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Profitable Cage Culture

by: Gregor N. Neff and Paul C. Barrett

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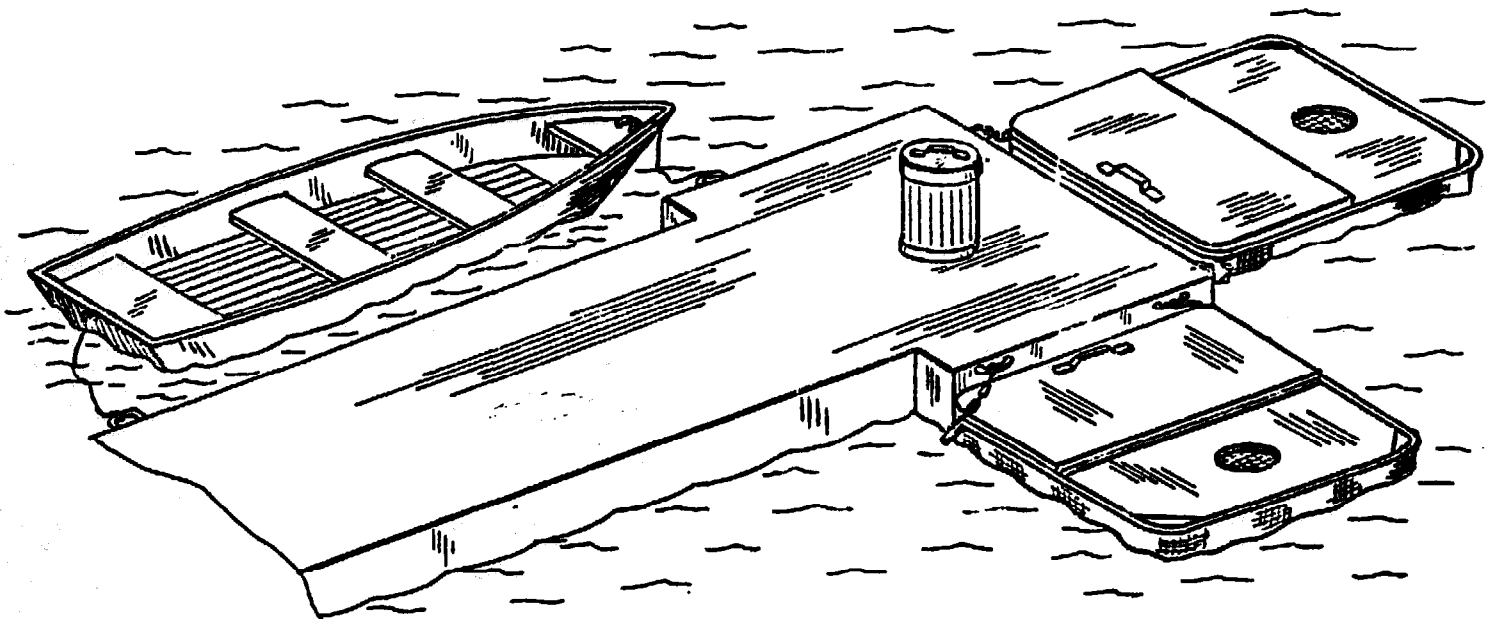
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PROFITABLE CAGE CULTURE

by

Gregor N. Neff and Paul C. Barrett



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INTRODUCTION

This booklet is dedicated to telling anyone how to grow fish in cages profitably - either for money profits or for cost savings in growing food or sport fish. Featured is the patented Inqua Double-Q[®] cage, which has been used for several years for growing channel catfish, trout, tilapia, bream (bluegills), and many other types of fish.

CHAPTER ONE: THE ADVANTAGES OF CAGE CULTURE

1. Existing Waters Can Be Used. The most important advantage of cage culture is that you can use it in water that is already there - an ordinary farm pond, a lake, an old quarry or strip-mine, a canal, etc. There is no need to dig expensive, flat-bottomed ponds like many fish growers do. There usually is no need to dig expensive wells to provide a water supply, because the natural water will not be there if mother nature doesn't already provide it. Much natural water presently is going to waste, and some of it, such as in old quarries and strip-mines, is considered by ecologists to be a useless blot on the scenery. Some states have made vast tracts of state-owned water available to fish culturists at low rentals, or even for free. The result is that many millions of acres of natural water suitable for cage culture are available in the U.S. - and in many other countries - at a very low cost or at no cost whatsoever.
2. Harvesting Is Very Easy. Fish grown in cages easily can be harvested simply by dipping the fish out of the cages with a dip net, or picking up the cage and dumping the fish out. In contrast, in commercial pond culture the fish usually are hauled out with a sein, and then most of the water is drained from the pond to make the remaining fish easier to get. These methods can not be used in many natural ponds or lakes because there are too many stumps or other snags, or the ponds and lakes are too large or too deep for a sein to be used. Draining is not possible. Any number of fish can be harvested at a time, whereas it is difficult to harvest small numbers of fish in pond culture.
3. Protection From Predators. Covered cages protect the fish from predators such as wild fish, snakes, birds, turtles, etc. Thus, more fish will survive to be sold or released for sport. Small fingerlings can be grown safely in cages in water containing large wild fish.
4. More Efficient Use of Feed. Feed is fed only to the fish in the cage, not to wild fish outside of the cage.
5. The Detection and Treatment of Disease Or Oxygen Depletion Is Easier. Since the fish are located in a confined space they can be observed more easily. Disease or oxygen problems can be detected and treated much more quickly.
6. Those Who Have Successfully Grown Fish In Cages. Those who have successfully grown fish in cages include individuals using farm ponds, lakes, quarries and strip-mine pits; commercial food and sport-fish growers; state fish and game agencies who grow fish for re-stocking public waters; universities and other research organizations; and fee fishing lake operators and fishing clubs who replenish their stocks.

Because of the wide variety of waters that can be used for cage culture, and the vast amount of water presently being unused, the potential for cage culture is great.

CHAPTER TWO: WATERS WHICH CAN BE USED FOR CAGE CULTURE

In general, most bodies of clean water around six feet deep or deeper can be used for cage culture.

1. Cleanliness. If the water already supports a healthy population of wild sport fish, it probably is clean enough for cage culture. However, if the fish are to be eaten, and pollution is suspected, the water should be tested. For example, insecticides are especially dangerous to fish, and water which receives the run-off from large fields in which insecticides are used to any substantial degree should be tested to determine whether its insecticide content is too high. Water testing is done by fishery and water management service companies. Also, water testing kits are available so that one can do his own testing. Free advice and testing often are available from the sources listed in Chapter 22.

2. Temperature, Oxygen. The water should have temperatures in the proper range and a sufficient oxygen content, as it is explained in Chapters 14 and 15.

Gently flowing water usually is preferable to still water because it brings more oxygen and food to the fish.

The water preferably should be protected or remote so as to avoid losses due to theft.

3. Heated and Cooled Waters. Channel catfish, which are warm water fish, have been grown successfully in the winter in cages in heated cooling water from electrical power plants. ^{1*} Rainbow trout, which are cold water fish, have been grown successfully in Southern lakes cooled to satisfactory temperatures by winter weather. ² Channel catfish can be grown in the same lake during warm summer weather so that two crops per year can be raised in the lake.

In certain parts of the country, such as the Magic Valley in Idaho, where there are ample supplies of hot and cold natural spring water, either warm-water or cold-water fish can be grown in water of the proper temperature formed by mixing the hot and cold waters.

CHAPTER THREE: SPECIES OF FISH WHICH CAN BE GROWN IN CAGES

In general, most types of fish can be grown in cages. However, some species are much more practical to grow in cages than are others. In the United States, catfish¹⁶, trout, and blue gills

*References are listed at the end of this booklet.

(sunfish or bream) have been grown in fresh water most successfully. However, many other species, including bass, carp and tilapia, also have been grown. In salt water, salmon, pompano, and other species such as yellow tail have been and are being grown in cages.

Cannibalism causes problems with all carnivorous fish, and especially with some species such as largemouth bass which tend to eat one another readily. However, with proper care, bass have been grown in cages quite successfully.³ See Chapter 16 for precautions to take against cannibalism.

Certain species of fish are better than others for cage culture. For example, channel catfish (*ictalurus punctatus*) grow much faster, utilize feed more efficiently, and generally adapt to cage culture better than blue catfish (*ictalurus furcatus*), white catfish (*ictalurus catus*), or flathead catfish (*pylodictis olivaris*). Similarly, it is reported that rainbow trout (*salmo gairdneri*) adapt themselves to cage culture better than other types of trout.⁴

CHAPTER FOUR: CAGE SELECTION

Selection of the proper cage is quite important to successful cage culture. The cage will form the home for hundreds or thousands of fish during their entire growing period.

Most cages have certain features in common; an enclosure in the water made out of mesh, and a frame to which the mesh is attached, and floats to float the cage on the water. Some cages have covers, some do not. The size of cages varies considerably. Very large and deep cages are used in salt water for growing relatively large fish such as salmon. In fresh water, the cages usually are smaller.

With the foregoing general comments in mind, let us examine the various things to look for in selecting the proper cage.

1. Corrosion Resistance and Durability of Materials. Since the cage will be immersed in water almost all of the time that the fish are growing, the materials of which the cages are made are subjected to heavy attack from corrosion, rust, and rot. One of the most serious problems in cage culture has been that most cages last only a year or two.

Most cages have been made out of wire mesh, with a coating of tar to resist corrosion, and with wood frames. Usually, the wire rusts away after one or two years. Sometimes it rusts away without anyone being able to see it. Then, when the cages are lifted out of the water full of fish, the sides burst and the fish escape, never to be recaptured.

Another type of mesh which has been used is vinyl-coated wire mesh. This resists rust and corrosion better than the tar-coated wire,

but it still rusts and corrodes, especially at the ends where it is cut, and wherever the vinyl coating is cut or scratched away so that the water can reach the wire inside. The vinyl-coated wire often does not last any longer than the tar-coated wire.

It is difficult to keep the wood which is immersed in the water from rotting, even with proper painting. Thus, the wood frame often lasts no longer than the wire.

The "DOUBLE-Q"® cage manufactured by Inqua Corporation has solved the rust, rot, and corrosion problems. The cage is made of strong aluminum alloy and DuPont VEXAR® netting, both of which are highly resistant to corrosion, rot, rust and deterioration.

The DOUBLE-Q cage is notable in that it is the first cage ever offered to the public with a guarantee of long life. The guarantee of five years usefulness for growing fish means that the fish grower can count on at least five years of use, and perhaps eight or ten years use of the cage.

2. Strength. The strength of the cage and its materials is also important. The mesh or netting should be strong enough to keep out underwater predators such as snakes, turtles, alligators, etc. The cage should be strong enough to be lifted out of the water with a full load of fish in it.

Wire mesh cages usually will have the required strength - if rust and corrosion have not weakened the wire or frame too much. Inqua's DOUBLE-Q cage has a unique patented top frame of strong aluminum alloy pipe and sheet metal which are tightly bolted together. The VEXAR netting panels are fastened together and to the frame with a unique patented construction which enables the cage to lift over a thousand pounds of load, well over the weight that most people will put in it.

3. Covering For The Cage. The use of a covered cage is important to profitable cage culture.⁵ The cover will keep out predators such as snakes, turtles, water birds, etc. Furthermore, it has been shown that many species, such as channel catfish, grow much better in the shade provided by the cover. Also, a strong cover can be locked to increase the protection of the fish against theft.

In the past, cage covers typically have been made out of wood or plastic. Many of the plastic covers have been flimsy and do not last long. Wooden tops, as noted above, eventually will rot, and they require yearly painting and scraping in order to give them any substantial life whatsoever.

The DOUBLE-Q cage by Inqua solves these problems by the use of a cover and a hinged lid made of heavy aluminum alloy sheet metal. It retains its strength over many years, and does not need painting or scraping. It is strong and locks can be added to keep out human predators as well as animals.

4. Ease of Handling When Empty. In order to keep labor requirements and the cost of handling equipment at a minimum, the cages should be easy for one man to handle.

Cages made out of wire or wire and wood tend to be heavy and bulky. Therefore, it is difficult for one man to handle them.

The DOUBLE-Q cage, because of its use of modern materials, is lightweight (about 35 pounds). Further, it has the unique property that it folds up. Thus, although the cage is four feet deep when floating in the water, it is less than 12 inches deep when folded-up for handling or storage. It is easy for one man to carry the DOUBLE-Q cage, and he easily can load the cage into a boat and drop it in the water without any help.

5. Cage Wall Material Hardness. The walls of the cage should be soft so that when the fish rub against them their skins will not be scraped and rubbed raw by the cage material. Scrapes on the sides of fish can quickly become infected and cause the death of the fish. Wire mesh is hard and scrapes the fish when they contact it. Vinyl coated wire is somewhat better in this regard, but still causes some abrasion. Woven nylon netting is quite soft, but it does not have a very long life, even when coated with protective materials.

The Vexar netting used in Inqua's DOUBLE-Q cages has just the right combination of softness, strength and body. It is soft on the fish so that they do not scrape themselves, and yet it has enough body so that it holds its shape well and so that catfish will not catch their horns in it.

6. Mesh Size. The size of the mesh depends mostly on the minimum size of the fish to be raised in the cage. The standard wire mesh size is 1/2 inch by one inch. This will hold channel catfish and fingerling trout four inches long or longer. Mesh of a 1/4 by 1/4 inch size will hold fingerlings down to one inch length.

Another factor in determining mesh size is the degree of algae formation on the cage. If algae formation is very heavy, the smaller mesh sizes tend to clog quickly and do not permit enough water to flow through the cage, with the result that the fish may get inadequate oxygen, and their fecal matter may not adequately be washed away, unless the algae is removed from time to time. For this reason, if possible, one should try large mesh sizes first.⁵

The DOUBLE-Q cage comes in two standard mesh sizes, 1/2 inch by 1/2 inch, and 1/4 inch by 1/4 inch. Whereas wire mesh usually is considerably more expensive in the smaller mesh sizes, the DOUBLE-Q cage costs the same, regardless of the mesh size. The 1/2 inch mesh material has thicker strands and is more resistant to damage than the 1/4 inch mesh.

7. Size Of the Cage. Whereas cages for salt water fish such as salmon often are deep (12 feet or more) most fresh water cages

and salt water cages are considerably shallower. A depth of about four feet (1.22 meters) has been found to be ideal for most types of fish.

The other dimensions of the cage depend upon the number of fish it is desired to put in the cage, the ease of cage handling desired, and the cost one is willing to pay for each cage.

Whereas larger cages can hold many more fish than the smaller cages, and the feeding labor can be somewhat reduced by reducing the number of cages to be fed, larger cages are also more difficult to handle, and there is a much bigger loss of fish if a whole cage of fish is lost.

Very small cages suffer less chance of major losses due to disease, and they are usually smaller and easier to handle. However, the labor required in feeding the cages is multiplied in proportion to the decrease in size.

DOUBLE-Q cages come in two sizes; the "standard" cage is approximately four feet by four feet, with a volume of 64 cubic feet (weight, 35 lbs.); and the "commercial" cage is eight feet by eight feet by four feet deep, 256 cubic feet in volume (weight, 100 lbs.).

8. Ease of Harvesting And Sampling. The cage should be designed so that it is easy to get fish in and out of it. The cage should be designed so that it can lift a full load of mature fish without breaking, and it should have no obstructions in the outlet so that the fish will easily pour out of the cage when it is tipped up.

If the cage has a cover, it should open easily so that fish can be removed from time to time with a dip-net for sampling in order to diagnose disease, weigh the fish for growth rate, etc.

The DOUBLE-Q cage is built so that there are no obstructions in the outlet and the fish flow smoothly when dumped out of the cage. The cage has a sturdy, strong cover at one side which easily can be reached from a boat or a dock for sampling.

9. Ease And Efficiency Of Feeding. The cage should have something to hold the food in the cage until it is eaten by the fish. Usually, feed that floats on top of the water is fed. Therefore, a "feed ring" should be provided. A feed ring is an enclosure which extends into and above the water a little bit and forms a ring or enclosure. Feed dropped into the ring will not float out of it before being eaten.

If sinking feed is fed, a submerged tray should be positioned below the place where the feed is dropped into the water. The tray will hold the feed until the fish can eat it.

Some cages have relatively small feed rings and this is undesirable because not enough fish can reach the feed in it. The result is

that the larger fish or "hogs" end up getting most of the feed and the runts get little or none.

The DOUBLE-Q cage has the largest possible feed ring. The feed-ring is formed by a "feed skirt" which extends all the way around the top of the cage. This gives the fish the entire water surface inside the cage as a feeding area.

Most cages which have covers also have holes into which the feed can be thrown. The holes should be covered with a mesh material in order to keep out snakes, birds, and other predators. The DOUBLE-Q cage has such a feed hole.

10. Cage Shape. The two most common cage shapes are round (cylindrical) and square (cubical).

There is no conclusive evidence of superiority of one shape over the other, but many experienced cage culturists prefer either a round cage or a cage with gently rounded vertical corners. They believe that the fish do not tend to bunch up in the corners as much, and that it is beneficial for them not to do so.

The DOUBLE-Q cage is of the cubical shape, but its vertical corners are gently rounded so the fish do not tend to bunch up in them.

11. Lockability. If humans have any access to the water in which the cages are located, theft may prove to be a problem. If so, it is desirable that the cage have a strong cover which can be padlocked to give further protection against theft.

The Inqua DOUBLE-Q cage has a heavy-gauge metal cover which easily can be fitted with a lock to protect against theft.

13. Cost. Cage culture cannot be profitable if the cages cost too much. However, the measure of cost is not simply the initial cost of the cage. If the intention is to grow fish over a period of years on a regular basis, then the proper measure of cost is the cost per year. For example, if a cage costs \$100 and lasts two years, its cost per year is \$50. On the other hand, if a cage costs \$150 and lasts five years, its cost is only \$30 per year. Which is the lower cost cage? Obviously, it is the one which sells for \$150.

The price of the Inqua DOUBLE-Q cage is a little higher than for some other cages, but it actually costs less because it lasts longer. Because the cage is guaranteed to last five years, its life and its maximum cost per year are predictable.

The DOUBLE-Q cage has made an important contribution to profitable cage culture.

CHAPTER FIVE: THE NUMBER OF FISH PER CAGE

The number of fish which can be grown successfully in a cage depends upon the size of the fish, the size of the cage, the dissolved oxygen in the water and the type of fish.

1. Minimum Densities. The capacity of a cage usually is expressed in terms of weight of fish per unit of cage volume. For example, channel catfish now are being raised to an average weight of one pound in cages having a volume of 64 cubic feet or approximately 1.8 cubic meters, at the rate of 1,000 fish per cage. This works out to a stocking density of 15.6 pounds of fish per cubic foot, or around 550 pounds per cubic meter of cage volume.

Happily for cage culture, high stocking densities usually are better than small densities. Certain species, such as channel catfish, tend to fight if they are stocked at densities lower than 150 per cage. At higher densities, the fighting stops.

2. Maximum Densities. The maximum stocking densities have not yet been determined for all species. However, capacities of up to one thousand pounds per cubic meter have been reported for channel catfish and rainbow trout grown under ideal conditions.⁶

Cages which will be in water which gets hot during the summer probably should not be stocked as densely as those in cooler water, unless artificial aeration of the water will be used. Cool water has a greater capacity for carrying oxygen than does hot water. If there are too many fish in the cage, and if artificial aeration is not used, the fish may die from oxygen depletion during hot weather.

If water flows through the cage, even very slowly, this will greatly increase the carrying capacity of the cage, even during hot weather. More oxygen-rich water is present for the fish to use, and the fecal matter is washed away more rapidly than in still water.

3. Testing For Maximum Density. A practical test program for determining the maximum stocking density might consist of loading three cages with different numbers of fish; one at 400 fish, one at 600, and the other at 800, and then take regular weight samples to see how the fish gain weight. If, over a complete season, the fish in the cage with the highest stocking density gained approximately as well as the others, and if mortality losses were not high, then the higher density can be used, and might even be increased the next season. In general, it is best to start with low densities and work up to high densities because errors in stocking density, when combined with other problems which can occur during the first attempts at cage culture, can result in disastrous losses. A cautious program is the best program.

CHAPTER SIX: SIZE OF FISH STOCKED

In general, the smaller the fish when stocked, the better. The reason for this is that smaller fish seem to acclimate themselves better to confinement in cages. Larger fish sometimes tend to dash around and batter themselves against the sides of the cages, causing injury and sometimes death.

On the other hand, the fish should be large enough to grow to the desired size during the growing season. The best source of information on the growth rate of a given species in a particular area usually can be obtained from live fish dealers in the area, or from one of the government or university offices listed in Chap. 22. Remember that the length of the growing season is tied to the temperature of the water you will grow the fish in, and not necessarily the air temperature.

CHAPTER SEVEN: WHEN TO STOCK FISH IN CAGES

Fish should be stocked when the water temperature first reaches the temperature at which the fish begin to feed. For warm water species this usually will be in the early spring in the Southern U.S., and later in the spring in the North.

It is very dangerous to stock fish in cages during hot weather. Therefore, stocking should be done when the water temperatures are cool, and should be avoided when the weather is hot.

CHAPTER EIGHT: STOCKING PROCEDURES AND DISEASE PREVENTION

Stocking the fish is a critical procedure and should be done very carefully.

1. Avoid Stress. When fish are transferred from one place to another, they often undergo "stress". "Stress" is caused by periods of inadequate oxygen, rough handling, quick temperature changes, etc. all of which can weaken the fish and lower their resistance to disease, or kill the fish outright. When handling the fish, great care should be taken to avoid such stress. If you buy fingerlings, be sure to buy from a reliable dealer who knows how to minimize stress.

2. Relieve Stress. If you know or suspect that the fish have been stressed, the stress should be relieved as promptly as possible. This can be done by placing the fish immediately in clean water of high oxygen content having the same temperature as the water the fish came from, and feeding the fish feed treated with an antibiotic. The amount of feed fed for the first 3 or 4 days after stocking should be around 1/3 normal. If it is available, place the fish in a large tank of circulating clear water with a high oxygen content and hold them there for a week or two before stocking them in cages. However, stocking the fish directly in cages also is acceptable.

3. Observe Fish For Injuries. The fish should be observed for a period of time, perhaps a week or two, to see if any of them are injured or have diseases when delivered to you. All responsible dealers will replace injured or diseased fish without charge. Badly injured fish should be removed promptly.

4. Treatment For Disease Prevention. It is best practice to treat the fish as soon as received to make sure that they are free of parasites. The fish should be dipped in a solution of 50 parts per million formalin or other recommended treatment solution to rid them of parasites. If a tank is available, the fish can be treated most easily by adding the formalin in the proper amount to the water in the tank, and making additions from time to time as necessary to maintain the proper concentration for about two hours.

The fish can be treated while in the cage by one of several different procedures. The authors have found that perhaps the easiest method is to mix the formalin or other chemical with water and a dye such as methylene blue and pouring the mixture into the cage in an amount sufficient to give the water a proper blue color. The proper color can be determined beforehand by diluting the mixture to the 50 parts per million concentration in a container and observing the color. Since the mixture in the cage will be diluted gradually and will lose its strength and its ability to kill parasites, more of the dye-formalin mixture usually must be added from time to time in order to maintain adequate strength for about two hours.

Another treatment method is to wrap a thin plastic bag around the outside of the cage, and then put in the correct amount of formalin to form a solution of the proper strength with the water in the plastic bag. Since the water around the cage cannot dilute the solution in the bag, the solution will have the proper strength until the bag is removed, after about two hours. However, it is essential that the water in the bag be artificially aerated by the use of a commercial aerator or the like, at all times when the bag is in place. This must be done because fresh oxygen-laden water cannot come into the cage when the bag is around it, and the fish in the cage soon will die without artificial aeration of the water in the bag.

A third treatment method is to simply immerse the whole cage with fish in it in a tank containing the dip solution for about two hours. This method should not be used if the quantity and size of the fish is such that they will pile on top of one another and injure or kill one another by the sheer weight of their numbers. Thus, this method is limited to use with small numbers of small fish. The water in the tank must be artificially aerated at all times.

During the first two weeks when the fish are in the cages, they should be fed feed treated with terramycin antibiotic at the rate

of 83 grams per 100 lbs. feed, or the rate recommended by the manufacturer. Terramycin is available from most fish feed and veterinarian supply dealers.

Do not stock in your cages any fish which are not in top condition. The period immediately after stocking the fish is hard on them because they must get used to being confined, and this may prove to be the death of weak, injured, or parasite or bacteria-infected fish.

5. Sorting And Culling. Weak or sickly looking fish should be culled out before stocking the fish in cages. Also, the fish can be sorted (separated as to size) with fish of uniform size being stocked in each cage. This promotes better growth of the fish.

CHAPTER NINE: LOCATING AND ANCHORING CAGES IN THE WATER

The cages should be anchored so that they will not drift with the wind into areas where they are not safe or wanted. The cages can be tied to a dock (see Figure 1) or an anchored floating raft (Figure 2b), or they can be tied to a cable strung between two points on nearby shore lines (Figure 2a), or a separate anchor can be used for each cage.

When substantial numbers of cages are used, it has been found most convenient to connect the cages together with a cable in a line, or in two or more parallel lines (Figure 2c). This greatly simplifies the feeding procedure by boat since the boat can be driven along the line or between parallel lines of cages to feed the fish in the cages more easily.

If a lake has a thermocline and a turnover problem, it probably is best to locate the cages in shallow water which is far away from the area of the thermocline, if this is possible. See Chapter 18 for a more detailed discussion of the turnover problem.

CHAPTER TEN: THE NUMBER OF FISH IN A GIVEN BODY OF WATER

The number of caged fish which can be put in a body of water depends largely on the oxygen available to the fish in the water, and the oxygen needs of the fish. The needs of the fish depend mostly on their size, although some types of fish need a higher oxygen content in the water than others. The oxygen available depends on many factors, such as water flow and temperature, wild fish population, natural agitation and splashing of the water, etc.

In flat-bottomed ponds used for commercial fish farming, such as those used for raising channel catfish, the general rule of thumb is that the water will safely support no more than about two or three thousand pounds of channel catfish per acre. Of course, such ponds are relatively shallow (e.g. four to six feet deep) and usually do not have any significant natural flow through them. Since oxygen content is the factor which limits the carrying

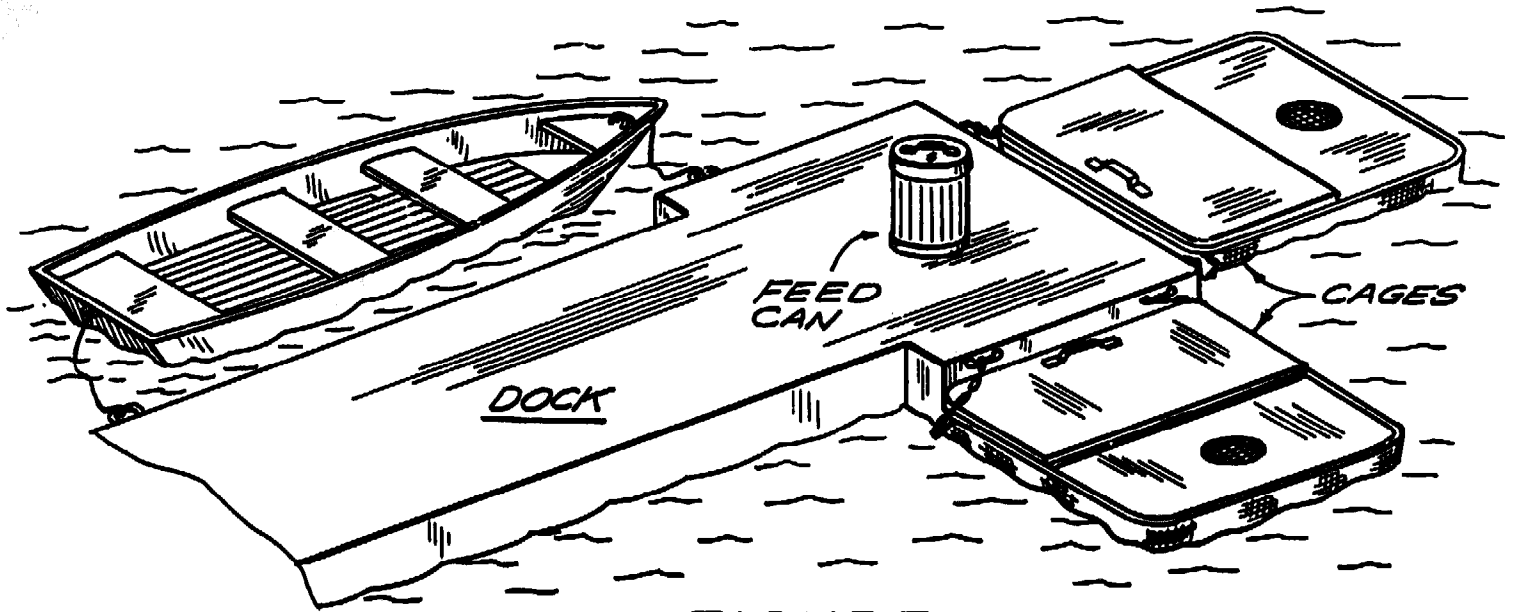


FIGURE 1
CAGES TIED TO DOCK.

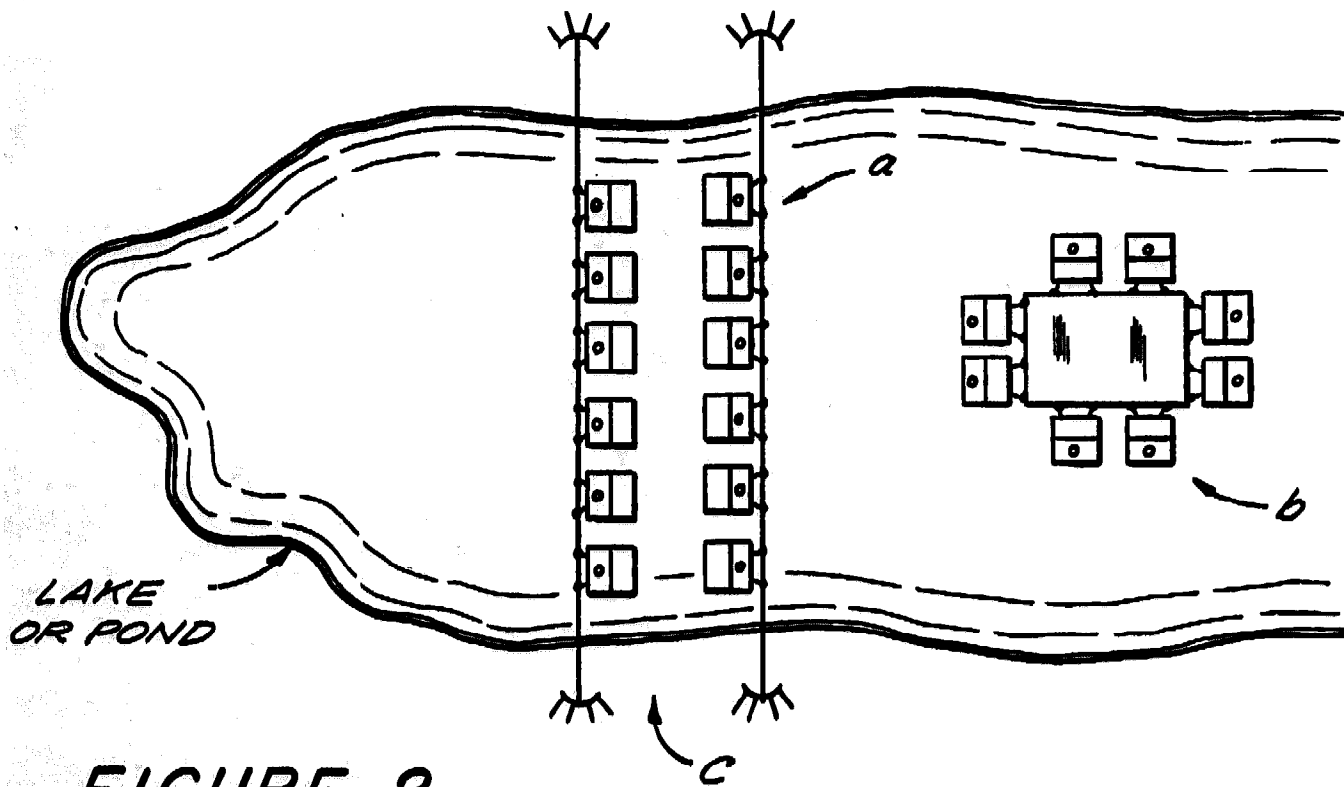


FIGURE 2

- (a) CAGES FASTENED TO CABLE ANCHORED AT BOTH ENDS TO OPPOSITE SHORES.
- (b) CAGES FASTENED TO FLOATING RAFT.
- (c) CAGES CONNECTED IN PARALLEL TO CABLES.

capacity of the pond, the same limits would apply to fish in cages in the pond.

Fortunately, cage culture is not limited to the use of shallow, flat-bottomed ponds. In lakes or larger ponds, where the water is deeper, and in rivers or streams, there often is good natural circulation of the water. If so, many more fish can be grown on an acre of water. There are reports of the growth of many cages filled with catfish or trout in a small area of a large lake. ⁶

The carrying capacity of each body of water will have to be determined by trial and error, keeping the above principles in mind. At first, the stocking density should be low because the penalty for error is the loss of fish.

Methods of treating water to increase its oxygen content and carrying capacity are discussed in detail in Chapter Fifteen.

CHAPTER ELEVEN: FEEDS

Foods eaten by caged fish fall into three broad categories: natural foods that the fish take from the water; prepared food pellets; and scraps and waste by-products.

1. Natural Foods. Caged fish eat insects, small minnows, tadpoles, small shrimp, and other such water life which comes into the cage. However, the amount of this food which the fish get often is somewhat less than the same fish might get if they were not confined in cages.

2. Prepared Food Pellets. Prepared food pellets are manufactured in the United States by several different feed companies. Some pellets are made specially for the growing of fish in cages. Usually, the cage food has a little higher protein content than food used for growing fish in ponds, for example, 36% protein versus 32% for pond food. Furthermore, the usual cage food has vitamins which pond food does not have.

Both floating and sinking pellets are available. The floating pellets cost a little more but are more desirable because they allow you to see whether the fish are feeding or not, and do not need special trays which are needed to hold sinking food pellets in the cage until they are eaten.

Food pellets come in several different sizes for different sizes of fish. The pellet sizes fed in cages are no different from the sizes fed in other types of culture, and the feed manufacturers' regulations and recommendations should be followed.

3. Selecting Feeds. Because caged fish do not get the vitamins they would get if they were swimming free, it is essential that the feed have the vitamins in it. Commercial food pellets for

cage culture are supposed to have the vitamins in them. However, in most such pellets, the vitamins disappear fairly rapidly. Vitamin C seems to disappear most rapidly. Without Vitamin C, many fish develop crooked backs and die.⁹ Therefore, do not accept any feed that is more than two months old. Also do not store food for more than two or three months, unless you are willing to add vitamins to the feed. If you suspect that your feed is lacking in vitamins, have it tested. Inqua or others listed in Chapter 22 can tell you where to have the testing done, where to get vitamins, and how to add them to the feed. Following are some useful recommendations:

Reject Feeds which:

- Have no fish meal, or
- Have no ascorbic acid (Vitamin C), or
- Have more than 3% "fines" ("fines" are broken pellets); or
- Are more than two months old.

Suspect Feeds which:

- Have no corn gluten meal, or
- Have free methionine or lysine, or
- Have more than 1% fines, or
- Have the Vitamin C (ascorbic acid) added during preparation rather than sprayed on after.

4. Scraps or Waste Products: Forage Fish. Caged fish also can be fed waste by-products from various food processing industries. For example, carnivorous (meat eating) fish such as trout, catfish and bass can be fed meat scraps, ground up poultry entrails, etc. Non-carnivorous fish such as white amur and tilapia have been reared in cages and will eat commercial feed pellets. However, such fish will eat other less expensive feeds such as rice bran, waste fish parts from processing plants, and some vegetation.

CHAPTER TWELVE: FEEDING METHODS, QUANTITIES, AND DEVICES

The following feeding methods are available:

1. Hand Feeding. The simplest method of feeding caged fish is either by hand; that is, by simply pouring some feed through the feed hole each day.
2. Automatic Feeding. Automatic feeders are available for dispensing measured amounts of feed at specific times during the day. Such feeders are used in raceways and tank culture systems, and sometimes in pond culture. They also should be usable in cage culture, although their expense may make them impractical.
3. Demand Feeders. Demand feeders dispense feed only when the fish push a lever to release some feed to them, or when they otherwise indicate a need for feed. Demand feeders are used regularly in ponds, but as far as it can be determined, they have not been widely used on cages up to now. The main proven advantages of demand feeders for cages are that they save feeding labor and avoid over-feeding of the fish.

4. When and How Often To Feed The Fish. For maximum growth rates, the fish should be fed every day. Studies have shown that, for every day you miss, the fish will take two days longer to mature. Of course, if the water is very hot or very cold, feeding every other day or even less frequently usually is required because the fish will not eat enough at each feeding to warrant the trouble of daily feeding.

Caged fish usually are fed once or twice daily; just before dark or early in the morning, or at both times. Although feeding the fish twice daily does increase the growth rate a little, the increase usually is not great enough to warrant the extra labor. Therefore, most people prefer to feed only once a day.

5. Quantities. The amount of feed to be fed at each feeding depends upon the feed itself, the size of the fish, the number of fish, the amount of natural food available, and the type of fish, as well as such things as the water temperature and oxygen content. A general rule of thumb is that the fish should be fed only the amount that they will eat completely in 15 minutes. Usually, this is around 3% of the body weight of the fish, for maximum growth. Generally speaking, about 1% of body weight per day is required merely to maintain the fish at their current size.

The easiest way to determine how much feed to use is by trial and error. That is, start with small amounts of feed and increase the amount of feed each day until the fish do not eat it all in 15 minutes, and then reduce the amount a little. This test should be repeated frequently as the fish grow. The amount can be calculated by first determining the weight of the fish in the cage. This can be done by sampling, in which some of the fish are dipped out of the cage and weighed. The fish are counted, and the total weight is divided by the number of fish to get the average weight per fish. Then, multiply the average weight by the number of fish in the cage and you have the total weight of fish in the cage. Then take 3% of that weight and you will have the weight of feed to be fed.

When the temperature of the water is too high or too low, the amount of feed fed should be reduced. For example, when the water temperature is over 90° F. or under 70° F., channel catfish tend to eat considerably less. Therefore, less feed should be fed. Trout should be fed less at temperatures below 38° F. or above 60° F. When the oxygen content of the water is below about 3 parts per million the fish probably will not eat.

6. Dangers In Over-Feeding. Over-feeding (feeding more than the fish will eat in 15 minutes) should be avoided for several different reasons. Not only does it waste food, but it can have serious effects on the health of the fish. Uneaten food eventually drops to the bottom of the lake or pond where it decays and uses oxygen that the fish need for breathing. Furthermore, it tends to fertilize the water and increase the growth of algae and other plants which, when they die, decay and use up even more oxygen.

CHAPTER THIRTEEN: FEED CONVERSION RATES

The feed conversion rate is the rate at which fish convert feed into flesh. The conversion rate usually is given in terms of the number of pounds of feed required to grow a pound of flesh. Fingerlings usually have a conversion rate considerably higher than that of grown fish.

Feed conversion rates in cage culture can be as good as or better than the conversion rates in pond or other types of culture. With channel catfish, for example, conversion rates of 1.5 to 1 are common in raising the fish from 5 to 7 inch fingerlings (around one ounce in weight) to one pound weight in cages.¹⁰ Similar rates prevail in pond culture and raceway culture.

Conversion rates for raising trout of similar sizes in cages also has been reported to be around 1.5 to 1.8.¹¹ For profitable cage culture of food fish of such sizes, a feed conversion rate of between 1.5 and 2 to 1 should be obtained. If it is not, then check to make certain that the fish are healthy, check to see if you are over-feeding, check the water temperature, and try reducing the number of fish per cage.

CHAPTER FOURTEEN: OXYGEN DEPLETION AND REPLENISHING

1. Detection Of Oxygen Depletion. Oxygen depletion is a condition in which the dissolved oxygen of the water in which the fish are located becomes so scarce that the fish are either dying or having great trouble in breathing. The condition can be detected quickly by two different methods. One is by observing the fish. The fish typically will be gasping at the surface, trying to obtain more oxygen. Another way is by use of an oxygen test kit or meter. For most fish, the dissolved oxygen content should be around 4 or 5 parts per million (PPM) at six inches below the water surface. Most fish stop eating when the oxygen content drops below 3 PPM. Most fish will die when the oxygen level is below 1.0 PPM.

2. Causes of Oxygen Depletion. Causes include algae and water plant decay, hot weather, the slow-down of the flow of water through the cage, over-feeding, overcrowding of the fish, excessive wild fish populations, and other causes.

In still water, in both pond culture and cage culture, by far the most common cause of oxygen depletion is excessive algae and water weed growth (principally algae growth) coupled with hot weather and the crowding of too many fish into a given body of water. The algae and weeds give off oxygen during sunlit days, but use up oxygen at night and during cloudy days. The accumulation of fecal matter and uneaten feed from a heavy concentration of fish fertilize the algae, causing it to grow faster and die faster. The dead algae decomposes and uses up more oxygen from the water. Then, during the night and on cloudy days, especially during hot weather, the oxygen content is reduced to such very low levels that the fish will die immediately, or they will

become so badly stressed that they will be susceptible to diseases and die later from the diseases.

3. Prevention. Prevention is the best cure for oxygen depletion. First and foremost, prevent excessive algae growth. The first step is to observe turbidity or cloudiness of the water. This can be done with a device called a "Secchi" disc, but a shiny tin can lid is a good substitute. Tie a string to the tin can lid and drop it into the water. If the water is a cloudy green color and you cannot see the lid when it is 18 inches below the surface, you have a serious algae problem which needs immediate attention. If you do not tend to the problem, you are likely to find your fish dying or stressing during the next night or cloudy day. If the water is so cloudy that the lid is difficult to see, the problem still needs your attention. In either case, the water should be treated with a chemical to gradually reduce the growth of the algae. The authors have had good success with the gradual application of "Aquashade"® , a harmless combination of food-type dyes which block out some of the light needed by the algae for growth, thus reducing the algae population to a safe level. Do not use a full dose suddenly, because that may cause the sudden death of so much algae that its decay will cause oxygen depletion.

Chemical herbicides can be used to kill the algae and water weeds, if the algae population is not yet very heavy. However, the herbicides can kill fish if they are not used very carefully. Aquashade can be applied in full doses if it is applied well before the algae population gets very large, and its protection lasts for a substantial length of time, depending on the water flow through the pond or lake.

Another preventive measure which can be taken is to kill not only the weeds, but also the wild fish in the water before stocking fish in cages. This reduces the competition for oxygen later on when the fish grow large.

Control of stocking rates, water temperature, water flow, over-feeding, etc. which are discussed in other chapters of this booklet, also will help prevent oxygen depletion.

4. Remedies. Oxygen depletion is an emergency condition which must be remedied immediately to prevent the death of your fish.

(a) Aeration. Aeration usually is the best remedy, and it often is easier with cages than with other types of fish culture. Simply put a commercial aerator (often called an "agitator") into each cage and turn it on (see Figure 3). The aerator agitates the water and mixes it with the air to dissolve more oxygen in it. The same result can be accomplished as shown in Figure 4. Pump air from an air compressor through a hose and

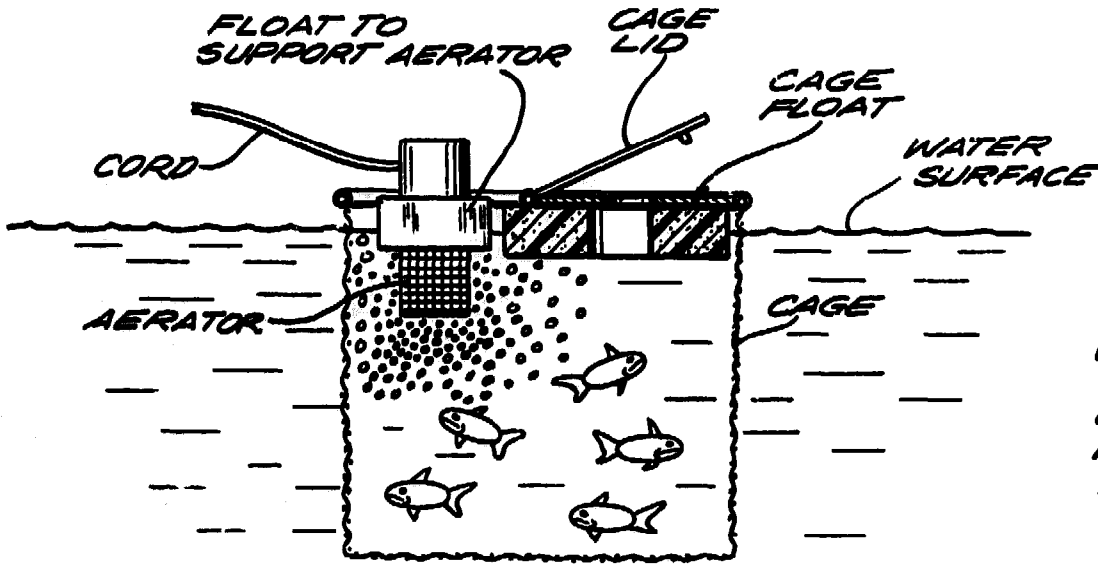
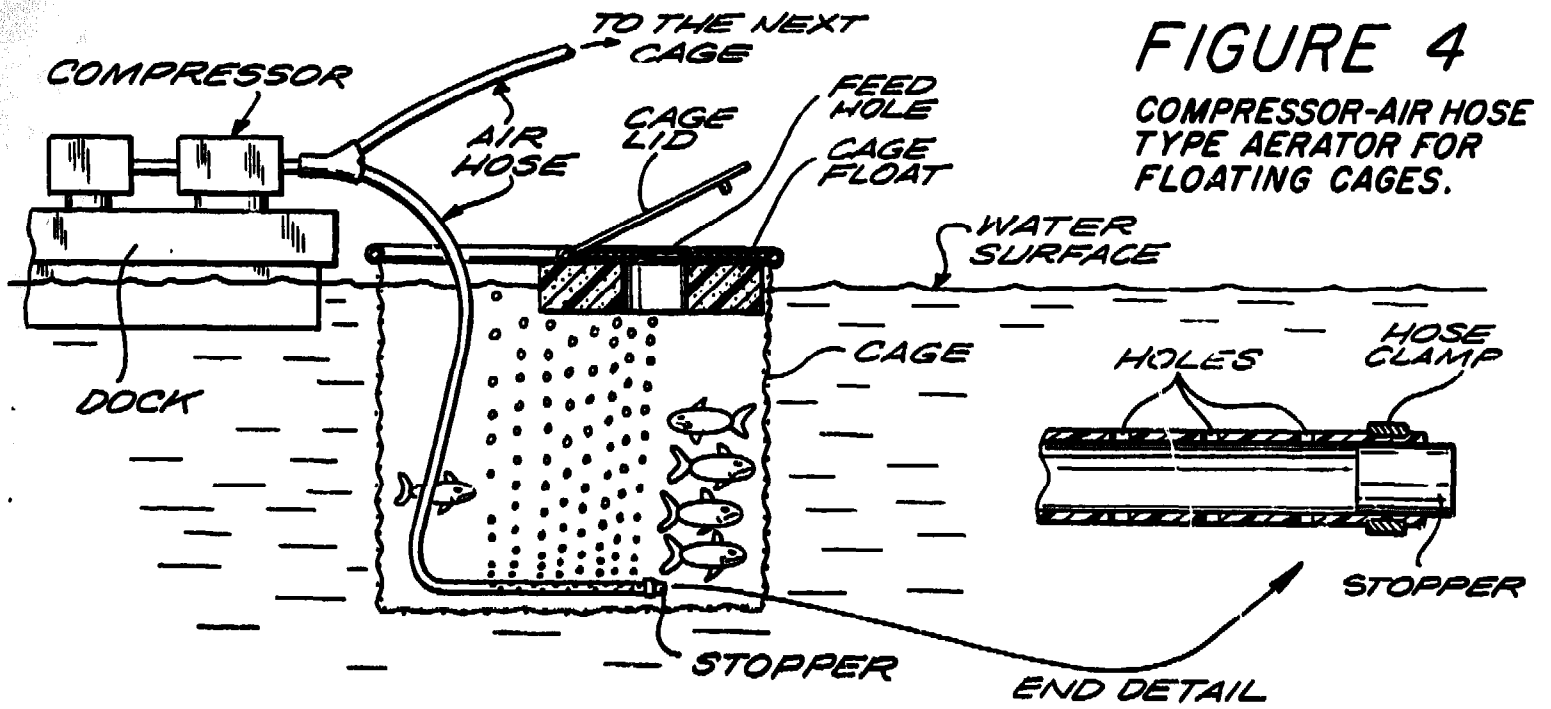
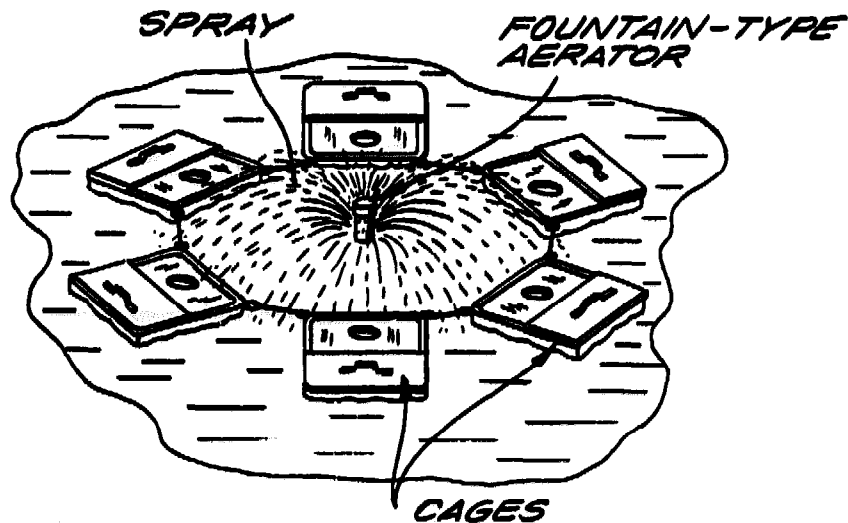


FIGURE 5

AERATION OF
WATER IN CAGES
BY CLUSTERING
CAGES AROUND
FOUNTAIN-TYPE
AERATOR SO
AS TO RECEIVE
OXYGENATED
WATER SPRAYED
INTO THE AIR
BY THE AERATOR



bubble it up through the water in the cage, much in the manner of a bubbler in an aquarium for tropical fish. Figure 5 shows a method using a large fountain-type aerator. The cages are gathered around the aerator so that aerated water is circulated to all of the cages. Another method for use in smaller bodies of water is to simply pump in large amounts of fresh oxygenated water.

(b) Moving The Cages. If the oxygen depletion appears to be a local problem, it may be solved by simply moving the cages to an area where the water has more oxygen.

CHAPTER FIFTEEN: WATER TEMPERATURE CONTROL

Sudden changes in water temperature mean sudden death for fish and should be avoided at all costs.

If the water in which the cages are located gets too hot it will stress the fish or kill them. If the high temperatures are merely a local problem, the temperatures can be reduced merely by moving the cages to a cooler, perhaps shadier area. If a cold spring is known to have an inlet to the body of water, locating the cages near the spring may provide some temperature relief. In a pond, cold well water can be pumped in to cool all of the water.

In the wintertime, the water can be warmed by the use of waste or low-cost hot water from hot springs or electric power generating plants. Ice can be kept from forming on ponds and lakes so that the cages can be left in the water. Ice formation is prevented by use of a bottom aerator pump or bubbler which brings the bottom water to the top to prevent freezing.

One method which has been suggested for reducing the temperature of the water for caged fish in the summer is to sink the cages into the cooler deep water of a lake as the water temperatures rise near the surface. This procedure is experimental in the U.S., although the Japanese have done this with cages for growing yellowtail in the ocean in order to protect the cages from storms.¹² Sinking feed is fed through a tube which extends up to the water surface. A tray is provided in the cage to catch the food as it falls through the tube, unless the fish are fast enough to catch the food as it falls. The oxygen content of the deeper water should be checked because it may not be high enough to support the fish in the cage.

CHAPTER SIXTEEN: SORTING

1. To Promote Best Growth.

Fish growing in cages, just like other fish, tend to grow at widely varying rates. Some of the fish seem to grab large portions of the food and grow much faster than the others. These fish are commonly called "hogs". For best growth it is desirable to remove the hogs and sort the fish periodically. This can be done by taking fish out of the cage and putting them through a fish grader

which will separate the fish according to size, and then putting the large fish in one cage and the small fish in another cage.

2. To Prevent Cannibalism. Sorting of carnivorous fish such as catfish, bass and trout is necessary to keep the large fish from eating the smaller fish. Bass should be sorted most often. They should not be allowed to become more than an inch or two different in length. Catfish and trout are not quite as cannibalistic and greater differences are permissible. Frequent feeding of the fish also reduces cannibalism.

CHAPTER SEVENTEEN: DISEASE PREVENTION AND TREATMENT

A detailed description of all the diseases and vitamin deficiencies which can attack all of the fish that can be grown in cages is beyond the scope of this booklet. However, the fish in the cages should be checked regularly, preferably daily, for abnormal behavior which might indicate a disease problem. The diseases which attack caged fish are the same as those which attack the same type of fish grown in other ways.

Regular treatment of the fish to prevent the widespread outbreak of disease is strongly recommended. Once every one to three months, depending on the needs of your fish in your water, add a dose of antibiotic to a batch of feed. It is important to not use the same antibiotic twice in succession, because the germs quickly develop immunities to one antibiotic if it is used repeatedly. For example, use Terramycin one month and Furacin the next, etc. Similarly, treat for parasites regularly, even if the fish do not seem to need the treatment badly. Small outbreaks of disease can spread quickly to all of the fish in the cage.

Literature¹³ listed at the end of this booklet is available describing most of the diseases and treatments. Much of the literature is free. It should be obtained and read by those unfamiliar with the subject. Help can be obtained from the sources listed in Chapter 22 for uncommon diseases or special problems. Even the most experienced fish culturists have to get help with disease problems now and then.

Caged fish diseases can be treated by the methods described in Chapter Eight above.

A certain number of fish will die in any type of intensive fish culture, including cage culture. It is difficult to estimate what a "normal mortality rate" might be. However, a loss of 5% to 10% or 12% is not unusual. Unless there is a major outbreak of disease, most of the losses will occur during or soon after stocking of the fish in the cages. Therefore, careful handling of the fish at these times, and vigilance in caring for the fish at all times, should result in minimum losses.

CHAPTER EIGHTEEN: NOISE, LIGHT AND ENVIRONMENT

1. Noise. Noise in the vicinity of the cages generally is not good for the fish. However, some species seem more readily excited by noise. For example, it has been reported that channel catfish are easily excited, whereas rainbow trout are not. In any event, since fish excited by noise sometimes batter themselves against the cage walls and injure themselves, excessive noise should be avoided.
2. Light. It has been reported that some fish grow better with covers on the cage in order to keep the light out. This is true for channel catfish, but has not been reported to be true for trout. However, the covers usually should be provided anyway in order to keep predators out.
3. Algae and Bryozoa Growth On Cages. Algae growth on the cages usually will not be a serious problem, especially if the mesh size is large. If it is heavy enough to cause flow problems, the algae can be removed mechanically by scrubbing the algae off, but this is time-consuming and laborious, and it disturbs the fish. A better and easier solution is to treat the pond with an algacide or algae growth retardant chemical. Bryozoa growth occurs in some parts of the U.S. Mechanical removal (preferably after the cage has been removed from the water and dried) is recommended.
4. Turnover. "Turnover" usually is not a problem, but when it is a problem, it can be quite serious. "Turnover" is caused when the water at the top of a thermally stratified lake or other deep body of water becomes colder than the water below and suddenly sinks, bringing the bottom water to the top. The bottom water in many stratified lakes has sufficient oxygen to support fish. If this is the case, then turnover is not a problem for caged fish in that lake. However, in some bodies of water, the bottom water is devoid of oxygen or has too low an oxygen content to support fish life. In this case, when the turnover occurs, the caged fish suddenly will be surrounded with water having little or no oxygen, and the fish will die if the situation is not corrected promptly.

In most bodies of water in the northern part of the United States, the only potentially dangerous turnover occurs only in the late fall, when the water temperature near the surface approaches freezing. This turnover usually can be detected rather easily and the problem is avoided by simply removing the fish from the water before the turnover occurs.

In other waters, especially in the far southern portions of the country, turnover can occur at anytime when a significant amount of cool water flows to the surface of the water. This can happen

in the spring when heavy rains come, for example. Often such turnover is local in nature, and the problem can be avoided by vigilance - watching for signs of the turnover (e.g., change in water color) - and moving the cages to a portion of the body of water where the turnover does not occur. Later, the cages can be returned to the area when the bottom water has been at the top long enough to become oxygenated again.

If the water is not too deep (30 feet or less), a better solution is available. Aerator pumps are sold for bringing bottom water to the top and aerating lakes. These aerators can be used to prevent the turnover problem. The initial cost of these pumps is relatively high, but the peace of mind they give you can be well worth the cost.

CHAPTER NINETEEN: HARVESTING

If the crop has been planned properly, the fish will be of the desired size and will be ready to harvest at the end of the growing season. If the fish are to be maintained alive, the temperatures at the time of harvest should be cool so as to avoid stress on the fish.

Harvesting can be done by simply dipping the fish out of the cage with a dip-net, or by lifting the cage up and pouring the fish into a hauling truck or other container. Power hoists can be used to lift the cages.

If the cage is heavily loaded with fish, lifting of the whole cage full of fish usually will crush a good portion of them. Furthermore, with catfish, they tend to horn one another, with the result that many fish die. If the fish are being harvested to be sent to the processors, this will not matter. If they are intended to be maintained alive, then the dip-net or other harvesting procedure is preferred.

Harvesting is particularly easy with the Inqua DOUBLE-Q cage. Any of the foregoing methods can be used. Figure 6 shows the DOUBLE-Q cage 10 being lifted by four hooks 30 and ropes or cables 32. The hooks fit through access holes at the corners of the cage top to hook onto the pipe frame of the cage.

Dipping the fish out of the DOUBLE-Q cage can be done by one man working on a small dock, as illustrated in Figure 7.

The cage 10 full of fish is floated up to the dock 11. The frame pipe 12 at the front of the cage is propped up on the edge of the dock. The frame pipe 13 at the back of the cage then is lifted up until the top frame of the cage is at an angle of about 45° and the frame is tied in that position by means of a rope 14. The fish 15 are gathered together only a short distance below the surface of the water 16. With the hinged lid 17 of the cage open, it is easy to dip the fish out of the cage by means of a dip-net through the mouth 18 of the cage.

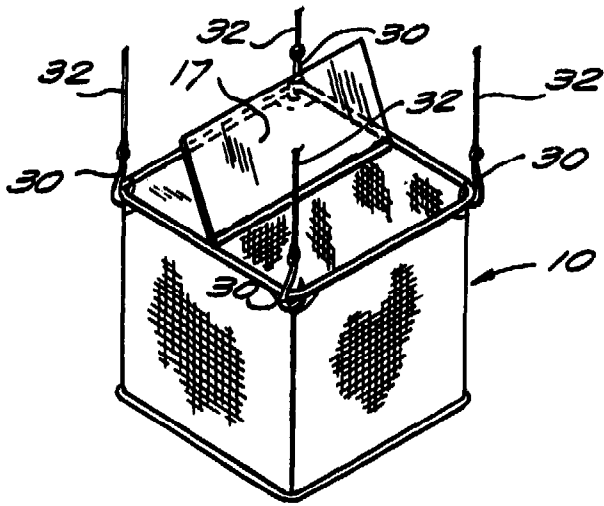


FIGURE 6

DOUBLE-Q CAGE BEING LIFTED BY FOUR HOOKS AND LINES. HOOKS FIT INTO OPENINGS LEFT AT THE FOUR CORNERS OF THE CAGE TOP.

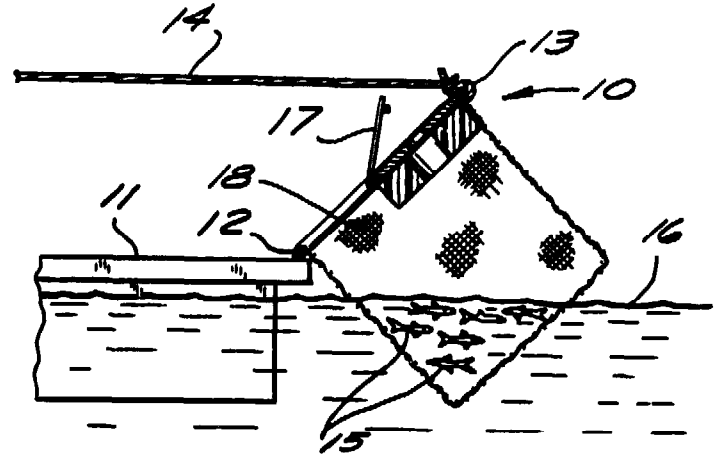


FIGURE 7

DOUBLE-Q CAGE TIPPED UP ON DOCK TO MAKE DIPPING FISH OUT EASIER.

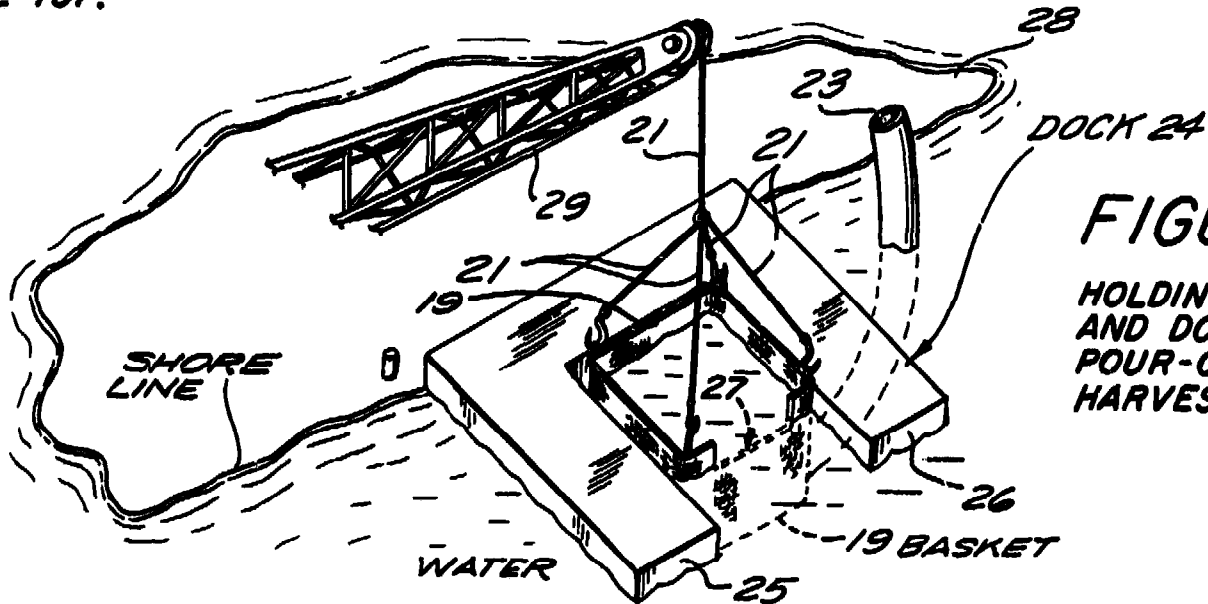


FIGURE 8

HOLDING BASKET AND DOCK FOR POUR-OVER HARVESTING.

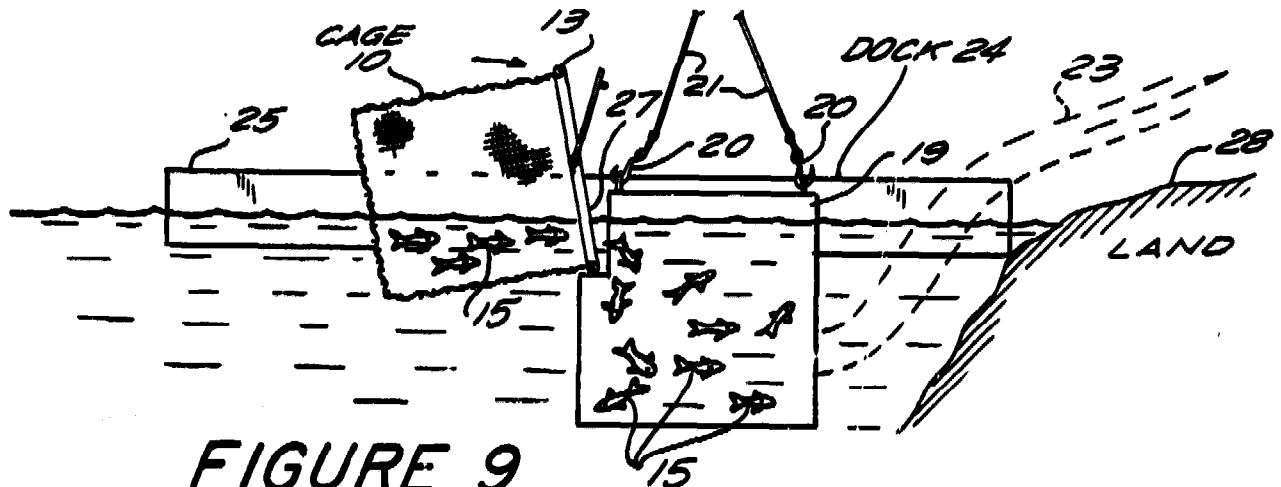


FIGURE 9

POUR-OVER HARVESTING, DOUBLE-Q CAGE TIPPED UP IN THE WATER TO LET FISH SWIM INTO HOLDING BASKET.

The extreme light weight of the netting and aluminum forming the cage makes it easy to tip the bottom up as shown in Figure 7 merely by tipping the top frame. The fish offer no resistance to this movement because they keep swimming to avoid hitting the cage walls.

Another unique harvesting method is shown in Figures 8 and 9. This method, called the "pour-over" method, is similar to that shown in Figure 7, except that it is easier, both on the fish and on the fish grower.

In the "pour-over" method, the cage full of fish 10 (Figure 9) is floated up beside a dock 24 and next to a steel mesh fish-holding basket 19 which is suspended from a set of hooks 20 and ropes 21. The mouth of the cage 10 is inserted into a cut-out area 27 of the holding basket 19 and the cage is tipped so that the fish 15 swim from the cage into the holding basket as shown in Figure 9. The fish tend to seek the deepest available water, which is in the basket 19.

The basket 19 can be hoisted by a hoist 29 (Figure 8) pulling up on the ropes 21, and then emptied into a hauling truck or other container. This saves the hard work of using a dip-net. It also allows the fish to be removed from the cage 10 in batches small enough to prevent damage to the fish from piling onto one another, or in very large batches to speed-up the harvesting operation.

The hose 23 of a fish pump is shown in dashed outline in the drawing. The hose can be inserted into the basket 19 to pump out the fish 15. If desired, instead of the basket 19, a tank shaped to make it easier to pump out the fish can be used.

The dock 24 is U-shaped and has two extensions 25 and 26 on which two men can stand to handle the cages 10.

The DOUBLE-Q cages and ordinary cages both can be lifted when full of fish by placing a sling or lifting platform underneath the cage, and then lifting the platform or the sling. This usually makes it easier to tip the cage up to dump it when it is out of the water.

Regardless of the harvesting method used, the unprecedented light weight and unified structure of the DOUBLE-Q cage make it practical to use much simpler harvesting techniques than with prior cages.

CHAPTER TWENTY: EQUIPMENT, STOCK AND SUPPLIES NEEDED

1. Absolute Necessities.

- a. *Cages; "DOUBLE-Q" cages, for example
- b. *Fish for stocking in the cages.
- c. *Fish food.
- d. Anchors, cables or other devices for holding cages.
- e. Access means, such as a dock or a boat to get to the cages.
- f. *Thermometer.
- g. *Oxygen measurement kit or meter.
- h. *Antibiotics and one or more basic parasite control chemicals
- i. *Dip net.
- j. *Weighing scales for weighing fish and feed.

2. Strongly Recommended.

*Aerator devices. (Including bottom aerators to fight the "turnover" problem - see Chapter 18).

3. Recommended.

- a. *Fish grader for sorting.
- b. *Holding tanks and pumps.

The cages are available from Inqua Corporation, P.O. Box 86, Dobbs Ferry, New York 10522, or from authorized dealers.

The other equipment is available from any well-equipped fish farming equipment store, water management service, etc. Fish and feed often are available from the same source.

For those who do not have access to such sources, Inqua can supply the items indicated with an asterisk () by mail. You do not need to hunt all over the country for suppliers of the separate items, you can get them from a single source - Inqua. Inqua also will recommend to you reliable fish dealers in your area, or will ship fish to you by air, and will arrange for you to get the necessary feed so that you can get started in cage culture with ease. As to the items without an asterisk, it is best to build your own dock facilities and buy a boat, cable, etc. locally. Inqua can give you advice on these items too.

CHAPTER TWENTY-ONE: PROFITS

1. How To Estimate Potential Money Profits. In estimating potential profits, the following costs should be determined beforehand:

- a. The cost of fingerlings to stock in the cages.
- b. The estimated cost of feed to feed the fish to the desired weight.
- c. Cost of use of the water.
- d. Cost of labor.

e. Cost of boats, docks, cages and other equipment. Initial purchase price should be divided by expected life of the equipment to obtain the cost of using it for that crop of fish.

f. Cost of hauling fish to market.

g. Other normal business expenses (power, rent, gasoline, stationery, etc.).

If food fish are being raised, the size of fish desired by the local processors should be determined. The price being paid for such fish by local processors also should be determined, and past price trends should be studied in order to estimate what the price might be when your crop is ready for harvest. You should estimate the weight of fish you will grow in each cage (be sure to allow 10% or so for mortality losses) and divide your costs for each cage by the weight of fish, and you will have your growing cost per pound of fish. Then when you compare that figure with the price per pound you can obtain from selling the fish, you will have an estimate of your profit.

The prices obtainable for fish sold live to fee-fishing lakes usually are higher than those for food fish.

2. Cost Savings In Sport Fish Raising. If the fish are to be raised for sport purposes and not for the market, the cost savings available should be calculated before it is determined whether to grow your own fish or to buy them from a fish dealer. The costs are the same as for growing fish for the market. This cost often is significantly lower than the cost of buying large live sportfish.

3. The Most Important Ingredient In Profitable Cage Culture. The most important ingredient in profitable cage culture, assuming the proper equipment is on hand and the proper techniques have been learned, is care on the part of the fish grower. Careful cage culturists, using the equipment and techniques described in this booklet, should find cage culture quite profitable.¹⁶

CHAPTER TWENTY-TWO: WHO TO CONTACT FOR HELP

The best sources of free advice, in addition to Inqua Corporation, are:

1. The Bureau of Sport Fisheries and Wildlife of the U.S. Government;
2. Personnel at several universities;
3. The National Marine Fisheries Services (selected offices);
4. State fish and game agencies; and
5. The Catfish Farmers of America (warmwater fish).¹⁴

The following offices of the Bureau of Sport Fisheries and Wildlife have fish farming advisory services:

Regional Offices (For general advice on fish farming):

Pacific Region, 730 Northeast Pacific Street, Portland,
Oregon 97208

Denver Region, Federal Center, Building 67, Denver,
Colorado 80225

Southwest Region, Federal Building, 500 Gold Avenue,
Albuquerque, New Mexico 87103

North Central Region, Federal Building, Fort Snelling,
Twin Cities, Minnesota 55111

Southwest Region, 17 Executive Park Drive, N.E.,
Atlanta, Georgia 30329

Sport Fishery Research Laboratories (For technical problems on
warmwater fish farming):

Fish Farming Experimental Station, Post Office Box 860,
Stuttgart, Arkansas 72160

Southeastern Fish Cultural Laboratory, Marion, Alabama 36756

Fishery Services Offices (For general advice on warmwater fish
farming):

Leader, Cooperative Fishery Unit -

Auburn University, Auburn, Alabama 36830

University of Arizona, Tucson, Arizona 87521

Humboldt State College, Arcata, California 95521

University of Georgia, Athens, Georgia 30601

Louisiana State University, Baton Rouge, La. 70803

University of Missouri, Columbia, Mo. 65201

North Carolina State University, Raleigh, N.C. 27607

Oklahoma State University, Stillwater, Okla. 74074

Virginia Polytechnic Institute, Blacksburg, Va. 24061

Fishery Biologist -

Central States Fishery Station, Post Office Box 18,
Princeton, Indiana 47570

Fort Niobrara National Wildlife Refuge,

Hidden Timber Star Route, Valentine, Nebraska 69201

BSFW Biologist, Soil Laboratory, Bureau of Indian
Affairs, Gallup, New Mexico 87301

Hatchery Biologist Offices (For disease and parasite problems):

Coleman National Fish Hatchery, Route 1, Box 2105,

Anderson, California 96007

National Fish Hatchery, Post Office Box 158, Pisgah Forest,
North Carolina 28768

National Fish Hatchery, Springville, Utah 48663

National Fish Hatchery, Post Office Box 252, Genoa, Wisconsin
4632

Hatchery Biologist, Box 292, Stuttgart Arkansas 72160

The following offices of the National Marine Fisheries Services
offer advice on fish farming:

Regional Office:

Federal Building, 144 First Avenue South, St. Petersburg,
Florida 33701

Marketing Office:

Post Office and Courts Building, 600 West Capitol Avenue,
Little Rock, Arkansas 72201 15

The above sources can advise you on the availability of paid consultants to help you with your more difficult problems.

Auburn University is an excellent source of free literature on aquaculture. Specific references listed in the footnotes of this booklet can be obtained by writing to: Publication Clerk, Dept. of Fisheries and Allied Aquacultures, Swingle Hall, Auburn University, Auburn, Alabama 36830, U.S.A. Auburn publishes a revised "List of Available Publications" from time to time, and this list can be obtained from the same source.

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1. "Catfish Culture In Effluent Water", by Richard A. Collins, pages 7-11* "The Catfish Farmer", May-June, 1970.
2. "Cage Culture of Trout In Warmwater Lakes", by R. A. Collins, pages 4-7* "The American Fish Farmer", June, 1972. The culture of both carp and trout in cages in power plant cooling water in the U.S.S.R. is reported in Vol. 3 "Fish Farming International" p. 117, 1974, published by Fishing News (Books) Ltd., 23 Rosemount Avenue, West Byfleet, Surrey England.
3. "Training Bass to Eat Fish Food Pellets", pages 4 and 15, "Farm Pond Harvest", Winter, 1975. Back issues are available from the magazine's publishers, Professional Sportsman's Publishing Company, Box AA, Momence, Illinois 60954.
4. See Reference No. 2 above.
5. See: "The Culture of Channel Catfish in Cages Suspended in Ponds" by H. R. Schmittou, 1969. Reprint can be obtained from Auburn University as explained in Chapter 22. Ask for Publication No. B-23 from the April, 1975 List of Publications.
6. See References Nos. 1 and 2 above.
7. "Cage Culture in White Oak Lake", pages 18 through 22, "The American Fish Farmer", February, 1971. Also see References 1 and 2 above.
8. See: "Protein Requirements of Cage-Cultured Channel Catfish" by R. T. Lovell (1972). Reprint available from Auburn University, as explained in Chapter 22. Ask for Publication No. C-10 (April, 1975 List). Note that some fish, such as channel catfish, apparently use the protein

in fish meal much more readily than protein in other foods, such as corn. Therefore, be sure that your feed has some fish meal in it - the more the better.

9. See: "Essentiality of Vitamin C in Feeds for Intensively Fed Caged Channel Catfish" by R. T. Lovell (1973). Reprint available from Auburn University as explained in Chapter 22. Ask for Publication No. C-11 (April, 1975 List).
10. See Reference No. 1 above.
11. See Reference No. 2 above.
12. "A Visit to Japan's Fish Farm Industry" by P. H. Milne, Vol. 2, "Fish Farming International", pp. 42-45, 1974; "Floating Enclosures and Nets for Fish Farming" by P. H. Milne, Vol. 3, "Fish Farming International", pp. 84-85, 1974.
13. "Parasites and Diseases of Warm-Water Fishes", U.S. Dept. Fish & Wildlife, Service, Fish Farming Experimental Station, Stuttgart, Arkansas 72160;
"The Biology of Channel Catfish Production", Circular No. 535, available from the same source.
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"Textbook of Fish Culture", by Marcel Huet, Chapter XV, published by Fishing News (Books) Ltd., 23 Rosemont Avenue, West Byfleet, Surrey, England.
"Commercial Catfish Farming" by Jasper S. Lee, 1973, Chapter 8, and pages 190-195, Interstate Printers, Danville, Illinois.
"Culture and Diseases of Game Fishes" by H. S. Davis, 1970, Part Two, University of California Press, Berkeley, California. Also see Reference No. 15 below, and its bibliography.
14. Catfish Farmers of America, P.O. Box 2451, Little Rock, Arkansas 72203, U.S.A.
15. Taken from "Second Report to the Fish Farmers", by the Bureau of Sport Fisheries and Wildlife - Resource Publication 113 (1973). Available for \$2.10 from the U.S. Government Printing Office, Washington, D.C. 20402.
16. "Catfish Cage Culture", Charles M. Collins, 1978. This booklet is available free from The Kerr Foundation, Inc., Agriculture Division, P.O. Box 588, Poteau, Oklahoma 74953.

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