Barrier Islands and Hurricane Fran

An Educational Guide for the UNC-TV Videos
Hurricane Fran: The Science Behind the Storm and
Hurricane Fran: Lessons Learned

When Hurricane Fran hit North Carolina's southern beaches in September 1996, intense winds and storm surges changed the face of the barrier islands and inlets and destroyed many homes and businesses. A new scientific understanding of coastal processes and an increased focus on management and policy are positive legacies of the storm. They will provide guidance for how we should live on barrier islands in the future. Two special episodes of UNC-TV's science series *I.Q.* explain Hurricane Fran's impacts and the knowledge gained in the storm's aftermath. Educational videos based on the programs are excellent tools for both educators and decision-makers.

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Introduction

The consequences of choices we make about barrier island development come into sharp focus when a major hurricane hits the coast. Fortunately, better weather models, which now more accurately predict storm paths and surges, help assure human safety. Effective evacuation plans and greater lead time help people protect themselves and their property.

As we learn more about the dynamic nature of our sand-based islands, we enact laws and regulations to ensure that we correctly situate and construct buildings on barrier islands. Local building codes and insurance criteria aim to lengthen the structural life of buildings. Coastal setback requirements increase the survivorship of individual buildings by accommodating local long-term shoreline retreat (erosion) rates. Building codes mandate deeper pilings and stronger connections between a structure's roof and sides, which result in increased structural survival through storms. In this way, the Coastal Area Management Act protects public trust areas, such as beaches and wetlands, and encourages wise use of the resources.

The two 26-minute videos *The Science Behind the Storm* and *Lessons Learned* together with this instructional guide and other resources will help people understand complex hurricane impacts and barrier island dynamics. More importantly, these programs will help students grasp issues concerning development on the islands. Each video is divided into timed segments to facilitate discussion. Suggested questions, vocabulary, activities and resources are provided in this guide.

The Science Behind the Storm

This 26-minute video focuses on meteorology and coastal geological processes.

Objectives:

To understand how forecasters predict hurricane tracks and storm surges.

To differentiate between wind and water impacts from a hurricane.

To recognize that:

a. there are migration differences among barrier islands and also differences within segments of a single barrier island that determine the erosional response and potential for recovery;
b. each barrier island or barrier island segment has an underlying geologic structure and sand sources;
c. barrier islands are storm-dependent systems that dynamically change and migrate in response to high energy events.

Video Segments:

Segment 1:
"The Evolution of Hurricane Fran"
(0-10 minutes)

"The Evolution of Hurricane Fran" focuses on the progress and path of the hurricane, from its development over the Atlantic Ocean to its landfall in North Carolina. This segment describes and illustrates the hurricane's physical features and its effects. Data on Hurricane Fran's track throughout the segment provide students with an opportunity to map the path of the storm (see Activity 2 in the activities section). Scientists explain how their models projected the storm surge and estimated the damage from Hurricane Fran.

Vocabulary terms

Coastal Resources Commission (CRC)
eye of the hurricane
flood potential
high wind warning
hurricane
hurricane categories
hurricane warning
hurricane watch
landfall
overwash
storm surge
tropical depression
tropical storm

Discussion Questions:

1. As a hurricane crosses over you, where is the least wind?

2. Which quadrant of a hurricane causes the most damage? Why?

3. What agency tracks major storms and communicates the latest information to local officials in North Carolina?

Segment 2:
"Effects of Hurricane Fran"
(10-20 minutes)

"Effects of Hurricane Fran" discusses the impacts of the hurricane after it made landfall at Bald Head Island, N.C. The video graphically depicts physical changes to the barrier islands, structural changes to coastal development, and wind and water damage across the state. Experts give reasons for the varying types of damage that resulted from Hurricane Fran. Scientists explain how geological features such as dunes and offshore rocks influence the extent of storm damage and beach recovery.

Vocabulary terms

acute erosion
beach profile
beach nourishment
berm
chronic erosion
foredune ridge
scarp (dune)
seasonal erosion
surf zone

Discussion Questions:

1. Why are overwashes important for barrier island migration?

2. When beach sand is stripped from dunes and berms into nearby coastal waters, where does it go?

3. What conditions can trap this sand and make it unavailable for beach recovery?

Segment 3:
"Barrier Island Response"
(20-26 minutes)

"Barrier Island Response" focuses on the dynamics of barrier islands and how they respond to natural forces. Geological features of the barrier islands — inlets, dunes and beaches — are shown in a historical context and in response to the forces of Hurricane Fran. This segment illustrates overwash and island migration and includes a summary of how to manage island development for the future.

Vocabulary terms

inlet hazard zone
island migration
peat
setback line

Discussion Questions:

1. What are some of the possible reasons that damage from Hurricane Fran was more severe on north Topsail Island than on south Topsail Island?

2. What evidence found on barrier island beaches supports island migration theories?

3. What are the processes that cause barrier islands to migrate landward?

Lessons Learned

This 26-minute video focuses on Hurricane Fran's impacts and the recovery efforts.

Objectives:

To differentiate between chronic and acute erosion.

To explain that rates of island migration and erosion differ among islands and even on one island.

To identify the purpose of coastal regulations, such as setback and building codes, in ocean hazard and inlet hazard areas.

To identify public trust areas in the coastal zone.

To disclose how policy decisions are made concerning hardening of the shorelines, temporary stabilization, beach nourishment and building regulations.

Video Segments:

Segment 1: "Hurricanes and Buildings" (0-10 minutes)

"Hurricanes and Buildings" covers the need for placing permanent structures so that the dynamic systems of barrier islands put them at less risk. Hurricane Fran illustrated the consequences of building in ocean and inlet hazard areas. Students will get an overview of how past hurricanes have motivated people to modify building codes. The successes or failures of current and past building codes are linked to three types of shoreline erosion and the process of island migration observed during Hurricane Fran.

Discussion Questions:

1. Describe the changes in building practices based on evolving codes from the 1950s to the present. How did these changes increase survival of structures on Topsail Island after Fran?

2. How does high wind, storm surge, high waves, sand movement or a combination damage beach homes? Which is most damaging?

3. What is a structure's best natural defense against acute erosion? What should people do to safeguard against long-term erosion from oceanfront development?

Vocabulary terms

island migration
seasonal erosion
acute erosion
chronic erosion

Segment 2:
"Dunes and Setbacks"
(10-17 minutes)

"Dunes and Setbacks" looks at barrier island migration and erosion in relation to property and buildings. Hurricane categories and erosional effects are described in relation to future barrier island development. This segment examines specific regulations for building structures and setbacks. Also included is a discussion of repairing homes with less than 50 percent damage or rebuilding homes with more than 50 percent damage under new permits.

Vocabulary terms

seasonal erosion
acute erosion
chronic erosion
island migration
ocean hazard zone
setback line

Discussion Questions:

1. Hurricane Fran affected shoreline erosion, and now some houses sit almost in the ocean. What happened to the pre-Fran location of beaches and dunes?

2. What is the function of setback lines for development on a barrier island? Why are some houses that were built according to setback regulations endangered by ocean advances?

Segment 3:
"Strategies for Protection"
(17-26 minutes)

"Strategies for Protection" summarizes how inlet and island migrations threaten existing barrier island development, particularly during hurricanes. This segment discusses shoreline stabilization and beach nourishment strategies to restore sand back to beach areas. The closures of north Topsail Island and the Shell Island Resort in Wrightsville Beach after Hurricane Fran demonstrate the need for full disclosure within ocean hazard zones to potential buyers of coastal property.

Discussion Questions:

1. Consider the following situation. A beach house on Topsail Island suffers a loss of 65 percent of its value and now sits on the beach in front of the primary sand dunes. The size of the lot is reduced, and the back line is a road. How could the state regulation for setback prevent the owner from rebuilding the beachfront home?

2. Mason Inlet, located at the north end of Wrightsville Beach and adjacent to Shell Island Resort, is migrating southward. What effect does a hurricane have on inlet migration on nearby structures?

Vocabulary terms

inlet hazard area
ocean hazard area
setback line

Classroom Activities

Activity One: History of Hurricanes

For grades 4-12

Inquiry Question

Have hurricanes affected your county during the last century?

What to Do

Students research past hurricanes that affected their county, including the physical and social impacts of each storm. Examples of things that students should try to discover are how high the local creek rose, which highways and roads washed out and shortages (e.g., water, food, electricity) local residents suffered.

Reflection Question

How would a major hurricane affect your county now?

Sources of Information

County flood maps, newspapers, oral histories from senior citizens or grandparents, and World Wide Web sites on hurricanes are valuable resources for this activity.

Activity Two: Tracking Hurricanes

For grades 6-12

Inquiry Question

What was Hurricane Fran's track and where did the most coastal damage occur?

What to Do

Provide a hurricane tracking map to students as you watch Segment 1 of *The Science Behind the Storm*. Use the data in Table 1 or the video to track a hurricane. Students can record and graph changes in wind speed, category type and direction of movement from data on the video. At the close of Segment 1, students should be able to predict landfall (time and location) and wind speed at time of landfall. Extend this concept by predicting past hurricane landfalls using historical data. Students can predict storm surge effects using topographic maps of coastal counties and predictive storm surge models (included in this packet). They can work individually or in groups with their predictions to estimate where the most damage will occur along the coast and what types of damage will result. Use Segment 2 to show Fran's actual landfall and impact.

Reflection Question

What is the advantage of being able to predict the path of hurricanes?

Sources of Information

This package includes a tracking map useful for this activity. Tracking maps are available from most television stations. World Wide Web sites on hurricanes listed in the resources section of this guide provide past storm tracks as well as detailed hurricane information on current and past storms.

Activity 3: Beach Debris Clues to Offshore Geology

For grades 6-12

Inquiry Question

What debris found on the beach gives clues to the offshore geology of North Carolina's barrier islands?

What to Do

Collect shells, rocks, peat, seaweed and sea creatures from the tidal debris on beaches. Bring these to the students for classification. Try to determine if these artifacts come from ecosystems found on the offshore hardbottoms (sea whips, corals, sponges, shark's teeth) or soft, sandy bottoms (sand dollars, clam shells, scallop shells). Have students pretend they found their item on a local beach and then predict whether their item indicates a hardbottom or sandy bottom off their beach. To work with this video, beach debris from Topsail Island is most useful.

Reflection Question

What do near-shore rocky ledges indicate about potential sand recovery to beaches?

Sources of Information

Undersea Oasis: The Science of Hardbottoms is a 14-minute video that can be ordered from Environmental Media. Various field guides to the seashore such as the Peterson or Audubon series are helpful. The U.S. Coast Guard's chart of North Carolina (#11539 — New River Inlet to Cape Fear) includes Topsail Island and Wrightsville Beach. The geologic guide written by William Cleary is another valuable resource. (For more information on these sources, see the list of resources in Chapter 5.)

Activity 4: Designing with Nature

For grades 6-12

Inquiry Question

What design for an oceanfront house meets CAMA regulations and is hurricane resistant?

What to Do

Have students review Segment 2 and the construction practices necessary for building a house to resist a hurricane's forces. Give students blank paper and have them design their house. Include such mandatory features as pilings and roof-to-floor-to-piling connections. Using a 2-foot erosion rate on a 150-foot-deep lot, determine where this house should sit on an oceanfront lot.

Sources of Information

Contact the N.C. Division of Coastal Management, county governments and building contractors for construction criteria. Use computers, scanners and digital cameras to prepare architectural drawings.

Reflection Question

If you really built the house described in "What to Do," would you build on the setback line or farther back? What are the pros and cons of each decision?

Activity 5: Preparing for Hurricanes

For grades 6-12

Inquiry Question

Whether you live inland or on the coast, how do you prepare your house and your family for a hurricane?

What to Do

Using information from state and local governments and the World Wide Web, design a brochure on hurricane preparedness for distribution during Hurricane Awareness Week, which takes place the week of the Independence Day holiday.

Sources of Information

Contact the National Weather Service for information on Hurricane Awareness Week. Consult World Wide Web sites and the tracking and evacuation maps accompanying this guide.

Reflection Question

What is the most important step you can take to prepare for a hurricane? What is your evacuation plan?

N.C. Standard Course of Study Correlation Examples

Science

Grade level

5-12 Goal 1: The learner will develop an understanding of the nature of science.

The geological sciences provide the basis for policy that regulates development on barrier islands. In turn, changes in policy reflect new scientific knowledge. The pattern of hurricanes has historic significance and is becoming more predictable.

Goal 2: The learner will develop the ability to use science process skills.

The setback requirements for building on ocean hazard areas requires a knowledge of the average erosion rate for that site multiplied by 30. Therefore, the closest a building can be constructed is determined by that distance from the first line of stable, natural vegetation.

Goal 3: The learner will develop a positive attitude toward science.

Protection of a barrier island's public areas requires an understanding of public rights, government policies and the needs of private landowners.

5 Goal 4: The learner will gain understanding of energy concepts.

The relation between a land form (barrier islands) and weather (hurricanes) is demonstrated.

6-12 Goal 5: The learner will have an understanding of the relevance of current topics in science.

The recurring nature of storms and the ensuing devastation are current topics requiring an understanding of meteorology and geology.

6-12 Goal 6: The learner will construct an understanding of scientific concepts through patterns and cycles in the natural world.

Scientific research clarifies the patterns of hurricanes and island erosion.

9-12 Goal 7: The learner will have an understanding of geology (earth/environmental science).

The new understanding of sand movement as it relates to the underlying geology of barrier islands provides clues to predicting hurricane impact recovery rates.

9-12 Goal 8: The learner will have an understanding of meteorology (earth/environmental science).

Modeling and other new technologies explain the nature of hurricanes.

Social Studies

Grade
level

8 **Goal 1: The learner will assess the influence of geography on North Carolina's economic, social and political development.**

The increased number of people living on North Carolina's barrier islands has intensified the physical and economic impacts of natural disasters.

8-12 **Skill I: The learner will acquire information from a variety of sources.**

The oral history of hurricanes from older people, the World Wide Web, various news media and books all are sources of hurricane science and human impacts.

Skill II: The learner will use information for problem-solving, decision-making and planning.

Coastal policies and regulations require citizen input, scientific knowledge and a balance between conservation and economic use.

Skill III: The learner will participate effectively in civic affairs.

The Coastal Resources Commission is a state regulatory body that holds public meetings to discuss island development policy.

9-12 **Goal 9: The learner will explain how the political and legal systems resolve conflict and provide balance for competing interests.**

Developing and regulating coastal construction in relation to public trust rights requires public debate.

Computer Skills

Grade
level

5-12 **Goal 1: The learner will understand important issues of a technology-based society and the ethical use of computer technology.**

Technology plays a role in many areas of society, including sciences such as meteorology, and its impact is making our world a global community.

Goal 2: The learner will gain computer knowledge and skills.

Learning the fundamental skills of operating a computer will help the student access necessary information, solve problems and communicate effectively.

Goal 3: The learner will use a variety of computer technologies to access, analyze, interpret, synthesize, apply and communicate information.

By applying essential computer skills to access, analyze and share weather and hurricane data, students learn to process information.

VOCABULARY

acute erosion — Rapid, short-term erosion caused by high energy events such as northeastern storms and hurricanes that often remove beach and dune sand offshore or wash sand over the island.

beach profile — A transect of the beach from the primary sand dune to the water that indicates zones based on topography and slope, biology, chemistry and geology.

beach nourishment — Restoring sand to or widening a beach by dredging and pumping sand from offshore or sound areas to replace sand lost by erosion.

berm — A nearly level crest of a beach parallel to shore that marks the normal limit of wave action.

Coastal Area Management Act (CAMA) — Act that created the Coastal Resources Commission and gave it responsibility for designing state regulations to manage development activities in the coastal area. CAMA applies to 20 coastal counties, the estuarine waters within these counties and the Atlantic Ocean 3 miles seaward.

chronic erosion — Long-term erosion caused by rising sea level and continuing coastal processes.

Coastal Resources Commission (CRC) — Commission that consists of members appointed by the governor to recommend coastal regulations.

erosion — Coastal processes in which shorelines retreat. On barrier islands, erosion relates to island migration.

eye of the hurricane — The center of a hurricane, which is marked by low pressure and little wind.

eye wall of the hurricane — The area immediately around the eye in which air rapidly rises and produces intense low pressure near the storm center. This area has the most violent wind activity of a hurricane.

foredune ridge — The primary dune line that forms a near-continuous ridge and the first set of dunes found landward of the beach.

hardening of the shoreline — The practice of using hard structures such as sea walls, jetties or groins to stabilize eroding shorelines.

high wind warning — A warning issued to inland areas where winds are expected to average 40 mph or higher.

hurricane categories — The five hurricane classifications, which are based on disaster potential. Category five hurricanes are the most serious.

inlet hazard area — The land adjacent to inlets that is especially vulnerable to erosion, flooding and other adverse effects of sand, wind and water. Building in this area requires permits.

island migration — Shoreline retreat and landward movement of barrier islands through overwash and inlet migration in response to rising sea level.

landfall — The time and place that the eye of a hurricane first touches land. For example, Hurricane Fran made landfall near Wilmington at 8 p.m.

ocean hazard area — Oceanfront areas identified by the Coastal Area Management Act as having special vulnerability to erosion or other adverse effects of sand, wind and water. Uncontrolled or incompatible development could endanger life or property. Ocean hazard areas include beaches, frontal dunes, inlet lands and other areas in which geologic, vegetative and soil conditions indicate a substantial possibility of excessive erosion or flood damage.

overwash (or washover) — Transportation of beach and dune sand, typically from high water and storm surge during a storm, across the dune line to the back side of barrier islands.

peat — A rich, fibrous organic mat of accumulated plant material, typically found in marsh or wetland ecosystems.

scarp — Erosional cliff of a few inches to several feet that marks the landward limit of the most recent high energy storm events. The scarp may be a cliff on the face of a dune or a cut anywhere on the level beach berm.

seasonal erosion — Sand loss that results from seasonal variations in wave energy. Low-energy summer waves often restore beach sands, while higher energy winter waves remove beach sand to offshore bars.

setback line — The prescribed distance from the first line of stable natural vegetation or from the measurement line along the primary or frontal dune that determines how close to the ocean a structure can be built. The equation to determine the distance is the average erosion rate multiplied by 30 for residential structures and multiplied by 60 for structures over 5,000 square feet. For example, to build on an oceanfront lot with an average erosion rate of 3 feet, the structure would be "set back" 30 x 3, or 90 feet, from the first line of natural, stable vegetation.

storm surge — A low-pressure induced rise in sea level associated with a hurricane. The storm surge usually precedes a hurricane's landfall and, when accompanied by high waves, causes most of the damage to life and property. Hurricane Fran had a storm surge of 8 feet.

surf zone — Area of water close to the shoreline where waves break.

Resources

Books and Field Guides

Ackerman, Jennifer. "Islands at the Edge." *National Geographic*. August 1997. 2-31.

Amos, William, and Stephen Amos. *The Audubon Society Nature Guide to the Atlantic and Gulf Coasts*. New York: Knopf, 1988.

Barnes, Jay. *North Carolina's Hurricane History*. Chapel Hill, N.C.: UNC Press, 1995.

Cleary, William J.(ed). *Environmental Coastal Geology: Cape Lookout to Cape Fear, NC*. 1996. (Available from W. J. Cleary, Department of Earth Science, UNC-Wilmington, Wilmington, NC 28403-3297. $13.)

Frankenberg, Dirk. *The Nature of the Outer Banks: Environmental Processes, Field Sites, and Development Issues, Corolla to Ocracoke*. Chapel Hill, N.C.: UNC Press, 1995.

Frankenberg, Dirk. *The Nature of North Carolina's Southern Coast: Barrier Islands, Coastal Waters, and Wetlands*. Chapel Hill, N.C.: UNC Press, 1997.

Gosner, Kenneth L. *Guide to the Atlantic Seashore*. Boston: Houghton Mifflin, 1979.

Leatherman, Stephen P. *Barrier Island Handbook*. College Park, Md.: University of Maryland Press, 1982.

Meyer, Peter. *Nature Guide to the Carolina Coast*. Wilmington, N.C.: Avian-Cetacean Press, 1992.

Undersea Oasis: The Science of Hardbottoms. Fourteen minutes. North Carolina Sea Grant. (Available from Environmental Media Corporation, P.O. Box 99, Beaufort, SC 29901-0099. Or call 1-800-ENV-EDUC.)

World Wide Web Resources

Duke University Program for the Study of Developed Shorelines, Hazard Area Mapping — http://www.geo.duke.edu/psds_hazmaps.htm

National Hurricane Center — http://www.nhc.noaa.gov/

National Weather Service — http://www.nws.noaa.gov/

National Weather Service Office, Raleigh, N.C. — http://www.nws.noaa.gov/er/rah/noframe.html

Newport/Morehead City National Weather Service Office — http://www.nws.noaa.gov/er/mhx/nwswebg.htm

North Carolina Severe Weather Reports — http://www.met.tamu.edu/personnel/students/mkay/warnins_nc.html

North Carolina Special Weather Statements — http://iwin.nws.noaa.gov/iwin/nc/special/html

North Carolina State University Weather — http://meawxl.nrrc.ncsu.edu/

North Carolina Storm Tracking Guide — http://ncstormtrack.com/guide/evacuation/html

U.S. Hurricane and Tropical Storm Reports — http://iwin.nws.noaa.gov/iwin/us/hurricane.html

Wilmington, N.C., National Weather Service Office — http://www.wilmington.net/nwsilm/

Table 1. Hurricane Fran Track

(The information below was taken from the National Hurricane Center's web site: http://www.nhc.noaa.gov/fran.html. Note that times are in Greenwich Mean Time.)

Date/Time (UTC)	Position Lat. (N)	Position Lon. (W)	Pressure (mb)	Wind Speed (kt)	Stage
23/1200	14.0	21.0	1012	25	tropical depression
24/0000	14.2	24.8	1010	25	"
1200	14.1	28.2	1009	30	"
25/0000	14.1	30.8	1009	25	"
1200	14.6	33.4	1009	25	"
26/0000	14.9	37.0	1009	25	"
1200	15.3	40.0	1009	30	"
27/0000	14.9	42.7	1007	30	"
1200	14.6	44.9	1005	35	tropical storm
28/0000	14.6	47.5	1002	45	"
1200	15.5	50.7	995	55	"
29/0000	16.4	53.7	987	65	hurricane
0600	17.0	55.0	987	65	"
1200	17.8	56.3	988	65	"
1800	18.6	57.5	988	65	"
30/0000	19.1	58.5	991	65	"
0600	19.4	59.4	991	65	"
1200	19.8	60.1	989	65	"
1800	20.2	60.6	990	60	tropical storm
31/0000	20.5	60.9	988	60	"
0600	20.8	61.2	987	60	"
1200	21.1	61.4	984	65	hurricane
1800	21.5	61.7	983	65	"
01/0000	21.7	62.1	978	65	"
0600	21.9	62.6	982	65	"
1200	22.2	63.2	982	70	"
1800	22.5	63.9	981	75	"
02/0000	22.9	64.7	978	75	"
0600	23.3	65.7	976	75	"
1200	23.6	66.7	976	75	"
1800	23.9	67.9	976	75	"
03/0000	24.2	69.0	977	75	"
0600	24.4	70.1	975	80	"
1200	24.7	71.2	973	80	"
1800	25.2	72.2	968	85	"
04/0000	25.7	73.1	961	95	"
0600	26.4	73.9	953	100	"
1200	27.0	74.7	956	105	"
1800	27.7	75.5	952	105	"
05/0000	28.6	76.1	946	105	"
0600	29.8	76.7	952	105	"
1200	31.0	77.2	954	100	"
1800	32.3	77.8	952	100	"
06/0000	33.7	78.0	954	100	"
0030	**33.9**	**78.7**	**954**	**100**	**Landfall near Cape Fear**
0600	35.2	78.7	970	65	"
1200	36.7	79.0	985	40	tropical storm
1800	38.0	79.4	995	30	tropical depression
07/0000	39.2	79.9	1000	30	"
0600	40.4	80.4	1001	30	"
1200	41.2	80.5	1001	30	"
1800	42.0	80.4	1000	30	"
08/0000	42.8	80.1	999	30	"
1200	44.0	79.0	1000	25	"
09/0000	44.9	75.9	1002	25	extratropical
0600	45.4	74.0	1004	20	"
1200	45.7	72.3	1006	15	"
1800	46.0	71.1	1008	15	"
10/0000	46.7	70.0	1010	15	"
0600	—	—	—	—	absorbed by a front

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