# Farming A New Fish:



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# Hybrid Striped Bass

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A new fish, fresh from the farm pond, is gaining favor in gourmet restaurants and seafood markets. The fish, called a hybrid striped bass, is also earning substantial profits for farmers willing to invest in pond production of this new species.

The hybrid striped bass is a cross between the white bass and striped bass. Scientists developed pond production technology for the hybrid because populations of the popular striped bass had dwindled significantly. A substitute was needed to fill dinner plates and seafood counters. The resulting hybrid grows faster and is more disease-resistant and hardier than its parents.

Scientists discovered that striped bass, an anadromous fish, could complete its life cycle in fresh water when Santee Cooper reservoir was closed in the 1950s. Consequently, fishery biologists became interested in stocking stripers in the numerous reservoirs being built in the Southeast. Striped bass was a favorite of recreational anglers and a predator for the gizzard and threadfin shad that abounded in the reservoirs.

Researchers developed hybrid striped bass in the mid-1960s. Scientists chanced upon the cross while spawning striped bass to stock in inland reservoirs for recreational fishing.

The "original" hybrid was created in South Carolina. Biologists stripped eggs from a female striped bass and fertilized them with sperm from a white bass. This cross proved to be easier to raise than striped bass. It grew faster, survived better, and was hardier than striped bass.

The value of hybrid striped bass was soon recognized. Many state fish-and-game agencies, especially in the Southeast, began producing hybrid striped bass to stock in reservoirs. The hatchery technology to spawn female striped bass and to produce fingerling hybrids and striped bass spread. Florida biologists subsequently developed "reciprocal" cross hybrids from white bass females and striped bass males. They exhibited the same culture characteristics as the original cross.

Interest in the culture of hybrid striped bass for food began in the late 1970s. Sea Grant programs in North Carolina and South Carolina began sponsoring research into the pond production of hybrid striped bass in 1979 and 1981, respectively.

Hybrids adapted to ponds, and by the mid 1980s, information about pond culture was available to the public.

But no commercial pond production of the hybrids was occurring. The industry was hesitant because of the expense involved and the uncertainty of transferring research production figures to commercial harvests. A commercial-scale demonstration project was needed.

The National Coastal Resources Research and Development Institute (NCRI) funded a project in 1987 in North Carolina to demonstrate that commercial production of hybrid striped bass in ponds was viable and profitable. The project was successful. The first hybrid harvest of 70,000 pounds was sold during the winter of 1988-89. Since that time, the commercial culture has grown rapidly. A survey conducted by the Striped Bass Growers Association showed that total production of hybrid striped bass in the United States in 1993 was approximately 6 million pounds. Pond production accounted for nearly 2 million pounds of the total. North Carolina growers produced 600,000 pounds of the 2 million. Pond production predominates in the Southeast from North Carolina to Texas.

Because of this success, interest in culturing hybrid striped bass remains strong. The industry continues to grow throughout the country with pond production sites now located in Maryland, Virginia, North Carolina, South Carolina, Georgia, Alabama, Florida, Mississippi, Louisiana and Texas.

The intent of this manual is to describe the pond production technology that has been developed and demonstrated through funding from Sea Grant and NCRI. This manual should help people interested in producing hybrid striped bass understand how hybrids are cultured in ponds.

The techniques used by culturists to produce hybrid striped bass include broodstock collection, hormone injection, spawning and incubation of eggs and larvae.

## Broodstock Collection

Because the parental stocks, striped bass and white bass, have not been totally domesticated, broodstock is still collected from the wild during spring spawning runs. Methods of collection vary according to species, type of habitat and regulations. The most commonly used methods are hook-and-line fishing, gill nets, pound nets and electrofishing.

Hook-and-line collection works well for white bass because they can be caught readily and without undue stress. Also, creel limits in most states allow significant numbers of white bass broodstock to be legally retained by a few fishermen. They are caught in the spring as the schools of fish migrate toward the spawning grounds. This method is also effective for collecting striped bass males because only a few fish are needed and the stress of capture is less likely to affect their ability to produce viable gametes than in the case of females.

Hook-and-line capture does not work well for collecting striped bass females because of the high mortality associated with the stress of capture. These large fish are played to near exhaustion, and females that do survive are often difficult to ovulate, probably because the blood supply to the ovaries is reduced during capture. Unfortunately, hook-and-line collection is frequently the only way private culturists can collect striped bass broodstock. Other methods may be restricted by state law.

Gill nets offer an alternative for collecting striped bass in some areas. The nets must be checked frequently to reduce stress and prevent mortality, especially in the case of female striped bass. Gill nets with 7.6-centimeter to 10.2.-centimeter (3-inch to 4-inch) bar-mesh webbing can net striped bass. But 3.2-centimeter to 4.5-centimeter (1.25-inch to 1.75-inch) bar-mesh webbing would be needed for white bass.

In large, open areas, hybrid producers can use pound nets to collect striped bass in some states. Using pound nets causes less stress on broodstock than most other collection methods. A long lead on the net guides the fish into a heart, or pound, where they are collected. However, sites suitable for setting the nets are often located in estuaries far from spawning areas. If caught in these areas, female broodstock may not be mature enough to respond correctly to hormone injection.

Electrofishing is the most efficient and least stressful method for collecting white bass and striped bass. But this method requires a permit that usually is not issued to private culturists.

Broodstock, especially females, should be handled carefully. Keep stress to an absolute minimum. Frequent handling or unnecessary roughness inhibits ovulation and increases mortality due to stress.

Transport fish in saline water (0.5 to 1.0 percent NaCl or reconstituted seawater). Do not use salt that contains the anticaking agent, yellow prussiate of soda (sodium ferrocyanide), because it can kill fish. If you handle the fish properly, mortality should be negligible. Sometimes culturists use an anaesthetic (MS-222, 3 to 5 mg/1) to sedate the fish. Ice may be added to reduce the water temperature to a range of 18 C to 20 C (64 F to 68 F) or lower depending on the length of the trip.

Agitators will aerate the water, but pure oxygen supplied through a diffuser system is a better way to keep dissolved oxygen levels above 6 mg/1. For long trips, you can use agitators along with oxygen to prevent supersaturation of oxygen and buildup of other dissolved gases. However, this is usually not necessary.

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*female str*
*brooc*
*egg deve*

## Hormone Injection

Human chorionic gonadotropin (HCG) hormone is injected intramuscularly below the dorsal fin to induce final maturation and ovulation of eggs in females and to enhance sperm production in males of both species. The synthetic analogue of mammalian gonadotropin-releasing hormone (GnRHa) also induces female ovulation and enhances male sperm production in striped bass.

HCG is injected intramuscularly below the spinous dorsal fin with a 22-gauge, one-inch needle. Inject striped bass females as soon after capture as possible, either before they are transported or immediately after they arrive at the hatchery. Water temperature in the hatchery should be 18 C to 20 C (64 F to 68 F) for female striped bass.

Eligible (oil droplets in the eggs are starting to coalesce) female striped bass are given a single injection of 330 International Units (IU) of HCG per kilogram of body weight (150 IU/lb) to induce ovulation. Males are usually given an HCG injection of 165 IU per kilogram (75 IU/lb) of body weight at least 24 hours before females are expected to ovulate.

Take an egg sample 20 to 28 hours after a striped bass female is injected with HCG. At 18 C to 20 C, it requires 15 to 16 hours before the hormone begins to work. At colder temperatures, it may take slightly longer for HCG to affect the female. To sample eggs, insert a glass or plastic catheter (3-mm outside diameter) through the urogenital opening and into the ovary. The ends of the catheter should be fire-polished for glass or ground smooth for plastic. Insert the catheter carefully through the vent about 50 to 75 millimeters (2 to 3 inches) into the ovary. Before removing the catheter, place a finger over the end of the tube to create a vacuum to hold the eggs in the tube. Some culturists prefer to slip a short piece (18 inches) of surgical tubing on one end of the catheter. The other end of the tubing can be held in the mouth so that suction can be applied to pull eggs into the catheter. If you use this method, be sure to release the suction pressure prior to removing the catheter from the ovary. If the fish begins struggling, remove the tube quickly to avoid damage to the ovary and sphincter muscles. Damage to these muscles allows water to enter the ovary and causes eggs to water harden. Then the eggs can form a plug, preventing their flow and making detection of ovulation more difficult.

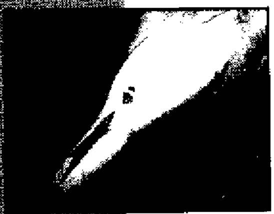
Examine the eggs under a 10-power to 30-power stereo microscope to determine when ovulation will occur. Ripeness is judged initially by coalescence of the oil globule and later by the clearing of the eggs. For photographs of maturing eggs, refer to "Culture and Propagation of Striped Bass and its Hybrids," which is edited by R.M. Harrell, J.H. Kerby and R.V. Minton and published by the American Fisheries Society, Bethesda, Md. Ovulation, the release of eggs from the ovarian tissues, usually occurs 28 to 50 hours after injection of the hormone. It depends on water temperature and the stage of gonadal maturation at injection. Female striped bass caught close to the spawning grounds may respond to the hormone faster than fish hooked or netted farther away. Also, a female about to spawn naturally when caught is more likely to ovulate successfully and produce viable eggs.

However, no reliable characteristics exist to determine whether a female is eligible for ovulation if her eggs have not begun to clear. Once eggs have begun to clear, striped bass females are less than 15 hours from spawning and are considered ineligible for injection with HCG. Some fish with mature (approximately 0.80 millimeters in diameter) but opaque eggs can be ovulated using a GnRHa pellet implanted into the dorsal sinus.

*Cholesterol/ cellulose pellet containing GnRHa to spawn striped bass.*

The pellet, developed by Craig V. Sullivan and R.G. Hodson at N.C. State University, is a matrix of cholesterol and cellulose containing 100 to 150 micrograms of GnRHa. The 2-by-8 millimeter pellets each weigh 32 milligrams and contain 80 or 95 percent cholesterol. The 80-percent cholesterol pellets release (fast release) their hormone over several days; the 95-percent cholesterol pellets release (slow release) hormone for weeks. Excellent results can be achieved by implanting two pellets, one of each type, at the same time. When the eggs clear enough to be considered eligible, an injection of HCG is given to make ovulation more predictable. The HCG is not necessary to induce ovulation. But without the HCG, it is very difficult to predict ovulation if you are strip spawning to make hybrid striped bass. With additional research, it may be possible to spawn fish with a single GnRHa pellet.

White bass females are injected with HCG at 330 IU/kg (150 IU/lbs) of body weight to induce ovulation. This quantity may exceed the threshold level for induction of ovulation. Recent studies have shown that the threshold level of HCG for white bass is 330 to 440 IU/kg (150-200 IU/lbs). Depending on water temperatures, female white bass usually ovulate 25 to 50 hours after injection. Eggs samples may be taken from white bass females using a 1.5-millimeter diameter catheter, but many culturists do not sample white bass eggs because the females are easier to handle if not stressed. Remember that white bass are partial spawners and not all eggs will be at the same stage of development.



Ovulated eggs flowing down side of striped bass [illegible]

To verify ovulation in female striped bass and white bass, apply slight pressure to the abdomen of the fish. If the eggs flow freely, at least partial ovulation has occurred. Experience is the key to determining complete ovulation. Culturists learn how to distinguish between partial and complete ovulation based on the amount of pressure required to extrude eggs. When eggs flow freely from the fish while pressing the anterior portion of the abdomen, full ovulation has usually occurred.

Accurate prediction of ovulation is critical to obtaining viable eggs. Eggs detach from the ovarian tissue (the source of oxygen) during ovulation. An hour after the detachment, anoxia occurs and the eggs become too ripe. Ideally, eggs should be stripped immediately after complete ovulation occurs. But in practice, it is difficult to determine whether the female is fully or partially ovulated. Check females one hour before the predicted time of ovulation. If the females have not ovulated, revise your prediction and check at that time. It is important to predict ovulation as accurately as possible because too much handling of the female is stressful, increasing the likelihood of problems. Experienced culturists seldom take more than one egg sample and handle the fish as little as possible. Optimally, you should strip the eggs about 30 minutes after the first indication of ovulation.

White bass are partial spawners, but good results can be achieved with one stripping if the timing is correct. If many of the eggs did not ovulate the first time, strip them again — one to two hours later. Some culturists prefer not to biopsy white bass females for egg maturation. Instead, they examine a few female white bass about 24 to 28 hours after injection of the hormone. Slight pressure is applied to the abdomen to see if ovulation has occurred. Separate females into groups of similar maturation rates. Re-examine the females every hour or two, depending on their progress. If the eggs flow freely from the vent when slight pressure is applied, the fish have ovulated.

Broodfish about to ovulate occasionally exhibit specific behavioral characteristics. Swimming activity decreases. If left undisturbed, the females will remain stationary in the tank five to six hours prior to ovulation. During the final hour or two, the fish are very lethargic and move slowly even when netted. When ovulation is imminent, females often lie still with their heads down and tails up. Some physical changes also occur. The abdomen softens as the eggs reach final maturation. The vent dilates slightly and becomes hemorrhagic and distended.

If you have too many males, excess ones need not be injected. They can be held in water 12 C to 16 C (54 F to 60 F) for later use. White bass males that are held for extended periods may develop acute *Ichthyophthirius* (Ich) infections. To cure the infection, place the fish in a salt solution (3 parts per thousand) for 1 to 2 days. Repeat the treatment until the Ich is eliminated. If males (either striped bass or white bass) are held more than a week, they should be fed to keep them in good health.

*HCG being injected intramuscularly into striped bass broodstock.*

## Collection of Eggs

Females and males should be anesthetized with MS-222 before the eggs and sperm are manually stripped. This prevents unnecessary thrashing by the fish and makes the removal of eggs easier. Fish may be anesthetized by immersion in a bath of MS-222 (100 parts per million). In poorly buffed water, MS-222 may cause a drastic pH shift that can kill the fish. Use an equal amount of sodium bicarbonate and MS-222 to correct this situation. To avoid contact between MS-222-laden water and the eggs or sperm, dip the fish in clean water and wipe it dry with a towel before stripping the eggs. During this process, cover the female's vent to prevent egg loss. Quinaldine has been used to anesthetize fish, but it is not approved for use on food fish.

Striped bass females can be spawned by manual stripping or by tank spawning. Use circular tanks 6 to 8 feet in diameter for tank spawning. The tank should receive a water supply of a few gallons per minute. Maintain a circular current in the tank or use diffused air to provide turbulence instead of circular flow.

*Stripp... fro... bas...*

Culturists can only use tank spawning to produce pure striped bass. Female striped bass will not ovulate in the presence of white bass males. To produce hybrid striped bass, manually strip the eggs and sperm from the ripe fish into a container. Sperm is stripped from two or more males to fertilize the eggs of one female striped bass. To fertilize striped bass eggs, use either a wet or dry fertilization method. In practice, there is no

Stripping sperm from striped bass male.

difference in the success rate of the two methods.

For wet fertilization, strip the eggs from the female into a plastic pan or stainless steel bowl containing a small amount of water. Add sperm periodically as the eggs are being stripped. Sperm are motile for only one to two minutes. Also, the eggs begin to harden as soon as they come in contact with water. Water-hardening will eventually prevent sperm from entering the egg. For successful fertilization using the wet method, use two or three workers to efficiently remove eggs and sperm from the broodfish simultaneously. Add fresh sperm to the eggs every 20 to 30 seconds. By using this procedure, urine and drugs may be diluted before contact with eggs, minimizing any harmful effects.

To dry spawn striped bass females, manually strip the eggs into a dry, clean container. Dry the female with a towel, and keep water away from the container until the sperm has been added. Mix in the sperm thoroughly, and add water to mobilize the sperm. Fertilization is completed in two minutes.

Use the dry method for stripping eggs from white bass females. The eggs from two or three females may be stripped into the same container. The eggs are adhesive and must be treated to remove the adhesiveness to incubate successfully. Use tannic acid or Fullers Earth. After fertilization is complete, add the eggs to a tannic acid solution (150mg/1) and aerate vigorously for seven to 12 minutes. The agitation period depends on the alkalinity and/or hardness of the water. To agitate, fill a McDonald jar approximately two thirds full of water. Add the appropriate amount of tannic acid (about 0.75 g). Add the eggs, and place a weighted air stone in the jar to stir and separate them. Do not keep the eggs in the tannic acid solution too long. It may harden the chorion and inhibit hatching. For Fullers Earth, use 40 g/liter (0.33 lbs/gallon) and agitate until the adhesiveness is eliminated (about 15 minutes).

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## Incubation of Eggs and Larvae

After excess water is decanted from the fertilized striped bass eggs, pour the eggs into a calibrated cup. To determine quantity, figure 150 milliliters of egg mass equals 100,000 striped bass eggs. White bass eggs are smaller than striped bass eggs — 200,000 eggs in 100 milliliters of egg mass. Eggs increase in size as they water harden so estimates will change after the first one to two hours. Eggs from two or three white bass females may be incubated together. To incubate striped bass and white bass eggs, use a modified McDonald jar. The jar is a tube within a tube. It circulates water into the bottom of the jar to keep the eggs in motion, but allows air bubbles to escape without carrying the eggs away. One jar holds 100,000 to 200,000 striped bass eggs or 200,000 to 300,000 white bass eggs. Optimum water flow rate is 0.4 to 1.1 liters (0.1 to 0.3 gallons) per minute but will vary according to fluctuations in egg buoyancy. The buoyancy of the eggs increases as they water-harden during the first hour after fertilization. Monitor water flow closely to avoid flushing eggs from the jar.

*Collecting*
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Eggs can be transported in plastic bags filled with oxygen and a small amount of water (7.6 liters; 2 gallons) for up to 12 hours after they are fertilized. Transporting eggs later is riskier because of the increased chance of fungus or other problems that lead to deformities in the developing embryos.

Eggs may also be incubated in cones (18 inches in diameter or larger) with a screened center standpipe. This method is used primarily with eggs taken from Chesapeake Bay striped bass. They have very buoyant eggs that will not stay in a McDonald jar. In cones, the movement of the water circulates the eggs, which are retained by fine mesh screens. After the eggs hatch, the larvae can be kept in the cones or removed to other containers.

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The water temperature for egg incubation should be similar to the broodstock holding tanks, ranging from 18 C to 20 C (64 F to 68 F). Aerated well water is preferred because temperature variation is minimal. The incubation period decreases as the water temperature increases. At 18 C to 20 C, incubation ranges from 40 to 48 hours for white bass and striped bass eggs.

Only water of the highest quality should be used during incubation of eggs and larvae. Even short periods of low dissolved oxygen can cause death or deformities to the fish. Hydrogen sulfide and iron are common in many sources of well water. These compounds must be eliminated before using the water in the hatchery because they are deadly to eggs and small fish. Also check levels of carbon dioxide and ammonia. They may cause problems if levels get too high.

Culturists can determine fertilization success by counting the number of uniformly cleaving eggs two to six hours (four to six hours is best) after eggs and sperm are mixed. Unfertilized eggs will show no sign of cell division and exhibit asymmetrical cleavage. These eggs are not viable and will die after 12 to 24 hours.

After two to three hours, an estimate of the total number of eggs can be determined volumetrically by letting the eggs settle to the bottom of a jar calibrated in 100-milliliter increments. To calculate the number of eggs per milliliter, count the eggs in several subsamples of a known volume (1 to 2 milliliters). Allow the egg subsamples to settle in a small graduated cylinder. Average the egg counts from the subsamples and multiply the number per milliliter times the milliliters of eggs in the jar. The size of the eggs will vary after water hardening due to differences in water quality and individual fish. Striped bass eggs usually number 150 to 350 per milliliter; white bass eggs, 900 to 1,200 per milliliter. Eggs held in water with a high mineral content tend to swell less than those held in water with low mineral content.

A fertilization rate of 50 percent is acceptable; 60 percent to 80 percent, good. The hatch rate of eggs that survive 24 to 28 hours should be more than 80 percent.

Newly hatched larvae swim up. As they move upward, upwelling water currents carry the larvae out of the jar and into a holding aquaria placed under the lip of the hatching jar. Enough water must be pumped into the aquaria to provide complete water exchange every hour. Use diffused aeration to keep larvae in motion. Do not aerate the water too vigorously because it may damage the larvae. Screens (300 microns pore size) prevent larvae from escaping, and standpipes control the water level. Place a perforated aeration tube around the base of the screen to create a bubble curtain and prevent impingement of the larvae on the screen.

The larvae are held in aquaria or cones (114 to 284 liters; 30 to 75 gallons) for four to five days before stocking them into ponds. To determine the number of larvae available for stocking, count the larvae in a series of random samples of known volume and average the quantity counted. The number per milliliter then can be extrapolated to the total volume of the tank. To take a sample, stir the water to assure uniform distribution; dip a sample (about 40 milliliters) using a small beaker. Some culturists take samples from several predetermined locations in the tank rather than stir the larvae. For this method, use a glass tube to take 10- to 40-milliliter samples. Place the sample in a white cup; count the larvae as they pour from the cup into a container. Add water to the cup if all the larvae cannot be counted in one pouring. The accuracy of this method is poor when the concentration of larvae is less than two to three per milliliter.

Newly hatched hybrids have no mouth opening, an enlarged yolk sac and a large oil globule protruding behind the head. Four to five days after hatching, the mouth parts develop and the larvae are ready to feed. Stock larvae into fertilized ponds two to 10 days after hatching. If larvae are held more than five days in aquaria or cones, provide live food such as rotifers, newly hatched brine shrimp nauplii, wild-caught copepod nauplii or cladocerans. Under these circumstances, feed the larvae every three hours until they are stocked into a pond.

Culturists can transport larvae one to two days after hatching. It is better to transport them at this age than four to five days after hatching because mortality is decreased. Larvae are concentrated in the aquarium and then dipped and placed into plastic bags. In each bag, add 7.6 liters (2 gallons) of water per 50,000 to 100,000 larvae. Place the bag in a styrofoam shipping container. Fill the bags with oxygen and close them. Larvae can survive in these containers for 48 hours, but reduce the density if they will be held more than 24 hours. Avoid direct sunlight and hold water temperatures between 59 F and 64 F. Culturists can place blue ice under the plastic bag to maintain acceptable temperatures.

Stock larvae into fertilized ponds at night because exposure to ultraviolet light may kill them. Float the bags of larvae in the pond for at least 30 minutes to equalize the temperature. After the bags are opened, periodically add small amounts of pond water for the next 10 to 30 minutes. This helps the larvae adjust to differences in water quality.

During production of hybrid striped bass fingerlings, culturists aim to maximize the number of fish that survive the first 30 to 45 days of life. Culturists stock 2- to 10-day old larvae into fertilized ponds. (Actual pond selection and construction is described in Chapter 3.) Thus far, private culturists have not utilized intensive culture methods such as flow-through and recirculating systems. Fingerling quality and survival in these systems have not justified the use. However, research in the area is ongoing.

## Pond Preparation

Depending on water temperatures, fill nursery ponds 5 to 14 days prior to stocking larvae. At higher temperatures, pond blooms develop more rapidly than at lower temperatures. Ponds filled too early will develop large populations of predacious insects that will eat the small larvae. Most hatcheries use fresh water, but some pump brackish water [up to 5 grams/liter (ppt)]. Hatcheries that use brackish water or hard fresh water (more than 100 milligrams/liter calcium hardness) are more successful than those that rely on soft fresh water.

Dry and disk pond bottoms prior to filling to promote the breakdown of nutrients. Agricultural limestone may also be applied if necessary.

Fingerling success depends on the presence of adequate populations of zooplankton, such as rotifers and crustaceans, and suitable phytoplankton. To stimulate the production of aquatic bacteria, green unicellular phytoplankton and protozoans, apply a combination of organic and inorganic liquid fertilizers. In return, a large population of crustacean zooplankters, such as copepods and cladocerans, will develop.

Established ponds normally do not require inoculation. However, new ponds or ponds filled with well water may require inoculation with phytoplankton and zooplankton to foster development of desired populations. To inoculate, add water from a nearby pond with an established population of phytoplankton and crustacean zooplankters. Water from the established pond should account for 1/8 to 1/4 of the volume of the new pond. Use a sock screen (200 microns) over the inlet to remove undesirable zooplankton and insects from the water being added. Remember to clean the screen periodically or it may burst.

### Choosing Fertilizers

Two weeks before ponds are stocked with larvae, fertilize them with organic and inorganic fertilizers. Organic fertilizers are preferable to inorganic types because the slower decay of organic materials provides a more sustained production of zooplankton. Too much inorganic fertilizer can produce dense phytoplankton blooms that tend to cause high pH, oxygen depletion and/or dominant blue-green algal blooms.

Organic materials, such as manure and meat scraps, are used but not recommended. They can deplete oxygen and cause other management problems. Instead, use organic fertilizers such as cottonseed meal and alfalfa pellets. They decay slowly and provide essential nutrients — carbon, nitrogen and phosphorus — for primary production of phytoplankton and secondary production of zooplankton. But even when using these fertilizers, watch for oxygen depletion. If possible, apply small amounts often as opposed to large amounts infrequently. Organic fertilizers should be high in crude protein to support large numbers of crustacean zooplankters. They should also provide adequate nitrogen and phosphorus in usable forms and be small enough to allow fast colonization by bacteria, algae and protozoans. This enables quicker decomposition and solubilization of key nutrients. Apply organic fertilizers at a rate of 1,000 to 2,700 kilograms per hectare (200 to 500 pounds per acre) when the pond is filled. At weekly intervals, apply 60 to 170 kilograms per hectare (50 to 150 pounds per acre) to maintain the zooplankton bloom. You can apply organic fertilizers more than once per week, but do not apply more than 60 to 170 kilograms per hectare per week.

Inorganic fertilizers commonly used include ammonium nitrate (52 percent nitrogen) and phosphoric acid (32 percent $P_2O_2$). These fertilizers are available in liquid and granular form. When mixing liquid forms in a tank, be sure to always add the fertilizer to the water. Liquids fertilizers are preferred because they are easier to apply and work faster. Diammonium phosphate and superphosphate are two commonly used liquid fertilizers. Start by applying the fertilizers at a rate of 2.5 pounds per acre; adjust your rate up or down depending on the bloom. Water with high hardness (greater than 150 milligrams/liter) requires more inorganic fertilizer. Apply inorganic fertilizers often and at low rates.

Inorganic fertilizers should contain nitrogen to enhance bacterial growth and increase decomposition of organic fertilizers. Adequate amounts of soluble phosphorus allows rapid uptake by phytoplankton and minimizes sediment absorption or chelation into unusable inorganic complexes. Mix fertilizers thoroughly with water and disperse evenly over the pond surface to maximize distribution of nitrogen and phosphorus.

Application rates for fertilizers vary depending on the type of fertilizer and water conditions. To determine application rates, see Table 1.

Schedule for pond fertilizer application rates.

| | *Organic* | *Inorganic* |
|---|---|---|
| 2 weeks prior to stocking | ~200 to 500 lbs/ac<br>1 time/wk | ~2.5 lbs/ac<br>3 times/wk |
| Week 1 | — | ~2.5 lbs/ac<br>1 time/wk |
| Week 2 | — | ~2.5 lbs/ac<br>1 time/wk |
| Week 3 | ~25 lbs/ac<br>1 time/wk | ~2.5 lbs/ac<br>1 time/wk |

### Stocking Rate

Stock larvae at a rate of 250,000 to 500,000 larvae per hectare (150,000 to 250,000 larvae per acre). Food supply, dissolved oxygen and other water quality variables are especially important to fish survival. Aeration and circulation of pond water helps moderate daily water quality shifts, improve dissolved oxygen levels and increase plankton production. As the fingerlings eat the zooplankters, cladocerans and copepods decrease as rotifers and protozoans increase. To ensure good fingerling growth, keep crustacean zooplankton populations as high as possible.

If 45 percent of your striped bass female/white bass male crosses survive to be fingerlings, you have done well. Fifteen to 20 percent survival is typical for white bass female/striped bass male crosses because of the difficulty in developing and maintaining a rotifer bloom during the initial few days of culture. Survival of larval fish is affected by rapid changes in temperature, pH or hardness, dissolved oxygen levels and salinity. To improve fish survival, monitor water quality and food supply regularly and remedy problems quickly.

### Feeding Prepared Feed

Introduce hybrid striped bass to prepared food when they are 20 to 25 millimeters long (22 to 25 days old). The particle size of prepared food is critical to successful transition. Use mash or number 1 crumble of a high protein salmon starter. Feed the hybrids five to 10 pounds of food per acre per day. This feeding level assumes a 20 percent larval survival and is administered at 20 to 30 percent of body weight per day. Feed the fish increasing amounts of food as they grow and as their acceptance of it increases. Food particle size is increased as fish grow, but it is better to err on the small side. Offer food three times per day with the amount depending on the amount of natural zooplankton in the pond.

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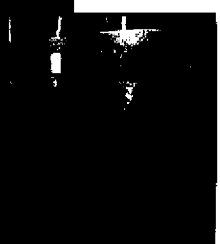
*d jars.*



### Harvesting

Harvest fingerlings 30 to 45 days after stocking by seining and draining the ponds. For restocking ponds for food-fish production, hybrids should measure 50 millimeters in length and weigh 1 gram or more (500 fish/pound or larger). Avoid using fish smaller than 1 gram for pond culture because they are too small to be graded effectively.

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fi

When harvesting fingerlings from a pond, use salt (up to 10 grams per liter) in the transport tank. The salt should not contain an anticaking compound. Under certain conditions, this compound can be toxic to fish. Temper the fish one hour for every 4-degree (C) difference in water temperature.

Improper or poor grading can leave a culturist with 10 to 20 percent runts (small fish that are not eating pelleted food) and a large variation in size of fish at the end of the first year of growth. Grading also reduces losses to cannibalism. Regardless of how well the fish are graded when stocked into the pond, expect 5 to 10 percent runts at harvest several months later. Fish intended for aquaculture are graded in tanks or raceways using a bar grader and trained to feed on pelleted food. Training the fish to eat pelleted food is easier if it has already been presented to them in the rearing ponds. If you are purchasing fingerlings, buy fish that have been trained to eat pelleted feed in a confined area — a raceway or tank — because a higher percentage of them will be eating feed when you receive them.

Fingerling feed should contain at least 45 to 50 percent protein, fish oil or whole processed fish and be a size that is easy for the fish to eat. Culturists usually feed number 1, 2, 3 or 4 crumble of a good quality salmon starter to fingerlings. Use larger crumble sizes as the fish increase in size.

Cannibalism is prevalent at this stage but can be minimized by grading. Significant losses can occur the first few weeks after stocking fingerlings into a pond if they were not properly graded. Cannibalism occurs because of the size variation that develops as some fingerlings grow faster than others. Hybrid striped bass are naturally inclined to eat fish, and their preference for fish starts at a very early age. Fast-growing fish should be graded and separated before they learn to cannibalize. Once trained to take pelleted food, fish are ready to stock into ponds.

### Transport

Fingerlings are commonly available for purchase from mid-May to August, depending on the producer's location. They are transported to fish farms in specially designed, insulated hauling tanks. The hauling medium consists of a 0.5 to 1 percent salt solution (NaCl or reconstituted seawater) coupled with liquid oxygen. The salt helps the fish with osmoregulation; liquid oxygen enables haulers to travel long distances and maintain adequate dissolved oxygen levels in the hauling tanks.

Maintain oxygen levels by bubbling pure oxygen through diffuser devices. Although oxygen levels usually remain high, problems may occur with carbon dioxide buildup on long hauls. Culturists sometimes use agitators in combination with oxygen to maintain water quality for a long trip. Ammonia buildup can also be a problem on extended hauls because it is not removed by agitation.

Fingerlings are transported at temperatures of 70 F or below. The hauling rate for fingerlings should not exceed 60 grams/liter (0.5 pounds/gallon) for short trips (one to four hours), 40 grams/liter (0.33 pounds/gallon) for medium-length trips (four to eight hours), and 30 grams/liter (0.25 pounds/gallon) for long hauls (more than eight hours).

Upon arrival at the pond, temper the fingerlings before releasing them. Tempering acclimates the fish slowly to different water quality conditions. Remove half of the water from the hauling tank, and replace it with pond water. After 30 minutes, repeat this process. Continue the procedure until water temperatures in the pond and the hauling tank are similar. Allow 30 minutes after the last addition of water before removing the fish. Or try this method. Slowly pump water from the receiving pond into the tank until all the water in the hauling tank has been replaced. Wait 30 minutes before releasing the fish. Most hauling tanks are designed for quick release. If the fish must be netted, use a soft dip net, take small numbers of fish per dip and treat the fish gently.

Culturists can accomplish grow-out in a variety of culture systems — raceways/pools, cage/net pens and ponds. Each system has advantages and disadvantages, but pond culture is an efficient method for producing hybrids.

### Raceways/Pools

Circular pools and raceways make excellent culture containers for hybrid striped bass and use either flow-through or water recirculation systems. They allow more control of the culture environment than other systems. They also offer the advantages of accessibility and reduced handling. But their disadvantages include dependence on mechanical devices, the need for backup systems and high operating costs.

Flow-through pool and raceway systems may be useful when large volumes of water are available at low costs, such as at power plants or where there is abundant groundwater. These systems require liquid oxygen injection or other means of aeration to maintain water quality. Production costs for raceway/pool culture are not well known because public research on hybrid bass production is these systems has been very limited.

Only a few producers use water recirculation systems. Research on the systems is ongoing, but water recirculation is not economically viable for food-fish production of hybrid striped bass.

### Cages/Net Pens

Producers can use cages/net pens when harvesting cannot be accomplished by seining or draining the water body. Abandoned gravel pits and quarries, reservoirs, ponds, estuaries and ocean sites are examples of places where cages/net pen culture may be appropriate. Confinement in cages can be very stressful for hybrid striped bass. Consequently, successful cage/pen commercial hybrid production has been limited to areas with excellent water quality.

### Ponds

Pond production of hybrid striped bass is successful where adequate natural resources are available. The two most important factors are land and water. The topography should be flat to minimize pond construction costs, and the soil must contain enough clay for the levees to hold water. The land should be easily drained and not subject to periodic flooding. Make sure the soil does not have high levels of chemical residues from prior activities.

Abundant groundwater of good quality is a must. Water alkalinity and hardness values should be greater than 100 grams/liter (contributed mostly by calcium ions). Brackish water aquifers, where available, can be very good sources of water for hybrid striped bass production.

Once a site is selected, plan to use 20 to 25 percent of the acreage for levees, support structures and drainage ditches. If you plan to raise hybrids from fingerlings to market size, divide the remaining acres accordingly: 25 percent for fingerling ponds and 75 percent for grow-out ponds.

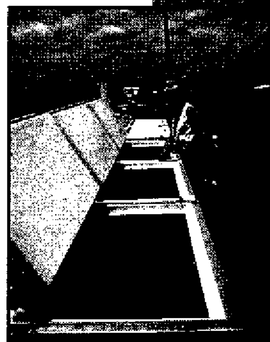
Pond size will depend on the size of the farm and the pond shape desired. For fingerling ponds, two to four acres is recommended; for grow-out ponds, five to 10 acres. Base your pond size on the cost of construction and ease of site management.

Water quality is easier to manage in smaller ponds, and the fish are easier to harvest. But the cost of construction is greater for small ponds because more levees must be built and more water inlet and outlet structures must be installed. Also, smaller ponds decrease the amount of water available for production. Each producer must select pond size based on his own needs and preferences.

Levees should be 14 to 20 feet wide. Levees with top widths that are too narrow make it difficult to move equipment and trucks. The pond bottom must slope gently to the drain and be free of all roots, stumps and debris to allow seining. At its deepest end (the bottom of the slope), the pond should measure no more than 5 to 6 feet.

The steepness of the levee slope will depend on the soil type. For most soil types, a 3-to-1 slope is satisfactory if properly compacted. Gentler slopes require more cubic yards of dirt per linear foot and cost more to construct. But for ponds larger than eight acres, a slope of 4 to 1 is recommended because erosion is greater in large ponds and steeper slopes erode faster.

Construction can be accomplished with bulldozers or tractor-pulled pans. Soil type and economics will determine which construction method is best for each location. Ponds should drain by gravitational flow. The slope should be .01 to 0.2 feet per 100 linear feet. Culturists can install several types of drainage systems. But regardless of pond size, the drain pipe must allow the pond to empty in a minimum of seven days.



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## Pond Production of Food Fish

Hybrid striped bass is an excellent food fish. It exhibits a mild taste and firm texture. Early studies found that hybrid striped bass exhibit superior early growth rates, improved survival and better hardiness than striped bass. As commercial harvests of striped bass declined and prices increased, culturists examined the potential for producing hybrid striped bass for food and found them well-suited to pond culture. The production of food fish begins with 35- to 45-day-old graded fingerlings that have been trained to eat pelleted feed.

Culturists can buy fingerlings from private producers from May through August. Limited supplies may be available at other times of the year. If you plan to purchase fingerlings, contact producers before the season to get fish when you want them instead of having to wait. It takes 18 months or two growing seasons to grow a 0.035-ounce (l-gram) fingerling to a market size of 0.7 kilograms (1.5 pounds) or larger in a pond.

## Production of Phase II Fingerlings

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*hybrid str*
*finge*
*product*

Stock fingerling ponds with fish of uniform size, 1 gram (500 to the pound) or larger. Culturists can not effectively grade fish smaller than 1 gram to remove fast growing hybrids. Grading with a bar grader reduces losses due to cannibalism and variation at the end of the first growing season. These two factors are responsible for most losses during the first growing season. Poorly graded fish also result in a high percentage of stunted fish, or runts, at the end of the first year.

For their first year of growth, stock hybrid striped bass fingerlings at a rate of 10,000 to 15,000 fish per acre. Initially, feed fish a commercial trout-feed crumble (45 to 50 percent protein) three times a day at a rate of 25 to 30 percent of the body weight. Increase the size of the crumble as the fish increase in size.

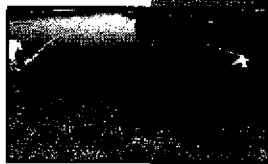
After several weeks, the fish should be large enough to eat a small pellet (3/32 inch). When the protein needs of the fish decrease, culturists can switch to a 38 to 40 percent protein feed. Reduce the feeding frequency to twice a day, and gradually taper the amount of feed to 3 to 5 percent of body weight by the end of the growing season. By then, culturists could be using 50 to 70 pounds of feed per surface acre, depending on fingerling density in the ponds.

Seine samples of the fish biweekly or monthly to estimate growth and adjust feeding rates. Weigh known numbers of fish (20 to 100) to determine mean weight. By the end of the first growing season, October to December (depending on location), mean weight should be 90 to 225 grams (0.20 to 0.50 pounds). Fish that are 0.20 pounds or larger should reach a marketable size in the second year. Expect survival rates of 85 percent unless a serious water quality problem occurred during the growing season. Remember, this figure accounts for all surviving fish, including runts. Runts are small fingerlings (less than 60 grams) that did not grow well in the pond, generally because they did not get enough food. At the end of the first growing season, runts can account for 5 to 10 percent of your total fish.

These fish will grow if separated from large fish that prevent them from getting food. But they may be out of sequence for a scheduled marketing program. You may not have enough runts to stock a pond, particularly if your production facility is small. A high percentage of runts (15 to 20 percent) is indicative of a problem, and you should examine your fingerling source and your own culture practices to correct the problem in the future.

Harvest phase II fingerlings (advanced fingerlings) after the growing season ends, usually in December when pond temperatures cool to 12 C to 16 C. Harvest can continue through March or April. Advanced fingerlings can be moved at a wider range of temperatures than once thought if they are healthy and water quality conditions are good. Check your fish and pond conditions before moving them. If the pond has a dense phytoplankton bloom or the fish are not healthy, correct these problems before moving them. Convert your ponds to brackish water prior to moving fish if possible.

To harvest, reduce the water level in the pond to a depth of 3 feet at the shallow end. Drag a large seine across the pond. Have a large holding net, or live car, ready to attach to the seine at the deep end of the pond. Complete most of the seine pull before attaching the live car and move slowly to allow the fish time to enter it. After seining, detach the live car and position it at a convenient place in the pond to remove the fish.



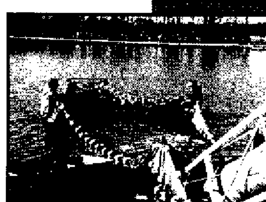
*Seining ... hybrid str... fingerl... product...*

Before moving the fish to another pond, estimate the size of the fish by weighing several samples of a known quantity. If 100 fish weigh 15,000 grams (33.03 pounds), the mean weight will be 150 grams (0.33 pounds); 500 kilograms (500,000 grams or 1102.3 pounds) of fish equals 3,333 fish (500,000 grams/150 grams per fish). Weigh the fish as they are moved. Their numbers will based on the sample weights. Weigh the fish in water to reduce stress.

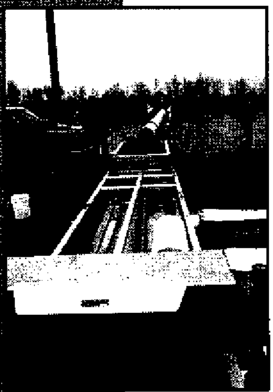
It is also possible to estimate the number of fish by displacement in a hauling tank if you have a way to dewater them as they are moved into the tanks. To do so, determine how many fish it takes to displace a known volume of water, for example 1 gallon or 100 gallons. Then record the volume of fish added to the tank.

To move phase II fingerlings, use a hydraulically controlled boom. Attach a scale to the end of the boom. Partially fill the container with water, weigh and position it near the holding net to be filled with fish by a dip net. Lift and weigh the fish and water prior to putting the fish into a hauling tank or an adjacent grow-out pond. The weight of the fish in each container is obtained by subtraction. When harvest is complete, the total number of fish in each pond can be estimated based on weight.

*Phase II f... ready fo...*



It is preferable to grade Phase II fingerlings before stocking them into grow-out ponds. Grading reduces the size variation in each pond and improves feed conversion ratios. No defined grading technique exists for advanced fingerlings. Some producers use a fish auger (pescalator) to lift fish out of the live car into a fish



*er ready*

*e fish.*

grader with a counter attached. This combination of equipment provides good results when used correctly. No one grading method is better than another; culturists should determine which works best for their farm and budget. Some successful culturists do not grade their fish.

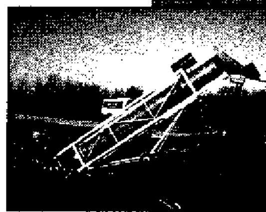
### Production of Food Fish

Stock fingerlings (0.20 to 0.50 lbs or 90 to 225 grams) into grow-out ponds at a density of 3,000 to 4,000 fish per acre. With proper management, these fish will reach market size by October or November of the second year. Survival rates for the second growing season should be approximately 90 percent unless fish die due to oxygen stress or disease.

Daily feed the fish a commercial hybrid striped bass feed with at least 38 to 40 percent protein at a rate of 1 to 5 percent of the body weight. In spring, while temperatures are low and dissolved oxygen levels are high, fish can be fed at a rate of 3 to 5 percent of body weight. As the fish increase in size, they consume less food. As water temperature and biomass in the pond increases, dissolved oxygen levels become more difficult to manage. Then the feeding rate should drop to 1 to 2 percent of the body weight. Food conversion ratios of 2:1 can be achieved during the second year with proper management.

Hybrids do feed during the winter. The amount they eat will depend on the water temperature. They feed better during rising rather than falling temperatures. When the temperature is 12 C to 15 C, feed the fish daily about 1 percent of their body weight. At water temperatures below 12 C, feed the fish every two to four days at a rate of 0.5 to 1 percent of their body weight.

Water quality requirements for second-year fish are similar to first-year fish. Daily monitoring of water quality, especially dissolved oxygen, is important because of the increased biomass of fish in the ponds. Low dissolved oxygen levels can become a major problem. Aeration will be necessary during culture. Use electric or tractor-powered devices. Electric floating paddlewheels should be installed in each pond at a rate of 1 to 2 horsepower per acre. Electric paddlewheels are the most cost efficient aeration method for large ponds. Typically, the aerator is turned off during the day and turned on at night when the dissolved oxygen falls below 5 parts per million. You should try to maintain dissolved oxygen levels above 4 milligrams/liter. Locate paddlewheels at the midpoint of the levees along the long axis of the pond. Use tractor-powered aerators, such as paddlewheels and pump sprayers, for emergency aeration. You will need one unit for every 3 or 4 ponds.



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Optimum growth occurs at 25 C to 27 C (77 F to 81 F) and at dissolved oxygen levels above 6 milligrams/liter. Growth slows as dissolved oxygen levels approach 4 milligrams/liter. Some mortality may occur at 1 to 2 milligrams/liter, and all fish will die if levels remain lower than 1 milligram/liter. Disease problems are more prevalent when fish are stressed by low dissolved oxygen levels. When fish are stressed by low dissolved oxygen, watch them closely for the next seven to 10 days for disease problems. Treat them quickly when problems arise.

To harvest market-size fish, lower the pond level to a depth of 3 feet and seine the fish into a live car, as with the Phase II fingerlings. Using a hydraulic boom with a harvesting basket, transfer the fish from the holding pen into a container partially filled with salted ice-water. After the fish are stunned by the cold water, weigh and pack them on ice for delivery to a buyer.

*Harvest*
*fish fro*

**Water Quality**

Hybrid striped bass survive and grow well in a wide range of water quality variables. But growers should strive to maintain good water quality during all phases of production. Monitor temperature and dissolved oxygen levels two to three times a day, always in the morning and evening and between 10 p.m. and 11 p.m. as needed. Use aerators to keep dissolved oxygen levels above 4 milligrams/liter. Maximum growth occurs between 25 C to 27 C (77 F and 86 F), but some growth occurs at temperatures from 16 C to 32 C (60 F to 90 F). There is no growth below 10 C (50 F) and above 33 C (93 F). Hybrids can survive a temperature range of 4 C to 34 C (39 F to 94 F).

Dissolved oxygen is important in any aquaculture operation. Hybrids may survive dissolved oxygen levels as low as 1 milligram/liter for a short time, but these levels are stressful.

Dissolved oxygen levels below 4 milligrams/liter reduce food consumption and growth, increase the amount of energy needed for respiration and increase mortality.

Alkalinity, hardness and pH levels are related, and hybrid striped bass grow well over a wide range of values. Alkalinity and hardness of 100 milligrams/liter or above are desirable. Hybrid striped bass can thrive in waters of lower alkalinity and hardness, but it is very difficult to handle hybrid striped bass in water with low amounts of calcium. Chloride ions also help the fish withstand the stress of handling. When fish flare their gills and become tetanus during handling, it is a good indication that calcium and/or chloride levels are too low.

Hybrids survive in a pH range of 6 to 9.5, although 7 to 8.5 is optimum for growth. Pond-reared hybrids have survived repeated exposure to low pH.

Ammonia, the principal excretory product of fish, should be monitored weekly. Concentrations should not exceed 1 milligram/liter.

The culture of any fish usually involves stressing the fish at some point. Stress weakens the fish and can result in serious disease or parasite problems—major causes of mortality in the pond culture of hybrid striped bass. The best defense against infection is a program of good health management. This translates to a healthy environment, good nutrition and minimal stress. Because stress is unavoidable in fish culture, be prepared to treat the fish for disease problems.

## Common Pathogens and Parasites

Four diseases of major concern to hybrid striped bass producers are columnaris, motile aeromonas septicemia (MAS), vibriosis and parasites. Columnaris, MAS and vibriosis are pathogens caused by bacteria.

Columnaris is caused by *Flexibacter (Chondroccus) columnaris* and is one of the most frequent bacterial diseases to strike striped bass. It occurs in freshwater ponds and intensive culture systems. Growers can recognize advanced stages of Columnaris by the macroscopic, external lesions that appear as a yellow patch on the gill filaments and grey patches on the skin. Lesions can also occur as tail rot and fin rot. Evidence of the disease can be detected in the blood and the organs. This disease is stress-related. To prevent its occurrence, maintain optimum water temperatures, reduce handling during warm weather, maintain the best possible environmental conditions and avoid overcrowding.

*Aeromonas sp. and Pseudomonas sp.* cause MAS. This disease infects hybrid striped bass in fresh and brackish water. MAS is a bacterial hemorrhagic septicemia that breaks down capillary walls, giving a bloodshot appearance to infected areas. It is sometimes called red sore disease because of the appearance of such spots. The disease is obvious in the intestine of the fish. The abdomen of the fish becomes distended; the anal pore becomes enlarged and inflamed. Frequently, a yellow discharge can be pressed from the pore. An accumulation of organic materials in the water, which leads to increased bacteria and low oxygen, causes MAS.

Vibriosis can cause high mortality of hybrid striped bass cultured in marine, estuarine and freshwater systems. *Vibrio anguillarum* is considered to be the agent of the disease. Symptoms do not appear until the fish have been in salt water for two weeks or more under crowded conditions. Two symptoms are hemorrhages around the bases of the pectoral and anal fins or a bloody discharge from the anal vent. Prevention methods include good sanitation, no crowding and minimal handling.

## Treatments

Salinity appears to prevent the spread of some diseases, but many pathogens affect fish in a wide range of salinities. There are no drugs approved for treating diseases in hybrids cultured for food. However, the U.S. Food and Drug Administration (FDA) has placed 17 compounds on a low regulatory priority list. Consequently, growers can administer these compounds if they are used as prescribed. If used properly, FDA does not consider these compounds a health risk to the public even though they have not received FDA clearance.

Due to the large volume of water involved in pond culture, disease treatment is difficult and expensive. Because of the expense involved, the choice of chemicals for disease treatment in ponds is different from that for fish cultured in tanks. Take every treatment seriously, and administer compounds properly.

All drugs and chemicals used to control infectious organisms can be toxic to fish if concentrations are too high. When temperatures are high, shorten the length of the treatment because the chemicals act more quickly. In the case of food fish, such as hybrid striped bass, also consider the possible effects on the consumer before the treatment is applied. Consult a veterinarian before treating your fish with some chemicals.

Potassium permanganate turns the water a deep wine red. The color changes to dark brown as it breaks down. If a color change occurs in less than 12 hours, repeat the treatment.

Administer Terramycin, furanace and sulfamerazine orally by adding the proper dose to the pelleted food. For ease, use the water-soluble powder concentrate of Terramycin. Purchase it in 4-ounce preweighed packages. Dissolve as many as two packages of this antibiotic in one quart of warm gelatin solution (40 grams gelatin/1 quart warm water). Spray the solution over the daily food ration.

## Predation and Other Problems

Cannibalism is a significant problem for intensive culture systems. It is prevalent in the fingerling stage as hybrids change from live to prepared food. Unless intensive grading eliminates size differentiation before stocking, losses will occur after pond stocking.

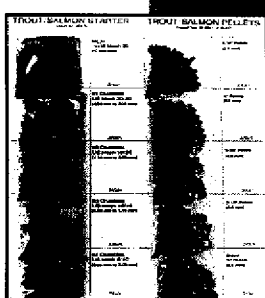
As hybrids grow from juveniles to adults in ponds, outdoor tanks and raceways, they may become prey for kingfishers, gulls, herons, ospreys, diving ducks and cormorants. Use an integrated strategy — scare techniques, exclusion devices and, if necessary, death — to prevent bird depredation. Be sure to secure appropriate permits before killing any predators.

Other predators include mink, otters, turtles and humans. Also, muskrats and nutria can damage pond levees and should be controlled.

The nutritional requirements of hybrid striped bass are not fully understood. However, research efforts supported by Sea Grant and the U.S. Department of Agriculture have enabled companies to produce feeds designated for hybrid striped bass. Because feed costs are a major cost in hybrid striped bass production, researchers and growers seek to keep feed conversion ratios low while maintaining good nutrition and a proper feeding regime.

Growers switch post-larvae and juvenile hybrids reared in intensive culture systems from live food to prepared feed 14 to 21 days after hatching. Prepared feeds for fingerlings should contain at least 38 percent protein, fish oil or whole processed fish and be a size that is easily eaten. Many culturists use trout or salmon crumble containing 45 to 55 percent protein when the fish are small. They switch to a 38 to 42 percent protein hybrid striped bass feed when the fish are large enough to take the smallest pellet size, usually 3/32 to 1/8 inch. Use the following feeding regime:

*Number 2 crumble — 1- to 5-gram fish,*
*Number 3 crumble — 5- to 10-gram fish,*
*Number 4 crumble — 10- to 15-gram fish,*
*3/32-inch pellet — 0.5- to 1.8-ounce (15- to 50-gram) fish,*
*1/8-inch pellet — 1.8- to 2.8-ounce (50- to 80-gram) fish,*
*5/32-inch pellet — 2.8- to 10.6-ounce (80- to 250-gram) fish,*
*3/16-inch pellet — 10.6-ounce (250-gram) or larger fish.*



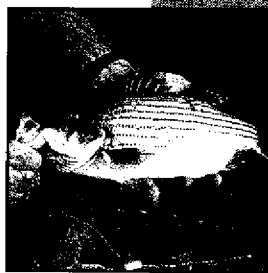
Most cultured hybrid striped bass that are sold to conventional seafood markets and restaurants weigh 0.68 kilograms (1.5 pounds) or more. Fish more than 1.40 kilograms (3 pounds) may not sell as well as the smaller fish because they are the same size as some wild fish. The majority of cultured fresh fish are sold whole (in the round) on ice to assure high quality and extended shelf life. Fish iced immediately following harvest can spend 12 days on the shelf before any detectable change in taste occurs. Growers can harvest and ship cultured fish the same day.

Some states require special labeling to distinguish cultured hybrid striped bass from wild-caught striped bass. If sold whole, hybrids may not require labeling because their unique meristic characteristics allow wholesalers and enforcement personnel to distinguish them from striped bass. Wholesalers receive hybrid striped bass in-the-round or gutted.

Cultured hybrids can be sold to live-fish markets, fresh fish markets, restaurants, private clubs, gourmet specialty stores, catering companies, supermarkets and other institutional markets. However, 61 percent of all U.S. seafood consumption occurs in restaurants, and most hybrids are sold into this market.

Traditional striped bass markets exist in the Northeast for large fillets and in the South for pan-size fish. The central market centers, such as New York, Baltimore, Philadelphia, Boston and Washington, distribute most of the wild striped bass supplied by commercial fishing, and they remain the best markets for cultured hybrid striped bass. All producers should strive to increase the market base for their product.

The economic feasibility of developing a hybrid grow-out industry depends on: 1) sufficient demand to establish and maintain a price attractive to culturists, 2) further refinements in culture techniques, 3) reducing the costs and uncertainty about availability of broodstock and fingerlings, and 4) the skill and competence of the farm manager.



Potential culturists must develop expectations about production and facility costs and revenue returns. Budget estimates presented here are based on actual farm-pond operations in North Carolina. The values used for any one variable represent the best value available using data from several farms. The National Coastal Resources Research and Development Institute supported research on a commercial-scale farm to obtain economic data.

The budgets presented in Tables 2 and 3 are for new enterprises. They assume that all of the inputs to the farm will be purchased new. Thus, the budgets presented are full costs.

The budgets assume that all financing for capital construction and operating costs will come from the owner's equity and a loan. Assume the business needs approximately $1 million to cover capital construction and operating costs for an 80-acre farm that includes 60 acres of water. If the owner contributes one-fourth ($250,000) of the start-up costs, he will need to secure a bank loan for $750,000. Financed at 11 percent for 20 years, such a loan will yield a capital expense of $94,182 a year.

This farming operation uses two sizes of levee ponds to raise fingerlings to market size. The five fingerling ponds are 3 acres each and the eight grow-out ponds are 5.6 acres each. The budgets assume that the fingerlings will be purchased.

Table 4 lists the capital construction and equipment requirements and costs for the 80-acre farm. Land costs $1,000 per acre and is the largest budget item. Miscellaneous equipment includes a side-mount mower, disk harrow, lime spreader and front-end loader. These items could be leased or the tasks which require their use could be contracted.

Table 5 also presents the construction parameters for the ponds. The table shows the items in the capital budget that vary with pond size. The length of the water pipe needed for 60 acres of water was estimated from a pond layout with a

## First-year Production Cost Estimates And Returns Per Acre

| *Category* | *Unit* | *Price Or Cost/Unit* | *Quantity* | *Total Cost-Value of Ponds* | *Value Or Cost Per Lbs.* | *Value Or Cost Per Acre* |
|---|---|---|---|---|---|---|
| A. Gross receipts | | | | | | |
| production/HSB | lbs. | $0.00 | 0 | $0 | $0.00 | $0 |
| Total | | | | $0 | $0.00 | $0 |
| B. Variable costs | | | | | | |
| Fingerlings | each | $0.20 | 195,000 | $39,000 | $0.71 | $2,600 |
| Feed | lbs | $0.26 | 136,744 | $35,553 | $0.65 | $2,370 |
| Chemicals | acre | $30.00 | 15 | $450 | $0.01 | $30 |
| Fuel | acre | $226.00 | 15 | $3,390 | $0.06 | $226 |
| Electricity | acre | $100.00 | 15 | $1,500 | $0.03 | $100 |
| Total variable costs | | | | $79,893 | $1.46 | $5,326 |
| C. Returns to land labor, capital machinery, overhead and management | | | | ($79,893) | ($1.46) | ($5,326) |
| D. Capital costs | | | | | | |
| Total interest charge | farm | $94,182 | 1 | $94,182 | $1.72 | $6,279 |
| E. Return to land labor, capital machinery, overhead and management | | | | ($174,075) | ($3.18) | ($11,605) |
| F. Ownership costs | | | | | | |
| Insurance | farm | $1,500 | 1 | $1,500 | $0.03 | $100 |
| Utilities | farm | $1,500 | 1 | $1,500 | $0.03 | $100 |
| Maintenance | | | | $7,672 | $0.14 | $511 |
| Depreciation | | | | $16,557 | $0.30 | $1,104 |
| Property and payroll taxes | | | | $5,272 | $0.10 | $351 |
| Total ownership costs | | | | $31,001 | $0.57 | $2,167 |
| G. Return to labor and management | | | | ($205,076) | ($3.75) | ($13,772) |
| H. Labor costs: | | | | | | |
| Manager salary | | | | $30,000 | $0.55 | $2,000 |
| Hourly wages | hour | $6.00 | 0 | $0 | $0.00 | $0 |
| Total labor costs | | | | $30,000 | $0.55 | $2,000 |
| I. Returns to management | | | | ($235,076) | ($4.30) | ($15,772) |
| Breakeven price, cash | | | | | $1.46 | |
| Breakeven price, all | | | | | $4.30 | |

Based on 15 acres stocked at 13,000 fish /acre. Assumed survival = 85 percent; mean weight = 150 g

## Second-year Production Cost Estimates And Returns Per Acre

| *Category* | *Unit* | *Price Or Cost/Unit* | *Quantity* | *Total Cost-Value of Ponds* | *Value Or Cost Per Lbs.* | *Value Or Cost Per Acre* |
|---|---|---|---|---|---|---|
| A. Gross receipts | | | | | | |
| production/HSB | lbs. | $2.50 | 202,381 | $505,952 | | |
| Total | | | | $505,952 | $2.50 | $8,433 |
| B. Variable costs | | | | | | |
| Fingerlings | each | $0.20 | 195,000 | $39,000 | $0.19 | $650 |
| First year feed | lbs | $0.26 | 136,744 | $35,553 | $0.18 | $593 |
| Second year feed | | $0.20 | 323,809 | $64,762 | $0.32 | $1,079 |
| Chemicals | acre | $20.00 | 60 | $1,200 | $0.01 | $80 |
| Fuel | acre | $226.00 | 60 | $13,560 | $0.07 | $904 |
| Electricity | acre | $77.00 | 60 | $4,620 | $0.02 | $308 |
| Total variable costs | | | | $158,695 | $0.78 | $3,614 |
| C. Returns to land labor, capital machinery, overhead and management | | | | $347,257 | $1.72 | $4,819 |
| D. Capital costs | | | | | | |
| Total interest charge | farm | $94,182 | 1 | $94,182 | $0.47 | $1,570 |
| E. Return to land labor, capital machinery, overhead and management | | | | $253,075 | $1.25 | $3,249 |
| F. Ownership costs | | | | | | |
| Insurance | farm | $1,500 | 1 | $1,500 | $0.01 | $25 |
| Utilities | farm | $1,500 | 1 | $1,500 | $0.01 | $25 |
| Maintenance | | | | $12,700 | $0.06 | $212 |
| Depreciation | | | | $22,860 | $0.11 | $381 |
| Property and payroll taxes | | | | $10,440 | $0.05 | $174 |
| Total ownership costs | | | | $47,500 | $0.23 | $792 |
| G. Return to labor and management | | | | $205,575 | $1.02 | $2,457 |
| H. Labor costs: | | | | | | |
| Manager salary | | | | $30,000 | $0.15 | $500 |
| Hourly wages | hour | $7.00 | 4,000 | $28,000 | $0.14 | $467 |
| Total labor costs | | | | $58,000 | $0.29 | $967 |
| I. Returns to management | | | | $147,575 | $0.73 | $1,491 |
| Breakeven price, cash | | | | | $0.78 | |
| Breakeven price, all | | | | | $1.77 | |

Based on 45 acres production water stocked at 3,683 fish /acre. Assumed survival first year = 85 percent; 2nd year = 81.4 percent. Assumed payroll and property taxes at 18 percent of total labor costs.

| Requirements and costs independent of pond size | | Each | Total |
|---|---|---|---|
| Land | 80 ac | $1,000 | $80,000 |
| Wells | 1 | $40,000 | $40,000 |
| Buildings | 1 | $15,000 | $15,000 |
| Feed storage | 1 | $4,000 | $4,000 |
| Nets | 1 | $5,400 | $5,400 |
| Test equipment | | $1,100 | $1,100 |
| Trucks | 2 | $12,000 | $24,000 |
| Tractors | 4 | $14,000 | $56,000 |
| Feeders | 2 | $3,000 | $6,000 |
| Misc. equipment | | $19,000 | $19,000 |
| PTO-drive pumps | optional | $3,600 | $0 |
| **Total** | | | **$250,500** |

| | |
|---|---|
| No. of ponds | 13 |
| Ft. of levees | 14,600 |
| Cubic yds. earthmoving | 88,000 |
| Ft. water pipes | 2,200 |
| No. valves | 15 |
| No. drainage structures | 13 |
| No. aerators | 17 |

| | | |
|---|---|---|
| Levees | $89,760 | |
| Water pipes | $11,000 | |
| Valves | $3,000 | |
| Drainage structure | $5,200 | |
| Aerators | $59,500 | |
| Electric service | $11,000 | |
| **Subtotal** | | **$179,460** |
| **Total** | | **$429,960** |

2,100-foot long central levee. The number of valves is specified as one per pond plus two per well. One drainage structure and one aerator are needed per pond plus one emergency aerator per four ponds. Once these physical requirements are translated to dollar costs, the total capital costs for construction and equipment are given.

After developing equipment lists and construction costs, determine the costs of depreciation and maintenance. The depreciation charges are straight line with zero salvage values. The maintenance costs are a constant percentage of the new price of each item.

According to standard accounting practices, the operating costs of the farm are divided into fixed and variable costs. Once the farm is producing, fixed costs do not change with the level of output for the facility. Included are the costs of labor, utilities, property and payroll taxes, insurance, maintenance and depreciation. The farm operates with one manager who is paid $30,000 per year. For hired labor, employ one full-time person (50 40-hour weeks) per 30 acres of water per year at an hourly rate of $6. The overhead on wages is 15 percent. Harvesting and sales costs are 15 cents per pound, including temporary labor. Utilities and insurance are a set charge per year. Property taxes are $8 per thousand dollars of improvements and equipment plus $8 per acre of land.

Other costs vary directly with the level of production on the farm. Phase I fingerlings are purchased at a quantity to stock the grow-out ponds at 3,500 to 3,800 fish per acre. Given a first-year survival rate of 85 percent, stock 13,000 Phase I fingerlings per acre. Fingerlings cost 18 cents each plus shipping for a total of 20 cents per fish.

Feed costs depend upon growth, feed conversion and survival rates of the fish. As a basis, use a feed conversion rate of 2.5 pounds of feed per one pound of fish. The first-year survival rate is 85 percent; the second-year rate, 81.4 percent. In the first year of growth, the fish reach a weight of 0.33 pounds; in the second year, 1.5 pounds. The price of feed averages 23 cents the first year; 20 cents, the second year. Second-year production includes operating costs for growing first-year and advanced fingerlings to harvest.

| Projected costs and income | |
|---|---|
| Bank loan | $750,000 |
| *Owner's equity* | *$250,000* |
| Beginning balance | $1,000,000 |
| *Cost of construction and equipment* | *$429,960* |
| Remaining balance | $570,040 |
| *Cost of 1st year operations* | *$235,076* |
| Balance | $334,964 |
| *Cost of 2nd year operations* | *$358,377* |
| Balance | ($23,414) |
| *Sale of first harvest* | *$505,952* |
| Beginning balance year 3 | $482,538 |
| *Cost of 3rd year operations* | *$358,377* |
| Balance | $124,161 |
| *Sale of harvest* | *$505,952* |
| Beginning balance year 4 | $630,113 |
| *Cost of 4th year operations* | *$358,377* |
| Balance | $271,736 |
| *Sale of harvest* | *$505,952* |
| Beginning balance year 5 | $777,688 |

To estimate other annual variable costs, figure chemicals at $30 per acre of water. Fuel costs are $226 for pumping, feeding and mowing per acre of water. Electricity costs $100 per acre of water to run aerators. Harvesting and sales costs are 15 cents per pound of fish. The fixed and variable costs are compiled into first-year and second-year enterprise budgets (Table 2 and 3).

Table 5 shows projected gross profits for the first four years. Once the capital costs are subtracted from total equity, a balance of $52,500 remains to cover costs that may occur before the first harvest. Once the first harvest is sold, the beginning balance of each consecutive year grows by $145,000; no more loans are needed.

To be a fish farmer, you do not need to know all the answers. But you do need to know where to find them. Many information sources are available: federal government, state agencies, universities, the private sector, aquaculture organizations and books and magazines. The information provided is not comprehensive, but a general review of what is available.

**Federal Agencies**

The U.S. Fish and Wildlife Service (FWS) conducts fisheries research in three main areas: fish husbandry, pest control and reservoir ecosystems. Even though FWS focuses primarily on sport fish, much of their information can be applied to aquaculture. For example, FWS studies fish diseases and distributes leaflets that describe symptoms, ways to test for the disease and treatments. These fish disease leaflets are specific for each disease. To obtain them, write: Library, National Fisheries Center (Leetown), Rt. 3, Box 41, Kearneysville, WV 25430. To get an overview of FWS research, purchase a copy of "Progress in Sport Fishery Research" from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

The National Marine Fisheries Service (NMFS) conducts research on marine fish and shellfish. For information, write NMFS, 3300 Whitehaven Parkway, Washington, DC 20240.

The National Sea Grant Program is a part of the National Oceanic and Atmospheric Administration. Sea Grant initiated much of the university-based aquaculture research. To contact Sea Grant, write 1335 East-West Hwy., Silver Spring, MD 20910.

The U.S. Department of Agriculture (USDA) is the prime federal agency for aquaculture information. It has several subdivisions. The Natural Resources Conservation Service (Washington, DC 20250) provides information about pond construction and watershed management. Land-grant universities receive some support for aquaculture research from the Agricultural Research Service and the Cooperative State Research Service (Washington, DC 20250). The Cooperative Extension Service (Washington, DC 20250) helps communicate research information to the extension technical staffs at the land-grant institutions.

The Environmental Protection Agency (U.S. Waterside Mall, Washington, DC 20460) monitors how the draining of ponds and other facilities into navigable waters affects the environment. The Food and Drug Administration (5600 Fishers Lane, Rockville, MD 20852) regulates the chemicals and drugs used to control diseases in food fish and weeds in ponds.

## Other Sources

**State Agencies** — Each state has an agriculture and conservation (possibly named the Wildlife and Fisheries Commission) department that can be helpful to fish farmers.

**Universities** — Many colleges and universities are involved in aquaculture research. Each land-grant institution has an agricultural experimental station. There are now more than 50 in the United States and its territories that focus on aquaculture. For bulletins and publications on aquaculture, contact the Cooperative Extension Service.

**Private Sector** — If they are willing, established fish farmers are one of the best sources of information. They speak from experience.

**Aquaculture Organizations** Aquaculture organizations track the latest technology, meetings and related matters. The World Aquaculture Society holds annual meetings and offers a quarterly journal, newsletter and special publications. Other related organizations include the American Fish Farmers Federation, American Fisheries Society, European Aquacultural Society and Striped Bass Growers Association.

**Books and Magazines** provide an excellent account of aquaculture research and enterprises. *Aquaculture Magazine* offers dates and locations of upcoming meetings, book reviews, research reports and information about private fish farming. Its annual buyers' guide provides a directory of products and services; international, national, regional and state associations; universities offering aquaculture degrees; available diagnostic services; and other related information.