Mixing and Stratification

A lake's water quality and ability to support fish are affected by the extent to which the water mixes. The depth, size and shape of a lake are the most important factors influencing mixing, though climate, lakeshore topography, inflow from streams, and vegetation also play a role.

Water density peaks at 39 Deg. F. It is lighter at both warmer and colder temperatures. Variations in density caused by different temperatures can prevent warm and cold water from mixing.

When lake ice melts in early spring, the temperature and density of lake water will be similar from top to bottom. The uniform water density allows the lake to mix completely, recharging the bottom water with oxygen and bringing nutrients up to the surface.

This is called spring overturn. As surface water warms in the spring, it loses density. Wind and waves can circulate the warmed water only 20 to 30 feet deep, so deeper areas are not mixed. If the lake is shallow (less than 20 feet), however, the water may stay completely mixed all summer.

During the summer, lakes more than 20 feet deep usually experience a layering called stratification. Depending on their shape, small lakes can stratify even if they are less than 20 feet deep. In larger lakes, the wind may continuously mix the water to a depth of 30 feet or more. Lake shallows do not form layers, though deeper areas may stratify.

Summer stratification, as shown below, divides a lake into three zones: epilimnion (warm surface layer), thermocline or metalimnion (transition zone between warm and cold water), and hypolimnion (cold bottom water). Stratification traps nutrients released from bottom sediments in the hypolimnion. In the fall, the surface cools until the water temperature evens out from top to bottom, which again allows mixing (fall overturn). A fall algae bloom often appears when nutrients mix and rise to the surface.

Winter stratification, with a temperature difference of only 7 Deg. F (39 degrees on the lake bottom versus 32 degrees right below the ice), remains stable because the ice cover prevents wind from mixing the water.

The lake's orientation to prevailing winds can affect the amount of mixing that occurs. Some small, deep lakes may not undergo complete mixing in the spring or fall if there is not enough wind action. The mixing that takes place in the bays of a large lake will more closely resemble that of a small lake because the irregular shoreline blocks the wind.

Because mixing distributes oxygen throughout a lake, lakes that don't mix may have low oxygen levels in the hypolimnion, which can harm fish. Some fish species require lake stratification. The cold water in the hypolimnion (bottom) can hold more oxygen than warmer water in the epilimnion (top) and thus provide a summer refuge for cold water fish such as trout. But if the lake produces too much algae, which fall into the hypolimnion to decay, oxygen becomes depleted. The steep temperature gradient of the metalimnion prevents any surface water with dissolved atmospheric oxygen from reaching the bottom waters.
Annual temperature cycles in stratified lakes