Cage Culture of Fish in the North Central Region

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Introduction

The commercial production of fish is most commonly performed in open ponds, raceways, water reuse systems, and cages. Cage culture of fish is an intensive production method that allows the farmer to utilize existing farm ponds, borrow pits, or strip pits normally unsuitable for open pond culture, by enclosing fish in cages or pens.

Generally, yields (pounds/acre) are greater in open pond culture. However, there are times when existing bodies of water do not lend themselves to open pond culture and cage culture may be the best alternative. Other advantages to cage culture include:

1. Cage culture is an inexpensive method to develop fish husbandry skills before considering more expensive production systems.
2. Fish health and growth are easier to monitor.
3. Harvesting is simpler.
4. Pond construction costs are eliminated when existing ponds are used.

In spite of the advantages cage culture offers, there are disadvantages that are largely a result of high densities of fish confined to the small volume of a cage. The disadvantages must be weighed against any advantages before attempting cage culture. The primary disadvantages are:

1. Water quality problems, especially dissolved oxygen, can develop due to high stocking densities.
2. Disease outbreaks spread very quickly.
3. Damage to the cages can result in escape of fish.
4. Fish are easier to poach or vandalize.
5. The farmer must have daily access to the cages.
6. Production rates are lower than in production ponds.

Site selection

As indicated, cage culture can be practiced in standing bodies of water such as ponds, strip-mine pits, and barrow pits. In addition, large public reservoirs, rivers, and streams can be used for cage culture if permitted by regulatory agencies. Agencies that may have authority over public waters are the State Departments of Natural Resources or Conservation, the U.S. Environmental Protection Agency, or the U.S. Army Corps of Engineers.

The ideal pond for cage culture should have the following characteristics:

1. Be at least one surface acre with larger ponds preferred.
2. The pond should have a depth of eight feet in at least ⅓ to ½ of the pond area. The remainder of the pond should be at least four feet deep.
3. Water levels should not fluctuate more than 1 to 2 feet during the summer.
4. There should be not more than a 10 acre watershed per surface acre of water.
5. Livestock should not have direct access to the pond.
6. There should be no runoff from row crops or livestock feedlots.
7. There should be no chronic problems with aquatic weeds.
8. The watershed should be vegetated to prevent siltation.

Water quality

Maintaining high water quality will determine the success or failure of any aquaculture operation. Fish are dependent on water for all their bodily functions and slight changes in water quality will affect fish. Guidelines for the most important parameters will be given.

Many water quality parameters are measured using units called parts per million (ppm) or milligrams per liter (mg/l). Because both units are the same, ppm will be used in the following discussion of water quality .

Temperature

Ponds will stratify when the water warms and cools — a warm layer of water forms over a cooler layer beneath. During the summer these two layers will not mix. This results in poor water quality (low oxygen and high ammonia) in the cooler bottom layer. Mixing (turnover) of the two layers results in similar temperature throughout the water column.

Fish are cold-blooded animals and will have approximately the same temperature as their surroundings. Different species have different optimum growth temperatures. Each species can be categorized into coldwater, coolwater, or warmwater species, based on optimum temperatures for growth. Coldwater species (such as trout and salmon) grow best within a temperature range of 48° to 65°F. Coolwater species (such as hybrid striped bass, yellow perch and walleye) grow best between 60° and 82°F. Warmwater fish (such as catfish and tilapia) grow best within a temperature range of 85° to 90°F.

Oxygen

Suitable concentrations of dissolved oxygen (DO) are vital to successful fish culture. The amount of oxygen that can be dissolved in water is dependent on water temperature, altitude, and salinity. For example, water at 68°F is saturated with oxygen at 8.8 ppm while at 90°F saturation is 7.3 ppm. Optimal fish growth occurs when oxygen levels are maintained above 6 ppm for cool- and coldwater species and above 5 ppm for warm water species. Death may occur at levels less than 3 ppm. Symptoms of low DO are fish not feeding and fish gasping near the surface. Low DO levels can be expected to occur during the early morning hours and during or after extended periods of cloudy weather.

pH

The scale used for measuring the degree of acidity is called pH, and ranges from 1 to 14. A value of 7 is neutral, neither acidic nor basic; values below 7 are considered acidic; values above 7, basic. The acceptable range for fish culture is between pH 6.5 and 9.0. The pH will increase during the day as photosynthesis removes free carbon dioxide (decreasing carbon dioxide levels result in decreasing levels of carbonic acid). At night, photosynthesis ceases and carbon dioxide produced by respiration decreases the pH.

Alkalinity and hardness

Alkalinity is a system which prevents or “buffers” wide pH fluctuations. It is a measure of the carbonates (CO_3^{2-}) and bicarbonates (HCO_3^-) as expressed in terms of calcium carbonate ($CaCO_3$). Fish will grow over a wide range of alkalinities but values from 120-400 ppm are considered optimum.

Alkalinities in natural water sources will vary depending on alkalinities of soils within the watershed. For example, mining pits often have very low alkalinities which must be increased for fish production through addition of some form of buffers. The most common buffer used to increase alkalinity is ground agriculture limestone. Hence, abandoned gravel quarry pits often have very high alkalinities.

Ammonia

Fish excrete ammonia and a lesser amount of urea into the water as wastes. Two forms of ammonia occur in aquaculture systems, ionized and un-ionized. The un-ionized form of ammonia (NH_3^+) is extremely toxic to fish while ionized ammonia or ammonium (NH_4^+) is not. Both forms are grouped together as total ammonia nitrogen. The percent of total ammonia nitrogen which is in the un-ionized form is dependent on pH and temperature. Higher pH and temperatures result in a higher percentage of the un-ionized form.

In natural waters, such as lakes, ammonia may never reach toxic levels due to the low densities of fish. However, in cage culture where water circulation is restricted, ammonia buildups can occur. Ammonia buildups and low DO can be reduced through proper spacing of cages and regular cleaning of the cage netting.

Species selection

The desired species characteristics for cage culture are:

- fast growth rate, in regional environmental conditions,
- tolerance for crowded conditions,
- native to the region, and
- good market value.

Species that have been raised in cages in the North Central Region include: channel catfish, bluegill, hybrid striped bass, walleye, and trout.

Stocking rates are impacted by the quantity and quality of feed being used and by the water itself. In the event that the cages are placed into flowing water (streams or rivers with a constant flow) it may be possible to increase the stocking rates listed under each species in Table 1 (next page).

It is often best to stock cages two weeks prior to the anticipated growing season (based on preferred temperatures). Fish handled during these cooler water temperatures are less active and thus, are less excitable. Reduced stress decreases the potential for injury. As with all forms of aquaculture, the individual fish farmer should buy only high quality fingerlings that are relatively free of disease.

Channel catfish

Channel catfish are closely related species to the blue catfish and black bullhead. Emphasis will be given to channel catfish.

Channel catfish is a warmwater species that has a well-established market. Availability of fingerlings, tolerance for variable water conditions, and adaptability to cages increase their suitability for cage culture.

Fish are typically found in warmer waters, and optimal growth occurs in water temperatures between 80° and 85°F. Growth stops below 45°F and above 95°F. These preferred water temperatures limit their culture in this region.

Channel catfish may be stocked into cages when water temperatures exceed 50°F. Stocking at temperatures above 80°F may adversely stress the fish and lead to disease.

The size of channel catfish fingerlings to be stocked depends on the length of growing season, availability and marketing strategy. Generally 6- to 8-inch fingerlings are stocked into cages. If a 1¼- to 1½-pound fish is the desired market size, it may be necessary to stock a larger fingerling or to stock at a lower rate. It is not uncommon to stock 8- to 10-inch fingerlings where the growing season is 180 days or less — most of the North Central Region has a short growing season. Availability and cost of larger fingerlings may make stocking these sizes prohibitive. Also, a fingerling over 10 inches long may not adapt well to a cage.

Stocking densities for channel catfish fingerlings in cages range from 6 to 14 per cubic foot of cage. This equals to 250 to 600 fish in a 4 x 4 feet cylindrical cage. Generally speaking it is best to stock at the low densities (7 to 9 per cubic foot) when first attempting cage culture and particularly if supplemental aeration is not present. You should not stock below a density of 6 per cubic foot or channel catfish will fight, leading to injury and disease. Some recommended stocking rates for small cages are given in Table 1 (next page).

Even with supplemental aeration available it may be advantageous to stock additional cages rather than overstock individual cages. Overstocking

Table 1. Suggested stocking rates for cage culture.

Cage Size	Stocking Rates
4 X 4 feet (cylindrical)	300 - 400
4 X 4 X 4 feet	400 - 500
8 X 4 X 4 feet	800 - 1000
8 X 8 X 4 feet	1500 - 2000

individual cages can lead to serious growth and health problems.

Blue catfish and bullheads have been stocked in cages with limited success. Blue catfish have a slightly cooler temperature preference than channel catfish. This preference for lower temperature may make this species more appropriate in this region than the channel catfish. Additional research needs to be done to address the possibility of culturing the blue catfish.

The black bullhead has been successfully cultured in cages in New York. Researchers found that it was possible to get these fish to marketable size (greater than ½ pound) in one growing season by stocking 6-inch fingerlings. Stocking rates varied between 4 to 12 fish per cubic foot. Fingerlings of both bullheads and blue catfish are usually difficult to find and may be expensive.

Bluegill

Bluegill and their hybrids have been reared in cages with some success. Of the variety of crosses, the fry obtained from the female green sunfish X male bluegill cross are the major hybrids available to aquaculturists. Temperature tolerances and preferences of bluegill are similar to those for channel catfish. Bluegill, are more aggressive, will take food at lower temperatures than catfish, and should be stocked before the water temperatures reach 60° F. Bluegill and their hybrids are considered to be good candidates for aquaculture in the North Central Region because they will feed during lower water temperatures than channel catfish.

Fingerling bluegill should be 3 inches or larger at stocking and should be graded carefully to assure uniformity. Stocking densities for bluegill are at the upper range of those given in Table 1. At present there are no diets formulated for bluegills. Catfish, trout, and salmon diets have all been used to feed these fish with limited success.

Striped bass

Striped bass and associated hybrids have been successfully raised in cages. Hybrids survive under more extreme environmental conditions and grow faster then the pure striped bass.

Since the preferred water temperature of striped bass is 77° and 82°F, this fish is better suited for culture in the North Central Region than channel catfish.

Tentative stocking rates for hybrid striped bass are approximately 6 fish per cubic foot. At present the greatest problem in cage culture of hybrid striped bass is the availability of large or advanced fingerlings at a reasonable price. A minimum 6-inch fingerling is needed for stocking and 8-inch fingerlings would be preferable. Fingerlings should be graded closely because cannibalism is a problem in young hybrid striped bass.

Walleye

This species has been cultured recently in cages in the North Central Region, but written information is limited. After fish are trained to formulated feed, the optimal temperature for growth is 68°-75°F with the ideal temperature around 73° F.

The greatest losses result from disease and difficulty in training the fish to consume commercial diets (i.e., “non-feeders”. In one recent Iowa study, walleye fingerlings were stocked at 4 fish per cubic foot for the first year. Fish were again graded in the fall and restocked at one fish per cubic foot. These studies indicated that competition is still a problem at stocking densities as low as one fish per cubic foot.

Production costs are high for these various reasons, plus the commercial diets that are available are expensive, and the feed must be shipped from Utah or Washington. However, the market price for walleye is quite high compared to channel catfish and trout. Additional research is required to develop acceptable diets and lower costs of food-trained fingerlings.

Trout

Rainbow, brown, and brook trout have been reared in cages. Rainbow trout are most often cultured because of the availability of fingerlings, established markets, and adaptability to cages. Basic culture of all three species is very similar. Several salmon species have also been cultured in cages, but discussion here will be limited to the rainbow trout.

Trout are cold water species that require well-oxygenated waters. Optimum growth temperature for trout is between 55° and 65°F, but acceptable growth is attained between 50° and 68°F. At 70°F severe heat stress begins, usually followed by death if exposure is prolonged. Below 45°F feed conversion drops significantly and therefore, growth. These temperature regimes make cage culture of trout a fall through spring activity in this region, except where cold spring water or high altitude maintains lower summertime water temperatures.

It is necessary to stock a 6- to 8-inch fingerling trout in most of the North Central Region to obtain a ½- to 1-pound trout by the end of the growing season. Stocking should begin as soon as the water temperature drops below 68°F. Harvesting should begin as soon as the water warms in the spring to 68°F. Failure to harvest in time will mean loss of fish and profit.

Stocking densities for trout in cages may be higher than those for catfish. The higher oxygen levels maintained by cooler water and smaller sizes at harvest allow trout to be stocked at the higher densities of Table 1 (page 4) without concern for aeration and low dissolved oxygen. With experience, densities as high as 15 fish per cubic foot may be acceptable.

Other species

The species discussed are by no means the only species that may be cultured in cages. Selection of other species not listed in this publication should be made with desirable culture characteristics (listed in the first portion of this text) in mind. As interest intensifies and additional research takes place, further information regarding species selection and techniques will develop.

Floating fish cage construction

Fish cages can be constructed from a variety of materials. Generally, the longer a material can last in contact with water, the more expensive it is to use. Some consideration should be given to the expected "life" of the fish cage.

There are a few basic principles to consider when planning to build a fish cage:

1. All materials used for the cage should be durable, nontoxic, and rustproof. Copper and zinc can be toxic. Galvanized wire has been used in the past, but it usually rusts-out after only one year and fish may injure themselves on the rough surface. Plastic netting is often used; however, the presence of animals (minks, muskrats, and beavers) may require the use of vinyl coated wire fabric. Sunlight can also damage the plastic mesh, so leaving

the cages in the water year-round may be better than pulling them out and storing on the pond bank.

2. The netting material used for the body of the cage must allow maximum water circulation through the cage without permitting fish escapes. Mesh sizes less than ½ in. often clog with algae. Netting material of ½ in. and ¾ in. mesh size are most commonly used. A 4-in. channel catfish will be held within ½ in. fabric but not within ¾ in. fabric. Similar materials are used for a feeding ring that extends about 12 in. down from the top of the cage. The feeding ring must be small enough to hold in the floating pellets, yet large enough to stay clean (usually ⅛ in. mesh size.
3. Some type of flotation is needed to suspend the cage at the water's surface — small inner tubes, plastic jugs, or pieces of styrofoam. Clear plastic jugs do not last as long as colored ones. PVC cement should be applied to the cap threads to prevent water leakage into the jugs.
4. Sunlight stresses fish, therefore a lid should be included to block some of the light. Lids also prevent predators from entering the cage and fish from jumping out. The lid should incorporate a feeding hole for free access. Cage fabric lids covered with burlap or fiberglass (filon) lids are suggested.
5. Fish cages should have a volume of at least 1.3 cubic yards or 35.7 cubic feet (1.0 cubic meters).

Cylindrical shaped cages appear to work the best; however, square or rectangular shaped cages are widely used. The cylinder has no corners for the fish to bump into and become injured. When constructed properly, they are light enough for one person to pull partially out of the water to crowd the fish. Regardless of the shape, do not lift the entire cage out of the water with the fish inside unless the cage is properly reinforced. The plastic will usually break at the seams.

A sturdy, long-lasting cylinder cage can be made with the following finished dimensions: 4 feet tall by 38 inches in diameter, having a cubic volume of 31.5 cubic feet (1.2 cubic yards).

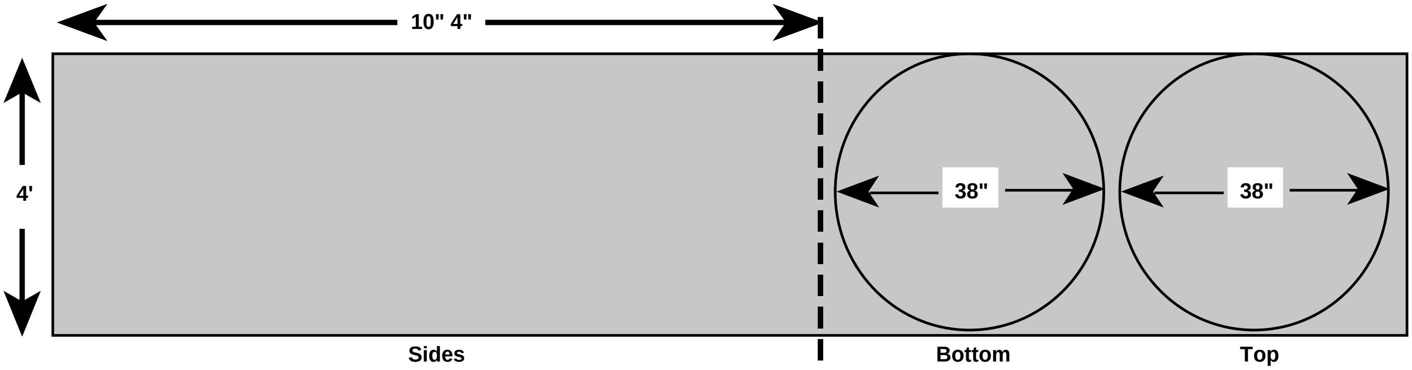
The materials needed are:

1. Three plastic hoops, each 38 inches in diameter. Either ½- or ¾-in. black plastic water supply line with an insert coupling (glue with PVC cement) works fine. A 10-ft. length of water line makes a 38-in. diameter hoop.
2. Plastic netting (½- or ¾-in. mesh) 4 ft. wide by 18 ft. long will be needed for the walls, top, and bottom of the cage.
3. Plastic netting (⅛-in. mesh size) 12 in. wide by 10 ft. – 4 in. long will be needed for the feeding ring.
4. Nylon rope (⅛ inch in diameter) 50 ft. long will be needed to sew the netting together.
5. About 50 cable ties at least 4 in. long will be needed to hold the fabric in place during sewing.

The steps for building a cage are:

1. Cut and glue the hoops together.
2. Cut the 18 foot piece of plastic mesh at 10 ft. - 4 in. for the cage wall. Lay two hoops on the remaining piece of mesh and cut around them for the top and bottom pieces. It is easiest to place the hoops under the fabric and then trim around the outside of the hoop with scissors (see Figure 1).
3. Attach the cage wall to the outside of one of the hoops (see Figure 2) using 6 to 8 of the cable ties. Position the hoop at the top full row of squares or diamonds in the fabric and let the cage wall overlap itself by about 4 in. The cable ties hold the mesh in place for the next step. Three ties will hold the overlap in place.
4. With the cage wall standing on end, lace the top full row of mesh to the hoop using the ⅛-in. nylon rope. Skip every two spaces on this top ring; make sure the starting knot is secure and remove any slack when the ring is

Figure 1. Cut the 18-foot piece of plastic mesh into three pieces.



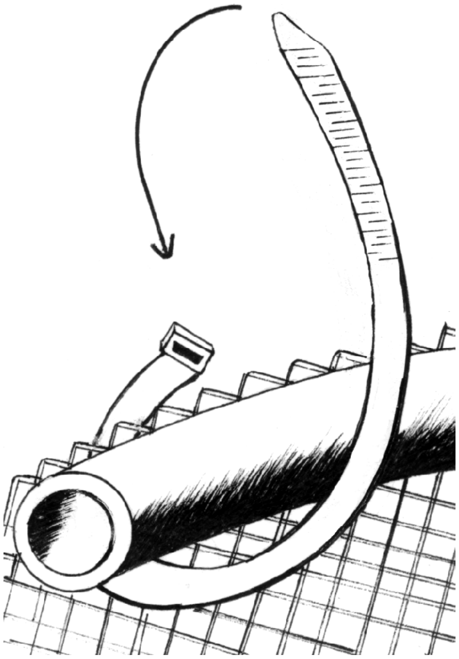


Figure 2. Attach the cage wall to one of the hoops with cable ties.

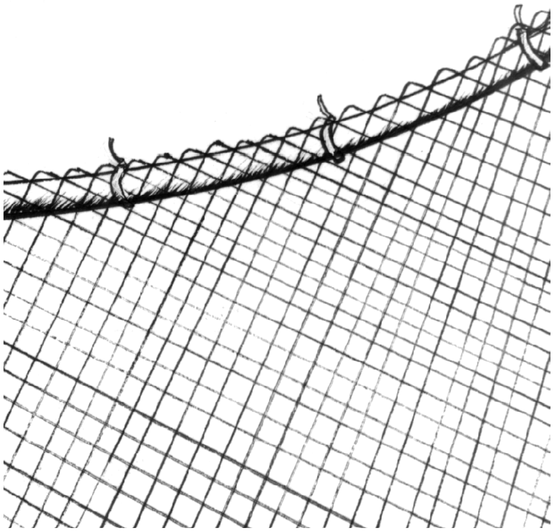


Figure 3. The cable ties hold the fabric in place while you sew with the rope.

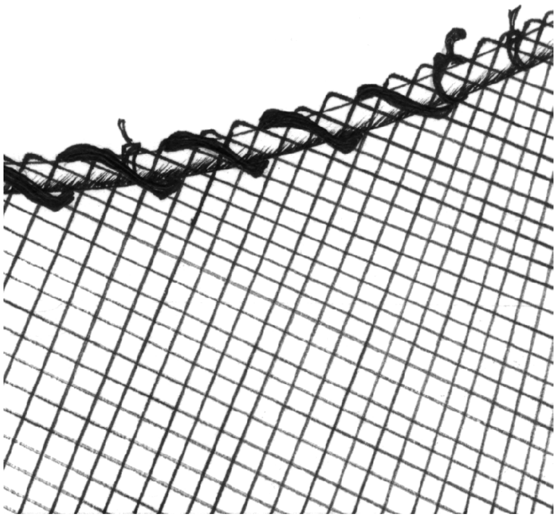


Figure 4. Lace the top full row of mesh to the hoop.

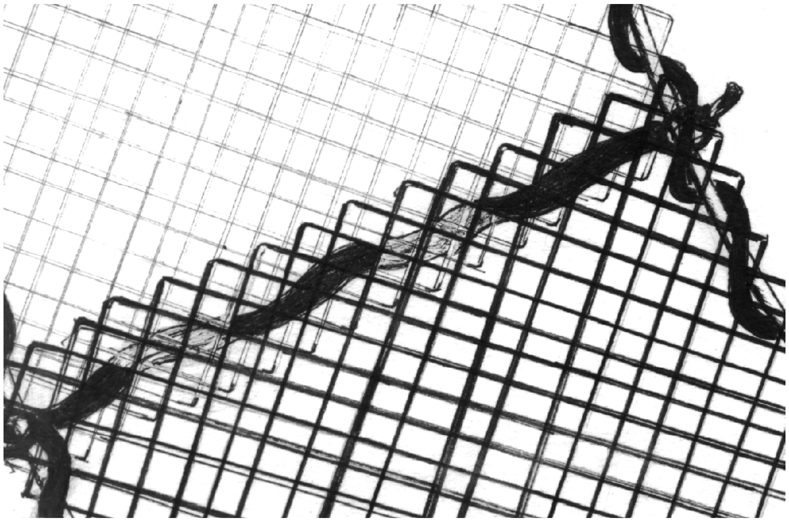


Figure 5. Lace down the overlap (seam) on one edge.

completed. Tie another secure knot once around the ring (see Figures 3 and 4).

5. Cut another piece of the rope and lace down the overlap (seam) on one edge or the other (see Figure 5). Again skip every two spaces and remove any slack. At the bottom, tie a knot and then lace up the other edge of the overlap. It is critical for the overlap to be flat and have no gaps or folds that would enable the fish to escape.
6. Turn the cage over, position a second hoop inside the top full row of spaces, secure it with a few cable ties, place the bottom piece of mesh (38 in. diameter) over the opening and lace the cage wall, hoop, and bottom piece in one operation. Again, no gaps can be left. It is helpful to have a second person inside the cage to send the rope back to the outside on each stitch. Depending on the height of the second person, the cage can be placed on three chairs to raise it up and allow easier lacing.
7. Lace the other 38-in. piece to the last hoop for the lid. Two spaces can be skipped between stitches. The lid should be tied to the top of the cage by short lengths of rope once the fish are stocked. Burlap or other light materials can be fastened to the lid to offer shade.
8. Make a feeding ring by fastening the ⅛-in. mesh fabric inside the top opening of the cage with cable ties. Attach both top and bottom of the ring to the cage wall.
9. Position the flotation devices on the cage wall so the top of the cage will be about 4 inches above the surface of the water. Four empty one-gallon bleach jugs will float the cage easily. A few small holes must be made in the bottom ring so it will fill with water to stabilize the cage (see Figure 6).

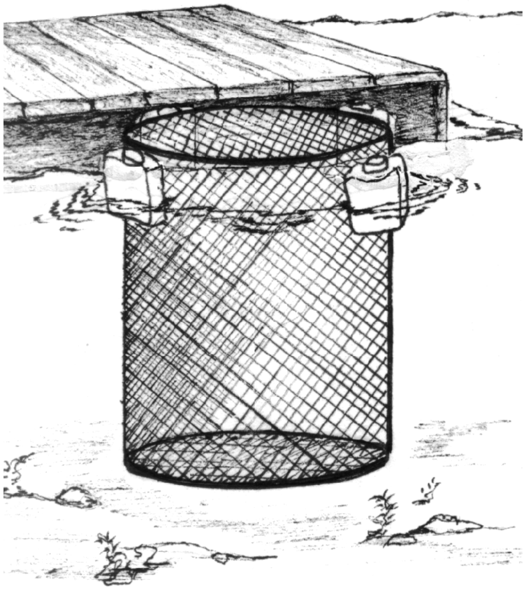


Figure 6. Position the jugs on the cage so the top of the cage is about 4 inches above the surface of the water.

Fish cage placement

One of the most important considerations affecting cage culture is the placement of the cage. It is very important that the wastes from the fish and excess fish feed fall through the cage and away from the immediate area of the cage. Therefore, the fish cage should be placed in an area where there is at least two feet of water between the bottom of the cage and the pond or lake bottom. It is undesirable for wastes to accumulate near the fish cage.

The fish cage should also be placed where the water can move freely through and around the cage. Vascular aquatic plants (those with stems), wind-protected coves, and areas around excessive structures should be avoided. Since wind action is the primary contributor to water movement, the cage should be placed in open water where the prevailing winds can create water movement. Even the slightest breeze helps to flush water through and around the cage, remove waste products, and provide fresh, oxygenated water.

Disturbances near the cage, such as swimming, boating, and fishing activities are not desirable. Channel catfish are especially susceptible to distractions, leading to reduced feeding, stress, and secondary diseases.

Fish cage placement should take into account daily feeding. Easy access during all sorts of weather conditions is desirable. The fish are more easily fed and managed when they can be approached by foot (cage tied to a dock) as opposed to by boat (cage attached to a rope and/or concrete block).

The cages should be at least three to four feet apart for proper water circulation. If the location of the cage does not offer adequate wind action for water circulation, it may be desirable to have a source of electricity nearby so supplemental aeration devices can be used.

Feeding

Feeding is the most important management practice that a fish farmer does each day. Simply stated, no feed will mean no growth. Without growth there will be no profit. It is important also to realize that feed will be the highest cost incurred on a fish farm. In fact, feed may comprise over 50% of your variable costs.

In cage culture, feed selection is extremely important because fish are not able to forage for insects and other food items that are available in the pond. As a result the feed selected should be nutritionally complete. Because fish cannot feed on the bottom, the feed used should float. There are processed feeds made for cage culture which meet these two requirements. However, any high quality feed that floats can be used in cage culture.

When selecting fish feed, keep in mind that different species will require different protein levels. Channel catfish are usually fed a 32% protein floating pellet. Trout and salmon are fed floating diets with protein levels ranging from 40-46%. Unfortunately, there are no commercial diets prepared for other species such as bluegill, hybrid striped bass, and walleye. Most farmers raising these species use trout or salmon diets.

Feeding frequency is as much a management consideration as it is a concern for the fish. Fish should be fed as much as they will eat in ten minutes in the morning and again in the afternoon. If this is not possible, feed fish all they will eat in 15 minutes around mid-morning.

Harvesting and overwintering

Harvest time is one of the most enjoyable aspects of aquaculture. In cage culture where small cages are used, the harvest process is usually easier than in open pond culture. Fish are concentrated in the cages and can be removed using dip-nets. In larger cages or pens the harvesting process is more complicated. Fish must be crowded to harvest. Cages may be partially lifted from the water or some type of screen or grate used to crowd the fish inside the cage.

Overwintering of fish in cages is not difficult. If adequate oxygen levels are maintained, fish can survive the harshest winters. There are two methods of overwintering caged fish. The preferred method is to keep the cages on the surface. Ice cover should be minimized to prevent damage to the cages. The second method involves suspending the cages below the ice. This method requires more care to avoid low dissolved oxygen levels.

Diseases and other problems

Cage culture is a complex form of aquaculture. Fish that are crowded are susceptible to many types of diseases. If a disease outbreak occurs, medicated feeds or baths in chemicals are sometimes used to treat fish. These are costly, time consuming, and sometimes ineffective.

The best way to avoid disease outbreaks is to practice good fish and water management. Water quality should be monitored on a regular basis and steps taken if DO or ammonia levels are unacceptable. Proper handling of fish is also important. Fish live in water and excessive time out of water will place disease-causing-stress on them.

Economics of cage culture

Before deciding whether to undertake or to continue a commercial aquaculture enterprise, the successful aquaculturist needs to develop a business plan and evaluate potential profitability. Enterprise budgeting is a management tool useful for both planning and profitability analysis. Developing an enterprise budget is an excellent, organized method for helping the aquaculturist understand all aspects, costs, and input requirements of every stage of the operation, from production system selection to product marketing.

To facilitate profitability analysis, enterprise budgets require numerical estimates of production assumptions and factors (such as pond size and feed conversion), direct costs (for feed), indirect costs (for equipment), marketing revenues, and input requirements (such as investment costs and feed quantities needed). Additionally, enterprise budgets encourage consistent and accurate record keeping.

Enterprise budget

The enterprise budget in Table 2 (opposite page) outlines the financial considerations important to hybrid striped bass cage culture. With appropriate changes the enterprise budget can be used for other species. The budget reflects specific production and marketing conditions, as set forth in the first section of the table; it represents an average year in the operation of the enterprise. The budget is divided into four sections: Assumptions and Production Factors, Direct Costs, Indirect Costs, and Profitability Calculations.

The assumptions and estimates of production factors, costs, and revenues summarized in Table 2 should serve only as guidelines for potential or current aquaculturists. Even though the figures reflect average management skills and costs, they cannot accurately represent any particular situation. A column titled “Your Farm” has been included in the budget for the individual to adjust the given budget figures to the realities of each aquaculturist’s situation.

The equations used to make budget calculations are included in Table 2 to enable aquaculturists to calculate their own figures, whether through use of a calculator or computer spreadsheet. Farmers with their own computers can easily incorporate budget items and equations into a spreadsheet program. Alternatively, County Agricultural Extension agents can assist interested parties in the use of FINPACK or other software packages for computerized budget analysis.

Sensitivity analysis

The budget parameters with the highest sensitivity percentages have the largest impacts on total costs, break-even prices, and profitability. The producer should therefore spend relatively more time managing these parameters. The data in Table 3 (page 12) reveal that death loss and interest costs are less important than harvest size, feed cost per unit, feed conversion, and fingerling costs per unit for a profitable hybrid striped bass cage culture enterprise.

Sensitivity analysis can be conducted by means of a five-step process.

Step 1. Calculate the proportion of total yearly costs for which each budget item accounts, and list the items with the highest proportions. In Table 2, the top three budget items

continued on page 12

Table 2. Enterprise Budget for Hybrid Striped Bass Cage Culture in an Existing 5-Acre Pond in Indiana.

Assumptions and Production Factors

Pond size: 5 acres	Production: 1,000 lb/A = 5,000 lb.
Harvest size: 1.5 lb	Market price: $2.00/lb.
Production cycle: 6 months	No. of harvested fish/cage: 250
Cage description: 3.5'x4', cylindrical	Interest rate: 12%
Fish marketing: fish sold live, pond-side	Death loss: 10%
Labor needed: 45 min/day = 22.5 hrs/month	Fingerling size: 6-8 inches

No. of fish harvested: 5,000 lb - 1.5 lb = 3,333 fish
No. of fingerlings purchased: No. of fish harvested ÷ (1-death loss)=3333 ÷ (1-.10)=3333 ÷ .9=3704 fingerlings
No. of cages: No. fish ÷ Fish/cage = 333 ÷ 250 = 13.33 + 1 = 14 cages
No. of fingerlings/cage: No. fingerlings ÷ (No. cages-1)=3704 ÷ 13=285 fingerlings/cage
Feed conversion: 2.0 lb. feed/lb. gain
Feed quantity: No. fingerlings purchased x harvest size x feed conversion=3704 x 1.5 x 2.0=11,112 lb. of feed
Cage construction costs: $15 labor + $20 frame, flotation + $5 wire + $25 netting = $65/cage
$65/cage x 14 cages = $910 total

Direct Costs

Budget item	Unit	Cost/Unit	Quantity	Annual Cost	% of TC	Your Farm
Fingerlings	head	$0.75	3,704	$2,778.00	$43.7%	____________
Feed	lb.	$0.25	11,112	2,778.00	43.7%	____________
Chemicals	cage	$2.50	14	35.00	0.6%	____________
Subtotal of operating capital				$5,591.00	88.0%	____________
Interest on operating capital	$	6%	$5,591	335.46	5.3%	____________
Total Direct Costs/Year				$5,926.46	93.2%	____________ _

Indirect Costs

Budget Item	Useful Life A	Initial Investment B	Annual Depreciation C = B + A	Average Interest D = (B ÷2)xi.r	Annual Cost E = C ÷ D	% of Total Costs	Your Farm
Cages	10 yrs.	$910	$91.00	$54.60	$145.60	2.3%	__________
Boat	10 yrs.	500	50.00	30.00	80.00	1.3%	__________
Oxygen meter	5 yrs.	400	80.00	24.00	104.00	1.6%	__________
Permits, etc.	1 yr.	50	50.00	3.00	53.00	0.8%	__________
Miscellaneous[a]	4 yrs	150	37.50	9.00	46.50	0.7%	__________
		$2,010		$120.60			__________
Total Indirect Costs/Year					$429.10	6.8%	__________

[a] Scales, rope, dipnets, and buckets.

Profitability Calculations		Your Farm
Total yearly costs (Direct + Indirect)	$6,355.56	__________
Break-even price (Total Yearly Costs ÷ Production)	$1.27/lb	__________
Break-even price - direct (Direct Costs ÷ Production)	$1.18/lb	__________
Gross revenue (Production x Market Price)	$10,000.00	__________
Net revenue (Gross Revenue - Total Yearly Costs)	0	__________
First year cash requirement (Total Investment + (2 x Total Average Interest) ÷ Total Direct Costs)	$3,644.44	__________
First year cash requirement excluding interest (Total Investment ÷ Subtotal of Operating Capital)	$8,177.66	__________
	$7,601.00	

Table 3. Effect of Changes in Key Budget Parameters on Break-Even Price and Profitability.

Budget Parameters	Break-Even Prices (Percent Change from Budget)				Sensitivity Pctg.[a]
	Alternative Values (Percent Change from Budget)				
Harvest Size	$1.39 (+9%)	$1.27 (0%)	$1.19 (-6%)	$1.12 (-12%)	57-35%
(lb. per fish)	1.25 (-17%)	1.50 (0%)	1.75 (+17%)	2.00 (+33%)	
Death Loss	$1.21 (-5%)	$1.27 (0%)	$1.34 (+6%)	$1.42 (+12%)	12%
(percent)	5 (-50%)	10 (0%)	15 (+50%)	20 (+100%)	
Feed Conversion	$1.12 (-12%)	$1.27 (0%)	$1.42 (+12%)	$1.57 (+24%)	44%
(lb. feed/lb. gain)	1.5 (-25%)	2.0 (0%)	2.5 (+25%)	3.0 (+50%)	
Feed Cost	$1.04 (-18%)	$1.15 (-9%)	$1.27 (0%)	$1.39 (+9%)	44%
($ per lb.)	0.15 (-40%)	0.20 (-20%)	0.25 (0%)	0.30 (+20%)	
Fingerling Cost	$1.11 (+13%)	$1.19 (-6%)	$1.27 (0%)	$1.35 (+6%)	44%
($ per head)	0.55 (-27%)	0.65 (-13%)	0.75 (0%)	0.85 (+13%)	
Interest	$1.24 (-2%)	$1.26 (-1%)	$1.27 (0%)	$1.29 (+2%)	7%
(% per annum)	8 (-33%)	10 (-17%)	12 (0%)	14 (+17%)	

[a] Percentage by which total costs and break-even price will change given a 100% change in the value of a budget parameter; or, given any percentage change in a budget parameter, the proportion of that change that is passed along to total costs and break-even price.

are fingerlings (43.7%), feed (also 43.7%), and interest (7.2%).

Step 2. Identify for each budget item the components needed to calculate the annual cost. Fingerling annual cost in Table 2 does not depend only on cost per unit and quantity (number of fingerlings purchased) because the quantity is calculated from the production level, harvest size of the fish, and death loss. Since the production level is assumed to remain constant in this budget, only harvest size and death loss, along with fingerling cost, can vary and affect enterprise profitability. The budget parameters listed in the left-hand column of Table 3 are the variable components of the three most important budget items from Table 2.

Step 3. Determine whether each component directly or indirectly affects the annual cost of each budget item. Of the six components in this example, four directly affect annual costs: fingerling cost per unit, feed cost per unit, feed conversion, and interest cost per unit.

Step 4. Calculate sensitivity percentages. Recalculate the budget for each alternative value of each indirect component to obtain new total cost figures. For each combination of component value and recalculated total cost, divide the percentage change in the total cost by the percentage change in component value. Multiply this ratio by 100 to obtain the sensitivity percentage. For some indirect components, this percentage remains the same regardless of the value of the component or the size of the component's change. This is the case for death loss. As can be seen in Table 3, the sensitivity percentage for death loss remains a constant 12% (roughly). The sensitivity percentage changes for harvest size, though, as harvest size increases. The sensitivity percentage for each direct budget parameter is the same as the percentage of total costs for which the associated budget item accounts. From the budget in Table 2, then, all direct components of fingerling and feed annual costs have a sensitivity percentage of roughly 44%.

Step 5. List budget parameters and compare sensitivity percentages. After listing each budget parameter, write in the sensitivity percentage calculated in Step 4. For those with a non-constant percentage, write in the range of percentages corresponding to the expected range of alternative values of that component. For instance, since harvest size is not likely to be less than 1.0 lb. or more than 2.0 lb., the corresponding range of sensitivity percentages is 71-35%. Producers should concentrate on budget parameters with higher sensitivity percentages since these parameters have relatively large impacts on profitability.

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