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Dr. Sarah Tebbens interned at Lamont-Doherty Geological Observatory in Palisades, New York after receiving her bachelor's degree from Vassar College. She continued her education at Columbia University where she received two masters' degrees (1989, 1991) and a Ph.D. (1994). She is married and has two children, Nicholas (6 years old) and Katie (3 years old).

Her research interests include the studies of tectonic evolution of the ocean floor and coastal processes. She has studied the evolution of the Chile ridge and the mid-ocean triple junction in the southeast Pacific. Additionally she has collected data to help establish scaling laws for tsunamis and is interested in volumetric coastal change studies to determine economic impact of natural and human influences.

She has always been interested in science and remembers collecting rocks as a child. She likes being able to work with scientists from around the world and being able to see and understand new things.

## Unit VI Detecting Coastal Change with Lasers

### On the cutting edge...

Barrier Islands provide natural protection against the destructive wind, waves, and tides that wash the shores of coastal communities. As more people reside in these areas, officials are looking for accurate and cost effective ways to assess storm damage and emergency response times. In the past, scientists have had to rely on data obtained through aerial photography and radar. Today, laser technology has provided the basis for more sophisticated instrumentation. Researchers today at the University of South Florida are on the cutting edge of science using airborne LIDAR (LIght Detection And Radar) technology to more accurately determine coastal changes due to beach erosion. This new technology gives scientists the opportunity to accurately measure eroded sand volume and observe coastal change.

## Modern Coastal Studies

**Lesson Objectives:** Students will be able to do the following:

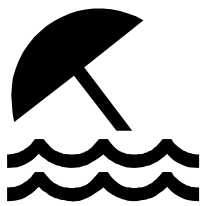
- Name and define the basic parts of a beach
- Explain airborne LIDAR (LIght Detection And Ranging) technology
- Discuss the importance of sand erosion and economic impact

Key concepts: topography, barrier islands, beach drift, accretion, erosion, LIDAR technology

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### Beach Morphology

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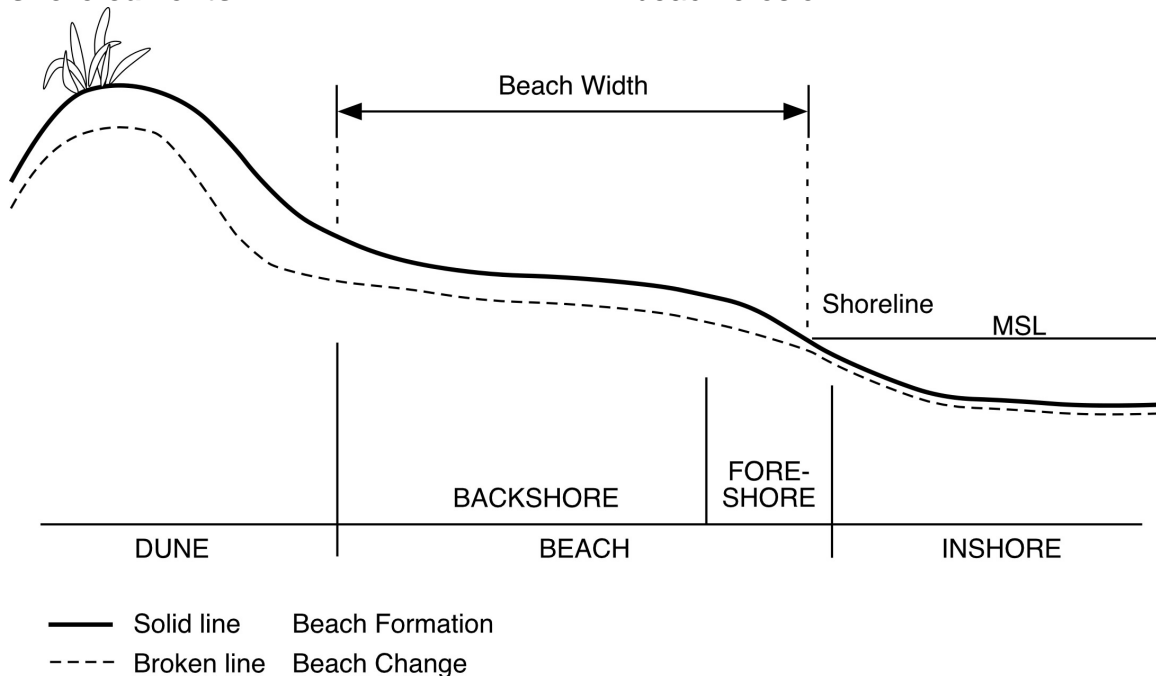
Beaches are an important part of the coastal **topography** of **barrier islands**.

They provide an expanse of recreational area that also acts as a buffer between the ocean and the **dunes**. They are areas that sustain a wide variety of organisms both plant and animal in a dynamic **ecosystem** that responds to energy changes on an hourly basis.

The **beach** is generally considered the area between the mean low water line and the dunes. This area is usually an expanse of relatively flat sand. The beach can be divided into two distinct regions: the **foreshore** and the **backshore**. The foreshore area is regularly affected by wave and tidal action as it slopes toward the ocean. The backshore area extends from the foreshore to the dunes. This area is rarely subject to water action except during storm surges.

Waves affect beaches both seasonally and tidally. As waves approach the shoreline they break causing a **swash**. Water in a swash rushes up the beach and then washes back down the beach. This affect causes some of the beach sand to drift or move. Over time the shape of the beach begins to change as sand is moved from one place to another accumulating in some areas and eroding away in others. This phenomenon is called **beach drift**. A number of factors influence the sand movement on beaches including: tidal frequency, wave height and duration, wind strength, and **long shore currents**.

Beach movement is important because it explains the behavior of barrier islands. Barrier islands protect the coastlines from incoming storms. The effects of **accretion** and **erosion** seen along their beaches help to minimize these same effects on the mainland. Scientists have recorded changes in coastlines through maps and aerial photography for decades. As technology developed, radar also became available to researchers. Today with the advances in laser technology more accurate Light Detection And Ranging (**LIDAR**) technology can be used to study beach erosion.



## LIDAR Technology.

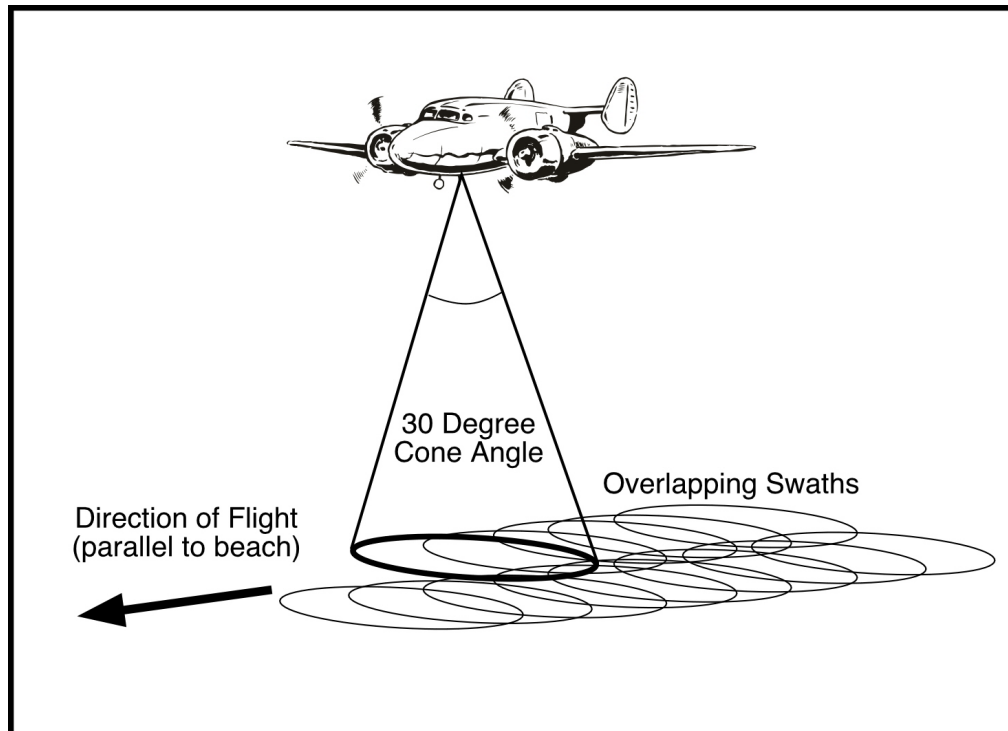
Today LIDAR (Light Detection And Ranging) is used to interpret topographical data with much more accuracy than has been possible in the past. This technology has been

used since the 1960's and is a cost effective way to study coastal change. LIDAR uses a **laser** as an energy or light source. The laser produces an intense beam of light

due to its **monochromatic** nature. The light beam is then transmitted to a target and the energy is reflected back to the source. Since the speed of light is known (186,000 miles per second) the distance to the target can be calculated by the amount of time elapsed from the emission of the beam to its return. (Velocity of light beam x round trip time ÷ 2 = distance to the target) The intensity of the light from the pulsed laser determines the properties of the particles being studied.

Airplanes equipped with LIDAR instruments gather data that identifies small areas by shooting laser beams in rapid succession over a grid area. The angle of the light

reflection and plane height must also be calculated with accuracy to obtain useable data. This information can also be used to create topographical maps that are accurate to within 10 to 15 centimeters vertical. There are several advantages to Airborne Topographical Mappers (ATMS) compared to their earlier counterparts. They can measure both sea and land elevation accurately and can be used in shallow water areas to replace the more cumbersome swath bathymetry. This means the ATM can measure both shoreline topography as well as the **bathymetry** of shallow coastal water.



Picture adapted from NOAA's Coastal Services Center-ALACE website.

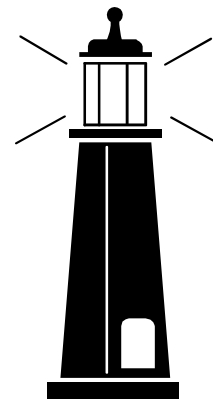
## Importance of Beach Morphology Studies

Scientists and government officials study barrier island systems because they protect economically important coastal areas. Researchers are interested in gathering information comparing coastal changes over time resulting in data that could be used by insurance companies, local and federal disaster agencies, urban planners and other officials. Field studies following major storms currently include LIDAR surveys, oblique aerial photography, and ground surveys. The data compiled from these studies presents a comprehensive picture of coastal change and impact due to major storms.

For example, in 1999 Hurricane Dennis came ashore in North Carolina as a tropical storm. Prior to landfall it churned the ocean water for a week creating the third highest waves recorded in the past twenty-year history of North Carolina. After the storm, surveys showed a loss of beach width and major dune destruction. Overwash displaced large amounts of sand necessitating the reconstruction of a protective dune and movement of the highway landward. The Cape Hatteras Lighthouse had also been relocated inland several weeks prior to Hurricane Dennis because of its close proximity to the shore. This move may have saved the

lighthouse from destruction during the storm. Actual photographs of these coastal changes are available on the United States Geological Survey web page at <http://coastal.er.usgs.gov/hurricanes/dennis>

The barrier island system off the North Carolina coast is the focus of a new study. This area was chosen because data exists that could be used for comparison purposes. Maps and aerial photographs show the accretion of these barrier islands over several years as they were affected by severe storms and human intervention. Using this database scientists hope to discover patterns of sand response to natural energy levels and human influences. New technology will even allow researchers to determine spatial patterns and volumes of eroded sand.



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**Activity: Coastal Beach Erosion**

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**Adapted from an activity by Guy Jacob in the Resource Guide for Oceanography and Coastal Processes published for the Institute of Marine Sciences-J.L. Scott Marine Education Center and Aquarium administered by The University of Southern Mississippi.**  
(Please see references for complete citation.)

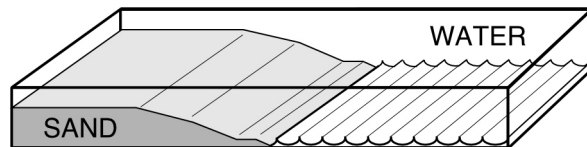
Our coastal beaches change on a daily basis due to natural and human affects. Wind, waves, and tides work together to sculpt the beaches before, during, and after storms. Humans as they move into coastal areas try to protect their investments by building seawalls, jetties, or even erecting fences and planting grass.

**Objectives:** Students will be able to do the following:

1. Demonstrate the effects of wind and waves on beach erosion.
2. Make predictions based on observation and experimentation.

**Materials:**

- Three rectangular containers (at least 9" by 12" by 3" deep)
- Sand
- Grass
- Plastic mesh or screen
- Ruler
- Brick
- Fan
- Paper and pencil



**Procedure:**

1. Set up the containers leaving enough room between them for student observation
2. Have students put approximately 2" of sand in one half of each container. This will represent the beach.
3. Have students pour approximately 1 1/2" of water into the other half of each container. This water represents the ocean.
4. Have students plant sprigs of grass along the beach in the second container.
5. Have students place a mesh or screen barrier on the beach in the third container. This represents a fence.
6. Have students observe and record results throughout the experiment. Students may draw pictures or make written notations.
7. Have students use rulers to create gentle "wave" action along each beach.
8. Have students create larger waves using a brick. This represents storm wave action.

9. Have a fan strategically placed to blow gentle breezes across the beaches, and repeat the first experiments.
10. Have the breeze increase to a gale force wind and repeat for all three beaches.
11. Try a hurricane if you are not afraid.
12. Have students compare and discuss the results of their observations and experimentation.

**Possible Extensions:**

1. Have students design beaches with dunes, housing developments, seawalls, jetties, etc, and compare the effects of wind and waves on these beaches.
2. Design beaches with various types of particulate matter or combinations of sand and soil. Compare results.

## Student Information: The Importance of Coastal Studies

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People began using maps long ago to study the changes in coastlines. If you live in a coastal community, the maps showing your area have probably changed over time. In some places the land size has dwindled and in other places it has grown larger. We know that these changes in land size are due to a combination of human made and natural conditions.

Nature's forces work together to sculpt the land. The wind, wave, and tidal action rearrange the sand on the beaches. When storms occur the effects are even greater. Natural disasters, such as hurricanes and earthquakes, change the beach areas and the lands behind them. Large piles of sand can be pushed from place to place forming dunes that are anchored by grasses. Low areas become flooded with rains and over wash from **tides** creating **wetland** areas. Nature creates an effective coastal barrier that humans sometimes destroy.

People like to live near the water and on the beach areas. Sometimes they build on ground that is not stable or is prone to flooding. They want to protect their homes, so they change the landscape using concrete walls and other means to direct the water and redirect the sand. This sometimes causes an upset in nature, and the effects are more far reaching than people imagine.

Today scientists are using the latest technology called LIDAR (Light Detection And Ranging) to explore coastal areas and record the movement of sand on the beaches. By gathering data researchers will be able to direct developers and help prevent people from losing their homes during disasters.



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## Coastal Vocabulary

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**Accretion**-growth or increase in size by addition of material

**Backshore**-beach area extending from the foreshore to the dunes

**Barrier Island**-a long relatively narrow island running parallel to the mainland built up by the action of waves and currents

**Bathymetry**-topography of underwater features-bottom depth

**Beach**-area between the mean low water line and the dunes

**Beach Drift**-change in the shape of the beach due to wind and wave action

**Dune**-a hill or ridge of wind blown sand

**Ecosystem**-a community of living organisms and their environment

**Erosion**-washing away of the soil

**Foreshore**-sloping part of the beach that is regularly affected by wave and tidal action

**Laser**-a device that creates, amplifies, and transmits an intense beam of light

**LIDAR (Light Detection and Ranging)**-technology that uses lasers and radar to measure topography or bathymetry

**Long Shore Current**-a current running parallel to the shore

**Monochromatic**-of only one color

**Morphology**-form and structure of an object

**Swash**-wave after it breaks on the beach

**Tide**-periodic change in the level of the ocean caused by the gravitational pull between earth and the moon and sun.

**Topography**-surface features of a place or region

**Wetland**-a lowland area such as a marsh that is saturated with water

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## Coastal References

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