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 the 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, beginning with the list of resources and contacts listed in the **Further Resources** section and in the four **Appendices**.

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

Introduction

Aquaculture has received considerable interest because of increased consumer demand for fish and shellfish, and a declining fisheries catch. Aquaculture is expanding to exploit 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 are you looking to become a full-time aquaculturist? But whether it 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 the article *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 follow:
>
> **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; and 7. Harvest, process, market.
>
> **Catfish Farming**: 1. Secure funds and permits to begin if needed; 2. Build ponds and get a source of water; 3. Stock fingerlings; 4. Fertilize pond water and/or feed fish, and maintain good water quality; 5. Control weeds, wild fish, and pests; 6. Control parasites and diseases; and 7. Harvest, process, market. Once these concepts are understood, you must establish goals and preferably put them 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: which species to culture, where to locate, any legal constraints, marketing potential, profit outlook, and other aspects. (Avault, 2002)

The *Aquaculture Site Evaluation Questionnaire* from West Virginia University Extension can be used to help determine whether your proposed aquaculture

operation will meet the basic requirements for both natural and personal resources necessary to operate successfully. The questionnaire is located at *www.wvu.edu/~agexten/aquaculture/sitequest.htm*.

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 them 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.

Related ATTRA Publications

Aquaponics: Integration of Hydroponics with Aquaculture

Agricultural Business Planning Templates and Resources

Organic Aquaculture

Consumer concerns over reports of contaminants in farmed and wild seafood is leading to increased interest in organic fish and seafood. However, as of July 2005, there are no organic aquaculture standards other than the general USDA National Organic Program (NOP) standards for organic livestock production. The NOP standards, including livestock standards, are available at *www.ams.usda.gov/nop/NOP/standards/StandardsNoScript.htm*. These NOP livestock standards must be followed for any animal or product sold with the USDA organic seal.

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 multi-faceted 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 post-harvest processing, for nutrient management, and for required animal identification and record-keeping? (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 that are available at *www.ams.usda.gov/nosb/AquaticAnimalsTaskForce/AquaticAnimalsTaskForce.html*. However, it is important to remember that the NOSB recommendations are not official until they have been approved and adopted by the USDA.

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

For the interval, until official aquaculture standards are approved, the USDA National Organic Program has issued a Guidance Statement (April 13, 2004), Topic Area—National Organic Program Scope, 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% 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.

This means that even if there are no national standards for organic aquaculture, organic certifying agencies that have aquaculture standards and are accredited by USDA may certify aquaculture products as organic, but the products are **not allowed** to carry the USDA organic label. So, 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 is listed at *www.ams.usda.gov/nop/CertifyingAgents/Accredited.html*.

At this writing (2005), there are only two certified organic aquaculture operations in the United States, both shrimp farms. OceanBoy in Florida, at *www.oceanboyfarms.com*, and Permian Sea in Texas, at *www.usmsfp.org/farm-websites/texas%20news/seafoodwithoutthesea.htm*, are both certified by Quality Certification Services (QCS).

Natural and Personal Resources

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 single 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—capital, labor, and time—influence the choice of production system and species. Generally, the more intensive the production system (i.e., the more fish grown per volume of water), the more capital, labor, and time required. For example, lightly stocked farm ponds practically take care of themselves, while closed systems need almost continuous monitoring.

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

Industry resources—including supplies, services, and markets—are well developed in some parts of the country 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 certain species is less well 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.

In order 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 bio-engineered species, are major concerns for many consumers and need to be addressed by the aquaculture industry.

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 county Extension Service 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 program, Regional Aquaculture Centers, or other federal sources of information (see **Further Resources** section for more details) about the programs and services available in your state or region.

Regulatory Aspects

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

In the article "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/or federal permits or licenses required for an aquaculture operation in your locale. The permit type will vary, depending upon 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 environment, natural resources, and agriculture for more information on the requirements in your state and locale. The National Association of State Aquaculture Coordinators (NASAC) has their *Directory of State Aquaculture Coordinators* listed at *www.marylandseafood.org/aquaculture/nasac.php*. The State Coordinators are responsible for coordinating aquaculture programs at the state and territorial levels.

Your state 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, the Department of Commerce (DOC), the Food and Drug Administration (FDA), and the U.S. Department of Interior Fish and Wildlife Service (FWS) all have certain areas of responsibility to the aquaculture industry. The Alternative Farming Systems Information Center (AFSIC) at the USDA National Agriculture Library has the Internet links for most of the U.S. Federal Government Agencies dealing with aquaculture listed at *www.nal.usda.gov/afsic/afsaqua.htm#Fed*.

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 the species you finally decide on, 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.

Coldwater species such as trout and salmon can be successfully farmed wherever water temperature does not consistently exceed 75°F. This usually limits production of coldwater 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. Coldwater species can also be grown anywhere adequate cold groundwater is available. Coolwater species such as walleye, perch, sturgeon, and certain shellfish tolerate warmer water than coldwater species, but their growth is inhibited at the optimal-growth temperatures of warmwater species.

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

Warmwater 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° and so 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.

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.

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

Production Systems

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

Open systems allow water to flow through them without reusing the water. Generally, the more intensive an aquaculture system, the more water must flow through it. 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. 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) will provide technical assistance for pond siting and construction. The University of Arkansas at Pine Bluff Aquaculture and Fisheries Web site has the publications *Recreational Fishing in Small Impoundments: Alternative Management Options* and *Farm Pond Management for Recreational Fishing* at *www.uaex.edu/aqfi/extension/publications/factsheet*.

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

Cage culture, 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 warmwater and coldwater species in the same pond.

Tank culture, 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 transporting or relocating. 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—long, narrow canals with large flows—are the most widely used production system for the intensive culture of salmon, trout, and charr.

Rotation systems, 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 much potential for beneficial rotation effects in such systems. Rotation benefits are similar to those seen in other agricultural systems: 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 U.S. The beneficial interactions between the different elements of such a system help to 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 (e.g., various carps) are not well accepted as food items here.

Integrated aquaculture and hydroponics—termed aquaponics—is a subject receiving increasing attention in the U.S. 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 entitled "Marketing Options for Small Aquaculture Producers," innovative marketing can be the key to financial success or failure.

> Most producers would like to sell to one of two high-volume buyers such as a processing plant or distributor. This is a good marketing strategy if you are producing large quantities of fish. However, small-scale producers are not in the same economic level as larger producers are and, therefore, must usually sell for a higher price to remain profitable. Their best option is to establish niche markets for their products.
>
> 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 the middlemen. 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 exploit 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, ethnic markets, or live for pond stocking; fee fishing or pay lakes for food-size sport fish; bait fish; and 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, Langston University Fisheries Extension Program, states 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)

It is much more profitable to determine market demand and plan production accordingly.

Market price will vary with each marketing strategy. Live fish sold directly to the consumer usually bring the highest price, but this requires much 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 has pulled together different aquaculture marketing documents and they are available at *http://agebb.missouri.edu/mac/links*. Click on A for Aquaculture, marketing listings.

Business Planning

Business planning is crucial to success for both new and established enterprises. Going through the planning process increases the chances for 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, because many financial institutes require a formal business plan. A business plan should be a working document that is reviewed and updated at least a couple of times 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 and other information that is specific to aquaculture. The Missouri Alternatives Center Web site has pulled together different aquaculture business planning documents and they are available at *http://agebb.missouri.edu/mac/links*. Click on A for Aquaculture, business plan listings.

The ATTRA publication *Agricultural Business Planning Templates and Resources* does not tell you how to write a business plan, but it does refer you to sources of business planning information and assistance that are more relevant to the smaller scale or alternative agricultural/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 will help develop a detailed business plan and looks at ways to take advantage of new marketing opportunities. It is available on-line at *www.misa.umn.edu/publications/bizplan.html* or can be purchased from:

Minnesota Institute for Sustainable Agriculture
411 Borlaug Hall
1991 Upper Buford Circle
St. Paul, MN 55108
800–909–MISA (6472)
misamail@umn.edu

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.

Further Resources

Many electronic resources are available to beginning aquaculturists. Excellent starting locations are the Aquaculture Network Information Center (AquaNIC) Home Page at *http://aquanic.org* and the Delaware Aquaculture Resource Center's *AquaPrimer: Introduction to Aquaculture* at *http://darc.cms.udel.edu/AquaPrimer/Aquaprimerindex.html*. Search engines such as Yahoo can also be used to locate other lists on the World Wide Web.

Many federal and state agencies such as the Cooperative Extension Service, Fish and Wildlife Service, Department of Agriculture, and Natural Resources Conservation Service (NRCS) provide technical and diagnostic services, as well as publish information on specific aquaculture topics.

In the 1980s, the USDA established five regional Aquaculture Research and Development Centers. These centers develop research and Extension education programs and publications in aquaculture having either regional or national applications. These centers work in association with universities, colleges, state agencies, and private industry to address research priorities and technology transfer 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 between universities and the National Oceanic and Atmospheric Administration (NOAA) that started in 1966. 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 listed in **Appendix II** or visit the National Sea Grant Program Web site at *www.nsgo.seagrant.org*.

The Alternative Farming Systems Information Center (AFSIC) at the USDA National Agriculture Library (NAL) is another excellent source for aquaculture information. The AFSIC serves as a national clearinghouse for aquaculture information and provides materials to a variety of clientele, including farmers, government agencies, industry personnel, and prospective farmers. The AFSIC has Internet links for most of the U.S. federal government agencies dealing with aquaculture listed at *www.nal.usda.gov/afsic/afsaqua.htm#Fed*. 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
afsic@nal.usda.gov
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 inter-library loan. Additional sources of books on aquaculture are local bookstores and aquaculture book suppliers (see list of book dealers in **Appendix III**).

Aquaculture periodicals, journals, newsletters, and magazines are good sources on all aspects of up-to-date research and recent developments covering various topics in aquaculture.

An excellent magazine is the bi-monthly *Aquaculture Magazine*, dealing 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. An annual subscription to *Aquaculture Magazine*, which includes the *Annual Buyers Guide and Industry Directory*, is $24.00, or just the *Annual Buyers Guide and Industry Directory* for $22.00. They are available from:

Aquaculture Magazine
Subscription Department
P.O. Box 1409
Arden, NC 28704-9817
828–687–0011
828–681-0601 FAX
editor@aquaculture.com
www.aquaculturemag.com

There are also many state, regional, national, and international professional and/or 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 *http://aquanic.org*, or in the *Aquaculture Magazine Annual Buyer's Guide*.

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Appendices

Appendix I: List of U.S. Regional Aquaculture Centers
Appendix II: List of Sea Grant Programs by State
Appendix III: Aquaculture Book Dealers
Appendix IV: Scientific Names of Aquaculture Species

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
http://www.ncrac.org/

Northeast Regional Aquaculture Center
University of Massachusetts Dartmouth
Violette Building, Room 201
285 Old Westport Road
Dartmouth, MA 02747-2300
508–999–8157
866–472–6722 (toll-free)
508–999–8590 FAX
http://www.nrac.umd.edu/

Southern Regional Aquaculture Center
127 Experiment Station Road
P.O. 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
Box 355020
University of Washington
Seattle, WA 98195-5020
206–543–4291
206–685–4674 FAX
www.fish.washington.edu/wrac

Appendix II

SEA GRANT PROGRAMS

(From National Sea Grant Program Web page, July 2005)

The National Sea Grant Program is a partnership between universities and the National Oceanic and Atmospheric Administration (NOAA) that started in 1966. 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.

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907–474–7949
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allee@sfos.uaf.edu
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9500 Gilman Drive
La Jolla, CA 92093-0232
858–534–4440
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rmoll@ucsd.edu
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213–740–5936 FAX
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302–831–4389 FAX
ntargett@udel.edu
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Building 803
McCarty Drive
Box 110400
Gainesville, FL 32611-0400
352–392–5870
352–392–5113 FAX
jcato@mail.ifas.ufl.edu
www.flseagrant.org

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220 Marine Sciences Building
Athens, GA 30602-3636
706–542–6009
706–542–3652 FAX
mrawson@uga.cc.uga.edu
www.marsci.uga.edu/gaseagrant/

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2525 Correa Road, HIG 238
Honolulu, HI 96822
808–956–7031
808–956–3014 FAX
sg-dir@soest.hawaii.edu
www.soest.hawaii.edu/SEAGRANT/index.php

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217–333–6444
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cwilson@lsu.edu
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Appendix III

AQUACULTURE BOOK DEALERS

(From Aquaculture Magazine Buyer's Guide & Industry Directory 2005)

Alternative Aquaculture
P.O. Box 109
Breinigsville, PA 18031
610–393–5918
610–395–8202 FAX
altaqua@ptd.net
www.altaqua.com

AquacultureCX
13727 SW 152 Street, #299
Miami, FL 33177
305–972–2960
305–242–2225
office@aquaculture.cx
www.aquaculture.cx

Aquatic Eco-Systems, Inc.
2395 Apopka Blvd.
Apopka, FL 32703
407–886–3939
877–347–4788 (toll-free)
407–886–6787 FAX
aes@aquaticeco.com
www.aquaticeco.com

AVA Publishing Company Inc.
P.O. Box 84060
Baton Rouge, LA 70884-4060
225–763–9656
225–766–0728 FAX
AVApub@cox.net
www.AVApub.com

CropKing, Inc.
5050 Greenwich
Seville, OH 44273-9413
330–769–2002
330–769–2616 FAX
pbrent@cropking.com
www.cropking.com

Florida Aqua Farms
33418 Old Saint Joe Road
Dade City, FL 33525
352–567–0226
352–567–3742 FAX
sales@Florida-Aqua-Farms.com
www.Florida-Aqua-Farms.com

Miami Aqua-culture, Inc.
4606 SW 74 Avenue
Miami, FL 33155
305–262–6605
305–262–6701 FAX
dan@miami-aquaculture.com
www.miami-aquaculture.com

Old World Exotic Fish
Box 970583
Miami, FL 33197
305–248–6640
305–245–4228 FAX
www.oldworldexoticfish.com

Seacoast Information Services Inc.
135 Auburn Drive
Charlestown, RI 02813
401–364–6960
401–364–9757 FAX
info@aquanet.com
www.aquanet.com

Shrimp News International
10845 Scripps Ranch Blvd, Suite #4
San Diego, CA 92131
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858–271–0324 FAX
bob@shrimpnews.com
www.shrimpnews.com

Appendix IV

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*
Artic 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*		

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Aquaculture Enterprises: Considerations and Strategies
By Lance Gegner
NCAT Agriculture Specialist

Paul Driscoll, Editor
Cynthia Arnold, Production

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