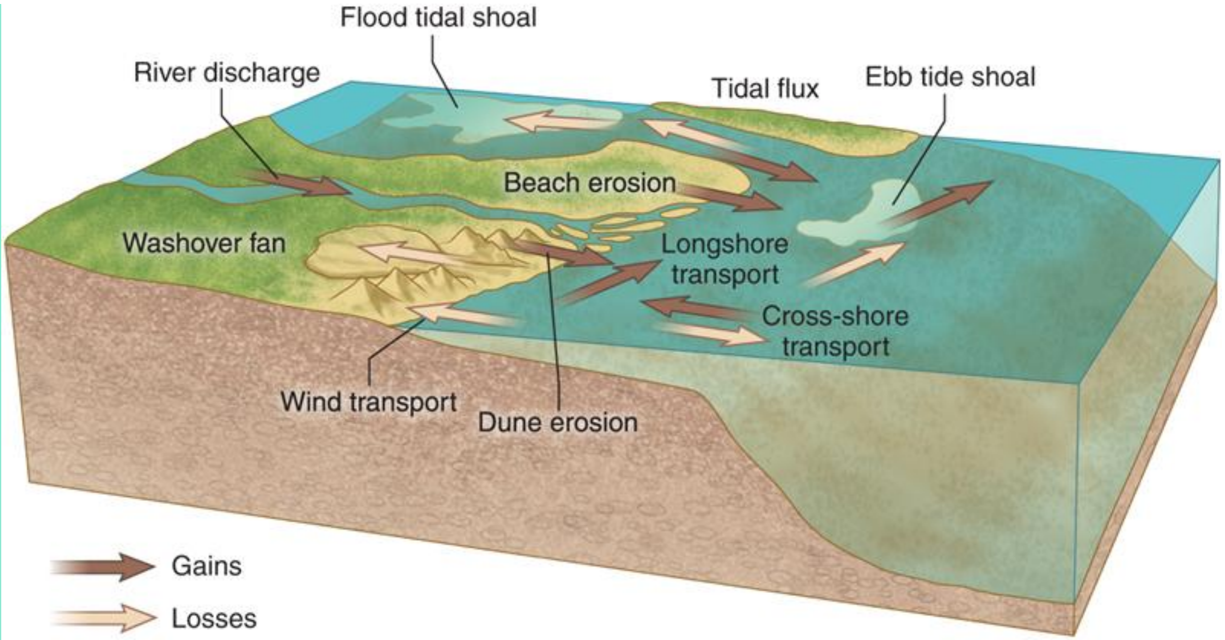
Coastal Processes and Landforms

Tides & Beaches

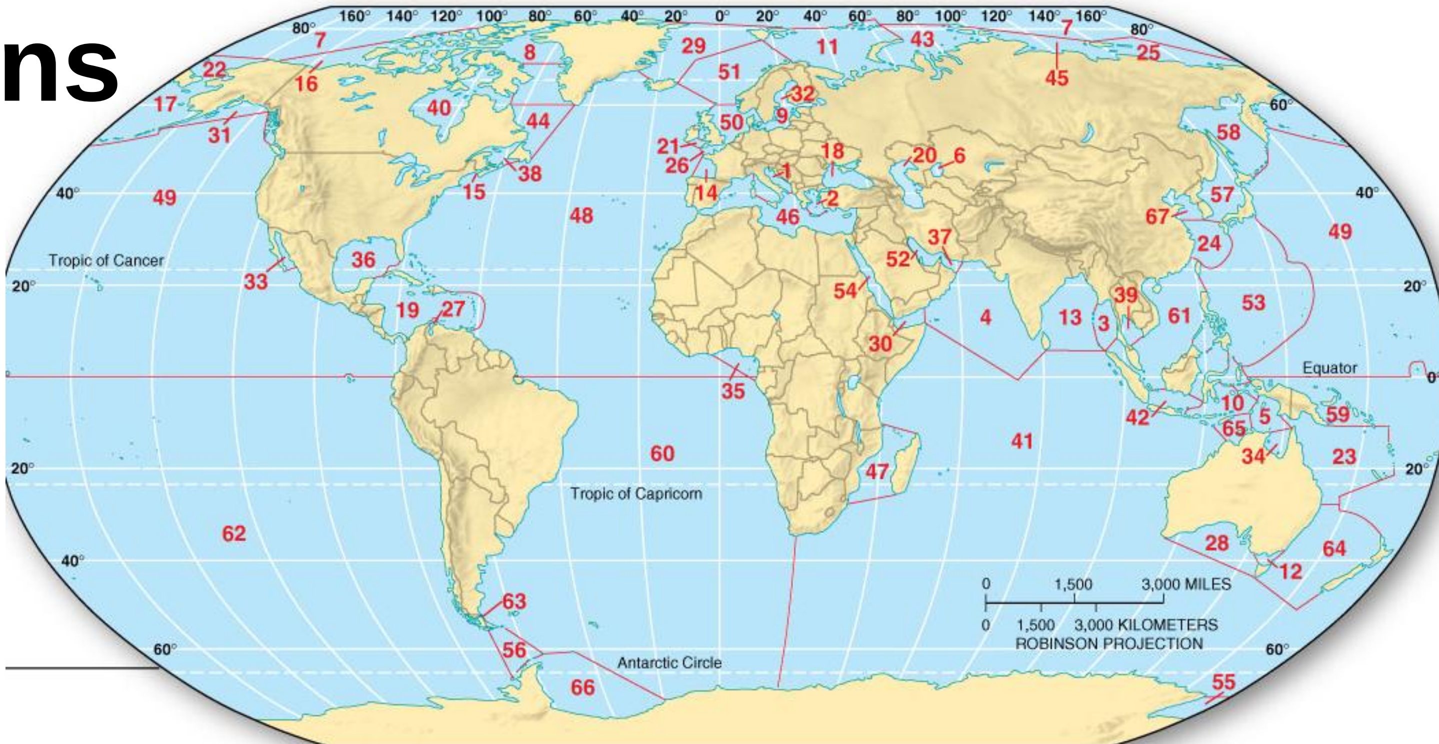
Nearshore Sediment Transport –

What influences the loss of sediment on Beaches?

- Waves
- Winds
- Tidal Currents
- River discharge
- Runoff



Oceans

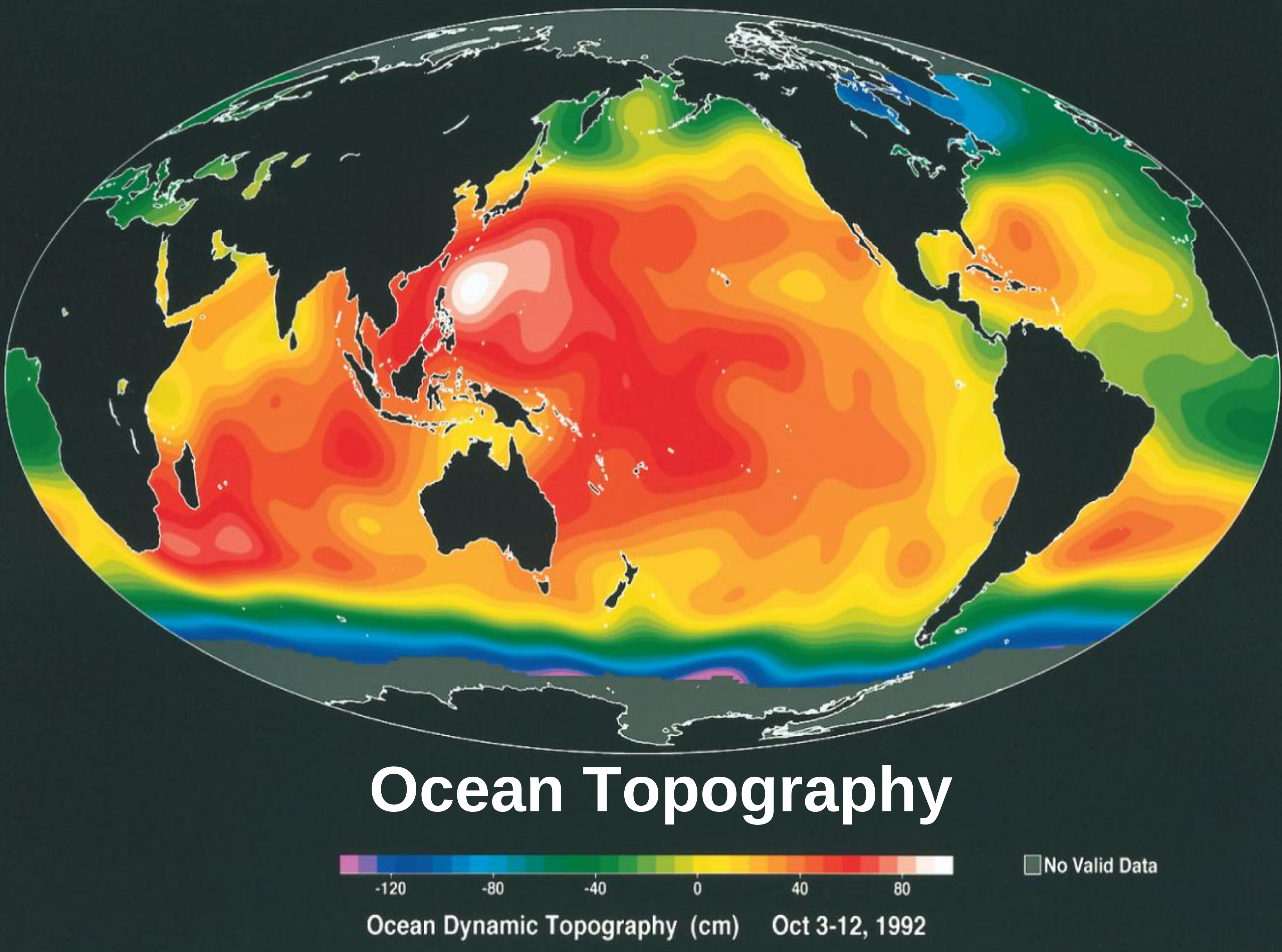


1 Adriatic Sea
2 Aegean Sea
3 Andaman Sea
4 Arabian Sea
5 Arafura Sea
6 Aral Sea
7 Arctic Ocean
8 Baffin Bay
9 Baltic Sea
10 Banda Sea
11 Barents Sea
12 Bass Strait
13 Bay of Bengal
14 Bay of Biscay
15 Bay of Fundy
16 Beaufort Sea
17 Bering Sea
18 Black Sea
19 Caribbean Sea
20 Caspian Sea
21 Celtic Sea
22 Chukchi Sea
23 Coral Sea
24 East China Sea
25 East Siberian Sea
26 English Channel
27 Golfo de Venezuela
28 Great Australian Bight
29 Greenland Sea
30 Gulf of Aden
31 Gulf of Alaska
32 Gulf of Bothnia
33 Gulf of California
34 Gulf of Carpentaria
35 Gulf of Guinea
36 Gulf of Mexico
37 Gulf of Oman
38 Gulf of St. Lawrence
39 Gulf of Thailand
40 Hudson Bay
41 Indian Ocean
42 Java Sea
43 Kara Sea
44 Labrador Sea
45 Laptev Sea
46 Mediterranean Sea
47 Mozambique Channel
48 North Atlantic Ocean
49 North Pacific Ocean
50 North Sea
51 Norwegian Sea
52 Persian Gulf
53 Philippine Sea
54 Red Sea
55 Ross Sea
56 Scotia Sea
57 Sea of Japan
58 Sea of Okhotsk
59 Solomon Sea
60 South Atlantic Ocean
61 South China Sea
62 South Pacific Ocean
63 Strait of Magellan
64 Tasman Sea
65 Timor Sea
66 Weddell Sea
67 Yellow Sea

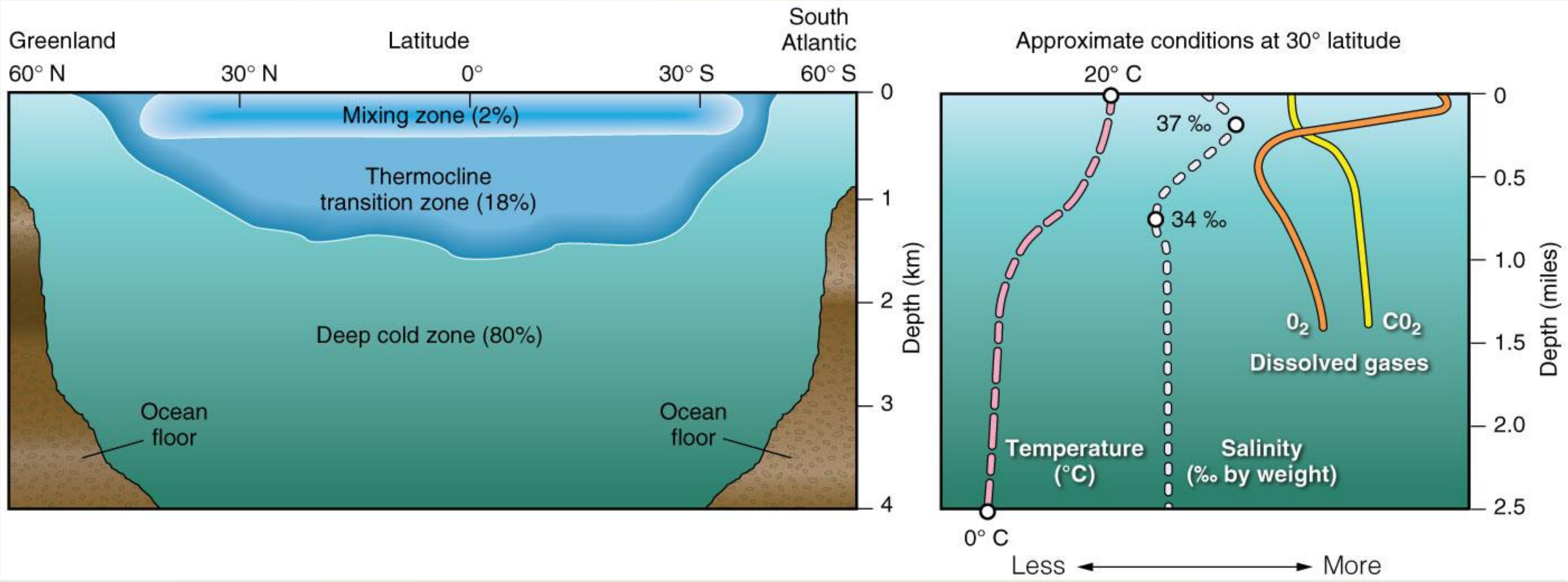
Ocean	Earth's Ocean Area (%)	*Area [km^2 (mi^2)]	*Volume [km^3 (mi^3)]	Mean Depth of Main Basin [m (ft)]
Pacific	48	179,670 (69,370)	724,330 (173,700)	4280 (14,040)
Atlantic	28	106,450 (41,100)	355,280 (85,200)	3930 (12,890)
Indian	20	74,930 (28,930)	292,310 (70,100)	3960 (12,900)
Arctic	4	14,090 (5440)	17,100 (4100)	1205 (3950)

*Data in thousands (000): includes all marginal seas

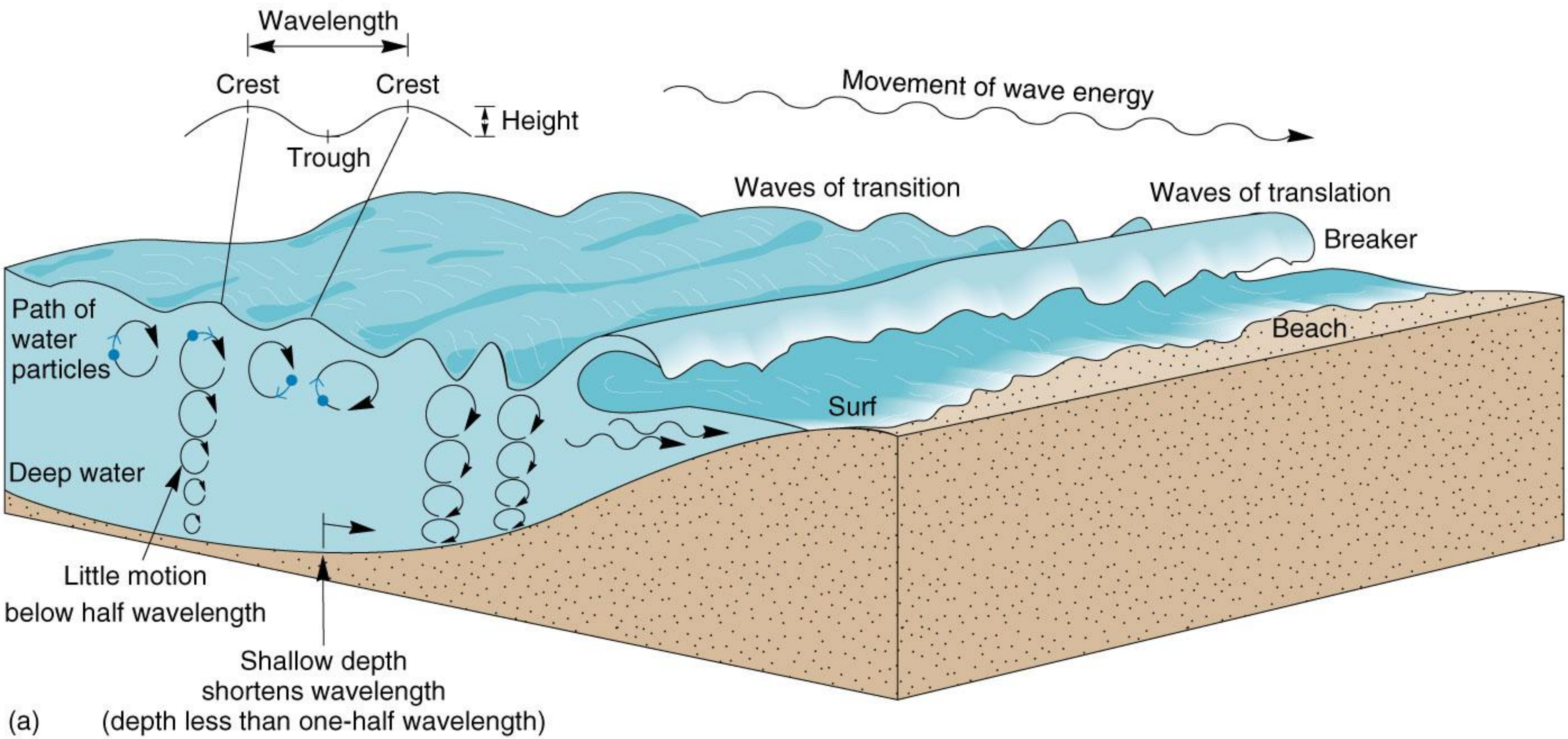
Ocean Topography

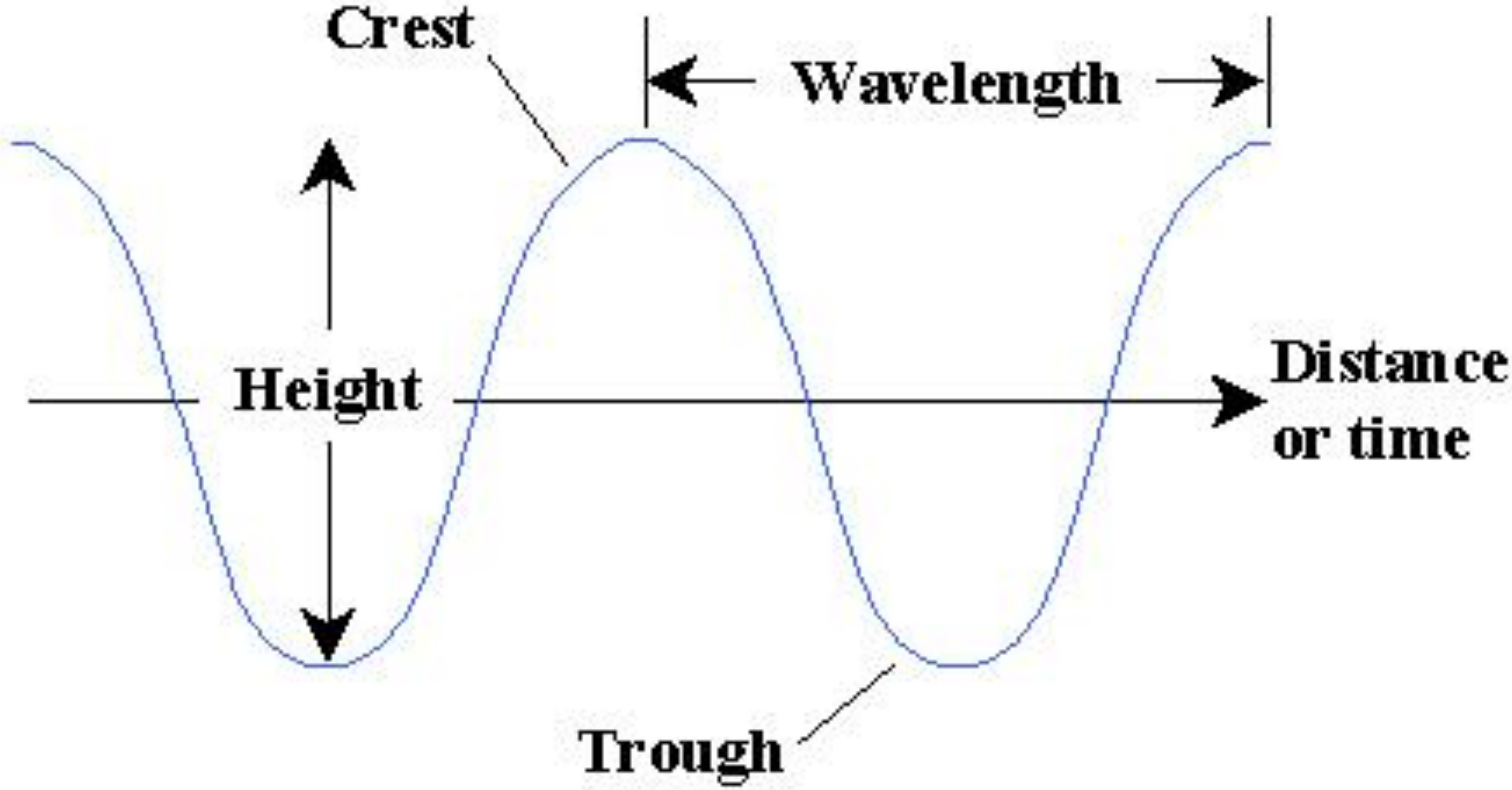


Physical Structure of the Ocean



Wave Formation




Crest
Wavelength
Height
Distance
or time
Trough

Transport of Sediments by Wave Action

Rock particles are eroded from one area and deposited elsewhere. Wave refraction affects this process.

Beach Drift:

Swash and **backwash** rarely occur in exactly opposite directions

Upward movement occurs at some oblique angle
Backward movement occurs at right angles to the beach.

This creates **lateral movement** of particles (beach drift)

Wave Refraction

Straight shoreline

- drag exerted by the ocean floor causes waves to break parallel with the shoreline.

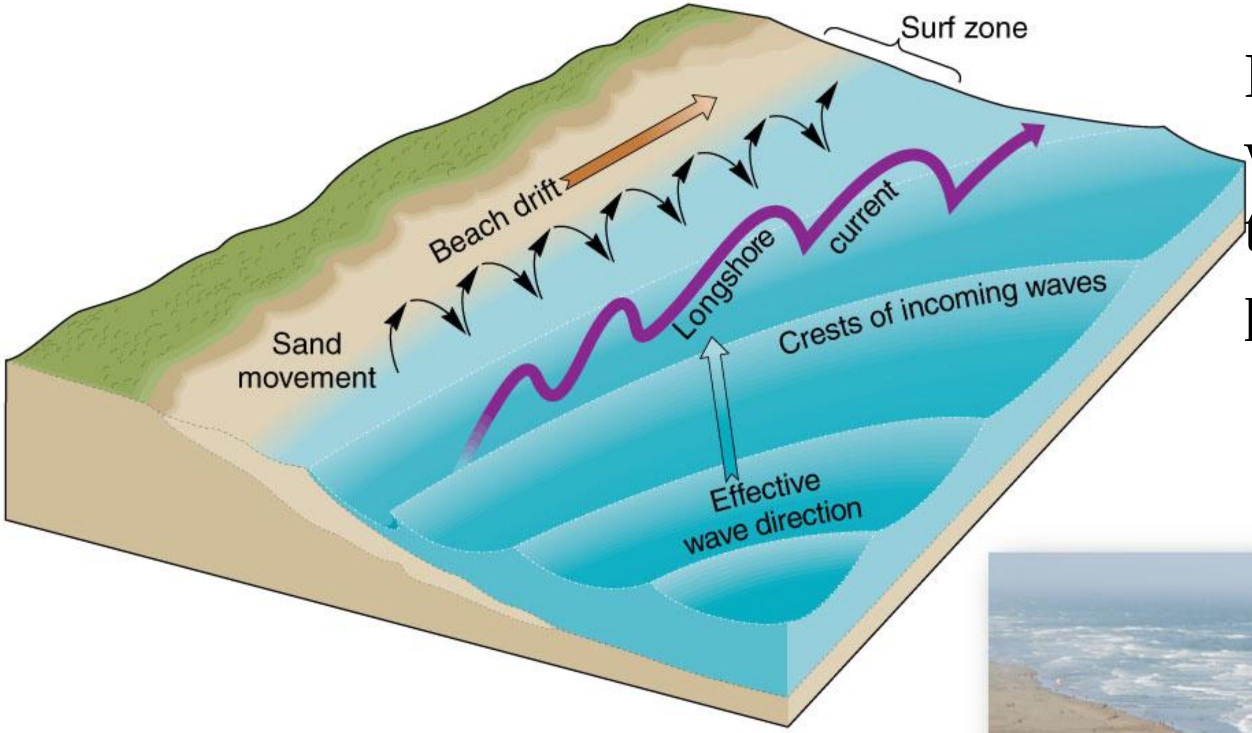
The direction of travel of a wave varies as it approaches an **indented coast**.

Crests approaching the headlands experience the drag of the ocean floor first, which causes:

1. **Increase in wave height**
2. **Decrease in wavelength**
3. **Decrease in velocity**

Longshore Current and Beach Drift

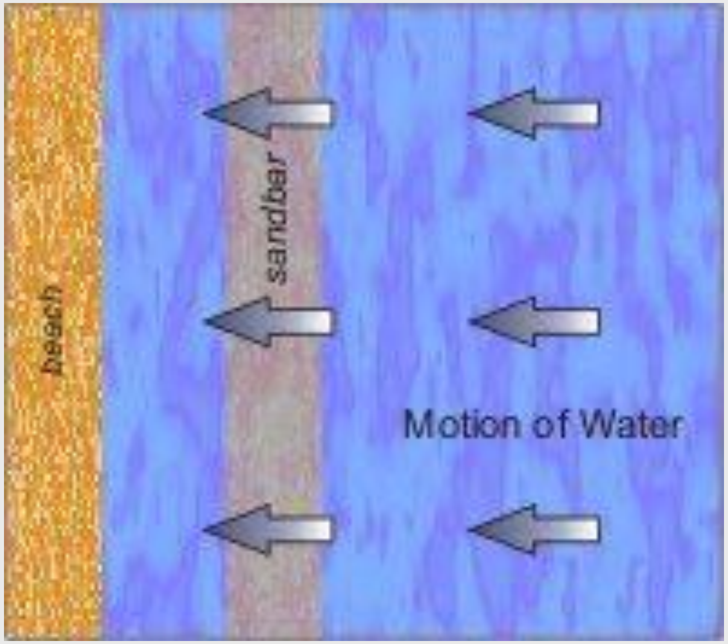
Longshore Current is a water current that moves the sand in a zigzag pattern along the beach.

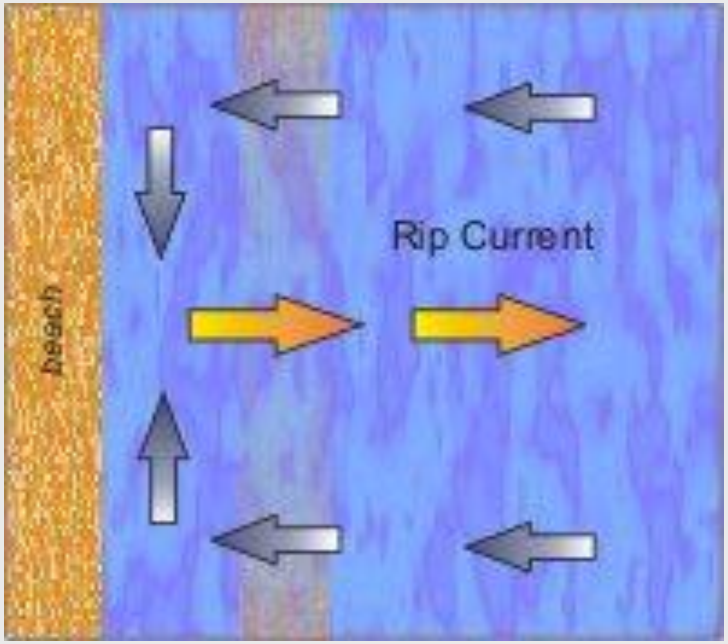


(a)


(b)

Rip Currents

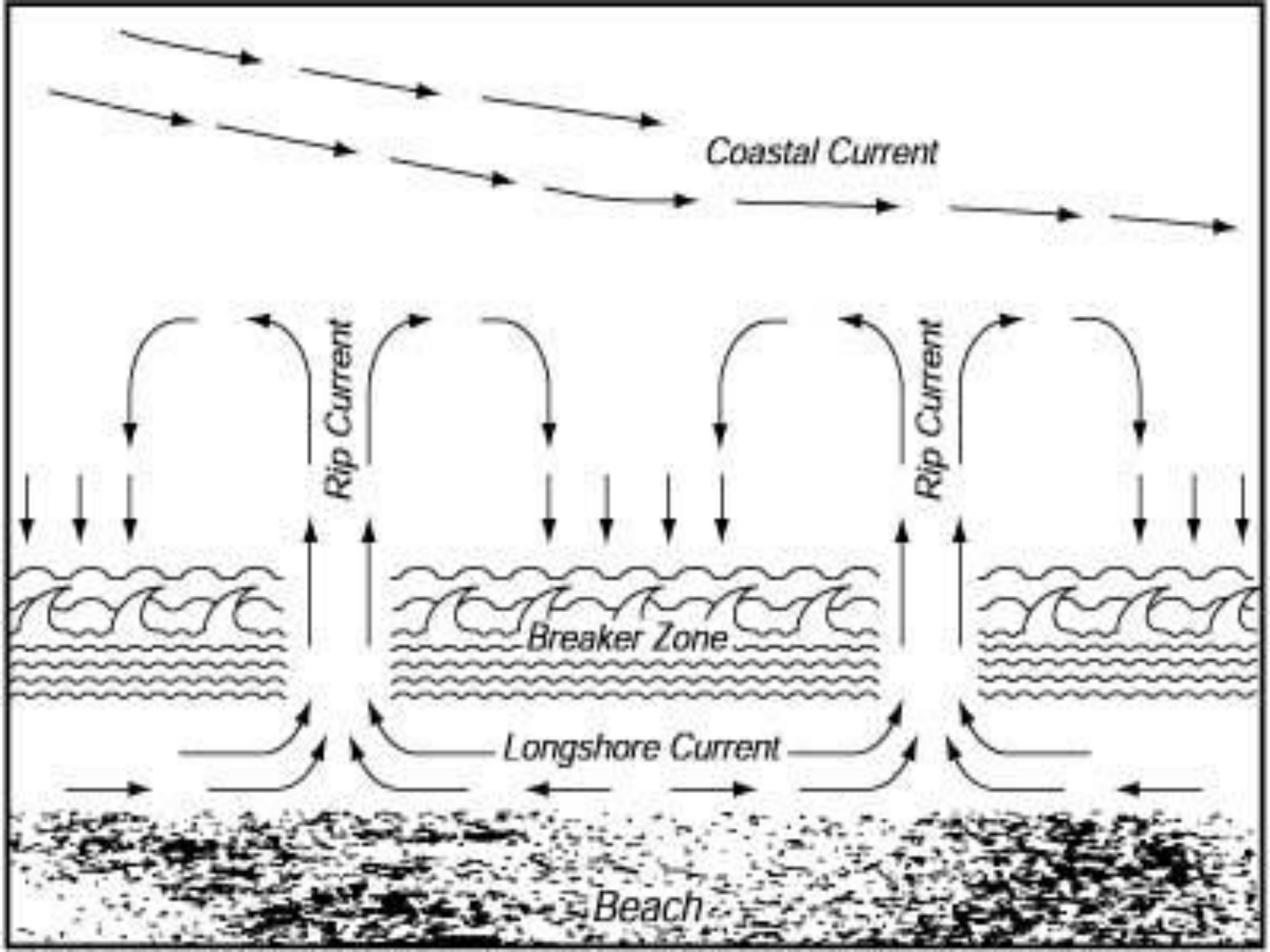




Rip currents form when waves are pushed over **sandbars**.

The weight of excess water near the shore can **'rip' an opening in the sandbar**, causing **water to rush seaward.**

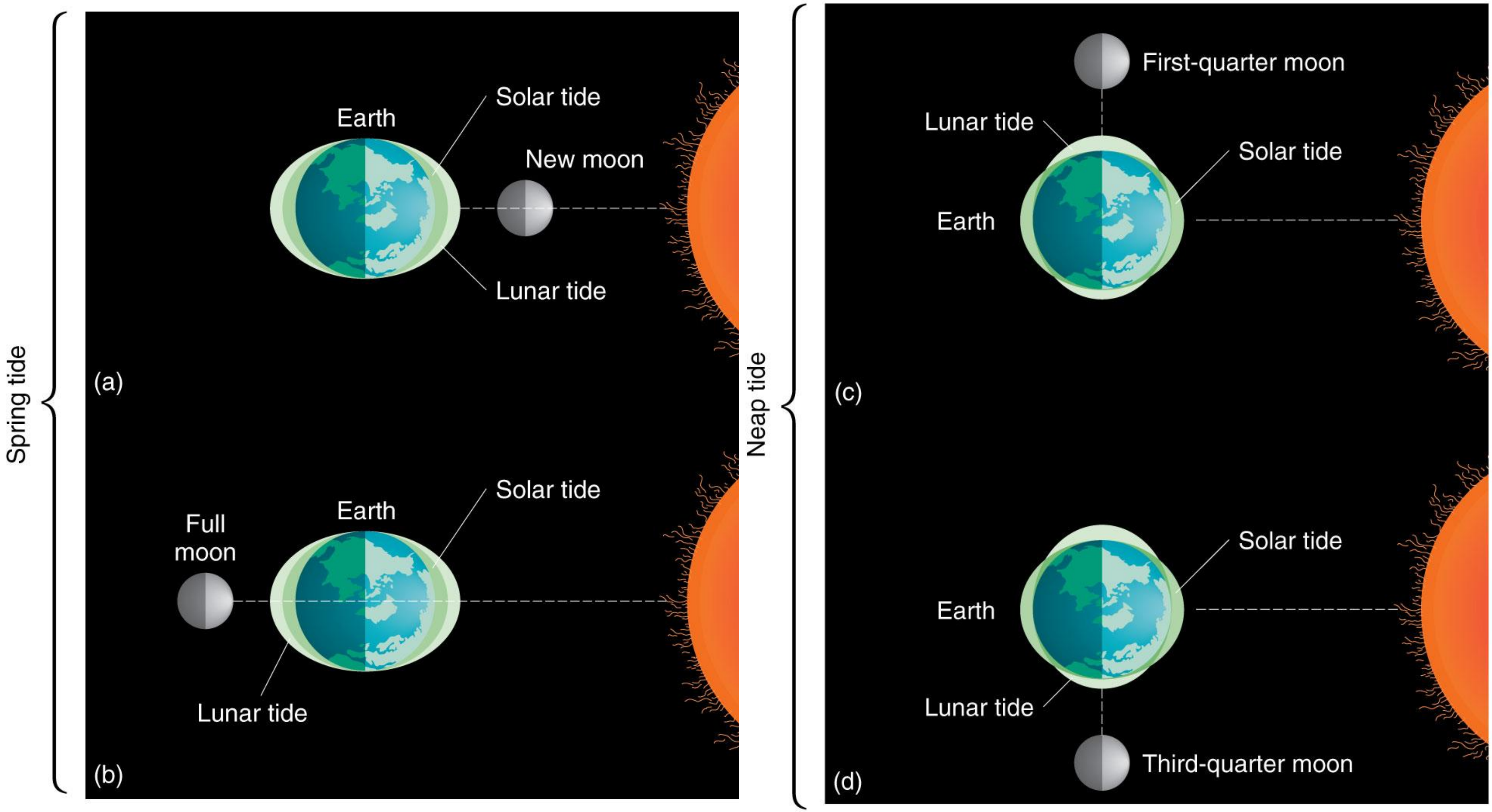
Source: NOAA



Coastal Current
Rip Current
Rip Current
Breaker Zone
Longshore Current
Beach

Rip Current

Tidal forces



Tides enhanced during full Moon and new Moon

Sun-Moon-Earth closely aligned

Annapolis Tidal Power Generating Station

Hopewell Rocks, New Brunswick

Coastal Processes and Landforms

Erosional and depositional landforms of coastal areas are the result of the action of **ocean waves**.

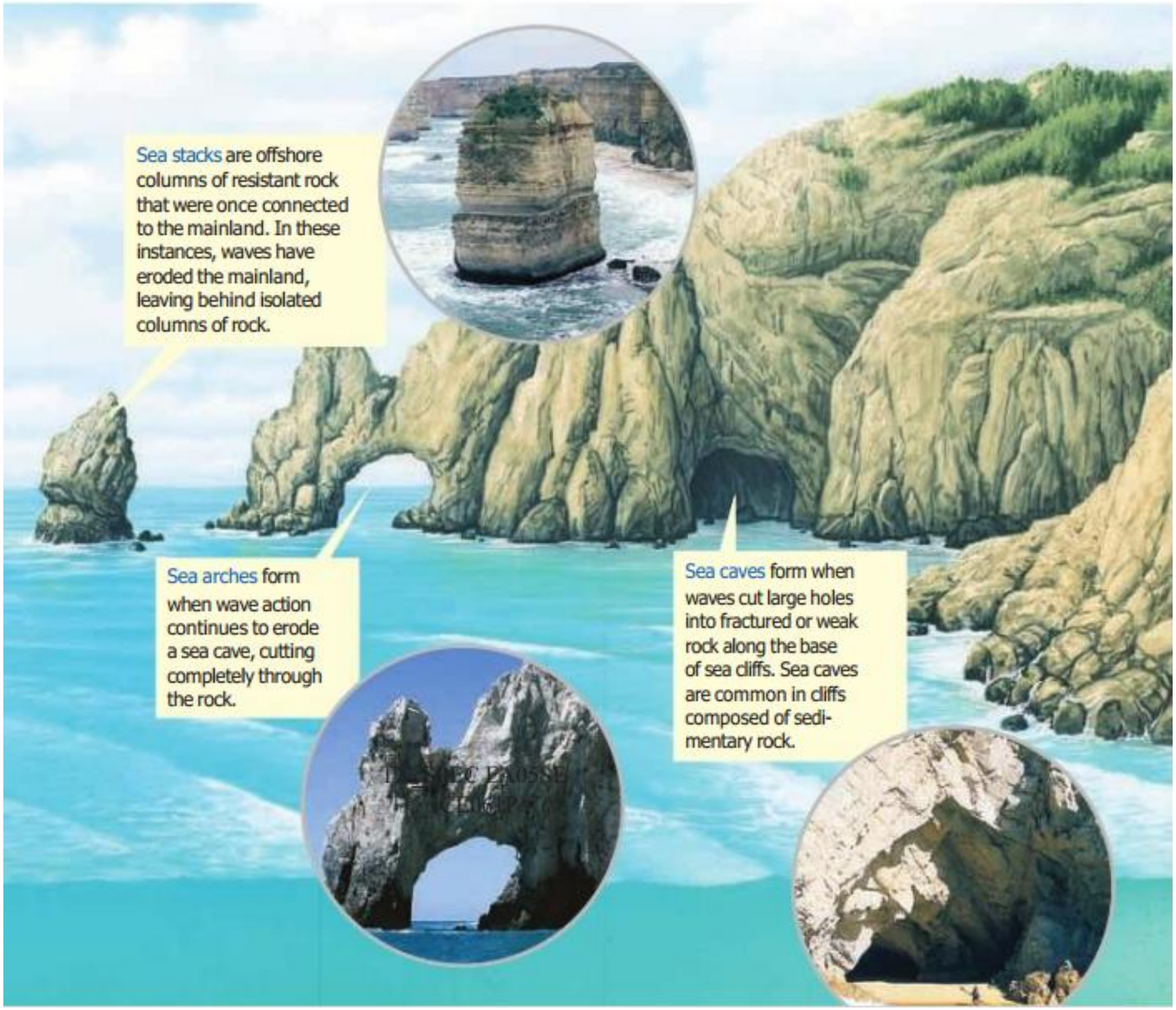
Erosional Landforms

Sea Cliffs
Wave-cut Notches
Caves
Sea stacks
Sea arches

Depositional landforms

Beaches
Barrier Spit
Baymouth Bar
Lagoon
Tombolo

Figure 4 Coastal Landforms Created by Wave Erosion



Erosional Coastal Landforms

Along rugged, high-relief, tectonically-active coastlines

Sea cliffs
A tall, steep rock face, formed by the undercutting action of the sea

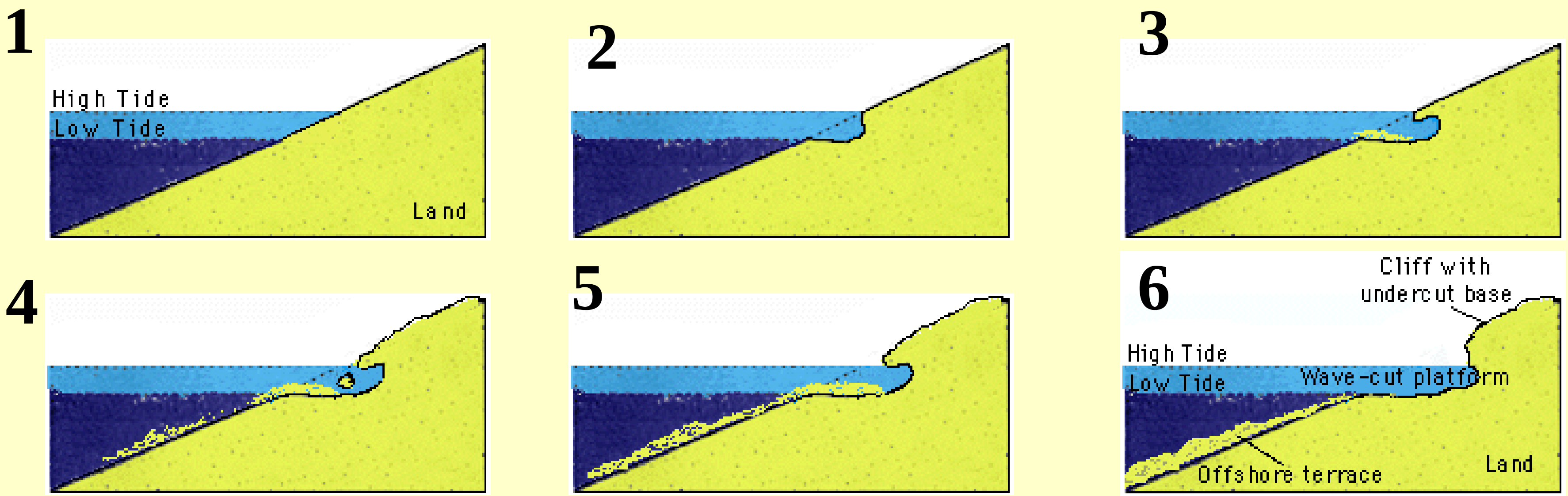
Wave-cut notches
A rock recess at the foot of a sea cliff where the energy of waves is concentrated

Sea Caves
Caves form in more erosive sediment when the rock does not fully collapse in a deeply-notched environment

Wave-cut platform

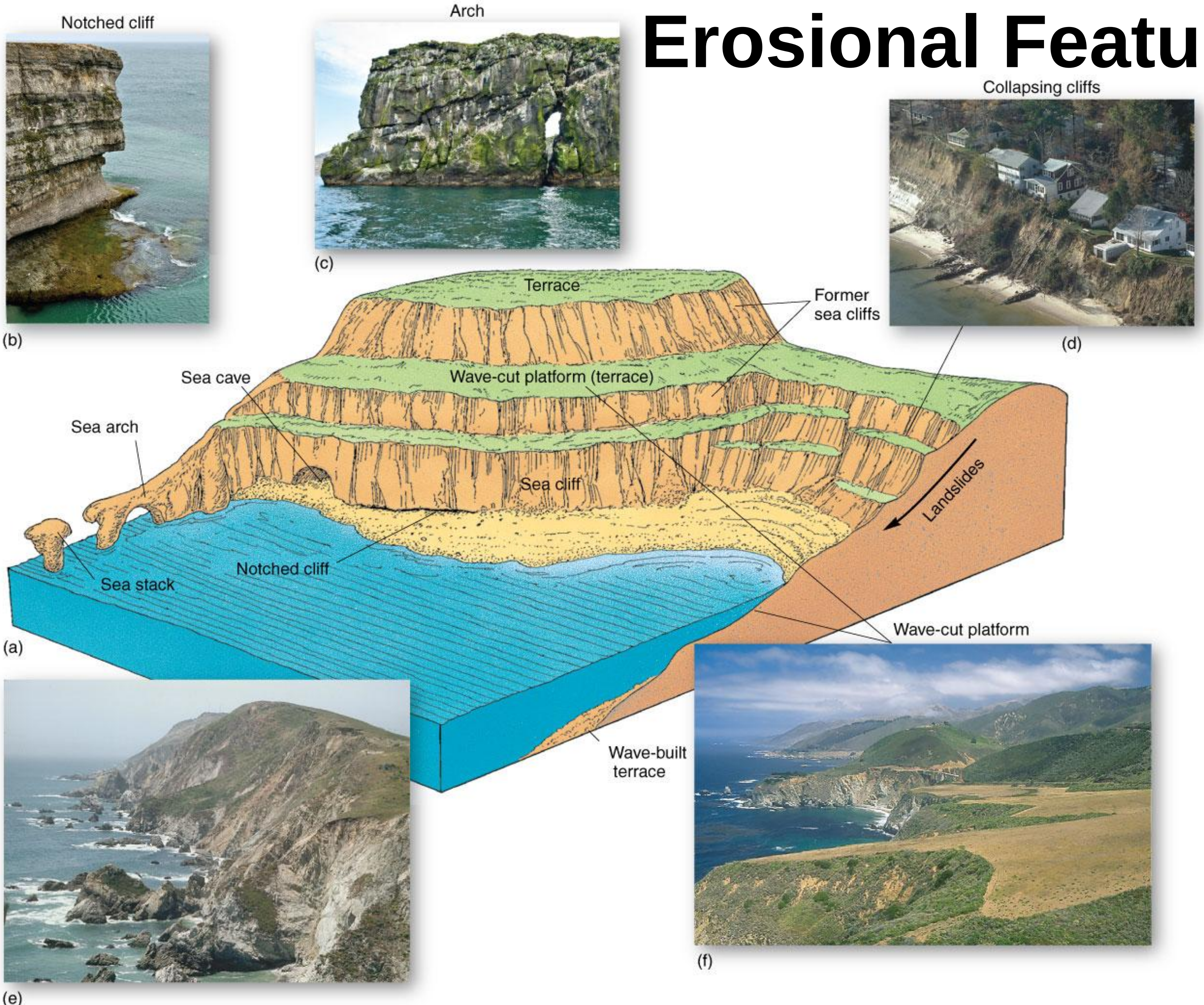
Horizontal benches in the tidal zone extending from the sea cliff out into the sea

If the sea level relative to the land changes over time (becoming lower with respect to the land due to uplift), multiple wave cut platforms (terraces) result

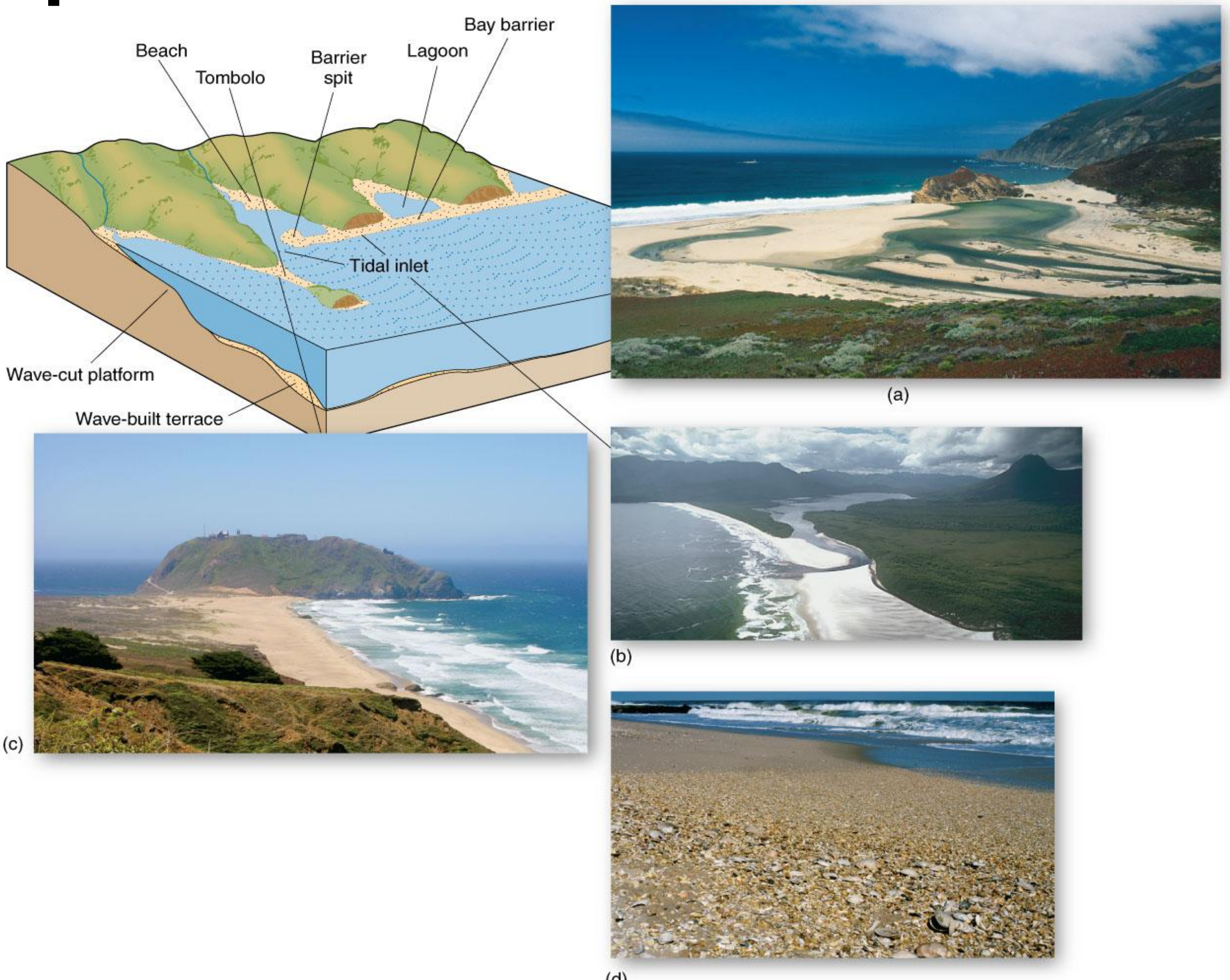


http://www.rgs.edu.sg/events/geotrip/cliff.html

Erosional Features

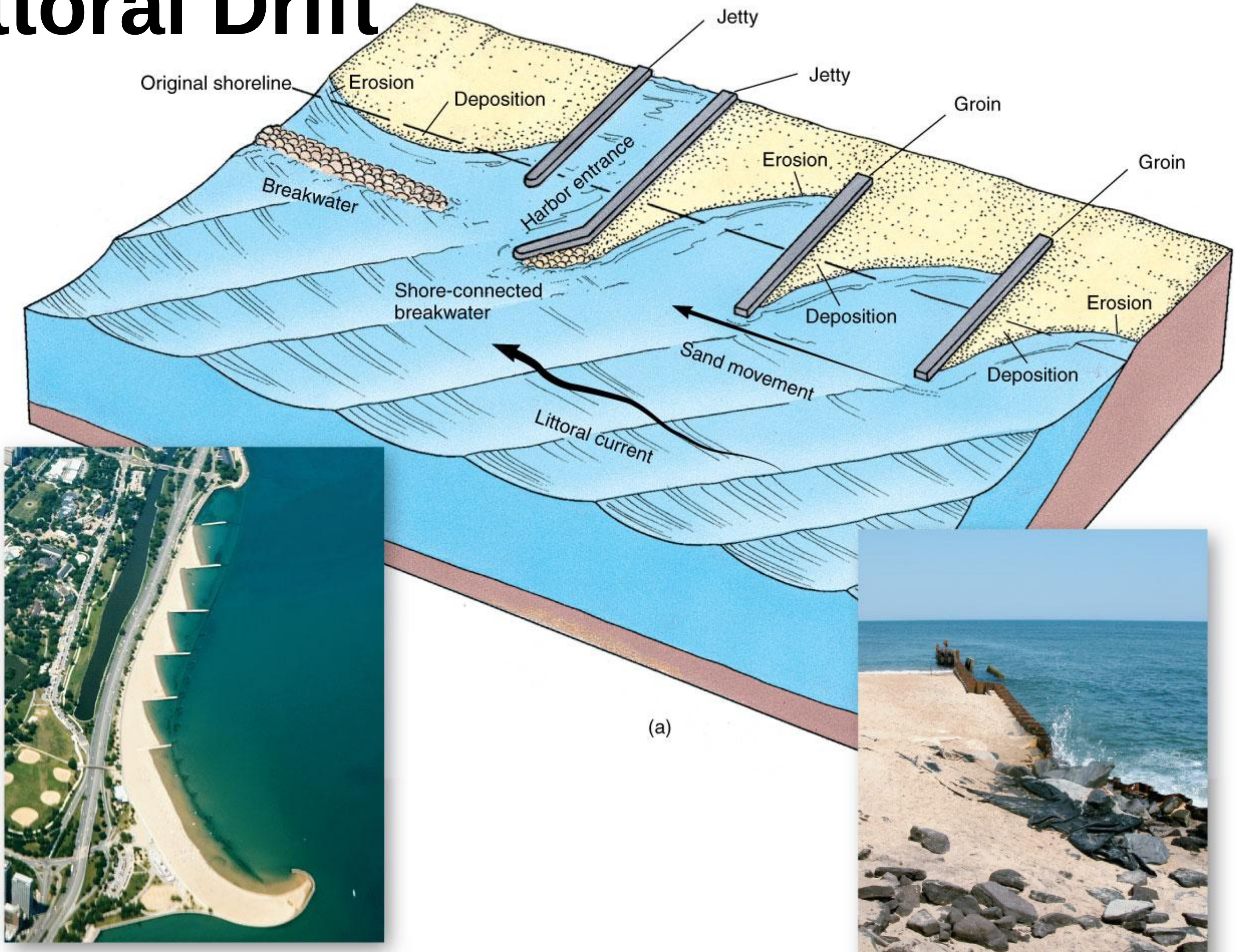


Depositional Coastal Features



Coastal Erosion:
https://www.youtube.com/watch?v=zUh3WeilFN4

Littoral Drift



(a)

Barrier Spit

A **Barrier Spit** is an exposed sandbar that is connected to the shoreline.

A **lagoon** is a body of water
behind the barrier

Figure 7 *A barrier spit, such as Cape Cod, Massachusetts, occurs when an exposed sandbar is connected to the shoreline.*

Bay Barrier

Near Eureka, CA

Coastal Straightening

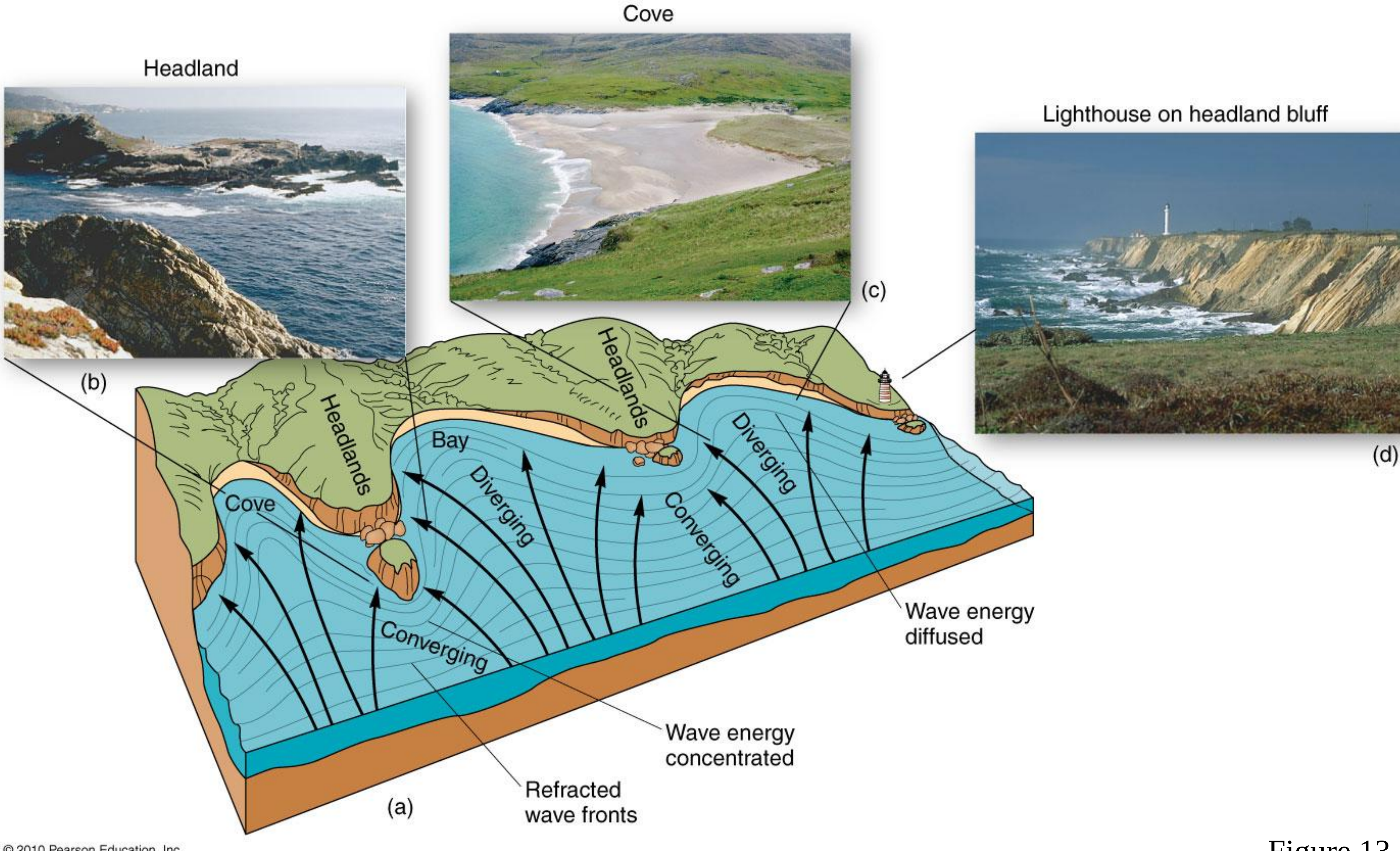
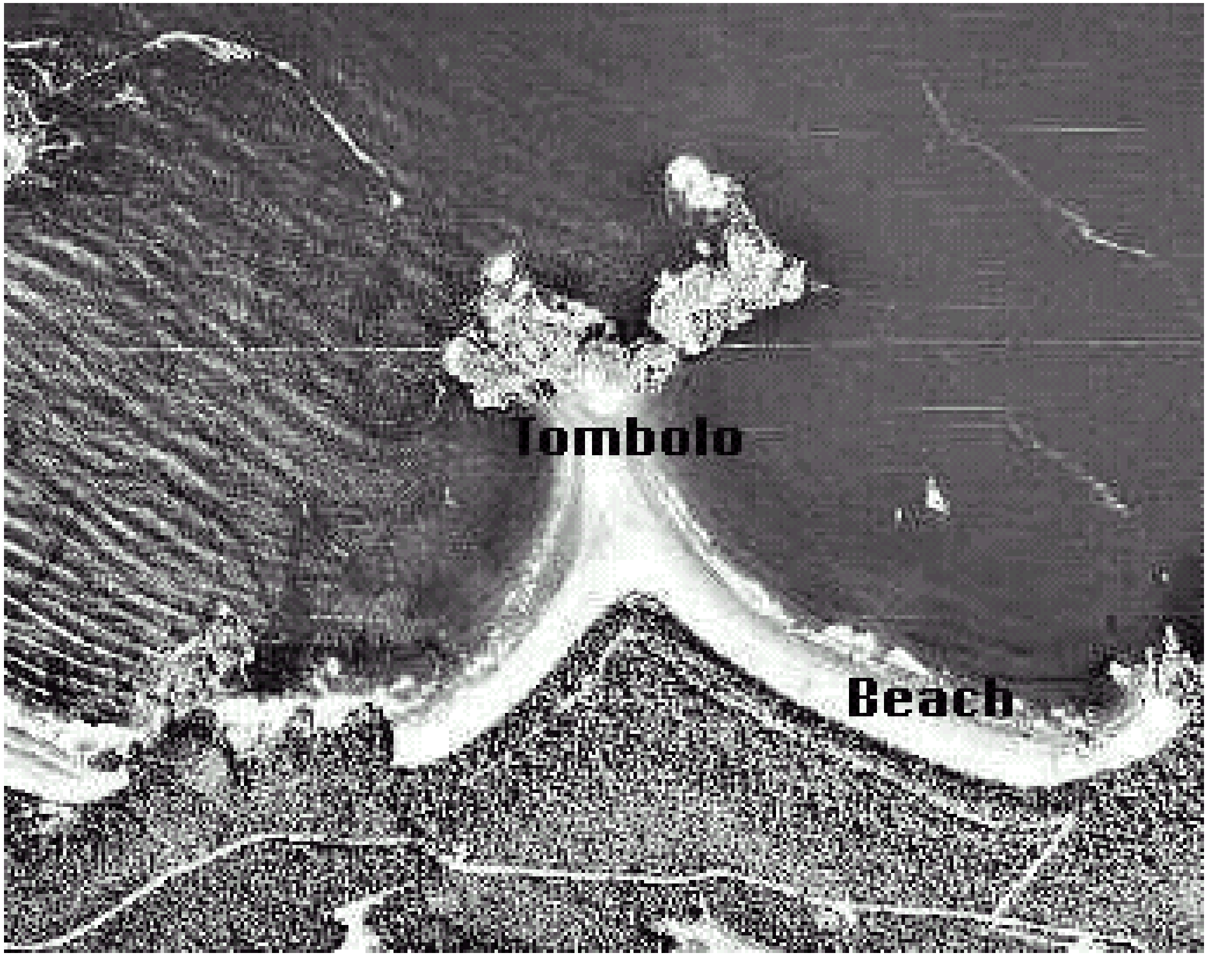


Figure 13.8


Frost Island, WA

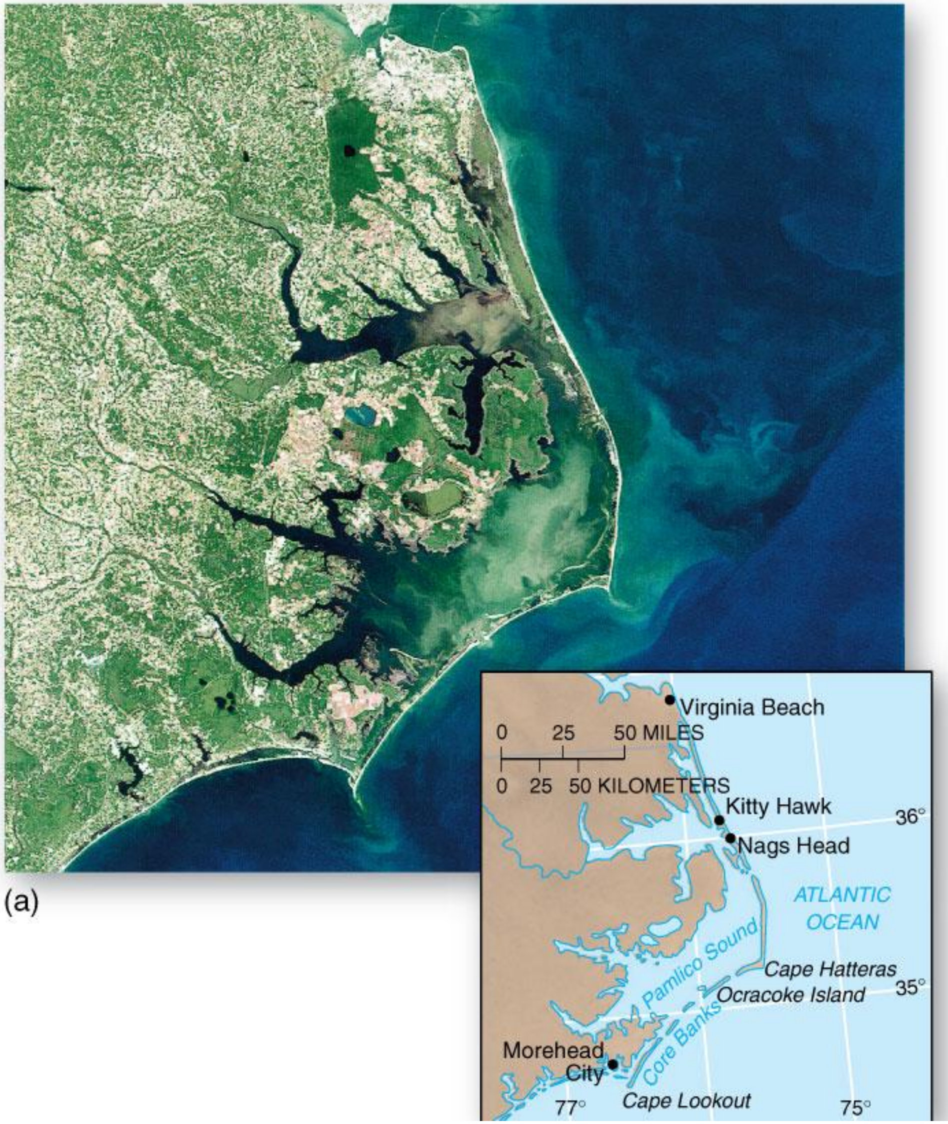
A **tombolo** occurs when sediment deposits connect the shoreline with an offshore sea stack or island



Rebounding Coast

isostatic rebound

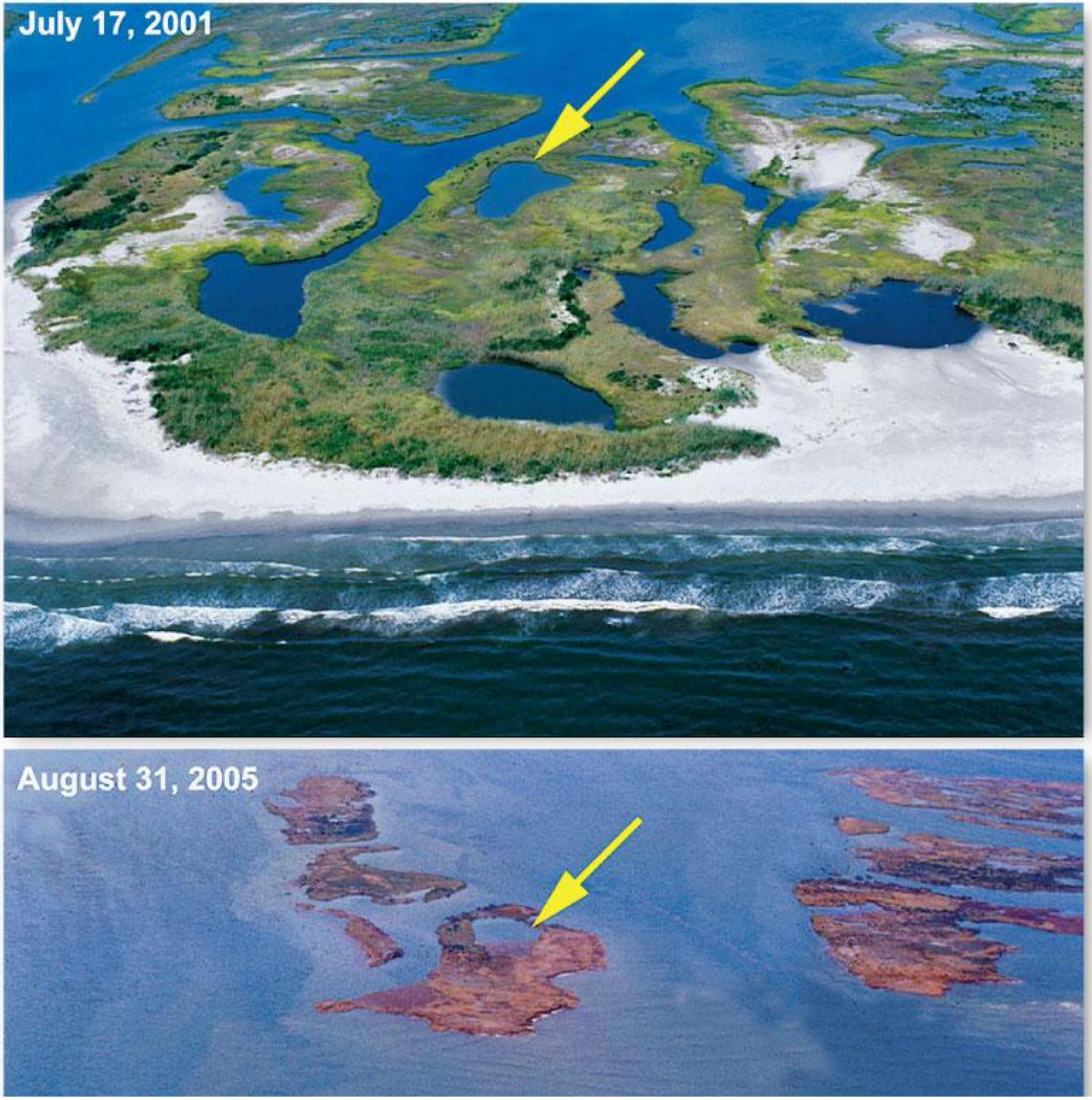
Barrier Islands



(a)

(b)

(c)


July 17, 2001
August 31, 2005

Coral Reef Distribution

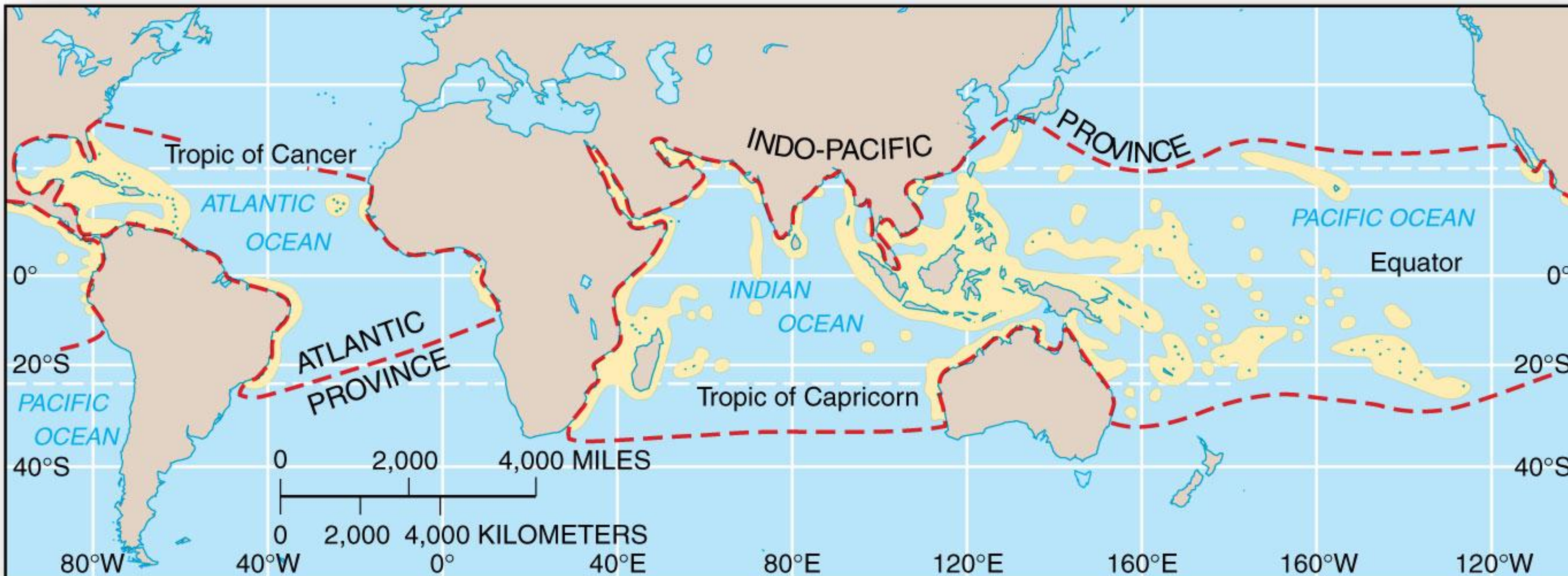


Figure 13.17

Coral Reef Formations

Mangroves


(a)


(b)


(c)

Coastal Erosion and Stabilization

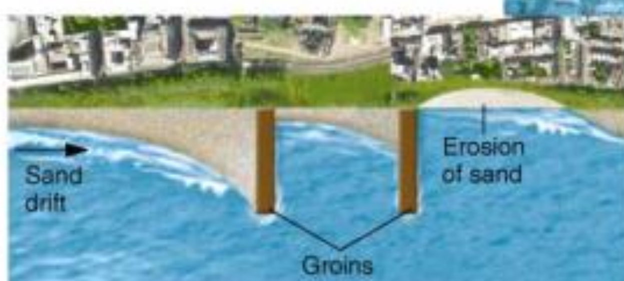
- There are three major approaches used by humans to try and solve the problem of coastline erosion.
- **Hard structural stabilization** such as:
  - groins, jetties, seawalls and breakwaters
- **Soft structural stabilization** such as:
  - beach nourishment
- **Nonstructural strategies** such as:
  - land-use restriction and zoning
- In the long run, only one of these approaches really works...

Hard Structural Stabilization

- Federal, state and local governments have had long-term love affairs with groin, jetty, seawall and breakwater structures.

Groins

- …are impermeable structures that extend, fingerlike, perpendicularly from the shore.
- Groins disrupt the normal ocean current flow, therefore the physical shape of the beach is changed.
- Sand deposition is greatly increased on the upcurrent side of the groin and beach erosion increases on the down-current side



Jetties

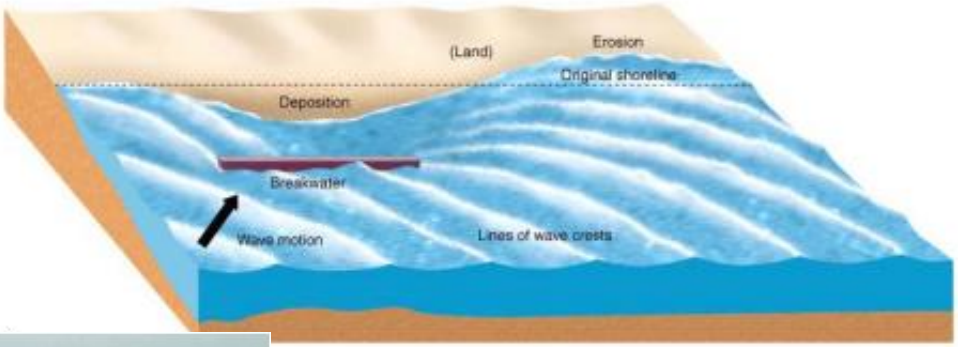
- A pair of jetties are used to stabilize the channel where harbors, rivers, lagoons and estuaries open out into the ocean.
  - Jetties will allow a boat or ship to make it safely into the harbor
- Jetties are also used to protect man-made structures like docks and piers.

Seawalls

- A seawall is a hard structure constructed on the inland part of a coast to reduce the effects of strong waves and to defend the coast around a town or harbor from erosion.
- Seawalls are effective defenses in the short term, but may cause erosion in the long run

Breakwaters

- **Breakwaters** are structures built parallel to a shoreline to protect an anchorage from the effects of weather and longshore drift.



Soft Structure Stabalization

- **Beach Nourishment** is the addition of sand and sediment to a beach to replace sand and sediment that has been eroded away.
- Advantages...
  - Beach nourishment restores and widens the recreational beach
  - Structures behind the beach are better protected as long as the added sand remains
  - When erosion continues, beach nourishment does not leave hazards on the beach or in the surf zone

- Disadvantages...
  - This is a very expensive process, costing over one million dollars per mile of beach
  - Miami Beach holds the expense record of 17.5 million dollars per mile of beach

- Beach nourishment sand usually erodes faster than natural sand on the beach
  - It is different sand, usually larger or smaller sand grains
  - This causes the beach to change shape because the waves will erode it differently

Nonstructural Strategies

- Nonstructural strategies such as land-use restrictions, prohibiting development and mandating minimum setback from the coast are the only way to minimize property damage.