Hybrid Striped Bass Culture: Status and Perspective

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September 1987
UNC Sea Grant College Publication UNC-SG-87-03

This publication is based on work supported in part by the National Office of Sea Grant, NOAA, under Grant No. NA86AA-D-SG046 to the UNC Sea Grant College, and the North Carolina Department of Administration. The U.S. Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright that may appear hereon.

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Conference Welcome

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Good morning! I have two goals in my opening remarks to you as you begin this conference on culture of the striped bass and hybrid striped bass.

First, I welcome you here on behalf of the university's Sea Grant College Program and the N.C. State University campus. These fine facilities are at your disposal and we trust that they will serve you well for this conference.

Second, I challenge you to search the depths of your knowledge and experience to proclaim the state of the art for culturing the hybrid striped bass. You represent a unique combination of minds from academic research, university extension and private development. It's a combination needed to boost hybrid striped bass from a potential species to commercial reality.

It is intrinsic to the cause of the Sea Grant College Program to realize application of fundamental research and transfer of results. Therefore, I urge you to keep foremost the need to publish the proceedings of this historic conference. We must be able to communicate all that you know to others in an understandable form.

I am convinced that the potential for hybrid striped bass aquaculture development along the Eastern seaboard can be as strong and as prosperous as catfish culture in Mississippi or crawfish in Louisiana. From the time that Howard Kerby first introduced the idea to us, we have supported research designed to develop commercial culture. You are here today to help make hybrid striped bass culture a commercial enterprise. Just as modern agriculture has advanced through research and extension, so shall aquaculture. In the case of striped bass, the future is in your hands. This conference is a milestone along the way.

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INTRODUCTION

On 2-3 December 1986 a workshop on striped bass and hybrid culture (Morone sp) was held at the McKimmon Center at North Carolina State University, Raleigh, N.C. The intent of the workshop was to bring together researchers and culturists from university, government and private agencies who were actively involved in the culture of striped bass and hybrids. Not everyone who met these requirements was present, but a working group of about 30 experts participated in the discussions.

The purpose of the meeting was to summarize the existing data base upon which the industry is being built, discuss the major impediments to the development of the industry, and to recommend research and other actions to stimulate industry development and lead it forward over the next several years.

The culture of striped bass has a long history, beginning around the turn of the century. But the first real emphasis for the development of a food fish industry based on the culture of this species and its hybrids began in the mid-1960s as the result of two major developments. The first was the use of hormones, human chorionic gonadotrophin to induce ovulation in striped bass females. Although striped bass had been spawned in captivity prior to that, the production of fry and fingerlings was unreliable. The use of hormones to induce ovulation greatly enhanced the ability of culturists to consistently produce fry and fingerlings. These products were used almost exclusively in fisheries management programs to enhance declining striped bass populations and develop new recreational fisheries in freshwater reservoirs where striped bass did not exist.

The second development involved the hybridization of striped bass with white bass. This hybrid exhibited hybrid vigor, heterosis, and was quickly accepted and stocked in many parts of the country because of its exceptional qualities as a sport fish. The technology for producing fingerlings of this hybrid spread rapidly throughout state game and fish agencies that were using the fish in recreational fisheries management programs.

Commercial culture of striped bass and the hybrid began in the mid to late 1970s when a few researchers began to examine the production characteristics of striped bass and hybrids with the idea of developing a food fish industry for the species. This effort was stimulated in large part because of declining stocks of striped bass, particularly along the East Coast.

Many state and federal agencies were becoming concerned about these declines and were imposing increasingly stringent restrictions on existing commercial fisheries. Research on utilizing these fish as food focused in North Carolina and South Carolina where the hybrids were first developed and used as recreational species. It quickly became apparent that striped bass and particularly hybrids had excellent potential for aquaculture. However, as interest in the species grew, researchers and culturists around the country, particularly in the Southeast, worked on a number of commercial culture techniques aimed at developing a food fish industry for striped bass and hybrids.

The striped bass and hybrid industry evolved during the 1980s to the point where there are a few fingerling producers in the country, a few culturists producing or attempting to produce fish for the food fish market, and a growing number of researchers and culturists. This interest is sparked in large part because natural populations of striped bass have continued to decline, resulting in elimination of commercial fisheries in many areas. Commercial catches of striped bass have declined from approximately 15 million pounds in 1973 to approximately 1 million pounds or less in 1986. Many culturists think that cultured striped bass and hybrids could fill this void. Because of the increasing demand for seafood products we can expect new and higher priced markets for this cultured species.

The expansion of this industry, like any new industry, depends upon our ability to see problems as they arise and to search for solutions. Now there are major impediments to the development of the industry in almost every phase of the biology of production as well as in marketing, economics and legal restrictions. Although we must seek solutions to all these problems, some are more severe than others and must receive priority in our efforts to solve them. However, the industry itself must be the one to recognize and set the priority for these problems.

EXECUTIVE SUMMARY

The discussions at the workshop and the text of this paper were organized to follow in as much as possible a natural sequence of events in the production of striped bass and hybrids. What follows is a summary of the workshop discussions.

HATCHERY PRODUCTION

Hatchery production of eggs and larvae for the striped bass and hybrid aquaculture industry is generally based on the same technology that state and federal hatchery managers use. This technology is still dependent on collecting ripe broodstock from spawning grounds, transporting them to nearby hatcheries and injecting the fish with human chorionic gonadotrophin to induce ovulation.

Ovulation of a striped bass female usually occurs 25 to 50 hours after injection. The eggs are manually stripped from the female and fertilized with sperm from a white bass or striped bass male which has also been injected with hormone.

These eggs are incubated in McDonald jars at a rate of 100,000 to 200,000 eggs per jar until they hatch (except in the case of Chesapeake Bay stock whose eggs must be incubated in tanks). Survival rate and hatching rate are dependent upon the quality of eggs, but figures in the 60- to 80-percent range are considered good. The eggs hatch in 40 to 48 hours depending upon water temperature (usually 16 to 21 C), and larvae are incubated in tanks for approximately five days when they are ready to begin feeding. Then they should be placed in fertilized ponds or intensive culture systems.

Because of difficulties in obtaining and spawning ripe female striped bass, hybrid cultrists in particular have begun examining the production of hybrids using white bass females and striped bass males. White bass females are more dependably obtained from the wild than striped bass, and they can be cultured and matured in outdoor facilities. The hatchery technology to produce this cross is similar to that used for striped bass. The females are injected with hormones and manually spawned. Sperm from the striped bass male is used to fertilize the eggs. Because white bass eggs are adhesive, the eggs must be treated with tannic acid before they are incubated in McDonald jars.

Development of the hatchery will not require extensive facilities. But site selection is important because an abundance of high quality fresh water is required for the hatchery. Ponds and tanks will be required to hold domesticated broodstock from season to season.

There is unanimous agreement that lack of broodstock is a major constraint to the development of a striped bass and hybrid aquaculture industry. Problems still exist in the capture and spawning of wild-caught females, and laws and regulations pertaining to the collection of wild broodstock by private culturists are highly restrictive. Ultimately the long-term solution most beneficial to the industry would be to develop domesticated broodstock.

Specific recommendations and activities which would most help the industry are: 1) modification of laws and regulations to enhance the private sector's ability to collect broodstock, 2) research to develop better handling and spawning techniques for wild broodstock, 3) seed stock provided to private growers by government hatcheries, and 4) development of domesticated broodstock.

FINGERLING PRODUCTION

Many of the difficulties associated with striped bass and hybrid culture occur during the 45-day fingerling production period. Fingerlings are typically produced by stocking 5-day-old larvae in fertilized ponds at a rate of approximately 200,000 per acre (500,000 per hectare). Survival rates of 25 percent to 50 percent are considered acceptable in the industry. Successful production of fingerlings is dependent upon fertilization techniques aimed at the development of zooplankton populations which provide food for the young fish. A combination of organic and inorganic fertilization, which generally begins two weeks prior to stocking, with supplemental fertilization two weeks after stocking, provides the best results when using larvae from crosses involving a striped bass female.

Larvae from white bass females are much smaller than those from striped bass and therefore require a smaller food item, usually rotifers, at first feeding. Pond fertilization techniques to induce and maintain rotifer populations for production of reciprocal fingerlings (white bass female x striped bass male) are less reliable. Survival of reciprocal larvae to the fingerling stage may vary from 0 to 80 percent, depending upon the rotifer populations in the ponds. Striped bass and hybrids can be readily trained to accept prepared diets at a size of about 25 m (1 inch), and many culturists begin supplemental feeding in the ponds at this time.

Small fingerlings are normally harvested from the pond approximately 45 days after stocking, at which time they are 35 to 50 m long (1 1/2 to 2 inches). These fish may be stocked for fisheries management purposes or trained to feed and sold to culturists interested in growout production. Cannibalism is a serious problem during this stage, and the fish must be graded on a regular basis to prevent losses which can range from 30 to 50 percent.

Five-day-old larvae may also be stocked in intensive culture systems and fed brine shrimp until they can be trained to take prepared foods. Survival to the fingerling stage is usually poor with values of around 10 percent considered good. Problems with swim bladder inflation may cause mortalities of up to 80 percent of the fish in intensive culture systems. A lack of gill development or gill degeneration can also cause substantial mortalities. Poor nutrition is a problem for fish produced in intensive culture systems. The lack of a formulated diet that can be substituted for brine shrimp after the first few days of culture is a major hindrance to intensive striped bass and hybrid culture.

The production of 150 to 200 m (6 to 8 inches) advanced fingerlings is accomplished by restocking small fingerlings into ponds during late June or July where they will remain until the end of the growing season. Stocking densities during this phase of production may be as high as 25,000 per hectare (10,000 per acre). Survival rates of 80 to 85 percent are considered good during this phase of production. These fish are usually fed a high protein trout or salmon diet at a rate of 3 percent to 5 percent of body weight per day.

FOOD FISH PRODUCTION

Growout of striped bass and hybrids can be accomplished in ponds, cages/net pens and raceways/pools in fresh water and brackish environments (0 to 25 parts per thousand). Pond culture may be extensive or intensive depending upon the ability and the resources available to culturists. Extensive practices usually consist of stocking 2,500 to 5,000 advanced fingerlings per hectare (1,000 to 2,000 fish per acre) in late winter. Intensive production of striped bass and hybrids involves stocking up to 10,000 advanced fingerlings per hectare (4,000 fish per acre) during late winter. It is critical that sufficient water and adequate aeration capabilities exist for the intensive culturists.

During the growout phase, striped bass and hybrids are fed a high protein trout or salmon diet at a rate of about 3 percent of body weight per day. Those practicing intensive culture may have to reduce the feeding rate during hot weather. Survival rates are usually over 90 percent although major losses can occur if water quality variables, particularly dissolved oxygen, are allowed to deteriorate during extended periods of high temperatures.

Standing crop at the end of the growing season, can range from 2,550 kilograms per hectare (2,250 pounds per acre) for those using extensive culture practices to approximately 5,700 kilograms per hectare (5,000 pounds per acre) for using those using intensive culture practices. Average weight should be around 0.7 kilograms (1.5 pounds) a size favored by the food fish market. Food conversion values of 1.8 to 2.5 may be expected for fish grown in ponds.

Growout of striped bass and hybrids may also be accomplished in cages/net pens. Advanced fingerlings are stocked at 100 to 200 per cubic meter. Feeding rate, survival and mean weight are similar to those found in pond production systems. Food conversion values of 2 to 1 are not uncommon for a cage/net pen cultured fish.

Striped bass and hybrids may also be cultured in raceways/pools when large volumes of water are available at low cost. Although a couple of groups in the country are using this culture method, more research needs to be done with this system. Feeding rates, feed conversion, survival and mean weight of fish in these systems are generally similar to those reported for other culture methods.

Striped bass and hybrids survive and grow well at a wide range of water quality variables. Advanced fingerlings of striped bass and hybrids will generally survive a temperature range of 4 to 34 C with pond temperatures of 18 to 32 C being considered suitable for rearing. Maximum growth occurs at temperatures around 28 C. Dissolved oxygen levels in culture systems for striped bass and hybrids should remain above 5 mg/l although they may survive levels as low as 1 mg/l for a short time.

Culture of striped bass and hybrids in freshwater systems with hardness values of less than 100 mg/l (contributed mostly by calcium) should be approached with caution because of the greater susceptibility of these fish to stress. The pH of culture systems should be in the range of 7.0 to 9.0 although fish can survive within the general limits of pH 5.5 to 10. The toxicity of ammonia to striped bass and hybrids is not well known although concentration should generally not exceed 1 mg/l in most culture systems. Salinity from 0 to 25 parts per thousand have proved suitable for food fish production of striped bass and hybrids.

Recommended to improve production of striped bass and hybrids for the food fish market include: 1) determine the optimum size, depth, and stocking density for pond growout, 2) determine the relationship between density in cages/net pens and growth rate, 3) evaluate raceway/pool systems for their potential as production systems, 4) develop a better understanding of the nutritional requirements and feeding behavior of this species, and 5) develop ways to handle and grade these fish without causing substantial mortalities.

DISEASES AND TREATMENTS

Several disease problems appear to be routinely encountered in culture of striped bass and hybrids. However, because the industry is in an embryonic stage of development, much of the information on the disease instances is not published. The infectious agents that are commonly found such as *Columnaris Aeromonas Vibrio* and *Amyloodinium*, are not unique to striped bass and hybrids.

Salinity appears to be a significant barrier to the spread of some diseases but many pathogens can affect fish in a wide range of salinities. There are no approved drugs for treating diseases in striped bass and hybrids being cultured for food except those which are exempted from licenses because they are generally regarded as safe (e.g., salt).

A number of medications that are approved for use in other food fish could be used in treating similar diseases in striped bass and hybrids. Licensure of existing agents for use in striped bass and hybrids would be useful, but it would not satisfy the needs of the industry for effective therapeutants. There is a critical need to develop an effective fungicide to replace malachite green and a need for an alternative to copper for the treatment of *Amyloodinium*.

The pharmacology of therapeutants that may be used in treatment of diseased striped bass and hybrids is poorly known. Most of the available information on drug treatments of striped bass and hybrids is based on freshwater systems, yet the efficiency and toxicity of many waterborne treatments are influenced by the concentration of different minerals in salt water.

Activities and research efforts which could increase our ability to treat disease problems in striped bass and hybrid culture are: 1) development of effective legal treatment regimes for the important disease problems facing the industry in the most common cultural situations, 2) make a quantitative determination of disease problems that are most important in the striped bass and hybrid industry, 3) determine how environmental factors affect the metabolism and efficiency of therapeutants and 4) develop standardized methods of disease inspection for interstate transported fish.

NUTRITION

The nutrient requirements of striped bass and hybrids are poorly understood. Much of the work that has been done deals with developing artificial diets for larval striped bass and hybrids because of efforts by culturists to develop intensive culture techniques. Many of the problems in working with prepared diets for larval fish result from the poor acceptance of such feeds.

Larval striped bass and hybrids begin feeding at 4 to 5 days post hatching. Live or frozen brine shrimp nauplii, Artemia, are normally used to feed larval striped bass and hybrids in intensive culture systems because of poor results with prepared foods. High densities of brine shrimp nauplii (100 to 500 nauplii per liter) are normally maintained in intensive systems. Prepared diets are not accepted well by the larvae until day 14 or later. Yolk reserves are exhausted by day 10 and larvae that have not begun feeding by that point will die. However, there is evidence that larvae that do not eat by day 7 may never accept feed and therefore will die because of degenerative changes in body tissues.

Food problems associated with the pond culture of larvae generally center around the inability of culturists to produce zooplankton in sufficient numbers and diversity to supply food for the larvae. This pond management normally involves the use of organic and inorganic fertilizers to stimulate zooplankton blooms although the species and concentrations of zooplankton required are not well known. Required concentrations of zooplankton may be as high as 1,000 to 1,500 organisms per liter, and there is some evidence that the larvae prefer pelagic zooplankton species rather than benthic species.

Specific nutrient requirements for striped bass and hybrid larvae have not been investigated, although it has been recommended that the diet contain no less than 43 percent protein and provide 5,700 calories per gram dry weight. Although prepared diets are not recommended for larvae because of limited acceptability, there is also evidence that brine shrimp may be nutritionally deficient as a diet for larval striped bass and hybrids.

Postlarvae and juveniles of striped bass and hybrids reared in intensive culture systems are usually switched to prepared feeds 12 to 21 days after hatching. This switch is accomplished by presenting a combination of brine shrimp and prepared feeds for 7 to 10 days. Significant mortalities may occur at this stage because of cannibalism and starvation. Fish that survive to 25 millimeters are readily trained to accept prepared feeds, and juveniles harvested from ponds at approximately 45 days post hatch are easily trained to take prepared feed.

Prepared feeds for fingerlings should contain at least 38 percent protein and fish oil or whole processed fish. However, many culturists use trout or salmon feeds which contain 40 to 48 percent protein. Best protein efficiency was found in fish with a 34 percent protein diet with no significant difference in growth of fish fed a 55 percent protein diet.

Nutritional requirements of striped bass broodstock have not been studied. Although some success has been achieved in maturation of cultured striped bass broodstock, egg quality is generally inferior to that of wild-caught fish. These differences may be due to nutritional inadequancies.

Recommended research and activities needed in the area of nutrition are: 1) basic research to determine the nutritional requirements of larvae, 2) development of prepared diets that are accepted by and meet the nutritional needs of striped bass and hybrid larvae, 3) development and management techniques to produce reliable amounts of a variety of zooplankton, especially rotifers which are important in the production of reciprocal cross hybrids, 4) develop methods to make the switch from brine shrimp nauplii to prepared diets more reliable and productive in intensive fingerling production systems, 5) conduct basic research to develop an understanding of the interactions of energy in protein, carbohydrates and lipid as energy sources, 6) develop a prepared diet for striped bass broodstock.

GENETIC MANIPULATION

Genetics in aquaculture is just beginning to be explored. Research on hybridization, introgressive hybridization, triploidy, tetraploidy, gynogenesis and gene insertion for a variety of species is being supported by the National Sea Grant Program and other research agencies. However, commercial application for most of these techniques is still in the future.

The production of hybrid striped bass has increased the potential for a successful aquaculture industry centered on striped bass. Hybridization involves the crossing of strains or species to provide equal numbers of chromosomes from each parental species and a combination of their traits. This technique includes outcrosses to the third species and back crosses to one of the original parents. Several hybrids of striped bass have been produced: the striped bass female x white bass male cross, which is presently considered the most viable candidate for aquaculture; the white bass female x striped bass male (also a good aquaculture candidate); striped bass female x white perch male; white perch female x striped bass male; F2 striped bass female x white bass male; and striped bass female x F1 striped bass female by a white bass male. These crosses have been made in attempts to improve culture characteristics.

Polyploidy, particularly triploidy, has been studied in hybrid striped bass because studies of other species indicate that triploids sometimes have significantly better growth rates and feed conversion than their diploid counterparts. Triploids are also sterile and their use in culture situations could alleviate concern about hybrids escaping from culture facilities.

The potential of gynogenesis and tetraploidy for aquaculture is still questionable. Research with striped bass and hybrids in this area has been very limited.

Recommended research and other activities in the area of genetic manipulation that would assist in the development of the striped bass and hybrid industry are: 1) development of a domesticated broodstock for hybrid seed stock production through selective breeding programs, 2) evaluation of tetraploidy and gynogenesis as a means of enhancing broodstock development programs, 3) development of technology for gene insertion in striped bass and hybrids to enhance production characteristics, 4) evaluation of the production characteristics of triploid hybrids and development of economical procedures to produce 100 percent sterile triploids for culture operations and 5) evaluation of the use of introgressive hybridization in the Morone complex.

PROCESSING AND MARKETING

The sale of cultured striped bass and hybrids to conventional seafood markets and restaurants is generally limited to one-pound and larger fish. A wide variety of processing techniques may be used, although fresh fish are often sold whole, gutted or dressed and on ice to assure high quality and extended shelf life. Special labeling may be required to distinguish cultured striped bass and hybrids from illegally obtained fish. Wholesalers generally prefer to receive fish iced and packed in-the-round. Weight loss from degrees of processing can be significant. Scaling, heading and gutting account for 18 percent loss when processing cultured hybrid striped bass. Fish ranging in size from 1 to 2 pounds round weight processed as fillets with skin on have a 40 percent yield. A 1.5-pound fish (0.68 kilograms) will yield a single 10-ounce portion fillet whereas two 8-ounce fillets can be produced from a 2.5-pound hybrid (1.1 kilogram) fish.

Regulatory constraints have been imposed on the commercial capture and sale of striped bass in many states and these sometimes apply to the sale of cultured striped bass and hybrids. Marketing of cultured striped bass and hybrids is restricted by some states along the East Coast because of two major problems:

1) the inability or unwillingness of enforcement agencies to distinguish farm-raised hybrids from wild-caught striped bass and

2) laws prohibiting the sale of striped bass and hybrids because they are game fish.

Although many states allow the sale of cultured striped bass and hybrids, laws and regulations in several states will have to be changed to allow the sale of cultured fish on a year-round basis. Proper product identification is important in distinguishing cultured striped bass and hybrids from wild-caught striped bass. The advantages which cultured fish have over commercially landed fish must be retained through uniform quality control and product grading standards.

Distribution of cultured striped bass and hybrids may be accomplished by selling the product directly to retailers or by taking advantage of an established network of fish brokers and wholesalers. Each producer must evaluate the cost of direct marketing versus use of professional intermediators.

The total retail sales value is often divided as follows: ex-vessel, 39 percent; processor, 19 percent; wholesale, 17 percent; and, retail, 25 percent. The distribution network used most often for marketing cultured striped bass and hybrids has been to deliver freshly harvested fish to local wholesalers and distributors who process them and send them on to targeted marketing areas.

Declines in commercial landings of striped bass have created a significant demand for cultured striped bass and hybrids. The per capita consumption of seafood in the U.S. is projected at over 30 pounds per person by the year 2000. The total amount of cultured striped bass and hybrids sold by the private sector to date is estimated to be less than 50,000 pounds. Based on inventories in stock, sales in 1987 should exceed 250,000 pounds.

Surveys of fresh fish wholesalers and distributors and information from test marketing of cultured hybrid striped bass have shown that prices of $4.50 to $5 per pound for live cultured fish and $2 to $4 per pound for fish in-the-round are realistic.

Fisheries products may be sold in a variety of outlets. However, 61 percent of all U.S. seafood consumption is in restaurants. Traditional markets for striped bass exist in the Northeast and in central market centers in New York, Baltimore, Philadelphia, Boston and Washington, D.C. Markets also exists in Virginia, Atlanta, Chicago, Minneapolis, Dallas, Phoenix, San Francisco and Los Angeles.

Recommended research and actions in processing and marketing to assist the industry are to: 1) identify established markets and develop new ones, 2) assess and possibly reduce competitive pressures, 3) evaluate consumer acceptance and promote education, 4) promote the differentiation of cultured product as a premium product and 5) expand demonstration and test marketing programs.

ECONOMICS

The economic feasibility of developing a striped bass and hybrid growout industry depends upon being able to have sufficient demand to establish and maintain a price attractive to growers, refinements in grow-out technology to reduce costs and reduced uncertainty about availability of fingerlings. Test marketing of hybrid striped bass produced in North Carolina, South Carolina and California offers preliminary evidence that farm-raised hybrids may command a higher price than striped bass. Cultured hybrids have been sold for an average price of $1.99 per pound up to $5 per pound. However a survey of wholesalers across the country showed much resistance to prices in the $4- to $5-per-pound range.

Regulatory constraints on sales of striped bass and hybrids may also affect price expectations of potential growers. In some states striped bass and hybrids cannot be sold at all. In other states they must meet minimum size limit requirements which are large enough to effectively eliminate farm-raised fish from being sold there. Such regulations restrict the potential market for farm-raised hybrids and have a impact on price expectations.

Industries must also develop expectations about production costs and costs of facilities. Information available on production costs is incomplete and difficult to obtain. Production costs are available for net pen culture in an estuary and their determination is planned for pond growout experiments in South Carolina and from farm production in North Carolina. Budget estimates could be improved with a better understanding of the relationship between growth, alternate stocking densities, water quality variables and feed formulations. The availability of small fry for stocking growout facilities is also important in estimating growout costs and the uncertainty of seed stock supply affects the costs of fingerlings.

A general model to look at questions of optimal timing of harvest, stocking density and size at stocking is being developed to help producers better manage their production operations.

Recommended research and action steps needed to better understand the economic feasibility of the developing striped bass and hybrid growout industry are: 1) reduced uncertainty of fingerling production, 2) improved estimates of growth and cost responses to different production variables, 3) research into the demand and supply functions of striped bass and hybrids as related to seasonality, 4) development of cost return budgets based upon better growth function estimates and reduced uncertainty of future fingerling supply and 5) formation of a trade association.

LAWS AND REGULATIONS

Development of a commercial aquaculture industry for hybrid striped bass is restricted by laws and regulations which deal primarily with fishery resources and do not address the needs and problems encountered by commercial aquaculturists. Unlike agriculture, the aquaculture industry has been unable to streamline federal, state and local regulations by coordinating policy and programs within a comparatively few agencies. Approximately 50 federal statutes directly impact aquaculture, and 120 federal statutory programs have a significant relationship to aquaculture. One survey has identified over 1,200 state laws which also impact aquaculture development.

This maze of laws and regulations results in reduced economic incentives. Although many of these restrictions are necessary, they should be critically examined and consolidated if possible. These laws generally fall into several major regulatory categories such as land, water, health and fisheries.

Land use regulations fall into several categories. Zoning laws may not allow aquaculture because such activities were not considered by zoning authorities and therefore not incorporated into local master plans. The Coastal Zone Management Act which established land use regulations in critical coastal areas of the United States may also require permits for certain activities. Similarily the U.S. Army Corps of Engineers has jurisdiction over many activities in coastal areas and may require the appropriation of an environmental impact statement.

Water use is required in aquaculture operations, and aquaculturists face the unusual problem of requiring semi-exclusive and, in some cases, exclusive access to high quality water. The complexity of regulations varies with the type of water to be used in a geographic location. Depending upon the source of the water, aquaculturists may require permits from federal agencies such as the U.S. Army Corps of Engineers, the U.S. Coast Guard and an NPDES discharge permit from the Environmental Protection Agency in addition to permits from state agencies.

When faced with disease problems, the aquaculturist has very few prophylactic treatments which are approved by the Federal Drug Administration for use on food fish. Many drugs have been banned or have not been licensed because they have not met the lengthy and expensive process of registration for aquaculture use. Therefore food fish producers are left with few legal alternatives for control of disease in fish.

Laws related to the management of wild fisheries comprise the largest single impediment to striped bass and hybrid culture and include activities from broodstock collection to marketing. Striped bass and hybrids are considered game species in many states and cannot be cultured or sold or they may have to meet minimum size limits which are designed to protect a fishery before they can be sold. Aquaculturists are often confronted with restrictive laws in their attempts to get permits to collect broodstock from wild populations. Private growers are prohibited from taking wild broodstock in some states while recreational fishermen are allowed to take the same fish as long as they meet size and creel limits.

The restrictive attitudes of many fisheries agencies are based on three primary concerns: 1) the potential for contamination of the gene pool of native fishes by escapes from aquaculture operations; 2) fear of encouraging poaching wild fish and 3) the potential for the spread of fish diseases.

Recommended actions which would assist the developing industry are: 1) review, revise or delete current laws to encourage proper development of the hybrid striped bass industry, 2) designate a coordinating agency for aquaculture development at a national level, 3) enact laws which permit taking of brood fish from wild populations for aquaculture development until domesticated broodstocks are available, 4) develop laws which allow for exclusion of cultured products from restrictions placed on products from wild fisheries, 5) management and permitting of aquaculture activities should come under the jurisdiction of agriculture which regularly deals with commodity groups rather than fisheries agencies which deal with management of natural resources and 6) aquaculture should be defined as agriculture for purposes of land and water use, tax incentives, extension programs and other activities.

INFORMATION TRANSFER AND EXTENSION SERVICES

The technology for the culture of striped bass and hybrids has been established at the experimental level but has not been demonstrated conclusively at the commercial level. This technology is being transferred to culturists via Sea Grant Marine Advisory programs and, more recently, through the USDA Cooperative Extension Service. The Department of Agriculture is looking at hybrid striped bass as a alternate crop for coastal and inland farmers. Efforts are being made to coordinate Department of Agriculture and Sea Grant Extension efforts for hybrid striped bass interests.

The USDA has established a national aquaculture information center at the National Aquaculture Library in Beltsville, MD. The information center plays a major role in the acquisition and dissemination of literature and other aquaculture-related materials and is an important part of any technical transfer system. At this stage of development in the hybrid striped bass industry, there is a special need to transfer economic information which can be used by potential entrepreneurs in their decision-making process.

The National Sea Grant Program maintains a national depository for all literature produced through Sea Grant research at the Pell Library, Narragansett campus, University of Rhode Island. Striped bass and hybrid literature is available on loan from this facility.

Recommended activities related to technology transfer which would greatly assist the development of a hybrid striped bass industry are: 1) expand current hybrid striped bass research facilities to provide for pilot scale demonstration projects, 2) develop educational materials for state and federal policy-makers concerning the potential economic risks of hybrid striped bass culture, 3) develop technical how-to manuals on aspects of the hybrid striped bass culture industry, 4) incooperate marketing and processing analysis into educational materials and 5) provide short courses, workshops and seminars on hybrid striped bass culture after the technology is fully verified for economic feasibility.

HATCHERY

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BACKGROUND

Historically, site selection has been critical to the success of striped bass hatcheries (Harrell 1984). The first production hatchery was located in Weldon, N.C., adjacent to natural spawning grounds. Ripe fish were available to support hatchery operations. The highly productive Monck's Corner hatchery in South Carolina was adjacent to striped bass spawning grounds on the Tail Race Canal just below Pinopolis Dam on the Cooper River.

Recently, hatcheries have not been constructed in close proximity to natural spawning areas. Consequently, broodstock must be captured and transported to the hatchery.

State and federal hatchery operators have had difficulty collecting suitable numbers of ripe broodstock in recent years. This difficulty is due, in part, to increased demand for fingerlings for stocking recreational waters and to a decrease in abundance of striped bass populations over the past several years. Thus, government collection efforts are intensifying each year, and annual production goals are often not being met.

SEEDSTOCK SUPPLY

The private and public sector must rely on wild-caught broodstock to produce fingerlings because government hatcheries do not provide fingerlings to commercial aquaculturists. All states have laws and regulations controlling collection of ripe broodstock. And the more productive fishing areas and collection techniques used by public hatcheries are typically not permitted to be used by the private culturists. Thus, the private aquaculturist is in a situation in which the availability and predictability of collecting broodstock for the hatchery is tenuous at best. Consequently, seedstock supplies are not dependable and, when available, they are expensive.

Besides the legal restrictions on broodstock collection, there are still unresolved biological issues involved in spawning ripe striped bass. Ripe fish are highly susceptible to stress from handling and capture. Spawning success and the viability of the sex gametes is not always predictable.

Research is needed to identify proper handling procedures, FDA approved anesthetics and other techniques that minimize stress. And work with approved hormones which induce spawning and ovulation is needed to increase seedstock production. The unreliable supply of seedstock for the private sector was identified as a major constraint to the development of private aquaculture of hybrid striped bass (Joint Subcommittee on Aquaculture, 1983).

BROODSTOCK DEVELOPMENT RESEARCH

Efforts to alleviate the seedstock problem have been under way in South Carolina for the past five years. Research has focused on development of cultured broodstock and demonstration of controlled spawning techniques. Substantial progress has been made on a research scale. Tank-reared striped bass have been spawned out-of-season using photoperiod and temperature control (Smith and Jenkins 1984, 1985a, 1986).

However, research indicates that maturation of cultured female striped bass will require at least four to five years. Handling of these large, mature fish during the spawning season also can result in substantial mortality. In contrast, mature males can be produced in two to three years in tank systems and are less affected by handling even when they are ripe.

Work to develop cultured broodstock raised in outside ponds was performed at the U.S. Fish and Wildlife Service hatchery at Edenton, N.C. However, this work has been terminated after a number of years of limited success. Continuance of some of this work is currently underway at the USFWS facilities in Marion, Ala.

Recently, progress was made in inducing wild striped bass to spawn after 13 months of tank captivity. Texas Parks and Wildlife Department personnel successfully conditioned and spawned two females and two males using controlled photoperiod and temperature. These fish weighed 8 to 12 kg. Egg viability was low; only 19,000 fry were produced from a total of 2.6×10^6 eggs (Henderson-Arzapalo and Colura 1987). Nevertheless, this is an important step forward, and the poor hatching results obtained in this study may be more related to broodstock selection or maturation rather than to spawning procedures.

Work on the domestication of wild striped bass and the production of domestic broodstock is expected to continue in South and North Carolina. However, the production of striped bass fry from domestic broodstock sources will be limited in the near-term. Although female striped bass seem sensitive to maturation attempts and are difficult to handle because of their large size, substantial progress has been made in the past several years. Increased research efforts should help refine spawning techniques for striped bass and improve our ability to induce maturation in female broodstock.

AQUACULTURE DEVELOPMENT

Striped bass hybrids were first produced in South Carolina in 1965 by crossing a female striped bass with a male white bass (M. chrysops). This original cross has become very popular for recreational stockings as has the reciprocal cross --- female white bass x male striped bass (Stevens 1984). Both crosses are made by manually stripping broodfish injected with hormone (human chorionic gonudatropin, HCG) and artificial mixing of the gametes.

The recent work on production of hybrids through use of captive broodstock is of particular interest to striped bass aquaculturists. Original cross hybrids can be produced using cultured female striped bass and wild white bass males (Smith and Jenkins 1985a; 1985b; 1986).

There still are problems in obtaining and spawning wild-caught ripe female striped bass. In contrast, wild male and female white bass and male striped bass can be easily cultured and matured in outdoor tanks (Smith and Jenkins 1985a; 1985b; 1986). White bass females are more easily obtained from the wild than striped bass, and their collection does not elicit the same emotional response from recreational fisherman as does the collection of striped bass females. This progress suggests that it soon may be possible to develop hybrid striped bass hatcheries, based on the reciprocal cross, which will be nearly self-sufficient and not require any significant numbers of wild brood fish (Smith and Jenkins 1986). However, the grow-out production characteristics of the reciprocal cross hybrid are not well known. Current research in North Carolina and South Carolina suggests that both the original and reciprocal crosses will perform similarly under aquaculture conditions.

INCUBATION AND PRODUCTION OF LARVAE

Incubation techniques are well established for striped bass and white bass crosses (Bayless 1972, Bonn et al. 1976). Except for Chesapeake Bay, striped bass eggs generally are incubated in McDonald jar incubators with hatching occurring about 40 to 48 hours later, depending on temperature (16-20oC). Chesapeake Bay striped bass eggs are bouyant and will float out of McDonald jars and must be incubated in tanks. White bass eggs are highly adhesive, and this adhesiveness is usually eliminated by chemical treatment (tannic acid) or addition of silt, clay, etc., before incubation. Stocking density in the McDonald jars is typically 100,000 to 200,000 eggs. Hatch rates are variable, depending primarily on the quality of the broodstock, and are around 50 to 80 percent with good broodstock.

Development of a hatchery will not require extensive facilities. The most critical site selection concern should be the provision of an abundance of high quality fresh water for the hatchery. Spawning and incubation is a relatively quick process. However, it may be desirable to extend the natural spawning season through employment of artificial environmental conditioning techniques. If domestic broodstock are used, ponds or tanks will be required to hold these fish from season to season.

SUMMARY AND CONCLUSIONS

There is unanimous agreement that lack of broodstock is a major constraint to the development of a hybrid striped bass aquaculture industry. Current laws and regulations pertaining to collection of wild broodstock are highly restrictive to the private entrepreneur. Further, even if restrictions were lifted soon, an industry based on an uncertain supply of natural broodstock would still be in a precarious position.

A number of immediate and long-term recommendations are suggested as a means to help develop the industry. From a political, social and economic perspective, the last recommendation would be the most acceptable and, in the long-term, it will also be the most beneficial to the industry. Specific needs are:

1. modify laws and regulations to be less restrictive to the private sector's attempts to collect broodstock.

2. develop better handling and spawning techniques for wild broodstock.

3. develop centralized, in-state private suppliers of seed stock.

4. have government hatcheries provide seed stock to private farmers.

5. develop culture systems and techniques for the production of domesticated broodstock.

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CULTURE OF STRIPED BASS AND ITS HYBRIDS: FIRST FEEDING TO SIX MONTHS

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INTRODUCTION

The majority of striped bass and hybrid striped bass culture activities date from the development of hormonal injection techniques to induce ovulation (Stevens, 1966). This procedure allowed more consistent procurement of fertilized eggs and stimulated investigations into the culture requirements for the early life stages. Hormonal spawning techniques also permitted experimentation with various hybrid crosses.

Reviews of spawning techniques are provided by Bonn (1976); Setzler et al. (1980); Lewis, Heidinger and Tetzlaff (1981); Rogers, Westin and Saila (1982); Kerby et al. (1983).

Many of the unresolved difficulties associated with striped bass and hybrid culture occur during their first 45 days of life. Development of "out-of-season" spawning with domestic broodstock would permit multiple experiments in one year. Hatchery technology may be responsible for some of the mortalities and deformities that are frequently observed, but these problems may also be a result of genetics, nutrition and/or egg maturation development at the time of spawning.

This section deals with the period between first feeding and approximately 6 months of age, and includes the time period containing many unresolved problems. Culture difficulties observed during this period may result from inadequate culture technology. However, some problems are undoubtedly a result of pre-existing conditions which manifest themselves at a later stage.

Culture conditions for striped bass and hybrids during the larval to fingerling stage are generally considered to be similar, but this observation is not well documented. Information on general culture conditions for striped bass and hybrids is summarized in Tables 1 and 2. Although optimal levels are presented for many variables, interactions between the variables were often not reported nor were they addressed in the original experimental designs.

Some insight into the effects of soft-water pond culture and holding systems on striped bass and hybrids was provided by

Grizzle et al. (1985). This work and the contaminant work at Columbia National Fisheries Research Laboratory indicate that the relationship between salinity, alkalinity or hardness, pH and their interactive effects on survival requires further research in both intensive and extensive systems.

Another major need in the striped bass and hybrid culture industry is to determine effects of density on growth and survival during the first 45 days of life especially as it relates to zooplankton densities in ponds. Techniques for pond fertilization and production were recently reviewed and updated by Geiger (1983a, 1983b). A combination of organic and inorganic fertilization two weeks prior to stocking and two weeks after stocking provided good results. Research is still needed to maximize rotifer production techniques for culturists who make reciprocal cross hybrids. These larvae are small and must have rotifers as a first food.

Fertilization coupled with inoculation of the desired crustaceans two weeks prior to stocking the fry, would maximize the reproduction potential of zooplankton prey species. An additional inoculation of prey species may be required two weeks after the fish larvae are introduced.

The remainder of this section will review those areas in which we believe minimal research has been done and in which solutions would yield major improvements in our ability to culture striped bass and hybrids. These areas are development, nutrition, disease, cannibalism and a generalized class "other."

DEVELOPMENT

Developmental problems are common in fish reared in intensive culture conditions. Anecdotal reports indicate 80 percent or more of fish reared in intensive culture do not have inflated swim bladders. Typical intensive culture conditions yield 5 to 30 percent deformities, many of which are associated with swim bladder inflation. This condition leads to spinal deformities, difficulty in swimming and probably a reduction in survival. The importance of this syndrome for fish in ponds has not been documented, but some of the variation in survival of various stockings could be attributed to this phenomenon.

We have anecdotal reports of various techniques that seem to yield higher rates of swim bladder inflation. Oxygen saturation in the water may have something to do with inflation, but mechanisms of inflation are poorly understood. Research to determine how much of this process is controlled by larval "health" and how much by the appropriate partial pressures of various gases in the water is needed. Effects of dissolved gases on fingerlings have not been examined. Striped bass and hybrid larvae may be very susceptible to gas super-saturation, and research in this area could be beneficial. We have observed striped bass larvae eating fine air bubbles. This behavior is probably related to feeding but may increase the problem of air bladder disease.

Gill development during the larval stages has not been researched although it may be a significant cause of mortality in young fish. Losses of larval striped bass and hybrids up to 45 days appear to be related to lack of gill development or degeneration in many instances (see disease below). The factors regulating gill development and the interactive effects of water quality, toxins, nutrition and disease relative to gill development need to be investigated.

NUTRITION

The nutritional aspects of the first feeding stages have not been addressed. Observations indicate that fish will attack particles in the water (e.g. eating fine air bubbles) and that certain species of zooplankton provide adequate nutrition for survival and development. Eldridge et al. (1981) provide some guidance on the number of brine shrimp nauplii and calories required per fish per day for the first 31 days. The amount of ration, frequency of feeding and nutritional characteristics of live foods require intensive research.

The lack of a formulated diet that can be substituted for brine shrimp after the first few days is a major hindrance to intensive striped bass and hybrid culture. The "diseases" that become apparent after days 12 to 18 could be due to nutritional deficiencies, culture conditions (water quality or density) or genetics. The new microencapsulated diets that have been developed recently should be tested for striped bass and hybrids.

Conversion to dry feed and the nutrition required for optimum growth under a variety of temperature and salinity combinations have not been studied extensively. Formulations of diets for pond and intensive culture situations must be tested for efficacy. Hybrids may have a slightly higher temperature requirement than striped bass (Woiwodie and Adelman 1984), which could influence nutritional requirements. This is a good example of the kind of nutrition studies that need to be done. Studies similar to this effort and those of Millikin (1982, 1983) and Cox and Coutant (1981) need more effort under a wider variety of conditions.

Food size, feeding techniques, ration, feeding frequency, nutritional composition, effects of salinity, density and scale effects need to be incorporated into a well-designed sequential experiment for pond and intensive culture situations.

DISEASE

Many parasites and diseases have been described for striped bass larvae and fingerlings, and most are not a problem in routine culture. However, bacterial infections are known to cause major mortalities of fingerlings and are often suspected of causing larval mortalities. Documentation of the specific disease-producing organism is often lacking for larval mortalities. These mortalities often take place so rapidly that standard diagnostic techniques are often of limited use.

Intensive culture systems typically lose the majority of fish between day 1 and day 45, and mortalities occurring between days 14 and 45 are of major concern. Once the fish have grown to 20 to 25 mm, mortalities decrease and are more easily controlled.

The cause of these early mortalities and their cure require major research efforts. Evidence suggests some of the mortality is associated with degeneration of the gills. A pathological analysis suggests either disease or bacterial toxins may be the cause. Identification and control techniques for gill diseases will enhance the intensive culture of striped bass and hybrids more than any other factor.

Better means of assessing the health of young fish and better techniques for treatment, particularly for larval and early juvenile stages are needed. Investigations into the development of the immune system and initiation of various immunological methods of disease prevention are important long-range needs.

FDA approved chemicals are desperately needed for use at all stages, but particularly in young fish. Research on the dose levels and time of treatment for various temperature, salinity and density combinations is needed. Reliance on one or two broad spectrum antibiotics is insufficient for long-term development of hybrid striped bass culture.

CANNIBALISM

Cannibalism can be a serious problem for private and public fingerling producers. Although it is difficult to evaluate losses due to cannibalism, most culturists who hold fingerlings in small tanks or raceways must grade frequently or face losses that may exceed 50 percent in a week or two. Losses due to cannibalism in ponds are difficult to assess but much of the mortality observed in ponds during the first six months may be due to cannibalism.

Braid (1981) found between 21 and 43 percent losses due to cannibalism from day 7 to day 23 (16 days) and between 12 and 44 percent from day 6 to day 20. A means of handling (grading) large numbers of small fish is required to reduce cannibalism in the early stages. The use of progeny from a single brood fish appears to help reduce early cannibalism by avoiding size or growth rate differences that result from genetics or egg sizes. More work is needed to determine if food type, feeding rate, nutritional content or density manipulations offer a means for reducing cannibalism.

OTHER

There are a number of promising biotechnology avenues for increasing striped bass and hybrid growth and production during the first year of life. Treatment of larvae and fingerlings with growth hormone may increase growth rates, yield better food utilization and improve economic returns. Biotechnology promises to provide a means of genetic manipulation of the hormonal system to yield faster-growing fish.

SUMMARY

The first 45 days of life for striped bass and hybrids are generally thought to be the most critical and the area which we know the least about. Because production of 45-day-old fingerlings is one of the limiting areas for the industry, a considerable amount of research should be directed to this life stage. In general, research is needed to:

1. understand the relationship between alkalinity or hardness, pH and calcium levels as they affect survival and ability to withstand the stress of handling.

2. determine the relationship between density, growth and survival during the first 45 days

of life, especially as it relates to zooplankton densities in ponds.

3. develop techniques to maximize rotifer production in ponds used for reciprocal hybrid production.

4. improve our understanding of air bladder inflation, especially in intensive culture systems.

5. determine the effects of water quality, toxins, nutrition and disease on gill development in young fish.

6. develop a formulated feed which can be substitued for Artemia in intensive culture systems.

7. identify and develop control techniques for gill diseases of young fish.

8. develop methods to reduce or eliminate cannibalism during the first 45 days of life.

Table 1 Tolerance limits and Optimum levels of water quality variables for postlarval striped bass and hybrids

	Survival	Optimum	Citation
Temperature	10-27	18-22	1
	10-27	16-19	2
	-32	23-25	3
Salinity ppt	5-15	10-20	1
	0-20	10-15	2
Oxygen mg/l	2.4	air saturated	1
	3-20	6-12	2
		6	3
Turbidity mg/l			
Light Shock	no adverse effect	natural photo-period	1
	+		2
	response		4
	no effect		5
pH	6-10	7-9	2
	above 5.5	6.7-8.4	3
		7.5-8.5	6
flow rate m/s	0-5	0-1.0	2
Alkalinity CaCO3 mg/l		150	3
Hardness mg/l		150	6
	25-30	150-200	3
Ammonia ppm Total		0.6	6
Nitrate ppm	1500-2000	100	1
	800	38	3
Nitrite ppm	4.6	0.33	3
Density #/l		10-30	1
		260	6
		3-9	7

1. Rogers, Westin and Saila (1982)
2. Setzler et al. (1980)
3. Lewis, Heidinger and Tetzlaff (1981)
4. McHugh and Heidinger (1977)
5. Braid (1977)
6. Bonn (1976)
7. Carlberg et al. (1984)

Table 2 Tolerance limits and Optimum levels of water quality variables for juvenile striped bass and hybrids

	Survival	Optimum	Citation
Temperature	0-30	10- 25	1
	10-27	16-19	2
			3
Salinity ppt	0-30	10-30	1
	0-20	10-15	2
Oxygen mg/l	2.4	air saturated	1
	3-20	6-12	2
		6	3
Turbidity mg/l	0-10	4	1
	0-2000		1
Light Shock	no adverse effect	natural photo-period	1
pH	6-10	7-9	1
	6-10	7-9	2
Density #/100 l		2-10	1
Feeding rate	5-8% of body wt/day		1

1. Rogers, Westin and Saila (1982)
2. Setzler et al. (1980)
3. Lewis, Heidinger and Tetzlaff (1981)

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FOOD FISH PRODUCTION OF HYBRID STRIPED BASS

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BACKGROUND

Hybrid striped bass (*Morone saxatilis* x *M. chrysops*) were recognized for their potential as an aquaculture species soon after the first cross was made in 1965 (Bayless 1968). Early studies demonstrated that hybrid striped bass exhibit superior early growth rates, improved survival and overall general hardiness when compared to either parent stock (Bishop 1968; Logan 1968; Ware 1975; Williams 1971; 1976; Bonn et al. 1976; Kerby and Joseph 1979). With the decline in the commercial harvest of striped bass, prices increased and culturists began to examine the potential for producing striped bass and hybrids for the food fish market.

This paper will focus on the third phase of what is generally a three phase production system. The first two phases, hatchery/fingerling production (Smith paper) and advanced fingerling production (Kraeuter paper) have already been discussed. These two phases occur during the first year of a two year cycle and end with production of advanced fingerlings (ca 100-150 g) which are stocked into grow-out facilities during the winter between growing seasons.

CULTURE SYSTEMS

Grow-out of striped bass and hybrids can be done in a variety of culture systems. These systems can be generally categorized into ponds, cages/net pens and raceways/pools. Each system has advantages and disadvantages, but pond culture is probably the best known method of producing hybrids.

PONDS

Grow-out of striped bass and hybrids in ponds begins during winter when water temperatures are low and when advanced fingerling (sometimes referred to as Phase II fingerlings) are available. Accomplishing this task when water temperatures are low also seems to reduce mortalities due to handling stress. Better techniques for handling and grading all sizes of fingerlings need to be developed to reduce mortality during this process.

Pond size can vary from 1 to 10 acres depending on location. Generally information and experience available from the channel catfish industry is used as a guideline for pond construction. Although some experts think that large ponds (>5 acres) should be used for grow-out, others think that smaller ponds (2 to 5 acres) may be best for the short term because "cull" harvesting techniques have not been developed for hybrid striped bass. The producer could manage the harvesting process better with smaller ponds.

Stocking density varies depending upon whether extensive or intensive culture practices are followed. Without aeration, extensive culture practices must be used, and generally only 1,000 to 1,500 fish/acre are stocked. This density generally keeps the risk of oxygen depletion at a minimal level. But it is still advantageous to have aeration equipment available especially at densities approaching 1,500 fish/acre. With these stocking rates, standing crops at harvest should be 1,500 to 2,500 pounds/acre with a mean fish weight of about 1.50 pounds.

More intensive culture practices can be followed if aeration equipment is available for constant or emergency use. Stocking density can be increased to approximately 4,000 fish/acre. Standing crop at harvest should be around 6,000 pounds/acre with a mean weight of approximately 1.5 pounds (Kerby et al. 1983a; 1983b). A highly managed, intensive pond system in South Carolina had a standing crop of 7,400 pounds/acre at harvest with a mean weight per fish of 1.7 pounds (Ted Smith, personal communication). Research on pond production is continuing in North Carolina (R.G. Hodson and H.S. Kerby) and South Carolina (Ted Smith) to further refine production variables.

Survival during this phase of culture is generally high and survival rates over 90 percent are common (Wawronowicz and Lewis 1979; Kerby et al. 1983a; 1983b; Ted Smith, personal communication, Marine Resources Research Institute, South Carolina). Survival rates less than 80 percent are generally due to poor management decisions or unavoidable problems such as equipment failure and/or electrical outages at critical times. Ongoing research should substantiate these survival rates.

Food conversion ratios for pond culture of hybrid striped bass are variable depending on management practices, but ratios between 1.8 and 2.5 for grow-out are realistic. Kerby et al.

(1983b) reported a mean food conversion of 2.3 for hybrids cultured intensively in ponds in North Carolina.

CAGES/NET PENS

Cages/net pens are generally used to produce fish 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 cage/net pen culture may be appropriate.

Striped bass and hybrids have been grown to foodfish size in estuarine and marine situations in enclosures ranging from 0.5 m^3 to 13.6 m^3 (Powell 1973; Valenti et al. 1976; Williams et al. 1981; Woods 1983; Kerby et al. 1983a). Cage culture studies in freshwater ponds are being conducted in Maryland (R. Harrell personal communication). One producer in North Carolina is using cage culture for grow-out and for production of advanced fingerlings (R. Hodson, UNC Sea Grant, North Carolina State University, Raleigh, N.C.). His first crop of 3,200 to 3,600 kg (7,000 to 8,000 pounds) should be ready to harvest in late 1988.

Production of striped bass and hybrids in enclosures has been encouraging. Stocking densities of 55 (Valenti et al. 1976) to 393 fish/m^3 (Powell 1973) have been used in experimental studies. Studies with both striped bass and hybrids have reported standing crop values in the range of 16 kg/m^3 to 89 kg/m^3 (Powell 1973; Valenti et al. 1976; Woods 1983; Kerby et al. 1983a). Even at the highest density when standing crop exceeded 89 kg/m^3 there was no evidence that maximum carrying capacity had been reached. However, growth does appear to be density-related with fish in high density cages exhibiting slower growth rates than fish in low density cages (Powell 1973; Woods 1983; Kerby et al. 1983a). Additional research is needed to determine the effect of density on growth rate.

Growth rates for striped bass and hybrids reared in cages have ranged from less than 1 gram per fish per day to over 2 grams per fish per day. Powell (1973) reported a mean growth rate of 2.3 grams per fish per day for striped bass over a 60-day period, whereas hybrids of similar size grew at a rate of 1.9 gram per fish per day over a comparable 55-day period (Woods 1983). An average growth rate of 0.8 gram per fish per day was reported for hybrids grown in a South Carolina estuary (Williams et al. 1981).

With proper management and maintenance of high water quality, survival values for hybrid striped bass grown in cages to food fish size should be 90 percent or better (Powell 1973;

Woods 1983; Williams et al. 1981). Poor survival (20 percent) in a study of striped bass held in cages in a New York coastal lagoon was attributed to poor conditions of the fish and low water temperatures (1.0C) during January and February. Poor survival (16 percent) of hybrids reared in cages has been attributed to inadequate conversion to dry food.

Food conversion ratios of 2:1 or lower are not uncommon for cage/net pen cultured fish. Woods (1983) reported ratios of 1.6:1 or less for cage cultured fish. Other researchers have reported feed conversion ratios of 1.4:1 to 1.6:1 for striped bass (Valenti et al. 1976).

RACEWAYS/POOLS

Circular pools and raceways make excellent culture systems for striped bass and hybrids. These systems allow for more control of the culture environment than in other systems. They also offer the advantages of accessibility and reduced handling. Some major disadvantages are the dependence on mechanical devices, the need for backup systems and higher operating costs than other systems. There are also several biological problems related to high density culture that still need to be researched. The effects of crowding on growth rate, resistance to stress and disease are relatively unknown.

Pools and raceways may be extremely useful in situations in which large volumes of water are available at low costs, such as at power plants and where artesian wells exist. Liquid oxygen injection or other means of aeration may be required to maintain water quality for food fish production in these systems. Because of these requirements, productions costs will probably be higher than in pond or cage culture situations. Aquatic Systems, Inc. in California (Jim Carlberg, personal communication) and Pennsylvania Power and Light Company (Todd Beck, personal communication) are using raceways and pools to culture striped bass and hybrids to food fish. Liquid oxygen injection systems and constant temperatures are maintained at levels which promote rapid growth.

Advanced hybrid fingerlings of striped bass and hybrids stocked in 38 m^3 pools approximately 1 m^3deep at 9 and 18 fish/m^3 produced a standing crop of 3.4 to 4.0 kg/m (Woods 1983; Woods et al. 1985). Mean weights were 350 and 275 respectively by the end of the growing season. Growth in this trial was retarded by cool temperatures. Well water was used in the system and temperatures averaged 22 C or less. Development of economical ways to elevate water temperatures would increase the potential of raceway/pool systems for foodfish production.

Survival rates in tanks are generally high. Woods et al. (1985) reported 74 and 88 percent survival, respectively, in high- and low-density studies in pools.

Feed conversion ratios in raceway/pool systems (1.56:1 to 1.83:1) are similar to ratios reported for other culture studies (Woods et al. 1985).

WATER QUALITY

Striped bass and its hybrids survive and grow well at a wide range of water quality variables (Humphries and Cumming 1973). These requirements are not well known, but there appears to be little correlation between water quality and production within a rather broad range of conditions. It is generally thought that striped bass and hybrids become more tolerant to variable water quality conditions with age. By the time they reach the advanced fingerling stage (after the first year of growth), they are very hardy (R. Hodson, personal observation). This increasing tolerance probably accounts for the excellent survival values during the grow-out period regardless of culture system.

Striped bass and its hybrids can survive a wide range of temperatures. Striped bass occurs naturally on the Atlantic Coast from New Brunswick to Florida and along the Gulf Coast (Blair et al. 1968). The species has been introduced into a variety of locations and has reproducing populations in several states (Stevens 1984). Similarly, white bass occurs naturally throughout much of Mississippi River drainage from Wisconsin south and is found along the Gulf Coast in Florida, Alabama, Mississippi and Texas (Blair et al. 1968). This species has also been widely introduced in freshwater habitats throughout the United States.

Advanced fingerlings of hybrid striped bass will generally survive a temperature range of 4 to 34 C in culture systems (R. Hodson, personal communication). Pond temperature of 18 to 32 C are considered suitable for rearing striped bass (Bonn et al. 1976). Striped bass and hybrids have survived in cages under ice cover in Maryland (R. Harrell, personal communication). Growth is retarded at the lower and upper ends of this range with maximum growth around 28 C (Woods 1983). Other water quality variables may also influence temperature tolerance. Feed consumption is reduced at temperature below 15 C.

Dissolved oxygen is important in any culture operation and especially for striped bass and hybrids. Although striped bass and hybrids may survive dissolved oxygen levels as low as 1 mg/l for a short time, these levels are very stressful.

Dissolved oxygen levels below 4.0 to 4.5 mg/l are thought to reduce food consumption, increase energy used for respiration and reduce growth rate (Klyashtorin and Yarzhombek 1965). Production facilities should not allow dissolved oxygen levels to fall below 5 mg/l for very long.

Alkalinity, hardness and pH levels are usually related, and striped bass and hybrids do well over a wide range of values. In fresh water, alkalinity and hardness values as low as 20 to 30 mg/l appear satisfactory for growth but seem to be more sensitive to stress in water with low calcium levels (R. Hodson, personal communication; Grizzle et al. 1985). Alkalinity values of 100 mg/l or above are probably desirable in all culture systems. Mortality can be significant during transfers from water with high alkalinity/hardness values to water with low values (Grizzle et al. 1985). Fish must be tempered to avoid losses during transfer. The addition of salt seems to improve "soft" low alkalinity water for culture purposes. Some workers use calcium chloride during handling of fish to reduce mortality.

The pH tolerance of striped bass and hybrid advanced fingerlings is not well defined. Generally the limits range from near pH 5.5 to 10.0. Hybrids being reared in ponds in North Carolina have survival repeated exposure to pH 2.5 (R. Hodson, personal observation). However, for culture purposes, a pH in the range of 7.0 to 9.0 is recommended.

Ammonia, the principal excretory product of fish is frequently a major cause of mortality of cultured fish (Lewis and Heidinger 1981). The toxicity of ammonia to striped bass and hybrids is not well known. Our experience with an intensive recirculating system is that ammonia levels of 1 to 2 mg/l are tolerated as long as the pH is around 8.5 or less. When the pH is above 8.5, mortalities begin to occur. Bonn et al. (1976) recommended that ammonia concentrations should not exceed 0.6 mg/l in intensive systems. The 96-hour LC_{50} values for NH_4OH in striped bass ranged from 1.5 to 2.8 mg/l (Hazel et al. 1971). They noted sublethal ammonia levels around gill damage, reduced feeding, reduced growth and reduced disease resistence. Ammonia concentrations should probably not exceed 1 mg/l in most culture systems.

Striped bass and its hybrids can be produced in fresh water or brackish water culture systems. There is little published data on which medium is best for production systems. There is ome feeling that hybrids will avoid full strength seawater if possible (H. Kerby, personal communication, North Carolina State University). Studies in South Carolina indicated that hybrids would adapt to salinities as high as 35 ppt but there was some evidence to suggest a reduced survival rate at 35 ppt (T. Smith, personal communication). Salinities from 0 to 25 ppt have proved suitable for food fish production of hybrids (Kerby et al. 1983a; 1987a; Williams et al. 1981; Woods 1983). Low salinities (10 to 15 ppt) have been used to improve survival and reduce stress during handling, harvest and transport.

RECOMMENDED RESEARCH NEEDS

1. Research is needed to determine optimum size, depth and stocking density for pond grow-out facilities. At low stocking densities it may be difficult to get all the fish to take pelleted feed. Results of nursery trials indicate that fish grew more rapidly and were more uniform in size when reared at densities of 4,000 and 8,000/acre as compared to 2,000/acre (T. Smith, personal communication). Similar results have been observed in North Carolina (R. Hodson, personal observation).

2. More study is needed to determine the relationship between density in cages/net pens and growth rate. The relationship between pond volume and the total biomass that can be produced in cages/net pens is poorly known and should be studied.

3. Stocking density in pool/raceway systems is still poorly known. Economic data are needed to evaluate operating and production costs of pool/raceway systems. High technology systems using liquid oxygen injection need to be evaluated for their potential as production systems for hybrid striped bass.

4. There are several research needs that all culture systems have in common with regard to feed. How often and when should feed be presented to get good growth and feed conversion? Can demand feeders be used successfully? Is it better to feed at certain times of day than at others? How important is pellet size? Most culturists use sinking food, but could floating feeds be used? Will live forage such as tilapia improve growth rate when coupled with pelleted feed? How can we improve on and be more consistent in the area of feed conversion?

5. There are several research needs concerning harvesting. Can hybrids be selectively seined and graded without

injurying or killing the culled fish? What is the best way to grade fish? What management techniques can be used to make fish available for market on a year-round basis?

6. There are several research needs in the area of water quality. A better understanding of the relationship between temperature, growth, dissolved oxygen and food conversion is needed to evaluate production strategies. What is the interaction between nutrition and temperature?

7. The relationship between stress and alkalinity/hardness is poorly understood. Better information is needed on how to transfer fish from hard to soft water without causing significant mortalities. Calcium may be more beneficial than sodium during the transfer process, but what level of calcium is beneficial? Can CaCl be used during the transfer process and in production systems to prevent mortalities?

8. Research is needed to better understand the tolerance limits of striped bass and hybrids to ammonia in culture systems. What is the influence of other water quality variables on ammonia toxicity? Research is needed to determine efficacy of drugs that are used in saltwater systems versus freshwater systems. We also need clarification of what drugs can legally be used in the production of food fish.

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FISH HEALTH:
DISEASE AS AN IMPEDIMENT TO THE CULTURE OF STRIPED BASS AND ITS HYBRIDS

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INTRODUCTION

The continued development of hybrid striped bass as an aquaculture commodity would be enhanced considerably with the development of a regime for the effective control of disease. Disease in its broadest sense refers to any abnormal state that is a departure from "health." Nutrition, environment and infectious agents may all interact to produce disease by affecting the physiology and immunity of the host. Disease problems can present themselves in many ways, including mortality and decreased production (morbidity).

MAJOR DISEASE PROBLEMS

Because the hybrid striped bass industry is in an embryonic stage of development, most of the information on disease incidence is anecdotal. However, several disease problems appear to be routinely encountered in culture operations (Table 1). These diseases may be the most likely candidates to present major problems to the industry. The development of more quantitative estimates of the importance of different diseases in production facilities would help to focus efforts on the most important disease problems and help to estimate the production losses due to disease.

The infectious agents listed in Table 1 are not unique to striped bass. This list represents only a small fraction of the number of diseases which have been reported to affect Morone. Salinity appears to be a significant barrier to the spread of specific diseases, although many pathogens can affect fish in a wide range of salinities (e.g., Vibrio spp.). Some pathogens, such as the parasite Trichodina, are considered less important because an effective (but presently not legal) treatment is available for other foodfish species. Formalin, which is an effective treatment for Trichodina, is approved for use in many other foodfish, but is not approved for use in striped bass and hybrids. These disease organisms would be much more important if such therapeutants were barred totally from use.

DISEASE IN DIFFERENT LIFE STAGES

More than any other age class, larvae have a unique set of disease problems. Large and catastrophic mortalities frequently occur prior to metamorphosis. Many of these diseases are of uncertain origin (e.g., swim bladder inflation deficiency). Treatment of fish at this stage is often difficult due to the rapid course of the disease outbreaks and the sensitivity of the fish to chemotherapeutants. Effective control of these problems would significantly enhance the success of striped bass and hybrid production by providing more stable and predictable stocks of fingerlings for grow-out as well as reducing the number of wild broodfish required. Studies should also focus on methods for rapidly diagnosing these problems so appropriate control measures can be quickly applied.

DEVELOPMENT OF LICENSED CHEMOTHERAPEUTANTS

There are no approved drugs for treating diseases in striped bass and hybrids except those which are exempted from licensure because they are generally regarded as safe (e.g., salt). A number of medications that are approved for use in other food fish appear efficacious in treating similar diseases in striped bass and hybrids, but use of these drug treatments is not based upon pharmacological studies with striped bass. Instead, they have been extrapolated from information in other food fish. Thus, knowledge concerning tissue residues and minimal withdrawal times required prior to slaughter are not established.

There is a critical need to develop the database of information required to license these agents for use in striped bass and hybrids. Among those which should receive top priority for licensure include the antibacterial agent oxytetracline and ormetoprine-sulfadimethoxine, the parasiticide formalin and the anesthetic tricaine methanesulfonate. Although not approved for use in any food fish, the ovulating agent human chorionic gonadotropin should also be given top priority for approval since it is critical to successful induction of spawning (Table 2).

While every effort should be made to have the above agents approved, it will not by any means satisfy all the needs of the industry for effective therapeutants. There is also a critical need to develop an effective fungicide to replace malachite green and a need for an alternative to copper for the treatment of Amyloodinium.

A number of other drugs, especially antimicrobials, have been tested in other food fish. These agents should be closely examined for potential use in striped bass and hybrids because their approval would be less costly than the licensing of an agent never used in aquaculture. Pharmaceutical companies in the process of licensing such agents should be encouraged to include striped bass and hybrids in their approved labels. Also, any regulatory reforms that would facilitate the licensing of agents for striped bass and hybrid culture by reducing the costs of such activities should be encouraged.

PHARMACOLOGY OF THERAPEUTANTS

Striped bass/hybrids are cultured in a wide range of salinities. There is a need to determine the salinity and other water quality factors on the efficacy of drugs. The efficacy and toxicity of many waterborne treatments are profoundly influenced by the concentrations of different minerals. But most of the available information on drug treatments of striped bass and hybrids is based on freshwater systems. These protocols are many times inappropriate for brackish or marine systems.

Salinity may also influence the metabolism and excretion of systemic agents, especially those which are eliminated by renal excretion, since renal flow rate is profoundly affected by salinity.

REGULATORY REFORM OF DISEASE INSPECTION PROCEDURES

The regulations governing the interstate transport of live striped bass and hybrids vary considerably among states. There is a need to adopt more uniform procedures for certifying fish free of disease. These regulations would best be national in scope and should be aimed at preventing the undesirable introduction and spread of pathogens that are restricted to one geographic area. Conversely, many fish pathogens are ubiquitous, and it would serve no purpose to screen for those pathogens (e.g., *Aeromonas hydrophila*).

SUMMARY OF RESEARCH NEEDS IN STRIPED BASS AQUACULTURE

1) Develop effective, legal treatment regimens for the important disease problems facing the industry in the most common culture situations.

2) Quantitatively determine which disease problems are most important, with special emphasis on those problems affecting the larval stages.

3) Determine how environmental factors may affect the metabolism and efficacy of therapeutants.

4) Develop standardized methods of disease inspection for interstate transport of fish.

Table 1. Major disease problems affecting striped bass and hybrids. Plus sign (+) indicates disease has infected fish in that environment. Minus sign (-) indicates disease is not known to infect fish in that environment.

Pathogen	Environment: Freshwater	Environment: Brackish/Marine
Bacteria		
Columnaris	+	-
Aeromonas	+	+
Vibrio	-	+
Edwardsiella	+	-
Fungi		
Oomycetes	+	-
Parasites		
Amyloodinium	-	+
Idiopathic		
Larval Disease Complex *	+	+

* includes a number of clinical syndromes of uncertain etiology including swim bladder inflation deficiency and "gill degeneration"

Table 2. Heirarchy of drug testing and development requirements for striped bass and hybrid culture

Top Priority
- oxytetracycline (antibacterial)
- formalin (parasiticide)
- tricaine methanesulfonate (anesthetic)
- effective fungicide
- marine parasiticide (copper-free)
Intermediate Priority
- other effective antibacterials
- copper-free algaecide
- copper-free herbicide

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NUTRITIONAL REQUIREMENTS OF STRIPED BASS AND HYBRIDS

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Present Knowledge

LARVAL STAGES

Little progress has been made in developing artificial diets for larval striped bass and hybrids in spite of intense efforts by culturists. Many of the problems in working with artificial food result from the poor acceptance of such feeds by larval fish. Larval fish possessing yolk for short periods usually have difficulty accepting and utilizing artificial feeds (Baragi and Lovell 1986). Because of these problems, little progress has been made in understanding nutritional requirements of larval striped bass and hybrids.

Larvae begin feeding during the late yolk sac period and can become cannibalistic if food is limited. The mouth parts and guts of larval striped bass and hybrids are functional at day four or five post-hatch (Rulifson, et al. 1986). The digestive process is estimated to take from 1 to 6 hours for larvae feeding on brine shrimp, depending upon temperature, age of larvae and amount ingested (Rogers, et al. 1982). Hofer (1985) suggested that larval fish obtained their digestive enzymes by eating living prey that contained the enzymes. However, trypsin, chymotrysin and carboxypeptidase were present in the gastrointestinal tract of striped bass larvae at day four post-hatch, before feeding, and remained active whether the larval fish were fed either live brine shrimp, heat-killed brine shrimp or artificial food (Baragi and Lovell 1986). However, larvae fed artificial food did not accept the diet well until day 14. Bonn, et al. (1976) believed that larvae that do not eat by day 7 may never accept feed and many will die. Degenerative changes were found in non-feeding larvae at 5.5 days post-hatch even though the striped bass still retained yolk (Rulifson et al. 1986). There were reduced hemopoietic tissue in pronephric kidney, collapsed guts, reduced eye pigment and tissue degeneration, and thin and separated muscle fibers by day 11. These changes may be severe enough to preclude late feeding. Others think that a "point of no return" does not exist because food-deprived striped bass larvae were found to recover growth when refed (Rogers et al. 1982).

Live brine shrimp nauplii, _Artemia sp._, are used extensively for feeding larval striped bass and hybrids because results with artificial foods are usually poor. Frozen brine shrimp have also been used when live nauplii were not available. And live zooplankton of the proper size (0.2 to 0.5 mm) have been used to supplement or replace brine shrimp (Al-Ahmad 1978; Bonn, et al. 1976; Rogers, et al. 1982). Most investigators recommend presenting nauplii in high densities to larval fish every four to eight hours. However, no significant difference in growth of striped bass hybrid larvae fed live brine shrimp nauplii in concentrations of 100 or 500 nauplii/l was found (Houde and Lubbers 1986).

Investigators have also examined food problems associated with pond culture of larvae. Pond culture conditions allow the production of zooplankton in numbers and diversity, which at present cannot be produced or fed in any other system. For this reason, most efforts have been directed toward appropriate pond management in order to produce appropriate zooplankton blooms for ingestion by larvae. Organic and inorganic fertilizers are used to stimulate zooplankton blooms (Bonn et al. 1976; Geiger 1983). Although species and concentrations of zooplankton required have not been adequately defined, Rogers et al. (1982) reported a preference for pelagic zooplankton species as a food source rather than benthic species. Required concentrations of zooplankton were estimated at 1,000 to 1,500 organisms/l.

Specific nutrient requirements have not been investigated, although Rogers et al. (1982) recommend that the diet for larvae contain no less than 43 percent protein and provide 5,700 cal/gm dry weight. These values were based upon their calculation of the protein and energy content of yolk.

Most culturists do not recommend artificial diets because of limited acceptability resulting in poor growth of larvae and decreased water quality (Bonn et al. 1976; Lewis and Heidinger, 1981; Rogers et al. 1982). Many commercially available starter feeds have been tested. Salmon starter and Tetra brand baby fish food (which are high in protein about percent) have been reported to give better or equal survival as compared to brine shrimp, but growth is always much lower. Artificial feeds may enhance growth and survival when added to larvae being fed primarily on brine shrimp (personal communication, MLG). This is true even when the feed will not support growth if fed separately. These results support the idea that brine shrimp may be nutritionally deficient as a diet for larval striped bass and hybrids. The nutrients in question are not known but may be those associated with connective tissue synthesis such as vitamins A (retinol) and C (ascorbic acid), or with transport or utilization of specific fatty acids from the yolk sac. Love (1980) noted that plasm amino acid patterns in larval fish are consistent with connective tissue synthesis. He also described the utilization of specific fatty acids (16:0, 22:6) from the yolk sac and conservation of other (18:1, 18:2). At present, however, specific nutrient requirements are unknown.

POSTLARVAL AND JUVENILE STAGES

Whether larval fish are fed brine shrimp in the laboratory, zooplankton in ponds or both, eventually they must be trained to feed on prepared or pelleted food. Fish are usually switched to dry feed between day 12 and day 21 post-hatch in intensive culture systems. A combination of brine shrimp and dry prepared food is provided, usually until around day 28. During the switch from live food to dry feeds, high mortalities and stunting of the larvae often occur. It is critical that methodology for the switch-over period be developed to reduce mortality and increase the production of healthy, normally feeding fish. However, fish that survive to 25 mm (1 inch) or more are readily trained to accept prepared feeds. Striped bass and hybrid fingerlings reared in ponds are usually harvested and trained to feed at approximately 45 days post-hatch.

JUVENILE FISH

Prepared feeds for fingerlings (>50 mm) trained to dry food should: (1) contain at least 38 percent protein, (2) contain fish oil or whole-processed fish, and (3) be composed of particles that can be readily consumed by fish (Bonn, et al. 1976). But many culturists use trout or salmon feed which contain from 40 to 48 percent protein. Feeding rates between 3.5 and 5 percent of body weight per day are suggested for juvenile striped bass and hybrids fed trout feed. Milliken (1982, 1983) found that 2.5-g fish grew best on diets with 55 percent protein. However, best protein efficiency was found in fish fed 34 percent protein; differences in growth between fish fed 55 percent protein and 34 percent protein were not signficiant.

We have trained juvenile hybrid striped bass (striped bass X white perch) to ingest semi-purified diets consisting of casein, egg white, corn starch, cellulose and cod liver oil plus vitamins and minerals. Growth using these diets was lower compared to fish fed trout diets. However, significant difference in growth occurred as protein and/or calories were manipulated. Caloric levels of 4.5 kcal/g of diet result in significantly poorer growth compared to caloric levels of 3.5 and 2.5 kcal/g, with best growth occurring at 2.5 kcal/g. No significant differences in fish weight were observed when protein levels exceeded 30 percent of the diet.

In summary, an understanding of the nutrient requirements of striped bass and hybrids is in its infancy. A great deal of basic and applied research work needs to be done to build our knowledge base.

Research Needs

LARVAL FISH

Brine shrimp nauplii play an important part in the intensive culture of striped bass and hybrid larvae. But there is a need to reduce use of brine shrimp nauplii in intensive larval culture, especially for long periods of time (i.e., up to 20 days post-hatch). Variability in growth and survival of fish fed different strains of nauplii, cost, supply and production management are all problems with brine shrimp nauplii. Alternatives that should be investigated further are:

1) Basic research needs to be conducted to determine the nutritional requirements of larvae. The development of the digestive process in larval fish is poorly understood and needs intensive study to support work on development of prepared feed. It is important to know when specific digestive enzymes develop and what triggers their activation.

2) Production of prepared diets that meet the nutritional needs of striped bass and hybrid larvae. Many researchers have tried various types of prepared diets. So far none is as successful in both growth and survival as brine shrimp nauplii or some type of zooplankton. Good prepared diets are needed: 1) as backup to zooplankton if bloom is lost, 2) to support the switch-over from zooplankton to prepared diets for grow-out, and 3) to support intensive larval culture not based on natural zooplankton or brine shrimp.

3) Management of ponds to produce reliable amounts of a variety of zooplankton. Various methods of organic (i.e., grass, manure, hay) and inorganic fertilization have been used. However, means of controlling the specific zooplankton species and the concentration of zooplankton are not known. Proper amounts and types of zooplankton in ponds will increase the survival of larvae stocked directly into ponds. A critical need is the development of management techniques to produce rotifer blooms for production of reciprocal cross hybrids.

4) Develop methods for use in intensive culture systems to make the switch from brine shrimp nauplii or zooplankton to prepared diets more reliable and productive in terms of fingerling production.

FINGERLING CULTURE

Fingerling striped bass and hybrids readily accept prepared pelleted diets after a short training period. A number of commercially prepared diets have been used successfully. However, research is needed to understand the interactions of energy and protein, carbohydrate and lipid as energy sources in dietary preparation. Such work would optimize growth, weight gain and desirable body compositions with respect to muscle mass and body fat and improve feed conversion ratios.

BROODSTOCK CULTURE

A critical need is the development of a prepared diet for striped bass broodstock. Some success has been achieved in maturation of cultured striped bass broodstock, but eggs obtained from these fish are generally inferior to those obtained from wild-caught fish.

Decreases in quality may be due to nutritional inadequacies. Broodstock can be reared on a number of diets including pelleted feeds, but they may accumulate excessive amounts of body fat, which could result in eggs of high lipid content. Therefore, the interrelationships of lipids, carbohydrates and protein in the diet and their effects on body composition, egg composition and egg quality need to be investigated.

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GENETIC MANIPULATION OF *MORONE*

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INTRODUCTION

Hybridization has been recognized in recent years as a tool for improvement of fish stocks, both for management purposes and for aquaculture. Hybrids are generally intermediate between the parental species in morphological and growth characteristics, but many are endowed with heterosis, revealed as superior initial growth, greater disease resistance, improved survival and general hardiness. (Krumholz 1950; Alm 1955; Hubbs 1955; Piggins 1965; Kerby 1972; Kerby and Joseph 1979; Williams et al. 1981 and Kerby et al. 1983a). Heterosis is a characteristic that has been demonstrated by striped bass X white bass and striped bass X white perch hybrids (Kerby 1972; Williams et al. 1981; Kerby et al. 1983a; Kerby et al. 1987a; 1987b), thus characterizing these hybrids as prime candidates for aquaculture. Recent research to evaluate hybrid striped bass for use in aquaculture has clearly demonstrated that such potential exists. Striped bass X white bass appears to offer the greatest potential because of generally faster growth rates, but the striped bass X white perch appears to be hardier and, if growth rates can be increased, may be a potentially viable candidate.

Use of genetic manipulation techniques, as described in this paper, may be useful in producing or improving characteristics desirable to fish culturists. Further, certain techniques might allow avoidance of some of the problems of "seed" production associated with hybrid striped bass.

DEFINITIONS

Genetics is a broad, all-inclusive term. Only a small portion of this discussion focus on the traditional usage of the term in breeding domestic animals. Genetic manipulation, as used in this discussion, is the artificial manipulation of genetic characteristics of an organism for a specific purpose (e.g. increased growth, viability, production).

A. Terms

1. Hybridization - Crossing of strains or species to provide equal numbers of chromosomes from each parental species and a combination of their traits. Outcrosses (cross between an F1 hybrid and a third species) and backcrosses (cross between and F1 hybrid and one of the original parents) are variations that can be used experimentally to try to obtain desired characteristics.

2. Introgressive hybridization - A means by which hybridization and backcrossing can establish a population of genotypes which contain a few genes or chromosomal segments derived from one species on the genetic background of another.

3. Triploidy - Organisms which have three sets of chromosomes (3N) rather than the normal two sets (2N). Triploids are normally produced by effecting retention of the second polar body.

4. Tetraploidy - Organisms which have four sets of chromosomes (4N) rather than the normal two. Tetraploids are normally produced by effecting either karyokinesis (separation of chromatids) or endomitosis (cytokinesis) at first cleavage.

5. Gynogenesis - Organisms which have two sets of chromosomes, but both sets are derived from the female parent. Gynogens are normally produced by fertilizing eggs with sperm in which the male genome has been destroyed (usually by some type of irradiation) and by effecting retention of the second polar body.

6. Gene insertion - The artificial insertion of genetic material (at the molecular level) belonging to one organism onto the genetic background of another. This is usually done manually (with micromanipulators) at the time of fertilization or with the aid of biological "carriers."

GENETIC MANIPULATION: STATE-OF-THE-ART

A. Hybridization - A thorough discussion of Morone hybridization experiments would involve more space than is available here. However, a brief, very general summary of the various crosses is in order.

1. Striped bass female X white bass male (original cross) - This cross is probably the most viable candidate for aquaculture given present knowledge. The F1 is hardier, growth is rapid and can be exceptional under optimum conditions (Williams et al. 1981; Kerby et al. 1983a).

2. White bass female X striped bass male (reciprocal) - This cross also appears to be an excellent candidate but not as much is known concerning growth rates. However, this hybrid seems to be hardy and growth rates will probably approach, if not equal, those of the original cross.

3. Striped bass female X white perch male - This hybrid has been demonstrated to be hardier than the SB X WB, but growth rates have been highly variable (Kerby 1972; 1979; Kerby et al. 1987b). At present, the SB X WP is not a preferred aquaculture candidate.

4. F2 striped bass female X white bass male - This cross is not a good aquaculture candidate. It is less hardy than the F1 or parental species, survival is generally poor and growth rates (and morphology) are highly variable (HJK, unpublished data).

5. Backcrosses and outcrosses - Only one backcross, (striped bass female X F1 striped bass female X white bass male) has been examined for aquaculture potential. This backcross was found to be hardy and growth rates appeared similar to the original F1 hybrids (HJK, unpublished data). Other backcrosses and outcrosses have been produced, but no evaluations have taken place.

B. Introgression - Artificial introgression was suggested as early as 1956 to be a mechanism by which desirable qualities might be transferred from one species to another (Buss and Wright 1956). For example, the rainbow trout's natural resistance to furunculosis might be transferred to the brown trout. This idea is good in principle, but difficult to achieve in practicality, and little work in this area has been accomplished.

C. Polyploidy - Polyploidy, in the form of triploidy and/or tetraploidy, may represent a possible means for increasing production (Purdom 1976; Wolters et al. 1981; Swarup 1959; Valenti 1975). Polyploids in fish can be produced by "shocking" normally fertilized eggs at certain stages to produce either 3 or 4 sets of chromosomes. The shock is normally represented by application of temperature (either cold or heat) or increased hydrostatic pressure, although chemicals that inhibit spindle formation (colchicine or cytochalsin B) have also been used.

Triploids are of particular interest because studies of other species indicate that they sometimes have significantly better growth rates and feed conversion than their diploid counterparts (Wolters et al. 1982). A growing body of evidence indicates that this phenomenon normally is not observed until the diploids begin to attain sexual maturity, suggesting that metabolic energy normally used for development of gonads and sex products and subsequent reproduction may be used for growth instead (Allen and Stanley 1978).

Tetraploids have been more difficult to produce in fish, and they are normally less hardy than their diploid counterparts. However, at least in one instance, rainbow trout tetraploids have been successfully reared and spawned. Successful rearing and spawning of tetraploids with normal diploids could be a method of circumventing de novo triploid induction, while increasing survival and achieving virtually 100 percent triploidy production.

Using thermal shocks up to 40 C, we have produced up to 90 percent triploidy in hybrid striped bass. However, results for ploidy induction have been very inconsistent, and the combinations of temperature and treatment interval that result in the highest percentages of triploids tend to also result in the greatest egg mortality. Differences in natural egg stage between females may also have some effect. We have cultured mixtures of diploids and triploids for over two years. Significant differences in growth were not apparent at two years of age, but the fish were just beginning to mature.

We have produced greater than 90 percent triploidy using hydrostatic shock, in reciprocal hybrids, with mean survival to hatch approaching 50 percent.

Triploidy is readily verified from blood samples using a flow cytometer and techniques modified from the literature. We developed a successful technique to determine ploidy in batch samples of larvae using flow cytometry, which allows us to determine approximate percentages of triploids immediately subsequent to hatching (Hinshaw et al. 1986). This method allows more efficient use of facilities since percentages of ploidy can be determined prior to stocking in ponds, and batches of larvae low in triploids can be discarded or used for other purposes.

D. Gynogenetic diploidy - Production of gynogens presents another method for increasing production and might eventually solve some other production problems as well. Gynogenetic offspring from those F1 hybrids exhibiting the fastest rates of growth would contain the same genetic material as the female.

However, fusion of the female pronucleus with the second polar body produces a zygote with sister chromosomes and results in homozygosity for all gene pairs except those which might have been involved with previous crossovers between homologous chromosomes. Thus, offspring from artificial gynogenesis would likely be homozygous for most gene pairs.

Artificial gynogenesis might eventually allow continuous production of F1 hybrids from hybrid brood stock, which would alleviate the necessity of acquiring or maintaining two different parental stocks. Additionally, artificial gynogenesis may be useful in selective breeding, since homozygosity can be achieved in fewer generations than with inbreeding. Clones have been produced in carp and zebra fish. Homozygosity can also result in expression of lethal recessive traits, but second generation gynogenomes are likely to be purged of most lethal genes. For example, only 20 percent of the first generation of zebra fish gynogenomes survived to maturity, but 68 percent survived in the second generation (Streisinger et al. 1981). Different clones had varied viability, longevity and fecundity, but more vigorous "hybrids" could be produced by crossing two clones of homozygous individuals through matings with hormonally created males. Gynogens have been artificially produced in a number of other fish species, including grass carp (Stanley 1976), channel catfish and salmonids (Chourrout 1984).

We have attempted production of gynogen striped bass by irradiating spermatozoa from white bass with ultraviolet light and heat shocking the fertilized eggs at various temperatures. However, we have been unable to confirm production of true gynogens.

Because gynogens have a normal chromosome complement, it is necessary to rear larvae created with "attenuated" sperm from a difficult species to a stage that they can be morphologically or biochemically distinguished as a pure species or a hybrid. The only other option is to use fish with a prominent genetic marker, such as albinism in channel catfish, which to my knowledge, does not occur in striped bass.

E. Selective breeding - A discussion of Morone genetics for aquaculture purposes would not be complete without at least mentioning the traditional selective breeding process used for many years for stock improvement in domestic animals. In aquaculture, rainbow trout is a prime example of a fish species that has undergone extensive selective breeding; there is even a compendium of the various strains. Results show that trout have been domesticated and considerably improved over wild strains for aquaculture uses.

Very little selective breeding has been done with any of the Morone species. Initial efforts to "domesticate" striped bass and provide for a captive broodstock were first undertaken by the Edenton National Fish Hatchery. Recent efforts in North and South Carolina have made substantial progress in broodstock development (Smith and Jenkins 1984; 1986). However, selective breeding studies have not been attempted.

F. Gene insertion, etc. - Biotechnology techniques to insert genes or chromosomal segments from one species to another are providing dividends and appear to offer considerable potential in mammals. However, research with respect to fish has thus far not been particularly productive.

RESEARCH NEEDS

Genetic manipulation in fish is in its infancy and all areas mentioned need additional research particularly for striped bass and hybrids. The feasibility studies have not been attempted or completed in most of these areas. For example, the idea of introgressive hybridization was suggested 30 years ago, but its feasibility has not been demonstrated, and there is little to suggest that serious attempts were made to develop this mechanism.

Research efforts in genetic manipulation have focused on induction of polyploidy and production of gynogens. However, results have been mixed and researchers generally agree that considerable potential exists, but thus far it has not been fully realized. Production of triploid trout, particularly all female triploid trout, is presently the only practical development to become commercially desirable for production of foodfish. The potential of gynogens and tetraploids for aquaculture is still questionable. Research with Morone, in these areas have been very limited but should be continued and expanded. Selective breeding and the use of biotechnology programs to improve Morone hybrids need to be developed at dedicated research facilities. Research in selective breeding is needed to domesticate Morone sp and develop broodstock to improve consistency and reliability of quality seedstock, similar to the degree of consistency that now characterizes rainbow trout. This effort will require many generations and dedicated facilities. Biotechnology research involving direct transfer of genetic material from one fish species to another is also an area with potential. However, this research will require highly trained personnel and specialized equipment to fully explore the possibilities.

SUMMARY

Research in the area of genetic manipulation with fish has begun within the past 10 years, primarily with rainbow trout, grass carp and channel catfish. Efforts in this area have begun with striped bass and hybrids but there is no published information available. Although research on genetic manipulation of striped bass and hybrids has tremendous potential for improving aquaculture potential of the Morone complex, it will be a long process and will require that research facilities be dedicated to these efforts for a long time. Assuming that facilities can be dedicated to the effort, research is needed to:

1. Develop domesticated broodstock for hybrid seedstock production through selective breeding programs.

2. Evaluate tetraploidy and gynogenesis as means of enhancing broodstock development programs.

3. Develop the technology for gene insertion to enhance production characteristics such as growth rate, disease resistance and resistance to stress.

4. Evaluate the production characteristics of triploid hybrids and develop economically viable means of producing 100 percent sterile triploids for culture operations.

5. Evaluate the feasibility of introgressive hybridization in the *Morone* complex.

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PROCESSING AND MARKETING*

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INTRODUCTION

Private striped bass and hybrid culturists in the United States have made major advances recently. A number of products (including eggs and fry, fingerlings, adult broodstock and foodfish) are offered for sale to several different markets.

This paper concurs the sale of cultured striped bass and hybrids to conventional seafood markets and restaurants. These markets generally prefer one-pound and larger fish. These markets may be difficult for the industry to penetrate, but they may be the most lucrative.

PROCESSING

There are a wide variety of processing techniques available for fisheries products. Fresh finfish are often sold whole, gutted or dressed and on ice to ensure high quality and extend shelf life. Cultured striped bass and hybrids are often required to be labeled to distinguish them from illegally obtained fish. Special regulations exist in some states in which commercial harvest of wild stocks is prohibited.

Hybrids also can be sold live or whole to distinguish them from striped bass. Hybrids are easily identified with meristic characteristics and may not be subject to the packaging and labeling requirements imposed in some states for commercially landed or cultured striped bass.

Wholesale purveyors generally prefer to receive fish iced and packed in-the-round. Restaurants want fillets from larger fish, food chains want frozen products and institutional markets want fish cleaned and headed (Swartz 1984). Test marketing programs for farm-raised striped bass and hybrids have indicated that most wholesale distributors prefer to

*This material is based on work partially sponsored by the National Science Foundation under grant number OCE-8314570 to Aquatic Systems Incorporated.

purchase cultured striped bass and hybrids whole, in-the-round or gutted. Shipping costs are less for gutted and gilled fish than for whole fish. The wholesaler either processes the fish prior to delivery to the end users or sends it to a secondary wholesaler for processing and distribution. Fish are presented whole to the consumer and deboned at the table in some French restaurants.

Fresh product has been sold on ice in lots from 50 pounds up to several thousand pounds. Container shipments of multiple boxes that each hold approximately 100 pounds net weight have been used for large orders.

Most of the product receives little processing prior to consumption. Although some experimental quantities of processed fillets, sealed in blister packs, have been sold in New York, most striped bass and hybrids receive little processing prior to consumption. Weight loss from different degrees of processing can be significant. Scaling results in about a 3 percent weight loss, and gutting and heading results in another 15 percent loss (Smith et al. 1985). Cultured bass, ranging in size from one to two pounds round-weight, processed as fillets with skin on, resulted in a 40 percent yield. A single 10-ounce portion fillet can be produced from a 1.5-pound fish and two eight-ounces can be produced from a 2.5-pound hybrid striped bass (Carlberg and Van Olst 1983). The end product can be served baked, broiled or poached. Most cultured fish will be too small to sell as steaks, but there appears to be a strong demand for 6- to 9-pound fish.

Most central wholesale market centers deal in fresh fish. For example, in the Fulton Fish Market in New York, over 70 percent of the sales are fresh fish. Their distribution is divided into three major areas: 41 percent to restaurants and purveyors, 53 percent to retail outlets, and about 6 percent to other wholesalers.

Traditionally, over 95 percent of the striped bass landings from the Chesapeake Bay were sold to wholesalers (Strand et al. 1980, Norton et al. 1983). To capitalize on the advantages of the cultured product, farm-raised striped bass and hybrids are sold fresh rather than frozen.

REGULATORY CONSTRAINTS

Many states have legal and regulatory provisions governing the sale of striped bass and hybrids. Some New England states, especially those states adjoining the Chesapeake Bay, impose moratoriums on the commercial capture of striped bass, and their sale is strictly prohibited. Cultured striped bass and hybrids can be sold in some states if size limits and labeling requirements are met. Season limits are generally not imposed for cultured fish.

Marketing regulations for states along the East Coast were surveyed by North Carolina State University researchers. Their results identified two major problems: 1) the inability or unwillingness of enforcement agencies to distinguish farm-raised hybrids from wild-caught striped bass that are prohibited from sale in many states, and 2) laws prohibiting the sale of striped bass because it is a gamefish.

Hybrids are considered to be stripers and therefore illegal to sell in New Hampshire, Rhode Island, New Jersey and Maryland. They are also considered to be striped bass, but can be sold if minimum legal size limits are met in Massachusetts and Connecticut (over 33 inches), Delaware (over 15 inches), and in Virginia (over 24 inches). South Carolina prohibits the sale of hybrids because they are considered game fish. Farm-raised hybrids are presently allowed for sale in New York, Pennsylvania, North Carolina, Florida and Arkansas.

In most states which have regulations affecting the sale of striped bass, the sale of hybrids, either live or processed, does not usually require any special labeling on the fish because there are several meristic characteristics (number of scales above the lateral line and the distinctive shape of the head) that enable enforcement officers to quickly distinguish between cultured hybrids and wild-caught striped bass. However, the sale of farm-raised striped bass does require special labeling techniques in some states. For example, cultured striped bass markets in New York must bear a metal operculum tag indicating that approval has been obtained from the Department of Environmental Conservation. Similarly, in California cultured striped bass sold in the processed form must bear a consecutively numbered spaghetti tag, a nitrogen freeze brand, or be packaged in properly labeled, sealed containers. Live striped bass sold to Oriental markets do not require this identification, since illegally obtained striped bass would be difficult for poachers to capture and transport live without showing hook or net scars. In most cases in which striped bass and hybrids are allowed for sale, neither minimum size or season limits apply.

Live hybrid striped bass cannot be sold to fish markets or for stocking purposes in some states where they are deemed as undesireable by fisheries management agencies. Also, live deliveries often require prior notification, possession of a waybill and disease certification for stocks transported between states.

It will be necessary to change laws and regulations in several states to allow the sale of small cultured fish on a year-round basis. Most states require certification that the product is cultured and impose inspection requirements for fish reared in other states. An importation license and advance application may be needed and inspection and disease certification required to import cultured striped bass and hybrids from out-of-state.

Some states require that the fish can only be sold in the state of their origin. In addition to the state wildlife resource departments, other state and federal agencies have regulations affecting the processing and sale of cultured striped bass and hybrids.

PRODUCT IDENTIFICATION

The name and quality of the product are important in distinguishing cultured striped bass and hybrids from wild-caught striped bass. Cultured fish have advantages over commercially landed bass, and these advantages should be emphasized in any marketing program.

Uniform quality control and grading standards must be established to ensure the product retains its reputation as a luxury product and specialty item. Attention must be given to potential problems related to preserving firm texture and fresh odor and avoiding problems from off-flavor, contaminants or parasites. The responsibility for product liability and the need for appropriate insurance lies with the producer.

Hybrid striped bass produced in experimental research projects at North Carolina State University have been test marketed under the name "Farm-Raised Rock" in Atlanta and Philadelphia (M. T. Huish and J. H. Kerby, personal communication). The wholesale distributor felt that the phrase "hybrid striped bass" created adverse connotations, and it may be incorrect to label hybrids as striped bass.

Striped bass are commonly referred to as rock fish along much of the Atlantic coast and recognized by this name in restaurants. However another name may be more appropriate in another area.

DISTRIBUTION

The culturist has the option of delivering his product directly to the retail end user or taking advantage of the established network of fish brokers and wholesale distributors

(Swartz 1984). The use of intermediates often facilitates the distribution and marketing of large volumes to central wholesale market outlets. The producer must evaluate the cost efficiency of direct marketing versus the use of professional intermediaries.

When middlemen are involved, the total retail sales value is often divided as follows: ex-vessel, 39 percent; processor, 19 percent; wholesale, 17 percent; and, retail, 25 percent. As production volume grows, specific processors and distributors will evolve to meet the needs of the growing industry.

For marketing cultured striped bass and hybrids, the distribution network used most often has been to deliver freshly harvested fish to local wholesale distributors. They are then processed or sent whole to distributors in the target marketing area. The existing infrastructure for fresh fish transport is sometimes used for distribution. Air shipment is generally used in the transport of fresh product from production sites to distant markets that pay premium prices. In addition, there is a growing demand for live fish sales in the Oriental and kosher markets in some regions of the country.

Since fresh fish is a perishable item, it is often necessary to ship it on a space guaranteed basis. Some refrigerated truck transport services can be used where production is near major markets.

SUPPLY, DEMAND, AND PRICE

The supply of striped bass has historically come from the commercial fisheries on the East Coast. Declines in wild populations and the closure of many commercial fisheries have created a large unsatisfied demand for striped bass in estbalished markets on the East Coast. Commercial landings of striped bass reached a record high of nearly 15 million pounds in 1973. But the catch has fallen to a low of 1.2 million pounds in 1985 (Thompson 1986). The annual average landings from 1981 through 1985 have been only about 2.5 million pounds. During the early part of this century there also was a commercial striped bass fishery on the West Coast.

Per capita consumption of seafood has increased by 30 percent in the United States since 1970 and is expected to continue to increase at a rate of 3.4 percent annually. U.S. Department of Agriculture projections show the per capita consumption of fish increasing from a high in 1985 of 14.2 pounds to over 30 pounds by the year 2000. Part of this increase is probably attributable to the increased awareness of the nutritional and health-related benefits of a diet high in fish.

The volume of supply affects price by the quantity/price matrix relationship. This relationship has not yet been fully established for the sale of cultured striped bass and hybrids. Only small quantities of cultured striped bass and hybrids have been sold in recent years by a few private operators and research institutions in North and South Carolina. Small amounts also have been sold to wholesalers from pond culture operations in Mississippi and Arkansas. Most of the sales have been hybrids rather than striped bass.

The total amount of cultured striped bass and hybrids sold by the private sector to date is estimated to be less than 50,000 pounds. However, it is expected to exceed a quarter of a million pounds in 1987, based on inventories currently in production.

The form in which the cultured product is sold influences the selling price. There appears to be little or no demand by wholesalers for small fish less than 0.50 pound, and only moderate demand for pan-sized fish 1.50 to 1.75 pounds that yield a single serving portion. However, the smaller fish are still acceptable for sale to many live fish markets in some regions.

The traditional market is for large fish that can be filleted. Therefore wholesalers prefer cultured fish from two pounds and larger that can be filleted to yield multiple portions. The industry will have to expand the market for pan-size fish that are butterflied and sold whole, similar to that developed for rainbow trout and coho salmon. This expression is essential to satisfy need for cash flow in start-up ventures and to maximize the use of facilities by providing markets for large quantities of one- and two-year-old fish.

Preliminary surveys of numerous fresh-fish wholesalers and distributors indicate the following prices: live cultured striped bass and hybrids, $4.50 to $5 per pound; in-the-round, from $2 to $4 per pound; and dressed, $3.25 to $4.75 per pound. These prices are for delivered product, adjusted for weight loss from processing, and cost added for ice, boxes and freight.

Aquatic Systems Incorporated surveyed 80 wholesalers in 14 states and found that the weighted average price for delivered, gutted striped bass was $4.13 (range $3 to $5) and that the average volume desired by wholesalers was just over 2,000 pounds per week (range 300 to 20,000 lbs).

Initial marketing results for research projects in North Carolina indicate a price of about $1.99 per pound when delivered whole to a local wholesaler with an estimated need for 8,000 to 10,000 pounds per week. The precise schedule of availability of cultured striped bass and hybrids will affect price. There has been a broad range in price caused by a shortage or glut from seasonal fisheries supplies. Products available during the off-season command higher prices. Cultured product has been sold in Philadelphia by the NCSU research team after the season for a higher price than that received during the season in Atlanta. Cultured hybrids were of a lower value during the fishing season. Small quantities of hybrid striped bass have been produced and sold by the Pennsylvania Power and Light aquaculture project to wholesalers in New York, Baltimore, and Washington, D.C. at a price of $1.85 per pound, whole weight. Marketing of cultured product may have to be restricted or avoided during these seasons. The price also is high on the East Coast during the summer tourist season, a time when cultured product also can be sold at a high price.

Preliminary results from test marketing of hybrids produced in research projects in South Carolina indicated a price of $3.30 per pound for whole fish delivered to a wholesaler in New York. Through careful negotiations, Aquatic Systems Inc. consistently receives over $4 per pound for whole fish delivered to wholesalers in California and on the East Coast and up to $5 per pound for live fish.

The marketing information indicates a pondside price of $3 to $3.50. The wholesale price of gutted, head-on hybrids to restaurants has ranged from $4.25 to $6.25 per pound. Retail prices in fresh fish markets have been as high as $7.99 per pound. Commercially landed frozen striped bass were sold in European markets for $3 to $7 per pound in quantities of 1,000 pounds per week.

No information on the market demand or degree of product substitution is currently available. Projected price trends and forecasts of demand for cultured striped bass and hybrids are needed. Current statistics show that the retail price for fish products has increased by 26 percent in the past five years, so the forecast appears favorable.

MARKET ZONES

There are a variety of outlets for cultured fisheries products. They may be sold in live-fish markets, fresh fish markets, restaurants, private clubs, gourmet specialty stores, catering companies, supermarket chains and other institutional markets. However, 61 percent of all U.S. seafood consumption is in restaurants.

Striped bass markets have traditional geographical territories divided between the Northeast for large fillets and the South for pan-size fish (Swartz 1984). Central market centers in New York, Baltimore, Philadelphia, Boston and Washington, D.C., have distributed most of the striped bass supplied by the commercial fisheries. Valuable markets also exist in Virginia, Atlanta, Chicago, Minneapolis, Dallas, Phoenix, San Francisco and Los Angeles.

Competition will eventually have a strong influence on the sale price of cultured striped bass and hybrids. This competition will come from: 1) legal commercial landings in Virginia and North Carolina, 2) fisheries products, such as white bass from Lake Erie and coastal stocks of swordfish, halibut and sea bass, and 3) imports of similar bass species.

The striped bass and hybrid culture industry will have the advantage of reviewing the experiences of the boom production from the trout and catfish culture industries, in which only the most efficient producers survived the initial market fluctuations.

MARKET STRATEGY

Fish culture in general is a "market-oriented production" industry, rather than "production-oriented marketing." However, there is a need to develop broader markets, to assess the market potential and to identify appropriate market entry procedures.

Cultured striped bass and hybrids should be market-oriented, and not sold as a commodity product. They should be sold as a premium quality item.

Cultured product has many advantages over fishery landings: continuity of supply, certainty of quality and consistent price.

There may be a justified need for vertical integration to coordinate harvesting, preservation, packaging, storage and shipping. A producer's cooperative could be created to function as a trade association to facilitate market development. This type of organization could assist with the coordination of centralized contract buying or collective contract buying. However, most companies will want to acquire some of their own proprietary marketing information.

There is value in working with one wholesaler to ensure the consistency of supply when production is low during the industry's fledgling stage of development. There will be difficulty in attempting to balance the rate of development in the production sector with the rate of development of new markets. An industry association could coordinate and accelerate market development and perhaps solicit the use of professional marketing companies and assistance from governmental agencies, similar to that utilized by the Catfish Farmers of America.

ADVERTISING AND PROMOTION

Information from consumer surveys should be expanded to indicate preference, attitude, consumption patterns and buying habits. Advertising and promotional programs need to be created to: 1) identify established markets and develop new ones, 2) assess and possibly reduce competitive pressures, 3) evaluate consumer acceptance and promote education and 4) promote the differentiation of the cultured product as a premium product.

Demonstration and test marketing programs should be expanded. Advertising can be accomplished by a variety of methods including: personal selling, below-line techniques using free samples and coupons, and public relations campaigns (Chaston 1983). Promotional campaigns can be developed to identify striped bass and hybrids as aquaculture products and describe their use and method of preparation. This development can be conducted at the point-of-sale by visual aids or cooking demonstrations. Consumer surveys can assess preferences, attitudes and consumption patterns. Striped bass and hybrid culturists can use methods developed successfully by the trout and catfish producers to educate the retail buyer about the unique cultured project.

The industry can use existing associations, such as the National Fisheries Institute and trade shows at annual meetings of Seafood Expo to assist. Several agencies in the government can play a valuable role, including the Department of Agriculture and the Department of Commerce, the National Marine Fisheries Service and the Office of Sea Grant. University extension activities can provide services for information exchange to influence public policy and to identify priority research needs. Joint industry-government advisory panels have been used effectively and should continue to be used to collect, analyze, and disseminate production and marketing data.

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ECONOMIC RESEARCH: THE STRIPED BASS-WHITE BASS HYBRID

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INTRODUCTION

Economic feasibility of developing a hybrid grow-out industry will depend upon several important factors. These include: 1) sufficient demand to establish and maintain a price attractive to growers (given expected grow-out costs), 2) continued refinements in grow-out technique to reduce costs, and 3) reduced uncertainty surrounding future availability of broodstock and hence fingerlings. Other potential impediments might be cited, but these three summarize most of the concerns expressed by striped bass and hybrid culturists.

These factors are discussed in the following sections. Their collective importance is obvious: any potential grower will invest in grow-out facilities only if anticipated profits will cover opportunity costs (what could be earned with similar labor and capital devoted to their next best use). A producer must be able to predict with some degree of certainty what revenue and costs will be.

Expected output and market price(s) determine expected revenue, and input prices and technology determine production costs. Because fingerlings are an obvious input for grow-out, certainty in supply will be important to the decision to invest in specialized facilities, and more important perhaps than their current relatively high price.

Discussion at the hybrid workshop emphasized the research and information that would assist potential growers in formulating these expectations. That discussion is summarized in the following sections, with emphasis on future research needed to answer some of the questions.

FORMULATING PRICE EXPECTATIONS

As noted above, grow-out investors must form expectations about the price they will receive. Both average price and variability in competition with wild harvests are important. Because the hybrid striped bass is a new product, how consumers view the fish relative to other species is important. If it is accepted as a close substitute for other highly valued species and commands a price comparable to those species, then grow-out potential is improved. The hybrid is expected, at least initially, to compete with or replace the striped bass in traditional markets.

Test marketing of hybrid striped bass produced in North Carolina, South Carolina and California offers preliminary evidence that farm-raised hybrids may command a higher price than stripers (Carlberg and Van Olst 1987; J.H. Kerby and T. Smith, personal communication).

Approximately 4,200 pounds of hybrids produced in North Carolina were sold in the first half of 1986, for an average price of $1.99 per pound (J.H. Kerby and M.T. Huish, personal communication). Striped bass prices to North Carolina fisherman from March to May in 1986 averaged about $1 per pound. However, they received $3 per pound on small shipments to Philadelphia. Most eastern states other than North Carolina were under a striped bass harvesting moratorium at the time. Because several eastern states had restriction (including some bans) on sales, caution is suggested where using the North Carolina price for comparison.

Hybrids produced in California were sold in small lots for $4 to $5 per pound (Carlberg and Van Olst 1987). On larger shipments, they received $2.50 to $2.80 per pound (on direct sales). They also reported that a survey of approximately 80 wholesalers across the country showed much resistance to prices in the $4 to $5 range.

Approximately, 6,000 lbs (round weight) of fish produced in South Carolina were sold for $3.30/lb and delivered to New York markets in late 1986 (Ted Smith, personal communication). Further test marketing with larger quantities will be helpful in formulating price expectations. Also useful would be further study of the striper market as (or if) the striped bass stock recovers and commercial landings increase. If hybrids compete with stripers, rebuilding of striper stocks may reduce future striper prices.

Research at the University of Maryland found demand to be price elastic (personal communication, Ivar Strand). That is, reasonably large changes in striper landings are necessary to generate a given change in striper prices. Such sluggish price response may dampen effects of changes in striper landings on hybrid prices.

But these elasticity estimates hold for reasonably small changes. If striper stocks rebuild such that landings increase by some multiple, striper prices may become more responsive to changes in landings. This market will be important for growers to watch (and economists to research), particularly if the hybrid is viewed by consumers as a close substitute for the striper. If the hybrid develops its own market and becomes viewed as a "better" or different product, then changes in striper landings will have smaller effects on hybrid prices.

Regulatory constraints on sales of hybrids and/or stripers also affect price expectations of potential growers. A phone survey of state fisheries regulatory agencies on 18-21 November 1986, revealed the following (note that regulations are subject to change and to interpretation by individual contacted) (John Brown, personal communication):

(1) A hybrid is a striped bass, and striped bass cannot currently be sold in New Hampshire, Rhode Island, New Jersey and Maryland.

(2) A hybrid is a striped bass and can be sold if the minimum size limit for striped bass is met in Massachusetts and Connecticut (33 inches), Virginia (24 inches) and Delaware (15 inches).

(3) A hybrid is a game fish and game fish cannot be sold (South Carolina), unless the hybrids are farm raised (North Carolina, New York, Pennsylvania and Florida).

Such regulations restrict the potential market for farm-raised hybrids. However, if an industry begins developing and the hybrid has widespread consumer acceptance, perhaps restrictions will be relaxed. A fairly large industry has already developed in food sales of another game fish, i.e., rainbow trout and channel catfish.

Investors in striped bass and hybrid production farms should be made aware of these restrictions and perhaps assisted in seeking regulatory relaxation of sales. The workshop consensus was that such an effort is likely to be more successful if industry based. Recreational fishermen might support this effort if assured that native genetic stocks will not be adversely affected.

FORMULATING COST EXPECTATIONS

Potential striped bass and hybrid grow-out investors must form expectations about production costs and up-front costs of facilities in addition to revenue expectations. Because pond and other holding facility costs are site specific and amenable to estimation, this discussion will concentrate on production costs.

Information available on production costs is currently incomplete and difficult to obtain. Liao (1985) has studied pen culture in an estuary, and reported investment costs, production costs and net returns under alternative assumed prices. Similar budget estimates and test marketing are planned from current pond grow-out experiments in South Carolina and from farm production in North Carolina. Private growers in North Carolina should have approximately 150,000 lbs of hybrids to market in late 1988 and early 1989 (R.G. Hodson, personal communication).

Budget estimates are only as good as the input prices and production technology underlying them. One critical area of production research that directly affects economic returns is the response of the hybrid's growth to alternative stocking densities, water quality variables and feed formulations. Research into these responses will assist the potential grower in formulating expected production costs prior to investing, and, subsequently, in narrowing the range of his own "experiments" aimed at finding profit-maximizing combinations of inputs.

Thus, growth functions are of central importance to estimating grow-out costs under alternative management practices. Growth response under selected conditions has been examined by Kerby and Huish (N.C.), Carlberg (CA), Smith (S.C.) and Harrell (MD).

Also important in estimating grow-out costs is the availability of small fry for stocking. The future availability of broodstock may be precarious and this uncertainty will require solution prior to development of a significant grow-out industry. Dependence upon wild-harvested brood stock suggests biological research for alternatives. The development of alternatives suggests reduced uncertainty and the possibility that fingerling prices (currently around $.15 for 35 to 37 mm, to $.30 for 50 mm) may be reduced in real terms.

OPTIMAL GROW-OUT/HARVESTING STRATEGIES

Researchers at N.C. State University are examining use of growth functions in a more general model to look at questions of optimal timing of harvest, stocking density and size at stocking. The type of functions that are to be fit are illustrated in Appendix I. These graphs (T. Johnson, personal observation) are "eyeball" fits of data on growth, market price, price adjusted by size of fish and a cost function estimated per fish. The final chart shows net value (revenue less cost per fish). These graphs are shown only to illustrate the type of functions that must be estimated to determine production costs and optimal harvest timing (assuming the hybrid competes, at least initially, in the striped bass market).

This exercise illustrates the variability that might be expected in net revenue, largely because of variability in price. Research into optimal timing of harvest, and how sensitive those prices are to quantities sold (which will have feedback on optimal harvest timing) should be especially helpful to initial producers.

Functions that must be estimated to help answer these questions include growth and cost functions, and market demand and supply (of stripers) functions. Timing issues will require that dynamic functions be estimated.

SUMMARY OF SUGGESTED FUTURE RESEARCH AND ACTIONS

The following list of research and action steps are recommended, by order of approximate importance. Industry, university and government agency cooperation is encouraged. Industry leadership for some actions may be appropriate.

1. Reduce uncertainty of broodstock availability, hence fingerling production.

2. Improve estimates of growth and cost responses to different stocking densities, water quality variables and feed composition. Note that cost data, including labor, should be recorded, and tests should mimic commercial production as closely as possible. A large-scale pilot farm was suggested as a vehicle for these experiments as well as to provide larger quantities for test marketing.

3. Coincident with test marketing, further research into demand and supply functions of striped bass and their seasonality is suggested.

4. Economic research into optimal timing of harvests and stocking will be valuable to initial producers. This work requires that growth functions and demand and supply function estimates for hybrids be available.

5. Cost-return budgets are needed as decision aids for growers but must be based upon better growth function estimates and reduced uncertainty of future fingerling supply.

6. As significant quantities of hybrids are marketed, examination of demand for and profitability of different product forms will assist processors (and growers) in increasing net revenue from hybrid sales.

7. Research and monitor the effects of future striped bass stocks (and harvests) on future hybrid prices.

ACTIONS SUGGESTED

1. Formation of a trade association is encouraged.

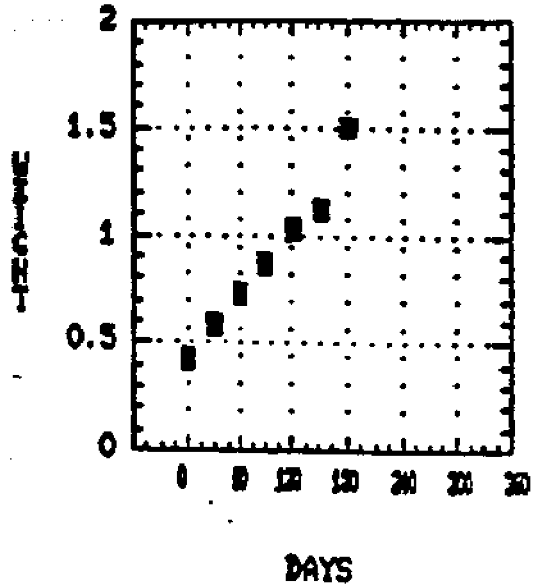
2. Begin examining alternatives for broodstock provision, possibly including joint industry and state or federal "brood pool."

3. Begin careful examination of regulations prohibiting (or otherwise restricting) sales of hybrids. This may include summarizing "pros and cons" of hybrid sales.

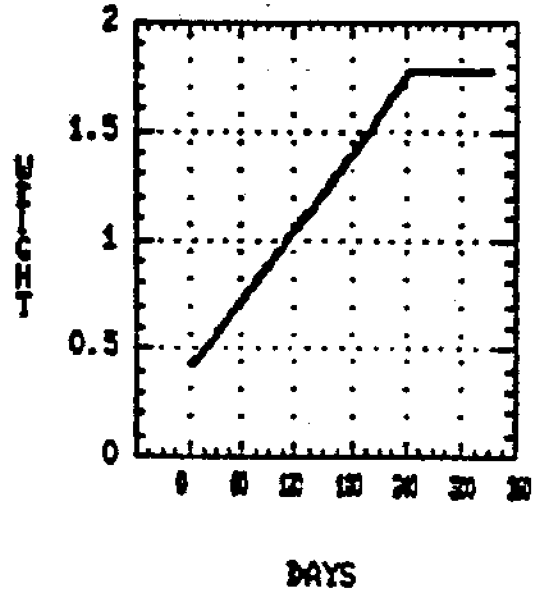
4. In conjunction with grow-out, examination of industry marketing strategies (including advertising) is encouraged. It is suspected that the immediate future is not likely to include proprietary products (e.g., McRockfish), but generic products (e.g., blackened rockfish) may become established.

See two pages of figures.

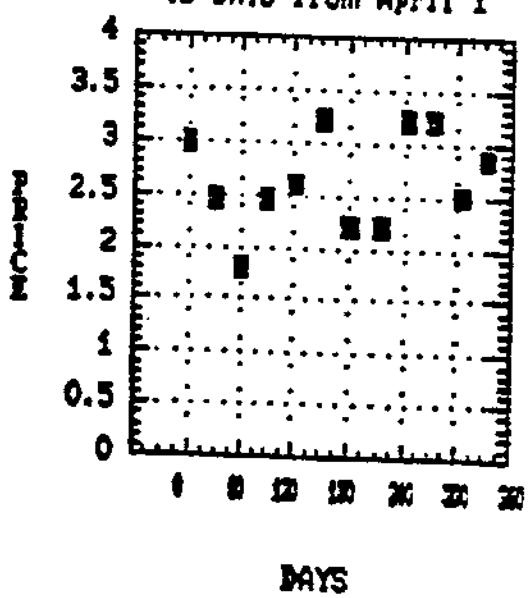
OBSERVED WEIGHT (lb per fish)
vs DAYS from April 1



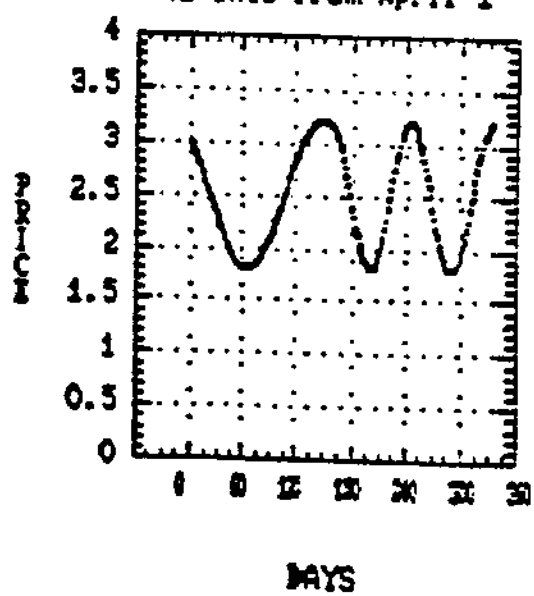
FIT WEIGHT (lb per fish)
vs DAYS from April 1

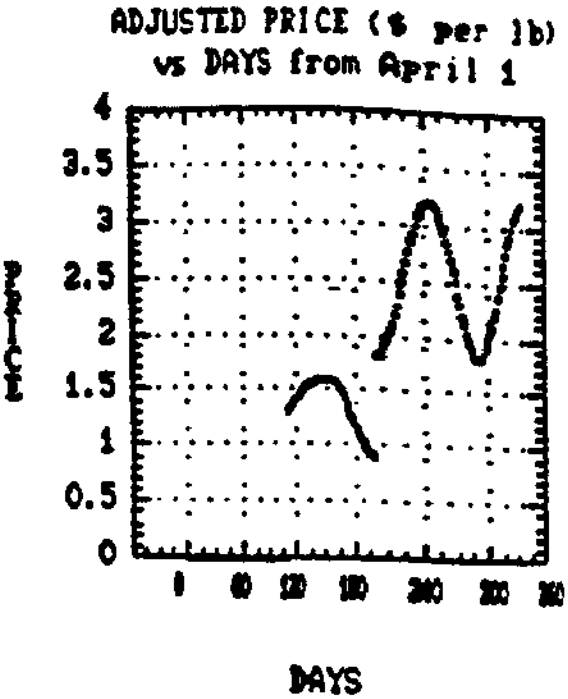


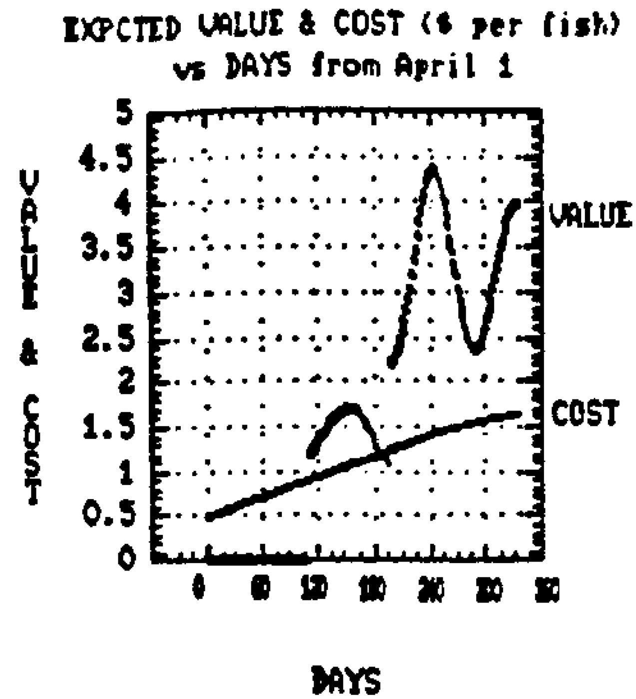
OBSERVED MARKET PRICE ($ per lb)
vs DAYS from April 1

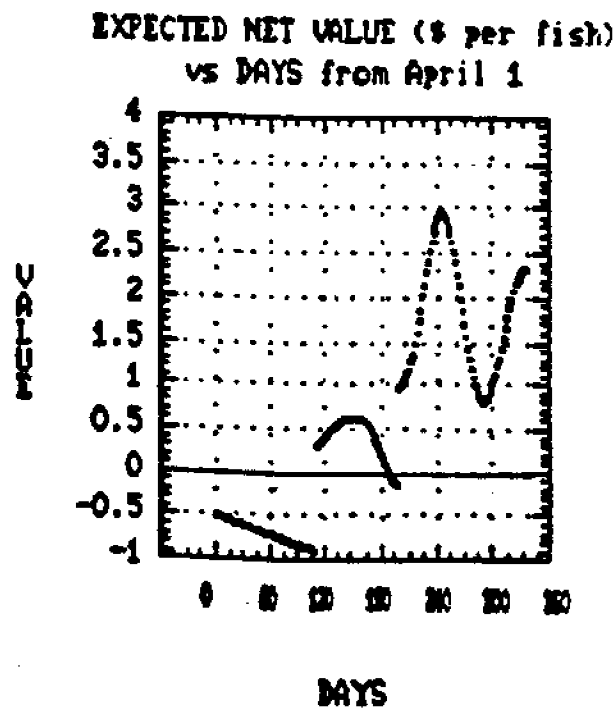


FIT MARKET PRICE ($ per lb)
vs DAYS from April 1




ADJUSTED PRICE ($ per lb)
vs DAYS from April 1
PRICE
4
3.5
3
2.5
2
1.5
1
0.5
0
DAYS


EXPCTED VALUE & COST ($ per fish)
vs DAYS from April 1
VALUE & COST
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
VALUE
COST
DAYS


EXPECTED NET VALUE ($ per fish)
vs DAYS from April 1
VALUE
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
DAYS

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LAWS AND REGULATIONS

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INTRODUCTION

Commercial aquaculture of hybrid striped bass and other species is still in its infancy in the United States. Development of this industry is somewhat impaired by laws and regulations which deal primarily with fishery resources and do not address the needs and problems encountered by commercial aquaculturists. Like agriculture, aquaculture enterprises are confronted by a number of federal, state and local regulations which are in place to protect the nation's natural resources and public health. However, the agriculture industry has been able to streamline these regulations by coordinating policy and programs within a comparatively few agencies (Wypyszinski 1984).

In contrast, aquaculturists must confront each regulatory agency separately. During the permitting process aquaculturists are likely to encounter regulatory gaps, inconsistent policies and overlapping jurisdictions that retard aquaculture development (Wypyszinski 1984).

A recent congressional study of federal and state regulatory restrictions to aquaculture development reported that approximately 50 federal statutes directly impact aquaculturists, and 120 federal statutory programs have a significant relationship to aquaculture (USFWS 1979). And a survey of 32 states identified over 1,200 state laws which impacted aquaculture development (USFWS 1979). In California up to 42 federal, state and local permits and licenses would be involved in regulating a single aquaculture venture (Joint Subcommittee on Aquaculture 1983a).

This maze of laws and regulations results in reduced economic incentives by creating lengthy and uncertain permitting processes, adding to costs and delaying construction (Joint Subcommittee on Aquaculture 1983a). Although many of the restrictions may be necessary, they should be critically examined and consolidated where possible to avoid placing undue economic strain on the developing aquaculture industry.

The laws which govern aquaculture enterprises fall into several major regulatory categories: land, water, health and fisheries. Some of these regulations are encountered by all businesses, while others are directed primarily at aquaculture enterprises.

LAND USE REGULATIONS

Land use regulations fall into several categories, each of which may require approval before an aquaculture operation can begin. Zoning laws are frequently the first group of land regulations encountered by aquaculturists and may not allow certain activities in particular locations. These laws usually establish requirements and ordinances which classify land use into residential, commercial industrial, agricultural and conservation districts (Nussman 1984).

Often the use of land for aquaculture was not contemplated by zoning authorities, and usually it is not incorporated in the local master plan unless aquaculture is identified or classified as agriculture.

The aquaculturist may have to obtain variances and changes in the zoning code which are usually time consuming and costly. Further, problems may arise if local authorities become confused over whether aquaculture falls under agricultural or industrial use.

Another potential hurdle is the Coastal Zone Management Act which established land use regulations in critical coastal areas of the United States. Permits in these areas are required for any activity or alteration proposed on tidal wetlands, beaches, sand dunes or in coastal waters. These activities include installation of piers, bulkheads, intake structures, etc. The construction of dikes, dredging operations and other activities are also covered under this act. And, the U.S. Army Corps of Engineers also has jurisdiction over many of these same activities. The application for permitting an aquaculture operation may also require the preparation of an Environmental Impact Statement (EIS). The requirements of an EIS are fairly extensive and costly, and include a complete inventory of existing environmental conditions including previous history at the proposed site and the surrounding area in addition to a project description which specifies what is to be done to the site.

WATER USE REGULATIONS

By definition, aquaculture involves the use of water. Thus many aquaculture ventures involve the use of a resource normally considered part of the public domain. Aquaculture facilities face the unusual problem of requiring semi-exclusive and, in some cases, exclusive access to high quality waters of the state. In addition, the needs of others who want to use these waters for their livelihood or recreation must be met.

The complexity of regulations varies with the type of water to be used (fresh or saline) and the geographic location (high land, coastal rivers, open water etc.). Use of freshwater wells as a source of culture water is usually less restrictive. But permitting and record keeping are required in some areas for facilities using large volumes of water (>100,000 gallons/week in South Carolina) (Nussman 1984) or drawing water from specific aquifers.

When surface water is used aquaculturists must determine the ownership of the water rights in order to assure a sufficient supply. If the planned operation is to be located in navigable water (i.e., net pen systems), permits must be obtained from the U.S. Army Corps of Engineers and the U.S. Coast Guard.

Aquaculture facilities which are not closed systems will probably require a National Pollutant Discharge and Elimination System (NPDES) permit from the Environmental Protection Agency. This permit is required for any discharge which contains effluent from ponds or raceways which discharge at least 30 days per year and produce more than 100,000 pounds of warm water aquatic animals per year (Nussman 1984). And limits may be lower than this in special areas. Fish farmers complain that the NPDES permitting system does not distinguish between biodegradable waste of aquaculture operations and the chemical waste produced by industrial users (Wypyszinski 1984).

HEALTH REGULATIONS

As with all operations in which animals are reared at high densities, disease can be a potential problem. However, unlike other industries, the aquaculturist has very few prophylactic treatments which are approved by the Federal Drug Administration (FDA) for use on food fish. Many drugs have been banned because of potential harmful side effects to humans or have not been licensed because they have not met the lengthy and expensive process of registration for aquaculture use.

The current FDA system requires a separate test for certification for use with each species. Thus, the drugs which are currently registered for use with catfish may not be registered for use on the same disease in hybrid striped bass. Because aquaculture is still a comparatively small industry, pharmaceutical companies are unwilling to spend the time and money required to register therapeutic agents. This situation leaves foodfish producers with few legal alternatives for control of diseased fish other than eradication (Joint Subcommittee on Aquaculture 1983a).

Another problem associated with disease control is the requirement in some states for disease certification of live fish entering the state. In California the list of disease species which can result in destruction of a fish shipment includes Aeromonas sp. and Vibrio sp. (Calif. Dept. Fish and Game 1986). Both of these diseases are ubiquitous and occur in wild populations. The rejection of such shipments will do little to control outbreaks of these diseases in wild populations. Disease certification requirements should be formulated primarily to prevent the spread of infectious diseases which are not present in wild populations.

FISHERY REGULATIONS

The legal issues that have been discussed up to this point are common to all aquaculture enterprises. However, potential hybrid striped bass culturists face an additional group of especially restrictive laws related to management of wild fisheries. These laws comprise the largest single impediment to striped bass and hybrid culture and include activities from broodstock collection to marketing.

Unlike other laws discussed so far, fisheries' laws in many states have no provision for aquaculture. Aquaculturists will have to have existing laws amended to allow culture of striped bass and hybrids before even initiating preliminary aquaculture activities (site selection, development permits, etc.).

Striped bass and hybrids are considered game species in many states and cannot be cultured or sold. And in states that allow the sale of striped bass, laws often require that wild-caught fish meet a minimum size limit which was implemented to protect the fishery. These minimum sizes are often in excess of 20 inches (50 cm) and in many states cultured fish have not been exempted from these regulations. Because hybrid striped bass growers could more profitably produce a smaller pan-size fish, these regulations limit marketing alternatives.

Aquaculturists are often confronted with restrictive laws during the process of getting permits to collect broodstock from wild populations. Some states prohibit private growers from taking broodstock from th wild. However recreational fishermen are allowed to take the same fish as long as they meet size and creel limits (Calif. Dept. of Fish and Game 1986).

Other states permit the taking of broodfish by private individuals but require that a specified number of fry, fingerlings or juveniles be returned to public water as mitigation for each broodfish removed from the wild. Biological justification for this requirement is not provided in many cases. The fish taken by culture operations is insignificant when compared to the number of fish taken by recreational fishermen.

The states that allow culture operations may also restrict which fish can be cultured in a particular location. For example, hybrid striped bass cannot be cultured in certain river drainages within some states (i.e. California). These restrictions are made to reduce the possibility of hybrids escaping into specific river systems. The laws and regulations in general accommodate rather than encourage the development of hybrid striped bass aquaculture.

The restrictive attitudes of many fishery agencies are based on three primary concerns: (1) that there is potential for contamination of the gene pool of native fishes by the accidental escape of cultured hybrids from aquaculture operations; (2) fear of encouraging illegal poaching of wild fish for sale in legal markets; and (3) the potential for the spread of fish diseases.

Although this first concern has some hypothetical merit, such escapements should be minimal or nonexistent from properly sited, designed and managed operations. Further, many of today's introductions were intentionally or accidentally made by fishery managers and recreational fishermen who attempted to manage recreational fisheries and/or increase fishing opportunities. No major problems have occurred as a result of these introductions.

The possibility of limiting the genetic diversity of native populations through stocking enhancement programs which often release progeny from only a few females is of more concern (Harrell 1986).

Restrictions on the identification, transportation and marketing of cultured fish can be employed to discourage or eliminate illegal sales of wild game. Such restrictions could include quarterly production projections, tagging of individual fish or batches of fish, advanced notification of law enforcement of planned sales and shipments, and designation of market outlets for cultured fish. The availability of cultured fish could fill the demand niches currently filled by illegally taken wild fish and could reduce illegal poaching.

SUMMARY AND CONCLUSIONS

The laws discussed above are just a few that impact the culture of striped bass and hybrids. Many of the existing regulations are necessary and serve to protect public resources but many are restrictive, unnecessary and serve to inhibit development of hybrid striped bass culture. A critical need exists to reevaluate current regulations and to eliminate those restrictions that serve no valid purpose (Joint Subcommittee on Aquaculture 1983b).

Numerous laws overlap in such areas as fish disease control, pollution abatement and interstate shipments. Such overlapping jurisdictions and conflicting laws need to be identified and consolidated into functional and meaningful regulations.

The outlook for development of hybrid striped bass culture appears promising. However, educational programs and cooperation between the private sector and government will be needed for the industry to reach full potential. Current laws must be streamlined into reasonable regulations which not only protect public resources but also allow for proper development of a hybrid striped bass aquaculture industry.

RECOMMENDATIONS

1. Current laws need to be reviewed, revised or deleted as appropriate to encourage proper development of the hybrid striped bass aquaculture industry.

2. Designate a coordinating agency for aquaculture development to assist the hybrid striped bass industry at a national level.

3. Laws need to be enacted which permit taking of broodfish from wild populations for aquaculture

development until domesticated broodstocks are available.

4. Develop laws which allow for exclusion of cultured products from restrictions placed on products from wild fisheries.

5. Management and permitting of aquaculture activities should be under the jurisdiction of agriculture which regularly deals with commodity groups rather than fishery agencies which deal with management of natural resources.

6. Aquaculture should be defined as agriculture for purposes of land and water use, tax incentives, extension programs and other activities.

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TECHNOLOGY TRANSFER FOR STRIPED BASS CULTURE

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BACKGROUND

The technology for the culture of striped bass and its hybrids has been established at the experimental level but has not been demonstrated conclusively at the commercial level. Techniques for spawning striped bass and its hybrids, rearing of the larval stages, nursery of juveniles, and growout to market size have been established. The cross between white bass and striped bass appears to be superior for culture compared to straight striped bass stocks. We still need more information on stocking rates, feeds, hatchery techniques, production economics, marketing, risk assessment, and drug clearance in order to get a better idea of the commercial feasibility of hybrid striped bass culture. The technical feasibility seems clear.

Even so, the institutional constraints to the industry are greater than the technical ones. Several states prohibit the culture and sale of striped bass or its hybrids because of laws regulating wild stocks. The declining harvests of wild stocks have led to size limits and other regulatory restrictions for striped bass and its look-alikes. These restrictions have had a negative effect on the development of aquaculture for hybrid striped bass. The permit procedures for aquaculture ventures are formidable and confusing, with considerable variation from state to state. Prospective investors in aquaculture will have to have clear guidelines on what they can and can't do in setting up hybrid striped bass or striped bass farms.

For several years, the National Sea Grant Program has provided funding to universities for hybrid striped bass and striped bass research. One of the functions of the Sea Grant Program is to provide extension services and education to the public after research projects have developed the technology. Marine Advisory agents exist in most coastal areas, and several Sea Grant programs already have aquaculture specialists on their staffs. Education and communication specialists are available to develop the necessary educational materials to support the industry once the commercial feasibility has been established.

The U.S. Department of Agriculture is interested in hybrid striped bass culture as part of its role as the new lead agency for aquaculture activities in the United States. The Department of Agriculture is looking at hybrid striped bass as an alternate crop for coastal and inland farmers.

USDA also has an extensive network of state extension specialists, county extension agents as well as many agricultural experiment stations that help determine and demonstrate the feasibility of different agricultural techniques. Precedent has been set for pilot scale demonstration activities within the USDA. Demonstration projects will be necessary to obtain information on scale and other economic factors that will determine the advisability of investment. Efforts are being made to coordinate Department of Agriculture and Sea Grant extension efforts for hybrid striped bass interests.

The USDA also has established a National Aquaculture Information Center at The National Agriculture Library in Beltsville, Md. The Information Center plays a major role in the acquisition and dissemination of literature and other aquaculture-related materials. It serves as a contact point for the gathering and exchanging of knowledge provided by aquaculturists, extension personnel and researchers in the field. New developments in computer technologies are also being explored as a means to enhance information transfer in aquaculture.

This facility is an important part of any technical transfer system. To develop commercial production of hybrid striped bass, extension personnel will need a variety of educational and technical materials. Details of culture techniques, disease treatment and nutritional information need to be made available in terms the layman can understand.

The economics of hybrid striped bass culture also needs to be established so that loans for production facilities can be obtained. Economic analyses must be developed for decision-making by potential entrepreneurs, and care must be taken not to promote investments until it is clear that potential for profitability exists. This will require some idea of the scale of the farms that must be established in order to be economically viable.

We will also need to know the relative costs of hatchery, nursery and growout activities as well as labor, utilities and the other standard expenses associated with aquaculture operations. Marketing studies to determine optimum size of fish, time of harvest and distribution channels also need to be conducted for use in determining the economics of culture.

One of the greatest constraints to aquaculture is the lack of research and demonstration facilities. Dedicated facilities for evaluation of hybrid striped bass aquaculture as a food fish exist at the Waddell Mariculture Center in South Carolina, at the UNC Sea Grant Aquaculture Center in Aurora, N.C., and to some extent at the Horn Point Laboratory of the University of Maryland. But these facilities are also used for research on other species, and it is difficult to obtain enough ponds to conduct statistical analyses and to establish commercial feasibility of hybrid striped bass culture.

Some research-field testing can be done on private land with innovators that are willing to take the high risk of present technology, but the average farmer should not be involved until the technical and economic feasibility is firmly established.

SUGGESTIONS FOR ACTIVITIES RELATED TO TECHNOLOGY TRANSFER

1. Present striped bass/hybrid research facilities should be expanded to provide for pilot scale culture to determine the scale and economic considerations of hybrid striped bass and striped bass culture. Sea Grant, USDA, Department of the Interior and other state and federal agencies should explore arrangements to create pilot scale programs that would provide the necessary information for use by extension services. There should be a training component to these programs so that those interested in learning the techniques of culture can gain the necessary experience.

2. Appropriate educational materials should be developed for state and federal policymakers regarding the economic potential and risks for hybrid striped bass culture. The positive aspects of aquaculture should be developed as selling points. This material should be coupled with information on how other governmental bodies have enacted legislation and regulations that have encouraged or allowed aquaculture development. Aquaculturists should listen to the legitimate concerns of the natural resource agencies.

3. Other technical materials should be developed for industry users who need to improve their operations. This should include how-to manuals on brood stock care and maintenance, and on the hatchery, nursery and growout phases of the industry. A state of the art publication on hybrid culture should take a non-advocacy approach and should realistically approach the economics and risks involved.

4. Marketing and processing analyses should be completed and incorporated into the educational materials. This should include information on optimum size of fish for marketing, value added processing (i.e. filleting, smoking, butterflying), and what it means to profits. Other information on proper marketing channels for the products and lists of wholesalers and retailers would be useful.

5. Marketing information should capitalize on the potential differences in quality between aquaculture products and wild harvested products, including nutritional information on the product. The recent demonstration of the value of Omega 3 fatty acids in fish could be exploited. But care must be taken to be sure that culture techniques preserve these healthful qualities in the fish produced through aquaculture.

6. All informational materials should be submitted to and maintained through the USDA National Aquaculture Information Center, located at the National Agriculture Library in Beltsville, MD 20705. Sea Grant Depository technical materials and other technical materials should be contributed to the new "expert system" being developed for aquaculture by the National Agricultural Library.

7. Short courses, workshops and seminars on hybrid striped bass culture should be given through USDA's Extension Service and Sea Grant's Advisory Services after technology is fully verified for economic feasibility. Videotape programs should be developed for use in the training sessions.

8. Technology that has been developed elsewhere and for other species should be evaluated and utilized if appropriate for hybrid striped bass culture in the target geographical areas.

9. Information on disease control, FDA clearances, etc. should be developed so that prospective investors know the limitations of their activities and how this could affect profitability.

10. Extension agents and marine advisory personnel should spend significant time with innovative potential aquaculturists in order to establish a cadre of aquacultural industry leaders. Care should be taken to point out the uncertainties and risks involved in establishing an industry.

11. Once the industry has developed to a scale large enough, a scheme of diagnostic services that could provide a grower with quick disease identification should be established as part of the public service commitment of USDA and OSG.