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Cage Culture

Handling and Feeding Caged Fish

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Fish stress induced by handling and poor feeding practices is a common cause of cage culture problems. Handling stress occurs whenever fish are captured, moved, or confined. Handling stress is usually associated with seining, holding, hauling, or stocking of fish. Problems associated with incorrect feeding practices are particularly acute in cages since no natural foods are usually available to the caged fish, and water quality deterioration from waste feed has a more direct effect on confined fish. Feeding problems common in cage culture include poor quality feed, incomplete feed, inadequate feeding or underfeeding, overfeeding and feeding at the wrong time of the day. Many of these problems have no simple solution and some degree of stress will occur. In most cases the management goal must simply be to reduce the total stress placed on the fish by handling and feeding practices.

Handling

Caged fish are confined at high densities in a small area. It should be obvious, therefore, that the caged fish are in a situation where frequent stresses are likely to occur.

Most cage culturists do not start out producing their own fingerlings. If fingerlings are purchased from outside sources, it is possible that they may have already been stressed in handling.

Common handling stressors during harvest, holding and transport from fingerling ponds to the culture pond include heat or cold shock, oxygen deficiencies, exposure to disease, high ammonia or nitrite levels, pH, shock, overcrowding and rough handling. The first encounter the fish culturist usually has with the fingerlings is at purchase. Therefore, it is at purchase that the culturist must make a determination of the fingerlings' health (i.e., quality). Stocking quality fingerlings that are free of disease and of uniform size is essential to successful cage production.

Purchase fish from a reputable producer who will guarantee his product. If possible, the fingerlings should be inspected by a certified fish disease specialist. If that is not possible look for signs of disease and stress, such as:

- skin abrasions or discolorations, thin bodies and variation of skin color within the group;
- condition of the fins and gills, frayed fins or pale, swollen and eroded gills;
- odd behavior, weak or erratic swimming, piping and lack of net avoidance.

All of these are indicators of problems. Starting with stressed or diseased fish will probably lead to disaster and not make cage culture a positive experience.

Stocking into the cage is always stressful on the fish. Appropriate equipment and experience are important in transporting fish. Transport the fish in a well oxygenated container with water the same temperature as the water the fish were in when purchased. To reduce stress and remove certain parasites during transport, add salt to the hauling container (see SRAC publications 390, *Transportation of Warmwater Fish—Equipment and Guidelines*; 392, *Transportation of Warmwater Fish—Procedures and Loading Rates*; and 393, *Transportation of Warmwater Fish—Loading Rates and Tips by Species*). Stock at pond temperatures which will not stress the fish (see SRAC Publication No. 163, *Species Suitable for Cage Culture*). If the temperatures of the pond and the hauling water differ by more than a few degrees, temper the fish by slowly adding pond water

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to equalize the temperature. A wait of at least 20 minutes is needed for a 10ºF change in water temperature. Failure to properly adjust the temperature can lead to immediate death or can lower the fingerlings' ability to resist infections and lead to secondary diseases or parasites. Finally, do not feed the fish for 1 or 2 days after stocking. Let the fish recover from the haul and adjust to the cage.

Problems which occur immediately after stocking were either brought in with the fingerlings, occurred during stocking, or are an indication of severe pond problems. A cage culturist should know his pond and its water quality before stocking, and not stock fish into a pond with problems. (See SRAC Publication No. 161, *Cage Culture—Site Selection and Water Quality*.)

During the growing season the fish should be disturbed as little as possible. Moving the cage, lifting the cage to look at the fish, netting the fish, swimming or fishing near the cage, or placing the cage where it is disturbed by other animals can stress the fish. Stress can lead to reduced feed consumption (i.e., reduced growth) and increased incidence of disease.

Feeding practices

Nutritional stress is common in cage culture. In fact, most of the failures of both research and commercial cage culture prior to 1975 can be related to feed quality. Today the science of fish nutrition has progressed to the point that balanced and complete diets can be formulated for the important commercial species. These complete diets are available from commercial feed mills and are essential to the health and growth of caged fish. Caged fish in most cases will receive no natural food and, therefore, must have a nutritionally complete diet which has adequate protein and energy levels, is balanced in amino acids and in essential fatty acids, and is supplemented with a complete array of vitamins and minerals. Many commercial feed mills manufacture both supplemental and complete diets. The cage producer must be sure he is purchasing a **complete diet—**one that is suitable for the species being cultured.

Caged fish should be fed a floating pelleted feed. Floating feed is trapped inside the feeding ring and will allow the fish farmer the opportunity to observe the fish. Sinking feed will fall through the cage (unless the cage has a bottom) and not be eaten by the fish. In general, warmwater species such as catfish, tilapia, bluegill and carp can be successfully reared from large-sized fingerlings on 32 percent protein complete diets although many fish farmers prefer 36 percent. Red drum and striped bass (and its hybrids) need diets with 38 to 42 percent protein. Coldwater species such as trout need a higher protein diet of 40 to 42 percent. Pellet sizes normally available include 1/8, 3/16, and 1/4-inch diameters. Usually large fingerlings can accept 1/4-inch pellets. Small fingerlings and species with small mouths (e.g., bluegill) may need to be started on 1/8-inch pellets.

Fish will feed most aggressively near their preferred or optimum temperature and when oxygen levels are high (i.e., above 60 percent of saturation). Oxygen is usually at acceptable levels (unless heavily overcast) between mid morning and late afternoon. From a temperature standpoint, warmwater fish such as catfish will feed better as the temperature rises in late afternoon in the spring, but prefer mid morning during the heat of the summer. Generally fish will adapt to any feeding time as long as it is consistent. Changes in the feeding schedule should be made gradually (e.g., not changing more than 30 minutes per day). Most studies have shown that fish will grow faster and have better feed conversion if their daily feed ration is divided into two feedings given at least 6 hours apart. This is particularly true of small catfish, trout, tilapia and bluegill.

Recent research on cage culture of catfish has shown that dusk feeding can increase growth and improve feed efficiency. Dusk is the natural feeding time for many species of fish. **Dusk feeding cannot be practiced without a means of nighttime aeration.** (See SRAC Publication No. 162, *Cage Culture—Cage Construction, Placement, and Aeration*.) Dusk feeding can begin within 1 hour of sunset and can continue for an hour or more after sunset. The key to dusk feeding is not to overfeed (see page 3). If mechanical aeration is not available, do not consider dusk feeding.

Correctly feeding the proper amount of feed is extremely important. Overfeeding wastes feed and money, and can cause water quality deterioration leading to stress and increased incidence of disease. Underfeeding reduces the growth rate, total production and profit. A general rule of thumb for most warmwater fish is to feed fish all they will eat in 10 to 30 minutes when the water temperature is above 70ºF. Caged fish, particularly catfish, are sometimes shy and may not start feeding immediately. Also, when fish are first stocked into a cage they usually adjust slowly to feeding. **Keeping good feeding records is essential to becoming a successful fish producer**.

It is a good practice to offer caged fish one-half of the amount of feed they consumed the previous day, so as not to overfeed if there is a weather, water quality or disease problem that reduces consumption. After adding feed observe the feeding response, adding more feed as needed at 20- to 30-minute intervals. If the fish have not consumed the feed after 20 to 30 minutes, do not add more feed. Many producers and researchers have found that catfish will continue to consume feed for several hours if fed at dusk. The key is to get as much feed into the fish as they want to eat (satiation) without leaving or wasting feed. The more feed eaten the more fish produced!

Demand feeders have been used successfully with caged fish. The problems with demand feeders are:

1) the fish must be trained to use the feeders,
2) the feeders need frequent adjustment, and
3) the producer must observe feeding behavior of the fish to head off water quality and disease problems.

Demand feeders should only be used by **experienced producers** who have produced fish using hand-feeding and feel they know how to observe fish behavior.

Demand feeders should be filled daily at the time when feeding normally begins, so that feeding behavior can be observed immediately. Since species like catfish tend to feed on demand feeders at dusk or after dark, it is best to fill these at dusk. Again, **dusk feeding** (and demand feeding of species that feed at night) **should not be practiced unless nighttime aeration is available!**

Fish in cages should be fed at least 6 days a week, unless precluded by bad weather, poor water quality, or disease. The daily amount of feed fed will need to be increased as the fish grow. Feeding should be discontinued during periods of heavy overcast weather (unless aeration is available) and if water temperatures exceed 95ºF.

Feeding rates

Feeding rates for fish are calculated on a percent of body weight per day basis, based on the fish size and water temperature. Small fish consume a larger percentage of their body weight than larger fish, and all fish increase consumption as water temperatures approach optimum temperature range. Small fingerlings will usually eat 4 to 5 percent of their body weight. After they reach advanced fingerling size the rate will decrease to 3 percent and nearing harvest size will drop to only 2 percent or less (see Table 1).

Experienced cage culturists prefer to estimate feeding rates. There are two methods commonly used to determine proper feed amounts. One method estimates growth based on feed conversion and adjusts feeding rates weekly to this estimate. The second method estimates growth based on a sample of fish from the cage and adjusts feeding rates based on this sample.

Feed conversion method

This method requires that the initial weight of the fish stocked be known and that records be kept on the total weight of feed fed each week.

For the first week start by determining the average individual stocking weight of the fish (total weight of fish stocked in pounds divided by number of fish stocked). Use Table 1 to find the percent body weight which fish that size should consume. Multiply the percent body weight by the total weight of fish stocked into the cage. This gives the amount of feed that should be consumed each day for the first week.

A new estimate should be recalculated each week, based on estimated growth. Estimated growth is calculated by multiplying the total amount of feed (in pounds) fed during the week by the estimated feed conversion ratio (FCR) of 1.0/1.8 (1 pound of gain for each 1.8 pounds of feed eaten or 0.556). This estimated growth weight is added to the total weight at the beginning of the week. This new total weight is divided by the number of fish (less any deaths) to get a new weight of individual fish. Use Table 1 to get the estimated percent body weight the fish should now consume and multiply this by the total cage weight. This is the new amount of feed that should be fed daily for the next week. This sounds complicated but with a little practice it becomes easy. The formulas and example which follow should help.

In this example, the fish were averaging 1/2 pound (0.5) each at week 10 and there had been no deaths; therefore, 300 fish x 0.5 = 150 pounds = total cage weight. At that cage weight they were consuming 3.75 pounds of feed each day for 6 days or 22.5 pounds of feed during the week.

Table 1. Estimated consumption by various sizes of channel catfish* when water temperature is above 70 degrees F.

Average weight/ length per fish (pounds/inches)	% Body weight consumed
0.02 / 4	5.00
0.04 / 5	4.00
0.06 / 6	3.00
0.25 / 9.5	2.75
0.50 / 12	2.50
0.75 / 13.5	2.25
1.00 / 15	2.00
1.50 / 17	1.75

*Applicable to most warmwater species.

Feed Conversion Method:
Estimated wt gain = total pounds of feed consumed x 0.556 (FCR)
New total cage wt = estimated wt gain + last week's total cage wt
Avg wt of individual fish = new total cage wt/total no. of fish in cage
New daily feed wt = new total cage wt x % body wt consumed (Tbl 1)

Example for week 10, cage of 300 fish, feed 6 days per week:
Estimated wt gain (wk 10) = 22.5 x 0.556 = 12.5 pounds
New total cage wt (wk 11) = 12.5 + 150 pounds = 162.5 pounds
Avg wt of individual fish = 162.5/300 = 0.54 pounds
New daily feed wt = 162.5 x 0.025 (2.5/100%) = 4.1 pounds

Consuming 22.5 pounds of feed with a feed conversion of 1.0/1.8 (or 0.556) gives an estimated weight gain of 12.5 pounds during week 10. Adding this 12.5 pounds of weight gain to the 150 pounds of fish (estimated) in the cage at the start of week 10 gives a new total cage weight of 162.5 pounds. Since 300 fish weigh 162.5 pounds, or 0.54 pounds each, they will eat 2.5 percent (or 2.5/100 percent = 0.025) of their body weight according to Table 1. Therefore, the new feeding rate (pounds) is 162.5 x 0.025 or 4.1 pounds of feed daily. This amount should be fed each day for six days the next week.

Measured growth estimate

This method calculates feeding rates based on the weight of a sample of fish from the cage. This should be done at 2-week intervals and usually requires that at least 10 fish be weighed from each cage. The total weight of the sample of fish is divided by the number of fish sampled, to get the average individual fish weight. This weight is used with Table 1 to estimate the percent body weight consumed. The average fish weight is multiplied by the number of fish in the cage to get the total cage weight, which is then multiplied by the percent body weight consumed to get the new daily feeding rate. The formulas and example which follow should aid understanding.

In this example the fish were averaging more than a half pound (0.54) each at week 10 and there had been no deaths; therefore, 300 fish x 0.54 = 162.5 pounds = total cage weight. At 0.54 pounds each of the fish should be consuming 2.5 percent (or 2.5 divided by 100 percent = 0.025) of their body weight per day (Table 1). Therefore, the new feeding rate (pounds) is 162.5 x 0.025 or 4.1 pounds of feed daily. This amount should be fed each day for the next 2 weeks.

Handling is stressful on the fish, not only those handled but the other fish in the cage trying to avoid capture. During periods of questionable water quality or extremely hot weather conditions it may be best to avoid handling the fish and estimate the weight gain.

Sampling Method:
Avg of individual fish = wt of 10 fish/10
New total cage wt = average wt of individual fish x number in cage
New daily feed wt = new total cage wt x % body wt consumed (Tbl 1)

Example for week 10, cage of 300 fish:
Avg wt of individual fish = 5.4/10 - 0.54 (pounds)
New total cage wt = 0.54 x 300 = 162.5
New daily feed wt = 162.5 x 0.025 = 4.1

Winter feeding

Many species of warmwater fish can be overwintered in cages. Tilapia are the exception and will die as water temperatures reach about 55°F. Caged fish can be fed during the winter at a reduced feeding level. Table 2 gives general guidelines for feeding catfish during the winter in cages. Floating feed can continue to be fed throughout the winter in the Southeast. Feeding is usually most successful if done on warm, sunny afternoons. Research has shown that catfish can gain 10 to 20 percent of their body weight over the winter if fed, but feed conversion is poor (>3.0). Research has also shown that catfish can survive the winter without being fed and may be more resistant to bacterial diseases if deprived of feed.

Finally, probably the most important aspect of feeding: Do not over-feed the pond. The pond must decompose and detoxify all organic matter it receives. Included in this organic matter are plant materials from inside and outside the pond, runoff of nutrients from fields and pastures (possibly including livestock wastes), all fish wastes and uneaten feed. Dumping pound after pound of feed into the pond puts a tremendous burden on these natural decomposition systems which use oxygen. If the systems are overloaded the pond will become depleted of oxygen and the fish will die. Unless livestock or fertilizer runoff is a problem, the greatest organic load placed on the pond is from the fish feed.

In general, the recommended maximum pond feeding rate is not more than 35 pounds of feed per surface acre of pond per day (35 pounds/acre/day). Even at this feeding rate problems may occur in some ponds. Mother Nature is unpredictable and unforgiving! At this feeding rate the greatest number of pounds of fish which should be cultured in cages would be 1,750 pounds/acre, calculating that a 1-pound

Table 2. Winter feeding schedule for caged fish.

Temperature °F	% of Total fish weight to feed	Feeding frequency
66 - 70	2.0	every other day
61 - 65	1.5	every other day
56 - 60	1.0	every other day
51 - 55	1.0	twice per week
45 - 50	0.5	once per week

fish will eat 2 percent of its body weight daily (1,750 x 0.02 = 35).

Recommended pond feeding levels can be increased if aeration is available. Aeration can help maintain dissolved oxygen concentrations and support higher decomposition rates, or at least, keep the fish alive during times of low oxygen. The recommended maximum feeding rate with aeration is 60 pounds/acre/day. At this rate the greatest number of pounds of fish which should be cultured in cages would be 3,000 pounds/acre (3,000 x 0.02 = 60).

Feeding rates above these levels are practiced by many experienced cage producers. The key word is experienced. Beginning cage producers should not push their ponds until they have gained experience in water quality and fish management. Unfortunately, much of this experience is usually gained by killing fish.

Guidelines on feeds and feeding

1. Observation of the fish at feeding time is vital. Feeding behavior is the best index of overall health. Actively feeding fish indicate everything is all right, for the moment. Poor feeding behavior should always be viewed with suspicion (see SRAC Publication No. 165, *Cage Culture Problems*).

2. Reduce feeding levels when water temperatures drop below 60° or above 90°F.

3. Reduce or stop feeding on heavily overcast and windless days. These weather conditions reduce oxygen production and diffusion, particularly if sequential, and can lead to low dissolved oxygen. Feeding will only complicate the problem. Run aeration if available.

4. Feed quality must be excellent. Purchase feed which is known to be complete and keep it stored in a very dry, cool place. Feed should be fed within 90 days of the manufacture date.

5. Never feed moldy or discolored feed.

6. Automatic or demand feeders are not recommended for most warmwater species because of the need to observe the fish feeding (except for experienced producers with aeration systems).

7. Keep accurate records on the amount of feed fed.

8. Never feed more than 35 pounds of feed/acre/day without aeration or 60 pounds of feed/acre/day with aeration.

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