

Objectives

- Explain how shoreline features are formed and modified by marine processes.
- Describe the major erosional and depositional shoreline features.

Vocabulary

 – wave refraction

 – beach

 – estuary

 – longshore bar

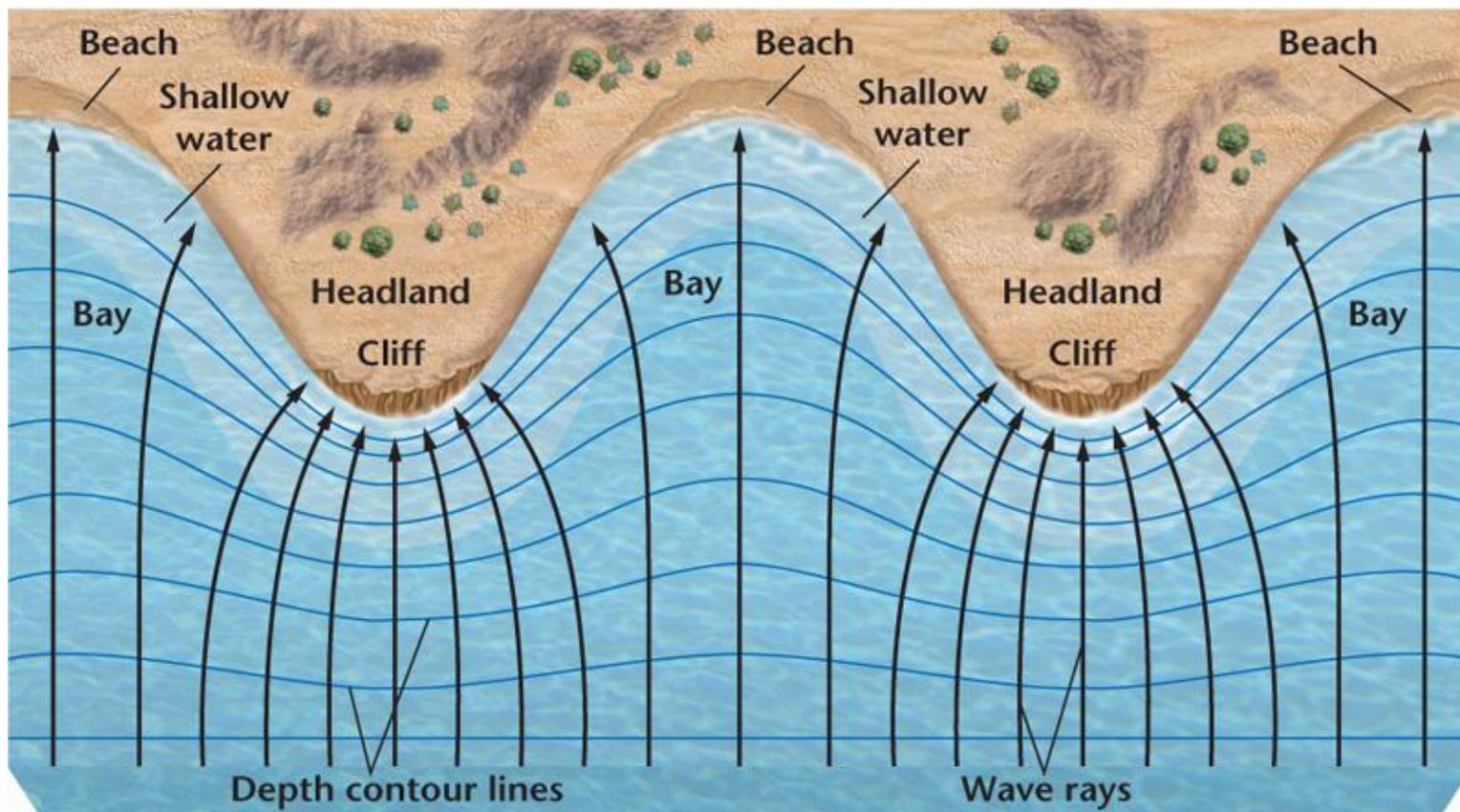
 – longshore current

 – barrier island

Erosional Landforms

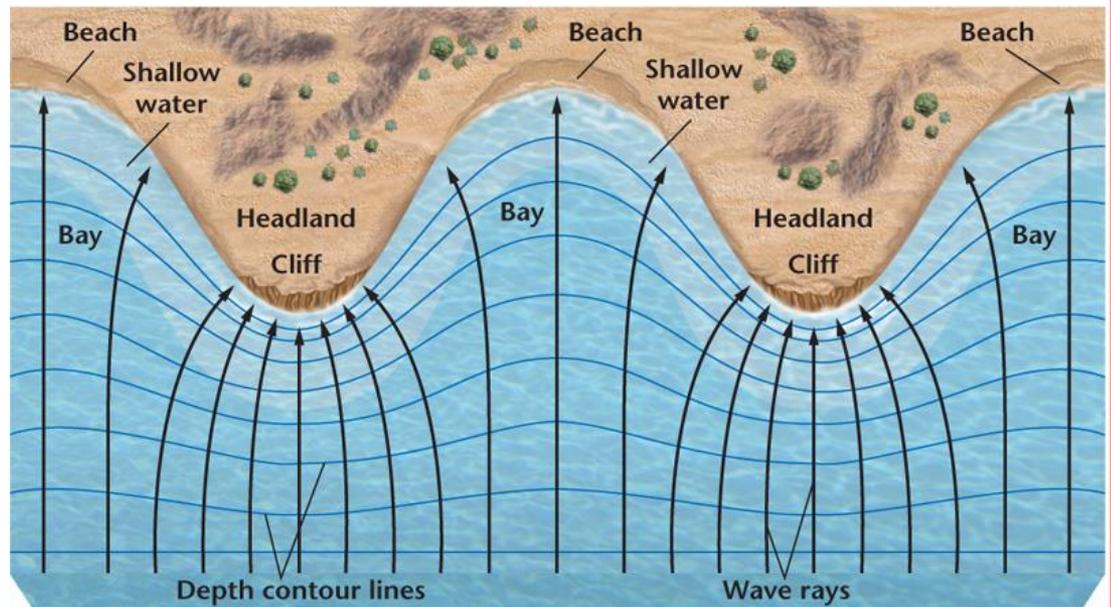
- Waves increase in height and become breakers as they approach a shoreline.
 - The energy in large breakers, together with suspended rock fragments, can erode solid rock.
 - Waves move faster in deep water than in shallow water.
-  **Wave refraction** is a process that causes initially straight wave crests to bend when part of the crest moves into shallow water due to the difference in wave speed.

Erosional Landforms



Erosional Landforms

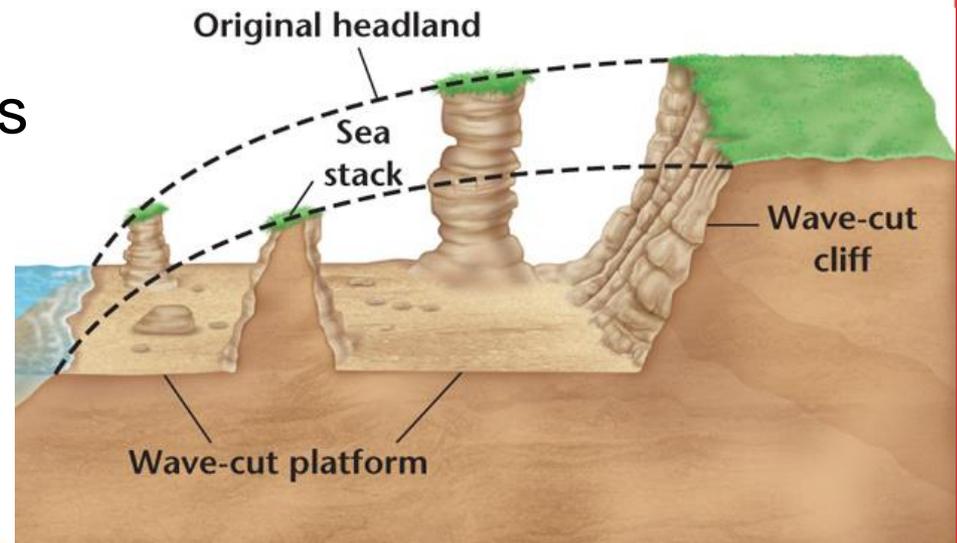
- Along an irregular coast the wave crests bend towards the headlands concentrating most of the breaker energy along the relatively short section of the shore around the tips of the headlands.
- Given enough time, irregular shorelines are straightened by wave action.



Erosional Landforms

Landforms of Rocky Headlands

- Generally, as a headland is gradually worn away, a flat erosional surface called a wave-cut platform is formed.
- The wave-cut platform terminates against a steep wave-cut cliff.
- Differential erosion, the removal of weaker rocks or rocks near sea level, produces sea stacks, sea arches, and sea caves.



Beaches

- 🔊 A **beach** is a sloping band of sand, pebbles, gravel, or mud at the edge of the sea.
- Beaches are composed of loose sediments deposited and moved about by waves along the shoreline.
- The size of sediment particles depends on the energy of the waves striking the coast and on the source of the sediment.

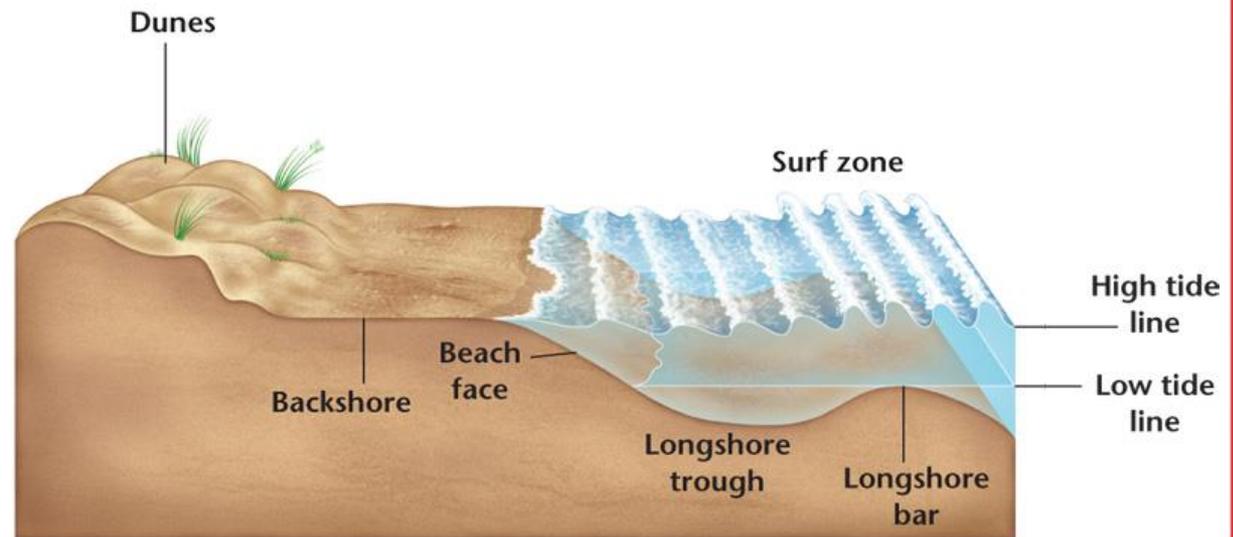
Estuaries

- ▶ An **estuary** is the area where the lower end of a freshwater river or stream enters the ocean.
- The water in estuaries is brackish—a mixture of freshwater and salt water.
- Estuaries are nurseries to the young of many different species.



Longshore Currents

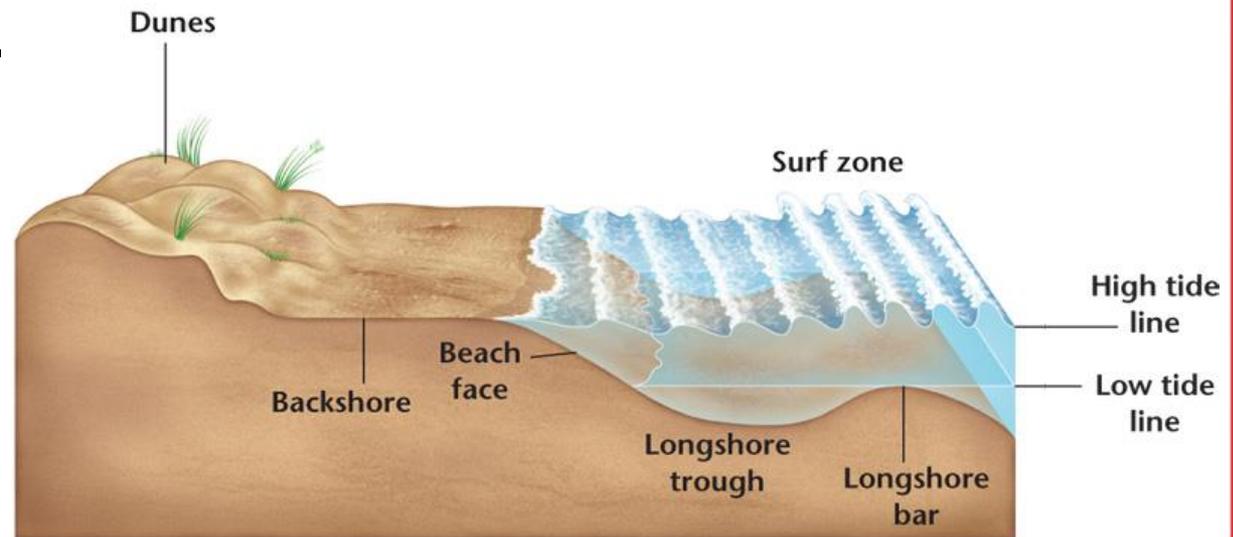
- The **longshore bar** is a sand bar that forms in front of most beaches.
- Waves break on the longshore bar in the area known as the surf zone.



Longshore Currents

- The longshore trough is the deeper water closer to shore than the longshore bar.

 The **longshore current** is a current flowing parallel to the shore that is produced as water from incoming breakers spills over the longshore bar.



Longshore Currents

Movement of Sediments

- Longshore currents move large amounts of sediments along the shore.
- Fine-grained material such as sand is suspended in the turbulent, moving water, and larger particles are pushed along the bottom by the current.
- The transport of sediment is in the direction of the longshore current, generally to the south on the Atlantic and Pacific Coasts of the United States.

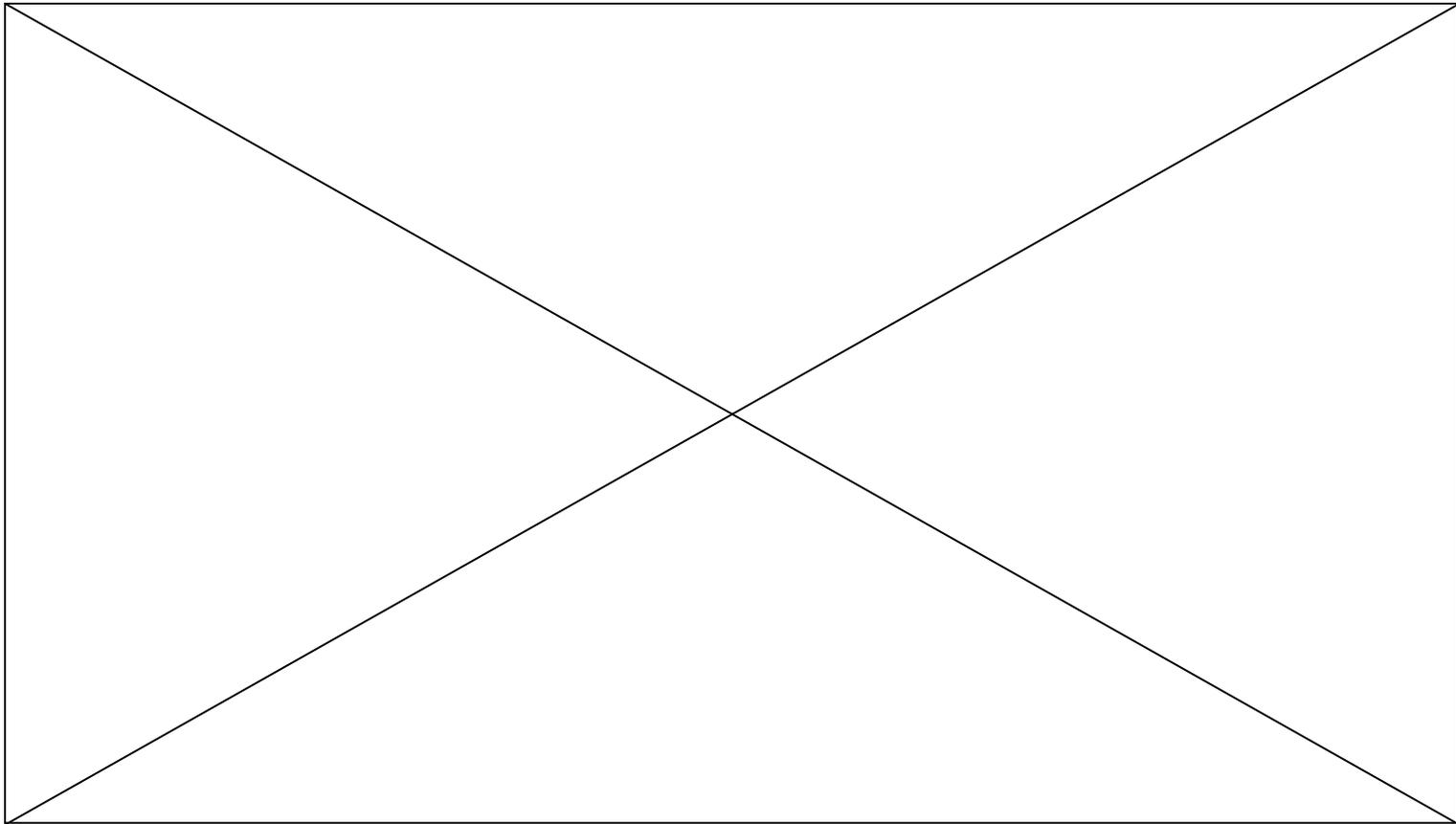
Longshore Currents

Rip Currents

- Wave action also produces rip currents, which flow out to sea through gaps in the longshore bar.
- These dangerous currents can reach speeds of several kilometers per hour.
- If you are ever caught in a rip current, you should not try to swim against it, but rather swim parallel to the shore to get out of it.

Longshore Currents

Rip Currents

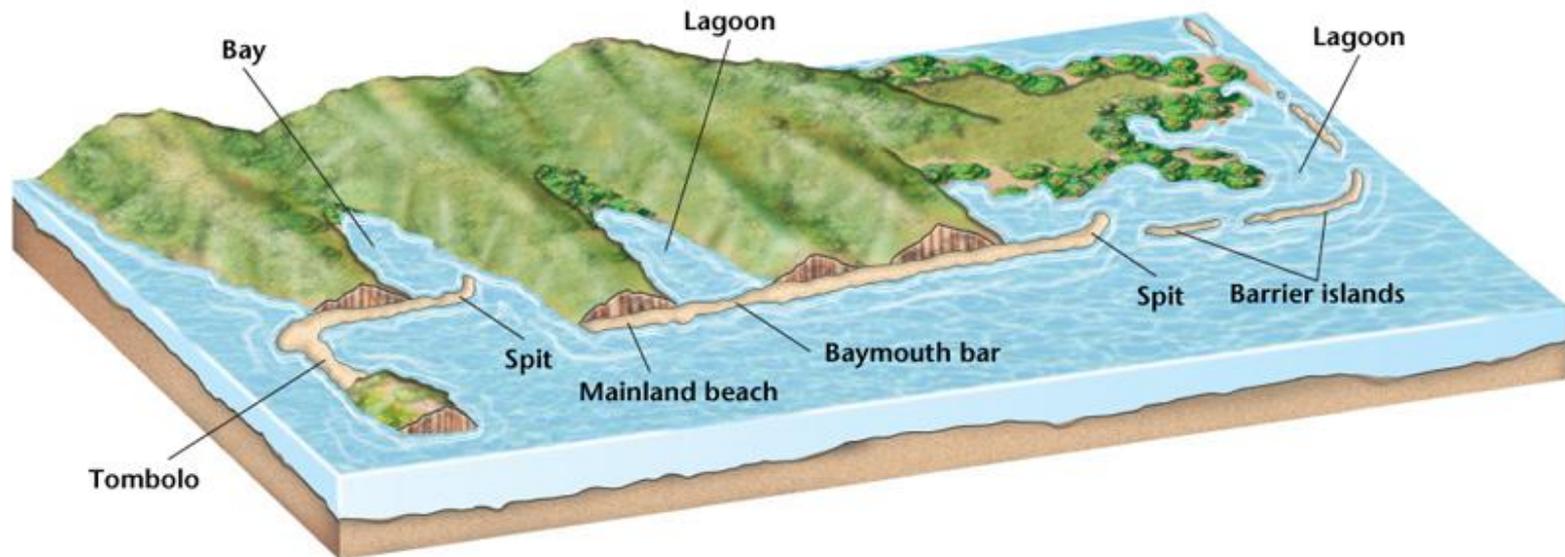


Depositional Features of Seashores

- Sediments moved and deposited by longshore currents build various characteristic coastal landforms.
 - A spit is a narrow bank of sand that projects into the water from a bend in the coastline.
 - A baymouth bar forms when a growing spit crosses a bay.
 - **Barrier islands** are long ridges of sand or other sediment, deposited or shaped by the longshore current, that are separated from the mainland.

Depositional Features of Seashores

- The shallow, protected bodies of water behind baymouth bars and barrier islands are called lagoons.
- A tombolo is a ridge of sand that forms between the mainland and an island, and connects the island to the mainland.



Depositional Features of Seashores

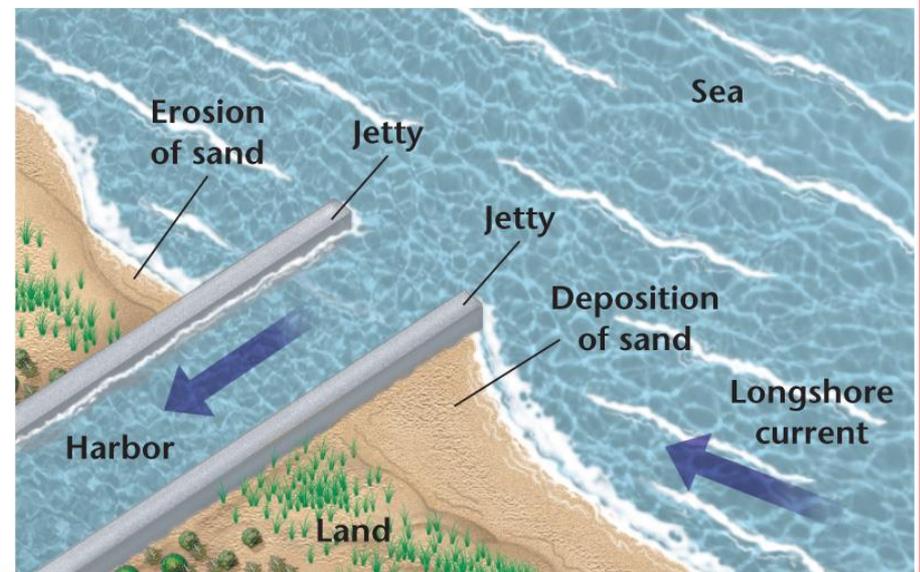
- All depositional coastal landforms, including large barrier islands, are unstable and temporary.
- Tides, currents, storm waves, and winds all play a role in building coastal features that rise well above sea level.

Protective Structures

- In many coastal areas, protective structures are built in an attempt to prevent beach erosion and destruction of oceanfront properties.
- These artificial structures interfere with natural shoreline processes and can have unexpected negative effects.

Protective Structures

- Seawalls are built to protect beachfront properties from powerful storm waves by reflecting the energy of such waves back towards the beach.
- Groins are wall-like structures built into the water perpendicular to the shoreline for the purpose of trapping beach sand.
- Jetties are walls of concrete built to protect a harbor entrance from drifting sand.



Protective Structures

- Breakwaters are built in the water parallel to straight shorelines to provide anchorages for small boats.
- The longshore current slows down behind the breakwater and is no longer able to move its load of sediment, which is then deposited behind the breakwater.
- If the accumulating sediment is left alone, it will eventually fill the anchorage.



Changes in Sea Level

- In the last 100 years, the global sea level has risen 10 to 15 cm and estimates suggest a continued rise in sea level of 1.5 to 3.9 mm/year.
- Many scientists contend that this continuing rise in sea level is the result of global warming.
- As Earth's surface temperature rises, seawater will warm and expand and water flow into the oceans from melting glaciers will increase.
- Scientists predict that global sea levels could rise another 30 cm in the next 70 years.

Changes in Sea Level

Effects of Sea Level Changes

- Although unlikely anytime soon, if Earth's remaining polar ice sheets melted completely, their meltwaters would raise sea level by 70 m.
- This rise would totally flood some countries, such as the Netherlands, along with some coastal cities in the United States, such as New York City, and low-lying states such as Florida and Louisiana.
- If Earth's temperature keeps rising, an unstable part of the Antarctic ice sheet eventually could melt and cause a rise in sea level of about 6 m.

Changes in Sea Level

Effects of Tectonic Forces

- Tectonic sinking along a coastline causes a relative rise in sea level along that coast.
- Tectonic uplift along a coastline produces a relative drop in sea level.
- Much of the United States West Coast is being pushed up much more quickly than the sea level is rising.
- Because much of the West Coast was formerly under water, it is called an emergent coast.
- Emergent coasts tend to be relatively straight because the exposed seafloor topography is much smoother than typical land surfaces.

Section Assessment

1. Match the following terms with their definitions.

B beach

D estuary

C longshore bar

A barrier island

A. a long ridge of sand or other sediment, deposited or shaped by the longshore current, that are separated from the mainland

B. a sloping band of sand, pebbles, gravel, or mud at the edge of the sea

C. a sand bar that develops parallel to the coast in many locations

D. the area where the lower end of a freshwater river or stream enters the ocean

Section Assessment

2. What is the purpose of a jetty and what are its negative effects?

Jetties are walls built to protect a harbor entrance from drifting sand. Jetties trap sand upshore from a harbor and prevent sand from reaching beaches downshore leading to excessive erosion.

Section Assessment

3. Identify whether the following statements are true or false.

true

On an uneven coast, most wave energy is directed toward headlands.

false

Waves speed up down when they encounter shallow water.

true

Chesapeake Bay is an example of an estuary.

true

Construction of a breakwater might lead to the development of a tombolo.

End of the Section

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Objectives

- **Explain** the reason for the existence of continents and ocean basins.
- **Compare** the major geologic features of continental margins and ocean basins.
- **Describe** the different types of marine sediments and their origin.

Vocabulary

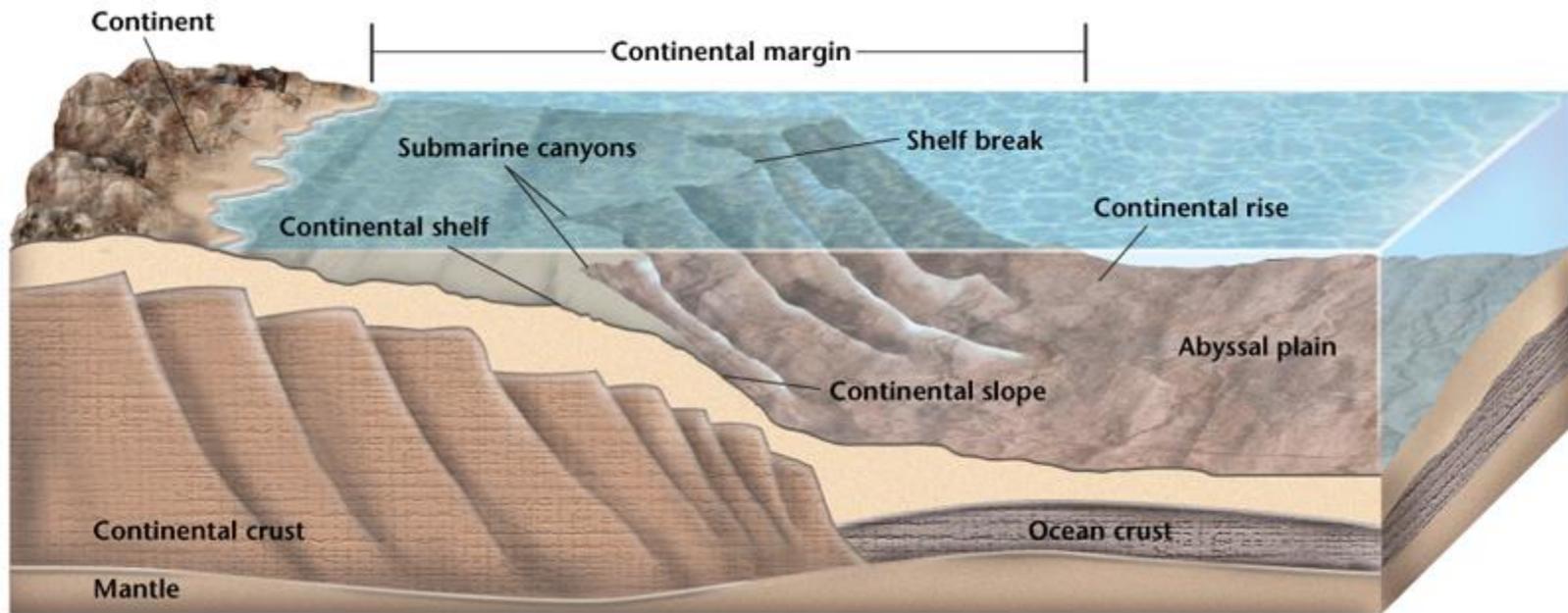
-  – continental margin
-  – continental shelf
-  – continental slope
-  – turbidity current

-  – continental rise
-  – abyssal plain
-  – deep-sea trench
-  – mid-ocean ridge
-  – seamount

Oceanic and Continental Crust

- Earth has two types of crust: thick continental crust and thin oceanic crust.
- Crustal elevation depends on crustal thickness.
- 🔊 **Continental margins** are submerged parts of continents that include the continental shelf, the continental slope, and the continental rise.

Oceanic and Continental Crust

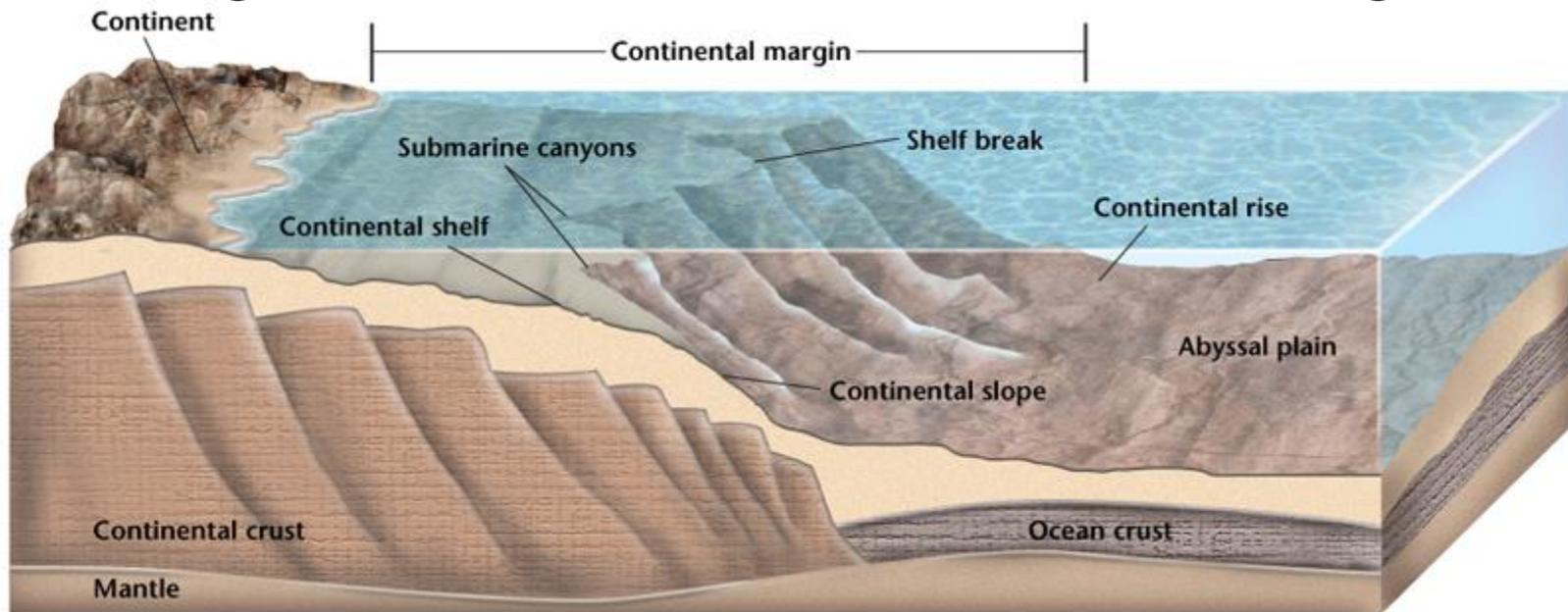


Continental Shelves

- The continental margins are the areas where the edges of continents meet the ocean.
-  The **continental shelf** is the shallowest part of a continental margin extending seaward from the shore.
- The average depth of the water above continental shelves is about 130 m, thus most of the world's continental shelves were above sea level during the last ice age.

Continental Shelves

- Continental shelves are home to large numbers of commercially valuable fishes.
- Thick sedimentary deposits on the shelves are also significant sources of oil and natural gas.



Continental Slopes

- 🔊 **Continental slopes** are where the seafloor drops away quickly to depths of several kilometers marking the edge of the continental crust.
 - In many places, this slope is marked by deep canyons that were cut by turbidity currents.
- 🔊 **Turbidity currents** are rapidly flowing water currents along the bottom of the sea that carry heavy loads of sediments, similar to mudflows on land.



Continental Slopes

- The sediments carried down the continental slope by these currents eventually come to rest at the bottom of the slope and beyond.
-  A **continental rise** is a gently sloping accumulation of deposits from turbidity currents that forms at the base of the continental slope.
- In some places, especially around the Pacific Ocean, the continental slope ends in deep-sea trenches and there is no continental rise.

Ocean Basins

- Ocean basins are deeper parts of the seafloor that lie above the thin, basaltic, oceanic crust beyond the continental margin.
- Ocean basins represent about 60 percent of Earth's surface and contain some of Earth's most interesting topography.

Ocean Basins

Abyssal Plains

- The **abyssal plains** are the smooth parts of the ocean floor 5 or 6 km below sea level.
- Abyssal plains are plains covered with hundreds of meters of fine-grained muddy sediments and sedimentary rocks that were deposited on top of basaltic volcanic rocks.

Ocean Basins

Deep-Sea Trenches

- **Deep-sea trenches** are elongated, sometimes arc-shaped depressions in the seafloor several kilometers deeper than the adjacent abyssal plains.
- Many deep-sea trenches lie next to chains of volcanic islands and most of them are located around the margins of the Pacific Ocean.

Ocean Basins

Mid-Ocean Ridges

- **Mid-ocean ridges** are chains of underwater mountains that run through all the ocean basins and have a total length of over 65 000 km.
- Mid-ocean ridges have an average height of 1500 m, but they may be thousands of kilometers wide.
- Mid-ocean ridges are sites of frequent volcanic eruptions and earthquake activity.
- The crests of these ridges often have valleys up to 2 km deep, called rifts, running through their centers.

Ocean Basins

Mid-Ocean Ridges

- Instead of forming continuous lines, the mid-ocean ridges break into a series of shorter, stepped sections called fracture zones, which run at right angles across each mid-ocean ridge.
- Fracture zones are about 60 km wide, and they curve gently across the seafloor, sometimes for thousands of kilometers.

Ocean Basins

Hydrothermal Vents

- A hydrothermal vent is a hole in the seafloor through which fluid heated by magma erupts.
- Most hydrothermal vents are located along the bottom of the rifts in mid-ocean ridges.
- A black smoker is type of hydrothermal vent that ejects superheated water containing metal oxides and sulfides that produce thick, black, smokelike plumes.
- A white smoker ejects warm water.

Seafloor Volcanoes

- Most of the mountains on the seafloor are probably extinct volcanoes.
- There are two types of extinct seafloor volcanoes: seamounts and guyots.
-  – **Seamounts** are submerged basaltic volcanoes more than 1 km high.
 - Guyots, also called tablemounts, are large, extinct, basaltic volcanoes with flat, submerged tops.
- Unlike features on land, seafloor structures persist practically forever due to a lack of erosional mechanisms.

Marine Sediments

- Most of the sediments that cover the ocean floor come from the continents.
- Much of the coarser material supplied by rivers settles out near shorelines or on beaches.
- The dominant type of sediment on the deep ocean floor is fine-grained, deep-sea mud.
- Some sandy sediments occasionally reach the abyssal plains in particularly strong turbidity currents.

Marine Sediments

Ooze

- The shells and hard parts of marine organisms are another major source of deep-sea sediments.
- Sediments containing a large percentage of particles derived from once-living organisms are called oozes.
- Most of these particles are small and consist of either calcium carbonate or silica.
- The oozes and deep-sea muds of the deep ocean typically accumulate at a rate of only a few millimeters per thousand years.

Marine Sediments

Manganese Nodules

- Manganese nodules consist of oxides of manganese, iron, copper, and other valuable metals that precipitated directly from seawater.
- Their growth rates are measured in millimeters per million years.
- Manganese nodules cover huge areas of the seafloor.

Section Assessment

1. Match the following terms with their definitions.

D continental shelf

C continental slope

B continental rise

A abyssal plain

A. the smooth parts of the ocean of the ocean floor 5 or 6 km below sea level

B. a gently sloping accumulation of deposits from turbidity currents

C. feature that generally represents the edge of the continental crust

D. the shallowest part of a continental margin extending from the shore

Section Assessment

2. How can ocean basins only occupy 60 percent of Earth's surface when oceans cover 71 percent?

Part of the oceans cover the continental margins, which are submerged parts of continents. The ocean basin begins at the bottom of the continental slope.

Section Assessment

3. Identify whether the following statements are true or false.

true

The continental shelves were probably above sea level during the last ice age.

false

Most of the sea floor is covered in a thick layer of sand.

false

Ooze is directly affiliated with oil deposits.

true

The highest peaks in mid-ocean ridges emerge from the ocean as volcanic islands.

End of the Section

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Study Guide

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Section 16.1 Main Ideas

- Wave erosion of headlands produces wave-cut platforms and cliffs, sea stacks, sea arches, and sea caves. Wave refraction concentrates breaker action on headlands.
- Beaches consist of loose sediment deposited along the shoreline. Wave action and longshore currents move sediment along the shore and build barrier islands and other depositional features. Artificial protective structures interfere with longshore transport.
- Sea levels in the past were 130 m lower than at present. When the land is rising, coasts are emergent and relatively straight.



Section 16.2 Main Ideas

- The oceans cover the thin oceanic crust and the lower parts of the thicker continental crust. The submerged part of a continent is the continental margin, the shallowest part of the ocean.
- A continental margin consists of the continental shelf, the continental slope, and the continental rise. Turbidity currents cut submarine canyons in the continental slopes and deposit their sediments in the form of continental rises.

Section 16.2 Main Ideas

- The flat part of the seafloor is the abyssal plain. Most deep-sea trenches are in the Pacific Ocean. Mid-ocean ridges extend through all ocean basins. Countless active and extinct volcanoes are on the mid-ocean ridges and deep seafloor.
- Most deep-sea sediments are fine-grained and accumulate slowly. Sediments may be derived from land or living organisms, or they may precipitate from seawater. Oozes are rich in sediment derived from organisms. Deep-sea muds are mostly derived from the land. Manganese nodules are precipitated from seawater.



Multiple Choice

1. Pamlico sound is an example of a(n) _____.

a. estuary

b. barrier island

c. longshore trough

d. spit

Numerous rivers flow into Pamlico Sound which is separated from the Atlantic Ocean by a string of *barrier islands*.



Multiple Choice

2. How much has global sea level risen over the past 100 years?

a. 0–5 cm

c. 50–75 cm

b. 10–15 cm

d. 1 m

Sea level continues to rise slowly; estimates suggest a rise in sea level of 1.5–3.9 mm per year. Scientists predict that global sea levels could rise another 30 cm in the next 70 years.



Multiple Choice

3. What is the approximate total length of mid-ocean ridges?
- a. 15 000 km
 - b. 35 000 km
 - c. 50 000 km
 - d. 65 000 km

Mid-ocean ridges run through all the ocean basins and their total length is more than Earth's circumference.

Multiple Choice

4. A rip current flows ____ the shore.
- a. parallel to
 - b. toward
 - c. away from**

Rip currents flow out to sea through gaps in the longshore bar and usually dissipate just beyond the surf zone. They are a major danger to swimmers. If you are caught in a rip current, do not try to swim against it. Swim parallel to the shore to get out of it.

Multiple Choice

5. Which is not part of the continental margin?
- a. continental shelf
 - b. continental slope
 - c. submarine canyons
 - d. abyssal plains**

The *abyssal plains* are smooth parts of the ocean floor 5 or 6 km below sea level. These plains extend from the continental margins and are probably the flattest surfaces on Earth.

Short Answer

6. What is an emergent coast?

An emergent coast is a coastal area that was previously underwater. Emergent coasts can be the result of either dropping sea levels or tectonic uplift that raises the coastal area.

Short Answer

7. Why are numerous extinct volcanoes scattered across the ocean floor but not on land?

Extinct volcanoes on land erode within a few million years. On the deep seafloor, the currents are generally too weak to erode solid rock and no other mechanism of erosion exists. Once they are formed, seafloor structures persist practically forever.

True or False

8. Identify whether the following statements are true or false.

true Large barrier islands are temporary and unstable.

false Groins are effective for stabilizing beach erosion.

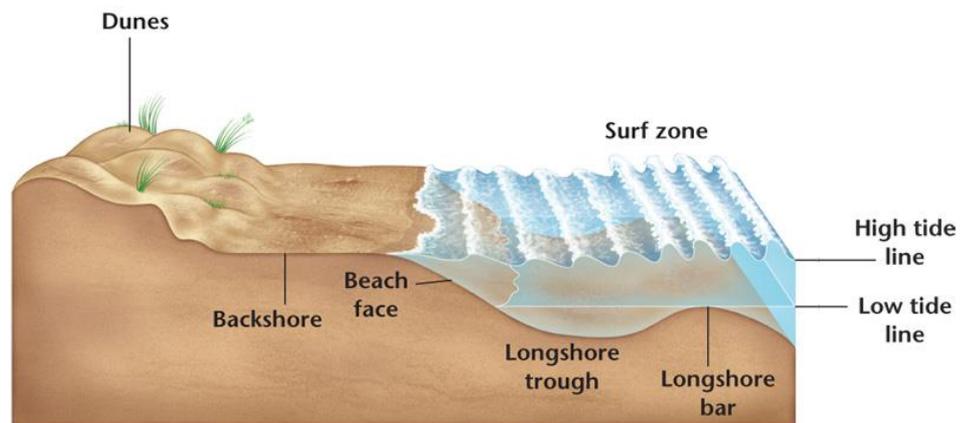
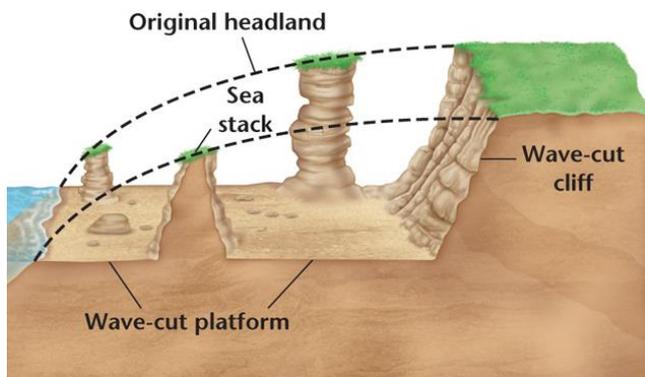
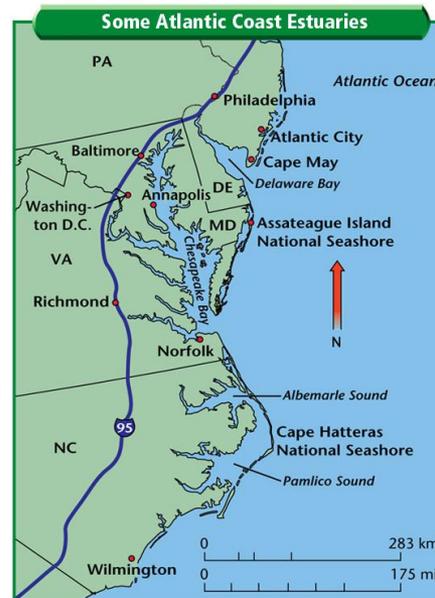
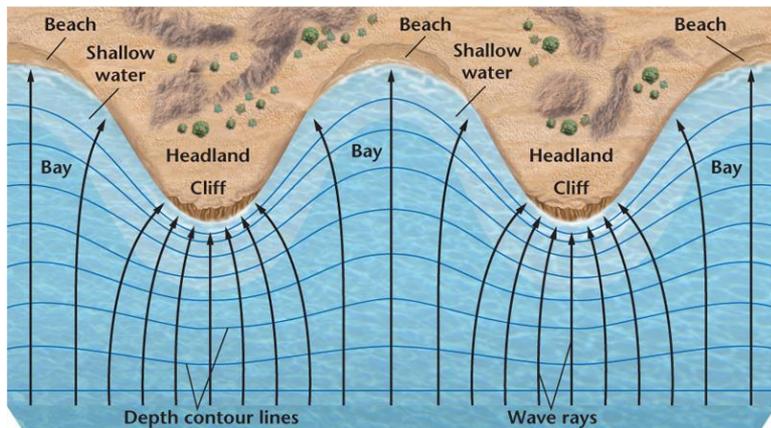
true A kilogram of warm sea water has more volume than a kilogram of cold sea water.

false Manganese nodules grow at the rate of several millimeters per year.

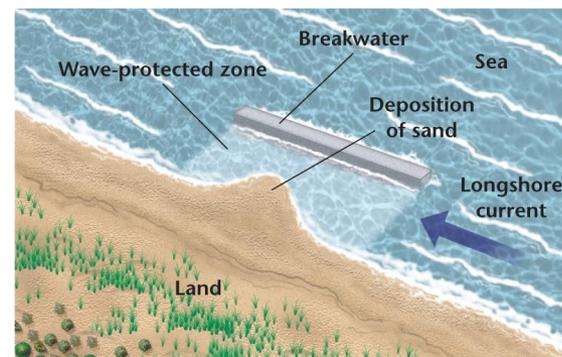
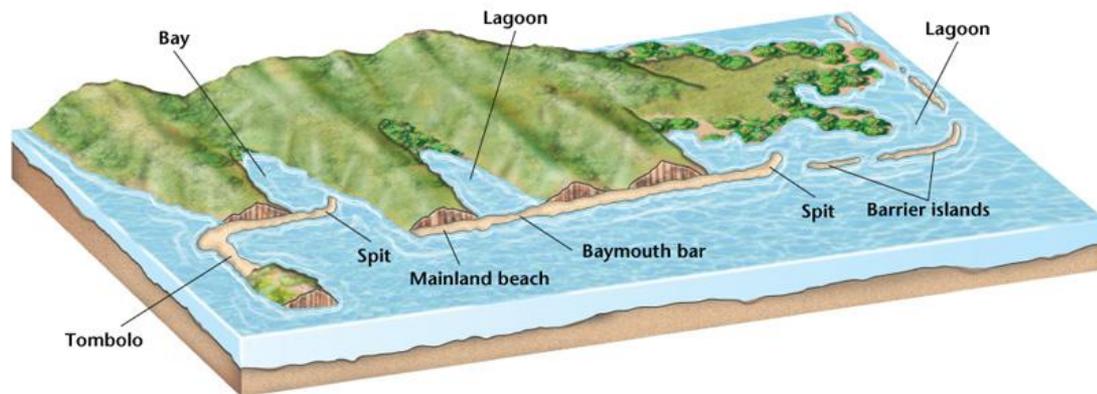
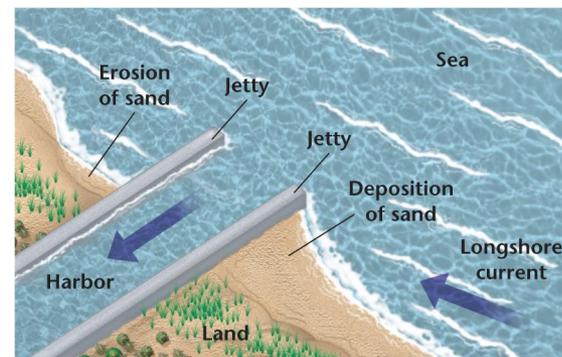
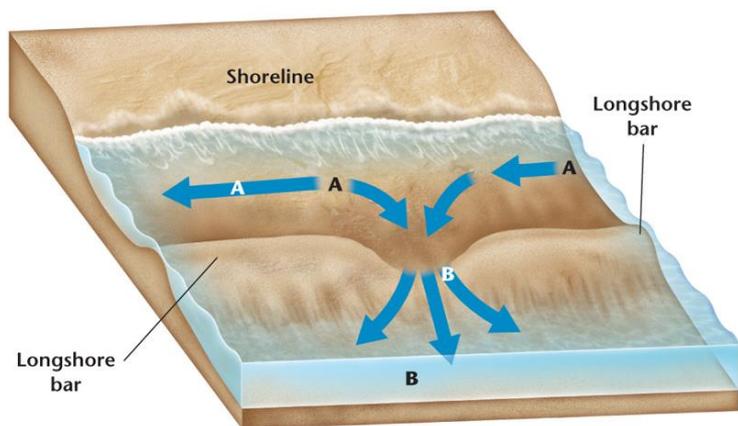
true The longshore current runs parallel to the beach.



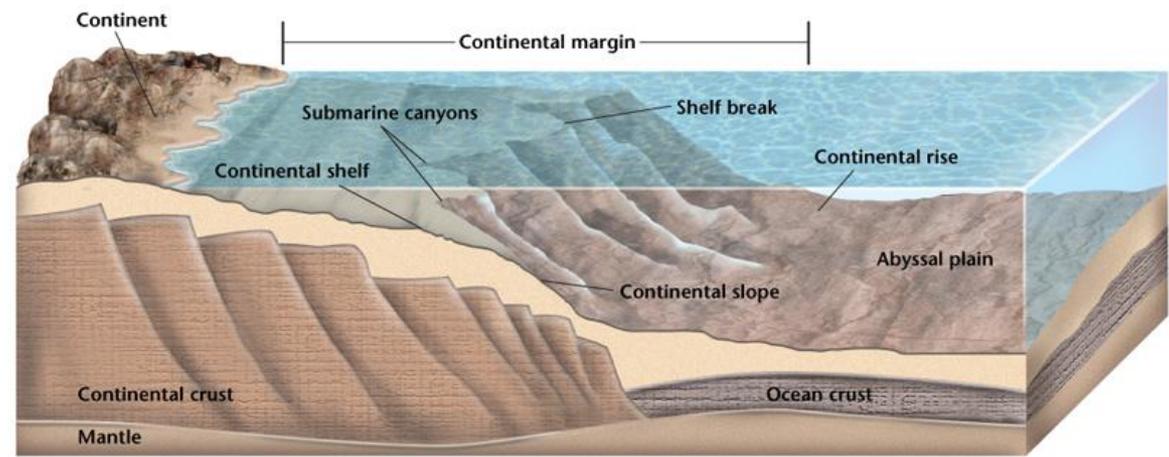
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