SPECIES SELECTION FOR CAGE CULTURE

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Cages were probably first used centuries ago for the storage of 'wild' fish. Since those earlier times, cage culture of fish has developed. Cage culture (principally catfish culture) has existed for a number of years in various regions of the U.S. A renewed interest in this form of aquaculture has taken place in the Midwest as part of agricultural diversification.

The selection of the appropriate species of fish is necessary for the future success of any aquaculture venture, including cage culture. Depending on their temperature requirements for growth, fish may be labeled as warm, cool or cold water species. The desired species characteristics for cage culture are: 1. fast growth rate; 2. tolerance for crowded conditions; 3. grows well in regional environmental conditions; 4. is native to the region; and, 5. one that has a market value. Several species are suitable for cage culture. Species that have been raised in the U.S. include catfish, bluegill sunfish, striped bass, walleye and trout. This paper will entail discussion regarding the culture of each of the aforementioned species.

This paper will also discuss stocking rates of cages. These rates are impacted by the quantity and quality of feed being used, and the water itself. In the event that the cages are placed into flowing water (streams, rivers, etc.), then it may be possible to increase the stocking rates listed under each species.

Catfish

Channel catfish is but one of 39 different species in the catfish family Ictaluridae. Closely related species are blue catfish, black bullhead, brown bullhead and yellow bullhead. This paper will concentrate on the culture of the channel catfish in this region.

This species (a warm water fish) has a well established market due to the success of the catfish industry in the southeast. However, to sell this fish in the midwest, the production costs must be below or at least the same as for fish that may be shipped into this region from the southeastern U.S. In addition to the established market, availability of fingerlings, tolerance for variable water conditions and adaptability to cages combine for their suitability to cage culture.

Since these fish are typically found in warmer waters, optimal growth occurs when water temperatures approach 80-85°F.

Growth stops at 45°F, while the upper range of water temperature is 95+ °F. The preferred water temperature of this species is the principle reason for the limitation of their culture in this region.

Channel catfish may be stocked into cages when water temperature of this species is the principle reason for the limitation of their culture in this region.

Channel catfish may be stocked into cages when water temperatures exceed 80°F. However, stocking at warmer water temperatures (above 80°F) may adversely stress the fish, and lead to disease and ultimately death. It is often best to stock cages two weeks prior to the anticipated growing season, based on preferred temperatures for growth.
Fish handled during these cooler water temperatures are less active and, thus, are less excitable which reduces the potential for their injury. As with all fish, the individual should buy only high quality fingerlings that are relatively free of disease.

Size of catfish fingerlings to be stocked depends on the length of growing season, availability and marketing strategy. The minimum size fingerling which can be stocked into a cage made of 1/2-inch mesh is 4 to 5 inches. Generally 6-to-8 inch fingerlings are stocked into cages. If a 1 1/4 to 1 1/2-pound fish is the desired market size at harvest it may be necessary to stock a larger fingerling or to stock at a lower stocking rate. Larger fingerlings must be stocked in the midwest as the growing season is shorter than in the southeast. It is not uncommon to stock 8-to-10 inch fingerlings where the growing season is 180 days or less. Availability and cost of larger fingerlings may make stocking these sizes prohibitive. Also, a fingerling over 10 inches in length may not adapt well to a cage.

Stocking densities for catfish fingerlings in cages range from 6 to 14 per cubic foot of cage. This equates 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. Do not stock below a density of 6 per cubic foot or catfish will fight, leading to injury and disease. Some recommended stocking rates for small cages are given in Table 1. Even with supplemental aeration available it may be advantageous to stock additional cages rather than overstock individual cages to reduce stress. Overstocking individual cages can lead to serious growth and health problems.

Table 1. Suggested stocking rates for cage culture.

<table>
<thead>
<tr>
<th>Cage Size</th>
<th>Stocking Rates</th>
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<tbody>
<tr>
<td>4 x 4 feet</td>
<td>300 - 400</td>
</tr>
<tr>
<td>(cylindrical)</td>
<td></td>
</tr>
<tr>
<td>4 x 4 x 4 feet</td>
<td>400 - 500</td>
</tr>
<tr>
<td>8 x 4 x 4 feet</td>
<td>800 - 1000</td>
</tr>
<tr>
<td>8 x 8 x 4 feet</td>
<td>1500 - 2000</td>
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</tbody>
</table>

Blue catfish and bullheads have been stocked in cages with much success. Blue catfish do not do well in small cages and have a slightly cooler temperature preference than channel catfish. This preference for lower temperature may make this species more appropriate for culture in the Midwest. Additional research needs to be done to address the possibility of culturing the blue catfish in this region.

Bullheads have been raised in cages and appear to do well. Recommended stocking size is a 6-inch fingerling. Bullheads do not grow as large as channel catfish, however, and are only expected to get to 1/2 pound in a growing season. Fingerlings of both bullheads and blue catfish are usually difficult to find and may be expensive. A specially formulated caged catfish diet may be used to feed these fish.
Bluegill

Bluegill and other sunfish belong to the family Centrarchidae. Bluegill sunfish and their hybrids have been reared in cages with some success. Of the variety of crosses, the fry obtained from female green X male bluegill cross are the major hybrids available to aquaculturists. This cross results in fry being approximately 90% males and 10% females, which results in limited reproduction. Temperature tolerances and preferences of bluegill are similar to those for channel catfish (described previously). Bluegill, however, are more aggressive and will take food at lower temperatures than catfish and should be stocked before the water temperatures reach 60°F. Bluegills and associated hybrids are considered to be good candidates for aquaculture in the Midwest since they will feed during lower water temperatures than channel catfish.

Fingerling bluegill should be 3 to 4-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.

There are no diets formulated for bluegills. Catfish, trout and salmon diets have been used to feed these fish.

Striped Bass

Striped and white bass are members of the family Percichthyidae. Striped bass and associated hybrids have been successfully raised in cages. Hybrids consist of original cross (female striped bass X male white bass) and reciprocal cross (female white bass X male striped bass). Due to the limited supply of striped bass brood stock, the reciprocal cross is becoming the prominent hybrid used in aquaculture. Both hybrids exhibit "hybrid vigor" what enables them to survive under more extreme environmental conditions and grow faster than pure striped bass. This fish may be called wipers or sunshine bass.

Much of the potential market is due to the decline of commercial catches along the Atlantic Seaboard. It is hoped that the cultured fish will supplement this open market niche. Since the preferred water temperature of striped bass is 77-80°F, this fish is more suited for culture in the midwest than channel catfish.

Stocking densities recommended are the same as given in Table 1. At present the greatest problem in cage culture of striped bass is the availability of large or advanced fingerlings. Most fingerlings are sold at sizes too small to be stocked into cages. A minimum 4-inch fingerling is needed for stocking and 8-inch fingerlings would be preferable. Fingerlings should be graded closely as cannibalism is a problem in young striped bass.

To date there are a limited number of diets formulated for these fish. As a substitute, both trout chow and salmon chow have been used with some success. Dietary components still need to be established for these fish.

Walleye

This species has been recently cultured in cages in the Midwest. Current information is limited in scope. Preferred temperature for growth is 68-77°F with the ideal temperature being 73°F.
The greatest losses are due to cannibalism and difficulty training to artificial diets. Thus, a greater density of fish need to be stocked if they are not 'food trained' prior to their placement into cages. Production costs are considered to be high due to the previously stated reasons and because the artificial diets that are available are expensive and limited in supply.

**Trout**

Trout and salmon all belong to the family Salmonidae. Rainbow, brown and brook trout can all be reared in cages. Rainbow trout are most often cultured because of the availability of fingerlings, established market and adaptability to cages. Basic culture of all three species is very similar. Rainbow trout will be described here, but the information should apply to other trout species. Salmon have also been cultured in cages, but discussion will be limited to trout.

Trout are cold water species that require well oxygenated waters. Optimum growth temperature for trout is between 55 and 65°F, but good 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 wintertime activity in the Midwest, except where cold spring water or high altitude lowers summertime water temperatures.

It is necessary to stock a 6- to 8-inch fingerling trout in most of the midwest to obtain a 1/2- 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 product and profit.

Stocking densities for trout in cages may be a little 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 without concern for aeration and low dissolved oxygen. In fact, densities as high as 15 fish per cubic foot may be acceptable. Trout diets are available for use to feed these fish.

**Other Species**

The afore-mentioned species 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 the list of 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.

**Sources of Information Used in This Publication**


FEEDING FISH IN CAGES

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If you are going grow fish, you have to feed them. This may sound somewhat simplistic, but feeds and feeding are areas that are often overlooked as aquaculturists begin new operations. One of the factors that can be overlooked is the relative cost of feed, which is one of the largest operating costs in most aquacultural systems and easily one of the largest costs in cage culture. Thus, purchasing the best quality feed at the lowest price is a vital consideration in terms of economics of your operation.

In pond culture, getting feed to all your fish and reducing wastage can be difficult because of the relatively large area you are working with, but there will be some nutritional contribution from naturally-occurring pond organisms, such as tadpoles, aquatic insects, etc. Feeding fish in cages is simpler than feeding fish in ponds because of the relative ease you can feed a small group of fish in a much smaller area, but the diet has to be nutritionally complete because few pond organisms will find their way into the cage. Thus, you can find diets that are formulated specifically for cage culture where the contribution of pond organisms is minimal.

The two most commonly used feed types are floating and sinking pellets. More and more aquaculturists, regardless of species raised or culture system, are moving to floating or extruded diets. Floating feeds cost a little more to manufacture, but have distinct benefits. When feeding an extruded diet, you can actually see the fish come to the surface and feed, but when feeding a sinking feed, you do not know if the majority of your fish are feeding. This management benefit is important. One of the first indications of sick fish or poor water quality is cessation of feeding. Additionally, floating feeds usually stay intact better than pelleted feeds and retain their form after several hours in water, which is beneficial if fish are feeding slowly. Feed manufacturers are able to make some relatively small floating feeds, but be aware that some feed sizes are manufactured only in pellet (sinking) form.

Nutritional Composition

One of the first steps in deciding which feed is best for your situation and species is selection of the optimal protein concentration which is considered the most expensive major nutrient in animal diets. There are many recommendations regarding optimal protein level and the figures you might here can be confusing. Points that might help you decide which level is best is to understand how we conduct nutritional requirement studies with fish and understand the "natural" feeding habits of the species you want to raise.

Most nutritional studies are conducted with juvenile fish (in the range 2-7 g initial weight or 2-8 cm (1-3 inches)). These fish are growing rapidly and their nutritional requirements are relatively high at this age and size. Further, most of these studies are conducted in aquaria, where the fish has no other nutritional contribution except the diet provided—similar to cage culture. Thus, if the minimum amount of protein required for maximum weight gain in an aquaria system is 30-32%, it should be adequate for similar-size fish fed the same type of diet and raised in cages. For smaller fish, the optimal protein level is usually higher. First-feeding channel catfish grow better when fed a 50%
protein salmon feed, whereas the optimal protein level for grow out is 32%. Another important point to consider are the feeding habits of the fish you are trying to raise.

Channel catfish are omnivores (that is, they naturally eat a variety of feeds), while trout are carnivores (primarily eat smaller fish or insects). These are the two species for which the most nutritional information has been developed, but are not necessarily the species you are raising in the Midwest. The optimal protein concentration for catfish (an omnivore) is 30-32% and the optimal level for trout (more carnivorous than catfish) is 40-45%. Until we establish the optimal levels for other species, you would be wise to consider the natural feeding habits of the species you want to raise and buy the feed that intuitively makes sense, given the optimal levels for catfish and trout. For example, many producers of hybrid striped bass are feeding a 36% protein catfish fingerling diet, while others are feeding 40-45% protein trout diets. Walleye and yellow perch producers are feeding one of the higher protein (40-45%) trout diets, and sunfish producers are primarily feeding catfish-type diets.

There are approximately 55 nutrients required in fish diets; thus, making sure the diet you are purchasing is nutritionally complete can be difficult. Several important points should be considered when you compare diets. For example, make sure that the diet you are considering has good quality protein feedsstuffs (such as fish or meat meals, soybean meal, etc.), supplemental vitamins, including vitamin C (ascorbic acid), and minerals (including selenium or sodium selenite). These ingredients will be reported on the feed tag in decreasing order of incorporation. For example, the first ingredient listed is incorporated at a higher level than the second, the second is incorporated at a higher level than the third, etc. Fish meal can be an important attractive component in diets, and should be near the top of the ingredient list for certain species.

Many aquaculturists find themselves conducting feed evaluations because relatively few people are raising a particular species (also known as, "trial and error"). Until the research community conducts appropriate studies and can firmly recommend particular feed types, you would be wise to consult with as many people as possible and find the feeds they prefer.

Another important consideration is availability. The best diet for your species may not be manufactured in the Midwest, and transporting that diet to your farm could double the price of feed. If you can buy feed in bulk and store it, you will usually save money. However, several key nutrients (particularly vitamin C) degrade when feeds are stored. So if you buy feed in bulk, make sure you can efficiently store that feed and that the manufacturer uses a stable form of the labile ingredients. Several feed companies located in the Midwest are manufacturing fish diets and several others will be entering this market in the near future; transportation costs should diminish.

Feeding Practices

Now that you have your feed, how are you going to get it to your fish and how often are you going to feed? Hand feeding is feasible when raising fish in cages, however, this requires a good portion of your time. Many aquaculturists with other time commitments or large numbers of fish use one of the automatic or demand feeders. Automatic feeders provide feed at regular intervals, whereas the demand feeders rely on the fish triggering a switch that releases feed from a hopper. Both alleviate the time commitment on your part, but require frequent monitoring and refilling.

Small fish (first-feeding through fingerling size) require feed at frequent intervals; as often as every 15 minutes for some species. Thus, automatic feeders of some type may
be necessary. As fish grow, the frequency of feeding can be reduced. Most larger fish grow better when fed 2-3 meals per day. However, if you have numerous cages, feeding once per day may be all the time you can spare.

Feed rates will vary depending on species and size of fish. For maximal growth of your fish, most aquaculturists feed to satiation, or all the fish will eat in a given amount of time (usually 10-30 minutes). All fish are similar to other animals in that there is some control over feed intake and they will usually not eat excessively when fed an optimal diet.

Conclusion

Feed is a major operating cost in cage culture and protein is the most expensive component in diets. Thus, selection of the most palatable diet that contains the minimum protein level resulting in maximal weight gain will improve the economic outlook of your fish farming operation. Several factors have to be considered, such as availability, and the best advice we can provide is to talk to as many people as possible prior to investing large sums of money in a particular feed. Further, use some common sense in your choice of feed and your feeding practices. Is it worthwhile buying diet A for 50% more money when you can buy a similar formulation for less? Do you get hungry if you skip a meal or a day without eating? Several feed manufacturers are participating in this workshop and we encourage discussions with them regarding your needs and with us regarding questions we might answer for you through research studies.