

Introduction to the Aquatic Biomes

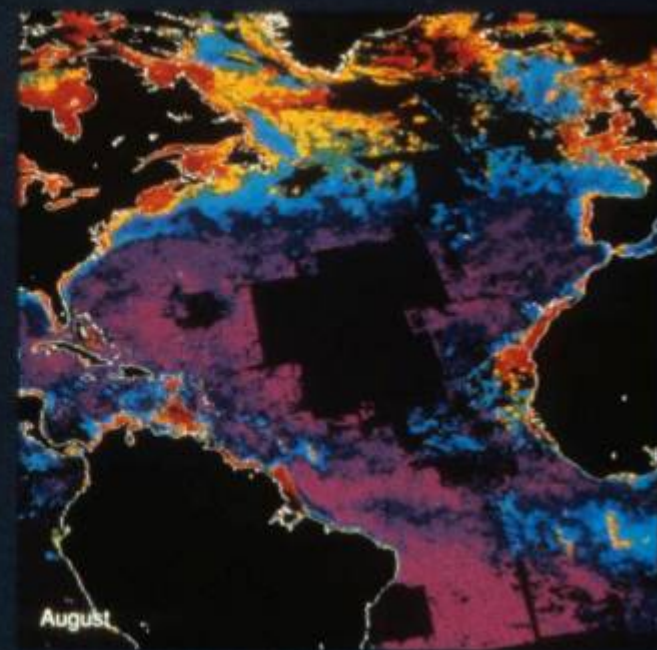
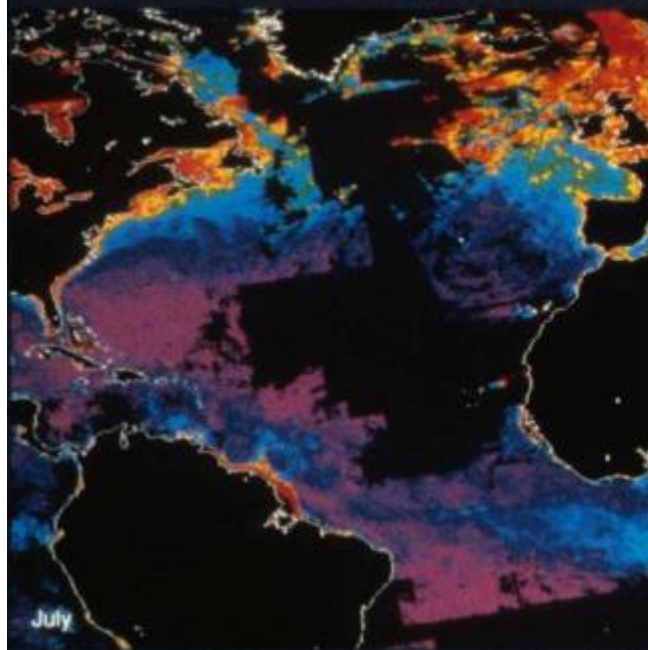
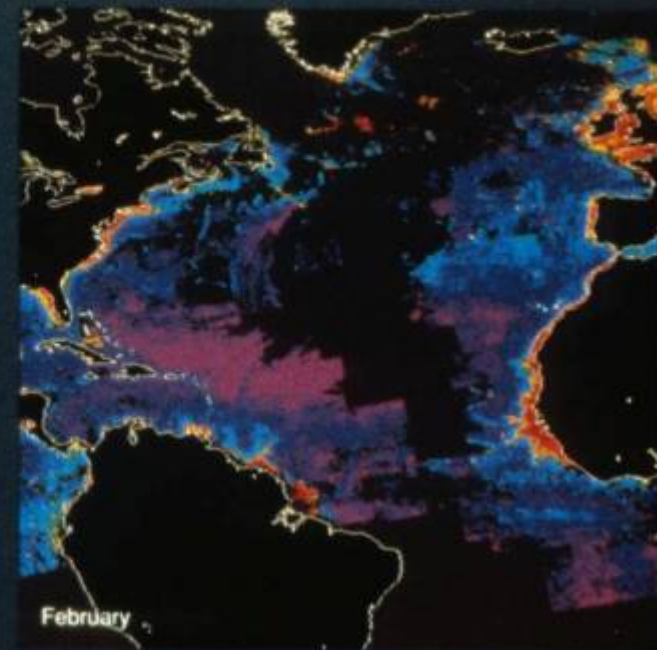
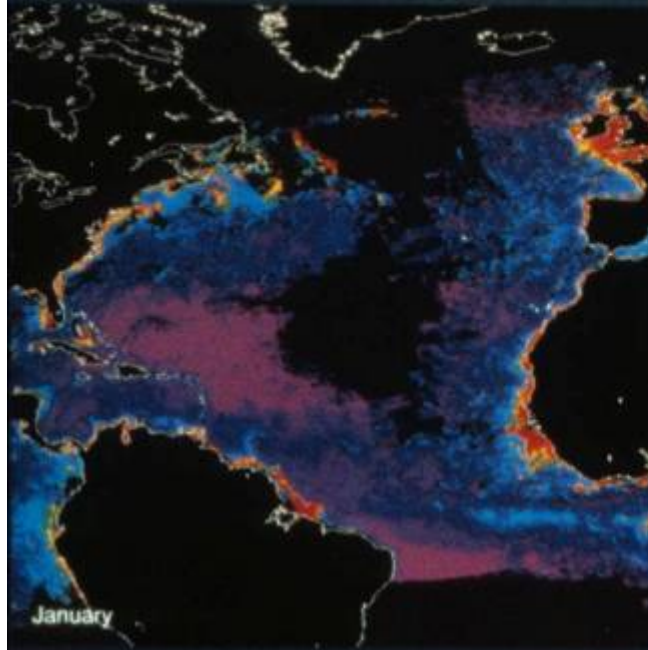
Lecture 15

Hydroclimate

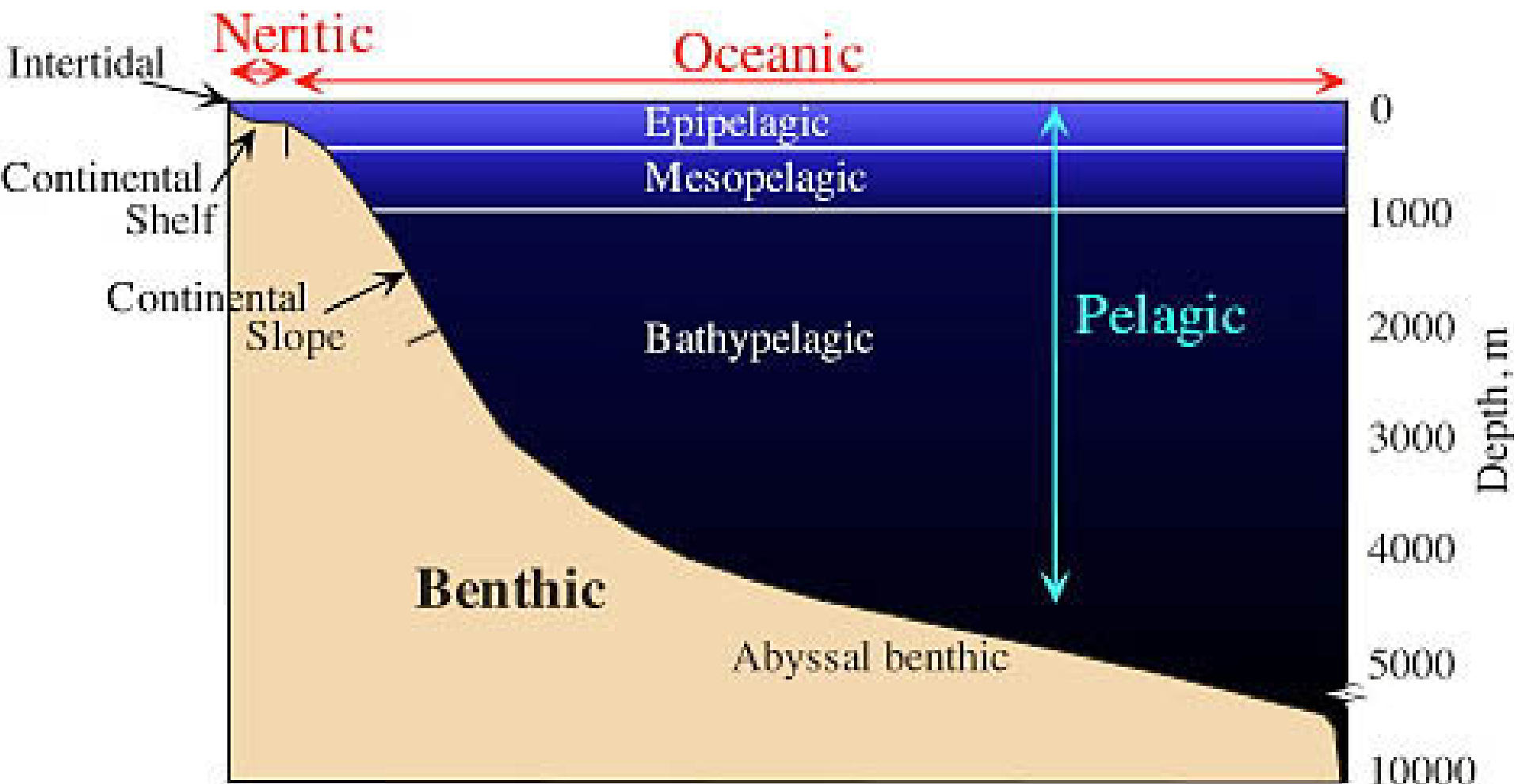
- Aquatic systems are very different from terrestrial ones, *but*.
- A soils analogy
 - Think of the surface of lakes and oceans as very watery soils
 - Nutrients incorporated into particles sink 1-10 m/day
 - Aquatic “soils” weather hyper-rapidly
 - A nutrient rich body of water can be stripped of its nutrients in a single season
 - Aquatic systems will be plant growth deserts unless nutrients are supplied to surface waters regularly
- A Tundra Biome/forest understory analogy
 - Recall that dim light can limit plant growth in some situations when everything else is favorable
 - Aquatic systems are lighted enough for photosynthesis only near the surface
- Hydroclimates suitable for rapid plant growth are the relatively rare situations where light and nutrients are both present.
- Most hydroclimates are more or less severely light or nutrient limited

North Atlantic Productivity

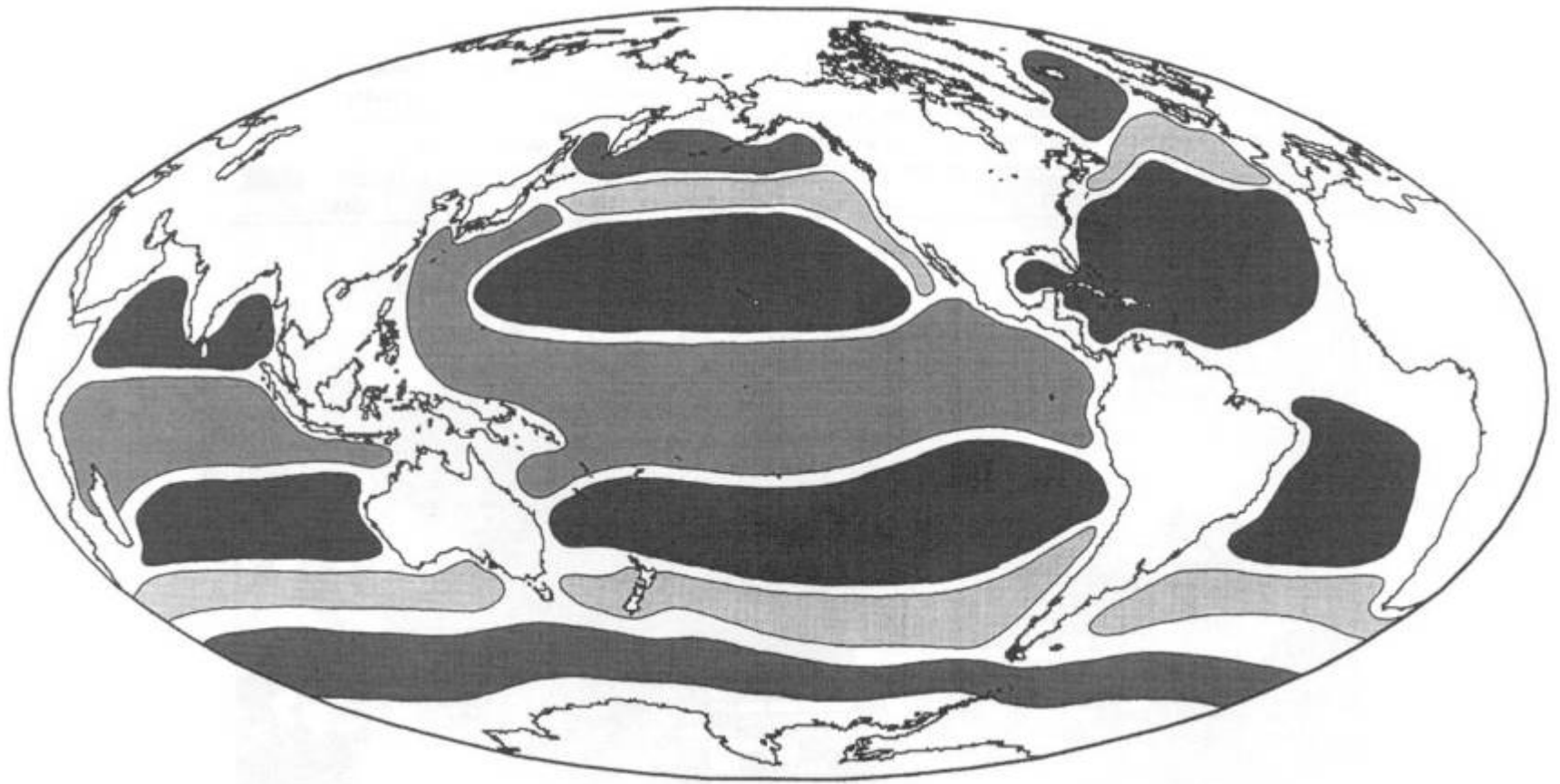
Atlantic Ocean chlorophyll during winter and summer. “False color” picture based on satellite observations. Reds and yellows are high chlorophyll; blues and purples low chlorophyll. Black areas are no data. Note that most of the Atlantic is not productive in either summer or winter. A few small areas (the shallow seas around the British Isles, the coast of West Africa) are always productive. A huge area of the North Atlantic is productive in summer but not in winter. These are the patterns for which we seek hydroclimatic explanations.







Classifying the aquatic biomes. This is a standard terminology for the oceans. The important dimensions are water column (pelagic) versus bottom (benthic), and water depth (continental shelf, continental slope, abyssal). Note also the terms “planktonic” for plants and animals of the pelagic (more generally any plants or animals that live suspended in the water column), “Benthic” for plants and animals that live on the rocks or muds of the bottom, and “littoral” for the subset of benthic animals that live at shallow enough depths for photosynthesis to be important.

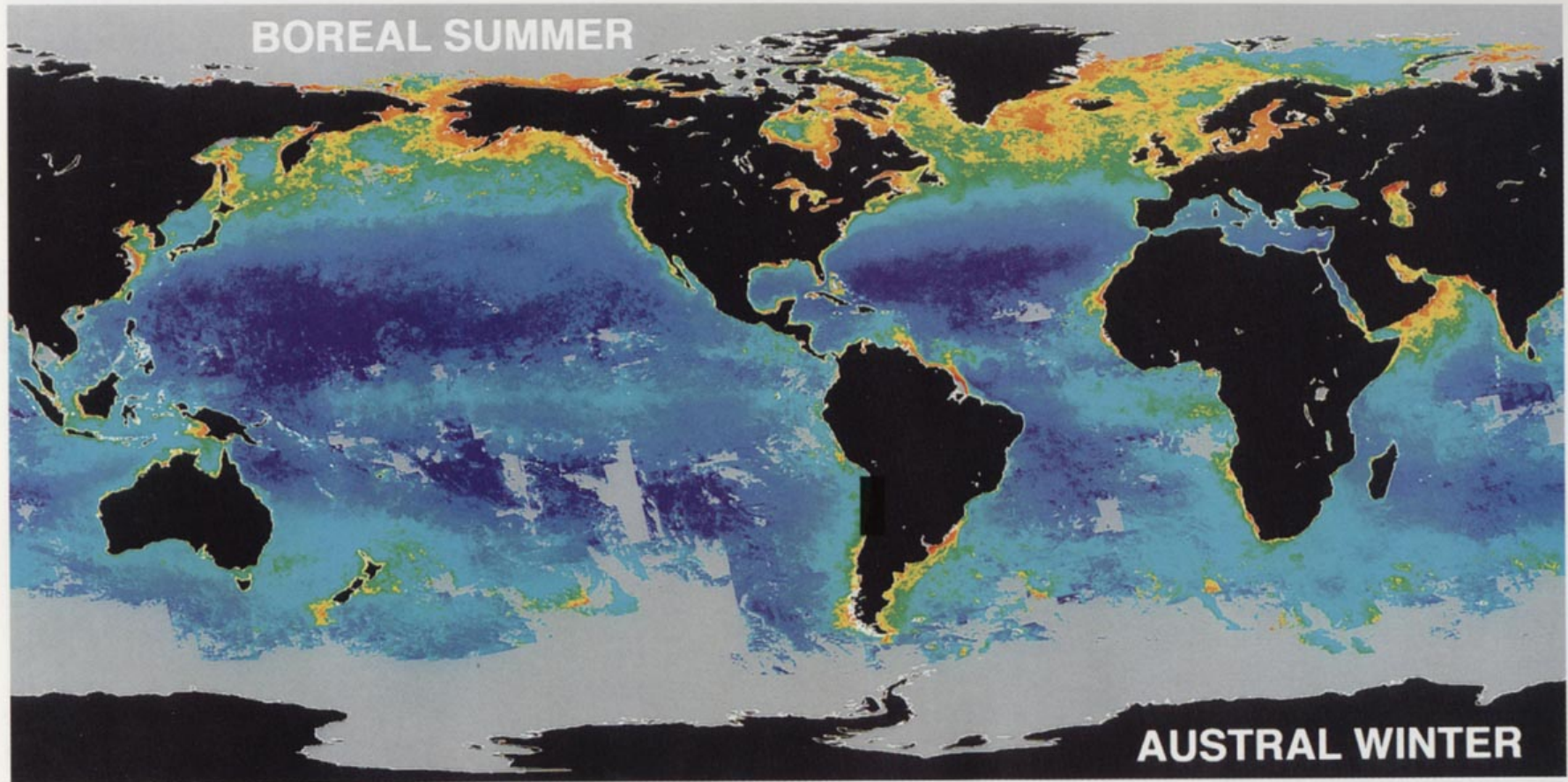


Oceanic Biomes according to A.R. Longhurst.



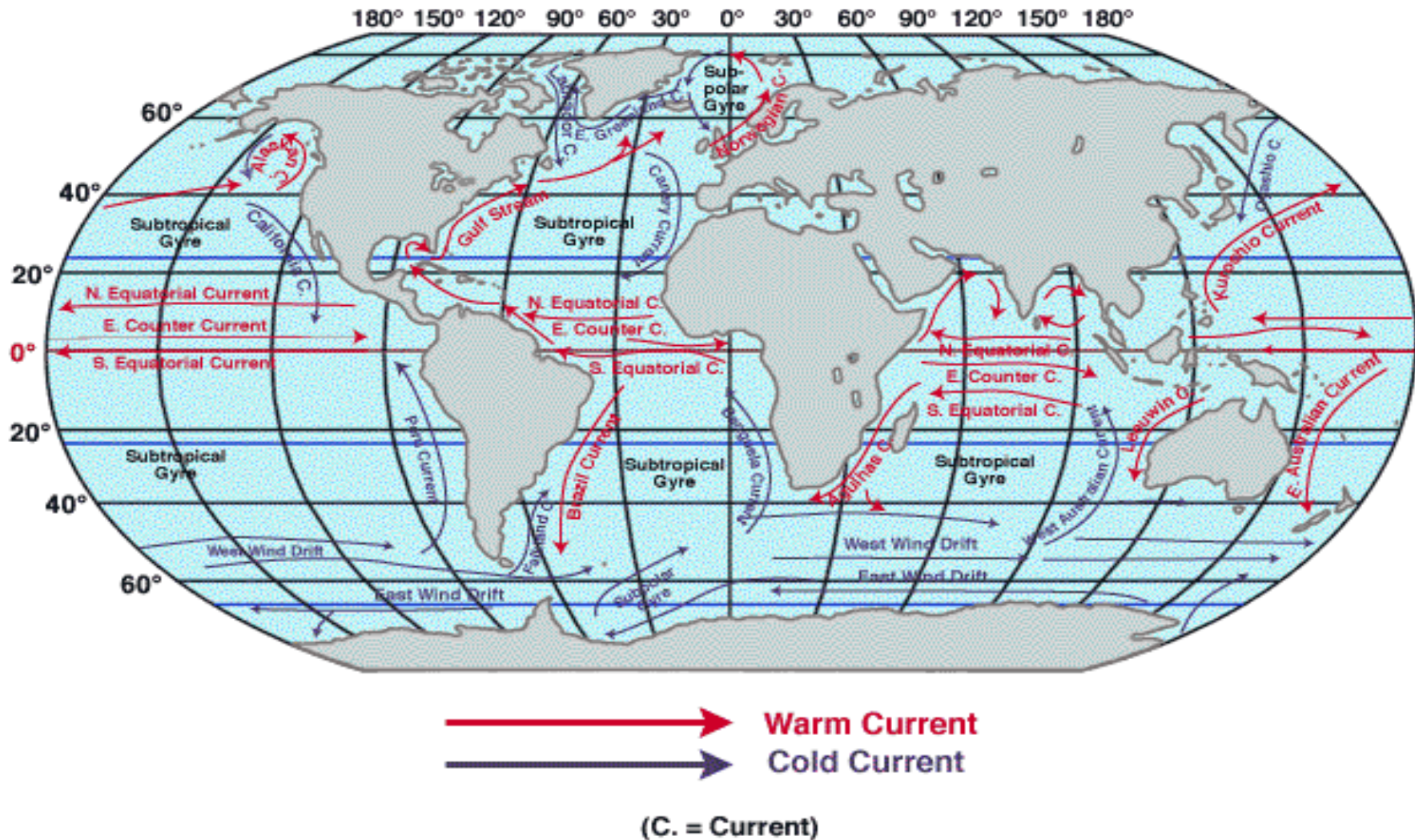
-  Subpolar
-  Transitional
-  Central
-  Tropical

Oceanic and neritic biomes as visualized by chlorophyll concentrations. Note how the Bearing Straits, Baltic Sea, North Sea and other neritic regions tend to have high chlorophyll. Also the narrow upwelling zones along the west sides of continents. Notice the large area of high chlorophyll water in the Arabian Sea, an intense summer upwelling zone. Otherwise Chlorophyll tends to be relatively high in the Sub-polar, Transitional and Tropical Biomes and lowest in the Central Biome. Gray color indicates cloudy weather and poor sampling by the satellite.



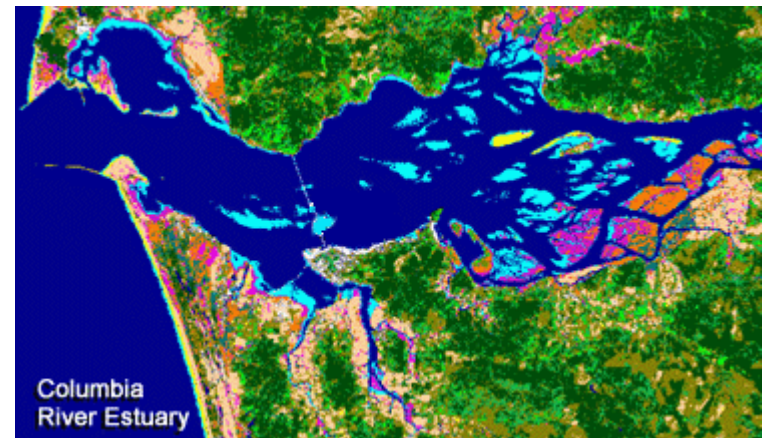
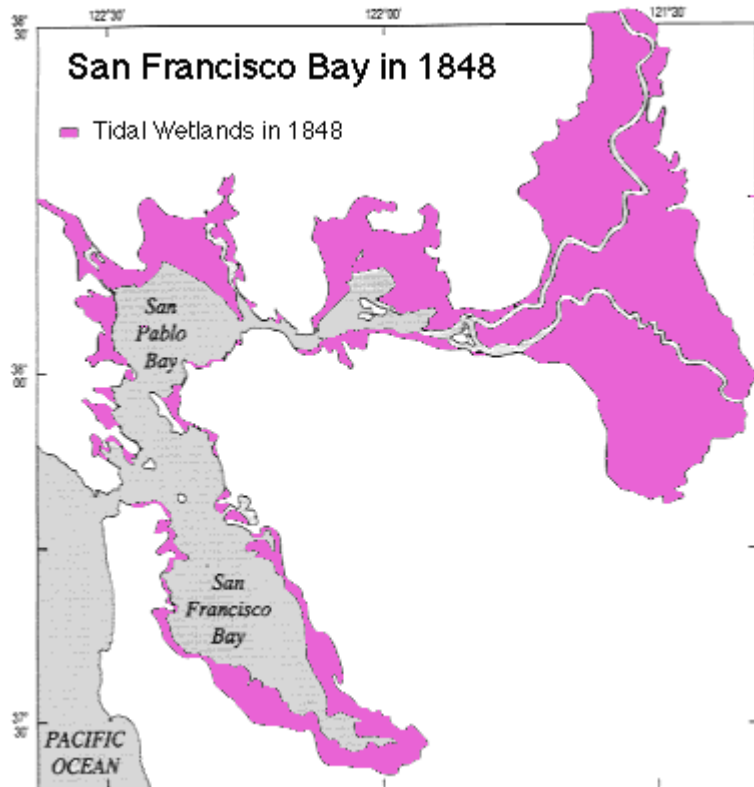
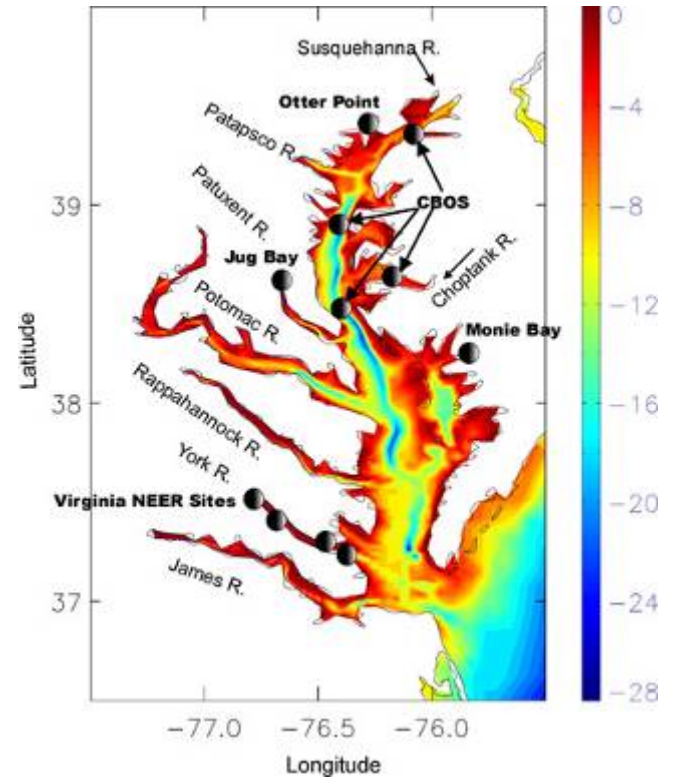
COLOR PLATE I Climatological (1978–1986) seasonal sea surface chlorophyll field obtained with Coastal Zone Color Scanner sensor for boreal summer (June–August). Color is a log scale for chlorophyll: purple = $<0.06 \text{ mg Chl m}^{-3}$, orange-red = $1\text{--}10 \text{ mg Chl m}^{-3}$. Provided by NASA/Goddard Space Flight Center.

Ocean current system. Note how the Oceanic Biomes are relate to the currents. Each ocean basin north and south of the equator is dominated by a subtropical gyre, home of the Central Biome. The Subpolar Biome is poleward of the northern and southern currents of the subtropical gyre. The Transitional Biome occupies the poleward currents of the central gyres extending equatorward with the cold currents of the gyres. The Tropical Biome is situated on the equatorial currents of the subtropical gyres, extending poleward on the west side of the ocean basins with warm currents like the Gulf Stream



Estuaries. Estuaries are bodies of water where salt and freshwater mix. Apart from having considerable scientific interest because of their unusual properties, they are very important to humans. Estuaries frequently make good ports. They tend to be very productive and have large fish and shellfish yields. They are also useful for transporting wastes. “Reclaiming estuary salt marshes and mud flats for agriculture. Municipal, and industrial purposes is often cheap and easy. Human settlement around and impact on estuaries is unusually heavy.

Chesapeake Estuary



Lakes and Rivers. Inland waters are mostly fresh. They also are mostly rather small bodies of water compared to the oceans. Otherwise, this principles of hydroclimate are very similar to marine systems and estuaries. At right, Lake Tahoe and the Mississippi River.



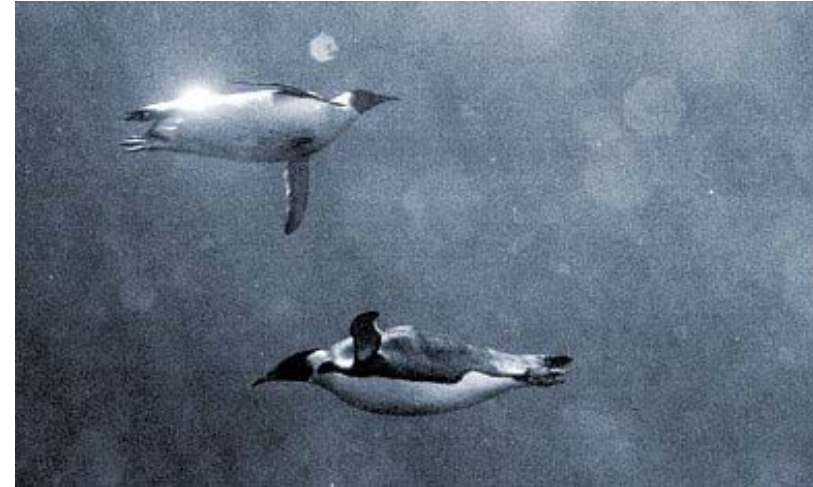
Properties of Water

Water is relatively dense (compared to air)

In particular, since plant and animal tissue is mostly water, plants and animals are generally only a little denser than water. This makes planktonic and nektonic life possible. Octopus can walk and penguins fly with tiny wings.



Each flap a penguin's wing moves against a dense fluid driving the heavy-bodied bird swiftly with a tiny wing are compared to a flying bird



Because an octopus' body is almost the same density as water, it can stand up and walk without a skeleton



Zooplankton can migrate up and down the water column with little expenditure of energy because they are only a little heavier than water

Tiny phytoplankton live suspended in the water column



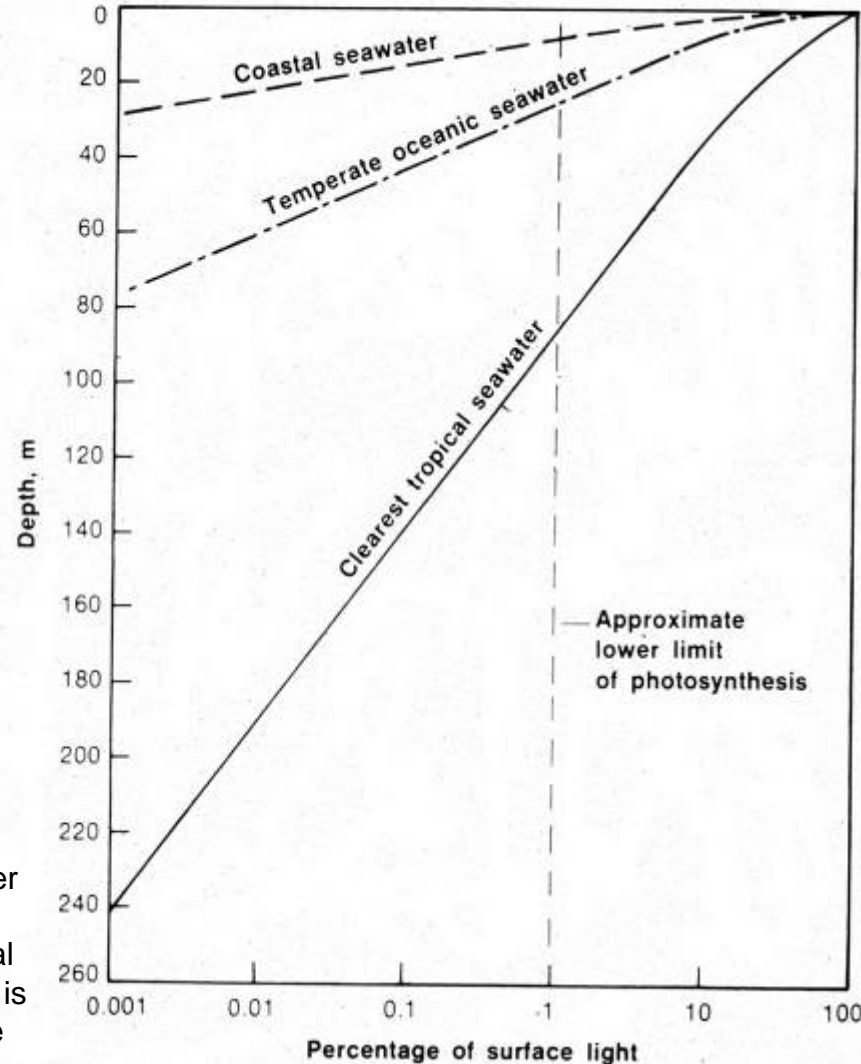
Water has low transparency



Fig. 5.4. Relative penetration of sunlight in varying types of seawater. Note the logarithmic scale for percentage of surface light. Adapted from Jerlov 1951.

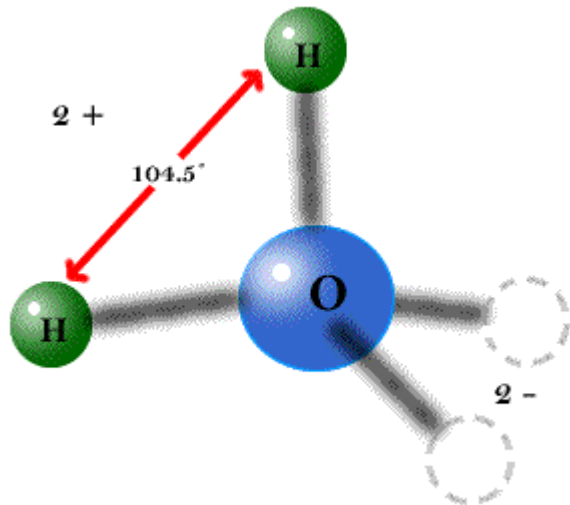
Oceanographers and limnologists (students of inland waters) use an extremely sophisticated instrument to estimate water transparency, a white dinner plate on a metered string, otherwise known as a “Secchi Disk.” You lower it over the side of a boat until it just disappears from view, giving the secchi depth. The secchi depth can be related to more sophisticated measures of light penetration.

Typically, the transparency of water is mainly related to the amount of phytoplankton growing in it. Central Biome water or Lake Tahoe water is very clear because it has very little phytoplankton.



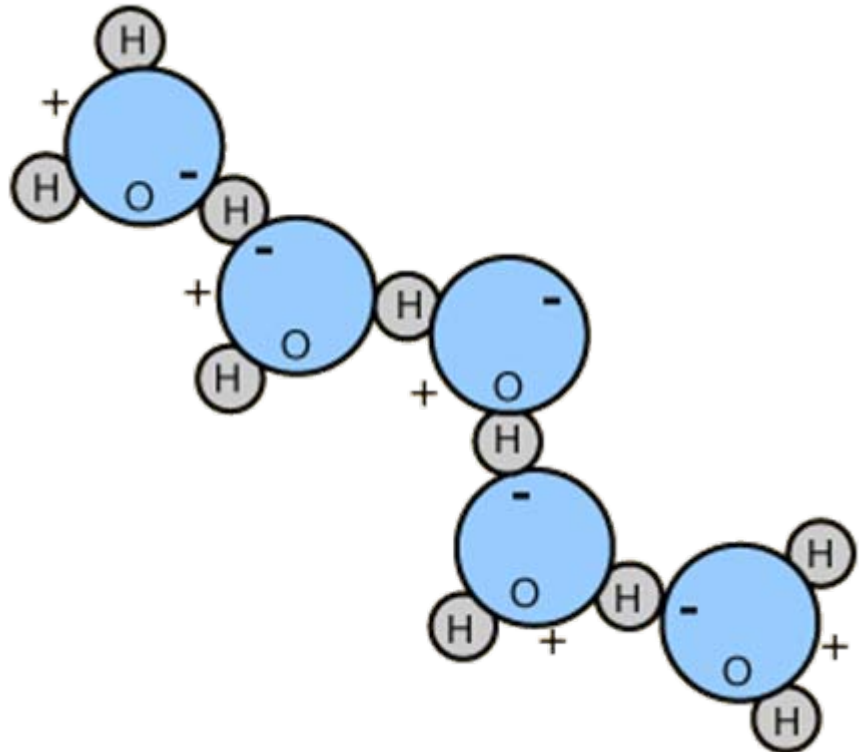
Water has high heat capacity

Water is a polar molecule. Oxygen is such a strong attractor of electrons compared to hydrogen that the O side of the molecule has a strong negative and the H side a strong positive charge.



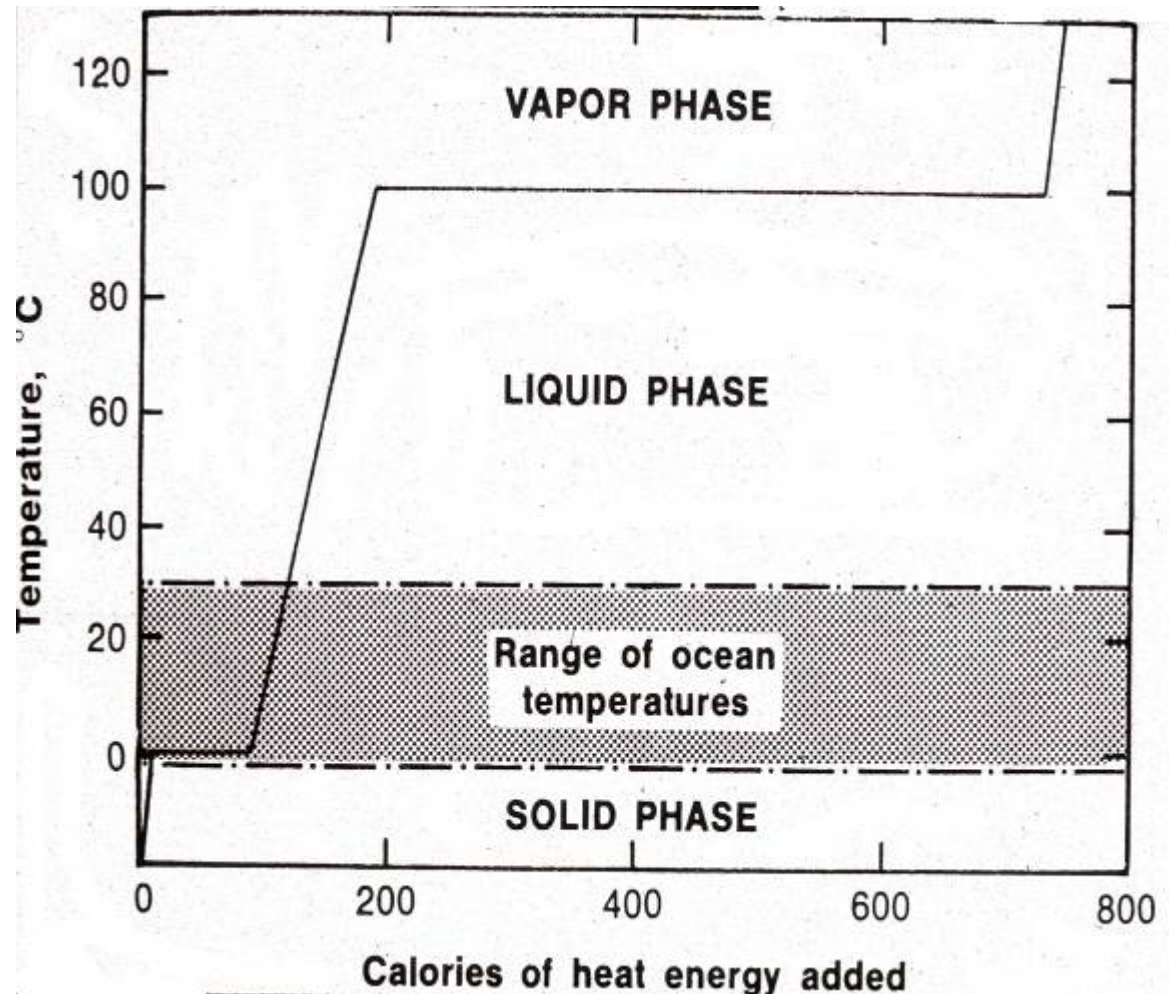
Ball and stick model of water.

Liquid water has strong H-O bonds between adjacent molecules. As heat is added to water they act like rubber bands, holding the molecules together. To get a given amount of vibration in a given molecule (which is what we measure as temperature) heat energy has to work against these rubber band bonds. Water's bond between molecules is unusually strong, allowing it to absorb a lot of energy per degree rise in temperature.



Phase changes occur at earth temperatures and pressures

All three phases of water occur on earth. Changes from the solid to liquid and liquid to gas phase require large amounts of energy, the latent heat of fusion and the latent heat of vaporization to tear down solid crystals and especially to tear apart the O-H bonds between water molecules. We have already discussed the latent heat of vaporization in connection with heat transport by water vapor and the release of latent heat of vaporization in the powering of storms.



Water has peculiar density changes with temperature

Most substances get heavier as they get colder. So does fresh water, down to 4C. Then it begins to reorganize into a big open crystalline form. This reorganization results in a regular structure forming at 0C, ice, which is about 9% less dense than water at 4C. Seawater is basically the same except that the temperature of maximum density is about -2C but sea ice excludes some salt, making the density contrast a little greater. Note that the rate of expansion of water goes up more rapidly at higher temperatures.

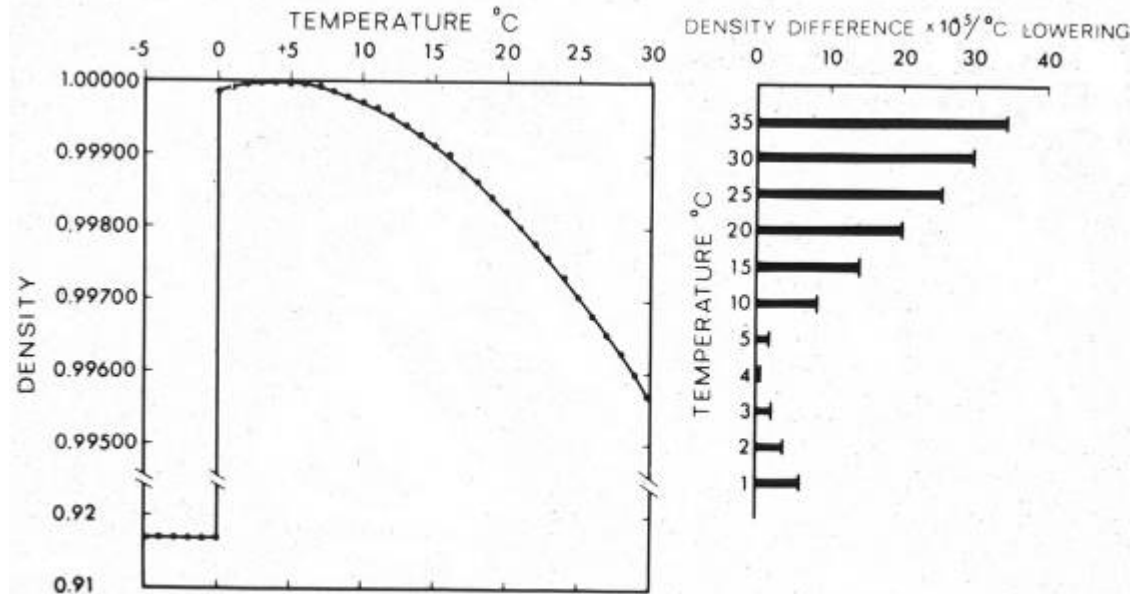
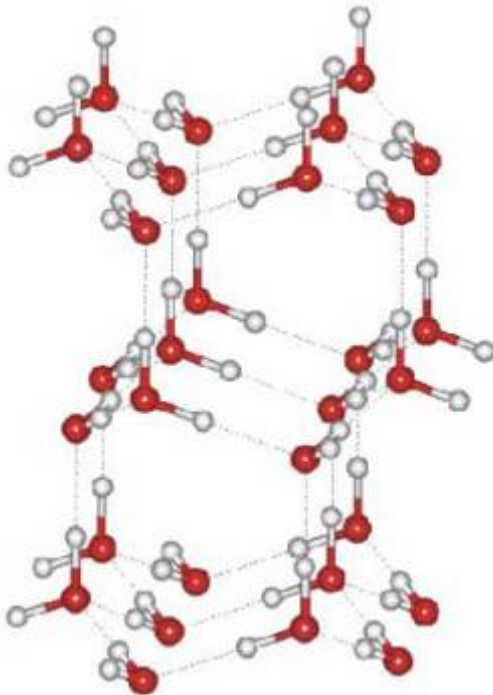
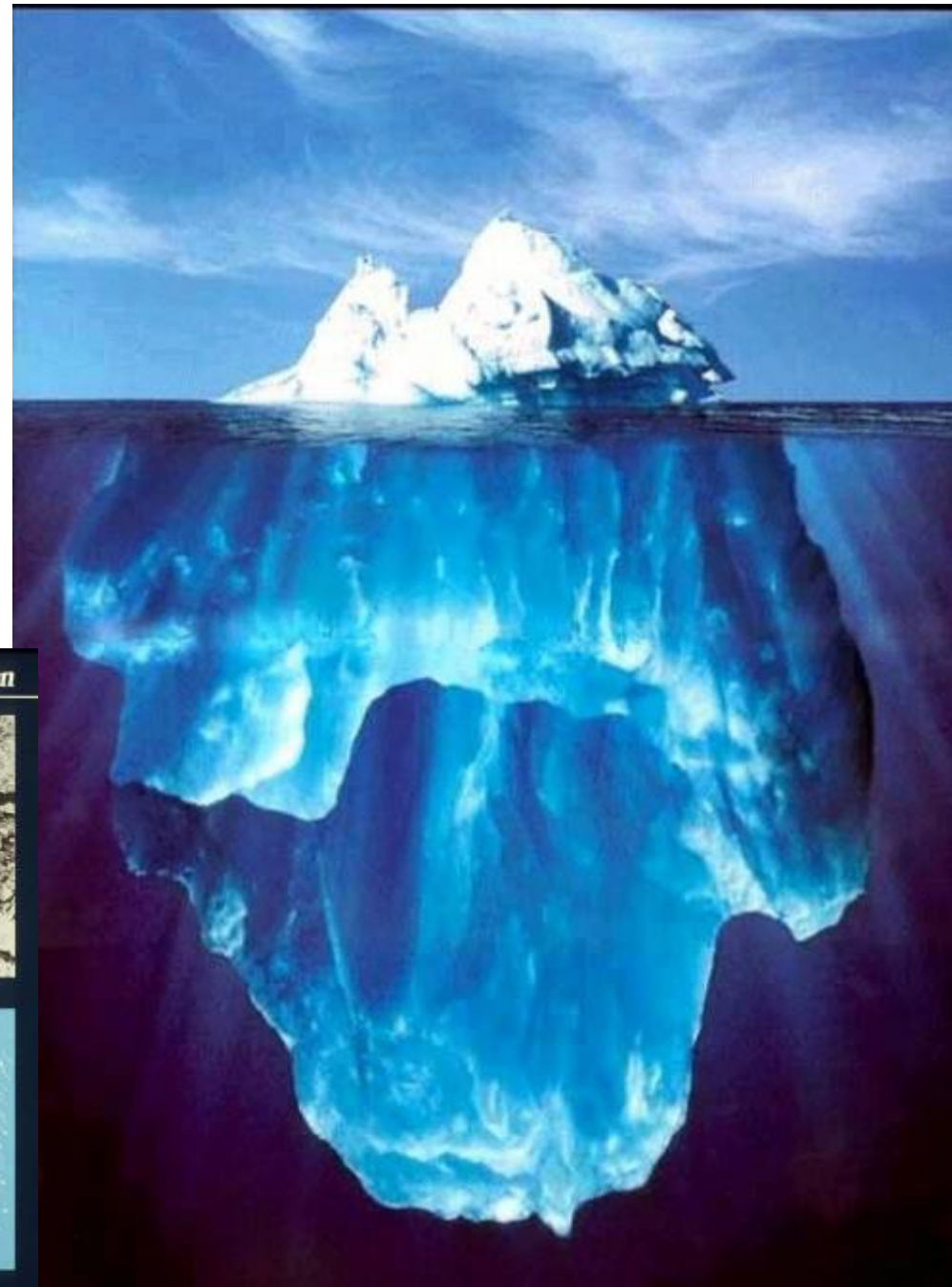


Figure 2-3 Density as a function of temperature for distilled water at 1 atm. The density difference per °C lowering is shown in the righthand portion of the figure at various temperatures. (Modified from Vallentyne, 1957.)

Ice floats. Most solids sink to the bottom of their liquids. Think how much different the earth would be if ice sank! At least at the present time, the oceans would be almost all ice with a little melt-water at the surface, thicker at tropical latitudes and thinner at the poles.



Arctic Pack-Ice Motion



Water is a strong solvent for many substances

Highly polar water molecule tends to surround negatively and positively charged atoms or molecules with one end of the water molecule or the other. As the other atom or molecule acquires a thick coat of water, its bonds with other charged atoms or molecules become weak, and the substance like NaCl dissolves.

