Ocean Motion

The Composition of Seawater

Salinity

- **Salinity** is the total amount of solid material dissolved in water.
- Most of the salt in seawater is sodium chloride, common table salt.

Element	Percent	Element	Percent by mass		
Oxygen	85.84	Sulfur	0.091	Hydrogen	10.82
Calcium	0.04	Chlorine	1.94	Potassium	0.04
Sodium	1.08	Bromine	0.0067	Magnesium	0.1292
Carbon	0.0028				

The Composition of Seawater

Salinity

- Sources of Sea Salt
  - Chemical weathering of rocks on the continents is one source of elements found in seawater.
  - The second major source of elements found in seawater is from Earth's interior from volcanoes

Salts in Seawater

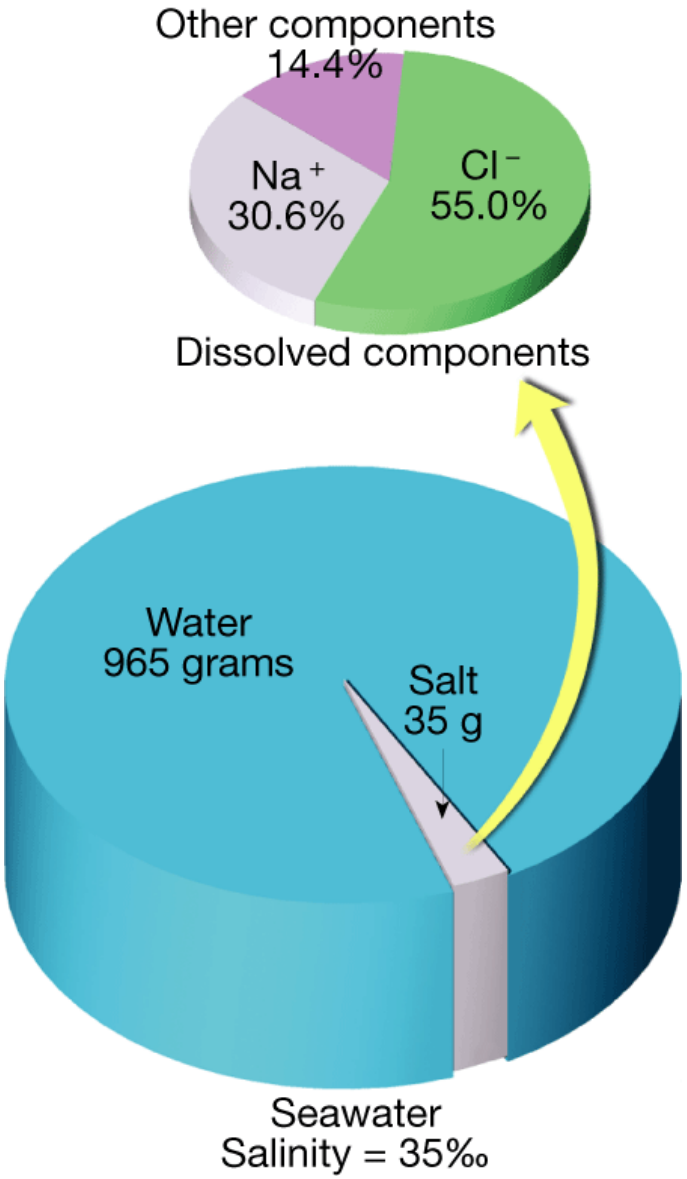
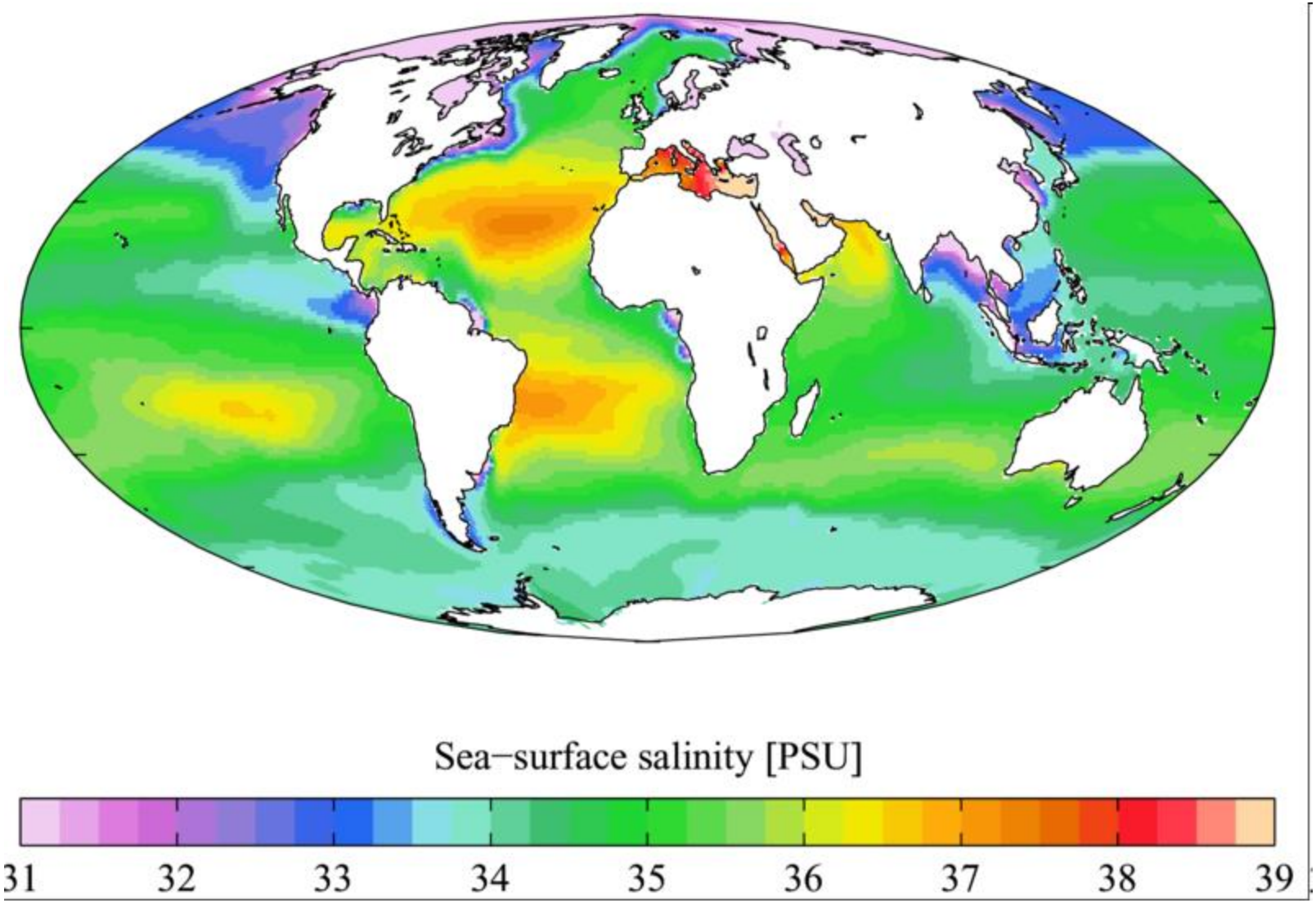


Table of Top 14 Out of 70 Trace Elements in Natural Sea Water

Parts per million (ppm) and milligrams per liter (mg/l) are relatively the same in sea water, therefore the measurements shown are used synonymously.

Chromium (Cr) 0.00005
Cobalt (Co) 0.0005
Copper (Cu) 0.003
Fluorine/Fluoride (F) 1.3
Iodine/Iodide (I) 0.05
Iron (Fe) 0.01
Manganese (Mn) 0.002
Molybdenum (Mo) 0.01
Nickel (Ni) 0.0005
Phosphorus/Phosphate (P) 0.07
Selenium (Se) 0.0002
Tin (Sn) 0.003
Vanadium (V) 0.002
Zinc (Zn) 0.01

References: Periodic Table of Elements from Faculty of Chemical


Sea−surface salinity [PSU]
31
32
33
34
35
36
37
38
39

The Composition of Seawater

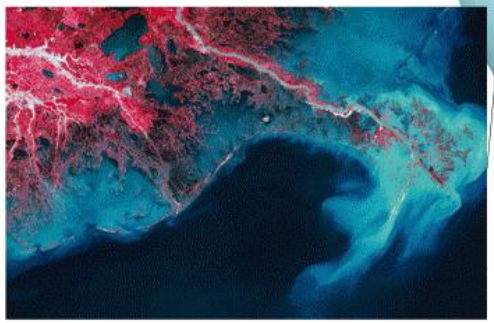
Salinity

- Processes Affecting Salinity
  - Processes that decrease salinity:
    - Precipitation
    - Sea ice melting
    - Icebergs melting
  - Processes that increase salinity:
    - Evaporation
    - Formation of sea ice
    - Runoff from land

Natural Processes Affecting Salinity

Icebergs

Sea ice



Runoff

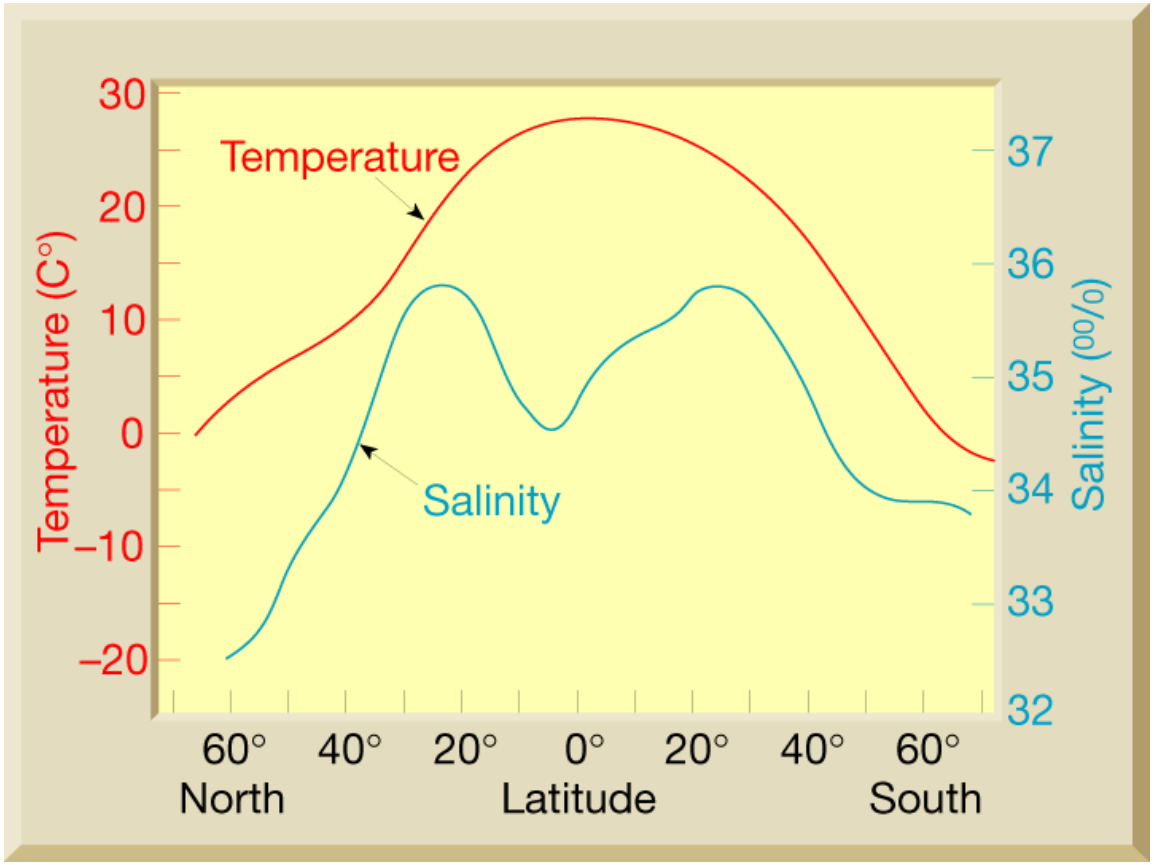
Evaporation

Temperature of Seawater

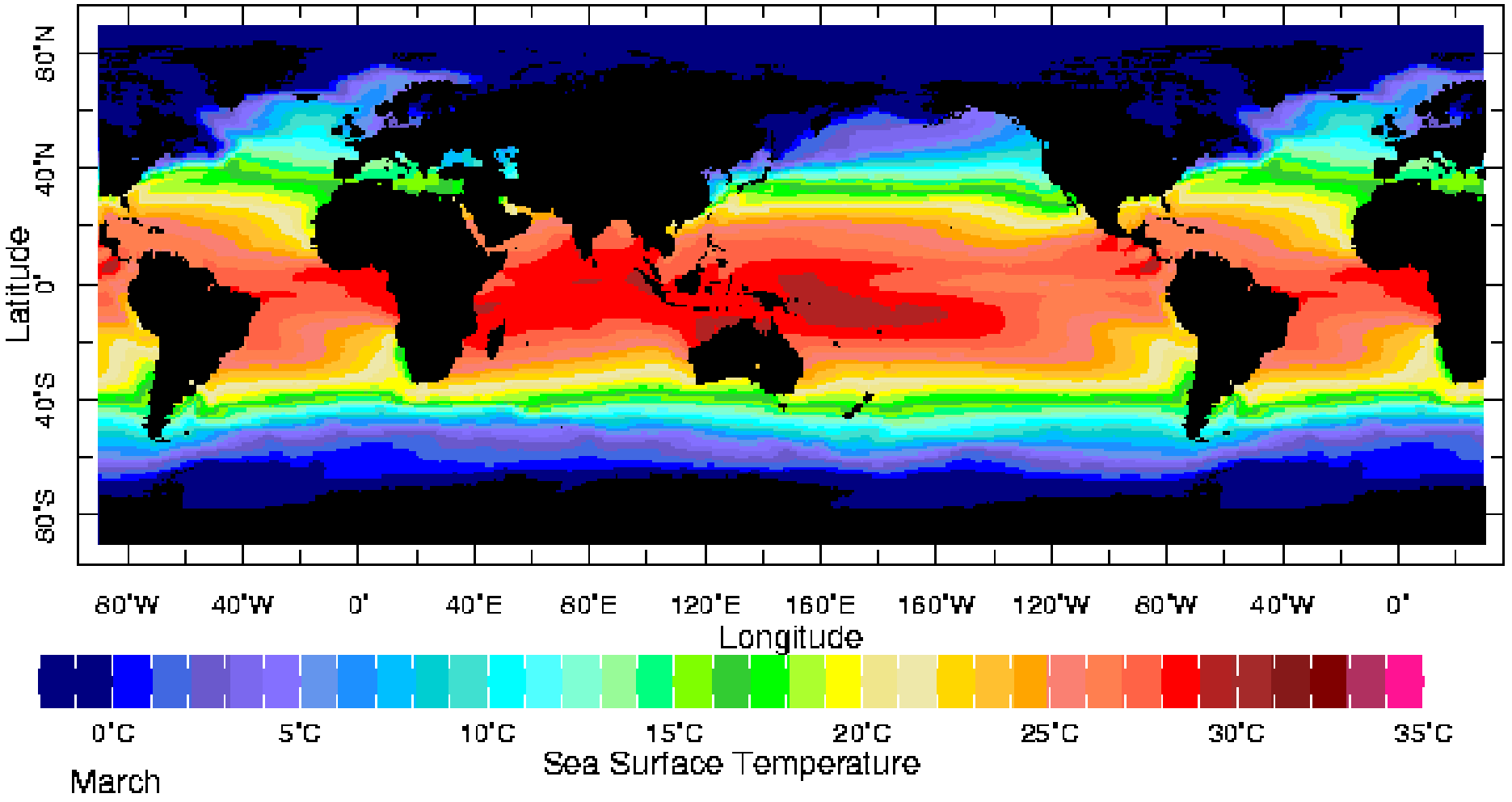
Ocean Temperature Variation

- The ocean's surface water temperature varies with the amount of solar radiation received, which is primarily a function of latitude.
- Temperature Variation with Depth
  - The **thermocline** is the layer of ocean water between about 300 meters and 1000 meters where there is a rapid change of temperature with depth.

Variations in Ocean Surface Temperature



Sea Surface Temperature



http://www.ldeo.columbia.edu/dees/ees/climate/slides/sst_march.gif

The Density of Seawater

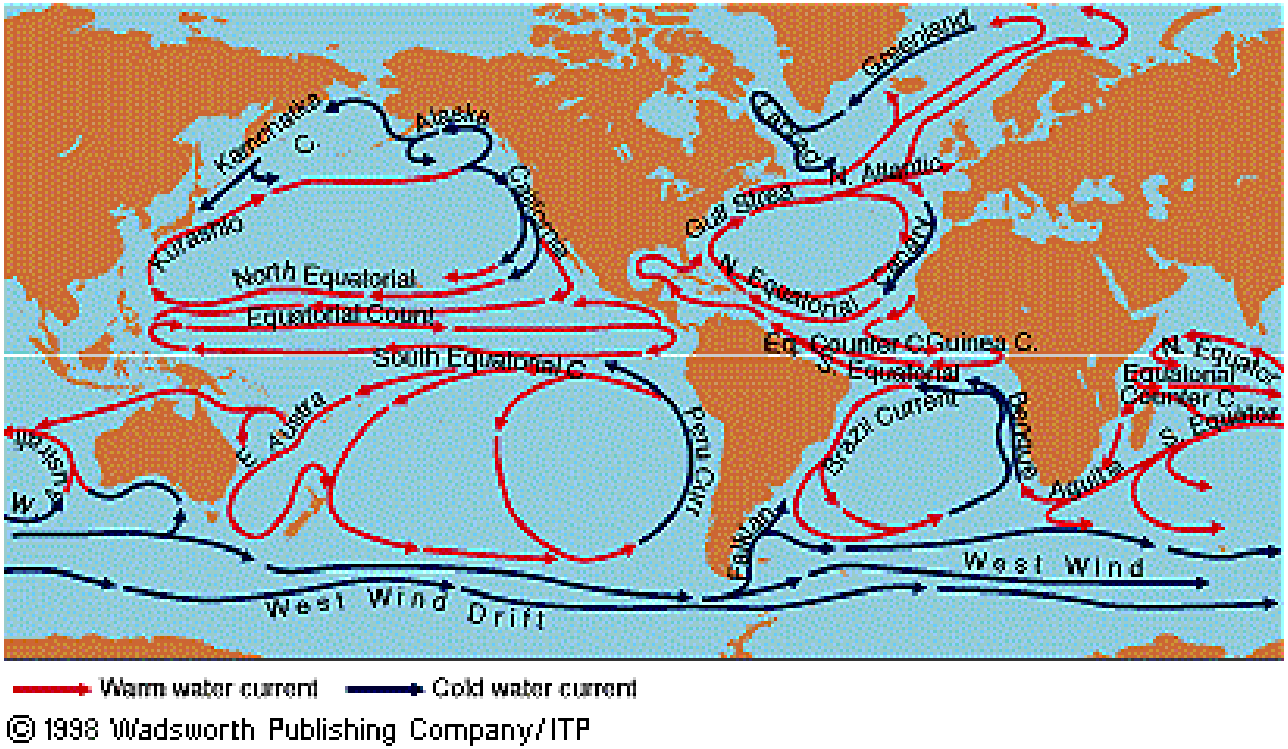
Ocean Density Variation

- Density is defined as mass per unit volume. It can be thought of as a measure of how heavy something is for its size.
- Factors Affecting Seawater Density
  - Seawater density is influenced by two main factors: salinity and temperature.

Ocean currents

- **Caused by:**
  - **Wind**
  - **Density**
  - **Coriolis effect**

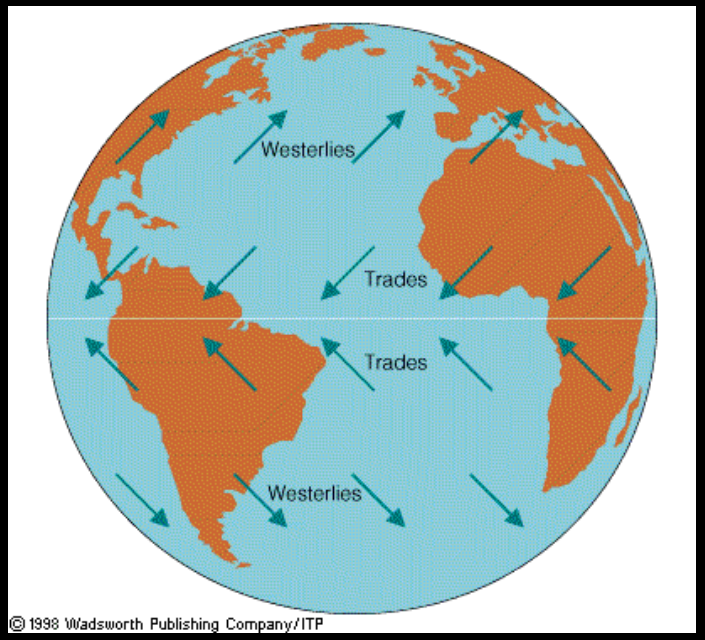
Wind driven surface currents

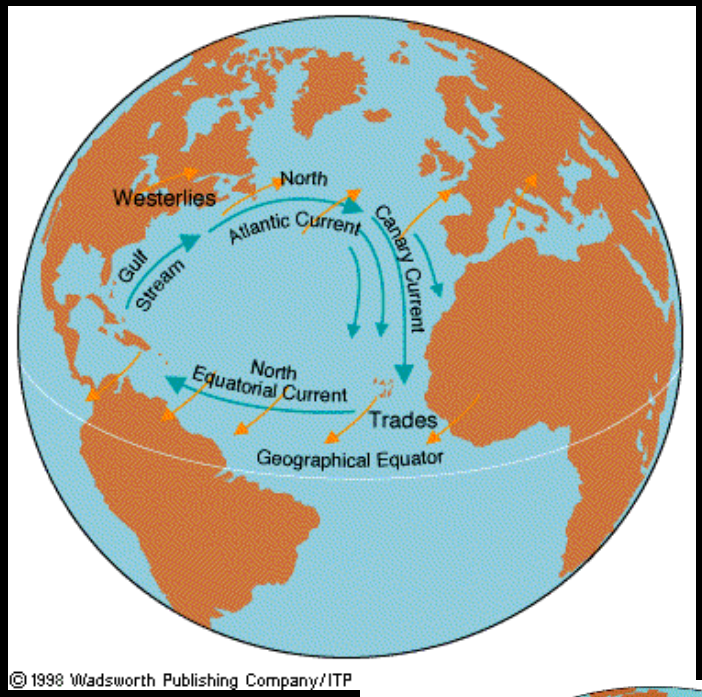


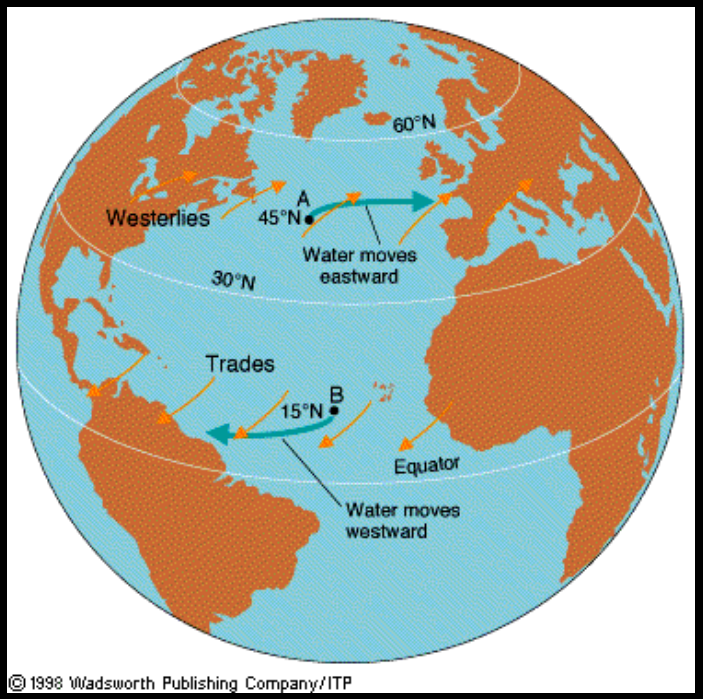
- **How fast?** A few miles/hr (Gulf Stream off of Miami = 4.5 mph)

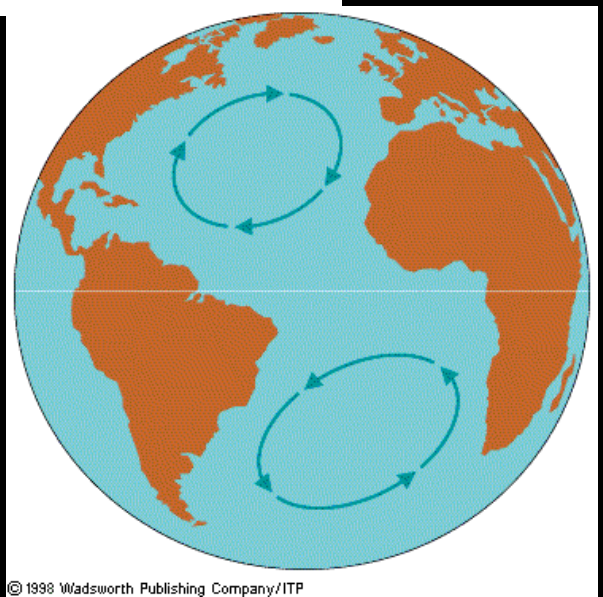
- **How much? Total water in ocean surface circulation = about 100 Amazon Rivers (20 million m^3/s).**

Ocean Circulation

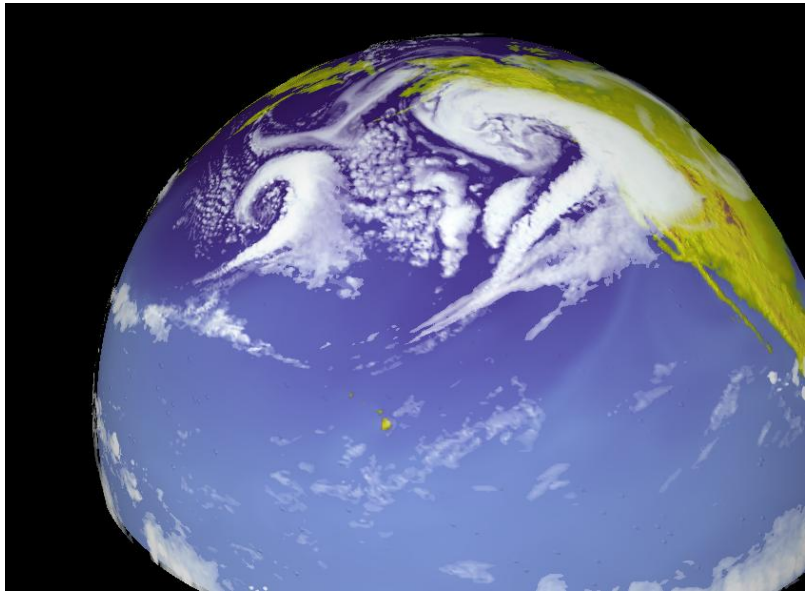




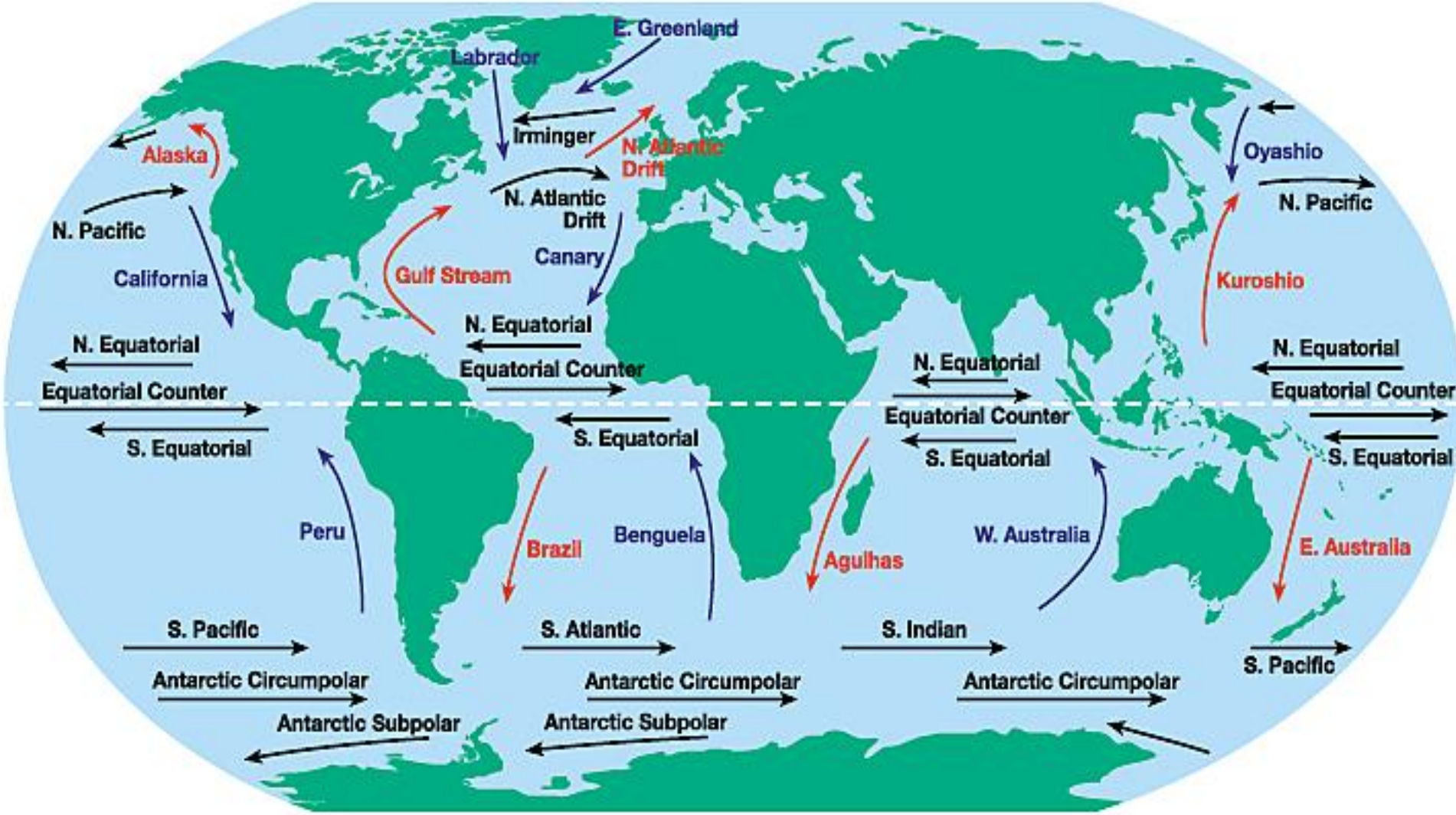




Atmosphere & Ocean Circulation



- Atmospheric Circulation
  - Depends on density
- Ocean Surface Circulation
  - Depends on the wind
- Deep Ocean Circulation
  - Depends on density


E. Greenland
Labrador
Irminger
N. Atlantic Drift
Alaska
N. Atlantic Drift
N. Pacific
California
Gulf Stream
Canary
N. Equatorial
Equatorial Counter
S. Equatorial
Oyashio
N. Pacific
Kuroshio
N. Equatorial
Equatorial Counter
S. Equatorial
N. Equatorial
Equatorial Counter
S. Equatorial
Peru
Brazil
Benguela
Agulhas
W. Australia
E. Australia
S. Pacific
S. Atlantic
S. Indian
S. Pacific
Antarctic Circumpolar
Antarctic Circumpolar
Antarctic Circumpolar
Antarctic Subpolar
Antarctic Subpolar

Ocean Waves and Tides

Waves

Caused by:

- Wind
- Earthquakes
- Gravitational force of the Moon and Sun.

Waves

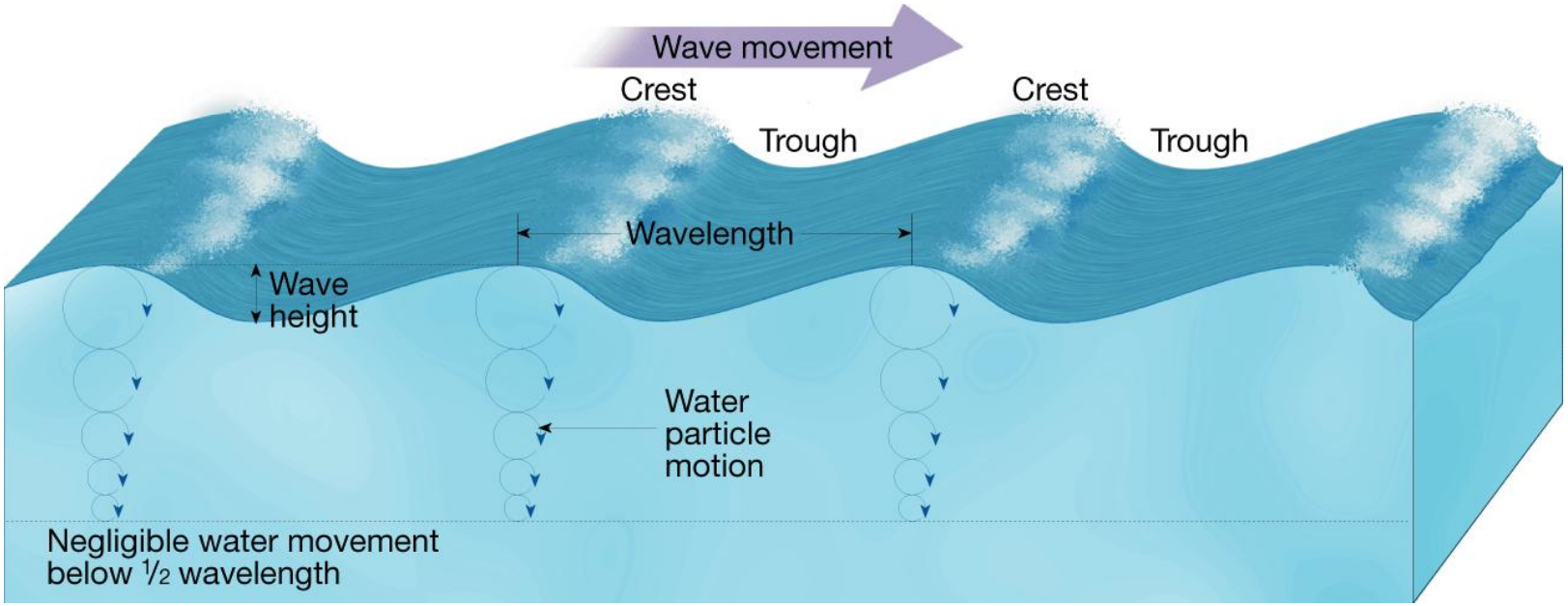
Waves

- Wave Characteristics
  - The **wave period** is the time it takes one full wave—one wavelength—to pass a fixed position.
  - Crest is the highest point of a wave
  - Trough is the lowest point of the wave.

Wave Movement

- When a wave passes through the ocean, individual water molecules move up and down but they do not move forward or backward.

Anatomy of a Wave



Waves

Waves

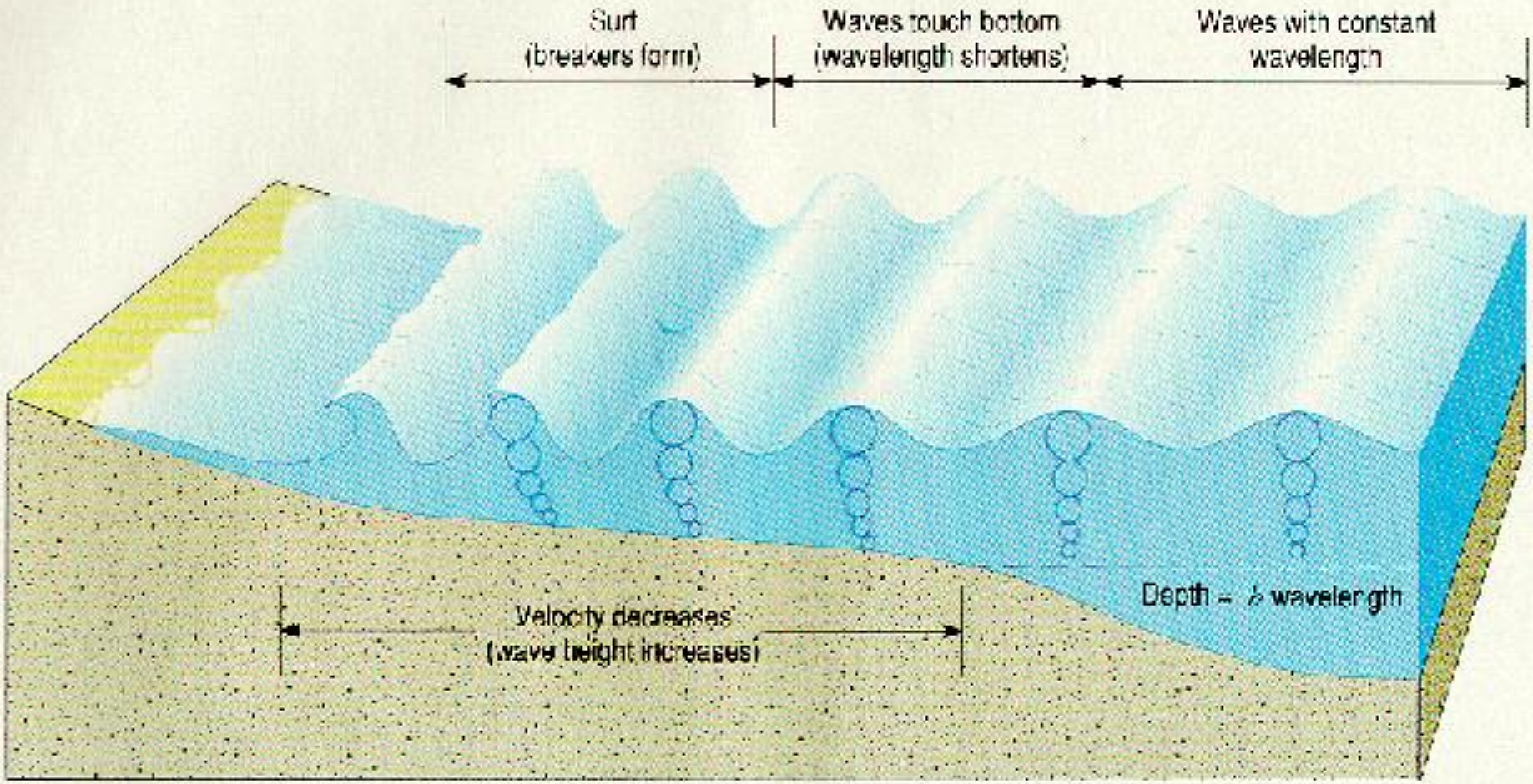
- Wave Motion
  - Circular orbital motion allows energy to move forward through the water while the individual water particles that transmit the wave move around in a circle.

Waves Caused by Wind

- When wind blows across a body of water, friction causes the water to move along with the wind.
- Wave Height depends on –
  - Wind speed
  - Distance over which the wind blows
  - Length of time the wind blows

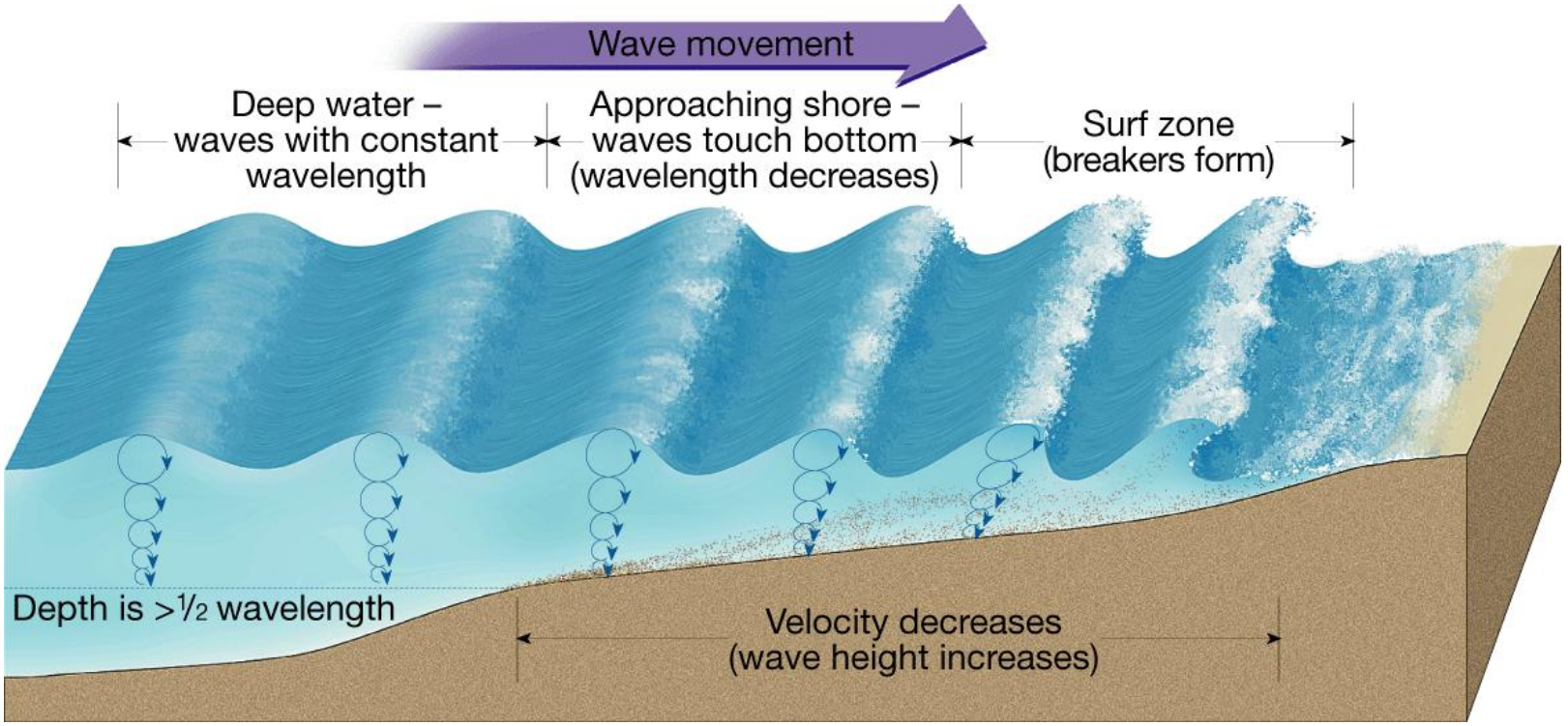
Wave Movement

- When a wave breaks against the shore, the crest outruns the trough and the crest collapses.
- Called a breaker.
- In this case, water does move forward and backward.



Changes when a wave moves onto shore.

Breaking


Wave movement
Deep water –
waves with constant
wavelength
Approaching shore –
waves touch bottom
(wavelength decreases)
Surf zone
(breakers form)
Depth is >½ wavelength
Velocity decreases
(wave height increases)

Tides

- The rise and fall in sea level is called a tide.
- Caused by a **giant wave**.
- One low-tide/high-tide cycle takes about 12 hrs and 25 min.
- Tidal range is the difference in ocean level between high-tide and low-tide

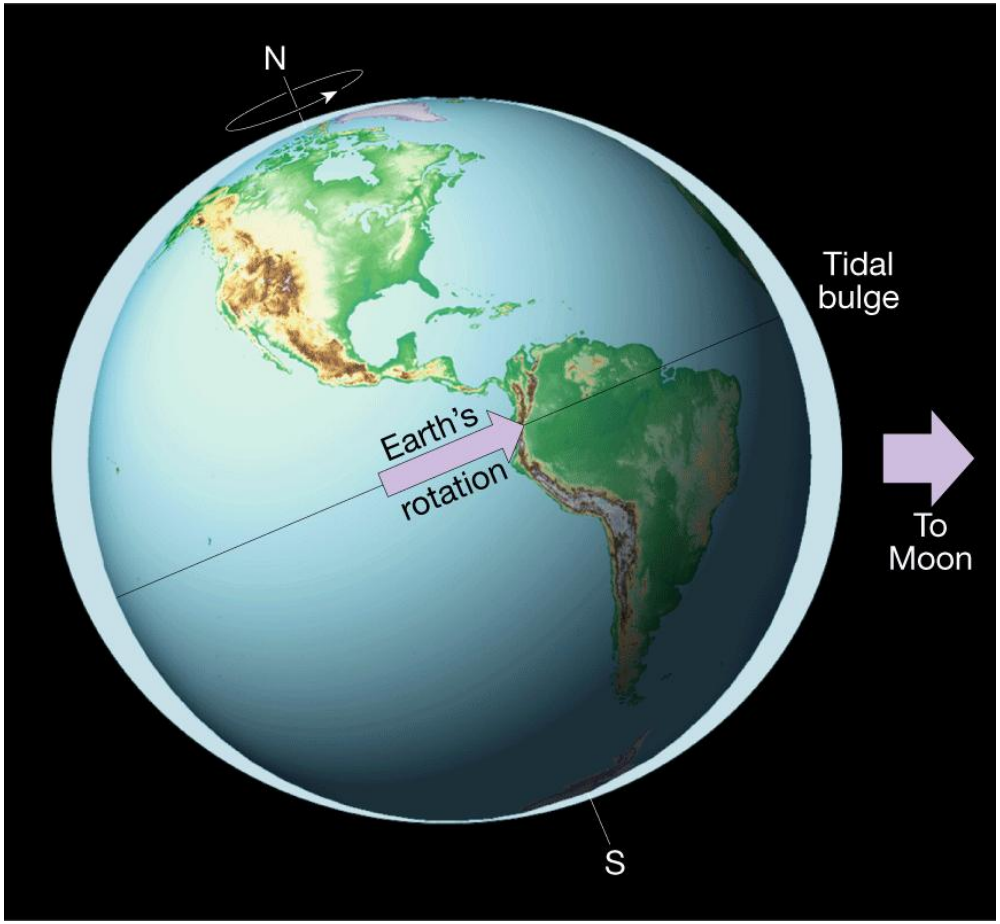
Gravitational Effect of the Moon

- Two big bulges of water form on the Earth:
  - one directly under the moon
  - another on the exact opposite side

- As the Earth spins, the bulges follow the moon.

Tide Bulges on Earth

Caused by the Moon

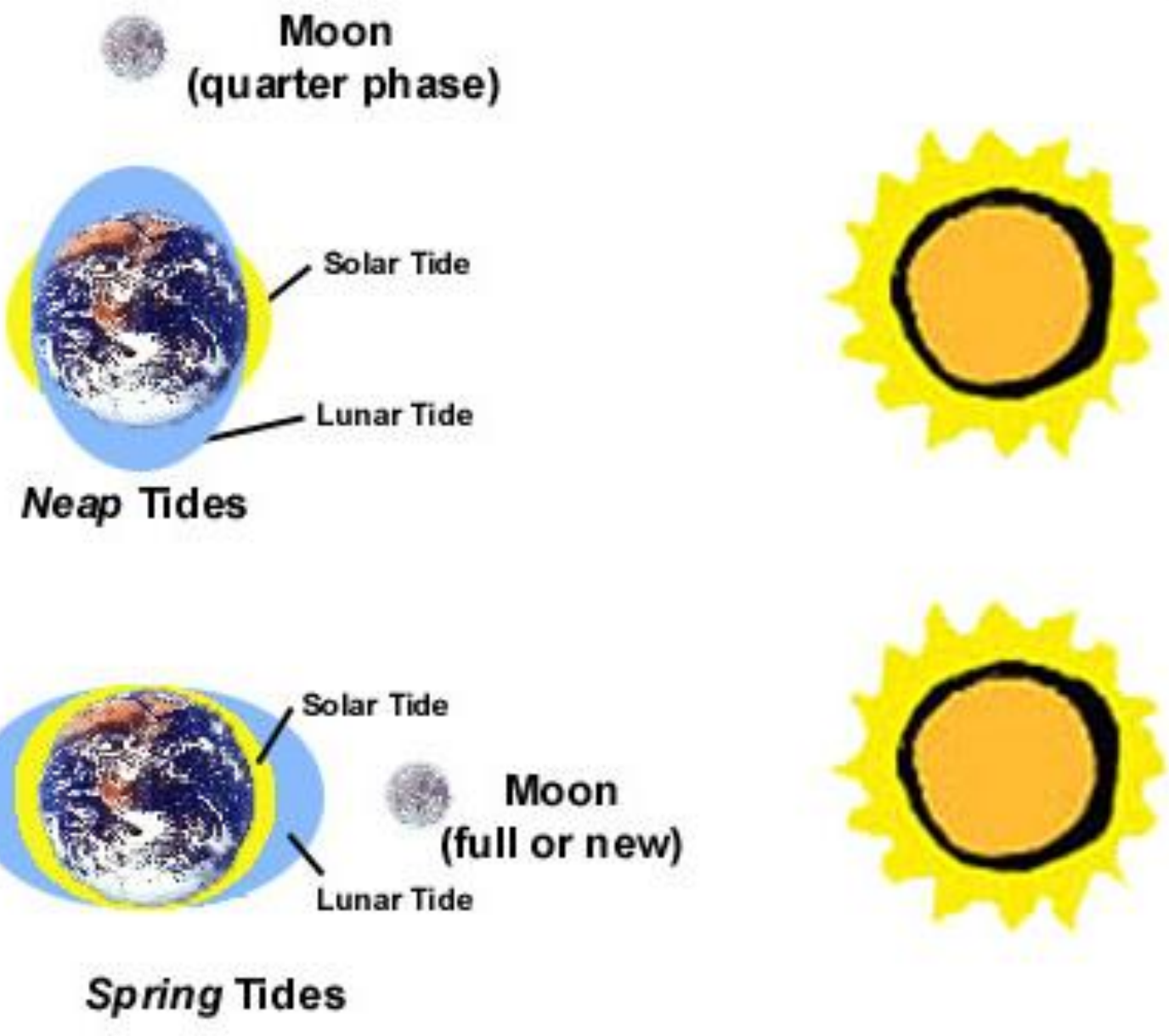


Tides

Tides

- Tide Cycle
  - **Tidal range** is the difference in height between successive high and low tides.
  - **Spring tides** are tides that have the greatest tidal range due to the alignment of the Earth–moon–sun system.
  - **Neap tides** are tides that have the lowest tidal range, occurring near the times of the first-quarter and third-quarter phases of the moon.

Spring tide/ Neap tide



Shoreline Processes and Features

Forces Acting on the Shoreline

- A **beach** is the accumulation of sediment found along the shore of a lake or ocean.
- Waves along the shoreline are constantly eroding, transporting, and depositing sediment. Many types of shoreline features can result from this activity.

Shoreline Processes and Features

Forces Acting on the Shoreline

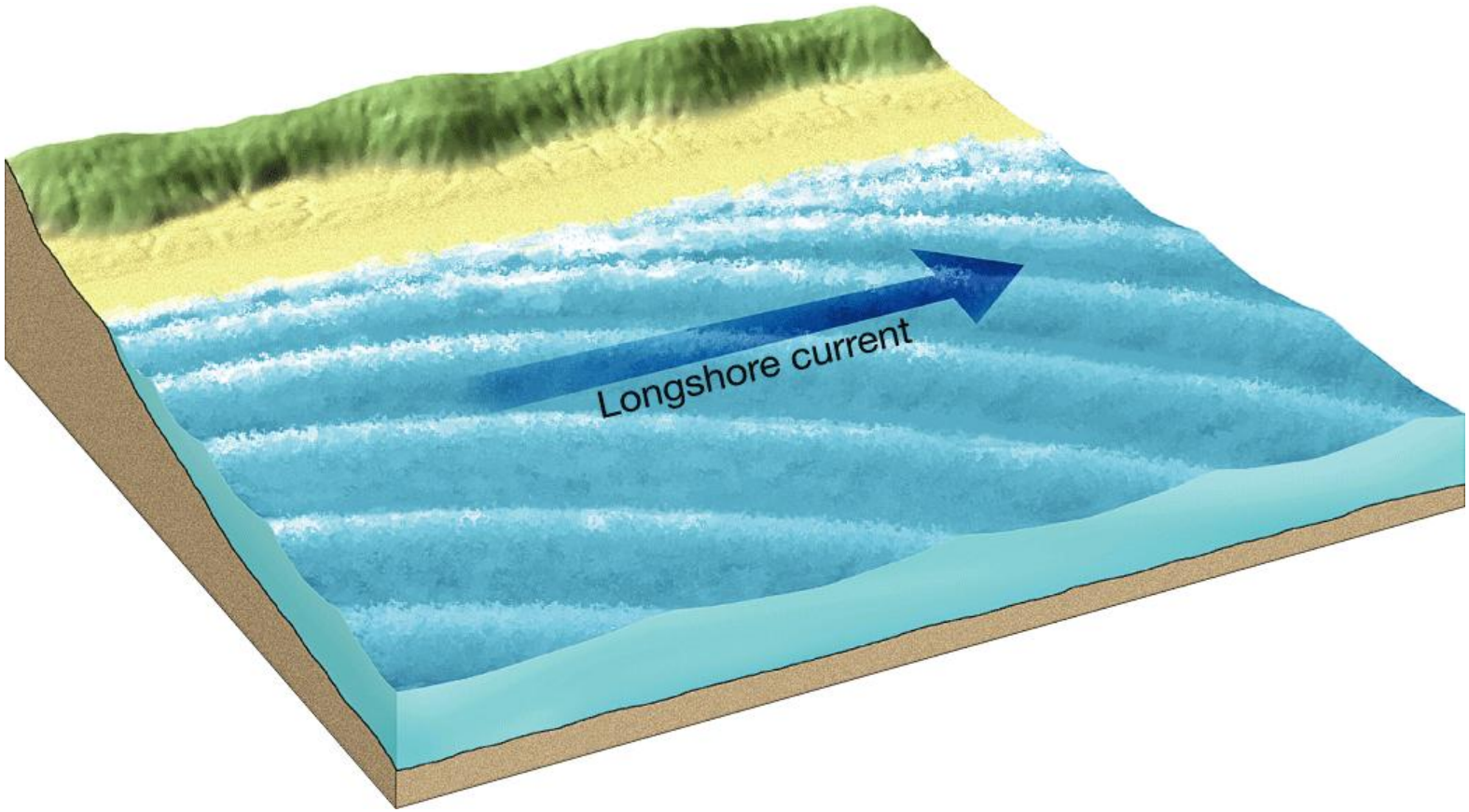
- Wave Impact
  - The impact of large, high-energy waves against the shore can be awesome in its violence. Each breaking wave may hurl thousands of tons of water against the land, sometimes causing the ground to tremble.
- Abrasion
  - Abrasion is the sawing and grinding action of rock fragments in the water.
  - Abrasion is probably more intense in the surf zone than in any other environment.

Shoreline Processes and Features

Forces Acting on the Shoreline

- Longshore Transport
  - A **longshore current** is a near-shore current that flows parallel to the shore.
  - Turbulence allows longshore currents to easily move fine suspended sand and to roll larger sand and gravel particles along the bottom.

Longshore Currents



Shoreline Processes and Features

Erosional Features

- Shoreline features that originate primarily from the work of erosion are called erosional features. Sediment that is transported along the shore and deposited in areas where energy is low produces depositional features.

Shoreline Processes and Features

Erosional Features

- Wave-Cut Cliffs and Platforms
  - Wave-cut cliffs result from the cutting action of the surf against the base of coastal land. A flat, bench-like, wave-cut platform forms in front of the wave-cut cliff.
- Sea Arches and Sea Stacks
  - When two caves on opposite sides of a headland unite, a sea arch results. Eventually, the arch falls in, leaving an isolated remnant, or sea stack, on the wave-cut platform.

Sea Arch and Sea Stack

Shoreline Processes and Features

Depositional Features

- Barrier Islands
  - **Barrier islands** are narrow sandbars parallel to, but separate from, the coast at distances from 3 to 30 kilometers offshore.

Barrier Islands