CAGE CONSTRUCTION
"ROUND OR SQUARE?"

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Introduction

I am sure that at this point in our workshop everyone is eager to obtain the last piece of the puzzle which will allow you to get started on your way to becoming a new or better fish farmer. I hope that you understand by now too, that constructing your cages is really the simplest part of cage fish farming. Nevertheless, after determining if you have a market for you fish and whether your pond or ponds are suitable for cage culture, cage construction is still one of the first things you will have to do. You may also think that between now (late summer) and next spring there is really nothing that you can do in preparation for next year. On the contrary, constructing cages this winter will give you a head start next spring.

For those of you that prefer, cages may be purchased from many companies handling aquaculture products. Many of these companies advertise in popular aquaculture magazines such as Aquaculture and Water Farming Journal. Other local companies also construct cages. But, like most of us who are "handy" will a few simple tools and are always looking for a way to save money, constructing your cages probably is the answer.

Every good fish cage built was constructed only after considering several factors. Three of these are:

1. Cages should be made of sturdy materials. Small cages will cost at least $50, therefore a cage fish farmer wants his cage to last several years. I think it is correct to say, that with proper care and maintenance, a ten year life expectancy is possible from a cage.

2. The netting selected is very important. The netting mesh size should be as large as possible and still prevent your fingerlings from escaping. A pretty good rule of thumb for catfish is to allow one fourth inch mesh size for every two inches of fingerling length. For example, 6-8 inch fingerlings will require 3/4 inch mesh. Other species that have different body girths should be tested prior to stocking. Selecting the largest mesh possible that will still retain your fish is critical to the health of your fish by allowing good water circulation. Since your fish will be confined to a small volume of water, a good exchange of water in the cage will carry out fish wastes while bringing in fresh oxygenated water.

3. The design should be as economical as possible while keeping in mind the first two factors.
During the next few minutes I would like to discuss:

1. The parts of a cage
2. Cage Design and construction
3. Placement of the cage in the pond
4. Stocking the cage

Parts of a Cage

A cage consists of a frame, netting, feeding ring, floatation and a lid. The frame of the cage can be constructed from wood, iron, steel, aluminum, fiberglass polyethylene or PVC. Frames of wood or steel must be coated with a non-toxic yet water-resistant substance to prevent rot or rust. The frame serves as a place to attach the netting and in some instances (polyethylene or PVC) serves as floatation.

The netting material can be galvanized wire, plastic coated welded wire, solid plastic mesh or nylon netting. Nylon netting is the least desirable of these since the accumulation of uneaten food will attract turtles which may chew through the cage bottom. Mesh size will vary according to the size of fingerlings selected, but for food fish production it is recommended to use at least 1/2 inch mesh.

As a result of wind and the feeding activity of the fish a feeding ring is used to prevent floating fish food from passing through the cage. It can also be constructed of netting if the mesh is small enough to retain the feed. Plastic netting constructed of 1/8 or 3/16 inch mesh and extends six inches below the water surface is a good choice for a feeding ring.

The floatation is necessary to maintain the top of the cage just above the water surface. Flotation can be provided by Styrofoam, waterproofed foam rubber or sturdy plastic jugs such as antifreeze jugs. Milk jugs are not good floatation devices since they break down after exposure to sunlight. In certain instances, the frame when constructed of polyethylene or PVC pipe will provide adequate floatation.

The lid for the cage can be constructed from the same type netting as the rest of the cage or from plywood, masonite, or light gauge aluminum. One advantage to constructing the lid from netting is that feeding is made easier by throwing feed directly through the lid rather than removing it each time you feed.

Cage Design and Construction

There are probably as many different cage designs in use as there are materials used to construct them; each has its advantages and disadvantages. I will not go into these numerous designs except to give you an idea of their dimensions. The three most common types used on smaller farms are the round, square and rectangular cages. Where large quantities of water are available, such as along the coast and large privately owned lakes, cages containing several thousand cubic feet of rearing area are in use.

I will give the design and construction procedures for a round and a rectangular cage having volumes of 37 and 160 cubic feet respectively. After gaining experience or when larger lakes are available, larger cages should be considered.
**Round Cage Design and Construction**

The round cage has one advantages over a square cage. For pelagic species which constantly swim, such as hybrid striped bass, round cages have no corners that these species can bump into. Constructing round cages of this size will allow two complete cages and the wall of a third cage to be constructed from one 50 feet roll of netting. The completed cage will have a volume of 37 cubic feet.

**Materials Needed for One Round Cage:**

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>3/4 in. plastic mesh netting</td>
<td>18 ft. 6 in. X 4 ft.</td>
</tr>
<tr>
<td>1/8 in. plastic mesh netting</td>
<td>11 ft. X 12 in.</td>
</tr>
<tr>
<td>1/4 in. galvanized steel</td>
<td>11 ft.</td>
</tr>
<tr>
<td>1/4 in. galvanized steel couplers</td>
<td>1</td>
</tr>
<tr>
<td>1 1/2 in. polyethylene pipe</td>
<td>11 ft.</td>
</tr>
<tr>
<td>1 1/2 in. plastic coupler</td>
<td>1</td>
</tr>
<tr>
<td>1 1/2 in. hose clamps</td>
<td>2</td>
</tr>
<tr>
<td>1 in. polyethylene pipe</td>
<td>23 ft. 7 in.</td>
</tr>
<tr>
<td>1 in. plastic coupler</td>
<td>2</td>
</tr>
<tr>
<td>1 in. hose clamps</td>
<td>4</td>
</tr>
<tr>
<td>18 gauge plastic coated wire</td>
<td>100 ft.</td>
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**Procedure:**

1. From the 18 ft. and 6 in. piece of 3/4 in. plastic netting cut a piece 11 ft. and 2 in. length. This will be the cage wall (Fig. 1).

2. Roll the cage wall into a tube that is 3 1/2 feet in. diameter. Using a few short pieces of wire, temporarily tie the edges together allowing a 2 in. overlap.

3. Using 18 gauge wire lace the wall together. Be sure to allow two inches of overlap and go through every mesh when lacing.

4. Using the 1/4 in. galvanized steel, cut a 11 ft. piece. Form a hoop 3 1/2 ft. in. diameter connecting with the galvanized coupling. This hoop will form the bottom of the cage.

5. Using the steel hoop for a template, cut a piece of 3/4 in. mesh plastic netting for the bottom (Fig. 1).

6. Temporarily tie the bottom netting to the hoop with a few short pieces of wire.

7. Lace the bottom of the cage to the wall (Fig. 2). Again be sure to go through each mesh.
8. Slip two 1 and 1/2 in. hose clamps onto the 10 ft. section of 1 and 1/2 in. polyethylene pipe then insert the 1 and 1/2 in. plastic coupling into one end of the pipe. Tighten one of the clamps securely over the joint. Carefully form a hoop by joining the other end of the pipe to the coupling. Tighten the second clamp securely to this joint. This hoop should be 3 ft. in. diameter and will form the top of the cage.

9. Attach the top of the cage to the wall using wire (Fig. 3). Be sure to go through every mesh.

10. Form a hoop 3 ft. 6 in. in diameter as in step 8 using a 11 ft. piece of 1 in. polyethylene pipe, 1 in. coupling and 1 hose clamps. This hoop will provide additional support and flotation to the cage wall.

11. Attach the hoop mid-way down the cage wall on the outside using wire.

12. Using the 1/8 in. plastic netting form a feeding ring on the inside of the cage by attaching the netting to the top of the cage wall. The feeding ring should extend six inches above and below the water surface.

13. Form another hoop 4 ft. in diameter as in step 12 using the 1 in. polyethylene pipe, 1 in. coupling and 1 in. hose clamps. This will form the lid of the cage.

14. Using this hoop as a template cut from the remainder of the 1 plastic netting a piece for the lid (Fig. 1).

15. Lace the plastic netting to the 1 in. pipe with wire.

**Rectangular Pen Design and Construction**

Larger cages have two advantages over smaller cages. They are usually cheaper to construct on a per cubic foot basis and total labor required to feed is less than smaller cages. There are, however, disadvantages to larger cages. Larger cages are harder to maneuver around than smaller cages and will require more labor to harvest. Outbreaks of diseases can cause higher mortality because of larger numbers of fish per cage. With these advantages and disadvantages in mind, the design and construction procedures for a pen, 4 ft. x 4 ft. x 10 ft. are given. The completed cage will have a volume of 160 cubic feet.
Figure 1. Diagram of dimensions needed for plastic netting to construct cage wall, bottom and top for a 3 1/2 ft. x 4 ft. round cage.

Figure 2. Photo illustrating cage bottom being attached to cage wall.
Figure 3. Photo illustrating cage top being added to cage wall.

Figure 4. Dimensions for the top frame and flotation of a 10 ft. x 4 ft. cage.
Materials:

<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>1. 4 in. diameter PVC pipe</td>
<td>30 ft.</td>
</tr>
<tr>
<td>2. 4 in. diameter PVC elbows</td>
<td>4</td>
</tr>
<tr>
<td>3. PVC primer</td>
<td>8 oz</td>
</tr>
<tr>
<td>4. PVC cement</td>
<td>8 oz</td>
</tr>
<tr>
<td>5. 3/4 in. mesh plastic coated welded wire</td>
<td>38 ft. 3 in.</td>
</tr>
<tr>
<td>6. 1 in. PVC pipe</td>
<td>37 ft.</td>
</tr>
<tr>
<td>7. 1 in. PVC elbows</td>
<td>4</td>
</tr>
<tr>
<td>8. 1 in. PVC tee</td>
<td>2</td>
</tr>
<tr>
<td>9. 1/2 mesh netting</td>
<td>5 ft. X 11 ft.</td>
</tr>
<tr>
<td>10. 18 gauge bell wire</td>
<td>200 ft.</td>
</tr>
<tr>
<td>11. 1/8 in. plastic netting</td>
<td>28 ft. 3 in. by 1 ft.</td>
</tr>
<tr>
<td>12. 1/4 in. nylon mesh netting</td>
<td>12 ft. X 6 ft.</td>
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</table>

Procedure:

1. Cut two pieces of the 4 in. diameter PVC pipe that are 9 ft. 8 in. long.

2. Cut two other pieces of 4 in. diameter PVC pipe 3 ft. 8 in. long.

3. Using the 4 in. PVC elbows, sections of pipe, PVC primer and cement construct a rectangular frame that has inside dimensions of 10 ft. X 4 ft. (Fig. 4). The plastic coated wire box will be attached to this frame.

4. Cut a section of the 3/4 in. plastic coated wire 28 ft. 3 in. Bend the netting in four places to create a rectangular box 10 ft. X 4 ft. (Fig. 5). The excess 3 in. will be the overlap used when lacing walls together.

5. Lace the wall together at the overlap using the 18 gauge plastic coated wire. Be sure to go through every mesh.

6. Form a bottom by lacing the remaining 10 ft. section of netting to the walls (Fig. 6)

7. Attach the frame to the cage walls using the 18 gauge wire. Be sure that there is no space (which could allow fish to escape) between frame and top of netting.

8. Using the 1/8 in. plastic netting form a feeding ring on the inside of the cage by attaching the netting to the top of the cage wall. The feeding ring should extend six inches below the water surface.

9. Cut 4 pieces of 1 in. PVC pipe 5 ft. 5 in. long and 3 pieces that are 5 ft. long. These will be used to make the lid.

10. Using the pre-cut sections of 1 in. PVC pipe, 1 in. tee's and the 1 in. elbows construct a rectangular frame that is 11 ft. by 5 ft. Sew the 1/4 in. nylon netting to the frame using the 18 gauge wire.

11. Place the lid on the cage, and make a hinge using two pieces of wire. Use another piece of wire for the latch.
Fold mesh plastic coated wire netting 90° making first side of cage.

Fold again in the same direction to make the second and third sides.

Fold remaining 4' netting in the same direction and attach to first side.

Figure 5. Diagram of wall formation for a plastic coated wire mesh cage 10 ft. x 4 ft.

Attach bottom panel to the cage leaving only the top open.

Figure 6. Diagram of constructed cage wall and cage bottom.
Placement of Cages in Ponds

Placing a cage into the pond means more than just throwing it into the water. First, you need to find a good location in the pond. Then, you must make sure the cage is floating properly. Finally, you should anchor the cage so it will not drift away.

Location

Location of the cage is critical since water must circulate through the cages to ensure adequate waste removal and high levels of dissolved oxygen. In addition, the farmer must go to the fish when feeding and for observing, instead of the fish coming to the farmer. Therefore, prior planning is essential before placing the cages so the farmer can minimize his efforts for day-to-day activities. Piers, either floating or permanent, are a convenient way of taking care of your fish by attaching cages to them. However, they require time to construct and are somewhat expensive.

A good location for cages is just as important as other aspects of cage culture. It is important that there be at least two feet of clearance between the bottom of the cage and the pond bottom (Figure 7). There should also be at least two cage widths between each cage to provide better water circulation. Cages placed too close together will increase the chances of low dissolved oxygen levels. Placing cages too close together will reduce circulation and is a sure way to kill your fish. The best location for cages is one which receives lots of wind action. Shallow areas and areas with aquatic vegetation should be avoided. Consideration should also be given in regard to disturbances from people and other animals which can increase the chances of stress and resulting disease outbreaks.

Floatation and Anchoring

Adequate flotation should be provided by the polyethylene or PVC pipe used. If addition flotation is required it can be provided by securely attaching Styrofoam or jugs to the frame.

Cages need to be anchored to the bottom of the pond, a pier or a cable so they do not drift about freely in the pond. When anchoring be sure to allow enough slack line to prevent high water levels from covering the top of the cage which will allow the fish to escape.

Overwintering

Cages containing fish have been overwintered. Generally, it is best to reduce densities in cages and try to maintain ice free areas around the cages. These ice free areas can be made by aerating or manually breaking ice from around the cages.
Figure 7. Diagram of pond showing properly spaced cages.
Stocking of Cages

Contrary to popular belief, there is no single stocking rate that is perfect for every pond. Stocking rates are at best—guidelines that have been developed through research and experience. The maximum pounds of fish that can be harvested from a surface acre will depend on many different variables. The two single most important variables to consider are feed type and amount and dissolved oxygen levels. By now, it is understood that feeding is essential in cage culture. However, if permanently high oxygen levels were maintained, using for example mechanical aeration, then the maximum yield would also be increased. For the beginning cage fish farmer, who is feeding but not aerating, a maximum yield of 1,500 pounds per acre (lbs./a.) is a good estimate. Using aeration, the maximum yield can be increased to well over 2,500 lbs./a.

Assuming that 1,500 lbs./a. is your maximum yield, you will want to know how many fish to put in each cage and the number of cages needed per acre. To determine the number of fish to stock, assume a stocking rate of 10 fish per cubic foot of cage. Using the stocking rate of 10 fish per cubic ft. you could stock the round cage with 370 fish and rectangular cage with 1,600 fish.

To determine the number of cages needed for per acre it is necessary to know the market size of your fish in addition to the maximum yield of 1,500 lbs./a. Market size of four potential cage culture species are given:

- Catfish = 1.5 lbs.
- Trout = 1.5 lbs.
- Hybrid striped bass = 1.5 lbs
- Bluegill = 0.5 - 0.75 lbs.

As an example for determining the cages required we will use the round cage design containing 37 ft.3 and farm catfish, which have a market size of 1.5 lbs./fish.

First, divide maximum yield by market size.

1,500 lbs divided by 1.5 lbs. = 1,000 fish per acre

Then, divide number of fish per acre by cage capacity

1,000 fish divided by 370 fish = 3 cages

From this example you will need 3 cages, each containing 370 fish to yield 1,500 lbs. of 1.5 lbs. fish. Two important factors not included in these determinations are stocking size and percent mortality. Stocking size is a function of the growing season in your area and the growth rate of the farmed species. For the Midwest, stocking 6-8 in. catfish fingerlings should be large enough for them to grow to marketable size within one growing season.

The mortality rate is another factor to consider when calculating the number of fish to stock in each cage. There will be fish lost during the course of the growing season. The number of which depend usually on water quality. For a farmer just starting out in fish farming expect to lose more than someone who has several years experience. If you want to compensate for expected mortality then add 5 percent to the stocking number.

As you gain experience, this figure can be adjusted for your operation. The last point I want to discuss is handling fish during stocking and harvesting. The most important fact to remember is that fish live in water and anytime they are out, you increase the likelihood of death.
A few guidelines for handling during and after stocking are given:

1. Temper fish before stocking by gradually equalizing water temperature.

2. Always move fish in well aerated water and if possible use 0.5-1.0 percent salt solution

3. After fish are first stocked feed medicated feed for the first ten days.

If these general guidelines for construction and stocking are followed then the chance of success for the beginner is greatly increased. Good luck in your endeavors and do not become discouraged.

Summary

Cage construction is not complicated if prior planning is used. Cages should be constructed of sturdy-rust proof materials. Plans are given for the construction of a 37 ft.² round cage and a 160 ft.² rectangular cage. Cages should be anchored securely in an area of the pond which receives adequate water circulation. There needs to be at least two feet of clearance between the bottom of the cage and bottom of the pond. Also allow two cage widths between each cage. Proper spacing and adequate depth will allow proper waste disposal and water circulation. Ponds with no other fish in them can yield up to 1,500 lb./a. with daily feeding, but no aeration. Stock no more than 10 fish per cubic foot of cage volume for food fish production.