first major hurricane (Category 3) of the 1998 season. The winds and flooding rains damaged buildings and cut off power to nearly a half-million people. The storm was nearly 400 miles wide as it crossed the coast.

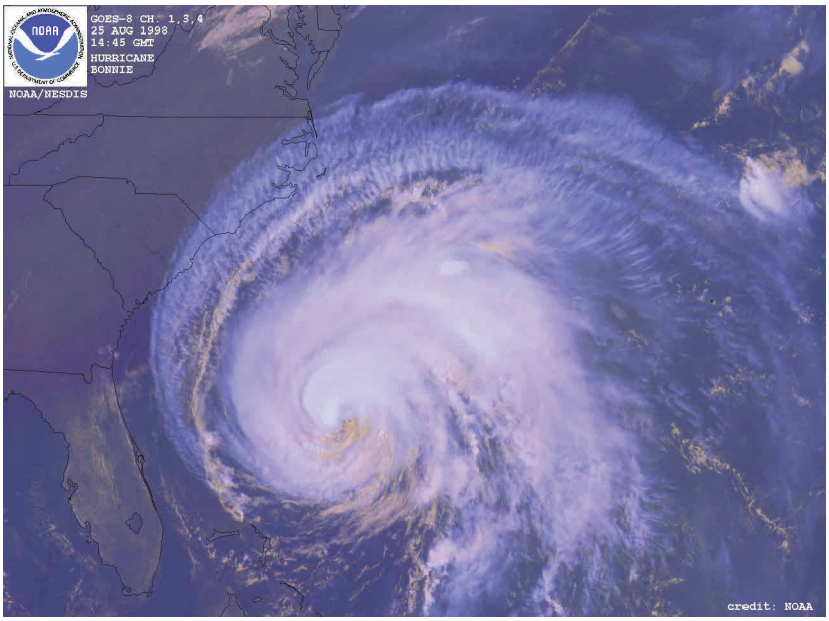


Figure 3.
Hurricane Bonnie making landfall on the eastern coast of the United States.

To understand the effects of a major storm on an estuary, refer to *Student Data Sheet 2 — Impact on an Estuary by an Extreme Weather Event: A Case Study*. Study the graphs of precipitation and water quality for the Zeke's Island reporting station for August 1 to September 17, 1998. As you review the data, remember that Hurricane Bonnie made landfall on August 26.

3a. What do you think caused the severe drop in salinity on August 26?

3b. Why do you think the salinity of the water in the reserve continued to fall and then remain as such low levels for weeks after the storm event?

3c. What was the change in water temperature caused by the storm?

3d. How was the pH of the water in the estuary affected by the storm?

3e. What caused the huge increase in turbidity around Zeke's Island during the storm?

3f. How long did it take for each of the water qualities to return to normal? Why do you think it took longer for some factors to return to normal than others?

Student Data Sheet—1

Activity 4: Which National Estuarine Research Reserves Are Affected by Hurricanes?

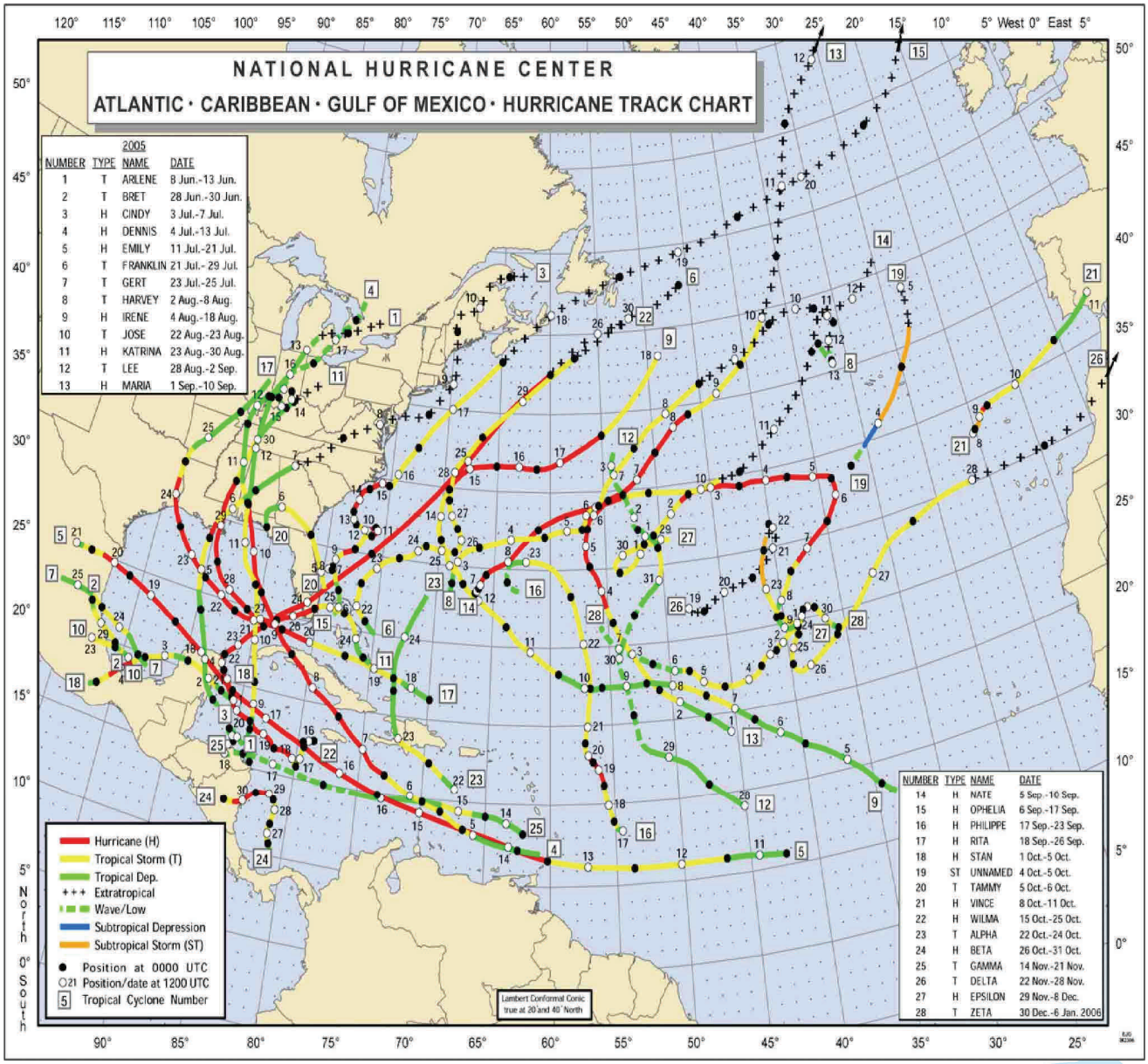


Figure 4. The hurricanes are numbered and named in the order of their appearance during the 2005 hurricane season. The change in color and pattern indicate the change in the intensity of the storm.

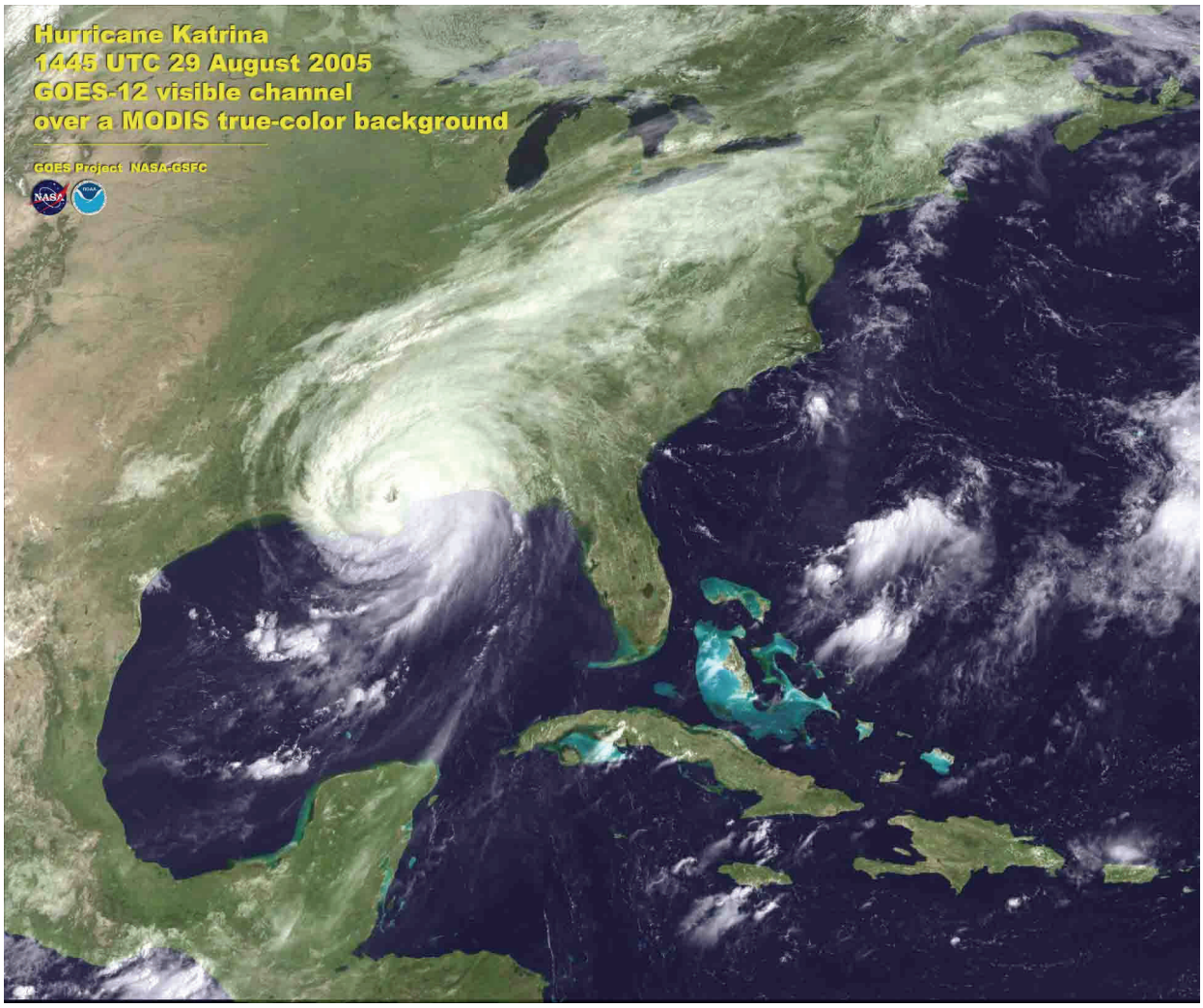
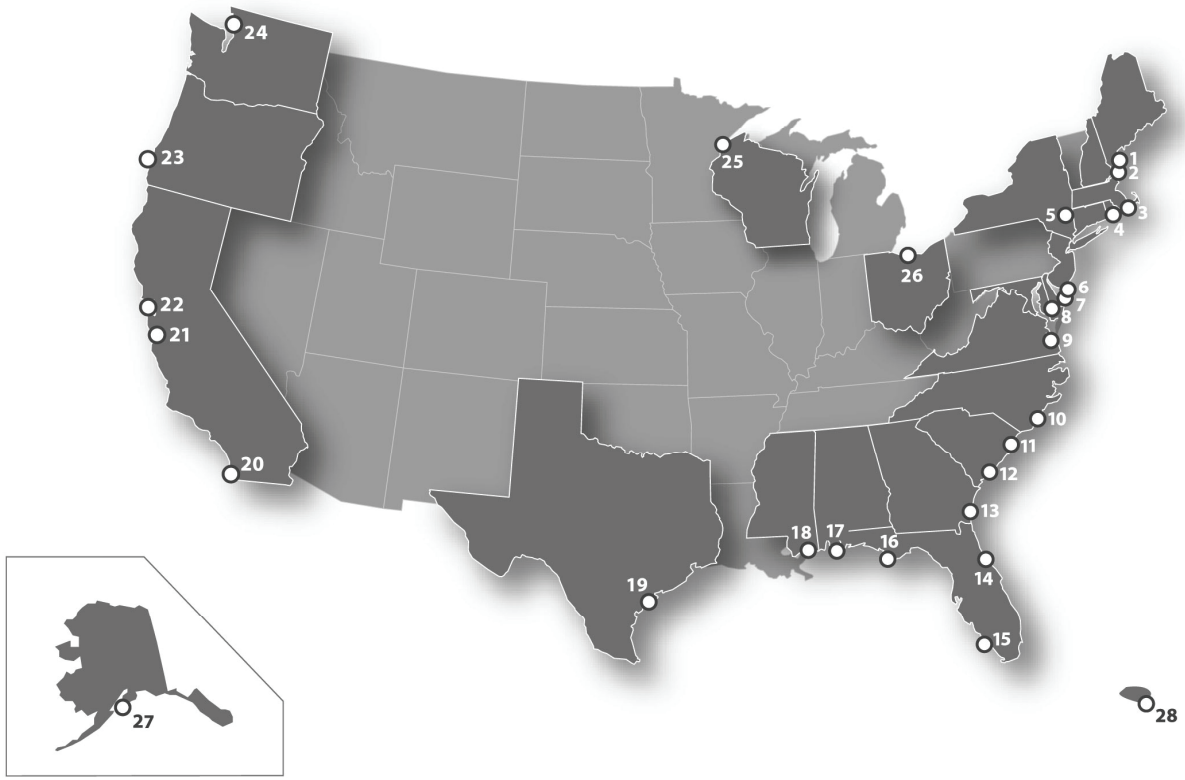


Figure 5. Keep in mind that hurricanes are truly huge objects, sometimes hundreds of miles across.

The National Estuarine Research Reserve System (NERRS)



1. Wells, Maine
2. Great Bay, New Hampshire
3. Waquoit Bay, Massachusetts
4. Narragansett Bay, Rhode Island
5. Hudson River, New York
6. Jacques Cousteau, New Jersey
7. Delaware
8. Chesapeake Bay, Maryland
9. Chesapeake Bay, Virginia
10. North Carolina
11. North Inlet-Winyah Bay, South Carolina
12. ACE Basin, South Carolina
13. Sapelo Island, Georgia
14. Guana Tolomato Matanzas, Florida
15. Rookery Bay, Florida
16. Apalachicola, Florida
17. Weeks Bay, Alabama
18. Grand Bay, Mississippi
19. Mission-Aransas, Texas
20. Tijuana River, California
21. Elkhorn Slough, California
22. San Francisco Bay, California
23. South Slough, Oregon
24. Padilla Bay, Washington
25. Lake Superior, Wisconsin
26. Old Woman Creek, Ohio
27. Kachemak Bay, Alaska
28. Jobos Bay, Puerto Rico

Figure 6 — Twenty-seven sites compose the National Estuarine Research Reserve System

Table of Estuaries Affected by Severe Storm Events in 2005

Site Name	Storm(s)	Predicted Impact (severe, moderate, mild)
1)		
2)		
3)		
4)		
5)		
6)		
7)		
8)		
9)		
10)		

Student Data Sheet—2

Activity 4: Impact on an Estuary by an Extreme Weather Event: A Case Study

Water Quality — Zeke's Island Aug 1- Sept 17, 1998

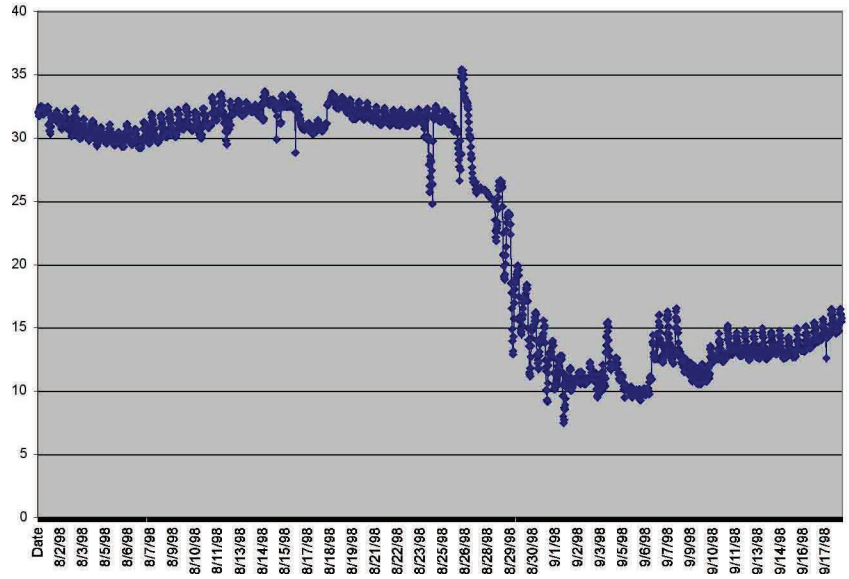


Figure 7 — Salinity in parts per thousand (ppt)

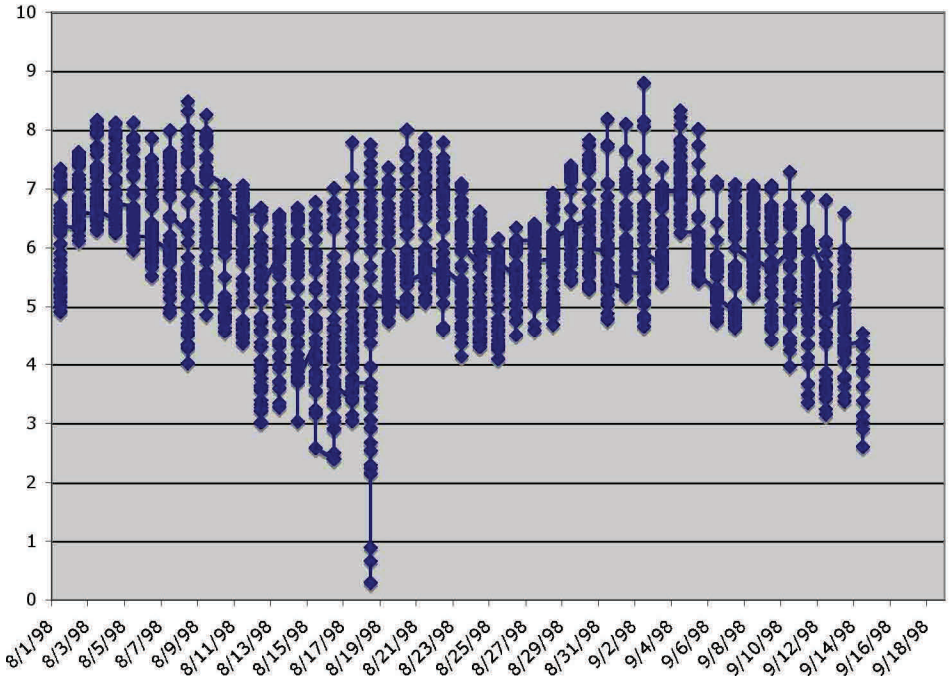


Figure 8 — Dissolved Oxygen in mg/l

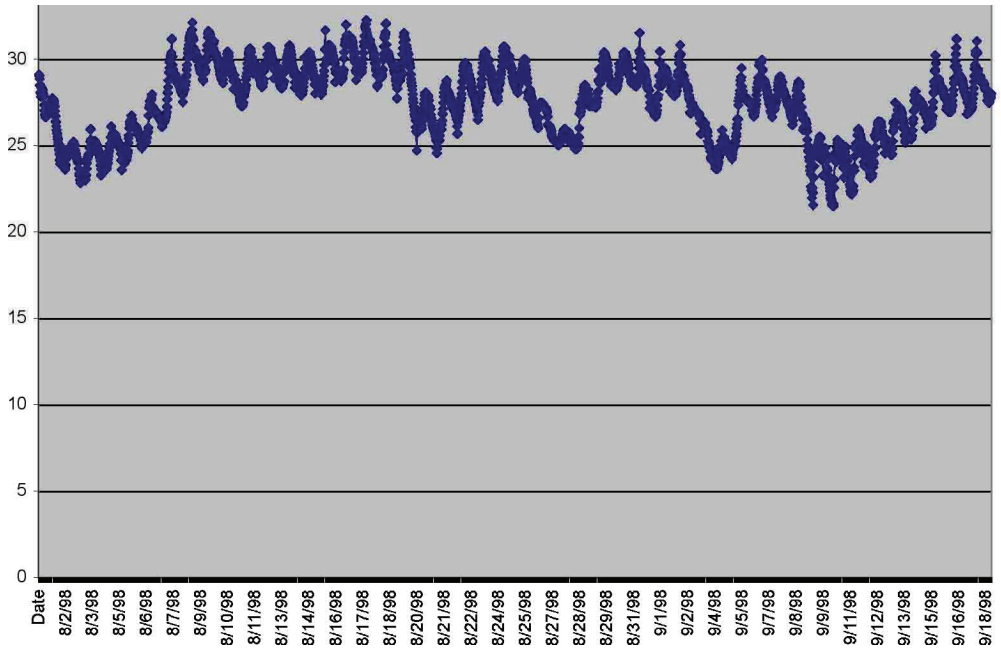


Figure 9 — Water Temperature in °C

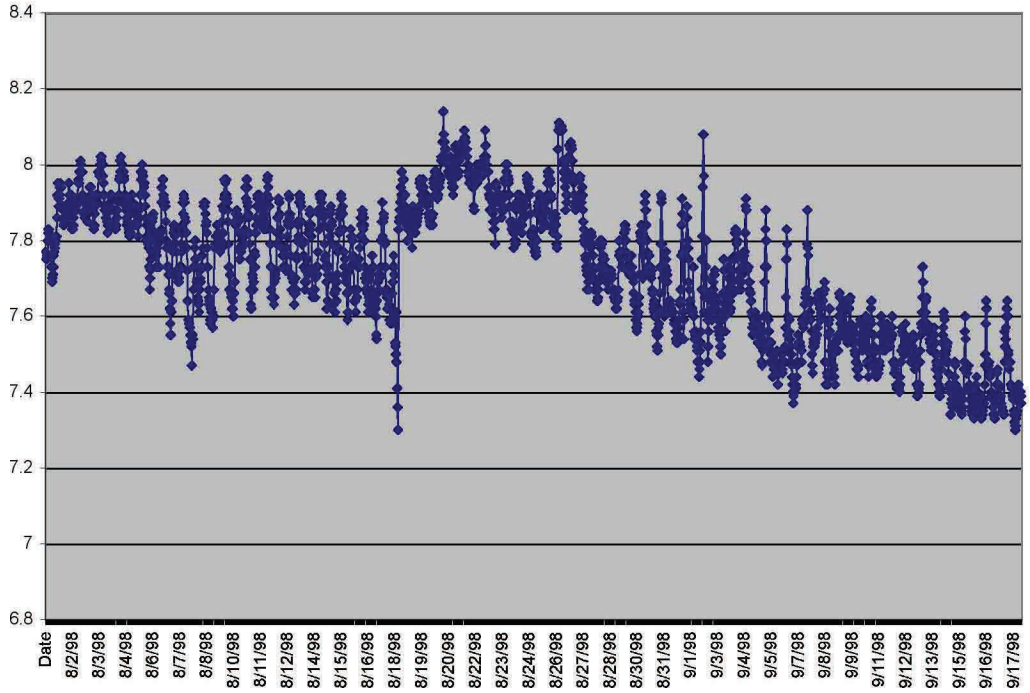


Figure 10 — Water pH

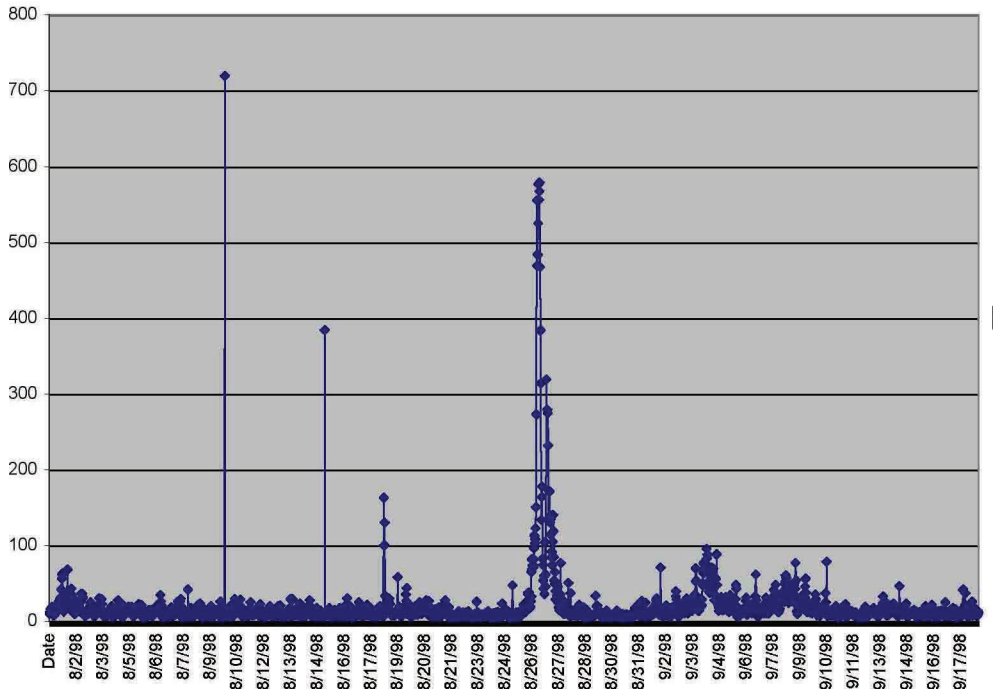


Figure 11 — Water Turbidity in NTU units