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Cage Culture

Site Selection and Water Quality

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In the U.S. the majority of cage culture is practiced in ponds or quarries. Not all ponds and quarries are suitable for cage culture of fish. Many failures in cage production have occurred because of poor site selection. Before attempting cage culture make sure the body of water chosen will support the increased biological demand placed upon it.

Site criteria

Many different sites may be adapted to cage culture. Potential sites include lakes, reservoirs, ponds, quarries, rivers and streams. Each state may have specific laws governing the use of "public waters." These laws may restrict private individuals from engaging in fish farming in public waters or may require permits for use of public waters. Check with the Department of Natural Resources, Department of Fish and Wildlife, or with the Cooperative Extension Service's fisheries (or aquaculture) specialist in your state before using public waters for cage culture. Many ponds and quarries are not suitable for culturing fish in cages. The following are criteria that should be considered before attempting cage culture in an existing pond or quarry.

- The surface area should be at least one half acre and preferably an acre or larger (but should not include weed infested areas of the pond).
- The pond should be at least 6 feet deep over a sizable area, and most of the pond should be more than 3 feet deep.
- The pond must have good water quality and should be located where prevailing winds blow across it.
- The pond should not have direct access by livestock or large numbers of livestock in the watershed.
- The pond should not have a highly erodible watershed or one that allows the accumulation of large amounts of organic debris.
- The water level of the pond should not fluctuate greatly (2 to 3 feet) during the summer.
- The pond should not have chronic problems with aquatic weeds, surface scums, overpopulations of wild fish, or oxygen depletion problems.
- The pond should have an all-weather access road.

Pond problems

Problems frequently arise when small ponds (less than one acre) are used for cage culture. Those problems usually center around water quality deterioration, low oxygen, ammonia or nitrite buildup, and excessive algal blooms. These problems may also occur in ponds larger than one acre but are not as common. Adequate depth of the pond (6 feet or greater) is important for keeping the fish wastes away from the cage, maintaining adequate circulation through the cage, and for reducing the chance of weed encroachment around the cage. Very deep ponds are more likely to experience low dissolved oxygen problems in the summer.

The characteristics of the pond's watershed can be critical to successful cage culture. Livestock with direct access to the pond, or located in large numbers within the watershed, may cause water quality problems. Livestock wastes can overfertilize the pond leading to severe algal blooms, water quality deterioration, and eventually disaster. This is partic-

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ularly true of small ponds (less than 5 acres). Livestock should be fenced out of the pond and not allowed to use the immediate pond watershed as a loafing area. As shorelines are trampled, erosion increases and ponds age prematurely. Even ponds frequented by livestock in previous years may contain large amounts of organic matter.

Highly erodible watersheds may cause turbidity/silting problems which can irritate the gills of fish and cause reduced dissolved oxygen concentrations. Watersheds where large amounts of organic matter wash into the pond can result in oxygen depletions due to rapid bacterial decomposition of the detritus.

Ponds that have a greater watershed than is needed to fill and maintain the water level can also have problems. Excessively large watersheds can cause rapid temperature changes, turnovers, and associated oxygen depletions due to water exchanges after heavy rains.

Ponds that have chronic problems such as severe weed infestations, surface scums, fish kills, stunted wild fish populations, and severe water level changes during the summer are not good candidates for cage culture. These problems must be brought under control first. It may be necessary to treat chemically for weeds or to stock grass carp (check state regulations), remove wild fish, and/or renovate (rebuild) the pond. Finally, an all-weather access road to the pond is essential to the maintenance, health and survival of the caged fish. A day or more without access to the pond could lead to a catastrophe.

Water quality

Water quality management is a key ingredient in a successful fish operation. Most periods of poor growth, disease and parasite outbreaks, and fish kills can be traced to water quality problems. Water quality management is undoubtedly one of the most difficult problems facing the fish farmer. Water quality problems are even more difficult to predict and to manage. A more thorough discussion of water quality problems and equipment needs can be found in other Extension-Aquaculture publications.

Oxygen

Oxygen stress is the most frequently encountered water quality problem in cage culture of fish. The concentration and availability of dissolved oxygen (DO) are critical to the health and survival of caged fish.

Critical dissolved oxygen levels will vary depending on species being reared and with interactions with other water quality parameters; e.g., carbon dioxide, ammonia and nitrite. In general, warmwater species such as catfish and tilapia need a dissolved oxygen concentration of 4 mg/l DO (or ppm) or greater to maintain good health and feed conversion. Healthy warmwater fish can tolerate 1 mg/l DO for short periods of time but will die if exposure is prolonged. Prolonged exposure to 1.5 mg/l DO causes tissue damage, and any prolonged exposure to low dissolved oxygen levels will halt growth and increase the incidence of secondary diseases, apparently by reducing the fishes' ability to resist infection. Many parasites, diseases and chemical agents can damage the gill filaments affecting oxygen transport across the gills. This can cause the fish to behave as though the dissolved oxygen concentration is low, when in reality the cause is a disease problem.

The concentration of dissolved oxygen in any body of water varies over time and is affected by physical, biological and chemical factors. Physical controllers of dissolved oxygen are temperature, atmospheric pressure and salinity. As temperature and salinity increase, and as atmospheric pressure decreases, the solubility of oxygen will decrease. Temperature is an important physical controller of dissolved oxygen. As water temperature increases 10ºF the amount of oxygen that will dissolve in water decreases by approximately 10 percent. The physical transfer of oxygen between the atmosphere and water occurs across the water surface when dissolved oxygen concentrations are above or below saturation. The rate of this transfer is regulated by turbulence across the water surface.

Biological factors which affect dissolved oxygen are plant photosynthesis (both phytoplanktonic and macrophytic), and plant and animal respiration (fish, invertebrates, bacteria, etc.). Most of the oxygen in aquaculture ponds is produced by plant photosynthesis during sunlight hours. Planktonic algae (phytoplankton) usually produce the bulk of this oxygen. High densities of aquatic macrophytes (rooted underwater plants) usually reduce phytoplankton growth and water circulation and, therefore, can cause dissolved oxygen problems in cage production ponds.

Plant and animal respiration are the most important oxygen reducing processes in aquaculture ponds. Fish must compete with all other living organisms for the ponds' available dissolved oxygen. This is particularly acute at night when plants in the pond are also consuming oxygen through the process of respiration. In most aquaculture ponds nighttime phytoplankton respiration is the major consumer of oxygen. Respiration rates are temperature-driven in cold-blooded animals (i.e., fish) and plants, increasing oxygen consumption with rising temperatures. Total plant and fish biomass is also usually greatest during warm weather and high light intensity conditions. For all of these reasons, summer nights, with high water temperatures and respiration and low wind turbulence, bring most oxygen problems.

In cage culture situations low dissolved oxygen is particularly acute because the fish are crowded into such small areas. Most fish kills, disease outbreaks and poor growth in cage situations are directly or indirectly due to low dissolved oxygen.

Turnovers and plankton die-offs are two other situations in which dissolved oxygen levels may fall below critical levels. Turnovers occur during cold rains, heavy winds and prolonged cold spells in summer. These conditions cause the upper oxygenated layer of water to mix with the cold oxygen-depleted layer of water on the bottom of the pond. The mixing of the two layers reduces the total dissolved oxygen in the whole pond to critical levels due to both dilution and chemical reduction. Turnovers can be particularly common in deep ponds with large watersheds.

Plankton die-offs can occur as a natural consequence of algal population dynamics due to seasonal changes in temperature, pH, light intensity, nutrients, diseases, parasites, toxins, or other factors which are not clearly understood. Plankton die-offs can also occur as a consequence of nighttime low dissolved oxygen. In this case, the density and biomass of the plankton become so great that a critical dissolved oxygen concentration is reached in the pond due to nighttime respiration demands. The plankton dies from lack of oxygen along with the fish.

Dissolved oxygen management is one of the most critical management techniques that must be learned by a fish farmer. Dissolved oxygen management includes both biological and mechanical manipulation. Biological manipulation can include fertilization and submerged aquatic plant control to maintain a healthy phytoplankton bloom. Mechanical manipulation through aeration may help maintain adequate dissolved oxygen concentrations and may save fish during chronic low DOs, turnovers, and plankton die-offs. See SRAC publications 370, *Pond Aeration*; 371, *Pond Aeration—Types and Uses of Aeration Equipment*; 372, *Selecting the Proper Pump*; 374, *Open Channel Flow in Aquaculture*; and 375, *Powering Aquaculture Equipment* on pond aeration and equipment.

Temperature

Temperature is the single most important physical factor controlling the life of a cold-blooded animal. Temperature is critical in growth, reproduction and sometimes survival. Each species of fish has an optimum temperature range for growth, as well as upper and lower lethal temperatures. Below the optimum temperature feed consumption and feed conversion decline until a temperature is reached at which growth ceases and feed consumption is limited to a maintenance ration. Below this temperature is a lower lethal temperature at which death occurs. Above the optimum temperature feed consumption increases while feed conversion declines.

Refer to SRAC Publication No. 163, *Species Suitable for Cage Culture,* for species specific information on temperature optima and tolerances.

pH

pH is a measure of the relative acidity of the water. The pH in a pond fluctuates daily due to uptake and release of CO_2 during photosynthesis and respiration. The pH is lowest at or near dawn and highest at mid-afternoon. The desirable range of early morning pH for fish production is from 6.5 to 9. The acid death point is a pH of approximately 4 and the alkaline death point is approximately pH 11. When the pH is outside the desirable range, fish growth is slowed, reproduction reduced, and susceptibility to disease increased (see SRAC Publication No. 464, *Interactions of pH, Carbon Dioxide, Alkalinity and Hardness in Fish Ponds*).

Ponds with acidic bottom muds and soft water usually are not productive fish ponds. Lime can be added to these ponds to increase the pH and alkalinity (total concentration of bases). Limed ponds have fewer pH, dissolved oxygen and other related problems. A total alkalinity of 20 mg/l is considered the minimum concentration for a pond used in fish production.

For more information on liming ponds contact your county Extension office or state fisheries (or aquaculture) specialist.

Ammonia and nitrite

Ammonia is the primary nitrogenous waste produced by fish from protein digestion. Mammals produce urea, which is a complex of ammonia and carbon. Any nitrogenous waste from manure runoff into the pond, inorganic fertilizer, plant decomposition, and/or uneaten feed is transformed into ammonia by bacteria in the pond. Bacteria of the genus *Nitrosomonas* convert ammonia into nitrite. Both ammonia and nitrite are toxic to fish. The level of ammonia toxicity depends on the species of fish, water temperature and pH. The level of nitrite toxicity depends on the species of fish and the chloride ion concentration in the pond water. Sublethal levels of ammonia are known to cause gill and tissue damage, poor growth and increased susceptibility to disease. Nitrite at sublethal levels reduces oxygen transport into the fish, resulting in poor feed conversion, reduced growth and increased susceptibility to disease.

At stocking densities normally recommended for cage culture, neither ammonia or nitrite toxicity problems should be encountered. In ponds where higher density cage culture is attempted, where livestock manure can wash into the pond during rains, or where a plankton die-off has occurred, the level of ammonia (and later nitrite) may pose problems.

For more information on the nitrogen cycle and problems associated with nitrite and ammonia, refer to SRAC publication numbers 462, *Nitrite in Fish Ponds*, and 463, *Ammonia in Fish Ponds*.

Turbidity

Turbidity is the degree to which light penetrates the water. Light penetration is blocked by suspended soil, organic material (detritus), and the plankton (floating or suspended microscopic plants and animals) of the pond. Turbidity caused by suspended soil and detritus (muddy color) may reduce photosynthesis and, therefore, oxygen production. Ponds which always have a moderate amount of suspended clay (i.e., muddy) may actually prevent wild fluctuations in oxygen levels. Large quantities of suspended soil particles washed into a pond during heavy rains, however, may cause irritation and clogging of the gills which can lead to secondary diseases. In general, high concentrations of suspended soil or detritus in a pond are not desirable.

Since photosynthesis can occur only to the depth of light penetration into the pond, plankton turbidity is a measure or index of a healthy phytoplankton bloom (green color) in the pond. A healthy bloom will produce oxygen, reduce undesirable macrophytic plant growth, and reduce fish stress because of reduced visibility. Reduced visibility in ponds used for cage culture reduces stress on the fish caused by reactions to seeing people and possibly other animals in close proximity.

A healthy phytoplankton bloom (green water) is one with a Secchi disc visibility of 15 to 24 inches. Clear ponds with a visibility above 24 inches indicate a need for additional fertilization and possible liming (check with your Extension agent). Visibility of less than 12 inches indicates a plankton bloom which is too dense and may cause low dissolved oxygen problems. Visibility of less than 6 inches is critical. Low visibilities due to intense plankton blooms are usually associated with high feeding levels and may necessitate aeration and a reduction in the daily feed ration (see SRAC Publication No. 164, *Cage Culture—Handling and Feeding of Caged Fish*).

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