Temperature

Why Is it Important?

Most aquatic organisms are poikilothermic - i.e., "cold-blooded" - which means they are unable to internally regulate their core body temperature. Therefore, temperature exerts a major influence on the biological activity and growth of aquatic organisms. To a point, the higher the water temperature, the greater the biological activity. Fish, insects, **zooplankton**, **phytoplankton**, and other aquatic species all have preferred temperature ranges. As temperatures get too far above or below this preferred range, the number of individuals of the species decreases until finally there are few, or none. For example, we would generally not expect to find a thriving trout fishery in ponds or shallow lakes because the water is too warm throughout the ice-free season.

THE Q_{10} RULE

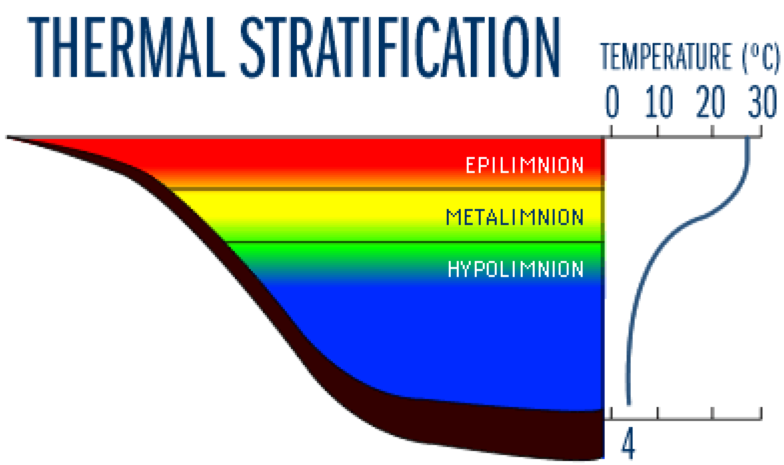
> Changes in the growth rates of cold-blooded aquatic organisms and many biochemical reaction rates can often be approximated by this rule which predicts that growth rate will double if temperature increases by 10°C (18°F) within their "preferred" range.

Temperature is also important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperature, which in turn affects biological activity. An important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less oxygen that cool water, so it may be **saturated** with oxygen but still not contain enough for survival of aquatic life. Some compounds are also more toxic to aquatic life at higher temperatures.

Temperature is reported in degrees on the Celsius temperature scale (C).

Reasons for Natural Variation

The most obvious reason for temperature change in lakes is the change in seasonal air temperature. Daily variation also may occur, especially in the surface layers, which are warm during the day and cool at night. In deeper lakes (typically greater than 5 m for small lakes and 10 m for larger ones) during summer, the water separates into layers of distinctly different **density** caused by differences in temperature. Unlike all other fluids, however, as water approaches its freezing point and cools below 4°C, the opposite effect occurs and its density then begins to decrease until it freezes at 0°C (32°F). This is why ice floats. This process is called **thermal stratification.** The surface water is warmed by the sun, but the bottom of the lake remains cold. You can feel this difference when diving into a lake. Once the **stratification** develops, it tends to persist until the air temperature cools again in fall. Because the layers don't mix, they develop different physical and chemical characteristics. For example, **dissolved oxygen** concentration, pH, nutrient concentrations, and species of aquatic life in the upper layer can be quite different from those in the lower layer. It is almost like having two separate lakes. The most profound difference is usually seen in the **oxygen** profile since the bottom layer is now isolated from the major source of oxygen to the lake - the atmosphere.



When the surface water cools again in the fall to about the same temperature as the lower water, the stratification is lost and the wind can turbulently mix the two water masses together because their densities are so similar (fall **turnover**). A similar process also may occur during the spring as colder surface waters warm to the temperature of bottom waters and the lake mixes (**spring turnover**). The lake mixing associated with a turnover often corresponds with changes in many other chemical **parameters** that in turn affect biological communities. Watch for these changes in your lake this fall and spring.

Because light deceases exponentially with depth in the **water column**, the sun can **heat** a greater proportion of the water in a shallow lake than in a deep lake and so a shallow lake can warm up faster and to a higher temperature. Lake temperature also is affected by the size and temperature of **inflows** (e.g., a stream during snowmelt, or springs or a lowland creek) and by how quickly water flushes through the lake. Even a shallow lake may remain cool if fed by a comparatively large, cold stream.

Expected Impact of Pollution

Thermal pollution (i.e., artificially high temperatures) almost always occurs as a result of discharge of municipal or industrial effluents. Except in very large lakes, it is rare to have an effluent discharge. In urban areas, runoff that flows over hot asphalt and concrete pavement before entering a lake will be artificially heated and could cause lake warming, although in most cases this impact is too small to be measured. Consequently, direct, measurable thermal pollution is not common. In running waters, particularly small urban streams, elevated temperatures from road and parking lot runoff can be a serious problem for populations of cool or cold-water fish already stressed from the other contaminants in urban runoff. During summer, temperatures may approach their upper tolerance limit. Higher temperatures also decrease the maximum amount of oxygen that can be dissolved in the water, leading to oxygen stress if the water is receiving high loads of **organic** matter. Water temperature fluctuations in streams may be further worsened by cutting down trees which provide shade and by absorbing more heat from sunlight due to increased water **turbidity**.

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