

# Coastal Geomorphology I - Beaches and Shoreline Processes

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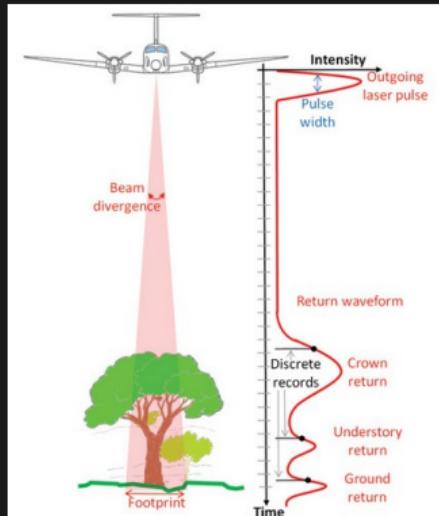
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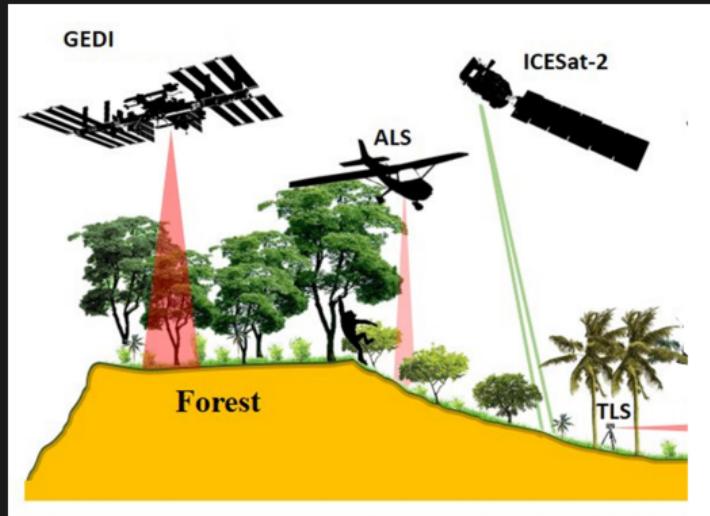
# Background

- 2021 Postdoc: East Carolina University
- 2020 Ph.D. Geophysics: University of Houston
- 2015 M.S. Geophysics: Chinese Academy of Sciences
- 2012 B.S. Geology: Peking University

# Mangrove forest structure change over time



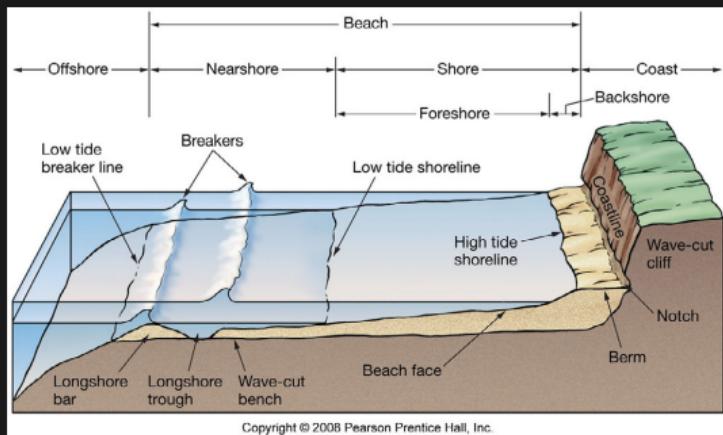
(Fernandez-Diaz, 2011)



(Modified from Silva, 2022)

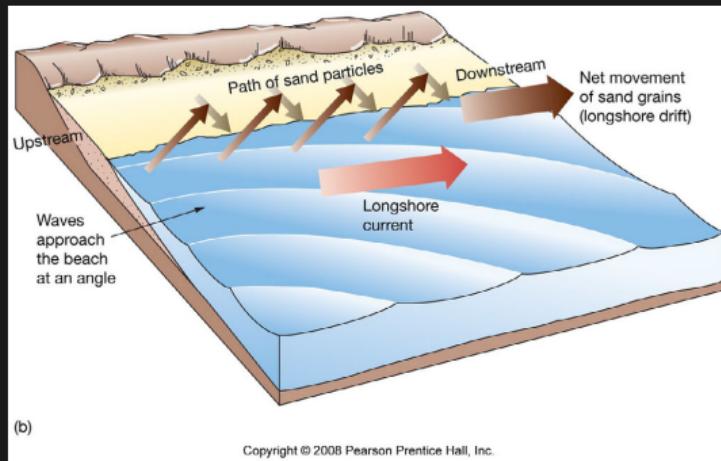
# Beach anatomy

- Shore – the zone that lies between the low tide line and the highest area on land affected by storm waves
- Coast – extends inland as far as ocean related features are found.
- Coastline – boundary between shore and coast
- Beach - part of the land that touches the sea and is a zone of sediment transport



# Sand movement along beach

Sediments can either move perpendicular or parallel to the shoreline. Swash is when water rushes up the beach and backwash is when water drains back to the ocean. Longshore currents are generated by onshore prevailing winds that cause waves crash on the beach at an angle - the swash and backwash move in a zigzag motion that pushes water along the shore. This results in a net movement of the sand along the beach, longshore drift.

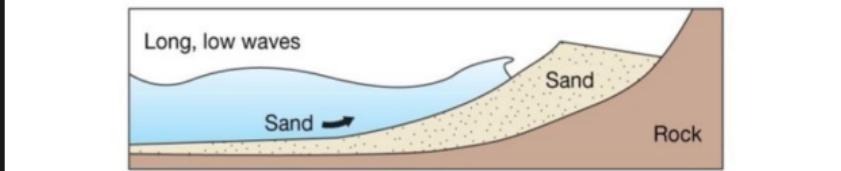


# Long Shore Drift

<https://www.youtube.com/watch?v=B1DzaIE-ajQ&t=91s>

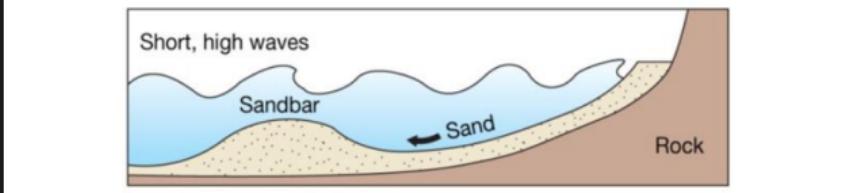
# Summer beach

During periods of light wave activity, the swash processes dominate and sediments are moved toward the shore and the beach becomes wider. These fair-weather waves generally occur during the summer months when winds are generally slower.



# Winter beach

During periods of heavy wave activity, the backwash processes dominate and sediments are moved away from the shore and the beach becomes narrower. These stormy weather conditions create sandbars offshore and tend to occur during the winter months.



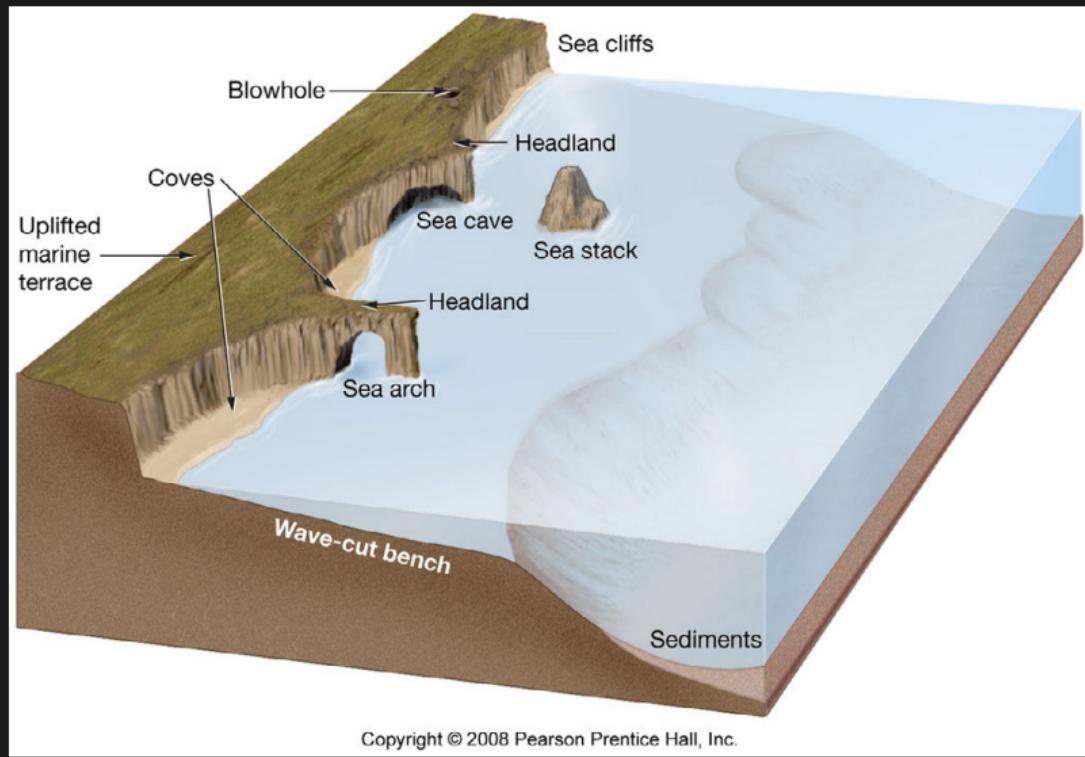
# La Jolla Beach Timelapse (Winter-to-Summer Comparison)

<https://www.youtube.com/watch?v=UCU6PrjB08c&t=9s>

# Erosional shorelines

- Erosional shorelines are formed in areas with little to no sediment. These occur in areas of high relief and rugged topography which are characterized by well-developed cliffs and "recent" tectonic activity. These types of shorelines have erosive features like headlands, wave-cut cliffs, sea caves, sea arches, sea stacks, marine terraces.
- Often, but not necessarily always, erosional coasts are associated with coastal zones along active plate margins where there is a steady uplift of the landform, and few well-developed drainage basins and rivers systems have developed to deliver large quantities of sediment to the coast.

# Erosional shorelines



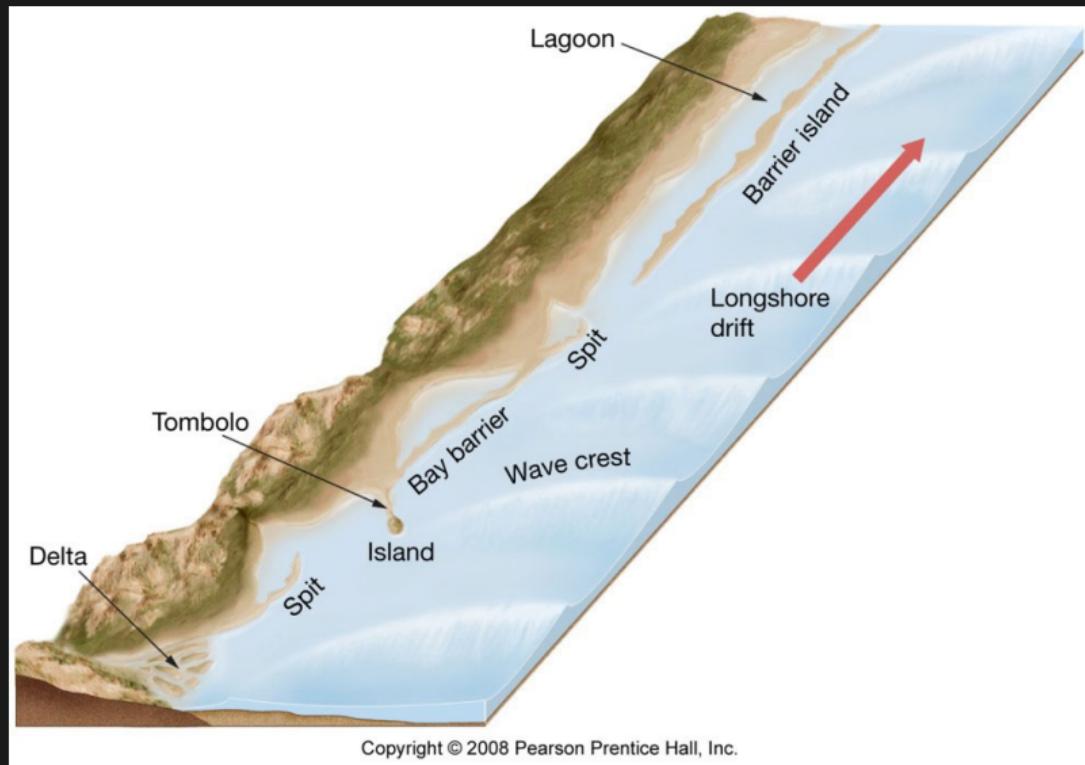
# Sea Stack: A Landform of Coastal Erosion

<https://www.youtube.com/watch?v=9w8ttSMSVFg>

# Depositional shorelines

- Depositional shorelines are primarily deposited by longshore drift and generally occur on subsiding coastlines. Here sediments are abundant and form depositional features such as beaches, spits, bay barriers, tombolos, barrier islands, and deltas.
- They are most common along mature, tectonically inactive continental margins where ample geologic time has passed for large drainage basins and rivers to develop, which can provide large quantities of sediment that can be distributed by waves and tides at the coastline.

# Depositional shorelines



# Depositional shorelines



# What is barrier island?

Barrier Islands are depositional landforms that are formed narrow islands offshore. They migrate over time due to rising sea levels. Older peat deposits can be found on ocean beach.

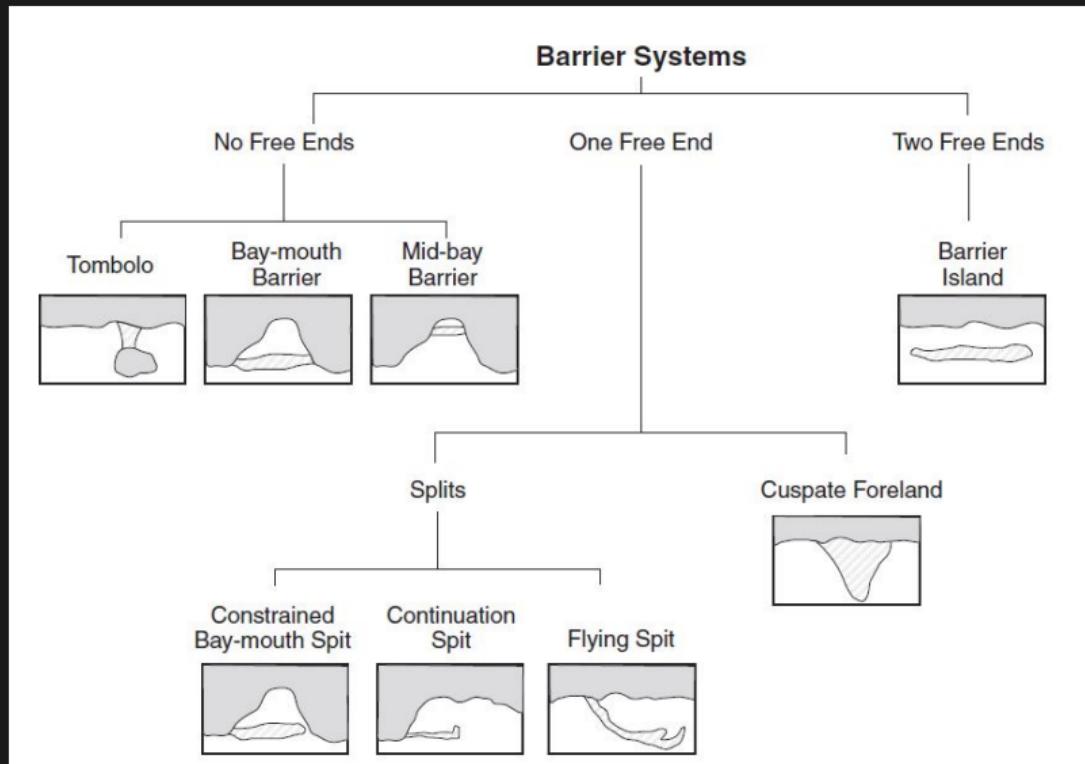


Figure: Cape Hatteras National Seashore in OBX NC,  
Credit: NASA's Earth Observatory

# Physical Geology - Barrier Islands - Introduction

<https://www.youtube.com/watch?v=VkxKNTMqvjM>

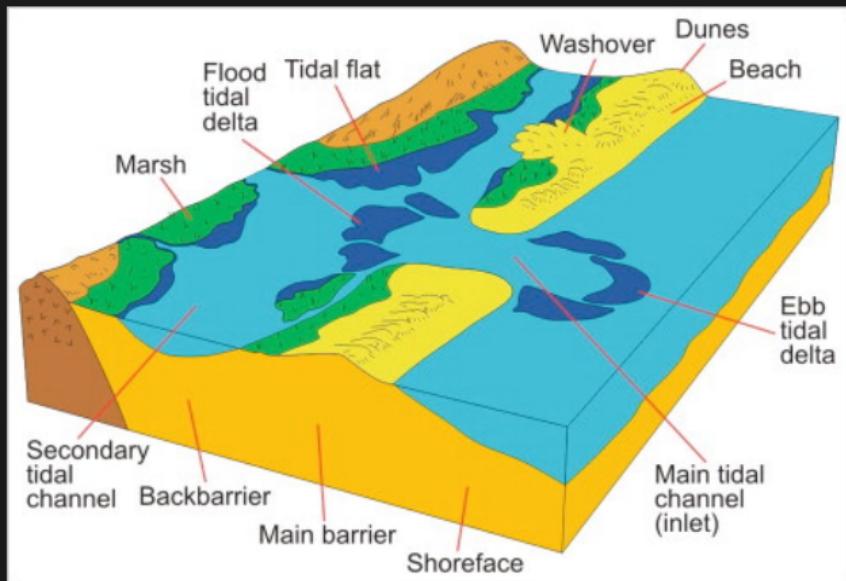
# Classification of barrier islands



(Ollerhead, 1993)

# Structure and components of a barrier island system

- 1) mainland
- 2) lagoon, bay or extensive marsh
- 3) subaerial barrier
- 4) subaqueous platform
- 5) shoreface
- 6) inlets and tidal deltas



After Walker (1979)

# Barrier dynamics: overwash and inlets

- Barrier islands are dynamically changing.
- Both overwash and inlet formation during storms are important controls on the dynamics and evolution of barriers.
- They are key to the preservation of transgressive barriers because the landward transfer of sediment results in the rollover or landward migration of the barrier.
- This acts to preserve the barrier as a depositional landform through time while the location moves to accommodate reduced sediment supply or sea level rise.

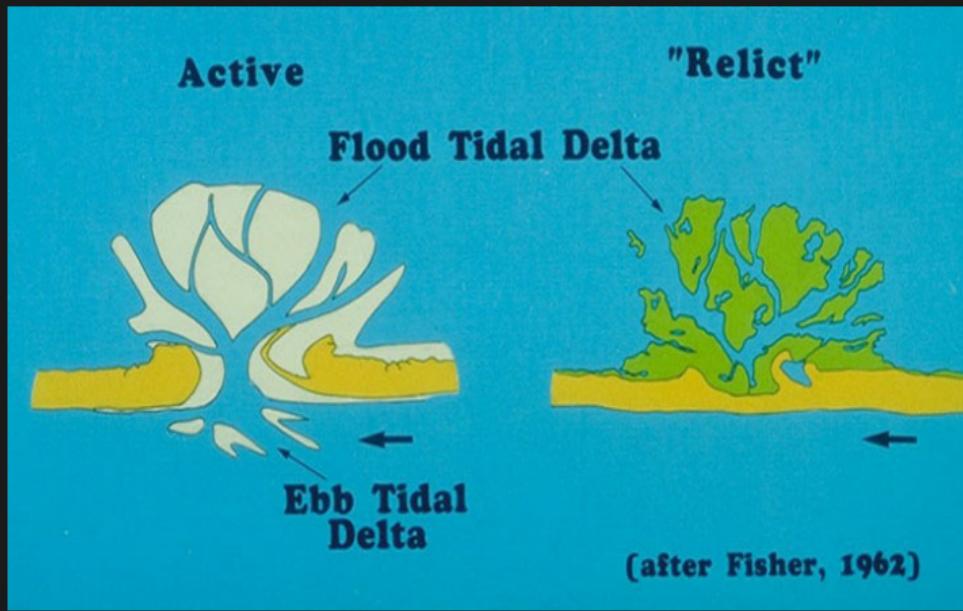
# Barrier island dynamics

Barrier islands maintain themselves with three main processes: 1) overwash, 2) longshore transport, and 3) flood-tide delta accretion.



# Flood-tide delta

A flood-tide delta is the accumulation of sediments on the shoreward side of an inlet. They are initially created by severe storm events but then maintained by flood tides. These deltas are eventually stabilized once salt marshes or mangroves establish on the accumulated sediments.

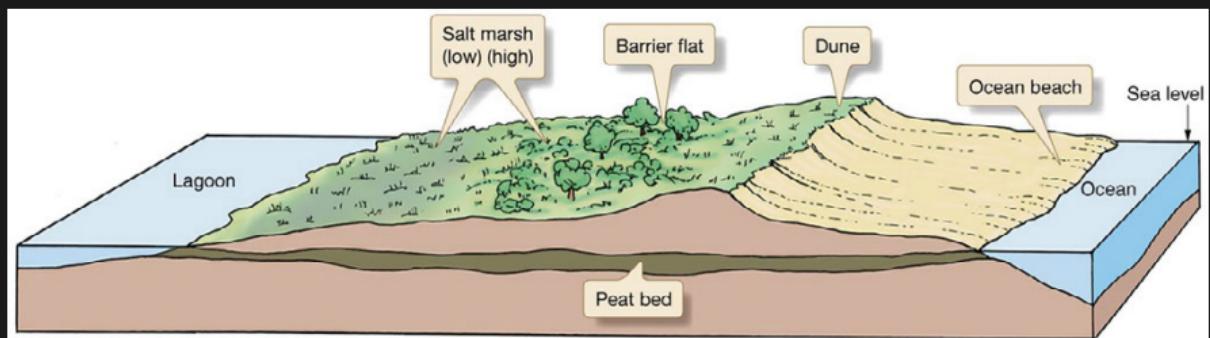


# Storm surge and overwash

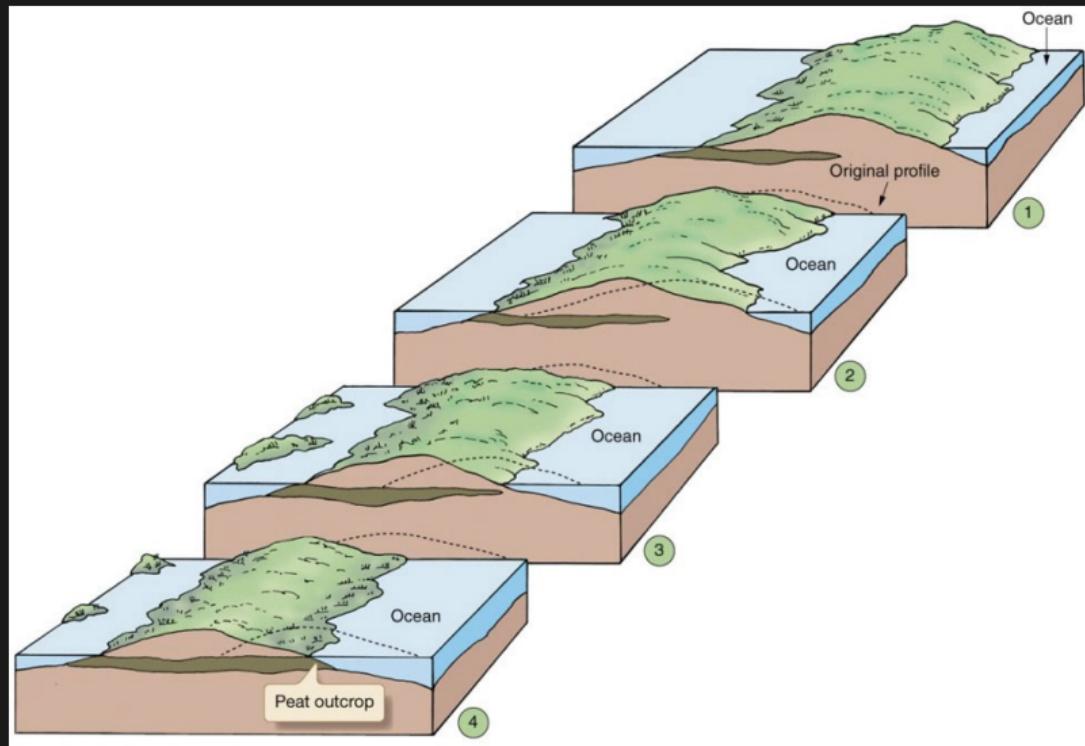
Pre and Post Hurricane Dorian along NC coast



# Barrier island features



# Barrier island evolution



# Barrier island in US

- More than 2000 barrier islands identified worldwide
- Almost 300 along Atlantic and Gulf coasts of U.S.

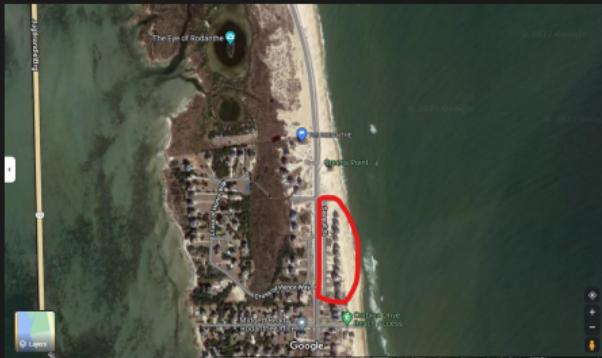


# Watch the Formation of a Barrier Island

<https://www.youtube.com/watch?v=hR9NyjcnkNs&t=51s>

# Coastal Areas: Where People Meet the Sea

<https://www.youtube.com/watch?v=ewGXdskfyb8&t=4s>

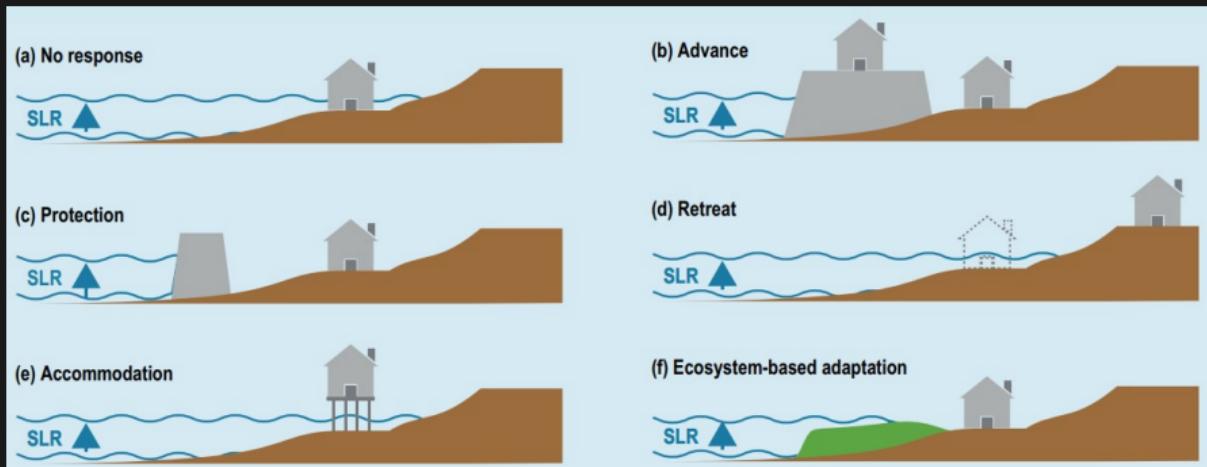


**Editor's Blog: What will happen to the famous Mirlo Beach sign?**

October 17, 2022 | Editor's Blog | By: Joy Crist



# Different types of responses to coastal risk and sea level rise (SLR)



IPCC report, 2019, Chapter 4: Sea Level Rise and Implications for Low-Lying Islands, Coasts and Communities

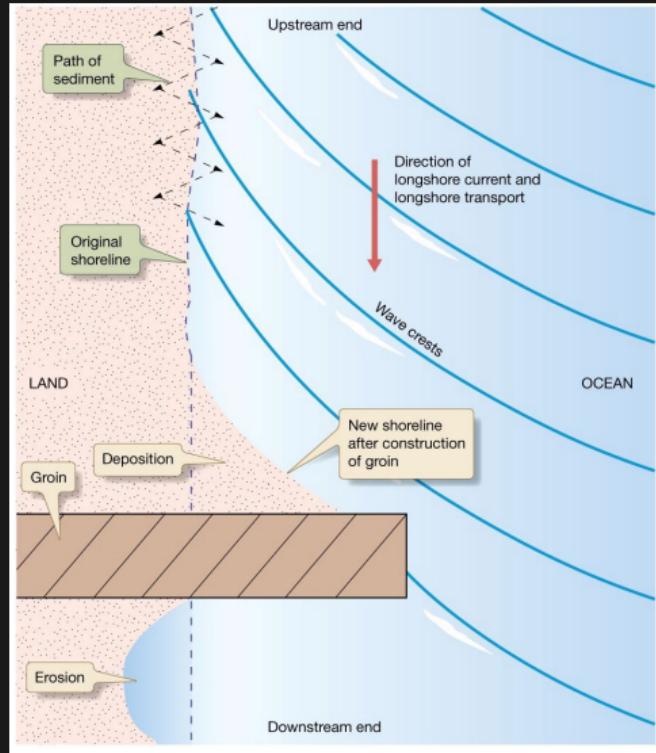
# Hard Stabilization

Four major types of stabilization structures:

- 1. Groins and groin fields
- 2. Jetties
- 3. Breakwaters
- 4. Seawalls

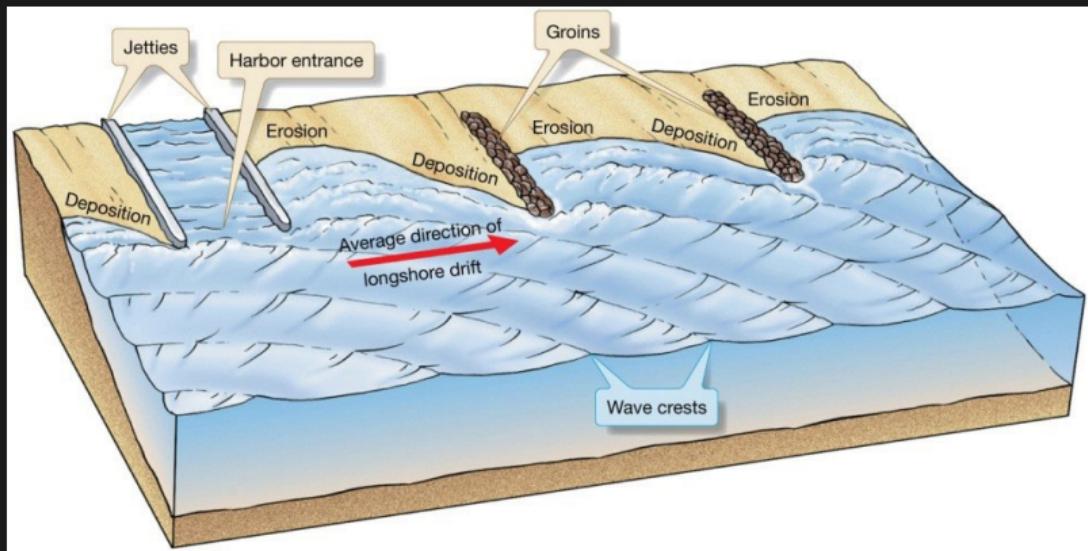
# Groins and groin fields

Groins and groin fields are built perpendicular to the beach. They are often made of riprap, or large blocky material. The groins trap sand upcoast, which can cause erosion downcoast of the longshore current



# Jetties

Jetties are similar to groins, in that they are built perpendicular to the shore, but are built in pairs to create channels that protect harbor entrances.



# Breakwaters

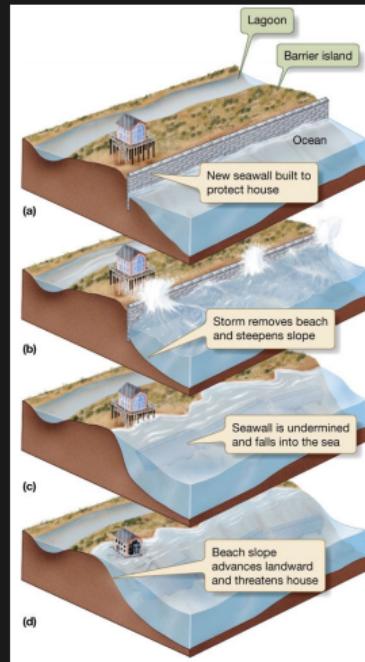
Breakwaters are built parallel to the shoreline. They are designed to help protect harbors from waves. Excessive erosion can occur, requiring dredging to keep the area stable.

Collaborative Living Shoreline Research

[https://www.youtube.com/watch?v=o1716DfaND0&feature=emb\\_title](https://www.youtube.com/watch?v=o1716DfaND0&feature=emb_title)

# Seawalls

Seawalls are the most destructive (conversion) of the environment. They are designed to armor coastline and protect human developments. One large storm can remove the entire beach. Wave activity eventually undermines seawall structure and needs continual repair or will collapse.



# beach replenishment

Several alternatives to hard stabilization can help to minimize environmental impact. Beyond construction restrictions that limit building in vulnerable regions, some areas plan for beach replenishment, or in some cases, relocation.

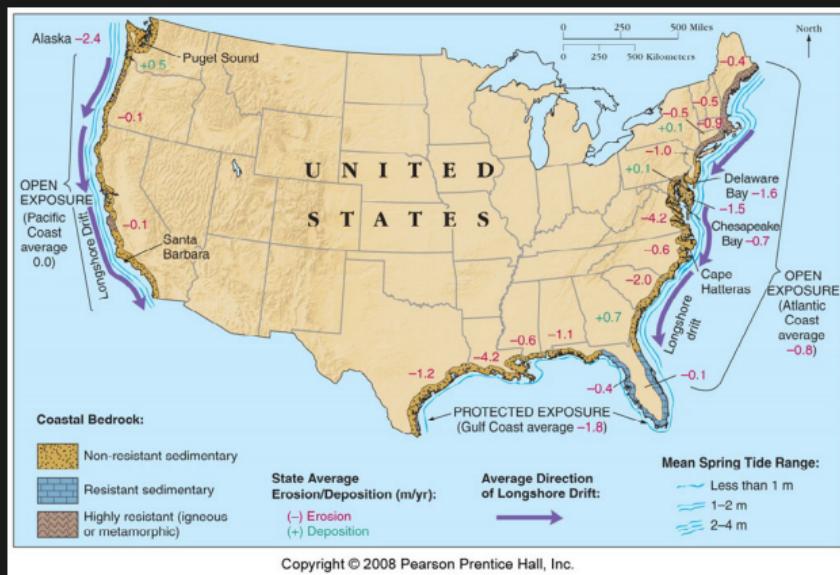
For Beach Replenishment, sand added to beach/longshore current. But this can be expensive - between \$5 and \$10 per cubic yard. Sand must be dredged from elsewhere.

## Outer Banks Beach Nourishment Projects 2017

<https://www.youtube.com/watch?v=kKoc3x97BsY>

# Coastlines in US

The three coastlines of the contiguous US, 1) Atlantic, 2) Gulf of Mexico, and 3) Pacific. There are areas with erosion or deposition dominates. These processes are controlled by the type of bedrock or underlying sediments, the tidal range and wave exposure, active tectonics, and eustatic changes in sea level



# Coastlines in US



# Atlantic Coast

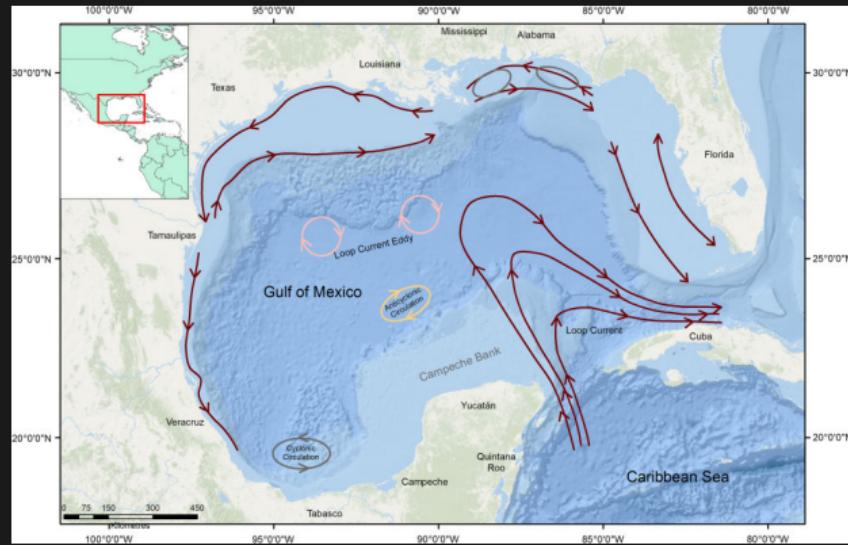
Most of the coastline is open to wave processes with sufficient sediment supply ("old" coast) leading to high occurrence of barrier islands. Drowned river valleys are common. The bedrock varies from south to north - Florida bedrock is resistant limestone, Northward through New Jersey is composed of easily erodible recent deposits, and New York through Maine has glacier-affected rocks metamorphic and igneous rocks.

# Atlantic Coast



# Gulf Coast

The Gulf Coast is a "protected" basin which has a low tidal range and generally low wave energy. Tectonic subsidence is common, but primarily a result of groundwater pumping and compaction. Average rate of erosion is 1.8 meters (6 feet) per year.



# Pacific Coast

The Pacific Coast is being uplifted by plate tectonic processes. The bedrock is comprised generally of non-resistant sedimentary rocks. The coastline is exposed to high energy waves.



# A Rapid Terrestrial Laser Scanning Method for Coastal Erosion Studies



**sensors**

Open Access Article

## A Rapid Terrestrial Laser Scanning Method for Coastal Erosion Studies: A Case Study at Freeport, Texas, USA

by  Lin Xiong <sup>1,\*</sup>,  Guoquan Wang <sup>1,\*</sup>,  Yan Bao <sup>2,\*</sup>,  Xin Zhou <sup>1</sup>,  
 Kuan Wang <sup>1</sup>,  Hanlin Liu <sup>3</sup>,  Xiaohan Sun <sup>4</sup> and  Ruibin Zhao <sup>5</sup>

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Article Menu

# Assignment – summary of this paper?

<https://www.nature.com/articles/s41598-020-76521-4>