SRAC
Southern Regional Aquaculture Center

SRAC Publication No. 391
March 2013
Revision

Sorting and Grading Warmwater Fish

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Size variability is common among many species of same-age farmed fish. Because this variability in growth can be a major shortcoming in the long-term viability of a commercial aquaculture facility, producers often grade and sort fish. This practice optimizes production by reducing cannibalism, decreasing size variability among harvested fish, and improving feed conversion efficiency by using the appropriate size food particles for the size of fish. Size grading before stocking also allows an accurate determination of stocking size and number. Otherwise, stocking ungraded fish can result in under- or overstocking and may lead to poor feeding practices and increased production costs. In several fish species, one sex is larger than the other. In European sea bass, male fish are larger than females. Conversely, female fish are larger than males for largemouth bass, sturgeon, and eels. Grading juvenile fish could be used to establish faster growing monosex populations in aquaculture facilities. The following discussion covers the advantages and disadvantages of grading and the various techniques used to grade and sort fish by size.

When not to grade

Grading can sometimes do more harm than good, particularly when water temperatures are high or fish are still very small. Certain species of fish, such as crappie, shad, and many ornamental fish, are very sensitive to handling. When these fish are heavily crowded they experience severe stress and often do not survive. Life stage can often determine the sensitivity of fish to grading. Larval fish are more susceptible to handling stress than juveniles. Juveniles are usually more robust than adults when graded. When grading fish, be careful to prevent stress or at least keep stressful conditions to a minimum.

There are times when all species of fish react negatively to grading and sorting. If water quality is poor, as with low dissolved oxygen or high water temperatures, grading and sorting fish is not recommended. Stressed fish use more oxygen, and since warmer water contains less dissolved oxygen than cooler water, oxygen depletion can occur rapidly, resulting in high mortality rates. If disease outbreaks have occurred in fish stocks, it is best not to grade the fish until they recover from the disease. Diseased fish usually have compromised immune systems and additional stress makes them weaker. It is best to refrain from grading when these and similar conditions occur.

Advantages of grading

Most fish sold for stocking, bait, or food are sold by size or grade. Individual fish grow at different rates, resulting in fish of various sizes at harvest. Grading can remove the fish not in the size range most processors and live markets will accept.

Some species are cannibalistic and must be graded regularly to maintain survival rates. Largemouth bass, striped bass and their hybrids, and cobia are cannibalistic fish. The frequency of grading will depend on the growth rate of the fish and their size uniformity. The first two months post hatch are usually the most critical for minimizing losses from cannibalism.

Grading enables producers to obtain more accurate estimates of the number of fish from a weight-number relationship. If graded to a uniform size, fish count estimates are more accurate than if there are several sizes of fish within the batch. This is important to baitfish retailers who sell fish of a uniform size by the number.

Another advantage of grading is the opportunity it gives to remove unwanted fish species, undesirable organisms, and nuisance aquatic plants that could be considered

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invasive nuisance species when stocked into other water bodies. For example, mosquito fish are considered an aquatic nuisance species in some states. Eliminating unwanted fish reduces the chances of stocking them into other waters.

In the production of some fish species, males and females must be separated to prevent reproduction or to determine the quantities of each on hand. Sexes of fathead minnows can be crudely separated using 15⁄64- to 16⁄64-inch bar spacing. In other species, like channel catfish and tilapia, the sexes grow differently; therefore, frequent grading may result in skewed sex ratios in the graded fish.

Food fish producers want to grade fish to avoid harvesting fish too small for marketing or processing. Often processors will dock producers for fish that are not within the desirable size range. Grading requires labor, time, and equipment, but in many markets it is essential and may improve profits.

Grading and sorting equipment and methods

Several types of commercial graders are available, but many producers make their own graders to fit their needs. It is important to know what the market requires with respect to fish size before purchasing or constructing a grader. Most graders are made out of smooth material such as aluminum, brass, or netting. Be sure the corners are not sharp and the netting is not abrasive so fish will be less likely to be injured during the grading process. There are several types of grading equipment available.

Box graders are designed to float in a vat (Fig. 1). The frame holds interchangeable baskets made of 3⁄16-inch aluminum bars held at equal spacing by rubber bars. Spacing between the bars is in increments of 1⁄64 inch. These are used to grade small amounts of fish. Fish are crowded to one end of the vat using a block net, which is made of netting on a frame large enough to keep fish from swimming around it. Fish are then dipped into the box grader where large fish are retained and smaller fish swim through the grader. This process can be repeated with a smaller size grader. To decrease the amount of time required, splash water inside of the grader box to encourage the fish to exit the grader more quickly. Minnows grade faster when the water surface is disturbed by snapping the fingers. The loading rate of fish in a grader box should not exceed 5 pounds per cubic foot of water.

A simple method of grading fish into several size classes simultaneously uses a series of multiple grading boxes that nest inside each other. There should be enough space between boxes to accumulate 10 to 30 pounds of fish of a similar size. The inner box may have l-inch mesh, with other boxes having ½-inch, ⅓-inch, and ¼-inch meshes. The nested boxes are put in the tank and ungraded fish are dipped or poured into the inner box. Fish pass through the different meshes until they can no longer pass. The smallest fish may be collected in the tank. When enough fish of a given size accumulate, the boxes are separated and fish can be processed by counting, weighing, or passing to another tank or compartment.

Panel graders or **drag graders** also have smooth bars evenly spaced and welded or bolted to a rectangular frame (Fig. 2). Since vats can vary in size, the graders are generally equipped with adjustable clips on the sides and rubber flanges that allow them to fit snugly against the vat walls. Panel graders usually have handles to make moving them easier. The grader is placed vertically to the tank bottom and pulled from one end of the vat to the other. Larger fish are retained and smaller fish swim through the bars. This process can be repeated several times using a smaller grader each time. Panel graders require less handling of fish and cause less stress than box graders.

Figure 1. Grading boxes. (Photo by Anita M. Kelly)

Figure 2. Custom panel grader. (Photo by Anita M. Kelly)

Grading troughs can be made of wood or fiberglass and are usually transportable for use next to a pond. These types of graders are useful for fish that swim against a current, such as tilapia. These troughs are designed to have a current flow through them; therefore, they must have an inlet and an outlet. Grading panels are placed with the smallest mesh closest to the inflow and the largest mesh farthest from the inflow. The flow is adjusted so that the smallest fish can swim against the current.

Seining allows fish to be graded in ponds versus vats or tanks. The fish must be crowded by the seining net. Using seines with the proper mesh size retains fish of the desired size. If nylon nets are used, they should be treated with a net coating material to decrease injury to the fish during seining. Polyethylene nets do not need special coatings.

A **cutting seine** is a seine that is used to "cut" or grade fish that are already crowded in a harvest seine. In this method, the harvest seine is gathered until the fish are moderately crowded, then held in place using harvesting stakes. The harvest seine mesh size is chosen to let as many of the non-target fish escape as possible. A second seine, or cutting seine, that has a smaller mesh size is then used to harvest fish. The second seine is pulled to crowd fish close to the bank. Fish are then dipped and placed into a lift basket for loading onto the hauling truck.

The **live car,** or **harvest sock,** is used to further grade fish after they are seined. The live car is attached to the seine and fish are shunted through a funnel in the seine into the live car. Previous versions of live cars had a 3-foot by 5-foot tunnel and metal frame attached to the harvesting seine by a drawstring. However, the drawstring design has been replaced with industrial strength zippers for attaching the live car to the seine. The zipper eliminates the "bottleneck" effect of crowding fish through a tunnel and frame and can significantly reduce the amount of time required to land fish in live cars. For more information on live cars, see SRAC Publication No. 1805, *Advances in Catfish Harvesting Gear: Seines and Live Cars.*

A live car measures 8 to 10 feet wide by 50 to 100 feet long and is designed to hold 50,000 to 100,000 pounds of fish at a density of 20 pounds per cubic foot. The live car has floats along the top to keep it above the water and to keep fish from escaping over the top of the live car. It is important to secure the net enclosure firmly into the pond bottom. Support the net with harvesting stakes to keep it from rolling up in currents created by an aerator or water well. The live car can also be used to hold two lots of sorted fish by putting the center of the sock over the harvesting boat to form two separate compartments. This works well to select and sort males and females. Fish loading rates in live cars should not exceed 5,000 pounds per 10-foot length; lower fish loads are recommended at temperatures above 60 °F (15.6 °C). An aerator can be placed to gently pull water through the sock to prevent low oxygen problems.

The major problem with any net grader is the possibility of gilling fish in the mesh net. Bass and their hybrids snag easily in nets by their fins and operculum (or gill flap) if a seine with an improperly sized mesh is used to grade widely mixed sizes.

A **flexible panel grading sock** is a standard small-mesh sock that has been fitted with three or four 15-foot x 40-foot flexible grid panels with a set aperture (Figs. 3a and 3b). Sections of the sock side walls are cut out and flexible panels are sewn in. The mesh in the rest of the sock is small (usually around 1 inch) so fish can be graded only through the flexible grid. This is particularly useful for species that cannot otherwise passively grade from a net because of their body shape. The flexible panels can be made with bar spacings of practically any size necessary. Although this grader was developed for hybrid catfish, it is also used to grade other species.

Figure 3a. Flexible panel grader. (Photo by David Heikes)

Figure 3b. Flexible panel grader being used to grade hybrid catfish. (Photo by David Heikes)

Fish pumps are used to move large numbers of fish from ponds without having to physically lift them. Fish pumps are usually attached to grader boxes and can be used to load and grade fish simultaneously. Specially designed dewatering towers are required to separate fish from water and return the water to the pond or raceway. Fish weights are determined by water displacement rather than by weighing scales. Although fish pumps work well with coldwater fish such as trout and salmon, they have not been widely used with warmwater fish. When handled, catfish and sturgeon often lock their pectoral spiny fins in an extended position, leading to inaccurate grading.

An **in-pond horizontal bar grader** consists of an 8-inch water pump (A), an eductor box (B), and a floating platform grader (C) (Fig. 4a). This system does not require the fish to be lifted or placed into the grader. Once the fish have been seined and placed into a live car or harvest sock, the net is attached to the eduction chamber. Water is pumped through the eduction chamber, which directs fish and water up and onto the floating platform grader (Fig. 4b). Smaller fish escape through the grader and return to the pond, while larger fish swim off the end of the grader and into a separate live car. The bar spacing on the floating platform grader is adjustable from 2 inches down to ½ inch. For a more detailed description see SRAC Publication No. 3901, *Components and Use of an In-Pond Fish Grading System.*

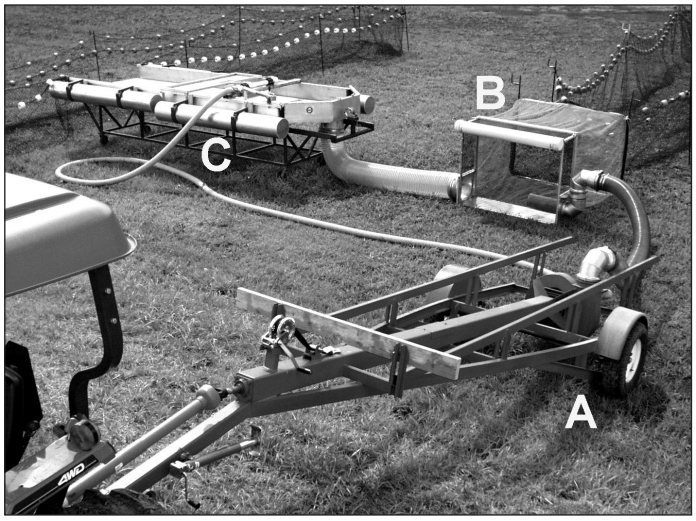

Figure 4a. In-pond horizontal bar grader with 8-inch water pump (A), an eductor box (B), and a floating platform grader (C). (Photo by David Heikes)

Figure 4b. In-pond horizontal bar grader in use. (Photo by David Heikes)

Grading by hand is done when fish do not grade well with conventional grading systems. For example, sturgeon have pectoral fins that are rigid and extended outward from the body. Although they would pass through a grader, the fish would be graded based on the span of the pectoral fins and not the body width. This leads to mixed sizes when using conventional graders. Grading fish by hand is often done on a sorting or grading table. The table is constructed with a smooth top and sides. The sides of the table can be any height as long as they prevent the fish from falling off the table. Fish are netted out of the water and placed on the table. The table contains openings large enough for the fish sizes being separated. The openings lead to individual containers of fresh, well-oxygenated water. If fish are sorted by length, rulers or reference length measurements inscribed into the table surface can be used. The top of the table should always be covered by a thin sheet of water to allow easy movement of the fish. It is important to work fish up quickly to reduce stress. If the species is very susceptible to handling stress, then avoid using this method.

Recommended bar and mesh spacings

When using either graders or nets to separate fish, the spacing of the bars or the mesh sizes should be appropriate to the desired sizes of fish to be graded. Bar spacing on commercial grader baskets ranges from 12/64 to 74/64 inches. Net or seine square mesh sizes normally range from ¼ to 3 inches. Whether a fish is retained by a grading device depends on its body shape, dimensions, and condition factor. An aquaculturist should always check the sorted sizes each time a culture cycle is started.

Tables 1 through 13 give recommended dimensions or guidelines for grading various fish species to different sizes. There is always a range between the largest and smallest fish in a length group; the fish sizes reported are approximate values. The length-weight relationship of catfish and other species varies with the condition of individual fish. Differences are greater with smaller fish because a l-inch length increment can result in a big difference in weight between different lots of fish. Repeated trials are required to determine bar spacing or mesh size required to grade other species to desirable sizes.

Table 1. Net mesh sizes for grading catfish.

Square mesh size in inches	Length or weight of fish held
¼	1-2 inches
⅜	3-4 inches
½	4-5 inches
¾	7-8 inches
1	8-10 inches (½ lb)
1⅜	¾ lb
1⅝	1½ lb
1⅞	2 lb

Table 2. Bar grader size for channel catfish.

Bar width in inches	Size retained in inches	Pounds/1,000 fish
27/64	3	8-10
32/64	4	18-20
40/64	5	32-35
48/64	6	60
62/64	7	93
64/64	8	112-140
96/64	11	750-1000

Table 3. Bar grader size for striped bass.

Bar width in inches	Size retained in inches	Pounds/1,000 fish
12/64	1	-
19/64	2¾	-
21/64-27/64	3	10
29/64	3½	15
31/64	3⁹/₁₀	20
32/64	4	23
33/64	4⅕	25
36/64	4½	35
38/64	4⅘	40
40/64	5	45
42/64	5⅕	50
44/64	5⅖	55
46/64	5⅗	60
52/64	6	78
58/64	6⅗	95
62/64	6½	100

Source: Modified from Ludwig and Tackett, 1991.

Table 4. Bar grader size for sunshine bass.

Bar width in inches	Size retained in inches	Pounds/1,000 fish
14/64 or less	1	0.8-1.5
14/64-21/64	1½-2	2.2-6.5
21/64-25/64	2-3	8-11
25/64-32/64	3-5	16.5-33
32/64-42/64	4-6	34-50
42/64-56/64	6-8	52-100
56/64 and larger	8-10	110-250

Data from producer interviews.

Table 5. Bar grader size for golden shiner.

Bar width in inches	Size retained in inches	Pounds/1,000 fish
12/64-14/64	1¾	3
14/64-16/64	2½	5
16/64-18/64	3	8
18/64-21/64	3½	13.5
21/64-23/64	4	20-25
23/64-25/64	4½	30
25/64-27/64	5	40
Larger than 29/64	5½	60

Source: Modified from Ludwig and Stone, 1997.

Table 6. Bar grader size for fathead minnows.

Bar width in inches	Size retained in inches	Pounds/1,000 fish
13/64-15/64	1¾	3
15/64-17/64	2¼	4
Larger than 17/64	2¾	6

Source: Adapted from S. A. Flickinger, 1991.

Table 7. Bar grader size for Nile tilapia.

Bar width in inches	Size retained in inches	Pounds/1,000 fish
2/64	⅓	0.02-0.11
4/64	½	0.13-0.22
5/64	¾	0.44-0.88
8/64	1	1-2.2
12/64	1¾	3.3-4.4
13/64	2½	5.5-6.6

Data modified from ftp://ftp.fao.org/fi/CDrom/FAO_Training/FAO_Training/General/x6709e/x6709e12.htm

Table 8. Bar grader size for tilapia.

Bar width in inches	Size retained in inches	Pounds/1,000 fish
25/64	3	11
37/64	3½	22
50/64	4½	44
63/64	5¾	88
67/64	7	176
88/64	8	264
100/64	9	353

Data modified from ftp://ftp.fao.org/fi/CDrom/FAO_Training/FAO_Training/General/x6709e/x6709e12.htm

Table 9. Bar grader size for common carp.

Bar width in inches	Size retained in inches	Pounds/1,000 fish
25/64	3	11
37/64	3½	22
50/64	4	44
63/64	5	88
67/64	7	220
88/64	9	375
100/64	10	529

Modified from J. C. Schneider and J. W. Merna, 2000. Pages 1-4. Manual of Fishing Survey Methods II and ftp://ftp.fao.org/fi/CDrom/FAO_Training/FAO_Training/General/x6709e/x6709e12.htm

Table 10. Bar grader size for goldfish.

Bar width in inches	Size retained in inches	Pounds/1,000 fish
16/64-23/64	1-2	3-5
23/64-32/64	2-3	6-17
32/64	3	17

Data from producer interviews.

Table 11. Bar grader size for largemouth bass.

Bar width in inches	Size retained in inches	Pounds/1,000 fish
14/64-15/64	2	3.5-4
18/64	2¾	8
21/64	3	12
44/64	6	100
60/64	8	250

Data from producer interviews.

Table 12. Bar grader size for bluegill.

Bar width in inches	Size retained in inches	Pounds/1,000 fish
13/64-23/64	1-3	4-17
23/64-31/64	3-4	18-32
31/64-36/64	4-4½	33-54
36/64-42/64	4½-6	55-100

Data from producer interviews.

Table 13. Bar grader size for redear sunfish, crappie, or hybrid crappie.

Bar width in inches	Size retained in inches	Pounds/1,000 fish
13/64-21/64	1-3	4-16
21/64-27/64	3-4	16-28
27/64-33/64	4-5	varies
33/64-40/64	5-6	varies

Data from producer interviews.

Environmental factors that affect grading and sorting

Temperature

Most fish do not handle the stress of grading when water temperatures are high. Fish must be crowded for efficient grading and most fish are more active and grade faster at higher temperatures. Unfortunately, significant mortalities or disease outbreaks can occur in fish that are handled when pond temperatures are highest. It is best to grade or sort fish when water temperatures are cooler. For example, golden shiners are very excitable and more difficult to handle when water temperatures are above 60 to 65 °F (15.6 to 18.3 °C). Striped bass and their hybrids handle better when graded at water temperatures below 60 °F (15.6 °C). Grading in the winter requires more time for fish to separate into the various sizes. Catfish require more time for pond grading in winter to prevent many small, off-sized fish from being harvested. Using larger than normal mesh sizes also helps grading when temperatures are cold.

Water hardness, chloride, alkalinity, and pH

Water hardness measures the amount of magnesium and calcium, as well as a few other positive ions, in the water. Fish have to maintain a constant internal body fluid concentration, a process called osmoregulation. Chlorides play an important role in osmoregulation. The risk of mortality is greater when grading fish in water with low chlo-

rides. Freshwater fish are subjected to a continuous influx of water because the salt concentration in their body fluids and tissues is higher than in the surrounding water. Marine fish have a continuous outflow of water from their body tissues and fluids. The greater the difference in concentration between the fish's body fluids and the surrounding water, the greater the osmotic effect. As hard water contains more chlorides than soft, there will be less energy spent on osmoregulation and a reduction of stress.

Alkalinity is another form of water hardness that measures carbonate and bicarbonate ions and directly reflects the buffering capacity of the water. Waters with moderate to high alkalinity values (and similar water hardness values) maintain a relatively stable pH. pH indicates whether the water is acidic or basic. Most fish can tolerate pH values between 6.5 and 9.0 without negative effects. pH values outside of that range are stressful to fish. For more information, see SRAC Publication No. 464, *Interactions of pH, Carbon Dioxide, Alkalinity and Hardness in Fish Ponds.*

Feed depuration

Fish stomachs should be empty before fish are graded. Fish that are not kept off feed for at least 24 hours may grade out as larger than they actually are. Also, fish that have feed in their stomachs may regurgitate undigested feed and foul the water.

Fish condition

Fish condition refers to how thick or thin a fish is relative to its length. A fish with a high condition factor will grade out as a larger fish. A thin fish can grade out as a smaller fish. Since most producers sell fish based on a length-to-weight relationship, this could result in financial losses when the fish are sold.

Crowding

Crowding increases the speed at which the fish will move through a grader, but it also increases stress levels in fish. Try to keep the time the fish are crowded to a minimum and always crowd fish when other stressful conditions are minimized.

Larval fish

Larval fish are very sensitive to handling stress, so grading them is generally not recommended. Initial size differences in fish are usually not sufficient to cause cannibalism. If larval fish must be graded, do so only when water temperatures are cool, but do not dip them out of the water because the netting process can crush many small fish.

Conclusions

There are several different methods of grading and sorting fish. Producers should choose the method best suited for the species of fish. Select graders by using Tables 1 through 13 or by visually estimating the sizes of fish. To determine grader sizes for fish not listed, place a few fish in a grader and check the fish for uniformity in size. Adjust the grader size used if an excessive or unacceptable size difference exists among the graded fish. If no fish or very few fish remain in a grader, then a smaller grader would be needed.

Knowledge of fish behavior is also helpful when choosing a method of grading. For example, baitfish will grade out through the sides of a grader box, while catfish grade more through the bottom. Fish should not be fed for at least 24 hours before they are graded. This will help maintain water quality throughout the grading process.

SRAC fact sheets are reviewed annually by the Publications, Videos and Computer Software Steering Committee. Fact sheets are revised as new knowledge becomes available. Fact sheets that have not been revised are considered to reflect the current state of knowledge.

United States Department of Agriculture

National Institute of Food and Agriculture

The work reported in this publication was supported in part by the Southern Regional Aquaculture Center through Grant No. 2010-38500-211422 from the United States Department of Agriculture, National Institute of Food and Agriculture.