

Thank you for contacting the Florida Fish and Wildlife Research Institute. Low dissolved oxygen (DO) is the most common natural cause of fish kills in the state of Florida. Fish kills can be the result of low dissolved oxygen due to weather pattern changes and water level variations. Algae blooms in ponds or freshwater canals that have received a large influx of nutrients can also deplete the oxygen. A clear sign that oxygen levels in the water have been depleted is when fish are surfacing to gasp for air. Large fish require a lot of oxygen and usually are stressed by inadequate oxygen before other fishes. DO levels fluctuate throughout the day, readings in the morning may be lower than readings during mid-day, or late afternoon and thus fish kills are usually observed in the morning. Attached, you will find scientific literature that provides a lot of information regarding fish kills.

Thank you for your concern,

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Fish Kill Hotline Coordinator

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Dissolved Oxygen for Fish Production¹

Ruth Francis-Floyd²

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, derived from photosynthesis, 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).

What is Oxygen Depletion?

Oxygen depletion refers to low levels of DO and may result in fish mortality. A concentration of 5 mg/L DO is recommended for optimum fish health. Sensitivity to low levels of dissolved oxygen is species specific, however, most species of fish are distressed when DO falls to 2-4 mg/L. Mortality usually occurs at concentrations less than 2 mg/L. The number of fish that die during an oxygen depletion event is determined by how low

the DO gets and how long it stays down. Usually larger fish are affected by low DO before smaller fish are.

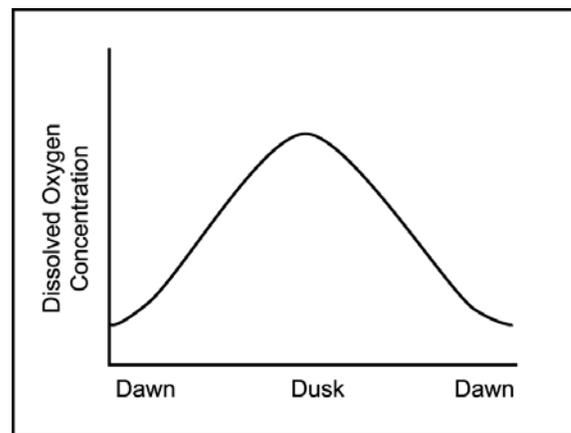


Figure 1. Dissolved oxygen concentration in ponds fluctuates on a 24-hour basis. This fluctuation is called a diurnal oxygen cycle. Dissolved oxygen increases during daylight hours when photosynthesis is occurring and decreases at night when respiration continues but photosynthesis does not.

What Causes Oxygen Depletion?

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.

¹ This document is Fact Sheet FA-27, one of a series from the Department of Fisheries and Aquatic Sciences, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. First published: September 1992. Reviewed May 1997, February 2003. Please visit the EDIS Web Site at <http://edis.ifas.ufl.edu>.

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Why are Oxygen Depletion Events Most Troublesome in the Summer?

In outdoor ponds, oxygen depletion events can occur at anytime, however, they are most likely to cause fish kills during hot summer weather. A decrease in oxygen production is caused by incidents such as cloudy weather and plant or algae die-offs that shut down photosynthesis. 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 depletion events are more common in the summer and they are discussed below.

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 mg/L DO at saturation, whereas water that is 45° F can hold 11.9 mg/L DO at saturation. This physical phenomenon puts the fish in double jeopardy because at high water temperatures their metabolic rates increase, hence their physiologic demand for oxygen increases.

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 from photosynthesis. 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 waters. 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 rapidly be 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

- 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 event severe enough to result in significant fish mortality is often observed in water with heavy populations of algae or aquatic plants.

What To Do if Low DO is Suspected as the Cause of a Fish Kill

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. Some county extension agents are equipped with water testing equipment. In addition, biologists with the Florida Game and Freshwater Fish Commission or an IFAS Aquaculture Extension Specialist may be available to assist.

Preventing Oxygen Depletion

An oxygen depletion event 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 the DO concentration in each pond at two-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 2-4 mg/L) depending on the fish species.

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 (5-6 p.m.) and late evening (8-10 p.m.). 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 a.m. emergency aeration is recommended.

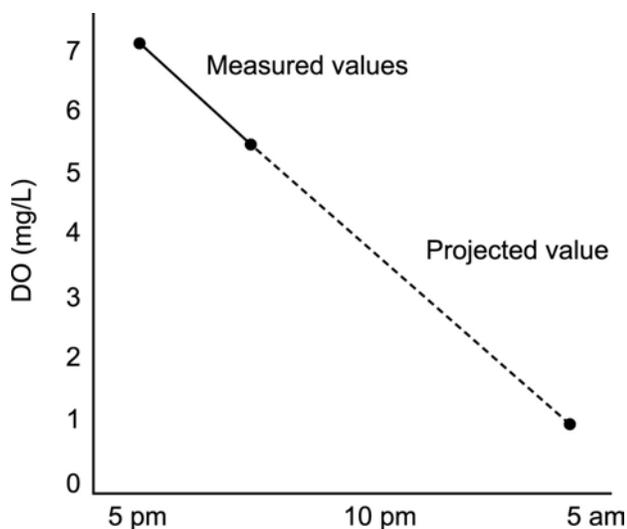


Figure 2. Estimation of potential for dissolved oxygen depletion.

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

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

Many recreational pond owners purchase aerators and place them on electric timers. Proper use of the timer should have the aerator turn on during the late evening (10 p.m. to midnight) and turn off after daylight (7-8 a.m.). Using an aerator is not a complete substitute for monitoring DO concentrations and an oxygen depletion event resulting in a fish kill may still occur. However, use of an aerator is recommended and will prevent many problems.

Summary

Dissolved oxygen (DO) is oxygen gas (O_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 event.

Understanding Fish Kills in Florida Freshwater Systems



A fish kill is an event in which dead or dying fish are observed in a lake or waterbody. Some fish kill events involve small numbers of fish and others may involve hundreds, or even thousands of fish.

There are many factors that can contribute to a fish kill. This pamphlet was created to explain the most common factors and how they affect Florida's freshwater systems. It includes discussion of both natural and human-induced causes, as well the effects that stress can have on fish — a component of virtually every fish kill situation.

We hope this information will provide a greater understanding of the processes that commonly occur during a fish kill event, and perhaps alleviate some of the concerns you may have.

Should a fish kill occur in your area, the last section of this pamphlet (pages 14-16) provides steps you can take to help determine the cause. While this task can be challenging, the chances for success are greatly increased if both fish samples and water samples can be collected from the waterbody and analyzed in a timely manner. A listing of fish health diagnostic laboratories is provided on page 16.* If too much time has already passed or if you don't have time to submit samples, the observations you collect can still provide important clues about what may have happened. Be sure to gather this information as soon as possible and contact the appropriate agency, listed on page 14.

** There are usually fees associated with having samples tested in a laboratory; it is recommended that you call ahead and discuss the cost before going to the trouble of collecting and submitting samples.*

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loridians are proud of the diversity and abundance of fish life found throughout the state, and for good reason. More than 225 different species of fish can be found in freshwater systems, including about 150 native species and approximately 75 non-natives. Of course, this doesn't even include the abundance of saltwater species!

With such a variety to choose from, it's easy to see why Florida is considered the Fishing Capital of the World — a place where virtually every day, thousands of anglers take to the water to land a trophy bass, catch a delicious fish dinner or enjoy the therapeutic qualities that fishing has to offer. In fact, freshwater anglers contribute nearly two billion dollars to the state's annual economy.¹

However, anglers aren't the only people who care about fish. There are just as many individuals who enjoy feeding or watching them school under a dock. Some lake residents have even "adopted" or named individual fish that are seen on a regular basis. Still others feel good simply knowing that there are fish living in their neighborhood lake, pond, or canal, serving as indicators of the ecosystem's health.

Such strong connections to the aquatic environment may help explain the concern that surfaces when reports of a fish kill appear in the local media — especially if large numbers of fish are involved. Often the first assumption is that something is terribly wrong with the lake or waterbody. Suspicions are raised as to whether human activity, such as a chemical spill, may have caused the fish to die. Sometimes these suspicions are warranted but often they are not. What many people don't realize is that the vast majority of fish kills in Florida are due to natural

¹ According to the National Survey of Fishing, Hunting and Wildlife-Related Recreation. U.S. Census Bureau. 2001.

The Bad News

- Fish kills occur frequently in Florida and most of them are natural.
- It is difficult to predict when a fish kill will occur.
- Even if a fish kill is predicted, there is not much that can be done to prevent it, especially in larger waterbodies.

The Good News

- In the event of a fish kill, you may see a lot of dead fish but there are usually a lot more that are still alive.
- If water quality should change for the worse, there are often many refuges for fish to escape to.
- Because fish are known to lay many eggs, their reproductive potential is usually strong. As a result, they are generally able to rebound from a fish kill within a couple of years.



Photos by Joe Fichard

Naturally Occurring Fish Kills

Naturally occurring fish kills can be related to physical processes (e.g., rapid fluctuations in temperature), water chemistry changes (e.g., lack of oxygen or changes in the pH), or they can be biological in nature (e.g., stress from spawning activity, viruses, bacterial infection, parasites, etc.). Such processes are common to every lake in Florida and generally become lethal only after a fish is weakened by stress. As described on page 8, stress is usually caused by a number of factors — in addition to the daily challenge of living in an aquatic environment and continuously having to hide from predators.

In Florida, the vast majority of fish kills are caused by one or more natural causes. The most common are low dissolved oxygen levels, spawning fatalities, mortality due to cold temperature, and fish parasites or diseases. On occasion, toxic algae blooms may be suspect. The following segments provide basic descriptions of these factors and how they can adversely affect fish health.

Low Dissolved Oxygen Levels

Fish need oxygen just as you and I do, even if they breathe a little differently. (Fish absorb oxygen from the water as it passes over their gills, whereas you and I use our lungs to absorb oxygen from the air.) For optimum health, warm water fish generally require dissolved oxygen (DO) concentrations of at least 5 parts per million, also expressed as 5 milligrams per liter or 5 mg/L.

Just like humans, fish can endure brief periods of reduced oxygen. However, if DO levels drop below 2 mg/L, they aren't always able to recover.² When concentrations fall below 1 mg/L fish begin to die.³

The periodic depletion of dissolved oxygen in a lake or waterbody is by far the most common cause of fish kills in Florida. These events are easy to recognize because they usually affect many different sizes and species of fish, whereas cold temperature-related or spawning-related fish kills tend to affect only one or two species. If it is a DO-related fish kill, large fish tend to be affected first and more severely than other fish. Another clue: small fish can be seen gulping or gasping for air at the surface just before a fish kill occurs.

When it comes to understanding the dynamics of oxygen and water, the most important thing to remember is that the amount of dissolved oxygen found in an aquatic system changes constantly, day and night. It is affected by weather, temperature, the amount of sunlight available, and the amount of plants and animals living in the water. Each of these factors can influence the amount of oxygen released or removed from the water at any given time. See pages 4 -6 for more about these processes.

² Dissolved oxygen refers to oxygen gas that is dissolved in water.

³ Fish kill data reported to the South Florida Water Management District documents that 87% of the fish killed in South Florida (i.e., from 1991 to 2001) occurred when surface DO was 3 mg/L or less. Measurements were taken during or shortly after each fish kill event.

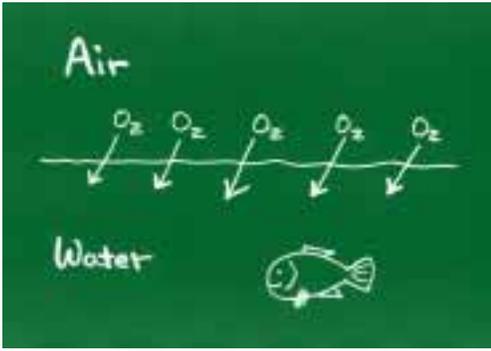


Joe Richard



Chuck Cichra

The periodic depletion of dissolved oxygen in a lake or waterbody is by far the most common cause of fish kills in Florida.



Oxygen enters water from two main sources:

The atmosphere: The same oxygen that we breathe from the atmosphere is also slowly and continuously being dissolved into our oceans, lakes, rivers, streams, and ponds through a process known as **diffusion**. Wind and wave action can accelerate this process.

Photosynthesis: Photosynthesis is a process whereby algae and aquatic plants use carbon dioxide, water, and sunlight to make their own food. Oxygen is a by-product of this activity. Therefore, as long as photosynthesis is taking place, oxygen is continuously being released into the water.

At the same time that oxygen enters the aquatic environment, it is also being removed by the following natural processes:

Biological activity in the water column – refers to the regular day-to-day functions carried on by various aquatic organisms in a lake including algae, aquatic plants, bacteria, fish, insects, zooplankton, etc. Just as you and I use oxygen from the air, these organisms are constantly using or removing oxygen from the water. This is usually not a problem during daylight hours because the algae and submersed aquatic plants generally produce a surplus of oxygen via photosynthesis. However, once the sun goes down, algae and plants are no longer able to photosynthesize and they become oxygen *consumers*, instead of oxygen *producers*. After a long night of limited oxygen production, the organisms in a lake are ready for some fresh DO.

Water temperature – affects how much oxygen water can hold at a given time. As a general rule, warm water holds less oxygen than cool water.⁴ In fact, not only does warmer water hold less oxygen, it also speeds up a fish's metabolism. Of course, this dynamic puts fish in double jeopardy; as the water becomes warmer, fish need more oxygen for respiration,⁵ but are getting less because warm water holds less oxygen.

Decomposing aquatic plants and/or algae – can result in the loss of oxygen in a waterbody and it works like this: once the plants or algae die, a feeding frenzy is often triggered within the detrital aquatic community,⁶ as bacteria begin to break down or "decompose" the dead vegetation. The increased activity can result in a loss of oxygen because these organisms are working harder and therefore using more oxygen. If there is a large amount

⁴ There are times when cooler water may not necessarily hold more dissolved oxygen than warm water. See **Lake Turnover** section described on page 5.

⁵ (i.e., the act of breathing)

⁶ (i.e., microbes and/or insects that feed on rotting vegetation and debris)



Just as you and I use oxygen from the air, aquatic organisms and plants are constantly using or removing oxygen from the water.

of dead vegetation or algae, such activity can result in a severe loss of dissolved oxygen and, consequently, a fish kill. Lakes or ponds with heavy populations of aquatic plants or algae are more susceptible to this type of event and can result in large numbers of dead fish. That is why, when using chemicals (i.e., algicides or herbicides) to remove algae or aquatic weeds from a lake, it's recommended that treatments be staggered in order to avoid large amounts of algae or plants dying all at once.⁷

Lake turnovers – generally occur in the fall but can sometimes occur in the summer. During hot weather, the surface water of a lake warms much faster than deeper water. This results in a temporary layering effect, with warm water on top and cool water underneath. Scientists refer to this as stratification. Because the top layer has constant access to the atmosphere, it tends to have more oxygen than the bottom layer — even though it's warmer.⁸ If a heavy wind or cold rain should occur during these conditions, the stratification may be broken, causing the two layers to mix. Once this happens, oxygen-rich surface waters are suddenly mixed with the low-oxygen bottom waters.

If the volume of low oxygen water (i.e., from the bottom of the lake) is much greater than the oxygen-rich surface layer, this mixing action can result in low DO levels throughout the water column, and potentially result in a fish kill.

To summarize: Although oxygen depletions can happen at any time, they are most likely to occur during warm summer months due to the factors described above. A combination of hot weather and cloudy skies can be particularly deadly for fish, as the decrease in sunlight (i.e., from cloud cover) makes it difficult for algae and plants to photosynthesize. The reduction in photosynthesis results in a decrease in oxygen being released into the water column. When overcast skies persist for several days, oxygen levels can become severely depleted.

Heavy thunderstorms can also have an adverse effect on oxygen levels, especially after extended periods of dry weather or during hot weather. If conditions have been dry for a long time, heavy rains tend to wash large amounts of organic matter such as dried leaves, grasses, etc. into nearby canals, lakes, and ponds. As bacterial organisms begin to decompose the new material, oxygen is used at a faster rate than normal. This can be a problem during hot weather as there is less oxygen in the water.

See Figure 1 on page 6 for more on the relationship between fish kill events and rainfall in Florida.

⁷ *A Beginner's Guide to Water Management - The ABCs (Information Circular 101)*. 1999. Florida LAKEWATCH. University of Florida/Department of Fisheries and Aquatic Sciences. Page 12.

⁸ While cooler water has the potential to hold more oxygen, there are times when dissolved oxygen levels are lower in cool water — especially at greater depths where there is no access to atmospheric oxygen and photosynthesis is limited due to a lack of sunlight.



Amy Richard

Lakes with large amounts of aquatic plants or algae are more susceptible to oxygen-related problems, especially if the plants happen to die all at once.



Chuck Cichra

The graph below provides strong evidence that many of the fish kills in Florida are related to rain events, particularly during the summer months. It's also a good example of how useful long-term data can be for making such comparisons. Data for the graph was supplied by the South Florida Water Management District.

Figure 1

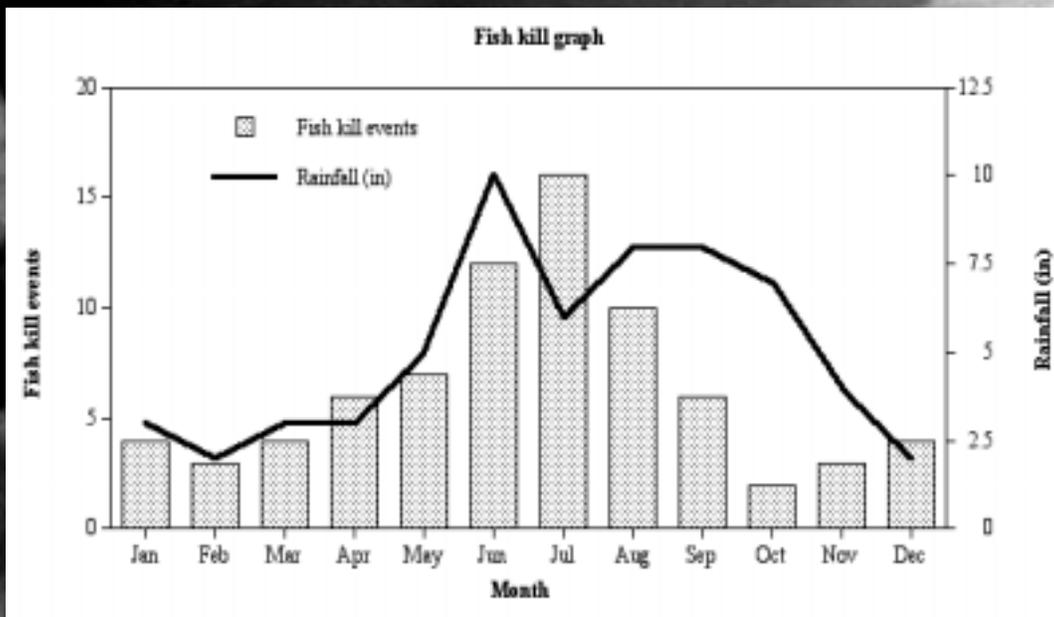


Figure 1 illustrates the relationship between the total number of fish kill events and average monthly rainfall in South Florida, from 1991 to 2001. Notice the strong correlation between the number of fish kill events and the amount of rainfall during the same time. Also notice that a large majority (64%) of the fish kill events occurred between May and September — traditionally known as Florida's rainy season. Average rainfall for this time period accounted for 61% of the annual average, whereas rainfall for the preceding four months accounted for only 18% of the annual average.

Spawning Fatalities

Another type of fish kill event that is both natural and common in Florida waterbodies occurs after fish spawning activities. This is usually due to exhaustion from courtship behavior, nest building, and the release of eggs or milt. Fish have also been known to suffer fatal injury from defending their young. During and after spawning, fish are often quite weak and any change in the environment can stress them significantly and lead to death.

These type of events are most common in the springtime and early summer when the majority of the fish are spawning.⁹ They are generally identified by the deaths of adult fish (only), belonging to one or two different species.



Mortality Due to Cold Temperatures

Fish kills can also be the result of a dramatic drop in air, and consequently, water temperature. This type of event is easily identified because it generally happens after extended periods of cold weather and almost all of the dead fish will be cold intolerant species. In almost every instance, these cold intolerant species are “exotic” fish that have accidentally been introduced to Florida waters. One example is the blue tilapia (*Tilapia aurea*) from Africa’s Nile River. This fish was inadvertently introduced into Florida waterbodies in 1961 and is now successfully reproducing in 18 counties. Because they are from a tropical region of the world, blue tilapia don’t fare well in cold temperatures; they stop feeding when water temperatures drop to about 60 degrees Fahrenheit and die when it reaches approximately 45 degrees.

Those who worry about the further spread of exotic tropical fish species can take some comfort in knowing that their distribution is often naturally limited by their sensitivity to low temperatures. This natural control mechanism was recently demonstrated at Lake Alice, a small waterbody on the University of Florida campus in Gainesville in North Central Florida. For several years, the lake supported a population of blue tilapia estimated to be around 12,000. However, in early January 2001, a severe cold front passed through Gainesville bringing temperatures that were considerably colder than the tilapia’s native African habitat. Within a week, dead tilapia began to float to the surface. By the middle of the month, thousands of these fish had died, while native species survived the cold snap just fine. Several more cold fronts have effectively reduced the tilapia population to almost nothing.



Photos by Joe Richard

Cold temperature related fish kills are easily identified because they generally occur after extended periods of cold weather and almost all of the dead fish will be cold intolerant species, such as the blue tilapia pictured above.

⁹ Some fish spawn year round in Florida, but the peak season is generally from January through April.



As you've learned from reading this pamphlet, there are many factors that can contribute to a fish kill. However, stress seems to be a common element linked with virtually every one of these events.

The term "stress" is used to describe the physical changes that fish experience as they adjust to a changing environment. While it may not be the actual cause of disease or death, it is always a predisposing factor.

As with humans, there are numerous degrees of stress and a fish can recover from many of them, especially if it can remove itself from the negative events it is experiencing. However, if it cannot escape, or the events increase in severity or duration, the fish may be pushed beyond a level from which its system can recover.

The typical stresses that a fish may experience on a daily basis, such as the predator/prey example described on page 9, are natural situations that fish are designed to deal with. However, continuous stress tends to break down a fish's immune system and can lead to disease or death. Examples of continual stressors include poor nutrition, poor water chemistry, and overcrowding. Multiple stresses occurring at the same time, can have a magnified effect and often represent the fatal blow to a fish's health.

The Mechanics of Stress

When fish experience stress, various physical and chemical processes occur. To be more

specific, stress triggers a series of events known as the **General Adaptation Syndrome**. This syndrome affects a fish's metabolism and immune system and occurs in three phases:

Phase 1 Alarm Reaction - This first phase involves the release of certain stress hormones, resulting in an immediate reaction from the fish. Also known as the "flee or fight" response, the release of stress hormones acts as a signal to the fish to swim away as quickly as possible or stay and fight.

Phase 2 Resistance Stage - The second phase involves the use of a fish's energy stores to compensate for the challenge it has detected (i.e., to flee or fight). If the "stressor" does not decline, the fish will continue to use its energy reserves until they are depleted, leading to the third phase.

Phase 3 Exhaustion Phase - During the Exhaustion Phase there is minimal ability to adapt or resist death.

Anglers are familiar with the fish behavior just described as it is (hopefully) played out many times during a fishing trip. Sometimes the angler wins, sometimes the fish wins. However, the General Adaptation Syndrome is most often associated with a fish's ability to survive in its normal aquatic environment full of hungry finned predators.



Photos by Joe Richard

The following is a description of a typical predator/prey encounter:

A largemouth bass spots a bluegill and begins to chase it. The bluegill senses the approaching bass and attempts to escape. Stress hormones are released, triggering an increase in blood flow to the bluegill's skeletal muscles and gills, and a decrease in blood flow to the digestive system (a low priority at this point). The increased blood flow to the gills and muscle tissue allows for a burst of fast swimming.

If the bluegill makes it to cover before the bass swallows it, the stress stops almost immediately — for the bluegill, anyway. Once the bluegill is safe in its new hiding place, it can rest and slowly replenish its depleted energy stores. However, if it is too far from cover or makes a mistake and bolts for open water, then the stressor (i.e., the bass) will continue the chase, "burning up" the bluegill's energy stores as it flees. Eventually the bluegill will exhaust its supply of quick energy and will begin to tire and slow until the bass captures it with one big gulp!

This synopsis is a good example of an "all or nothing" situation where the outcome is very distinct (i.e., recovery or death). However, there is also a more complex form of the General Adaptation Syndrome that exists when stress occurs at lower levels, but for prolonged periods of time. When this happens, stress slowly catches up to the fish, resulting in disease and sometimes, death.

Such chronic low-level stress stimulates the production of a second type of hormone-induced process that affects the fish's metabolism and osmoregulation (water-ion salt balance).

The results are a prolonged reaction within the fish's body chemistry — a contrast to the more immediate "flee or fight" response described earlier. Though the release of low-level hormones is more gradual, it is similar in that it also occurs in three phases:

Step 1 When a fish begins to experience a stressor, substances known as "releasers" are produced by the hypothalamus in the brain.

Step 2 These releasers travel through the bloodstream to the pituitary gland, where they trigger the release of hormones to the kidney.

Step 3 The hormones themselves produce a chemical that suppresses the immune system, resulting in an increased susceptibility to disease.

In addition to these steps, there is another physical process that occurs that can be beneficial to fish for the short term, but detrimental over the long term. When hormones are released, extra blood is shunted to the fish's gills, providing a quick source of oxygen and energy. However, if the stress continues, the gill tissue remains engorged with blood, and water flowing over the gills will remove too many salts and ions from the fish's bloodstream. This can be corrected on a short-term basis (i.e., predator/prey chase scenario). However if the stress continues over a prolonged period of time, there is no recovery phase and the fish will most likely become ill and experience a fatal outcome.

Diseases and Parasites

Fish diseases (i.e., from viruses, bacteria, and fungi) and parasites (i.e., protozoans, crustaceans, flukes, and worms) occur naturally in Florida lakes and under certain circumstances, fish can contract one or more of these afflictions. Of course, a healthy fish is usually able to fend off such problems, but if a fish is weak from spawning or from extreme water quality conditions, it has a much greater chance of getting sick or possibly dying.

See sidebar: [Stress in Fish on pages 8 & 9.](#)

Fish infected with parasites or diseases may have physical clues on their bodies or they may display abnormal behavior. Some physical clues can be obvious, such as open sores on the body, missing scales, lack of slime, or strange growths on the body, head, or fins. If a fish is large enough (e.g., a largemouth bass), the careful observer may even notice parasites crawling on its skin or gills. Abnormal behavior may include swimming weakly, lazily, erratically, or in spirals; scratching or rubbing against objects in the water; twitching, darting, or convulsing; failure to flee when exposed to fright stimuli; gasping at the water surface or floating head, tail, or belly up.

These types of fish health problems are perhaps a little more difficult to spot in the natural environment whereas fish farmers are all too familiar with it. In channel catfish aquaculture ponds, for example, a protozoan known as *Aurantiactinomyxon ictaluri* is known for causing the dreaded Hamburger Gill Disease. In some instances, it has killed up to 100% of the fish in an infected pond. Fish with this particular problem may exhibit a reduction in feeding habits and can be seen swimming lethargically. They may also be gasping for air at the surface and frequently will congregate around aeration equipment. Their gills will be swollen and mottled with red and white colored streaks, closely resembling ground hamburger meat, hence the name.

If a fish disease problem is suspected in a lake or pond, it is helpful and informative if one is able to collect water samples and also capture several live fish samples for examination — especially fish that are near death.

Note: Once dead fish are observed floating at the surface of a lake or waterbody, decomposition is usually advanced and the fish are not suitable for diagnostic evaluation.

For more on the correct procedures for sampling, see [Collecting Fish and Water Samples on page 15.](#)



Joe Richard

Fish infected with diseases or parasites may have physical clues on their bodies such as sores, or they may display abnormal behavior.



Chuck Cichra

Fish diseases such as the dreaded “Hamburger Gill Disease” can be devastating — particularly in ponds.

Toxic Algae Blooms

The appearance of large amounts of algae or scum floating on the surface of the water is often referred to as an “algae bloom” or “algal bloom.” Such occurrences can be smelly, unsightly, and — depending on the species of algae — the color of the water may even change. In some instances, a number of dead fish may be seen floating on the surface or washed up on the shoreline. As alarming as these events may seem, there are several factors to consider before assuming that an algal bloom is toxic:

- In Florida’s freshwater systems, there are relatively few species of algae that are known to produce toxins.¹⁰ The most common species found here are the blue-green algae *Microcystis*, *Cylindrospermopsis*, *Anabaena* and *Aphanizomenon*, as well as the microflagellate *Prymnesiam*.¹¹ It’s important to note that not all of the species within these algal groups produce toxins; those that do, produce toxins in varying amounts, depending on prevailing conditions.
- While toxins produced by these algae have the potential for killing fish, there are very few cases that have been definitively linked to toxins. (This will most likely remain an important focus of research for years to come.)
- Algae blooms are a natural component of nutrient-rich lakes and rivers, particularly those with high levels of nitrogen and phosphorus.
- Algae blooms are fairly common in Florida either because of natural geologic conditions (nutrient-rich soils) or human induced increases in nutrients.
- It’s thought that most algae-related fish kills are the result of oxygen depletion, as opposed to toxicity problems.

See the Dissolved Oxygen segment on pages 3 - 6 for more on this.

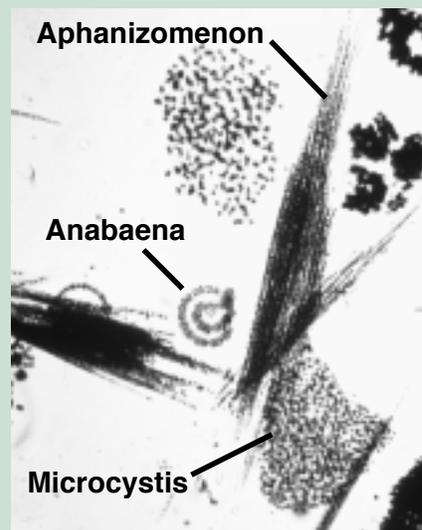
¹⁰ Coastal residents are perhaps familiar with toxic-algae related fish kills that occur periodically in coastal waters (i.e., in the form of red tides).

¹¹ A class of single-cell organisms such as a flagellate protozoan or alga.



Amy Richard

In Florida’s freshwater systems, there are relatively few species of algae that are known to produce toxins. The algae pictured below represent a few of the most common “toxic” blue-green algae found in Florida freshwaters.



University of Florida

Human Induced Fish Kills

Michael Connert — <http://www.fluoridealert.org>



Amy Richard



Michael Connert — <http://www.fluoridealert.org>



There is no doubt that human impacts can lead to fish kills. However, in the United States, it is also true that point source pollution problems have been reduced dramatically since the turn of the 20th century, or even as recently as the 1960s, when raw sewage and industrial waste were routinely dumped into rivers, lakes, and oceans. (Remember the Hudson River fires?)

In recent decades such practices have been virtually eliminated. Nowadays, if a human-induced fish kill does occur, it's usually the result of contaminants unintentionally being spilled or leaked into a nearby waterbody. Obviously, the goal should be to prevent these occurrences in the first place. But accidents happen and they can happen in any number of ways: Highway accidents involving tanker trucks full of fertilizers or other toxic substances have resulted in chemicals spilling into nearby waterbodies. Barges have been known to run into things, rupturing storage tanks and releasing oil or other contaminants. Gas pipelines have also been known to crack and leak oil into various aquatic environments.

In some instances, a spilled substance may not even be toxic, but if enough of it is introduced into a system, it can be detrimental in another way such as causing a shift in water temperature or a change in pH.

As far as toxic spills are concerned, the effects of such an event often depend on the toxicity of the spilled substance and the surface area and volume of the waterbody. In other words, if a lake is large enough, it may be able to dilute the substance enough so that aquatic organisms, including fish, are able to avoid any detrimental effects. Of course, this isn't always the case.

One example of a catastrophic human-induced fish kill involved a phosphate plant in Mulberry, Florida in December 1997. Nearly 60 million gallons of acidic process water from the plant was accidentally dumped into Skinned Sapling Creek, a tributary to the Alafia River. In five days, the spill traveled 36 miles down river and changed the pH of the water from around eight to less than four.¹² A fish kill occurred along that entire stretch of river, killing an estimated 1,300,000 fish. Fortunately, such occurrences are rare.

¹² In addition to their sensitivity to changes in temperature and dissolved oxygen, fish can also be detrimentally affected by rapid changes in the pH of the water.

Sometimes, human-induced fish kills can occur from the sheer amount of foreign substances entering a waterbody. When this happens, fish die mostly from low oxygen levels that have resulted from an increase in biological activity in the water.

See [Low Dissolved Oxygen Levels / Biological Activity in the Water Column](#) on pages 3 & 4.

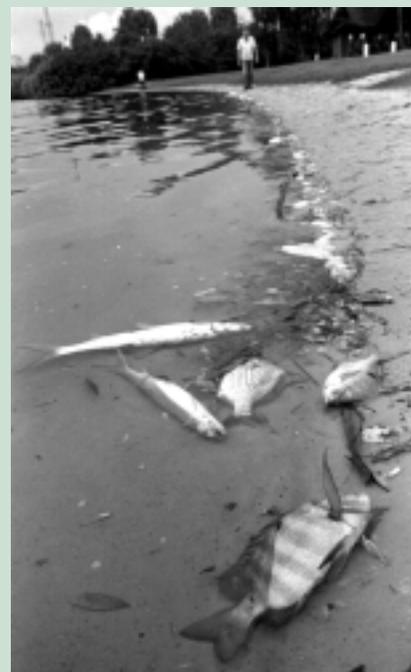
A related example of this involved an explosion at the Wild Turkey whiskey factory located along the banks of the Kentucky River, near Lawrenceburg, Kentucky. The explosion resulted in many thousands of gallons of bourbon flowing into the river. Officials were unsure whether it was the bourbon that killed the fish or a lack of oxygen from the millions of aquatic microbes that rapidly began to devour the liquor, essentially sucking all the dissolved oxygen from the water. Hundreds of thousands of fish died in that event.

If a human-induced spill or fish kill event should occur, there are often clues that will help bring attention to the problem: A “film” or “slick” can sometimes be seen on the surface of the water, or the color or clarity of the water may change.¹³ Strange odors might also be noticeable or there may even be more obvious evidence such as large containers of the substance sitting near the shoreline. A thorough investigation of the local area, along with written observations of changes in water quality, can direct investigators to the possible contaminating source. Observers should look for evidence of other wildlife species being affected such as birds, frogs, snakes, turtles, etc.

If you see an oil spill or unknown substance in a lake or waterbody, the best bet is to call Florida’s 24-hour Hazardous Substance Hotline at (800) 320-0519 or (850) 413-9911.

If a fish kill has occurred as a result of the spill or substance, you may also want to call the Fish Kill Hotline at (800) 636-0511.

¹³ An oily sheen on the water is not always an indication of a human-induced spill. There is a naturally occurring algae, known as *Botryococcus*, that produces an oily substance that can be seen on the surface of the water. In Florida, *Botryococcus* algae blooms are fairly common, especially during the summer months. Its presence has caused some alarm among lakefront citizens, as the algal cells are red or burnt orange in color and, in large enough concentrations, they have been known to temporarily change the color of a lake from green to orange. Also, in some instances, it will look very much like a gasoline spill or oil slick.



Tampa Tribune

One example of a catastrophic human-induced fish kill involved a phosphate plant in Mulberry, Florida In 1997. Nearly 60 million gallons of acidic process water from the plant accidentally spilled into Skinned Sapling Creek, a tributary to the Alafia River. In five days, the spill traveled 36 miles down river and changed the pH of the water from around eight to less than four. A fish kill occurred along that entire stretch of river, killing an estimated 1,300,000 fish. Fortunately, such occurrences are rare.

What You Can Do If You Observe a Fish Kill

If you are especially concerned or interested in finding out what caused a fish kill, you should start off by collecting fish and water samples as quickly as possible. The proper procedures for collecting are discussed on page 15. Samples must be collected within hours of the fish kill. If too much time has already passed or if you don't have time to collect and submit samples, the following observations can still provide important clues as to what might have happened. Once you've gathered this information, call your local wildlife agency (listed below) to report it.

- Record the date and approximate time you first noticed dead fish.
- Observe and record the weather conditions from the past three or four days (e.g., temperature, amount of rainfall, cloud cover, wind strength and direction).
- Record any changes in the color of the lake water (e.g., did the water change from green to brown or black?).
- Record the type of dead fish, by species name, if possible.

Note: If you cannot identify a species of fish, place one or more in a plastic bag and freeze it for identification purposes only. However, DO NOT FREEZE fish that you are submitting for diagnostic evaluation (i.e., for determining the cause of the fish kill). For more information on collecting and submitting fish and/or water samples for diagnostic evaluation, see page 15.

- Record the number of dead fish and, if possible, categorize them by species.

Note: If the dead fish are too numerous to count, try to estimate the number by first counting the number of dead fish in a 10-foot X 10-foot area. Then estimate the total distance along the shoreline and out into the water in which dead fish are present. These numbers can be used to estimate the extent of the kill.

- If possible, take a few minutes to study the appearance of the dead fish and record the following observations:

- Size, to the nearest inch;
- The condition of the bodies (e.g., thin, bloated);
- Are one or both eyes normal, sunken in, or popped out ?
- Are the fins clamped down, bloody, or frayed?
- Are the gills discolored, bloody, or frayed?
- Are there lesions or growths on the fish?
- What else looks abnormal on the fish?

- Talk to your neighbors. Ask them if they've noticed anything unusual about the lake in the past few days. Were fish gulping air at the water's surface? Were there unfamiliar containers near the shore? Was there a "film" or "slick" present on the surface of the water? Any strange odors coming from the lake?

- Call the Florida Fish and Wildlife Conservation Commission (FWC) Fish Kill Hotline to report the event and they will pass it along to the appropriate regional biologist or enforcement officer.

**FWC Fish Kill Hotline
(800) 636-0511**

**Florida's 24-hour Hazardous
Substance Hotline
(800) 320-0519 or (850) 413-9911**

Collecting Fish and Water Samples

If you are trying to determine the cause of a fish kill, one way to improve your chances of an accurate “diagnosis” is to obtain both fish samples and water samples from the area where the fish kill occurred. The sooner the samples are collected, the more accurate the diagnosis will be. Also, keep in mind that it’s best to collect fish that are near death or showing signs of distress, such as gasping for air at the surface, etc. Careful sampling techniques and packaging procedures will also play a role in your success. The agency or fish health specialist that you report the fish kill to may provide you with specific sampling or packaging procedures but the following techniques may also be used. Also, be aware that there are usually fees associated with laboratory diagnostic services. If you are unable to pay for these services, you could just try to answer the questions on page 14 and report your observations to the nearest wildlife agency.

Note: Some commercial carriers (UPS and Fed-Ex) will ship samples, but only if they are packaged correctly.

Fish Samples

Live Fish

If the fish are alive and appear to be able to make the trip to the laboratory, place them into well-

aerated water in a heavy ply plastic bag (fish shipping bag or commercial freezer bag) in a Styrofoam® cooler to regulate temperature. It’s best to collect between three and five fish of each species involved. This ensures an accurate diagnosis of the population as a whole.

Dead Fish

Even though the usefulness of dead fish is severely restricted for determining the cause of death, if they are in good condition (i.e., eyes are clear and the gills red), they may still be of value. Collect between three and five fish of each species and keep them moist with wet paper towels in a heavy-ply plastic bag. Pack the samples with ice in a Styrofoam® cooler and then place in a shipping carton. If the fish are obviously decomposed or malodorous, do not submit them.

Hint: If there is a very strong noxious odor associated with the dead fish, they are rarely suitable for diagnostic evaluation.

IMPORTANT: DO NOT FREEZE SAMPLES.



Water Samples

If you are submitting fish samples from a fish kill event, you should also submit a water sample. When collecting a water sample for analysis, a few

simple yet important procedures must be followed.

Note: No matter how “clean” you think the water is, it is important to submit a water sample for analysis.

- Water samples should be collected and submitted in separate containers from fish samples. This is important, as the chemistry of a water sample will change significantly if it contains a live or dead fish.
- Use a clean (approximately) 1 quart-sized container. Thoroughly rinse any foreign matter or soap residue from the container before collecting your sample.
- Submerge the empty container 6 - 12 inches under water and hold it there until full. Place the cap back on the container while it is still beneath the surface. This removes air bubbles, which can interfere with the dissolved oxygen measurements. Check the sample to ensure no visible air bubbles are present.
- Label sample with the following information: sample location, water depth, date, time of collection.
- Keep water sample in cold storage once collected (on ice or ice packs in a cooler). If shipping samples to a lab, package them in a Styrofoam® cooler and then inside a shipping box. **DO NOT FREEZE.**

Fish Health Diagnostic Facilities in Florida

UF/IFAS Facilities

Department of Fisheries and Aquatic Sciences
7922 NW 71st Street
Gainesville, FL 32653
Phone: (352) 392-9617 ext. 230
Email: rffloyd@ufl.edu

Zoological Medicine Service, College of Veterinary Medicine
P.O. Box 100125
Gainesville, FL 32610
Phone: (352) 392-4700 ext. 5686
Email: riggsa@mail.vetmed.ufl.edu

Florida Department of Agriculture & Consumer Services (DACS)

Note: DACS facilities require referral by a licensed veterinarian

Kissimmee Diagnostic Laboratory
2700 N. Bermuda Avenue
Kissimmee, FL 34741
Phone: (407) 846-5200

Live Oak Diagnostic Laboratory
P.O. Drawer 0
Live Oak, FL 32064
Phone: (386) 362-1216

Note: There are fees associated with any diagnostic procedure performed by state agencies or by private consultants. Typically, state agencies are open Monday - Friday from 8:00 am to 5:00 pm. Some private consultants may have after-hours services at an additional cost. All laboratories must be notified prior to sample submission.

Acknowledgments

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A Beginner's Guide to Water Management – Fish Kills (Information Circular 107)

This document is the seventh in a series of educational publications produced by Florida LAKEWATCH © 2003. For more information or to obtain copies, call 1-800-LAKEWATCH (525-3928) or (352) 392-4817.

Free copies are also available for download from our website:

<http://lakewatch.ifas.ufl.edu/>