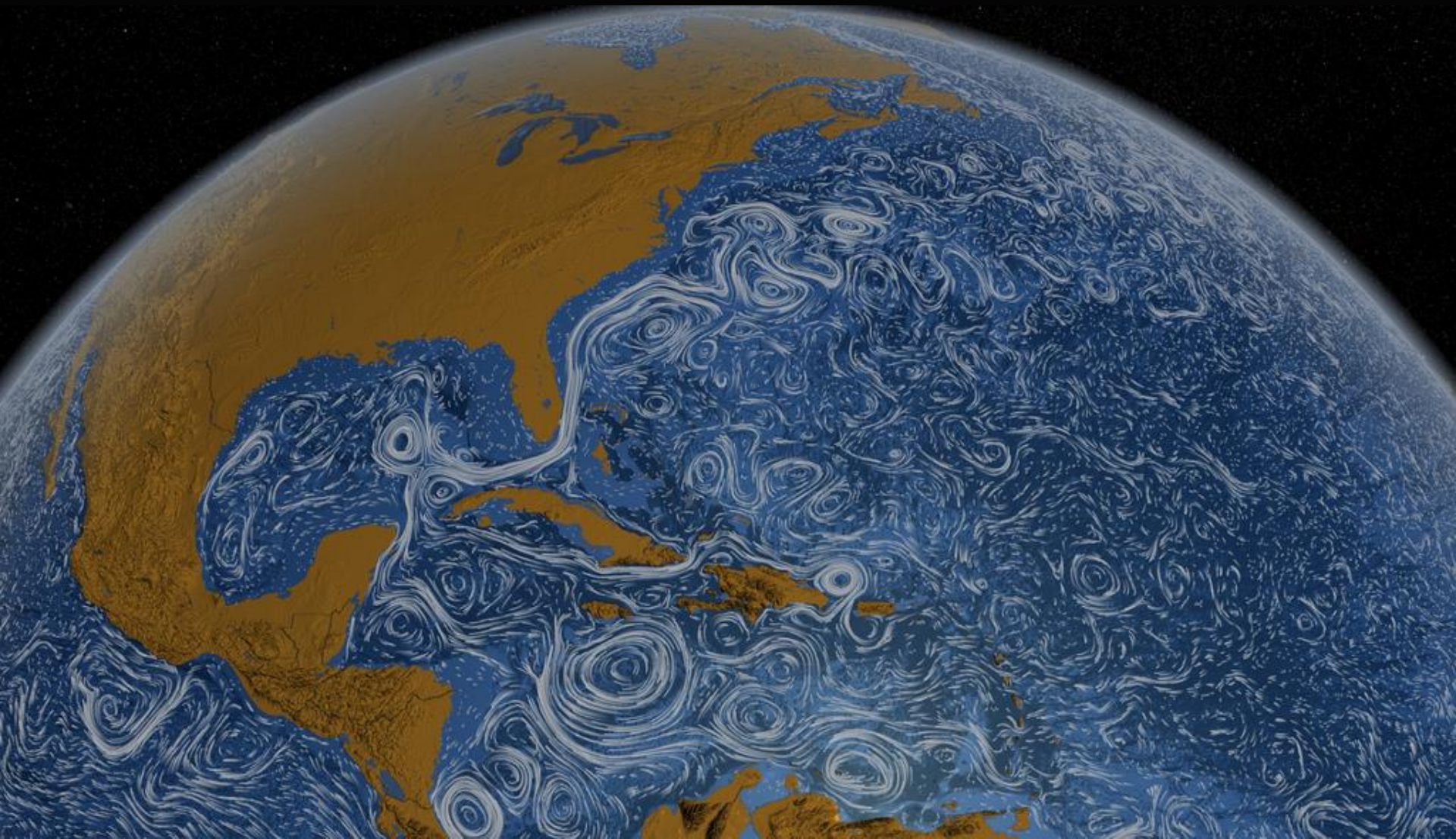
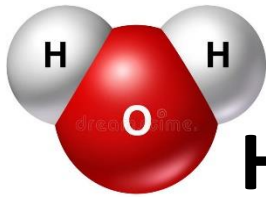


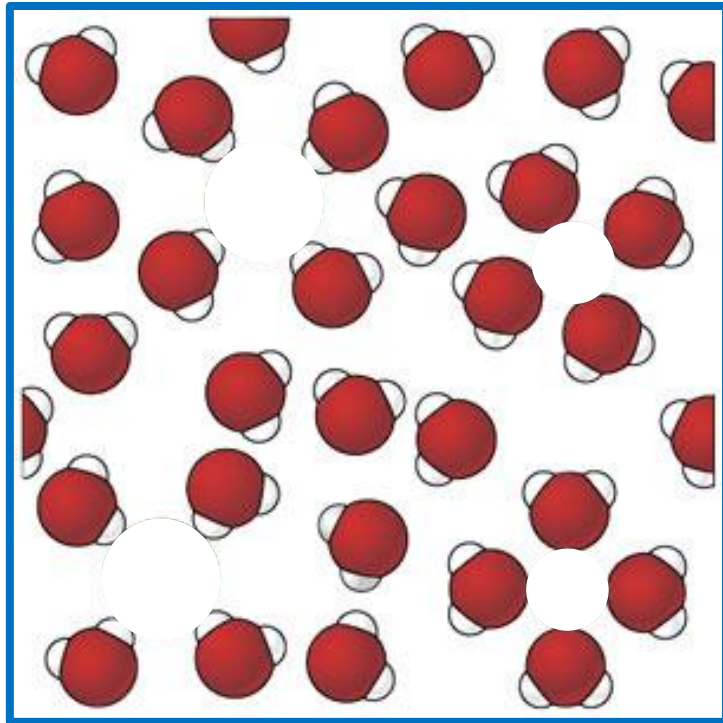
WORLD OCEAN



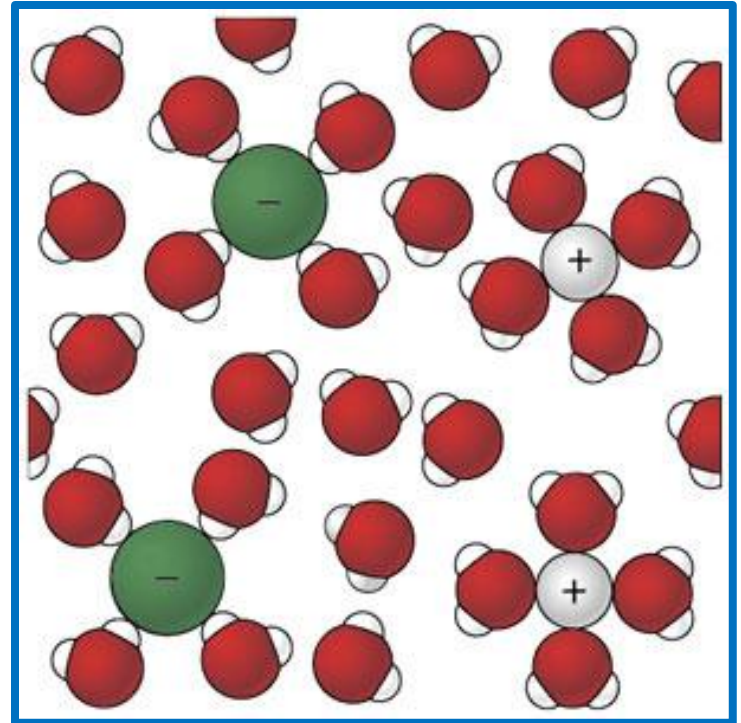
What Kind of Water?



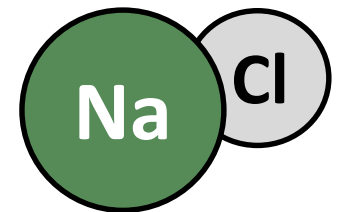
H₂O (water)



VS



**NaCl
(table salt)**



Saltwater (Saline Water)

- Saltwater is water that contains a **certain amount of salts** with dissolved salt concentration of **more than 1%**.
- **Oceans and seas.**
- Saltwater is also found in some lakes and ponds as well as underground.



Seas: large bodies of **saline water** connected with an ocean.

Ancient literature often spoke of the **Seven Seas**...

...how many seas are in the world?

I counted 111!

- **Atlantic Ocean (27!)**

Baltic Sea, Mediterranean Sea, Black Sea, Caribbean Sea, Argentine Sea, Bay of Biscay, Bay of Campeche, Bay of Fundy, Celtic Sea, Chesapeake Bay, Davis Strait, Denmark Strait, English Channel, Gulf of Guinea, Gulf of Maine, Gulf of Mexico, Gulf of St. Lawrence, Gulf of Venezuela, Irish Sea, Labrador Sea, **Marmara Sea**, North Sea, Norwegian Sea, **Sargasso Sea**, Sea of Azov, Sea of the Hebrides, Wadden Sea

- **Southern Ocean (19!)**

Amundsen Sea, Bass Strait, Bellingshausen Sea, Cooperation Sea, Cosmonauts Sea, Davis Sea, D'Urville Sea, Drake Passage, Great Australian Bight, Gulf St Vincent, King Haakon VII Sea, Lazarev Sea, Mawson Sea, Riiser-Larsen Sea, Ross Sea, Scotia Sea, Somov Sea, Spencer Gulf, Weddell Sea

How many seas are in the world?

- **Pacific Ocean (35!)**

Arafura Sea, Banda Sea, Bering Sea, Bismarck Sea, Bohai Sea, Bohol Sea (also known as the Mindanao Sea), Camotes Sea, Celebes Sea, Ceram Sea, Chilean Sea, Sea of Chiloé, Coral Sea, East China Sea, Flores Sea, Gulf of Alaska, Gulf of California (also known as the Sea of Cortéz), Gulf of Carpentaria, Gulf of Thailand, Halmahera Sea, Java Sea, Koro Sea, Molucca Sea, **Philippine Sea**, Salish Sea, Savu Sea, Sea of Japan, Sea of Okhotsk, Seto Inland Sea, Sibuyan Sea, Solomon Sea, South China Sea, Sulu Sea, Tasman Sea, Visayan Sea, Yellow Sea

- **Indian Ocean (10!)**

Andaman Sea, Arabian Sea, Bay of Bengal, Gulf of Aden, Gulf of Oman, Laccadive Sea, Mozambique Channel, **Persian Gulf**, **Red Sea**, Timor Sea

- **Arctic Ocean (15!)**

Amundsen Gulf, Baffin Bay, Barents Sea, Beaufort Sea, Chukchi Sea, East Siberian Sea, Greenland Sea, Hudson Bay, James Bay, Kara Sea, Kara Strait, Lincoln Sea, Prince Gustav Adolf Sea, Pechora Sea, White Sea

- **Landlocked seas (large saltwater lakes actually) (5!)**

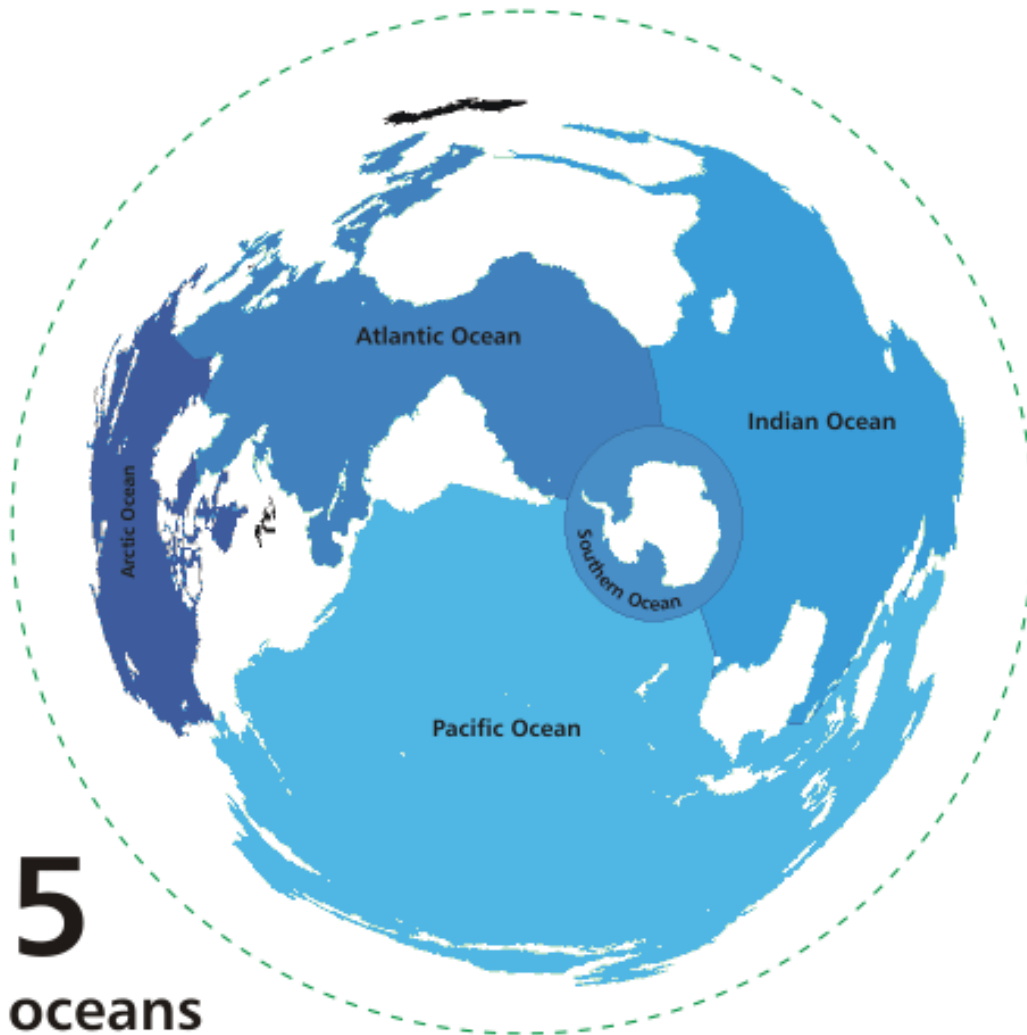
Aral Sea, Caspian Sea, **Dead Sea**, Great Salt Lake, Salton Sea

Quick Sea Facts



1. Largest sea: **Philippine Sea**, ~2 million sq mi.
2. Smallest sea: **Marmara Sea (Turkey)**, at 4,380 sq mi.
3. Saltiest true (open) sea: **Red Sea**, ~4.0%, due to high evaporation, little precipitation, and few (and mostly seasonal) inflowing rivers.
4. Saltiest land-locked sea: **Dead Sea**, ~30%!
5. Lowest salt content: **Baltic Sea**, only 1.0-1.5%, due to low evaporation and many inflowing rivers.
6. Warmest sea: the **Persian Gulf** contains the warmest sea water in the world reaching at 35°C (95°F); Red Sea is the second warmest.
7. Coldest seas are found near the poles.
8. The only sea without a land boundary: **Sargasso Sea**, home to free-floating seaweed called Sargassum and an amazing variety of marine species.

Oceans are the **largest bodies of water** on Earth (contain salt water only)



5
oceans

- Historically, people first began exploring **shoreline shape**, **ocean depth**, and **tides**.
- **Temperature** and **salinity** are two important factors that influence **ocean circulation** and as a result, the **climate** of the Earth.

Tides

Tides are the slow, periodic vertical rise and fall of the ocean surface.

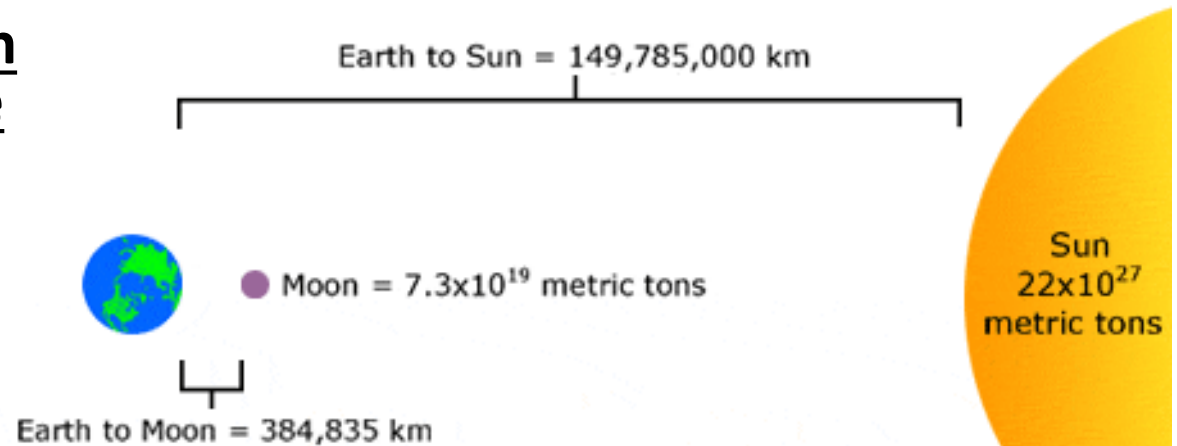


- Tide is a **giant wave** caused by **gravitational pull** of the Moon and Sun on the rotating Earth.
- The gravitational pull on liquids is much more noticeable than on solids (because liquids move more easily than solids).
- One low-tide/high-tide cycle takes about **12 hours and 25 minutes** (the *lunar day* is equal to about 24.8 hours).
- Tidal range is the difference in water level between high-tide and low-tide.
- Tides produce oscillating currents known as tidal streams.
- While tidal changes in sea level are easier to observe where land and water meet, they **exist everywhere** - even in the middle of the ocean.

Gravitational Pull of the Moon and Sun

The relationship between the masses of the Earth, Moon and Sun and their distances to each other play a critical role in affecting the Earth's tides.

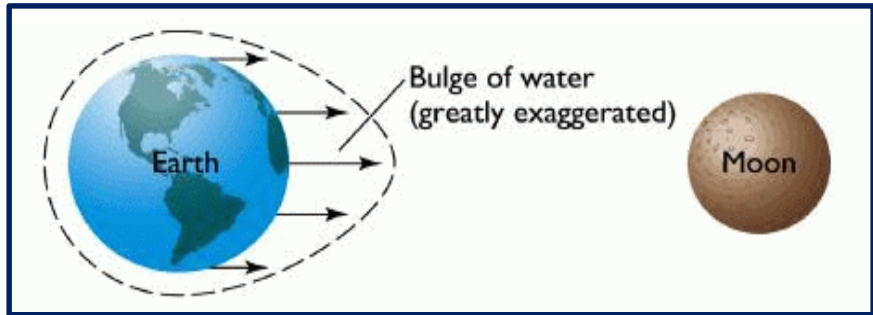
- The Sun is 27 million times more massive than the Moon.
- It is also 390 times further away from the Earth than the Moon.
- As a result, the Sun's tide-generating force is about **half** that of the Moon.



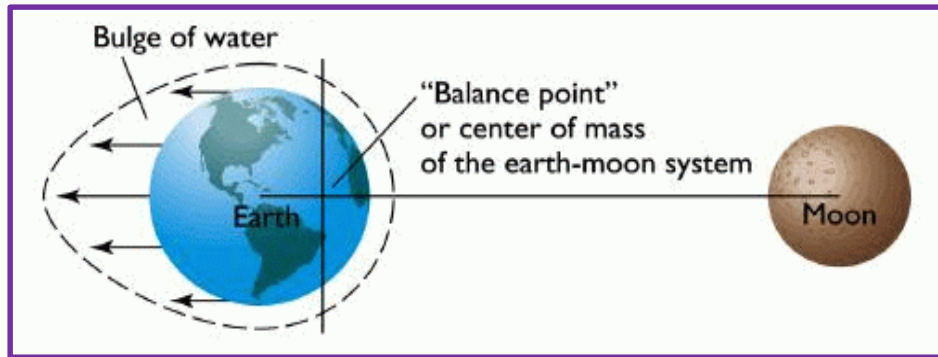
$$\text{Tide-Generating Force} \sim \frac{\text{Mass}}{(\text{Distance})^3}$$

The **Moon** is the **dominant** force affecting the Earth's tides.

Tidal Bulges



gravitational attraction of the Moon



centrifugal force due to Earth rotation



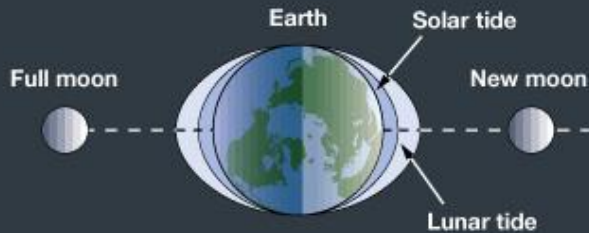
two tidal bulges of water

The Sun has a similar effect, however ~2 times smaller.

Monthly Tidal Cycle (29½ days)

About every 7 days, Earth alternates between:

Spring Tide



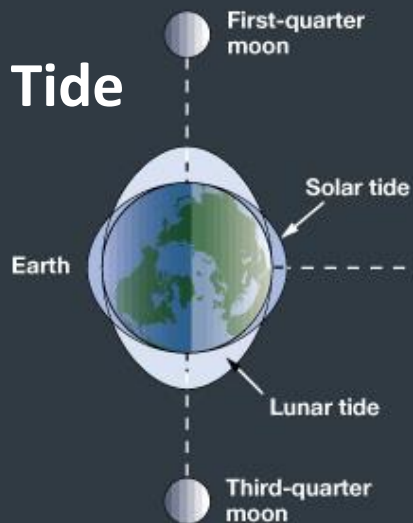
Alignment of Earth-Moon-Sun system (syzygy)

Spring Tide

large tidal range,

highest high tide and lowest low tide

Neap Tide

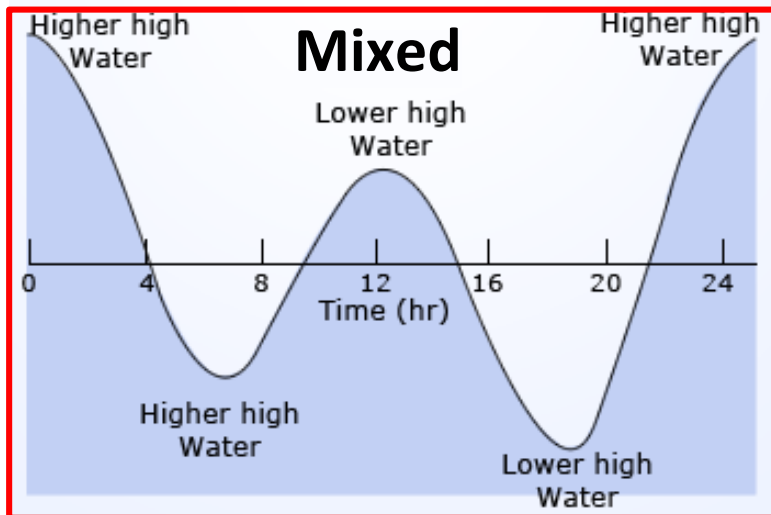
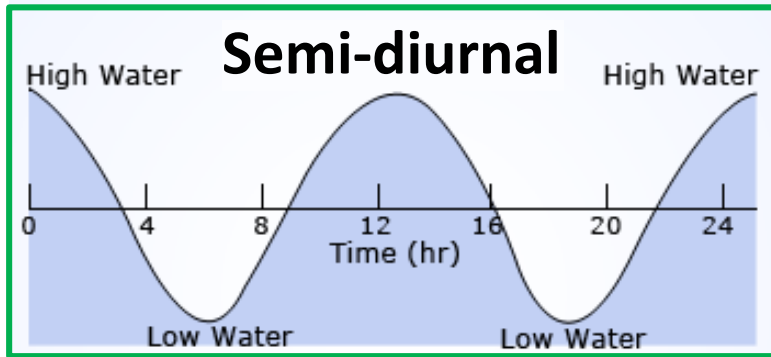
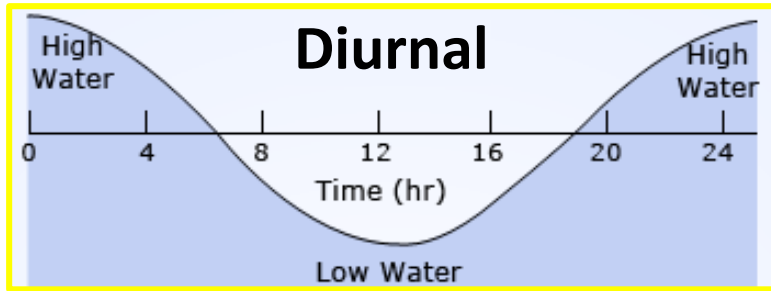


Earth-Moon-Sun system at right angles (quadrature)

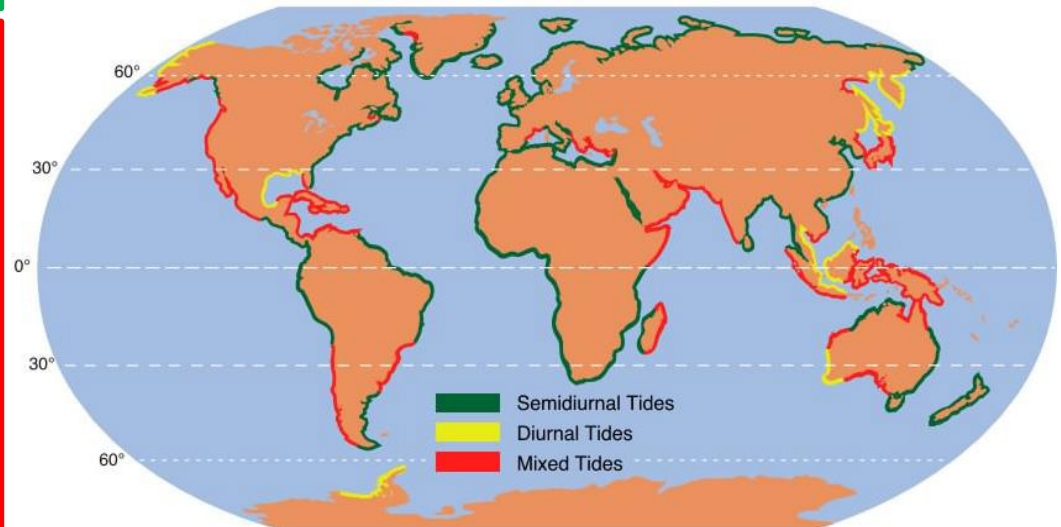
Neap Tide

moderate tidal range

Types of Tides



- **Diurnal**: one tidal cycle per day (Gulf of Mexico)
- **Semi-diurnal**: two high waters and two low waters each day (Boston, MA)
- **Mixed**: two high and two low waters each day, all four with different heights (Los Angeles, CA).



The Bay of Fundy, Canada: world's largest tidal range

- Tidal energy is focused by shape and shallowness of bay.
- Maximum spring tidal range in Minas Basin = 17 meters (56 feet).

Alma harbor at **High Tide** and **Low Tide**

