AGRICULTURAL ALTERNATIVES

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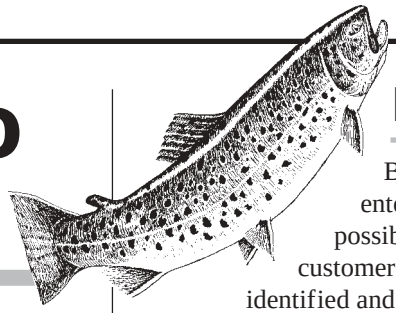
Introduction to Aquaculture



Aquaculture, the cultivation of freshwater and marine plants and animals, is one of the fastest-growing segments of U.S. agriculture, with sales tripling since 1987 and doubling since 1992. The latest data on the entire U.S. aquaculture industry is the 1998 Census of Aquaculture, which showed that at that time, aquaculture was a nearly $1 billion industry in the United States (Table 1). In 1998 there were 51 aquaculture operations in Pennsylvania, with sales totaling $7.6 million. Basic aquaculture enterprises include food fish production, fee fishing, and ornamental fish production.

Table 1. Value of aquaculture products sold and number of farms in production in the United States, 1998.

TYPE	FARMS	$ SALES (MILLIONS)	% OF INDUSTRY
Food fish	2,168	691.7	71%
Mollusks	535	89.1	9%
Ornamental	345	69.0	7%
Other aquaculture	216	46.7	4%
Baitfish	275	37.5	4%
Crustaceans	837	36.1	3%
Sport/game	204	7.4	1%
Other fish	11	267.0	<1%
Total	4,591	977.8	

Marketing

Before beginning an aquacultural enterprise, it is wise to research possible markets in your region. Potential customers for your product should be identified and surveyed to determine their needs and expectations. You should also understand the nature of your competitors, both domestically and internationally. U.S. producers are at somewhat of a disadvantage in the production of warm water species, but they do have a comparative advantage in the production of cool and cold water species grown in fresh water on a largely grain-based diet. The impact of increasing foreign competition from China and Central America for tilapia, from China and Southeast Asia for shrimp, and from Vietnam for catfish have had significant impacts on the prices for aquaculture products in the United States despite increasing demand.

Aquaculture products can be marketed through farm-based retail sales, farmers' markets, supermarkets, mail order firms, restaurants, and food brokers. Some producers also develop value-added products like smoked trout, which are marketed through gourmet shops and the Internet.

Fish grown on small farms may be sold whole (for processing by the buyer) or as dressed whole fish or fillets. If you are planning to start an aquaculture operation, check with your state health department and department of agriculture about regulations concerning processing requirements.

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

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

Planning and Permits

The type of aquaculture operation that you begin 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, five acres of ponds generally is considered the minimum size for small-scale commercial aquaculture, while a large spring on five acres of land can be developed into a full-time enterprise.

If you do not have any existing water resources on your property, you can still 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; it is also management intensive.

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. Consult with these agencies when planning your operations.

Facilities and Equipment

Water Resources

Water source, quality, and supply are critical considerations in planning an aquacultural enterprise. Sources include groundwater, surface water (ponds and streams), and recirculation systems that continually purify and reuse water. Groundwater can be drawn from natural springs or well systems. While springs and wells usually are good water sources, the cost of pumping water 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 for the production of a variety of species, pond-based culture represents the most widely practiced form of aquaculture in the United States. Production levels of 2,000 pounds per surface acre are typical, but increased production can be realized with intensive management and aeration. 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 use one pond simultaneously for recreation, irrigation, or other agricultural purposes. New pond construction for aquaculture can be very expensive. The returns from a small-scale aquaculture business may not justify the costs of constructing a new pond.

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 that the producer 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 because of the typically high fish density of recirculation systems; adequate oxygen 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 for maintaining 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 also is available from the Pennsylvania Fish and Boat Commission, Bureau of Administrative Services, Box 67000, Harrisburg, PA 17106-7000.

Fingerling prices vary from 35¢ to $1.50 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 in 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 for disease treatment can be prepared or purchased.

Feeding, the most expensive component of aquaculture production, can account for over 30 percent of production costs. To be successful, you 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.

You can help prevent disease by maintaining a healthy environment (especially water quality). If you suspect a disease, it is important to get an accurate diagnosis before treatment is begun. Contact your county 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 attract various predators, including herons, ospreys, raccoons, and mink. Fish in isolated facilities also are subject to poaching. You can reduce or eliminate losses by covering cages and tanks with mesh or by using various repellents. Predators such as 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. For answers to questions concerning predators and their control, contact 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 your 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.*

For More Information

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

Landau, M. *Introduction to Aquaculture.* Somerset, NJ: John Wiley, 1992.

McLarney, W. *The Freshwater Aquaculture Book: A Handbook for Small Scale Fish Culture in North America.* Points Roberts, WA: Hartley and Marks, 1984.

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

Stickney, R. R. *Principles of Aquaculture.* Somerset, NJ: John Wiley, 1994.

Periodicals

Aquaculture Magazine
Box 2329
Asheville, NC 28802
www.aquaculturemag.com

Farm Pond Harvest
1390 N 14500 E Road
Momence, IL 60954
www.farmpondmagazine.com

North American Journal of Aquaculture
Published by the American Fisheries Society

Associations

National Aquaculture Association
P. O. Drawer 1569
Shepherdstown, 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

Web Sites

Missouri Alternatives Center
agebb.missouri.edu/mac

Aquaculture Network Information Center
aquanic.org/

National Agricultural Library, Alternative Farming Systems Information, Aquacultural Resources
www.nalusda.gov/afsic/afsaqua.html

USDA Economics and Statistics System
usda.mannlib.cornell.edu/usda
Note: Under the link "Specialty Agriculture" the following titles can be found: "Aquaculture Outlook" (USDA—Economic Research Service), "Catfish Production" (USDA—National Agricultural Statistics Service), and "Trout Production" (USDA—National Agricultural Statistics Service)

American Fisheries Society
www.fisheries.org

Ecotao's Aquaculture Links
www.ecotao.com/holism/agric/aqua.htm

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