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Algae Blooms in Commercial Fish Production Ponds

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One of the most difficult challenges facing commercial fish producers is the constant balancing act required to maintain a stable relationship among the water, fish, and microscopic flora and fauna in their pond systems.

In nature, where densities of fish and other living organisms are low, complex ecological systems maintain this delicate balance to prevent explosive shifts in populations and the negative effects that they can have on the total systems.

In commercial fish production ponds, however, natural carrying capacities are greatly exceeded, and a heavily laden artificial ecology is established among the various organisms and the environment in which they live. It is this artificial system that the fish producer must understand and maintain to maximize production and profitability. Unfortunately, we do not know enough about many of the dynamics in commercial pond systems to understand how best to manage them.

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Important primary components of the ecosystem in a fish production pond are the microscopic algae, or phytoplankton. Suspended in the water, these microscopic, single-celled plants are often collectively referred to as the “bloom.” Like all green plants, phytoplankton produce oxygen during the daylight hours as a by-product of photosynthesis. This is a major source of oxygen in fish pond waters.

Blooms are also responsible for consuming much of the oxygen produced. Fortunately, during daylight they usually produce more oxygen than they use, resulting in a surplus for fish and other organisms. At night or in cloudy weather, however, production of oxygen through photosynthesis ceases or is greatly reduced, but the consumption rate does not change, often resulting in a deficit in the oxygen “budget.” Under certain conditions, the level of oxygen can become critically low and fish may suffocate or at least become stressed to the point of being susceptible to disease.

Phytoplankton blooms also serve the useful purpose of shading the pond bottom, thus preventing growth of aquatic weeds. Uncontrolled weed growth can prevent fish producers from effectively seining their ponds.

The pond community

The two most common types of algae found in blooms belong to the green and blue-green families. While green algae generally dominate cool weather blooms, blue-green algae usually account for as much as 50 to 75 percent of a bloom in the summertime. Once blooms become dense enough to significantly reduce sunlight penetration, conditions favor growth and development of the blue-green groups of algae. Blue-green algae are often associated with off-flavor problems in either of two ways. Some blue-green algae produce substances called geosmin and MIB (methylisoborneal), which impart undesirable flavors in fish. Additionally, when weather conditions or other factors stress the algae and they begin to die off in large numbers, off-flavor compounds are produced by the decomposition process.

A complex community of microscopic animals is also typically associated with a phytoplankton bloom (Figure 1). Most of these

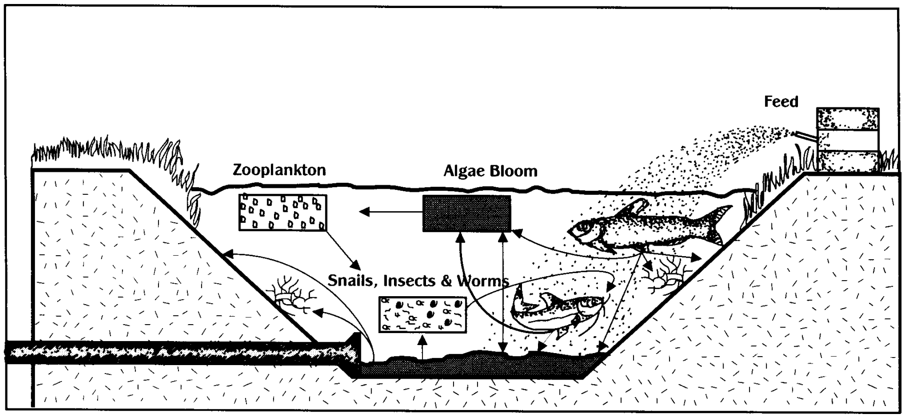

Figure 1. Commercial fish pond nutrient flow.

tiny animals, referred to as zooplankton, are herbivores that graze on the phytoplankton "pasture." As a major food item for small fish in natural aquatic habitats, zooplankton provide a link between the bloom and the rest of the food chain. Apart from the zooplankton and the fish being cultured, most of the other animal life present can be found on and in the pond bottom. A typical pond bottom community includes bacteria, protozoans, insect larvae, true worms, crustaceans, snails and other animals in varying proportions. These organisms survive by feeding on or breaking down fish wastes and any uneaten feed that reach the pond bottom.

Fish production systems

Commercial fish production ponds in the southern U.S. are usually operated as "static" systems, with little or no water going in or out. All ponds lose water through evaporation and seepage and gain water through rainfall, but these processes tend to remain more or less in balance. Occasional addition of water to replace evaporative losses and infrequent flushing of ponds for management purposes represent the only additions of water to most ponds.

Food, however, is added daily to almost all ponds, and represents the major source of nutrients in commercial fish production ponds. During the summer growing season in the catfish industry, for example, daily feeding rates can exceed 150 pounds per acre. It generally takes 1.8 to 2.2 pounds of feed to produce one pound of harvestable catfish. Since fish contain about 80 percent water, roughly 5.7 pounds (on a dry weight basis) of waste products for every pound of catfish harvested eventually end up in the pond. Fortunately, uneaten feed and fish wastes are usually biologically degraded and reused by certain pond organisms. For a detailed discussion refer to SRAC Publication No. 462, *Nitrite in Fish Ponds* and SRAC Publication No. 463, *Ammonia in Fish Ponds.*

These waste product breakdown processes take place naturally in lakes, ponds and other natural aquatic habitats, and buildup of nitrogen compounds usually does not become a problem. However, the heavy feed inputs needed for profitable commercial fish culture result in rapid nutrient accumulation and these processes are more easily pushed out of balance. Pond fish production depends on natural processes to transform and use waste products as they accumulate; research has shown that it is impractical and ineffective to flush fresh water through large ponds. High costs of pumping and the sheer volumes that would be required preclude the use of flushing to improve water quality in commercial-scale ponds.

As fish wastes and uneaten feed enter the pond system, nutrients accumulate in the bottom mud or in solution in the water where they are utilized by plants and animals. A large portion of these nutrients is chemically or biologically transformed and then released into the water and taken up by the phytoplankton bloom. As fish waste products accumulate, they create a tremendous demand for oxygen and usually take the form of several toxic compounds, especially ammonia. Consequently, the transformation and uptake of nitrogenous fish waste by the bloom is very important in achieving profitable levels of fish production. Except for situations where excessive vegetation is present, most nutrients that become dissolved in the water are taken up by the bloom.

Interactions in the system

Algal blooms are essential to successful fish production because of the dissolved oxygen they produce through photosynthesis during the daylight hours and their uptake (assimilation) of nitrogenous waste products. All plants, including phytoplankton, consume oxygen 24 hours each day. Normally, the bloom in a natural water body or a fish production pond produces far more oxygen in daylight hours than it consumes, thus leaving a surplus to last through night hours when photosynthesis is not taking place. In a sense, the fish help keep the bloom alive by fertilizing it, and the bloom helps keep the fish alive by producing oxygen and by breaking down and absorbing fish wastes, rendering them harmless to the fish population.

Unfortunately, fluctuations in a phytoplankton population can result in an unstable, unpredictable balance among the bloom, its nutrient sources and the pond oxygen supply. Once a pond is in production and a bloom has been established, daily feeding and fish metabolism provide a source of fertilizer to keep the bloom growing.

Occasionally, however, a specific trace mineral or nutrient needed for continued growth may be used up, causing most or all of the bloom to die back temporarily. This is probably the most common cause of phytoplankton die-offs, especially in heavy blooms with competition for light and nutrients. This process can be very abrupt and difficult or impossible to anticipate.

Oftentimes, however, a pond headed for critically low oxygen can be spotted by recording and charting trends in morning and evening dissolved oxygen concentrations. A change in the water color from dark green to a pale green or brown color can also indicate changes in plankton status and serve as a warning that problems may be imminent.

Under normal conditions, as individual algal cells die and begin to decompose, most nutrients are re-used almost immediately by other phytoplankton or bacteria. When a large portion of the bloom dies off at once, however, other algal cells may already be under stress and unable to use this surge of nutrients. Bacterial decomposition and the reduction in normal oxygen production can lead to oxygen depletions, high ammonia levels, and stressed or dead fish.

Blooms may respond gradually or abruptly to changes in weather, depending on a number of factors. Photosynthesis slows down under conditions of moderate cloud cover, and less oxygen is produced. Extremely calm days may also reduce photosynthesis and oxygen production in the total pond by preventing phytoplankton in the middle layers of the pond from being exposed to sunlight due to lack of mixing. The resultant layering effect, due to increases in surface water temperature, is called stratification, which is discussed in SRAC Publication No. 370, *Pond Aeration*. In these situations, the phytoplankton bloom, fish and other pond organisms continue to consume oxygen at night, even though daytime oxygen production is reduced. This often results in an overdraft on the oxygen budget account and an oxygen depletion.

Even when a moderate or dense bloom produces an abundant surplus of oxygen through photosynthesis, that oxygen is often unavailable when it is needed during the nighttime hours because of a simple physical property of water. As water becomes warmer, its capacity to hold dissolved oxygen decreases. At other times, an abundant surplus (supersaturation) of oxygen may be present in the upper waters, but events such as a late-afternoon thundershower can cause a sudden redistribution of oxygen throughout the pond. Such vigorous agitation can, in effect, dilute the oxygen concentration.

Apart from weather-related problems, at some point, as a bloom becomes denser, one or both of two phenomena will take place: a reduction in daytime photosynthesis will occur because of competition for light and nutrients among the phytoplankton or the temperature-dependent oxygen-holding capacity of the water will be reached. In either case, the bloom will take more oxygen out of the water during the night than what remains in solution from daytime photosynthesis. When this occurs, dissolved oxygen levels begin to decrease and, if not supplemented, can result in fish literally suffocating. In these cases mechanical aeration must be applied to meet the increased demand for oxygen and prevent oxygen depletion and subsequent fish losses or stress.

A number of other problems are associated with dense algal blooms. In waters that have a low or moderate buffering capacity (alkalinity), dense blooms create wide fluctuations in pH during the day. Occasionally, phytoplankton populations cause pH to reach afternoon values of 10 or above which depress fish growth and health. Algal die-offs can result in high ammonia concentrations that can affect fish appetites and growth rates for extended periods. This can result in reduction of the growing season for fish producers each time an algal bloom dies back in a pond. Losses from stress-mediated diseases triggered by oxygen and water quality stress can be even more costly.

Shading caused by dense blooms limits photosynthesis and dissolved oxygen levels at the pond bottom, often resulting in buildups of toxic gases and waste products, even in aerated ponds. This situation can lead to physiological stress, reduced fish growth and even fish kills when bottom waters are rapidly mixed with the rest of the pond. This type of mixing, referred to as a turnover, occurs when cool rain water, heavy winds on the pond surface, or mechanical aeration break down layering patterns. Turnovers are often observed in natural waters and production ponds during the fall or spring following severe weather disturbances where surface water temperatures change rapidly.

Control options

Blooms produce the greatest amount of oxygen at intermediate densities. As phytoplankton density increases, the amount of oxygen produced per algal cell drops off because of competition for light and nutrients. If it were possible to regulate the density of the bloom in a pond, producers might be able to maximize the amount of oxygen produced during the daylight hours in relation to what would be needed at night. However, no practical and effective means of regulating plankton blooms in this manner has been developed.

The use of chemicals to regulate algal densities in fish production ponds has generally proved unsuccessful, often resulting in the same problems as a partial or complete phytoplankton die-off. With large amounts of feed entering ponds, blooms return to their previous levels over several days or weeks unless nutrients are somehow removed. Researchers have begun to consider various biological methods to do just this, including several filter-feeding fish (such as bighead carp, paddlefish and tilapia) and freshwater mollusks, but most of these trials have been unsuccessful to date.

Commercial producers must balance the potential for oxygen depletions with the need for heavy feeding to achieve high yields and profitability. Feeding at rates less than 50 pounds per acre per day reduces the likelihood of low oxygen and poor water quality occurring but is usually not economical for most commercial fish producers. On the other hand, feeding at more than 100 pounds of food per acre per day usually leads to water problems, including low oxygen and waste product accumulation. Mechanical aeration is used to make up for oxygen deficits encountered in warmwater fish ponds, and a variety of aerator designs are currently marketed. For detailed information on aeration, refer to SRAC Publication No. 370, *Pond Aeration*, and SRAC Publication No. 371, *Pond Aeration - Types and Uses of Aeration Equipment.*

Although aeration capabilities are essential for successful fish production, they are of little value once an oxygen depletion has taken place. Aeration practices must be proactive and designed to prevent critically low dissolved oxygen levels. Producers should maintain and service aeration equipment regularly. Even more importantly, dissolved oxygen levels must be checked diligently every night during spring, summer and fall months.

Signs such as color or odor changes, or a buildup of foam on the down-wind bank, can sometimes be useful in anticipating when a bloom will die back. Experienced producers, however, know that almost any bloom can collapse without warning, and they are prepared to take emergency aeration measures. The more producers understand the circumstances that contribute to such die-offs, the better their chances of anticipating and dealing with problems that may arise because of sudden fluctuations.

Phytoplankton blooms for weed control

Phytoplankton blooms can prevent weed growth by shading the pond bottom and not allowing the weeds enough sunlight to grow (Figure 2). The bloom usually needs to be heavy enough so you cannot see your fingers moving when your arm is submersed to the elbow (about 18 inches deep into the water). Fish production ponds usually receive enough feed to provide a nutrient level in the water sufficient for supporting a healthy bloom. At times, though, some fertilizer may need to be added. Recommended fertilizer rates vary dramatically and are dependent upon local soil and water chemistry. Fertilizer is also often necessary for getting a bloom established in a fingerling pond because feeding rates at first are not high enough to maintain a consistent bloom. Weed prevention in fingerling ponds is essential, because harvesting for restocking into food-fish ponds at the end of the season must be performed without stress caused by seining and entrapment in weeds.

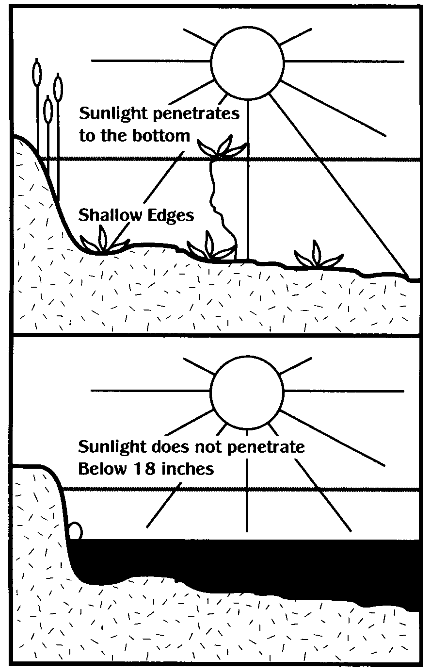

Figure 2. Shading effect of algae bloom in fish pond.

Conclusions

Although our knowledge of commercial fish pond ecology has greatly increased as aquaculture has become established and grown, we have much yet to understand before we can effectively manage this artificially dense pond system.

Until biological control methods for algal blooms are identified and made available to the industry, producers will be forced to live with the "boom and bust" nature of phytoplankton blooms in fish production ponds. These blooms are an inescapable part of the process that producers rely on to break down excess nutrients. For a profitable operation, develop the capability to monitor and detect algal bloom die-offs. Monitor and respond to potential oxygen depletions with aeration equipment and manpower to operate it. And, finally, make management adjustments as needed to minimize impacts on fish health and growth.

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