SPORTFISH

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BACKGROUND

A number of freshwater sportfish species (and associated forage species) are cultured for the purpose of stocking private waters for providing sportfishing recreation. Channel and blue catfish are two of the most popular species stocked in private water but these are discussed in more detail in other status reports. Another major species produced is the largemouth bass (the northern and Florida sub-species as well as their intergrades). Other species include bluegill (primarily as forage for largemouth bass), redear sunfish, hybrid sunfish, black and white crappies and hybrid striped bass. Additional forage species stocked into sportfish ponds include tilapia, fathead minnows, golden shiners and threadfin shad.

There is little doubt that the largemouth bass is one of the most important sportfish cultured for stocking private waters. As a result, this report will center on the status of largemouth bass culture in Texas but will also address the various forage species cultured for bass production.

Largemouth bass have been cultured in the United States since about 1890. Historically, a variety of sportfish were available to the pond owner at no cost from Texas Parks and Wildlife. This service was discontinued in the late 1970's and as a result, the private sector assumed the role of producing sportfish for the purpose of private lake stocking.

The introduction and success of Florida bass stockings in the 1970's created considerable interest in the stocking of this sub-species as well as intergrades between the northern and Florida sub-species. Initially, techniques for discerning between sub-species and their intergrades were unreliable. However, advances in electrophoresis techniques the last few years has made specialty marketing of sub-species and their intergrades possible. The ability to determine the genetic
background of stocks has the most immediate impact on largemouth bass but could impact the genetic management of a number of other sportfish species in the future.

CURRENT STATUS

Today, the private sector produces sportfish fingerlings almost exclusively through the use of open ponds. State and federal agencies rely on tank and raceway production techniques in addition to ponds, particularly for largemouth bass. Currently, approximately 15 producers advertise sportfish species available for sale at their farms. Unlisted sources of sportfish fingerlings not included on availability lists for stocking public and/or private waters include Texas Parks and Wildlife, the U.S. Fish and Wildlife Service and other private producers not listed on availability lists at the present time.

Acreage in production is estimated at 150 acres by agencies and 250-300 acres by private industry. Production is primarily geared toward producing 1 to 3 inch bass and sunfish. However, some producers provided advanced fingerlings of these species on a limited basis. The major market outlets for these species are private pond owners, fish farmers, golf courses, and racing lakes. Total value of the sportfish fingerling industry is estimated at $1.5 million dollars annually. Price breakdown for selected species include bass $0.25-$0.35/inch up to 6 inches with large bass costing $10.00-$18.00/lb.; sunfish average $0.15-$0.25/inch; hybrid striped $1.00-$1.50 for 3-5 inch fish; fathead minnows $12.00/lb.; and threadfin shad $140.00/thousand.

POTENTIAL

The potential for the sportfish fingerling industry in general is favorable. However, the industry is leveling off in both size and production. The ever increasing demand for quality sportfishing will dictate production of sportfish fingerlings and their associated forage species, particularly in small impoundments that are intensively managed.

At this time, development of quality urban fisheries appear to have the greatest potential for future development. Continued drought conditions throughout the southern portion of the state continue to have a negative impact on the industry in that region.

DEVELOPMENT NEEDS

While certain sportfish and related forage species readily accept artificial rations, largemouth bass remain difficult to rear using this technique. Problems cited by industry include ration costs and the intensive labor requirements necessary to train fish to accept the rations. In addition, research on the performance of ration-reared sportfish after stocking should be conducted.

Other needs cited (in no particular order of importance) include:
1. Better pedigree certification procedures for largemouth bass stocks.
2. Development of unisex female bass and crappie.
3. Further research on "catchability" of largemouth bass sub-species and intergrades.
4. Continued strong public educational efforts on proper stocking and management techniques.
5. Increased availability of large bass at reasonable prices.
6. Increased utilization of the private fingerling industry by government.
7. Greater interaction between fish farmers and professional societies (i.e., Texas Chapter - American Fisheries Society).
8. Feasibility of on-farm use of electrophoresis techniques.
9. Further research on relative growth rates of largemouth bass sub-species and their intergrades.
10. Improvement of the image of fish farmers.

IMPEDIMENTS

A number of impediments have been identified as being potentially detrimental to the present and future of the sport-fish fingerling industry. These impediments include:
1. Predation by cormorants - ineffective legal control techniques.
2. Excessive regulation by government.
3. Competition by governmental sources producing sportfish fingerlings.
5. Water rights and cost of water pumping, etc.
6. Public perception of aquaculture as a detriment to public waters.
7. Drought

IMPLEMENTATION PLAN

The sportfish fingerling industry differs from the food fish industry in several ways. Primarily, sales are based on the desire by a landowner to properly stock and manage a body of water in order to increase recreational opportunities through sportfishing. If proper management techniques are employed, that
landowner may not purchase additional sportfish or forage species for several years. In contrast, the food fish industry relies heavily on establishing repeat business with expansion into new market areas.

This unique characteristic of the sportfish industry requires strong educational efforts on the part of governmental agencies and the industry itself. Landowners need factual information concerning the benefits and techniques associated with sportfish management. Further support should be generated for research in critical areas by educational agencies, industry and landowners. The Texas Agricultural Extension Service should play an active role in this process by assisting both industry (through improved culture techniques) as well as landowners (through educational programs).
OTHER FRESHWATER SPECIES

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Many other freshwater forms have potential for culture in Texas or are currently being produced and sold. It is not possible to provide complete status reports for all of these. This review is intended to focus attention on additional opportunities for the expansion of aquaculture.

Most of these groups have not been investigated thoroughly enough to determine their eventual potential. Because much of the future of aquaculture lies in the use of species not presently cultured, efforts should continue to research and conduct pilot scale testing of new species and/or new approaches to production. This includes but is not limited to utilizing polyculture rather than the traditional monoculture methods presently in use.

ALLIGATORS

Hides of the alligator (Alligator mississippiensis) have rapidly increased in value over the past ten years. The impetus for this was the banning of alligator hunting during the late 1960's. At that time it was feared that the alligator population in the United States might become extinct without protection.

Subsequently an open season for hunting and capture of wild alligators was reinstated in Texas as well as Louisiana and Florida. Nonetheless this resumption of the wild harvest has not been a detriment to the production of alligators on farms in Texas, Louisiana, Florida and Georgia.

The most recent figures from sales in the United States (1988) indicates that farm raised alligator hides sold for $21.00 per foot to $46.00 per foot. This resulted in total hide sales values in excess of $4.1 million in the United States from farm produced animals during 1988. The percentage of this from Texas producers is quite small though it has been reported that there are 16 active alligators farms in the State. The farm gate value of alligators produced in Texas during 1989 was estimated as $52,000. Sales of alligator meat are reported to be excellent but the extent of the market is poorly documented and is considered to be mostly a novelty item.

Most farm raised alligators that are sold on the hide market are about 6 feet in length and three years of age. Larger alligators are sometimes found on the market and these tend to command premium prices. Alligators can be raised extensively in fenced outdoor
earthen ponds. Their growth rate is dependent on temperature and for that reason some growers have gone to a more sophisticated indoor temperature controlled environment. Though more expensive to operate these do have the advantage of a longer growing season because alligators grow very slowly at temperatures below 70 degrees F.

Brod stock are normally secured from domesticated stocks as wild-caught alligators tend to be overly aggressive. Because there is a shortage of high quality domesticated broodstock some growers are forced to rely on wild-caught animals. Brood enclosures vary in size but are a minimum of four acres in size surrounded with welded wire fencing and treated posts. Because alligators are excellent climbers there is usually a section of fencing angled inward from the top of the fence to discourage escapes. In addition the fencing is buried about six inches below ground or boards are used to prevent escapes from under the fencing. Females are allowed to build nests and lay their eggs wherever they desire inside the enclosure. There are problems with predation on the eggs from birds, raccoons and other small mammals. Most growers remove the eggs from the nests and hatch them artificially. Care must be taken to place the eggs in the incubator in the same position as when found in the nest. Young animals are retained in the incubator area until they reach a length of 2-3 feet when they are released into outdoor pens for rearing.

During the growing period alligators are segregated by size to reduce predation by larger alligators. There are few other predators on the sub-adult alligators. Feeds used are fresh or frozen fish and fresh or fresh-frozen meat. This is usually ground up for the smaller animals but can be chunked for the adults. There is a need for research on low-cost diets using artificial feeds and a better understanding of the basic physiology of alligators which should result in increased growth rates as well as increased viability of the young. This will require an improvement in diets for adults, development of treatment methods for disease control and a better understanding of environmental condition required during the initial growth stages. Market promotion will become a necessity in the near future to compete with the growing wild crop industry as well as sales from foreign competitors.

**AQUATIC PLANTS**

Production and sales of aquatic plants across the United States are poorly documented. There is a sizable market in some areas for plants to be used in reclaiming wetland areas and also for landscaping of selected areas. In Florida it has been reported that this is the fastest growing segment of the aquaculture industry.

In Texas the six major growers produce mainly ornamental waterlilies and plants for the aquarium trade. In the past most of the latter were harvested from the wild but concerns about environmental degradation and the possible contamination of aquariums with undesirable animals has curtailed this effort. Some plants are sold for use in pilot scale waste and sewage treatment facilities. The use of plants for this purpose holds great potential across the entire nation.

Though Texas and Florida enjoy a reputation as the largest producers of aquatic plants for sale there is very little market information available. Best estimates placed the 1988 farm-gate value in Texas at $2.4 million.

The broad potential for the use of aquatic plants for food, energy, water reclamation, chemicals, pigments and other special products makes them deserving of further research. Basic physiology, reproduction, nutrition, and environmental requirements all need further study. In addition the lifting of restrictive regulations concerning utilization of plants in private bodies of water is a necessity. The natural aquatic environment can be protected while still allowing private growers to use the most efficacious species available.

**BUFFALO**

Though buffalo was one of the first types of fishes cultured in ponds for food in the Southern United States, it is not produced except in isolated instances in Texas. The major reason is that buffalo commands a very low market price and is perceived as less than desirable as a table fish by most householders. The three native species of buffalo are bigmouth buffalo (Ictiobus cyprinellus), smallmouth buffalo (I. bubalus) and black buffalo (I. niger). Methods for extensive production of these fish are well documented and growers in the State will not increase production without additional financial incentives.

The farm-gate value of buffalo in Texas is estimated as only $10,000. To increase production of these species, studies on marketing acceptance by region will need to be conducted as well as improved product forms and improved diets for the fish.

**CHINESE AND INDIAN CARP**

Grass carp (Ctenopharyngodon idella), silver carp (Hypophthalmichthys molitrix), and bighead carp (Aristichthys nobilis) are all utilized in aquaculture to
some extent at this time. The black carp (Mylopharyngodon piceus) and the mud carp (Cirrhinus molitorella) are also being studied for possible use in the Texas. These fish occupy separate portions of the aquatic ecosystem and have been grown in polyculture operations with good success.

The major use of these fishes is for control of nutrients in waste waters though the grass carp and the bighead carp are marketed for food in the major metropolitan areas of the state. Bighead carp are also used for trotline bait in selected areas.

All of these species have a demonstrated potential for intensive culture. They grow rapidly, utilize feed of a low trophic level, are quite hardy, and extremely high yields have been reported.

Chinese and Indian carps are under intense regulatory pressure because of the possibility that they might reproduce in public waters of Texas and disrupt the ecological balance of native species. Whether or not this possibility is realistic is highly debatable. Nevertheless, carp are considered to be a threat to the environment in the minds of many in the public sector.

All of these fish are easily spawned under controlled hatchery conditions with the use of hormones. Procedures for production of functionally sterile triploid grass carp has helped to relieve some of the pressure against release of these fish into private water systems in the state. Production of economical quantities of these fish is quite possible in the state if regulatory requirements are satisfied. The procedures for intensive production do not differ significantly from those used for other omnivorous fish.

The farm-gate value of Chinese and Indian carps in Texas is estimated as $80,000 during 1989. The major constraint on production at this time is the regulatory environment, as production techniques and marketing channels are fairly well established.

COMMON CARP

Common carp (Cyprinus carpio) have been cultured for over 3,000 years in the Orient, 600 years in Europe, and 100 years in the United States. The numbers or poundage produced for food is quite small (1989 Texas farm-gate value less than $10,000), but a market does exist in areas with certain ethnic populations. The fish are in demand as bait, primarily for trotlines, in many areas. Certain varieties are cultured for ornamentals in aquariums and garden pools.

The common carp is easy to spawn in captivity, very hardy and will eat most plant and animal matter. Because of this fact, they are widely cultured throughout the world and are generally considered to be the species with the greatest tonnage sold each year on the world markets. Though this international market exists, there has been little interest in developing it in Texas.

FRESHWATER SHRIMP

Although several species of freshwater shrimp (also called prawns) are native to Texas, problems with cannibalism and small size have caused culturists to select the Malaysian prawn (Macrobrachium rosenbergii). Culture of these animals has been promoted because of the desire by many Americans for a large tasty shellfish similar to the lobster or salt water shrimp. Production in Texas is limited by optimum temperature requirements of 80-85 degrees and a minimum of 60 degrees.

Prawn farmers generally buy their seed stock from a commercial hatchery. Most of these hatcheries are located in tropical climates (Hawaii, Puerto Rico, Guadelupe), but there is at least one hatchery currently operating in Texas. Though this is a freshwater species it requires brackish water for the first 3-6 weeks of its life.

Prawns have a relatively long larval development (25-45 days) as compared with saltwater shrimp larvae (20 days). Newly hatched brine shrimp are the staple diet used in the hatchery, however, this is frequently supplemented with cheaper sources of animal protein such as minced fish, egg curd, etc. Gradually, the larvae are shifted to prepared feed sources.

Postlarvae or head-started juveniles are usually stocked into fertilized freshwater ponds. Culture methods vary from low-density (1000 - 5000/acres) polyculture with catfish to moderate-density (20,000 - 30,000/acres) monoculture. Commercially available feed is added to the pond as the shrimp get larger when high stocking rates are used. The growing period from postlarvae to harvest varies from 120-150 days. Because these shrimp have widely varying growth rates, initial grading or selective harvesting is recommended. The largest males are usually harvested first. This serves two purposes: 1) the larger animals command the best price and 2) this removes the more aggressive and cannibalistic individuals.

Marketing and product handling have been major constraints on this animal. To capture the best prices and avoid competition with saltwater shrimp, producers usually attempt to grow prawns to a large size and market them head-on as a distinct, high-value product. Undersized Macrobrachium may be sold as ornamental shellfish for aquariums.
At this time the farm gate value of this species in Texas is estimated to be less than $25,000 annually.

FROGS

Though frog legs are on the menus of many restaurants, procedures for economically viable production in captive situations have not yet been proven. Eleven producers in the state indicate that they have bullfrogs (Rana catesbeiana) or tadpoles available for stocking, but these are all as sidelines to viable fish production facilities. The farm-gate value of this species is assumed to be negligible in Texas. At the same time, it is reported that the demand for frog legs far exceeds the supply, and that there continues to be a demand for frogs for biological research.

General procedures for frog production start with collection of the egg masses from brood ponds. The eggs are usually hatched in troughs under closely monitored environmental conditions inside a building. After hatching, the tadpoles are fed in these same troughs until they metamorphose and then they are moved to pens or troughs with a small amount of standing water. At this stage, they are fed living foods such as small minnows. Flies and worms are also used after frogs are trained to accept them. Food size and quantities must be increased often and grading of the frogs is essential as they tend to be highly cannibalistic.

Probably the greatest requirement for frog culture is an effective sanitation program. Bacterial diseases are the biggest problem and must be avoided or controlled. Temperatures need to be between 68 and 80 degrees F at all times for best growth. Under optimum conditions a saleable frog can be produced from an egg in about 8 months.

Additional research needs include better methods of disease control, improved diets and improved genetic strains. Marketing surveys have indicated that more frogs could be sold, but present prices are too low to make this an attractive industry.

GOLDFISH

The market for goldfish (Carassius auratus) has continued to expand in recent years. The market for the ornamental varieties has remained steady, but the demand for feeder-fish (live feed for aquarium fishes) has increased steadily. At this time there are very few records available on the extent of production or sales in the state. Most of the goldfish sold are bought from out of state suppliers and then sold to retailers directly or held in growth facilities until marketed. The producers who do spawn and grow their own fish report that they cannot meet the demand, especially for the smaller sizes though they are often growing three crops per year in a single pond. Markets are usually to wholesalers, but goldfish are sold directly to retailers for trotline bait.

Brood fish are carefully selected for the desired colors and shapes. Near spawning time, goldfish are easily sexed and then placed into spawning ponds. Stocking rates for open pond spawning are from 40-80 pounds per acre. If the egg transfer methods are used, up to 1,000 pounds (2,500 fish) are often stocked. Spawning usually occurs within 24 hours after stocking when water temperatures are above 70 degrees F. Hatching occurs within 96 hours at this temperature. Finely ground feed is then offered within 48 hours. Feeding rates after the first month are adjusted to insure that fish reach saleable size at the desired time for marketing.

The 1989 farm-gate value of goldfish (excluding those used as bait) is estimated as $150,000. To increase production and sales of goldfish in the state, improved feeds and a better understanding of the selection criteria for brood stock to secure better egg production and improved animal health measures are needed. In selected areas a more complete understanding of the effects of water quality on growth rates and handling qualities is also needed.

ORNAMENTAL FISHES

The demand for ornamental fishes continues to grow throughout the United States. Production of these fish in Texas is rather limited but has expanded in each of the last five years. Exact figures are not available on the actual extent of locally produced fish because many of the species are cultured primarily inside buildings in tanks and aquariums. Pond production is limited to the warmer months of the year because most of the species in demand are natives of tropical or subtropical regions. It is expected that Texas production will continue to increase because of unpredictable wild stock supplies and increasingly complex import restrictions.

Most of the ornamental fish produced in the state are freshwater species. Production of marine ornamental fishes is difficult and there is a general lack of knowledge of culture techniques. There is considerable potential for development in this area. Nonetheless the wholesale and retail arms of the ornamental fish industry have continued to grow utilizing fish caught in the wild in Asia, South America and Africa. Again the extent of these portions of the industry are poorly documented but it has been reported that the retail sales in the aquarium industry in Texas exceeded $4 billion in 1988. Of this approximately 10 percent was for livestock and the
remainder for aquariums, feed and supplies. Assuming that 25% of the retail sales value represents the wholesale value, then the wholesale value of the ornamental fish business in Texas during 1988 was about $1.5 billion. Verification of these figures is not possible at this time but studies to document the extent of the industry should be initiated.

Ornamental fish producers in Texas grow a wide variety of species with a variety of life cycles, nutritional and environmental requirements. Some fish are egg-layers and others are live bearers. Some are nest builders and others do not tend their young at all. Some eat only fish, others eat plankton and others readily eat prepared diets. Because all of these fish are sold live, delivery to markets of a high quality fish in good health is mandatory. This requirement needs further testing and research effort. Plastic bags are the most common shipping container. These are placed in styrofoam containers and then into cardboard boxes. Recently airlines have become increasingly reluctant to accept such containers and new methods need to be developed.

There is no standard price for ornamental fish. Bulk shipments of commoner varieties may be sold at the producer level for 25 cents each, while rarer species may be priced at $25 or more for single animals. Much of the price differential is directly dependent on the brilliance of the colors of the fish. Color is to some extent dependent on the nutrients available to the fish. Therefore producers need more and better information on the nutrient requirements of all of the species of fish that they culture.

Other problems that plague producers of aquarium fish include predation, environmental requirements for spawning and growth and handling requirements for broodstock and eggs. Predation by birds is a major concern and regulations generally prohibit destruction of fish-eating birds even though relief from losses is available to more traditional agricultural crops. Fish produced indoors are not susceptible to this problem, but adjustment of the production system to the desired environmental requirements is costly.

Major constraints on the ornamental fish industry in the state include the following:

1. It is necessary to change the belief that only fish actually produced in the state contribute to aquaculture. In fact, the wholesale/retail part of the industry is the largest segment of the industry in Texas.

2. Regulations governing ornamental fish production need clarification and consistency. It is questionable whether to start a production installation without some assurance that regulations will not be a detriment in the immediate future.

3. Research on nutritional requirements is of immediate concern.

4. Marketing and promotion needs are varied depending on the fish being produced. Collection of reliable data in this area is essential for this industry to grow.

5. Methods for adapting the technology being used in other fields of aquaculture should be delineated.

MISCELLANEOUS SPECIES

Another potential aquaculture species for Texas is the American eel which is being produced in at least five other states. Sturgeon and paddlefish may also have potential as either food fish or stock enhancement species.
PENAEID SHRIMP

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HISTORY

Shrimp farming began in Texas with the research of Harry Cook and coworkers at the National Marine Fisheries Service (NMFS) Laboratory in Galveston in the early 1960’s. Through their efforts, laboratory-scale spawning and larval rearing techniques were developed for a variety of indigenous penaeids, including the white, brown, and pink shrimp (Penaeus setiferus, P. azteca, and P. duorarum, respectively).

This success in larval rearing stimulated a number of grow-out trials in ponds during the late 1960’s and 1970’s). The Dow Chemical Company attempted to commercially produce shrimp near Freeport, but that effort proved to be premature. One of the most significant findings of grow-out trials was that two non-indigenous species, P. vannamei and P. stylirostris, yielded higher production than native species. In order to utilize non-indigenous species, it became necessary to control reproduction in captivity.

During the late 1970’s and early 1980’s, methods for inducing reproduction of penaeids were implemented by researchers at the NMFS Laboratory and at Texas A&M University. Soon afterwards, commercial development efforts began.

Laguna Madre Shrimp Farms began constructing hatchery and pond facilities in 1981. A brackish water impoundment near Anahuac was stocked in 1984 and 1985. Several 30-70 acre intensive pond systems were built during the period from 1985 to present. In addition, two semi-intensive pond systems of 120 and 230 acres were developed by King Ranch and Marquest respectively. Most Texas shrimp farms are located on the coast, but several small-scale, intensive farms have developed in West Texas using saline ground water.
CURRENT STATUS

Principal Species
Virtually all penaeid shrimp currently farmed in Texas are P. vannamei, a Pacific white shrimp native to the region between northern Peru and southern Mexico. There is interest in testing the performance of other species such as P. monodon because of its large size and fast growth and P. chinensis because of its cold tolerance and potential as a second crop. In addition, the indigenous white, brown, and pink shrimp may receive new consideration as researchers begin to question whether early disqualification of those species remains justified considering nutrition and management advancements that have been made.

Typical Production Methods

Hatchery
The hatchery process begins by either collecting brood stock from their natural spawning grounds or raising juveniles to adulthood in ponds. Adult shrimp are induced to mature indoors by simulating natural offshore conditions through control of temperature, salinity, lighting, and nutrition. Eyestalk ablation is often used to stimulate maturation. Individual females generally release 200,000-300,000 eggs/spawn. Fertilization occurs externally as the eggs discharge past the spermatophore attached to the ventral side of the female by the male.

Eggs hatch about 12-15 hours after spawning. Hatching rates generally average about 50%. The first larval stage, nauplius, subsists on yolk and requires about 36 hours to pass through 5-6 substages and metamorphose to the protozoa stage. At this point, the larvae filter feed on unicellular phytoplankton, particularly diatoms. After 3 substages, protozoa transform to mysis and become more predatory and are generally fed newly hatched brine shrimp (Artemia) nauplii. After 3 substages, mysis transform to postlarvae (PL’s) which resemble miniature adult shrimp and are gradually weaned off live foods onto prepared dried diets.

Postlarvae are generally held in the hatchery 5-8 days beyond postlarval metamorphosis before transferring them to ponds for grow-out. The entire hatchery duration from egg to PL-5 is about 3 weeks. The above feeding regime is modified in some cases to include microparticulate or microencapsulated diets as supplements and partial replacements of algae and Artemia nauplii.

Growout
Management procedures for grow-out vary according to the stocking density utilized. Extensive management utilizes low density (,000/acre) fertilization but little or no feeding, and minimal water quality control. Yields from extensively managed ponds or impoundments generally range from 50 to 500 pounds/acre.

Semi intensive management utilizes moderate stocking densities (40,000-60,000/acre), fertilization, feeding, and water quality control through daily water exchange. Yields from intensively managed ponds generally range from 500 to 1500 pounds per acre.

Intensive management utilizes high stocking densities (100,000-200,000/acre), high quality feeds, aeration, and water exchange. Yields from intensively managed ponds generally range from 2500 to 4000 pounds per acre.

Closed system, indoor facilities are also being tried on a pilot scale. These systems plan to use environmental control to produce a fresh, high value crop year round. Target yields are projected to be about 1 pound per square foot.

Status of Industry

Hatcheries
Currently, demand for postlarvae in Texas exceeds the capacity of the single Texas hatchery. The Laguna Madre Shrimp Farms hatchery has a production capacity of about 25 million postlarvae/month, but demand during the 2.5 month spring stocking period is about 90 million PL’s. However, plans have been announced by Lone Star Aquaculture for construction of a small (3-4 million PL’s/month) hatchery at Matagorda Bay. Also, several farms are considering the possibility of developing a coop hatchery.

Grow-out
The Texas shrimp farming industry is centered along the Gulf coast between Brownsville and Freeport. A few small farms have also developed in the Trans Pecos area of West Texas. Of the 1100 acres which have been utilized for shrimp production at some time during the 1980’s, only about 478 acres (10 farms) are expected to be in production during 1990. Most of the producing acreage is under intensive pond management. Unutilized acreage is largely attributed to extensive impoundments or semi-intensive ponds that are being modified for intensive management.
Average pond yields are about 2500 pounds/acre with one crop per year.

Product Form and Markets
Marketing methods tend to vary with the size of the farm. Small farms often utilize pond bank and direct retail sales. Intermediate sized farms generally sell directly to processors. Large farms arrange to have their shrimp processed on contract and then market their own product.

Market price varies widely, depending upon the product size, product form (e.g., head-on fresh versus frozen tails), and market level (e.g., wholesale versus retail). Prices received for unprocessed, head-on shrimp at the farm generally range between $2.00 and $3.00 per pound. Of course, retail sales can be substantially higher, but this presently represents a small portion of total sales.

Associated Infrastructure
Several large shrimp processing plants which have traditionally processed wild-caught shrimp have accepted farm-raised shrimp for processing. This has not been a perfect adjustment because farm-raised shrimp, unlike wild catch, are not headless when they arrive at the processing plant. Special arrangements must be made to have shrimp deheaded or markets developed for head-on shrimp.

CURRENT AND PROJECTED VALUE

Based on the estimated 1990 production area of 478 acres, the estimated yield of 2500 pounds per acre, and an average farm-gate value of $2.50/pound, the shrimp farming industry in Texas is expected to have a 1990 farm-gate value of about $3 million.

If current development plans are successfully implemented, the Texas shrimp farming industry is expected to steadily grow both in acreage and in yield over the next five years. Acreage will probably double and average yield increase to 3,000 pounds per acre, causing industry farm-gate value to reach $5-6 million.

IMPEDEMENTS

South Carolina has less coastal area suitable for shrimp farming than Texas, and temperatures there are less favorable for the raising of tropical shrimp. Yet, even though the shrimp industry in South Carolina got started later than the industry in Texas, it is growing at a faster rate. At a recent meeting, commercial producers indicated concern about seven major issues impeding development. In a subsequent mail survey to shrimp farming producers and researchers the seven issues were ranked (Table 1).

Table 1. Ranking of issues facing the Texas shrimp farming industry (in order of decreasing importance) according to a survey (n = 11) during October 1989.

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Regulations
Several regulatory issues are of concern to shrimp farmers:

Shrimp Baculovirus
Two commercial shrimp ponds near Collegeport, Texas, were recently shutdown by Texas Parks and Wildlife Department (TP&WD) for the entire growing season and mandated to be disinfected due to detection of Baculovirus penaei in a sample of P. vannamei postlarvae. This virus is widely distributed in penaeid shrimp worldwide, and it is known to be indigenous to native shrimp in the Gulf of Mexico. However, since it was imported in an exotic species, it was considered a potential threat. In South Carolina, where this virus was also identified in imported shrimp, there was no regulatory action was judged necessary.

Intake Water Screening
Recommendations are currently placed on applications for Army Corps of Engineers section 10 or section 404 permits for water pumping stations to require fine-mesh screening systems to reduce possible mortality of planktonic estuarine organisms, including eggs and larvae. These recommendations require that water be prescreened through a mesh of 0.5 mm to prevent entrainment of eggs and larvae. Such regulations are unprecedented in other states and among other major Texas water users such as coastal power plants.

Compliance with this regulation is difficult and expensive from an engineering point of view, because fine mesh screens tend to clog very quickly in turbid estuarine water. Fortunately, the regulatory agencies are cooperating with a private producer to test a relatively inexpensive, after-the-pump, self-cleaning
screen which is designed to return small organisms to the bay with minimal damage.

**Exotic Species Regulations**

According to a new TP&W ruling, a cultured exotic species can be placed on the prohibited list without allowance for public comment if that species is found in state waters. This makes the entire industry liable for a single incident. There is concern among farmers and potential investors that new regulations such as this can be enacted which cannot be dealt with economically by ventures which have already invested substantial amounts of money.

**Bivalve Inspection**

Several shrimp farms have expressed an interest in polyculture of shellfish such as clams or oysters with shrimp to reduce algal densities in ponds and provide a secondary source of revenue. According to current regulations of the Texas Department of Health, private waters of the state of Texas are not approved for shellfish culture, because they haven't been sampled to evaluate water quality. However, due to budgetary constraints, the Health Department is unable to implement a program to allow sampling of private waters. Also current statutes prevent private laboratories from being certified to provide appropriate testing. Thus, current regulations effectively prevent polyculture of shrimp and oysters in Texas.

**Post Larval Shortage**

The shrimp farming industry needs a reliable, source of high quality, reasonably-priced post larvae for pond stocking. During 1989, shrimp farms in Texas and South Carolina suffered economic hardship due to lack of sufficient postlarvae. Many of the farms either were not stocked at full capacity or were stocked late. This situation arose, because most farms had relied on a single hatchery in Central America, but that hatchery experienced disease problems and was unable to meet demands. Another problem is that large variations in quality and health of postlarvae occur among hatcheries.

**Research**

There is concern among commercial shrimp farmers that publicly funded research may not reflect the needs of the industry. Research is not always well coordinated with the commercial sector to prioritize objectives and with research interests in other states to avoid duplication. Furthermore, the results of research trials often are not made available to the industry as quickly as possible.

**Marketing**

The U.S. currently imports approximately 75% of the total shrimp consumed. To be competitive, the Texas shrimp farmer must maintain a technological edge in production efficiency and be able to sell to high value portions of the shrimp market. It is critical that "Texas raised" be distinct from the large volumes of low-priced imports.

**Feed Cost**

The most expensive part of any shrimp farming operation is feed. The availability of quality feed is essential to a successful operation. At this time there is no source of high quality shrimp feed in Texas. Most Texas shrimp farmers presently rely on a feed mill in Idaho for high quality shrimp feeds. The shipping cost associated with that distance adds about 10% to the cost of feeds. This also bypasses Texas feed mills for the job and income related to shrimp feed production.

**Industry Organization**

We need an effective means of communicating problems and solutions between farms, government and research institutions. Industry Size

Several of the problems listed above would be much easier to solve if the overall size of the shrimp farming industry in Texas were larger. It is difficult to get feed mills, processors or marketers interested in spending money on program development unless they perceive a reasonable return on their investment. Better operating techniques will be developed sooner if more farms are operating.

**RECOMMENDED ACTION**

* A forum is needed where problems regarding proposed regulations or the execution or interpretation of an existing regulation can be discussed. Hopefully, this will be provided through the newly created position of Aquaculture Liaison Officer.
* Shrimp farming should be given the full status of an agricultural operation in Texas. This would make available federal crop insurance, eligibility for disaster relief and loan assistance.
* To ensure a reliable, high-quality, and reasonably priced source of postlarvae, several hatcheries should be located within Texas. Thus, technical problems in any one hatchery would not result in lack of supply. These problems are already moving toward solution. Texas shrimp farmers met in September 1989 and estimated their postlarval requirement would be about 66
million during 1990. Most of the required post larvae will probably be supplied by one hatchery, Laguna Madre Shrimp Farms. Granada Corporation also intends to begin operation of a commercial hatchery in College Station.

- Commercial enterprises should be involved in setting research goals and priorities. The state's aquaculture research should be directed toward the development and promotion of a commercial aquaculture industry. Basic research goals should be set jointly with input from commercial interests. Execution of the research should be carried out by the research institutions. Results would be reviewed with commercial enterprises. Applied research objectives, execution and results analysis should be done jointly. To avoid duplication of effort, continue to coordinate shrimp farming research through the five-state research consortium.

- The Texas shrimp farming industry should seek a marketing edge for its product by stressing product quality and promoting "Texas raised" status.

- If the industry is to develop, quality feeds will have to be manufactured locally. Several Texas mills are currently trying to develop a quality feed. This effort should be supported through research assistance in developing and evaluating feed formulations.

- Profitability can be increased through appropriate technology. Examples of areas that deserve attention include: head starting techniques, feeding methods, aeration and circulation methods, bivalve polyculture possibilities, and potential winter crop species. In order to address these topics, a suitable public-sector salt-water pond facility should be developed in Texas for the purpose of implementing practical pond production trials.

- Shrimp farmers are in the process of organizing in a loose association. An Industrial Advisory Committee is being formed to communicate between commercial interests and various research institutions. Hopefully the Aquaculture Liaison Officer can provide some overall coordination as well as interaction with the Aquaculture Executive Committee.

**SUMMARY**

There are approximately 10 shrimp farming enterprises currently operating in Texas. The short-term expansion of this industry in Texas will depend to a large extent on the success or failure of these companies. Very few if any of these operations can afford to wait years to attain profitability. Therefore emphasis should be placed on those areas which can be expected to aid the current investments as quickly as possible. This means granting full agricultural status, concentrating on applied research which can be tested now in a commercial environment and work with the commercial interests in the regulatory areas to minimize the risk of an economic disaster for the farmer while maintaining a rational protection of the environment.
RED DRUM

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INTRODUCTION

Interest in commercial red drum (\textit{Sciaenops ocellatus}) culture emerged only about 10 years ago, primarily as a result of changes in the market value of this species. Historically, red drum have been considered a popular recreational species with commercial sales occurring primarily in the Gulf and South Atlantic states. Its relatively low U.S. commercial demand (3–4 million pounds per year) was met by the traditional inshore gill net fishery concentrated in Texas and Louisiana. However, when cajun chef Paul Prudhomme introduced his blackened redfish recipe in 1981, the national demand for red drum dramatically increased.

Conflicts between recreational and commercial fishing interests had resulted in bans on commercial fishing for red drum in several states including Texas. Consequently, the traditional inshore gill net fishery was unable to supply the increasing market demand. As red drum supplies tightened and prices rose, the formerly undesirable adult ("bull") red drum were targeted to fill the market gap. Efficient offshore purse seineing vessels began locating offshore schools by spotter plane and capturing large of the 20–40 pound fish. This strong fishing pressure on red drum broodstock alarmed fishery workers and conservationists and ultimately resulted in a ban on purse seineing of red drum in federal waters of the Gulf of Mexico in 1986. Most of the noncommitted Gulf states also banned commercial fishing of red drum in state waters during this period. By the late 1980's, nearly all avenues for commercial fishing of red drum in the United States were closed. Legislation passed by the 1989 Texas legislature culminates this process by prohibiting sale of red drum in Texas unless they are farm raised.

Commercial interest in red drum aquaculture began during the early 1980's as demand and price were rapidly rising.
TECHNOLOGY DEVELOPMENT

Although researchers first reported growing captive red drum in ponds over 30 years ago, red drum aquaculture did not significantly advance until 1975 when Connie Arnold (at that time with the National Marine Fisheries Service Laboratory in Port Aransas, Texas) succeeded in spawning them using temperature and photoperiod control.

Control of Reproduction

The temperature/photoperiod method of spawning involves holding red drum adults in indoor tanks for several months while simulating the passage of seasons through programmed changes in water temperature and photoperiod (hours of light each day). When such conditioned red drum arrive at the simulated Fall season (temperature of 24-26°C and photoperiod of 12-12 hours), they begin courtship behavior, mating, and spawning automatically—just as they do in nature. Unlike many species which are capable of only one spawn per year, red drum are capable of repeated spawning at regular intervals over extended periods of time. This prolific egg production capability of red drum is a major advantage.

Egg Collection and Hatching

Fertilized red drum eggs contain an oil globule which makes them buoyant at salinities of at least 25 ppt. This characteristic has simplified egg collection from the large broodstock tanks. Typically, a water drainpipe is positioned to draw water from the surface of the broodstock tank, thereby skimming the buoyant eggs from the large tank and transporting them to an appropriate collection area. Using this technique, the water hardened eggs automatically accumulate in the collection basket during the night following spawning. The following morning, the eggs are removed with a soft net, and transferred into a graduated cylinder where the floating egg mass is enumerated (1 ml of displacement = 1,000 eggs). The eggs are then placed in a tank of gently aerating water until hatching (about 24-30 hours after fertilization) and larval development. When the larval yolk sac is absorbed and mouth parts develop, they are capable of feeding (approx. 3 days after hatching).

Fingerling Production

Two methods were developed during the late 1970's for rearing the sensitive first-feeding larvae to fingerling size. The laboratory method, first developed by Connie Arnold, involves rearing larvae indoors and feeding them live rotifers (which are in turn sustained by live algae cultures) and brine shrimp. This method requires considerable equipment and expertise for maintenance of cultures. Survival rates are often poor, but this is an excellent method of producing small quantities of fingerlings on demand year-round.

The fertilized pond method was developed by Bob Colura at the Texas Parks and Wildlife Department Marine Fisheries Research facility near Palacios. This method, which is similar to one which earlier had proven successful for production of striped bass fingerlings, involves release of first-feeding larvae into fertilized ponds. It is critical that the ponds be properly prepared in advance to develop a rich complement of the appropriate-sized plankton. The fertilized-pond method has proven to be relatively consistent and amenable to mass culture applications. It was adopted for the red drum population enhancement program (10 million fingerlings/year) sponsored by the Texas Parks and Wildlife Department and the Gulf Coast Conservation Association. This joint program is designed to increase depleted coastal populations of red drum by producing and releasing fingerlings into various Texas estuaries.

As a result of the above research and mass production efforts, technology for spawning, hatching, and larval rearing of red drum was well developed by early 1980's, when commercial interest began. However, at that time, little was known about techniques of raising red drum from fingerling size (enhancement program typically released fish 1-2 inches long) to marketable size (2-4 pounds).

COMMERCIAL DEVELOPMENT

During the initial stages of commercial development in the early 1980's, industry growth was stymied by lack of a consistent supply of fingerlings for grow-out trials (fingerlings produced for stock enhancement were unavailable for commercial use). Fortunately, the existing research and stock-enhancement facilities provided models for industry development of commercial hatcheries. Several hatcheries were built in Texas to satisfy projected fingerling demands for anticipated commercial growth. After a relatively brief learning period, all of the hatcheries were successful to varying degrees in inducing spawning and producing fingerlings.

Initial grow-out attempts utilized a wide variety of culture systems and locations, because opinions differed about appropriate methods of rearing fingerlings to market size. Small scale grow-out trials were conducted at pre-existing coastal pond systems ranging from Beaumont to Port Isabel, and at inland
sites utilizing both fresh and brackish ground water. A number of production trials experienced nearly complete loss of stocks in outdoor ponds in a severe freeze during the winter of 1983-1984. Experimental trials in South Carolina during the mid 1980’s apparently were spared exposure to those severe winter temperatures. Intermittent winter mortality has continued to plague Texas pond grow-out efforts.

Some trials have been successful at producing and marketing one and two-year-old fish. These attempts demonstrated that red drum were capable of reaching 1-2 pounds in 1 year and 3-4 pounds in 2 years. Yields in South Carolina reached as high as 20,000 pounds per acre in small intensively managed ponds.

Laboratory research during the 1980’s has substantially advanced our knowledge about red drum culture. Continuing nutrition studies at Texas A&M University are resulting in feed formulations tailored to the protein, lipid, mineral, and salt requirements of red drum. Physiological studies have contributed information about the tolerance of red drum to combinations of salinity, water hardness, and temperature.

Interest in red drum culture was high by 1987 when the Texas Agricultural Extension Service and the University of Texas marine Science Institute offered a 3-day educational conference on red drum aquaculture. Over 300 participants attended.

STATUS OF THE INDUSTRY

Hatchery

Four red drum hatchery facilities presently exist in Texas. These are estimated to have a total production capacity of approximately five million eggs and three million fingerlings per year. However, at this time, only one red drum hatchery is producing significant quantities of fingerlings for outside sales. Current selling price for 2-4 inch fingerlings is $0.25 each.

Growout Ponds

A total of 154 acres of ponds have been used for red drum grow-out in Texas. However, only 48 acres are currently in use. Pond production trials have utilized various facilities along the entire length of the Texas coast and as far inland as West Texas. Production methods vary from extensive to semi-intensive. At least one extensive pond is being used for fee fishing. Targeted semi-intensive production rates are 4000 - 9000 lbs/acre with one crop per year. The primary problem facing red drum producers continues to be low temperature mortality. Some producers have reported that losses due to cormorant predation also can be severe during the winter. A variety of approaches have been used to maintain red drum through the winter. These include:

- transferring fish from outdoor ponds to indoor facilities during the winter. This arrangement is most feasible for overwintering/headstarting small fingerlings that require a minimum water volume.
- using a continual flow of well water or heated ambient water to maintain a warm zone within the pond during the winter. This method has been utilized by many producers with mixed results.
- using greenhouse covered pond. This is a relatively expensive but effective approach.

Of these approaches, only the greenhouse and indoor methods were successful during the record-breaking freeze of December, 1989.

Indoor Systems

In order to avoid the danger of winter mortality and to sustain rapid growth rates year-round, several producers are attempting to raise red drum in indoor tanks equipped with recirculating water systems. At present, the industry is operating eight 10,000-30,000 gallon raceways and several smaller recirculating systems (500-4200 gallons) for fingerling production and growout. The primary problem with indoor systems has been their relatively high capital and operating costs. Given the present high market value of red drum, intensive systems may have the luxury of improving their efficiency over time before prices fall to lower levels.

Processing and Marketing

No processing plants have been constructed specifically for red drum in Texas. The relatively small quantities of fish that are presently produced are generally processed by hand and sold to restaurants and wholesalers. Market forms include whole, gilled and gutted, and filleted. Most fish are marketed fresh rather than frozen. Current prices for whole fish range from $1.75 to $3.00 per pound.

Value of Texas Industry

The annual farm-gate value for Texas red drum production was estimated at $250,000 during fall, 1989. However, it is unlikely that this estimate will apply to 1990 production, because heavy losses were sustained as a result of the record cold temperatures which occurred during December, 1989.

IMPEDEMENTS

Low temperature mortality has been and continues to be the primary impediment limiting
development of red drum aquaculture in Texas. An engineering and cost analysis of various alternatives for maintaining minimum safe temperatures in ponds is badly needed by the industry.

Another problem identified by red drum producers is disease control. The parasite Amyloodinium ocellatum is difficult to control with conventional FDA-approved treatments. Research is needed to screen alternative treatment chemicals or methods.

Information is needed concerning the relationship between water quality changes in intensive culture systems and the susceptibility of red drum to disease.

Other issues of concern to red drum producers include:

- need for cooperative feed purchasing to reduce transportation costs
- need for cooperative processing and marketing to reduce costs and provide a more consistent supply
- need for sources of financing
- need for depredation permits to reduce losses due to cormorant predation during the winter
- need for more competitively priced fingerlings (producers felt that fingerling prices would decline as the industry grows and evolves)