Water & Temperature

Rather than just hot or cold, temperature can be defined as the measurement of the the average thermal energy of a substance. Temperature is usually expressed in degrees Fahrenheit (F) or Celcius (C). The conversion formulae are F=(1.8 * C)+32 or C=(F-32)*5/9 . Both systems are based on the freezing & boiling points of water

Why is water temperature important when assessing water quality? Changes in water temperature can impact the following : -

Water Temperature & Aquatic Organisms

We know that most fish prefer cooler water temperatures while most plants like warmer water temperatures to flourish. Salmon for instance like a temperature range of 12-16 C while perch thrive in 20-24 C water. It is interesting that some algae species have different peak temperatures for maximum photosynthesis. Above and below that temperature photosynthesis is reduced.

Water temperature & Compound Toxicity

Higher water temperatures can increase the solubility of cadmium & zinc for example as well as compounds like ammonia. At the same time the lethal limit may drop as temperature increases because of changes in tissue permeability, metabolic rate etc.

Water Temperature & Dissolved Oxygen

Colder water can hold more dissolved oxygen (DO) - warm water less - resulting in certain species not thriving and at some point just killing them. Warmer water may impact reproduction at lower temperature levels before it actually kills organisms..

Water Temperature & Conductivity

An increase in temperature increases conductivity at the rate of 2-3% per degree C due to ionic mobility. In addition salts are usually more soluable at higher temperatures and as they dissolve, they break down into their respective ions increasing ion concentration and conductivity.

Water Temperature & pH

pH is based upon the number of ions in a solution. Pure water (a neutral solution) does not become more acidic or basic with temperature changes but the pH shifts. Pure water will remain neutral at 0 (pH =7.47) 25 (pH=7.00) 100 (pH=6.14)

Water Temperature & Density

This relationship is very interesting and impacts stratification and turnover in the lake.

As the temperature of water changes it alters the water density. The relationship is unique in that when pure water freezes it's density decreases about 9% which is why ice expands & floats on water. Water is at its maximum density at 4 degrees C. This means water above and below 4 degrees will float on top of 4 degree water and in a freshwater lake the 4 degree water sinks replaced by warmer lighter water. This process continues until the water is uniformly cool. Colder water will float on top of the 4 degree water which explains why the lake doesn't freeze from the bottom up. This convection pattern mixes water with possibly different DO (dissolved oxygen) concentrations and happens seasonally in holomictic (mixing) lakes.

Thermal Stratification of a Lake

Stratification is the division or separation of a water column into layers of water with different properties. These layers are usually defined by temperature & density and thermal stratification in freshwater lakes is usually seasonal with clear delineations between the layers in summer and winter. Mixing or "turnover ", if it happens, usually occurs in spring & fall and produces fairly uniform temperatures throughout the water column.

These layers (from top to bottom) within a lake are usually called the epilimnion, metalimnion and hypolimnion. **The epilimnion (top layer)** is exposed to solar radiation , the atmosphere and mixing by the wind and as a result is fairly uniform. It extends down as far as sunlight and the wind can penetrate and is usually deeper in lakes with a wide open and greater surface area and good wind exposure.

The next layer the metalimnion is the boundary layer that has the most rapidly changing temperature. It also can fluctuate in thickness and depth due to weather conditions and seasonal influences. The metalimnion is bordered on both the top and bottom by an edge called the thermocline and the top plane or edge is crossed when the temperature decreases at a rate greater than 1 degree per meter.

The bottom layer (the hypolimnion) is below the lower thermocline and usually is too deep to be affected by wind or solar radiation. The temperature of the hypolimnion is usually deterimined by the spring turnover. Temperature of the hypolimnion in deeper lakes may remain close to 4 deg. C while in some shallow lakes it may reach 10 deg. C

Once stratified in the summer it may change very little.

Turnover or mixing of the lake water by the wind can only occur when the entire lake is about the same temperature and density. Once the lake is stratified it is difficult for the wind to generate sufficient energy to incorporate hypolimnetic water (from the bottom layer) into the mix. **In the spring** once the ice melts and the sun heats the surface water to 4 degrees C the lake will be a uniform temperature and strong spring winds can begin the mixing process. If heating continues without wind the lake will begin to stratify. During the summer the top (epilimnion) layer will be well mixed and will deepen and push the metalimnion deeper but the bottom layer will not get mixed except in shallow lakes. **In the fall** the surface water cools and begins to sink and the metalimnion begins to break down and the lake water mixes freely until ice-up. Lakes that completely mix at least once per year are called holomictic lakes.

Factors That Influence Water Temperature

Sunlight is the greatest source of heat transfer to water temperature. If the lake is deep enough to stratify, sunlight will only transfer heat through the photic (light reaching) zone. More than 50% of the energy is absorbed in the top 2 meters

Atmospheric heat transfer occurs at the waters surface and can go both ways. When the air is cold, warm water transfers energy to the air and cools off . The result is often seen as fog or a "steaming" lake or river. Water temperature fluctuations are more gradual than air.

Turbidity (the amount of suspended solids) in water will impact water temperature because the suspended particles absorb heat from solar radiation more efficiently than clear water and will then transfer the heat to the surrounding water.

Groundwater or streams can alter the temperature of water bodies they enter.

Man made influences such as the thermal pollution from the cooling water discharge from a factory or power generating station can have a significant local impact on a water body including lower dissolved oxygen levels. Runoff from parking lots & other impervious surfaces are another form of thermal pollution.

Information for this article was gleaned from many sources including articles published on the Fondriest website www.fondriest.com