CATFISH FARMING IN KENTUCKY

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Catfish Farming

Catfish farming in the United States began in the early 1960's and has grown to 189,000 acres (in January, 2000). Opportunities for raising catfish profitably in Kentucky are present due to a large pay lake market that consumes about 2 million pounds of catfish a year. Kentucky-based live-haulers who deliver fish to the pay lakes would prefer to get fish from their own state if they could find enough reliable producers. The live fish market also lies largely untapped by residents in Kentucky - the mega processors in the deep South have a strong hold on the frozen processed fish market but have left the live fresh fish market wide open for local Kentucky fish growers seeking niche markets. These markets include pay lakes, local residents, grocery stores and restaurants. Although Kentucky has a slightly shorter growing season than states farther south, stocking strategies unique to Kentucky allow its fish farmers to approach the higher production levels obtained in the deep South. The Stocking section of this manual explains these strategies. This publication compiles the best works of aquaculture biologists from several states and puts them into one manual for convenient referencing and explains catfish farming in a manner customized for Kentucky residents.

Decision to Become a Catfish Farmer

To help you determine if catfish farming is feasible for you in your particular situation, a checklist is provided below. It does not cover all of the possibilities, but it does list most of the important considerations. Answering "yes" to all or most of the questions does not guarantee success, just as answering "no" does not mean failure.

Management	**Yes**	**No**
Do you already have suitable ponds or a pond site?	☐	☐
Do you have most of the equipment (tractors, pumps, storage building, etc.) needed?	☐	☐
Do you have the necessary financial resources (about $3000/acre investment and $2500/acre annual production cost)?	☐	☐
Have you made an estimate of investment costs and annual cost and return?	☐	☐
Have you estimated the impact of changes in fish prices and feed costs on projected income?	☐	☐
Will current interest rates and interest costs on investment and operating capital permit a reasonable profit?	☐	☐
Will the expected profit provide an adequate return for your labor, management and risk?	☐	☐

Management *(continued)*	**Yes**	**No**
Is catfish farming the best alternative for the land you intend to use?	☐	☐
Can you afford to forego income until you sell your first crop (usually 15-24 months after starting)?	☐	☐
Have you looked at record systems available and picked one best suited to your situation?	☐	☐
Can you afford to absorb occasional losses?	☐	☐
Are you willing to devote the time and effort required?	☐	☐
Marketing		
Do you know of an established market for your fish?	☐	☐
Is there a market for your fish at the time of year you plan to sell them?	☐	☐
Will you have harvesting and transport equipment, or do you have a suitable arrangement for harvesting your fish?	☐	☐
Will you be able to harvest fish year round?	☐	☐
Do you have an alternative marketing strategy?	☐	☐

Physical Factors	**Yes**	**No**
Will the soil hold water?	☐	☐
Is the topography of the land suitable for pond construction?	☐	☐
Is there adequate ground water close enough to the surface for catfish farming or is the amount of rain run-off from your watershed sufficient?	☐	☐
Is the water quality suitable for fish farming?	☐	☐
Is the pond area protected from flooding?	☐	☐
Are the drains in existing ponds adequate for rapid draining?	☐	☐
Can you prevent wild fish from entering the pond?	☐	☐
Is there daily access to the ponds, regardless of weather, for feeding, treating, and harvesting?	☐	☐
Is the pond bottom suitable for harvesting (smooth and stump free)?	☐	☐
Will someone live close enough to the pond to allow frequent observation and necessary management?	☐	☐

Production	Yes	No
Are good quality feeds available at competitive prices?	☐	☐
Is there a convenient source for drugs and chemicals?	☐	☐
Are fingerlings available at competitive prices?	☐	☐
Can you make or purchase needed aeration equipment?	☐	☐
Is dependable labor available?	☐	☐
Is dependable diagnostic service available?	☐	☐
Do you have adequate storage facilities for feed?	☐	☐
Are you aware of the government agencies that can provide you with educational and technical assistance?	☐	☐

A Note to Non-Farmers

A large number of information requests that are received by Extension Offices for fish farming are from non-farming, urban residents. Most farmers were born and raised on a farm. Very few learned how to farm as an adult. This puts the non-farmer at a considerable disadvantage. Non-farmers will need to go through a period of on-the-job training. Are you the kind of person who does most of the maintenance and repair work? Can you put up with outdoor work during bad weather and odd hours? If so, great - these are skills and tolerances you will need on a fish farm. If not, you may wish to reconsider before getting into fish farming. In addition, farming today requires much more than just being able to produce a crop. Successful farmers must have a sound understanding of the economics of their operation, keep good records and work to find the best markets for their product.

Small Scale Catfish Production

The high capital investment and operating capital requirements of commercial catfish production have prevented many small-scale farmers from participating in this enterprise when they receive less than $1.00 per pound. Small-scale catfish production is a lower-cost option that can provide an income opportunity for individuals willing to market their fish directly to consumers. There are a number of important considerations before beginning small-scale catfish production and direct marketing. This section explains differences between large and small catfish operations and the importance of direct marketing to the success of small fish farms.

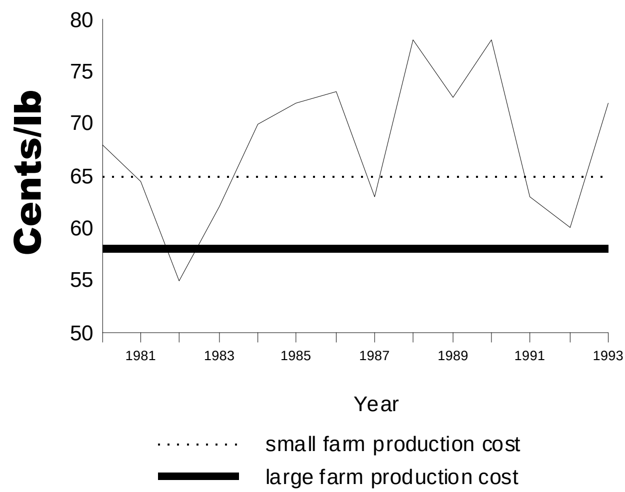
Large vs Small Farms

Large catfish farms are expensive to build and operate. Cooperative Extension budgets show that pond construction, equipment and operating expenses may average $5,000 per acre before the first fish is harvested. Experts on catfish culture believe that for a catfish farm to be successful, based on sales to processors, a minimum of 80 to 100 acres of ponds is required. This means that $400,000 to $500,000 investment capital is needed to start this kind of commercial catfish farm. Since lenders typically require at least 65 percent owner equity for catfish loans, financing may be available for less than half of the total initial capital cost.

Like many agricultural crops, there are economies of scale in commercial catfish production. Larger farms are able to produce fish at a lower price per pound than smaller farms. For example, large farms can buy catfish feed in bulk by the truckload while smaller producers, in order to have fresh feed, must purchase bagged feed which costs 10 to 20 percent more. Intensive catfish production on a part-time basis is risky because the farmer cannot watch the ponds on a regular basis, day and night. If an aerator fails, fish may die in a matter of minutes. Large farms have night-time oxygen crews that monitor ponds regularly. Small-scale producers generally get lower yields because they stock and feed at lower rates to reduce the risk of water quality problems.

Cost of Production

Large fish farms typically sell most of their production to fish processing plants. Most farmers own shares in these plants that entitle them to sell certain quantities. Profit margins per pound are low, but the large quantity of fish sold allows a farm to operate profitably. Larger producers also save a portion of their earnings to allow them to survive periods of low catfish prices when fish production is not profitable.



The above chart shows the average price/lb paid by processors over the past 14 years. The dotted line indicates a break-even price of 65¢/lb, representing the cost of producing catfish on a small-scale.

The solid line shows a typical break-even price for a large farm. It is obvious that, in many years, potential profits are slim to none especially for a small farm.

Based on these numbers, the average profit over the 14-year period would be 1.9¢/lb. For a farmer with a five-acre pond producing 4,000 lb/acre/year (assuming no oxygen or disease problems), even a 2¢/lb profit means a return to labor and management of only $400/year. This would provide a wage of less than $2.50/hour because a farmer would easily labor for more than 160 hours a year doing the work of feeding and watching the fish. A small operation simply cannot survive by selling to a large scale processor. Having part ownership in a small processing plant, however, will add to the profits of the small farmer.

Advantage of Direct Sales

Does all this mean that there is no place for a small-scale producer? Not at all. It means that a small-scale producer must look to other markets to sell his or her fish rather than selling only to a large processor. The key is that profits are made by selling the fish, not by raising them. The distribution of processed fish through food brokers and supermarkets adds a mark-up to the price of fish, so the consumer pays far more for the fish than the processing plant receives. Bypassing these middlemen avoids such markups, allows directs sales of fish to the consumer to be profitable, and provides the consumer with a less expensive product, especially if the consumer will dress their own fish.

Catering fish dinners.

Another factor in favor of direct sales is the freshness of the product. Fish are notorious for spoilage, and consumers are wary of products on ice or frozen. Families, churches, business, social organization and political organizations all hold fish fries. A local producer can supply the desired fresh fish, or he/she can **cater** these events, selling the final cooked product to the public.

In the early days of the catfish industry in the deep south, retail sales of live catfish were common and were critical to the success of a number of new operations. As the industry grew, farms expanded in acreage and moved to selling fish to processors and live haulers, where 10,000-20,000 pound truckloads of fish could be sold at one time. This has resulted in a large and unmet demand for live farm-raised fish. Live catfish sold directly to the consumer can bring $1.00 to $1.35/lb, with an additional 35-45¢/lb for cleaning fish. Returns are higher than what can be obtained from sales to a processor.

Fish markets selling wild-caught fish have traditionally supplied the bulk of the market for fresh fish. However, concerns about contaminants in wild fish have been heightened in recent years. Farm-raised fish provide an alternative source of high quality fresh fish for local communities.

Marketing catfish on a small-scale is not for everyone. It is not a way to get wealthy. It may be best to start as a part-time business as a means to supplement other income. Information on how to raise catfish is readily available from the Cooperative Extension System. Commercial catfish production practices can be adapted to small-scale operations. A successful small-scale operation is possible especially when the producer works to develop a market and sells fish directly to consumers. Before starting a catfish farm, get all the information you can on marketing and know where you will sell your fish. Direct marketing of fish requires time, money, hard work and people skills, but it provides a way for the small-scale producer to make money in the catfish business.

Using Existing Farm Ponds

Thousands of farm ponds dot the Kentucky landscape. It is tempting to consider using existing farm ponds for commercial catfish farming because pond construction is a major cost in starting a catfish farm. While it may be possible to do so, it is important to evaluate carefully the condition of an existing pond before using it to start a catfish enterprise.

Existing ponds may be suitable for aquaculture.

An existing pond needs to be inspected to determine if it is suitable for commercial catfish culture or, if not, what the costs would be to remedy deficiencies. Contact your local USDA Natural Resources Conservation Service (NRCS, formerly SCS) office for assistance in pond inspection and renovation.

If you simply want to raise a few catfish as a hobby or to provide subsistence for your family and friends, you should probably consider leaving the pond in its present condition to avoid unnecessary costs. For commercial catfish culture, however, a pond should be accessible by an all-weather road. This will allow daily pond management as well as providing access at harvest time. Roads need to be graveled and of sufficient width and sturdiness to allow passage of a hauling truck. Levees at least 16 feet wide are recommended.

Many existing farm ponds are constructed away from roads and houses. Distant ponds may suffer from a lack of attention; fish may not be fed and water quality may not be monitored on a regular basis. This is particularly true for a part-time operation where the owner will have many other concerns to attend to during the day. Where there are a number of farm ponds, these are typically some distance apart. It takes more time to feed ponds that are spread out, and management tasks such as moving portable aerators are more difficult.

Theft can be a major problem because isolated ponds away from houses or located near woods are vulnerable to poachers. Security lighting will deter poachers. Installation of three-phase electrical service may involve a charge for ponds located more than several poles away from existing power lines. If power can be provided to several ponds through one new line, there may not be any cost. Check with your power company for information on your particular situation.

Electric aerators are commonly used in commercial catfish ponds and can be used if electricity is available at the pond. Diesel or gasoline powered aerators can be used, but require manual operation. Without aeration, annual fish production is limited to about 1,000-1,500lb/acre, because feeding should be restricted to less than 34 lb/acre/day to maintain water quality.

Modifying Farm Ponds for Catfish Production

Existing ponds may not be suitable for commercial catfish production without modification. Many ponds were originally constructed for watering cattle or recreational fishing. In commercial catfish production, it is essential that you are able to harvest fish from the pond when desired. The only way to reliably harvest commercial ponds is through seining (netting) the entire ponds. Complete or partial draining is usually necessary. Modifications to allow a pond to be seined may prove more expensive than construction of a new pond. Major modifications that may be required by farm ponds are: levee work, silt removal, stump removal, grading of the pond bottom and installation of a drainpipe.

Levee work

Over time, pond levees can be damaged by erosion and burrowing animals such as muskrats. It may be impossible to cut grass and weeds on eroded dams, and the tops of levees must be wide enough to allow vehicle traffic. If trees and brush have grown up on the levees, their roots may penetrate the dam, decompose, and form channels that can cause leaks or eventual dam failure. Trees will also interfere with harvesting equipment and leaves will pollute the water and clog harvest nets. Most existing farm ponds will need at least some clearing and levee work before they can be used for commercial catfish culture.

For ponds filled by rain water runoff, careful attention must be paid to the pond's emergency spillway. Most ponds are constructed with a low section to one side of the dam that allows excess water to exit a full pond during heavy rains. This spillway must be kept free of trash so that it can function properly. In order for fish to remain in the pond, water leaving over the emergency spillway should not be over 1 to 2 inches deep. Fencing the spillway is not recommended as trash and leaves can clog the mesh and cause water to pour over the top of the dam, leading to erosion and possible dam failure. A horizontal bar spillway barrier constructed of parallel iron bars, one inch apart, retains fish and is less susceptible to clogging.

Silt removal

Many pond sites were not cleared when the ponds were constructed initially, and ponds may contain standing timber or stumps. Obviously, ponds with stumps cannot be harvested using a seine.

Costs for removing stumps vary with stump diameter and condition of the pond bottom. Some contractors may charge by the acre rather than by the number of stumps. Stump removal is relatively inexpensive if the pond bottom can be dried. A bulldozer can push out stumps in the process of grading the pond bottom. If the pond bottom is always wet, stump removal must be accomplished using other equipment such as a bulldozer with a cable or winch, a backhoe with mats, a front end loader or explosives. It should be noted that when stumps are removed, there is a risk of breaking the seal of the pond, causing a leak.

Grading pond bottom

Pond basins that contain deeper pockets or drop-offs are difficult to seine. A clean, smooth and gently sloping pond bottom is desirable for harvesting fish. Because water depths of less than 2½ - 3 feet promote the growth of aquatic weeds, the ends and edges of ponds may need to be deepened to reduce shallow areas.

As with stump removal, costs for grading work vary tremendously for dry or wet conditions. A bulldozer can quickly grade a pond bottom under dry conditions. If the pond bottom cannot be dried, the contractor must resort to a dragline, a backhoe with mats or hauling in additional earth to mix with the pond bottom mud. In many cases, it is impossible or a waste of time to try to grade pond bottoms under wet conditions.

Care is needed in the renovation process. Reworking farm ponds can lead to seepage problems in some cases. Deeper cuts during the reworking process could expose areas of permeable soils.

Ponds may have sealed over time through the accumulation of organic matter which may be disturbed or oxidized during renovation. Some clay pond bottoms will crack when dried, allowing water to leak out of the pond when it is refilled. Check with your local NRCS representative for further help.

Drainpipe installation

Many farm ponds in Kentucky were constructed without drains. At least partial draining is required for harvesting fish from most farm ponds, because many have areas where the water is deeper than the maximum 4 to 5 feet depth that can be harvested with a seine. Cutting a pond levee to install a drain in an existing pond is very expensive, because extensive earthmoving is required in the highest and thickest portion of the dam. The cut must be made in a v-shape, so that proper compaction of replacement soil can be obtained. There is a risk however, of dam failure when this is done.

While the cheapest way to install or replace a drainpipe is to cut a trench with vertical walls, it is very difficult to properly compact the fill material in a vertical cut. Without proper compacting, there is a greater likelihood of dam failure. Costs of contracting to install drainpipes may be prohibitive for small-scale farmers.

Pumping out water at each harvest would be expensive and slow in most cases. Another alternative is to use a siphon structure. Siphons can be constructed over the top of a dam or underground to drain ponds. Permanent siphon pipes laid on top of the dam restrict access to the dam and increased labor is required to control vegetation. Burying the siphon pipe in the dam would allow vehicle traffic, but would require substantial labor. Siphons are relatively slow and will quit working if air leaks into the system, but are a lower cost option for draining ponds.

Alternatives

If modifications required for a pond to be used for commercial catfish production prove to be too expensive, ponds can still be used to produce increased quantities of fish for home consumption. Fish can be removed by hook and line or fish traps. When fish are fed on a regular basis and at least a portion of the pond bottom is smooth and free from obstructions, larger quantities can be obtained by trapping fish with a seine.

In this method a 100-200 foot seine is left in the pond parallel to the bank. Fish are fed regularly in the space between the seine and the shore. Ropes attached to the two ends of the seine allow it to be pulled to the shore, trapping feeding fish in the seine for harvest. While repeated trapping can catch a majority of fish in ponds of less than two acres, only a portion of the fish in large ponds can be removed by trapping, so it cannot be used as the sole harvest method for commercial producers.

Marketing

A marketing plan should be the first step taken when one is considering catfish production. No profits are made until your crop of fish is sold. Catfish are sold in all forms of their life stages. Egg masses are sold by the pound, and the price changes annually depending on the supply or success of local hatcheries in spawning fish. Catfish fry are sold by the piece, and fingerling fish longer than 1-inch are usually sold singly by the inch up to about six or eight inches; longer fish may be sold by the pound. Food fish are normally three-fourths to two pounds in weight and are sold by the pound. Some specialty markets exist for brood fish, especially if they are an improved or selected strain. Albino catfish are a novelty sometimes sought by fee-fishing operations or the aquarium trade.

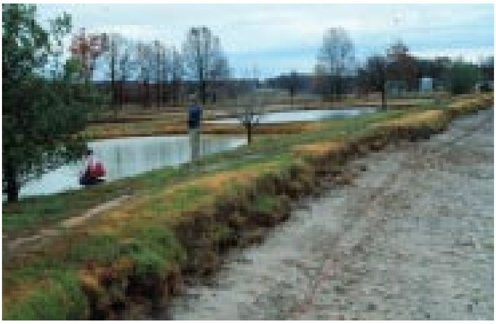
Retail Markets

Retail marketing is practiced mostly by smaller, commercial farms. The small farms usually cannot take advantage of discounts for bulk purchases of feed and seed stock. Production costs per pound of fish produced are usually higher than those of larger farms because of the economy of scale. Ponds are often smaller and more costly to build per acre. Profits may be low if fish are sold to a processor wholesale market. Retail prices are usually influenced by local competition, if any, and advertising is usually required to be successful. Fish are sold undressed or live through fee-fishing ponds, out of holding tanks or when harvested. Fish can be sold off trucks in areas where there is demand.

Fee-fishing ponds or pay lakes are most successful when they are located near a large urban area. A good, weekly supply of market-sized fish is usually required, and customer satisfaction and service are important for repeat business. Live weight prices for farm raised catfish in Kentucky pay lakes range from about $1.40 to $2.00 per pound, depending on the location or demand. Some pay lake operators provide fish cleaning services, sell concessions and rent fishing equipment. Liability insurance is recommended and certain regulations should be adopted. Pay lakes offer a good marketing opportunity in some areas.

Other retail markets include local stores and restaurants. They usually want processed fish delivered on a regular basis. This means regular harvesting and the ability to hand-process fish. (Some local businesses will run a special if fish cannot be delivered regularly). Local health department and FDA regulations must be met to process legally. This is typically a very expensive procedure.

Producers also sell fish to local residents in a variety of ways. The value of fish sold depends on location, the production capacity, innovativeness and local competition. Results can be excellent to poor, depending on efforts and the specific situation. Fish can be sold live or dressed. Easy access to fish is needed to fill orders quickly. Some producers cater fish fries, and others sell fish only at harvest time. Some broker fish through local residents who desire to market fish. Small-scale producers should consider a direct-retail market if feasible. Many producers do not enjoy doing their own marketing. If this is the case, then it is important to carefully evaluate the economic feasibility for a small-scale operation before money is invested in production.



Retailing fish through pay lakes.

Retail markets also exist for the sale of catfish fingerlings or stocker fish. These fish are marketed primarily to people who have recreational or farm ponds. A higher price is usually obtained compared to wholesale sales to commercial farms. Advertising is required, and live fish need to be transported and delivered to the customer's pond. This can be a good business; a quality product and good service are required. It is preferable to be in an area where farm ponds are numerous.

The Kentucky Department of Fish and Wildlife Resources is also in the business of stocking people's private ponds. Although private fish growers cannot compete against their low stocking application fee, they can sell to customers who do not follow Fish and Wildlife's strict guidelines and cannot qualify for the free fish. Private growers are also able to sell fish larger than the small fingerlings stocked by Fish and Wildlife. A required fish propagation permit from Fish and Wildlife allows a Kentucky resident to raise, transport, and buy and sell fish.

Economics

Taking the plunge into catfish farming should be done only after careful economic planning. This may not be as complicated as you think. A good way to start is to list the income and expenses you expect. First, consider the **income** your fish farming operation will produce. Generally this means estimating the amount of fish you will produce and the price you will receive for them.

Next, make a list of the expendable items you will need to buy each year to produce your fish. This will include feed, fingerlings, labor, fuel, electricity, equipment, repair, interest on borrowed money, etc. These are your **variable costs**.

Finally, make a list of costs for everything associated with machinery. These are your **fixed costs**. Examples include pond construction, wells, pumps, trucks, feed bins, tractors, aerators and buildings. Do not overlook the cost of buildings, tractors or other equipment that is already purchased. They should be charged off some each year of the expected life since they will eventually need to be replaced. Equipment used for other jobs on the farm also needs to be partially charged so each enterprise can stand on its own. For example, a tractor that is used 20 percent of the time for fish farming would show up on your list as 0.20 tractors.

One major reason to estimate income and expenses is to be able to project your return or profit. Another use of the same numbers is to project a break-even cost for what you produce. To get these critical numbers you will need to organize your information into a form known as an enterprise budget. Your numbers are already divided into three lists: income, variable costs and fixed costs. Now put these numbers into four columns; item, quantity, $/unit and total as shown below.

A Sample Fish Farm Budget

Income Item	quantity	$/unit	Total
Fish	65,625 lbs	$0.74/lb	$48,563
Total Income			$48,563 (A)

Variable Costs Item	quantity	$/unit	Total
Feed	66 tons	$250/ton	$16,500
Fingerlings	52,500	$0.15 each	7,875
Hired labor	300 hrs	$6.00/hr	1,800
Electricity			800
Equipment repair			750
Sub Total			$27,725
Interest 12%			$ 3,327
Total variable cost			$31,052 (B)

Fixed Costs Items	quantity	$/unit	total	useful life	annual depreciation
Pond Construction	15 acres	$3,000	$45,000	20 yrs	$2,250
Well	1	$10,000	10,000	20 yrs	$500
Truck	0.2	$18,000	$3,600	10 yrs	$360
Oxygen meter	1	800	$800	5 yrs	$160
Tractor	0.2	$12,000	$2,400	10 yrs	$240
Aerator	1	$1,500	$1,500	10 yrs	$150
Storage Bldng.	0.40	$8,000	$3,200	20 yrs	$160
Harvest Equipmnt.	1	$2,000	$2,000	5 yrs	$400
Sub Total			$68,500		$4,220
Interest 12%			$8,220		$8,220
Total yearly fixed cost					$12,440 (C)
Estimated Return (A-B-C)					$5,071
Break Even Costs (B+C)/total lbs. produced					$0.66/lb

Do not get discouraged if the estimated return is tiny or even negative. The first budget is just a starting point. Consider ways to reduce your costs. In this example, doing your own pond construction work with used equipment could reduce pond construction costs by half. This would raise total return by $3,825 per year.

Another way to reduce costs would be to use your own funds instead of borrowing. If you were able to take money out of a Certificate of Deposit yielding 7 percent, your savings on interest over a 12 percent bank loan would be 5 percent or a total of $4,811.

A third way to reduce per-pound production costs would be to get bigger. This is often the best way to earn a profit when selling to high volume, low price buyers such as processing plants. Being established as part-owner of a processing plant can also produce income through profit sharing of the processing plant.

Income can be increased by seeking out different buyers. Please see the section on small-scale catfish production earlier in this booklet. Be creative - time spent finding and developing specialty markets can yield good returns. Then the $0.74/lb income listed at the top of the sample fish farming budget may be increased to a value closer to $1.00/lb to $1.20/lb. Before making your final decision about raising catfish, keep in mind that the break even cost of $0.66/lb listed in the sample fish farm budget should be modified to fit your exact situation - one study concluded that break even costs for small catfish farms are as high as $0.92/lb when considering total costs (Stone et al. 1997).

Permits Required For Aquaculture in Kentucky

Permits are required in Kentucky for all aspects of aquaculture from pond construction to water discharge. Following are descriptions of these permits.

Propagation Permit

Commercial Propagation Permits are required for the production of all fish, frogs, crayfish, and other aquatic organisms. The permittee may also sell and transport the species under this permit. These permits are obtained from the Division of Fisheries, Kentucky Department of Fish and Wildlife Resources, telephone (502) 564-3596. Special authorization is needed for seine nets larger than 10 feet. An issued metal identification tag must be attached to these seines. All endemic species (those occurring naturally in Kentucky) may be cultured and sold with a propagation permit. Most exotic species are not permitted for commercial production. No fish or any aquatic organism may be raised in public waters.

Grass Carp

Triploid (sterile) grass carp require special propagation, transportation, and holding and rearing permits. These fish may be purchased only from producers who are certified by the Division of Fisheries.

Live Fish and Bait Dealers License

A Live Fish and Bait Dealers License is required for everyone selling live fish retail or wholesale. It is available from the Kentucky Department of Fish and Wildlife Resources. Holders of the Propagation Permit are **not** required to have this Dealers License to buy and sell fish.

Transportation Permit

Persons hauling any live aquatic organisms in Kentucky must have a Transportation Permit for the species being hauled. This is obtained from the Kentucky Department of Fish and Wildlife Resources.

Pond Construction Permit

Pond construction approval is required from the Kentucky Department for Environmental Protection, Division of Water, Floodplain Management Section prior to construction in or along a stream that could obstruct flood flows. Check first with your local NRCS to see if it is necessary to contact the Division of Water.

The Division of Water, Floodplain Management Section's telephone number is (502) 564-3410 (18 Reilly Road, Frankfort, KY 40601). In some cases, the State Historic Preservation Officer from Frankfort will evaluate the prospective pond site for its archeological value.

Wetlands

Before constructing ponds, check with the NRCS to see if your land is classified as wetlands. Wetlands are characterized by moist soil, a predominance of wetland vegetation, or a flooded or saturated root zone. Exempted are prior-converted wetlands, which are lands producing crops prior to December 23, 1985, that no longer have wetland characteristics. If a "farmed" or "converted" wetland is drained, filled, cleared of trees or altered beyond the effect of original drainage, penalties or fines may result, USDA program benefits may be forfeited or ponds may be required to be filled.

If the NRCS determines that the land is a wetland, then the U.S. Army Corps of Engineers must be contacted at the following numbers (depending on your location): Tennessee and Cumberland Rivers Drainage in Nashville, TN (615) 736-5181; Mississippi River Drainage in Memphis, TN (901) 544-3471; Kentucky River Drainage in Louisville, KY (502) 315-6687; or Eastern Kentucky in Huntington, WV (304) 529-5210.

Water Withdrawal Permit

A Withdrawal Permit is needed for aquaculture. The Kentucky Department for Environmental Protection, Division of Water can be contacted at: (502) 564-3410.

Water Discharge Permit

Kentucky Pollution Discharge Elimination System (KPDES) requires that a Discharge Permit is needed in Kentucky, unless you are exempted by one of the following:

- Less than 20,000 pounds of coldwater fish are produced each year.
- Less than 5,000 pounds of food are used each year.
- Less than 100,000 pounds of warmwater fish are produced each year.
- Warmwater ponds discharge only during periods of excess runoff.
- Water is discharged less than 30 days per year.

If you do not meet any of these listed qualifications, you need to obtain a Discharge Permit from the Kentucky Department for Environmental Protection, Division of Water in Frankfort at (502) 564-3410.

Pay Lakes

In order to qualify as a pay lake, the lake must be stocked at least twice a year with not less than 500 pounds of adult fish per surface acre. A Pay Lake Operation License is needed if the owner issues permits to pay lake patrons, giving them permission to fish at the lake without a fishing license. The Kentucky Department of Fish and Wildlife Resources, Division of Water, issues the license. No Pay Lake Operation License is needed if the pay lake does not distribute fishing permits to its patrons (each person, of course, must then have a Kentucky fishing license).

Pond Site Selection

Subsoils

A suitable pond site should have a soil type and composition that holds water economically. The soil should contain preferably at least 20% to 30% clay by weight to minimize seepage. Areas with pockets of gravel, rock fissures or sand should be avoided.

Meet with your County Agricultural Extension Agent and a soil scientist or geologist from the NRCS, and refer to a soils map for your area for information on the types of soils found on your land. Also use several visual tests to evaluate the suitability of your soil. Make a ball of soil with your fist and drop it to the ground. A soil with good clay content will remain intact. Roll the soil out like a thread; poor quality soils will break apart.

Topography

The topography is the lay of the land. It can be flat or hilly. The topography determines the amount of dirt that has to be moved and also the size of the pond. Less dirt is moved per acre to construct ponds on flatland compared to watershed ponds of equal size built on hilly terrain. Flatland permits construction of large ponds while pond size is limited in areas with slopes of more than 3% to 5%. Hill ponds are not ideal for commercial catfish farming, but they can be used successfully. A dam is usually constructed between two hillsides, and the water supply is surface runoff from the surrounding watershed and springs. Small wells are also sometimes used to supplement hill ponds.

The topography around ponds should permit drainage by gravity flow during any season. Make sure that ponds do not block drainage from a neighbor's land or interfere or cause any damage off your property. Good drainage is important because eventually ponds will require complete draining for repairs, maintenance and to reestablish fish inventories. Low, wet ground should be carefully evaluated for agricultural chemical residues because these areas receive runoff from surrounding farmland. Also avoid building ponds on lands classified as wetlands due to legal restrictions. Check with NRCS or the U.S. Army Corps of Engineers for current guidelines.

Water Supply

Catfish are raised under various management levels using different sources of water. The intensive production of catfish, where annual yields reach 3,000 to 6,000 pounds per acre, requires a dependable year-round supply of water. Preferably, food fish production ponds should have a filling time of 10 days or less. Ponds used to grow stocker fish (fingerlings) should fill in five days or less. The size of well and output in gallons per minute (gpm) should match the water requirements for ponds. For a quick fill, pump all water into one pond and fill it completely before distributing water to others. When filling ponds, locate a boat or metal roofing material below the discharge site to minimize scouring and erosion from the force of flowing water.

Determine the desired water requirement for the largest pond, then the water requirement will be met for all equal or smaller ponds. One well of 250 gpm to 500 gpm capacity can be used to serve a group of four ponds each about 5 acres in size. The resources of ponds and wells such as this are available in some western Kentucky counties. Smaller well water capacities may suffice especially if supplemented with rainwater run-off from a watershed. Water is required to fill ponds and maintain water levels to compensate for losses from evaporation and seepage. These losses can be 0.1 to 0.2 inches per day or more. Direct rainfall should be captured in ponds by keeping the water level several inches below the overflow pipe. This supplemental water reduces the need for pumping. Refer to **Table 1** to determine filling times for ponds at different pumping rates.

The depth to groundwater will determine the cost of pumping water and the cost of the pumping station. The availability of groundwater varies with location. Groundwater maps may be available for your area. Contact NRCS, local water well drillers, or other persons with operating wells to learn more about the availability of water in your area. A test bore well should be drilled to evaluate the quality, quantity and location of groundwater. Analyze the quality of the well water to detect any possible problems with heavy metals or other possible contaminants.

Table 1. Estimated pond filling time in days at different pumping rates

Pond Size (Acres)	Pumping Rate (gpm)					
	200	500	1,000	1,500	2,000	3,000
1	4.5	1.8	0.9	0.6	0.5	0.3
2	9	3.6	1.8	1.2	0.9	0.6
5	23	9	4.5	3.0	2.3	1.5
10	45	18	9	6.0	4.5	3
20	90	36	18	12	9	6

Catfish are also raised in hill ponds where surface runoff, wells and springs may supply water. Production levels seldom exceed 4,000 pounds per acre and are usually closer to 2,000 pounds per acre or less. Water is not available year-round, and serious water drawdown can occur during a summer drought. Fish are often stocked in the spring and harvested completely during the fall when ponds are partially drained. Ponds are refilled during the fall and winter and are restocked in the fall or the following spring to produce another crop.

For hill ponds, the ratio of the watershed area to the pond area is important. An oversized watershed area may damage the dam from excessive water or require a diversion canal. An undersized watershed area may supply insufficient water to fill the pond in the desired time. All watershed ponds should have emergency spillways to prevent damage to the dam and loss of fish from excessive runoff water during heavy rains.

Check the average rainfall amount by month for your area. The annual average should be at least 50 inches. Evaluate the water flow from natural springs during the fall, when discharge is usually lowest, if spring water will be an important water source. Remember that spring water is cool, and a continuous flow through a pond may inhibit growth of warmwater catfish. Continuous water exchanges often lead to infertile water that is clear and very susceptible to aquatic weed problems. A retention time of at least three weeks is desirable.

Water pumped from surface waters in rivers or streams is less desirable for intensive production, but must often be used in many situations. Activities upstream or in the watershed can contaminate the water and silt loads often are heavy. Undesirable wild fish are more apt to enter ponds, and disease transmission is more likely.

Coal strip mining pits

Water from Coal Mining Land

Water from coal mining land is often a good reliable water source if the coal is low in sulfur content. Low sulfur coal is not typically associated with extremely low pH as is high sulfur coal. Strip mining pits can serve as a water source for adjacent production ponds; the water is pumped laterally from the coal mining pits at a fraction of the cost of pumping from a deep aquafer (and, of course, digging a well is not necessary). Mining land can also be reclaimed into production ponds with a large reservoir water source as a routine part of the mining company's legal obligation to reclaim mined land. Such a reclamation plan, however, would first have to be approved by the Kentucky Department of Surface Mining Reclamation. Use of abandoned deep mines is also a feasible source of water; water is siphoned from one such mine in Eastern Kentucky and allowed to flow through circular fiberglass tanks that hold rainbow trout. The water is constantly replenished, maintaining cool, clean water with a high oxygen content.

General Location

Take precautions if the site is in a flood plain or low-lying area. Severe flooding can damage levees and ruin a fish crop. Wild fish may enter ponds through open drainpipes, and pond draining may be impossible during times of flooding. Determine the location of the nearest power line and telephone line and evaluate access cost.

Note activities in the surrounding watershed where surface runoff reaches ponds. Livestock feedlots or agricultural production can produce harmful contaminants. Evaluate access to your land from major roads and the condition of roadways that will be used by heavily loaded trucks. Secure legal right-of-way if needed. Check for the presence of any under or above ground lines for power, natural gas or water in the proposed pond site to avoid possible legal problems. Determine the cost of feed and stocker fish for your area and your proximity to necessary chemicals, supplies, services and markets.

If you are beginning to farm catfish with a commitment to develop it as a sole source of income, then make sure enough land is available for possible future expansion. The pond layout should also allow for expansion if desired.

Pond Construction

Construction of ponds for the commercial production of catfish is one of the most expensive and important aspects in developing a fish farm. Unless careful consideration is given to the design and the cost of pond construction, you may find the layout is not suitable for the species of fish you want to raise or the cost of building makes it impossible to make a profit.

Large ponds in the Mississippi Delta

Drainage

Ponds should be laid out and constructed to permit independent draining of each by gravity flow. This means that the lowest elevation in the ponds must be higher than the level of water or ground in the ditch where water is drained. This elevation difference at the discharge site should be at least two feet to prevent entry of wild fish. The bottom of the pond should be smooth and slope about 0.1 to 0.2 feet per 100 feet from the shallow to the deep end. This is important when fish are harvested or the pond is drained. All drain lines for a series of adjacent ponds should be at the same end and drain water by gravity flow into a common ditch or drainage area. Inside or outside harvest basins are not recommended unless for some special purpose.

Drain structures vary in design and location. They should also be large enough to drain any ponds in the desired time. Refer to Table 2 for discharge rates in gpm for drainpipes of various sizes. The most common design is the turndown pipe. The drain is located at the lowest elevation in the ponds and extends through the levee. The level of water is determined by raising or lowering the pipe. The standpipe also functions as an overflow pipe or trickle tube to discharge any overflow following heavy rains. Make sure that the pipe is held in place securely to prevent accidental drainage and possible fish losses. Attach a chain to the end of the drain and a post either alongside the drain or on the bank. Maintenance and repair of the underwater swivel joint are difficult and dangerous unless the pond is drained (the force of water draining into the standpipe can easily hold a person underneath and lead to drowning). The discharge end of the drain should extend at least 5 to 10 feet past the toe of the levee to prevent erosion and soil sloughing at the discharge site. Some riprap may be desirable to minimize erosion in the drainage ditch, especially at the discharge pipe.

Drains can also be placed outside the pond. This minimizes obstruction in the pond during harvesting and allows easier access for maintenance and use. The end of the pipe inside the pond is screened and is 5 to 10 feet beyond the toe of the levee to prevent clogging from any sloughing dirt. The screening also keeps out debris, turtles and fish. The outside end of the pipe is fitted with a "T." The height of the upward vertical standpipe maintains the desired water level in the pond. The end of the "T" has an alfalfa (sunshine) valve for adjusting the water level or draining the pond.

A modification of the "T" is the use of a two-foot high vertical valve. The end of the "T" is capped. Water level is maintained by opening the alfalfa valve to remove any excess rainwater. This method allows rapid draining of water from the pond and prevents entry of wild fish through the drainpipe. The pond is drained completely by removing the cap at the end of the "T."

It is desirable for the drainpipe to remove poorer quality water from the bottom of the pond rather than higher quality water from the surface.

Levee Width and Slope

For large commercial ponds, the levee should be at least 16 feet wide at the top. Levees need to be wide enough for easy feeding, harvesting and loading of fish.

The slope of the levees can be 3:1 if the soil is compacted well. Increasing the slope will increase the cost to build ponds and impound less water surface area. Slopes of 4:1 or higher create shallower water along the bank where aquatic weed problems are most common. A 4:1 slope is recommended only if the levee will not hold a 3:1 slope, due to poor soil texture. A 3:1 slope on the outside of the levee can be tractor mowed. This is more difficult and dangerous with steeper slopes. Construct one or more ramps from the nearest road to the levees for access to the ponds. The ramps should be well constructed and not too steep for easy travel by large trucks.

Freeboard and Water Depth

The freeboard is the difference in elevation between the top of the levee and the normal water level in the ponds. The freeboard should be about 18 inches and no more than two feet or no less than one foot. Large ponds in areas with strong winds that can produce large waves should have a 2-foot freeboard.

The minimum water depth for pumped ponds should not be less than three feet at the toe of the levee at the shallow end. Shallower water makes it more likely that nuisance aquatic weeds will grow & clog your pond, making it harder to seine. The maximum depth should not exceed eight feet at the toe of the levee at the deep end.

Table 2. Estimated average discharge rates for short drainpipes in fish ponds of various sizes with low head pressure [1]

Diameter of Pipe (Inches)	Approximate Discharge (gpm)
4	120
6	350
8	600
10	1,000
12	1,600
14	2,400

[1]To estimate the drain time in days for a pond using various sizes of drain pipe, use this formula:

$$\frac{\text{Acre-Feet Water x 325,851 gallons/ac-ft}}{\text{Discharge gal/min x 1,440 min/day}} = \text{Drain time in days}$$

Example for a 1 acre pond averaging 4 feet deep with an 8 inch drain pipe:

$$\frac{\text{4 ac-ft x 325,851 gal/ac-ft}}{\text{600 gal/min x 1,440 min/day}} = \frac{\text{1,303,404 gal}}{\text{864,000 gal/day}} = \textbf{1.5 days}$$

Ponds without a year-round supply of dependable water should be deeper to allow for natural water drawdown, especially during drought. A minimum depth of four feet at the shallowest end and six to ten feet at the deepest end is recommended for ponds of this type.

Levee Building

For large ponds, dirt buckets and earth scrapers (pans) are used to build levees economically. The equipment can be pulled by large tractors or bulldozers. The scraper works well to shape the pond and levees and grade the pond bottom. The dirt buckets move dirt economically over long distances and can put dirt where needed.

Each layer of dirt should be well compacted as it is put down to build up the levee. Sheeps-foot rollers do a good job of compacting soil layers, but frequent back and forth traffic by heavy equipment works satisfactorily. Soil with a heavy clay content should not be worked if it is too dry or wet. Avoid the use of loamy soils and organic matter as fill material for the levee. These materials can cause slumping in the levee as they settle or decay. Also, trees and roots should be removed to prevent leakage through the levees by way of the root systems. Remember that levees do settle or shrink in height over time. A settling allowance should be included when the unsettled height of the levee is determined. The amount of settling depends on the soil type and degree of compaction during levee building. Well constructed levees with good clay soils generally do not settle more than 5% to 10%.

The base of the levee should tie into mineral subsoil rather than unmoved topsoil that contains a higher content of organic matter. A core trench is usually required to key the levee into underlying subsoils to prevent lateral seepage under the base of the levee. Topsoil can also be stockpiled and used later to top dress the levee. This soil is more desirable for establishing a vegetative cover than are heavy clay subsoils. An earthen spillway with grass cover should be built beside the dam on watershed ponds to allow rapid discharge of water during heavy rains without doing damage to the dam.

Gravel on top of levees allows for vehicle access to the ponds in all types of weather. The main levees are the most important to gravel.

A new catfish pond under construction

Three-Sided Ponds

The term three-sided ponds is applied to ponds with three levees constructed against a hill that serves as the fourth side. Rainwater runs off of the hill filling and maintaining the pond's water level; a small well is sometimes used as a supplemental water source. This kind of pond is feasible on gently rolling land with adequate flat land at the base of the hill. They have drains in the levee opposite the hill and have smooth, gradually sloping bottoms which facilitate seining the ponds for harvesting. A manageable depth allowing efficient harvesting is usually a characteristic of this pond type. Ravine ponds, on the other hand, which are built with a dam at the base of two converging hills, are often too deep to manage efficiently for commercial aquaculture. Three-sided ponds are found frequently in the rolling hills of western Alabama and eastern Mississippi.

Before taking the first step in constructing ponds, it is advisable to contact your NRCS office. They will help you in pond design.

Stocking

Fingerlings six inches or longer are stocked into growout ponds with the goal of producing a market-sized fish. The number of fish stocked at this final stage in the production cycle varies widely. Factors that determine a suitable stocking rate include amount of time that the producer can spend with the fish, experience of the producer, desired fish size at harvest, maximum daily feeding limit, availability of water and aeration equipment, and length of culture period. With these factors in mind, stocking rates usually vary from 1,000 to 6,000 fish per acre of water.

Annual production ranges from 1,000 pounds per acre in watershed ponds without aeration to about 8,000 pounds per acre in levee ponds supplied with pumped well water and aeration. First-time producers should consider not stocking more than 3,500 fish per acre in aerated ponds if desired market size is 1¼ pounds or more. It is advisable to grow a fish crop successfully at a moderate risk level, then consider increasing the stocking rate after acquiring some pond management experience.

Marketable food fish can range from three-fourths to two pounds or more, depending on the customer. The production cycle from spawning to marketable fish can range from 16 to 24 months in Kentucky. Once most of the fish reach marketable weight, they may be harvested several times during the year, grading or "topping off" the largest, marketable-sized ones. This practice assures a year-round supply of fish to processing plants or other markets.

The number and size of fish stocked in a pond are important. Management level, stocking date and initial size determine the time required for fish to reach market size. Stocking rates are based on the surface area of water in the ponds and not the volume of water.

The preferred stocking rate in commercial ponds should be based on the maximum safe and economical feeding rate, the desired size of fish at harvest and the food consumption rate reached at the maximum feeding rate. Refer to **Table 3** below for maximum feeding rates for different pond situations. Values vary depending on experience and specific site conditions.

Table 3. Food Fish Stocking Rates

Pond Situation	Suggested Maximum Feeding Rate (Pounds/acre/day)	Suggested Maximum Stocking Rate (Fish/acre)
Watershed pond, no aeration	34	1,000
Pond with aeration and well	100	3,500 to 6,000 depending on experience and time available

Catfish fingerlings are weighed before stocking.

The size of fish desired at harvest should be acceptable to customers and economical to produce. A good money-making fish for the producer is a fish weighing between one to one and a half pounds that converts feed efficiently, gains weight well and does not take too long to produce. Pay lakes usually prefer a larger fish.

A desired stocking rate can be determined by knowing the maximum feeding rate, average desired fish size at harvest and estimated feed consumption rate at harvest. This method is more difficult to use for ponds with mixed fish sizes that represent a more complex situation.

Table 4. Estimated percent body weight consumed by channel catfish of different sizes at water temperature above 70°F.

Fish Size		
Average Weight Pounds	Pounds per 1,000 Fish	Estimated Percent Body Weight Consumed Daily
0.02	20	4.0
0.06	60	3.0
0.25	250	2.7
0.50	500	2.5
0.75	750	2.2
1.00	1,000	1.6
1.50	1,500	1.3

Determine the number of fish to restock after "topping" by recording the total weight of fish harvested and determining the weight of a sample of harvested fish.

Example: 700 pounds of fish were harvested, and a random sample of 50 fish weighed 62 pounds.

$$\text{Number fish to restock} = \frac{\text{Fish in sample x total harvest weight}}{\text{Weight of fish sampled}}$$

$$= \frac{\text{50 fish x 700 lbs.}}{\text{62 lbs}}$$

$$= \text{565 Fish}$$

Economic research on stocking rates has shown that stocking light (e.g. 3,500/acre) in intensive culture ponds is more profitable when farm gate prices are low (around $0.60/lb or less), while higher stocking rates (e.g. 5,000 or more/acre) are more profitable when prices are high ($0.70/lb or higher).

Fish can be stocked into ponds anytime of the year when ponds are at least one-half full and filling and fish are available. Fish handle best at temperatures below 70°F. Special precautions are required when fish are handled at warmer temperatures. Risk of loss to disease is increased when fish are handled at temperatures higher than 70°F. The best months for growth are April to October. Make sure that ponds contain no wild fish before they are stocked with catfish. Use of a fish toxicant or pond draining and drying may be required to eliminate undesirable fish. Also, avoid stocking wild fish into ponds when catfish are stocked.

Many commercial producers partially harvest or "top" the larger fish in ponds when they reach market size. When ponds are "topped," usually one-fourth to one-third of the fish are harvested. The harvested fish are replaced, usually by stocking one 5-inch or longer fingerling for each fish harvested.

Table 5. Length-Weight relationship for channel catfish fingerlings and food fish.

Total Length (inches)	Average weight per Thousand Fish (pounds)	Number of Fish per Pound	Average Weight per Fish (pounds)
1	1.3	767.7	.0013
2	3.5	285.7	.0035
3	10.0	100.0	.0100
4	20.0	50.0	.0200
5	32.0	31.1	.0321
6	60.0	17.0	.0588
7	93.0	10.8	.0926
8	112.0	9.0	.1111
9	180.0	5.5	.1818
10	328.0	3.1	.3280
11	395.0	2.5	.3950
12	526.0	1.9	.5260
13	656.0	1.5	.6560
14	909.0	1.1	.9090
15	1090.0	0.92	1.0900
16	1220.0	0.82	1.2200
17	1432.0	0.69	1.4320
18	1750.0	0.57	1.7500
19	2200.0	0.45	2.2000
20	2890.0	0.35	2.8900
21	3290.0	0.30	3.2900
22	3470.0	0.29	3.4700
23	3600.0	0.28	3.6000

Stocking Strategy: for Catfish Culture in Kentucky

(and other areas in northern latitudes of the southeastern United States)

Channel catfish fingerlings are typically stocked at high densities (about 40,000 per acre in Kentucky) during their first summer of growth, and are then thinned out to lower grow-out densities (e.g.. 1,000 to 6,000 per acre) in late fall or the following spring. In Kentucky and other states in northern latitudes of the south-eastern United States, the majority of catfish stocked under this system typically fall short of marketable size by the end of the second growing season, often averaging significantly less than a pound. A better stocking schedule developed by Wurts and Wynne (1993) and Webster et al. (1994) at Kentucky State

University involves an early stocking of fingerlings into low-density grow-out ponds in early fall, allowing the young fish to grow at an increased rate during the last few weeks of the growing season and during warm periods throughout winter and early spring. Approximately 2000 channel catfish fingerlings per acre averaging about 7 inches long (100 to 110 lbs./1000) were stocked in early October. They were fed a 36% protein feed at 1 to 3% of their body weight daily until temperatures dropped below 50°F. In late winter/early spring the fish were fed a 32% protein feed to satiation when temperatures rose above 50°F. By the third week in April the fingerlings averaged 9 inches in size (186 to 192 lbs./1000) and were able to reach 1 ½ pounds by the end of the growing season in late October.

Feeding

Feeding is the most important task in the intensive pond production of catfish. In a normal situation, catfish can be seen only when they are coming up to feed, and their feeding behavior can be an important clue to general health and the pond condition. Potential problems with the fish or pond water quality can be recognized early by noticing abnormal feeding behavior.

Nutritional Requirements

Feed used in intensive pond culture of catfish must be nutritionally complete. Catfish feed that lacks all essential nutrients in the proper amounts is called supplemental feed and has no place in a production system where stocking rates are at or above 1,000 fish per surface acre. Use of a supplemental feed when catfish are stocked at higher densities will, at best, result in poor growth and, at worst, death of the fish due to a nutritionally-induced disease. Feed must contain all essential nutrients at adequate levels to meet total nutritional requirements of catfish for normal growth and health.

Most catfish feed manufacturers now use the "least cost", instead of "fixed feed" method of feed formulation where the formula varies, within limits, as ingredient prices change. Because the kind or amount of ingredients needed to provide essential nutrients for catfish is not secret, the feed manufacturer should be willing to reveal the type and amount of ingredients in his feed.

Form and Size

Not only must the feed contain all of the essential nutrients, it must also be palatable to the catfish and of a size that can be eaten. If they don't eat or can't eat it, maximum growth is not achieved, costing the producer money. The feed must be offered in a way and at a time that promotes total consumption.

Form and size of feed available include four types:

- meal
- crumbles
- floating (expanded or extruded) pellets
- sinking (hard or compacted) pellets

Feed size and form used depends on fish size, water temperature and type of management. Meal and crumbles are used for fry and small fingerlings. Although extruded or floating feed is more expensive than sinking pellets, it is generally preferred when water temperatures are above 65°F (18°C) because feeding behavior is much easier to monitor. Most producers feel that seeing the fish when they are feeding is well worth the extra cost.

Sinking feed is used when the water temperature falls below 65°F (18°C) or slightly higher. If you wait until the fish completely quit feeding at the surface, usually about 60°-63°F (16°-17°C), it may be difficult to get them to accept sinking feed.

If a topping-off or multiple harvest scheme is used in intensive pond production of catfish, the size of catfish in a pond at any given time may vary from 4 inches to 2 pounds or larger. Since it is not practical to feed the catfish two or more sizes of feed every day, most farmers compromise by feeding a 3/16- to 3/8- inch pellet.

Feeders

Catfish may be fed by hand from the bank or boat, or by using some type of mechanical feeder. Hand feeding more than 10 acres of intensively cultured catfish ponds is too time consuming and laborious, thus some type of mechanical feeder should be used on larger farms.

The blower type feeder with a 1- to 3-ton hopper, mounted on a truck bed or pulled by a tractor, is best. The blower type feeder can be calibrated to blow a known amount of feed per minute or can be equipped with a scale that allows the operator to know the amount that has been fed. The hopper of the blower is filled from a bulk storage tank.

Small acres of catfish can be fed by hand.

Two other types of mechanical feeders are the demand feeder and the automatic feeder. Neither has any place in intensive pond production of catfish because frequent observation during feeding is not possible. The demand feeder is activated by the catfish, thus allowing a few large, aggressive fish to consume most of the feed. When demand feeders are used in intensive production ponds, there is a large difference in the size of the fish produced. Waterfowl, particularly coots, quickly learn to use demand feeders and may consume more feed than the catfish. The automatic feeder is programmed to release specific amounts of feed at predetermined times during the day. It must be carefully monitored to avoid over or underfeeding the catfish. Unless large numbers of automatic feeders are used, many catfish will not get enough feed while a small number of the more aggressive fish will eat most of the feed.

This feeder blows feed into the pond.

Feeding Rates

Several factors affect the amount of feed a catfish will eat, such as:

- water temperature
- water quality
- size of the feed
- palatability or taste of the feed

- frequency of feeding
- the way fish are fed
- location of feeding sites
- type of pellet used (floating or sinking)
- health of the fish
- size of the fish

Table 6 (on page 52) gives the amount to feed daily, based on average expected gains, at stocking rates of 1,000 6-inch fingerlings per acre. To get the amount to feed per acre at higher stocking rates, divide the number of catfish stocked per acre by 1,000 and multiply the answer by the daily amount to feed per acre in Table 6.

Amount to feed daily = % body wt fed x total wt fish in pond

Example: 40,000 pounds of catfish in a pond are being fed at a rate of 2.5% of their body weight daily.

Amount to feed daily = 0.025 x 40,000 lbs. = 1,000 lbs of feed

The amount fed daily must be adjusted at least every 2 weeks or the catfish soon will be underfed causing a reduction in both growth and profits. This is best done by taking a sample of fish from the pond, usually by seine, and counting and weighing them. Then use the formula given to calculate the total weight of catfish in the pond at that time.

Total weight in pond = wt. fish in sample x no. fish in pond ÷ no. fish in sample

Example:

There are 45,000 catfish stocked in a 10 acre pond that are being fed at 3% of their body weight daily. To adjust the amount to be fed daily for the next 2 weeks, a sample of fish is seined, counted and weighed. The sample contains 200 fish weighing 80 pounds. The new amount to feed daily is calculated:

Total weight in pond = wt of fish in sample x no. fish in pond ÷ no. fish in sample = 80 lbs x 45,000 fish ÷ 200 fish = 18,000 lbs of catfish in the pond

Lbs. to feed daily for next 2 weeks = 3% x 18,000 lbs = 0.03 x 18,000 lbs = 540 lbs of feed

Rather than seining a sample of fish and counting and weighing them every 2 weeks, growth of the fish can be estimated. Some assumptions can be based on your ponds historical data or on industry averages about the percent of body weight fed daily and feed conversion factors. Table 6 is a feeding guide which shows how to make these calculations. It can be used with good results, but it is much better to use feed conversion ratios and percent of body weight to feed daily which are valid for your ponds. It is a good practice to remove a sample of fish occasionally for counting and weighing to calculate the weight of fish present and see how close your growth estimates have been.

Another method of estimating the amount of feed to use daily when the water temperature is above 65°F (18°C) is to feed the fish what they will eat in 10 to 15 minutes. If feed is still floating on the surface at the end of 15 minutes, the fish are being overfed which increases costs.

Feeding Practices

Manner and time of feeding, as well as the amount and type of feed, can have a profound effect on the growth and size variation and the quality of the catfish produced. A large variation in the size of catfish produced usually is the result of underfeeding (feeding the fish less than they should have) or feeding in a small area of the pond. In underfeeding, the larger, more aggressive catfish eat a larger share of the feed and become bigger at the expense of the smaller catfish. This also happens when feed is offered in only a small area of the pond since the larger, more aggressive catfish quickly learn where the feed will be put in the pond and are there waiting for it. Thus, to produce catfish uniform in size, and to maximize profits, it is equally important that catfish are fed the proper amount of feed daily and the food is distributed as evenly over the pond as possible.

Feeding twice daily, if possible, will usually improve feed consumption and feed conversion. This means that one-half of the daily allowance is fed in the early morning, and the other half later in the day. If the catfish are fed only once a day, morning is the preferred time since feeding in the late afternoon increases the amount of fat deposited, and this can affect the quality of the processed fish. Feed should not be offered until the oxygen level of the pond water is at least 4 parts per million (ppm) or higher because feed consumption goes down dramatically at lower oxygen concentrations. Oxygen requirements for catfish increase greatly during feeding, so it is best not to feed in the early evening when oxygen concentrations in the water are decreasing.

Record Keeping

You must be able to closely estimate the number of fish and the weight of fish in every pond at any given time if you want to be successful at raising fish. If the weight of fish in a pond is underestimated, not enough food will be fed, resulting in poor growth, poor feed conversions, and increased time required to get the fish to harvestable size. If the weight of fish in a pond is overestimated, the result will be overfeeding, poor feed conversions, and very likely, severe water quality problems.

An important reason for keeping good records is that many lending institutions require good records before they will lend money. Also, without good records you don't know if you are making or losing money, and you can't identify problem areas.

Ask your state aquaculture specialist about available computer programs for catfish record keeping. Manual forms are also effective.

1. Daily Feeding Record (on Page 53)

Record the amount fed daily to each pond on this form. At the end of the week total the amount fed for the week.

2. Weekly Pond Record (on Page 54)

Record date of stocking, stocking rates and weights, amount of food fed weekly, weekly weight gain and weight of fish harvested for each pond. Other information concerning disease treatments, weed control, etc., can be noted in the remarks section.

Most of the information required on this form is self-explanatory. The estimated conversion ratio should be determined by you from experience gained from previous years. The estimated conversion ratio can be obtained from Pond Conversion Ratio Calculations, which should be completed as soon as the pond is harvested.

Column (1) of the Weekly Pond Record (on Page 54) is for the feed week just ended and need not be for the calendar week. Column (2) is derived each week from the Daily Feeding Record. Column (3) is obtained by dividing each entry in Column (2) by the estimated conversion ratio. Column (4) is an accumulated or running total of the original stocking weight plus the weekly gains. Column (5) is for any removal of fish from the pond either by loss or harvesting. When harvesting is completed, the total harvested weight is subtracted from the last figure in Column (4) so that

Column (4) always reflects the total fish weight in the pond. Column (7) may be used for notations of importance such as average size fish (total fish weight divided by the total number of fingerlings), treatments for parasites or disease, or explanations for losses. Totals of columns (2) and (5) are made for use on other forms for calculations of conversion ratios and production.

If an estimate of fish weight in the pond determined by sampling indicates feed conversion is lower or higher than previously estimated, an entry should be made in the "Remarks" column (column 7) that an adjustment has been made. Subtract or add to the "Total Fish Weight" column (Column 4) the appropriate poundage of fish and adjust conversion rates accordingly.

3. Adjustment Calculations for Feed Fed

Since the feeding quantities are estimated, it is necessary to adjust the total feed fed during the year (or any period, but certainly not less than once per year) after all ponds are harvested. Use the table (below) for calcualting the amount to adjust.

RECAP AND ADJUSTMENT CALCULATIONS
FOR FEED FED

1. Beginning feed inventory	=	__________
2. Total feed purchased	=	__________
3. Ending feed inventory	=	__________
4. Feed used (1 + 2 - 3 above)	=	__________
5. Total feed fed from pond records	=	__________
6. Correction factor (4 ÷ 5 above)	=	__________

(enter at the top of table on page 55)

		COL 1	COL 2	COL 3	COL 4	COL 5	COL 6	COL 7
Dates	Water temp °F	Wt of 1,000 Fish at beginning	% of body wt fed daily	Lbs. of food fed/acre/day/1,000 fish	Feed conversion	Gain in lbs per day	No. of feeding days	Gain in lbs per period
10/1-31	55-60	60.0	1.0	0.60	2.0	0.30	31	9.3
11/1-30	45-55	69.3	0.5	0.35	2.0	0.17	30	5.2
12/1-2/28	30-50	74.5	0.2	0.15	2.0	0.07	90	6.7
3/1-31	40-55	81.2	0.5	0.41	2.0	0.20	31	6.3
4/1-30	50-65	87.5	2.0	1.75	2.0	0.87	30	26.2
5/1-15	55-70	113.7	3.0	3.40	1.75	1.95	15	29.2
5/16-31	60-70	142.9	3.0	4.29	1.75	2.45	16	39.2
6/1-15	65-75	182.1	3.0	5.46	1.75	3.12	15	46.8
6/16-30	70-75	228.9	3.0	6.87	1.75	3.92	15	58.9
7/1-15	70-80	287.8	3.0	8.63	1.75	4.93	15	74.0
7/16-31	75-85	361.8	3.0	10.85	1.75	6.20	16	99.2
8/1-15	75-80	461.0	3.0	13.83	1.75	7.90	15	118.6
8/16-31	70-80	579.6	3.0	17.39	1.75	9.94	16	159.0
9/1-15	65-75	738.6	3.0	22.16	1.75	12.66	15	189.9
9/16-30	60-70	928.5	2.5	23.21	1.75	13.26	15	199.0
10/1-31	55-60	1127.5	1.0	11.27	1.75	6.44	31	199.7

Total expected weight of fish = 1,327 lbs

Total weight of food fed = 2,231 lbs

Average fish size = 1⅓ lb

Method of calculating projected growth of fish during the year:

(1) Column 1 x Column 2 ÷ 100 = Column 3

(2) Column 3 ÷ Column 4 = Column 5

(3) Column 5 x Column 6 = Column 7

(4) Column 7 + Column 1 = Column 1 next time period

Table 6. Feeding guide is based on average expected gains with a feed conversion of 1.75 at a stocking rate of 1,000 6-inch fingerlings per acre

Daily Feeding Record

Week of __________ to ___________

Pond #	Sun	Mon	Tues	Wed	Thurs	Fri	Sat	Total

Weekly Pond Record

Pond #		
Size		Acres

Date Stocked	Weight Fingerlings	Number Fingerlings	Total Stocked Weight

Est. Conv. Ratio:		Total	

Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7
Week Ended	Lb Feed Fed	Lb Gain	Total Fish Weight	Lb Harvested or Lost	Price Received Per lb	Remarks (treatments feed, etc)
Total						

Fish larger than 1½ to 2 pounds may have FCR values of 2 to 2.5. Commercial producers should try to obtain FCR values of about 1.8. The FCR for winter feeding is usually poor and can reach three or higher, however the weekly feed allowance is low. Winter feeding is economical because of potential weight gains, and more importantly, prevention of weight losses.

Feed Conversion Ratio Calculations

Correction Factor (CF) =__________________________

Pond #	Column 1 Est. Lb Feed Fed	Coumn 2 Actual lb Feed Fed (1) x (CF)	Column 3 Total Stocking Weight	Column 4 Total lb Harvested	Column 5 Conversion Ratio 2/(4-3)

Feed Conversion Ratio

Healthy catfish convert quality feed efficiently when fed properly under good water quality conditions. The food conversion ratio (FCR) is the total pounds of feed given your fish divided by the weight gained for any period of time. The feed conversion ratio increases as fish grow. It costs more money per pound to grow large fish, especially when they are 1½ to 2 pounds and larger. The FCR reflects the efficiency of producing fish. Table 7 shows the effect of the FCR on the cost of producing catfish.

Table 7. Cost of feed in cents to produce a one-pound fish at different feed conversion rates and feed prices.

	Cost Per Ton				
FCR	$200	$225	$250	$275	$300
1.5	15.0	16.9	18.8	20.6	22.5
1.6	16.0	18.0	20.0	22.0	24.0
1.7	17.0	19.1	21.3	23.4	25.5
1.8	18.0	20.3	22.5	24.8	27.0
1.9	19.0	21.4	23.4	26.1	28.5
2.0	20.0	22.4	25.0	27.5	30.0
2.1	21.0	23.6	26.3	28.9	31.5
2.2	22.0	24.8	27.5	30.3	33.0

Feed Conversion Ratio Calculations

After obtaining the correction factor (C.F.), record it on the feed Conversion Ratio Calculation Form. Record the information required in columns (1), (3) and (4). To obtain Column (2) (actual lb feed fed), multiply the correction factor by column (1) (estimated lb of feed fed). Calculate Column (5) by subtracting the value in Column (3) from Column (4) and then dividing this result into the value in Column (2).

Winter Feeding

Although some research indicates that winter feeding is not necessary, many biologists feel that it is an important management practice. It may mean more profit for the farmer, and the catfish may be in better condition during the winter and spring to withstand stresses that can cause disease outbreaks. Some research has shown that when catfish are not fed from November 15 to March 15 (121 days), they will lose about 9 percent of their body weight . However, when put on a winter feeding program, catfish can gain as much as 20 percent of their body weight during this same period.

There are two basic winter feeding programs: (1) feed sinking food at 0.5 to 1 percent of the body weight on alternate days when water temperature is above 49°F (9°C): or, (2) feed sinking food at 0.5 to 1 percent body weight whenever the water temperature at a depth of 3 feet is 54°F (12°C) or higher.

Feed Storage

Feed should be stored properly in a cool, dry area. Make sure feed is at air temperature before it is off-loaded into a feed bin. Poor storage conditions can produce mold or changes in feed that can be toxic to fish. During the summer, feed should not be stored longer than 30 to 45 days. Storage should be adequate for at least one week's supply. Fresh feed assures quality and palatability. To estimate the storage time of feed for two sizes of feed bins for several farm sizes and feeding rates, refer to **Table 8**. (page 58)

Feed Storage bins for large feed volumes

Table 8. Capacity in days of feed for two sizes of bulk storage feed bins for five farm sizes and three feeding rates.

Farm Size in Water Acres	50 lbs/acre/day Bin size		75 lbs/acre/day Bin size		100 lbs/acre/day Bin size	
	10 Ton	23 Ton	10 Ton	23 Ton	10 Ton	23 Ton
15	26.7	61.3	17.8	40.9	13.3	30.7
40	10.0	23.0	6.7	15.3	5.0	11.5
70	5.7	13.1	3.8	8.8	2.9	6.6
100	4.0	9.2	2.7	6.1	2.0	4.6
140	2.9	6.6	1.9	4.4	1.4	3.3

Water Quality

Maintaining good water quality in production ponds is absolutely essential. Failure to do so will result, at best, in poor growth and high feed conversions or, at worst, a total loss of all fish in the pond. Remember that the fish in the pond are living in their own wastes. Thus, the weight of fish that can be produced in a pond is limited by the ability of that pond to provide adequate oxygen, (not only to keep the fish alive but to enable them to metabolize their food and grow) and to break down nitrogenous wastes.

To achieve production in excess of 1,000 pounds per acre per year, the farmer must be able to insure that good water quality is maintained 24 hours a day, 365 days a year.

Physical Properties

- Water changes temperature more slowly than the surrounding air or soil changes temperature.

- In still water, differences in temperature cause a layering effect known as stratification. Upper layers are warm and bottom layers are cool in summer. The reverse is true in winter.

- Considerable force is required to break down stratification if temperature differences are great.

Oxygen

Oxygen is necessary for all life to make available energy contained in food. The atmosphere is 21-23 percent oxygen at sea level.

Source of oxygen in water. Oxygen dissolves in water and occurs as a simple solution. It does not combine chemically with water.

Diffusion - of minor importance. The rate at which oxygen diffuses into water is governed by physical laws which relate to the solubility of gases. Rate of diffusion can be increased by agitation which allows more contact of surface water with air.

Photosynthesis - the single most important source of oxygen in pond water. All green plants manufacture food by a process called photosynthesis. Plants use nutrients (N, P, K, etc.), carbon dioxide (CO_2), water (H_2O), and energy from sunlight to make their food. A waste product of this process is oxygen which is given off and is dissolved in the water.

Oxygen cycle. The oxygen concentration in water changes from minute to minute depending on many factors but essentially it follows a definite pattern during any 24-hour period. **Figure 1** illustrates a typical 24-hour oxygen cycle in a pond.

O_2 concentration is lowest at sun-up. O_2 concentration is highest in mid afternoon.

O_2 concentration at dark must be high enough to meet Biological Oxygen Demand (BOD) during the night with enough left to keep fish healthy.

Amount of oxygen that water can hold depends mostly on temperature:

As temperature increases, the amount of oxygen that can stay in solution decreases. (see Table 9).

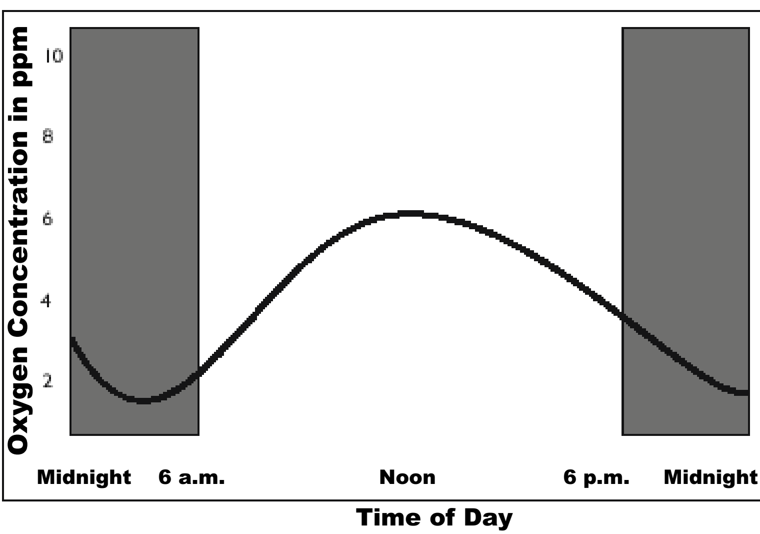


Figure 1. 24-hour oxygen cycle in ponds.

Table 9. Soulubility of oxygen in parts per million (ppm) in fresh water at various temperatures and at a pressure of 760 mm Hg (sea Level).

Temperature °F	°C	Concentration of Oxygen in ppm	Temperature °F	°C	Concentration of Oxygen in ppm
32	0	14.6	69.8	21	9.0
33.8	1	14.2	71.6	22	8.8
35.6	2	13.8	73.4	23	8.7
37.4	3	13.5	75.2	24	8.5
39.2	4	13.1	77	25	8.4
41	5	12.8	78.8	26	8.2
42.8	6	12.5	80.6	27	8.1
44.6	7	12.2	82.4	28	7.9
46.4	8	11.9	84.2	29	7.8
48.2	9	11.6	86	30	7.6
50	10	11.3	87.8	31	7.5
51.8	11	11.1	89.6	32	7.4
53.6	12	10.8	91.4	33	7.3
55.4	13	10.6	93.2	34	7.2
57.2	14	10.4	95	35	7.1
59	15	10.2	96.8	36	7.0
60.8	16	10.0	98.6	37	6.8
62.6	17	9.7	100.4	38	6.7
64.4	18	9.5	102.2	39	6.6
66.2	19	9.4	104	40	6.5
68	20	9.2			

■ Causes of oxygen depletions

Respiration - Uptake of oxygen by plants and animals in the water exceeds the ability of photosynthesis and diffusion from air to maintain oxygen levels adequate for life.

Algae die-off - Color of water will usually change from greenish to a blackish, brownish or clear color. This can be caused by chemical treatments, excessive algae blooms which can release material toxic to itself or other types of algae, and heavy rain or high winds which can force algae to the bottom where there may be oxygen-deficient water causing a die-off.

Turn-over - As algae blooms become denser in the spring and early summer, light penetration and warming are restricted to the upper layers of water. On bright, still, hot days the surface water warms rapidly, resulting in marked differences in water temperature from top to bottom. The surface water is warm and less dense than the cool water at the bottom, and these layers tend to resist mixing. When this happens, the pond is said to be stratified.

Because there is no mixing of the two layers of water, the bottom layer (hypolimnion) becomes devoid of oxygen by respiration and can develop a high biological oxygen demand. Anything that causes a mixing (turn-over) of these low layers, such as high winds, cold rain, seining, aerators, etc., can result in an oxygen depletion.

Chemical reactions - Chemical reactions are constantly going on in pond water and mud, and many of these reactions require oxygen.

■ When well water that is devoid of oxygen but rich in iron is pumped into a pond, the iron is changed chemically and forms a reddish-brown precipitate. In this reaction, oxygen is removed from the water.

Temperature of water - As temperature increases, the amount of oxygen that can be dissolved in water decreases (see Table 9).

Addition of water devoid of oxygen - This is typical of most well water and reduces available oxygen by dilution.

- **Time & methods to take oxygen measurements**

Take measurements at the same time every day.

Take oxygen profile of deep end at least twice a day.

Take readings at surface, mid-depth, and bottom. Take corrective action when oxygen concentration drops below 4 to 5ppm It is best if the oxygen is monitored in at least two places in each pond.

A simplified method for predicting nighttime oxygen depletions in fish ponds is described. Although it will not replace keeping close watch on all of your ponds and using common sense management programs, it will indicate whether or not a problem is likely to develop and the approximate time to take measures to prevent a low oxygen stress situation.

Remember, this method is not foolproof. Many factors can influence the rate at which oxygen is removed from pond water during the night. It does, however, indicate which ponds are likely to develop oxygen problems during the night so these ponds can be monitored closely.

This method is based on the fact that a decline in dissolved oxygen in ponds during the night is usually a straight line with respect to time. Measure the dissolved oxygen concentration at dusk and plot this point on a graph; then measure the oxygen again 2 or 3 hours later and plot this point. If a straight line is drawn between these two points and extended to the point where it crosses a line drawn from the 4 ppm oxygen concentration, you can estimate the time during the night when oxygen concentration reaches a level where corrective action should be taken (see **Figures 2-4**). Aeration should be started before dissolved oxygen concentrations drop to 4 ppm.

Using this method along with close observation will put manpower and equipment on the pond bank when the fish need help. Remember, no matter what method is used to monitor oxygen levels, make sure the equipment and management expertise are on the pond when they are needed.

Depending on the health of the fish and the parasite load on their gills, channel catfish will not begin to come to the surface piping or gasping until the oxygen concentration in the pond drops to about 0.75 to 1.0 ppm. However, as the oxygen concentration drops below 4.0 ppm, channel catfish will suffer from stress. Although they might not die, the stress caused by low oxygen levels may cause the fish to go off feed or develop a bacterial infection that could result in serious losses. Thus, it is important to try to maintain at least 4 ppm oxygen in the pond at all times even though healthy catfish usually won't begin to die until the oxygen drops to 1 ppm or less.

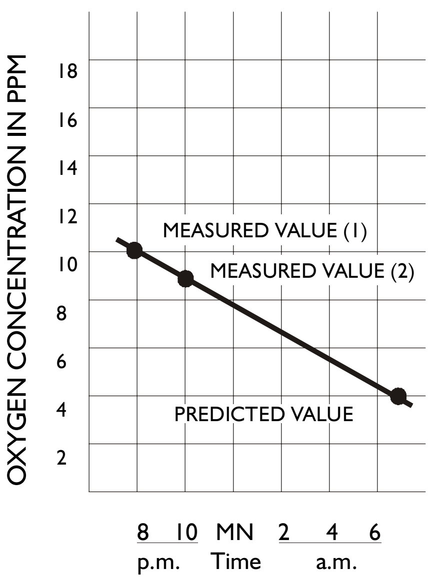


Figure 2. *Graphic method of predicting nighttime oxygen depletions in catfish pond. In this example, it is predicted that no problem will develop in the pond during the night.*

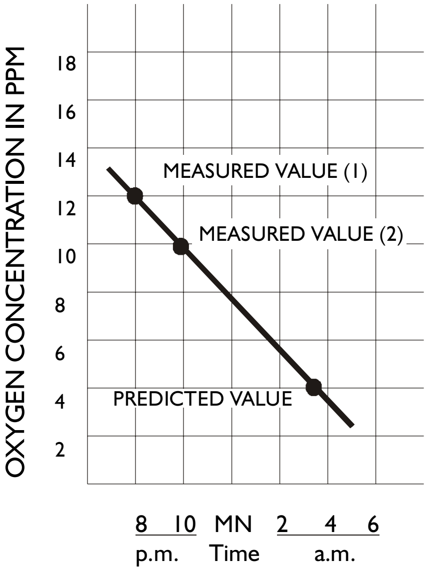


Figure 3. *Graphic method of prediciting nighttime oxygen depletions in catfish pond. In this example, it is predicted that the oxygen concentration will drop to 4 ppm by about 3:30 am, thus indicating that corrective measures should be taken before 3:00 am.*

- **Preventing oxygen depletion**

Turn-overs occur when a pond is allowed to stratify or become layered because of temperature differences. Prevent turnovers by checking oxygen concentration at the bottom of the pond and draining the bottom layer when it becomes devoid of oxygen, or by using a paddlewheel aerator to break up layering before it can become a serious problem.

Algae die off - use an aerator to mechanically add oxygen to the pond.

- **Correcting oxygen depletions**

Pump oxygen rich water from adjacent pond(s) if available. This is the most effective way to provide oxygen to keep fish alive in a pond with oxygen problems.

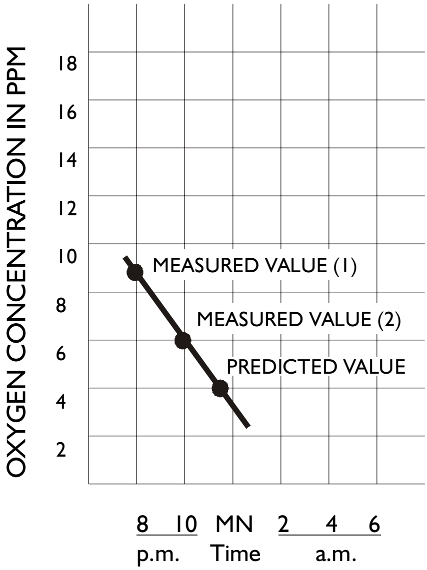


Figure 4.*Graphic method of prediciting nighttime oxygen depletions in catfish pond. In this example, it is predicted that the oxygen concentration will drop to 4 ppm by about 11:30 pm., thus indicating possible corrective measures should be taken before 10:30 pm. Unless emergency measures are taken a severe fish kill will probably occur at about 2:00 am.*

Paddlewheel Aerators - Research has shown that the paddlewheel aerator with a spiraling pattern of paddles is most effective at adding oxygen to the water and most economical in terms of cost per pound of oxygen added.

Depth at which the paddlewheel is placed is also very important. Increasing paddlewheel depth from 4 to 14 inches on a tractor pto-powered paddlewheel aerator tripled the oxygen transfer rate but only increased fuel consumption by about ½ gallon per hour. The power of the tractor, however, will limit the depth at which the paddles can be submersed.

Stationary floating paddlewheel aerator.

The number of paddlewheels to use and the site in the pond where they should be located depends on the situation. Positioning of aeration equipment in a pond is critical. Place equipment in an area where the oxygen concentration is highest. Be sure the fish are in this area and not trapped in another area of the pond. Also, be careful not to strand the fish by removing the aeration device before the oxygen is high enough to support them.

A relatively new type of aerator, the “side-winder” paddlewheel aerator, is oriented to move and spray water parallel to the pond bank.

<u>Other Aerators</u> - Other types of aerators include impeller pump sprayers, fountain aerators and others that draw water from underneath the aerator, aspirators, circulators, and air diffusion aerators. Many of these can be the aerator-of-choice for specific cases; for example, the surface aerators that draw water from underneath are often a good economical choice for small ponds, while impeller pump sprayers that direct water along the shore line where fish congregate during low-oxygen situations are recommended for these emergencies. Circulators are very useful in preventing stratification, thus avoiding low oxygen emergencies.

Paddlewheel aerator powered by tractor pto.

Fountain-like aerator draws water from underneath.

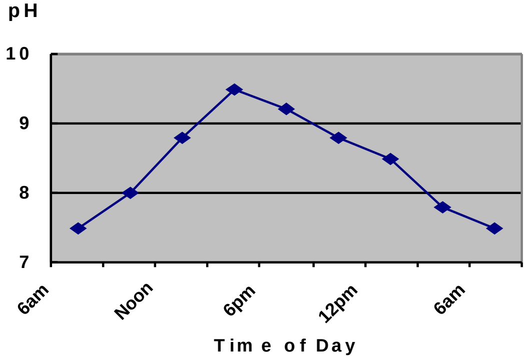


Figure 5. 24-hour pH cycle in ponds

pH

pH is a measurement of the acidity or alkalinity of a substance or the relationship between hydrogen (H^+) and hydroxyl (OH^-) ions.

- pH values always fall between 0 and 14 on the pH scale.

- At pH 7.0 the number of H^+ and OH^- ions are equal and the solution is neutral.

- Values below pH 7.0 denote increasing acidity (H^+ions). Values above pH 7.0 denote increasing alkalinity (OH^-ions).

- Each one unit change in pH represents a 10 fold change in the H^+ ion concentration.

- pH values for a given body of water reflect complex interactions between various types of plants, amount of photosynthesis taking place, basic chemical composition of the water supply, and respiration of the living organisms present. pH 4 and pH 11are the acid and alkaline death points of fish. Optimum pH range for fish culture is about 6.5 to 9.0. pH of pond water has a 24-hour cycle and is changing constantly depending on many factors. In daylight, aquatic plants remove carbon dioxide (CO_2) from the water during photosynthesis so pH increases during the day and decreases at night (**Figure 5**).

- Under normal conditions, the pH is checked only when ammonia is present. This must be done to calculate the amount of toxic un-ionized ammonia in the water.

- pH affects the toxicity of certain chemicals, e.g., Fintrol, (antimycin A), copper sulfate, and ammonia.

Ammonia

Ammonia is present in water in two forms, ionized and un-ionized. The Total Ammonia Nitrogen (TAN) concentration in pond water is the sum of the ionized plus un-ionized ammonia present ($NH_4^+ + NH_3 = TAN$). Nitrogen (N), a major component of protein, is necessary for all life forms. Ammonia gets into a pond in several ways, but the main source is feed. Effective removal of ammonia from the pond depends primarily on biological processes.

(See **Figure 6**)

- **Ionized ammonia (NH_4^+) is non-toxic to fish.**
- **Un-ionized ammonia (NH_3) is toxic to fish.**

The 96 hour LC_{50} varies from 0.4-3 ppm; however, reduced growth and gill damage occur at concentrations as low as 0.06 ppm. The amount of un-ionized ammonia increases in two ways: as the pH increases and as temperature increases (**Table 10**) .

- A level of 1 ppm TAN indicates pollution, and 2-3 ppm is cause for concern. Watch for high ammonia levels after a bloom die-off.

- **There are several sources of ammonia in water:**

1. metabolic wastes from animals and plants. The major source of ammonia in pond water is fish feed. For each 100 pounds of catfish feed fed, about 2.2 pounds of ammonia are being added to the pond.
2. uneaten feed.
3. decaying plants and animals.
4. inflowing water, especially water run-off from a barnyard with livestock.

Table 10. Fraction of un-ionized ammonia in aqueous solutions at different pH values and temperatures.

To determine the amount of un-ionized ammonia present, get the fraction of ammonia that is in the un-ionized form from the table for a specific pH and temperature. Multiply this fraction by the total ammonia nitrogen present in a sample to get the concentration in ppm (mg/l) of toxic un-ionized ammonia present.

	Temperature (°C)												
pH	6	8	10	12	14	16	18	20	22	24	26	28	30
7.0	.0013	.0016	.0018	.0022	.0025	.0029	.0034	.0039	.0046	.0052	.0060	.0069	.0080
7.2	.0021	.0025	.0029	.0034	.0040	.0046	.0054	.0062	.0072	.0083	.0096	.0110	.0126
7.4	.0034	.0040	.0046	.0054	.0063	.0073	.0085	.0098	.0114	.0131	.0150	.0173	.0198
7.6	.0053	.0063	.0073	.0086	.0100	.0116	.0134	.0155	.0179	.0206	.0236	.0271	.0310
7.8	.0084	.0099	.0116	.0135	.0157	.0182	.0211	.0244	.0281	.0322	.0370	.0423	.0482
8.0	.0133	.0156	.0182	.0212	.0247	.0286	.0330	.0381	.0438	.0502	.0574	.0654	.0743
8.2	.0210	.0245	.0286	.0332	.0385	.0445	.0514	.0590	.0676	.0722	.0880	.0998	.1129
8.4	.0328	.0383	.0445	.0517	.0597	.0688	.0790	.0904	.1031	.1171	.1326	.1495	.1678
8.6	.0510	.0593	.0688	.0795	.0914	.1048	.1197	.1361	.1541	.1737	.1950	.2178	.2422
8.8	.0785	.0909	.1048	.1204	.1376	.1566	.1773	.1998	.2241	.2500	.2774	.3062	.3362
9.0	.1190	.1368	.1565	.1782	.2018	.2273	.2546	.2836	.3140	.3456	.3783	.4116	.4453
9.2	.1763	.2008	.2273	.2558	.2861	.3180	.3512	.3855	.4204	.4557	.4909	.5258	.5599
9.4	.2533	.2847	.3180	.3526	.3884	.4249	.4618	.4985	.5348	.5702	.6045	.6373	.6685
9.6	.3496	.3868	.4249	.4633	.5016	.5394	.5762	.6117	.6456	.6777	.7078	.7358	.7617
9.8	.4600	.5000	.5394	.5778	.6147	.6499	.6831	.7140	.7428	.7692	.7933	.8153	.8351
10.0	.5745	.6131	.6498	.6844	.7166	.7463	.7735	.7983	.8207	.8408	.8588	.8749	.8892
10.2	.6815	.7152	.7463	.7746	.8003	.8234	.8441	.8625	.8788	.8933	.9060	.9173	.9271

- **There are two forms of un-ionized ammonia toxicity:**

acute - causes impairment of brain energy metabolism.

chronic - damages gills, affects uptake of oxygen, affects salt balance, damages organs, and increases susceptibility to disease.

- **Correct ammonia problems in these ways:**

Lower the pH - (usually not economically feasible).

Choose a lower feeding rate for long term (gradual) reduction of ammonia concentration.

Flush pond - this does not remove the ammonia but does provide a diluted area where the fish can go until the problem is corrected.

Insure adequate oxygen is available during the period of high ammonia.

Add 20 pounds of triple super phosphate (0-46-0) per surface acre. Since phosphorus is the limiting factor in the use of ammonia by plants, the addition of phosphorus will stimulate algae growth, thus removing ammonia in the water in 2 to 3 days. Remember, however, that the increased algae bloom can lead to oxygen problems and the pond must be watched closely. Treating ammonia in this manner should probably be avoided during the summer.

■ Check ammonia concentrations every week during spring, summer, and fall.

Nitrite

Nitrite (NO_2) causes ***brown blood disease***

■ Nitrite is normally not present in natural water. Build-up of nitrites in water is due to a breakdown in the nitrogen cycle prompted by an abundance of nitrogen entering production ponds by way of feed protein.

■ Nitrites are taken in across the gill membranes and are tied up with hemoglobin (the oxygen carrying part of blood) forming a compound called methemoglobin which cannot transport oxygen. The blood turns brown, giving the fish brown blood disease. Fish act as if they are suffering from an oxygen depletion.

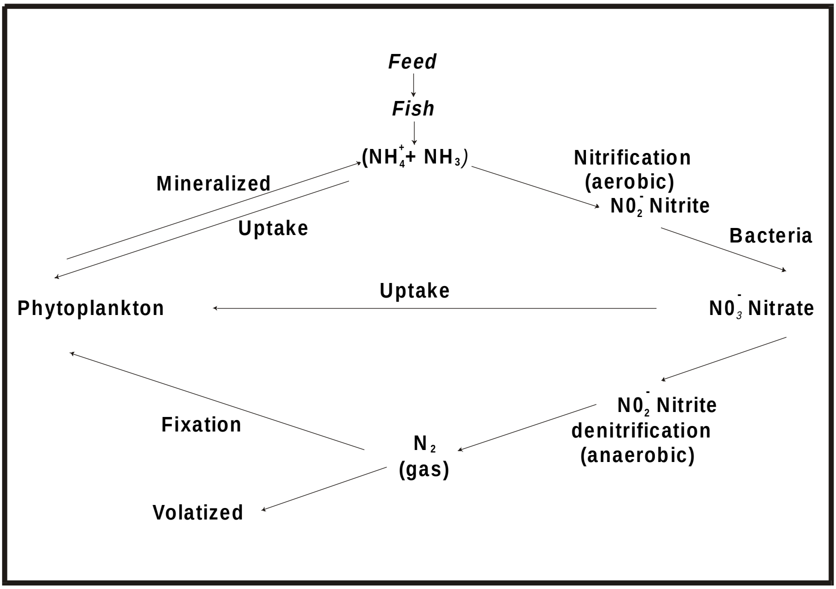


Figure 6. Nitrogen cycle

■ The amount of nitrite toxic to catfish depends on the amount of chlorides present in water and oxygen concentration. Nitrite concentration as low as 0.5 ppm can cause problems.

■ Chlorides (Cl^-) protect fish from nitrite toxicity. The ratio of chloride to nitrite needed to protect fish is about 10:1. If you find nitrites in pond water, check the chloride concentration to determine the amount of chloride to add to the pond.

Use the following formula to calculate the concentration of chloride (Cl^-) needed for treatment.

Concentration of chloride needed = (10 x N) - C

where:

concentration of chloride in ppm in water = C

concentration of nitrite in ppm in water = N

10 to obtain the desired 10:1 ratio of chloride to nitrite

Example:

Chloride in pond water = 17ppm

Nitrite in pond water = 7 ppm

Thus , Chloride needed = (10 x 7) - 17 = 53 ppm, the concentration of chloride to add to the pond..

There are three different forms of chloride that can be used as a pond treatment for brown blood disease: sodium chloride (NaCl), anhydrous calcium chloride ($CaCl_2$) or dihydrous calcium chloride ($CaCl_2 \cdot 2H_20$). The amount of each of these required to give 1 ppm chloride per acre foot of water is:

Sodium chloride (NaCl) = 4.5 lb

Anhydrous calcium chloride ($CaCl_2$) = 4.3 lb

Dihydrous calcium chloride ($CaCl_2 \cdot 2H_20$) = 5.6 lb

To calculate the amount of sodium chloride to add to a pond, you would use the formula

Acres x average depth x ppm chloride needed x 4.5 pounds of salt/acre-foot/ppm.

Using the above example, if 53 ppm chloride were needed in a one-acre pond that averages 4 feet deep, calculate the pounds of salt (NaCl) needed as follows:

1 acre x 4 feet x 53 ppm chloride x 4.5 pounds of salt/ac-ft/ppm = 954 pounds of salt, or about 1/2 ton of salt.

- Catfish that have some infectious disease are much more susceptible to brown blood and require a higher chloride concentration for protection. Therefore, a 15:1 chloride : nitrite ratio should be used if the catfish have an infectious disease present.

- Nitrites are usually more of a problem during the cool months but can occur at any time. Therefore, you should check all ponds at 2 to 3 day intervals because nitrites can increase to toxic levels very rapidly. If nitrites are present, it is necessary to check for chlorides.

- Many farmers maintain a protective concentration of chloride in their ponds of around 30 to 100 ppm in case the nitrites increase suddenly.

Total Hardness

Total hardness is a measure of the total concentration of divalent metal ions, usually calcium (Ca^{++}) and magnesium (Mg^{++}), in water and is expressed in ppm (mg/1) of equivalent calcium carbonate.

- Desirable range is from 20 to 300 ppm.

- Concentration less than 20 ppm may cause problems in hatcheries but can be corrected usually by adding calcium in the form of calcium chloride ($CaCl_2$).

- Water with a total hardness higher than 300 ppm (mg/1) can cause some management problems, but there is no practical way to reduce total hardness to desirable levels.

Prevention

Preventing fish diseases from occurring is much more effective for avoiding losses than waiting until fish start dying and then trying to "put out the fire" with chemical or medicated feed treatments. Stress caused mainly by excessive stocking densities or poor water quality is the main cause of fish diseases. Experienced growers should not exceed about 6,000 food fish per acre when aeration is available or 150,000 catfish fingerlings per acre. A classic example of over-stocking is the fingerling producer who gets a larger-than-expected hatch and runs out of pond space for his fingerlings. Some have stocked as many as one or two million per acre as small fry; as they become fingerlings of a few inches in length, they are very crowded and commonly acquire heavy loads of gill flukes which may lead to high mortalities. Channel Catfish Virus Disease as well as bacterial infections also occur more readily in crowded ponds.

Routinely monitoring water quality and taking corrective action when needed also prevents fish diseases. Dissolved oxygen concentrations below 4 ppm as well as toxic ammonia concentrations above 0.4 ppm and nitrite levels of 0.5 ppm or higher can all lead to stress, causing disease either immediately or several days after the exposure.

Disease can be defined in many terms, but perhaps the easiest is that disease is any process than can cause a fish discomfort and can lead to death. Diseases can be broken down into two broad categories, infectious and non-infectious.

Infectious diseases (caused by a living organism)

■ Parasite. An organism that lives in or on another at the expense of its host is a parasite. There are many different kinds of parasites, both internal and external, ranging from the very small to some that are 5-6 inches long. Most problems are caused by protozoans (single-cell animals) that live on the gills.

Trichophrya is a protozoan parasite It has tentacles appearing like pins struck into a pin cushion.

■ Bacteria. There are many different kinds that can cause serious losses of catfish. They can be internal or can occur on the skin and gills. Specialized laboratory techniques are necessary for their isolation and identification.

Enteric Septicemia of Catfish (ESC) is caused by the bacteria *Ewardsiella ictaluri*.

■ Fungi are a specific group that lack chlorophyll and are mainly secondary invaders of fish. Usually they can grow only on dead organic matter and often indicate there is something else wrong with the fish. Winter Fungus Disease (*Saprolegniasis*) however, is caused by an active invasion of the fish by fungus.

Winter Saprolegniasis (fungus).

■ Viruses. Submicroscopic particles that live within the cells of living organisms are called viruses. Sophisticated laboratory techniques are required for diagnosis. Their location makes them almost impossible to treat with chemicals or drugs.

Non-infectious diseases

(causes other than living organisms)

■ Nutritional. Caused by too much or too little food or by the use of old food. Vitamin deficiencies in the food can also lead to nutritional disease.

■ Environmental. Oxygen depletions, gas bubble disease, toxic algae, brown blood disease, ammonia, etc. The environment changes so rapidly or to such a degree that the fish are not able to adjust to the changes.

■ Chemical toxicants. Pesticides, overtreatment.

Symptoms or Clinical Signs of Disease

Appearance or actions can indicate the fish is not normal. Usually the first indication that fish may be sick is a reduction in feeding activity. It is, therefore, very important that the person feeding the fish be an experienced fish culturist to detect any change in feeding behavior. Any unusual behavior or abnormal physical appearance should be a "red flag" that something is wrong and should be checked immediately. Failure to do so could result in the loss of some or all of the fish in the pond.

- Physical - external and internal. You must know what normal fish look like to be able to tell if abnormalities are present. Here are some abnormalities to look for:

  sores
  discolored areas
  bloody spots, external and internal
  frayed fins
  popeye (exophthalmia)
  curved backbone
  swollen belly
  pale internal organs

- Behavior. You must know how normal fish act. Here are some abnormal behavior patterns to look for:

  listless
  reduced activity
  piping or gasping (anoxia, lack of oxygen)
  flashing or scratching
  convulsions or erratic behavior
  grouping in shallow water
  grouping around in- or outflowing water
  death

The video and DVD, *Diseases of Warmwater Fish*, are available from Kentucky State University, Communications Department in Frankfort. Phone (502) 597-8103. It can help the viewer identify and become familiar with fish diseases.

The following Southern Regional Aquaculture Center (SRAC) information sheets are also helpful for learning about catfish diseases in more detail:

- Proliferative Gill Disease (Hamburger Gill Disease), SRAC pub. no. 475,
- Ich (White Spot Disease), SRAC pub. No. 476,
- ESC - Enteric Septicemia of Catfish, SRAC pub. no. 477,
- Aeromonas Bacterial Infections – Motile Aeromonad Septicemia, SRAC pub. no. 478, and
- Columnaris Disease – A Bacterial Infection Caused by *Flavobacterium columnare*, SRAC pub. no. 479.

These publications can be obtained from your closest Land Grant University or on the Internet at
http://www.msstate.edu/dept/srac/publicat.htm
Click on fact sheets.

Stress

Stress is the inability of fish to adapt to change. There are several causes of stress:

- Dissolved oxygen. Minimum of 4 ppm; maximum not to exceed 150 percent saturation for 4-6 hours.

- Water temperature. Minimum 33°F (0.6°C), maximum 120°F (48.9°C). Don't allow a rapid increase or decrease in temperature;

fish must be acclimated to new temperatures.

Temperature dependence of diseases - Each disease organism has an optimum growth temperature.

Temperature dependence of host immune system - Effective immune response is hindered by temperatures that are too high or too low.

Immunity is efficient at temperatures between 75° and 90°F and is most efficient at about 86°F (30°C). Cool temperatures of spring, fall and winter leave fish with a compromised immune system especially when rapid cooling occurs.

Temperature affects the toxicity of certain chemicals added to fish ponds.

■ pH. Ideal pH is between 6.5 and 9.0; pH of 5 or lower and 10 or higher cause fish to eat less and convert feed to flesh less efficiently. pH values of 4 or below and 11 or above are the acid and alkaline death points. Ammonia becomes more toxic at a high pH and less toxic at a low pH. Copper sulfate on the other hand is more toxic at a low pH than at a high pH.

■ **Nutrition.**

lack of vitamins

lack of essential amino acids

excess or lack of protein, fat carbohydrates or minerals

■ **Improper feeding practices**

feeding during low oxygen and/or the wrong time of day

feeding prior to transport

- **Handling**

  rough handling

  holding too long in confinement

- **Chemical toxicants**

  improper dosage used in treatment

  improper chemicals used in treatment

  improper application of chemical treatment

  accidental application of agricultural chemical residue in soil or feed

- **Poor water quality**

  increase in number of disease organisms

  reduced ability of fish to resist infection

Disease Treatments

Before treating any fish, consider the following questions and decide whether or not treatment is warranted:

1. What is the prognosis? Is the disease treatable, and what is the possibility of a successful treatment?
2. Is it feasible to treat the fish where they are, considering the cost, handling, prognosis, etc.?
3. Is it worthwhile to treat, or will the cost of treating exceed the value of the fish?
4. Can the fish withstand the treatment considering their condition?
5. Does the loss rate and the type of disease warrant treatment?

Before any treatment is started,
know the following four factors:

- **Know your water.** Know the volume of water of the holding or rearing unit to be treated, and know the chemical and physical properties of the water before treating.
- **Know your chemical.** Know the toxicity of the chemical to the particular species of fish to be treated. The effect of water chemistry on the toxicity of the chemical should also be known.
- **Know the disease.** Although this factor appears to be self-evident, it is one which is widely disregarded. Submit a good fish and water sample to a qualified fish health professional.
- **Know the fish.** Certain fishe species are mor sensitive to some of the chemicals used for disease treatment.

Submitting a Sample for Fish Disease Diagnosis

When fish kills or disease outbreaks occur on a catfish farm, it is usually an emergency situation. To optimize the responses to a fish kill, producers should be prepared in advance.

How can I best be prepared for a fish kill or disease problem?

To minimize fish losses, the following preparations should be made

- Have a water quality test kit and know how to use it;
- Know the telephone number and address of the fish disease diagnostic laboratory in your area;
- Call the laboratory & inquire about how they prefer samples to be shipped & what days & times samples can be delivered;
- Know how to collect appropriate samples;
- Have the type of container(s) needed to ship samples; and
- Determine the best method of transportation (personal delivery, bus, air freight, overnight express) and schedule that will ensure prompt delivery.

How can I determine if I have a water quality problem?

Poor water quality can cause massive fish kills and is often a major factor contributing to fish disease and parasite infections. Water quality does not remain constant. In ponds, it can change dramatically over a few hours. Even water from deep wells and springs can change over time. Commercial fish farmers should not rely on diagnostic laboratory results to identify water quality problems. It is extremely important and cost effective to have a water quality test kit, know how to use it, and be able to interpret the results. Water quality should be monitored routinely to identify problems before fish kills occur. In addition, any time fish appear stressed or fish mortalities are observed water quality should be evaluated immediately for dissolved oxygen, total ammonia, pH, and nitrite. Other tests may be appropriate depending on results of the initial screening.

What type of sample should be submitted for evaluation?

In most instances live, sick fish and a water sample are required to have a high probability of determining the cause of a fish kill. An excellent sample would include several (three to six) live fish that exhibit obvious physical disease signs such as:

- open sores
- yellowish or light-colored, slightly eroded areas on the body, fins, gills, or in the mouth;
- swollen gills; or
- eroded or bloody fins.

An excellent sample would also include fish exhibiting abnormal or unusual behavior such as lying listlessly in shallow water or at the water surface or swimming erratically or in circles. Recently-dead fish that have gills, eyes, color and mucus that still appear as those of live fish are fairly good samples if live sick fish are unavailable.

Dead fish that have floated to the surface of a pond are useless for diagnostic purposes. It is difficult to tell if the bacteria found in the dead fish were responsible for its disease condition.

A water sample should be submitted to the diagnostic laboratory along with the fish sample. A water sample without fish, however, is usually of little value in determining the cause of a fish kill. Sometimes, however, toxic fish waste products such as ammonia and nitrite are responsible for the death of the fish.

What is the best method to collect sick fish?

The best method for collecting sick fish is to walk around the pond bank with a dip net or cast net and selectively remove fish which are at the surface, at the water's edge, or otherwise appear abnormal. It may take extra effort to find and catch sick fish in this manner, but the quality of the resulting information will be well worth it. A random sample of fish taken from a seine has a poor probability of identifying the cause of the fish loss, because most of the fish in the pond are probably healthy. The worst way to collect sick fish is by hook and line. Sick fish usually do not eat; the healthiest fish in the pond will still be actively feeding. Therefore, the use of a rod and reel to collect fish will result in a sample of the most healthy fish, which will be of little or no diagnostic value.

How many fish and how much water should be included in the sample?

Ideally, a minimum of three to six sick fish should be submitted for examination. If only one fish is submitted it is possible that an inaccurate or incomplete diagnosis will result; one fish is usually not completely representative of a population. Most fish disease outbreaks involve more than one problem. Therefore, a representative sample is essential for good management decisions.

A one-pint water sample should be collected from the pond for analysis. Dissolved oxygen should be checked by the producer at the pond bank; this parameter cannot be accurately measured at the laboratory. ***Do not combine fish and water in the same container.***

What containers are best for shipping samples to a diagnostic laboratory?

Ideally, sick fish should be transported live. If the diagnostic lab is within an hour's drive, sick fish can be transported in a container of water. Sick fish can also be shipped live in a plastic bag with water and oxygen for several hours. The bag is sealed and is placed in an insulated shipping box with ice to keep the water temperature cool. For longer shipping times, sick fish or fish that have just died should be placed in a plastic bag (without water), and transported with ice packs (or a large amount of ice) in a cooler or Styrofoam lined shipping box. Make sure that the container is thick enough to not break in the mail carrier's truck, allowing the melted ice to leak from the container (most ice chests purchased at convenience stores are too thin). It is usually best to use next day delivery service to avoid delays that could render your sample useless to the laboratory. Sick or recently dead fish can be frozen and used for bacterial cultures but are of little value for parasite identification on skin, fins, and gills.

Water samples can be collected in any clean glass or plastic jugs or jars. The water sample, of at least a pint in volume, should be transported on ice with the fish sample.

What information should be provided with the samples?

The following information should be included with each sample submitted to a fish disease laboratory.

1. Name, address, and phone number of the owner of the fish.
2. Name or designation of pond or tank from which fish were removed. (Note: Fish collected from different ponds or tanks should be labeled and put in separate plastic bags and accompanied by a water sample from each unit.)
3. Dimensions of pond or tank, including depth.
4. Species, number, and average size of fish stocked.
5. Date when fish were last stocked (include number, species, and size stocked).
6. Amount fed per day. (Are fish still eating? If not, when did they stop eating?)
7. Date when mortalities were first noticed.
8. Number of fish that have died per day since mortalities were first noticed.
9. The most recent treatment used, including treatment date and amount of chemical used.
10. Any water quality information collected by the owner.

Information

For more details on fish diseases, please refer to Southern Regional Aquaculture Center (SRAC) publications 472 (Submitting a Sample for Fish Kill Investigation), 473 (Use of Medicated feed in Food Fish) and 474 (The Role of Stress in Fish Diseases). A list of disease diagnostic laboratories in the southern United States follows on page 109.

Occurrence of Weed Problems

Some plant life will always be present in catfish ponds, but the type of aquatic plant community that becomes established in a pond depends on the relative abilities of particular plants to compete for resources. The growth of phytoplankton is favored in waters with high concentrations of nitrogen, phosphorus, and other plant nutrients dissolved in the water. Phytoplankton are efficient at using dissolved nutrients and reproduce rapidly. Once established, the phytoplankton community competes effectively for nutrients and also restricts the penetration of light so that aquatic weeds that germinate on the bottom do not receive enough light to continue growing.

Rooted submersed aquatic weeds tend to establish in ponds with low supplies of nutrients in the water. These ponds often are clear with light penetrating to the bottom, and rooted plants can use the nutrients in the bottom muds for growth. Established stands of submersed weeds compete for nutrients and light and prevent phytoplankton from becoming established. Some submersed plants also produce chemicals that inhibit the growth of phytoplankton.

Emergent plants usually colonize only the margins of ponds where the water is less than 2 ½ feet deep. If the levees or banks of the pond are eroded and have large areas of shallow water, expansive growth of emergent plants may be present. Emergent plants are rooted and can use nutrients in the mud. Thus, their establishment is also favored by low nutrient levels in the water.

Many weed problems are found in fry nursery ponds. Nursery ponds have more weed problems because they are managed differently than food-fish pond. Food-fish ponds contain large numbers of fish and receive large amounts of feed. This results in high concentration of plant nutrients in the water which favors the growth of phytoplankton. Food-fish ponds are rarely drained and once the phytoplankton community is established, it remains the dominant plant form in the pond year after year. Fry nursery ponds are usually drained every year and refilled with water in late winter or early spring so they will be ready for stocking with fry in late spring or summer. Nursery ponds receive no feed for several weeks before stocking. This results in clear water with low nutrient levels, and this favors the growth of rooted submersed weeds such as *Najas* spp. or filamentous algae such as *Chara* spp.

Prevention of Aquatic Weeds

Certain management procedures can be used to minimize the chances of infestations of submersed and emergent plants and filamentous algae. Such procedures should become part of common pond management and may help avoid the use of chemical control measures.

Pond construction

Most noxious weed growth starts in the shallow (less than 2 ½ feet) areas of ponds. If the area of the pond where light can penetrate to the bottom is reduced, rooted plants have less chance to become established. Every effort should be made to minimize the shallow areas of the ponds by increasing the slope of the pond margin as much as is practical. (Please refer to levee width and slope section on page 34). Ponds should also have an adequate supply of water so they can be filled quickly.

Refilling an empty levee pond

A pond full of clear water with no nutrient input will quickly be colonized by nuisance weeds. It is easier and less expensive to disc under terrestrial plants that may start growing in the empty pond bottom than it is to rid a pond of submersed weeds. If a pond must be filled well in advance of stocking, it should be fertilized to encourage a phytoplankton bloom. Also grass carp may be stocked to prevent growth of nuisance weeds. When the pond is to be filled, it should be flooded as quickly as possible. It is better to fill ponds one at a time rather than to slowly fill several ponds at once from a common water supply. By increasing water depth as quickly as possible, plants that grow up from the pond bottom have less chance to become established. If the supply of water is limited and logistics allow, ponds should be filled in winter. Many higher aquatic plants are dormant or grow slowly in cold water allowing for the development of a phytoplankton community that will shade the water and prevent weed growth when the water warms.

Fertilization

The implementation and continued use of the proper fertilization program is perhaps the best method of preventing the growth of troublesome weeds in fry nursery ponds. To avoid weed problems, establish a phytoplankton bloom as quickly as possible after filling the ponds. The best way to do this is to add inorganic fertilizers to the pond.

The key ingredient in fish pond fertilizers is phosphorus. The most common phosphorus source in bagged, granular fertilizers is triple superphosphate (0-46-0); however, this is not an efficient form of phosphorus for fish pond fertilizers. When triple superphosphate is broadcast over ponds, it settles to the bottom because the granules are very insoluble. Most of the phosphorus reacts with bottom muds and never reaches the water. Granular fertilizers should be put on an underwater platform or in a porous container such as a live minnow holder so they can dissolve slowly into the water before they contact the mud bottom.

Liquid fertilizers are more effective than granular fertilizers at stimulating a phytoplankton bloom, especially in hard, alkaline water. The phosphorus in liquid fertilizers is already in solution and immediately available for uptake by the phytoplankton.

The most common, and best, analysis for liquid fertilizers runs from about 10-34-0 to 13-38-0. This general analysis of about three times as much phosphorus (expressed as P_2O_5) as nitrogen (expressed as N) has been found to have an excellent balance. The rate used successfully by commercial catfish producers in Mississippi is about 1 quart per acre applied every other day for about 4 applications. Liquid fertilizer is heavier than water, so it should first be diluted in water before it is applied to the pond, preventing it from sinking into the bottom muds. It can be sprayed from the bank or applied from a boat outfitted for chemical applications.

Manual harvesting

Removing potentially noxious emergent weeds by hand is another management practice that may reduce the possibility of having to use chemicals. As small areas of the pond margin become infested, plants are removed manually. Manual harvesting of weeds is only suited for controlling emergent vegetation in relatively small ponds. Care should be taken to remove as much of the rootstock or rhizome as possible to minimize regrowth. Mechanical removal of filamentous algae or submersed plants almost always proves to be futile.

Biological Control of Aquatic Plants

Biological weed control in catfish ponds involves the use of fish to consume unwanted aquatic vegetation. Several fish species have been evaluated as biological control agents in warmwater ponds. These fish include the grass carp, common carp, and tilapia. They are most often used to control submersed plants or filamentous algae. With the exception of the grass carp, all these fish have undesirable characteristics that make their use impractical in commercial catfish ponds.

The grass carp or “white amur” was introduced into the United States from southeast Asia in 1963 and is now widespread especially in the southeastern states. The fish is banned in more than 30 states and some states allow only sterile, triploid grass carp. Where legal and available, this fish is a valuable tool to control nuisance aquatic weeds.

The controversy over the distribution and use of grass carp is based on the potential effect of this fish on native fish and wildlife. Considerable discretion should be used when planning to stock these fish into catfish ponds and every effort should be made to prevent their escape into natural water. To further diminish the likelihood that grass carp will reproduce and thrive in natural water, it is required by Kentucky law that only sterile, triploid carp be used in the state.

The grass carp has several traits that make it a good species to polyculture with channel catfish. Small grass carp (less than 1-2 pounds) are almost completely herbivorous and will not compete to a significant degree with catfish for feed. Grass carp tolerate a wide range of environmental conditions: they can survive at water temperatures of 33° to 105°F and are nearly as tolerant as catfish to low dissolved oxygen concentration. The fish grows rapidly, as much as 5 to 10 pounds a year. It must consume large quantities of plant material to grow and may consume 2 to 3 times its weight in plant material per day.

Grass carp prefer to eat succulent submersed plants such as *Najas* spp. and *Chara* spp. Fibrous plants such as grasses and smartweed are less preferred and grass carp will not eat these plants if more preferred plants are available. Food consumption by grass carp is greatest at a water temperature of 80° to 85°F, and the fish stops feeding when the temperature falls below about 55°F.

Grass carp should be stocked into nursery ponds prior to stocking the catfish fry to prevent weed growth rather than waiting until weeds develop to treat the problem. Fry nursery ponds usually are drained each year and grass carp must be restocked each year.

Grass carp also are used by some catfish producers to control existing weeds in food-fish ponds. However, considerable time is required for grass carp to reduce weed infestations, particularly if coverage is extensive. Results may take a year to be realized. Food-fish ponds are usually not drained each year and grass carp become a permanent inhabitant of the ponds. Larger grass carp learn to feed on pelleted feeds and often do little to control weeds in the second or third year they are present. Usually weed problems have been controlled by this time and a phytoplankton community has developed which prevents further weed growth. As the catfish are harvested, any grass carp also captured in the seine can be removed.

The stocking rate of grass carp depends on the severity of the weed problem. When used to prevent the establishment of submersed weeds, 5-10 small (3-6 inch) carp per acre should be stocked. The same stocking rate is also adequate if the pond is lightly infested with weeds. For more severe weed problems, 10-15 fish per acre should be stocked. For heavily weed infested ponds, stocking rates can be increased to 15-25 per acre or greater. Grass carp must be stocked at a size large enough to prevent them from being eaten by predator fish such as bass and large catfish.

Chemical Control of Aquatic Plants

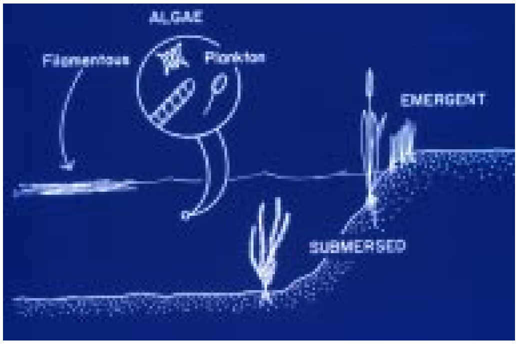
Control of aquatic weeds with chemicals is the most common means of eradicating weeds in catfish ponds. In cases where prevention measures have not been taken and weeds become established, it is usually quicker and more effective to use herbicides than any other method. A high percentage of the time, however, even chemical treatment fails to eradicate established weed problems.

Many different herbicides have been used in and around water. Most of these are illegal to use in water that constitute a “fishery” and even fewer can be used in waters used to raise food fish. Only herbicides labeled for use in food-fish ponds should be used by catfish farmers, and label instructions should be followed carefully. Skin and eye protection should be worn when working with all chemicals to prevent absorption into the body.

The following table, (**Table II**) summarizes the type of weed and the herbicides used to control them. In a short-cut approach to choosing an appropriate herbicide for a particular weed one can, first of all, categorize weeds into 4 separate groups: Algae, Submersed Weeds, Emergent Weeds, and Floating Weeds.

Table 11. Prefered herbicides for controllong aquatic weeds.

WEED	HERBICIDE
Filamentous Algae (excluding Pithophora)	Copper Sulfate or Chelated Copper
Pithophora	Hydrothol 191
Submersed Weeds	Reward or Aquathol or Aquathol K
Emergent Weeds	Rodeo or 2, 4-D liquid
Floating Weeds	Reward or 2, 4-D liquid



Algae and weed types in a pond.

Most algae can be controlled by copper-based herbicides such as copper sulfate. The filamentous algae *Pithophora*, however, is not controlled by copper compounds; it requires Hydrothol 191. *Pithophora* feels like wet wool as opposed to most other filamentous algae which feel slick and slimy (often *Spirogyra*). The other major algae weed problem is muskgrass or *Chara* which has a garlic or skunk-like odor when crushed. Copper-based compounds can be used to control *Chara*.

Pithophora is a filamentous algae.

Submersed weeds are mostly underwater with leaves, blooms, and stems sometimes breaking the water surface. They include *Najas* and other types of pondweed. Submersed weeds are controlled by either Reward or Aquathol or Aquathol K.

Heavy pondweed growth.

Emergent weeds which include smartweed, cattails, and willows are rooted in the pond bottom and emerge prominently from the water. Rodeo or 2,4-D liquid work well in controlling emergent weeds.

Smartweed is an emergent weed.

Floating weeds float on the water surface and have relatively shallow roots suspended in the water column but not rooted in the pond bottom. Duckweed and watermeal are common floating weeds; they are controlled by Reward or 2,4-D liquid.

Duckweed floats on the ponds surface

Harvesting

Methods and Considerations

Different methods can be used successfully to harvest fish. The method used depends on the production system, type of pond and harvest strategy. Fish can be harvest by fishing, trapping or seining.

On commercial farms, seining is the most efficient method to harvest a predictable large volume of fish with one effort. For hill or watershed ponds with deeper water, and irregular bottoms and banks, partial harvesting can be done by trap-seining using various techniques. Trapping fish with a seine is best accomplished when fish are feeding well and ponds are several acres and larger. Fish can become wary of this method and difficult to catch unless it is used infrequently (only once every week or longer). In small ponds, large lift nets with centrally located feeding rings have been somewhat successful when used infrequently. Many producers use a seine to harvest only the market-sized fish from levee ponds that have graded bottoms. This method is often referred to as topping and became popular in the 1970's. A seine with a selected mesh size is used along with other grading devices to capture fish of a desired minimum size; smaller fish remain in the pond.

The only way to harvest all fish from a pond is by draining. When complete harvesting is desired, fish are removed by seining and the few remaining fish are harvested by dipnetting. Harvesting the last remaining fish (scraping out) from a pond is time consuming, especially if many pot holes or low areas exist in the pond basin. Draining ponds and refilling means lost feeding days and a fuel bill if pumping is required.

A big decision is whether to purchase harvesting equipment or pay for a custom harvesting service if it is available. That decision is best determined by an economic analysis of the situation. The annual ownership cost of harvesting equipment can be excessive for small farms with infrequent harvesting. Labor shortages may also be a problem.

The purchase of a seine only, without other high cost equipment, is often satisfactory for small farms. Large farms often have their own harvesting crews and equipment because of frequent harvesting and available labor. Levees and roadways need to be large enough for travel by large trucks. Gravel on the main levees helps to make harvesting in poor weather possible.

Using a seine net to harvest a small pond by hand

Equipment and Procedures

The equipment required for pond seining depends on the size of pond, pounds of fish harvested, and cost and labor considerations. For trap-seining, a seine about 150 to 200 feet long and six to eight feet deep should be used. Locate the seine in an area that has water less than four feet deep and is smooth and unobstructed. Stretch the seine parallel to and away from the bank by about 50 feet. Coil about 50 feet of the seine at each end and connect a rope from each end to a stake on the bank. Feed in the area between the bank and seine until fish are feeding well in the trapping area. Some feed placed outside the catch area can help lure wary fish. Harvest fish anytime many fish are feeding in the trap area by pulling both ends of the seine to the bank. Feed fish at the time of day that trapping is desired, and move slowly to avoid scaring fish out of the area. Pull in the seine, making sure to keep the mud line on the bottom or many fish can escape. At least two people are required to operate a seine trap.

Fish often do not resume normal feeding until several days after trap-seining. Harvesting small numbers of fish a few at a time may be achieved by use of trot lines or by snagging fish from the deep end of the pond using two treble hooks attached to a fishing rod line.

More equipment is involved to harvest catfish from ponds five to ten acres and larger. Long seines (>200 to 300 feet) are difficult to pull because of their weight and dragging action on the pond bottom. A tractor is used to pull each end of the seine. With this procedure, ponds should have a regular shape, levees should be at the same elevation & banks cleared of high grass, weeds or trees.

A heavy duty commercial harvesting seine is required. Seines made of nylon should be treated with a net coating to prevent catfish spines from hanging in the seine. Polyethylene seines require no coating treatment. The seine should be about 1.5 times as long and deep as the width and depth of the pond. A mud line or bottom-line rollers are recommended to lessen digging into the bottom. A device (bracket or catch bar) mounted on the bow of a boat can be used to push the seine and dump mud as it accumulates. The mesh of the seine should be sized to catch the smallest desired fish. Refer to **Table 12** for information on recommended mesh sizes for catfish of different sizes.

One tractor pulls a hydraulic-operated seine reel mounted on a two-wheeled trailer that stores and reels the seine. The two tractors pull the seine in a zigzag manner to prevent tight stretching of the seine. While the seine is being pulled, a person should be walking the seine along the toe of the levee to prevent the seine from rising off the bottom, allowing fish to escape. The boat can be used to push the seine with a catch bar and herd fish in the direction the seine is pulled. Fish should be harvested near the water inlet and preferably in water at least three feet deep.

Crowded fish can be put into live cars or socks for further grading or holding. These special nets can be attached and detached from the harvesting seine using a loading frame and drawstrings. Fish are easily harvested from live cars with loading baskets. Fish can also be further crowded and graded using shorter cutting seines of various mesh sizes. The cutting seine is pulled inside of the larger harvesting seine. Both methods work well.

Once fish are crowded into live cars or seines, good water quality must be maintained during holding. Seines can be held in place with seine support rods ("dead men"). Pumped well water or an aerator should be used to maintain good water quality at all times. If an aerator is used, then stake the seine securely to prevent the aerator current from rolling up the seine.

A live car or sock holds fish and allows them to grade.

Table 12. Seine mesh size needed to retain catfish of various sizes

Square Mesh Size (in inches)	Holds Fish Larger (or Equal to)
2	2 pounds
1 7/8	1 3/4 pounds
1 3/4	1 1/2 pounds
1 5/8	1 pound
1 1/2	3/4 pound
1 3/8	1/2 pound
1	5 ounces

Note: Fish are more difficult to grade in cool water. More time is required for grading. Larger mesh sizes reduce the chance of harvesting undesirably small fish.

In small ponds, seined fish can be harvested from ponds by dipnetting them into large tubs or plastic fish baskets that are carried to a vehicle. In large, commercial ponds, crowded fish are loaded into a fish basket by scooping the basket into the fish or by dipnetting. The basket is attached to a hydraulic boom and in-line scales are used to record fish weights. The boom can be mounted on a truck, or a strong metal pole can be chained to a lift on a back hoe. Fish are unloaded from the fish basket directly into compartments in fish tanks for delivery to the market destination.

Fish handle best in cool weather, so it is desirable to avoid harvesting and handling fish during the summer. Also, at cooler water temperatures, fish grade slower. Consider using a larger mesh seine during cool temperatures to minimize the harvest of smaller fish that should not be harvested.

Transporting

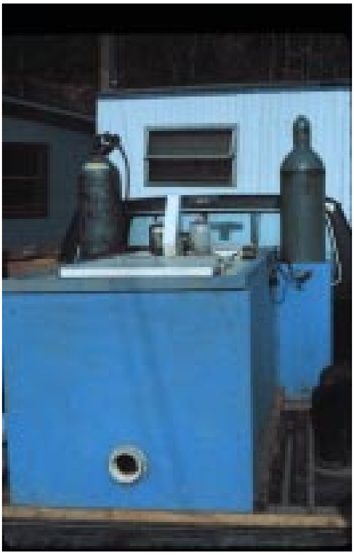
Catfish, like other livestock, are sensitive to changes that occur when they are handled. Transportation stresses fish due to crowding, changing temperature conditions, and general over excitement from handling. Fish may become spined or water quality conditions can quickly deteriorate. Fish have to be in good condition and healthy before they are transported. Sick or weak fish will probably die, or a disease problem will worsen. Fish not handled properly may develop a disease or die one to seven days after they are transported. This delayed reaction is common.

This fish hauler has multiple hauling tanks

The following steps should be taken to prepare fish for hauling. Do not feed fish for at least two to three days in the summer and four to five days in the winter before they are transported. Fish with full stomachs handle poorly, and any regurgitated food or expelled fecal matter fouls the hauling water.

Fish should be hauled at cool water temperatures to lower their metabolic rate, calm them and lower their oxygen consumption. In summer, fish should be hauled in water 60° to 65°F, and in winter, in water 45° to 50°F. Use ice or cool well water to lower the temperature during summer, and use well water or sunlight to warm water during winter. About one-half pound of ice per gallon water is required to reduce the water temperature about 10°F.

Fish should not be stocked directly into hauling tank waters if the temperature difference is more than about 5°F. Smaller fish require a narrower temperature difference.



Hauling tank on the back of pick-up truck.

Transport fish in good quality well or spring water if possible, rather than pond water, unless the water is cool and clear, or if only a short trip is required from pond to pond. Pond water with an algae bloom should be avoided unless absolutely necessary and the trip is short. Catfish appear to haul better in water with a total hardness and alkalinity above 50 to 100 ppm. Calcium chloride can be added to raise the hardness.

Handle fish during the coolest time of the day, and avoid time out of water, especially when it is hot or windy. Do not overload dip nets and loading baskets, and try to move fish in a cushion of water. Make sure all nylon seines and dip nets are coated to avoid injury to fish when they are released from entanglement. Be sure water has adequate aeration both during the loading and hauling of fish. Salt is often used to reduce stress at a concentration of 0.1% to 0.3%, while many catfish live-haulers in Kentucky are now successfully using up to 0.8% salt in their hauling water; they add about 6 pounds of salt per 100 gallons of water for stress reduction.

During long trips, know where non-chlorinated water can be obtained if required. Carry an extra agitator for backup and any essential spare parts and tools in case equipment failure occurs. Before fish are unloaded, check for water temperature differences. Catfish have more difficulty when transferred into water warmer than their hauling water temperature more so than being stocked into water cooler than their hauling water. Pump water from the receiving water into the hauling containers to gradually acclimate (tempor) the fish to their new water. The acclimation is not only for temperature adjustment but for other less apparent water quality factors such as pH and hardness. Acclimation is easily done using a 12-volt submersible pump to mix pond water with the hauling water before fish are unloaded. A chute hung on the door of the haul tank works well to unload fish without excessive handling.

Disinfect tanks between different loads of fish to prevent possible spread of disease. Dry each compartment thoroughly or use a chlorine solution.

Loading Rates

Catfish are transported in tanks made of fiberglass, wood or metal. Insulated tanks are recommended for long transport trips in summer. Aeration is usually from agitators, air-blowers or liquid oxygen. A backup system is common. The transport tank should be vented to permit the escape of carbon dioxide gas. The loading rates in transport tanks can vary considerably, depending on design of tank, aeration system, size and health of fish, water quality, temperature, and transport time. **Table 13** provides some guidelines for catfish hauled in tanks with water at 65°F with a source of pure oxygen gas bubbled into the water.

Table 13. Estimated pounds of channel catfish that can be hauled safely per gallon of 65°F water for various times.

Size of Fish		Transport Time In Hours		
Pound per 1,000 Fish	Number per Pound	8	12	16
0.1	10,000	0.2	0.2	0.2
1	1,000	1.3	1.0	0.7
2	500	1.8	1.7	1.3
4	250	2.2	1.8	1.5
8	125	3.0	2.2	1.8
20	50	3.5	2.5	2.1
250	4	5.0	4.1	3.0
500	2	5.9	4.8	3.5
1,000	1	6.3	5.6	4.8

Adjustments are required when fish are transported at higher temperatures or longer transport times. Reduce the pounds hauled by 25% for each 10°F rise in temperature. Note: the number of gallons used to calculate hauling rates should be the amount of water before fish are added. For example, 600 gallons of water loaded at 5 lbs of fish per gallon (3,000 lbs) will bring the water level up to the 1000 gallon mark in the tank.

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Alabama Fish Farming Center
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Greensboro, AL 36744
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Arkansas
University of Arkansas at Pine Bluff
P.O. Box 4912
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Fish Disease Laboratory
Arkansas Cooperative
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Chicot County Extension Office
Highway 85 and 62
Lake Village, AR 71653
(870) 265-8056

Fish Disease Laboratory
Arkansas Cooperative
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Lonoke Agriculture Center
P.O. Box 357
Lonoke, AR 72086
(501) 676-3124

Fish Farming Experimental
Laboratory
P.O. Box 860
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