

THE ATMOSPHERIC RESERVOIR

Examining the Atmosphere and Atmospheric Resource Management

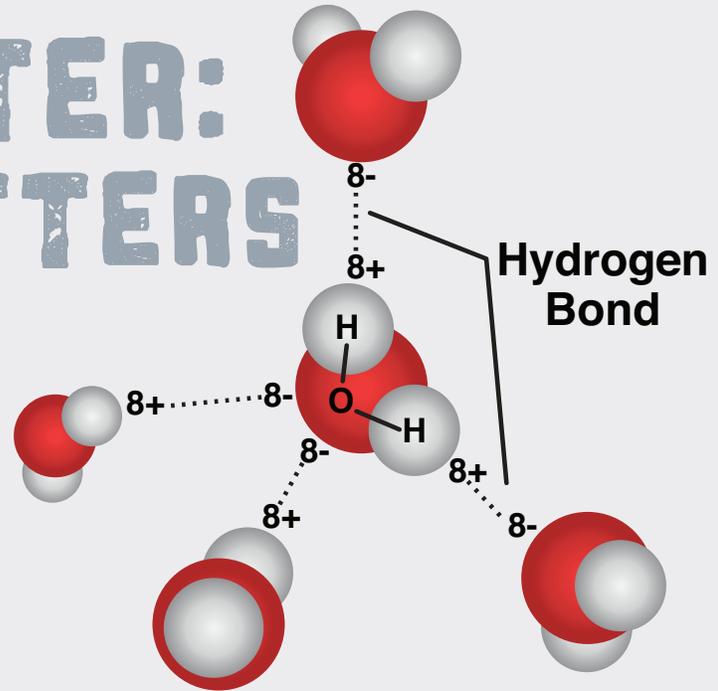
ICE VS. WATER: DENSITY MATTERS

By Mark D. Schneider

The average ice fisherman isn't contemplating the density of ice vs. water while jigging for walleye. Water is unique, however, because its solid state (ice) is actually less dense than its liquid phase, allowing walleye and other aquatic life the ability to survive underneath the ice in cold, but unfrozen waters each winter. Density is equal to mass per unit volume and can be changed by either increasing or decreasing the temperature or pressure. When we freeze a liquid, we lower its temperature and it becomes a solid. The solid states of other liquids are denser because the molecules pack together tightly when the kinetic energy (temperature) decreases.

The hydrogen bonds in water ice are indeed strong, but their orientation causes molecules to push apart, actually lowering density. As pictured in the above diagram, slightly positive hydrogen atoms are attracted to slightly negative oxygen atoms and when these bonds occur during freezing, a lattice or crystalline structure is formed. The extra hydrogen bonds that occur when water freezes increase the space between molecules, causing a decrease in overall density. In fact, each water ice molecule forms hydrogen bonds with four other molecules, while water molecules only form hydrogen bonds with an average of 3.4 other molecules.

Water has a peak density at a temperature of approximately four degrees Celsius, which means that the bottom layers of water in the lake will usually maintain this peak density temperature even though the top layers have frozen. The layer of ice on the surface of a lake works to insulate the water below. Air pockets form in the ice, like the air bubbles inside an ice cube, and these trap heat much like the multiple layers of blankets or clothes that we're accustomed to using during the winter months. It would be disastrous to aquatic



life if lakes froze from the bottom-up! Another scientific consideration is the compression of water. The upper levels of a body of water provide a compressional force that acts to heat the lower levels, but this is a relatively small contributor to the overall temperature.

There are other benefits to water's greater density. Imagine how difficult it would be for giant cargo or cruise ships to float on water if it were less dense. Our oceans contain salt water and this further benefits the shipping industry because salt water has greater mass (and thus density) than fresh water, so this helps with overall buoyancy. Try this water density experiment at home: First, place an egg in a glass of water and observe what happens to it. Next, remove the egg, sprinkle salt into the water and stir. Keep adding salt until it won't dissolve in the water. Finally, place the egg back in the water and observe what happens.

Water is indeed essential to sustain life on Earth. When we look at specific properties such as density and its applications to science, it becomes more clear just how intricately woven into our lives it really is.