AGRICULTURAL ALTERNATIVES

Introduction to Aquaculture

Aquaculture, the cultivation of freshwater and marine plants and animals, is one of the fastest growing segments of U.S. agriculture. As shown in Table 1, overall sales in the industry have increased 50 percent over the last five years. Basic aquacultural enterprises include food fish production, fee fishing, and ornamental fish production.

Table 1. Growth of aquacultural operations and sales over a five-year period (1987–1992).

VARIETY	YEAR	FARMS	SALES (MILLIONS)	% OF INDUSTRY	% CHANGE IN SALES 1987-92
Catfish	1987	432	$192.851	57.9%	
	1992	443	$268.776	53.3%	39.4%
Trout	1987	201	$65.236	19.6%	
	1992	203	$78.150	15.5%	19.8%
Striped bass	1987	NA	NA	NA	
	1992	35	$11.950	2.4%	NA
Other fish	1987	434	$62.603	18.8%	
	1992	341	$118.766	23.5%	89.7%
Crawfish	1987	NA	NA	NA	
	1992	41	$5.418	1.1%	NA
Other aquaculture	1987	136	$12.465	3.7%	
	1992	200	$21.673	4.3%	73.9%
Total	1987	1203	$333.155	—	
	1992	1263	$504.733	—	51.5%

Census of Agriculture, 1992.

Marketing

Producers should research possible markets in their region before beginning an aquacultural enterprise. Potential customers for your product should be identified and surveyed to determine their needs and expectations.

Aquaculture producers can market their product through farm-based retail sales, farmers markets, supermarkets, mail order firms, restaurants, and food brokers. Some producers also are developing value-added products like smoked trout, which are marketed through gourmet shops in large cities.

Fish grown on small farms may be sold whole (to be processed by the buyer) or as dressed whole fish or fillets. Individuals who plan to start an aquaculture operation should check with the appropriate health department about regulations concerning processing requirements.

Fee fishing operations also are proving to be an excellent investment opportunity. Fee fishing operations in the South report on-farm sales of 2,000 to 4,000 pounds of fish a week. Successful fee fishing operations often rapidly outstrip their ability to stock their own ponds and must rely on other aquaculture operations for product.

Aquatic plants, koi, and goldfish can be readily produced for the ornamental or homeowner market. This rapidly developing industry has capitalized on increased interest by homeowners in water gardening. Ornamental production is a very competitive and specialized industry, however, and producers should research this niche market very carefully before entering it.

This publication was developed by the Small-scale and Part-time Farming Project at Penn State with support from the U.S. Department of Agriculture-Extension Service and research funds administered by the Pennsylvania Department of Agriculture.

PENNSTATE

1855

College of Agricultural Sciences ■ Cooperative Extension

Planning and Permits

The type of aquaculture operation that you initiate will be influenced by your financial and labor resources as well as available markets. For example, a small pond in a suburban area might be best for producing ornamental aquacultural plants, while a large spring in a rural area might be more suitable for rainbow trout production. In food fish production, 5 acres of ponds is considered the minimum size for small-scale commercial aquaculture, while a large spring on 5 acres of land could be developed into a full-time enterprise.

Producers who do not have any existing water resources on their property still can consider developing an aquaculture enterprise. A production method called recirculation aquaculture has been used in tanks, troughs, and even swimming pools to raise fish or plants successfully. However, closed-system or recirculation aquaculture can be very expensive and difficult to operate.

The Pennsylvania Fish and Boat Commission requires a propagation license for commercial aquaculture operations. Discharges from aquaculture facilities are regulated by the Pennsylvania Department of Environmental Protection. New pond construction is handled through the county soil conservation district. Producers should consult with these agencies when planning their operations.

Facilities and Equipment

Water resources

Water source, quality, and supply are critical considerations when planning an aquacultural enterprise. Sources include groundwater, surface water, ponds and streams, and recirculation systems that continually purify and reuse water. Groundwater drawn from natural springs or well systems also may be used. While springs and wells usually are a good source of water, the cost for pumping makes springs the more cost-effective choice.

Ponds and streams tend to have variable chemical and physical characteristics. However, most aquaculture species are tolerant of some environmental fluctuation. The successful U.S. catfish industry is based on pond culture.

Stream-based aquaculture operations are likely to be limited by discharge and water appropriation permits. In addition, producers have no control over stream water quality, and operations using streams can develop serious contamination problems.

Production methods

Pond culture. Because ponds are well suited to the production of a variety of species, pond-based culture represents the most widely practiced form of aquaculture in the United States. Existing ponds often can be used for aquaculture without modification. Cage culture, a technique in which fish are grown in cages, permits aquaculture production in many ponds that are not well suited to fish culture. Cage culture also allows producers to simultaneously use one pond for recreation, irrigation, or other agricultural uses.

New pond construction for aquaculture can be very expensive. The returns from a small-scale aquaculture business may not justify the construction costs of a new pond. Production levels of 2,000 pounds per surface acre are normal, but increased production can be realized with intensive management and aeration.

Flow through. Flow-through systems involve the continual flow of a high-quality water source through a tank or raceway. Fish wastes are flushed through the system by water flow. Treatment of these fish wastes is often required before the water can be discharged into the environment. Many high-yielding springs have been adapted for this type of fish culture. New technology makes the production rates from smaller springs attractive for a small-scale or part-time aquaculture enterprise. Yields of up to 100 pounds per gallon of water flow per minute can be obtained with the proper conditions and management.

Recirculation and reuse systems. Recirculation and reuse systems are expensive and require the producer to have advanced technical skills.

Closed or recirculation systems often are used in areas with limited water resources and stringent discharge regulations, or when warm water fish like tilapia are being raised for local markets. These systems consist of tanks, particulate filters (to remove fish wastes and feed particles), and biological filters (to convert toxic ammonia from fish excretion to nitrate, which is considered harmless). An adequate supply of oxygen is critical due to the typically high fish density of recirculation systems and can be supplied by mechanical aerators or liquid oxygen. In recirculation systems, water is purified and used continually. Fresh water is added only to compensate for evaporation and losses that occur when wastes are removed.

Water reuse systems use a percentage of their water several times before discharge. An example of a reuse system is one in which water flows through a series of tanks or raceways, with each unit receiving discharge from the preceding one. Reuse systems also may use particle and biological filters with aeration to improve water quality.

Equipment

In addition to the culture system, various types of equipment are required for an aquaculture operation. Water testing equipment is essential for proper water quality management. Treatment chemicals used to maintain water quality include lime, bicarbonate, gypsum, calcium chloride, and permanganate. Small-scale producers often can use inexpensive test kits developed for aquariums. Larger operations, particularly reuse or recirculation systems, require more sophisticated testing equipment. Other necessary items include aeration devices, nets for harvest, a scale, feeding equipment, and processing equipment.

Hatcheries

Most part-time aquaculture producers purchase fingerlings from hatcheries for stocking and grow-out. Hatcheries specialize in spawning (breeding) and raising fish to sizes used by other segments of the aquaculture industry. Some hatcheries are part-time enterprises as well, but spawning and rearing fish from the fry to the fingerling stage requires more advanced technical skills than are required for a grow-out operation. Fingerlings of striped bass, rainbow trout, and tilapia are available in the mid-Atlantic region. Contact the cooperative extension office in your county for information about local hatcheries. A list of commercial fish hatcheries is available from the Pennsylvania Fish and Boat Commission, Bureau of Administrative Services, Box 67000, Harrisburg, PA 17106-7000.

Fingerling prices vary from 10¢ to 25¢ per inch depending on species and availability. Fry are much less expensive, but the grow-out time is longer and the mortality rate is higher. Deliveries of larger fingerlings generally are made by trucks with tanks equipped with aeration devices. Small fingerlings and fry can be shipped in plastic bags filled with oxygen to support the fish for several days of travel. Temperature shock is a major cause of fish losses. Mortality rates can be minimized by gradually adjusting the shipping water temperature by floating bags of fry in receiving water and checking temperature periodically or by pumping receiving water into the shipping tanks.

Nutrition

An important consideration when selecting a species to grow is whether a commercially formulated diet is readily available. Many species that appear attractive because of their high value may prove difficult and uneconomical to produce if nutritional requirements are poorly understood. Commercial feeds for established species often are substituted for diets formulated for new aquaculture species. Suboptimal dietary conditions, however, result in poor growth and inefficient feed utilization.

Aquaculture feeds are prepared from grain (corn and soybeans) and animal by-products (including fish meal), along with vitamin and mineral additives. The most obvious difference among feeds for different aquaculture species is the protein level, which may range from 25 percent for adult catfish to 38 percent for salmonids or hybrid striped bass. Feeds for well-established commercial species are available in different sizes and compositions to suit various stages of fish development. Feeds are available dry or moist and in floating or sinking forms. Medicated feeds can be prepared or purchased for disease treatment.

Feeding is the most expensive component of aquaculture production and can account for over 30 percent of production costs. To be successful, producers must select feeds and feeding methods that produce efficient and rapid growth.

Health

Fish are subject to a variety of parasites and pathogens. Stressful conditions such as poor water quality and poor nutrition can make fish more susceptible to infections, leading to decreased production and death. Producers can help prevent disease by maintaining a healthy environment (especially water quality). If a disease is suspected, it is important that an accurate diagnosis be made before beginning treatment. Contact your local cooperative extension office for the location of a diagnostic laboratory and the procedures for sending a sample. Once a diagnosis is made, a treatment can be prescribed, such as using sodium chloride for external parasites or administering the antibiotic terramycin in the feed to treat bacterial infection.

Predation

Fish confined in tanks, cages, raceways, and even open ponds can be attractive to various predators including herons, ospreys, raccoons, and mink. Fish in isolated facilities also are subject to poaching. Losses can be reduced or eliminated by covering cages and tanks with mesh or by using various repellents. Some predators like the great blue heron are a protected species and cannot be removed without a permit from the U.S. Fish and Wildlife Service. Losses to predation can be serious enough to result in business failure and should be anticipated when planning an aquaculture enterprise. Questions concerning predators and their control should be directed to the Pennsylvania Game Commission.

Budgeting

Enterprise budgets are important business planning tools. Budgets should be prepared to ensure that all costs and receipts are included in the calculations. Costs and returns often are difficult to estimate in budget preparation because they are numerous and variable. Therefore, make appropriate adjustments to reflect your production and resource situation. Additional information on the use of enterprise budgets can be found in *Agricultural Alternatives: Enterprise Budget Analysis.*

Prepared by Daniel E. Terlizzi, water quality specialist, University of Maryland Sea Grant Extension Program; Thomas Ford, county extension director, Fulton County, Penn State Cooperative Extension; George L. Greaser, senior research associate, Penn State; and Jayson K. Harper, associate professor of agricultural economics, Penn State.

For More Information

Bardach, J.E., Ryther, J.H. and W.O. McLarney. *Aquaculture: The Farming and Husbandry of Freshwater and Marine Organisms.* Somerset, N.J.: John Wiley & Sons, Inc., 1981.

Landau, M. *Introduction to Aquaculture.* Somerset, N.J.: John Wiley & Sons, Inc., 1992.

McLarney, W. *The Freshwater Aquaculture Book: A Handbook for small scale fish culture in North America.* Points Roberts, Wash.: Hartley and Marks, Inc., 1984.

Stickney, R.R. *Principles of Warm Water Aquaculture.* Alabama Agricultural Experiment Station. Auburn University, Alabama, 1990.

Stickney, R.R. *Principles of Aquaculture.* Somerset, N.J.: John Wiley & Sons, Inc., 1994.

Periodicals

Alternative Aquaculture Network
Box 108, Breinigsville, PA 18031

Aquaculture Magazine
Box 2329, Asheville, NC 28802

Farm Pond Harvest
Box 736, Momence, IL 60954

Water Farming Journal
3400 Neyrey Dr., Metairie, LA 70002

Associations

National Aquaculture Association
Drawer 1569
Sheperdstown, WV 25443

Pennsylvania Aquaculture Association
Box 484
Effort, PA 18330.

Pennsylvania Trout Growers Association
Box 484
Effort, PA 18330

Centers

Northeast Regional Aquaculture Center
University of Massachusetts-Dartmouth
Research 201
North Dartmouth, MA 02747

U.S. Department of Agriculture
Aquaculture Information Center
Room 304, National Agricultural Library
10301 Baltimore Boulevard
Beltsville, MD 20705

3M1295ps3437