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Can Aquaculture Thrive in Texas?

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Texas' next big agricultural superstar may not be a typical crop or a conventional farm animal.

Instead, shrimp, redfish, catfish, and other species being raised in "fish farms" or aquacultural operations may soon make up a sizable part of Texas' agricultural economy.

How big is aquaculture in Texas and how much could it grow? Hard numbers are not readily available. However, recent studies suggest that aquaculture now is worth about $20 million and could eventually blossom into $1.5 billion per year (based on aquacultural production on 1.4 million acres on "suitable" lands).

Part of the enthusiasm is fed by the increasing amount of seafood that Americans eat. Encouraged by the health and nutritional benefits, consumers have been adding fish to their diets over the past 20 years. Annual per capita consumption rose from 12 pounds in 1970 to 16 pounds in 1990 and should grow to 19 pounds by the year 2000. Ironically, much of the demand for seafood is in Texas, yet almost all of the aquacultural products

Texas producers that many more of the fish that are sold in grocery stores in the State will be raised in Texas. Although Texas has the potential for growing huge numbers of fish and shellfish, it ranks behind other states like Mississippi and Arkansas in the amount of catfish and shrimp that are produced.

consumed in the state are grown elsewhere. For example, Texans consume 45% of all the catfish grown in the U.S., but less than 2% of that amount is actually grown in Texas.

There are concerns that "natural" supplies may be unable to meet those demands. The harvest of redfish and other species has been restricted from the Gulf of Mexico in the last decade because of concerns that overharvesting may threaten the population base. Aquaculture produces the seafood people want without endangering natural populations. People are also worried about the pollution of off-shore waters from oil spills, fecal coliform bacteria, and toxic bottom sediments. This leaves many people to question if it's healthy to eat fish that were harvested there. In aquaculture, inputs like water, fish and chemicals can all be controlled, and corrected so there should be fewer problems with contamination. Aquacultural products are often fresher than those caught in the wild because they go directly to the producer and are not held on boats for days before reaching processing plants. Aquacultural operations can make seafood available year-round.

In Texas, the prospects for widespread aquacultural production are staggering. Texas' coastline contains many low-lying lands that are ideal for redfish and shrimp operations, and there are abundant water supplies to support inland aquacultural operations in east Texas. There are even plans to grow fish and shrimp in arid West Texas using salty groundwater.

Texas also has some marketing advantages. For example, Texans may be more willing to buy and eat products grown and raised in the State. If exports are the goal, Texas is one day closer to West Coast markets than its primary competitors.

With all of these factors in its favor, you might think that Texas dominates the Gulf aquaculture market. In fact, the opposite is true. So far, Texas aquaculture has not fulfilled it's promise.

What's gone wrong? For starters, most aquacultural products cost slightly more than seafood harvested from the wild. More competitive prices would increase sales. Because year-round production systems haven't been perfected, some aquacultural products like redfish and shrimp are only available during warm months. Another problem is that other states got a head start on Texas and now command most of the market. As a result, Texas grows far less catfish than Mississippi, and fewer crawfish than Louisiana. Most of the shrimp sold in Texas are imported from foreign countries‹not raised in Texas. This makes it hard for Texas to gain a share of the market. Redfish production has suffered from a lack of reliable methods to help fish survive cold weather. Texas also lacks the infrastructure (processing plants that produce value added products) to make aquaculture more successful. As a result, it's hard to encourage people to start growing catfish without providing linked marketing and processing opportunities.

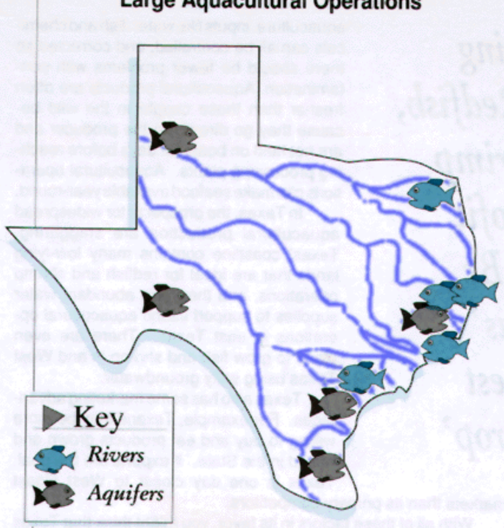
Recently, a catfish farm in San Antonio gave the aquaculture industry a "black eye." In 1990, the Living Waters catfish farm began using huge amounts of groundwater from an twri well along the Edwards Aquifer. Charges were levied that the firm wasted water because of its inefficient use, and polluted nearby streams with nutrients and fecal bacteria.

This issue of Texas Water Resources will focus on research at Texas universities that may make aquaculture successful and profitable. Studies at Texas A&M University have included such diverse topics as the nutritional needs of fresh and saltwater species; assessments of the economic feasibility of aquacultural operations; and developing ideal man-made seawaters that fish would thrive in. Texas A&M University's Sea Grant Program and the Texas Agricultural Experiment Station coordinate much of that research. The University of Texas Marine Science Institute at Port Aransas is evaluating "first feeds" that could replace expensive live feeds now being used for juvenile fish. Corpus Christi State University and Texas A&M University at Galveston are emphasizing the production of coastal species like redfish and oysters. Texas Tech University is studying if naturally salty groundwater and oilfield brine could be blended with cattle wastes to grow algae for use in aquacultural feeds. The Texas A&M College of Veterinary Medicine and the Texas Agricultural Extension Service (TAEX) are working to reduce problems with fish disease. The University of Houston is testing if solar ponds could protect redfish during cold weather, helping make year-round production more practical.

Texas' Aquaculture Advantage

Texas has many advantages that should help aquaculture. Surface water is available in many river basins, and fresh and salty groundwater is plentiful at many sites. In addition, the warm climate allows for extended growing seasons (south Texas has a two-month edge over Louisiana and Mississippi). On the negative side, high evaporation rates increase water use, and the composition of salt water varies widely along the coast and in inland areas.

Fig. 1 Regions with Enough Water to Support Large Aquacultural Operations



Graphic by Reagan Johnson. Data courtesy of the Texas Department of Agriculture.

Which areas in Texas have enough fresh and saline water to support aquaculture? To find out, the Texas Department of Agriculture (TDA) simulated the water needs of a "typical" aquacultural operation. Their example (an operation with 4,000 surface acres of four-foot deep ponds) was estimated to use 30,000 to 35,000 acrefeet (AF) of water per year. Most of the water would be used to fill and change water in the ponds and for harvesting and processing. Flows of 25 gallons per minute per acre were needed so that ponds could be filled quickly. TDA used this information to identify the sites with the greatest potential to support aquaculture (see Figure 1).

The Regulatory Framework

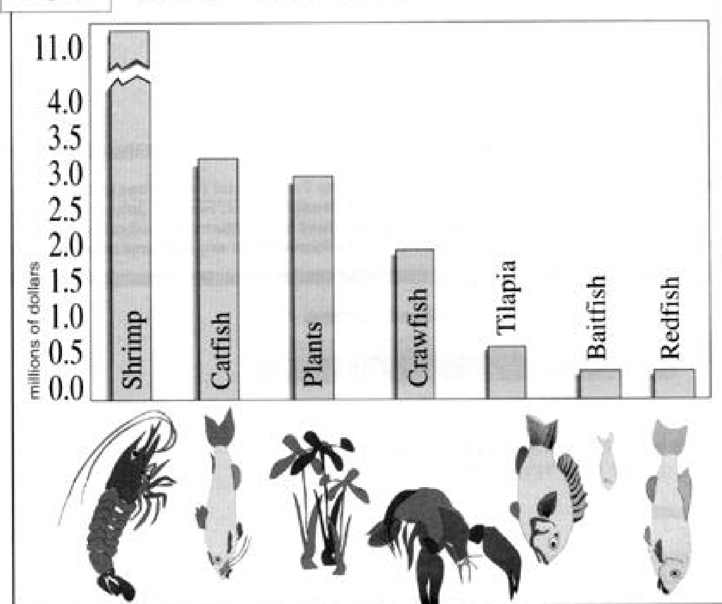
State and Federal agencies involved in aquacultural activities include the Texas Water Commission (TWC), the Texas Department of Agriculture (TDA), the Texas Parks and Wildlife Department (TPWD), and the Environmental Protection Agency (EPA).

In 1989, the Texas Legislature passed the "Fish Farming Act" to improve coordination and cooperation among state agencies that regulate and promote aquaculture. The act established the Texas Aquaculture Executive Committee, which is comprised of the TDA, TPWD and the General Land Office. Since then, the TDA licenses facilities, collects fees, and administers programs to provide affordable financing to producers and processors. TPWD is responsible for protecting native species of shrimp, fish and other aquatic resources and issues exotic species permits. Some argue that the TPWD regulations are too strict and impede the growth of the industry. The TWC examines if unappropriated surface water is available for new projects, issues water use permits, and sets wastewater standards. The TWC and the EPA regulate point source wastewater discharges under the Clean Water Act, and the U.S. Army Corps of Engineers is involved if wetlands are disturbed when aquacultural facilities are constructed.

Do the Economics Add Up?

Unfortunately, Texas aquaculture has only achieved modest success so far. In 1991, the total value of aquacultural production in the state was only $14 million, but forecasts suggest that total should increase by roughly 10% annually. Texas produces a variety of aquacultural products including catfish aquatic plants (water lilies and other ornamental plants), shrimp, crawfish, redfish, baitfish, and sportfish (see Figure 2).

Fig. 2 Value of Texas Aquacultural Products in 1991



Graphic by Reagan Johnson.
Shrimp and catfish data are from Texas A&M University Sea Grant Program.
Other data are from the Texas Department of Agriculture.

Catfish now constitutes 28% of Texas' aquacultural production. In 1992, there were 169 catfish farming operations spread over 3,300 acres of ponds that produced sales of roughly $3.1 million. Most of the sales have resulted from fee and recreational fishing (44%) and direct sales to consumers (31 %). It was hoped that a large catfish processing plant in Liverpool would create new markets for Texas producers, but it went out of business in 1992.

In 1992, Texas produced more than 3.8 million pounds of marine and freshwater shrimp worth nearly $11 million. Scientists are working on methods to produce two or three crops per year to increase overall yields, and some firms have begun producing young shrimp called "post-larvae" for grow-out ponds. A large shrimp farm was begun in Arroya City a few years ago. A pilot plant has recently begun in Caldwell to intensively produce premium quality shrimp indoors for sale to "high end" markets.

Commercial redfish operations in Texas have had mixed success. In 1991, the farm gate value of redfish grown in Texas was only $250,000. A large part of the problem centers around the inability of redfish to survive rapid temperature drops which killed large numbers of fish in 1983,1989, and 1990. In response, one company utilizes an indoor hatchery and grow-out facility.

Tilapia are being grown in the Houston area and are sold live as a specialty food. The value of the industry was about $500,000 in 1991. The industry could grow substantially if regulatory agencies allowed more species to be grown and sold in Texas. Now, only two tilapia species are allowed because of fears that they could disrupt natural systems if they were released uncontrolled into the wild.

In 1991, roughly 1,600 acres were used to grow roughly 600,000 pounds of crawfish worth $2 million . Prices tend to be unstable because the market is strongly dominated by Louisiana.

Recently, two mills began producing aquaculture feed south of Houston. One company now produces 80,000 tons per year. These feed mills should lower costs (many producers pay a 10% freight surcharge on imported feeds) by developing customized feeds for Texas conditions. Many crops that go into fish feed (including soybeans, corn, and rice bran) are now grown in Texas.

Aquaculture could also grow more profitable if marketing efforts were increased. For example, marketing studies show that aquacultural products should be profitable among "baby boomers" and families with incomes of more than $50,000 if these products were aggressively marketed. Research by Oral Capps and others at the Agricultural Economics Department at Texas A&M University show that consumers perceive that catfish are a nutritious, high quality product that is easy to prepare (Engle et al.,1990). There is also a potential for specialty products. For example, a Harlingen company grows freshwater prawns and ships them to restaurants using an overnight delivery service. Value-added processing (packaging seafood products for retail sales) can also bring more revenues. The worth of value-added shrimp products is roughly four times that of raw shrimp products.

Finding ways to help investors to accurately judge the profitability of new operations, and helping existing firms increase their productivity has been the focus of studies by Wade Griffin of the Agricultural Economics Department at Texas A&M University. Griffin has developed simulation models for shrimp, catfish, and redfish production that can then be used to evaluate the viability of different facilities, to recommend management strategies, and to analyze costs and returns for investors. Griffin and his colleagues have also investigated costs and returns for catfish farms that use recirculating ponds to control off-tastes (Lambregts et al., 1992); the impact of catfish farms on local economies (Lambregts, 1991); and the profitability of indoor and outdoor facilities for growing redfish. These studies show that aquaculture often should generate higher profits or rates of return than conventional agriculture (25% versus 5%) and that well-managed aquaculture can be profitable, barring major natural disasters. The research also suggests that catfish farms in Texas can be price competitive with other Gulf states.

Improving Aquaculture Production

Many aquacultural research projects investigate questions about the best conditions to rapidly produce large numbers of fish and shellfish.

Studies at the Wildlife and Fisheries Sciences Department at Texas A&M University emphasize the nutritional and environmental needs of many different species.

Texas A&M University's College Station campus is the site of an Aquaculture Center. The Center is directed by Del Gatlin and other researchers in the Wildlife and Fisheries Sciences Department at Texas A&M University. Research facilities at the site include many grow-out ponds and an indoor production laboratory. In this photo, a Texas A&M University student collects catfish from one of the ponds.

Delbert Gatlin and Bill Neill are developing improved diets for redfish. shrimp. hybrid striped bass. crawfish. including adding unsaturated fats into catfish diets. Results suggest that these feeds can increase the growth rate of the fish as well their ability to survive cold winter temperatures, and makes them a more healthy low-fat food for humans (Nematipour et al., 1992). Gatlin and his colleagues also tested improved diets for young redfish that helps the fish double their weight every other week over a 6-week period.

Gatlin and Neill are working with Steve Barnes of Corpus Christi State University to identify the ideal blend of ions and nutrients in natural and man-made waters. The studies involve mixing sodium, calcium, potassium, and chloride to find which combinations help fish grow as large and fast as possible. Results suggest that adding sodium chloride improves the growth rate of juvenile redfish in fresh and brackish waters. This could be important when these fish are produced at inland aquacultural sites or when saline groundwaters are utilized.

Neill and Gatlin are also investigating how oxygen levels affect fish growth. If too little oxygen is present, the fish will have to work harder to obtain the oxygen they need, may not eat as much, and may grow more slowly. Work is now underway to develop methods to generate optimal oxygen levels in production systems.

At the University of Texas Marine Science Center (UT MSI) in Port Aransas, studies are evaluating "first feeds" that could replace expensive and hard to maintain live foods. G. Joan Holt is developing "first feeds" that can wean larvae from live feeds after only one week. A semi-purified diet has also been developed to determine the nutritional needs of young fish. Holt is also evaluating the use of "novel" aquacultural species such as red and yellow-tail snapper. Connie Arnold has developed closed systems for intensive year round production of redfish and shrimp, and is now evaluating low pollution diets for fish grown in these systems. Arnold has also developed methods that simulate temperatures and day lengths to induce spawning in redfish.

Researchers with the Texas Agricultural Experiment Station Shrimp Mariculture Facility in Corpus Christi are experimenting with a variety issues that will improve aquaculture production for shrimp and redfish. This photo shows how the inside of the facility looks, while the close-up shows some of the large shrimp that are being produced.

One of the major problems that's limited the success of Texas aquaculture has been that redfish and tilapia have a hard time surviving cold winter weather. The problem is especially troubling because nearly all Texas' operations are outdoors and many aquacultural enterprises need year-round production and profits to survive. Studies at the University of Houston and at Texas A&M University are investigating techniques to help redfish survive these crucial periods. At the University of Houston Mechanical Engineering Department, Richard Bannerot and Stan Kleis are testing whether a thin layer of fresh water could be spread over a seawater pond that is heated by solar energy. The goal is to determine how long, and under which conditions, the freshwater will remain stable on top of the saltwater. This freshwater layer could suppress mixing and reduce the transfer of heat, thus conserving energy within the pond. At Texas A&M University, Michael Schwarz and Neill studied if heated water could amp;be pumped to a corner of a pond covered by a small sheet of plastic to create a thermal refuge. Field tests suggest that redfish would flock to the refuge when they sensed water temperatures were dropping in the pond.

TAEX specialists are involved in demonstration projects which include raising channel catfish in canal systems in Matagorda County, improving catfish yields from farm ponds in northeast Texas, and growing redfish in "net pens" near oil rigs in the Gulf of Mexico.

Studies by Addison Lawrence at the Texas A&M University Shrimp Mariculture Research Facility at Corpus Christi focus on better methods to commercially produce shrimp. Research has investigated how protein and other nutrients affect growth rates, intensive production systems, developing high quality breeding stocks, and the advantages of developing in-house breeding and nursery programs. Results suggest that in-house breeding programs may help lessen predators and may make it easier to predict survival rates, feeding needs, and yields. Studies at the Texas A&M University Entomology Department are investigating ways to get shrimp to produce more offspring without weakening the animals.

At the University of Texas Medical Branch in Galveston, Phillip Lee and other scientists are developing computer software that automatically monitors water quality and flow rates in closed aquacultural systems (Lee, 1991). The software alerts users if malfunctions are occurring that may harm the fish. It uses an expert system to recommend when pumps need to be turned on and off, if aeration is needed to boost oxygen levels, and other management decisions. Lee is also testing computer-aided systems that could keep ammonia levels within safe limits.

Marine Fish in West Texas

Odd as it may seem, inland, arid regions of West Texas may be a prime area to produce marine fish and shellfish.

In Pecos County, Neill and Jim Davis of TAEX are working with the Pecos County Water Improvement District No. 3 to develop a pilot facility at a site with saline groundwater. The pilot plant contains six one-acre ponds, two 1.7 acre ponds, and four raceways.

One advantage of the region is that there is a lot of salty groundwater (more than 30 million acre feet) that virtually nobody wants or knows how to use. Most of the water contains 5 to 20 parts per thousand of total dissolved salts, which makes it too salty for irrigation but ideal for producing marine fish. Land prices are low and the isolated area is far removed from off-shore contaminants.

Studies now underway are evaluating how the type and amount of naturally occurring salts influence redfish production; how saline soils affect shrimp production; oxygen dynamics and budgets; using microbes to reduce sulfates and other chemicals; and developing water reuse techniques. Results from laboratory studies suggest that redfish and shrimp may grow as well in West Texas groundwater as they did in natural coastal waters.

Many parts of the Texas A&M University System are working to evaluate if shrimp can be produced with naturally salty water near Imperial in West Texas. In this photo, a worker at the TAMU Aquaculture Farm is casting a net to harvest.

Not all has gone according to plan. Although shrimp and redfish grew rapidly in ponds, survival rates and yields were lower than anticipated. Long-term problems that still have to be worked out include understanding the chemistry (the waters contain much higher levels of sulfates than Gulf waters) and flows of area groundwater; finding methods to treat and re-inject wastewaters back into groundwaters without harming water quality; and avoiding cold kills.

Researchers at the Texas A&M University Shrimp Mariculture Research Facility in Corpus Christi have studied whether salty groundwater in Willacy County can be utilized to produce shrimp. Results suggest that the saline groundwaters produce roughly as much shrimp as natural bay waters (Smith and Lawrence, 1990).

Utilizing saline groundwater and cattle wastes from dairies and feedlots to produce aquacultural feeds is one of the goals of research at Texas Tech University. Nick Parker of the Wildlife and Range Management Department and Clifford Fedler of the Agricultural Engineering Department are trying to grow a single-cell purple sulfur bacteria as a protein source for commercial fish feeds, and are evaluating if fish can be grown in a lagoon system that can also treat cattle wastes. Fish from the system could be ground up and processed as an aquacultural feed product.

Summary

While Texas may have the potential to become one of the leaders in aquaculture, that promise has not been realized. Instead, many aquacultural operations have been economic failures and have gone out of business, while those still in business are not as profitable as anticipated.

This doesn't mean, however, that we should abandon Texas aquaculture as an enterprise that will never become profitable. A number of signals suggest that the demand for aquacultural products will continue to steadily increase and that Texas has the natural resources to become a major supplier of aquacultural products and services.

Many of the solutions that will make aquacultural more profitable and successful are now being investigated at Texas universities. Examples include ways to make year-round production more practical, improved diets that help aquacultural species grow larger and quicker, methods that entrepreneurs and investors can use to gauge if potential aquaculture operations are likely to be profitable, and many others.

Many backers of aquaculture have noted that state regulatory agencies are hindering the development of the industry by being overly restrictive about the types of imported and exotic species that are allowed. While economic fears are justified, care needs to be taken to make sure that natural ecosystems are not overrun by aquacultural operations.

Aquacultural producers need to be aware that they must use water carefully and must clean up the wastewaters that their operations produce.

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