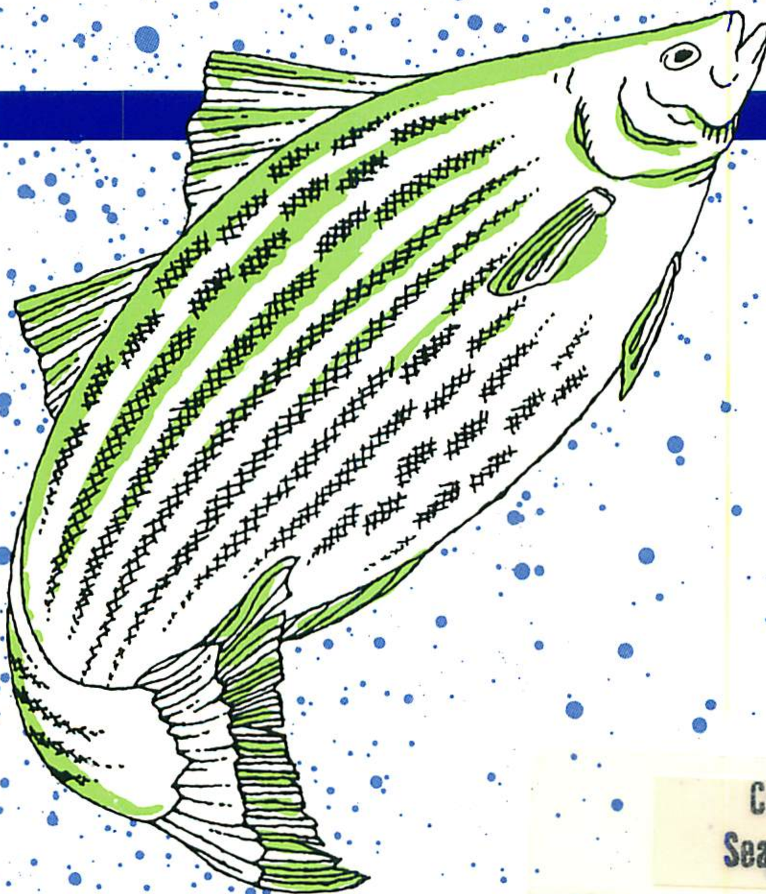

Raising Hybrid Striped Bass In Ponds

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UNC Sea Grant College Program

The National Coastal Resources Research & Development Institute is a federally-chartered agency that funds innovative implementation and demonstration projects that can translate ocean and coastal research into academic-industrial alliances and environmentally and socially compatible economic development throughout the nation's 35 coastal states and territories.

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INTRODUCTION

The hybrid striped bass were developed in the mid 1960s during research being done in South Carolina and North Carolina to spawn striped bass for recreational fishing in inland reservoirs.

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

The "original" cross hybrid striped bass 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 to fingerling size better, was more disease resistant and was hardier than the 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. And Florida biologists subsequently developed "reciprocal" cross hybrids from white bass females and striped bass males. They exhibited the same heterosis 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 production of the hybrids in ponds 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. This project was successful. The first crop of 70,000 pounds was sold during the winter of 1988-89. A second crop of almost 90,000 pounds was sold the next year, and a third crop of approximately 120,000 pounds is ready for market now.

Because of this success, six other hybrid striped bass farms are being developed in North Carolina, and more are expected in the future. In addition, production sites for hybrid striped bass are being located throughout the Southeast, including Virginia, South Carolina, Alabama, Kentucky and Louisiana.

The intent of this manual is to describe the pond production technology for hybrid striped bass 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.

HATCHERY PHASE

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 striped bass and their hybrids have not been domesticated, broodstock must be collected from the wild during their spring spawning run. Methods of collection vary with the species, type of habitat and local laws and regulations. The most commonly used methods are hook and line, gill nets, pound nets and electrofishing.

Hook and line works well for white bass because they can be caught readily and without undue stress. They are hooked in the spring as the schools of fish migrate toward the spawning grounds. This method is also effective for collecting striped bass males because few fish are needed and the stress of capture is less likely to affect their ability to produce viable gametes.

But 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. Females that do survive are often difficult to ovulate, probably because the blood supply to the ovaries was shut down during capture. However, hook and line is frequently the only way private culturists can collect striped bass broodstock. Other methods are restricted by law.

In some areas, gill nets offer an alternative for collecting striped bass. But 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- to 10.2-centimeter (3- to 4-inch) bar-mesh webbing can net striped bass. But 3.2- to 4.5-centimeter (1.25- to 1.75-inch) bar-mesh webbing would be needed for white bass.

In large, open areas, pound nets can be used to take striped bass. Using pounds causes less stress on broodstock. 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 there, female broodfish are not mature enough to ovulate.

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, especially for striped bass females. Frequent handling or unnecessary roughness increases mortality due to stress and inhibits ovulation.

Transport fish in saline water (0.3 to 1.0 percent NaCl or reconstituted sea water) with an antibiotic (Furacin 100 mg/l). Typically, quinaldine (2.0 mg/l) or MS-222 (21 mg/l) is used to sedate the fish. Ice may be added to reduce the water temperature to a range of 61 to 66 F or lower.

Agitators may be used to aerate the water, but pure oxygen supplied through a diffuser system is a better way to keep dissolved oxygen levels above 6 mg/l. For long trips, use agitators along with oxygen to prevent supersaturation of oxygen and to prevent buildup of other dissolved gases.

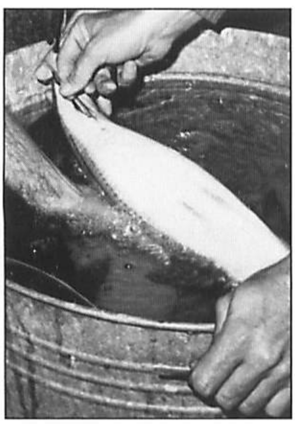
Hormone Injection

Inject human chorionic gonadotropin (HGC) hormone intramuscularly below the dorsal fin to induce final maturation and ovulation of eggs and to enhance sperm production of striped bass and white bass. Other hormones, such as LHRHa, have induced ovulation in female striped bass, but they were not as successful or successful or as easy to use as HCG. Research in this area is continuing. Scientists are developing techniques to increase the percentage of females that ovulate successfully and the number of viable eggs.

HCG is injected intramuscularly below the spinous dorsal fin with a 22-gauge, one-inch needle. Inject striped bass females as soon as possible after capture — either before they are transported or immediately after they arrive at the hatchery.

Female striped bass are given a single injection of 275 to 330 International Units (IU) of hormone per kilogram of body weight (125 to 150 IU/lb) to induce ovulation. For striped bass males, give an HCG injection of 110 to 165 IU per kilogram (50 to 75 IU/lb) of body weight to enhance sperm production.

Excess males need not be injected, but they can be held in 59- to 64-degree F water for later use. White bass males that are held for extended periods may develop acute *Ichthyophthirius* infections. To cure the infection, treat the fish with a solution of 0.1 mg/l malachite green and 75 mg/l formalin six hours a day. It may take several days to cure. If plenty of water is available, the flow rate should be maximized to flush away the spores that could reinfect the fish.



Taking an egg sample from a female striped bass

Take an egg sample 20 to 28 hours after a striped bass female is injected with HCG. It requires 15 to 16 hours before the hormone begins to work. To take a sample, inject 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 into the ovary. When the catheter is removed, place a finger over the end of the tube to create a vacuum to hold the eggs in the tube. Remove the tube quickly if the fish begins struggling to avoid damage to the sphincter muscles. Damage to these muscles allows water to enter the ovary and causes eggs to water harden. Then they can form a plug that will prevent the flow of eggs.

Examine the eggs under a 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. Ovulation, the release of eggs from the ovarian tissues, usually occurs 20 to 50 hours after injection. It depends on water temperature and the initial stage of gonadal maturation. The closer a female is to spawning naturally when collected, the higher the probability that she will 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. Fish whose eggs have begun to clear and are less than 15 hours from spawning are considered eligible. But many fish with mature (approximately 0.75 mm in diameter), but opaque eggs, can be ovulated.

Checking for ovulation in female white bass

White bass females are injected with HCG at 1,100 IU/kg (500 IU/lbs) of body weight to induce ovulation. This quantity exceeds the threshold level for induction of ovulation. But, because no studies have determined the appropriate levels for white bass, culturists inject excess hormone. Depending on water temperatures, female white bass usually ovulate 25 to 50 hours after injection. Eggs samples need not be taken from white bass to determine ovulation. If you do take samples, use a 1.5-millimeter outside diameter catheter and the same testing procedure used for striped bass eggs.

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 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 overripe. Ideally eggs should be stripped immediately after ovulation. But, in practice, it is difficult to determine whether the female is fully or only partially ovulated. Check females two hours before the predicted time of ovulation and repeat every hour until ovulation occurs. Optimally, you should strip the eggs 15 to 30 minutes after the first indication of ovulation. White bass are partial spawners. All of their eggs do not ovulate at once, and you may want to strip them twice — about an hour apart.

Broodfish about to ovulate frequently, but not always, exhibit specific behavioral characteristics. Swimming activity decreases. If left undisturbed, the female will remain stationary in the tank five to six hours prior to ovulation. During the final hour or two, the fish is very lethargic and moves slowly even when netted. When ovulation is imminent, the female will lie still with her head down and tail up. Some physical changes also occur. The abdomen softens as the eggs reach final maturation. The vent dilates slightly and becomes hemorrhagic and distended.


Stripping sperm from a male striped bass

Collection of Eggs

Females and males should be anesthetized with MS-222 or quinaldine 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 or by spraying a concentrated solution of quinaldine directly on the gills (one g/l). But avoid contact between water containing these drugs and the eggs or sperm. The fish may be dipped in clean water and wiped dry with a towel before they are stripped. During this process, cover the female's vent to prevent egg loss.

Wet method for spawning female striped bass

Striped bass females can be spawned by manual stripping or by tank spawning. Use circular fiberglass tanks for tank spawning. The tank should receive a water supply of eight to 10 gallons per minute and maintain a circular velocity of one-third to one-half foot per second around the perimeter.

The tank spawning method can only be used to produce pure striped bass. Female striped bass will not ovulate in the presence of white bass males. To produce hybrid striped bass, eggs and sperm must be manually stripped from the ripe fish into a container. Sperm is stripped from two or more white bass males to fertilize the eggs of one female striped bass.

To fertilize striped bass eggs, use either a wet or dry method. In practice, there appears to be no difference in the success rate of the two methods.

Dry method for spawning female striped bass

For wet fertilization, strip the eggs from the female into a plastic dishpan 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. By using this procedure, urine and drugs may be diluted before contact with eggs, minimizing any deleterious effects.

To dry spawn striped bass females, manually strip

Eggs being stripped from a white bass female

the eggs into a dry, clean container. Keep water from the container until the sperm has been added. The sperm is mixed in thoroughly, and water is added to mobilize the sperm. Fertilization is completed in two minutes.

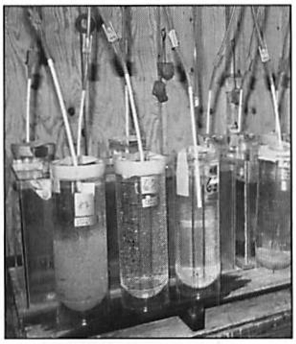
Use the dry method for stripping eggs from white bass females. They have adhesive eggs that must be treated to incubate successfully. To remove the adhesiveness of the eggs, culturists prefer tannic acid. After fertilization is complete, add the eggs to a tannic acid solution (150 mg/l) and aerate vigorously for seven to 12 minutes. To agitate, fill a McDonald jar approximately two thirds full of water. Add the appropriate amount of tannic acid. Add the eggs, and then place a weighted air stone in the jar to stir and separate them. But do not keep the eggs in the tannic acid solution too long. It may harden the chorion and inhibit hatching.

Incubation of Eggs and Larvae

After excess water is decanted from the fertilized eggs, pour the eggs into a calibrated cup.

To determine quantity, figure 100,000 striped bass eggs equals 150 milliliters. 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 eggs. Optimum water flow rate is .4 to 1.1 liters (0.1-0.3 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.

Newly hatched larvae swim up and are carried out of the jars by the upwelling water currents and into holding aquaria placed under the lip of the hatching jar.



Series of McDonald jars with incubating eggs

These aquaria may be 70 liters or larger, depending on the number of larvae produced. Water flowing into the aquaria is adjusted to provide total water exchange every hour and to keep larvae in motion. 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 to prevent impingement of the larvae on the screen.

Eggs may also be incubated in 18- to 24-inch diameter cones with a center standpipe covered with a fine mesh screen. 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 that are retained by fine mesh screens. After the eggs hatch, the larvae remain in the cones.

The water temperature for egg incubation should be similar to the broodstock holding tanks, ranging from 61 to 68 F. Aerated well water is preferred because temperature variation is minimal. The incubation period varies inversely with water temperature. At 61 to 68 F, incubation ranges from 40 to 48 hours.

Two hours after fertilization, determine the percent fertilization by counting the number of eggs with uniformly cleaving cells. Unfertilized eggs will show no sign of cell division, and some cells will exhibit asymmetrical cleavage. These eggs are not viable and will die after 12 to 24 hours.

After four hours, an estimate of total number of eggs can be determined volumetrically by letting the eggs settle to the bottom of a calibrated jar. To calculate the number of eggs per milliliter, count the number of eggs in a small subsample. The size of the eggs will vary after water hardening due to differences in water quality. Striped bass eggs measure 200 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 without mineral.

A hatch rate of 50 percent is acceptable; 60 to 80 percent, good. The larvae are held in 114- to 284-liter (30- to 75-gallon) aquaria or cones before stocking them into ponds. To determine hatching success, count the number of larvae in a series of random samples of known volume and average the number counted. The number per milliliter can then be extrapolated to the total volume of the tank. To take a sample, stir the water to assure uniform distribution, then dip up a 40-milliliter sample with a small beaker. Some culturists take samples from several predetermined places in the tank rather than stir the larvae. For this method, use a glass tube to take a 40-milliliter sample. Place the sample in a white cup, and count the larvae as they are poured from the cup into a container such as a plastic dishpan. 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 projecting behind the head. Four to eight days after hatching, the mouth parts develop and the larvae begin to feed. Stock larvae into fertilized ponds two to 10 days after hatching. If larvae are held more than five days, provide live food such as newly-hatched brine shrimp nauplii or wild-caught copepod nauplii and cladocerans. Larvae should be fed every three hours if they are held in tanks before being stocked in ponds.

Larvae may be transported one to two days after hatching. It is better to transport at this age than four to five days after hatching. Mortality is decreased. Larvae are concentrated in the aquarium and then dipped and placed into plastic bags. Place 7.6 liters (2 gallons) of water and 80,000 to 100,000 larvae in each bag. Sit the bag in a Styrofoam container. Fill the bags with oxygen and close them. Larvae can survive in these containers for 48 hours, but density should be reduced if they are going to be held for more than 24 hours. Direct sunlight should be avoided, and the water temperature should be held between 59 and 64 F. Blue ice may be placed under the plastic bag to help maintain acceptable temperatures.

Stock larvae into fertilized ponds at night because exposure to ultraviolet light may kill them. Float the bags of fry in the pond for 30 minutes to equalize the temperature. After the bags are opened, periodically add small amounts of pond water for the next 10 to 20 minutes so that the larvae can adjust to differences in water quality.

FINGERLING PRODUCTION

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 later.) Thus far, private culturists have not used intensive culture methods, such as recirculating systems, because fingerling survival is too low to justify their use.

Pond Preparation

Fill nursery ponds about two weeks prior to stocking larvae. Ponds filled too early will develop large populations of predaceous insects that will eat the small larvae. Most hatcheries use fresh water, but some pump brackish water [up to 5 g/liter (ppt)]. Hatcheries that use brackish water or hard fresh water (more than 100 ppm Ca 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 then if necessary.

Fingerling success depends on the presence of adequate populations of crustacean zooplankton 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 need to be inoculated. However, new ponds or ponds filled with well water may be inoculated 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. Introduce one-eighth to one-fourth the volume of the new pond. If you haul in pond water, a few thousand gallons would be the most that could be feasibly transported.

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. Inorganic fertilizers often produce dense phytoplankton blooms that tend to cause high pH's, oxygen depletion and/or dominant blue-green algae 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, Bermuda hay and alfalfa pellets. They decay slowly and provide essential nutrients, such as carbon, nitrogen and phosphorus, for primary production of phytoplankton and secondary production of zooplankton. Organic fertilizers should be high in crude protein to support large numbers of crustacean zooplankters and to produce large fish . 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.

Inorganic fertilizers commonly used include ammonium nitrate (52 percent N) and phosphoric acid (32 percent P_2O_2). These fertilizers are available in liquid and granular form. But the liquids are preferred because they are easier to apply and work more rapidly. Diammonium phosphate and superphosphate, two recommended liquid fertilizers, are applied at a rate of 25 pounds per acre. But if the water has a hardness greater than 200 mg/l, the fertilizer rate should be doubled to 50 pounds per acre. Inorganic fertilizers should contain nitrogen to enhance bacterial growth, which subsequently increases decomposition of the organic fertilizers. They should also contain adequate amounts of phosphorus in soluble form to allow rapid uptake by phytoplankton and to minimize sediment absorption or chelation into unusable inorganic complexes. Fertilizers should be well mixed with water and dispersed evenly over the pond surface to maximize distribution of nitrogen and phosphorus.

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

Table 1

Schedule for pond fertilizer appplication rates.

	Organic	Inorganic
2 weeks prior to stocking	~200-500 lbs/ac 1 time/wk	~25 lbs/ac 3 times/wk
POND STOCKED		
Week 1	—	~25 lbs/ac 2 times/wk
Week 2	—	~25 lbs/ac 2 times/wk
Week 3	~25 lbs/ac 1 time/wk	~25 lbs/ac 2 times/wk

Stocking Rate

Stock larvae at a rate of 150,000 to 250,000 larvae/acre (250,000 to 500,000 larvae/hectare). 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 zooplankters are subjected to fish predation, cladocerans and copepods decrease and rotifers and protozoans increase. For proper management of nursery ponds, keep crustacean zooplankter populations as high as possible.

If 45 percent of your striped bass female x white bass male crosses survive to be fingerlings, you have done well. Fifteen to 20 percent survival is typical for white bass female x striped bass male crosses because of the difficulty in maintaining a rotifer bloom. 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 approximately 25 millimeters long (approximately 21 days old). The particle size of prepared food is critical to successful transition. Use mash or #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 survival of larvae and is administered at 20 percent of body weight per day. Feed the fish increasing amounts of food as they grow and their acceptance of it increases. Food particle size is increased as fish grow, but it is better to err on the small side than on the large side. Offer food daily with the frequency (1 to 3 times per day) depending on the amount of natural zooplankton in the pond.

Harvesting

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

Improper or poor grading can leave a culturist with 10 to 15 percent runts and a large variation in size of fish at the end of the first year of growth. 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 ones that are trained to eat pelleted feed.

Fingerling feed should contain at least 45 to 50 percent protein, fish oil or whole-processed fish and be a size that is easily consumed by the fish. Number 1 or 2 crumbles are usually satisfactory for fingerlings. Salmon starter (45 to 50 percent protein) is commonly used.

Cannibalism is prevalent at this stage but can be minimized by grading. Losses of 50 percent or more can occur in one to two weeks if fingerlings are not graded frequently. Cannibalism is prevalent because of the size variation that develops as some fingerlings grow faster than others. The larger fish are naturally inclined to eat smaller fish. Fast-growing fish should be graded out before they learn to cannibalize. Once trained to take pelleted food, fish are ready to be stocked into ponds.

Transport

Fingerlings are available for purchase from mid-May to mid-July, depending on the location of the producer. They are transported to fish farms in specially designed, insulated hauling tanks. The hauling media consists of a one percent salt solution (NaCl or reconstitued sea water may be used), an appropriate antibiotic and an anesthetic (MS 222 at 20 mg/l). The salt helps the fish with osmoregulation, and the anesthetic slows down metabolism to reduce the chance of injury and shock.

Oxygen levels are maintained by bubbling pure oxygen through air stones or similar devices. Although oxygen levels usually remain high, problems may occur with carbon dioxide buildup on long hauls. Agitators are sometimes used 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 g/l (0.5 lbs/gal) for short trips (one to four hours), 40 g/l (0.33 lbs/gal) for medium-length trips (four to eight hours) and 30 g/l (0.25 lbs/gal) for long hauls (over 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. Let 30 minutes lapse after the last addition of water before removing the fish. Most hauling tanks are designed for quick release. But if the fish must be netted, use a soft dip net, take small numbers of fish per dip and treat the fish gently.

FOOD FISH PRODUCTION

Grow-out can be accomplished in a variety of culture systems. These systems can be categorized into 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


Pool culture

Circular pools and raceways make excellent culture systems for hybrids. 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. Also, biological problems related to high density culture require research. How crowding affects growth rate, stress resistance and disease are unknown.

Pools and raceways may be useful when large volumes of water are available at low costs, such as at power plants or where artesian wells exist. When using these systems, liquid oxygen injection or other means of aeration may be required to maintain water quality. Because of these requirements, production costs will probably be higher than in pond or cage culture.

Cages/Net Pens

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.

Ponds

Carefully choose a pond site. Select a site that:

- is not subject to periodic flooding,

- can be easily drained,
- has an adequate supply of suitable quality water,
- has impermeable soil (such as clay), and
- does not have high levels of chemical residue in the soil.

The topography of the site is also an important consideration. Pond construction on flat land requires less moving of dirt than building on hilly or rolling land.

Once a site is selected, plan to use 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 how large the farm is and the pond shape desired. For fingerling ponds, two to four acres is recommended; five to 10 acres is needed for grow-out ponds. Base your pond size on the cost of construction and ease of site management.

The water quality in smaller ponds is easier to manage, and the fish are easier to harvest. But the cost of construction is greater for small ponds because more pumping equipment must be used. 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 at least 16 to 20 feet wide. Levees with top widths that are too narrow erode. Maximum pond depth should measure 5 to 6 feet at the toe of the slope at the deepest end of the pond. The pond bottom must be flat and free of all roots, stumps and debris to allow for seining.

The steepness of the levee slope will depend on the soil type. For most soil types, a 3:1 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 4:1 is recommended because erosion is greater in large ponds.

Construction can be done by bulldozers, but tractor-pulled pans give the best compaction and are the most cost efficient way to build ponds. Ponds should drain by gravitational flow. The slope should be .01 to 0.2 feet per 100 linear feet. There are several types of drainage systems that can be installed in the pond. But regardless of the pond size, the drain pipe must allow the pond to empty in a minimum of seven days.

Pond Production of Food Fish

Hybrid striped bass are a desirable food substitute for the declining striped bass. As a food fish, the hybrid 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, prices increased and culturists examined the potential for producing hybrid striped bass for food. Aquaculturists found the hybrids 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.

You can buy fingerlings from private producers from May through early July. If you plan to purchase some, contact producers in advance of the season because supplies can be limited. It takes 18 months or two growing seasons to grow a 0.035-ounce (1 gram) fingerling to a market size of 1.5 pounds or larger in a pond.

Production of Phase II Fingerlings

Stock fingerling ponds with fish of uniform size (0.035 oz or larger). Fish smaller than 0.035 ounces can not be effectively graded to remove fast growing fish.

Feeding crumbles to fingerling hybrids

Grading with a bar grader reduces losses due to cannibalism and reduces size variation at the end of the first growing season. These two factors are responsible for most of the 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 8,000 to 12,000 fish per acre. Two- to four-acre ponds are recommended for commercial production. Initially feed fish a commercial trout feed (45 to 50 percent protein) three times a day at a rate of 15 to 30 percent of the body weight per day.

After several weeks, the fish are large enough to take a small pellet (3/32nd of an inch). And now that the fish's protein requirements are decreasing, switch to a 38-percent protein trout feed. Reduce the feeding frequency to twice a day. And gradually taper the amount of feed to 3 to 5 percent of body weight per day by the end of the growing season.

Sample the fish biweekly or monthly by seining 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 0.25 to 0.50 poundss (113 to 225 grams). Fish that are 0.25 pounds or larger should reach marketable size (1.5 lbs) in the second year. Expect survival rates of 85 percent at the end of the first growing season.

If you did not start with graded fingerlings, it will be obvious now. Ten to 20 percent of the fingerlings may be stunted if you bought small (less than 0.035 oz) or ungraded fish. The runts weigh less than 1.4 ounces each. 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.

Harvest phase II fingerlings after the growing season

Harvesting advanced (phase II) hybrid striped bass fingerlings

ends, usually in December when pond temperatures drop below 60 F (12 C), and continue through March. Handling hybrid striped bass at temperatures above 60 F increases the likelihood of fungus and disease problems, especially when brackish water is not available.

To harvest, reduce the water level in the pond to a depth of 2.5 to 3 feet. Drag the pond with a large seine that has a large holding net, or live car, attached to it. After seining, detach the live car and position it in the pond to remove the fish.

Before moving the fish to another pond or raceway, estimate the number of fish by weighing several samples of a known number of fish. The other fish are weighed as they are moved, and their numbers are based on the sample weights. Weigh the fish in water to reduce stress.

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 then 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 harvesting is completed, the total number of fish in each pond can be estimated based on weight.

Phase II fingerlings should be graded before being stocked into grow-out ponds. Grading reduces the size variation in each pond which in turn will improve feed conversion ratios. No defined grading technique exists for advanced fingerlings. But you can try one of the mechanical grading devices used in trout and salmon culture. It may also be possible to place the advanced fingerlings in raceways and use bar graders. Each culturist should work out his/her own method.

Production of Food Fish

Tractor-powered blower for feeding fish in ponds

Floating electric paddlewheel

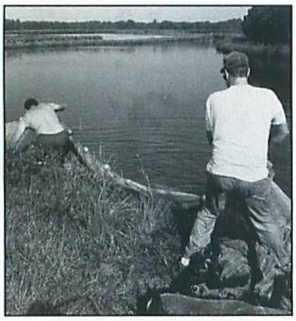
Stock fingerlings [.25 to .50 lbs (113 to 225 grams)] into grow-out ponds at a density of 3,000 to 4,000 fish per acre. With proper management, these fish will reach a marketable size of 1.5 pounds (680 grams) by October or November. Survival rates for the second growing season exceed 90 percent unless fish die due to oxygen stress or disease.

Feed the fish a commercial trout feed with at least 38 percent protein at a rate of 1 to 3 percent of the body weight per day. In spring, while temperatures are low and dissolved oxygen levels are high, fish can be fed at a rate of 3 percent or more of body weight per day. However, 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 per day. Food conversion ratios of 2:1 are expected during the second year.

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. Use electric or tractor-powered devices. Electric floating paddlewheels should be installed in each pond at a rate of 1 to 2 HP 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 to maintain dissolved oxygen levels above 4 mg/l. Locate paddlewheels at the midpoint of the levees along the long axis of the pond. Tractor-powered aerators, such as paddlewheels and pump sprayers, are used for emergency aeration. One unit for every 3 or 4 ponds is needed.

Optimum growth occurs at 77 to 81 F (25 to 27 C)

Tractor-powered paddlewheel used for emergency aeration



Harvesting hybrids from ponds with seines

and at dissolved oxygen levels above 6 mg/l. Growth slows as dissolved oxygen levels approach 4 mg/l. Some mortality may occur at 1 to 2 mg/l, and all fish will die if levels remain lower than 1 mg/l for very long. Disease problems are more prevalent when fish are stressed by low dissolved oxygen levels. Watch fish for fungus, disease or any other problems, and treat quickly when problems arise.

To harvest market-size fish, lower the pond level to a depth of 2.5 to 3 feet and seine the fish into a holding pen. Transfer the fish using a hydraulic boom with a harvesting basket from the holding pen into a container partially filled with super chilled water. After the fish are stunned by the cold water, weigh and pack them on ice for delivery to a buyer.

Water Quality

Hybrid striped bass survive and grow well in a wide range of water quality variables. But you should strive to maintain good water quality during all phases of production. Monitor temperature and dissolved oxygen levels daily, morning and evening. Use aerators to keep dissolved oxygen levels above 4 mg/l. Maximum growth occurs between 77 and 86 F, although hybrids can survive a temperature range of 39 to 90 F. Below 60 F, feed consumption is reduced and growth slowed.

Dissolved oxygen is important in any culture operation. Hybrids may survive dissolved oxygen levels as low as 1 mg/l for a short time, but these levels are stressful. Dissolved oxygen levels below 4 mg/l 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 of 100 mg/l or above is desirable in culture situations, but fish can survive alkalinity and hardness values of 20 to 30 mg/l. Mortality can be significant when hybrids are handled in water with low alkalinity/hardness levels. Although still unproven, calcium levels appear to be important when handling fish in fresh water.

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 a pH of 2.5.

Ammonia, the principal excretory product of fish, should also be monitored. Concentrations should not exceed 1 mg/l.

DISEASES AND TREATMENTS

Hybrid striped bass culture can be stressful to the fish. Stress encourages infection, and it is second only to hypoxia as a cause of mortality. The best defense against infection is a program of good health management. This translates to a healthy environment, good nutrition and a minimum of 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 (Chondrococcus) columnaris* and is the most frequent bacterial disease of striped bass. It occurs in freshwater ponds and intensive culture systems. *Columnaris* is recognized in its advanced stages by 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 Motile Aeromonas Septicemia (MAS). This disease infects hybrid striped bass in fresh and brackish water. MAS is a bacterial hemorrhagic septicemia that breaks down capillary walls and gives a bloodshot appearance to infected areas. The disease is most 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. MAS is caused by an accumulation of organic materials in the water. This leads to increased bacteria and low oxygen.

Vibriosis is a disease known to 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. Hemorrhages around the bases of the pectoral and anal fins or a bloody discharge from the anal vent are two symptoms. 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 approved drugs for treating diseases in hybrids cultured for food except those that are exempt from licenses because they are safe (e.g., salt).

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

All drugs and chemicals used to control infectious organisms can be toxic to fish if concentrations are too high. For example, 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.

Some recommended treatments for the previously mentioned diseases are given in Table 2. When using copper sulfate as a treatment, remember it is especially toxic in soft water. Do not rely on water hardness staying the same week to week or day to day. Always take an alkalinity reading immediately prior to treatment. If the water has a total hardness of 0 to 49 parts per million, run a bioassay. Determine the toxicity of copper sulfate to the fish under the conditions it will be used. Then administer the proper dose.

Potassium permanganate turns the water a deep

Table 2. Dose and number of treatments for various diseases

Drug	Dose	Treatments	Disease
	alkalinity dose		
Copper Sulfate	0-49 *ppmTH, run bioassay	1	Columnaris Parasites
	50-99 ppmTH, 0.5-0.75 ppm (1.35-2.02 **lbs/ac-ft)	1	
	100-149 ppmTH, 0.75-1.0 ppm (2.02-2.72 lbs/ac-ft)	1	
	150-200 ppmTH, 1.0-2.0 ppm (2.72-5.4 lbs/ac-ft)	1	
	not effective above 200		
Potassium Permanganate	2 ppm (5.4 lbs/ac-ft)	1-2	Columnaris Parasites
Terramycin+	4 grams active ingredient per 100 lbs fish/day	10	Columnaris MAS Vibriosis
Furanace+	3.3-6.7 grams active ingredient/100 lbs food/day	3-5	Columnaris
Sulfamerazine+	5-10 grams per 100 lbs fish/day	10-21	Columnaris MAS Vibriosis

* parts per million total hardness
** pounds per acre-foot
+ administered orally while being fed at 3 percent of body weight daily

wine red. The color changes to dark brown once it breaks down. If a color change occurs in less than 12 hours, repeat the treatment.

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

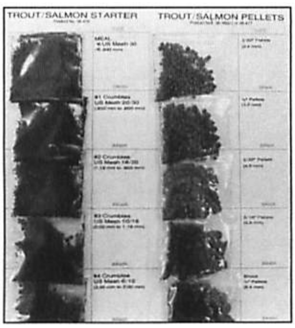
Predation and Other Problems

A significant problem for intensive culture systems is cannibalism. It is prevalent during the transition period from live to prepared food. Unless intensive grading eliminates size differentiation before stocking, losses will occur during and 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. An integrated strategy to bird depredation should be used. This method includes scare techniques, exclusion devices and, if necessary, killing the offending birds. But be sure to get the appropriate permits before killing any predators.

Other predators that should concern culturists are mink, otters, turtles and humans.

NUTRITION



Prepared feeds for fingerlings

The nutritional requirements of hybrid striped bass are poorly understood. Thus far, most research has focused on developing diets for larval striped bass and hybrids. To refine the food production of hybrid striped bass, advances must be made in the feeding of juveniles.

Post-larvae and juvenile hybrids reared in intensive culture systems are switched 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 feeds containing 45 to 50 percent protein when the fish are small. They switch to a 38-percent protein trout feed when the fish are large enough to take the smallest pellet size. Use the following feeding regime:

#2 crumble — 1 to 5 gram fish,
#3 crumble — 5 to 10 gram fish,
#4 crumble — 10 to 15 gram fish,
3/32-inch pellet — 0.5 to 1.8 oz (15 to 50 gr) fish,
1/8-inch pellet — 1.8 to 2.8 oz (50 to 80 gr) fish,
5/32-inch pellet — 2.8 to 10.6 oz (80 to 300 gr) fish,
3/16-inch pellet — 10.6 oz (300 gr) or larger fish.

PROCESSING AND MARKETING


Hybrids boxed for market

Most cultured hybrid striped bass that are sold to conventional seafood markets and restaurants weigh 1.5 pounds or more. Cultured fresh fish are sold whole, gutted or dressed and on ice to assure high quality and extended shelf life. If the fish are iced immediately following harvest, the shelf life is 12 days. Cultured fish can be harvested and shipped the same day.

Special labeling is required in some states to distinguish cultured hybrid striped bass from illegally obtained fish. If sold whole, hybrids may not require labeling because their unique meristic characteristics allow wholesalers to easily distinguish them from striped bass. Wholesalers prefer to receive hybrid striped bass whole, in-the-round or gutted.

Regulatory constraints have been imposed on the commercial capture and sale of striped bass in some states and these may apply to the sale of cultured hybrid striped bass. However, these constraints are disappearing as regulatory and enforcement agencies become better informed about aquaculture products .

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 is in restaurants.

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, distributed most of the striped bass supplied by the commercial fisheries.

ECONOMICS

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, and 3) reducing the costs and uncertainty about availability of broodstock and fingerlings.

Potential culturists must develop expectations about production and facility costs and revenue expectations. Budget estimates presented here are based on a farm pond operation in North Carolina. The project was supported by the National Coastal Resources Research and Development Institute to obtain economic data from a commercial farm.

The enterprise budgets presented in Tables 3 and 4 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. Let's assume the business needs $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 $94,181.73 a year.

This farming operation uses two sizes of levee ponds to raise fingerlings to market size. The six fingerling ponds are 2.5 acres each and the six grow-out ponds are 7.5 acres each. The budgets assume that the fingerlings will be purchased.

Table 5 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,

Table 3. 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 Lb.	Value Or Cost Per Acre	Your Estimate
1. Gross receipts from production/hybrid striped bass	lbs	$0.00	0	$0.00			
Total				$0.00	$0.00	$0.00	______
2. Variable Costs							
Fingerlings (0.035 oz)	each	$0.21	150,000	$31,500.00	$0.60	$2,100.00	______
Feed, 45% & 38% protein	lbs	$0.23	111,116	$25,556.74	$0.48	$1,703.78	______
Chemicals	acre	$20.00	15	$300.00	$0.01	$20.00	______
Fuel (pumping, feeding & mowing)	acre	$226.50	15	$3,397.50	$0.06	$226.50	______
Electricity (aeration)	acre	$77.00	15	$1,155.00	$0.02	$77.00	______
Total variable costs:				$61,909.24	$1.17	$4,127.28	______
3. Returns to land, labor, capital machinery, overhead and mgt.				($61,909.24)	($1.17)	($4,127.28)	______
4. Capital costs:							
Total interest charge	farm	$94,181.73	1	$94,181.73	$1.78	$6,278.78	______
5. Return to land, labor overhead, and mgt.				($156,090.97)	($2.95)	($10,406.06)	______
6. Ownership costs							
Insurance	farm	$1,500.00	1	$1,500.00	$0.03	$100.00	______
Utilities	farm	$1,500.00	1	$1,500.00	$0.03	$100.00	______
Maintenance				$7,672.00	$0.14	$511.47	______
Depreciation				$16,556.50	$0.31	$1,103.77	______
Property and payroll taxes				$5,272.00	$0.10	$351.47	______
Total ownership costs				$32,500.50	$0.61	$2,166.70	______
7. Return to labor & mgt.				($188,591.47)	($3.56)	($12,572.76)	______
8. Labor costs:							
Hourly wages	hour	$6.00	0	$0.00	$0.00	$0.00	______
9. Returns to mgt.				($188,591.47)	($3.56)	($12,572.76)	______
Breakeven price, cash					$1.17		______
Breakeven price, all					$3.56		______

Based on 15 acres stocked at 10,000 fish per acre.

Table 4. 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 Lb.	Value Or Cost Per Acre	Your Estimate
1. Gross receipts from production/hybrid striped bass	lbs	$3.00	172,125	$516,375.00			
Total				$516,375.00	$3.00	$8,606.25	______
2. Variable Costs							
Fingerlings (0.035 oz)	each	$0.21	150,000	$31,500.00	$0.18	$525.00	______
1st year fingerling feed	lbs	$0.23	111,116	$25,556.74	$0.15	$425.95	______
Advanced fingerling feed	lbs	$0.20	361,463	$72,292.50	$0.42	$1,204.88	______
Chemicals	acre	$20.00	60	$1,200.00	$0.01	$20.00	______
Fuel (pumping, feeding & mowing)	acre	$226.50	60	$13,590.00	$0.08	$226.50	______
Electricity (aeration)	acre	$77.00	60	$4,620.00	$0.03	$77.00	______
Harvesting	lbs	$0.05	172,125	$8,606.25	$0.05	$143.44	______
Sales costs	lbs	$0.15	172,125	$25,818.75	$0.15	$430.31	______
Total variable costs:				$183,184.24	$1.06	$3,053.07	______
3. Returns to land, labor, capital machinery, overhead and mgt.				$333,190.76	$1.94	$5,553.18	______
4. Capital costs:							
Total interest charge	farm	$94,181.73	1	$94,181.73	$0.55	$1,569.70	______
5. Return to land, labor overhead, and mgt.				$239,009.03	$1.39	$3,983.48	______
6. Ownership costs							
Insurance	farm	$1,500.00	1	$1,500.00	$0.01	$25.00	______
Utilities	farm	$1,500.00	1	$1,500.00	$0.01	$25.00	______
Maintenance				$12,700.52	$0.07	$211.68	______
Depreciation				$22,859.90	$0.13	$381.00	______
Property and payroll taxes				$8,152.22	$0.05	$135.87	______
Total ownership costs				$46,712.64	$0.27	$778.54	______
7. Return to labor & mgt.				$192,296.39	$1.12	$3,204.94	______
8. Labor costs:							
Manager Salary				$30,000.00	$0.17	$500.00	
Hourly wages	hour	$6.00	2,000	$12,000.00	$0.07	$200.00	______
Total labor costs				$42,000.00	$0.24	$700.00	______
9. Returns to mgt.				$150,296.39	$0.87	$2,504.94	______
Breakeven price, cash					$1.06		______
Breakeven price, all					$2.13		______

Based on 15 acres stocked at 3.333 fish/acre.

disk harrow, lime-spreader and front-end loader.

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 levees are the length of the water pipe needed for 60 acres of water. The number of valves is specified as one per pond plus two per well. One drainage structure and one aerator

Table 5. Start-up 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	12,000	12,000	
Feed storage	1	11,000	11,000	
Nets		4,000	4,000	
Test equipment		1,800	1,800	
Trucks	1	12,000	12,000	
Tractors	2	15,000	30,000	
Feeders	2	2,500	5,000	
Misc. equipment		19,000	19,000	
PTO-drive pumps	2	3,600	7,200	
Total				$ 222,000

Construction and equipment requirements

No. of ponds	12
Ft. of levees	14,520
Cu. yds. earthmoving	87,120
Ft. water pipes	2,100
No. of valves	16
No. drainage structures	12
No. aerators	14

Total costs of construction and equipment

Levees	$ 87,644	
Water pipes	8,400	
Valves	4,000	
Drainage structure	15,600	
Aerators	35,000	
Electric service	10,910	
Subtotal		$ 161,054
Total		$ 383,054

are needed per pond plus one emergency aerator per seven ponds. Once these physical requirements are translated to dollar costs, the total capital costs for construction and equipment is given.

After the equipment lists and construction costs are developed, the costs of depreciation and maintenance are determined. 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 60 acres of water per year at an hourly rate of $6. The overhead on wages is assumed to be 15 percent. Harvesting costs are estimated at 5 cents per pound, including temporary labor. Utilities and insurance are a set charge per year. Property taxes are calculated at $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. Fingerlings are purchased at a quantity to stock the grow-out ponds at 3,000 fish per acre. Given a first year survival rate of 85 percent, you would need 10,600 fish the first year. Fingerlings cost 20 cents each plus shipping. Thus a figure of 21 cents per fish is used.

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 assumed to be 85 percent; the second-year rate, 90 percent. In the first year of growth, the fish reach a weight of 0.4 pounds; in the

A hybrid at the end of its second growth year

second year, 1.5 pounds. The price of feed averages 23 cents the first year and 20 cents the second year. Second-year production includes operating costs for growing first-year and advanced fingerlings to harvest.

To estimate other annual variable costs, figure chemicals at $20 per acre of water. Fuel costs are $210 for pumping, $14 for feeding and $2.50 for mowing per acre of water. Electricity costs $77 per acre of water to run aerators. Harvesting costs are 5 cents per pound of fish, and costs of sales are 15 cents per pound. The fixed and variable costs are compiled into first-year and second-year enterprise budgets (Table 3 and 4).

Table 6 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.

Table 6. Projected costs and income

Bank loan	$750,000.00
Owner's equity	$250,000.00
Beginning balance	$1,000,000.00
Cost of construction and equipment	$383,054.00
Remaining balance	$616,946.00
Cost of 1st year operations	$193,459.42
Balance	$423,486.58
Cost of 2nd year operations	$370,946.60
Balance	$52,539.98
Sale of 1st harvest	$516,375.00
Beginning balance year 3	$568,914.98
Cost of 3rd year operations	$370,946.60
Balance	$197,968.38
Sale of harvest	$516,375.00
Beginning balance year 4	$714,343.38
Cost of 4th year operations	$370,946.60
Balance	$343,396.78
Sale of harvest	$516,375.00
Beginning balance year 5	$859,771.78

GETTING MORE INFORMATION

To be a fish farmer, you do not need to know all the answers. You only need to know where to find them. Many information sources are available: (1) federal, (2) state, (3) universities, (4) the private sector, (5) aquaculture organizations and (6) 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) (Department of the Interior) conducts fisheries research in three main areas: fish husbandry, pest control and reservoir ecosystems. Even though FWS's main concern is sport fish, most of the information can be applied to aquaculture. For example, the 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, 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) (Department of Commerce) conducts marine research on fish, shrimp, oysters and other crustaceans and mollusks. For information, write the National Marine Fisheries Service, 3300 Whitehaven Parkway, Washington, DC 20240.

The Office of Sea Grant, a part of the National Oceanic and Atmospheric Administration (NOAA) (Department of Commerce), directs the National Sea Grant Program. The Sea Grant Program initiated much of the aquaculture research at colleges and universities. The Office of Sea Grant can be contacted at 1335 East-West

Hwy., Silver Spring, MD 20910.

The U.S. Department of Agriculture (USDA) is the main agency for aquaculture information at the federal level. It has several subdivisions. The Soil Conservation Service (Washington, DC 20250) provides information about pond construction and watershed management. Land-grant institutions receive some support for aquaculture research from the Agricultural Research Service and the Cooperative State Research Service (Washington, DC 20250). The 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, D.C. 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 territories that focus attention on aquaculture. For bulletins and publications on aquaculture, contact the Cooperative Extension Service.

Private Sector Remember that established fish farmers are a valuable information resource who can answer questions that are otherwise hard to find.

Aquaculture Organizations Aquaculture organizations are excellent for keeping up with 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 and Hybrid Bass Producers Association.

Books and Magazines Magazines give an excellent account of aquaculture research and enterprises. Aquaculture Magazine offers dates and locations of coming meetings, a book review, 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; diagnostic services available; and other related information. Newsletters may also be a source for book reviews.

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