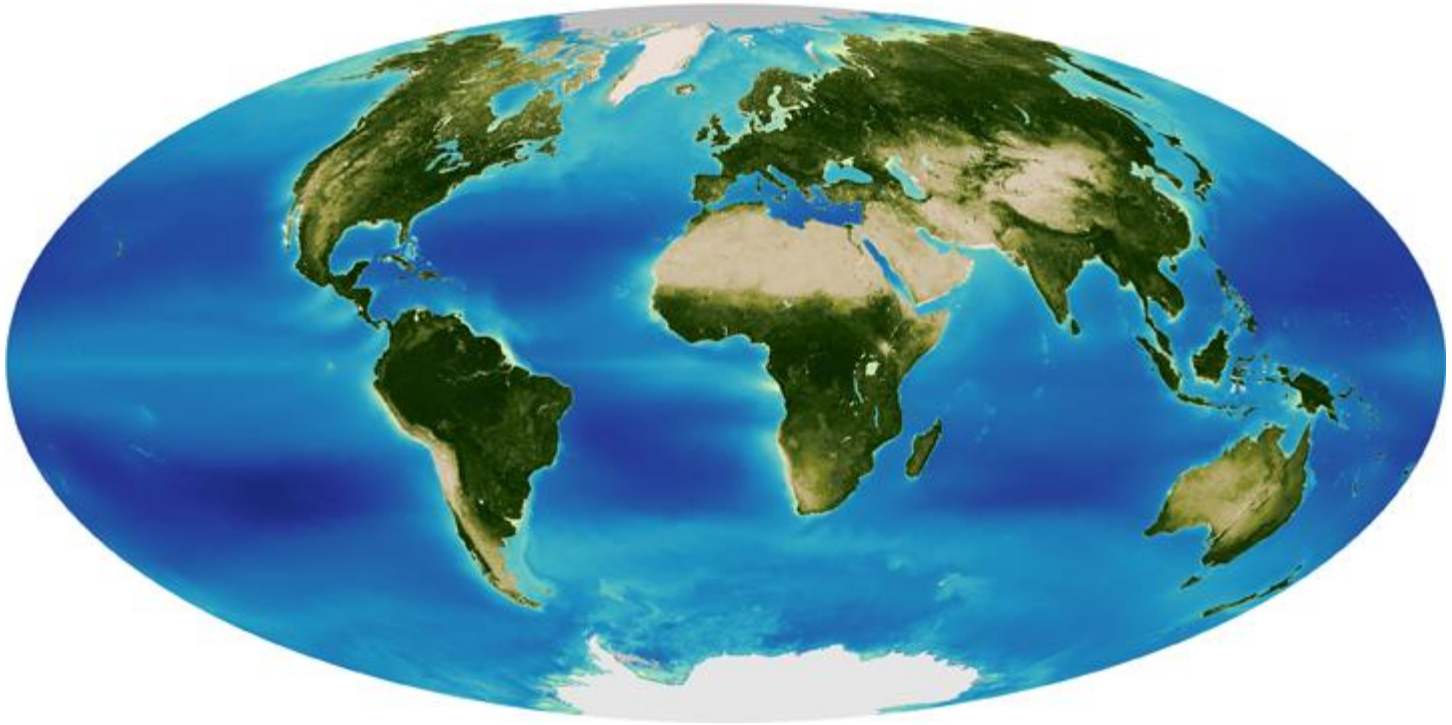
The Global Ocean

Ocean Features and Abiotic Conditions

The Global Ocean

- Earth is made up of 71% water, most of that water is marine (salt).
  - Only 3% of the Earth's water is freshwater.

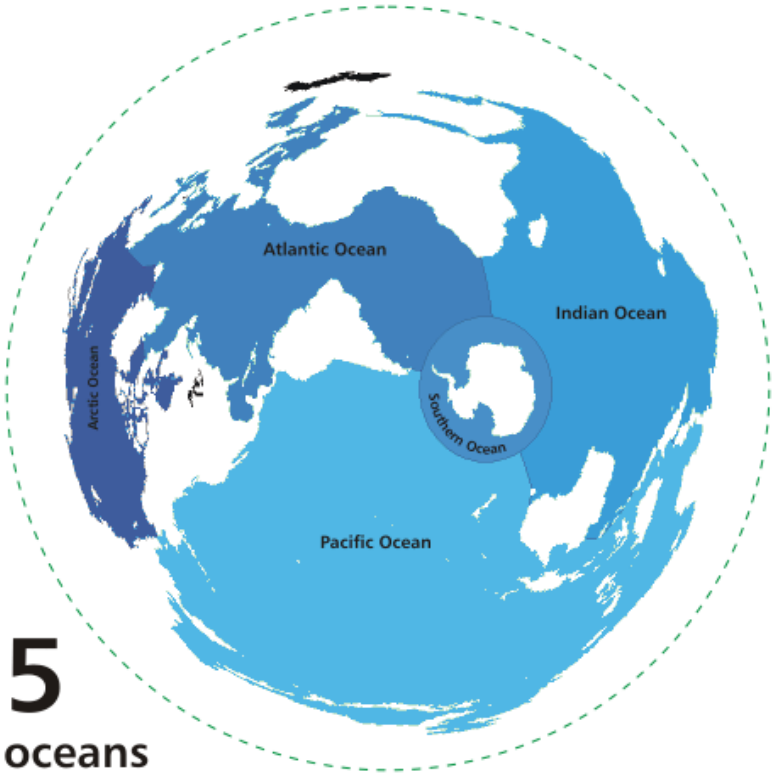


The Global Ocean

- Continents divide oceans into

  5 major parts:

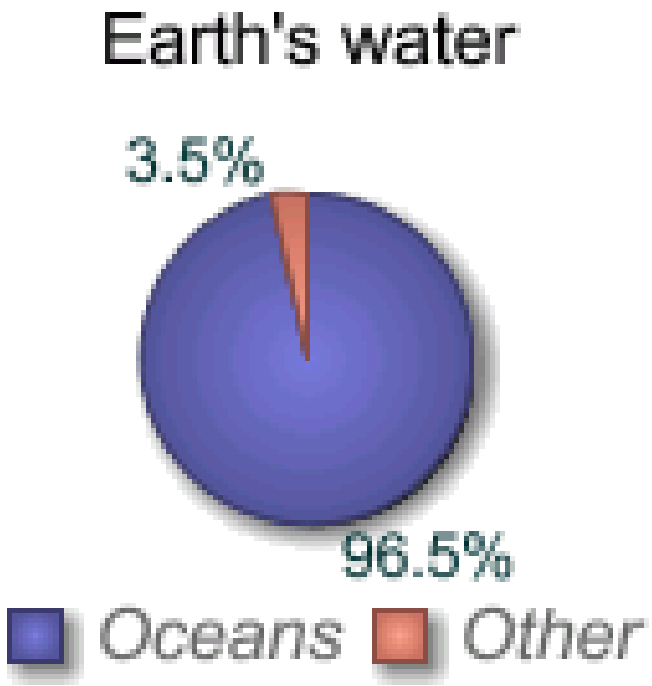
  1. Atlantic Ocean
  2. Pacific Ocean
  3. Indian Ocean
  4. Arctic Ocean
  5. Southern Ocean



- Where two major oceans come close together, they enclose a **sea**.

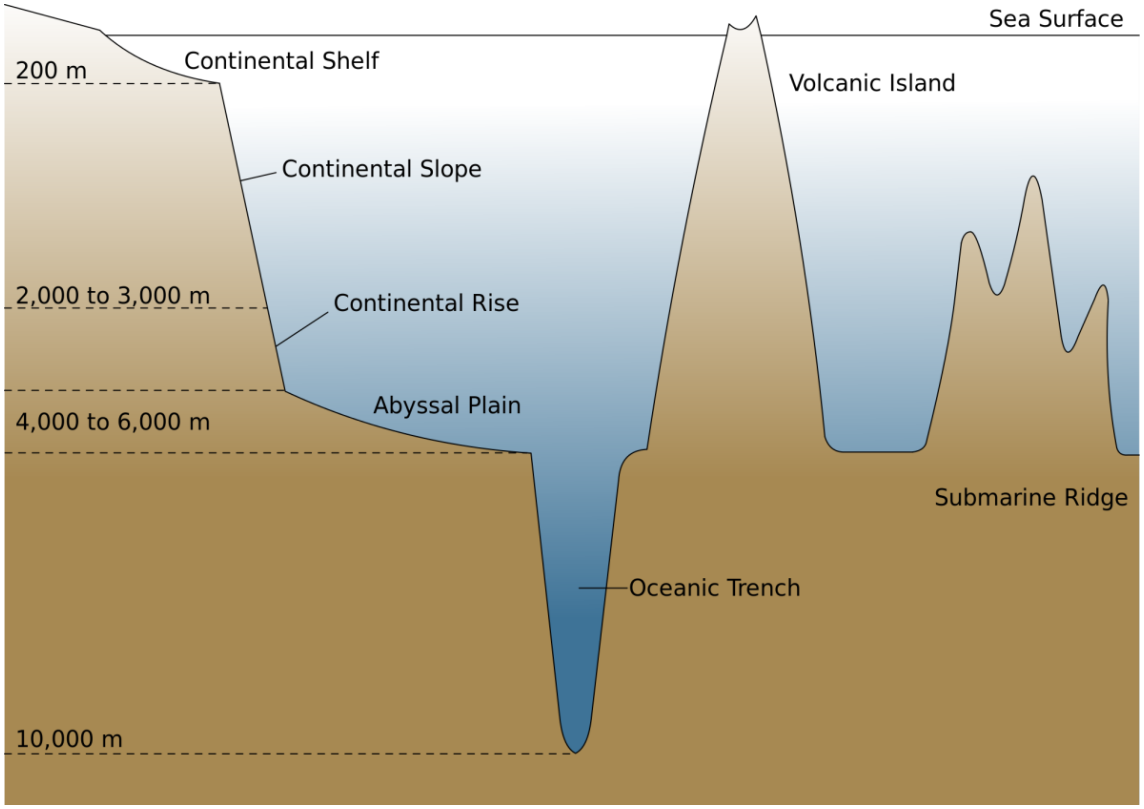
The Water Budget

- **Water Budget** = total amount of water contained in and on the planet.
- 97% of all water on Earth is in the oceans.
- The amount of water in the oceans controls **sea level**.
  - Sea level = the point where the ocean surface touches shore.



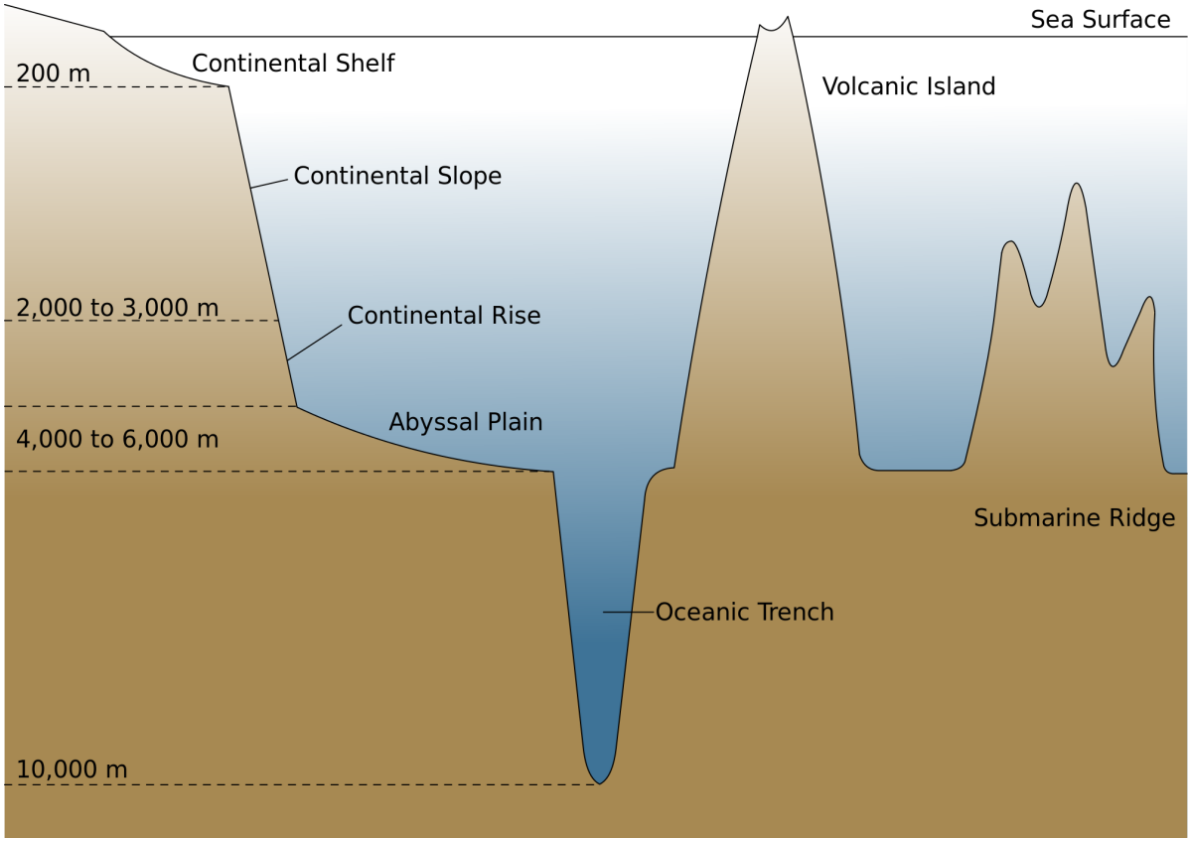
Ocean Basin

- Continental shelf: shallow, gently sloping from shore; extends out until depth of 200m
- Continental slope: abrupt drop of sea floor down 2000-3000m
- Continental rise: flattening out of slope



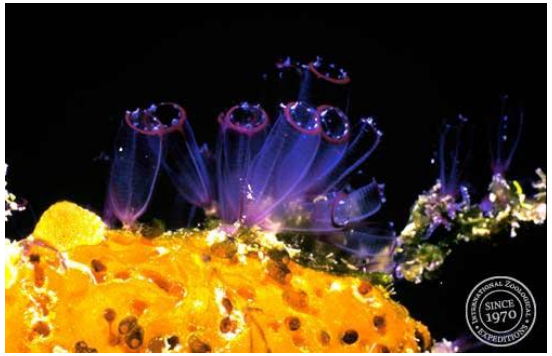
Ocean Basin

- Abyssal plain: flat, soft ocean bottom, 3000-5000m deep; 76% of ocean floor is here.
- Trench: narrow canyon, 3-4km deep
- Mid-ocean ridge: underwater mountain chain.



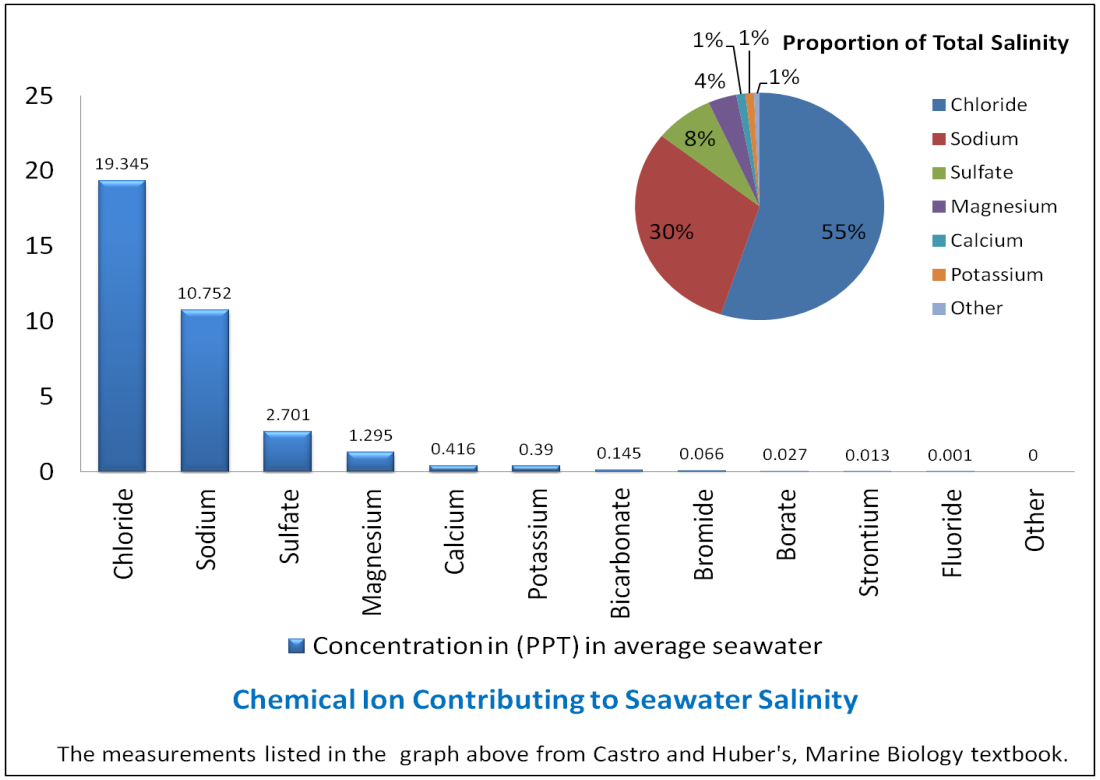
Ocean Environmental Conditions

- Water accounts for about 80-90% of the volume of most marine creatures' bodies!
- Properties of water:
  1. Salinity
  2. Temperature
  3. Density
  4. Buoyancy
  5. Oxygen
  6. CO_2
  7. Pressure



Salinity

- Salinity = total amount of salt dissolved in water.
- The average salinity of the ocean is about **3.5% (35ppt)**
- **Sodium and chloride** are most abundant (85%), but many ions are present.

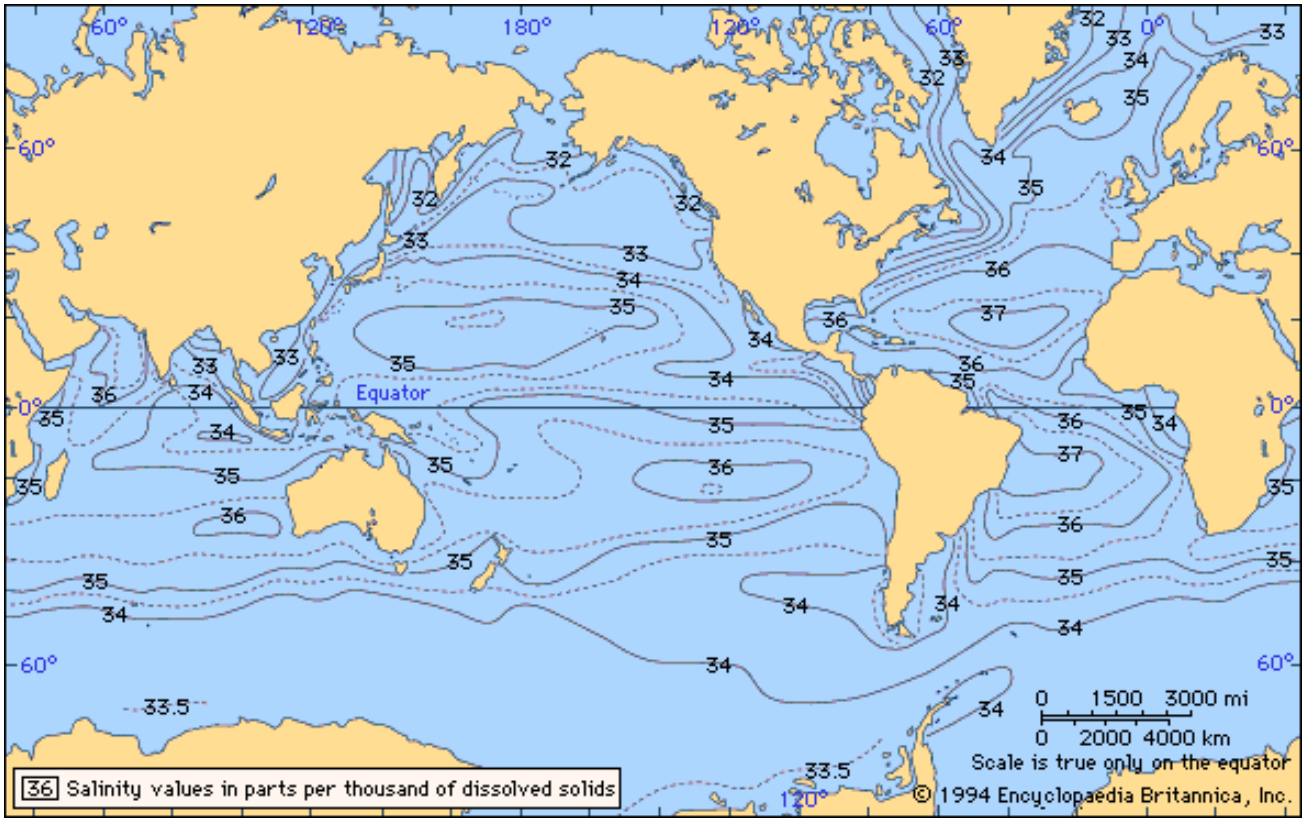


Chemical Ion Contributing to Seawater Salinity

The measurements listed in the graph above from Castro and Huber's, Marine Biology textbook.

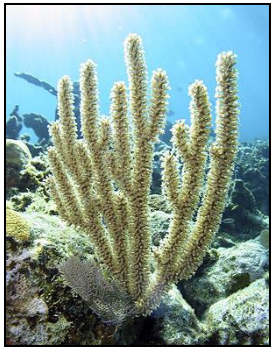
Salinity: Surface Variations

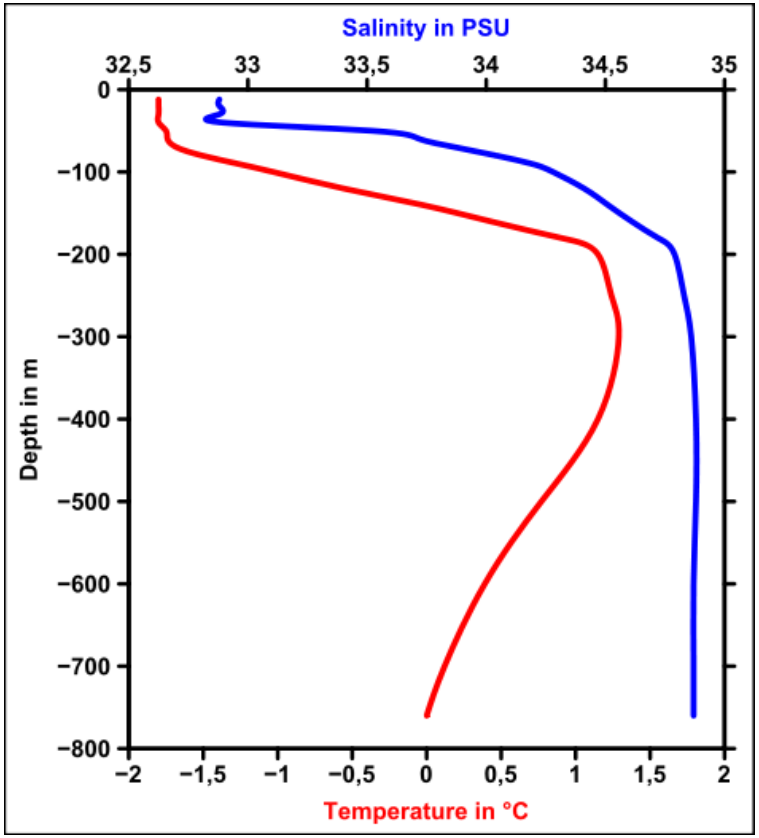
- High evaporation rates leave salt behind →higher salinity.
- High rainfall → lower salinity.
- Where a river or stream enters the ocean, the salinity of the nearby ocean is less.



Salinity: Species Adaptations

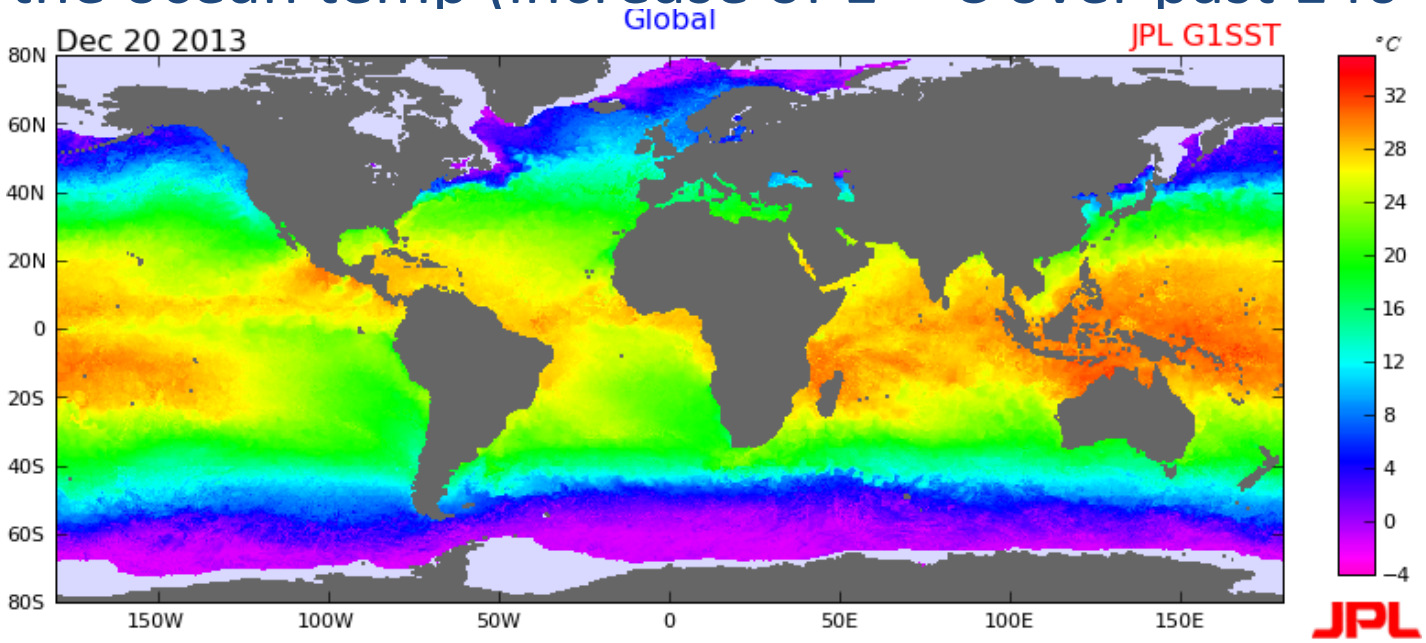
- **Eury**haline Species: organisms that CAN tolerate a wide range of salinity changes. Well adapted to estuaries (mixed water).
  - –Clams, oysters, crabs.
- **Steno**haline Species: organisms that can't tolerate a wide range of salinity changes. Not able to live in an estuary – must live in either SW or FW enviros.
  - –Corals, reef fishes prefer 30ppt
  - –Frogs, goldfish prefer 0ppt (freshwater)





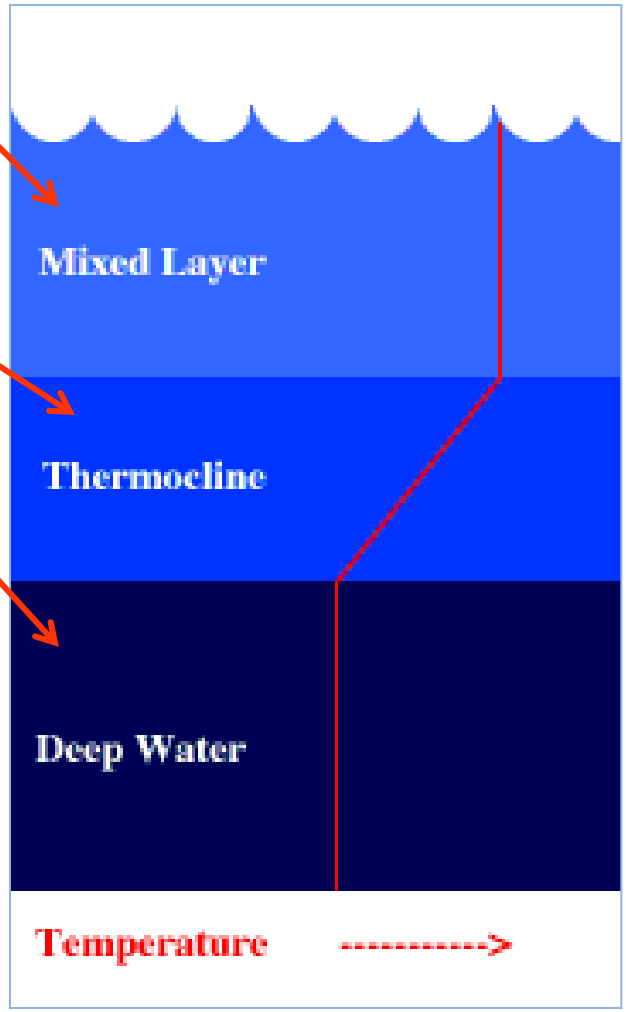
Temperature

- Terrestrial environments: very large range of temperatures.
- Marine environments: much less of a range in temperature – ranges with region (tropics; temperate regions; polar regions)
- Surface temperatures may range from warm tropical water at 30° C to an ice-covered surface in the polar regions.
- Global climate change: overall increase in temperature has impacted the ocean temp (increase of 1° C over past 140 yrs.)



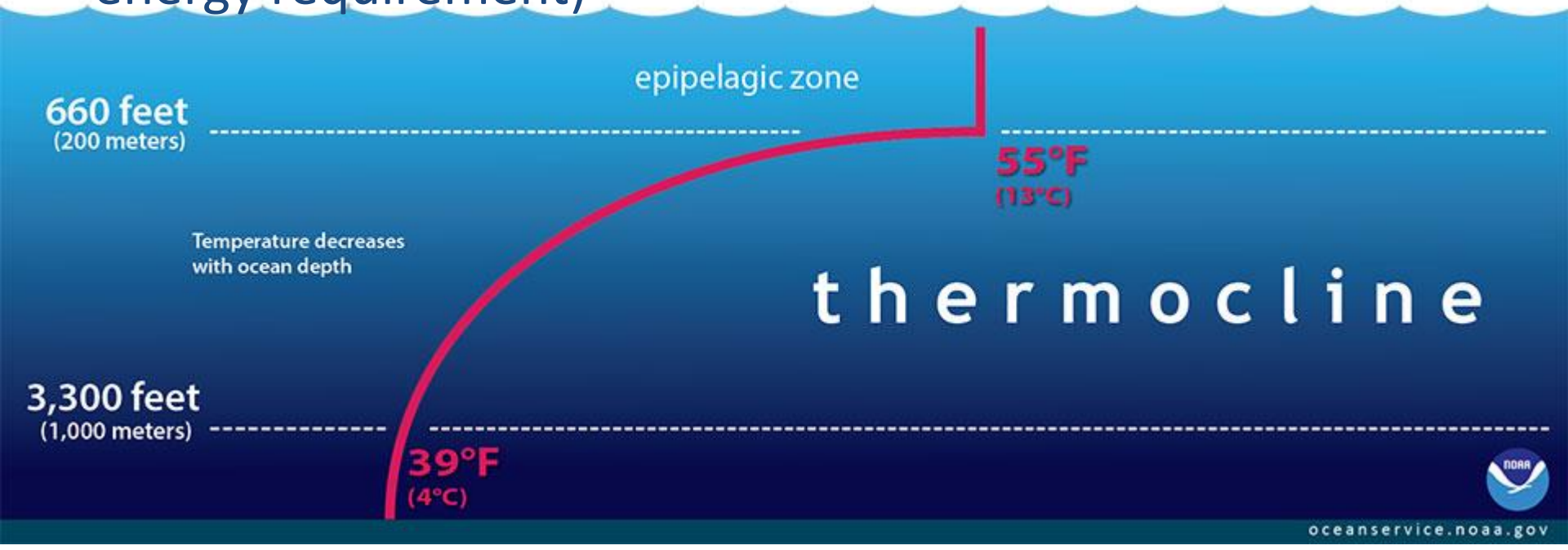
Temperature: thermocline

- Epipelagic zone: sunlight zone, water is warmer – mixed by winds and waves.
- Thermocline: transition layer between warmer, mixed surface water and colder, deeper water. **Temperature declines** with increasing depth.
- **Topics**: semi-permanent thermocline; starts around 100m depth.
- **Temperate regions**: seasonal thermoclines (strong in summer, less evident in fall and winter).
- **Polar regions**: almost non-existent.



Temperature: thermocline

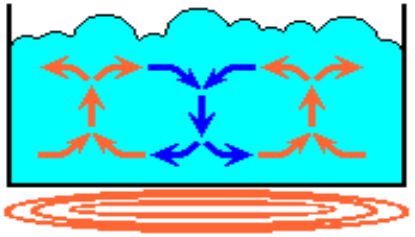
- Animals are adapted to specific temperature ranges:
  - Endothermic (warm-blooded) or ectothermic (cold-blooded)
  - Can affect how food is found, migrations, timing of reproduction
  - Metabolic activity increases with temperature (as does energy requirement)

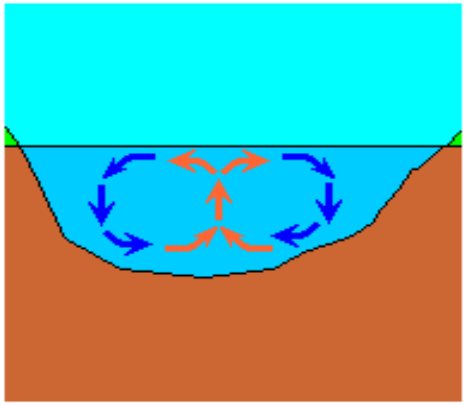


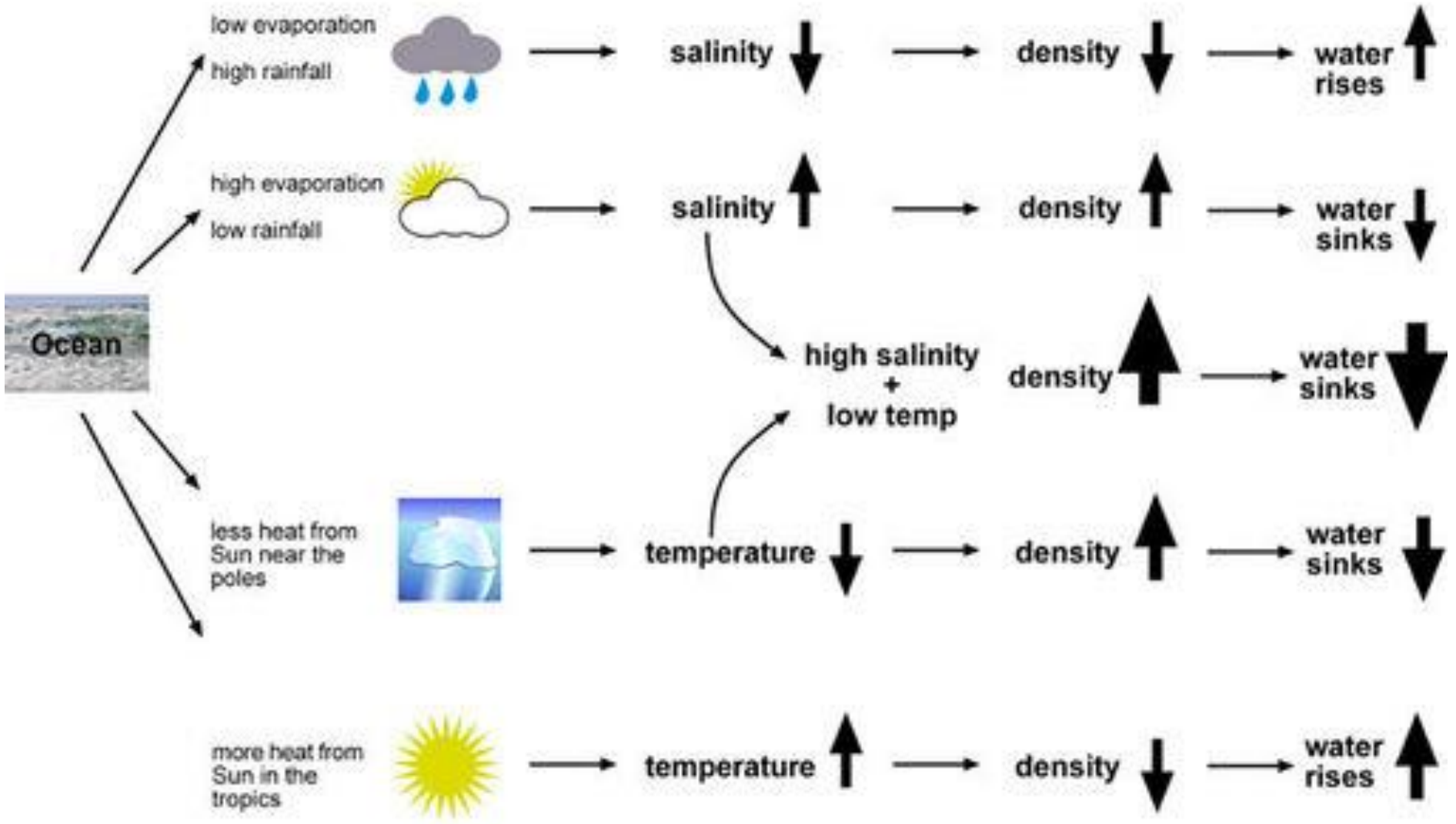
Density

- **Mass per unit volume** (mass ÷ volume)
- **Saltwater** is more dense than freshwater, because the ions give it mass.
- Temperature: cold water is more dense than warm water
  - molecules are “less excited”, are closer together and tend to sink to the bottom of the ocean.
- Salinity: as salinity increases, the density of the water increases.

There is a higher salinity in cold water, and a lower salinity in warm water.






low evaporation
high rainfall
salinity
density
water rises
high evaporation
low rainfall
salinity
density
water sinks
Ocean
high salinity + low temp
density
water sinks
less heat from Sun near the poles
temperature
density
water sinks
more heat from Sun in the tropics
temperature
density
water rises

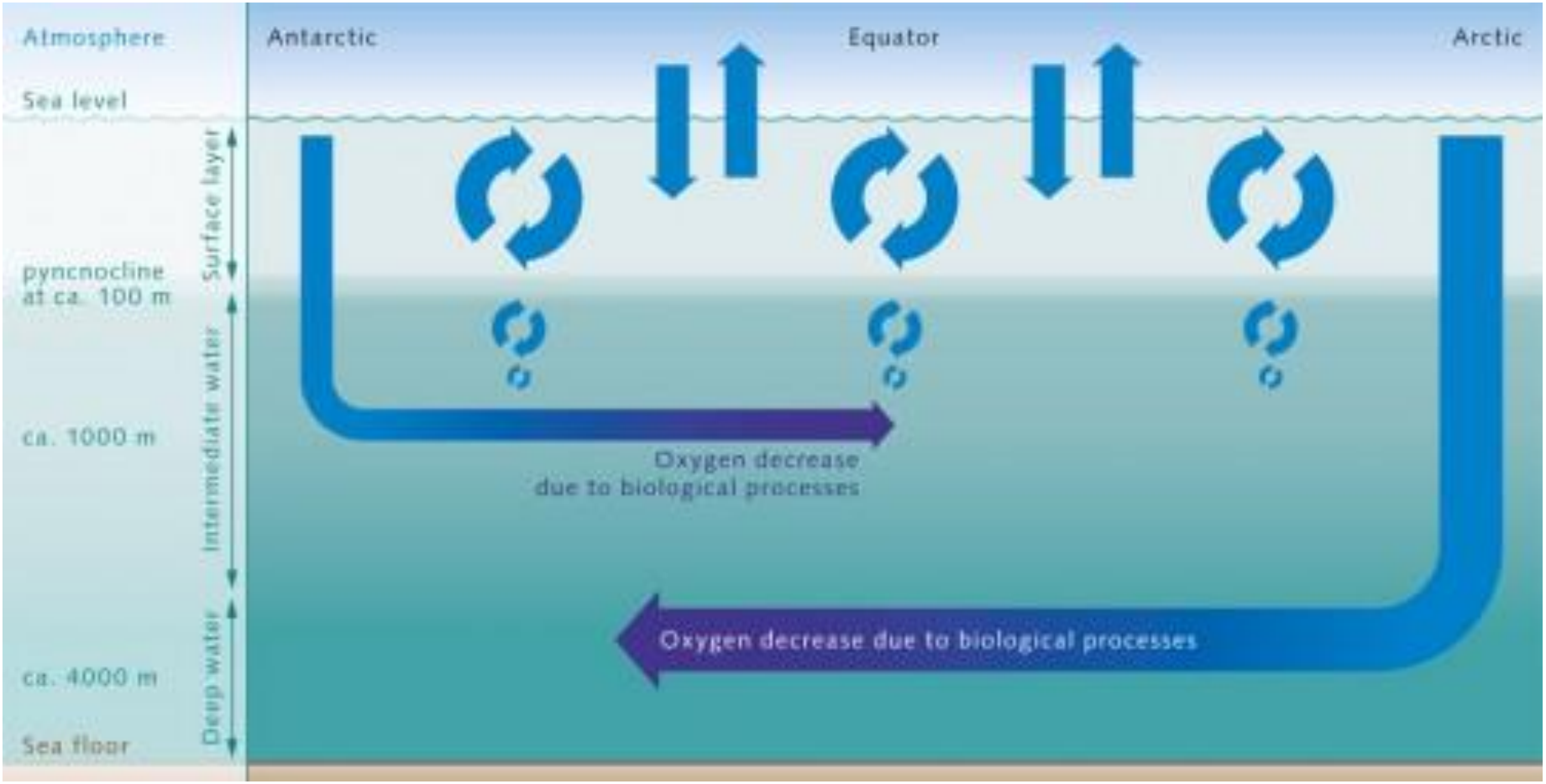
Buoyancy

- **the ability of an object to float in a liquid**
  - Buoyancy is an upwards force that supports floating objects.
- Dependent upon density of the object and the liquid
  - Objects **more dense** than ocean water **sink** (ex: rocks)
  - Objects **less dense** than ocean water **float** (ex: cork)
- If the average density of an object is less than ocean water, it will float (ex: a ship)
- Objects float more easily in saltwater
  - ships float higher or lower in the water, depending on the density of the ocean

Oxygen in Water

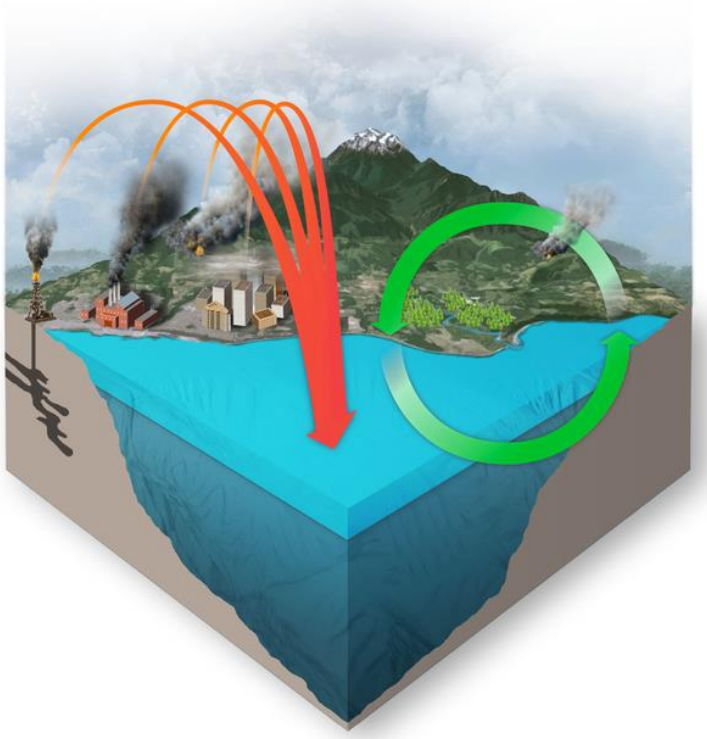
- Dissolved Oxygen (DO) = oxygen dissolved in water.
- Measured in parts per million (ppm)
- Temperature: as temp decreases, oxygen levels increase.
  - 20^oC = 5.4mL; 0^oC = 8mL
- Oxygen levels in water are highest between 10-20m depth
  - Photosynthesis produces oxygen, some dissolves in water, some is released into atmosphere.
  - Oxygen also enters water from atmosphere.
- As you go deeper in the ocean, DO decreases.
  - Little to no oxygen as you near the bottom.
- Oxygen levels increase at the sea floor
  - Oxygen dissolves better in colder water.
  - Colder water: metabolic rates and requirements are much lower.

Oxygen in Water



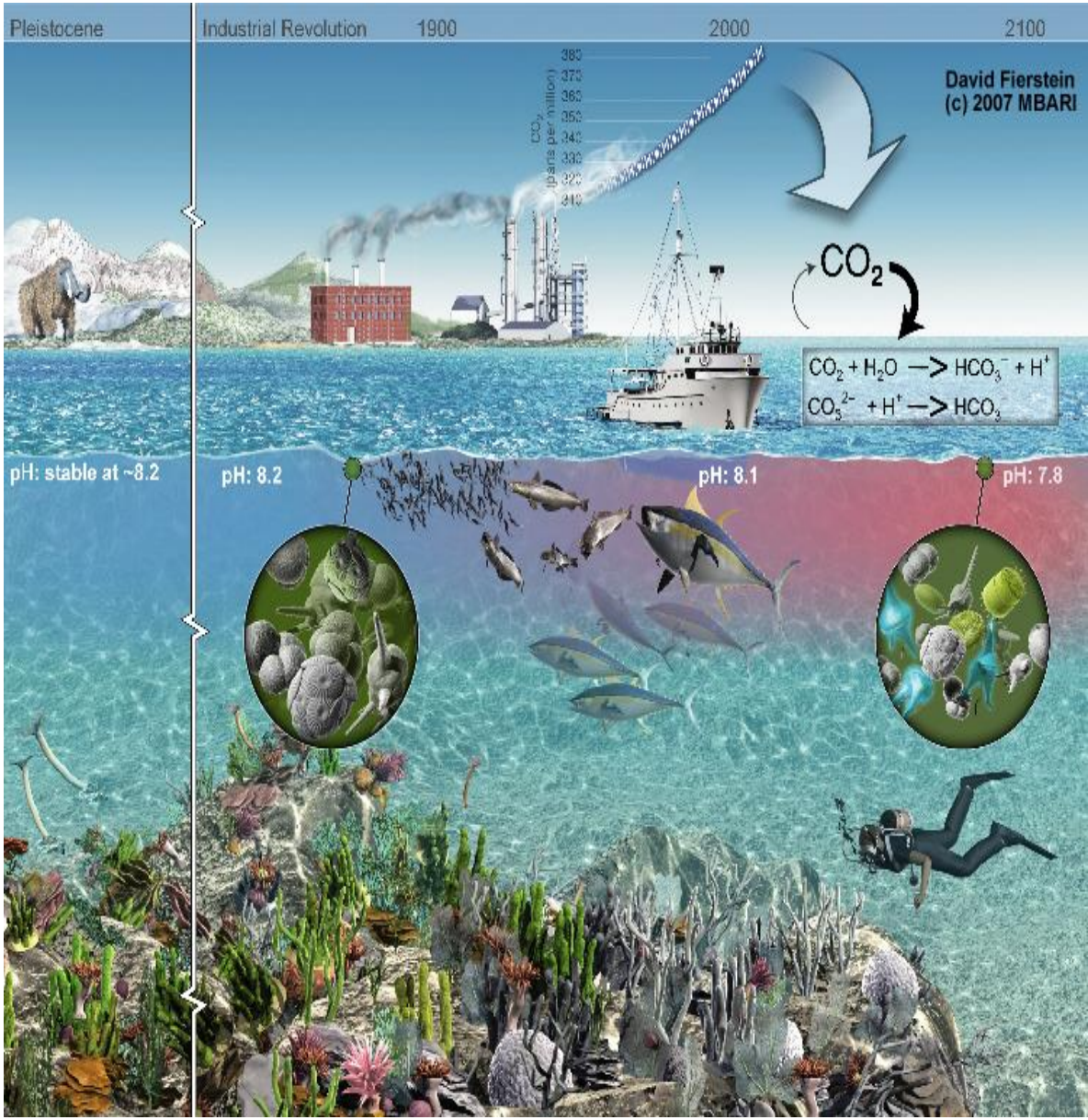
Carbon Dioxide in Water

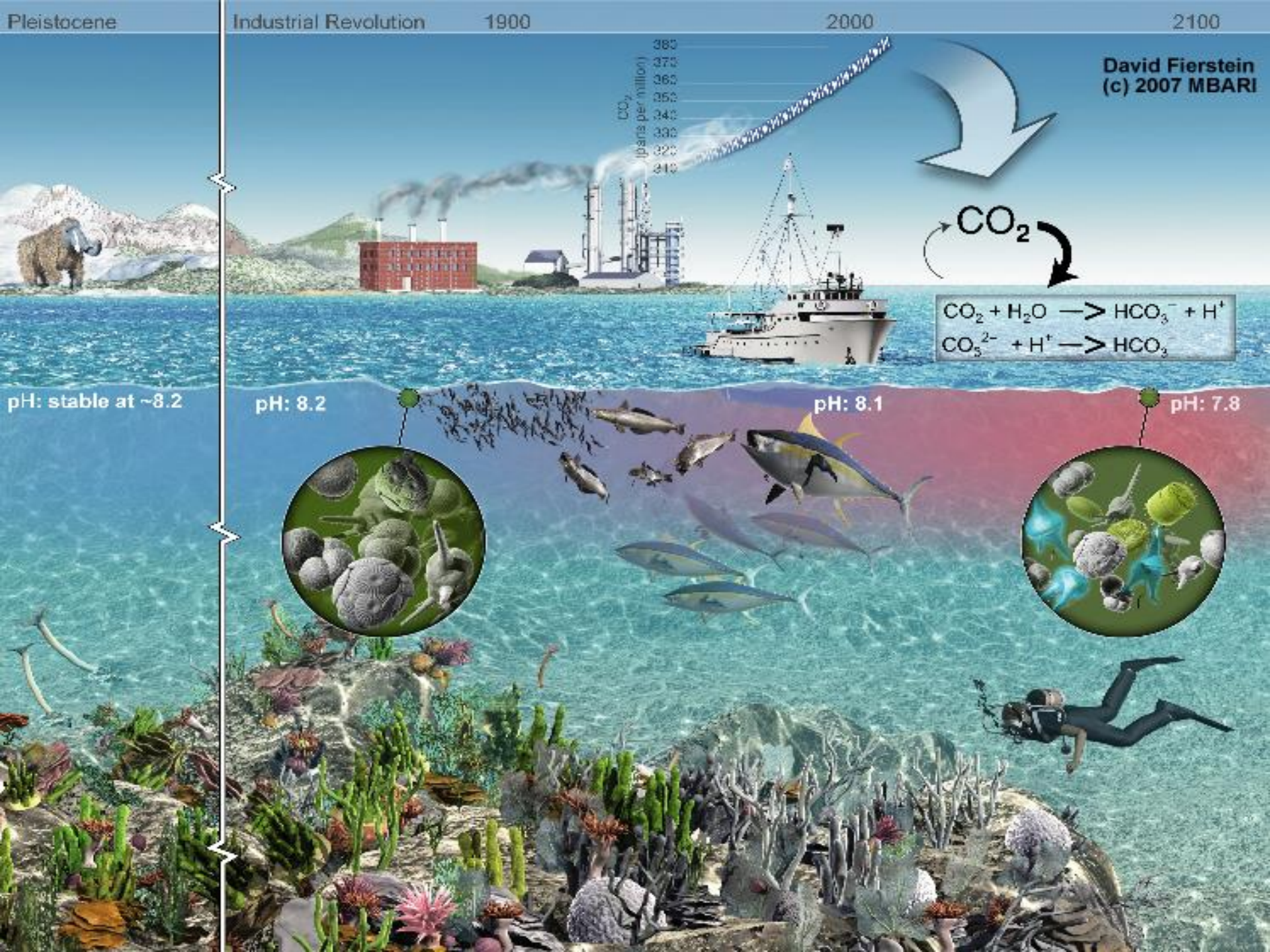
- Carbon dioxide (CO_2) is cycled in the ocean through photosynthesis and respiration by organisms, decay of organisms.
- When there is too much CO_2 being absorbed into the ocean, it can affect organisms and their environment in many ways.
- When CO_2 mixes with water, it forms carbonic acid – this increases the acidity of the water.
- Carbonate ions become less and sea shells need these ions to build their shells.
- 30–40% of the CO_2 released by humans into the atmosphere dissolves into water bodies.



Carbon Dioxide in Water

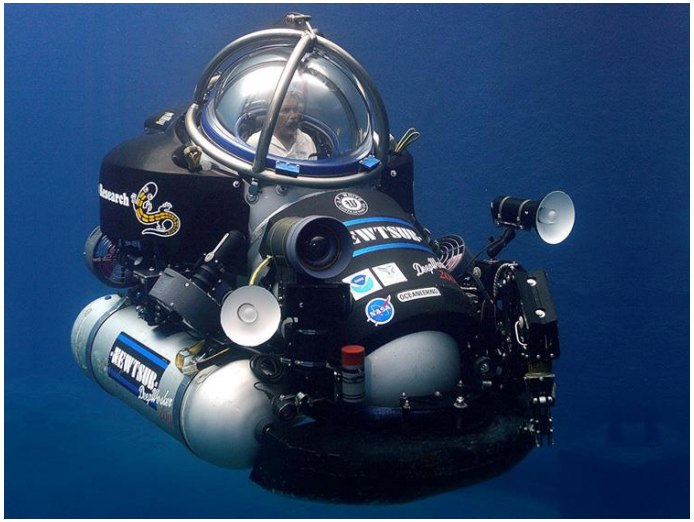
- Ocean pH is held stable around 8.2.
- Calcium carbonate in sea shells and coral acts as a buffer to maintain the pH.
- When the acidity of the ocean increases, coral has trouble building and recovering from disturbance.
- Shelled organisms are put at risk with higher acidity.



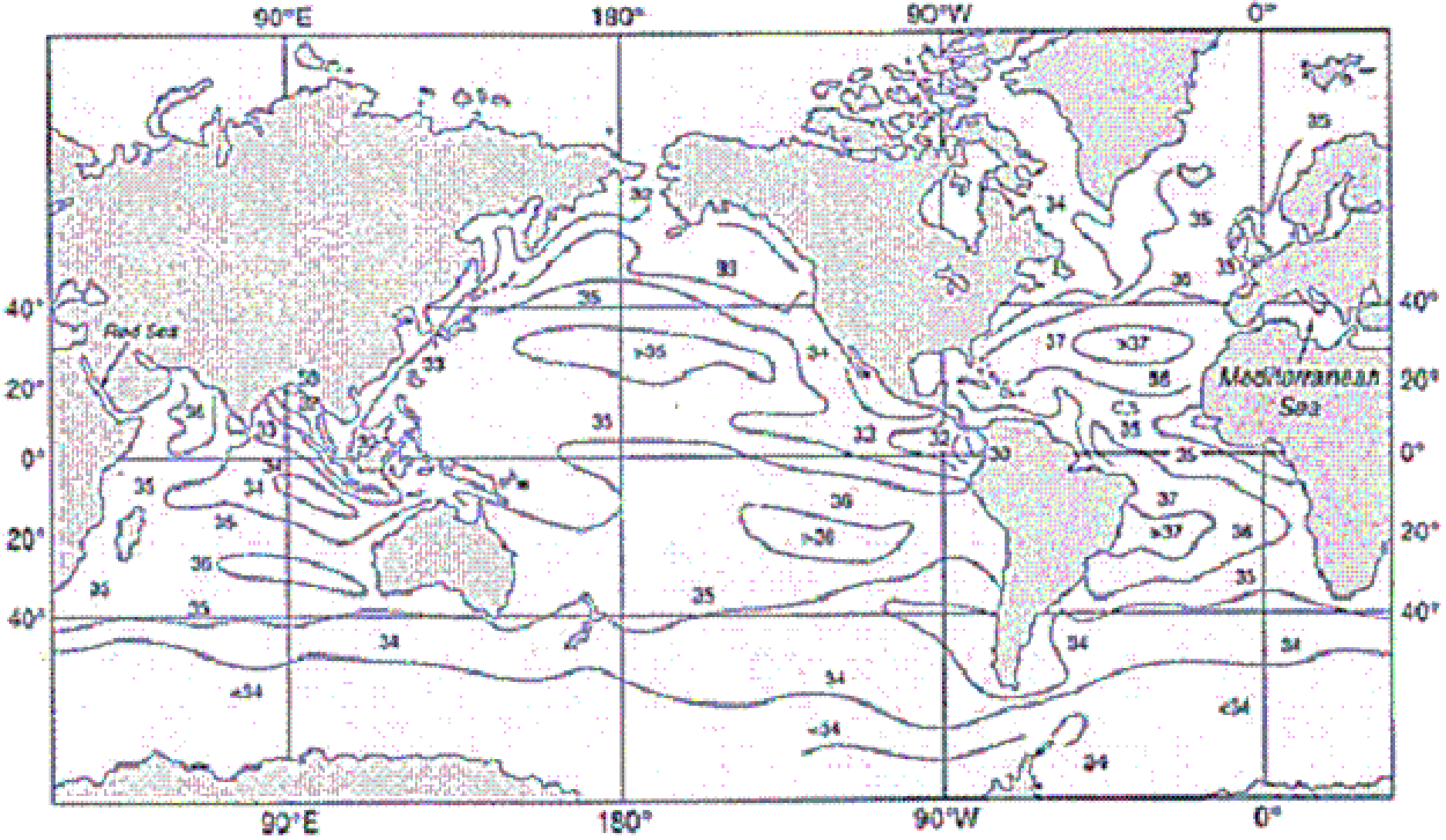

Pleistocene
Industrial Revolution
1900
2000
2100
David Fierstein
(c) 2007 MBARI
CO_2
$CO_2 + H_2O \rightarrow HCO_3^- + H^+$
$CO_3^{2-} + H^+ \rightarrow HCO_3$
pH: stable at ~8.2
pH: 8.2
pH: 8.1
pH: 7.8

Pressure

- Water has weight
- Pressure increases with depth since there is more water exerting a force on top of an object.
- Some organisms are well adapted to changes in pressure
  - With increased pressure, air-filled spaces in organisms can collapse
  - As pressure decreases, air-filled spaces will expand
- Many deep sea organisms lack internal spaces that are sensitive to high pressure.



Benthothuria sp.


90°E
180°
90°W
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40°
20°
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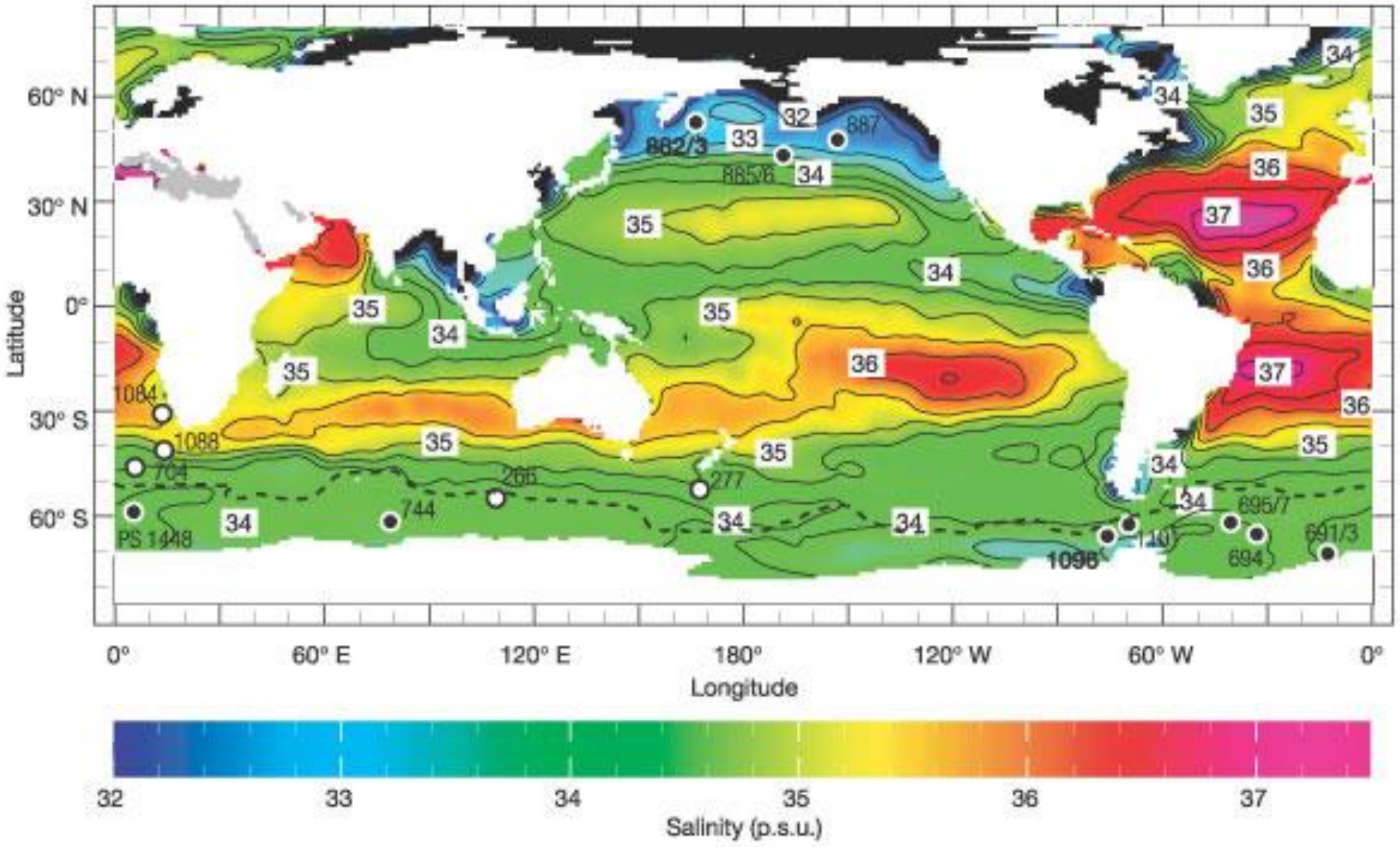
20°
40°
Red Sea
Mediterranean Sea
90°E
180°
90°W
0°


60° N
30° N
0°
30° S
60° S
Latitude
0°
60° E
120° E
180°
120° W
60° W
0°
Longitude
882/3
887
885/6
1084
1088
704
PS 1418
744
266
277
1096
695/7
694
691/3
32
33
34
35
36
37
Salinity (p.s.u.)