TECHNICAL INFORMATION SOURCES

Sterling K. Johnson
Extension Fish Disease Specialist
Department of Wildlife and Fisheries Sciences
Texas A&M University
College Station, Texas 77843

Aquaculture information is available from a wide variety of sources. This chapter describes sources and costs of technical information on aquaculture.

AQUACULTURE MAGAZINES


Aquaculture Today. For owners and operators of fish farms. Quarterly. $10/yr. 831 Helmcken St., Vancouver, B.C. V6Z 1B1 Canada.

Bulletin. Variety of information on aquaculture with Canadian emphasis. Quarterly. $35/yr. Aquaculture Assn. of Canada. P.O. Box 1987 St Andrews, New Brunswick, E0G 2X0 Canada.

Canadian Aquaculture. Magazine articles focus on Canadian aquaculture. Bimonthly. $20/yr. 4611 William Head Road, Victoria, B.C. V8X 3W9 Canada.

Catfish/Aquaculture News. Covers the farm raised catfish industry plus some information on general aquaculture. Monthly. $20/yr. P.O. Box 199, Ridgeland, MS 39158.

Crawfish Tales. The official publication of the Louisiana Crawfish Farmers Association. Quarterly. $15/yr. LCFA, P.O. Box 91544, Lafayette, LA 70509.


Farm Pond Harvest. General aquaculture in recreational ponds. P.O. Box 736, Mo, IL 60954. Quarterly. $8/yr.


Mollusk Farming USA. Bimonthly. $60/yr. Aquaculture Digest, 9434 Kearny Mesa Road, San Diego, CA 92126.

Naga, the ICLARM Quarterly. International Center for Living Aquatic Resources, MC P.O. Box 1501, Makati, Metro Manila, Philippines. $20/yr.

Pet Age. Pet industry news including ornamental fish. Monthly. $25. 207 S. Wabash Ave., Chicago, IL 60604.

Practical Aquaculture & Lake Management. Fish and shellfish farming and pond management tips. Bimonthly. $18/yr. P.O. Box 1294, Garner, NC 27529-1294. 33


Seafood Business Magazine. Seafood industry. Bimonthly. $25. P.O. Box 905, Rockland, ME 04841.


Texas Shores. General coastal topics which often include aquaculture. Quarterly. $7.50/yr. Sea Grant College Program, Texas A&M University at Galveston, P.O. Box 1675, Galveston, TX 77553.

The Catfish Journal. Publishes catfish industry information. P.O. Box 34, Jackson, MS 39202. (601-353-7916)


World Shrimp Farming. A bimonthly report on shrimp and prawn farming. $60/yr. Aquaculture Digest, 9434 Kearny Mesa Road, San Diego, CA 92126

NEWSLETTERS


Coastal Aquaculture. Produced by Texas Agricultural Extension Service and Texas A&M Sea Grant College Program. Irregularly issued. Free to Texas residents. Texas A&M Research and Extension Center, Route 2, Box 589, Corpus Christi, TX 78410.

International Association of Astacology Newsletter. Bimonthly crawfish news of international type. Obtained with membership of $25. P.O. Box 44650, University of Southwestern Louisiana, Lafayette, Louisiana 70504.

New Waves. Research newsletter of the Texas Water Resources Institute. Quarterly. TWRI, Texas A&M University, College Station, TX 77843-2118.

Texas Aquaculture News. Texas Agricultural Extension Service. Monthly. Free to Texas residents. P.O. Box 38, Overton, TX 75684. 33

Texas Shoreline. Texas A&M University Marine Advisory Service Newsletter. Free to Texas residents. Issued irregularly. Sea Grant Program, Texas A&M University at Galveston, P.O. Box 1675, Galveston, TX 77553.

Texas Water Resources. General water information. Quarterly. Texas Water Resources Institute, Texas Agricultural Experiment Station, College Station, TX 77843-2118.

The Texas WaterFront. Information newsletter of the Texas Water Commission. Office of Public Information, P.O. Box 13087 Capitol Station, Austin, TX 78711-3087.

Other Newsletters:

In addition to those listed above, aquaculture newsletters are produced by almost all: Agricultural Extension Services, Sea Grant Marine Advisory Services, and state aquaculture associations.

INFORMATION SYSTEMS

Aquatic Sciences and Fisheries Information System (ASFIS). An international bibliographic service covering the world's literature on aquatic sciences and fisheries, including aquaculture. FAO, Rome. Contact: Aquaculture Development and Coordination Programme (ADCP), FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

Aquaculture Information System, AQUIS. Global aquaculture information acquired by contacting designated aquaculture centers or Rome. AQUIS is connected to FAO's Aquatic Sciences and Fisheries Information System (ASFIS). Both conventional (bibliographic) and unconventional information are accessible.

Selective Fisheries Information Service. Smaller system containing tropical finfish information. ICILARM MC P.O. Box 1501, Makati, Metro Manila, Philippines.

Texas Natural Resources Information System (TNRIS). Information on water and other natural resources of Texas. Data from state and federal agencies are collected so that one source may be...
contacted. P.O. Box 13087, Austin, TX 78711. (512) 475-3321.

Other Information Systems
A number of aquaculture information systems of regional focus have begun in the 1980's. Most are public, because usage is too infrequent for profitability.

ABSTRACTING AIDS


STATISTICS

Aquaculture Situation and Outlook. Provides U.S. aquaculture statistics and explores industry trends. Published twice a year. $10/yr. U.S. Department of Agriculture, ERS-NASS, P.O. Box 1608, Rockville, MD 20850.


FAO Yearbook of Fisheries Statistics. Gives world statistics on catches and landings. Aquaculture is included. Publication runs about 18 months after end of year reported. This and other FAO publications are available from: Aquaculture Development and Coordination Programme (ADCP), FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

LIBRARIES

Aquaculture Information Center. Room 111, National Agricultural Library, Beltsville, MD 20705. This is the national library that services aquaculture.

Texas A&M University/Sterling C. Evans Library. The library which is located on the Texas A&M campus in College Station has an aquaculture database provided by NAL with actual page images (4000+ pages). The pages are not copyrighted and may be downloaded for personal use.

Other libraries with aquaculture listings may be found at nearby universities and field laboratories. Most aquaculture professionals maintain personal libraries and aquaculture professionals housed in groups for public service usually maintain common libraries.

ELECTRONIC MEDIA

Aquaculture: Its time has come. (18 min.) International Center for Aquaculture, Auburn University, Auburn, AL 36849.

Catfish Aquaculture. (19 min.) 3D 3

Redfish Aquaculture. (23 min.)

Crawfish Aquaculture. (22 min.)

Alligator Aquaculture. (19 min)

$30 each on VHS. Make checks payable to Louisiana Cooperative Extension Service and mail to: John Brooks, LSU Cooperative Extension Service, 128 Knapp Hall, LSU. Baton Rouge, LA 70803.

Catfish Farming in the South. (38 min.)

Red Drum Aquaculture. (35 min.)

Southern Regional Aquaculture Center funded these videos. Several others are in preparation. Available for $20 from: Ext. Wildlife and Fisheries, Nagle Hall, Texas A&M Univ., College Station, TX 77843.

MEETINGS AND TRADE SHOWS

Regional, national, and international meetings are excellent opportunities for exchanging aquaculture information. There are many aquaculture meetings promoted these days. The best ones occur annually or semiannually and have a good reputation. Because much information is obtained outside of formal meetings, it is wise to have a good idea of who will be attending.

Trade shows offer the chance to discuss new technological advances with vendors and provides an important opportunity to gain a broad variety of technical information. It is usually possible to obtain an advanced list of exhibitors. Meetings and trade shows are advertised in aquaculture printed media months in advance.

JOURNALS AND BOOKS

Aquaculture-related scientific/technical journals have proliferated in recent years. Only a very wealthy person could afford subscriptions to all of them. The
typical reader might be better served by making an occasional visit to a major library to review the journals. Books have become abundant also. Many are quite expensive and should be examined before purchase. Titles often misrepresent content. Helpful are the book reviews sometimes found in journals, magazines and newsletters.

EXTENSION LITERATURE.

Extension literature is available in all Texas County Extension Agent offices. Much of the printed material on inland aquaculture is consolidated in a large three-ring binder entitled "Inland Aquaculture Handbook". Recently published printed materials of regional interest which were funded by the Southern Regional Aquaculture Center also have been included in this handbook. Agents of coastal counties will have printed materials that relate particularly to marine aquaculture. Agents also facilitate the use of videos, slide programs, computer software and many other materials.

HANDBOOKS AND MANUALS.

Technical handbooks and manuals are widely available. The Food and Agricultural Organization of the United Nations (FAO) publishes many such materials which are available from the address mentioned above (see under FAO Yearbook). Locally, several handbooks have recently become available:

- **Handbook of Texas Water Law: Problems and Needs.** This revised (1987) booklet reviews legal status of Texas water resources. Texas Water Resources Institute, Rm 301, Scoates Hall, Texas A&M Univ., College Station, TX 778443.

- **Inland Aquaculture Handbook.** An updated resource book (mentioned above) which is maintained in every Texas A&M University county office. A published version is obtainable from the Texas Aquaculture Association, P.O. Box 2948, College Station, TX 77841. $25.

- **Laboratory Manual for the Culture of Peneid Shrimp Larvae.** Marine Advisory Service, Sea Grant College Program, Texas A&M University, College Station, TX 77843-4115. $20.

- **Manual on Red Drum Aquaculture.** This manual which was first issued as a conference draft is now in preparation for publication by Texas Sea Grant College Program.

- **Red Drum Aquaculture.** A proceedings of a symposium on the culture of red drum and other warm water fishes. Includes research reports. $15.

Marine Science Institute, University of Texas, Port Aransas, TX 78373-1267.

- **Shrimp Disease Handbook.** A 1989 revision of a publication last printed in 1978. Available for $2 from Sea Grant College Program, Texas A&M University at Galveston. P.O. Box 1675, Galveston, TX 77553.

- **Texas Shrimp Farming Manual.** This Manual was produced as part of a workshop held in Corpus Christi, Texas in the fall of 1985. It has been revised and is nearing printing. It will be available from Texas Sea Grant College Program at the above address.

AGENCY REPORTS

Certain state agencies and institutes produce reports that include information which is important to aquaculture. A limited number of copies are produced, but one can usually find a particular issue in major libraries. When focused on local topics, the reports are normally available for examination at county offices. Reports of national agencies are usually deposited in the government section of the larger libraries or are available from the National Agricultural Library. Examples of state reports which could be helpful in aquaculture planning are:

- **Soil surveys of Texas Counties.** The Soil Conservation Service prepares surveys (complete with maps) which characterize soil features of all Texas counties.

- **Texas Estuary Reports.** This report series was produced by the Texas Department of Water Resources in the early 1980's. It provides information on the influence of freshwater inflows and a variety of other information that could be helpful in aquaculture planning.

CONSULTANTS

Consultants are a very important source of technical information. Although some may be specialized in offerings, most are able to provide needed information and services from planning to implementation. There are a number of commercial consultants active in Texas.

AQUACULTURE ASSOCIATIONS

American Fisheries Society. 5410 Grosvenor Lane, Suite 110, Bethesda, Md. 20814. (301) 897-8616. Founded in 1870, 8,000 members. Scientific origination of fisheries and aquatic science professionals. Has 15 sections including a fish culture section (dues $5.00) and a Texas Chapter. Annual meeting, various publications. Annual Dues $43.50.


European Aquaculture Society. Dr. N. dePauw, Prinses Elisabethlaan 69, B-8401 Bredene, Belgium 145, 125.935125, 900 members. Quarterly bulletin.


Striped Bass and Hybrid Bass Producers Association. Promotes advancement of the commercial cultivation of striped bass and its hybrids. c/o Ron Hodson, UNC Sea Grant, Box 8605, North Carolina State University, Raleigh, N.C. 27695-8605. With membership.

Texas Aquaculture Association. P.O. Box 2948, College Station, TX. 77841. Purpose: Promotes aquaculture in Texas. Various membership categories with dues from $10 to $50. 150 members.


EXTENSION SERVICES

Sterling K. Johnson
Extension Fish Disease Specialist
Department of Wildlife and Fisheries Sciences
Texas A&M University
College Station, Texas 77843

In this country, the agricultural educational process is usually associated with the Cooperative Extension Service system developed by the Land Grant Colleges and the U.S. Department of Agriculture. This system has great capacity to deliver educational programs. Extension professionals staff offices in nearly all of the nation's 3,150 counties and they are joined by more than 2.5 million volunteers.

TEXAS AGRICULTURAL EXTENSION SERVICE

Cooperative Extension in Texas is represented by the Texas Agricultural Extension Service (TAEX) which is part of the Texas A&M University System. The university linkage provides opportunities for interaction with research. This is an important aspect of the process because Extension's goal is to deliver research-based knowledge to its clientele.

County Offices
A local office within each county attests the partnership of federal-state-local government. Local offices provide for easy access and interaction with people and affirms the mandate to provide education to those people who do not attend the university in a formal manner.

The local office is the place to start when one is seeking technical information. The county extension agent will either provide needed information directly or facilitate contact with appropriate resource persons.

Specialized Support
The county extension agent is supported by subject-matter specialists. There are many specialties represented, including aquaculture. Aquaculture specialists have offices at College Station, Corpus Christi and Overton.

In addition to services provided by agents and specialists, TAEX operates service laboratories that support aquaculture. The Extension Fish Disease Diagnostic Laboratory has served aquaculturists since 1971. The Extension Soil and Water Testing Laboratory has recently expanded its services in
water testing to better meet the needs of aquaculturists. Both labs are located at Texas A&M University in College Station.

Aquaculture Activities

Aquaculture and TAEX have grown together. For example, TAEX began to provide aquaculturists with an annual statewide fish conference in the 1960’s. This effort helped form the Catfish Farmers of Texas which later developed into the Texas Aquaculture Association. In the early 1980’s similar Extension programs helped to facilitate formation of crawfish farmer associations. During those years, a great number of educational programs in the form of demonstrations, media presentations, literature (refer to chapter, "Sources of Technical Information"), meetings, workshops, field days and other methods have been delivered to Texans.

Interaction with Sea Grant

Texas also has extension efforts that developed with the formation of the Sea Grant College Program. Agents that are involved in Sea Grant’s Marine Advisory Program have offices in coastal counties. These agents, which have job titles of County Extension Agents - Marine, normally work out of the same office as the County Extension - Agriculture and are supported by Sea Grant, TAEX, and local government.

Sea Grant also employs a mariculture specialist who works out of an office located at Texas A&M University - College Station. Texas Sea Grant projects were the first to demonstrate shrimp farming in the U.S. Recent demonstrations have been focused on shrimps, mollusks and several marine finfish.

OTHER EXTENSION ACTIVITIES

The Fish Farming Experimental Station at Stuttgart, Arkansas, a U.S. Fish and Wildlife Service facility, employs an extension biologist that works with fish farmers. The Soil Conservation Service employs regional biologists who are able to assist in matters relating to aquaculture.
Production of catfish in the United States reached more than 388 million pounds valued at $321 million in 1988. By far, the most widely produced species is the channel catfish (Ictalurus punctatus). Other species are the flathead (Pylodictus olivaris), blue (I. furcatus), and white catfish (I. catus), and the brown (I. nebulosus), yellow (I. natalis), and black bullhead (I. melas).

A recent survey by the USDA indicated that the acreage of catfish ponds is increasing, while the number of producers is decreasing (1,830 growers with 140,392 acres of ponds in 1989 compared to 2,003 growers and 130,252 acres in 1988). This growth in average farm size indicates a trend toward lowering of production costs through economies of scale by large producers who sell a generic product to the processing market.

Four states (Mississippi, Arkansas, Alabama, and Louisiana) account for 91 percent of the U.S. catfish pond acreage. Growers outside the Mississippi delta region generally utilize smaller operations and face higher prices for major items such as fingerlings, feed, and processing. These factors make it difficult for smaller operations to compete in major food fish markets.

**TEXAS INDUSTRY STATUS**

Compared with such states as Alabama, Arkansas, Louisiana and Mississippi, the industry for farming channel catfish has remained relatively small in Texas. Currently, about 250 fish farming licences are on record in Texas for production of catfish fingerlings or food fish.

**Farm Size**

The typical Texas catfish operation is a small, "family-farm" which sells product to a local market. The majority of farmers produce fingerlings for sale to private pond and lake owners. Food fish producers sell directly to consumers at the farm or through special arrangements with restaurants, caterers, etc.
Only 10 foodfish producers and an additional 11 fingerling producers advertise their catfish on a state-wide basis in the Fish Availability List published by the Texas Aquaculture Association.

Production Methods

Currently all catfish are being cultured in open earthen ponds with mechanical aerators and availability of ample replacement water. This type of facility is expected to dominate production systems in the near future.

Both channel catfish and blue catfish are currently being produced, with the latter generally being sold only as fingerlings for stocking in recreational ponds. There is some demand for flathead catfish stockers, but there is no known production of this species at the present time.

Processing and Marketing

Currently, there is no mechanized processing plant for catfish in Texas. Some producers hand-process fish for sale at the farm. However, at the present time, a catfish processing plant is under construction in southeast Texas by the Naiad Corporation. Operation of this plant will demand 8,000 to 10,000 acres of foodfish production to support full-time operation.

The 1989 farm-gate value of catfish fingerling and food sales by Texas producers was estimated to be $3.5 million.

Future Prospects

During the recent session of the Texas legislature, H.B.1587 was passed. Termed the "Fish Farming Act of 1989" and considerably revised from introduction to passage, it represents the first step by the legislature to foster development of an aquaculture industry and to reduce the number of legal and institutional impediments.

DEVELOPMENT NEEDS

Although the catfish industry is active in Texas and most of the biological problems involved with rearing them efficiently have been overcome, several aspects related to a profitable industry require further development.

The lack of adequate financing to support industry expansion in Texas seems to be the major limiting factor.

Marketing constraints are not viewed as a impediment to further development of the Texas catfish industry. However, entering into the existing market is viewed as a barrier to be overcome. Gaining a market share for fish produced in Texas will be difficult because of the competition from the highly developed integrated industries which already exist in several states.

Other significant development needs include:
- availability of competitively priced nutritional feeds,
- availability of aquaculture equipment and supplies, and
- improved live-hauling services.

While the above items relate to development needs, there are a number of institutional and legal constraints which must be moderated if Texas is to field a competitive and profitable industry.

Among the existing constraints are:
- water availability and usage,
- wetlands legislation as it relates to existing and proposed fish production ponds,
- prohibition of useful exotic fish species,
- unavailability of practically trained and educated personnel, and
- limited number of chemicals that are tested and approved for aquaculture use.

RECOMMENDATIONS

Financing for Catfish Farms

Education of the financial community is suggested as essential to improving the availability of financing for aquaculture ventures. Suggestions for accomplishing improved knowledge of fish farming by investors and lenders include:
- involvement of financial community members in activities of the Texas Aquaculture Association,
- arranging visits between financiers in Texas with those of other states who are currently providing funds for aquaculture development and production,
- state and federal loan guarantees as a means of collateral for the financier, and
- development of financial assistance programs in the Texas Department of Agriculture and the Texas Department of Commerce.

Marketing and Processing

Marketing of Texas produced catfish must develop hand-in-hand with increases in production. Strategically located processing plants will be essential to profitable production, effective marketing and profit. Generally, a single processing plant can serve fish farmers in a 20-30 mile radius from its location.

Research should be initiated on product development to improve the opportunity for use in the home. While the opportunity to sell catfish filets and
whole fish has not been exhausted, sales will be enhanced by the availability and promotion of new products, new recipes and convenience packaging. Promotion of Texas products should be a high priority of the Texas Department of Agriculture.

Research and promotion of the human nutritional values of farm raised catfish must be increased.

The persistent problems of off-flavor remains a major marketing problem for the industry. Research on detection and elimination must be continued until this problem is completely alleviated.

Water

Water use in Texas should be prioritized by the Texas Water Commission and Texas Water Development Board with aquaculture receiving a high priority. This high priority can be based upon efficient use in the production of a high quality food product. It should be pointed out that catfish production in ponds and closed systems represent an efficient use of water with evaporation being the major water loss. Good water quality must be maintained in fish farms in order to maintain fish health. Thus, water released from fish farms can be treated and used for domestic purposes. Water released from fish farms is excellent for irrigation, livestock water, etc.

Realistic discharge water quality monitoring procedures must be incorporated into discharge permits.

Wetlands

Jurisdictional wetland legislation must be ameliorated in a manner that allows protection of essential wetlands and the development of a catfish (aquaculture) industry in Texas. It is suggested that a study be done to determine the contribution of catfish ponds to wetland habitats.

Exotic Fish

The ability to compete in U.S. and world markets demands the most efficient production system. Currently, high technology polyculture production systems using exotic species have shown greater returns per acre, reduced incidence of off-flavor and conservation of water resources. Development of well researched criteria to determine the potential for harm when using exotic species in fish culture ponds will be essential. Currently prohibited lists are developed without any input from aquaculturists. Regulation of such species must be made in concert with equal inputs from all concerned. Presently, regulations on the use of exotic species are promulgated by an agency with little, if any, concern for aquaculture and its potential for the Texas economy.

Personnel

It is suggested that a work/study program be initiated at the university level. The program should include basic aquaculture courses and "hands-on" training to better prepare graduates for entry into the job market.

Fish Production

While current production technology will support a profitable industry, there are areas of research that will enhance production and profitability. These include competitively priced nutritional feeds, feeding practices and water quality maintenance. Future research will be needed on catfish genetics to improve growth and health in intensive systems. Genetics research will be needed to develop improved strains particularly adapted to specific environmental conditions.

Research is needed to explore the relationship between fish nutrition, environment, and fish flesh as it's consumption relates to human nutrition and health.

Field testing and demonstrations on the use of exotic species are needed to illustrate efficiency in improving water quality thus eliminating vegetation problems and the use of environmentally adverse chemicals. Polyculture of catfish and various carps is of high interest and potential and should be researched and demonstrated in Texas. For further information on carps, refer to chapter entitled, "Other Freshwater Species".

Therapeutics

While biological control can be used on problems with algae and higher aquatic plants, chemical therapeutics are needed to control, fish disease, and parasites. The therapeutics must be environmentally safe, effective against the target organisms and tolerated by the fish to be treated. Fish farmers need more approved chemicals to enhance fish production in Texas.
CRAWFISH

William R. Younger\textsuperscript{1} and Bill Yeager\textsuperscript{2}

County Extension Agent-Marine\textsuperscript{1}
Texas Agricultural Extension Service/Sea Grant College Program
Room 326, Courthouse
Bay City, Texas 77414-1178

Owner/Operator\textsuperscript{2}
Caddo Creek Crawfish
P. O. Box 8
Frankston, Texas 75763

INTRODUCTION

Crawfish are found over most of North America. They are fished for bait or food over their entire range. Over 300 species of crawfish have been identified in the United States, but the majority of commercial production is attributed to the red swamp crawfish (\textit{Procambarus clarkii}) and secondarily to the white crawfish (\textit{P. acuatus}).

Crawfish culture historically has been confined to south Louisiana. Culture of crawfish for food elsewhere in Louisiana increased markedly in the 1970's and early 1980's in response to demand for an increased and consistent supply. Louisiana continues to produce at least 95 percent of the total U.S. supply of crawfish. Texas, Mississippi, Alabama, Florida, Oklahoma, Oregon, California, Virginia, Missouri, North Carolina, and South Carolina are relatively minor producers of crawfish. However, the president of the Louisiana Crawfish Farmers Association recently reported a distinct decline in crawfish pond acreage in Louisiana to less than 100,000 acres.

A moderately strong, although poorly documented, demand for crawfish as bait and food also exists in Texas. In response to that demand, small scale, commercial production of crawfish was initiated in 1973 in Orange County (Stickney and Davis, 1981). According to a recent survey of producers by Haby and Younger (In Press), 5,000 acres of crawfish ponds are estimated to be in production in Texas.

PRODUCTION METHODS

Crawfish can be farmed in either rice-field ponds in which crawfish/rice polyculture is practiced or in open ponds used exclusively for crawfish. However, rice-field pond production in Texas is extremely rare,
if not nonexistent at this time. In both situations, the ponds are managed to make vegetation available to serve as forage for crawfish. Supplementary feeding has traditionally been used only in instances when natural forage is prematurely depleted. However, some farmers are beginning to eliminate the culture of forage vegetation (mainly rice) from their practices and replace it with season-long feeding of commercial crawfish feeds/baits. Preliminary evidence suggests that this practice may produce greater pond yields while easing labor and water quality management requirements.

Because crawfish reproduce in the production pond, only a single stocking is needed. Adults are stocked at a density of 50 to 100 pounds per surface acre of pond. After they are stocked, the adults burrow into the pond bottom. Young produced within the burrow emerge in the fall after flooding. At this stage, the animals feed and grow. Crawfish can be induced to spawn year-round in indoor hatcheries which may allow advances through selective breeding and elimination of seasonal stocking restrictions.

Production rates vary from about 200 pounds per acre in extensive systems to over 2,000 pounds/acre in intensive systems. The use of improved farming techniques results in a higher rate of production per acre in Texas than in Louisiana.

An established crawfish population in a well-managed pond provides a seasonal crop with an extended harvest generally lasting from late fall through late spring. However, some farmers have recently begun to carry their harvest into mid-and late-summer with acceptable results.

Harvests of crawfish ponds are conducted by trapping with as many as 30 traps per acre. Harvesting is a labor-intensive operation, but advances in the design of traps and in mechanical harvesting equipment have greatly reduced the amount of time and labor required for harvesting. Additional advances in harvest technology are expected. This will further reduce labor while increasing catch rates and overall profitability.

MARKETING

In Louisiana, an enormous but erratic harvest of wild crawfish from the Atchafalaya basin greatly impacts marketing of pond-reared crop. Undesirable characteristics of the wild crop include its great variation from year to year and its limited season. The former produces instability in marketing, while the latter causes a depression in prices received by both fishermen and farmers. In recent years, price has dropped to as little as $0.22 per pound. While prices this low are not usually experienced in Texas, the abundance of cheap Louisiana crawfish can and does depress Texas farm-raised crawfish sales and prices.

The purging process, which involves holding the animals in clean water without food for a period of about 24 hours, allowing them to clear their gut, greatly improves the quality and shelf life of this live seafood product. An increased recognition of these benefits by consumers and marketers mildly buffered periodic price declines in Texas due to the influx of both wild caught and farmed Louisiana crawfish, which generally are not purged. If Texas purged crawfish can continue to gain recognition for product quality, they will become more insulated from the influences of the Louisiana harvest. However, the probability that Louisiana fishermen and farmers will adopt this practice is high if the market demands this quality assurance. Thus such a competitive advantage for Texas interests may be short-lived.

CHARACTERISTICS OF TEXAS FARMS

Some general characteristics of the farm, the farmer and his/her customers can be drawn from the survey by Haby and Younger (In Press).

The typical farmer is relatively new to the industry, having been in operation less than 3 years. With little access to the farm credit system or other traditional lending sources, he/she has financed the start-up of expansion of his/her crawfish operation primarily with personal resources.

Over 89% of the state's production is done on farms greater than 30 acres with 81% of the state's production taking place in just four southeastern counties (Chambers, Jefferson, Liberty and Orange). Annual production varies with individual operations, but Haby and Younger calculated average yields of Texas survey respondents to be 409 pounds/acre. Assuming an average farm-gate value of $0.80/pound, the total farm-gate value of Texas crawfish production is estimated to be about $1.6 million.

Farmers marketed 71% of their crop live to three customer types: ultimate consumers (26%), wholesale interests (35%), and food service establishments (20%). Only 12% of Texas farm-raised crawfish went to processors. Since there are no known processors in the state at this time, it is assumed this amount went to Louisiana for processing.

Typically, Texas crawfish farming requires that producers also serve as product distributors which creates additional management and capital demands. Slowly, supportive market services such as cooperative marketing, brokerage and mixed-product distribution have evolved. However, it
appears that the majority of the current producers are either unsure of how to access these options or are unwilling to participate for varying reasons at this time.

**ISSUES**

Overall, those involved in this unique farming enterprise seem optimistic about the industry's potential for future growth, despite indications that recent production cuts have occurred. Indeed, as crawfish farmers face the 1990's, they are beginning to develop strategies to improve their chances for future growth. Recently, in an effort facilitated by the Texas A&M Marine Advisory Service (a component of the Texas A&M University Sea Grant College Program and the Texas Agricultural Extension Service), Texas crawfish aquaculturists developed a listing of critical issues and ranked strategies necessary to promote industry growth. The following are their recommendations (individual issues within categories are listed in order of producer rankings; however, the broad categories are unranked).

**Water Use and Management**

1. Find effective ways to deal with the rising costs of water.
2. Identify more effective ways to control water quality.
3. Devise strategies for more effective on-farm water use management.
4. Participate in governmental processes which will determine the regulation and allocation of water resources.

**Production Management Practices**

1. Develop a better understanding of crawfish nutritional needs.
2. Develop more cost effective harvest technology.
3. Establish effective predator and disease controls.
4. Establish adequate financing for new and expanding farms.
5. Proactively address regulatory issues such as licensing and permitting.

6. Develop adequate supply lines for seed stock and/or brood stock.

**Trade Association**

1. Develop supply and/or marketing cooperatives.
2. Proactively provide input into research and producer education programs carried out by state and federal agencies and the State's University System.
3. Develop alliances with other relevant trade associations and interest groups.
4. Establish greater, more timely input into governmental policies and regulations that impact aquaculture production.

**Marketing by Industry**

1. Develop and implement a comprehensive product promotion plan.
2. Develop a set of product standards which are supported by crawfish farmers.
3. Develop a standardized reporting system to assess the current status of the crawfish industry by lenders, policymakers, etc.

**Marketing by Individual Farmers**

1. Overcome the seasonal oversupply problem.
2. Develop or expand crawfish markets (i.e., new product forms and/or new market areas).
3. Expand promotion of crawfish to consumers.
4. Develop processing facilities in Texas.
5. Strengthen the distribution system for crawfish.
6. Develop enforceable quality standards for crawfish and crawfish products.

**LITERATURE CITED**


BAITFISH

James T. Davis1 and Harrell Arms2

1Extension Fisheries Specialist
Nagle Hall, Room 102
Texas A&M University
College Station, Texas 77843-2258

2Arms Bait Company and Fish Farm
Route 2, Box 115
Dublin, Texas 76446

STATUS OF THE INDUSTRY

Commercial development of baitfish began as early as 1915 but little progress was made until after World War II. During the 1950s and 1960s rapid expansion occurred, particularly in Arkansas. By 1972, Arkansas had developed 29,091 acres of baitfish ponds of which 91% were devoted to production of golden shiner (Notemigonus crysoleucas). In 1987, the U.S. baitfish industry utilized over 40,000 acres and produced 26 million pounds of baitfish. The average farm-gate value of all minnows in 1987 was about $2.75 per pound. Thus, the total value of U.S. baitfish production was $71.5 million. Arkansas still accounts for about 75% of baitfish production and acreage and about 115 of the 165 major producers in the U.S.

Most of the baitfish sold in Texas are trucked in from Arkansas. Although the farm-gate value of the Texas baitfish industry is estimated to be about $10 million, most of this value is associated with temporary holding and distribution of minnows from Arkansas. Fewer than 100 acres are devoted to production of baitfish in Texas, and the value of this aquaculture component is estimated at $250,000.

The largest use of baitfish is for freshwater sportfishing although some minnows are sold to the aquarium industry. Estimated annual per capita usage of baitfish is one half to one pound. Demand is linked to population. Thus, the rapidly growing urban areas in Texas represent obvious markets. Demand also tends to increase in the vicinity of new lakes or impoundments.

Bait Species

Although more than 20 species of fish have been grown for bait, three species clearly dominate U.S. production. These include, in order of importance, the golden shiner, the fathead minnow (Pimephales promelas), and the goldfish (Carassius auratus). Other species that may prove profitable to bait
producers in Texas include common carp (Cyprinus carpio), crawfish (Procambarus spp.), Mexican tetra (Astyanax mexicanus) and various other shiners (Notropis spp.).

The killifish (Fundulus grandis) is being produced in limited quantities in the Galveston Bay area of the Texas coast. Penaeid shrimp (Penaeus spp.) have strong potential as a saltwater sportfishing bait, but no commercial bait shrimp culture facilities exist at this time. This situation may change with the upcoming designation of several productive back-bay areas of the Texas coast as protected nurseries where trawling for bait shrimp is not allowed.

TYPICAL PRODUCTION METHODS

Bait minnow production techniques are well developed. Giudice et al. (1981) provided an excellent summary of methods in the booklet, "Manual for baitfish culture in the South" (publication number EC 550 of the U.S. Fish and Wildlife Service and the University of Arkansas Cooperative Extension Service). In summary, the reproduction and grow-out phases of baitfish production are generally accomplished in outdoor ponds. When the water temperature warms to 65-70 F during late spring and early summer, adult minnows begin spawning on appropriate substrate in the ponds. After spawning, the eggs or fry are generally transferred to separate fertilized ponds where a rich plankton bloom is encouraged. Although baitfish fry are omnivorous and can subsist entirely on natural plankton in the pond, production rates can be doubled by offering supplemental feed. As the fish grow, they are gradually transitioned from a finely ground, high protein starter feed to a coarser, lower protein grower feed.

The golden shiner reaches a size of 25 cm (10 in) when mature. However, most are marketed in smaller sizes. Fatheads are produced on fish farms using intensive culture systems and usually are sold at 6 to 8 cm (2.5 to 4 in.). Many farms raise goldfish both for bait and the aquarium trade. Often the most colorful go to aquarium dealers and the others are baitfish.

Production per acre generally ranges from 250 to 1,000 pounds. The industry average is just over 600 pounds (USDA, 1988). Yields as high as 4,484 kg/ha (4,000 lb/acre) have been produced by goldfish farmers and as high as 1,570 kg/ha (1,400 lb/acre) by golden shiner farmers.

The average baitfish farmer invests more than $2,500/acre before harvesting a single fish. This does not include the price of land, which may be as high as $1,000/acre. Capital costs include land clearing, pond construction, development of adequate water supplies, spawning materials, scines, holding tanks, and hauling trucks. Feed and energy account for about 45% of operating costs. Giudice et al. (1981) estimated that a small family could live comfortably on 40-50 water acres of baitfish ponds if, 1,000 pounds per acre of good quality, small bait were produced and marketing did not involve a wholesaler. The industry average for returns to land and management are estimated to be approximately 25% of sales value (USDA, 1988).

DEVELOPMENT PLAN

U.S. baitfish production increased 3% from 1986 to 1987. Expansion of the industry will depend upon continued growth of sport and commercial fisheries, construction of additional ponds and lakes in the state, and improvement in management techniques. As Arkansas producers face worsening problems with water availability and bird predation, Texas producers may have an opportunity to capture a larger share of the growing market. In order to provide a consistent supply of a variety of minnow sizes, relatively large farms are needed. However, there is considerable risk in competing with the mature, established industry in Arkansas. A combination of land, water, and climate favors concentration of the baitfish industry in Texas. Close proximity to markets also is a factor.

Resource Requirements

A successful baitfish enterprise requires relatively flat land with good water retention. Rocky, gravelly, or sandy soils and rolling or steep terrain usually are undesirable. Adequate quantities of water that is neither too acidic or too alkaline must be available. Surface waters often contain excessive amounts of silt and pesticides or undesirable fish species with attendant problems of disease and parasites. Therefore, absence of adequate underground water generally restricts development of a baitfish farm. Declining water tables make water reuse programs essential to the future of the industry.

Capital costs represent a major constraint to expansion of the industry. More readily available credit and increased profit margins would ease this limitation.

Research and Technology Needs

Much of the progress in this industry has been made by managers and production specialists, who, by trial and error, have found ways to improve their operations. Virtually no research on the culture of baitfish is currently being conducted in Texas. Studies should be
made on baitfish production potential in Texas where good data are currently unavailable. Such studies would be conducted primarily in ponds and feature various stocking levels of broodfish, fry or fingerlings, depending upon the species of interest.

A survey of the availability and popularity of various baitfish species of potential importance in Texas is of primary importance so that research can be aimed at those which offer the best probability of success for the aquaculturists. This survey should be conducted by an appropriate state government or university agency.

The nutritional requirements of many baitfishes are poorly known. Feeds are currently available for most species, but a great deal of research is required if feeds formulated to meet the nutritional requirements of each species are to be developed. A strong research program in baitfish nutrition should follow or parallel development the baitfish rearing industry in the state.

Environmental requirements of baitfishes are of great concern to producers. Studies aimed at providing information on the requirements for oxygen and susceptibility to high levels of metabolites, along with studies on the interactions of these parameters, are required.

Almost no research has been done in the field of genetics. Selection of brood stock represents a major problem because of the large numbers of fish involved. Baitfish farmers sometimes harvest the fastest growing fish, allowing others to be held over as brood stock. This may prevent improvements in yield. To remedy the paucity of knowledge in this field, the following is recommended: a) a study in which annually-selected and spawned brood fish are compared with those raised in control ponds; b) research to find strains that are resistant to diseases, parasites, stress, viruses, and other production problems; c) research on spawning with the object of defining methods to obtain spawns from brood stock in one season.

Under certain water quality and algae conditions, golden shiners produce only 338 kg/ha 1(200 lb/acre) per year. Farmers need to know what kinds of feeds to use before, during, and immediately after spawning. A great deal of knowledge about nutrition and diet has been borrowed from trout research. Specific information related to baitfish is lacking, such as how much dietary protein is needed during various seasons, and how much food to feed. Universities and experiment stations could develop this information.

Environmental requirements concern baitfish farmers more than any other. Oxygen depletion may cause losses amounting to thousands of dollars. Even if catastrophic losses do not occur, low-oxygen stress can predispose the fish to disease and parasitic infection.

Baitfish farmers traditionally use a number of chemicals to prevent oxygen shortages, treat bacterial infections, eradicate undesirable fish, and combat parasites. EPA and FDA have challenged the safety of these chemicals. Many chemical companies do not obtain clearance for their products because of cost involved. Baitfish farmers believe this problem should be addressed by the Federal Government. They also believe that high enough priority has not been given to clearance of chemicals used in the industry and that they should not be under the same restrictions as food producers.

Pond vegetation generates environmental concern. Algae such as Anabaena, Chana, Microcystis and Pithophora together with higher aquatic plants such as Ceratophyllum, Elodea, Najas and Potamogeton represent major problems. Restrictions by EPA and FDA hamper economical solutions. The few registered chemicals are often impractical or ineffective. Copper sulfates control some algae, but its corrosive qualities make large-scale use difficult.

Dryland vegetation presents another problem. Barnyard grass, smartweeds, and similar plants germinate quickly when farmers partially draw down ponds for harvesting. Disk harrowing controls the plants, but rain or high water table often prevent use of harrow equipment. The only alternative involves chemicals, most of which are banned.

Vegetation control studies should be funded for several years, with both universities and experiment stations participating. Such research would also be applicable to catfish farming, intensive culture of sport fish, farm pond management and management of ponds on Federal and State Hatcheries. Research in this area is badly needed.

Little research has been done on control of effluents from baitfish farms. Investigators at the USFWS Fish Farming Experimental Station studied the subject briefly and concluded that organic matter discharged from ponds had no significant pollution potential.

More research should be done on the rotation of baitfish and crops, such as grain, rice, sorghum and soybeans. Yields of crops increase dramatically following fish in rotation systems. Studies also are needed on the advantages of using pond water to irrigate crops.

A host of animals prey on baitfish, including otters, diving ducks, egrets, herons, mergansers, bullfrogs, alligators, snakes, snapping turtles, backswimmers, dragonfly nymphs and other aquatic insects. Baitfish farmers wage a constant battle...
against these predators and research is badly needed to develop methods to control them.

Many baitfish farms are near aerial-spraying operations. The chemicals may be causing fish deaths. Studies are needed to assess this problem.

When fishermen buy baitfish they expect healthy, hardy animals. To produce fish that meet these requirements requires quality control throughout the growing and harvesting process. It is important to grade healthy fish into sizes suitable for different kinds of sport fishing.

No facility specializes in baitfish research. Several universities have made important contributions, but considering the size of the industry, much remains to be accomplished. It is recommended that a 5-year program be developed incorporating the following items:

- establish a program of applied research and demonstrations and
- establish a program of basic research.

Studies should provide solutions to problems of growing baitfish in ponds and on methods for controlled culture systems.

Other Needs

The number one complaint by the Texas baitfish industry is the regulatory ban prohibiting use of tilapia as live bait. Tilapia have much potential as a farm-reared baitfish in Texas. Due to their sensitivity to low temperatures, tilapia can be more readily grown in Texas than in Arkansas, thus providing a competitive edge. Tilapia food-fish operations generally produce excess small fish which could be sold to bait dealers for distribution. Other exotic fish species also might make excellent bait for Texas fishermen, possibly better than those now cultured. An effort should be made to accurately evaluate all species for use as bait under conditions which will not damage the natural fish populations in the State.

More publications, workshops, seminars, field days and short courses are needed to transfer technology from the classroom to the field. The Extension Service can provide assistance in this area. Much of the technology developed for baitfish culture came from the industry itself. However, many problems cannot be solved by in-house technology.

Information on economics is limited. As in the case of technology, much needs to be done to develop and transfer such information to the baitfish industry.

Accurate, up-to-date economic information should help baitfish farmers to obtain loans.

A major land use problem involves the spread of urban areas into farming sections. Proper land use planning should solve this problem.

Numerous regulations, particularly those of the EPA, FDA and the TPWD, constrain orderly development of the baitfish industry. Fish health inspections are not standardized.

RECOMMENDED ACTION

1. Develop basic research on life history and biology of potential new species of baitfish. This would include providing information for use by TPWD in setting regulations for use of these in Texas.
2. Conduct research on genetics and reproduction, and through selection, develop superior strains of broodfish resistant to diseases and stress. This is a long-range program.
3. Initiate a study of water quality, including methods of managing algae blooms for maximum production.
4. Continue to develop information on nutritional needs of brood fish, fry, and fingerlings.
5. Continue research on ways to alleviate oxygen shortages.
6. Coordinate efforts by FWS, EPA and FDA to clear chemicals useful to the baitfish industry and for the aquaculture industry at large.
7. Establish research programs aimed at practical control of aquatic and dryland plants that cause problems.
8. Initiate research on better ways of constructing ponds and drain systems, and on the advantages of crop and fish rotations.
9. Continue research on control of disease and parasites.
10. Develop information on practical methods of controlling predators.
11. Upgrade methods of harvesting, grading, and transporting fish.
12. Test other fish species for potential as baitfish.
13. Develop mechanisms to coordinate research and development projects.
15. Initiate studies on the advantages of using pond water to irrigate crops.
TILAPIA

Joe T. Lock and Tim C. Moore

Extension Fisheries Specialist
Texas Agricultural Extension Service
Drawer 38
Overton, Texas 75684

K.S. King, Inc.
6200 South Old Hemphill
Fort Worth, Texas 76134

PRESENT STATUS

Tilapia (Oreochromis and Tilapia spp.) are exotic tropical fishes, having been introduced throughout the tropical and subtropical world from Africa and the Middle East. Except for extreme South Texas, tilapia cannot overwinter except during unusually warm winters, in constant temperature springs, or in the discharge canals of electrical generating stations. There is no indication that the lower lethal temperature tolerance of tilapia will increase with time.

From an aquaculture standpoint, tilapia have many advantages. Tilapia are well accepted when tried by consumers, are resistant to most parasites and diseases, grow rapidly, are tolerant to extremes in water quality and are largely herbivorous. High densities of tilapia can be grown with a reduced level of management as compared to channel catfish. Tilapia are important food fish in all tropical regions of the world and are becoming more so.

Tilapia, principally Oreochromis aureus, are present as year-round populations in various power plant cooling lakes around Texas and in the Rio Grande. Overwintering populations may occur in farm ponds in south Texas and may also occur as far north as Buffalo during unusually mild winters. In most regions, however, winter kills are common when water temperature falls below about 10 C for a period of several hours.

Although biological and historical data indicate minimal negative impact or, in most cases, positive impact on native fish populations, there is apprehension from sport fishermen about stocking
tilapia in Texas waters. Concern about exotics is shared by some regulatory fisheries officials, which has resulted in highly restrictive culture regulations.

About 500,000 pounds of tilapia valued at more than $500,000 are produced annually in Texas. Currently, producers are restricted to the use of two species of tilapia for production. These being Oreochromis mossambicus and O. aureus and their hybrids. Worldwide research indicates that both O. niloticus and O. hornorum are also valuable species for the production of fast growing, all-male hybrids which increase profitability. Yet neither of these are permitted in Texas because of environmental concerns considered by many in the industry to be ill founded.

If one were to examine the major agricultural breakthroughs of this century, a large proportion would be found to involve hybridization of species. Hybrids have given Texas the 1015 onion, the ruby red grapefruit, a dust resistant chicken in poultry breeding, and the Santa Gertrudis and Hereford cattle, to name a few. Most hybrids command premium market prices.

It is vital that tilapia producers be able to utilize the most effective hybrids of the differing species of tilapia. There are some 50 known species of tilapia worldwide, and over 20 have been cultured. Some of these species are recognized for their shorter growth seasons, some for their unique feeding habits, and others for their higher percentage of fillet yields in processing. Certain hybrids are recognized for producing high percentages of male offspring, which reduce the time required for growout.

Most pond aquaculture sites in Texas are located within floodplains. Texas regulations currently prohibit tilapia culture within flood plains. There are more than 800,000 private impoundments in Texas that could be used for cage and other forms of tilapia culture. Regulations prohibit their use because it is impossible or impractical to filter discharge flood water.

Low-income farmers are unable to take advantage of their existing resources for tilapia production because of regulatory restrictions and comparatively high species certification costs.

Investors are reluctant to invest in Texas because of the seemingly hostile regulatory climate. The multi-billion dollar aquaculture industry is located in other states more favorable to aquaculture.

**POTENTIAL**

The potential for rearing tilapia in many parts of Texas appears great, provided regulatory problems can be overcome. Of primary importance is the need to develop reliable and economical overwintering facilities for broodstock and fingerlings. Research has indicated that tilapia fry produced in the spring can be reared to as much as 300 g within a growing season in Central Texas. Whether there is a sufficiently longer growing season in the southern portion of the state to allow growth of 400-g or larger fish within a year has not been thoroughly tested. For many portions of the state, better culture strategy might be to use a system of recirculated, heated water for the cool months combined with outdoor ponds for summer production.

The ultimate potential of tilapia culture in Texas will be dependent upon consumer acceptance. Because Texans and, for that matter, most U.S. residents, are unfamiliar with tilapia, some innovative marketing techniques may be required. Fish, in general, sell well in Texas, and test marketing of tilapia in Texas and other states has indicated that these fish are well received wherever they are offered for sale. Live fish are well received in the urban areas.

Filets are well received but may face severe competition from imports, presently from the Peoples Republic of China.

No processing plants have been developed in Texas for tilapia, but privately owned processing facilities for channel catfish could process tilapia. Small tilapia and filet bones can be run through deboning equipment and the end product formed into fish cakes, sticks and other specialty products. Fast food restaurants might be an appropriate outlet for the deboned product as would the frozen retail grocery market.

From the aquaculturist's standpoint, few fish are more hearty than tilapia, nor easier to rear. Expected production levels per unit area of water far exceed those for channel catfish. Production as high as 40,000 kg/ha/yr has been achieved in ponds in some regions of the world.

**DEVELOPMENT NEEDS**

Texas tilapia producers were surveyed to prioritize problems and development needs (Table 1). Over regulation by the Texas Parks and Wildlife Department was identified overwhelmingly as the most critical issue. Reducing state restrictions was named in the top two critical needs by 94% of the 18 survey respondents.

Developing economical overwintering systems is a critical need. Energy and infrastructure costs have been prohibitive in many cases. Overwintering facilities which employ artesian warm water, high density confinement in closed systems located in structures heated with low-cost energy, utilization
and conservation of natural ground temperature and other possibly more innovative techniques should be developed.

Table 1. Ranking of issues facing Texas tilapia producers (in order of decreasing importance) according to a survey conducted during October, 1989

<table>
<thead>
<tr>
<th>Mean Score</th>
<th>Rank</th>
<th>Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4</td>
<td>1</td>
<td>Reducing state restrictions</td>
</tr>
<tr>
<td>3.8</td>
<td>2</td>
<td>Developing more efficient overwintering systems</td>
</tr>
<tr>
<td>3.9</td>
<td>3</td>
<td>Assessing and developing markets</td>
</tr>
<tr>
<td>5.5</td>
<td>4</td>
<td>Expanding supply of all-male fingerlings</td>
</tr>
<tr>
<td>5.5</td>
<td>5</td>
<td>Developing more efficient water filtration systems</td>
</tr>
<tr>
<td>6.1</td>
<td>6</td>
<td>Feeds and feeding; nutritional requirement</td>
</tr>
<tr>
<td>6.4</td>
<td>7</td>
<td>Developing more efficient culture systems</td>
</tr>
<tr>
<td>6.5</td>
<td>8</td>
<td>Researching environmental requirements</td>
</tr>
<tr>
<td>6.6</td>
<td>9</td>
<td>Researching use of mosambique tilapia as a food fish</td>
</tr>
<tr>
<td>7.7</td>
<td>10</td>
<td>Disease and parasite control</td>
</tr>
</tbody>
</table>

Market recognition and development was rated equally important. Tilapia should be positively portrayed as a high value food product. The product should be offered live and in various processed forms for varied Texas consumer preferences.

Water quality limitations need study. More economical and efficient biological and mechanical water filtration systems need to be developed to remove nitrogenous wastes from closed systems. Oxygenation and gas stripping systems should complement filtration systems. Technology for aeration and filtration is available, but applying these techniques in a way to produce a competitively priced product needs further development.

Expanding the supply of male fingerlings would not only increase production and profitability, but also reduce opposition from groups opposing exotics. More reliable and economical production techniques for both pure strains and hybrids need to be developed.

Competitively priced, high-quality feeds need to be available. Stocking tilapia in polyculture systems should improve profitability by providing a marketable aquaculture product while improving water quality.

Culture systems that optimize the most economical and productive technologies must be developed if tilapia culture is to be competitive in the world market.

Studying the use of alternative strains, species and hybrids for particular types of culture systems is important to development of the industry. Most culturists agree that one of the two species approved in Texas, *O. mossambicus*, is poorly suited for food production.

IMPLEMENTATION PLAN

The most important issue hindering development of the tilapia industry in Texas is over regulation (Table 1). Theoristic regulatory officials have convinced most of the public and the media that tilapia introductions are harmful to native fishes.

Public education conveying historical and biological facts about tilapia followed by effective legislative lobbying is necessary to overcome misconceptions. The Texas Department of Agriculture should promote tilapia as a nutritious and environmentally safe food product. The Texas Agricultural Extension Service should disseminate factual information to the public and media. Educational conferences should be held involving all interested parties to openly discuss the issues. The Texas Aquaculture Association should support educational and research activities related to tilapia environmental issues. If the public were aware of the economic potential and positive sportfishing impact of tilapia, there would not be a regulatory problem.

State and federal resources should support both basic and systems research and development. A partnership of public and industry interests should develop and support a pilot facility or enter into an agreement with an existing facility to solve production problems listed above.

State agencies and universities should support industry marketing efforts with information, promotion, education and research.

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