UNIVERSITY OF FLORIDA

Cooperative Extension Service
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Catfish Farming in Florida[1]

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Commercial catfish farming is an important agricultural industry in the United States, although Florida has lagged behind other southeastern states. More than 100,000 acres of water are currently used to produce around 225 million pounds of catfish yearly in the United States. Of this market, about 275,000 pounds of food-sized fish were raised on 88 acres in Florida during 1981. The low commercial production of catfish in Florida, compared with other southeastern states, is primarily the result of marketing and environmental constraints. A lack of adequate processing facilities for farm-raised fish and soils that are not suited for large, conventional embankment ponds have impeded development of the catfish aquaculture industry in the state. Nonetheless, catfish farmers are increasing their endeavors in Florida and prospects for future development of the industry may be promising.

This publication addresses the basic techniques and procedures used in culturing catfish and is intended to be a general guide for the farmer who is contemplating raising catfish in Florida on a commercial basis. Catfish farmers often specialize either in producing food-sized fish for processing and marketing to wholesale and retail outlets, or in spawning and rearing fry and fingerlings for stocking to grow-out ponds and other aquatic systems (e.g., raceways and cages).

Before building facilities and attempting to raise catfish, one must become thoroughly familiar with marketing potential, investment costs, and environmental constraints that apply to a given area. Prices of farm-raised catfish for consumption are currently noncompetitive with wild-caught fish in Florida. Moreover, consumers in the state seem to have a preference for “shorts" or "sharpies," i.e., fish of a relatively small-sized dressed carcass (2-5 ounces). Farmers who may be considering production of food fish should investigate marketing outlets for their product well before constructing facilities and stocking fish. Likewise, anyone intending to produce fingerlings for sale as seed stock should be sure that they will be able to sell and transport their fish successfully. Producers must make a preliminary assessment of expected economic expenditures and returns to determine the potential profitability of catfish farming. The greatest capital outlays will be land, pond construction, equipment, and supplies. Major operating costs are feed, fingerlings (for rearing as food fish), labor, fuel, electricity, chemicals, and processing or transportation costs. A marketing analyst should be consulted for assistance in estimating economic investments and profits. Environmental constraints such as the feasibility of pond construction, and water quality and quantity must be carefully considered when planning a fish farm and making an economic analysis.

Several unique features of Florida's topography, climate, and aquatic systems show promising avenues for

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development of the catfish farming industry. Construction of appropriate ponds for culturing catfish may be severely limited by soil types and topography throughout much of the state except in parts of the panhandle. However, there may be good potential for rearing fish by nontraditional methods such as in raceways or in cages placed in canals, borrow pits, or other suitable bodies of water. Because of the warm climate and long growing season, Florida farmers could possibly supply fingerlings or fresh food fish to markets in other states out-of-season or on a year-round basis. Cultivation of yellow bullheads (*Ictalurus natalis*), brown bullheads (*I. nebulosus*), white catfish (*I. catus*), or other species could provide alternatives to rearing channel catfish (*I. punctatus*). Some of these species might be suitable for supplementing current consumer markets, and they may be more amenable to culture under certain conditions than are channel catfish. However, culture techniques are best known for channel catfish, and the methods and procedures outlined here are those that apply principally to channel catfish unless otherwise noted.

FINGERLING PRODUCTION

Brood Stock Management

Selection of Brood Stock

Successful fingerling producers select high quality brood fish and maintain them in good health to obtain maximum yields of offspring. Many catfish producers prefer to buy mature fish rather than waiting for fingerlings to reach spawning age. The best source of brood fish is a reputable hatchery. However, be careful not to buy culls, or fish that have been discarded because they have undesirable traits. Fish-farming trade magazines usually carry advertisements for brood stock available through established producers and growers. It is advisable to inspect brood fish closely before buying to ensure that healthy fish are obtained.

Avoid purchasing fish recently taken from the wild, since they are often unreliable spawners and their fingerlings may grow more slowly and be less resistant to diseases than fingerlings from established hatchery stocks. Be especially careful to avoid any sources having a history of channel catfish virus disease, since this pathogen is untreatable and can spread quickly and destroy an entire stock. Inbred strains are less desirable than genetically superior crossbred strains. Healthy brooders should be full-bodied and free of sores or hemorrhages on the skin. Thin or emaciated fish may be old, diseased, or underfed.

Catfish farmers generally prefer brooders in the 2-10 pound range; smaller females do not produce as many eggs as larger ones, and bigger fish may be difficult to handle. Channel catfish reach optimal breeding condition in three to four years, when 40-50% of the fish may be expected to spawn under good conditions. Scientists are currently attempting to breed strains that will mature earlier. Proper nutrition of mature fish throughout the year is essential to ensure successful spawning, because the number and size of eggs produced by a female is strongly influenced by diet.

It is important to select the proper ratio of male and female brooders. A ratio of two or three females for each male is ideal. One male can mate with two or more females in a single spawning season if the eggs are moved to a hatchery or incubation chamber. Although catfish normally produce offspring in a 1:1 sex ratio, do not take this for granted when buying brooders. Males grow faster than females, so when fish reach 2-3 pounds, up to 80% of the largest individuals in the population may be males. It is advisable to determine the sex of each brooder you buy to ensure a proper ratio of males and females.

Determining Sex

Both primary and secondary sex characteristics are useful in distinguishing males and females. Primary sex characteristics are those features specifically involved in reproduction, whereas secondary sex characteristics are not directly involved in spawning. The primary characteristic used to distinguish the sexes is the urogenital opening; the secondary characteristics relate to coloration and body shape. (Figure 1)

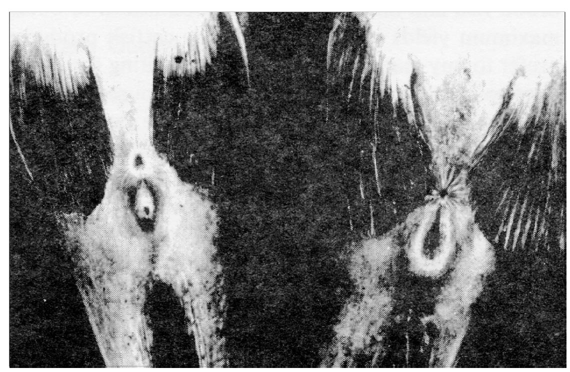

Figure 1. Male (left), female (right).

Secondary characteristics are most prominent during the spawning season. Males are usually larger and have broader heads than females of the same age. As the spawning season approaches, males become lean, develop large muscular heads that are wider than their bodies, and sometimes become darker, especially on the lower jaw. Females' heads are narrower than their bodies when viewed from above. They also develop soft, greatly distended bellies as the spawning season approaches.

Preliminary identification of sex should be confirmed by examining the urogenital opening. This is particularly important with young fish and during the fall or winter when secondary sex traits are less pronounced. With practice, one can reliably use the following method to determine the sex of fish as small as one pound. (Figure 2)

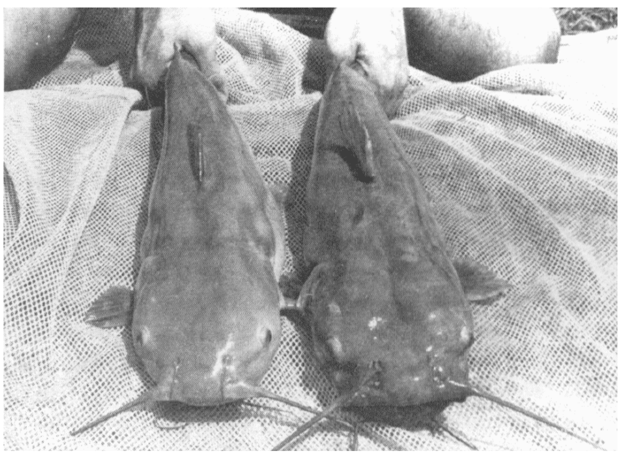

Figure 2. Male (right), female (left).

The fish should be turned upside down for examination of the genital area, which can be seen as a fleshy area about midway between the pelvic and anal fins. Two openings should be visible when examined closely: the one nearest the head is the anus, and the one nearest the tail is the genital pore. In males the genital pore terminates on a fleshy, nipple-like structure (the genital papilla), which usually becomes swollen and somewhat rigid as spawning season nears. The genital area of females is oval and flat, with the anus separated from two other openings by a small flap of skin. The slit or groove toward the tail end contains a urinary pore and the genital pore. Immediately prior to and during the spawning season, the entire genital area of the female becomes red, swollen, and may be covered with a thin layer of mucus.

A probe is useful in determining the sex, especially in young or nonbreeding fish. Immobilize the fish by holding it belly upward with one hand grasping the head and the other hand firmly holding the tail region. With the fish's head below your chest and the tail held away from your body, arch the fish's belly upward. This will allow the male genital papilla or the female slit to become more visible. Then have an assistant carefully and gently slide a blunt probe, such as a thin wire, over the genital area toward the tail, with the point leading the probe. Be cautious not to break the skin or penetrate the flesh with the probe. If the point of the probe catches in the genital opening, the fish is most likely a female. Drawing the probe across the genital area in the opposite direction, from the tail side toward the head, should cause the probe to catch on the genital papilla if the fish is a male.

Nutrition

Good spawning success requires a proper diet for brooders, especially in the fall and early spring months. During warm weather feed a nutritionally complete diet of about 35-40% protein at a concentration of 1-2% of the stock body weight daily (Table 1). Catfish do not require feeding when water temperature falls below 50 °F (10 °C). When water temperature is between 50° and 65 °F (10°-18° C), feed approximately 0.50-0.75% of the fishes' body weight three times per week. Estimate the amount to feed by observing feeding vigor, if possible. This can best be accomplished by using a floating pellet. During warm weather, the proper amount of food to offer is that which will be eaten in about 10 minutes. Feeding activity declines when the spawning season begins and during cold weather.

Stocking

Total weight of brood fish should not exceed 1200 pounds per acre at any time, hence ponds should be stocked initially at about 800 pounds of fish per surface acre to allow for weight gain. Successful spawners should gain about 50% of their weight from one spawning season to the next. Old, sick, and undesirable brood fish should be removed each spring and replaced with young brooders to maintain the total initial stocking density and to enhance vigor and productivity by reducing inbreeding.

The most popular brood ponds in more northern states are between 1 and 10 acres; smaller ponds may undergo extreme temperature changes and reduce spawning success, while larger ponds are difficult to manage. Problems with pond construction, temperature control, and weed management in Florida waters dictate that the most convenient size for brood ponds should be 1/10 - 1 acre. Brood fish should be stocked in more than one pond to minimize the likelihood of wholesale destruction of an entire stock from disease, oxygen depletion, or other catastrophes.

Spawning Management

Channel catfish begin spawning in late spring when water temperature reaches about 75° F (24° C). Males prepare nests in hollow logs or similar shelters and aggressively attack intruders. A female that is attracted to a nest will mate with the male over a period of several hours, depositing a large, yellow, jellylike egg mass. The number of eggs laid is dependent on the size of the female and averages around 2,000-3,000 per pound of body weight. A one pound egg mass will contain about 10,000-11,000 eggs. After spawning, the male chases the female away and guards the eggs. A single male may spawn with more than one female in one season.

Use Of Spawning Shelters

Artificial spawning containers should be provided to enhance spawning success and facilitate removal of eggs and young. Commonly used items include milk cans, nail kegs, ceramic or earthenware crocks, wooden boxes, ammunition cans, and plastic or metal buckets and drums. The spawning receptacle must be of sufficient size to accommodate the brooding pair and should have an opening just large enough for them to pass through. A hinged lid will make it easier to check for spawning and to remove eggs.

Spawning containers should be provided for 50-90% of the males, by placing containers in water 12-30 inches deep, 1-10 yards apart, and with the opening toward the pond center. Each nest container can be marked with a float or flag to indicate its position.

Containers should be placed in ponds at a time appropriate for the target date of fingerling production. Most spawning occurs at water temperatures between 75° and 85° F (24°-30° C), with an optimum around 80° F (27° C). Because of the large latitudinal temperature gradient in Florida, channel catfish can be expected to spawn at quite different times between about March and July throughout the state. As a result, more southern farms may have the greatest potential for supplying early seed stock to markets in the north.

Spawning activity sometimes diminishes for no apparent reason. Additional spawning may often be stimulated by lowering the water level of the pond about one foot and then rapidly refilling the pond, or by occasionally moving unoccupied containers. Since not all females spawn and a proportion of the eggs, fry, and fingerlings do not survive, about 1,000 fingerlings will be produced per pound of healthy female brooder if proper brood stock, hatchery, and rearing techniques are used.

Spawning Methods

A variety of methods are commonly used to spawn catfish. Some producers attempt to induce spawning by injecting brooders with hormones. Such injections may be useful in stimulating fish to breed out-of-season or in unnatural enclosures such as pens and aquaria. Catfish will respond to intraperitoneal injections of pituitary extract from carp and other fish, as well as synthetic hormones. Carp pituitary is typically given in doses of about 6 mg per pound (450 g) of fish in three injections over 24 to 48 hours. Prespawning catfish also respond well to a single injection of human chorionic gonadotropin (HCG) at an optimum dose of about 800 International Units (I.U.) per pound (450 g). Both ripe males and females may be injected. The following methods are the most popular techniques used in spawning catfish:

1. Spawning and Rearing Pond Method

This method requires the least skill, labor, and facilities. Spawning containers are placed in the pond, and the fish are allowed to spawn and hatch the eggs. Fry are left in the pond and cultured until ready for harvest. This method is unreliable, causes ponds to contain different size and age groups, and is not recommended for commercial production of catfish. In some cases it is a suitable method of producing catfish for recreational angling or noncommercial harvest.

2. Egg Transfer Method, Open Pond Spawning

This method is a productive way to spawn catfish but requires great technical and financial expenditure. Brooders are allowed to spawn in containers within the pond, but the fertilized eggs are removed and incubated in a hatchery. Removal of eggs minimizes the spread of diseases and parasites from the adults to the young, reduces predation on fry by the adults, and provides easier means to control stocking densities.

Spawning containers should be examined every two to four days, preferably in the late morning or afternoon, since most spawning probably occurs during the night or early morning. Eggs should be carefully removed as soon as they are found. Since male catfish aggressively defend their nests and can inflict painful bites, it is advisable to wear gloves and exercise caution when removing eggs or fry. Disturbed males may also eat or dislodge their eggs, so it is sometimes best to first chase the male away from the spawning container.

The adhesive egg mass should be gently scraped free of the floor of the container using a plastic spatula or similar device, and then carefully lifted into a bucket containing pond water. Eggs may be left in a bucket in the shade for 10 to 20 minutes, but if they are near hatching or if transport to the hatchery will be longer, aeration should be provided. Never place eggs in direct sunlight or transport them in coolers and other tightly covered containers that might result in suffocation. (Figure 3)

3. Fry Transfer Method, Open Pond Spawning

This method is similar to the egg transfer method, except that the male brooder is allowed to incubate the eggs until hatching. Newly-hatched fry are transferred from the spawning containers to the hatchery or nursery ponds. Spawning containers should be checked every three days, and when an egg mass is found a small clump of eggs should be gently pinched off and examined closely to determine the approximate age of the clutch (Table 2). Remove the fry one day after the predicted hatching date. Newly-hatched fry have a large yolk sac that impedes their movement, but they are

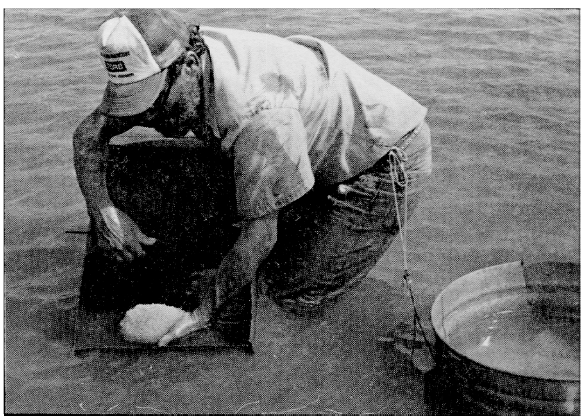

Figure 3. Removal of egg mass from spawning container.

still capable of swimming. Fry can be carefully caught with a small fine-mesh net or gently poured into a bucket of pond water and transferred to the nursery. After counting the fry (see "Counting Fry"), they should be released into the nursery by slowly submerging the bucket. If the water temperature of the nursery differs from that of the brood pond, be sure to properly acclimate the fry as during hauling and stocking.

4. Pen Spawning

Pen spawning uses submerged enclosures made of wood, concrete, wire mesh, or a combination of materials. Although this method requires additional construction and labor costs, it has the advantage of allowing selective mating. Pen spawning techniques are not currently in wide use in Florida, but there may be good potential for this method in pit ponds, canals, sinkhole and solution lakes, reclaimed phosphate pits, and other aquatic systems unusual or unique to the state.

Pens are usually built in at least 3 feet of water along a bank to minimize the amount of materials needed and for ease of observing and handling fish. Galvanized chain link fence, plastic-coated wire mesh, or other nonrusting materials should be used to construct rectangular pens about 4 x 6 feet and extending 12-24 inches above the water

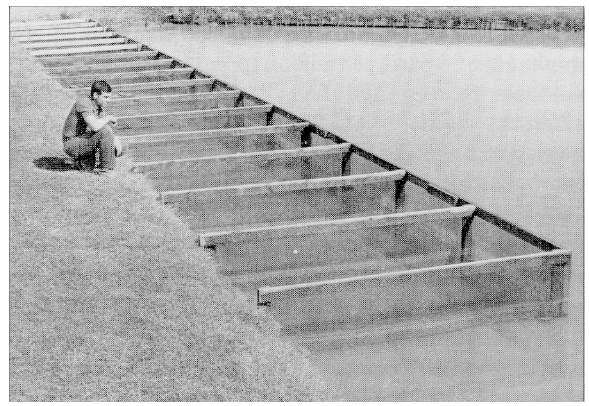

Figure 4. Spawning pens.

surface, with the narrow side open against the shoreline. Adjacent pens can have common sides to further reduce construction costs. Sides of the pen must be embedded in the bottom to prevent brood fish from escaping. Mesh size must be large enough to allow for good water circulation, but not so large as to permit the escape of brood fish; meshes of ½ -2 inches are usually satisfactory. A spawning container is placed in the pen, usually with the receptacle opening toward the center of the pond. (Figure 4)

A pair of ripe brood fish of similar size should be introduced into each pen. It is important to select fish, especially females, that are nearly ready to spawn. Some producers who use this method prefer to inject brood fish with spawning hormones a day or two before placing them in the pens. Cages should then be checked daily and any female that is being harassed or injured by a male should be removed at once. It is very important to transfer the female soon after spawning to prevent her from being seriously injured or killed by the male. Following spawning, eggs may be moved to the nursery or the male may be allowed to incubate them to hatching. If spawning does not occur in one to two weeks, double check the sexes of the pair and exchange brood fish if necessary.

5. Tank Method

Tank or aquarium spawning is the most intensive method of spawning management because it requires considerable investments of time, labor, and facilities. Aquaria, tanks, or troughs of at least 50 gallons (200 liters) are used as spawning enclosures. A pair of ripe brooders is selected and spawning is induced by injecting the female or both fish with pituitary extract or HCG. Depending on the dose of hormone, spawning usually ensues within a day or two of injection, but some females may require additional injections. As soon as spawning is completed, the eggs are transferred to the hatchery and the aquarium can be stocked with a new brood pair, or the same male can be used with a fresh female following a resting period.

The tank method has several advantages over other techniques: (1) variables such as temperature, light, and water chemistry can often be controlled more easily; (2) spawning period can sometimes be altered, allowing for earlier seasonal production of fry or limiting spawning to times that are convenient for the culturist; (3) fish that might not otherwise spawn may often be induced to; (4) diseases and parasites can be more easily controlled; (5) selected matings can be performed and easily recorded. Major disadvantages of the tank method are that (1) there are greater risks of losses from power outages, plugged pipes, and other mechanical failures; (2) the number of eggs produced per man-hour may be lower than other methods; (3) the tank method is comparatively expensive.

The Hatchery

The most efficient hatcheries use incubation chambers for hatching eggs, since predation, cannibalism, and disease can be reduced and stocking rates can be easily monitored. Hatcheries range from simple wooden paddle-wheel troughs to more sophisticated devices available through commercial equipment suppliers. Hatcheries need not be elaborate, so long as good water quality and disease control measures are maintained.

Trough construction

A typical incubation chamber consists of a flatbottomed wooden, fiberglass, aluminum, or stainless steel (14-gauge) trough about 8 to 10 feet long, 18 to 24 inches wide, and 10 to 12 inches deep (about 100 gallons). Some hatcheries have a divider in the middle of the trough for reinforcement and to allow eggs of different ages to be incubated at the same time. To provide adequate aeration, troughs are equipped with a series of paddles made of galvanized tin or similar material. Paddles should be mounted above the center of the trough on a one-inch pipe shaft, driven by an electric motor at 30 rpm. Paddles should be spaced at appropriate widths to accommodate six to eight wire-mesh baskets in which eggs are suspended. Baskets made of 1/4 inch plastic-coated hardware cloth and about 3 inches deep are hung by wires from the sides of the trough so the waterline is just below the basket tops. Paddles should be long enough to reach well below the baskets to gently roll the egg masses and force oxygen-rich water through them. Water should be applied to one end of the trough at a rate that will allow one complete water exchange in about 45 to 60 minutes (about 2 to 3 gallons per minute in a 100-gallon trough). A standpipe may be fitted into a drain at the other end of the trough to control water depth. The standpipe must be screened to prevent fry from escaping, and should be inspected and cleaned often to avoid clogging and trough overflows. Provisions should be made for emergency generators to supply power in case of electricity outages.

Water Quality

Proper water conditions are essential for successful fingerling production. A clean water source such as a well is best for hatching eggs, since risk of disease is minimized if there are no fish or fouling organisms in the water supply. However, water from many wells and other sources must often be aerated and warmed prior to filling hatchery troughs. (Figure 5)

Water temperature should be between 75° and 82° F (24° and 28° C). Hatching occurs in about 6 days at an optimal temperature of about 80° F for artificial incubation. Temperatures from 68° to 86° F (20° to 30° C) can be tolerated, but lower temperatures increase the hatching time and might increase disease problems.

Oxygen levels in troughs must be maintained at a minimum of 6 parts per million (ppm) to supply adequate amounts to eggs and fry. Total hardness and total alkalinity should exceed 20 ppm, and the pH should be between 6.5 and 8.5 for best results. Acidic or soft water can be corrected by adding limestone or a buffer on a case-by-case basis.

Further information on water quality is contained in Florida Extension Circular 715, "Management of Water Quality for Fish."

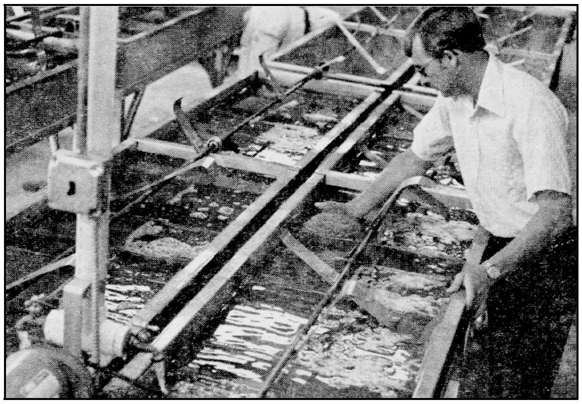

Figure 5. Hatchery trough with paddles.

Disease Control

Eggs and fry are highly susceptible to bacterial and fungal infections. Proper treatment requires complete familiarity with identification of pathogens and use of chemicals; additional references and diagnostic laboratories should be consulted for greater details of material presented here.

The best disease control is prevention by maintaining adequate aeration, clean water, and temperatures below 82° F (28° C). Equipment should be cleaned frequently and disinfected to prevent contamination. Eggs should be checked daily and any debris, shells, and dead or badly infected eggs removed with a siphon. Bacterial and fungal infections often appear as cloudy or cottonlike patches on eggs and should be treated or isolated when first detected. Chemical treatment may be successful provided standard recommended doses are not exceeded. Conversion tables and proper dosages are available in Plumb et al. (Southern Coop. Ser. No.225) and Jensen et al. (Alabama Coop. Ext. Service Circ. ANR-327).

Bacterial outbreaks can be treated by dips or baths in terramycin (20 ppm), potassium permanganate (3 ppm), and other drugs. Eggs with fungal infections can be treated with formalin (100 ppm for 15 minutes) and may require simultaneous treatment for bacterial growth. Formalin should never be used with eggs that are near hatching. Sanitary conditions maintained in the hatchery may provide added protection from parasites, channel catfish virus disease (CCVD), and other infections following hatching.

Fry Management

Handling Fry

Within one to two days of hatching young sac fry should be acclimated and transferred from the hatching troughs to rearing tanks, troughs, vats, screened boxes, or other facilities using a 1/2 inch or larger siphon or small net. After hatching, sac fry swim through the egg baskets and school together in tight clusters near the bottom. Fry rely on their large yolks and do not begin to feed until they become darkly pigmented and absorb their yolk sacs (about three to four days after hatching). Rearing tanks must have clean, well-aerated running water and should be scrubbed and sterilized with a mild chlorine (1 teaspoon of household bleach per gallon of water for five minutes) or formalin (1 part: 4000 parts water) solution between each crop of fry. Be sure to thoroughly wash chlorine or other antiseptics off equipment with three or more rinses in fresh water. Keep young fry away from bight lights to reduce stress.

Counting Fry

The number of fry transferred from hatching troughs to temporary rearing chambers can be estimated using volumetric or gravimetric methods. It is best to combine clutches of fry that are about the same age in order to facilitate counting and to keep equally-sized individuals together. Estimate the number of fry by water displacement in a household measuring cup or graduated cylinder prior to introducing them into rearing tanks. A rough estimate is that about 1,000 one-day-old fry will displace one ounce of water. A more accurate approximation can be obtained by counting a small sample of 200-300 fry, measuring the amount of water that they displace, and then recording the water level change for all fry. The total number of fry can then be estimated by Equation 1:

$$\text{Total Number of Fry} = \frac{\text{Total number in sample} \times \text{change in water level with all fry}}{\text{Change in water level of sample}}$$

EXAMPLE:

(1) A sample of 300 fry displaces water level in a 100 ml graduated cylinder from 50 to 62 ml.
(2) The entire clutch of fry displaces the water level in a larger container from 500 to 900 ml.
(3) The total number of fry can then be calculated in Equation 2:

$$Total\ number = \frac{300 \times (900 - 500)}{62 - 50} = 10{,}000$$

Estimating fry number by weight is similar to the above method. Water in a container is weighed, a sample of fry is counted and then added to the water, and the increase in weight is recorded. The total weight of all fry is then measured and the total number of fry can be approximated using the same general formula as that for volumetric counting. Estimating the number of fry by these methods allows the producer to determine appropriate stocking densities and feed allotments when moving fry to facilities for growing fingerlings. In addition, the number of fingerlings graded into various size classes must be counted when sold or transported to markets (see "Grading Fingerlings"). (Figure 6)

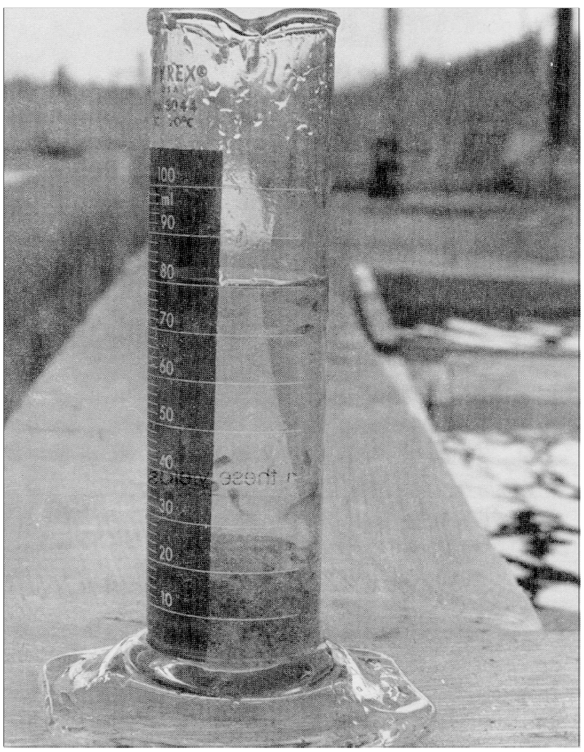

Figure 6. Counting fry by water displacement in a graduated cylinder.

Feeding Fry

Fry begin swimming up to the surface of the water and around the edges of the tank when they are ready to feed. Small ground pellets, "crumbles," and granules ("fry starter") are typically used for feeding fry. A nutritionally-complete, high protein diet is recommended for maximum growth (ideal feed contains at least 45-50% crude protein, of which 60% of the protein should be fish meal). Initial food particles should be 0.35-0.60 mm (standard seive gauge 30-40). Small particle feeds have greater surface areas and may lose valuable nutrients by leaching and erosion during processing or storage. Supplemental vitamins, minerals, or other nutrients may be required to fortify the diet. Young fry should be fed often with enough meal that will be eaten in 15 to 20 minutes. Avoid overfeeding and distribute meal over the water surface using a screen or fine strainer. Since fry grow rapidly the pellet size and amount of food must be gradually increased (Table 3).

Raising Fingerlings

Pond Preparation and Pest Control

Catfish can be grown to fingerling sizes, suitable for marketing as seed stock, in a variety of rearing facilities that include ponds, troughs, and raceways. In general, many of the precautions and techniques of raising food-sized fish in production ponds also apply to the methods used in rearing fingerlings. To be successful, a producer must maintain optimal water quality by practicing routine procedures such as the following: (1) take care to exclude all wild fish, predatory aquatic insects, tadpoles, and other potentially noxious animals from rearing areas; (2) monitor water chemistry frequently and take appropriate remedial measures to control improper levels of dissolved oxygen, pollutants, pH, sediments, etc.; (3) prevent excessive growth of aquatic weeds and avoid overfeeding and other sources of organic waste; (4) record water temperature often and be especially cautious to avoid heat-related stress; and (5) use appropriate drugs and chemicals, following local regulations and suggested procedures, to contain or eliminate diseases and parasites only after conventional preventive measures have failed. Diseases are a constant threat to cultivated catfish and are of special concern to fingerling producers. Prevention of serious diseases requires good management by minimizing stressful conditions such as unfavorable environmental factors, improper handling, and poor nutrition. Channel catfish virus disease (CCVD) poses a particular threat to fingerlings and requires special consideration.

Channel catfish virus infects fingerlings less than 6 inches long and is highly contagious and usually fatal. Symptoms include hemorrhaging at the base of the fins and in the skin, distended abdomen filled with a clear, yellowish fluid, exophthalmia (pop-eye), pale gills, and erratic swimming behavior (these symptoms should not be considered as exclusive evidence for the disease). CCVD occurs primarily during hot weather when water temperatures exceed 68° F (20° C), and develops more rapidly and results in greater losses as temperature increases. Very few effective treatments are available for viral diseases of fish, hence CCVD must be prevented to avoid losses of entire stocks. A diagnostic laboratory or fisheries specialist should be consulted to verify suspected cases of the disease. The following measures are imperative to prevent outbreaks of CCVD:

1) Prevent stress from low oxygen.

2) Do not move fingerlings when water temperature is over 85° F (29° C). If fingerlings must be moved during the summer, they should be handled gently and as briefly as possible (however, do not move fish if CCVD is suspected).

3) Prevent poor water quality from developing in rearing facilities by avoiding excessive buildups of ammonia, organic debris, and other toxic substances.

4) Avoid large outbreaks of external parasites on fingerlings by using prophylactic measures. Do not treat for external parasites if CCVD is already present.

5) Avoid very high stocking densities (i.e., greater than 150,000 fry per acre).

6) Do not use nets or other equipment that have been used in ponds or tanks where there has been a recent CCVD outbreak, without first disinfecting in Roccal (1 ,000 ppm for 5 minutes) or HTH (calcium hypochlorite) at 40 ppm for 5 minutes.

Stocking Fry

The optimal number of fry to stock depends on the management intensity, type of rearing facility, feeding schedules, water temperature, and other factors. Initial stocking density generally depends on the final size of fingerlings desired at harvest. Growth rate is determined by interactions between quantity of food consumed, stocking density, and water temperature, hence size of fingerlings at harvest may be highly variable (Table 4). At very high stocking densities, it is unwise to offer maximum amounts of food because water quality can deteriorate rapidly.

Fry should be stocked into rearing areas during the cool evening or morning hours by slowly conditioning them to the water, using aerated buckets or other containers to transport them. Fry stocked in ponds may survive better and can be more easily fed if they are provided with shelters such as wooden or plastic boxes around which they congregate. Some producers prefer to give added protection to fry by temporarily holding them in screened boxes within ponds until they reach slightly larger sizes.

To determine optimal stocking rate, divide the anticipated total weight produced per acre by the weight of the average sized fingerling desired for harvest. Since a maximum feeding rate of 100 pounds of feed per acre per day should generally not be exceeded, a maximum of about 3,500 pounds of fish per acre can be attained at harvest time. The following examples illustrate sample calculations required to estimate common stocking rates:

Example 1. If 0.06 pound average fish (6 inches) are desired for harvest, then the required stocking per acre is (see Equation 3):

$$\begin{aligned} \textit{Stocking rate/acre} &= \frac{\textit{Total pounds of fish/acre}}{\textit{desired weight of fish (lbs)}} \\ &= \frac{3{,}500 \textit{ pounds/acre}}{0.06 \textit{ lb average weight}} \\ &= 53{,}333 \textit{ fish/acre} \end{aligned}$$

Example 2. If 0.02 pound average fish (4 inches) are desired for harvest, then (see Equation 4):

$$\begin{aligned} \textit{Stocking rate/acre} &= \frac{3{,}500 \textit{ pounds/acre}}{0.02 \textit{ lb average weight}} \\ &= 175{,}000 \textit{ fish/acre} \end{aligned}$$

Feeding Fingerlings

Small fingerlings have large appetites and should be fed nutritionally-balanced diets at least two to six times daily for the first two weeks. As fingerlings grow, they can be fed larger pellets (Table 3), but they begin to eat less food in relation to their size. "Crumbles" or crushed pellets can be replaced with 3/16 inch pellets of at least 36% protein when fingerlings are four to six weeks old. Extruded or floating pellets are preferred by most catfish producers because the fish can be seen as they eat. Savings in food costs of 10-15% can sometimes be realized by using a combination of about 85% sinking and 15% floating pellets. However, feed loss must be avoided by distributing pellets near areas where fingerlings congregate and by placing sinking pellets over areas of hard bottom and free of rooted vegetation. Shelters and containers can be used to attract fingerlings to desired feeding areas.

The amount to feed is determined by fingerling size, stocking density, and water temperature. Most suggested feed schedules are rough guides and the manager must use good judgement in estimating a proper allowance. Standard recommended feeding rates are presented in Table 5. Actual feed allowances, usually expressed as pounds/acre/day, will vary widely but generally should not exceed 35 pounds/acre/day during summer to prevent oxygen shortages. In cold weather, fingerlings should be fed 1.5% of their estimated weight three to six days per week. Fingerlings fed from November to March in Florida will probably gain at least 25-40% of their initial body weight. Fish weight should be estimated weekly, and perhaps daily, in order to make accurate adjustments of feeding percentages. At very high stocking densities and high water temperatures it is unwise to offer maximum amounts of food because water quality can deteriorate rapidly.

Harvesting

When fingerlings are 3-10 inches long they can be harvested for marketing as seed stock. Harvesting can be done year-round but is discouraged when water temperature is over 85° F (29° C). Harvest during cool morning hours and handle fingerlings as briefly as possible during warm months to lessen stress.

Fingerlings grown in ponds can be removed by seining with a 100-200 foot net. About half of the seine should be stretched and staked in the water, parallel to the shore and about 50 feet from the bank near a hard-bottomed feeding area free of debris. Excess netting at the ends of the seine can be rolled or folded and hauling ropes extended from the seine to stakes on the shoreline. Fingerlings should then be fed in the trapping area for a few days to accustom them to the net. Harvesting is done by pulling the net toward the shore and around the fingerlings when they are actively feeding. Fish should then be dipped from the seine and loaded directly into grading vats or hauling equipment. (Figure 7)

Figure 7. Box-type grader for catfish fingerlings.

Figure 8. Tank with aerator for hauling fingerlings.

The sharp pectoral and dorsal spines of fingerlings can become tangled in nets and cause undue stress. Entanglement can be reduced by dipping nylon seines and nets in an asphalt-base net coat prior to harvesting, or by using polyethylene nets. Partial grading of different-sized fingerlings can be done in the pond by using seines with different mesh sizes (Table 6).

Some producers use traps to successfully harvest fingerlings from ponds. Harvesting fish from raceways, troughs, cages, and other facilities can be conveniently accomplished using catchment basins, dip nets, and other equipment.

Grading

Fingerlings must be graded and counted into different sizes before shipment. (Figure 8) Grading is most easily done in holding tanks or vats by using specially constructed boxes. Box-type graders usually have aluminum or stainless steel rods that are spaced at appropriate widths and retain certain size fish but allow smaller ones to pass through. Recommended bar widths for grading fingerlings are given in Table 6.

Counting

Fingerlings may be sold by weight, length, or a combination of both. Counting them is more accurate if they are first graded into uniform size classes. At least three samples with a minimum of 200 fish each are counted and weighed before, midway, and at the end of loading. The weight per thousand fingerlings is estimated from the samples. All of the fingerlings are then weighed as they are loaded into the transport tank, and the total number of fish is estimated from the average weight of the individual samples. For example, three samples of 200 fish each might weigh 10, 11, and 12 ounces, or a total of 33 ounces (2.06 pounds) for 600 fish. If a total of 500 pounds of fish is loaded into the tank, then the number can be estimated as in Equation 5:

$$\text{Sample Number} = 600 \text{ fish}$$

$$\text{Sample Weight} = 2.06 \text{ pounds}$$

$$\text{Total Weight} = 500 \text{ pounds}$$

$$\begin{aligned} \textit{Total Number of Fish} &= \frac{\textit{Number of fish in samples} \times \textit{total weight of all fish}}{\textit{Weight of fish in samples}} \\ &= \frac{600 \textit{ fish} \times 500 \textit{ pounds}}{2.06 \textit{ pounds}} \\ &= 145{,}631 \textit{ fish} \end{aligned}$$

The average weight in pounds of each 1,000 fish can then be calculated as in Equation 6:

$$\text{Total weight} = 500 \text{ pounds}$$

$$\text{Total Number} = 145{,}631 \text{ fish}$$

$$\begin{aligned} \textit{Pounds}/1{,}000 \textit{ fish} &= \frac{\textit{Total weight (pounds)} \times 1{,}000}{\textit{total number of fish}} \\ &= \frac{500 \textit{ pounds} \times 1{,}000}{145{,}631} \\ &= 3.4 \textit{ pounds}/1{,}000 \textit{ fish} \end{aligned}$$

Transporting Fingerlings

Healthy fingerlings can be transported alive for relatively long distances with proper equipment and careful handling. Hauling tanks vary in design but should always be well insulated and equipped with aerators or agitators and filled with clean, fresh water. When using tanks deeper than 30 inches or hauling crowded fish loads it is necessary to use efficient aerators and to have bottled oxygen for emergency backup. Oxygen should be released through porous diffusers as small bubbles into the water.

The number of fingerlings that can be safely hauled depends on the tank volume, efficiency of the aeration equipment, length of haul, water temperature, and size and condition of the fish. Fingerlings should not be fed for 12 hours prior to long hauls to prevent excessive buildups of toxic wastes. Oxygen should be maintained at levels greater than 4-5 ppm and the temperature should be kept cool if possible (about 60° to 65° F). Some producers add salt (0.4-0.8 pounds/100 gallons of water) to transport tanks to reduce stress. Suggested loading densities are presented in Table 7. If fingerlings are transported in conventional hauling equipment, be sure to keep them out of the agitator or aerator by screening all intakes with 1/16 inch mesh.

Catfish fry and small fingerlings can be shipped in 3-mil polyethylene bags for short distances. Bags should have four corners to prevent fish from congregating and suffocating in collapsed corners. Bags are doubled and partially filled with water before placing fry in them, then filled with oxygen (in a volume ratio of 3 units oxygen: 1 unit water) and securely tied with rubber bands or string.

RAISING FOOD FISH

Rearing Facilities

Pond Construction

Pond culture is the most common type and often the most productive way to raise catfish for marketing as food. The number, size, depth, and shape of ponds suitable for a given area are often limited by the local topography, soil type, and available water supplies. In areas with moderate topographical relief and nonporous soils, embankment or hill ponds are often constructed by building dams or earthen dikes across streams or runoff basins. Areas with flat terrain or porous soils are generally more suitable for leveed or excavated ponds, constructed by cutting basins into the water table. In most states where catfish are commercially produced, good conditions generally exist for embankment and/or excavated ponds ranging in size from about 1 to 20 acres or more. In Florida, however, prevailing geological conditions are generally not as suitable for conventional pond types used for rearing catfish.

There are three relatively distinct geographical regions in Florida insofar as pond construction and management is concerned. These regions are west Florida (the panhandle east to about Monticello), north Florida (north of Ocala), and central and south Florida (south of Ocala). These rough divisions correspond to general features of the topography, soil types, water availability, and natural fertility, but it should be realized that considerable local variation exists throughout the state. Limited areas of the panhandle have relatively impermeable hardpan clay soils that support embankment ponds, which are currently the most productive for raising catfish in the state. Many areas of peninsular Florida have widely-fluctuating water tables and relatively porous substrates and are not suitable for embankment ponds; standing fresh waters in these areas are generally in the form of natural solution lakes, swamps, and excavated or leveed ponds. The diversity of soil types and vegetation in peninsular Florida results in considerable variation between sites with respect to nutrient availability and productivity.

Because of the diversity of geological and climatic conditions throughout the state, it is impossible to provide uniform guidelines for pond construction in Florida. Before attempting to construct a pond, one should make a careful assessment of the topography, soil, water availability and chemistry, nutrient content, and other physical features of the proposed site to determine the most appropriate type of pond for the area. In general, traditional embankment ponds formed by damming streams or runoff areas in sloping valleys, ravines, or other hilly terrains are possible mainly in northwest Florida. In other regions of the state, ponds that are most promising for catfish culture would be of the excavated or leveed type. Your Soil Conservation Service (SCS) District Conservationist and other specialists should be consulted for resource analysis, planning assistance, and standards, regulations, and specifications pertaining to pond construction.

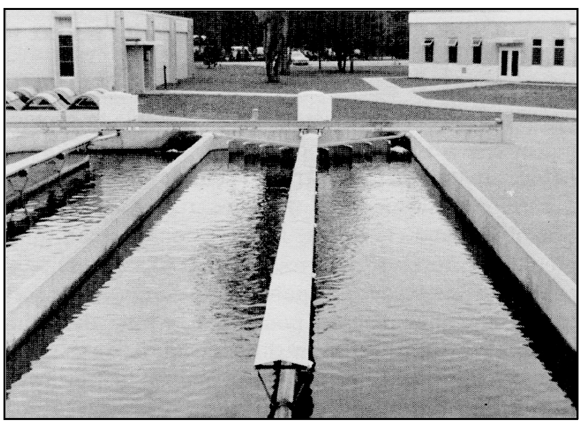

Figure 9. Raceway culture system.

A few general recommendations should be followed when considering building a catfish pond for commercial production. (Figure 9) Because of weed control, high water temperatures, and other management problems, large ponds would generally be more difficult to use for catfish culture in Florida. Consequently, ponds in the 1/10 - 1/4 acre size range are suggested for use. The depth of the pond should be planned so that there will be a minimum water depth of 4-6 feet during the driest time (survey in April or May). This may mean that a basin depth of 8-12 feet is needed in regions where water levels fluctuate widely. Much greater depths are discouraged because of the danger of oxygen depletions during hot weather. Ponds should have gently sloping basins and well-vegetated shorelines to prevent erosion. If possible, provisions should be made to allow for complete draining of the pond for harvesting and prior to stocking. Harvesting will also be easier if there are no stumps, logs, and debris present. The pond must have an acceptable spillway and overflow drain if runoff discharge is expected. The overflow pipe can be fitted with a sleeve of larger pipe and the spillway should be wide enough so that the maximum flow is less than 3 inches deep in order to prevent fish from escaping. In extremely permeable soils, plastic or rubber pond sealants or liners may be used to eliminate water loss from seepage, but use of such sealers can be relatively expensive for larger ponds in terms of installment costs for labor and materials. Some ponds and natural lakes, particularly in central and northern Florida, are poor in nutrients and have relatively low productivity. Artificial fertilization of these waters to improve productivity and enhance food availability is generally not recommended, due to associated problems with weed control and oxygen levels. Feeding catfish with prepared feeds is strongly encouraged to promote optimal growth and eliminate the need for supplemental fertilization of a pond.

Alternative Facilities

Because of various constraints that limit the efficiency and desirability of constructing ponds in many areas of Florida, use of other facilities may provide great potential for raising catfish in certain regions. Raceway systems have been successfully used by some producers, although they require more intensive management than pond culture. Raceways consist of series of long, narrow earthen or concrete channels through which there is a continuous flow of water. They may be either open systems, in which water flows through the raceways and waste treatment facility without recycling, or closed systems, in which water is recycled through an auxiliary storage reservoir, the raceway, and the waste treatment pool. Raceways require a ubiquitous supply of high-quality water. Construction of raceway systems should be done under the supervision of experienced professionals, due to their complex design and operation. They should be trapezoidal or parabolic in cross section, with bottom widths of 4-15 feet and a grade of 1-3 feet per 100 linear feet (1-3% slope). Each section should be no more than 100 feet long (sections may be constructed in series by installing earth or concrete check dams or bulkheads at the lower end of each section). Water depth should be about 3 feet at the upper end and 4 feet at the lower end of each section. A settling basin (lagoon) is built below the last section of a raceway to collect organic wastes. Size and depth of the lagoon must be determined after considering the number of sections to be installed and the size of the water reservoir. The lagoon should be wider and deeper than the raceway sections so that water movement will be slow enough to allow suspended wastes to settle, and should be drained and cleaned after each crop of fish is harvested.

Cage culture of catfish represents a second potentially good alternative to pond culture in Florida but still lacks the technology that provides all growers with consistent results. Some of the advantages to this method are: (1) cages can be put in many types of water, such as ponds, lakes, canals, borrow pits, etc., some of which might not otherwise be especially suitable for aquaculture; (2) cages allow for a combination of cultures in ponds, such as raising catfish in cages with bass and bream in open water; (3) cages can be used to rear small fish to large enough sizes to escape predation before releasing into a pond; and (4) cages allow for easy and complete harvest, by either removing fish all at once or periodically. The major disadvantages of using cages are that (1) fish are under a great deal of stress and may succumb to diseases and parasites more easily if they are crowded; (2) treatments for diseases are more difficult to administer; (3) feeding management of caged fish must be relatively intense; and (4) poaching becomes easier.

Cages are made of vinyl-coated wire, polyethylene, nylon, or other corrosion-resistant mesh on PVC, wood, or metal frames and are suspended freely in the water column. Many cage designs and sizes have been used, but most are 1-2 cubic yards (0.8-1.5 cu. meters) and made of 1/2 inch or larger mesh. Cages may be either cylindrical or rectangular, but the design and placement in the water must allow for a depth of at least 3 feet of water in the cage. Tops of cages are usually made of a solid opaque material, such as plywood or aluminum sheeting, and must have a feeding ring. The feeding ring is an enclosed cylinder of wood, mesh (1/8 inch), or other suitable material attached to the top of the cage and extending about 4 inches above the top and 12-16 inches beneath the water surface. Producers generally give caged fish floating feeds, which should be placed within the feeding ring to insure that food does not pass outside of the cage. Cages may be attached to metal or wooden stakes or piers in an open body of water, or they can be floated using Styrofoam pontoons, plastic bottles, or other bouyant materials. They should be floated with the lid about 3-6 inches above the water and with at least 12-36 inches between the cage and the bottom of the pond or lake, so that fish wastes are adequately dispersed. Cages should be placed at least 10 feet apart. It is important to frequently check caged fish for signs of stress, infections, and parasites and to treat them accordingly if necessary. Clean cages periodically to remove growths of filamentous algae.(Figure 10)

Water Quality

As with hatching fry, the rearing of food-sized fish depends vitally on good water quality. The most important water quality characteristics include dissolved oxygen, temperature, pH, total alkalinity, and total hardness. Standard instruments and kits for measuring these parameters are available through commercial suppliers. Water quality should be checked once per day around sunrise.

The pH of water to be used for catfish culture should be between 6.5 and 8.5. Water that is not in this range can be treated with effective buffering compounds, such as agricultural lime to increase pH, and hydrochloric acid or aluminum sulfate to decrease pH. If the total alkalinity or total hardness of pond water is below 20 mg/liter add lime during the late fall or early winter. Ponds in Florida near limestone or similar sediments ordinarily should require few corrections for total alkalinity and hardness.

Growth of catfish is greatest at water temperatures of 80° -85° F (27° -29° C) and is least at temperatures below

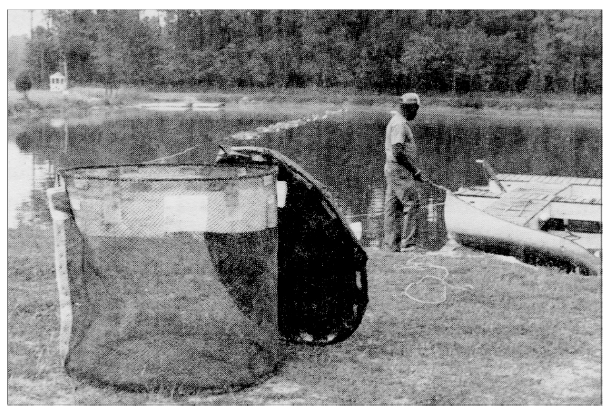

Figure 10. Floating cages can hold catfish for growout where traditional pond culture is not practiced.

60° F (16° C). This translates into a maximum growing season of 200 or more days per year in many areas of Florida. Catfish can tolerate the normal low water temperatures in the state, but their survival, growth, and food conversion may be jeopardized by combinations of high water temperature, low dissolved oxygen, high stocking density, disease, and other chemical and biological interactions. Consequently, Florida farmers should make a special effort to carefully monitor summer water quality and take remedial measures if poor water conditions develop that may adversely affect fish health.

Dissolved oxygen concentrations should be measured frequently and maintained above 4-5 ppm. Oxygen levels fluctuate widely and may be influenced by factors such as algal blooms and plant growth, wind, cloud cover, amount of decaying organic sediments, and temperature. Oxygen in the water is lowest at sunrise and can be low on overcast or rainy days, due to respiration by algae, bacteria, fish, and other organisms, and the lack of oxygen production by algae and aquatic plants. Algae are the main producers and users of oxygen. Moderate wind action helps to aerate water near the surface, but strong winds may stir up oxygen-deficient sediments and cause low oxygen levels throughout the water. To reduce stress and physical harm to fish from low oxygen, a successful producer must measure oxygen often, take preventive measures, and have emergency aeration equipment available. A variety of aeration devices are on the market or can be built with relative ease, ranging from tractor-propelled paddlewheel aerators to floating, electrically-powered models. Pond owners can further reduce problems associated with low oxygen by aerating incoming water if necessary and maintaining a proper algal bloom by not overfeeding the fish.

Water should never contain pollutants or toxicants. Certain metals, pesticides, and other compounds can be extremely toxic to fish. Galvanized equipment may release enough zinc to kill catfish, and copper toxicity may result from use of copper-based pipes and other materials. It is best to use plastic pipes, coated screens, and other nonmetal equipment whenever possible. Catfish are very sensitive to chlorine, so treated municipal water (usually containing < 2 ppm chlorine) should only be used if first dechlorinated with 7 ppm sodium thiosulfate to 1 ppm chlorine. Pesticides must always be used with extreme caution.

Salinity concentration of water is of special concern to farmers drawing their water supplies from coastal areas. Channel catfish can withstand salt in small amounts, but salinity should be checked if high levels are suspected. Channel catfish can tolerate salinities up to 12 parts per thousand (o/oo), but they will not breed if the level is over 7 o/oo (full strength sea water is about 30-35 o/oo). Higher salinity levels may result in physiological stress. Avoid abrupt changes between fresh and salty water.

Stocking

Catfish can be stocked in the late fall, winter, or early spring. Summer stocking must be avoided since high water temperatures and low oxygen in hot weather greatly increase stress and the possibility of death due to suffocation, disease, and other factors. If possible, avoid moving or handling fish in the afternoon and avoid drastic changes in water temperature. Fingerlings for stocking should be moved as quickly as possible in well aerated containers (see "Transporting Fingerlings").

The number of fish to stock depends on many factors, including water quality, size and efficiency of facilities and equipment, length of the growing season, feeding schedule, and size of fish desired for marketing. In general, fish are stocked according to the surface area of the water. If fish are not to be fed, stocking densities in ponds should not exceed 100-200 fish per surface acre. Fingerlings (4-8 inches) can be stocked in ponds at densities of 1,000-3,000 or more fish per acre and harvested in one to two seasons if feeding is planned. Raceways can be successfully stocked with as many as 2,000 fingerlings per 100 foot section when optimal water conditions exist. Initial stocking densities of 12 fingerlings per cubic foot of cage are possible. Regardless of the facilities used and degree of management intensity, lower stocking densities reduce risk of losses to oxygen shortages, parasites, and infectious diseases. Fewer fish should be stocked in waters that may become very hot in the summer or that have excessive water quality and weed problems. Higher stocking densities result in smaller fish at harvest if they are not fed at the same rates as fish stocked at lower densities. Water quality becomes limiting at high feeding rates. Prudent managers are aware of the limits of their facilities, equipment, and water conditions and stock fish at densities that are appropriate to their harvest goals.

Acclimating Fingerlings

Before stocking fish in a pond or other rearing area, adjust the water temperature and other water quality factors in the fingerling transport tank to match the pond water. This should be done by gradually transferring small amounts of water from the pond into the hauling tank until the tank water temperature equals that of the pond. Catfish can generally withstand a change of 10° F if the water is tempered over several minutes. For greater temperature differences, one must be very careful to slowly equalize water temperatures before moving fingerlings from the transport tank to the pond. It is best to adjust water temperature about 1° F every ten minutes. Improper acclimation can directly cause fish to die from temperature shock. If fish are not killed by the shock, they may be weakened and become more susceptible to infectious diseases and parasites.

Feeding

Catfish grown at high densities require a nutritionally complete feed to maximize growth and maintain good health. Commercially-prepared feeds should contain all essential nutrients and consist of 32-40% protein. Floating pellets or a combination of sinking and floating pellets are desirable in most situations. Fingerlings less than 6 inches should be given pellets smaller than 3/16 inch (Table 3). Fish over ½ pound can be fed 3/16 -3/8 inch pellets. Food must be stored in cool, dry areas to reduce mold and loss of nutrients that may result from excessive heat. Maximum storage time for feeds is usually 4 to 6 weeks.

Food should be distributed at the same locations and at the same time once or twice each day. Do not feed at night, since oxygen requirements of fish increase after feeding and oxygen levels in the water normally decrease at this time. The mid-morning or early afternoon hours are good times to feed. Make sure that food is accessible to all fish by distributing it over broad areas and along upwind shorelines. Do not overfeed since uneaten food can foul the water. Conversely, avoid underfeeding because it can result in poor health, lower growth rates, and greater size variation of harvested fish. Observe feeding activity to make sure that all food is consumed in about 10 to 20 minutes.

Recommended feeding allowances for catfish are based on a percentage of the body weight or standing crop weight. Since the conversion efficiency of food is influenced by many factors, such as stocking density, water quality, temperature, and fish size, suggested feeding rates are only approximate guides and the producer must exercise good judgement in establishing a feeding program. Ideally, fish cultured for food should be fed 1-3% of their weight at least once per day during the growing season. Avoid feeding more than 35 pounds per acre per day in hot weather unless emergency aeration is available. Feeding allowances must be increased as fish grow. Often this is done by feeding as much as the fish will eat each day without leaving excess food floating on the water. Alternatively, standing crop weight can be estimated weekly to make appropriate adjustments in the amount to feed. Estimate crop weight by removing a small sample of fish, weigh them, and multiply the average weight of individuals in the sample by the total number of fish present in the pond. Catfish held over winter should be fed sinking pellets at about 1% of their weight every 2 to 3 days when water temperature is below 65° F (18° C). Feeding rates should be reduced by 50% or more during very hot weather (water temperature > 85° F) and on rainy or overcast days. However, if aerators are available and fish are to be commercially produced, they should be fed to near satiation. Otherwise, fish will grow too slowly and return on investment may be too low to be profitable.

Disease and Pest Control

Catfish are susceptible to a large array of parasites and disease organisms, as well as being affected by a host of other plant and animal pests. In many cases, healthy fish may be resistant to or tolerant of pathogenic organisms if poor water quality and stressful conditions are minimal. At the other extreme, some catfish diseases may be highly contagious and debilitating, including those that directly cause or contribute to fish death. Other organisms that are not as intimately associated with the fish, such as aquatic plants and algae, may contribute directly or indirectly to poor fish health under adverse conditions.

Because of the variety of diseases and pests that afflict catfish, and the variable conditions with which they may operate, comprehensive and uniformly-applicable recommendations for their control cannot be made. The best way to ensure good fish health is to prevent unfavorable biological conditions from developing, by carefully monitoring all aspects of an aquaculture system, and to quickly isolate, identify, and properly treat any disease or pest problems that arise. A successful manager becomes familiar with procedures of identifying, preventing, and/or treating common pest agents and consults with diagnostic laboratories or specialists when dealing with unknown problems. Be sure to check local regulations governing the use of chemicals when treating culture systems with herbicides, pesticides, or medications.

For more detailed information concerning disease identification and control, consult Florida Extension Circular 716, "Introduction to Fish Parasites and Diseases and Their Treatment."

Diseases and Parasites

The large number of microscopic diseases and larger parasites that infect catfish range from those that are relatively benign and generally not harmful under normal conditions, to those that cause high mortalities and have no effective treatments. A good disease management program consists of precautionary measures to ensure clean water and healthy environmental conditions. Stress plays a major role in lowering the resistance of fish to pathogens, and all factors that may contribute to stressful conditions must be kept minimal. These include maintaining adequate oxygen levels, avoiding extreme temperatures, and handling or moving fish as little as possible. Chemicals should be used to treat disease outbreaks only when preventive measures have failed, and it is essential that appropriate medications be administered in proper dosages for treating specific diseases. For this reason, early detection and correct diagnosis of disease organisms is imperative if chemotherapy is to be successful. Some of the behavioral signs that may indicate a possible disease problem include: (1) a reduction or cessation of feeding; (2) erratic or lethargic swimming; (3) schooling just below the surface; or (4) swimming or scraping against the substrate or objects in the water. Physical signs that diseased catfish may exhibit include: (1) excessive mucous production; (2) abnormal coloration (lighter or darker, grayish or bluish, etc.); (3) erosion or fraying of the fins or skin; (4) sores, hemorrhages, or unusual growths on the body or fins; (5) swollen, eroded, or pale gills; (6) a swollen abdomen filled with a cloudy, clear, or bloody fluid; or (7) bulging of the eyes (exophthalmia). If an infectious disease or parasite outbreak is suspected, quick action should be taken to isolate, identify, and treat if necessary. Some individuals and laboratories diagnose fish diseases and recommend treatments, but unfortunately there are few diagnostic centers in Florida that provide these services. If diseased fish are to be sent to a laboratory for inspection, live fish showing symptoms of the disease should be selected and shipped alive in cooled bags or packed freshly on ice. Be sure to notify the laboratory that you are sending fish and give them any necessary information that may be helpful in identifying or treating the disease.

Weed Control

Excessive algal blooms or rampant growths of aquatic plants can be detrimental to catfish by causing oxygen depletions, and may impede harvesting and reduce available habitat. In Florida, exotic plants such as hydrilla, water hyacinth, and water pennywort can become extremely dense and cause acute problems. A moderate growth of aquatic weeds generally does not present a major problem in catfish ponds, but dense infestations should be avoided. Weeds that become a nuisance must be correctly identified and properly controlled using aquatic herbicides or biological agents. Approved herbicides must be used with caution, following specific recommendations and restrictions stated on the label. Stocking of hybrid grass carp, *Tilapia*, or other herbivorous fishes to control aquatic weeds should be done under the supervision of the Florida Game and Freshwater Fish Commission.

Microscopic algae that are suspended in the water play a beneficial role in the ecology of a pond by providing food to invertebrates, eliminating some organic wastes, and producing oxygen through photosynthesis. A healthy pond should have a moderate level of planktonic algae to keep conditions in balance. A proper algal bloom can be measured by lowering a white object, such as a painted board, into the water. If the water is not stained from organic compounds, the board should be visible to about 2-4 feet beneath the surface. If the water is excessively turbid, has a distinct green color, or a white object cannot be seen more than a few inches below the surface, algae could be too dense and there may be a danger of oxygen depletions at night. Extremely dense growths of algae are cause for concern. Attached filamentous algae can often be controlled with triploid grass carp, again under the supervision of the Florida Game and Freshwater Fish Commission. Large phytoplankton blooms are not practically controlled, even with copper compound herbicides. When excessive blooms occur, monitor dissolved oxygen frequently and be prepared with emergency aerators. Also, reduce nutrients that promote blooms by decreasing the level of feeding.

Other Pests

Florida catfish producers should be aware of other potential pests that may negatively affect catfish survival or health. Flying forms of fire ants can kill fish if they are ingested, and should be controlled with appropriate pesticides. Alligators, some snakes, and other predators that may eat fish should be kept out of rearing facilities by using fences or other structures. Farmers that use surface water supplies should prevent wild fish from entering catfish ponds by screening or filtering all inlet pipes, streams, etc.

Harvesting and Processing

Catfish stocked as fingerlings in the early spring should attain at least one pound by the following fall and can be harvested for consumption. It is generally preferable to harvest most or all of the stocked crop in a pond in one season unless larger dressed fish are desired. Many producers drain their ponds completely following harvesting and remove organic sediments or allow them to oxidize.

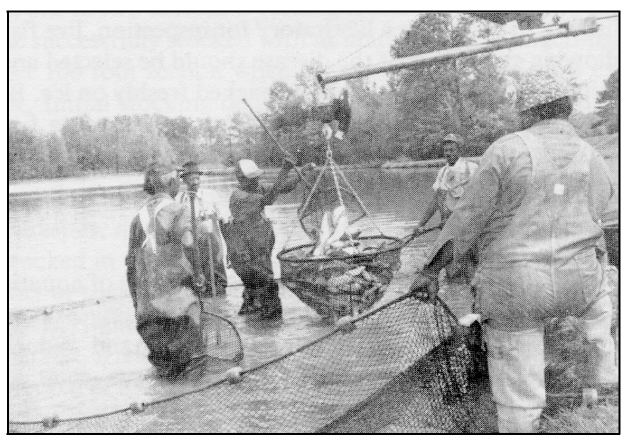

Figure 11. Seine harvesting of larger ponds can be mechanized with a modest crew.

Harvesting methods vary between farming operations, depending on the preferences of the producer. Fish are generally removed by seining, trapping, trot lines, or hook-and-line angling. Total harvest is most easily achieved by seining or trapping, especially if the rearing facility is drained or if fish are concentrated into a harvesting basin. Seining should be done with a large, coated net of 1 1/2 inch mesh. Catching fish by this method will be easier if the pond water is lowered or if fish are coaxed into a harvesting pool or lured near the seine by feeding them in a prescribed area over several days prior to harvesting. Catfish can be successfully trapped using wooden-slat traps, nylon hoop nets, and wire-mesh funnel traps. Hook-and-line angling is generally most popular in stocked catch-out ponds or fee-fishing areas. Harvesting for commercial sale of fish should be done when transport to processing facilities will be immediate. Do not feed fish for one day prior to harvesting. (Figure 11), (Figure 12).

Catfish are processed by removing the head and spines, skinning and eviscerating the fish, washing, and thoroughly packing them on ice. Properly dressed fish packed in ice can be held for up to 6 days if they are to be marketed fresh. Fish to be frozen should be wrapped in plastic bags or airtight containers and immediately frozen (frozen fish should not be held for more than a few months). Before marketing your product, prepare and taste a representative sample of the fish crop. If any off-flavor is detected, the fish should not be sold for public consumption.

Most large-scale producers ship their crops to fish processing factories, or have the necessary equipment and labor to process themselves. There are few commercial processing facilities in Florida, so producers in the state should be prepared to process their own crop or possibly transport them relatively long distances to processing plants in other southeastern states. Alternatively, depending on local markets, fish might be sold live at roadside stands or through fish-out ponds.

Figure 12. Seine harvesting small ponds may be unmechanized with few people.

Table 1. Recommended brood fish diet.

Ingredient	Percent of Total
Soybean meal (44% protein)	50.5
Ground corn	14.93
Wheat shorts	6.0
Distillers dried solubles	7.5
Fish meal	15.0
Animal fat	3.0
Pellet binder	2.5
Dicalcium phosphate	0.5
Vitamin premix	0.75
Coated vitamin C	0.057
Trace mineral mix	0.075
Analysis:	
Total crude protein	35.6%
Digestible energy	2640 kcal/kg
Energy to protein ratio (kcal/g)	7.3 : 1.0

Table 2. General characteristics used to estimate the age of channel catfish eggs.

Egg Appearance	Approximate Age[1] (78° F)	Estimated Days to Hatching
No Pulsations	< 24 hours	7-8
Pulsating motions	1-2 days	6-7
Faint bloody streak	2-3 days	5-6
Blood throughout egg	3-4 days	4-5
Eyes visible	4-5 days	3-4
Entire fish visible, embryo occasionally twists or moves	5-6 days	2-3
No bloody streaks	6-7 days	1-2
Hatching begins	7-8 days	0-1

[1]For every 2° F above or below 78° F, subtract or add one day to hatching time, respectively.

Table 3. Optimum feed particle size for catfish fry and fingerlings.

Fish size (inches)	Particle Size (millimeters)
< 0.5	0.42-0.60
0.5-1.0	0.60-0.84
1.0-1.5	0.84-1.19
1.5-2.5	1.19-1.68
2.5-4.0	1.68-2.38
4.0-6.0	2.38-3.36
> 6.0	3/16 inch pellet

Table 4. Estimated fingerling size after 120 to 150-day growing season under different stocking regimes. Optimal management techniques are required to attain these yields.

Fry Stocking Density (fish per acre)	Average Length (inches)
10,000	7-10
30,000	6-8
53,000	5-7
73,000	4-6
95,000	3-5
120,000	3-5
140,000	3-4
200,000	2-3
300,000	1-2
500,000	about 1

Table 5. Suggested feeding frequencies and allowances for fry and fingerlings at different temperatures.

Water Temperature (°F)	Feeding Allowance (% body weight/day)	Feeding Frequency
> 87	2	2 times/day
80-86	6	4 times/day

Table 5. Suggested feeding frequencies and allowances for fry and fingerlings at different temperatures.

Water Temperature (°F)	Feeding Allowance (% body weight/day)	Feeding Frequency
68-79	3	2 times/day
58-67	2	1 time/day
50-57	2	alternate days
< 50	1	every 3-4 days

Table 6. Seine mesh sizes and grader bar widths used for separating size classes of fingerlings.

Smallest Fish Length (inches)	Seine Mesh (inches)	Grader Bar Spacing	
		inches	millimeters
3	1/4	27/64	10.7
4	3/8	32/64	12.7
5	1/2	40/64	15.9
6-7	3/4	48/64	19.1
8-10	1	1	25.4

Table 7. Recommended loading densities for hauling fingerlings. Densities are for water temperature at 65° F and ideal aeration; reduce numbers by 25% for each 10° F rise in temperature.

Number of Fish per pound	Transport time (hours)		
	8 hrs	12 hrs	16 hrs
	Load Density (pounds fish/gallon water)		
1	6.3	5.6	4.8
2	5.9	4.8	3.5
4	5.0	4.1	3.0
50	3.5	2.5	2.1
125	3.0	2.2	1.8
250	2.2	1.8	1.5
500	1.8	1.7	1.3
1,000	1.3	1.0	0.7
10,000	0.2	0.2	0.2