# The Culture of Striped Bass and its Hybrids in Cages

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## BACKGROUND

The aquaculture of fish can be conducted either in net pens or in open ponds. One drawback to open-pond culture is that ponds should be designed specifically for aquaculture, and here in Maryland most ponds are not. Instead, they have been designed for watershed conservation, irrigation, livestock watering, or for such recreational purposes as fishing. These ponds usually cannot be adequately drained, or they may have structures (for example, stumps and felled trees) left in their bottoms for enhancing the habitat of largemouth bass and bluegill and other recreational fishes. Harvesting a crop of fish from the open waters of such ponds can be very difficult. Luckily, many of these ponds can still be used for aquaculture through the use of cages or net-pens.

## CAGE CULTURE

A cage, or net-pen, is a structure that encloses a number of fish in a confined area, thus preventing them from ranging freely. Harvest is accomplished by either dipping the fish out of the enclosure or by removing the enclosure itself. Because the fish are confined, they need to be more closely managed than if they ranged freely in an open pond. The management of caged fish—especially striped bass and its hybrids—is explained in this manual. More specific information on cage design and construction can be obtained from the University of Maryland Cooperative Extension Service's Sea Grant Extension Program.

## WHERE STRIPED BASS AND ITS HYBRIDS CAN BE CULTURED

The state of Maryland has recently passed laws that allow the culture of hybrids for commercial ventures, though such ventures are currently restricted to inland systems. Hybrid net-pen culture on the scale that is practiced with salmon sea-pen culture in Maine, Washington and foreign countries, is not legal in the Chesapeake Bay.

While both fresh and brackish water ponds may be used for aquaculture, before you begin growing any fish in Maryland you must first obtain the legally required permits. Your first step here is to contact the Maryland Department of Agriculture to determine what permits are needed and where you can obtain them.

## POND SIZE, DEPTH AND WATER CONDITIONS

Pond size is very important if you are considering a commercial culture operation. Although it is generally unwise to attempt commercial culture in ponds smaller than five acres (lest you encounter problems with insufficient oxygen production in the pond), smaller ponds can still be used for commercial culture if you mechanically aerate the pond to offset the increased likelihood of severe oxygen depletion. With proper management, ponds as small as one-half acre can be used to produce cage-cultured fish, especially if they are intended for personal consumption.

Fish, like people, need oxygen to survive, and the oxygen they breathe is dissolved in the water. The amount of oxygen the water can hold is inversely proportional to temperature. In other words, the cooler the water, the higher the saturation level of oxygen. Warmer water temperatures mean lower saturation levels—and here is where problems arise. As water temperatures increase, so does the metabolism of the fish. And this higher metabolism—whether from feeding, swimming or growth—consumes proportionately more oxygen. If the oxygen levels are low, the fish become stressed, which in turn stimulates their need for more oxygen, thereby further reducing oxygen levels in the pond. Thus for a culture operation to be successful, the higher the oxygen level that can be maintained the better off the fish will be.

How does oxygen get into a pond? Oxygen enters a pond biologically and mechanically. Biologically produced oxygen, oxygen that is produced as a byproduct of plant photosynthesis, is the primary source of dissolved oxygen. With adequate sunlight, plants (both microscopic algae and vascular plants) produce enough oxygen to support animal life in a pond. At night, however, when there is no sunlight, the plants consume oxygen and compete with the fish for the available oxygen in the water. Therefore, oxygen concentrations in the pond follow a 24-hour cycle where they are highest early in the afternoon and lowest before dawn (Figure 1). There is a critical balance between biological oxygen production and biological oxygen consumption or demand (BOD) which is often very difficult to manage.

Mechanical methods provide another means for introducing oxygen into pond water. One such method is natural, another artificial. In the natural method of oxygenation, the oxygen dissolved in water not derived from plants comes from the transfer of atmospheric oxygen through the surface of the pond. This transfer is heightened by wave action—even small waves created by gentle winds cause water to circulate in a pond, which exposes more water to the surface, which in turn allows more oxygen to dissolve. The small currents within a pond fostered and maintained by winds and waves also circulate oxygenated water through the cages themselves. This is why a pond five acres or larger is recommended—such a pond should have enough surface area for adequate oxygen exchange.

Mechanical devices such as paddlewheels, airlift pumps, or diffusers are artificial means of introducing oxygen into a pond; they simply expose more water surface to the atmosphere, thereby allowing a greater rate of transfer of oxygen into the water.

Oxygen is one of the major limiting factors that determine how many pounds of fish can be produced in a given body of water. That is why if you are serious about commerical culture of striped bass or hybrids, one of the first pieces of equipment to purchase is a good quality oxygen meter for monitoring what those levels are.

Keeping oxygen in mind, cages can be placed anywhere in a pond as long as there is enough open water around and under the cage to allow water to circulate. Avoid placing cages side by side so as not to restrict water movement. It is best to have a minimum of one to two cage widths between adjacent cages. The cages can be placed in a long line throughout the pond (Figure 2), grouped together, (Figure 3) or along a floating dock, (Figure 4) for ease of feeding.

Pond depth is another factor important to the success of a culturing venture. In general, the pond should be at least six to seven feet deep, but preferably no deeper than fifteen feet. Deeper ponds should be avoided because they tend to have a high degree of stratification, the layering of

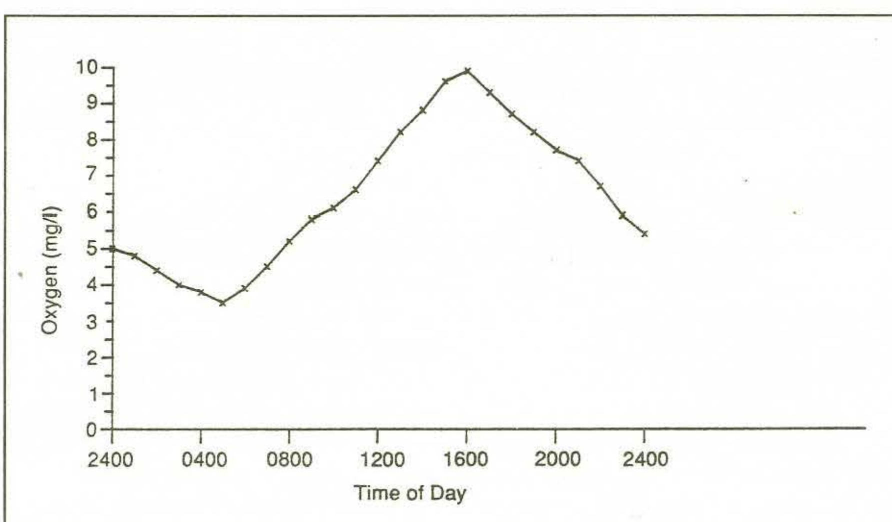
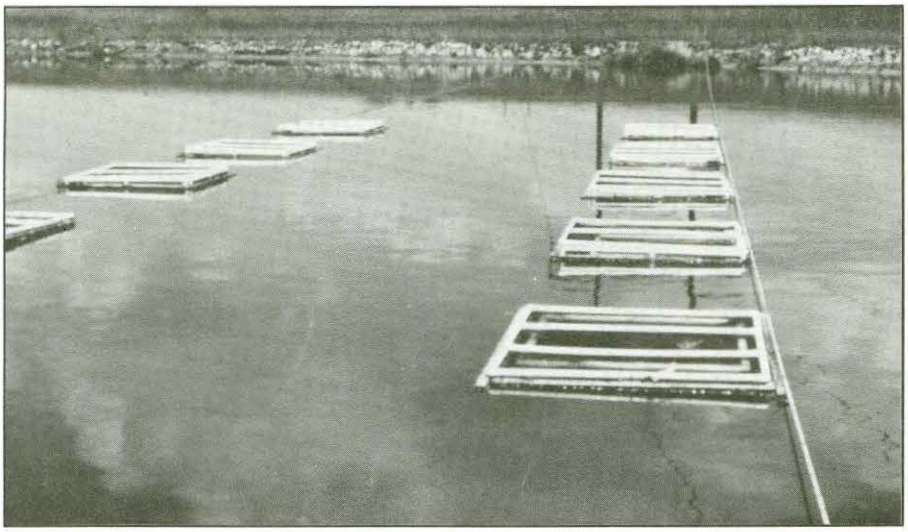
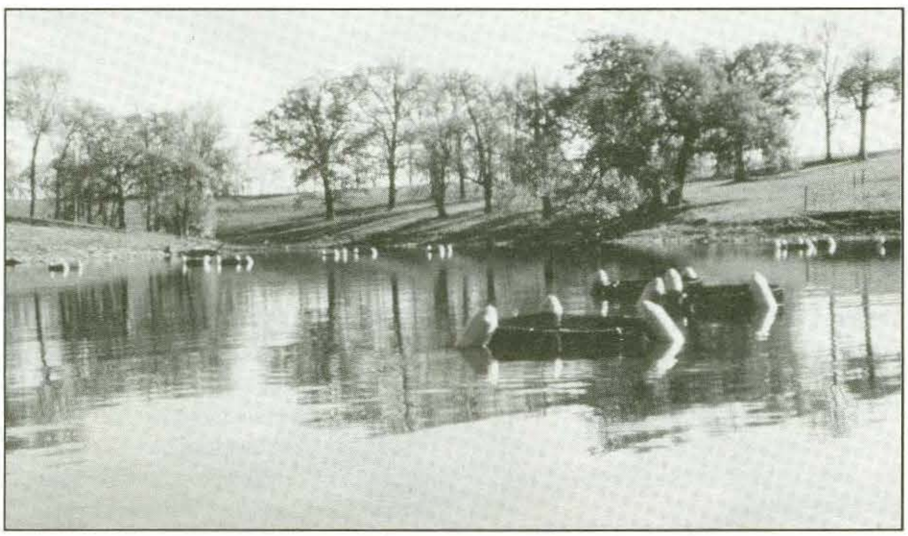



Figure 1. The amount of oxygen in a pond will rise and fall naturally over the course of a day.





Figures 2-4. Examples of cage placement in pond.

warm water over cooler waters. Since cool water is heavier than warm water, it will sink to the pond bottom, establishing a density gradient such that normal wind action on a pond will only circulate the upper warmer portion of the pond, the epilimnion. More often than not, the cooler, deeper layer of water, the hypolimnion, which is separated from the epilimnion by a thermocline (a layer of water where the temperature decreases rapidly), gradually loses its oxygen during the summer (Figure 5). This occurs because of bacterial activity and the lack of exposure of the hypolimnion to the surface of the pond.

If during severe stratification a heavy thunderstorm occurs, the cold rainwater may sink to the pond bottom and displace the bottom unoxygenated water causing the pond to "flip." In this case the entire pond can immediately become so low in oxygen that the fish may die.

To ensure an adequate buffer zone between the caged fish and the pond bottom, where organic material such as metabolic waste products and uneaten food accumulate, a minimum of two feet should be maintained between the bottom of the cage and the bottom of the pond (Figure 6).

The organic material is broken down by bacteria which consume relatively large amounts of oxygen during decomposition. This biological oxygen demand, or BOD, coupled with stratification, is the main reason a pond's bottom is usually low in oxygen. The depth of this low oxygen level is dependent upon many factors, such as temperature, wind action and the amount of organic loading in the pond. Mechanical aeration, such as paddle wheels, helps to alleviate this problem.

With respect to water temperature, striped bass and hybrids require water in the range of 72 to 78° F for optimal growth. Given Maryland's usually hot summers, farm ponds

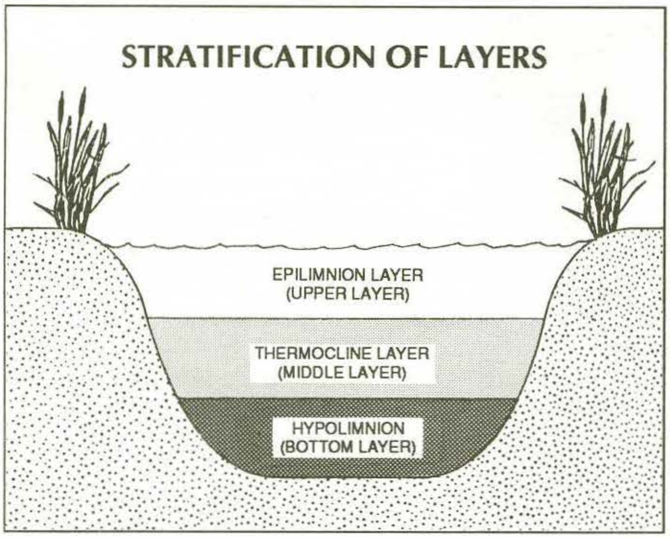



Figure 5. Stratification of layers of pond water.

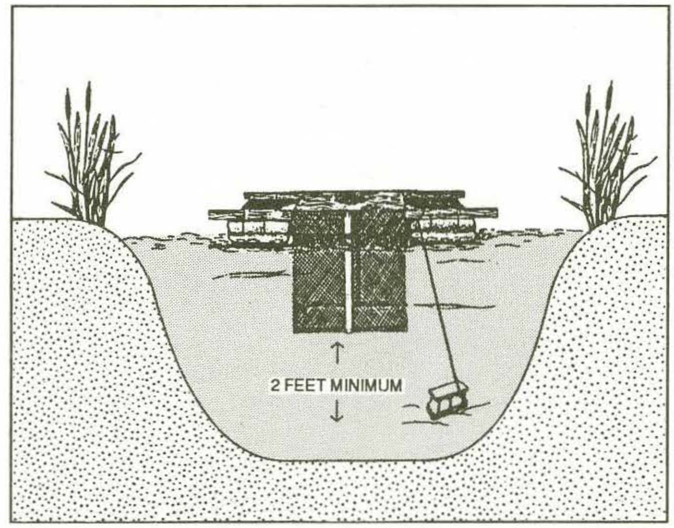



Figure 6. Cage must be a minimum of 2 feet from pond bottom to ensure an adequate buffer zone.

having a small spring that supplies cool water may be better suited for striped bass culture than ponds that do not.

Although an estuarine (salt water) fish, the striped bass and its hybrids do quite well in freshwater ponds. In fact, during preliminary studies conducted in Maryland, fish cultured in cages in freshwater grew and survived only slightly less well than those cultured in brackish water (10-15 parts per thousand salinity).

## WHAT SIZE FISH TO STOCK

Sixteen to twenty-four months are needed for a hybrid or striped bass to reach market size in Maryland. The first year is devoted to fingerling production while the second year is for market growout. When you consider cage culture of striped bass or hybrids, you have basically two options with respect to size at stocking. You may stock phase I fingerlings or phase II fingerlings or yearling fish.

A phase I fish is a fingerling 2 to 3 inches long and about two months old. Obviously a small mesh cage would have to be used to retain this size fish—the smaller the mesh size, however, the more restricted will be the flow of water in and out of the cage. There are several advantages to stocking phase I fish: they are cheaper to buy, they can be stocked at relatively high densities, and excess phase II fish can be sold to keep the growout density compatible with the pond's carrying capacity (maximum number of fish the pond will support). The major disadvantages to stocking phase I fish are higher mortalities and the need to train these fish to accept an artificial diet.

A phase II fish is 6 to 8 inches long, weighs up to one-third of a pound and is generally six to eleven months old. It is best to get these fish in the early spring of the second year so you will not have to overwinter them in your ponds. These fish are generally healthy, readily accept artificial diets, and are unlikely to experience significant mortalities as long as the water is well oxygenated. The major drawback to culturing phase II fish is that they are expensive. After all, someone else has taken the risk and expense of rearing them during the first year.

Generally it is better when first starting out in fish culture to buy the larger phase II fingerlings.

## HOW MANY FISH TO STOCK

Stocking density is related to the carrying capacity of the pond and depends upon many factors, such as size of the fish, feeding rates and whether the fish are in cages or in an open pond. Striped bass and hybrids cannot be stocked as densely in cages as in open ponds because fish in a confined environment use a large amount of oxygen in a limited area. In an open pond the fish can range freely throughout the pond actively seeking the highest oxygen levels. Inside a cage the fish have no option other than to use the oxygen available in that immediate area. And not only are the fish unable to seek the best oxygen level, high densities in cages also increase the fish's metabolism, which in turn increases the oxygen consumption.

As a general rule, an open pond will be able to support between 2,000 and 3,000 pounds per acre of striped bass/hybrids without supplemental mechanical aeration. Cages in the same body of water would generally be able to support a maximum of 1,500 pounds of fish without supplemental aeration.

It is safer, however, to base

stocking density on the amount of feed to be fed the fish at any given time. The reason is that during feeding, the fish's oxygen consumption and metabolic wastes are highest. Also, as previously explained, these metabolic wastes (such as uneaten or undigested food) use a large amount of oxygen in decomposition and breakdown. Therefore, it is better to not "feed a pond" more than 30 pounds of food per acre per day. With supplemental aeration this rate can be increased several-fold, though it is always safer to start low and work up in order to determine the maximum amount a particular pond will be able to support.

To equate this feeding rate approach to numbers of fish, you need to know the maximum feeding rate of the pond without supplemental aeration (given above as 30 pounds per acre), the feeding rate of the fish you're raising (percent of body weight of fish to feed per day) and the final harvest weight. For striped bass and its hybrids, a typical feeding rate is 3% of body weight per day at a typical harvest weight of 1.5 pounds per fish. So, to find the total number of fish to stock, you first calculate the total number of pounds of fish a one-acre pond would support (using formula no. 1).

You then calculate from this number the total number of fish (formula no. 2).

For example, according to formula no. 1, the number of fish that are fed 3% (or 0.03) body weight per day at a maximum of 30 pounds of feed per acre per day is 30 ÷ .03, or 1,000 pounds. For a final harvest weight of 1.5 pounds, according to formula no. 2, the pond should be able to support up to 667 fish per acre, or, 1,000 ÷ 1.5. For a 5-acre pond, that will be 3,333 fish.

Striped bass and hybrids appear to have a lower tolerance for reduced oxygen levels than catfish. For example, under similar conditions, the stocking density within a given cage is different: whereas you may be able to safely stock 8 to 10 catfish per cubic foot in a cage, it is recommended to stock no more than 5 striped bass or hybrids per cubic foot. To determine how many fish to stock in a cage of a given size, use formulas no. 3 and no. 4.

**Formulas for Calculating Stocking Densities**

No. 1
Total pounds of fish in pond = Maximum feed rate ÷ % body weight food consumed

No. 2
Total number of fish = Total pounds of fish ÷ average harvest weight

No. 3a
Volume of square or rectangular cage = Length × width × height

No. 3b
Volume of circular cage = 3.14 × $(\text{diameter})^2$ × height ÷ 4

No. 4
Number of fish per cage = Volume of cage (cu. ft.) × number of fish stocked per cu ft.

No. 5
Weight of the fingerling sample = Total weight — beginning weight

No. 6
Average weight per fingerling = Sample weight (pounds) ÷ number of fish in sample

No. 7
Pounds of fish needed for stocking = Total number needed × average weight sample per fingerling

For example, a square cage that is 4' × 4' × 4' has a volume of 64 cubic feet. If you begin with a stocking density of 5 fish per cubic foot, then the number of fish per cage equals 64 cubic feet times 5 fish per cubic foot, or 320 fish. Just as you begin conservatively with the total amount of food fed per day per acre, it is always better to start small and learn what each cage or pond can support; you can increase the number of fish per cage later. If you wish to find the number of cages required to hold the fish in a 5-acre pond (see previous example), divide 3,333 by 320 fish per cage. This yields 10 cages, each with 320 fish and a few left over.

The size of the cage is limited by logistics of building and harvesting. If you are considering commercial culture you may want to reduce relative expenses and go with larger cages (for example 8' wide × 4' deep × 20' long, which is ten times as large as the 64 cubic foot cage). However, if the pond is big enough to support only 320 fish then it does not make sense to build a cage that will hold several thousand fish.

## GETTING STARTED

Assuming that you have an adequate pond and have already constructed the cage or cages, then you must first determine how many fish your pond will support at your final harvest weight and then obtain fish for stocking. As suggested earlier, it is probably better to begin with phase II or yearling fish. These fish should give you a marketable product by fall of the year and you should not have any major mortality.

Fish suitable for stocking can be obtained commercially from a variety of producers in the United States—a list of suppliers can be obtained from the Sea Grant Extension Office or through various trade magazines.

First you want to check on the health of the fish you purchase: make sure that the fish have been actively feeding before shipment and do not have any obvious lesions or wounds. Also, make sure they are free of discoloration and that they are fairly uniform in color on the top half.

When the fish transport arrives, you will need to sample the fish to determine their average weight. This will help you to determine both the number of pounds of fish you will need to buy to stock to your desired rate and the average weight for feed calculations.

Fill a 5-gallon bucket half full of water; weigh and record this beginning weight. Add a sample of the fish you are buying (1 to 20 pounds) and weigh the bucket with water and fish. Record this as total weight. The weight of the fingerling sample will be the difference between total weight and beginning weight (formula no. 5).

Next, count the fish you place in the bucket. You'll need to know the number of fish in order to calculate the average weight per fingerling (formula no. 6), a value you must have for determining the pounds of fingerlings necessary to fulfill your desired stocking density.

By using forumula no. 7, you can determine how many pounds of fish would be needed to stock a five-acre pond at the maximum rate calculated above for a pond without supplemental aeration: 5,000 pounds, or 3,333 fish averaging 1.5 pounds each at harvest.

In our example we want 3,333 harvestable fish. With each fish weighing 0.22 pounds, the pounds needed for stocking = 3,333 fish × 0.22 pounds per fingerling or 740 pounds.

You cannot haul 740 pounds of fish from a central distribution point to your ponds in five gallon buckets—you will either have to arrange for the fish transport to meet you at your pond site, or have a transport unit large enough to haul the fish from the pickup point to the pond. To do this you should have enough containers (non-toxic wood, metal, or plastic) to hold 740 pounds of fish. Generally you haul one pound of fish per gallon of water, thus you would need close to 850 gallons of water because the fish displace water when they are placed in the containers.

Critical to successful shipment are temperature and oxygen. Fish are best transported in cool water, below 70° F. The container water should be within 5° F of both the fish transport tank and the pond. If it is not within this range, then water from the transport tank should be added slowly to the container until this range is reached. Likewise, if the pond temperature varies from the container tank, pond water should be added until the desired range is achieved. Fish can be hauled only a short distance if the container water is not aerated. The time and distance depends upon the poundage of fish in the containers. At no time should the loading rate of the container exceed the amount of oxygen in the water. Therefore, you must be able to aerate the water in your container or have the fish dealer meet you at your pond site.

If you do have to haul your fish in a container, then add 10 ounces of table salt to every 100 gallons of water to help alleviate stress. Once the fish are in your hauling containers go immediately to your pond and stock them as soon as possible. The fish can be stocked into the cage either by placing them directly into the cage or by dipping them out and putting them into the cage.

## FEEDS AND FEEDING

Caged striped bass or hybrids are totally dependent on you to feed them—since they are confined in cages there is no way for them to get food from the pond. Therefore, you must feed the fish daily with a high quality diet.

There are many factors that can affect the feeding of your fish, including water quality, water temperature, size of feed, palatability or taste, frequency of feeding, the way fish are fed and the type of pellet used. It is essential to monitor the feeding behavior of your fish. If the fish are not feeding (especially when water temperature is over 65° F), that is a general indication something is wrong. Therefore, when feeding caged fish, it is best to feed them by hand instead of by demand or automatic feeders. Because mechanical feeders do not require your presence at the pond, you may have a tendency not to manage the pond effectively.

Fish should be fed at least once a day, preferably twice. Feeding time should be in the morning, around 9:00 a.m., and in the afternoon, around 4:00 p.m. You do not want to feed fish after dark because that is when the oxygen level in the pond is beginning to drop (see Figure 1) and feeding increases the metabolism of the fish. Thus the fish are requiring more oxygen at a time when the available amount of oxygen in the pond is declining. Be consistent in your feeding schedule as changes can disrupt the behavior patterns of the fish.

If fish are being fed only once a day then a floating feed should be used. It has been found in Maryland that when fish are fed twice a day (in waters warmer than 60° F) there is no major difference between floating and sinking food. If you feed twice a day and use both feeds, it is best to use a mixture of about 25:75 of floating to sinking food.

## SUMMARY

The inland culture of striped bass hybrids in Maryland is often best undertaken in cages or net pens since most farm ponds are not well-designed for a culturing operation. Pond size is critical to the successful culturing operation since it relates to the availability of dissolved oxygen, often a limiting factor causing mortalities in otherwise healthy fish. The larger the pond, usually the greater the pool of available oxygen. Aquaculture can be undertaken in smaller ponds if efforts are made to supplementally aerate the water.

The stocking density of striped bass hybrids is dependent on the size of fish stocked, their feeding rate and the final harvest size. The total number of fish to stock is dependent on the cage volume.

Striped bass hybrids should generally be fed twice a day, around 9:00 in the morning and 4:00 in the afternoon. Commercial feeds such as those used for trout and salmon are sufficient for feeding striped bass hybrids, although the development of feeds engineered specifically for hybrids will improve feeding efficiency and thus profitability.

Diseases in striped bass hybrids are usually related to stress; the first sign of onset is often a cessation of feeding. Other symptoms, such as red sores, swollen bellies, or discolorations, should be checked with a fish pathologist.

Striped bass hybrids should be ready for marketing at the end of their second year of growth, although the size fish you sell should depend on the size desired in the market. Markets differ in their requirements and it is wise to first undertake a market survey before determining what size fish to harvest.

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