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Red Drum: Production of Fingerlings and Stockers

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Red drum production has become highly vertically integrated, with more than half of producers operating a hatchery, producing fingerlings, and growing out fish to market size, and some producers also adding processing or direct marketing to retailers. Historically, 1- to 4-inch (2.5 to 10 cm) fingerlings and 8- to 12-inch (20 to 30 cm) stocker red drum were produced primarily by specialty hatchery producers. Currently, the very few hatchery-only operations remaining rarely produce stocker red drum; instead, they focus on producing fingerling red drum to supply growout producers. Growout producers who do not operate hatcheries now typically buy fingerling red drum from hatchery operations and produce them in two phases: 1) production of stockers from larvae and fingerlings in Year 1, and 2) production of market fish (2.5 to 4 pounds) from stockers in Year 2. Fingerling and stocker production are vastly different undertakings, requiring different practices and expertise.

Indoor, intensive fingerling production

Several variations of indoor production methods for red drum fingerlings produce live foods, including marine rotifers, copepods, and *Artemia.* Although state and federally funded hatcheries and university researchers sometimes use these production methods, they have not yet become economically viable for the typical commercial operation in the Southern Region. As such, the information below includes only a synopsis providing the ranges of larvae-stocking densities and feeding rates for indoor production.

Red drum larvae are stocked into fiberglass rearing tanks at 38 to 152 larvae per gallon (10 to 40 larvae/L) and initially offered live feed in nursery tanks starting at 3 days post-hatch. Rotifers, typically *Brachionus plicatilis,* are fed to the larvae twice daily at concentrations of 5 to 15 rotifers per milliliter of water, increasing incrementally to between 15 and 25 rotifers per milliliter of water by 10 days post-hatch. Between 5 and 10 days post-hatch, an increasing portion of newly hatched *Artemia* nauplii are supplemented at densities of 5 to 35 nauplii per milliliter along with the rotifers at feedings. Later, the larvae are weaned from rotifers to only *Artemia* nauplii between 11 and 15 days post-hatch. Rotifers and *Artemia* nauplii must typically be enriched with commercially available enrichments containing highly unsaturated fatty acids such as arachidonic acid (ARA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) to provide suitable larval nutrition. For more information on live food production and enrichments, see Southern Region Aquaculture Center (SRAC) Publication No. 0701, *Culture of Small Zooplankton for the Feeding of Larval Fish,* SRAC Publication No. 702, *Artemia Production for Marine Larval Fish Culture,* and SRAC Publication No. 0703, *Introduction to Marine Copepod Culture for Live Feeds Production*.

Starting about 10 days post-hatch, a small portion of microparticulate diet is introduced at intervals between rotifer and *Artemia* feedings. The microparticulate diet contains at least 50 percent protein and 10 percent lipid. Use a high-quality microparticulate diet containing high percentages of krill and fish meal as well as fish oil. Between 12 and 15 days post-hatch, gradually wean the larvae off *Artemia* by slowly decreasing the number of *Artemia* offered at each feeding and increasing the amount of microparticulate diet. Offer the larvae only microparticulate diet starting about Day 16 post-hatch. Fingerling red drum may be moved to stocker production ponds once

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the larvae undergo metamorphosis to become fingerlings at about 21 to 30 days post-hatch and 1 inch (2.5 cm) long.

An alternative method involves skipping the feeding of *Artemia* nauplii in favor of adding a microparticulate diet earlier. Rotifers are typically fed from 3 to 12 days post-hatch, with introduction of the microparticulate diet starting between 5 to 7 days post-hatch and gradually increasing until the larvae are completely weaned off rotifers at Day 13 post-hatch. However, this method has demonstrated highly variable results with typically lower survival rates than feeding *Artemia*.

Pond fingerling production

Almost all commercial production in the Southern Region relies on outdoor pond methods of fingerling production. For pond production, larvae are obtained from the hatchery at 2 to 3 days post-hatch, depending on incubation temperature. For information on red drum broodfish management and egg and larvae production, see SRAC Publication No. 0320, *Red Drum: Reproductive Biology, Broodstock Management, and Spawning.*

Red drum larval development is temperature dependent. At 70°F (21°C), larvae mouths are developed and ready for first feeding at 30 to 36 hours post-hatch, but at 84°F (29°C) they are ready at 24 to 28 hours post-hatch. Timing the transfer of larvae to the ponds is critical, as the larvae must remain in the hatchery until they are developed enough to become mobile within the water column, but they must be stocked into ponds before they are ready for first feeding and the yolk-sac (oil-globule) is depleted.

Larvae obtained from hatcheries for fingerling production at other locations are normally shipped in standard, 5- to 7-gallon (19 to 27 L) plastic fish shipping bags with Styrofoam-insulated cardboard boxes. However, shipping in standard fish-hauling tanks is highly discouraged, as the larvae are very fragile, and sloshing within the tanks can result in high mortality rates. For short trips, typically less than 6 hours, up to 30,000 larvae per gallon (7,900 larvae/L) of water may be in bags containing about 50 percent water and 50 percent pure oxygen. For example, when using a 7-gallon (27 L) shipping bag, the bag should be filled with 3.5 gallons (13 L) of water; up to 105,000 larvae may be added, with the remainder of the bag filled with oxygen and sealed. An ammonia binder such as Cloram-X™ is typically added to the bag. Air shipments are limited in favor of overland transport because red drum larvae are very sensitive to gas supersaturation of water and overpressures caused by high-altitude flights.

Standard practices including floating the bags and partial water exchanges are used to acclimate the larvae to the fingerling production pondwater. The shipper needs to know the salinity and temperature of the receiving water so that arrangements can be made to begin the acclimation process before shipment. Red drum eggs hatch over a broad range of salinities [5 to 50 g/L (ppt)], but larvae develop successfully to first feeding at only 10 to 40 g/L salinity, with optimal development occurring at 25 to 35 g/L salinity. Although producers with access only to low-salinity water can easily grow out fingerlings through market size, it is difficult to successfully temper larvae to low-salinity ponds and produce fingerlings because most hatcheries operate and maintain larvae at 25 to 35 g/L salinity.

When the bags arrive at the receiving site, remove them from the shipping containers without opening the plastic bags. At this time, examine the larvae and estimate the percentage of larvae that are alive. This check will help preclude arguments with the shipper on "live delivery." When the larvae are loaded at the hatchery and again when they are stocked into the pond, they are "counted" by taking two or three samples of known water volumes from the hatching containers or shipping bag, counting the larvae in each sample, and dividing the total number of larvae in the sample by the smallest unit of water. This count is typically stated as the number of larvae per milliliter of water. However, large shipments may be counted as number of larvae per 100 milliliters or number of larvae per liter. The average number of larvae per unit of water is then multiplied by the total volume of shipment water to determine the total number of larvae being shipped or stocked into a pond.

Preparation of ponds to stock larvae

Ponds used for producing fingerlings from larval red drum are usually between ½ to 2 acres (0.2 to 0.8 ha), with 1 acre (0.4 ha) being fairly standard. The ponds are typically 3 to 4 feet (0.9 to 1.2 m) deep with a plastic-lined or concrete catch basin to make harvesting fingerlings easier. Adjust and maintain fingerling ponds as close as possible to the salinity of the larval rearing water from the hatchery of origin. Although the optimum salinity for fingerling ponds is 25 to 35 g/L, fingerlings can be produced in ponds with salinity as low as 10 g/L, depending on the salinity of the original hatchery water and slow, careful tempering of larvae by the producer.

Optimal fingerling temperatures are 75 to 81°F (24 to 27°C). However, fingerlings have been successfully cultured from larvae between 65 and 88°F (18 and 31°C). Below 68°F (20°C), larval development and subsequent growth slows dramatically, and survival is often reduced at above 85°F (29°C). Successful pond production of fingerlings depends primarily on the availability of suitable densities of live food of the proper size at all times. Most producers believe that the denser the food supply, the more larvae that will survive to harvest.

In ponds, red drum larvae feed primarily on zooplankton. Because of their small mouths, limited mobility, and restricted eyesight, they will feed only on select zooplankton of optimum size. Larvae may key on only one to a few species of preferred zooplankton in a pond at specific times during development. This preference means that for the average producer, pond fertilization regimes are vital, and a microscope and basic level of zooplankton identification and enumeration are required. Producers should be able to distinguish rotifers and copepods (Fig. 1) from other species of zooplankton in the pond as well as determine the average size of rotifers and copepods there.

The fingerling production ponds are drained before stocking to set back succession of the phytoplankton and zooplankton communities as well as to remove unwanted insects and fish that prey on newly stocked larvae. The ponds are then refilled and fertilized to stimulate primary productivity before stocking larvae. The timing of filling and fertilization is critical and should be set after consultation with the hatchery to determine exactly when the eggs will be produced and the larvae will be ready for stocking. If the pond is filled and fertilized too early, zooplankton will grow too large for the larvae to eat, and many predacious insects can develop in the pond. Filling or fertilizing the pond too late may result in too little zooplankton to support the larvae after stocking.

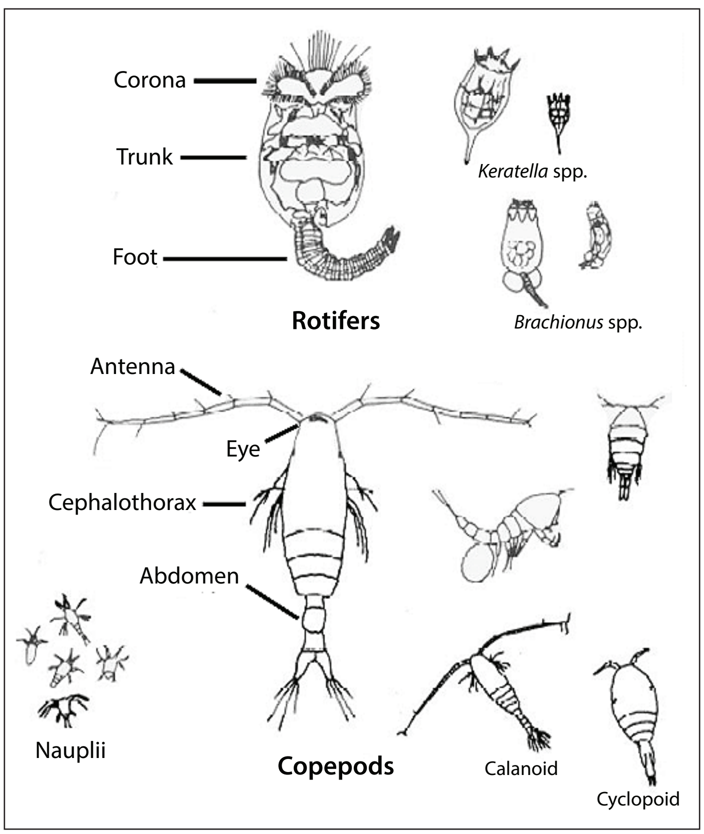

Figure 1. Distinguishing characteristics of rotifers and copepods, the two primary zooplankton groups consumed by larval marine fish in saltwater rearing ponds (not to scale).

Ponds are often treated with both inorganic and organic fertilizers. Fertilizer type and quantity vary with location, salinity, temperature, time of year, previous fertilizer treatments, and the nutrient content of the water source. Many farm managers spend years experimenting to perfect the fertilization rates for their fingerling ponds. For information on pond fertilization, see SRAC Publication No. 0469, *Fertilizing Fish Ponds*. For information on establishing phytoplankton and zooplankton blooms, see SRAC Publications No. 5004, *Phytoplankton Culture for Aquaculture Feed* and No. 700, *Zooplankton Succession and Larval Fish Culture in Freshwater Ponds*.

Fingerling production procedures

The rates below are only guidelines and should be modified based on the experience of the farm manager at a specific location to obtain optimum plankton populations. The following procedures are recommended for preparing ponds for larval red drum:

1. Begin filling the pond no more than 14 days before expected delivery date of the larvae. If more than 20 days elapse between commencement of filling and stocking of larvae, drain and refill the pond.
2. Ten days before stocking, add 1.4 to 1.6 pounds (635 to 726 g) of total nitrogen and 0.35 to 0.4 pounds (159 to 181 g) of total phosphorus per acre-foot of water. This can be accomplished using several types of widely available agricultural fertilizers such as urea, ammonium nitrate, phosphoric acid, and triple superphosphate. For example, 10 quarts (9.5 L) of liquid ammonium nitrate (33 percent N) or 3 pounds (1.4 kg) of urea can be used in combination with 4 quarts (3.8 L) of phosphoric acid (52 percent available P_2O_5) or 0.78 pounds (354 g) of triple superphosphate per acre-foot of water. Then add organic fertilizer such as cottonseed meal (6 to 7 percent nitrogen, 1 to 2 percent phosphorus, 1 percent potassium) at about 65 pounds (29.5 kg) per acre-foot of water. Inorganic fertilizers that are liquid or powdered should be first diluted 1:10 with water and distributed at several locations around the pond. Avoid using

granular fertilizers, as they may become trapped in the pond sediment before they can release the nutrients within the granules to the water column.

3. Ensure that the pond is finished filling by 7 days before stocking. Add the same amount or organic and inorganic fertilizers per acre-foot as above. Zooplankton of the appropriate size for feeding (100 to 340 µm) should reach at least 7.5 organisms per ounce of water (250 organisms/L) before the larvae are stocked.
4. Larval stocking rates vary among operations, and many producers practice density-dependent growth strategies, depending on the need for fish and the availability of stocker and growout ponds. When space is limited, producers stock at higher rates to slow growth. However, this strategy requires frequent grading in fingerling production ponds to prevent larger fish from becoming cannibalistic or simply dominating the feeding activities. If water is plentiful or fingerlings are needed immediately, producers stock lower densities of larvae to encourage rapid growth. Stocking rates vary from as few as 225,000 per acre (555,000 larvae/ha) to 375,000 per acre (925,000 larvae/ha). On average, 300,000 to 325,000 larvae are stocked per acre (740,000 to 802,000 larvae/ha). Return yields can vary greatly, depending on salinity, temperature, food availability, and bird predation, which can be a major source of loss in fingerling production ponds. In well-managed ponds, producers can expect to harvest 60 to 65 percent, although some producers claim occasional returns as high as 80 percent and as low as 20 percent.
5. After stocking, add more fertilizer as recommended above at 5-day intervals until the 20th day.
6. Traditionally on Day 20 after stocking, producers began feeding a high-quality fish feed in the form of a ground meal containing 44 to 50 percent protein. However, they are increasingly feeding a 50 to 55 percent protein fish feed in meal form as early as Day 13 after stocking to transition the larvae to commercial feeds more quickly. An argument has been made that even if the larvae do not eat much of the feed initially, the excess feed acts as a fertilizer to stimulate natural foods within the pond, and any high-protein feed they do consume improves growth and survival. Feed the fish feed meal at a rate of 5 to 6 pounds per acre (5.6 to 6.7 kg/ha) twice daily [10 to 12 pounds per acre per day total (11.2 to 13.4 kg/ha/day)].
7. Gradually switch the larvae to a 50 to 55 percent protein number 0 or 1 crumble starting at Day 25 by substituting 10 percent crumbles for 10 percent of the meal. On succeeding days, substitute an additional 10 percent until 100 percent crumbles are being fed by Day 35. Gradually increase feeding rates to 7.5 pounds per acre (8.4 kg/ha) twice daily [15 pounds per acre per day total (16.8 kg/ha/day)]. If the larvae are moved for any reason during the 10-day transitional feed period, do not change the ratio of meal to crumbles for at least 7 days after the move.
8. Plan to drain the pond, enumerate or estimate fingerling quantities, and thin out or move the fingerlings from the pond by the 35th day after stocking. The metamorphosed fingerlings should be about 1 to 1.25 inches (2.5 to 3.2 cm) long.

Feeds and feeding

Specialized red drum diets are available commercially from several domestic feed manufacturers. Feeding suggestions are shown in Table 1. Although the larvae must be fed during daylight because of their highly visual feeding habits, night feeding of larger fingerlings [> 3 inches (> 7.6 cm)] through growout to harvest has become commonplace in the industry to minimize predation and feed losses due to birds.

Harvesting and hauling

Before handling or moving the fingerlings, take them off feed for at least 1 day, and 2 days are recommended. Most fingerlings are moved by draining the pond into the holding basins discussed in SRAC Publication No. 321, *Red Drum: Site Selection and Pond Construction*. Seining the fingerlings is possible if less than a total harvest is desirable. Seines and nets should be knotless and treated with a recommended net preservative to reduce the physical damage to the fingerlings, but take care that the preservative does not make the nets overly stiff.

To provide well-oxygenated water, do not overcrowd fingerlings in the catch basin or seine, and seine and move the fingerlings early in the day. Fingerlings are normally moved in standard fish hauling tanks with oxygen supplied to each compartment. Because of the potential for injury, agitators and/or aerators are usually not used to move fish that are less than 3 inches (7.6 cm) long. Smaller fish tend to be drawn against the sides of such equipment and subsequently die. Also, salt water tends to corrode or short out electrical equipment such as agitators rapidly.

Table 1. Suggestions for feeding red drum.

Fish size	Feed form	Protein (%)	Lipid (%)	Feed rate
Larvae, 13–25 days post stocking	Meal (< 0.015 inch; < 0.38 mm)	50–55	16–18	10–12 pounds/acre/day (11–13.5 kg/ha/day)
Larvae, 25–35 days post stocking	#0 (< 0.025 inch; < 0.64 mm) or #1 (0.025–0.04 inch; 0.64–1.0 mm) crumble	50–55	16–18	15 pounds/acre/day (16.8 kg/ha/day)
1–3 inch (2.5–7.6 cm)	#2 crumble (0.04–0.05 inch; 1.0–1.3)	45–50	15–17	5% body weight/day
3–6 inch (7.6–15 cm)	#3 crumble or 3/32–1/8 inch (2.3–3.2 mm) slow-sinking or floating pellet	45–50	15–17	5% body weight/day
6–8 inch (15–20 cm)	3/32–1/4 inch (2.3–6.4 mm) slow-sinking or floating pellet	40–45	13–16	4% body weight/day
8 inch (20 cm)–harvest	3/32–1/4 inch (2.3–6.4 mm) slow-sinking or floating pellet	38–44	12–14	3% body weight/day

A major concern when hauling fingerlings and stockers is water quality. The water in hauling tanks should be clean and free from organic debris. The water temperature and salinity in hauling tanks should be as close as possible to those of the fingerling production ponds, but fingerlings tolerate small decreases in water temperature or salinity better than increases. About 10 g/L salinity is preferred for hauling, but salinities ranging from 5 to 25 g/L are used successfully. The water should be hard, preferably greater than 300 mg/L (ppm) hardness as $CaCO_3$, and slightly alkaline (pH 7.5 to 8.5). Water temperature while hauling is critical. Normally, fish are hauled at 68 to 75°F (20 to 24°C). To prevent excessive stress to the fingerlings, avoid water temperatures below 60°F (15°C) and above 80°F (27°C).

Normally while the fish are being loaded, dissolved oxygen concentrations in hauling tanks are held above saturation levels. Because of the high level of stress involved in harvest and transport, fish use oxygen at greatly increased rates. As soon as the fish become acclimated to their new surroundings, allow the dissolved oxygen levels to return to near-saturation levels. When red drum fingerlings are harvested from a pond during the warmer months and loaded directly onto a truck, the water temperature in the hauling tank should approximate pond water temperature.

Immediately after loading, use ice made from chlorine-free water to reduce the water temperature in the hauling tank to between 70 and 75°F (21 to 24°C). One-half pound of ice per gallon (60 g/L) of water reduces the water temperature about 10°F (5.6°C). If more than a 10°F (5.6°C) change is required, allow at least 30 minutes for each 10°F (5.6°C) change. Upon arrival at the stocking site, acclimate the fingerlings to the water slowly, allowing at least 1 hour per 10°F (5.6°C) change in water temperature, 1 hour per one unit change in pH, or 1 hour per 10 g/L change in salinity.

For local or on-farm hauls (less than 2 hours) with supplemental oxygen, l-inch (2.5 cm) fish can be loaded up to 0.5 pounds per gallon (60 g/L) of water and at 0.2 pounds per gallon (72 g/L) of water for up to an 8-hour haul. Stocker fish of 6 inches (15 cm) long or more can be loaded at up to 0.4 pounds per gallon (48 g/L) of water with supplemental oxygen for transport for up to 8 hours. Loading rates of stocker fish can be increased slightly for shorter haul durations. The use of an anti-foaming agents containing up to 10 percent food-grade silicon is recommended for all hauling of red drum.

Growout of fingerlings to stockers

Red drum do not survive sudden temperature drops well and can die during prolonged exposure to temperatures of 39°F (4°C) or less. These temperature requirements mean that producing stocker fish is impossible outside the far southern regions of the United States. In these far southern areas, it is critical to produce stocker fish of at least 8 to 10 inches (20 to 25 cm) long from fingerlings during the first year. Producing fish of this size allows them to achieve marketable size from stockers in one growing season (Year 2) before winter temperatures drop too low for survival, even when produced farther north in the Southern Region.

Stocker production involves overwintering the fish indoors, which is rarely done, or most commonly by using some type of thermal refuge. Procedures for indoor culture are expensive but possible. For more information on indoor closed system culture, growers should consult SRAC Publication Nos. 451 through 456 on recirculation aquaculture systems.

Red drum stocker production ponds typically average 4 to 6 feet (1.2 to 1.8 m) deep but are often built with a deeper basin of 6 to 8 feet (1.8 to 2.4 m) deep near an incoming well or deep bay water supply. When water temperatures are low, these deeper basins serve as thermal refuges, as the deeper water is more insulated from low atmospheric temperatures. Warmer groundwater from a well or deep bay water is slowly pumped into the pond as well to maintain temperatures above 39°F (4°C) and to even out rapid temperature fluctuations. Heated water effluents from power plants and other industrial discharges have been used successfully to produce stockers as well, although this practice is not widely used in the industry currently.

Because the number of red drum fingerling and stocker production facilities is limited, producers guard economic data closely, and detailed data is largely unavailable. The price of fingerlings depends on the supply available (due in part to season), hatchery production costs, and the perception of food fish producers on the market for red drum. Newly hatched drum larvae can be obtained relatively inexpensively. Depending on supply and time of year, larvae costs can range from $1,000 to $6,000 per 100,000 larvae (1 to 6 cents per larva). Larger orders can be contracted before spawning at even lower costs. The price for l-inch (2.5 cm) fingerlings can vary from as little as $0.08 to as much as $0.30 each. Eight- to 12-inch (20 to 30 cm) stockers typically vary from $0.65 to $1.10 each. Larger orders of fingerlings normally command a more favorable price, particularly if the orders are placed well in advance.

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