Channel Catfish Production in Ponds

Alabama Cooperative Extension System, Alabama A&M and Auburn Universities
Channel Catfish Production In Ponds
Michael Masser, Extension Fisheries Specialist
John Jensen, Extension Fisheries Specialist
Jerry Crews, Extension Economist

Catfish farming has grown rapidly since its beginning in the 1960s. More than 18,000 acres of water were used in commercial catfish production in Alabama in 1990. In the United States, catfish farming is the largest aquacultural industry, with more than 150,000 acres of water used to produce an estimated 425 million pounds of farm-raised catfish in 1989.

Much of the total U.S. commercial production is sold to catfish processors. Some producers sell live or dressed catfish through local outlets. Many growers stock their ponds for commercial recreational fishing, and others sell their catfish to live-fish haulers who deliver primarily to recreational fishing lakes.

Catfish are grown in ponds, cages, and raceways. However, pond culture is by far the most common method of production. Channel catfish require a warmwater environment for good growth. Optimum temperature for growth is 85 °F. North Alabama has about 200 days per year when water temperature is above 60 °F, while extreme South Alabama may have 250 days. All regions of Alabama are suitable for commercial catfish production. Other factors being equal, a greater annual production and return on investment will be achieved with a longer growing season.

The future for catfish farming in Alabama appears bright. Catfish producers do encounter some difficulties, including uncertain markets, “off-flavor,” water quality control, bird predation, harvesting difficulties, and disease control. Still, the risks are not much different from those encountered in other farm crops, and the industry continues to expand. However, management requirements are higher for catfish production than for most other crop or livestock enterprises. This publication briefly outlines the basic requirements for successful catfish farming in Alabama.

**Production Economics**

Is the catfish business something that could prove to be a wise investment decision? Even if one has a keen interest in producing catfish, could a higher return be earned by investing in some other venture?

To arrive at such a decision, the prospective producer should make an economic evaluation of the proposed investment. The catfish operation should be analyzed separately from the other farming operations to determine its profitability. If the estimates of yearly costs and returns are promising, the producer should perform a whole-farm analysis to measure the impact of incorporating a catfish operation into the farm business.

The economic feasibility of catfish production should reflect the producer’s own situation and resources. Making a realistic evaluation on paper will improve your chances of success once money is committed and will also reduce the possibility of unpleasant surprises.

**Investment Requirements**

Before the first fish is harvested, many investment items must be committed for efficient production. Listed below are items which may be required in many catfish operations:

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>Tractor</td>
</tr>
<tr>
<td>Pond construction</td>
<td>Mower</td>
</tr>
<tr>
<td>Drain pipe and fittings</td>
<td>Oxygen meter</td>
</tr>
<tr>
<td>Wells</td>
<td>Water testing equipment</td>
</tr>
<tr>
<td>Water pumps and pipe</td>
<td>Seines</td>
</tr>
<tr>
<td>Electric power lines</td>
<td>Dip nets</td>
</tr>
<tr>
<td>Aerators (electric and/or PTO)</td>
<td>Feed wagon/blower</td>
</tr>
<tr>
<td>Boat and motor</td>
<td>Waders and boots</td>
</tr>
<tr>
<td>Hauling tanks and agitators</td>
<td>Baskets and buckets</td>
</tr>
<tr>
<td>Truck equipment</td>
<td>Storage buildings</td>
</tr>
<tr>
<td>Feed storage bins</td>
<td>Miscellaneous equipment</td>
</tr>
</tbody>
</table>

**Enterprise Budgeting**

Estimating the costs and returns for a particular activity is called developing an enterprise budget. This procedure reflects the economic value of producing a specific output using a given set of inputs by following specific production practices. Profitability can be estimated by subtracting all the costs from the expected revenues.

There are two types of costs to be considered in developing enterprise budgets: variable and fixed. Variable costs are the expenses that vary based on production output, such as feed, fingerlings, etc. Fixed costs are the expenses that do not change, regardless of whether production occurs: expenses such as depreciation, interest on investment, in-
urance, taxes, etc. As in many other agricultural businesses, variable costs make up the largest portion of the total costs of catfish production. (See Figure 1.) In an examination of variable costs alone, feed comprises almost two-thirds of the costs, with fingerlings coming in a distant second, as shown in Figure 2.

![Figure 1. Breakdown of total costs for a catfish operation.](image1.png)

Catfish Budget (Open Pond); Stocking In Spring, Custom Harvest In Fall; Estimated Annual Costs/ Returns; Using Recommended Management Practices; 3,500 Fish Stocked Per Acre; 20 Lb./1,000 Beginning Weight; 2 Lb. Of Feed/Lb. Of Gain; 200 Days In Growing Season; 1 Lb. Ending Weight; 7.25% Death Loss/Unharvested Fish.

<table>
<thead>
<tr>
<th>Enterprise Acreage = 10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Item</strong></td>
</tr>
<tr>
<td>1. Gross Receipts</td>
</tr>
<tr>
<td>2. Variable Cost</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Total Variable Cost</strong></td>
</tr>
<tr>
<td>3. Income Above Variable Cost</td>
</tr>
<tr>
<td>4. Fixed Cost</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Total Fixed Costs</strong></td>
</tr>
<tr>
<td>5. Total Of All Specified Expenses</td>
</tr>
<tr>
<td>6. Net Returns Above All Specified Expenses</td>
</tr>
<tr>
<td>Net Returns Per Acre:</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Break-even Price (Per Cwt. Sold):</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Net returns are to land, existing pond, operator's labor and management. These estimates should be used as guides for planning purposes only.

![Figure 2. Breakdown of variable costs for a catfish operation.](image2.png)

Detailed enterprise budget estimates are developed annually for various catfish production systems and are available from your county Extension office. An example budget is shown in Figure 3.

![Figure 3. A sample enterprise budget for catfish production.](image3.png)
Cash Flow Statement

In addition to budget analysis, the prospective producer should also develop a cash flow statement. This prediction, or projection, reflects all cash inflows and outflows on a monthly and/or yearly basis. Projections of cash surpluses and shortages can assist the producer in making credit arrangements and in determining his or her ability to repay loans. Whole-farm cash flow projections are helpful if additional money is needed to supplement the catfish operation during the start-up period.

Cash flow projections should be estimated for 2 to 3 years to get a more accurate indication of pay-back potential. More information can be found in Extension publications ANR-355 and 355A, “Preparing and Using the Cash Flow Statement.”

Sensitivity Analyses Of Price And Production Factors

As with any business, it is important that good managers pay close attention to those factors which affect profits most. Table 1 (below) summarizes the sensitivity of major price and production efficiency factors and their effect on profit potential. For example, for every tenth of a pound that the feed conversion rate can be lowered, the cost of production would decrease by $1.69 for every 100 pounds of catfish produced.

| Table 1. Sensitivity Of Price And Production Factors and Their Impact on Profits for a 10-Acre Pond.* |
|-------------------------------------------------|-----------------|-----------------|
| **Item**                  | **Unit Change** | **Dollars Per Cwt. Sold** |
| Pond Construction         | $100/ac.        | 0.42             |
| Death Loss                | 1 ¾             | 0.41             |
| Stocking Rate             | 500/ac.         | 2.57             |
| Feed Conversion           | 0.1 lb.         | 1.69             |
| Feed Price                | $25/ton         | 2.24             |
| Interest Rate             | 1 point         | 0.44             |
| Fingerlings               | 1 cent each     | 1.13             |

*Assumes starting with 4-inch fingerlings and a selling weight of 1 pound.

Catfish production requires a great deal of money. The overall net worth and cash flow of the potential producer should be large enough to withstand both the start-up period and any unforeseen setbacks. An average producer may invest as much as $4,500 to $5,000 per acre before the first fish is harvested: $1,500 in operating costs; $1,500 to $2,000 in machinery and equipment; and $1,000 to $2,000 in pond construction.

Successful catfish producers are both good managers and good merchandisers. While catfish production has been successful for many producers, someone interested in the business would benefit by following this advice:

- **Gain knowledge.** Gather all the information you can, even before you make your investment.
- **Plan.** Lay a firm groundwork for financing, production, and marketing before the business begins.
- **Start small.** Limit your investment of time and money to minimize the risk for yourself and your farm.
- **Grow with success.**

Pond Construction

The site and design of the pond may be the most important factors controlling the profitability of the catfish farm. Ponds that leak, have irregular bottoms, or routinely suffer from a shortage of water will not produce a consistent crop of catfish.

Ideally, levee ponds built on flat land and filled with groundwater or surface water are more suitable for commercial catfish production. However, most Alabama terrain is rolling and not conducive to this kind of construction. Also, water supplies for filling levee ponds are often scarce and will eventually limit the use of the ponds. In hilly terrain, pond builders must take advantage of the natural formations by constructing dams across valleys between hillsides so that runoff from rainfall on the watershed will be stored behind the dam.

Water Supplies

Water to fill and maintain watershed ponds usually comes entirely from runoff, although groundwater (wells) and surface water (springs, streams, and reservoirs) can also be used as supplemental sources. The ratio of watershed to water surface acreage should be large enough so that ponds fill and sometimes overflow during rainy months but drop no more than 2 feet during drier months. The best ratio of watershed to water surface varies according to the type of land on which the pond is built. For a watershed of heavy clay soil on open land, the best ratio is 5 acres of land for each surface acre of pond. For a sandy watershed in a wooded area, the best ratio is 30 acres or more of land for each surface acre of pond.

When a watershed is too small and unable to supply enough water to the pond, or an outside source of water is needed for filling during dry periods, water from wells, streams, or rivers can be pumped into the pond. Water containing wild fish should be filtered to avoid introducing these fish into your pond.
When ponds are built in series in a valley, less watershed is needed to maintain an acre of water. Before harvest, water can be pumped or drained from one pond to another for storage. This procedure not only allows a producer to refill, using the stored water, immediately after harvest, but it also eliminates the possibility of draining nutrients into nearby natural waters.

**Soil Characteristics**

Good-quality soil that is at least 20 percent clay is necessary for building the core of dams. This includes clay, silty clay, and sandy clay soils. Soil should be sampled by frequent borings along a proposed dam site to determine if the clay foundation is large enough to build the dam.

Borings should also be taken from the proposed dam site and the shoreline to be sure there is enough clay to build the dam. Usually a good source of clay can be found in the hillside near the dam site. If such a source is available, using it to build the dam can add to the size of the pond. However, if removing the clay will uncover rock formations, sand, or gravel in the pond bottom, it is best to leave the clay in place.

Pond construction in limestone areas can be especially risky because of the possibility of underlying cracks and sinks which may cause the pond to leak. In areas where the soil of the proposed pond bottom could result in leaky ponds, soils should be bored to check for quality. Approximately four borings per acre are sufficient, unless there are variations in soil type in the pond bottom. Figure 4 shows the parts of a dam, including the core and drainage system.

**Topography**

Topography will greatly affect the size and shape of a watershed pond. Generally, steep slopes in V-shaped valleys require dams of larger volume per water surface acre than sites with gently sloping hills and wide, flat valleys. So, ponds built in steep terrain usually cost more per pond acre than those built in gently rolling terrain.

Ideally, watershed ponds should be less than 10 feet deep at the drain. This depth allows the producer to harvest the pond without draining it. Deep ponds must be drained of much of their water before they can be seined for a complete harvest.

Some sites with gentle slopes and large floodplains allow for the construction of two-sided and three-sided watershed ponds (Figure 5). These ponds are usually constructed parallel to hills bordering a creek. Runoff is used as a water source, but the dam does not cross a hollow or draw. The great advantage of this kind of pond is that it is a “seine-through” pond: it does not have to be drained for harvest.
Other Considerations

The site for a watershed pond should be selected so that pipes and valves can be installed to drain the pond completely. The proposed shoreline should be excavated to provide a depth of at least 3 feet around the edge of the pond. Pond bottoms should be smooth and slope gently to the drain pipe. Remember, a poorly constructed pond with an uneven bottom will cause incomplete harvests.

Make sure that floods from nearby rivers will not flow over the dam or that floods within the watershed will not weaken the dam. Ponds constructed in flood plains should be located so they will not cause damage to adjacent property if flooding does occur. Information on floods and their 100-year potential is available from the U.S.D.A. Soil Conservation Service field office in each county.

After deciding on a dam site, mark off the permanent waterline and the potential flood-stage waterline of the proposed pond to make sure that water will not encroach on other property. Also, if the pond site contains 1 acre or more of wetland, the U.S. Army Corps of Engineers will require a permit before the pond can be constructed.

Cost of Construction

The curves in Figure 6 were developed by the Alabama Fish Farming Center for ponds built in West Alabama. The curves are estimates for data generated during 1987 and 1988. Cost estimates include clearing, earthfill, excavation, pipe and drain, concrete, seeding, and road gravel. The term “sided” refers to number of sides of the dam. The measurements (such as “8 to 10 feet”) refer to the maximum depth of water at the stand pipe. Each pond site is unique, and these curves should be used only for rough estimates and comparisons. In general, a large, shallow, one-sided watershed pond is relatively inexpensive to construct in West Alabama. A three-sided pond may cost about twice as much as a one-sided pond.

Building The Pond

To obtain expert assistance in building the right pond for your needs, contact the Soil Conservation Service (SCS) field office in your county. The SCS provides site evaluations, design layout, and construction assistance.

Additional information on the construction of a levee pond can be found in the Southern Regional Aquaculture Center Publication No. 101, “Construction of Levee-type Ponds for Fish Production.” SRAC publications are available from your county Extension agent or from the Extension fisheries specialists at Auburn University.

Stocking The Pond

Several species of catfish can be grown commercially. They are the channel, the blue, and the white catfishes. The channel catfish is the one most commonly used because it has the best combination of characteristics for commercial production. The number of fish to stock in a pond depends on several factors:

- The size of the pond.
- The experience of the producer.
- The length of the growing season.
- The desired market size.

The most important of these factors is the size of the pond. Fish should be stocked according to the
surface area of the pond. Overestimating the area results in more fish per acre than can be safely grown. Depth plays no part in determining stocking rate.

Experienced producers can stock up to 6,000 fish per acre, to produce 6,000 pounds per acre per year. Inexperienced producers should stock no more than 3,500 fish per acre. A lower stocking density reduces the risk of losses to oxygen shortages and diseases. In time, a new producer will gain the management experience that allows higher stocking rates.

Fingerlings can be stocked at any time during the year. The best time to transport fingerlings is when the water is cool, so that stress on the fish is reduced. Fingerlings are trained to accept feed faster when the water is cool, so that stress on the fish is reduced. Temperatures begin to moderate, usually during February and March.

Wild Fish

Before stocking, eliminate all wild fish, such as bream, minnows, and bullheads, that might eat food intended for the catfish. Wild fish can also carry diseases.

If possible, eliminate wild fish from the water supply. Saran screen with 40 meshes per centimeter can be used to filter out unwanted fish and fish eggs. Saran can be used as a sock to fit over the water supply pipe, or it can be framed into a box when large flows of water must be filtered (see Figure 7).

![Figure 7. Saran sock.](image)

Largemouth bass fingerlings can be stocked with the catfish at a rate of 50 per acre. Bass will eat small wild fish, preventing a rapid increase in their numbers. Bass do not tolerate low oxygen as well as catfish. If the fish are not killed by the shock, they can be weakened, which lowers their resistance to disease. If wild fish are already in your pond, drain it completely and leave it dry for several weeks. Rotenone (5 percent wettable powder or liquid formulation) applied to remaining pockets of water at more than 3 parts per million (10 pounds per acre-foot) will eliminate any fish. In warm weather, rotenone detoxifies in 7 to 10 days. In winter, rotenone may remain toxic for more than 30 days.

Tempering

Before stocking fish in a pond, adjust the water in the transport tank holding the fingerlings to match the pond water in temperature and other water quality factors such as pH, alkalinity, and hardness. This can be done by putting small quantities of water into the tank from the pond (called tempering), so that the tank water is eventually similar to that of the pond.

As a general rule, catfish can withstand a 5°F change in temperature without severe stress and a 10 °F change if the water is tempered over a period of 30 minutes. For greater temperature differences, care must be taken to slowly equalize water temperatures before moving the fingerlings from the tank to the pond. In this case, adjusting water temperature 1°F every 10 minutes is a good rule to follow. Tempering is especially important if fish are going from cool water to warm water.

Insufficient tempering can kill the fish by temperature shock or shock from other water quality factors. If the fish are not killed by the shock, they can be weakened, which lowers their resistance to disease.

Starting with good-quality, healthy fingerlings of known genetic background is very important to profitably growing a crop of fish. Buy your fingerlings from a producer who has a reputation for producing good fish, who knows how to treat fish for disease, who has the equipment and the know-how to handle them without excessive stress, and who delivers accurate counts and weights.

Feeding

Catfish grown at high densities require a nutritionally complete feed for good growth and health. Commercially prepared catfish feeds, available in bulk or in bags, should contain from 26- to 36-percent crude protein plus all essential vitamins and minerals to be called “complete.” Feeds containing 32-percent crude protein are adequate and the most economical for food fish production. Feeds of 26-percent crude protein can be used for winter feeding and by people who produce small quantities of catfish for home use.

Both sinking (pelleted) or floating (extruded) feed can be fed to catfish. Both types, if complete, give adequate growth under normal conditions. Floating feeds are more expensive, but they allow the producer to observe feeding activity. Feeding activity is extremely important in determining how much to feed, and it is usually the best opportunity the producer has to judge the health and vigor of the fish. A mixture of 15-percent floating and 85-percent sinking feed can be used to cut costs and still allow observation of feeding activity.

Fish feeds come in various sizes. Crumbles (crushed pellets) can be fed when fingerlings are less than 3 inches long. Fish larger than 3 inches can be fed a 3/16-inch pellet until they reach market size. Fish are usually fed out on 1/4-, 5/16-, or 3/8-inch pellets once they reach 1/2 pound in weight.

Feeding Rates

One of the biggest problems producers encounter is knowing how much to feed each day. Overfeeding wastes feed and money, and it can cause water-quality problems. Catfish will grow at their maximum rate when fed all they will voluntarily eat (called “satiation”). However, trying to satiate the fish usually results in overfeeding.

Timed Feeding. Research has shown that catfish grow most efficiently when fed about 90 percent of all they will voluntarily eat. This optimum feeding rate is generally reached when catfish are fed only the amount they will eat in 5 to 10 minutes. It is important that the fish eat as much as they want, without leaving any excess.

Feed Conversion Method. Another way to estimate the amount to feed during summer months.
is to calculate the total initial weight of the fish in the pond and feed the percentage of body weight recommended in Table 2 each day for a 2-week period. Every 2 weeks, the weight gain can be estimated based on the feed conversion ratio (FCR) and the ration adjusted. The formulas for this procedure and an example computation are shown in Table 3.

In the example in Table 3, 185 pounds of feed would be fed each day for the next 2 weeks. Then a new feeding rate would be calculated using this method. It should be pointed out that this method is only as good as the ability to estimate the FCR.

**Fish Sampling Method.** A third method to calculate feeding rates is to estimate the total weight of the fish based on the weight of a sample. Although research has shown that average sample weights can vary from 8 to 19 percent from true average weights, this method is still effective.

At 2-week intervals, the producer captures a sample of 100 fish at random with a net (not hook and line) and weighs them. The producer can then calculate the next feeding rate by estimating the total fish weight in the pond from this sample. The formulas for these calculations and a sample estimate are shown in Table 3.

In the example in Table 4, 150 pounds of feed would be fed each day for the next two weeks. Then a new feeding rate would be recalculated based on another sample.

Using Table 2, the daily feed allowance, as a percentage of body weight, can be estimated as fish grow. Table 2 is a guide for feeding catfish during the spring, summer, and early fall growing seasons, beginning with fish newly stocked in April. Remember, this table is only a guide and fish may respond differently from day to day and from pond to pond.

Feeding less than 35 pounds of feed per acre of pond per day will minimize low-oxygen problems caused by high stocking densities and feeding rates. However, emergency aeration may be needed at times during the summer, even at this feeding rate. If effective aeration equipment is available, feeding rates of up to 100 pounds of feed per acre per day can be used. The majority of producers should try to maintain feeding rates below 70 pounds of feed per acre per day to grow out large numbers of fish but minimize risk.

**Table 2. Typical Feeding Schedule.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Water temperature °F</th>
<th>Fish percent of size weight</th>
<th>Feed allowance per day per acre</th>
<th>Weight of feed per day per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-15</td>
<td>68</td>
<td>0.04</td>
<td>2.2</td>
<td>0.9</td>
</tr>
<tr>
<td>4-30</td>
<td>72</td>
<td>0.06</td>
<td>2.8</td>
<td>1.7</td>
</tr>
<tr>
<td>5-15</td>
<td>78</td>
<td>0.11</td>
<td>3.0</td>
<td>3.3</td>
</tr>
<tr>
<td>5-30</td>
<td>80</td>
<td>0.16</td>
<td>3.0</td>
<td>4.8</td>
</tr>
<tr>
<td>6-15</td>
<td>83</td>
<td>0.21</td>
<td>3.0</td>
<td>6.3</td>
</tr>
<tr>
<td>6-30</td>
<td>84</td>
<td>0.28</td>
<td>3.0</td>
<td>8.4</td>
</tr>
<tr>
<td>7-15</td>
<td>85</td>
<td>0.35</td>
<td>3.0</td>
<td>10.5</td>
</tr>
<tr>
<td>7-30</td>
<td>85</td>
<td>0.42</td>
<td>2.8</td>
<td>11.8</td>
</tr>
<tr>
<td>8-15</td>
<td>86</td>
<td>0.60</td>
<td>2.4</td>
<td>14.4</td>
</tr>
<tr>
<td>8-30</td>
<td>86</td>
<td>0.75</td>
<td>2.0</td>
<td>15.0</td>
</tr>
<tr>
<td>9-15</td>
<td>83</td>
<td>0.89</td>
<td>1.8</td>
<td>16.0</td>
</tr>
<tr>
<td>9-30</td>
<td>79</td>
<td>1.01</td>
<td>1.6</td>
<td>16.0</td>
</tr>
<tr>
<td>10-15</td>
<td>73</td>
<td>1.10</td>
<td>1.2</td>
<td>13.2</td>
</tr>
</tbody>
</table>

*For channel catfish in ponds, stocked with 5-inch fingerlings and harvested at 1.1 pounds.

**Table 3. Feed Conversion Method.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Feed allowance per day per acre</th>
<th>Weight of feed per day per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-15</td>
<td>6,168</td>
<td>0.03</td>
</tr>
</tbody>
</table>

**For channel catfish in ponds, stocked with 5-inch fingerlings and harvested at 1.1 pounds.**

**Table 4. Fish Sampling Method.**

<table>
<thead>
<tr>
<th>Date</th>
<th>Water temperature °F</th>
<th>Fish percent of size weight</th>
<th>Feed allowance per day per acre</th>
<th>Weight of feed per day per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-15</td>
<td>6,168</td>
<td>0.03</td>
<td>2.2</td>
<td>0.9</td>
</tr>
</tbody>
</table>

**Feeding Schedule**

Feeding fish twice each day can be advantageous when fish are less than 10 pounds (usually April through July). Twice-daily feedings should be at least 6 hours apart to allow for digestion. When fed twice a day, catfish will eat and gain more than when they are fed once a day.

Catfish can be trained to eat at nearly any time of day. During the summer, it is not advisable to feed too early in the morning or after sundown, because of potential low-oxygen problems. Fish do not consume as much feed if oxygen is low, and the process of digestion increases oxygen uptake. Feeding around 9:00 a.m. in the summer is a good practice if oxygen levels are good. Once a feeding time is established, maintain it. Catfish will feed better if a daily routine is followed. For the same reason, try to feed in the same location each day. However, you may have to change the feeding location to account for wind direction and velocity when you are using floating feed.

Feed catfish 7 days a week. They will grow less quickly and efficiently if they are fed less often. Remember: no feed, no gain; no gain, no profit.

Catfish are naturally aggressive and attempt to dominate each other over food. So, spread the feed out over a large area in the pond to allow smaller fish a better chance to feed. This practice will result in a more uniform size at harvest. It is very impor-
tant to widely distribute feed across the surface of large ponds because of the large number of fish to be fed.

**Winter Feeding**

The growth of channel catfish slows during the winter, but feeding at a lower rate is important. Without feed during the winter, catfish will lose weight and be less resistant to disease when the water begins to warm in the spring. Catfish do feed at low temperatures, just not as often.

A satisfactory winter feeding schedule for catfish in ponds is to feed about 1 percent of their body weight every other day when the water temperature is between 55° and 65° F. Feed 1 percent of their body weight twice a week when the water temperature is between 45 ° and 54 ° F. Feed in the afternoon, when the temperature is highest, and on sunny days. Many producers feed sinking pellets in winter, if the fish will not come to floating feed. More information on winter feeding of catfish can be found in Extension circular ANR-457, “Feeding Catfish During Winter?”

**Feed Conversion**

Good feed conversion depends on good management. A producer who manages the catfish well can achieve feed conversions between 1.5 and 2 pounds of feed to 1 pound of fish gain. A producer can increase profits by about 1 to 2 cents per pound of fish for each tenth of a pound of improved feed conversion, depending on the price of feed (Table 5). The opposite is true when management is poor.

**Feed Storage**

Store feeds in a cool, dry place. Damp storage areas (bins or rooms) can cause mold to grow on feeds. Heat causes loss of vitamins. Do not use feeds that have been stored for more than 8 weeks during warm weather. Never use feeds that are moldy or clumped together. Eating contaminated or vitamin-deficient feed can slow growth, lower resistance to disease, and cause deformities or death.

**Water Quality**

The most serious threat to catfish in ponds is poor water quality. Water quality is not constant. It varies with the following factors:

- Time of day.
- Season.
- Weather conditions.
- Water source.
- Soil types.
- Temperature.
- Stocking density.
- Feeding rate.
- Chemical treatments.

A successful catfish producer must understand pond dynamics, the effect of catfish production on water quality, and management of water-quality problems.

Aspects of water quality of concern in catfish production include:

- Temperature.
- Dissolved oxygen.
- pH.
- Ammonia.
- Nitrite.
- Alkalinity.
- Hardness.
- Carbon dioxide.
- Chloride.

Temperature does not change very rapidly except in the case of small, shallow ponds. Dissolved oxygen, pH, and carbon dioxide levels change or fluctuate daily Ammonia, nitrite, alkalinity, hardness, and chloride generally change slowly, although exceptions do occur under extreme conditions. Relatively inexpensive and easy-to-use chemical tests are available for checking these water quality factors. For information on how to order test kits, contact your county Extension office or the Extension fisheries specialists.

**Pond Dynamics**

No two ponds are exactly alike. Pond color and water quality vary within a single pond from day to day. Adjacent ponds are seldom alike in their color, water quality, and the growth rate of the fish, even though they are stocked and fed at the same rates. These differences are not fully understood but may be related to soil conditions, algae (microscopic plants called phytoplankton), and bacterial populations of the pond.

**Temperature**

Water temperature is one of the single most important factors in ponds. The metabolic rates of the plants, bacteria, and fish depend on the temperature. Catfish are warmwater fish and perform most efficiently at warm temperatures (approximately 80 ° to 85 ° F). At higher temperatures, respiration rates are high, feed conversion is poor, and overall growth is

---

**Table 5. Cost Of Feed (In Cents*) To Produce A Pound Of Catfish At Various Feed Prices And Feed Conversion Ratios (FCR).**

<table>
<thead>
<tr>
<th>FCR</th>
<th>Feed Price/ton</th>
<th>$230</th>
<th>$250</th>
<th>$270</th>
<th>$290</th>
<th>$310</th>
<th>$330</th>
<th>$350</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3</td>
<td>15.0</td>
<td>16.3</td>
<td>17.6</td>
<td>18.9</td>
<td>20.2</td>
<td>21.5</td>
<td>22.8</td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>16.1</td>
<td>17.5</td>
<td>18.9</td>
<td>20.3</td>
<td>21.7</td>
<td>23.1</td>
<td>24.5</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>17.3</td>
<td>18.8</td>
<td>20.3</td>
<td>21.8</td>
<td>23.3</td>
<td>24.8</td>
<td>26.3</td>
<td></td>
</tr>
<tr>
<td>1.6</td>
<td>18.4</td>
<td>20.0</td>
<td>21.6</td>
<td>23.2</td>
<td>24.8</td>
<td>26.4</td>
<td>28.0</td>
<td></td>
</tr>
<tr>
<td>1.7</td>
<td>19.6</td>
<td>21.3</td>
<td>23.0</td>
<td>24.7</td>
<td>26.4</td>
<td>28.1</td>
<td>29.8</td>
<td></td>
</tr>
<tr>
<td>1.8</td>
<td>20.9</td>
<td>22.5</td>
<td>24.3</td>
<td>26.1</td>
<td>27.9</td>
<td>29.7</td>
<td>31.5</td>
<td></td>
</tr>
<tr>
<td>1.9</td>
<td>21.9</td>
<td>23.8</td>
<td>25.7</td>
<td>27.6</td>
<td>29.5</td>
<td>31.4</td>
<td>33.3</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>23.0</td>
<td>25.0</td>
<td>27.0</td>
<td>29.0</td>
<td>31.0</td>
<td>33.0</td>
<td>35.0</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>24.2</td>
<td>26.3</td>
<td>28.4</td>
<td>30.5</td>
<td>32.6</td>
<td>34.7</td>
<td>36.8</td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>25.3</td>
<td>27.5</td>
<td>29.7</td>
<td>31.9</td>
<td>34.1</td>
<td>36.3</td>
<td>38.5</td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>26.5</td>
<td>28.8</td>
<td>31.1</td>
<td>33.4</td>
<td>35.7</td>
<td>38.0</td>
<td>40.3</td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>27.6</td>
<td>30.0</td>
<td>32.4</td>
<td>34.8</td>
<td>37.2</td>
<td>39.6</td>
<td>42.0</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>28.8</td>
<td>31.3</td>
<td>33.8</td>
<td>36.3</td>
<td>38.8</td>
<td>41.3</td>
<td>43.8</td>
<td></td>
</tr>
</tbody>
</table>

*rounded to the nearest tenth of a cent
reduced. Channel catfish will die at temperatures above 96 °F.

Temperatures below the optimum range reduce metabolic rate, feed consumption, and growth. Very low temperatures impair the immune system and lower resistance to disease. Rapid changes in temperature, especially during hauling and stocking, stress fish and may reduce feeding and increase susceptibility to disease.

Algae

Algae are extremely important to catfish ponds. Algae produce most of the oxygen in the pond and remove most of the carbon dioxide and many of the nutrients. Algae also consume oxygen, produce carbon dioxide, cause pH to fluctuate, and release nutrients into the water as they die.

Algae populations change continuously, because different species flourish at distinct temperatures and under various pH and nutrient conditions. Algae populations, called “blooms,” can die off and result in fish kills. The only way a fish farmer can become an efficient producer is to continuously monitor and keep records of bloom conditions, oxygen concentration, and other water quality factors.

Dissolved Oxygen

Low dissolved oxygen is by far the most common water-quality problem in catfish production ponds. Ponds get oxygen from two sources: the air and photosynthesis. Oxygen diffuses into water from the air. Diffusion is a slow process unless it is aided by the action of wind or some type of mechanical agitation that mixes air and water together.

Most pond oxygen comes from photosynthesis. Photosynthesis is the process by which plants make food from carbon dioxide, water, nutrients, and sunlight. The by-product of photosynthesis is oxygen. On sunny days, algae produce and release oxygen, which dissolves into the water. At night, no oxygen is produced and the respiration of the algae and fish and the decomposition of wastes by bacteria remove oxygen from the pond.

Under natural conditions, more oxygen is produced by photosynthesis than is removed by respiration, as it cycles up and down during the day. Figure 8 shows a general oxygen cycle for ponds during warm weather conditions.

The amount of oxygen that will dissolve in water depends on the temperature, salinity, and atmospheric pressure. Salinity and atmospheric pressure are of little consequence in fresh water catfish production areas. Temperature, however, is an important regulator of dissolved oxygen levels in ponds.

Cold water holds or will dissolve more oxygen than warm water. Therefore, as temperature increases in the pond, less oxygen is available. The amount of oxygen that water will dissolve at different temperatures (saturation) is listed in Table 6.

<table>
<thead>
<tr>
<th>Temperature, Degrees F</th>
<th>Dissolved Oxygen, ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (32)</td>
<td>14.60</td>
</tr>
<tr>
<td>1 (34)</td>
<td>14.19</td>
</tr>
<tr>
<td>2 (36)</td>
<td>13.81</td>
</tr>
<tr>
<td>3 (37)</td>
<td>13.44</td>
</tr>
<tr>
<td>4 (39)</td>
<td>13.10</td>
</tr>
<tr>
<td>5 (41)</td>
<td>12.75</td>
</tr>
<tr>
<td>6 (43)</td>
<td>12.43</td>
</tr>
<tr>
<td>7 (44)</td>
<td>12.12</td>
</tr>
<tr>
<td>8 (46)</td>
<td>11.83</td>
</tr>
<tr>
<td>9 (48)</td>
<td>11.55</td>
</tr>
<tr>
<td>10 (50)</td>
<td>11.27</td>
</tr>
<tr>
<td>11 (52)</td>
<td>11.02</td>
</tr>
<tr>
<td>12 (53)</td>
<td>10.76</td>
</tr>
<tr>
<td>13 (55)</td>
<td>10.52</td>
</tr>
<tr>
<td>14 (57)</td>
<td>10.29</td>
</tr>
<tr>
<td>15 (59)</td>
<td>10.07</td>
</tr>
<tr>
<td>16 (61)</td>
<td>9.85</td>
</tr>
<tr>
<td>17 (62)</td>
<td>9.65</td>
</tr>
</tbody>
</table>

*Numbers in parentheses are degrees F.*
The amount of oxygen that dissolves in water is very small compared to the oxygen concentration of the atmosphere. The atmosphere contains about 20 percent oxygen, or 200,000 ppm (parts per million). Water at saturation at 85 °F contains less than 8 ppm oxygen. Ponds can supersaturate with oxygen on sunny days when algae in the pond are very dense (heavy bloom). Very high concentrations of oxygen (twice saturation) during the day sometimes indicate that an oxygen depletion will occur that night.

Critically low dissolved oxygen concentrations can usually be predicted. Low levels occur because of one of the following:

- Extremely high oxygen demands, due to high nighttime respiration caused by very dense algae blooms plus fish and waste decomposition.
- Excessive decomposition from algae bloom die-offs.
- Turn-overs related to weather changes such as rain, wind and cold air.
- Reduced oxygen production from photosynthesis due to reduced sunlight from cloud cover, fog, or haze.
- Lack of agitation from wind.
- Rapid reduction in algae population from die-offs.

Most low-oxygen problems occur between May and September. During this period, temperatures are warm, feeding rates are high, algae blooms are heavy, and fish are growing rapidly. All of these conditions can cause more oxygen to be removed from the pond at night than is produced during the day. Also, still and overcast days may reduce the amount of oxygen produced by wave action and by photosynthesis. This condition may promote an oxygen depletion. The result can be dead fish.

An oxygen depletion can also be caused by what is called a “turn-over.” In the summer, the surface of the pond heats up rapidly, forming a warm and less dense layer of water. This warmer layer traps a cooler, denser layer of water beneath it. The pond is said to be “stratified” in this condition.

The two water layers do not mix with each other under normal conditions because of their differing densities. Oxygen is only produced in the upper warm layer and slowly becomes depleted in the lower layer because of bacterial and chemical action.

A cool front or a thunderstorm with wind and cold rain can cool the surface of the pond enough to make the two layers mix. The result is the dilution of the oxygen that was in the upper layer and an increase in demand for oxygen. The increased demand is usually both biological and chemical.

The algae usually die off under these conditions, causing rapid oxygen removal through bacterial decomposition. Turn-overs are a common cause of catastrophic fish kills in deep ponds (more than 8 feet).

Oxygen concentrations should be maintained above 4 ppm at all times if catfish are to grow well. Growth can be severely affected when oxygen levels remain below 4 ppm for extended periods. Stress caused by chronically low oxygen will lower resistance to disease.

Predicting Low Oxygen

Monitoring and predicting low oxygen is critical. Dissolved oxygen can be measured using either electronic or chemical methods. Electronic oxygen meters are relatively expensive but have become standard equipment on commercial catfish operations (Figure 9). Electronic oxygen meters require maintenance and calibration, but they are quick and accurate. Chemical dissolved-oxygen tests are accurate if directions are precisely followed, but they take several minutes to complete. For this reason, chemical tests are not recommended if more than three ponds are to be tested. Accurately reading color changes of the chemical method is difficult at night in poor light.

Figure 9. Electronic oxygen meter.

Graphic Projection Method. Low dissolved oxygen can usually be predicted using the graphic projection method. This method relies on the fact that oxygen generally declines at a constant rate throughout the night. Based on this steady decline, low oxygen can be predicted by graphing the rate of decline and projecting this decline until morning. To use this method, oxygen readings must be taken near dusk and 2 to 4 hours later.

To use this method, mark graph paper as shown in Figure 10, with oxygen concentrations along the Y axis (vertical). Mark time along the X axis (horizontal). Next, mark the two oxygen readings on the graph and draw a straight line through them to the X axis. If this line indicates that the oxygen concentrations will fall below 3 ppm before sunrise, then aeration will probably be necessary.

One word of caution: this method only predicts low oxygen and gives the manager time to take appropriate action. It is not foolproof and still requires that oxygen be monitored to prevent unanticipated problems.
In Pond 1, the dissolved oxygen concentration at 8:00 p.m. is 12 ppm, and at 10:30 p.m. it is 6 ppm. Drawing a line through these two points indicates that the oxygen concentration will fall below 4 ppm between 11:00 and 11:30 p.m. Emergency aeration should begin before midnight.

In Pond 2, the dissolved oxygen concentration at 8:00 p.m. is 10.5 ppm, and at 11:00 p.m. it is 8.5 ppm. Drawing a line through these two points indicates that oxygen concentration will not fall below 4 ppm by sunrise. In this case, emergency aeration is probably not necessary.

**Pond Record Method.** Another method to predict low oxygen was developed from analyzing actual fish farm records. These records show that, if the oxygen concentration at dawn is 5 ppm or more and at dusk is the same as or greater than the day before at dusk, then no oxygen depletion will occur the upcoming night. But, if the oxygen concentration is less than 5 ppm and is less at dusk than it was the day before, then an oxygen depletion can be expected during the coming night. Figure 11 shows a sample graphic pond record which predicts that a nighttime oxygen depletion will occur.

Successful pond managers monitor oxygen every day at daybreak, at nightfall, and during the night throughout the growing season. Decreasing morning oxygen levels from day to day, low evening readings, and increasing supersaturation levels usually warn of upcoming problems. It is important to take readings at the same time and at the same location each day. In ponds larger than 5 acres, oxygen readings should be taken at two ends of the pond because oxygen may vary widely in the same pond. Keeping a chart (Figure 12) of daily oxygen readings will help you predict developing problems. **Do not rely on memory. Maintain good records and use them.**

**Aeration**

Commercial production in high-density catfish ponds requires aeration. Aeration strategies can be described as supplemental or emergency.

Supplemental aeration involves the nightly operation of aerators, regardless of the dissolved oxygen level, in an attempt to maintain oxygen concentrations above stressful levels. In supplemental aeration, aerators are run 5 to 7 hours per night beginning about midnight and ending about dawn.

Supplemental aeration appears to increase feed efficiency and total pounds of catfish produced over emergency aeration at moderate stocking and feeding rates (4,000 fish per acre and a maximum feeding rate of 50 pounds per acre per day). As stocking and feeding rates increase, supplemental aeration may not increase production.
Emergency aeration is used when the dissolved oxygen concentration drops to critical levels, when fish may die if not assisted. Emergency aerators must be available when using supplemental aeration.

Once emergency aeration is begun, it should continue until the oxygen level is above 4 ppm and the fish no longer gasp at the surface for air. This usually occurs after an extended period of aeration, after sunrise when photosynthesis begins, or when overcast cloud conditions break up during daylight.

**Aerators**

Many types of aerators are commercially available. Aerators can be powered by electricity, diesel engines, or the power-take-off (PTO) of a farm tractor. The efficiency of an aerator can be determined from its ability to transfer oxygen into water. Aerators are rated in terms of pounds of oxygen transferred per horsepower per hour.

Most producers prefer stationary electrical aerators used for supplemental aeration. Electrical aerators are usually more efficient and less expensive to operate and maintain. As a general rule, 1 to 1 1/2 horsepower per surface acre is sufficient capacity for supplemental aeration and for some emergencies, except in extreme cases such as a bloom die-off.

In extreme cases, portable emergency aerators, like PTO-driven paddlewheels, are needed in addition to whatever stationary aerators are already in the pond.

Both electrical-paddlewheel (Figure 13) and pump-sprayer aerators are efficient and effective emergency aeration devices for use in ponds. Both agitate the water and create a current. The moving water rapidly saturates with oxygen and the current (or waves) increases the absorption of oxygen across the surface of the pond. The current is also important in attracting fish to the aerated zone. Paddlewheels and pump sprayers can be powered by PTO’s, electricity, or diesel engines.

Figure 13. Electric paddlewheel.

Spray- or vertical-pump surface aerators that lift water (Figure 14) are usually not as efficient as paddlewheels or pump sprayers in emergency situations. However, they may be useful in small ponds in maintaining acceptable oxygen concentrations.

Figure 14. Surface aerator.

Propeller-aspirator pump aerators have high-speed propellers equipped with hollow drive shafts. As the propeller turns, it causes air to be drawn down the shaft and mixed into the water. These are not as effective as paddlewheel aerators, but they offer the added benefit of helping to destratify (break up temperature layers) deeper ponds. However, to destratify ponds effectively, they must be operated continuously. Propeller-aspirator pump aerators come in many sizes and, therefore, may be adapted to small ponds.

Diffuser aerators are operated by compressors or air blowers that release bubbles of air into the water. Diffusers are not very effective in most commercial catfish ponds.

Motorboats, twisting and turning at high speeds, have also been used for aeration in ponds. Large, tractor-powered rotary mowers, placed so that the mower blades agitate the surface water, have been used as well. However, the effectiveness of these methods is limited.

More detailed information on aerators and their efficiency can be found in Experiment Station Bulletin 584, “Evaluation of Aerators for Channel Catfish Farming,” available from the Alabama Agricultural Experiment Station at Auburn University.

**Placement of Aerators**

Stationary aerators should be placed where they will create the maximum circulation in the pond. In rectangular ponds, place stationary aerators in the center of the longest levee or side, with the discharge toward the middle of the pond. In this position, water is directed perpendicularly to the longest side and moves across the pond to create currents that reach most areas of the pond.

Placing aerators in the corner of the pond to direct water diagonally across the pond produces poor circulation. Locating fixed aerators in the middle of the levee will cause higher installation costs and may be inconvenient when aeration is needed at another location for harvesting operations. Portable aerators can be used during harvest.

Most aerators will not deliver adequate oxygen throughout the pond but will create oxygen-rich areas to which fish will be attracted and in which they can survive. Portable emergency aerators should be used before fish are stressed to the point that they cannot reach the aerated area. The best placement for an emergency aerator is in the area of the pond with the highest oxygen concentration. Fish will be gathered in this area.

If two aerators are needed, place them near each other (30 to 50 feet apart). This way, if one aerator fails, the other can hold the fish in the area and keep them alive until the problem is fixed. In single-
Aerator situations, if the aerator fails, the fish will move into oxygen-poor areas in search of more oxygen. At that point, during a severe oxygen depletion, the fish may be dead by the time additional aeration is moved to the pond.

Fish cover the surface of the pond, particularly along the banks, when they are severely stressed from low oxygen. Place aerators in the areas where the most fish are congregated and try to attract them to the aerator. In a hill-type pond, fish will usually go to the shallow end in search of higher oxygen. Be prepared to operate an aerator in shallow water. Bankwasher aerators are effective at quickly providing oxygen to fish along the shoreline.

Most producers do not have enough paddlewheel or pump sprayer aerators for all ponds and, therefore, move them to ponds as they are needed. One portable aerator for every three to four ponds is adequate. If aeration requirements exceed the oxygen supplied by available equipment, then the ponds with the fastest-falling oxygen levels or the most valuable fish should be aerated first.

A portable paddlewheel or pump sprayer aerator can be difficult to situate in a pond properly without damaging it or the tractor. Before emergencies arise, try running aerators in several probable locations around each pond, so that placement becomes more or less routine. This is particularly important because most aerator maneuvering is done at night.

**Common Aeration Practices And Designs**

This section briefly describes some common methods of aeration. Additional information can be found in Southern Regional Aquaculture Center Publication No. 370, “Pond Aeration” and SRAC Publication No. 371, “Pond Aeration: Types and Uses of Aeration Equipment.” These publications can be obtained from your county Extension agent or from the Extension fisheries specialists.

**Well water.** Pumping water from a well, stream, or adjacent pond with a high oxygen content is a good way to aerate in an emergency. Well water is often low in oxygen and must be splashed or sprayed before it enters the pond.

If well water is not available or not in sufficient quantity, then water from an adjacent pond or stream may be a good substitute. Water from streams or other ponds is not as desirable as well water, because it can be a source of wild fish and disease.

To aerate ponds in this way, you need equipment that will pump at least 100 gallons per minute for each acre of pond. Drain some water from the pond bottom while adding water at the surface. This method is more effective than allowing excess surface water to pass through the pond standpipe or spillway.

**Spraying.** Water from the pond low in oxygen can be sprayed into the air to add oxygen. Place pump intakes just beneath the surface, not on the pond bottom. Discharge the water just a few feet above the surface of the receiving pond.

A pump sprayer or relift pump powered by the PTO of a farm tractor (Figure 15) is an-effective aerator for this situation. The discharge can be capped and slots cut in the sides to increase efficiency. Another modification is to mount the discharge manifold parallel to the surface of the pond and discharge in opposite directions down the pond bank (called a “bank washer”). PTO-, electric-, and diesel engine-powered pump sprayers are commercially available.

![Figure 15. A pump-sprayer powered by a farm tractor.](image)

**Carbon Dioxide**

The same factors that produce low dissolved oxygen concentrations in ponds also contribute to high carbon dioxide (CO2) concentrations. Carbon dioxide increases through the night because of respiration. Carbon dioxide levels can also increase rapidly after an algae bloom die-off.

Carbon dioxide interferes with oxygen uptake at the gills, so fish will show signs of oxygen stress even though oxygen readings may be in a safe range. A concentration of over 25 ppm of carbon dioxide in pond water is generally harmful to catfish and may cause death.

Aeration is the best way to help rid the pond of carbon dioxide and increase oxygen levels. Up to 100 pounds per acre of hydrated lime, Ca(OH)2, may be added in extreme cases to remove some of the CO2.

**pH**

The pH is a scale on which the acidity (hydrogen ions) and alkalinity (hydroxide ions) of water is measured. A pH of 7 is neutral (balanced in H+ and OH- ions). Changes in the pH of a pond occur during a 24-hour cycle because of respiration.

Carbon dioxide from nighttime respiration reacts with water to form carbonic acid. Carbonic acid drives pH downward, making the water more acidic. During the daytime, pH moves upward (the water becomes more alkaline) because the carbon dioxide is removed for photosynthesis.

The optimum pH for catfish ponds is between 6.5 and 8.5. But in production ponds, pH can vary from 6.0 to 9.5 without severely stressing the fish.

The pH of the pond is usually checked only before certain chemicals are added or if ammonia levels are high. The pH of the pond affects the toxicity of chemicals like copper and ammonia. The pH of the pond water is strongly influenced by the pH of the pond mud and of the soils in the watershed.

The only way to modify pH in ponds is by adding lime, gypsum, alum, or bicarbonate. However, adding chemicals to alter pH should be done only in extreme circumstances.

**Alkalinity And Hardness**

Alkalinity is a measure of bases in water. These bases include hydroxides (OH-), carbonates (CO3^-2), and bicarbonates (HCO3^-). They are relat-
ed to, but not the same, as pH. Alkalinity acts as a buffer to absorb hydrogen ions and resist pH changes.

Hardness is a measure of divalent (+2) ions, mostly calcium and magnesium. In chemical tests, both are measured in ppm of calcium carbonate equivalence, which leads many people to think that they are the same.

If alkalinity and hardness are both derived from limestone soils, then they usually have similar values. It is possible, however, to have water that is high in alkalinity and low in hardness and vice versa.

Alkalinity and hardness should be maintained above 20 ppm. Alkalinity can be increased by adding agricultural limestone, hydrated lime, quick lime, sodium bicarbonate, or sodium hydroxide. Generally agricultural lime is the least expensive and most predictable chemical to adjust alkalinity.

More information on this use of agricultural lime can be found in Extension circular ANR-232, “Liming Fish Ponds.” This publication is available from your county Extension agent or from the Extension fisheries specialists at Auburn University.

Alkalinity affects the toxicity of copper treatments in ponds. A fish farmer should check alkalinity before determining the rate for applying copper compounds. More information is found in Extension circular ANR-414, “Tables For Applying Common Fishpond Chemicals,” available from your county Extension agent or from the Extension fisheries specialists at Auburn University.

Hardness can also be increased by the addition of agricultural limestone, hydrated lime, quick lime, gypsum, or calcium chloride. Low hardness can be a problem in catfish hatcheries. Hardness of hatchery water (pond or well) should be checked before the spawning season.

**Nitrogen Wastes**

Catfish, like all other animals, produce nitrogenous wastes from the digestion of the proteins in their diet. Ammonia is the principal nitrogen waste product. It is excreted directly into the water from the guts and kidneys of the fish.

Ammonia is also produced from bacterial decomposition of the proteins from uneaten feed and from any dead animal or plant, including algae. About 2.2 pounds of ammonia is produced from each 100 pounds of feed fed.

Ammonia, once released into the pond, can be absorbed by algae or bacteria. Algae use ammonia as a nutrient for growth and reproduction. Certain aerobic (oxygen-requiring) bacteria use ammonia as a food source in a process called “nitrification.”

Nitrification is an important process by which toxic nitrogenous wastes are decomposed. In the process of nitrification, bacteria of the genus *Nitrosomonas* convert (oxidize) ammonia to nitrite, and bacteria of the genus *Nitrobacter* convert nitrite to nitrate. Ammonia and nitrite are both toxic to fish; nitrate is not.

**Ammonia Toxicity.** Ammonia in water dissolves into two compounds: ionized (NH4 + ) and un-ionized (NH3) ammonia. Un-ionized ammonia is extremely toxic to catfish, while ionized ammonia is relatively nontoxic. Un-ionized ammonia levels as low as 0.4 ppm can cause death. Reduced growth and tissue damage can occur at 0.06 ppm.

The ratio of the total ammonia nitrogen (TAN) in the un-ionized form depends on temperature and pH (Table 7). The amount of toxic un-ionized ammonia increases as temperature and pH increase. Under reasonable feeding rates and good water quality conditions, ammonia is seldom a problem.

Ammonia can become a serious problem, however, if:

- Overfeeding is common.
- A sudden algae or phytoplankton die-off occurs.
- A high afternoon pH drives the un-ionized ammonia concentration to a toxic level.

Ammonia levels should be routinely checked each week and whenever an algae die-off occurs. High ammonia levels can occur at any time of the year, but they are most likely during the summer because of heavy feeding rates. Managing high ammonia levels is difficult. First, stop or reduce feeding rates and maintain good dissolved oxygen levels (ammonia damages the gills). Second, flush the pond if adequate water is available.

**Nitrite Toxicity.** Nitrite is also very toxic to catfish. Under normal conditions, nitrite does not accumulate to toxic levels. But it can reach toxic levels if bacterial decomposition (nitrification) is disrupted. Most nitrite problems occur during fall and winter, when sudden changes in pond water temperatures disrupt bacterial decomposition.

Nitrite passes through the gills of fish and attaches to hemoglobin of the blood, forming methemoglobin. Methemoglobin causes the blood to

| Table 7. Percentage Of Un-ionized Ammonia In Solution At Different pH And Temperatures. |
|-----------------------------------|-------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| **pH**                           | **16**                       | **18**         | **20**         | **22**         | **24**         | **26**         | **28**         | **30**         | **32**         |
| 7.0                              | 0.30                         | 0.34           | 0.40           | 0.46           | 0.52           | 0.60           | 0.70           | 0.81           | 0.95           |
| 7.2                              | 0.47                         | 0.54           | 0.63           | 0.72           | 0.82           | 0.95           | 1.10           | 1.27           | 1.50           |
| 7.4                              | 0.74                         | 0.86           | 0.99           | 1.14           | 1.30           | 1.50           | 1.73           | 2.00           | 2.36           |
| 7.6                              | 1.17                         | 1.35           | 1.56           | 1.79           | 2.05           | 2.35           | 2.72           | 3.13           | 3.69           |
| 7.8                              | 1.84                         | 2.12           | 2.45           | 2.80           | 3.21           | 3.68           | 4.24           | 4.88           | 5.72           |
| 8.0                              | 2.88                         | 3.32           | 3.83           | 4.37           | 4.99           | 5.71           | 6.55           | 7.52           | 8.77           |
| 8.2                              | 4.49                         | 5.16           | 5.94           | 6.76           | 7.68           | 8.75           | 10.00          | 11.41          | 13.22          |
| 8.4                              | 6.93                         | 7.94           | 9.09           | 10.30          | 11.65          | 13.20          | 14.98          | 16.96          | 19.46          |
| 8.6                              | 10.56                        | 12.03          | 13.68          | 15.40          | 17.28          | 19.42          | 21.83          | 24.45          | 27.68          |
| 8.8                              | 15.76                        | 17.82          | 20.08          | 22.38          | 24.88          | 27.64          | 30.68          | 33.90          | 37.76          |
| 9.0                              | 22.87                        | 25.57          | 28.47          | 31.37          | 34.42          | 37.71          | 41.23          | 44.84          | 49.02          |
| 9.2                              | 31.97                        | 35.25          | 38.69          | 42.01          | 45.41          | 48.96          | 52.65          | 56.30          | 60.38          |
| 9.4                              | 42.68                        | 46.32          | 50.00          | 53.45          | 56.86          | 60.33          | 63.79          | 67.12          | 70.72          |
| 9.6                              | 54.14                        | 57.77          | 61.31          | 64.54          | 67.63          | 70.67          | 73.63          | 76.39          | 79.29          |
| 10.0                             | 74.78                        | 77.46          | 79.92          | 82.05          | 84.00          | 85.82          | 87.52          | 89.05          | 90.58          |
| 10.2                             | 82.45                        | 84.48          | 86.32          | 87.87          | 89.27          | 90.56          | 91.75          | 92.80          | 93.84          |
change in color from red to chocolate-brown. For this reason, nitrite toxicity is called “brown blood” disease. If you suspect “brown blood,” check the gill color or cut off the tail of a fish and look for chocolate-colored blood.

Normal hemoglobin carries oxygen through the bloodstream, but methemoglobin cannot. Fish in this condition are under severe respiratory stress and will show signs of oxygen depletion. Nitrite toxicity is affected mainly by temperature, dissolved oxygen, and chloride ions. A nitrite concentration as low as 0.5 ppm can cause stress.

Nitrite concentrations can rise from 0 ppm to lethal levels in 2 to 3 days, so it is very important to test for nitrite regularly. Producers should check nitrite concentrations three times per week from August 15 to January 1 and throughout April and May. Checking nitrite one or two times a week is sufficient the rest of the year. Producers should also monitor nitrites closely after algae die-offs.

Chloride ions (not chlorine) in the water can block nitrite from entering across the gills, protecting the fish from “brown blood.” Research has shown that a minimum of 3 parts of chloride should be present for each part nitrite in the pond. Generally, a chloride to nitrite ratio of 5:1 or 6:1 is best.

Salt (sodium chloride) is commonly used to increase chloride concentrations in ponds. Calcium chloride, either anhydrous or dihydrous, has also been used for this purpose, but it is more expensive.

Some producers try to maintain chloride concentrations at 30 ppm in ponds. Applying 45 pounds of salt in 1 acre-foot of water will bring the chloride level to 10 ppm. So, to achieve 30 ppm, 135 pounds (45 x 30) is needed for each acre-foot of water. In a 10-acre pond with an average depth of 4 feet (or a total of 40 acre-feet), a 30-ppm chloride concentration would require the addition of 5,400 pounds of salt.

A more precise way to calculate the needed level of chloride is to measure the nitrite concentration and multiply it by 6.

Whenever nitrite levels rise, check chloride levels and add salt as needed. Flushing water through the pond can reduce nitrite levels but will also remove chloride ions. Watershed ponds lose chloride when they overflow. Test regularly and keep good records!

After the “brown blood” problem is corrected, watch the fish closely for bacterial infections. Bacterial infections often occur a few days after “brown blood” outbreaks.

Other Toxicity Problems. There are other potentially harmful chemical compounds that producers should consider.

Copper and zinc in small concentrations can be extremely toxic to fish. Galvanized equipment, such as pipes, containers, screens, and tanks used in holding and transporting fish may give up enough zinc to be toxic. Copper from algae treatment, pipes, and other equipment can also be toxic to fish in containers.

Catfish are very sensitive to chlorine. Water from city supplies should not be used for filling, handling, or holding tanks.

Some pesticides are also toxic to fish. Fish in ponds built on cultivated watersheds are always in danger of pesticide poisoning. Before stocking fish in these ponds, find out which chemicals have been used and their toxicity to fish.

Establish vegetative barriers between fields and ponds. Make sure that chemical applicators prevent chemical drift over ponds. Be aware that constant use of chemicals near ponds may eventually cause a serious problem.

In the future, one of the strongest selling points for aquaculture products should be their lack of chemical contamination. Keep dangerous chemicals away from your ponds and assure the consumer of the highest quality product.

<table>
<thead>
<tr>
<th>Component</th>
<th>Recommended Value Or Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved oxygen</td>
<td>4 ppm or more</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>less than 20 ppm</td>
</tr>
<tr>
<td>pH</td>
<td>6 to 9.5</td>
</tr>
<tr>
<td>Total alkalinity</td>
<td>20 ppm or more</td>
</tr>
<tr>
<td>Total hardness</td>
<td>20 ppm or more</td>
</tr>
<tr>
<td>Un-ionized ammonia</td>
<td>less than 0.05 ppm</td>
</tr>
<tr>
<td>Nitrite</td>
<td>less than 0.5 ppm</td>
</tr>
<tr>
<td>Temperature change</td>
<td>less than 5°F</td>
</tr>
</tbody>
</table>

Table 8. Recommended Water-Quality Requirements For Catfish Production.

Parasites And Diseases

Low oxygen, handling, crowding, transporting, and poor nutrition all cause stress, making fish more susceptible to parasites and diseases. If fish feed slowly or stop altogether, appear sick, or die, analyze the situation immediately.

Test the water to see if the condition could be caused by low oxygen, high carbon dioxide, ammonia or nitrite toxicity, or pesticide pollution. If these problems can be eliminated, watch the fish closely.

Are the fish:
- not eating?
- lying lazily in shallow water or at the surface and not swimming off rapidly when disturbed?
- nervous or irritable?
- flashing or swimming erratically?
- Catch some fish that seem sick. Do they have:
  - worn-away areas on gills, fins, mouth or skin?
  - open sores?
  - heavy mucous (slime) covering all or parts of their bodies?
- pale or swollen gills?
- protruding eyes?
- swollen or sunken bellies?

Figure 16 shows several signs of disease. If you see any of these signs, get a diagnosis immediately. Early diagnosis is essential for effective treatment.

The Southeastern Cooperative Fish Disease Project diagnoses fish diseases free of charge during working hours Monday through Friday.

Send your samples to:
Fish Disease Laboratory, Swingle Hall
Auburn University, Alabama 36849-5419
844-9307 or 844-4786.

Figure 16. Diseased catfish fingerling.
Or, if you live in the Greensboro area, send them to:
Alabama Fish Farming Center
529 Centreville Street
Greensboro, Alabama 36744
624-4016 or (800) 838-2332

A good diagnosis depends on proper sample collection and transportation. Samples must be transported quickly. If possible, bring your fish to the disease lab in person.

Bus transportation is most reliable when shipping to Auburn. Shipping by overnight carrier may be possible, but check with the carrier. Include a separate water sample along with the fish, so that water quality can be checked.

Finally, always call the disease lab and confirm the shipment.

Results of bacterial diagnosis take 2 or 3 days. The pond owner will be notified of the results and recommended treatments as soon as they are available.

More information on collecting and sending samples to the diagnostic labs can be found in Extension circular ANR-562, “Guidelines For Collecting And Shipping Diseased Fish.” This publication is available from your county Extension agent or the Extension fisheries specialists.

Chemicals

Chemicals should be used in fish culture only when there is no alternative. Ponds can require chemical treatment for:

- controlling disease.
- sterilizing ponds.
- altering water quality.
- eliminating undesirable fish.
- controlling undesirable insects and weeds.

Not all agricultural chemicals are approved for use in food fish ponds. Check with your county Extension agent or Extension fisheries specialist for the latest recommendations.

When chemical treatment is prescribed, how do you calculate the amount of chemical needed to get the required concentration? Before treating any body of water, you must consider these things.

The Fish

What are the tolerable limits of the fish to the chemical?

The Water

In the pond to be treated, what water quality factors will affect the chemical being used?

Could hardness or muddiness increase the toxicity of, or render ineffective, the chemicals being used?

The Chemical

What percentage of active ingredient is in the chemical formulation?

The Pond Size

What is the exact volume of water to be treated? Many fish have been killed because pond volumes have been exaggerated. Overestimating the pond size will cause an overdose and probably kill fish. On the other hand, underestimating the size may result in an ineffective treatment.

Know the volume of your tanks and ponds. Keep a record of this volume for future treatments.

To calculate the volume of a square or rectangular body of water, multiply length times width times average depth of water. This will give you cubic measurements of volume. Cubic feet (ft3) and acre-feet are the measurements most commonly used. The area and volume of irregularly shaped ponds are much more difficult to determine.

The local SCS office can assist you in determining surface area and possibly average depth. Average depth can be estimated by multiplying the maximum depth by 0.4. Remember to use the same units of measure for each body of water to be treated.

One very accurate way to measure pond volume is through the use of chloride tests.

1. Take a water sample from the pond and test it for chloride (ppm). Reserve this sample so it can be compared to later samples.
2. Broadcast 50 pounds of salt per surface acre of the pond. The total pounds of salt added must be known, but the pond acreage can be estimated.
3. Allow the salt to dissolve. Usually one day is sufficient.
4. Take several water samples from different areas and depths of the pond. Test these new samples for chloride concentration.
5. Calculate the average chloride concentration. Add the chloride concentrations of all the samples together. Divide by the number of samples.
6. Calculate the change in chloride concentration. Subtract the beginning chloride concentration (the concentration of the very first sample) from the average chloride concentration.
7. Calculate the pond volume using this formula:

\[
\text{Volume (in acre-feet)} = \frac{(\text{weight of salt applied} \times 0.6) + 2.71}{\text{change in chloride concentration (ppm)}}
\]

Measure accurately! Since 1 acre-foot of water weighs 2.7 million pounds, then 2.7 (2.71 in the formula above) pounds of any material (or active ingredient) dissolved in 1 acre-foot of water gives a solution of 1 part per million (1 ppm). This method will not work in hill-type ponds that are stratified.

The volume of water in watershed ponds may vary considerably from month to month. A producer should know the volume of ponds at different pond depths, so that chemicals can be applied correctly. Remember, low estimates may result in ineffective treatments and high estimates may cause overdoses and fish kills.

Table 9 shows the weights of chemicals that must be added to 1 unit volume of water to get a concentration of 1 ppm.

<table>
<thead>
<tr>
<th>Amount Active Ingredients</th>
<th>Unit Of Volume</th>
<th>Parts Per Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.7 Pounds</td>
<td>acre-foot</td>
<td>1 ppm</td>
</tr>
<tr>
<td>1,235 grams</td>
<td>acre-foot</td>
<td>1 ppm</td>
</tr>
<tr>
<td>1.24 kilograms</td>
<td>acre-foot</td>
<td>1 ppm</td>
</tr>
<tr>
<td>0.0283 grams</td>
<td>cubic foot</td>
<td>1 ppm</td>
</tr>
<tr>
<td>1 milligram</td>
<td>liter</td>
<td>1 ppm</td>
</tr>
<tr>
<td>8.34 Pounds</td>
<td>million gallons</td>
<td>1 ppm</td>
</tr>
<tr>
<td>0.0038 grams</td>
<td>gallon</td>
<td>1 ppm</td>
</tr>
</tbody>
</table>

Table 10 contains conversions that are helpful in calculating treatments. More conversions to assist in chemical treatments can be found in Extension circular ANR-414, “Tables For Applying Common Fishpond Chemicals,” available from your county Extension agent or the Extension fisheries specialists.
Table 10. Conversions For Treatment Calculations.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 acre-foot</td>
<td>= 1 surface acre of water</td>
</tr>
<tr>
<td></td>
<td>= 1 foot deep</td>
</tr>
<tr>
<td></td>
<td>= 4,356 cubic feet</td>
</tr>
<tr>
<td></td>
<td>= 2,718,000 pounds of water</td>
</tr>
<tr>
<td></td>
<td>= 326,000 gallons of water</td>
</tr>
<tr>
<td>1 cubic foot</td>
<td>= 7.5 gallons</td>
</tr>
<tr>
<td></td>
<td>= 62.4 pounds of water</td>
</tr>
<tr>
<td></td>
<td>= 28,355 grams of water</td>
</tr>
<tr>
<td>1 gallon</td>
<td>= 8.34 pounds of water</td>
</tr>
<tr>
<td></td>
<td>= 3,800 cubic centimeters</td>
</tr>
<tr>
<td></td>
<td>= 3,800 grams of water</td>
</tr>
<tr>
<td>1 quart</td>
<td>= 950 cubic centimeters</td>
</tr>
<tr>
<td></td>
<td>= 950 grams of water</td>
</tr>
<tr>
<td>1 pint</td>
<td>= 475 cubic centimeters</td>
</tr>
<tr>
<td></td>
<td>= 475 grams of water</td>
</tr>
<tr>
<td>1 cup</td>
<td>= 240 grams of water</td>
</tr>
<tr>
<td>1 tablespoon</td>
<td>= 14.8 grams of water</td>
</tr>
<tr>
<td>1 teaspoon</td>
<td>= 4.9 grams of water</td>
</tr>
<tr>
<td>1 pound</td>
<td>= 454 grams</td>
</tr>
<tr>
<td></td>
<td>= 16 ounces</td>
</tr>
<tr>
<td>1 ounce</td>
<td>= 28.35 grams</td>
</tr>
<tr>
<td>1 liter</td>
<td>= 1,000 grams of water</td>
</tr>
</tbody>
</table>

Off-flavor

Off-flavor in farm-raised catfish is a very important problem to producers. Off-flavor is the presence of objectionable flavors in the fish’s flesh. The off-flavor may be so intense that it makes the fish unmarketable.

During the fall, more than 50 percent of production ponds may have off-flavor fish. This means that ponds cannot be harvested, and harvest and processing schedules are disrupted. Producers are left feeding and maintaining these fish, which increases production costs, disrupts cash flow, and extends risks.

Off-flavor is a complicated problem and requires that producers understand the probable causes, possible cures, and, most important, how to check the fish before they are marketed.

Off-flavor is caused by chemical compounds which enter the fish from the water. Research has shown that some of these compounds are produced by certain pond bacteria and algae.

The bacteria belong to a group of filamentous bacteria called the actinomycetes. These bacteria are found in the water column, but they are most abundant in the bottom mud. Actinomycetes thrive in ponds during warm weather, using nutrients from fish wastes and uneaten feed.

Algae commonly associated with off-flavors belong to the blue-green group. Blue-green algae, though always present in ponds, are most abundant in the summer and fall. Blue-green algae also thrive in nutrient-rich ponds and can dominate other types of algae. Blue-green algae often float and form paint-like scums or a “soupy” layer near the surface.

Off-flavor is a complicated problem and requires that producers understand the probable causes, possible cures, and, most important, how to check the fish before they are marketed.

Producers check fish for off-flavor before scheduling harvests. Producers should check fish for off-flavor also. Start checking the fish at least 2 weeks before the planned harvest, again 3 days before harvest, and finally the day of harvest. Fish can go off-flavor within a few hours and even during harvest operations. If off-flavor is found, continue testing weekly. The future of the catfish industry depends on a quality product, so every producer must make sure that the fish are not off-flavor.

Use the following procedure to test catfish for off-flavor:

1. Select one fish from each pond.
2. Head and gut, but do not skin the fish. This step can be skipped if you do not plan to eat the rest of the fish later.
3. Cut off the tail section (the last third) with skin intact. Use this part for the test.
4. Cook the tail section until the flesh is flaky, using one of the following methods. Do not season the fish with any spices, not even salt.
   - Wrap the fish in foil and bake at 425 °F for about 20 minutes.
   - Place the fish in a small paper or plastic bag or a covered dish and microwave at high power for 1 1/2 minutes per ounce.
5. After cooking, smell the fish first. Do you notice any foul odors?
6. Next, taste the fish. Do you notice any foul or bad flavors?
7. Learn to check your fish. Know when an off-flavor problem exists. And remember, a first-time catfish consumer who eats an off-flavor fish may be a one-time customer.

Harvest

A market for fish must be arranged before harvesting. Most buyers prefer fish that weigh between 3/4 and 2 pounds.

Methods

Two harvesting methods are generally used: complete harvest, when all the fish are taken out of the pond, and partial harvest, when only a portion of the fish are taken out of the pond at one time.
A complete harvest is usually done by seining and draining the pond. In levee-type ponds, the pond is seined to remove the fish. In hill-type ponds, the pond is seined to remove the fish as soon as the water is lowered to about 5 to 8 feet deep at the drain. The remaining fish, in both cases, are captured by seines lowered to about 5 to 8 feet deep at the drain. The draining the pond. In levee-type ponds, the pond is vested pond from the storage pond. Harvesting for temporary storage. Then, refill the harvesting can be alternated among ponds or at different stations within larger ponds. Remember to feed fish at the time of day you plan to trap. More information on trap seining can be found in Extension circular ANR-257, “Corral Seine For Trapping Catfish,” available from your county Extension agent or the Extension fisheries specialists.

**Equipment**

The type and size of harvest equipment a producer needs depends on the size of the operation and the market served. Some producers harvest their own fish. However, some fish buyers and custom harvesters harvest the fish, reducing the producer’s need for equipment.

**Seines.** For every 2 feet of pond width to be seined, 3 feet of seine length is required. The same ratio applies to pond depth. Floats can be made of styrofoam or plastic attached on 18-inch centers.

Most catfish seines have a mud line on the bottom of the net. A mud line is made of many strands of rope or a roll of menhaden netting bound together (Figure 18). As the seine is drawn across the pond bottom, the mud line stays on top of the mud, eliminating the digging effect of lead-weighted lines.

Seines should be made of polyethylene or nylon. Catfish spines will not catch in polyethylene material. Nylon netting requires a net treatment to prevent spines from entangling.

The mesh size to be used varies according to the minimum size of the fish to be captured. Buying the proper mesh seine for your operation allows you to capture only fish that are large enough for your market. Table 11 gives the size of fish that can be caught by various sizes of mesh. The size of the fish caught varies somewhat with the mesh width and the condition and activity of the fish. Fish do not grade as well when water temperatures are cold. All sizes are given as bar mesh, which is the smallest distance between knots.
Table 11. Mesh Sizes And Sizes Of Fish Caught.

<table>
<thead>
<tr>
<th>Mesh Size</th>
<th>Fish Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 inches</td>
<td>5 ounces and larger</td>
</tr>
<tr>
<td>1 1/4 inches</td>
<td>7 ounces and larger</td>
</tr>
<tr>
<td>1 3/8 inches</td>
<td>8 ounces and larger</td>
</tr>
<tr>
<td>1 1/2 inches</td>
<td>12 ounces and larger</td>
</tr>
<tr>
<td>1 5/8 inches</td>
<td>1 pound and larger</td>
</tr>
<tr>
<td>1 3/4 inches</td>
<td>1 1/2 pounds and larger</td>
</tr>
<tr>
<td>1 7/8 inches</td>
<td>1 3/4 pounds and larger</td>
</tr>
<tr>
<td>2 inches</td>
<td>2 pounds and larger</td>
</tr>
</tbody>
</table>

*Live-cars.* Holding live fish is sometimes necessary if the market cannot take all the catch in one day, or if there is a delay between capture and hauling fish to market. Often, catfish producers may want to sell fish directly to consumers. In these cases, catfish can be held in live-cars. Live-cars are net enclosures that can be placed in a pond to temporarily hold the fish (Figure 19). They are made of the same materials as seines.

Use caution when holding fish in live-cars. Diseases, oxygen stress, weight loss, and poaching are common problems. It may be necessary to aerate near the live-car at night, particularly in warm weather. Limit the time the fish are held to only a few days to reduce weight loss and prevent disease. Disease can occur in holding devices during any season but is much more prevalent when water temperatures are highest. Poachers can easily steal fish from unguarded holding facilities.

**Other equipment.** For harvesting fish, producers may also need:
- A seine reel for hauling in and storing the seine.
- Seine stakes.
- Tractors.
- Sturdy dip nets.
- Baskets.
- Boots or chest waders.
- Scales.
- A boom.
- A boat and motor.
- A gasoline-powered pump for filling tanks.
- Fish hauling tanks (Figure 20).

Fish pumps for loading catfish are also gaining popularity.

**Transporting Live Catfish**

Transporting live fish requires maximum care to avoid fish losses. In transport, fish are crowded into a relatively small amount of water. Agitators, blowers, compressed oxygen, compressed air, or liquid oxygen can be used individually or in combination to keep the fish alive. Transport containers are usually made of wood, fiberglass, or aluminum. Many types are commercially available.

Generally, the dissolved oxygen content in the water is the factor that determines whether the fish live or die. Fish should not be fed for at least 24 hours before transport so that excessive fish wastes do not accumulate during transport. Fish wastes and regurgitated feed consume large quantities of oxygen and can produce ammonia and carbon dioxide problems.

Transporting fish in cool weather or in cool well water increases fish survival. Cool water holds more oxygen than warm water, and fish consume less oxygen at lower temperatures. Also, large fish consume less oxygen by weight than small fish. It is a good practice to have an oxygen probe in the hauling tank and the meter in the cab of the truck to monitor oxygen concentrations during transport.

Fish health and survival depend on your ability to limit stress. Stress from netting, loading, hauling, and stocking weakens the fish and makes them more susceptible to disease and water-quality problems. The more you limit stress factors, the healthier the fish will be.

Table 12 (page 20) shows some guidelines for hauling live catfish. The numbers are in pounds of fish per gallon of water in tanks using agitators or blowers for aeration. Assume that the water temperature is 65 °F.
Table 12. Load Limits For Hauling Catfish, In Pounds Of Fish Per Gallon Of Water.

<table>
<thead>
<tr>
<th>Size Of Fish</th>
<th>1 Hr.</th>
<th>6 Hr.</th>
<th>12 Hr.</th>
<th>24 Hr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-inch fingerlings</td>
<td>2</td>
<td>1 1/2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Z-inch fingerlings</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1 1/2</td>
</tr>
<tr>
<td>14-inch adult fish</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

*Adapted from Transport of Live Fish by S. K. Johnson, Texas A&M University.

As water temperature rises, decrease the load by 25 percent for each increase of 10 °F. The same calculation can be used for increasing the load as temperature decreases. Loads can be increased by about 25 percent when pure oxygen is used for aeration. Ice can be used to cool the water in hauling tanks. Be sure to temper the fish before stocking or loading them into water of a different temperature (refer to the Water Quality section for the tempering procedure).

**Marketing Catfish**

Before the first ponds are built or before fish are stocked in existing ponds, producers should know where they can sell their fish. The market options available to catfish producers include:

- Large processors.
- Small processors.
- Fish-out, on-farm sales.
- Local retail sales.
- Live-haulers.

A market should be selected based on the potential profits according to the scale of the operation. Each option should be carefully analyzed.

Large processors generally harvest fish for producers within a short radius of the processing plant (50 to 75 miles). Some accept fish delivered live by the producer. Fish producers within range of large processing plants should arrange harvest or delivery dates before fingerlings are stocked.

Many producers want to sell their fish in the fall, creating an oversupply of fish for the processors. Catfish harvested in the spring or summer usually command a higher price, because processor demand is higher and supplies are lower. Some producers are able to market their fish more profitably during times of short supplies by manipulating the fingerling size and the stocking date and by partial harvesting.

There are small-scale processors in some areas who process small quantities of catfish for sale to local businesses and individuals. These processors often produce much of their own fish but, at times, buy from local producers. Your county Extension agent has information concerning processors in your area. Information on building your own small-scale processing plant can be found in Experiment Station Bulletin 255, “Design Of Small-Scale Catfish Processing Plants In Alabama,” available from the Alabama Agricultural Experiment Station at Auburn University.

Fish-out, or fee fishing, is another market option for many catfish producers. A fish-out business depends on the numbers of fishermen in the area and their ability to catch fish. Fishing ponds located near cities are usually more in demand than in remote areas.

Small, densely stocked ponds are best for fish-out purposes. Catfish should be replenished when stocks become low, so that the fish will keep biting. Many successful fee-fishing operations buy fish from other producers or produce them in their own ponds to stock fish-out ponds. This results in better fishing success, more customers, and more sales.

Owners of fish-out operations should be aware of safety provisions necessary when opening ponds to the public. Insurance protection against liability claims is a must!

Wholesale and retail sales of live catfish are other ways for producers to sell their product. Fish can be captured to order or captured and held live for later sale. Local newspaper ads, road signs, and word-of-mouth can rapidly establish a good market. Remember that customer demand can be maintained by providing a consistent supply of high-quality catfish throughout the year.

Live-haulers, people who buy and haul live catfish from producers to retail outlets, are important buyers of farm-raised catfish. Usually these haulers want producers to harvest and load the fish into their tank trucks. Live-haulers often transport fish to fish-out ponds or other live markets near large cities such as Chicago or Atlanta. Live-haulers generally buy the majority of their fish from March through October.

A producer catering to live-haulers exclusively should have all the necessary equipment for seining and loading, plus all-weather roads around the ponds.

**Bird Predation**

Bird predation has been an increasingly serious problem for catfish producers since the mid-1980s. Most birds that cause problems are migratory and are therefore protected under the federal Migratory Bird Treaty Act (MBTA). The birds’ migratory nature complicates the problem, because predation varies greatly depending on migration patterns, time of the year, migratory concentrations, and the location of catfish ponds. Proximity to nesting or rookery sites can also compound the problem.

Besides eating the fish, these birds can damage property. They are known to transmit fish diseases. Predatory birds consume the individual fish that are easiest to catch. Fish that are easily caught are often those that are diseased. So, the birds pick up diseases and transmit them to other ponds through their excrement and through simple body contact.

Catfish in Alabama are preyed upon by cor- morants, egrets, and herons throughout the year and by kingfishers and anhingas (water turkeys) during the warmer months. Ospreys and pelicans can sometimes cause problems, too. The occasional visit by solitary kingfishers and ospreys causes little economic damage. Frequent visits by flocks of anhingas, herons, egrets, pelicans, and cormorants can be devastating, however. The problem is generally most pronounced in fingerling ponds.

The MBTA is often confused with the endangered species laws. Under the MBTA, migratory birds may not be killed or trapped without permits. But the species mentioned above can be harassed or frightened away from ponds, and habitat alteration and physical barriers are possible methods of control.

Physical barriers can include hanging netting or wires over ponds and erecting fences around the
edge of ponds. These measures are expensive and may cause physical problems to the producer during harvest.

The most common control measures are harassment techniques to frighten birds away from ponds. Birds can be frightened away by:

- Gunfire.
- Fireworks.
- Gas-powered noise cannons.
- Electronic noisemakers.
- Flashing lights.
- Reflecting material.
- Repellents.
- Bird distress calls.
- Water fountains or cannons.
- Scarecrows.
- Electronic shocking devices.

These measures have had mixed success. Most methods appear to be effective at first, but they become ineffective as the birds get used to them. For this reason, it is best to use a combination of techniques and to frequently move the devices randomly around the ponds.

Producers may contact the US. Fish and Wildlife Service and the USDA’s Animal and Plant Health Inspection Service (APHIS) for assistance. These agencies will recommend control measures. Permits can be issued to kill birds, if producers keep good records of control measures and estimated losses of fish. These permits are only issued after other methods have proved (by working through agencies and keeping good records) ineffective as certified by the APHIS Animal Damage Control Office. Comply with the law, try creative harassment techniques, report losses to state and federal agencies, and keep good records.

### Genetics And Breeding

Improving catfish through genetic research is a relatively new activity. Much of the improvement in the last 40 years in all phases of agricultural production, both plant and animal, has resulted from genetic selection and hybridization. Faster growth, higher yield, better feed conversion, and increased resistance to disease can all be improved through genetic manipulation.

Several universities in the Southeast are involved in catfish genetic research. Scientists are doing work in selection, strain identification and evaluation, cross-breeding, hybridization, polyploidy, sex reversing, and gene splicing. The results of this research are encouraging, and this type of research is expanding.

In general, domesticated strains of catfish have shown better growth rates than wild strains. The many domesticated strains vary in growth rates, body conformation (influences dress-out percentage), and resistance to disease. Crossbreeding has also shown some improvements in growth rates, spawning success, and disease resistance (attributable to hybrid vigor). Of course, not all strains or crossbreeds perform equally at different geographical locations.

Crossing female channel catfish with male blue catfish has produced improved growth, feed conversion, resistance to certain diseases, catchability by seining and angling, and higher dress-out as compared to pure channel catfish. However, production of the channel female X blue male hybrid can be difficult. The two species rarely spawn naturally when mated together, and they spawn inconsistently even when expensive hormone injections are used. Research is continuing so that this significantly improved fish will be available to producers in the future.

From a practical standpoint, producers should work with domesticated strains. If you buy fingerlings, buy from a producer who is practicing mass selection or who is working with improved strains. If you produce your own fingerlings, know what strain you have, try mass selection of your fastest growing fish, try to obtain improved strains for crossbreeding, and, most importantly, do not inbreed.

For help in identifying strains and understanding genetic improvement techniques request: Circular 273, “Ancestry and Breeding of Catfish in the United States,” and Southern Cooperative Series Bulletin 325, “Genetics and Breeding of Catfish.” These publications are available from the Alabama Agricultural Experiment Station at Auburn University.

More information on producing catfish fingerlings can be found in Extension circular ANR-327, “Producing Channel Catfish Fingerlings,” available from your county Extension agent or the Extension fisheries specialists at Auburn University.

### Permits And Regulations

No fish farming permit is required in Alabama. Processing facilities, however, must be certified and inspected by the Alabama Department of Public Health.

Permits to construct ponds are needed if the ponds are to be located in wetlands. Before constructing ponds, check with the USDA Soil Conservation Service for the latest information on permits required for building ponds. When constructing in a wetland, failure to have a permit from the Corps of Engineers could result in civil and criminal penalties.

Discharge from ponds must meet federal Environmental Protection Agency (EPA) standards as administered by the Alabama Department of Environmental Management (ADEM). Under present regulations, most producers do not need permits. Permits are necessary if a catfish farm produces more than 100,000 pounds each year and discharges water 30 or more days each year. Discharge does not include overflow from ponds during rains.

Alabama law (83-152) makes theft of farm-raised fish the same as livestock rustling. A person convicted of stealing fish is subject to a fine of not less than $500, not more than $1,000, and seizure of the property used in committing the theft. This includes the fishing equipment and the vehicles. The court can also imprison the convicted person for up to 1 year for the first offense.

Check on the laws of other states before transporting fish across state lines. Because laws and regulations can change frequently, check with the appropriate agencies if you have any questions.
Review

This publication was designed to inform the general public about the catfish industry and to help prospective and existing catfish producers make rational investment and operational decisions for commercial scale farms. It highlights some of the difficulties, complexities, risks, and opportunities of catfish farming. Catfish farming is one of the most intensive forms of large-scale agriculture practiced today. It requires considerable capital investment, and it is a high-risk venture not suited to everyone.

Catfish farming is in its infancy. Problems involving genetic improvement, off-flavor, disease prevention, predator control, drug registration, water use and discharge, and market development continue to be addressed by researchers, Extension workers, government agencies, fish farmers, and other interested parties. No one has all the answers required for risk-free operation. The future is bright but should be approached with caution.

For more information on fish farming or pond management and for copies of the publications mentioned here, contact your county Extension office or an Extension fisheries specialist with the Alabama Cooperative Extension System.
For more information, call your county Extension office. Look in your telephone directory under your county’s name to find the number.

Issued in furtherance of Cooperative Extension work in agriculture and home economics, Acts of May 8 and June 30, 1914, and other related acts, in cooperation with the U.S. Department of Agriculture. The Alabama Cooperative Extension System (Alabama A&M University and Auburn University) offers educational programs, materials, and equal opportunity employment to all people without regard to race, color, national origin, religion, sex, age, veteran status, or disability.