

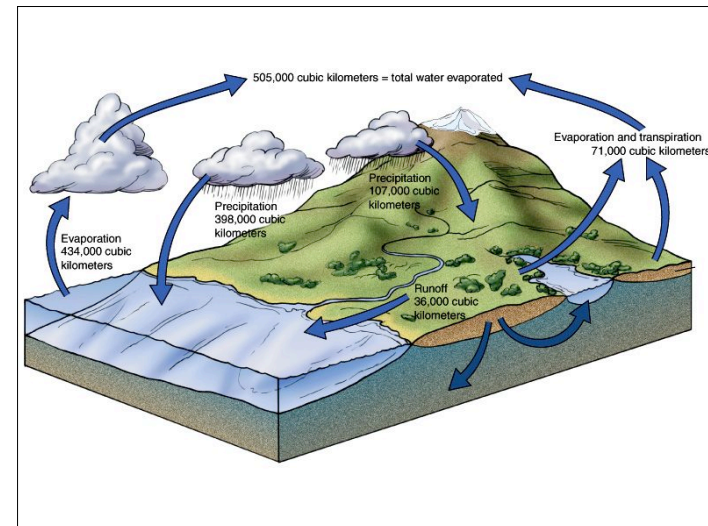
CHAPTER 6 - WATER (even more!)

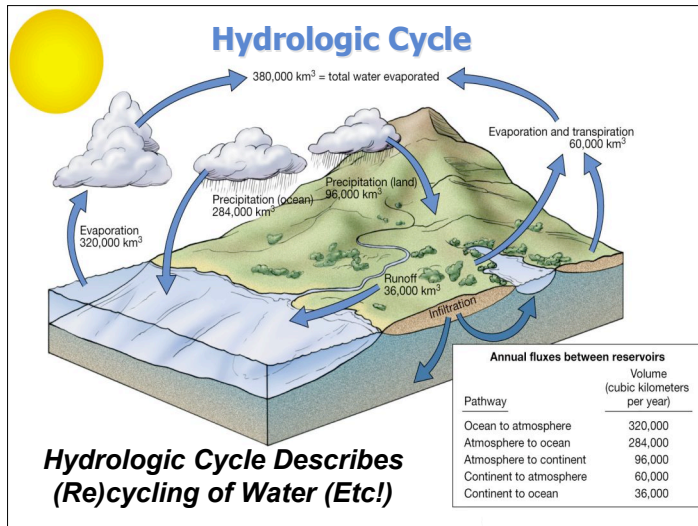
Review of Some Important Concepts

- Water is a polar molecule with the ability to dissolve more substances than any other natural solvent.
- Salinity is the measure of dissolved inorganic solids in water. Salinity can be expressed as a percent (%), but is more commonly expressed as “parts per thousand” (‰). Average ocean water salinity is about 3.5%, which equals 35 ‰.
- The most abundant ions dissolved in seawater are chloride, sodium, and sulfate. The proportions of dissolved ions in seawater is nearly the same everywhere.
- The most abundant dissolved gases in sea water are nitrogen, oxygen, and carbon dioxide. Oxygen and carbon dioxide levels are controlled mostly by the photosynthesis and/or respiration by marine organisms.
- Carbonate buffering keeps ocean pH ≈ 8 (slightly alkaline).

Outline

1. What's in seawater?
2. Salinity and solutions
3. Salinity factors
4. Dissolved gasses & the concept of pH
- 5. Residence time**
- 6. Variations in surface seawater**
- 7. S, T, P, and ρ (“the clines”)**





5. Residence Time*

= Average length of time a substance spends (remains dissolved) in seawater

$$\text{Residence Time} = \frac{\text{Amount of element in the ocean}}{\text{The rate at which the element is added to or removed from the ocean}}$$

- **Long r.t. = Unreactive**
⇒ Higher concentration in seawater
- **Short r.t. = Reactive**
⇒ Smaller concentration in seawater

*Residence time of water = Average length of time a water molecule remains in a particular reservoir -- e.g., ocean, atmosphere, etc.

Approximate Residence Times for Constituents of Seawater	
Constituent	Residence Time (years)
Chloride (Cl ⁻)	100,000,000
Sodium (Na ⁺)	68,000,000
Magnesium (Mg ²⁺)	13,000,000
Potassium (K ⁺)	12,000,000
Sulfate (SO ₄ ²⁻)	11,000,000
Calcium (Ca ²⁺)	1,000,000
Carbonate (CO ₃ ²⁻)	110,000
Silicon (Si)	20,000
Water (H ₂ O)	4,100
Manganese (Mn)	1,300
Aluminum (Al)	600
Iron (Fe)	200

Sources: Data from Broecker and Peng, 1982; Bruland, 1983; Riley and Skirrow, 1975.

Conservative & Nonconservative Constituents

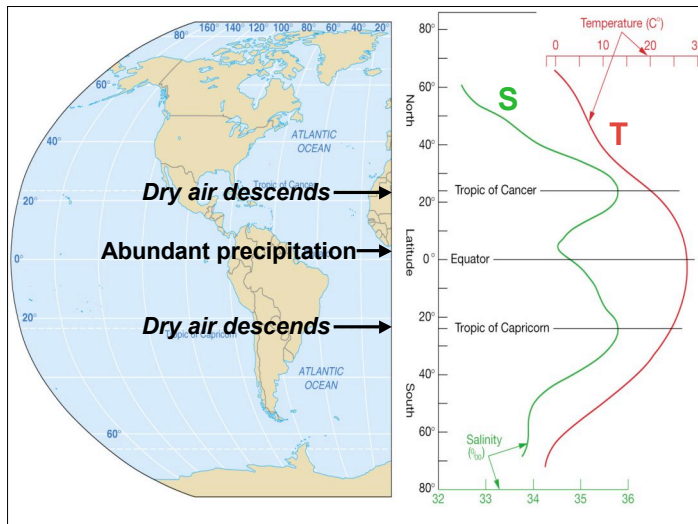
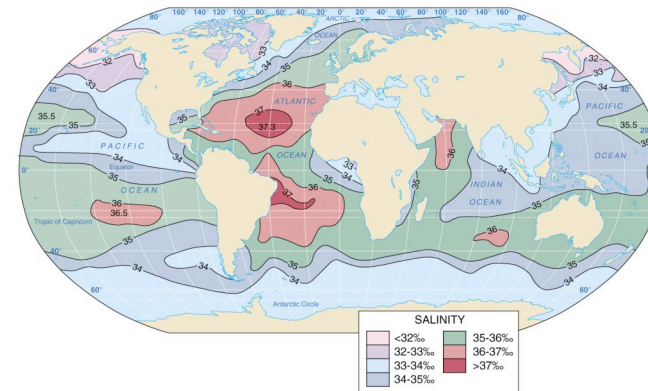
- **Conservative constituents**
 - Long residence times
 - Concentrations change slowly through time
 - Occur in constant proportions
 - Are the most abundant dissolved materials (major ions) in the ocean
- **Nonconservative constituents**
 - Short residence times
 - Concentrations change quickly through time
 - Usually seasonal, biological, or short geological or chemical cycles
 - Gases in seawater

Steady State

Is the salinity of the ocean changing over time?

- No, the ocean appears to be in **chemical equilibrium**
- The proportion and amounts of dissolved solids remain constant over time
- This concept is known as the “**steady-state ocean**”
- Ions are added to and removed from the ocean at about the same rates, so salinity stays about the same

6. Variations in Surface Salinity



Horizontal Variations of Salinity

- **Polar regions (high latitudes)**
 - Salinity is lower, lots of rain/snow and runoff
- **Mid-latitudes**
 - Salinity is high, high rate of evaporation
- **Near equator (low latitude)**
 - Salinity is lower, lots of rain
- **Salinity at the surface of the ocean varies primarily with latitude**

7. S, T, P, and ρ (“the clines”)

How are salinity, temperature, pressure, and density related?

How do they affect each other in ocean water?

“The clines” = Rapid change of ___ with depth:

- Pycnocline (ρ)
- Thermocline (T)
- Halocline (S)

Seawater Density

- Seawater is 2%-3% denser than freshwater
 - Density of pure water 1.000 g/cm³
 - Density of seawater 1.020 to 1.030 g/cm³
- The density is mainly a function of T and S
 - Cold, salty water *denser* than warm, less-salty water
 - Can have 2 samples with same ρ by different combinations of S & T

Temperature, Salinity, Density

The graph shows us that water becomes **denser** when:

- T goes down
and/or
- S goes up

In other words, **cold** water is denser than warm water, and **saltier** water is denser than less-salty water

Remember, denser stuff sinks → Ocean is layered by density

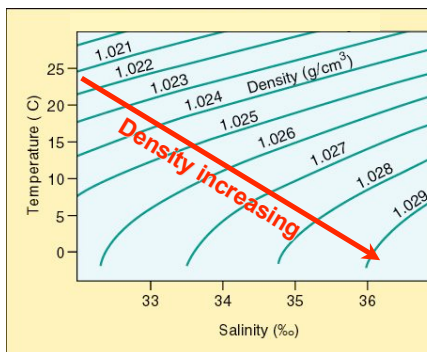
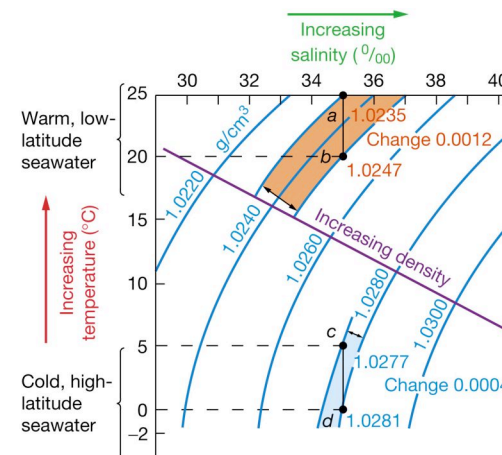


Fig. 6.18, p. 135



Density Structure of the Ocean

1. **Surface zone (mixed layer)** – Contains the least-dense water. T & S are mixed by waves and currents. In contact with atmosphere and exposed to sunlight. On average, extends to ~150 meters depth.
2. **Pycnocline** – *Density increases dramatically with depth here.* Extends to ~1000 meters depth. Acts as barrier to mixing between surface zone and deep zone.
3. **Deep zone** – Little change in density throughout this layer.

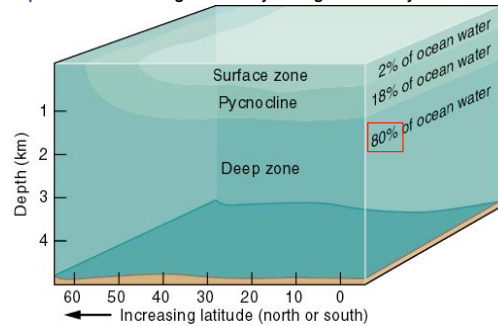


Fig. 6.19a, p. 136

Thermocline

Since temperature is the primary control on ocean density, the pycnocline generally corresponds to a **thermocline** = a zone of rapid decrease in water temperature with depth.

Note that a thermocline exists in the temperate and tropical ocean areas, but *not* in polar oceans, which are cold from top to bottom.

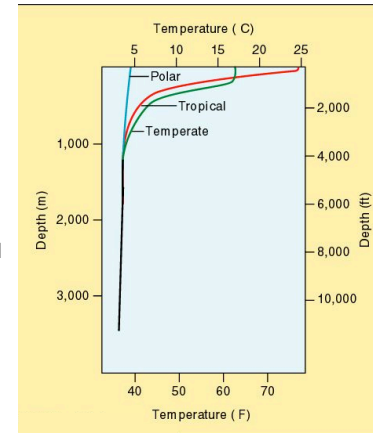
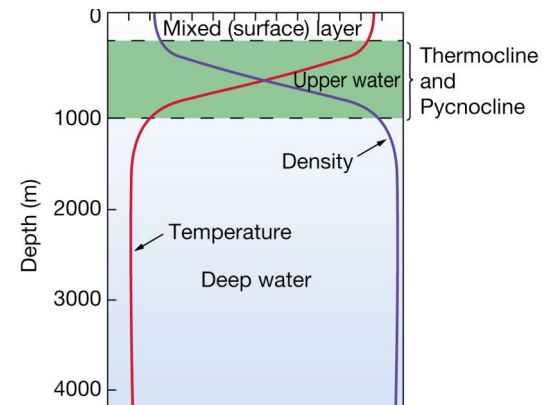
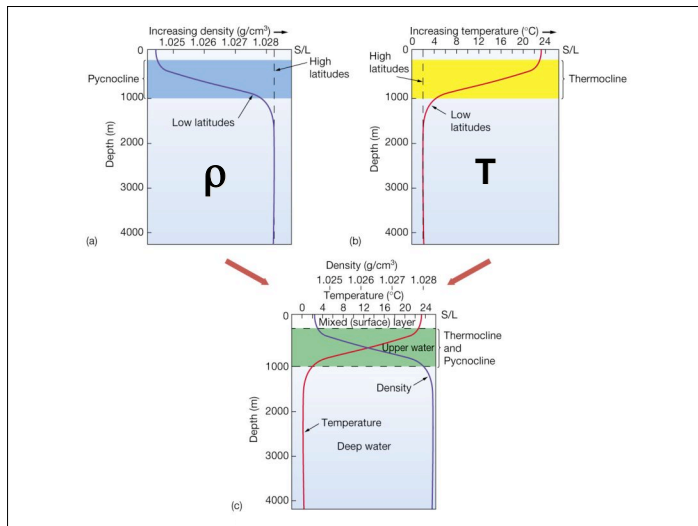


Fig. 6.20, p. 136



Halocline

- **Surface ocean salinity is variable** (by latitude, river inputs, etc)
- **Deeper ocean salinity is quite uniform** (polar source regions for deeper ocean water)
- **Halocline between them**
- **Polar ocean is isothermal** (all about the same T...cold!) → **Salinity is the greatest influence on density in polar oceans**

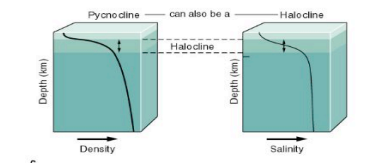
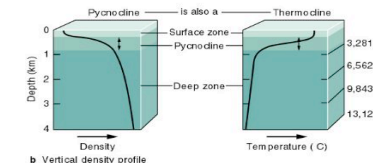
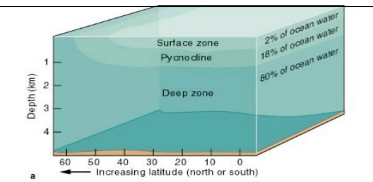
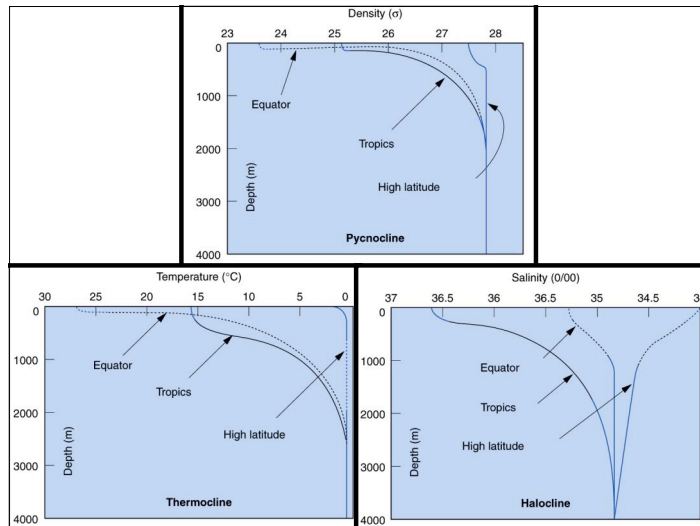
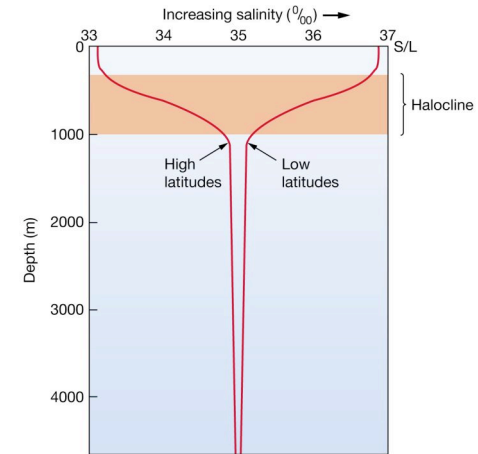


Fig. 6.19, p. 136

“ 5-Minute Write ”

Summarize the main points of today's lecture.

List 3 to 5 questions you have, based on today's lecture.

What did you find most interesting about today's lecture?

How was the lecture relevant to you?

Increased salinity decreases the temperature of maximum density

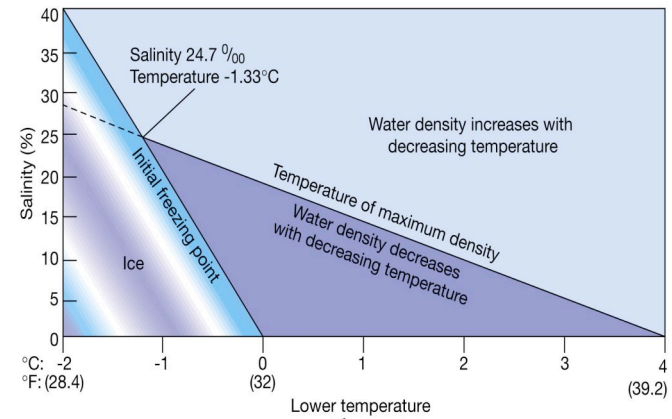


TABLE Comparison of selected properties of pure water and seawater.

Property	Pure water	35 ₀₀ ⁰ seawater
Color (light transmission)		
· Small quantities of water	Clear (high transparency)	Same as for pure water
· Large quantities of water	Blue-green because water molecules scatter blue and green wavelengths best	Same as for pure water
Odor	Odorless	Distinctly marine
Taste	Tasteless	Distinctly salty
pH	7.0 (neutral)	8.1 (slightly alkaline)
Density at 4°C (39°F)	1.000 g/cm ³	1.028 g/cm ³
Freezing point	0°C (32°F)	-1.9°C (28.6°F)
Boiling point	100°C (212°F)	100.6°C (213°F)

