CHAPeR 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 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.

### 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.

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### 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.
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
“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?

<table>
<thead>
<tr>
<th>Property</th>
<th>Pure water</th>
<th>35% seawater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color (light transmission)</td>
<td>Clear (high transparency)</td>
<td>Same as for pure water</td>
</tr>
<tr>
<td>- Small quantities of water</td>
<td>Blue-green because water molecules scatter blue and green wavelengths best</td>
<td>Same as for pure water</td>
</tr>
<tr>
<td>Odor</td>
<td>Odorless</td>
<td>Distinctly marine</td>
</tr>
<tr>
<td>Taste</td>
<td>Tasteless</td>
<td>Distinctly salty</td>
</tr>
<tr>
<td>pH</td>
<td>7.0 (neutral)</td>
<td>8.1 (slightly alkaline)</td>
</tr>
<tr>
<td>Density at 4°C (39°F)</td>
<td>1.000 g/cm³</td>
<td>1.028 g/cm³</td>
</tr>
<tr>
<td>Freezing point</td>
<td>0°C (32°F)</td>
<td>−1.9°C (28.6°F)</td>
</tr>
<tr>
<td>Boiling point</td>
<td>100°C (212°F)</td>
<td>100.6°C (213°F)</td>
</tr>
</tbody>
</table>

Increased salinity decreases the temperature of maximum density.

Salinity 24.7 %
Temperature -1.33°C

Water density increases with decreasing temperature.

Temperature of maximum density with decreasing temperature.

Increased salinity decreases the temperature of maximum density.