Cooperative
Extension
Program
University of Arkansas at Pine Bluff

Aquaculture/Fisheries

FSA9612

Stock Enhancement as a Fishery Management Tool for Largemouth Bass

Steve Lochmann
Associate Professor -
Aquaculture/Fisheries

Stocking fish, regulating harvest and improving habitat are three common management tools. Managers stock fish into new lakes to create fishing opportunities or into renovated lakes following a managed fish kill. Managers also stock fish to supplement natural production. Stock enhancement is when a manager puts fish from a hatchery into a lake or stream where a population of this fish already exists. This document is a review of the practice of largemouth bass stock enhancement.

Stock enhancement of largemouth bass originated in the late 19th century, and methods for culturing largemouth bass at hatcheries exist in culture manuals dating from 1897. Some agencies rely heavily on largemouth bass stock enhancement. Other agencies rely on harvest regulations or habitat improvements to enhance largemouth bass populations. The opinions of agencies, regarding the usefulness of largemouth bass stock enhancements, are based on research with complex and sometimes conflicting results. This publication outlines the process of growing and stocking largemouth bass, the circumstances when stock enhancements are useful or ineffective, the factors that contribute to the success of stock enhancement, the measures used to determine success and the challenges that managers face when using stock enhancement as a management tool.

Growing and Stocking Largemouth Bass

A brief overview of fingerling production is necessary because procedures at a hatchery can influence the expense and success of largemouth bass stock enhancement. Largemouth bass fry (newly hatched fish) feed on natural zooplankton (microscopic shrimp-like animals) and grow to approximately 2 inches by early summer. Largemouth bass this size require no forage fish or feed, and costs to purchase 2-inch fingerlings can range from 46 to 75 cents per fish.

Some hatcheries raise advanced fingerling largemouth bass (4 to 8 inches) by adding forage fish (bluegill, threadfin shad, fathead minnows or golden shiner) to ponds. Forage fish can cost $3.50 to $4.25 per pound, so advanced fingerling largemouth bass will cost more than smaller fingerlings. Costs for 4- to 6-inch largemouth bass fingerlings can range from $0.81 to $1.60 per fish. The use of feed pellets to produce advanced fingerlings is a relatively new practice. Feed training largemouth bass is an intensive process that adds cost. However, the cost of pellets (78 to 88 cents per pound) is less expensive than forage fish, so pellet-reared advanced fingerlings are cheaper to raise.

Largemouth bass fingerlings are harvested from ponds with small mesh seines and loaded onto hauling trucks at densities that depend on the size of the fish and the hauling duration (⅓ to 1½ pounds of fish per gallon of water). Smaller fish and longer trips require lower hauling densities. Oxygen levels are maintained on a hauling truck using liquid oxygen. To minimize hauling stress, salt and anesthetics are added to hauling water.

Largemouth bass fingerlings should not experience major changes in temperature during harvest, hauling or stocking. If there is a difference in temperature between hauling truck water and lake water, a gradual change in temperature should be provided by adding lake water to the hauling truck. The rate of temperature change should not be faster than 20 minutes for each 10°F difference in water temperature.

Fingerling largemouth bass are commonly stocked from a hauling truck at a single point (Figure 1). Occasionally, fish are loaded onto boats and released in small groups at different places throughout a lake.

Figure 1. A fish-hauling truck stocking fingerling largemouth bass at a boat ramp.

Photo: Arkansas Game and Fish Commission

When Is Stock Enhancement Useful?

Stock enhancement is a useful management tool under a variety of circumstances. If a population of largemouth bass experiences heavy fishing pressure, the population may be reduced in size. At a small size, a population might not be able to reproduce enough. In this case, stock enhancement makes up for the deficit in natural reproduction. With the imposition of restrictive harvest regulations, a small largemouth bass population might only need stock enhancement for a few years. Once hatchery fish mature, the population should be able to reproduce enough to maintain a reasonable size without further stock enhancement. A few years of stock enhancement might also be required following a fish kill.

Stock enhancement is useful when a population is adequate in size but natural reproduction is low or survival of young fish (<1 year old) is poor. Occasionally, spawning or nursery habitats are insufficient. If spawning habitat (firm silt-free bottom in quiet water) is limited or young largemouth bass have no aquatic vegetation in which to hide, inability of the population to produce sufficient young becomes a problem.

Natural reproduction depends on the amount of food and shelter available for young largemouth bass. These characteristics vary greatly among lakes. Because small fish experience high mortality, the density of young largemouth bass also varies with time. There will be more 1-inch largemouth bass in May than 3-inch largemouth bass in July, or 6-inch largemouth bass in October. In Illinois lakes, densities of ~1-inch age-0 largemouth bass ranged from 405 to 44,534 fish per acre in early June. In small impoundments in southeast Arkansas, densities of 4- to 5-inch age-0 largemouth bass ranged from 10 to 288 fish per acre in July. In backwaters of the Arkansas River, densities of 4- to 5-inch age-0 largemouth bass ranged from 6 to 11 fish per acre in September.

Natural reproduction from the previous year is also monitored by examining catch rates of age-1 largemouth bass in spring electrofishing samples. Biologists might annually sample largemouth bass populations in the spring. Based on analyses of historical electrofishing data, lakes with consistently poor natural reproduction (catch rates of fewer than 10 age-1 largemouth bass per hour of electrofishing) are often candidates for stock enhancement.

Stock enhancements are sometimes undertaken to influence the genetics of a largemouth bass population. In southern states, agencies may stock Florida bass fingerlings into a population of largemouth bass. Florida bass have a larger maximum weight, and anglers often prefer to catch large fish. Similarly, some agencies will encourage anglers who catch lunker largemouth bass (>5 pounds) to donate the fish to the agency's hatchery system. Agencies will produce fingerlings using these lunkers as brood stock and then stock the fingerlings into natural waters throughout their state. The philosophy driving lunker programs is that offspring from lunkers should be fast-growing and, therefore, liable to become lunkers like their parents. In these cases, stock enhancement would continue until some target proportion of the population has Florida bass genes or indefinitely (in the case of fingerlings from a lunker program).

Stock enhancements are appropriate under some unique circumstances. Urban and community fishing programs provide angling opportunities in areas where human population density is high or fishing opportunities are rare. Despite restrictive regulations (e.g., no largemouth bass harvest allowed), urban fisheries typically experience high largemouth bass mortality (from illegal harvest and stress after multiple releases). Stock enhancements are necessary to maintain urban largemouth bass fisheries. Since low population size is not a result of poor habitat or liberal harvest regulations, stock enhancements of urban fisheries are likely to be required indefinitely.

When Is Stock Enhancement Ineffective?

Largemouth bass stock enhancements are inappropriate under certain circumstances. When poor habitat (e.g., absence of woody debris, excessive aquatic vegetation) or a polluted environment (e.g., high turbidity, high levels of endocrine disrupters) results in a decline in size of a largemouth bass population, stock enhancements address the symptom, rather than the problem. Unfortunately, unless the habitat problems are resolved, continuous stock enhancement will be necessary to maintain a largemouth bass population in a degraded or polluted environment. Hence, stock enhancement is not a good long-term solution. Improving the habitat or eliminating the pollution would allow the largemouth bass population to maintain itself with natural reproduction and eliminate the need for stock enhancement. Similarly, a population that declines because of overfishing is better managed with restrictive harvest regulations than with stock enhancements.

If hatchery fish are genetically different from wild fish, stock enhancement might be inappropriate. As mentioned previously, the goal of a stock enhancement program might be to change the genetics of the population. However, unintended genetic changes may be detrimental to a population. Largemouth bass populations can be adapted to their environment. Genetic changes could negatively alter temperature tolerances, disease resistance or growth rates of a population. For this reason, brood fish are often taken from the population in need of enhancement.

If a largemouth bass population exhibits stable high natural reproduction, stock enhancement would be unnecessary and could be detrimental to wild fish. When natural reproduction is sufficient, stocking hatchery fish could result in a situation where the carrying capacity (the number of largemouth bass that can be supported by resources in a lake) is exceeded. Under these circumstances, there is likely to be competition between wild and hatchery fish for limited resources (food and shelter). If wild fish get fewer resources, they might experience reduced growth or increased mortality. Hatchery fish could end up replacing wild fish without an overall increase in size of the largemouth bass population. This is a clear waste of agency resources.

What Factors Contribute to the Success of Stock Enhancement?

A variety of factors directly related to rearing and stocking can influence the success of largemouth bass stock enhancement programs. Stress during seining, hauling or stocking can lead to handling mortality (the percent of hatchery fish that die right after stocking because of stress). Studies that estimate handling mortality indicate hatchery fish can suffer mortality rates from 0 to 83 percent by 96 hours after stocking (Table 1). High handling mortality is associated with long hauling times. For this reason, some agencies build fingerling-rearing ponds at the location where stock enhancement occurs. Fingerlings are released from the rearing pond directly into a lake, so they experience no handling mortality.

Table 1. Three factors that affect success of largemouth bass stock enhancements based on reports from published literature.

Factor	Median	Range
Handling mortality (%)	6	0 - 83
Length at stocking (inches)	4	1 - 12
Stocking density (number/acre)	24	1 - 181

Advanced fingerling largemouth bass raised on forage fish had lower mortality rates than advanced fingerling largemouth bass raised on pellets when both groups were stocked in an Illinois reservoir. Gut content studies show that pellet-raised largemouth bass have difficulty transitioning to forage following stocking. Poor nutrition during the transition to forage can make pellet-raised hatchery fish more susceptible to starvation and predation. For this reason, some hatcheries raise advanced fingerlings on pellets and switch the fingerlings to forage fish a few weeks prior to stocking.

Figure 2. Releasing fingerlings in small batches throughout a lake can be useful if predators are not a problem and if competition with wild fish for food and space is likely.

Predation mortality on hatchery fish will be high in lakes with lots of predators (walleye, northern pike and black basses). In natural settings, adult male largemouth bass guard fry for up to a month after fry leave their nest. Raising largemouth bass fry at a hatchery without male guardians or predators can hinder the development of predator-avoidance behavior. Hatchery fish become easy prey for predators immediately after stocking. Loading fingerlings onto a boat and releasing small batches around a lake in good nursery habitat may seem like a good idea (Figure 2). However, spreading fingerlings around allows predators throughout a lake to prey on hatchery fish. When all the hatchery fish are released at a single location, predators in the immediate vicinity prey heavily on them. Once the local predators are full, the remainder of the hatchery fish avoids predation while becoming accustomed to the presence of predators. Conversely, in systems without many predators, stocking at a single location will increase the competition for food and shelter among hatchery fish. In this case, spreading fingerlings around to reduce competition would be a better idea. Stocking in the fall, when water temperatures are cooler and predators are less active, can also reduce predation on hatchery fish.

The amount of forage fish can influence the success of stock enhancements. When fathead minnows were present in South Dakota reservoirs, hatchery largemouth bass grew faster. Largemouth bass that achieve a minimum length of 6 inches prior to their first winter have more energy and are less likely to die during the winter. Prey density was one criterion for prioritizing Oklahoma reservoirs for largemouth bass stock enhancement.

The size of hatchery fish can influence success of a stock enhancement effort. In general, larger fish are more likely to survive. Larger fish have bigger mouths, allowing them to eat a wider array of prey. Larger fish, with faster swimming speeds, are better able to avoid predation. Hatchery largemouth bass are stocked at sizes ranging from 1 inch to more than 12 inches (Table 1), but most fish are stocked at lengths less than 5 inches. Largemouth bass stocked at 2, 4 and 6 inches in Illinois reservoirs all experienced predation by adult largemouth bass. However, largemouth bass stocked at 8 inches were usually too big to be eaten. One study found that it took five times as many 2-inch fingerlings as 4-inch fingerlings to make the same contribution of hatchery fish to an age group. Stocking larger hatchery fish does not always guarantee success. Eleven-inch largemouth bass stocked into the Ohio River in the fall could not be found the following spring. Generally, larger fish are more expensive to produce, so the number of advanced fingerlings available for stock enhancement programs is usually low. Stock enhancements generally attempt to match the size of wild fish and hatchery fish at the time of stocking to minimize predation of one group on the other. Some compromise between survival probabilities, expense and availability generally determines what size fingerlings are stocked.

The number of fish stocked can influence success of stock enhancement programs. Stocking densities range from less than 1 fish per acre to more than 180 fish per acre (Table 1). Most stocking programs stock fewer than 25 fish per acre. Stocking hatchery fish at higher densities could result in a greater proportion of young fish coming from the hatchery and a higher total number of young fish (hatchery fish + wild fish). However, this is not always true. The total number of young largemouth bass that can be supported by resources in a lake varies from year to year and from lake to lake. Nutrient levels, vegetation density and other factors determine carrying capacity. When too many hatchery fish are stocked, the total number of young fish can exceed the carrying capacity. Young hatchery fish compete with young wild fish for limited resources, and both groups could experience high mortality. Ideally, a manager would determine the number of wild fish present and adjust the number of hatchery fish stocked so that carrying capacity of a lake is not exceeded.

What Methods Are Used to Determine Success of Stock Enhancements?

Success of a stock enhancement program can be defined in a variety of ways. Some agencies set a goal of increasing the number of adult largemouth bass in samples collected by managers (e.g., number of adults per hour of electrofishing). Five years of stocking 1- to 2-inch fingerling largemouth bass into a Georgia lake resulted in a 68 percent increase in the number of adult largemouth bass caught per hour of electrofishing. Another common goal is to increase angler catch rates (e.g., fish caught per hour of angling). Five years of stocking advanced fingerlings in a Kentucky lake resulted in higher angler catch rates of 8- to 12-inch largemouth bass.

Another measure of success is the proportion of hatchery fish in an age group. To determine this measure, hatchery fish are marked before stocking with one of several methods (e.g., visual tags, clipped fins, imbedded tags). Hatchery fish are typically stocked in early to midsummer. A sample of age-0 fish is collected in the fall, or a sample of age-1 fish is collected the following spring. The proportion of hatchery fish (e.g., the number of age-0 hatchery largemouth bass in the sample divided by the total number of hatchery and wild age-0 largemouth bass in the sample) is the measure of success. Studies show that the proportion of hatchery fish in fall or spring samples can range from 0 to 100 percent, meaning that hatchery fish can be totally absent or make up all of the age group. Proportion of hatchery fish often declines somewhat over the winter (Table 2). A majority of studies show that hatchery fish usually make up less than 20 percent of an age group, regardless of initial stocking density. If there are many age-0 wild largemouth bass in the system, the initial proportion of hatchery fish will be low, even at high stocking densities.

Table 2. Summary of the proportion of hatchery fish in samples of age-0 and age-1 largemouth bass based on reports from published literature.

Age Group	Median (%)	Range (%)
Fall Age-0	14	0 - 100
Spring Age-1	12	0 - 90

What Are the Challenges of Stock Enhancement?

The density of fish stocked can be calculated and reported several ways. In small lakes, the number of hatchery fish stocked divided by the total lake area is the stocking density. In medium lakes, the number of fish stocked divided by the proportion of lake area that is good nursery habitat for largemouth bass (near shore areas with adequate vegetation and cover) is a better estimate of stocking density. Young largemouth bass generally move less than ½ mile during their first year, so most stocked fish remain in the general area where they are stocked. Therefore, in large lakes and reservoirs, the number of fish stocked divided by the area of a cove where fish are stocked is the best estimate of stocking density. The density of young wild largemouth bass is rarely determined prior to stocking, and carrying capacity varies among lakes. Therefore, the best stocking density for hatchery fish is unclear.

The most common measure reported by stock enhancement programs is the proportion of hatchery fish in an age group. This measure is highly dependent upon the magnitude of natural spawning of wild largemouth bass. This measure could also be influenced by differences in how easily hatchery and wild fish are sampled. If hatchery fish are sampled more easily than wild fish, hatchery fish are likely to dominate a sample, even when they do not make up a high proportion of an age group. A high proportion of hatchery fish in a sample could also indicate that hatchery fish are replacing wild fish without producing an increase in population size or angler catch rate. For some agencies, the presence of hatchery fish in the fishery is enough to justify a stock enhancement program.

Assessments of increases in number of adult largemouth bass in samples collected by managers or increases in angler catch rates require expensive long-term monitoring. Hatchery fish need to grow and enter the fishery before these assessments can be accomplished. If largemouth bass are stocked as 2-inch fingerlings, it could take 2.5 years for these fish to reach 12 inches. Long-term studies of stock enhancement of largemouth bass rarely show sustained improvements in angler catch rates for the fishery. Modest improvements seem to persist only as long as the stock enhancement program. Angler catch rates often return to previous levels once stocking is discontinued. However, stock enhancement programs designed to influence the genetics of populations have shown some measure of success.

Major Factors Contributing to a Stocking Program's Success

- Proper care and handling of hatchery fish during harvest, hauling and stocking.
- Stocking where there is sufficient food and shelter for wild and hatchery fish.
- Stocking strategies to avoid predation on hatchery fish.

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Reviewed and recommended by Dr. Anita M. Kelly, Extension specialist - aquaculture, 1890 Cooperative Extension Program, University of Arkansas Division of Agriculture, located in Lonoke.

Printed by University of Arkansas Cooperative Extension Service Printing Services.

DR. STEVE LOCHMANN is an associate professor - fish ecology and management located at the Aquaculture/Fisheries Center at the University of Arkansas at Pine Bluff.

FSA9612-PD-8-13N