UNIVERSITY OF FLORIDA
Cooperative Extension Service
Institute of Food and Agricultural Sciences

Fact Sheet FA 27

Dissolved Oxygen for Fish Production[1]

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What Is Dissolved Oxygen?

Dissolved Oxygen (DO) refers to oxygen gas that is dissolved in water. Fish "breathe" oxygen just as land animals do. However, fish are able to absorb oxygen directly from the water into their bloodstream using gills, whereas land animals use lungs to absorb oxygen from the atmosphere.

What Are the Sources of Oxygen in an Aquatic Environment?

There are three main sources of oxygen in the aquatic environment: 1) direct diffusion from the atmosphere; 2) wind and wave action; and 3) photosynthesis. Of these, photosynthesis by aquatic plants and phytoplankton is the most important.

Oxygen is produced during the day when sunlight shines on the plants in the water. Oxygen levels drop at night because of respiration by plants and animals, including fish. These predictable changes in DO that occur every 24 hours are called the *Diurnal Oxygen Cycle* (Figure 1).

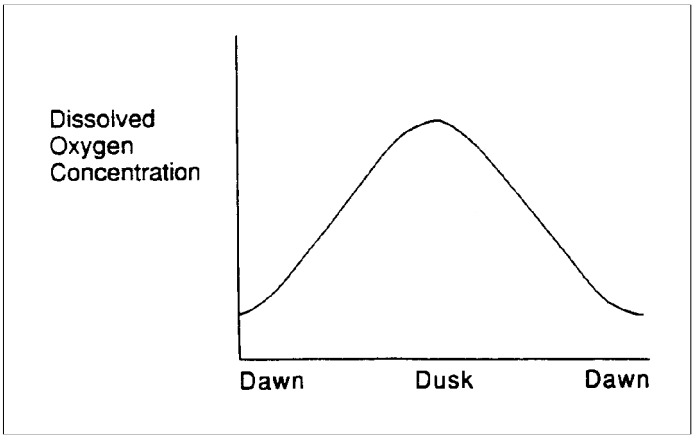

Figure 1. Dissolved oxygen concentration in pondsflucuates on a 24-hour basis. This fluctuation is called a "Diurnal Cycle". Dissolved oxygen increases during daylight hours when photosynthesis is occurring, and decreases at night when respiration continues but photosynthesis does not.

What Is an Oxygen Depletion?

An oxygen depletion refers to low levels of DO that result in fish mortality. A concentration of 5 parts per million (ppm) DO is recommended for optimum fish health. When DO concentrations drop below 2 ppm, fish are severely stressed, and when concentrations fall below 1 ppm they begin to die. The number of fish that die during an oxygen depletion is determined by how low the DO gets and how long it stays down. Usually large fish are affected by low DO before small fish are.

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1. This document is Fact Sheet FA 27, one of a series of the Department of Fisheries and Aquaculture, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Published: September 1992. Reviewed May 1997. Please visit the FAIRS Web site at **http://hammock.ifas.ufl.edu**.

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What Causes an Oxygen Depletion?

An oxygen depletion occurs when oxygen consumption exceeds oxygen production. Increases in oxygen consumption can be caused by an overabundance of aquatic plants or algae in the ecosystem, "turnover" of a body of water (see **Stratification/ pond turnover section**), increased organic waste entering the water (i.e., manure from feedlots, septic tank waste water, and excess fish feed), death and decay of organic matter (i.e., plant or algae die-offs), or by certain chemicals (i.e., formalin) that remove oxygen directly from the water column.

Why Are Oxygen Depletions Most Troublesome in the Summer?

Although oxygen depletions can occur at anytime, they are most common, and most likely to cause fish kills, during hot summer weather. Decreases in oxygen production are caused by events such as cloudy weather and plant or algae die-offs that shut down photosynthesis. These heavy populations of plants or algae are the most important producers of oxygen in the system. However, they are also the most important users of oxygen. There are several reasons why oxygen depletions are more common in the summer.

High Water Temperature

Warm water is much less capable of holding oxygen gas in solution than cool water. For example, water that is 90°F can only hold 7.4 ppm DO at saturation, whereas water that is 45°F can hold 11.9 ppm DO at saturation. This physical phenomenon puts the fish in double jeopardy because at high water temperatures the metabolic rate is increased, hence their physiologic demand for oxygen is increased.

Cloudy, Still Weather

Muggy, overcast summer days often precipitate oxygen depletions. During cloudy weather, the intensity of light reaching surface waters is greatly diminished, resulting in a marked decrease in oxygen production. Oxygen consumption, however, remains unchanged. This results in a net loss of oxygen over each 24-hour period. This loss of oxygen from decreased production is confounded by still, muggy, humid weather common on overcast summer days. Oxygen transfer (from the atmosphere into the water) is minimal because there is little or no wind/wave action. The net result over a period of several days is oxygen depletion and, often, fish kills.

Stratification/Pond Turnover

During hot weather, surface waters warm up more rapidly than deeper water. As the difference in temperature increases between warm surface water and cool bottom water, a thermocline develops. A *thermocline* is an area of rapid temperature change that acts as a physical barrier between warm water at the surface (*epilimnion*) and cold water at the bottom (*hypolimnion*). When a thermocline is present there is no mixing of surface and deep layers of water. Because photosynthesis and oxygen production only occur near the surface, water in the deep layer becomes devoid of oxygen and develops an oxygen demand. The thermocline can be broken by heavy wind and cold rain, common during summer thunderstorms. When the thermocline breaks down, the oxygen-rich surface waters mix with oxygen-deficient bottom waters. If the oxygen demand is sufficient, all DO present will be rapidly removed from the water column, resulting in severe oxygen depletion and a fish kill.

How to Determine If Low DO Is the Cause of a Fish Kill

Unfortunately, the only way to know for sure if oxygen depletion has caused a fish kill is to measure oxygen in the affected water while the fish kill is in progress. Indications of oxygen depletion as a probable cause of a fish kill include:

- All fish die at approximately the same time (often during the night or in the pre-dawn hours).
- Large fish may be affected more than small fish.
- Moribund fish may be seen at the surface "gasping" for oxygen (this is called "piping").
- Some species may die with their back arched, gills flared, and mouth open. This is most commonly seen in hybrid striped bass, and occasionally in catfish.
- The weather immediately prior to the fish kill may have been hot, still, and overcast. A severe thunderstorm may have occurred immediately prior to the fish kill.
- An oxygen depletion severe enough to result in significant fish mortality is often observed in water with heavy populations of algae or aquatic plants.

What Should I Do If I Suspect a Fish Kill Has Been Caused by Low DO?

The most important thing to do if fish are dying from low DO is to turn on an aerator. If emergency aeration is not available, little can be done to help the fish. To confirm the problem, oxygen levels should be tested while the fish kill is in progress. Many county extension agents are equipped with water testing equipment. In addition, biologists with the Florida Game and Freshwater Fish Commission or IFAS Aquaculture Extension Specialists may be available to assist.

Preventing an Oxygen Depletion

An oxygen depletion can be predicted and therefore prevented, by monitoring dissolved oxygen levels in a pond. The most efficient tool for measuring DO is an electronic oxygen meter. These instruments are available through most aquaculture supply companies at a variety of prices. Chemical test kits are also available. These are more troublesome to run, but are accurate and do not require as great an investment by pond owners.

Commercial catfish farms often hire night oxygen crews to monitor DO concentration in each pond at 2-hour intervals through the night. This is the surest way of avoiding a fish kill caused by low DO. Aeration systems can be turned on if oxygen levels drop below a certain concentration (usually 2 to 4 mg/L).

Monitoring oxygen throughout the night is impractical for recreational pond owners and part-time fish farmers. For these people it is easier to "predict" an oxygen depletion by measuring DO levels in the late afternoon (5 to 6 PM) and late evening (8 to 10 PM). The decline in DO during the night can be predicted by graphing DO concentration against time on standard graph paper (Figure 2). If the projected concentration of DO is below 4 mg/L before 7 AM, emergency aeration is recommended.

If equipment to test DO concentration (meter or test kit) is not available, the following observations and conditions can be used to anticipate oxygen depletion:

- Fish swim at or near the surface gulping air (piping).
- Fish stop feeding suddenly.

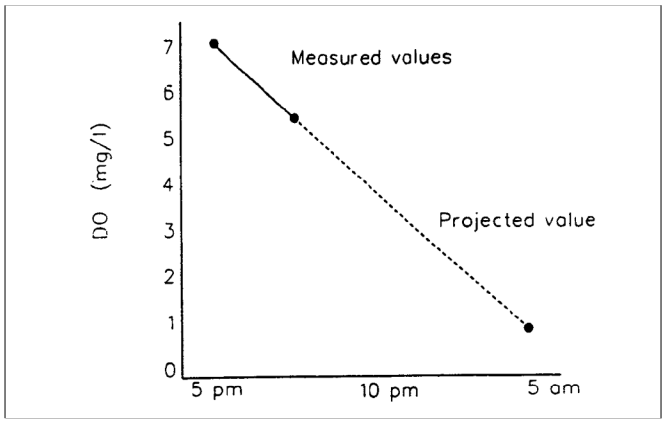

Figure 2. Estimation of potential for dissolved oxygen depletion.

- There is a rapid change in water color to brown, black, or gray.
- A putrid odor arises from the water.
- There is a loss of algae bloom.
- There has been an extended period of hot cloudy weather.
- There is a heavy summer wind and rainstorm.

Emergency aeration should be applied whenever fish show signs of oxygen depletion or when dissolved oxygen drops below 4 mg/L.

Summary

Dissolved oxygen (DO) is oxygen gas (0_2) that is dissolved in water. Most DO in ponds is produced during photosynthesis by aquatic plants and algae. For this reason DO increases during daylight hours, declines during the night, and is lowest just before daybreak. Dissolved oxygen concentrations below 5 mg/L may be harmful to fish, and piping (gulping air at the surface) may be observed when DO falls below 2 mg/L. Low levels of DO are most frequently associated with hot, cloudy weather, algae die-offs, or heavy thunderstorms. Dissolved oxygen can be monitored using an electronic oxygen meter or chemical test kit. Emergency aeration should be supplied whenever DO falls below 4 mg/L or environmental conditions favor an oxygen depletion.