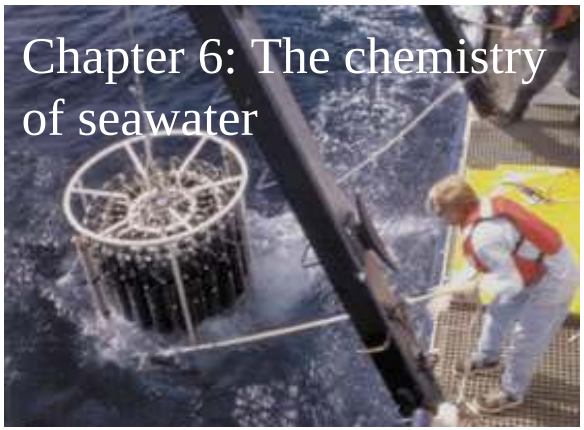
Chapter 6: The chemistry of seawater



- The water molecule
- Ocean salinity and the principle of constant proportion
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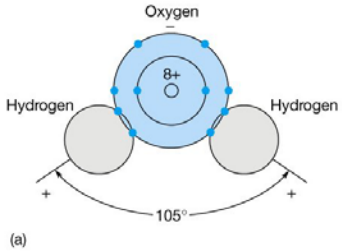
The water molecule

- Composed of 1 oxygen and 2 hydrogen atoms (H_20)
- Contains strong (covalent) bonds between atoms
- Unusual bend in geometry
- Has polarity (oppositely charged ends)



Interconnections of water molecules

See Table 6-1

- Polarity causes water molecules to form weak (hydrogen) bonds between water molecules
- Water sticks to itself and to other substances (adhesion)
- Allows water to be the universal solvent

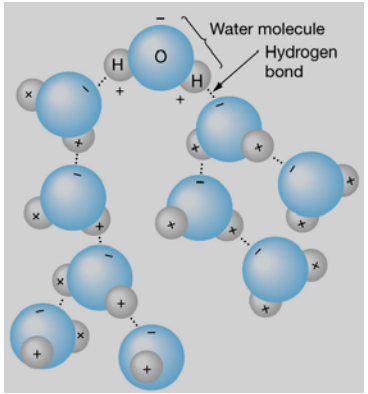
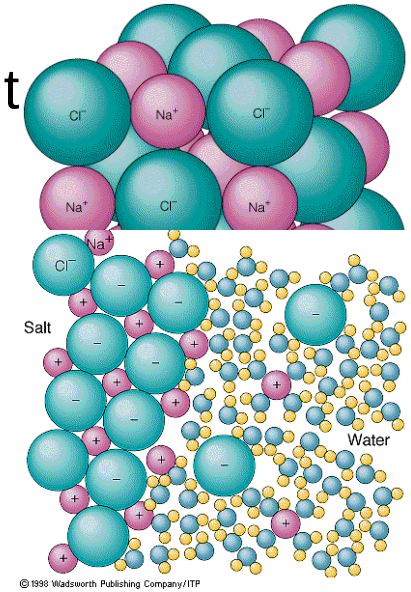


Figure 6-3

Water as a solvent

- Water dissolves table salt (NaCl) by attaching to oppositely charged particles
- Ions are surrounded by water molecules "hydration sphere"



Given enough time, water can dissolve more substances and in greater quantity than any known substance. **Note: substance has to be polar**

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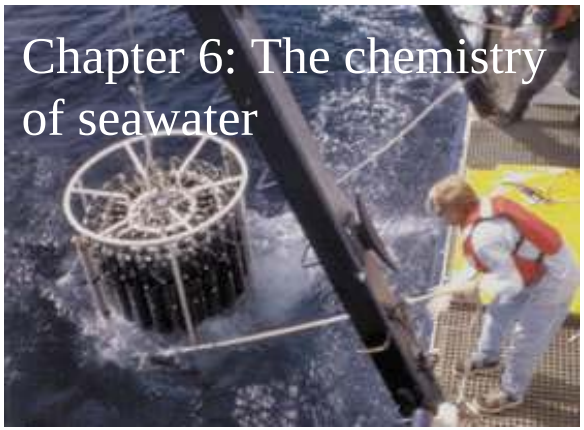

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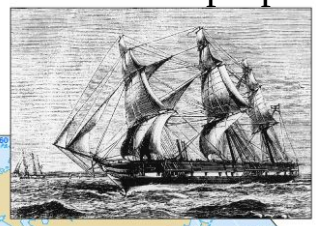
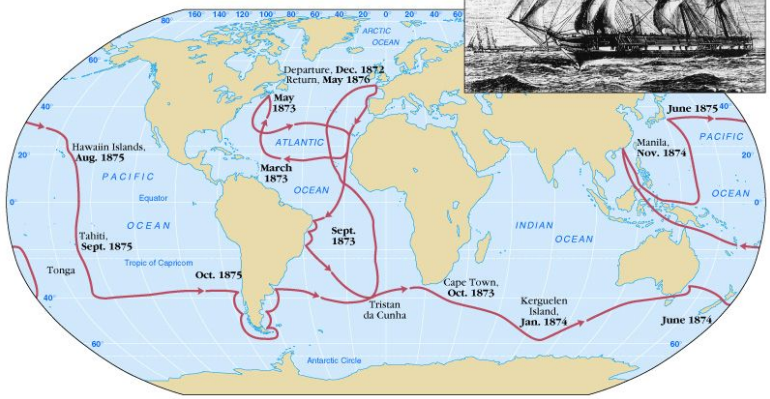
Seawater salinity: The principle of constant proportions

The Challenger expedition (1872-1876)
C. Wyville Thomson, chief scientist

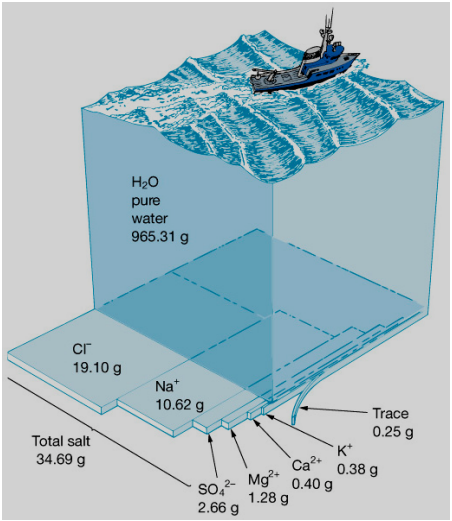


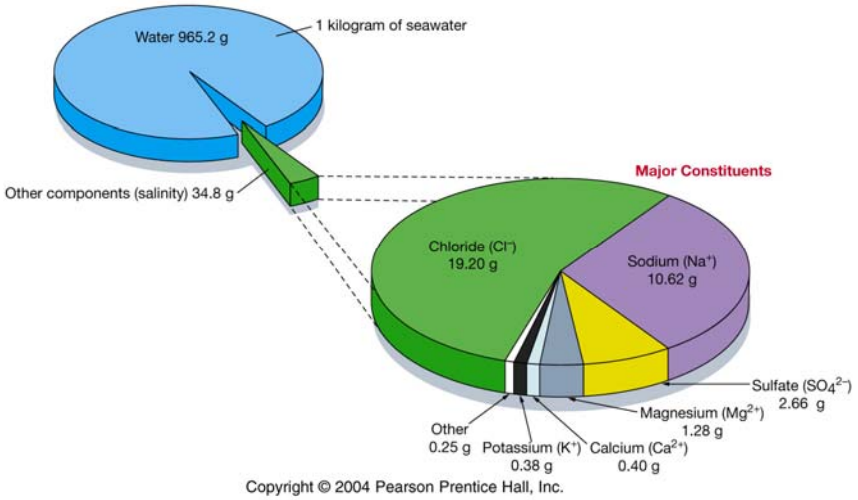


William Dittmar coined by analysis of the chemical composition of seawater samples collected on the Challenger expedition the 'Principle of Constant Proportions' (constant chemical composition of seawater despite varying salinity).

Constituents of ocean salinity

- Average seawater salinity = 35‰
- Main constituents of ocean salinity:
  - Chloride (Cl^-)
  - Sodium (Na^+)
  - Sulfate (SO_4^{2-})
  - Magnesium (Mg^{2+})
  - Calcium (Ca^{2+})
  - Potassium (K^+)
  - Bicarbonate (HCO_3^-)

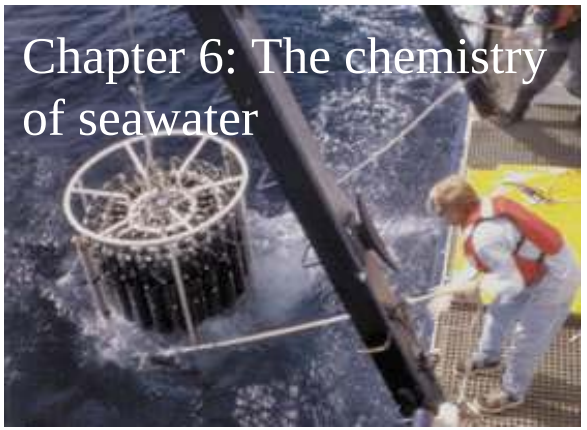




Representation of the most common components of a liter of seawater at 35‰ salinity.

Salinity variations

Location/type	Salinity
Normal open ocean	33-38‰
Baltic Sea	10‰ (brackish)
Red Sea	42‰ (hypersaline)
Great Salt Lake	280‰
Dead Sea	330‰
Tap water	0.8‰ or less
Premium bottled water	0.3‰



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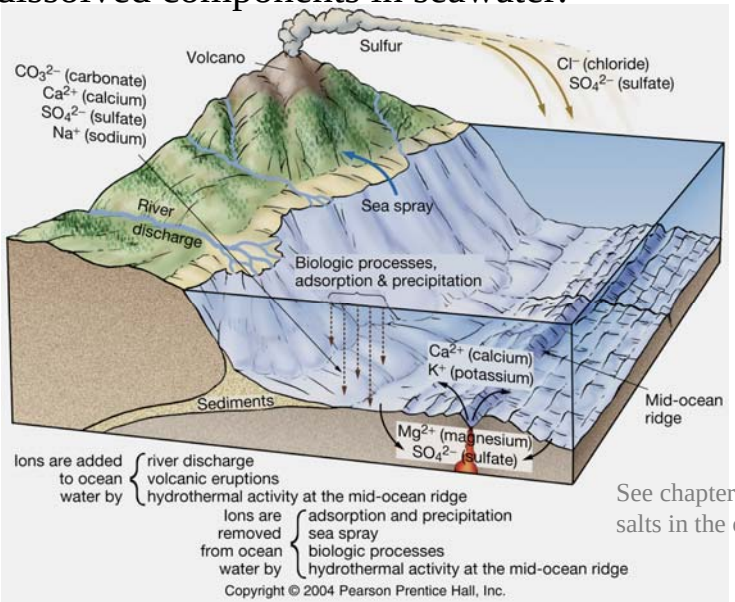
Where does the salt come from? Cycling of dissolved components in seawater.

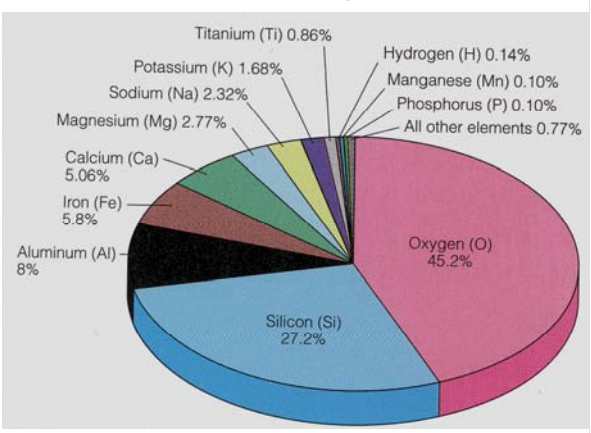
Fig. 6.14.



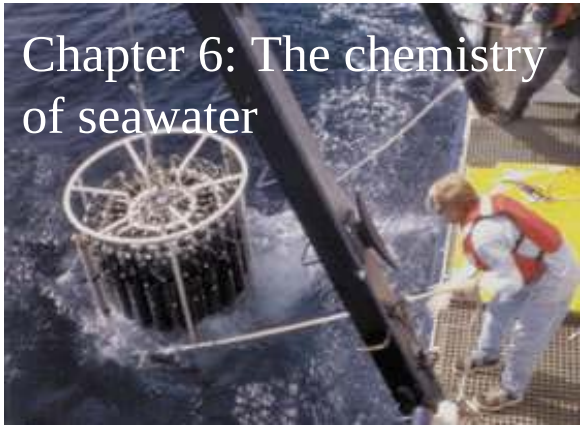
See chapter 2, sources of salts in the ocean

Minerals

Percent of elements by **WEIGHT**



Average composition of the continental crust



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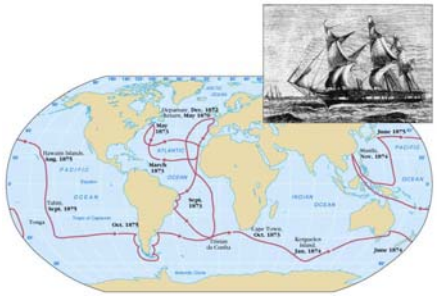
How to measure seawater salinity?

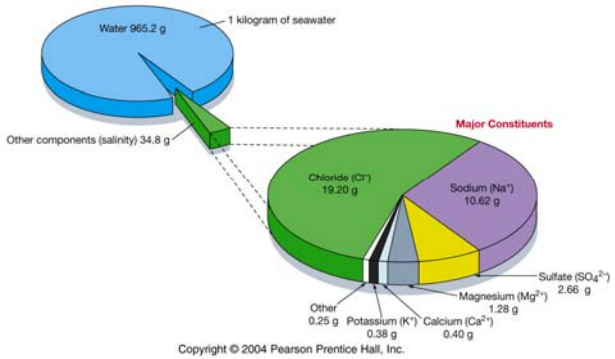
1. Chlorinity: Applying the principle of constant proportions

Remember: 'Principle of Constant Proportions' (constant chemical composition of seawater despite varying salinity).



How to measure seawater salinity?

1. Chlorinity: Applying the principle of constant proportions



Remember: most common components of a liter of seawater at 35‰ salinity. Chlorinity (concentration of Cl- ions) constitutes 55.04 % of total dissolved ions, or 1.80655 x Cl- equals total salinity.

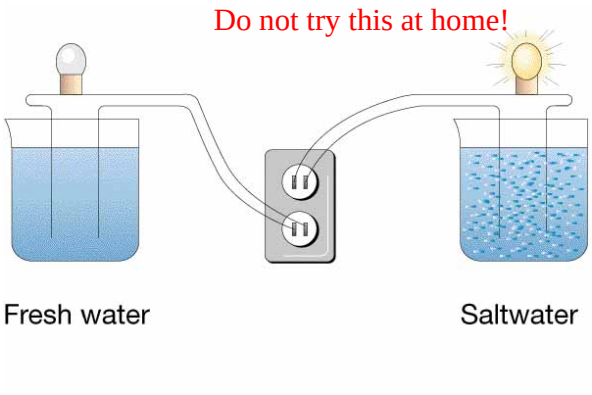
Apply principle of constant proportions:

Determine chlorinity (concentration of Cl^-) which constitutes 55.04 % of total dissolved ions and calculate total salinity

Salinity (‰) = 1.80655 x Cl^-

How to measure seawater salinity?

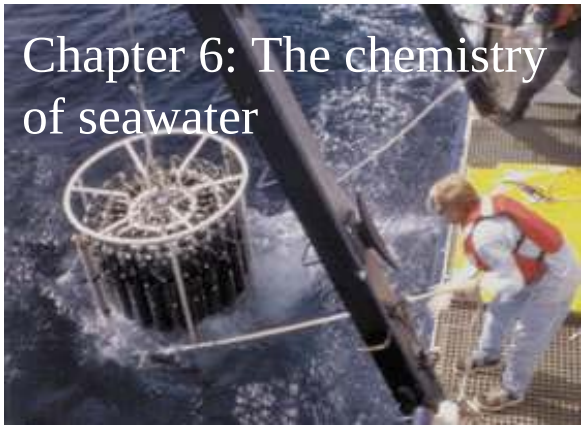
2. Using the principle of electrical conductivity to determine salinity.



The more salts are dissolved, the better water conducts electrical current (and the light bulb lights up).

2. Using the principle of electrical conductivity to determine salinity.

- A rosette of sampling bottles (10 l): Water samples can be taken from distinct depths in the water column.
- Attached to the rosette, a CTD (Conductivity-Temperature-Depth) sensor is also lowered and determines salinity (by conductivity) and temperature in the water column.



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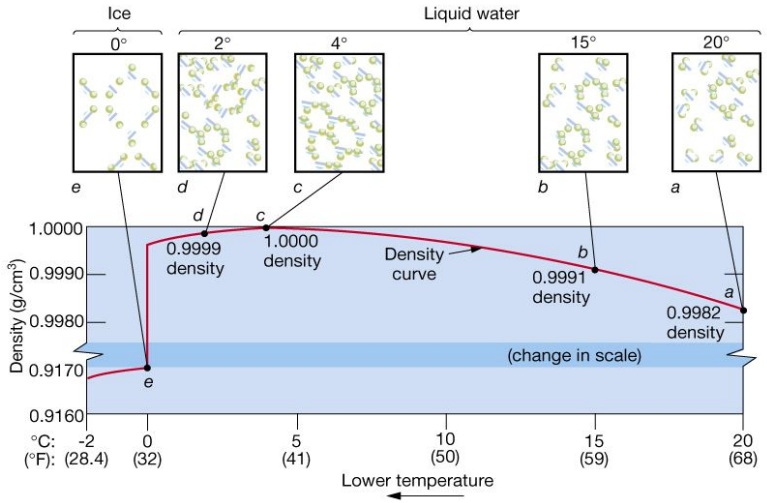
Water density: A) pure water



Pure water has its highest density at 4°C. It freezes at 0 °C.

Fig. 6-10a.

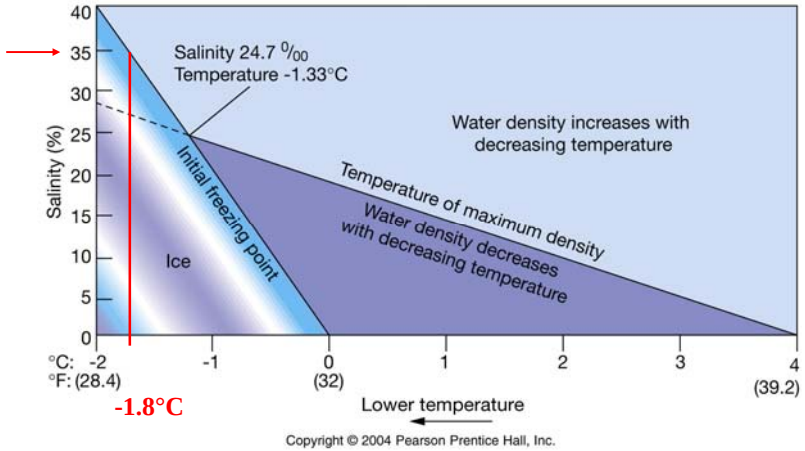


Fig. 6-10b

Water density: B) sea water

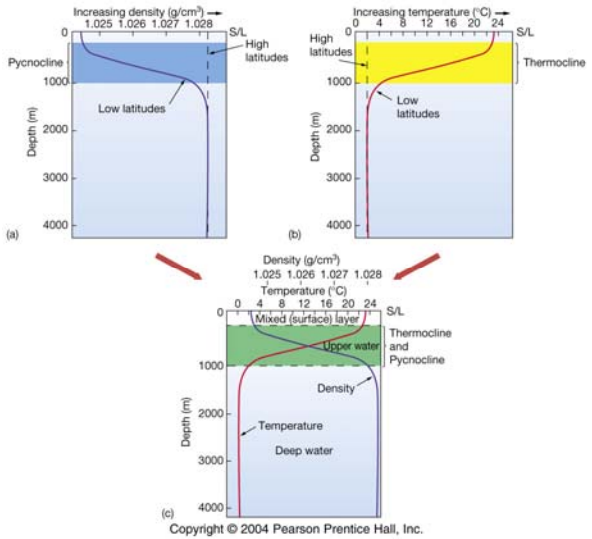
Influence of salt on density and freezing point:

* Dissolved salt decreases freezing point
* Dissolved salt decreases temperature of maximum density.

At 24.7‰ and -1.33 °C, freezing point and maximum density coincide

At the average seawater salinity of 35 ppt, sea ice forms at a temperature of -1.8°C.

Density and temperature variations with depth



Seawater density varies with temperature and salinity

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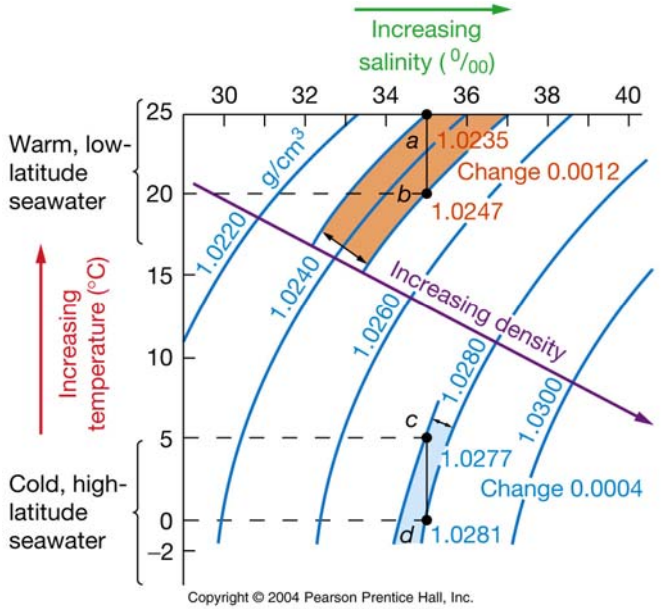

Fig. 6-23

TS diagram and different water masses