Aquaculture Enterprises: Considerations and Strategies

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Aquaculture—the cultivation of fish and aquatic animals and plants—is expanding to meet consumer demand. This publication surveys important considerations for planning an aquaculture enterprise. It will help you identify the production system, species and marketing strategy most appropriate to your situation. The wide range of cultured species and production methods makes it impossible to provide a full discussion of aquaculture in a single document of this kind. Determining the best aquaculture enterprise for you will require considerable research. A good place to start is the list of resources and contacts in the **Further resources** section and in the two **Appendices**.

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Introduction

Aquaculture has received considerable interest because of increased consumer demand for fish and shellfish, and a declining fisheries catch. Aquaculture is expanding to capture the resulting market potential. However, aquaculture producers must compete with wild-harvested products, as well as other farm-raised and imported products, in a very competitive market that includes other protein sources such as beef, pork and chicken.

Many of your decisions will depend on what you want to do with your aquaculture enterprise. Will it be a small part of your farming operation, or do you want to become a full-time aquaculturist? Whether yours is a small or a full-time operation, you will need to treat it as a business to make a profit. As in all businesses, you will need to acquire knowledge, have working capital and provide labor and management.

In an article titled *The Small Fish Farmer: Is There a Niche?,* James W. Avault, Jr., Louisiana State University Professor Emeritus of the Aquaculture Research Station, explains that farming an aquaculture species has many similarities to crop farming.

Simply put, aquaculture is agriculture. A simple comparison of steps involved in corn production and channel catfish farming follows:

Market-size catfish under harvest.
Photo by Peggy Greb, courtesy of USDA/ARS.

Chart 1: Comparing corn production and catfish farming

Corn production:

1. Secure funds to begin
2. Plow ground
3. Plant seeds
4. Fertilize soil
5. Control weeds and insects
6. Control parasites and disease
7. Harvest, process and market

Catfish farming:

1. Secure funds and permits, if needed, to begin
2. Build ponds and get a source of water
3. Stock fingerlings
4. Fertilize pond water and feed fish; maintain good water quality
5. Control weeds, wild fish and pests
6. Control parasites and diseases
7. Harvest, process and market

Once these concepts are understood, you must establish goals and preferably put the goals in writing. Once you visualize short- and long-range goals, a feasibility study should be conducted. Begin with a checklist. A partial list might include what species to culture, where to locate the ponds, any legal constraints, marketing potential, profit outlook and other aspects (Avault, 2002-3).

The *Aquaculture Site Evaluation Questionnaire* from West Virginia University Extension Service can be used to help determine if your proposed aquaculture operation will meet the basic requirements for both natural and personal resources necessary to operate successfully. It is available online at *www.wvu.edu/~agexten/aquaculture/sitequest.htm*.

Related ATTRA Publications

Aquaponics — Integration of Hydroponics with Aquaculture

Agricultural Business Planning Templates and Resources

Motivation and goals

To begin, you need to ask yourself why you want to start an aquaculture enterprise. What are your goals? The goal of a subsistence enterprise is to produce the amount of fish needed by a family at minimum cost, whereas the goal of a commercial enterprise is to produce the greatest profit with the available resources. Farm diversification is a common goal of many aquaculturists. Most aquaculture experts advise prospective aquaculturists to set modest initial goals with lower resource requirements and expand their goals as they gain experience. This advice can be followed by starting with a small-scale subsistence enterprise and gradually expanding it into a small commercial operation for farm diversification. Eventually, if the success of the aquacultural enterprise warrants, commercial aquaculture could become the main farm activity.

Organic aquaculture

Consumer concerns over reports of contaminants in farmed and wild seafood are leading to increased interest in organic fish and seafood. However, as of July 2009 there are no organic aquaculture standards other than the general U.S. Department of Agriculture (USDA) National Organic Program (NOP) standards for organic livestock production. These NOP livestock standards must be followed for any animal or product sold with the USDA organic seal. The NOP standards, including livestock standards, are available at *www.ams.usda.gov/nop*.

The Alternative Farming Systems Information Center (AFSIC) at the USDA National Agriculture Library published the document *Organic Aquaculture AFSIC Notes #5* in January 2005. It states:

> Defining *organic aquaculture* is very much a work in progress and, for many reasons, an endeavor marked by controversy. Members of both the organic and the aquaculture communities disagree on how, or even if, aquatic animal and plant production systems can qualify as *organic* as the term is commonly used. Any potential definition must be a multifaceted one. *Organic* in the context of food production connotes standards and certification—a verifiable claim for the production process and production practices—as well as more elusive characteristics such as consumer expectation for food quality and safety and general environmental, social and economic benefits for farmers and for society. The variety of species produced in aquacultural systems and vast differences in cultural requirements for finfish, shellfish, mollusks and aquatic plants add to the complexity of defining this sector. Some species and some production systems may prove quite difficult to adapt to a traditional *organic* system. ...
>
> Interpreting practices and standards developed for terrestrial species into practices and standards relevant to aquatic species, both animal and plant, remains a major challenge for organic aquaculture. How can aquatic operations comply with the requirements for an organic system plan, for obtaining acceptable stock, for implementing health care monitoring and management, for maintaining prescribed living conditions, for development and acceptance of allowed and prohibited substances lists, for organic feed requirements, for controlled postharvest processing, for nutrient management and for required animal identification and recordkeeping? (Boehmer et al., 2005)

Even if there are no official NOP organic aquaculture standards, the 2001 National Organic Standards Board's (NOSB) Aquatic Animal Task Force did make some recommendations. However, it is important to remember that the NOSB recommendations are not official until they have been approved and adopted by the USDA.

The NOSB is continuing to work on their recommendations to the NOP regarding organic aquaculture regulations, and released a formal recommendation on Nov. 19, 2008. The recommendation can be accessed at *www.ams.usda.gov*. Search for "net pens and related issues."

Until the final rule is published in the Federal Register by the NOP, the organic certification agency that certifies organic producers and handlers has final approval of materials used in organic aquaculture systems. Please keep in mind that all inputs used in an organic system must be explicitly stated on the producer's Organic System Plan (OSP) and submitted to their certifier for approval prior to use. In order to use a material in an organic system, a producer must satisfy the organic certification agency by submitting in writing a request to the organic certifier to use a specified material and disclosing the use and source of the material on their OSP. The certifier will review the request and investigate the source for compliance with NOP regulations. If the request is approved, a letter from the certifier will grant the material's use, and this use should be documented on the OSP and materials use record form.

In addition, in 2005 the NOP created the Aquatic Animals Task Force Aquaculture Working Group to provide recommendations. The list of members on this task force is at *www.ams.usda.gov/nop*.

Until official aquaculture standards are approved, the USDA NOP has issued a Guidance Statement explaining that the Organic Foods Production Act (OFPA) does provide coverage for aquatic animals. The Guidance Statement says:

> **Fish and seafood, farm-raised or wild-caught.** Although OFPA provided coverage for aquatic organic standards, NOP has not developed any standards for proposal to the public for comment.
>
> The products listed above may not display the USDA organic seal and may not imply that they are produced or handled to the USDA NOP standards. Consumers should be aware that the use of labeling terms such as 100-percent organic, organic or made with organic ingredients on these products may be truthful statements. But these statements do not imply that the product was produced in accordance with the USDA NOP standards, nor that the producer is certified under the NOP standards (Mathews, 2004).

This means that even if there are no national standards for organic aquaculture, organic certifying agencies that have aquaculture standards and are accredited by the USDA may certify aquaculture products as organic, but the products are *not allowed* to carry the USDA organic label. If you are interested in pursuing an organic label, you will need to find an accredited organic certifying agent that has aquaculture standards. The list of USDA-accredited certifying agents appears at *www.ams.usda.gov/nop*.

Natural and personal resources

Producer organizations are valuable sources of information about markets and marketing.

Natural resources such as water, land, soil and climate strongly influence the choice of species and production system. Abundant, high-quality water is usually the most crucial resource. Land can be limiting if the topography is not favorable for the construction of ponds, or if land is dedicated to other productive uses. Soil properties must be considered in pond construction, and soil fertility will influence pond productivity. Climate does not limit the scale of aquaculture, but it does determine the species that can be grown, except in the case of closed-system aquaculture technology described below.

Production resources, such as capital, labor and time, influence the choices of production system and species. Generally, the more intensive the production system, such as more fish grown in a volume of water, the more capital, labor and time are required. For example, lightly stocked farm ponds practically take care of themselves, while closed systems need almost continuous monitoring.

Industry resources, including supplies, services and markets, in some parts of the country are well developed for certain types of aquaculture. For example, in the Mississippi Delta region there are many catfish feed manufacturers and catfish processing facilities and a strong producer association that supports marketing to promote catfish

consumption. If aquaculture of a certain species is less developed in other parts of the country, the aquaculturists in these areas must be very resourceful. Producer organizations are valuable sources of information about markets and marketing.

For an aquaculture enterprise to remain viable and profitable, it must be environmentally sound. Environmental issues, such as safety of fish and seafood; water pollution by excess nutrients; destruction of coastal habitats; and damage to natural fish stocks by accidental release of farmed, exotic or bioengineered species, are major concerns for many consumers and need to be addressed by the aquaculture industry.

Producers need to know the laws that apply to all aspects of the aquaculture operation, including species under consideration.

Technical resources, information and expertise are critical to aquaculturists. Environmental and disease problems can develop quickly and threaten an entire crop. Quick access to professional diagnostic services such as fish disease labs can salvage a threatened batch of fish. Contact your local Cooperative Extension office for information about aquaculture in your area and for contact information for the state aquaculture specialist. Other sources of information are your state's Sea Grant Office, Regional Aquaculture Centers and other federal agencies. See the **Further resources** section at the end of this publication for more details about the programs and services available in your state or region.

Regulatory aspects

In an article titled *Legal Considerations in Commercial Aquaculture,* James W. Avault, Jr., Louisiana State University Professor Emeritus of the Aquaculture Research Station, discusses the history of laws governing aquaculture.

> Historically, wildlife and fisheries have been regulated and monitored by the U.S. Fish and Wildlife Service at the federal level and by departments of wildlife and fisheries at the state level. At both levels, laws and regulations have focused on wild populations of game and fish. As aquaculture developed in the United States, many of these laws were at odds with it. The cottage industry of aquaculture was put under the jurisdiction of federal and state agencies that historically regulated wild populations. In 1976, for example, the National Aquaculture Act recognized aquaculture as an emerging industry, but the Act placed the jurisdiction jointly with the U.S. Fish and Wildlife Service and the U.S. Department of Commerce. The U.S. Department of Agriculture was designated in a supportive role. Eventually, the U.S. Department of Agriculture was designated the lead agency for aquaculture, whereas at the state level the transition to state agriculture departments has been slower (Avault, 2004).

Make sure that you get all state and federal permits or licenses required for an aquaculture operation in your location. The permit type will vary depending on the species grown, culture techniques, local zoning ordinances, public or private water use and discharge regulations, land designated wetland or coastal zone and marketing strategy. Contact your state agencies concerned with the environment, natural resources and agriculture for more information on the requirements in your state and location. The National Association of State Aquaculture Coordinators (NASAC) has a directory of state aquaculture coordinators, available at *www.marylandseafood.org/aquaculture/nasac.php*. The state coordinators are responsible for coordinating aquaculture programs at the state and territorial levels.

Your state Cooperative Extension aquaculture specialists or state fisheries department may also be able to assist you. Remember, producers need to know the laws that apply to all aspects of the aquaculture operation, including species under consideration. Without proper permits, interstate transport of a threatened or endangered species or a species identified as an invasive pest fish or plant is punishable by fine or imprisonment.

Many federal programs work with various aspects of aquaculture regulations, assistance and research. The USDA, Department of Commerce (DOC), Food and Drug Administration (FDA) and U.S. Department of Interior Fish and Wildlife Service (FWS) all have certain areas of responsibility to the aquaculture industry. The AFSIC at the USDA National Agriculture Library has links for most of the U.S. federal government

agencies dealing with aquaculture; find them online at *http://afsic.nal.usda.gov*.

Species

There are about 60 potential aquaculture species that can be used for food (Cline, 2005). The main species being raised and marketed in the United States are channel catfish, trout, salmon, crawfish, tilapia and bait species. Whatever species you finally pick, you need to have a good knowledge of their biology in order to understand all their environmental requirements and to determine whether a problem is developing.

Cold-water species such as trout and salmon can be successfully farmed wherever water temperature does not consistently exceed 75 degrees Fahrenheit. This usually limits production of cold-water species to northern states and mountainous areas, including the southern Appalachians, Ozark Highlands, Rocky Mountains and Pacific Coast ranges. Idaho, North Carolina and California are the top three trout-producing states and Washington and Maine are the largest producers of salmon. Cold-water species can also be grown anywhere adequate cold groundwater is available. Cool-water species such as walleye, perch, sturgeon and certain shellfish tolerate warmer water better than cold-water species, but their growth is inhibited at the optimal-growth temperatures of warm-water species.

Rainbow trout fingerlings. Photo by Stephen Ausmus, courtesy of USDA/ARS.

Warm-water species such as channel catfish, striped bass, paddlefish and most shellfish need warm water over a relatively long growing season to be economically practical. Some tropical exotics such as tilapia die at water temperatures below 50 degrees and can only be grown during the warm months in most of the South or in thermal waters elsewhere. Egg and fingerling production has emerged as a specialty operation in the maturing aquaculture industry. Hatchery facilities, especially in the South, can provide advanced fingerlings to more northerly producers with marginal growing seasons. Larval and immature shellfish are also produced in hatcheries. Hatchery techniques are complicated and have many special requirements; therefore, they are not recommended for the beginning aquaculturist.

Striped bass. Photo by Gerald Ludwig, courtesy of USDA/ARS.

Bait production is a very large component of the aquaculture industry in the United States. Louisiana, Minnesota, Florida and Arkansas are all large producers of bait and ornamental species. Minnows, suckers, goldfish and crawfish are some of the commonly grown bait animals. Sometimes bait species can be raised along with food species.

Production systems

Extensive aquaculture is conducted in ponds that are stocked at a low density and yield small crops, but require little management. Intensive aquaculture is practiced in artificial systems such as ponds, cages, raceways and tanks that are stocked at a high density and yield large crops, but require a lot of management.

Open systems allow water to flow through without reuse. Generally, the more intensive an aquaculture system, the more water must flow through. In open systems, discharged water is lost from the system. Because water, as well as the cost to pump it, is becoming more of a limiting factor, technologies that reuse part or all of the water are being developed.

Closed systems recirculate and recondition all of the water used, largely freeing

aquaculturists from water supply constraints. Closed systems have the potential to allow the production of almost any species anywhere, provided the market price can pay for the capital and energy requirements of the system.

Pond aquaculture is the most commonly practiced form of aquaculture. Most large-scale aquaculture farmers construct levee-type ponds, but these require large amounts of relatively level land. Many small-scale and a few large-scale aquaculture farms use watershed ponds. Your local office of the Natural Resources Conservation Service (NRCS) can provide technical assistance for pond siting and construction. The University of Arkansas at Pine Bluff department of Aquaculture and Fisheries Web site, *www.uaex.edu/aqfi*, offers the publications *Recreational Fishing in Small Impoundments: Alternative Management Options* and *Farm Pond Management for Recreational Fishing.*

Marketing strategy is one of the most important aspects of an aquaculture business.

Cage culture, which is the growing of aquatic animals in floating or anchored net confinements, can be used in farm ponds or other existing water bodies that are otherwise unsuitable for aquaculture. Cage culture is often more compatible with other uses of the farm pond. Cages can be used to alternate warm-water and cold-water species in the same pond.

Tank culture, in both open and closed systems, can be adapted to a wide range of species and situations. Tanks made of steel, fiberglass or plastic can be dismantled and reassembled for transportation or relocation. The advantages of tank culture include minimal land requirements, portability and ease of expansion. Tanks can be located indoors to reduce climate limitations. High equipment cost, especially in closed systems, is the main disadvantage of tank culture.

Raceways, which are long, narrow canals with large flows, are the most widely used production system for the intensive culture of salmon, trout and char.

Rotation systems, which involve alternating aquatic and field crops in levee-type ponds, can benefit both aquacultural and agronomic crops. Crawfish-rice and crawfish-rice-soybean rotations are commonly practiced, but other aquaculture-agriculture rotations have been largely neglected, even though there is potential for beneficial rotation effects in such systems. Rotation benefits are similar to those seen in other agricultural systems and include disease and weed suppression, reduced fertilizer and chemical inputs and increased biodiversity due to the mix of aquatic and terrestrial habitats in the landscape.

Integrated, multiple-use systems incorporating fish, livestock, fowl and horticultural production are widely practiced in some parts of the world, but they have been largely neglected in the United States. The beneficial interactions between the different elements of such a system help reduce purchased inputs. Development of polyculture in commercial U.S. aquaculture will require finding appropriate combinations of marketable species. Many species used in the sophisticated polyculture systems of Asia, such as various carps, are not well accepted as food items here.

Integrated aquaculture and hydroponics, termed **aquaponics**, is a subject receiving increasing attention in the United States. Beneficial interactions between aquacultural and hydroponics operations reduce some inputs, but such technologies are capital intensive. See ATTRA's *Aquaponics — Integration of Hydroponics with Aquaculture* for more information on aquaponics.

Marketing

Marketing strategy is one of the most important aspects of an aquaculture business. When you choose the species you will be farming, you need to consider the market price for it. It is important to identify a reliable market, and even a backup market, before making capital investments in aquaculture. In the Langston University publication *Is Fish Farming for Me?,* the authors state:

> The most-often asked question, 'Are there profits to be made in aquaculture?' requires a qualified answer. Yes, aquaculture can be profitable IF the fish farmer has the right natural resources, good management abilities and sufficient

capital available for investment in the enterprise. (Gebhart and Williams, 2000)

As David J. Cline, an Extension aquaculturist at Auburn University, suggests in an article titled *Marketing Options for Small Aquaculture Producers,* innovative marketing can be the key to financial success or failure.

Most producers would like to sell to high-volume buyers such as processing plants or distributors. This is a good marketing strategy if you are producing large quantities of fish. However, small-scale producers are not at the same economic level as larger producers and usually must sell for a higher price to remain profitable. A small-scale producer's best option is to establish a niche market.

Niche markets have advantages and disadvantages. The main advantage in niche marketing is that producers become wholesalers and, in some cases, retailers. Consequently, producers have more control over the prices they set for their products and retain some portion of the profit that otherwise would have gone to a middleman. The main disadvantage of niche marketing is that considerable time must be spent analyzing and developing these markets (Cline, 2005).

A successful niche marketing aquaculture enterprise will need to enter markets that are not in direct competition with large-scale aquaculture. Some of these niche markets include selling fingerlings to other producers; selling live or processed fish to restaurants, grocers and ethnic markets; selling live for pond stocking; offering fee fishing or pay lakes for food-size sport fish; and selling bait fish, ornamental fish or aquatic plants.

Finding niche markets can be confusing, but careful evaluation and a good understanding of market requirements will help producers develop marketing plans that will fit their needs. Kenneth Williams, with the Langston University Fisheries Extension program, writes in his publication *Marketing Fish in Oklahoma:*

> It is much more profitable to determine market demand and plan production accordingly. Raising a crop of fish first and then looking for places to sell it can result in low or no profit. To determine possible markets, begin with an inventory of your operation. Ask yourself the following questions:
>
> - What kinds of fish can I produce?
> - How many pounds of fish can I produce?
> - Can fish be delivered throughout the year or in annual batches?
> - Can I tailor production schedules to produce the size of fish required for market?
> - Can I transport live or processed fish?
> - Is fee fishing a possibility?
> - Is a processing plant located nearby?
> - Am I willing to process fish? Do I have the equipment and labor force necessary?
> - Can I produce fingerlings, food-size fish or a combination? (Williams, 2000)

Market price will vary with each marketing strategy. Live fish sold directly to the consumer usually bring the highest price, but this strategy requires a lot of time and interaction with the public. Live fish sold to processors usually bring the lowest market price, but large volumes and specific, short harvest times somewhat offset this price difference. Selling processed fish is a value-added strategy that can increase market options and market price, but it also increases labor and regulatory requirements. The Missouri Alternatives Center Web site, *http://agebb.missouri.edu/mac/links,* has collected different aquaculture marketing documents. Click on "A" and follow the "Aquaculture, marketing" link.

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Business planning

Business planning is crucial to success for new and established enterprises. Going through the planning process increases the possibility of success and helps avoid costly mistakes. It can be very helpful to have your plan evaluated by several people to make sure that you haven't missed any vital components or issues. This critical evaluation will also be helpful when presenting the plan to lenders or other potential funders. Many financial institutions require a formal business plan. A business plan should be a working document that is reviewed and updated at least twice a year.

There is a great deal of information and assistance available for writing and using business plans. Every state has Small Business Development Centers and Cooperative Extension offices that offer such assistance, as do many state economic development agencies. However, many producers would like to have business plan examples that are specific to aquaculture. The Missouri Alternatives Center Web site, *http://agebb.missouri.edu/mac/links*, has collected different aquaculture business planning documents. Click on A and follow the Aquaculture, business plan link.

The ATTRA publication *Agricultural Business Planning Templates and Resources* does not tell you how to write a business plan, but it does provide sources of business planning information and assistance that are more relevant to the smaller-scale or alternative agricultural and aquacultural entrepreneur.

The Minnesota Institute for Sustainable Agriculture publishes the 280-page *Building a Sustainable Business: A Guide to Developing a Business Plan for Farms and Rural Businesses.* This guide can help you develop a detailed business plan and examines ways to take advantage of new marketing opportunities. It is available for free online at *www.misa.umn.edu/vd/bizplan.html.* You can also buy a print copy; see **Further resources** for more information.

Summary

There are many opportunities in the dynamic and expanding aquaculture industry. However, aquaculture has risks similar to those of any farming enterprise. The information provided here highlights many important factors to consider before proceeding with an aquaculture enterprise.

Should you decide to proceed with an aquacultural enterprise, remember that technical resources, information and expertise are critical to aquaculturists. Potential aquaculturists should get information about the specific cultural techniques and fish species they are interested in. They should also develop contacts with many associations and government agencies such as fish disease labs to get assistance if needed.

References

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Further resources

Many electronic resources are available to beginning aquaculturists. Excellent starting locations are the Aquaculture Network Information Center (AquaNIC), *http://aquanic.org*, and the Delaware Aquaculture Resource Center's AquaPrimer: *Introduction to Aquaculture, http://darc.cms.udel.edu/AquaPrimer/index.html*

Many federal and state agencies such as the Cooperative Extension System, Fish and Wildlife Service, USDA and NRCS provide technical and diagnostic services, and publish information on specific aquaculture topics. The USDA maintains an online database of local Cooperative Extension offices on its Web site at *www.csrees.usda.gov/Extension/index.html*. You will also find the phone number for your Cooperative Extension office in the county government section of your telephone directory. NRCS also maintains an online database of local service centers on its Web site at *http://offices.sc.egov.usda.gov/locator/app?agency=nrcs*.

In the 1980s, the USDA established five regional Aquaculture Research and Development Centers. These centers develop research and Cooperative Extension education programs and publications for aquaculture that have either regional or national applications. These centers work in association with universities, colleges, state agencies and private industry to address research priorities and dissemination of new research findings. For more information about your regional aquaculture center or its publications, contact your regional center, listed in **Appendix I**.

The National Sea Grant Program is a partnership that started in 1966 between universities and the National Oceanic and Atmospheric Administration (NOAA). Today, the Sea Grant University Programs produce and share research information on problems and new uses for the world's marine, Great Lakes and coastal resources. For more information, contact your state's Sea Grant Program from the National Sea Grant Program Web site, *www.seagrant.noaa.gov*, or from the National Sea Grant main office at:

NOAA/Sea Grant, R/SG
1315 East-West Highway
SSMC-3, Eleventh Floor
Silver Spring, MD 20910
(301) 734-1077
(301) 734-1066

The Alternative Farming Systems Information Center (AFSIC) at the USDA National Agriculture Library is another excellent source for aquaculture information. The AFSIC serves as a national clearinghouse for aquaculture information and provides materials to a variety of clients, including farmers, government agencies, industry personnel and prospective farmers. The AFSIC has links for most of the U.S. federal government agencies dealing with aquaculture. The AFSIC created the 48-page *Organic Aquaculture AFSIC Notes #5* in 2005. The document is available from AFSIC in print or at their Web site. For more information about AFSIC contact:

Alternative Farming Systems
Information Center USDA, ARS,
National Agricultural Library
10301 Baltimore Ave., Room 132
Beltsville, MD 20705-2351
(301) 504–6559
(301) 504–6409 FAX
www.nal.usda.gov/afsic

Reference books and textbooks are useful sources of general and technical information on various aspects of aquaculture. Many of these are available at public and university libraries or through interlibrary loan. Additional sources of books on aquaculture are listed below.

Aquaculture budgets

Aquaculture Enterprise Budget Spreadsheets. Auburn University Marine Extension & Research Center.
www.acesedu/dept/fisheries/aquaculturebugets.php

The Extension specialists at Auburn have developed four Excel spreadsheets that are available as a free download from their Web site. The budgets include:

Channel catfish pond farm
Hybrid striped bass pond farm
Rainbow trout raceway farm
Water recirculating fish farm

Building a Sustainable Business: A Guide to Developing a Business Plan for Farms and Rural Businesses.
The Minnesota Institute for Sustainable Agriculture.
280 pages.

This guide can help you develop a detailed business plan and examine ways to take advantage of new marketing opportunities. www.misa.umn.edu/vd/bizplan.html
or
Minnesota Institute for Sustainable Agriculture
411 Borlaug Hall 1991 Upper Buford Circle
St. Paul, MN 55108
1-800–909–MISA (6472)
misamail@umn.edu

Online aquaculture publications

Southern Regional Aquaculture Center Publications.
http://srac.tamu.edu

The Southern Regional Aquaculture Center has an online library of very helpful publications on all aspects of aquaculture.

Northeastern Regional Aquaculture Center (NRAC).
www.nrac.umd.edu

NRAC is a principal public forum for the advancement and dissemination of science and technology needed by Northeastern aquacultural producers and support

industries. Publications are located at www.nrac.umd.edu/publications/factSheets.cfm.

Alabama Education in Aquatic Sciences, Aquaculture, Recreational Fisheries and Natural Resource Conservation (ALEARN) *www.aces.edu/dept/fisheries*

Provides a highly informative, single-point, user-friendly information source for commercial growers and those with commercial aquabusiness interests.

Mississippi State University aquaculture publications *http://msucares.com/aquaculture/*

Informational sections on alligators, crawfish, farm-raised catfish, freshwater prawns, hybrid striped bass and tilapia.

Aquaculture/Fisheries (AQFI) Center at the University of Arkansas at Pine Bluff. *www.uaex.edu/aqfi*

The extension program offers diagnostic services to identify fish diseases and water-quality problems, and recommendations.

Water engineering

Bocek, Alex. Water Harvesting and Aquaculture for Rural Development. Auburn University: International Center for Aquaculture and Aquatic Environments. Also available in Spanish and French. *www.ag.auburn.edu/fish/international//waterharvestingpubs.php*

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Aquaculture books

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Van Gorder, Steven D. 2000. Small Scale Aquaculture: A hobbyist's guide to growing fish in greenhouses, recirculating systems, cages, and flowing water. Breinigsville, PA: Alternative Aquaculture Association, Inc. *www.altaqua.com*.

Hardy, David. 2006. Scallop Farming. Wiley-Blackwell; 2 Edition.

Web sites, organizations and journals

Aquaculture articles. Permaculture Activist #52 (magazine). Summer 2004. *www.permacultureactivist.net*

NOAA Aquaculture Program *http://aquaculture.noaa.gov.* The NOAA Web site has sections on:

What is aquaculture?
Aquaculture in the United States
About the NOAA aquaculture program
NOAA's aquaculture library
Funding opportunities news and notices

The World Aquaculture Society. *www.was.org.*

The WAS published World Aquaculture Magazine and conducts an annual international aquaculture conference.

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

Discussion group and extensive links to publications and organizations in aquaculture.

American Fisheries Society Online Journals. *http://afs.allenpress.com/perlserv/?request=get-archive*

The mission of the American Fisheries Society is to improve the conservation and sustainability of fishery resources and aquatic ecosystems by advancing fisheries and aquatic science and promoting the development of fisheries professionals. This Web site provides links to scientific journals in aquaculture and fisheries management. The journals require a subscription to view.

Aquaculture Magazine. *www.was.org*

An excellent magazine is Aquaculture Magazine, *which deals with all aspects of aquaculture. Their* Annual Buyers Guide and Industry Directory *is an excellent reference, providing information for all people interested in aquaculture, from the expert to the novice.*
Available from:
Aquaculture Magazine
Subscription Department
PO Box 1409
Arden, NC 28704–9817
(828) 687–0011
(828) 681–0601 FAX
info@aquaculturemag.com
www.aquaculturemag.com

There are also many state, regional, national and international professional and industry associations that deal with aquaculture development. Many of these associations have newsletters and other

publications available. For information on membership, annual dues and other services available, contact the associations directly. Many of these associations are listed on the electronic AquaNIC Web site *www.aquanic.org*, or in the *Aquaculture Magazine Annual Buyer's Guide*.

Appendix I: List of U.S. regional aquaculture centers

Center for Tropical and
Subtropical Aquaculture
The Oceanic Institute
41-202 Kalanianaole Hwy.
Waimanalo, HI 96795
(808) 259-3168
(808) 259-8395 FAX
www.ctsa.org

North Central Regional
Aquaculture Center
Michigan State University
13 Natural Resources Bldg.
East Lansing, MI 48824-1222
(517) 353-1962
(517) 353–7181 FAX
www.ncrac.org

Northeast Regional
Aquaculture Center
University of Maryland
2113 Animal Sciences Building
College Park, MD 20742-2317
(301) 405-6085
www.nrac.umd.edu/Contact%20NRAC.cfm

Southern Regional
Aquaculture Center
127 Experiment Station Road
PO Box 197
Stoneville, MS 38776
(662) 686–3285
(662) 686–3320 FAX
www.msstate.edu/dept/srac

Western Regional Aquaculture Center
School of Fishery & Aquatic Science
PO Box 355020
University of Washington
Seattle, WA 98195-5020
(206) 543–4291
(206) 685–4674 FAX
www.fish.washington.edu/wrac

Appendix II: Names of common aquaculture species

Common name	Scientific name	Common name	Scientific name
Abalone	*Haliotis rufescens*	Grass shrimp	*Palaemonetes spp.*
American alligator	*Alligator mississippiensis*	Killifish	*Fundulus spp.*
American bullfrog	*Rana catesbeiana*	Koi	*Cyprinus carpio*
American crocodile	*Crocodylus acutus*	Largemouth bass	*Micropterus salmoides*
American eel	*Anguilla rostrata*	Muskellunge	*Esox masquinongy*
American lobster	*Homarus americanus*	Paddlefish	*Polyodon spathula*
American oyster	*Crassostrea virginica*	Pearl oyster	*Pinctada martensii*
Arctic char	*Salvelinus alpinus*	Pike	*Esox lucius*
Atlantic salmon	*Salmo salar*	Pink salmon	*Oncorhynchus gorbuscha*
Bigmouth buffalo	*Ictiobus cyprinellus*	Pompano	*Trachinotus carolinus*
Black buffalo	*Ictiobus niger*	Pumpkinseed	*Lepomis gibbosus*
Black crappie	*Pomoxis nigromaculatus*	Rainbow trout	*Oncorhynchus mykiss*
Bloodworm	*Glycera dibranchiata*	Red drum	*Sciaenops ocellatus*
Blue crab	*Callinectes sapidus*	Red swamp crawfish	*Procambarus clarkii*
Bluegill	*Lepomis macrochirus*	Shiner	*Notropis spp.*
Bowfin	*Amia calva*	Smallmouth bass	*Micropterus dolomieu*
Brine shrimp	*Artemia salina*	Spiny lobster	*Panulirus argus*
Brook trout	*Salvelinus fontinalis*	Steelhead	*Oncorhynchus mykiss*
Bull minnow	*Fundulus grandis*	Stone roller	*Campostoma spp.*
Carp	*Cyprinus carpio*	Striped bass	*Morone saxatilis*
Channel catfish	*Ictalurus punctatus*	Threadfin shad	*Dorosoma petenense*
Chinook salmon	*Oncorhynchus tshawytscha*	Tilapia	*Tilapia mossambica*
Chub sucker	*Erimyzon spp.*	Top minnow	*Poecilia spp.*
Coho salmon	*Oncorhynchus kisutch*	Tubifex worm	*Tubifex tubifex*
Dungeness crab	*Cancer magister*	Walleye	*Stizostedion vitreum*
European eel	*Anguilla anguilla*	White bass	*Morone chrysops*
European lobster	*Homarus grammarus*	White crappie	*Pomoxis annularis*
Flathead minnow	*Pimephales promelas*	White river crawfish	*Procambarus blandingii*
Giant river prawn	*Macrobrachium rosenbergii*	White sturgeon	*Acipenser transmontanus*
Golden shiner	*Notemigonus crysoleucas*	Yellow perch	*Perca flavescens*
Goldfish	*Carassius auratus*		

Aquaculture Enterprises:
Considerations and Strategies

Updated by Lee Rinehart
NCAT Agriculture Specialist

Holly Michels, Editor
Amy Smith, Production

This publication is available on the Web at:
www.attra.ncat.org/attra-pub/aquaculture.html or
www.attra.ncat.org/attra-pub/PDF/aquaculture.pdf

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