A-8-01

THE OHIO STATE UNIVERSITY EXTENSION

Extension FactSheet

School of Natural Resources, 2021 Coffey Road, Columbus, Ohio 43210

Winter and Summer Fish Kills in Ponds

William E. Lynch Jr.
Extension Associate, Aquatic Ecosystem Management

Eric R. Norland
Assistant Professor, Natural Resources
Extension Specialist, Natural Resources

Fish kills in Ohio ponds are rare events considering the large numbers of ponds and small lakes located in the state. However, they do occur every year, and some years are worse than others. Visiting your pond and seeing many dead fish floating around would no doubt cause you concern, particularly if the fish population is to your satisfaction. Fish kills can result from a variety of causes but the most common are weather, pond vegetation, and the interaction of the two. The critical parameter of these scenarios is oxygen level. Oxygen is essential to aquatic life and should be maintained at levels of 4 ppm (parts of oxygen per million parts of water = milligrams per liter of water) or higher. This fact sheet will focus on these three common causes and what you can do to minimize the possibility of a winter or summer fish kill in your pond. If you experience a fish kill and you suspect it is the result of disease or chemical spill, contact your county Extension Agent for assistance.

Winterkill

The Winter Oxygen Cycle

During winter, contribution of oxygen from photosynthesis by green plants and algae is greatly reduced. This is caused by the normal fall die-off of plants and algae due to cold water. Additionally, those green plants that remain produce less oxygen because their metabolism slows in cold water. This does not mean that oxygen levels are much lower in winter. In fact, the reverse is true. In unfrozen ponds, high oxygen levels will occur during winter because the oxygen needs are less in cold water. Aquatic animal (primarily fish) metabolism and oxygen-consuming decomposition processes are greatly reduced in cold water. Also, cold water contains more oxygen than does the warm water of summer. The strong winter winds also keep the pond water circulating and continually add oxygen during winter. These factors combine to prevent winterkill in unfrozen ponds even though plants are contributing little oxygen during winter. Problems, if they are to occur, will happen once ice forms on the pond.

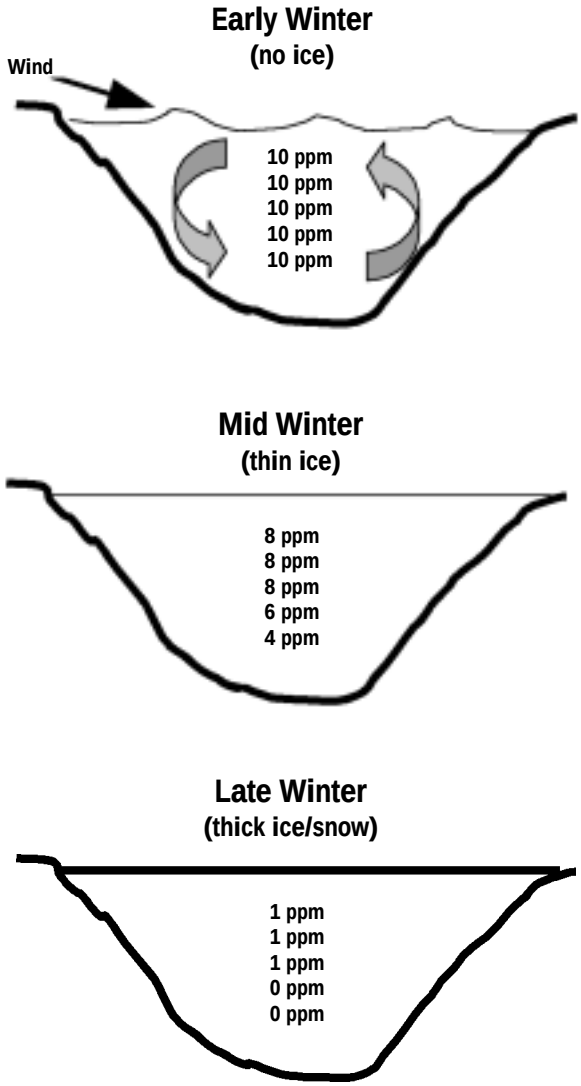
How Winterkill Occurs

Winterkill is the result of a significant decline in oxygen during a long period of ice cover. Figure 1 illustrates the sequence of events that can lead to winterkill. As long as the pond is open or partially open, oxygen levels remain high. This is because diffusion of oxygen from the air and wind agitation add more oxygen to the water than is used for animal metabolism and plant decomposition. This is even true for those very sheltered ponds that receive very little exposure to wind.

When ice forms, neither wind nor diffusion from the air contribute oxygen to the water. The sole source of oxygen becomes the small amount produced by the few remaining algae and plants. If the ice remains thin and clear, oxygen production by plants and algae can continue as enough sunlight can filter through the ice to allow photosynthesis to occur. This production can nearly compensate for that which is used by respiration and decomposition that is continually ongoing. If the ice remains into mid-winter or thickens slightly, oxygen levels will begin to decline by 1–2 parts per million. This is because each day the pond plants and animals use slightly more oxygen than is produced. At this point, however, the pond still has sufficient oxygen.

A serious problem develops when ice persists into late winter and thickens considerably or worse yet, is covered by snow. This reduces the amount of sunlight reaching the plants and algae, thereby substantially reducing the

Figure 1. Oxygen depletion scenario during winter ice cover. Oxygen levels are expressed as parts per million (ppm) and show generalized levels and trends.



amount of oxygen produced. Since metabolism and decomposition continue unabated, oxygen levels begin to drop and can approach levels that threaten fish survival. In cold water, oxygen levels less than 2–3 ppm for an extended time will begin to kill fish. If levels drop to 1–2 ppm or lower throughout the pond, a complete fish kill will result.

Factors Influencing the Likelihood of a Winterkill

Winter Severity—This is by far the most important factor in determining the likelihood of a winterkill. A mild winter means little or no ice and thus, no winterkill due to low oxygen levels. A harsh winter greatly increases the chances of problems. Ice thickness and clearness is important. As mentioned previously, thickening ice over time results in less and less light being available for photosynthesis. Perhaps the worst thing that can occur is for snow to cover the ice. Often, winterkill is avoided as long as there is no snow cover (unless the ice is very thick which rarely occurs in Ohio). Four inches of wet snow on top of the ice nearly eliminates sunlight penetration and oxygen levels will decline quickly.

Pond Volume—The more water volume (i.e., gallons) in a pond, the less likely the pond will experience winterkill. This is why fish over-winter better in larger and/or deeper ponds. A one-acre pond that averages 6 feet deep will have more winter oxygen available than a one-acre pond that averages only 3 feet in depth.

Decomposition—An important factor is the amount of decaying organic matter that is present on the bottom. Dead aquatic vegetation and tree leaves account for most of the organic matter undergoing decay during winter. A pond bottom covered with these materials is more likely to experience winterkill than a pond lacking such materials. This is why ponds having a very dense aquatic plant community in summer are the very ponds most susceptible to winterkill during harsh winters.

Fish Biomass—The amount of fish (numbers and pounds) in the pond during winter also influences oxygen decline under the ice. Even though fish metabolism has slowed during winter, they still require oxygen. A pond that contains many pounds of fish will experience a faster decline in oxygen than a pond with fewer pounds of fish. This is why fish farmers closely monitor ponds in winter as they are maintaining fish biomass at levels that greatly exceed a normal pond.

Worst Case Scenario—Pond owners should be most concerned during a harsh winter in which ice cover persists, there is considerable snow cover on the ice, the pond is small and shallow, and the pond contained a large amount of aquatic plants the previous summer. Less ice and snow, fewer aquatic plants the previous summer, and the deeper the pond, the less likely a winter fish kill will occur.

Winterkill Prevention

Fortunately, winter fish kills can be prevented in most cases, due in part to weather conditions. Even in Ohio's harsh winters, a warm spell can partially thaw a pond for a few days. Oxygen levels quickly rebound when a pond becomes ice-free. One timely warm period of 2–3 days can greatly reduce the possibility of a fish kill.

There are activities the pond owner can do to prevent a winterkill. The most important should occur during pond construction. Ponds should have shoreline slopes of 3:1 to limit the amount of shallow water where summer aquatic

plant growth occurs. The reduced summer aquatic vegetation means less decomposition and results in higher oxygen levels under the ice in winter. Because deeper ponds experience winterkills less often, it is important to have a maximum depth of 10–12 feet if possible.

What can be done for the existing pond? Any strategy that limits the amount of plant decomposition that will occur during winter is important. There are a number of methods to eliminate or reduce summer aquatic vegetation that will decrease the amount of oxygen-consuming decomposition that occurs the following winter. Ohio State University Extension Fact Sheets A-3-98 *Controlling Filamentous Algae in Ponds* and A-4-98 *Chemical Control of Aquatic Weeds* along with the *Ohio Pond Management* bulletin describe a variety of strategies for controlling aquatic plants.

Another activity to be considered is the installation of an aeration system that helps keep a small area of the pond ice-free. Aeration not only adds oxygen to the water directly via the bubbles and agitation, but the open area allows for considerable diffusion of oxygen into the pond from the air. The aeration system does not need to be run continuously all winter. Rather, turn it on when ice is forming on the pond. Leave it off when the pond is ice-free. Aeration can be used sparingly in winter to minimize ice cover.

Safety note: Aeration during winter generally prevents safe ice from developing anywhere on the pond.

Finally, if your pond is ice-covered and aeration is not an option, fish winterkills can often be prevented by simply removing some of the snow off the ice. About 25–50% of the pond surface needs to be kept free of snow to maintain enough light to allow sufficient photosynthesis to occur. This is particularly effective in small, shallow ponds where the volume of water may not be sufficient to allow oxygen to last the winter.

Safety note: Only remove snow when the ice is safe. Four inches of ice is a good rule to follow before stepping onto the ice to remove snow.

Summerkill

The Summer Oxygen Cycle

Oxygen production resulting from photosynthesis is highest during summer. This is because warm water and long hours of daylight maximize the amount of algae and aquatic plants in ponds. However, oxygen-using processes, including animal and plant respiration and organic matter decomposition are also at their highest levels in summer. In most ponds, the oxygen produced during daylight far exceeds the amount used by decomposition and respiration, especially at night. As long as daytime oxygen production exceeds nighttime oxygen use, summer fish kills due to insufficient oxygen will not occur. However, there are summer situations that can occur that can lead to fish kills.

How Summerkill Occurs

Excessive Vegetation Scenario—Many Ohio ponds become "choked" with vegetation during July and August. Fortunately, excessive vegetation by itself will not cause a fish kill as the high amount of oxygen produced during daylight easily compensates for respiration and decomposition. Problems can arise during a hot, calm, and cloudy weather pattern. A substantial reduction in sunlight causes the amount of oxygen produced to decline while oxygen consumption remains unchanged. Thus, oxygen levels slowly decline. Ponds can usually withstand several consecutive cloudy days but if clouds persist for longer periods, oxygen levels may decline to levels harmful to fish life, about 3–4 ppm for largemouth bass and bluegills. A fish kill due to insufficient oxygen may begin to occur, particularly just before sunrise when daily oxygen levels are at their lowest. The first fish to die are the larger individuals as their oxygen needs are greater. Fortunately, a sunny day will quickly raise oxygen levels and end the fish kill. A common result of this scenario is a partial fish kill which leaves the pond's fish community dominated by small fish.

Late-Summer Herbicide Treatment—Many owners prefer to have minimal vegetation but wait until the pond has become choked with plants before initiating any control measures. This can lead to a serious oxygen problem if all the vegetation is treated simultaneously with an herbicide/algaecide. Soon after treatment, a massive die-off of the treated vegetation will occur. The actual timing of the die-off depends on the herbicide used and other conditions. But once die-off begins, it proceeds rapidly. This causes a substantial build-up of organic material that begins to decay in the warm water, and which requires large amounts of oxygen to complete. Coinciding with the die-off is a decline in oxygen production as the plants responsible for that production are now lying dead on the pond bottom. Oxygen consumption far outpaces oxygen production and levels begin to decline significantly. Couple this situation with a calm, cloudy day or two, and a fish kill can occur.

Premature Fall Turnover—Any pond that stratifies during summer will undergo a normal fall turnover as water temperatures decline. This process is described in Ohio State University Extension Fact Sheet A-7-01, *Understanding Pond Stratification*. A fish kill can result in some ponds that experience a premature turnover in late summer.

Many ponds are stratified in summer, with a warm, upper layer of water on top of a colder, bottom layer. These layers do not usually mix until fall. In Ohio's productive ponds, a substantial amount of organic matter accumulates in the deeper areas. The decomposition of this matter results in the colder, bottom layer eventually losing most, if not all, of its oxygen by August. This is not a problem unless the pond turns over in August or September.

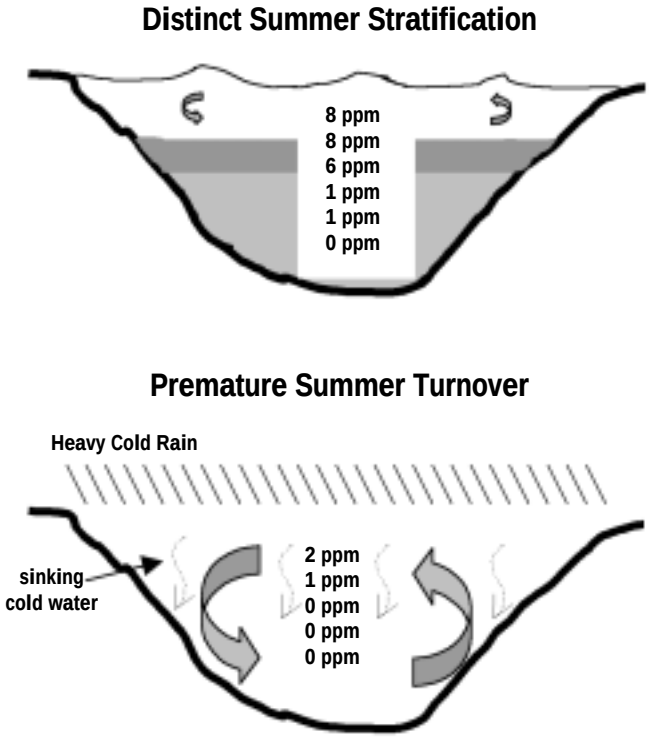
This premature mixing can be brought on by a heavy, cold rain. Figure 2 illustrates how premature turnover in summer results in a fish kill. In many ponds, the volume of the colder, oxygen-deficient bottom layer of water exceeds the volume of the oxygenated, upper layer. In a heavy rain event (several inches in just a few hours), the cold rain water plunges through the warm upper layer towards the bottom. This is because cold water is denser than warm water and therefore sinks. This rain event can cause the entire pond to mix. The mixing of oxygen-deficient water with the oxygenated water can occasionally cause oxygen to fall to levels lethal to fish.

A heavy rain event can also cause a stratified pond to mix in another manner. A large inflow of cold rain water from watershed runoff can also cause a sudden mixing of oxygen-deficient water with oxygenated water. Depending on the volume of the two layers, a fish kill may result. Ponds with a very large watershed are more prone to this scenario.

Premature turnovers are not a problem in June or after September. In June, stratification has just occurred and the colder, bottom layer still contains oxygen. While that oxygen level may be slowly declining, a sudden mixing does not result in low oxygen levels throughout the pond. Premature turnovers *generally* do not cause a problem until late July. After mid-September, pond temperatures begin cooling. Colder surface water holds substantial oxygen which allows the pond to more easily withstand turnover effects. Additionally, as temperatures decrease, the very distinct stratification diminishes which slowly allows oxygen to be re-introduced into the deeper waters.

Worst Case Scenario—The likelihood and severity of a summer fish kill is increased if the scenarios described above occur in conjunction with each other. For example, if a pond treated with an aquatic herbicide in late-July or August receives a heavy inflow of cold rain water, a fish kill is likely. This is because a very large quantity of dead plant material is decaying. A sudden turnover results in the upper layer oxygen being mixed throughout the pond where it is quickly consumed by the decomposing plants. The situation is further worsened because the pond has fewer oxygen-producing plants.

Figure 2. Oxygen depletion scenario during premature turnover during summer. Oxygen levels expressed as parts per million (ppm) and show generalized levels and trends.



Factors Influencing the Likelihood of a Summerkill

Vegetation Biomass—The quantity of vegetation in August and September plays an important role in the likelihood of a fish kill. Vegetation-choked ponds are much more likely to experience problems than a pond with little or no vegetation.

Weather—As described previously, weather plays a critical role in whether a summer fish kill will occur. A cool summer marked by breezy conditions generally reduces the chances of a summer fish kill. Conversely, a calm, hot summer or a cloudy summer increases the likelihood.

Pond Size and Depth—These factors influence the likelihood and severity of a premature turnover causing a fish kill. Small, very deep ponds (more than 12 feet) are

more susceptible to the effects of a premature turnover than are large, shallow ponds. This is because a small, deep pond has a higher proportion of the water that lacks oxygen as compared to a larger, shallower pond. If the ponds turn over, oxygen may decline to near zero in the deep pond but often remain high enough in the larger, shallow pond to keep fish alive. A large, windswept pond in an open area rarely stratifies because of the continual mixing and usually does not experience problems associated with a premature turnover.

Summerkill Prevention

Just as for winter fish kills, there are activities the pond owner can undertake to prevent a summer fish kill. As noted previously, ponds should have shoreline slopes of 3:1 to limit summer aquatic plant growth to the areas near shore. The reduced amount of summer aquatic vegetation means more balanced levels of oxygen between day and night. While oxygen production during the day may not be as great, plant respiration (oxygen consuming) at night will be greatly reduced. This prevents pre-dawn oxygen levels from plunging to lethal levels for fish.

In existing ponds, any early summer strategy that reduces the amount of plant growth is beneficial. This is particularly true for those ponds having a history of dense aquatic vegetation and/or may have had summer fish kills in previous years. If an herbicide/algaecide is used to eliminate or reduce summer aquatic vegetation, applications should be completed before July 1. Later applications run the risk of indirectly causing a fish kill as described earlier.

In situations where the pond owner decides late-season herbicide control is needed, the pond should be treated in sections. Granular formulations of herbicides allow for control in specified areas. Treat about 1/4 of the pond every 2–3 weeks, starting with the area where control is most important (e.g., swimming area). This spreads decomposition over a longer period of time as compared to total pond vegetation control with a liquid herbicide.

Perhaps the most effective way to prevent summer fish kills is to install an aeration system. Aeration serves to minimize the risk of a fish kill in several ways. First, aeration continuously adds oxygen to the water, which is important if oxygen begins to approach critically low levels. Fish will find the oxygenated water around the aerator. Secondly, aeration often prevents summer stratification from occurring. If the pond is not stratified, premature turnover will not occur. Finally, aeration keeps nutrients suspended which promotes single-cell algae growth. This reduces aquatic vegetation density due to the shading effect of green pond water. Most Ohio ponds do not require aeration during normal summers, but more pond owners are installing them as a preventative measure. Aeration does not need to be a 365 days, 24 hours a day activity. Using aeration at night during the May to September period will prevent summer fish kills.

A common type of aeration that many pond owners are installing is a windmill system in which wind power generates the aeration in the pond. While these systems can reduce the chances of a fish kill as long as a breeze is blowing, they are useless in those calm, cloudy, late-summer weather patterns that can lead to a summerkill. If these systems are installed, a pond owner would be well-advised to consider having the system equipped with the capability of using electricity to generate aeration as a back-up.

Summary

Winter and summer fish kills are uncommon, but they do occur on an annual basis. Fortunately, they are preventable with wise management. A common factor in fish kills is the presence of very dense aquatic vegetation. Any strategy that limits late-summer vegetation growth to less than 15–20% of the pond will greatly reduce the chances of a winter or summer fish kill. Weather is important in causing fish kills in both seasons. Very cold, calm winters lead to heavy ice cover which can, depending on other factors, lead to a fish kill. Similarly, calm summers can increase the chances of a summer fish kill. Perhaps the best method to prevent fish kills is to install an aeration system. In winter, they can limit ice cover and add oxygen. In summer, they prevent stratification and maintain, if not increase, oxygen levels during weather conditions that can lower oxygen to dangerous levels.

If an aeration system is not installed and lethargic fish near the surface are observed gulping for air, a serious situation exists and requires immediate attention. Any method that can significantly aerate the water may alleviate the crisis and prevent a fish kill. It may be as simple as using a 2- or 3-inch pump and spraying water up in the air which incorporates oxygen when it falls back into the pond. Whatever is used, aeration should continue (particularly at night) until conditions return to normal. Keep in mind that if a pond exhibits fish in distress, it is likely to occur again that summer if similar weather conditions occur again. Unfortunately, once a fish kill is actually underway, it is usually too late to stop it. The key is prevention.

Additional Pond Management Information

Placing Artificial Fish Attractors in Ponds and Reservoirs; Ohio State University Extension Fact Sheet A-1.

Pond Measurements; Ohio State University Extension Fact Sheet A-2.

Controlling Filamentous Algae in Ponds; Ohio State University Extension Fact Sheet A-3.

Chemical Control of Aquatic Weeds; Ohio State University Extension Fact Sheet A-4.

Muddy Water in Ponds: Causes, Prevention, and Remedies; Ohio State University Extension Fact Sheet A-6.

Understanding Pond Stratification; Ohio State University Extension Fact Sheet A-7.

Ohio Pond Management; Ohio State University Extension Bulletin 374

Controlling Weeds in Ohio Ponds; 41 minute videotape. VT50.

Visit your county office of Ohio State University Extension for copies of these resources.

Visit Ohio State University Extension's WWW site "Ohioline" at:
http://ohioline.ag.ohio-state.edu

Keith L. Smith, Associate Vice President for Ag. Adm. and Director, OSU Extension

TDD No. 800-589-8292 (Ohio only) or 614-292-1868

3/01—100 (7500)—klw