Water Currents

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Dear Reader:

Aquaculture, the rearing of aquatic organisms under controlled conditions, has been practiced extensively by the people of Southeast Asia for centuries, but only in recent years has it been taken seriously in the United States.

Texas is especially blessed with the right conditions for aquaculture. The state contains almost three million acres of fresh water, one and a half million acres of marshlands and tidal flats, extensive shorelines bordered by undeveloped land with soils suitable for pond construction, adequate amounts of rainfall, and optimum temperatures during at least part of the year for warm water species.

Already we have private enterprises producing catfish, crawfish, freshwater shrimp, bass, minnows and tilapia in Texas. Research is underway at a number of academic institutions with the goal of further developing those and other species, including redfish and marine shrimp.

Research which is especially important to further development of aquaculture includes maturing and breeding the animals in captivity to assure reliable sources of larvae or fingerlings for commercial aquaculture farms; identification of the nutritional requirements of each of the species so that proper feeds can be produced; and development techniques to immunize or protect the organisms in some way against disease. Other research needs include fish genetics and hybridization, environmental parameters that support optimum production, and market development and alternatives.

Progress is being made in all of these areas of research, and the future for aquaculture as a significant industry in Texas is bright and close at hand.

Feenan D. Jennings
Director
Sea Grant College Program
Texas A&M University

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Editor: Lou Ellen Ruesink

Designer: Karen Glenn

Cover photographer: Griff Smith

For further information on research presented in this issue; contact **Water Currents,** Texas Water Resources Institute, College Station, TX 77843; send subscription requests and mailing changes to the same address.

Improving Fish Production

"Real" Texans eat catfish and crawfish. But what must real catfish and crawfish eat? And what do other Texas delicacies such as shrimp, bass, and redfish need to grow to eating size?

Real fisheries experts ask and answer these questions as part of The Texas Agricultural Experiment Station (TAES) aquaculture research program.

Aquaculture is simply underwater agriculture. Just as a farmer cultivates his fields and plants his crops, or a rancher improves his pasture and tends his livestock, an aquaculturist provides the best possible environment and most efficient feed to encourage his stock to its maximum production.

And just as scientists with The Texas Agricultural Experiment Station provide information to help farm and ranch producers, they also conduct research useful to aquaculturists. Aquaculture research, a relatively new effort for TAES, helps producers choose species or breeds best suited for a particular location; determine which stocking and feeding rates are most efficient and most economical; analyze market pricing, capital investment costs, and labor costs; develop methods for highest possible production; and reduce losses from disease, predators and drought.

Wallace Klussmann, head of the Department of Wildlife and Fisheries at Texas A&M University (TAMU) says that in the future Texans must grow more fish in captivity. Current U.S. aquaculture produces only 3 percent of all fishery products consumed in the U.S., while in Japan, 35 percent of all fishery products consumed come from aquaculture. He predicts that by the turn of the century commercially raised fish will provide at least half of the total amount of fish needed in the world. Natural fish populations in oceans, lakes, and rivers will not be able to meet future demand, says Klussmann.

U.S. agriculture has largely ignored fish culture; as a result, importation of fishery products accounts for ten percent of this country's national trade deficit.

The potential for expansion of aquaculture in Texas is excellent. Rainfall and temperature patterns in the state are such that approximately two-thirds of Texas could support some type of aquaculture. Much of the state has a subtropical climate, and virtually all of the state has a long enough warm season for certain species to grow to market size.

Power plant cooling ponds also make aquaculture a promising industry for Texas' future. Perhaps the most unique untapped resource for aquaculture development is in areas of West Texas with readily available brackish groundwater. As unlikely as it seems, shrimp and redfish are two extremely promising crops for West Texas areas with brackish groundwater such as the Permian Basin.

Until recently, Texas fish farmers concentrated almost entirely on catfish. Now, however, they are seriously interested throughout the state in shrimp, redfish, bass, crawfish, tilapia and other species which have shown potential.

Channel catfish is still, however, the most commonly raised species in Texas. It is also - not surprisingly - the most extensively researched species by TAES scientists. Catfish research through the years has included nutritional requirements, breeding environments, and disease and parasite control for pond-raised catfish.

Crawfish is at the other extreme of the TAES research agenda. The very first crawfish project began this spring in wet labs on the TAMU campus. TAES researchers initiated the crawfish studies to meet a demand from rice farmers on Texas Gulf Coast for information on how to raise crawfish. Because Texas rice farmers are increasingly interested in raising crawfish to supplement income from their rice fields, crawfish culture is the fastest growing aquaculture activity in the state.

Those who know crawfish as anything but finicky eaters may be surprised that the first TAES crawfish project will study the nutritional needs of the crawfish. Knowledge of the nutrient requirement of crawfish should enhance the selection of supplemental feeds and perhaps lead to a nutritionally complete and economical diet for crawfish. Since 50 to 60 percent of the cost of raising fish and shell fish is for feed, it is imperative that researchers find out exactly what fish must have for an adequate diet. Developing adequate, economical diets for fish and shellfish is of primary importance in aquaculture today, says Ed Robinson, a TAES aquaculture expert.

Currently very little information exists on the nutritional requirements for most fish and shellfish, so practical diets for specific species cannot be formulated on known nutritional needs. Robinson hopes that current research by TAES scientists will provide basic information on:

- The protein, amino acid, carbohydrates, lipid, vitamin, and mineral needs of certain species of fish and shellfish.
- The most efficient ratio of protein and energy in a diet.
- What type of protein a species can use most efficiently.
- The feed efficiency rate_how much meat is produced for the amount of feed consumed.
- If reproduction can be improved by supplemental feeding for brood stock.

Researchers analyze diet requirements by comparing fish grown on different types of diets. In addition, comparisons are made in the laboratory by grinding up whole fish -

bones and all - and analyzing the body composition of fish fed different diets or by analyzing the nutrient content for selected tissues.

A large chunk of the TAES aquaculture program for the past several years has been directed at the feasibility of shrimp culture in both fresh water and salt water. Few scientists even considered raising shrimp in captivity ten years ago, but because of the research developments in Texas, shrimp culture now has a potentially bright future.

Texas leads the nation in shrimp culture research and has one of the largest and most productive programs in the world. Texas scientists have conducted a major portion of all shrimp research in the U.S. and have several major breakthroughs to their credit. TAES researcher Don Lewis , for instance, has developed immunization methods to control shrimp diseases. TAES researchers, in a cooperative effort with the Texas A&M University Sea Grant Program and the Texas Agricultural Extension Service:

- Produced (through artificial insemination) the first hybrid shrimp in history.
- Harvested two shrimp crops in one pond during one growing season - the first time ever in the continental U.S.
- Produced a single crop of shrimp having an approximate value of $5,000 per acre.
- Documented the first successful spawning of Gulf White Shrimp in captivity.

Texas probably has the greatest potential for commercial shrimp culture of any state in the nation, says Addison Lawrence, leader of the shrimp mariculture research at the TAES research center in Corpus Christi. The long Texas coastline, coastal topography, soil composition, and ideal climate are all conducive to a successful shrimp program. The millions of acres of land in West Texas with brackish water 10 to 25 feet underground could also be ideal for raising shrimp, says Lawrence.

Lawrence, who conducts his research at the Barney M. Davis Power Plant at Corpus Christi, cites the following reasons for the increasing interest in shrimp culture in Texas:

1. The harvest of shrimp from the oceans is either very near or at the maximum sustainable yields.
2. There is potentially a large margin of profit per acre for raising shrimp commercially.
3. The market for shrimp is tremendous (over one billion dollars dockside value per year in the U.S.).
4. Commercial shrimp culture, particularly in Central and South America, is very successful.
5. The level of technology available for shrimp mariculture is rapidly increasing.
6. Americans import over 50 percent of all the shrimp they eat, making shrimp a major negative balance of payment.

The production of "seedstock" (shrimp larvae) from marine shrimp in captivity is the most limiting phase to shrimp becoming a commercial reality in Texas. Additional research is needed concerning genetic selection, larviculture, pond nutrition, low-cost quality feed, and disease control.

The redfish (red drum) is another Gulf delicacy with potential for culture in Texas. It is a newcomer to the TAES aquaculture research program. Supplies of this popular restaurant fish have been reduced since 1981 when the Texas Legislature banned commercial harvest of redfish. Other states may also ban or at least establish quota systems for commercial harvests since natural stocks appear to be declining throughout the Gulf Coast region.

Ed Robinson, TAES scientist directing current redfish nutrition research, says that while no commercial aquaculture of redfish is currently underway in Texas, redfish culture is not only feasible, but may become a reality within the near future. Past redfish research at the Aquaculture Research Center near the Texas A&M University campus and by other agencies and universities in Texas has shown that:

- Redfish can survive very well in fresh water.
- Redfish adapt readily to prepared feeds even though they primarily consume fish and shellfish in nature. While redfish have shown good growth on prepared trout or catfish diets, Robinson hopes to formulate an efficient feed based on specific requirements of redfish. Nutritional studies are currently underway.
- Redfish adapt to crowded conditions and can spawn in captivity. Captive spawning of redfish depends upon carefully controlled light and temperature to simulate natural spawning conditions.

"Texans don't eat tilapia... yet," says TAES researcher Robert Stickney. Since tilapia is the second most widely cultured fish in the world, it may be just a matter of time before the fish, which resembles a sunfish, is accepted as a table fish in the state.

Stickney, however, can cite several reasons for Texans to study and raise tilapia whether they ever eat them or not. Tilapia are exceptionally hardy and less expensive to raise than other marketable fish. They can provide a relatively cheap source of protein, adapt to extremely dense populations, and live in very poor quality water.

The greatest limitation to raising tilapia in Texas is water temperature. They cannot live in water temperatures below 50_ Fahrenheit which means they cannot survive Texas winters except in extreme South Texas or in heated ponds. Stickney's research has, however, developed ways to maintain brood stock and to produce offspring in greenhouses so that when water temperature warms enough - usually in April - tilapia can be moved outside and grown to market size before water cools in the fall.

Stickney also works on ways to grow tilapia faster through better nutrition and pond management. He achieves faster growth by feeding very young fish a hormone which makes the entire population male. Males generally grow faster, and their growth is not hindered by reproduction activities.

Stickney has also studied tilapia as a way to reduce the most severe problems faced by feedlot and poultry house operators: odors and flies. He says that disposing wastes into ponds stocked with tilapia can reduce odor and fly problems significantly.

The very low dissolved oxygen and high ammonia levels associated with disposal in what are called aerobic lagoons limit most species of fish, but tilapia appear to be well adapted to waste environments. Another advantage of raising tilapia in waters which receive heavy loads of animal manure is that a high quality protein is produced, can easily be harvested, and could have commercial value as processed fish meal. After fish have been reared on livestock manure - although it may sound too good to be believed - they can be harvested, processed, and then fed to livestock.

Stickney says that tilapia culture is widespread, especially in tropical areas in Central and South America and in Southeast Asia. He believes that the research in College Station should benefit tilapia culture throughout the world. As a matter of fact, TAES researchers are now working directly with a project to develop a hatchery in the Philippines which Stickney hopes will produce 20 million tilapia a year for stocking ricefish culture projects. He says two crops of fish and rice can be produced annually in the Phillippines.

Tilapia can tolerate much higher population densities than most marketable fish, and they rarely suffer diseases or parasites unless water temperature falls too low. They can yield three times as much marketable fish per year as catfish in the same size pond. Since retail values of tilapia and catfish are similar, says Stickney, Texas aquaculturists in the future may very well grow tilapia instead of catfish.

Thanks to current work by TAES scientists, fish on Texas tables in the future _ whether shrimp, redfish, and tilapia or the old favorites catfish and crawfish _ will most likely come from efficient commercial enterprises.

Good Fishing Holes

Texans not only like to eat catfish, they like to catch them as well. Most fish grown commercially in Texas, in fact, are for stocking as sport fish or as forage to feed sport fish.

Managing bodies of water for recreational fishing is a major component in the TAES aquaculture research program. Richard Noble, a TAES pond management expert, directs research to help Texans who maintain the state's half million or so small impoundments with recreational fishing potential.

Nearly 20 percent of all inland fishing in the state takes place on private reservoirs. Since very few private reservoirs are managed in any way for fish production, Noble says, the potential for increasing production in private farm ponds alone is great.

Noble directs numerous studies on how to provide the best pond environment possible. He conducts his research in large part in flood control reservoirs built by the Soil

Conservation Service (SCS) on private land. There are 1,700 of these reservoirs in Texas which fall in size (and management) between a small farm pond and a large multi-purpose reservoir. They are an important research area, Noble says, because they are operationally different from both the small pond and the large reservoir. Since they are primarily on privately-owned land, the flood control reservoirs have received relatively little attention from researchers or managers in the past.

For the past eight years, Noble has directed research projects in over 80 Central Texas flood control reservoirs. The flood control reservoirs studied range in age from 5 to 20 years and average 30 surface acres in size. Less than a third of the reservoirs Noble sampled receive any type of fish management except for initial stocking.

Noble points out that good pond management includes manipulating the aquatic environment and maintaining a balance between desirable fish and available food. He has studied ways to change pond environment to encourage fish production such as intentionally drawing water levels down.

Drawdown of water levels, according to Noble, can be an important management tool for small flood control reservoirs. He found that fish respond to decreases in water level by changing the rate of reproduction, survival of offspring, and rate of growth. Drawdown also reduces the numbers of white crappie, a species which tends to overpopulate in small reservoirs. Noble found that summer drawdown also improves clarity and water quality, but it is substantially less beneficial than drawdown in the fall. Fall drawdown is effective in balancing populations of desirable fish and their prey .

Noble sampled fish populations in each lake and found most of the reservoirs to be in reasonable balance between predator and prey species. Of the lakes needing management changes, the most common problem encountered was lack of channel catfish reproduction. For such lakes, Noble recommends management through provision of spawning cans or through supplemental stocking of advanced fingerlings.

Noble's interest in sport fish production in ponds has led to his research in genetic studies of largemouth bass. Noble stocked ponds with equal numbers of native (Northern) and Florida largemouth bass in order to compare the growth, survival, crossbreeding and catchability of the native, Florida, and hybrid bass. Working with William Neill, a fish behavior expert, Noble compares movement and distribution of the types of bass by implanting transmitters into individual bass.

According to his research, Noble found that hybrid bass (a cross of a native male with a Florida female) generally has the best growth rate in farm ponds of less than one acre of surface water. Noble plans to continue his comparisons and warns that his results are preliminary at this time.

In a survey of reservoir owners, Noble found that they had a definite preference for largemouth bass and channel catfish. The researcher's sampling of fish populations found bullheads and crappies in as many reservoirs as largemouth bass and catfish.

Some or the reservoirs were overpopulated with largemouth bass. Noble suggests that reservoir managers thin bass population by electrofishing, an electric current sent through the water to harvest fish, or some other method of harvesting a large number of fish.

Noble continues his fish population studies in two new reservoirs where he has stocked largemouth bass using threadfin shad as prey. He has also stocked two established lakes with fingerling flathead catfish to evaluate their use as predators in controlling undesirable species. Noble hopes that through several years of sampling he will be able to determine the best management techniques for specific types of reservoirs and types of sport fish.

Noble says while there is not one "best" management technique or species to recommend to pond managers, his research can help pond owners properly stock and manage their ponds for bigger and better fun-to-catch, good-to-eat fish.

Ripples & Waves

Water and heat discharged from electric generating plants in Texas could provide valuable resources for raising fish and shellfish in the state. Less than five percent of water from power plants and other industrial dischargers, however, is presently used for aquaculture.

Scientists with The Texas Agricultural Experiment Station (TAES) continue to search for ways to use these "waste" waters discharged into more than 120 aquatic areas throughout the state. Their research already shows the value of this dependable source of good quality water for aquaculture activities.

TAES scientist Kirk Strawn has directed research projects in the water discharged by the Houston Power & Light Company (HP&L) Cedar Bayou Generating Station near Baytown for the past 12 years. The wide range of Strawn's projects indicate the diversity of opportunities for researchers in aquaculture. Strawn and his graduate students have successfully raised a variety of species including shrimp, redfish, pompano, mullet, catfish, trout, black drum, blue crab, oysters, and bait fish in heated water discharged from the generating plant. Research projects have included raising species in cages; studying effects of water quality, water temperature, and light; and analyzing feed types and rates of feeding.

The students which Strawn has directed at the study site also represent the far-reaching impact of the TAES research program. Strawn's former students now work in aquaculture in their native countries of Taiwan, Java, Bangladesh, Sri Lanka, Venezuela, and Mexico as well as in the U.S.

Even though he has studied more glamorous species, Strawn says that raising mud minnows just might be the best bet as a commercial venture in power plant discharge waters. He and his students have grown this popular flounder bait with great success using water warmed by the HP&L generating station. Their research showed that the mud minnow is extremely hardy, can be raised with an 85 percent survival rate, and can produce two crops per year in the heated water.

Another of Strawn's projects which could mean commercial success for aquaculturists was a study of whether heated water could extend shedding season and increase the shedding rate of soft shelled crabs. Researchers looked at the growth and molting rates of blue crabs at different seasons in the heated water and also studied effects of feeding schedules, cage sizes and depth in water, and water temperature on growth rate and molting rates.