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Hybrid Striped Bass:
Fingerling Production in Ponds

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Hybrid striped bass production is a rapidly expanding aquaculture enterprise in the United States and other countries, including Taiwan, Israel and Italy. Annual production in the U.S. has increased from about 400,000 pounds in 1987 to about 10.6 million pounds in 2001. The growth is in response to a market void resulting from the demise of natural fishery stocks of striped bass, an increased market demand for seafood in general (particularly in major cities), and the development of improved fish culture techniques.

Hybrid striped bass are a cross between striped bass, *Morone saxatilis*, and white bass, *M. chrysops*. When the female parent is a striped bass the hybrid is called a palmetto bass; when the female is a white bass the hybrid is called a sunshine bass. Production of market size hybrid striped bass begins with spawning and fry production followed by fingerling production and grow out to market size in one or two phases. Production of fingerlings is one of the riskiest phases.

At 5 days of age, fry of the palmetto bass (and striped bass) are 6 to 9 mm long, while those of sunshine bass (and white bass) are only 3 to 5 mm in length. The difference in size is an important consideration during the culture from fry to fingerling size. Like all predatory fish, the fry of these hybrids require live animals, usually zooplankton, as their first foods. The size of the zooplankton must be appropriate for the size of fry. In addition to being particularly small, the fry have only a small reserve of nutrients in their yolk sacs. Adequate amounts of the right type of live food must be available soon after they hatch. The small size of the fry of both crosses also makes them especially susceptible to predation by invertebrates. Because of the food requirements and risk of predation, special consideration must be given to pond preparation and stocking time for the fry.

Almost all palmetto and sunshine bass fingerling production takes place in ponds during the spring and early summer. As a result, there are seasonal restrictions on the availability of small fingerlings. Although significant advances have been made in fingerling production in tanks with cultured live feed, much more research is required to make that method economically feasible. In tank or pond production, the major objectives are to maximize the number, the size, and the condition of the fingerlings over the first 30 to 50 days of their life.

Ponds

Fingerling culture ponds are usually smaller than ponds used for grow out. While some commercial fry producers use ponds up to 20 acres (8.1 ha) in size, an ideal size for fingerling ponds is 3 to 5 acres (1.2 to 2.0 ha) and 3 to 6 feet (1 to 2 m) deep.

Although small ponds cost more to construct, they have several advantages for the production of hybrid striped bass fingerlings. Small ponds give the farmer more control over the growth of small lots of fish because he can provide different amounts of fertilizer or, when the fish are large enough, different amounts of artificial food. Farmers also can manipulate growth by varying the stocking rates in ponds. Thus, a variety of fish sizes can be available at the same time to fill market demands. With smaller pond the farmer can more easily keep track of fish size and survival because it is easier to locate the fish in the pond. Also, having many smaller ponds rather than a few large ponds gives a farmer places to store fish of different sizes after they are harvested and graded (an important culture step that decreases cannibalism).

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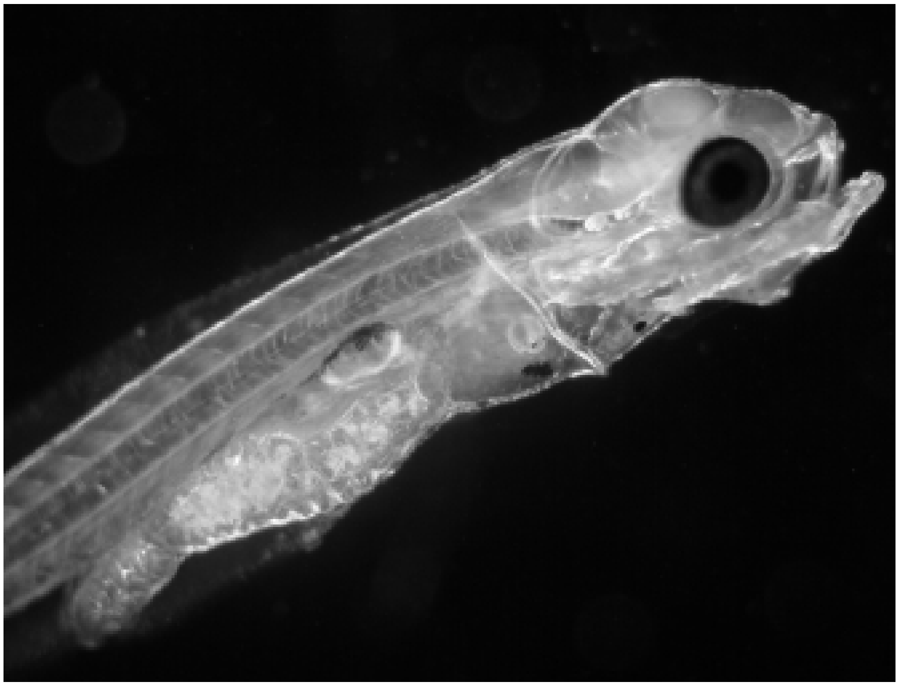

Figure 1. Eight-day-old sunshine bass fry with gut filled with rotifers.

There are many things that can go wrong in ponds during the culture of hybrid striped bass fingerlings, including sudden pH changes, excessive ammonia, rapid weather changes, and predation by large zooplankton or insects. Culturing fish in many small ponds rather than in a few large ponds helps ensure that a sufficient number of fingerlings get to market.

Natural food

Hybrid striped bass fry require live food, so fry ponds are managed to provide a maximum amount of zooplankton of the right size for the fry to consume. Previous recommendations for palmetto bass stated that fry should be stocked when large crustacean zooplankton such as copepods and cladocerans are numerous. It takes 2 or more weeks after ponds are filled and fertilized for that to happen during the striped bass and white bass spawning seasons. However, crustacean zooplankton are too large for the smaller sunshine bass to consume and may even prey on fry, so the ponds should be managed to contain large numbers of smaller rotifers when the fry are stocked. Masses of rotifers usually appear just before the larger zooplankton emerge. In recent research with striped bass fry (the same size as palmetto bass fry), the highest fingerling survival rates occurred when the fry were stocked before crustacean zooplankton became numerous. Because of that finding, the recommendations that follow apply to culture of both types of hybrids and striped bass.

Most of the hybrid striped bass now cultured are sunshine bass because female white bass produce viable eggs in captivity while female striped bass often do not, particularly when they are held in ponds and subjected to high water temperatures. Accordingly, when female striped bass are used they must be captured from public waters just before spawning every year. Male striped bass mature at the same age as female white bass and produce viable sperm when raised in captivity. Female white bass are smaller, easier to handle, and become mature at least a year earlier than female striped bass. This publication will focus on proven methods for culturing sunshine bass. These methods also produce higher survival rates of striped bass and palmetto bass than previously recommended methods.

Farmers who waited several weeks after filling their ponds to stock sunshine bass usually had little success. The average survival rate during the 1980s was about 10 percent. Farmers soon learned that they could get good survival when they stocked 4- to 5-day-old fry in ponds that had been filled and fertilized for about 5 days. The "Five Day Method" worked best during the peak of the white bass spawning season when water temperatures are 63 to 73 °F (17 to 23 °C). However, survival rates dropped off rapidly when fry were stocked earlier or later during the spring.

The reason the Five Day Method worked was that the farmers were stocking their fry at the proper stage of zooplankton succession in the ponds. Succession is the term describing the changes that occur in plant and animal communities over time. These changes are fairly predictable if conditions remain consistent. However, conditions such as temperature, rainfall and the amount of sunlight vary from year to year or during the spawning season and these changes affect the timing of events in the plankton community.

Pond succession most suitable for sunshine bass culture follows the sequence shown in Figure 2. In mid-spring in the southern U.S., when most sunshine bass fingerlings are produced, ponds that are filled with well water and fertilized soon develop a light green color. A phytoplankton bloom, the very rapid increase in concentration of microscopic algae, causes that color. Simultaneously, blooms of bacteria and protozoans usually occur. Within a few days, rotifer populations begin to increase rapidly. When that happens the green color fades as the rotifers consume the algae and the water often turns to tan or brown. As this occurs, copepod and cladoceran eggs are hatching. As these crustacean populations grow they out-compete the rotifers or prey upon them and

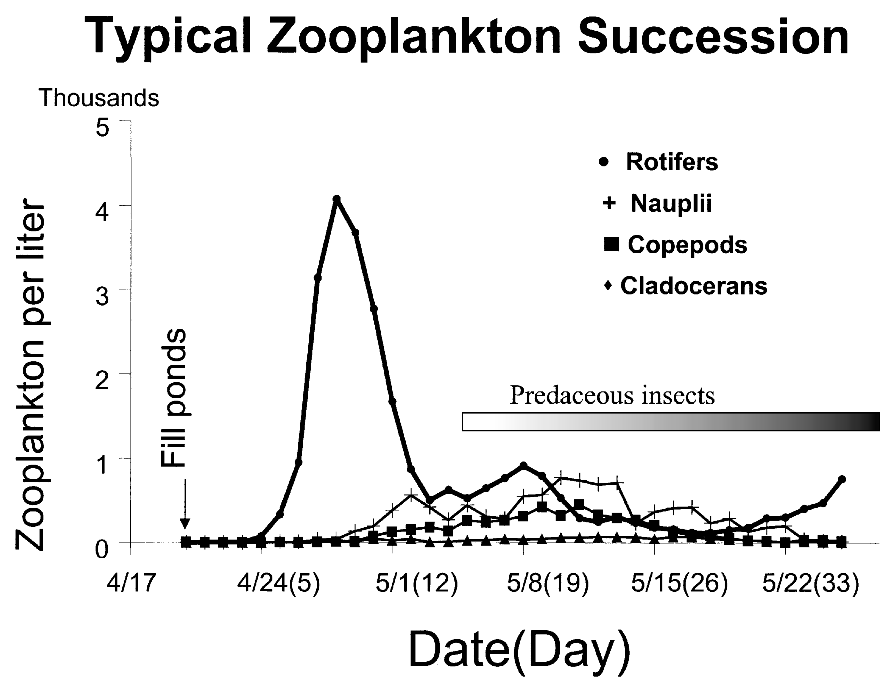

Figure 2. A typical sequence of events in the zooplankton community when ponds are filled and fertilized during spring. Soon after the ponds are filled rotifer populations rapidly increase, but then very rapidly decrease in abundance. The rotifers are replaced by smaller numbers of the larger copepod nauplii and then the even larger adult copepods. Along with the copepods, large cladocerans also make their appearance. Data for this graph was obtained from three ponds that contained sunshine bass fry that were preying on the zooplankton. Survival in the ponds averaged 59 percent.

rotifer numbers plummet. High concentrations of copepod nauplii, copepod adults and then cladocerans appear in succession and then decline as populations of larger rotifers and insects make their appearance. Sunlight and fertilizer fuel this whole sequence of events and the rate of succession is regulated by water temperature. One highly important key to successful fingerling culture is to stock the fry at the beginning of the rotifer population explosion. Hybrid bass thrive on these organisms and will grow large enough to consume the larger zooplankton when they appear. By that time the fry also should be able to escape predation by the cyclopoid copepods. The fry that are stocked should not be more than 5 days old if possible. Older fry may not have enough energy reserves in their yolk sacs to enable them to consume zooplankton. (See SRAC Publication No. 700)

It is important to be able to predict when the rotifer population is starting to rapidly increase. Water temperature is the main environmental variable that controls when this will happen. Day length and water fertility also influence the timing of peak populations. Fry should be stocked several days before the peak rotifer population is reached. During colder weather the time between stocking and the peak should be increased; the opposite is true during very warm weather. Table 1 shows the relationship between the mean morning water temperatures and the number of days it will take to reach the peak of the rotifer bloom. This information was determined by measuring water temperature and collecting zooplankton daily after ponds were filled and then relating the two values mathematically. This relationship is expressed by the equation:

$$D = 29.7 - 0.95\ (C)$$

or,

$$D = 46.6 - 0.53\ (F)$$

where D equals the number of days between when ponds are filled and the peak rotifer concentration occurs, and C or F equals the average of morning water temperatures in centigrade or Fahrenheit between the time ponds are filled and the rotifer peak occurs.

Farmers should keep records of water temperatures in order to predict when to stock their ponds during different times that fry are available. Although it is impossible to know what future water temperatures will be, the equations can be used to estimate the time it will take to reach a rotifer peak. For instance, if your records show that on April 15 the average water temperature is 65 °F, then it will take about 12 days to reach the rotifer peak. Assuming that

Table 1. The effect of the average water temperature on the time it takes to reach peak rotifer concentrations in ponds after being filled with well water and fertilized.

Average daily water temperature		
Degrees F	Degrees C	Days to peak rotifer population
45	7.2	23
50	10.0	20
55	12.8	18
60	15.6	15
65	18.3	12
70	21.1	10
75	23.9	7
80	26.7	4

65 °F occurs at the midpoint of the time before the peak, then ponds filled 6 days before the 15th should have a rotifer concentration peak 12 days later or on April 21. Fry that are stocked 7 to 9 days after the ponds are filled should have sufficient rotifers to ensure good survival. As the season progresses fry should be stocked closer to the time that ponds are filled. Since spring weather is highly variable, these equations are best used for general planning and, perhaps, to help understand why fingerling survival is high or low. For instance, using the Five Day Method in early spring places fry in the pond long before rotifers are present, while using it at the end of the season places fry into ponds were rotifers have been replaced with copepods that are too large to eat and that may even prey on the fry.

The relationship between air temperature and water temperature is another way to predict when the rotifer bloom will peak. Table 2 shows the relationship between the average daily air temperature in Stuttgart, Arkansas and the number of days before the peak in the rotifer population. That relationship follows the equation:

$$D = 27.3 - 0.88\ (C)$$

or,

$$D = 43.0 - 0.49\ (F)$$

where D equals the number of days between when ponds are filled and the peak rotifer concentration occurs, and C or F equals the average of morning air temperatures in centigrade or Fahrenheit between the time ponds are filled and the rotifer peak occurs.

There may be some minor variations in this relationship because of differences in pond depth, wind speeds, humidity and other factors, but the equation can be used to predict when rotifers will reach their population peak. The average daily air temperature can be obtained from local airports or from the U.S. Department of Commerce, National Climatic Data Center, Federal Building, Asheville, North Carolina 28801. Their publication, “Local Climatological Data—Unedited,” is also available from the National Climatological Data Center at *www.ncdc.noaa.gov.*

Pond preparation

Fingerlings survive best when well water is used to fill ponds. With well water, rotifer concentrations are easier to predict. Surface water should not be used because it usually contains zooplankton too large for sunshine bass to consume and that may prey on fry.

Pond alkalinity should be above 50 mg/L to help stabilize pH and facilitate the uptake of nutrients by phytoplankton. If the water has less than 20 mg/L total alkalinity, it should be limed. Waters with 20 to 50 mg/L alkalinity would benefit from the application of lime. Waters with more than 50 mg/L usually do not require lime applications (See SRAC Publication No. 469.) Although the exact relationship has not been determined, fingerling survival is generally better in ponds with alkalinities above 100 mg/L.

The greater the number of zooplankton of appropriate size, the greater the chances fry will survive and grow, as long as good water quality is maintained. Ponds must be fertilized to provide nutrients for the formation of plankton blooms. Applying both organic and inorganic fertilizers usually is best.

Organic fertilizers are the basis of a food pyramid that nourishes bacteria, protozoans, phytoplankton, zooplankton and eventually the fish fry. (Some organic fertilizers, such as rice bran, are ground fine enough that they are consumed by zooplankton.) Phytoplankton grow on the inorganic nutrients released when bacteria decompose the organic fertilizers. Protozoans and rotifers eat the bacteria and phytoplankton. Phytoplankton is also the main food source for many copepods and most cladocerans. It takes time for nutrients from organic fertilizers to be released, so drastic changes in zooplankton populations are less likely to occur than when only inorganic fertilizers are used.

Inorganic fertilizers make their nutrients available without bacteria. They release most of their nutrients to the water immediately, although some slow-release fertilizers are available. Phytoplankton blooms can be developed very rapidly when inorganics are used, but the bloom may “crash” quickly as the nutrients are depleted.

The diversity of plankton in a pond is probably greater and the total community more stable when both organic and inorganic fertilizers are used. The diverse community utilizes nutrients quickly. Nutrients may also be

Table 2. Normal average daily air temperatures at Stuttgart, AR and the number of days it takes to reach a peak in the rotifer population after sunshine bass culture ponds are filled with well water and fertilized.

Date	Normal average daily air temperature		Days to peak rotifer population
	Degrees F	Degrees C	
March 1	48	9	19
March 15	52	11	18
April 1	59	15	14
April 15	63	17	12
May 1	66	19	11
May 15	70	21	9
June 1	73	23	7

trapped in the pond bottom. As a result, ponds should be fertilized often in small doses rather than in a few larger doses. This procedure also helps prevent low dissolved oxygen, rapid pH changes and the increased chance of dangerously high un-ionized ammonia levels.

The following fertilization schedule has produced high survival and good growth in sunshine bass fingerlings. As ponds are being filled, add 125 pounds per acre (140 kg per ha) of rice bran or cottonseed meal and 2 gallons (7.5 L) of a 10-30-0 NPK liquid fertilizer. Add similar doses of organic and liquid fertilizer 3 days later. During each of the second and third weeks add two doses of 25 pounds per acre (28 kb per ha) of the organic fertilizer and two treatments of 1 gallon of liquid fertilizer. For the next 2 weeks reduce the application rate of organic fertilizer and liquid fertilizer by half. During subsequent weeks add fertilizer when vertical visibility, as measured by Secchi disc readings, is more than 18 inches (0.5 m). When using this schedule there is sometimes a spike in the pH that causes high un-ionized ammonia levels. If this happens, the inorganic fertilizer should be reduced or eliminated during the first week. This fertilization schedule is a recommended starting point that should be modified to suit the characteristics of each farm. Very good survival has been achieved with less fertilizer and when only inorganic or organic fertilizers were used.

Stocking fry

Several studies indicate that what happens to fry at the time of stocking probably has the greatest influence on survival of fingerlings at harvest. Only healthy fry of the proper age that have been cared for during and after shipment should be stocked. Ponds must be at the right stage of zooplankton development; farmers must estimate the time required for rotifers to reach their peak concentrations and then coordinate the filling and fertilizing of ponds with the shipment of fry from the dealer. Pond water chemistry must also be close to that of the water in which the fry are shipped. Great care must be taken to acclimate the fish to the pond conditions and it must be done at the right speed to avoid problems with metabolic wastes that accumulate in the shipping bags. Stocking rates vary from 100,000 to 200,000 fry per acre (247,100 to 494,200 per ha). Lower stocking rates may result in larger fingerlings at harvest but may also result in greater variation in sizes and, as a result, more cannibalism. Higher stocking rates produce smaller fingerlings and often cause zooplankton stocks to be depleted rapidly. The number of fry received is usually estimated by the fry dealer. Often he will make a volumetric estimate of the number of viable eggs he has placed in hatching jars. The culturist also can estimate the number of fry volumetrically. The volume of water the fry are shipped in is determined and then mixed to distribute the fry evenly. Then small samples of known volume are taken from the water and the number of fry they contain counted and a number per ounce (or other unit) determined. That number is multiplied by the total ounces of water the fry were shipped in. This must be done quickly once the bag is opened and oxygen levels decrease.

Hybrid striped bass fry have better survival rates when they are stocked under low light conditions, as in early evening. However, sometimes a rapidly developing phytoplankton bloom will use much of the dissolved carbon dioxide in a pond, and if the pond does not have adequate buffering capacity the pH may rise to an intolerable level (above 9 is usually harmful). If ammonia levels are also high, the elevated pH will increase the concentration of the toxic un-ionized fraction and that condition can rapidly become lethal to the fry, too. If pH is spiking during the late afternoon it is best to wait until early morning to stock the fry. Respiration and the absence of photosynthesis during the night usually causes pH to become more neutral by dawn.

When fry are brought to the farm in bags, the bags should be floated unopened in the ponds until the water temperature in the bags is the same as that of the ponds. If the bags, are opened for too long carbon dioxide that has accumulated will escape and pH will increase. When that happens ammonia that has accumulated may become un-ionized and harm the fry. When the water temperature is equalized, open the bag and roll the sides down to form a collar that allows the bag to float. A bucket without a bottom in it can be used to hold the bags. Pour a small amount of pond water (about a pint) into the open bag. About 5 minutes later, pour twice as much water into the bag. After each succeeding 5 minutes double the amount of water going into the bag. After 20 to 30 minutes pour the entire bag into the pond. This procedure allows the fish to gradually become adjusted to the temperature and water chemistry in the pond without being injured by rising un-ionized ammonia concentrations in the bag.

Fry survival in ponds is difficult to determine because they are small. About a week after being stocked, fry may be attracted to lights on dark nights and then caught with a zooplankton net. After 2 weeks in the ponds the number of fry captured with a constant number of net sweeps in similar ponds is often proportional to the survival rates in those ponds. Survival in ponds may be very roughly estimated at 3 to 4 weeks by standing still and closely observing the pond edges. Schools of small fingerlings may be seen streaming along.

Once the fish are in the pond they must have adequate amounts of zooplankton to eat until they can eat prepared feed. When survival is good the fish may consume zooplankton faster than it can be naturally produced. This can lead to cannibalism. To help prevent it, provide artificial feed to supplement the zooplankton. Supplementation also helps to wean the fingerlings so that they are ready for tank culture or culture in ponds with prepared feeds. Fry can survive on finely ground high-protein feeds after they are 26 days old or after about 3 weeks in the pond. Before they reach that stage, food such as a 45% or greater protein starter meal should be cast on the ponds one to three times a day at the rate of 2 to 10 pounds (0.9 to 4.5 kg) per acre per day. Mashes are fine enough that they may also be consumed by some zooplankton species. Fingerlings eating this zooplankton may become accustomed to prepared feeds more rapidly than when larger food is offered first. The size of the feed should be increased to a number one crumble when the fry are about 4 weeks old. At 4 to 5 weeks of age the fish should start feeding at the surface. After a few days of surface feeding the fingerlings' feeding behavior makes it possible to adjust the feeding rate. Feed should be applied to the pond until obvious feeding stops. A few minutes later check for uneaten feed and adjust the amount given accordingly.

Harvesting fingerlings

Harvesting is another critical time in the culture of sunshine and palmetto bass. These fish, particularly the palmetto bass, are highly susceptible to shock brought on by physical or chemical stress. Highly stressed fingerlings often have tetanized muscles that cause the fish to curl. Stress during harvesting may kill fingerlings or make them highly susceptible to future disease. Prevent stress by handling fish carefully, maintaining high levels of dissolved oxygen, preventing chemical or temperature shocks, and using salt.

After 30 to 45 days the fingerlings should be harvested and graded. If this is not done cannibalism may cause significant losses. Harvesting is done with a 1/4-inch mesh seine or by draining ponds that have catch basins. When seines are pulled to the bank it is important to cast salt on the area where fish are concentrated and to ensure that high levels of dissolved oxygen are maintained. A water pump or compressed air aeration can provide dissolved oxygen and keep the water clean. Do not let fish become crowded in the seine.

Survival can be estimated during harvesting. One method is to add fingerlings to buckets that are one-third to one-half full of water and have been weighed on a scale. Weigh the buckets again with the fish and add up the total weight of fish harvested. Then count out a small number of fish and weigh them to get the average weight per fish. Divide that weight into the total weight harvested to get the total number of fish harvested. That number divided by the number of fry stocked gives the survival rate. Experienced sunshine bass farmers average 25 to 40 percent survival.

Fingerlings should be removed from the seine without delay, using 1/4-inch, uncoated nets, then placed in buckets of water and loaded into a hauling truck that contains salted water (up to 10 grams per liter). Use salt that does not contain anti-caking compounds that may be toxic to the fish. Dissolved oxygen levels should be maintained at 5 mg/L or higher. If possible, use water from the pond being harvested. Upon reaching the holding shed, make sure the fish are not shocked by rapid changes in water temperature. Temper the fish by having water similar to that in the holding vats pass into the tanks on the hauling truck. Allow about a half hour for each 4 °F (2 °C) difference in water temperature.

Transfer the fingerlings to a tank where they can be graded the next day. The largest and the smallest fish should be separated from the rest. The largest fish are probably cannibalizing smaller fish, and the smallest fish are probably not acclimating well to prepared feed. The middle-sized group may be further divided into groups for shipment to customers, placement in grow-out ponds or tanks, or later shipment to grow-out facilities. More than one grading, particularly for fish held in tanks, is often necessary.

Before being restocked the fingerlings should be further trained to eat a prepared diet of at least 45 to 50 percent protein. Determine the proper size to feed by experimentation, starting with striped bass feed or salmon starter in number 1, 2, 3 or 4 crumble.

Fingerlings that are sold should be acclimated to cool water and allowed to purge for at least a day before being shipped. The shipping water should be salted (0.5 to 1% or 5 to 10 g/L $NaCl_2$, $CaCl_2$, or sea salt) to reduce the effects of stress. A commercial anti-ammonia compound is also added to the water. If the fish are going to be shipped by air (and sometimes by ground) they are placed in a few gallons of salted water and into doubled plastic bags that are inflated with oxygen and then placed into an insulated shipping box and sealed. Large shipments by ground transportation are loaded into insulated compartments on a hauling truck that has a supply of liquid oxygen and an aeration system. Dissolved oxygen should be kept above 5 mg/L. The water should be agitated to prevent buildup of carbon dioxide. Temperatures should be kept below 70 °F (21 °C).

It is important to fully coordinate the timing of harvesting and hauling operations with customers.

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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.

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