AQUATIC ECOSYSTEMS MANAGEMENT P.O. Box 82 Golf, IL 60029-0082 Phone: 847-579-3090 Fax: 847-724-8212

COMMON CAUSES OF FISH KILLS

Fish kills are not an uncommon occurrence in man-made impoundments. The causes vary, but fall into two main categories: Winter-kills and Summer-kills.

Winter Kills – are often associated with lack of dissolved oxygen under the ice. Though may result from increased gases that are toxic to fish that remain in the water column, such as ammonia or carbon dioxide. There is still some rate of oxygen production under ice, though rates are greatly reduced with low water temperatures and decreased light penetration. Accumulations of all gases in the water column occur when there is no surface to air mixing. The stress on the fish varies, based on species, size classes, water depth, sediment composition, and other factors. The end result is reduced populations in spring for further reproduction.

1) Ice-covered ponds may develop variations of DO concentrations dependent on depth. If there is little or no snow cover to block sunlight, algae and some plants continue to produce small amounts of DO even with cold water temperatures. Fish respiration, although at reduced rates, along with microorganisms decomposing material in the lower water column and in the sediment, oxygen is consumed and the DO is depleted. If snow covers the ice, no oxygen input from the air occurs and it becomes too dark for photosynthesis. This combination of factors can cause a winter fish kill. Additionally and often more toxic during the winters is the accumulation of carbon dioxide and ammonia, as the ice prevents gas exchanges at the pond surface. Ponds that do not have at least 25% of their surface area with a depth of at least 10 feet are more prone to winter kill.

Summer Kills – are associated with a much wider range of causes: high water temperatures, algae blooms, chemical applications to control nuisance growth, storm inflows with increased nutrients or bacteria loads, and disease, and the list goes on. Fish stress and death associated with low dissolved oxygen levels are most common, though if not quickly determined difficult to confirm.

1) Dissolved Oxygen - Time of day effects dissolved oxygen concentrations in a pond. This is mainly due to production of oxygen during photosynthesis and consumption during respiration and decomposition. Photosynthesis occurs only during the daylight hours. Respiration and decomposition, on the other hand, occur 24 hours a day. This difference alone can account for large daily variations in DO concentrations. During the night, when photosynthesis cannot counter balance the loss of oxygen to respiration and decomposition, DO concentration may steadily decline. DO concentrations are generally lowest just before dawn when photosynthesis resumes. Other sources of oxygen include the air and inflowing streams. Where air and water meet the tremendous difference in oxygen concentration causes oxygen molecules in the air to dissolve into the water. More oxygen dissolves into water when wind stirs the water creating more surface area. Another physical process that affects pond DO concentrations is the relationship between water temperature and gas saturation. Cold water can hold more oxygen. During the summer months in the warmer top portion of a pond, the total amount of oxygen present may be limited by temperature. Temperature effects can also cause reduced DO in deeper ponds (usually greater than 10 feet deep) as thermal stratification limits oxygen sources from reaching the lower depths. DO concentrations drop as organisms continue to respire and consume oxygen. Oxygen losses can also occur in summer if large amounts of plants or algae

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quickly die naturally, or as a result of an application of fast acting aquatic herbicides or algicides. Decomposition is more rapid in the summer due to warmer water temperatures. This uses a large amount of DO very quickly, causing a DO crash.

2) Algae Blooms & Chemical Applications – Both plant growth and plant death contribute to dissolved oxygen concentrations. During an algae bloom oxygen levels can become super-saturated and when hot water temperatures cause increased growth as well as fish respiration during the day, which then decrease rapidly during the night to such an extent that fish can die even when oxygen levels appear healthy. Similarly when dense algae or plant populations are present ponds are often treated to control nuisance growth. The plants and algae being affected by an algaecide or herbicide application are no longer producing oxygen, but consuming it as aerobic bacteria decompose and digest the organic matter.

CONSEQUENCES. If no action is taken, fish in ponds that experience DO concentrations of less than 3.0 mg/l (bass/bluegill/pike) or 5.0 mg/l (trout) throughout the water column can suffer severe oxygen stress. Under severe DO depletion in summer or winter, fish kills can occur. Ponds that frequently experience low DO concentrations throughout the water column usually can only support tolerant fish species such as carp and green sunfish. Also, some ponds have a small amount of the pond volume that has sufficient oxygen (<30%). Fish are squeezed into a smaller volume that may cause increased predation leading to an unbalanced fish population. A high quality fishery is difficult to sustain or achieve under these circumstances. Other aquatic organisms such as invertebrates require 4.0 mg/l to avoid severe oxygen stress. Besides the direct effects to aquatic organisms, low DO levels (<1 mg/l) can lead to increased release of phosphorus from the sediment that can fuel algal blooms when mixed into the sunlit zone. It also leads to the buildup of ammonium and hydrogen sulfide (H_2S, rotten egg gas) which can be toxic to bottom dwelling organisms. In extreme cases, sudden mixing of H_2S into the upper water column can cause fish kills. These gases are released causing potential odor problems. Since aerobic (with oxygen) decomposition breaks down organic matter faster than anaerobic (without oxygen), organic matter may buildup faster in the sediment due to low DO concentrations.

ARTIFICIAL CIRCULATION is probably the most widely used pond management technique. The principal effect of artificial circulation is to raise the DO content throughout the pond. In fact, artificial circulation should be called stratification prevention as the mixing process prevents thermal stratification. Stratification prevention allows water to come in contact with the air at the surface permitting oxygen diffusion to occur. In order to vertically move the entire water volume, the system must be sized properly. A recommended airflow rate for a typical disk diffuser aeration system is equivalent to 1.33 standard cubic feet per minute (scfm) per pond surface acre (Lorenzen and Fast, 1977). Ponds that have a single deep hole may only require one diffuser that can handle the required flow rate. Whereas, a pond with multiple holes and bays may require several diffusers and a flow manifold to properly distribute the required airflow. Ponds that are less than 6 feet deep rarely stratify in the summer and usually do not benefit from this option as they are already circulated. However, shallow ponds often have stagnant water conditions that benefit from the water movement provided by aeration. These shallow ponds may also benefit from aeration in the winter months. A pond management consultant will be able to choose a proper aeration system for each situation.

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BENEFITS. When properly sized for the pond, aeration systems can improve DO concentrations in the water column to help prevent fish kills and increase habitat for aquatic life. Zooplankton and warmwater fish such as bass and bluegill can inhabit a larger volume of the pond.

Algal blooms may be controlled through one or more of these processes: 1) mixing to the pond’s bottom will increase an algae cell’s time in darkness, leading to reduced net photosynthesis due to light limitation; 2) introduction of dissolved oxygen to the pond’s bottom may inhibit phosphorus release from the sediment; 3) rapid contact of water with the atmosphere, as well as the introduction of carbon dioxide-rich water during the initial period of mixing, can lower pH, leading to a shift from blue-greens to less noxious green algae; and 4) when zooplankton are mixed to the pond’s bottom, they are less vulnerable to sight-feeding fish, resulting in the increase of consumption of algal cells by the zooplankton (Olem & Flock, 1990; Lorenzen and Fast, 1977; Vandermeulen, 1992).

CAUTIONS. Mixing anoxic water from the hypolimnion (deep water) with oxygen poor surface waters can cause DO concentrations in the entire water column to fall below the amount needed for fish survival. Aeration systems should be started just after spring/fall turnover to avoid this situation. In the winter if the pond's DO was found to be 4.0 mg/L less than 2 to 3 feet below the ice, operation of the aeration system should begin. If artificial circulation is only used during the winter and the DO concentration is well below 4.0 mg/l near the surface, it may be too late to activate the aeration system. Mixing the anoxic water near the bottom with marginally oxygenated water near the surface can cause the entire water column to have DO concentrations below what is needed for fish survival.