# THE POND

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With the exception of Lake Michigan, the surface waters of Illinois are classified as "warmwater". These are waters that have a midsummer surface temperature of $70^0$F or higher. Temperature is one of the key factors that govern the lives of fish and regulate the kinds of species which can live in our streams and ponds. The amount of dissolved gases that water will hold varies with the temperature. The warm water of summer holds much less oxygen than cold winter water. Temperature is the principle regulator of physiologic change in fish, including feeding, growth, and spawning. Most warmwater fishes grow fastest at temperatures above $70^0$F and dissolved oxygen content of 5 to 8 parts per million (ppm).

NOTE: A part per million (mg/l) is literally one in a million, that is, one pound of oxygen for instance, in a million pounds of water.

Temperature is also one of the principle factors influencing the pond cycle through the year. The density (weight) of water depends on its temperature. Layers of water at different temperatures are layers of water of different densities. These layers float upon one another, each tending to remain distinct from the other, and they resist mixing. The heaviest (densest) that water gets is at about $39^0$F. Water warmer than this, or <u>colder</u> than this is lighter. If it were not for this fact, life on earth would not exist. If water just kept on getting denser as it got colder until it froze, ice would sink and all bodies of water, including the oceans, would be permanently frozen solid! Fortunately for us, the lightest water of all is ice, and it floats.

Let us look at <u>the annual cycle of the pond</u>. In the spring, just after the ice thaws, the coldest water is on top at $32^0$F and the warmest water is on the bottom, at about $39^0$F. As the warm breezes of spring begin to blow, the cold surface layers of water begin to warm. As they get warmer, they get heavier and sink into the depths of the pond, replacing the lighter, colder layers beneath. At some point, all the water reaches $39^0$F. This is known as the Spring turnover.

Up to this point, there have been layers of water at different temperatures and densities in the pond, making them difficult to mix. Now that the water is all the same temperature and density, it mixes easily and the winds of spring mix the pond thoroughly, bringing the water which has been on the bottom all winter to the top. Ponds can be thought of as breathing twice a year, once in the spring and once in the fall, breathing out the waste products of respiration of the aquatic life. These are carbon dioxide ($CO_2$) hydrogen sulfide ($H_2S$) and other gases. At the same time, the pond is breathing in new oxygen from the air to replace what was used up.

So the pond starts the year with its water refreshed and a new supply of oxygen from top to bottom. As the winds warm the surface layer of the pond above 39$^0$F, it becomes less dense and begins to float on the colder waters below. During the summer period, a layering effect called thermal stratification sets up, separating the pond into three zones of differing temperature and density called the epilimnion, the thermocline, and the hypolimnion.

These terms simply stated mean the upper lake, the transition zone, and the lower lake. The thermocline is a layer in which the temperature drops rapidly, at a rate of 0.5$^0$F or greater per foot of increasing depth. Most people who have dived into a pond or lake have experienced the thermocline. Often, they come back up thinking that they have dived into a spring!

The thermocline ends where the temperature ceases to drop rapidly. Once these layers set up in the summer, they are almost as difficult to mix as oil and water and tend to remain stable throughout the warm weather. The upper two layers then effectively seal the lower lake off from contact with the atmosphere. In a deep lake (50-60 feet or more), the temperature of this lower layer may remain 40-45$^0$F during the hottest of summer weather. The exception to this stability is that in shallow ponds, 6 feet deep or less, summer storms may be strong enough to disrupt the layering.

During this time, the aquatic life is gradually using up the dissolved oxygen present in the lower lake; by about mid-July, the oxygen is used up entirely. This is why you can't have trout in your lake over the summer, even though the temperatures on the bottom are plenty cold enough for them. In most Midwestern ponds and lakes there isn't any oxygen for fish to live below a depth of 12 feet in the summer.

As fall comes, the warm surface layers of the lake begin to cool. Being cooler than the layers below them, they are also denser. This cooler, denser water sinks, displacing the lighter, warmer water below. This process breaks up the thermal stratification which has been so stable all summer, and the pond takes its second breath of the year, the fall turnover. The deoxygenated water of the lower layer is brought to the surface, where its oxygen supply is renewed, and all the waste product gases which accumulated in the lower layer during the summer are exhausted to the atmosphere. The process is complete when all the water in the pond is once again at 39$^0$F.
The pond begins the winter period as it began the summer with its water refreshed and oxygen from top to bottom. As the air

temperatures continue to cool, water colder than 39$^{0}$F floats on the warmer water below it. This provides a (relatively) warm refuge for fish, frogs and turtles of the impoundment to survive the winter. Believe it or not, many of our fish would die of what we would call exposure if they were at temperatures below about 35$^{0}$F for very long during the winter.

Ice, being the lightest water of all, forms on the top and the pond is sealed off from contact with the atmosphere. As winter progresses, snow accumulates on the ice and, depending on the year, lasts for varying lengths of time. Meanwhile, the organisms of the pond continue to use oxygen, though at a reduced rate because of the cold temperatures.

At some point, the accumulation of snow may be sufficient to cut off sunlight. Aquatic plants can continue to renew the oxygen supply even under the ice, if they receive enough sunlight. Once the light is cut off, a count down clock begins, ticking off the number of days before the fish run out of oxygen. One factor that determines the number of days on the clock is the water volume. At the time the countdown clock starts, there will be more oxygen available in a deeper impoundment than in a shallower one, simply because the volume of water is greater. In the Midwest, a pond 8 to 10 feet deep over 1/4 of its area is deep enough to withstand most winters. When fish are found dead in the spring when the ice thaws, it is referred to as winterkill.

The cause of winterkill is not simply low oxygen under the ice. If it were, many more lakes would undergo winterkill than actually do. Other factors enter in, such as the amount of accumulated organic matter, leaves, dead aquatic weeds, unused fish food and so forth, which are slowly decaying under the ice, using up oxygen. There is also a simultaneous rise in carbon dioxide from ordinary respiration of fish, plants, and bacteria, as well as in $H_2S$, generated by anaerobic (no oxygen present) respiration of bacteria in the mud.

The fish, being cold in the winter, do not require a lot of oxygen to maintain life. However, when oxygen levels are low and, if the carbon dioxide (which acts as an anesthetic to fish) rises to an anesthetic level, and hydrogen sulfide rises to a mildly poisonous level, the fish are hit from three different directions at once. Winterkill may occur unless the aquaculturist is prepared, vigilant and takes steps to prevent it. In a very long, cold winter, the problem will be particularly severe.

As spring approaches, several freeze-thaw cycles may take place. These are characterized by partial thawing of the ice over the surface of the pond, which then re-freezes as the weather cools, only to thaw again and so on, until the final thaw occurs. Your author has seen severe gas bubble disease (the bends) in 4" channel catfish fingerlings, induced by thawing ice. This thawing ice had very little snow on it and there was no run off from snow. When the pond refroze, many of the fingerling catfish died of fungus infections of the areas damaged by gas bubbles in the skin.

After the final thaw, the cycle begins again.