A WHITE PAPER
ON THE STATUS AND NEEDS OF
LARGEMOUTH BASS CULTURE
IN THE NORTH CENTRAL REGION

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INTRODUCTION AND JUSTIFICATION OF THE DOCUMENT

Largemouth bass (*Micropterus salmoides*) are the most sought-after freshwater sport fish in the United States. Largemouth bass are a member of the family Centrarchidae. Currently the genus *Micropterus* contains seven species. As part of the development of the new strategic plan, the North Central Regional Aquaculture Center (NCRAC) is trying to address the concern that the long-term focus of research goals and priorities may be lost because the NCRAC Board of Directors (Board) and the Industry Advisory Council memberships change over time. The Board in the June 1999 meeting directed that an updateable white paper be written on largemouth bass. The white paper is not an exhaustive literature review, but a working document that defines the current status of largemouth bass culture including the critical factors limiting the economic production in order to make recommendations for future research. Industry participation and peer reviews are critical components for the evolution of this document.

CURRENT STATUS OF THE INDUSTRY

MARKETS

Most largemouth bass are marketed live for sport fishing and for food fish. Young-of-the-year fingerlings and yearlings are sold for stocking into lakes for non-commercial sport fishing. Larger bass are also used in a small but growing catch and release pay fishing industry. These fish are placed in ponds at high densities and maintained on prepared food. Only very large trophy fish are allowed to be kept and then at a premium price. Adult largemouth bass are also sold live for food. Most of these fish are transported to large cities such as New York, Chicago, Philadelphia, Toronto, San Francisco, etc., to supply the demand of the Asian community. At this time relatively few largemouth bass are sold in the food-fish industry in the form of a frozen or iced product.

Supply/Demand

Detailed statistics are not available on the number weight and dollar value of the largemouth bass produced in the United States. In 1997, a survey was conducted of state and federal hatcheries (R. Heidinger, unpublished data). Data obtained from each agency from either 1995 or 1996 indicated that approximately 21 million largemouth bass were stocked. Eighty-nine percent were stocked as fingerlings. It is not known how many largemouth bass are produced by the private sector; however, a survey of the Aquaculture Magazine Buyer's Guide '99 and Industry Directory (Aquaculture Magazine 1999) lists 103 hatcheries that produce largemouth bass. Twenty of these sources sell "market-size" fish. Many of these facilities are located in the North Central Region (NCR). It is likely that more largemouth bass are produced by the private sector than the public sector. One private aquaculturist takes four million eggs per year.

It is illegal to commercially harvest largemouth bass from any public lake or stream in the United States; however, in some bodies of water in Mexico it is legal to commercially harvest largemouth bass. From 1994-1997 Mexico has harvested an average of 2.4 million lb/yr of largemouth bass (FAO 1999). Many, if not most, of these fish are probably sold in the United States.

All 103 suppliers of largemouth bass listed in the Aquaculture Magazine Buyer's Guide '99 and Industry Directory (Aquaculture Magazine 1999) were sent a letter that explained the purpose of this white paper and requested information on what they felt were needed research areas. The majority did not respond. Additional phone contacts were made with known producers. In all, feedback was obtained from 20 private producers and managers of two state hatcheries. These aquaculturists were located in Florida, Illinois, Iowa, Maine, Missouri, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Texas, and France. The wholesale values of fingerling largemouth bass depend upon size, geographic location, and the number sold to the customer. Mean value from this survey for fingerlings sold in small lots, excluding the much higher values given for Maine, New York, and Pennsylvania are 1–2 in $0.35, 2–4 in $0.68, 4–6 in $0.94, 6–8 in $2.07, and 8–10 in $3.74. The sales price for large lots may be discounted 50%. Largemouth bass sold live to the Asian market sell for $3.00–$5.00/lb. Largemouth bass are being sold to the pay-fishing market for $6.00/lb.

A number of fish culturists indicated that they couldn't produce sufficient quantities of 8 in and larger largemouth bass to meet the demand. The demand for smaller fingerlings would increase if the natural resource agencies stopped producing largemouth bass. Many private state aquaculture associations have tried with little success to get their natural resource agency to phase out largemouth bass production. Tidwell et al. (In press) stated that the demand for largemouth bass greater than 1.0 lb has been identified to exceed 700,000 lb/yr with a value of over $3.00/lb live weight. Tidwell et al. (In press) made the following cost estimates; production estimates for an economic engineering approach were taken from research results at Kentucky State University. Cost estimates were based on numbers generated for a catfish production system composed of 4, 5-acre ponds under Kentucky conditions. Based on a stocker price of $0.50 per feed trained fingerling, a yield of 4,350 lb/acre, and a selling price of $3.00/lb (live sales) approximately $12,750/acre gross revenues are generated which allows a return of $6,623/acre above variable costs and $5,950 after operator labor. A break-even estimate under these assumptions would be $1.60/lb.

Until these higher yields have been routinely demonstrated for large ponds, it is recommended that cost estimates be based on 1,500–2,000 lb of production/acre.

LEGALITY

Some states require an aquaculture license to rear and sell fish, but others do not. In a few states, it is not legal to rear or sell largemouth bass for stocking. Also, there are a few states in which it is not legal to sell largemouth bass as food fish. Since regulations are continuously changing, one should check with the appropriate state regulatory agency before culturing or selling largemouth bass. There has been some resistance by "bass clubs" to the culture of largemouth bass for food.

BIOLOGY/AQUACULTURE TECHNOLOGY

The following discussion of largemouth bass culture techniques does not contain enough information for an inexperienced aquaculturist to economically produce this fish. Other suggested readings are Heidinger (1976), Heidinger (2000), Tidwell et al. (In press), and Williamson et al. (1993). In addition to a discussion of culture techniques for largemouth bass, these papers contain citations of literature that

go into much greater depth on many aspects of rearing largemouth bass. Readers interested in other aspects of largemouth bass culture such as water quality, pond construction, pond location, zooplankton production, prepared diets, etc. should consult Avault (1996), Piper et al. (1982), and Boyd (1990). In addition, producers should talk with their aquaculture extension specialist.

BIOLOGY

There are two recognized subspecies of largemouth bass: the northern largemouth bass, *Micropterus salmoides salmoides* and the southern Florida largemouth bass, *Micropterus salmoides floridanus*. The subspecies and their hybrids can be distinguished only by genetic testing. At the latitude of southern Illinois where ice cover occurs, pure non-selected Florida largemouth bass young-of-the-year usually winterkill in shallow ponds.

Like all members of the family Centrarcidae, largemouth bass are nest builders. The male will build a the solitary nest on any firm substrate usually in 1–4 ft of water depth. Spawning occurs at 65–86°F. The male guards the nest from predators and his movement over the eggs helps aerate them. Nests are usually at least 10 ft apart. Nests have been reported to contain eggs from more than one female, and a single female does not necessarily lay all of her eggs in the same nest. This has led some researchers to recommend stocking more males in the spawning pond than females. At 64–82°F eggs hatch in 55–49 hr. Male largemouth bass usually guard their schooling brood of fingerlings for 14–28 days. At 71°F it takes approximately five days for the gas bladder to inflate. Fry begin to eat after they become free swimming. Initially they feed on zooplankton. At 1–2 in total length, they eat primarily zooplankton and insects, but bass over 1.5 in will feed on fish, especially when they are crowded as in a culture situation. Because of their large mouth, cannibalistic tendency, and unwillingness to accept a prepared diet unless trained, they are more difficult to culture than channel catfish or rainbow trout.

CULTURE

It is interesting, but somewhat disconcerting, that various largemouth bass culture methods that work very well for some fish farmers do not seem to work at all for others, thus there is no single best method of production.

By far, most largemouth bass are spawned in ponds, but a few producers use large raceways. Fry are either left in the spawning ponds or moved to rearing ponds. In some cases the eggs are moved into a hatching facility. Fingerlings 2–4 in long can be raised at low densities on insects. If larger fish are desired, the 1–2 in fingerlings are trained to accept a prepared diet and then the trained fish are placed in rearing ponds.

Brood Stock

Largemouth bass brood stock are normally maintained in the hatchery. Genetic strains of largemouth bass have not been formally developed, although some hatcheries have maintained brood fish for ten generations or more. Sexual maturity is more dependent upon size than age. Attempts have been made to sex adult largemouth bass by looking at the shape of the scaleless area around the urogenital opening. The scaleless area tends to be more or less circular in males and more elliptical in females. This method frequently leads to misidentification of sex. Sexing of brood fish can be done in

the spring prior to spawning when the female has a distended abdomen, and a red swollen protruding vent. The males may be emitting milt. The most accurate way to sex largemouth bass is to insert a small tube into the vent and look for eggs or milt. Even though largemouth bass under a pound may be sexually mature, most culturists use 1.5–4 lb (3–5 year old) bass as brood fish. Larger fish are hard to handle and are usually replaced. Brood stock can be held in ponds at rates of 300–400 lb/acre (White 1988). Most producers maintain their brood fish on a combination of prepared diet and live forage fish. For good growth, adult largemouth bass are often fed a prepared diet of 3% of their body weight per day or what they will eat during a 10–15 min period. This is reduced to 1% during the cooler months. Most producers use 0.25–0.75 in diameter pellets. Feeds containing a minimum protein requirement of approximately 40% appear to be desirable for largemouth bass more than one year old (Anderson et al. 1981). Live forage fish may be particularly important during ice cover; however, forage fish can introduce disease organisms. Three pounds of forage fish per pound of bass is required for maintenance, and 10 or 11 pounds of forage fish per pound of largemouth bass is required for good growth. Pellet-fed largemouth bass seems to have at least as good gonad development and fecundity as prey-fed largemouth bass (Snow and Maxwell 1970, Rosenblum et al. 1991).

Brood stock is normally obtained from established largemouth bass producers. If offspring from these fish are going to be fed a prepared diet, then it is desirable to obtain brood stock that have been raised on a prepared diet for several generations. This will increase the number of fingerlings that will learn to take a prepared feed by 20–30%. In the NCR it is probably desirable to use brood stock that have originated from a local source, especially if the offspring are going to be sold for sport fish stocking of ponds and lakes.

Fry and Fingerling Production

The least intensive method of spawning largemouth bass is to place the adults into a fertilized pond free of other fish in the spring at densities of 10–40/acre. Fertilizing the pond with organic or inorganic fertilizer enhances zooplankton densities. After the largemouth bass eggs hatch, the adult bass may be left in the pond or removed. In 20–40 days the fingerlings will reach a length of 1.5–2.0 in. Production using this method is quite variable, ranging from a few hundred to 50,000 fish/acre.

In the more intensive fry-transfer method, largemouth bass brood fish are stocked into ponds free of predacious insects and other fish at densities of 40–100/acre. On average, with healthy adults, 100,000–200,000 fry/acre are produced. The fry will school for several weeks after hatching during which time they can be collected with small fine-mesh seines (cheesecloth), fry traps, or lift nets and moved to rearing ponds. To produce 1.5–2.0 in fingerlings, producers stock at 40,000–80,000 fry/acre. The number of fry can be estimated volumetrically (Swanson 1982).

To limit predacious insects in the rearing ponds and produce a good crop of zooplankton, the ponds are filled with water 10–20 days before stocking. Normally the ponds need to be fertilized with some combination of organic and inorganic fertilizer. Realistically, each producer of largemouth bass has to develop a fertilization regime that works well for his or her own unit. When the zooplankton is eliminated by the largemouth bass, they become very cannibalistic and large numbers of fish can be lost in just a couple of days. With good management, one can expect to harvest 75–80% of the stocked fry.

A much more intensive method is usually used to produce large fish. In order to produce high densities of 6–8 in or larger largemouth bass, most producers train the fingerlings to utilize a prepared diet. One to 1.5 inch fingerlings are moved from the rearing pond into circular tanks or rectangular raceways. Three to four hundred gallon tanks are stocked at densities of 10–40 fingerlings/gal (0.04–0.06 lb/gal). Snow (1968) used a moist pellet but largemouth bass have been trained on ground fish, fish eggs, freeze-dried krill, etc. Within 7–10 days, the fingerlings are switched to a high protein diet such as that used to raise salmon. To most efficiently train largemouth bass to accept a prepared diet, they are concentrated at water temperatures of 70–80°F, with oxygen levels of 6 ppm or more. The training food must be offered frequently. Automatic feeders are commercially available, but most producers hand feed every 5–10 min for at least part of the day. At least 50% of the largemouth bass should learn to accept the feed. If fingerlings from second or third-generation hatchery reared brood fish that have been trained to accept a prepared diet are used, then success should be in excess of 80%.

Unless the fingerlings are the same size, cannibalism can be a serious problem during training. Fingerlings may have to be graded several times during the training procedure to help prevent cannibalism; however, ideally one should start out with fingerlings of the same size. In order to produce fingerlings of the same size, some producers try to stock each rearing pond with fry that have hatched within 24 h of each other. Spawning boxes can be placed in raceways or ponds. The eggs are removed from the boxes and incubated in hatching trays or jars (Heidinger 2000). Only fry that hatch within a 24-h period are used to stock a rearing pond.

After the 1–2 in fingerlings are trained to accept a prepared diet, they are graded and separated from the cannibals and the non-feeders. The trained fish are stocked at rates of 15,000–20,000 bass/acre. Only 40–50% of the fingerlings will normally continue to feed on the prepared diet unless they are confined to one area of the pond for several weeks with a screen or net. In order to keep a higher percentage of the fish on the prepared diet, some producers concentrate the trained fingerlings at higher densities in small 0.5-acre ponds. These ponds must be aerated to maintain suitable oxygen levels. Mechanical feeders can be used to offer the food at hourly intervals.

In the southern portion of the NCR, the bass will reach 6–8 in by the end of their first year. Largemouth bass usually reach 0.75 lb by the end of their second year and 1.25–1.50 lb in their third year. Production levels of 1,500–2,000 lb/acre have been obtained.

Preliminary data indicates dress-out rates of 60% whole dress and 40% for the filets. Both values are similar to those obtained for catfish (Tidwell et al. In press).

Diseases and Pests

Pests and diseases of largemouth bass seem to be similar to those of other warm water fishes. Insects such as notonectids (back swimmers) can build up in a pond and kill large numbers of largemouth bass smaller than 1.5 in. Larger largemouth bass feed on these insects. Crayfish and bullfrog tadpoles can cause a problem when seining small largemouth bass. Chemicals that are not approved by the Food and Drug Administration for aquatic use on food fish have frequently controlled such pests. Pond management is probably the best way to control these pests.

Some producers have a tremendous problem with predation from fish-eating birds, such as cormorants and blue herons. The blackbird-grackle complex is skilled at taking small bass from un-screened raceways.

As with catfish, when stressed, largemouth bass are susceptible to bacterial infection of *Aremonas* and columnaris (*Cytophagas*, formally *Flexibacter*) and mortality can be very high, especially at water temperatures below 60°F. Tidwell et al. (In press) report that approximately 1,000 adult largemouth bass died in the Sante Cooper reservoir in South Carolina in 1995. Auburn University staff implicated an iridovirus. This is the first time that a virus has been implicated in killing Centracids.

Gill flukes (trematodes) and ciliated protozoans such as *Tricodina* and *Costia* can be treated with formalin and or salt. At this time there is no effective legal direct treatment for anchorworm (*Lernea*), *Ichthyophthirius*, bass tapeworm (*Proteocephalus*), or trematoda (grubs).

Water Quality, Handling, and Transport

Largemouth bass are similar to channel catfish in their tolerance of low dissolved oxygen and high un-ionized ammonia. They are more tolerant of high nitrite than are channel catfish (Tidwell et al. In press).

Healthy largemouth bass are no more difficult to handle than channel catfish. They can be hauled in aerated tanks at densities of 2 lb/gal of water for 24 h at 65°F. Largemouth bass tolerate a wide range of temperatures if acclimated but seem to be significantly stressed when handled below 40°F.

CRITICAL LIMITING FACTORS AND RECOMMENDATIONS

NUTRITION

Even though largemouth bass are being produced economically, the supply of large fish does not meet the demand. The bottleneck appears to be nutritional in nature. Very little nutritional research has been done on largemouth bass. Anderson et al. (1981) determined a protein requirement of 41% for 1–2 in fish. Pond reared second year largemouth bass up to 0.75 lb seemed to benefit from a 42–48% protein level. Their study, along with observations from many producers, has indicated a problem with pale, fatty livers and mortality. Over wintering mortality especially is thought to be a problem with nutrition of the feed.

A doctoral dissertation is being conducted at Southern Illinois University-Carbondale on the nutritional requirements of fingerling largemouth bass. Additional nutritional and feeding studies are needed, especially on larger bass. Since most large bass are sold alive, these studies should investigate artificial diets to maximize growth rate, and also consider how the diets and feeding regimes affect handling and hauling of the fish.

A related problem in the use of fingerlings reared for the sport fish stocking market involves the perception by some that largemouth bass reared on a prepared diet do not survive as well, especially over winter, as those reared on live forage. Relative mortality of the two groups of fingerlings needs to be documented.

PRODUCTION DENSITIES

After suitable diets are developed, feeding trials need to be conducted to determine the densities at which food-size largemouth bass can be routinely reared. Once these densities are determined, demonstration projects should be set up. This information is needed in order to predict profit margins.

MARKETING

Once the adult live food-fish market and the adult live sport fish market starts to become saturated, then fish will be available to develop the more traditional frozen and iced food fish market. At that time a market development plan will be needed.

DISEASES

As with all commercially raised fishes, more effort needs to be expended in getting chemicals approved for disease treatment. The role of the bass tapeworm in relation to mortality in adult largemouth bass needs to be better understood. Some effort should be made to document the existence, extent, and severity of the "Largemouth Bass Virus."

SPAWNING

Although largemouth bass are successfully spawned using a number of different methods, the degree of success is not consistent among producers. For example some producers very successfully use nest boxes. Others have tried this method and the bass do not spawn on them. For some producers, separating the males and females and delaying placing them together until after the temperature has stabilized works well. For others this method is a complete failure. Such inconsistency makes it difficult to advise new fish farmers. Sufficient research in this area needs to be done in order to understand why the outcome of these approaches is so variable.

TRAINING SUCCESS

Most established producers of largemouth bass are successful in training at least 75% of the fingerlings to feed on a prepared diet. Many still have a problem maintaining these fish on the prepared diet once they are placed in the rearing ponds. A technique needs to be developed that will insure that 90% or more of the trained fish continue to feed on the prepared diet.

PRIORITIZATION

A number of issues that limit the production of largemouth bass in the NCR have been identified. Clearly, determining an appropriate prepared diet and feeding regime is the most important issue. Priorities number 2 and 3 are of equal importance, but priorities 4 and 5 are not ranked.

(1) Develop appropriate feeds and feeding regimes
(2) Determine and demonstrate realistic production densities
(3) Improve the percentage of trained bass that stay on the prepared diet

(4) Develop the frozen and iced food fish market for largemouth bass
(5) Enhance better disease control including more approved drugs

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