Aquaculture: Realities and Potentials When Getting Started

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The outlook for aquaculture in this country is promising for those whose determination is supported by the proper resources and skills. Health conscious consumers are increasing their consumption of fish and shellfish, while ocean fish catches are declining and are subject to contamination scares. Thus, there is an increased demand for farm-raised fish. But as the market has expanded, so has competition from inexpensive imported aquaculture products.

Southern states have a long growing season and other resources that have contributed to the establishment of large catfish, baitfish, and crawfish aquaculture industries. However, even within areas where aquaculture is a major agricultural enterprise, the potential for individual success is site-specific. This publication is designed to help individuals interested in aquaculture gain a better understanding of the challenges involved in establishing a successful fish farm. Although most information here applies to traditional freshwater aquaculture, readers interested in marine culture systems and specialty type aquaculture will be able to glean useful information. A glossary, included at the end, defines many industry terms.

Is fish farming for you?

Operating a fish farm is similar to operating a cattle feedlot. Closely packed and heavily fed fish must be watched closely to detect problems early before they turn into disasters. This is difficult because fish cannot be readily seen. New fish farmers may feel as if they are working blindfolded until they become comfortable using water quality test equipment, water color changes, and feeding response as their "eyes" to detect early warnings of problems. In pond culture systems, nighttime work is done throughout the warm months and includes checking dissolved oxygen levels and running aeration equipment as needed. Starting a fish farm means committing to long hours. Pond culture systems do generally have some "downtime" in the winter, but in indoor tank culture systems, the producer has no holiday season since fish are produced year-round.

Even with good management practices, pond fish farmers can face disasters.

- Unusually hot, cold, or cloudy weather can stress fish and cause disease.
- Fish can be affected by off flavor, making them unmarketable for weeks or months.
- Flooding and the resultant loss of fish plague many fish farms.
- High feed prices and low fish prices can lead to economic losses even in years when production is good.

All fish farmers must deal with a shortage of approved antibiotics and other treatments for fish diseases. The use of unapproved drugs must be avoided. Food safety is a major concern for regulatory agencies and in the minds of consumers. Because traditional fish farming overlaps with public issues such as wildlife conservation and water quality, producers using outdoor ponds, raceways, or cages must be ready to endure a gauntlet of regulations and permitting procedures. For example:

- Many states have or are drafting laws to control water usage and discharges from fish farms.
- Fish-eating birds are protected by federal law and can be killed in limited number only after obtaining a permit or written permission.
- Regulations requiring water conservation and reuse for crop irrigation are likely to become increasingly common for aquaculture in the future (see SRAC Publication No. 467).

Aquaculturists interested in recirculating or aquaponic systems should be aware that these systems require extremely close management and there is little margin for error. Innovative, high-tech, and "ecological" appearances aside, these systems do not run themselves. To gain an appreciation for the complexity of water quality chemistry and its management, the reader is referred to SRAC Publication Nos. 452, 463, and 464. Recirculating or aquaponic systems are highly vulnerable to water quality and other problems, such as:

- Power failures — Lack of aeration can kill fish crowded in tanks in 10 minutes or less.
- Pipe clogging — A fish blocking a drain can result in tank overflow and fish flopping on the floor.

- Water quality problems — A sudden spike in unionized ammonia followed by another in nitrite levels will stress fish and may weaken fish immune systems, leading to a bacterial infection. Chemicals used in an attempt to control a disease outbreak can also kill the biofilter bacteria, leading to more stress and death of fish.
- Expensive ultraviolet light (UV) and ozonation systems may be installed in an attempt to control disease outbreaks by limiting the growth of disease organisms circulating in the system. Such measures are unlikely to have the desired effect. You cannot "buy your way out" of problems and bypass the need for excellent, close management of water quality.

In spite of the problems, established fish farmers enjoy a great way of life. Their work and lifestyle are rewarding experiences. Successful fish farmers enjoy a deep sense of pride and satisfaction as they watch their fish feeding, growing, and finally being harvested.

Facilities that work

Although fish farming may seem like a brand new idea, it really is not. Decades of work by farmers and researchers have led to the development of proven facilities for growing fish. As a new fish farmer, you should keep things simple by sticking closely to these tried and proven designs. Control your urge to invent until you have experience in fish farming and fully understand all the reasons why things are done certain ways. The great majority of aquaculture products in the South are produced in levee and watershed ponds. Other production facilities, including cages, raceways, and flow-through tanks and recirculating systems, have not been as widely successful for a variety of reasons.

Levee ponds are standing water impoundments built by excavating the pond area to a shallow depth and using the soil obtained to build a perimeter of levees or dikes. The advantages of levee ponds include the ability to harvest by seine without draining and the availability of oxygen all the way to the bottom of the pond. Disadvantages include relatively high construction costs, the need for a site with a slope of less than 5 percent, soil clay content of at least 20 percent, and wells or other reliable water sources. Occasionally, a fish farmer will choose a site with a shallow water table and excavate down into it. This should not be done because management of such a pond is difficult. Levee ponds may not be fascinating, but they are state of the art when it comes to reliable, economical production of catfish and most other warm water finfish. Crawfish are produced in much shallower levee pond structures (see SRAC Publication Nos. 100, 101, and 240).

Watershed ponds are standing water impoundments built by damming ravines or small valleys. From 5 to 30 acres (2 to 12 ha) of watershed are needed to supply the water for 1 surface acre (0.4 ha) of pond. Advantages of watershed ponds include lower construction costs than levee ponds and the ability to make use of steeper sites. Disadvantages include the inability to refill ponds at will and lack of oxygen at greater depths, which can lead to fish kills if a turnover occurs (see SRAC Publication No. 102).

Cages are floating enclosures in which fish are grown and fed a complete feed. The main advantage of cages is that fish are cultured in existing water bodies that would otherwise be impractical to harvest. Cage culture is an excellent way for novice fish farmers to gain experience with minimal investment and risk. The main disadvantages to cages are the potential for the quick spread of disease and greater vulnerability to theft, disturbance, and moderately low oxygen levels. There is a history of large-scale catfish cage culture in lakes and extensive cage culture in farm ponds in several states. None of these efforts have succeeded, most likely because of the vulnerability of caged fish to the problems mentioned above (see SRAC Publication Nos. 160 to 166).

Raceways and flow-through tanks are long channels or tanks through which fresh water flows continuously and is then discarded or used in irrigation. Generally, these are linear concrete channels arranged in stairstep fashion. Because of the potential for very expensive mistakes, a properly engineered design and experienced contractor should be secured well before any concrete is poured. The construction cost of a system capable of producing 6,000 pounds of rainbow trout per year is approximately $4,400 (see SRAC Publication No. 221). Such a system would require a water supply of 500 gallons per minute. It is also possible to construct earthen raceways, but the management of fish is more difficult and the velocity at which water can be flowed through the system is lower because of erosion concerns.

Raceways are excellent systems for producing fish but there are very few sites with adequate amounts of gravity fed water of a suitable temperature. The main advantages of raceways and flow-through tanks are ease of handling and harvesting fish and control of waste buildup by flushing. The main disadvantage is the shortage of sites having abundant water of the right temperature that is gravity fed or available without excessive pumping costs. Groundwater in the South is generally suitable for cold water fish such as trout, but too cold for warm water species such as catfish.

Heating water for raceways is prohibitively expensive. Using heated effluents from power generating plants has been attempted with poor results because of conflicts between the needs of the power plant and the requirements of fish culture. Such conflicts include plant maintenance shutdowns and the use of chemicals to control biofouling organisms within the power plant.

Recirculating systems are tank systems in which the water is constantly filtered to remove or reduce the toxicity of dissolved fish wastes. Filtration is conducted by large beds of bacteria, known as biofilters. In some systems plants are raised as a second crop and for additional filtration and uptake of nutrients from fish wastes. The main advantage of recirculating systems is that ideal growing temperatures can be maintained indoors year-round, so they can be located in any climate. The main disadvantages are lack of reliability, high production costs, and the need for constant attention. Biofilters can be killed by chemicals that are used for disease treatments. Excellent knowledge of water quality chemistry, constant monitoring of water quality, and the ability to quickly respond to emerging problems are needed to raise fish in recirculating systems. Recirculating systems often benefit from the addition of new water and the discharge of used water, which makes them less than 100 percent recirculating.

Recirculating systems have considerable futuristic and ecological appeal, but more research and development work appears necessary before they will be economical for most applications. At present these systems are being used successfully in some hatchery systems and for brood stock conditioning and production of high value species (see SRAC Publication Nos. 451 to 454).

Location is everything

Much time, effort, and money have been wasted trying to force fish farming ponds to fit in impractical locations. First and foremost, a fish farm needs abundant, good quality water. To raise just 1,000 pounds of catfish in a typical levee pond requires between 100,000 and 259,000 gallons (378,541 to 980,422 L) of water. Raising the same amount of catfish in a raceway requires roughly 65 times as much water as in a levee pond! Underground water from wells and springs is preferred for fish farming because it is free of wild fish and parasites. Some fish farms use water from lakes and creeks, but problems with fish parasites and invasion by unwanted fish are a constant threat. Surface waters also carry the threat of random contamination by pesticides or other harmful chemicals. Some ground and surface waters are totally unsuitable for fish farming. The water source should be tested before purchasing property or breaking ground for construction. The county Extension educator or Extension aquaculture specialist can assist in determining how best to test the suitability of water for fish farming (see SRAC Publication No. 4606).

Suitable soils and slopes are vital for the proper, economical construction of ponds of the type used to produce most aquaculture products in the South. To hold water, soils generally must have 20 percent or more clay content and be free of rock outcroppings, sand layers, and other causes of excessive seepage. Ponds built where soils do not hold water often must be abandoned because corrective measures are costly. Levee ponds generally are built only in areas with less than 5 percent slope; about 0.5 percent is ideal (see SRAC Publication Nos. 100 and 101). Areas with more than 5 percent slope are generally better suited for watershed type ponds. SRAC Publication No. 102 has more information on watershed ponds. The local Natural Resources Conservation Service office can assist in evaluating the suitability of a site for pond construction. Raceways and other production facilities are less dependent on soils and slopes.

Laws and regulations may prohibit fish farms on certain sites. A site classified as a wetland usually cannot be developed. Feeding of any livestock in the watershed of a municipal water supply lake may be prohibited. Sites close to public waters may not be feasible for fish farms because of concerns about the escape of fish or the discharge of water. Contact a county Extension agent or Extension aquaculture specialist for a list of agencies involved in permitting fish farms. Obviously, it is best to investigate possible restrictions and have permits in hand before making a major investment in a site.

Beware of “new and exciting”

One of the largest traps for beginning aquaculturists is to become overly enthused about experimental systems or species. Newcomers to aquaculture have a difficult time telling experimental from proven production systems. Seeing others investing often draws interest and investment from more newcomers and the rush is on. Beware of such situations. Investment by others does not necessarily mean that a system is economical.

Innovation is good when kept to a small, affordable size. It is dangerous when a large investment is made before technical problems are overcome and the cost of production is low enough to allow for profitable operation.

How do you tell the difference between proven and experimental?

- If only one person or a few people are doing it, then it is more likely to be technically or economically experimental.
- If invited to visit an aquaculture operation in a far-away state or another country, investigate to learn whether there are other farms in that area doing the same thing. If not, then why not? Beware of the glamour of a showcase farm. The owners may claim it is successful but be primarily in the business of selling equipment or design and consulting services.
- If the system technology is secret or proprietary, be cautious.
- If farms using the new technology have been in operation for only a few years, the risk of the technology being uneconomical is higher.
- Ask the opinion of an Extension aquaculture specialist with your county Cooperative Extension Service.

Investigate markets

A common error made by beginners is to assume that a ready market can be found for what they will produce. Many people mistakenly believe that marketing is advertising. Actually, marketing is everything a business does to acquire customers and maintain a relationship with them. Marketing matches products to the people who need and want them. Grow what people want and deliver it when they want it, at a price that gives you a profit, and you will succeed.

It takes time and effort to identify and develop potential markets. It is important to do this first because your buyers determine the species, sizes, and quantities you will need to produce. Small-scale producers should investigate ways to sell directly to the consumer through local food co-ops or “MarketMaker,” an online marketing tool produced by the Cooperative Extension Service. Additional ideas for developing markets are contained in SRAC Publication No. 350, Small-Scale Marketing of Aquaculture Products.

Here are some useful questions to consider:

- Who are your planned customers? How reliable are they?
- How much will they buy from you; how frequently will they buy it and at what price? How reliable is that price?
- What are their preferences/demands in product size, form, uniformity, and other factors?
- Is the market already saturated? Who is the competition and how will you compete against them? Get a realistic picture of your strengths and weaknesses by looking at the situation from the customer’s point of view.

Once your business is established, determine how you can work to earn and maintain the trust of buyers while continuing to search for new marketing opportunities.

What should I produce?

Chances are that you already have one or more species in mind. There may be others you should consider.

New producers have been known to pick a species for frivolous reasons—make sure that your choice is based on market demand, economics, and technical feasibility.

Be aware that some species may never be developed beyond the experimental stage. Many types of fish and shellfish are uneconomical or impossible to produce because of the lack of proven feeds or seed stock rearing techniques or other technical problems. Tried and proven fish species are best for beginners. There is no easy money to be made in aquaculture.

Here, then, are some leading potential species for culture in the south:

Catfish is the major aquaculture product in the South. Farming is centered in Mississippi, Alabama, Arkansas, and Texas, although smaller industries exist in most other southern states. Production is currently down because of competition from imported fish products. Catfish production is divided into fingerling production and food fish production. Many producers specialize in one or the other. Almost all production is of channel catfish (*Ictalurus punctatus*). Other species of catfish have not proven as efficient. A hybrid of channel catfish and blue catfish has been shown to have faster growth and better feed conversion than channel catfish. Spawning is labor and management intensive because of the need for hand stripping of eggs and surgical harvest of sperm to allow for fertilization (see SRAC Publication No. 190).

Key requirements for levee pond catfish farms include 25 gallons per minute (95 L/min) of water for each surface acre of pond and land suitable for levee ponds as described above. The investment needed ranges from $3,000 to $5,000 per surface acre ($1,200 to $2,000/ha), excluding land costs. Key land and water requirements for watershed pond catfish farms include those listed for watershed ponds in the previous section. The investment needed ranges from $2,000 to $4,000 per surface acre ($800 to $1600/ha), excluding land costs (see SRAC Publication Nos. 180 to 192 and 1800 to 1806 and Videos SP 295 and 296, as well as catfish farming fact sheets available in your state).

Crawfish production is centered in Louisiana and eastern Texas, although there are small farms scattered throughout the South. The red swamp and white river species of crawfish are the most commonly cultured. Key requirements for these and other burrowing species include heavy clay soils and 70 to 100 gallons per minute (265 to 379 L/min) of water per surface acre of pond. Production varies widely with temperature, abundance of vegetation, and other factors, but 600 pounds per acre per year (660 kg/ha/year) is within the ballpark for well managed red swamp and white river crawfish ponds. As they decay, forage plants provide the primary food for crawfish. Cultivated forages such as rice or sorghum-sudan hybrid (Sorghum bicolor) support the highest levels of crawfish production. Naturally occurring aquatic plants can be used for forage. They require less management but are less reliable.

Whatever the forage, care must be taken during the flooding of fields and at other times to avoid too much decay of plant material and the resultant loss of dissolved oxygen. Crawfish are sensitive to pesticides, so caution is needed with their use in and around crawfish production. Relatively flat sites are needed to allow economical pond construction. The labor needed to empty and reset traps daily during the harvest season may be difficult to obtain outside of major crawfish production areas. Bait and harvesting labor account for more than half of the cost of production. An investment of approximately $90,000 is required for a 40-acre (16-ha) crawfish farm, excluding land costs (see SRAC Publication Nos. 240 to 244 and 2400 to 2405 and Video SP 319).

Freshwater baitfish production in the South consists mainly of golden shiners and smaller amounts of fathead minnows and goldfish. Arkansas dominates baitfish production. Key requirements include a site suitable for levee ponds and 20 or more gallons of water per minute per surface acre (187 L/ha). In the past, baitfish were grown primarily on plankton and other natural pond foods whose production was boosted by fertilization. Nutritionally incomplete supplemental feeds, like cottonseed meal and rice bran, were also used by many producers. Today, research points to the economic feasibility of using nutritionally complete feeds to increase production (see SRAC Publication No. 121). The investment required for a 160-acre (65-ha) baitfish farm is $720,000 (see SRAC Publication Nos. 120 to 124 and Video SP 301).

Production of sport fish fingerlings for the stocking of farm ponds is one of the oldest and most widespread aquaculture industries in the South. Largemouth bass spawn in the spring when water temperatures stabilize around 60 °F (16 °C). It is a common production practice to stock 30 to 40 pounds of broodfish per acre (34 to 45 kg/ha) to produce from 20,000 to 50,000 fingerlings that are 1.5 to 2 inches in length. Cannibalism is a problem often experienced by largemouth bass fingerling growers. Grading to maintain uniform size is one solution. Largemouth bass can be trained to take a pelleted diet and some producers do so to meet the needs of specialty markets. Such pellet-trained bass are grown to food size by a few producers (see SRAC Publication Nos. 200, 201, and 722).

In addition, **bluegill and other sport fish fingerlings** are widely produced for stocking recreational fishing ponds. These serve both as forage for largemouth bass and as desirable sport fish. Bluegill are the most common forage fish produced for stocking with largemouth bass. They spawn in the late spring when water temperatures reach 70 °F (21 °C). Special skills are required to spawn fish and handle, protect, and provide food for very young fish. For this reason, it is best to first get experience in growing fish from fingerling up to adult size (see SRAC Publication Nos. 140, 200, 201, 722, 724, 7204, and 7205). Many sport fish fingerling producers broaden their businesses by offering aquatic herbicides, fertilizers, and other pond management items of use to pond owners. Those interested in this form of aquaculture should be prepared for competition from experienced and well established growers.

Rainbow trout farming in the South centers on the Appalachian Mountains of North Carolina, Georgia, Virginia, Tennessee, and Kentucky. This region produces approximately one-quarter of the nation's farm-raised trout. In these systems water from mountain streams is diverted to flow through concrete raceways and tanks. From 55 to 65 °F (13 to 19 °C) is considered the ideal growout temperature. A small farm is considered to be one with a water flow of 500 gallons per minute (1,900 L/min). One thousand gallons per minute (3,800 L/min) is the minimum for a commercial-scale farm. Production costs vary from $0.82 to more than $1.00 per pound live weight. Typical construction cost is $0.65 to $0.75 cents per pound of annual fish production capacity (see SRAC Publication Nos. 220 to 223 and Video SP 299).

Striped bass and hybrid striped bass for food are produced in North Carolina, Mississippi, and a few farms concentrated in coastal areas. Industry production has grown to 12 million pounds a year. Three-ounce hybrid fingerlings are stocked in June of year I and harvested at 1.5 to 2.0 pounds in October of year II. Water should have an alkalinity and calcium hardness of 100 mg/L or more. Striped and hybrid striped bass do well in salinities ranging from 0 to 25 ppt. Levee pond culture predominates, with some interest in flow-through and recirculating systems (see SRAC Publication Nos. 300 to 303).

Tropical aquarium fish for the pet market are raised mainly in Florida because of the favorable climate. Both small earthen ponds and recirculating systems are used. The conditions required to spawn and rear tropical aquarium fish can be difficult to provide and may be proprietary. Requirements vary from species to species and information on spawning and culture of high-value species may be difficult to obtain.

Marine baitfish are harvested from the wild but there is a demand for more. Gulf killifish (*Fundulus grandis*), also known as bull minnows and other common names, are sold throughout the Gulf coast. Basic production methods have been researched, ranging from moderate to very high management levels: brackish water ponds, tanks, and recirculating aquaculture systems (see SRAC Publication Nos. 1200 and 1202). Bait shrimp production also is a promising possibility but management-intensive methods of seedstock production are required (see SRAC Publication No. 1201). The primary species being investigated are Atlantic white shrimp (*Litopenaeus setiferus*), Gulf brown shrimp (*Farfantepenaeus axtecus*), and Gulf pink shrimp (*F. duorarum*) (see SRAC Publication No. 1201). Other promising marine bait species are Atlantic croaker (*Micropogonias undulatus*), pigfish (*Orthopristis chrysoptera*), and pinfish (*Lagodon rhomboides*) (see SRAC Publication Nos. 7208 to 7210).

Marine foodfish most notably includes red drum (*Sciaenops ocillatus*). This species is important along the Gulf coast for anglers and commercial fishermen. Red drum are vulnerable to low winter temperatures and two growing seasons are required for growout. Culture sites are usually on the coast but red drum can be grown inland if saline water of the proper quality is available (see SRAC Publication Nos. 320 to 324 and Video SP 333).

Other candidate species under research and development include groupers (a large, diverse group of fish in the subfamily Epinephilinae), mutton snapper (*Lutjanus analis*), southern flounder (*Paralichthys lethostigma*), cobia (*Rachycentron canadum*), Florida pompano (*Trachinotus carolinus*), and black sea bass (*Centropristis striata*) (see SRAC Publication Nos. 721, 725, 726, 7202, 7206, and 7207).

Marine shellfish include the eastern oyster (*Crassostrea viriginica*), which is widely cultured in coastal waters. Be aware that the extent of production is restricted by limited site availability. Attempts are being made to overcome this by developing other growout systems (see SRAC Publication Nos. 432, 434, 4302, 4307, and 4308). Hard clams (*Mercenaria mercenaria*) likewise have a well developed production technology but are limited by the availability of suitable shallow coastal habitat for growout (see SRAC Publications Nos. 433 and 4301). Raising shellfish in “other than approved waters” is not advised because they accumulate bacteria and viruses that could cause illnesses.

Marine shrimp include several species that are candidates for production. As with other forms of aquaculture, when shrimp are raised intensively water quality management is of paramount concern. The fouling of pond bottoms by organic matter is a special concern in shrimp ponds. Inland production using brackish water has been done in Texas, Alabama, and Arizona, but standards for the quality of source water are exacting. Salinity also is critical (see SRAC Publication Nos. 260, 2600, and 2601).

Start small

While it is tempting to begin on a large scale, it is often better to begin modestly. Consider the following points as you make plans for your initial facility:

- Big mistakes are expensive. There is little use for facilities built the wrong way or on the wrong site. The most common examples are ponds that will not hold water or cannot be drained.
- With a smaller facility, you will have more time to develop markets and learn what your customers need. You may find a more profitable market than you had originally planned and need to change your way of growing and harvesting to fit this new market.
- You can improve the design of ponds and facilities. Changes in pond size or other structures can be made easily when expanding.
- Fish farming may not be to your liking. The labor or management required may not be what you had expected.

Water quality management

The most critical technical factor in aquaculture is water quality. Oxygen levels in water can drop quickly and suffocate fish. Dissolved wastes produced by fish can build up in water, damaging delicate gills and elevating levels of harmful substances in the bloodstream. Fish farmers can deal with these dangers, but only after they have learned how to use water quality test equipment. The Cooperative Extension Service in most southern states offers water quality workshops for fish farmers. These workshops provide hands-on experience using test equipment and teach what the water quality numbers mean and what management actions to take (see SRAC Publication Nos. 370, 371, 462, 463, and 464). New fish farmers who delay buying and learning to use test equipment often believe the warnings do not apply to them. Then suddenly they discover an entire pond of dead or sick fish (Figure 1). Producers who take the time to check oxygen, ammonia, nitrite, and other water quality factors on a regular basis find that it pays off by greatly reducing fish kills and disease problems.

Figure 1. The price of poor water quality management is dead or sick fish.

Think like a banker

Before you make a significant investment it is vital to do some detailed financial planning. Depending on the scale of investment, it can be essential to enlist the help of a skilled accountant or other financial expert. Questions to be tackled include:

- Financial position: Will the business survive in the long run?
- Profitability: Is the business profitable in both the short and long term?
- Liquidity and cash flow: Can the business generate enough cash when needed to pay its bills?

These are complex assessments that allow for confidence in the viability of an aquaculture enterprise. They are arrived at through the use of balance sheets, cash flow statements, income statements, and enterprise budgets (see SRAC Publication Nos. 4400 to 4403).

Enterprise budgets

Enterprise budgets for widely produced species are often available through the Cooperative Extension Service in your state. They can be an excellent planning resource. Read them carefully and make changes as needed to update prices and to fit your situation.

Raising nontraditional species will require an original budget. First, consider the income your fish farming operation will produce. Generally this means estimating the number of fish you will produce and the price you will receive for them. Next, make a list of the expendable items you will need to buy each year to produce your fish. This will include feed, fingerlings, labor, fuel, electricity, equipment repair, interest on borrowed money, etc. These are your variable costs. Finally, make a list of costs for everything associated with equipment. These are your fixed costs. Examples include pond construction, wells, pumps, trucks, feed bins, tractors, aerators and buildings. Do not overlook the cost of buildings, tractors, or other equipment that you already own. Part of their costs should be charged off each year of their expected life, as they eventually will need to be replaced. Equipment also used for other jobs on the farm should be partially charged so each enterprise can stand on its own. For example, a tractor that is used 20 percent of the time for fish farming would show up on the list as 0.20 tractors. A major reason to estimate income and expenses is to be able to project your return or profit. Another use of the same numbers is to project a breakeven cost for what you produce. To obtain these critical numbers, organize the information into an enterprise budget format (Figure 2). The numbers already are divided into three lists: income, variable costs, and fixed costs. Now put these numbers into four columns: item, quantity, dollars per unit ($/unit), and total, as shown in Figure 2. Do not forget to include any charges for interest if variable or fixed costs are financed.

Do not get discouraged if the estimated return is tiny or even negative. The first budget is just a starting point. Consider ways to reduce costs. For example, doing your own pond construction work with used equipment may reduce pond construction costs by half. Another way to reduce costs would be to use your own funds instead of borrowing. A third way to reduce costs would be to expand. This is often the only way to earn a profit when selling to high-volume, low-price buyers such as processing plants. Try developing budgets for different size fish farming operations to determine how large your operation must be in order to reach different income levels. Managers of small operations generally need to seek out buyers other than processing plants in order to operate profitably. This will incur additional marketing costs. SRAC Publication No. 350, Small-Scale Marketing of Aquaculture Products, discusses many of these alternatives. Be creative—time spent finding and developing specialty markets can yield good returns.

Income

Item	Quantity	$/unit	Total $
______	______	______	______
		Total income	______ (A)

Variable Costs

Item	Quantity	$/unit	Total $
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______
		Interest	______
		Total variable costs	______ (B)

Fixed Costs

Item	Quantity	$/unit	Total	Useful life	Annual depreciation
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
______	______	______	______	______	______
				Total fixed costs	______ (C)

Estimated return (A – B – C) ______

Breakeven cost (B + C)/total lbs. produced ______ /lb.

Figure 2. An enterprise budget format.

Further assessment

Regardless of the scale of the investment, you will find it to your advantage to ask some hard questions as a part of your business plan. Find out if your ideas make good technical and economic sense by talking with a wide range of people. This includes potential customers, Extension specialists, Natural Resource Conservation Service professionals involved in pond design, business people, and others. Visit as many fish farms as you can. Keep an open mind but remember that some fish farmers have pet theories and ideas that may or may not apply to your situation. Following are some topics to be investigated before a sizeable investment in a fish farm is made.

The market

- The importance of market research cannot be overemphasized. Review the questions covered in the marketing section above. When developing a business plan to seek financing, addressing the market is essential.

Production technology

- Is the species you plan to produce being profitably produced on commercial farms or is it still in the experimental stage of development? Be skeptical of claims of recent breakthroughs.
- Has the proposed production facility design been proven through widespread profitable use or is it an experimental system? Experimental species or production systems may be more interesting, but few individuals can afford to risk the money needed for such research.

Physical resources

- Does the proposed site have the right soil, slope, water quantity and quality, and electrical supply for the type of production facility planned?
- Does the proposed site have suitable road access? One common problem is bridges that will not support the weight of fish hauling trucks.
- Is there a better type of production facility for this site?
- Is the proposed site only marginally suitable? If so, consider other sites before committing yourself.
- Is it feasible to obtain needed permits for the proposed site and type of production system? Some sites may be located in or close to highly regulated resources such as public water supply lakes or sensitive wildlife habitat areas.

Seed stock, feed, and specialized supplies

- How will you obtain a reliable supply of fingerlings or other seed stock at a reasonable price?
- Can you afford the extra investment in time and money needed to develop your own seed stock production capacity?
- Is there a proven, economical feed available for the species you plan to produce?
- Do you have a reliable, affordable source for other specialized supplies and equipment?

Financial factors

- What is your strategy for obtaining funding? A formal business plan should be prepared any time a major investment is planned. Your county Extension agent should be able to provide fact sheets or other assistance in preparing business plans (see SRAC Publication No. 381).
- Are there other ways that the money could be invested for greater return at less risk and equal personal satisfaction?
- Can your financial situation support a new fish farm that will suffer a loss or only break even the first several years of operation?

Personal factors

- Can your personal situation stand the extra stress of starting a new enterprise?
- Do you and/or your employees have the skills needed to make the proposed operation work? Consider management skills as well as mechanical and farming skills needed.
- Would you hire yourself to do the planning, management, and day-to-day labor required? Be honest with yourself about your strengths and weaknesses.

> *"If it won't work on paper, chances are it won't work at all."*

Planning for the unexpected

- How will you minimize or cope with construction delays caused by bad weather, slow acquisition of government permits, lack of specialized equipment, or other bottlenecks? Hope for the best but be prepared for the worst.

For non-farmers

Most of today's farmers were born and raised on farms. Very few farmers learned how to farm as adults. As a non-farmer, this puts you at a considerable disadvantage. You will need to go through a period of on-the-job training. Are you the kind of person who does most of his or her own maintenance and repair work? Can you put up with outdoor work during bad weather and odd hours? If so, great. These are skills and tolerances you will need on a fish farm. If not, you may wish to reconsider the vocation of fish farming. Agriculture has never been an easy way to make a living. Far from leading a peaceful, worry-free life, farmers often face weather problems, low market prices, crop losses to diseases and disasters, and long working hours. Farming today requires much more than just being able to produce a crop. Successful farmers must have a sound understanding of the economics of their operation, keep good records, and work to develop the best markets for their product.

The bottom line

Commercial aquaculture involves all the struggles that go with any form of farming. In addition to these, fish farmers must plan carefully to make sure that their production facility is based on a tried and proven design, that the site conditions are right, and that reliable markets exist or can be developed. In return for their efforts, fish farmers enjoy an independent, rural lifestyle and can expect to receive a reasonable return on investment, similar to many other forms of agriculture.
Further information and assistance County Extension offices may offer the SRAC publications listed, as well as other fact sheets tailored to fish farming conditions in your state. SRAC fact sheets are also available at srac.tamu.edu . County agricultural Extension agents, especially those in major aquaculture regions, are increasingly likely to be knowledgeable about opportunities for aquaculture in your area. Also, most southern states have Extension aquaculture specialists. The Natural Resources Conservation Service offers free pond planning and layout services based on expert knowledge of local soil conditions. The pond specifications they provide can help ensure that fish farming ponds are built properly.

Glossary

Aquaculture — The production and sale of farm-raised aquatic plants and animals.

Aquaponics — The production of vegetables or other plants in combination with fish in a recirculating aquaculture system.

Bacteria — Microscopic life forms, some kinds of which are responsible for the breakdown of dead materials and fish wastes, such as ammonia.

Biofilters — Plates, beads, or other media that provide a large surface area upon which bacteria can grow using dissolved fish bodily wastes as food. The bacteria convert ammonia and nitrite into nitrates, which are much less harmful to aquatic life. A component of recirculating systems.

Dissolved oxygen — A measure of the concentration of oxygen in water. This is generally expressed in mg/L or ppm (1 mg/L = 1 ppm). Oxygen dissolves poorly in water and is often in short supply for aquatic animals. Warm water holds even less oxygen than cold water.

Fingerlings — Young fish from 1 inch in length up to 1 year of age. This stage comes after the fry stage.

Fry — Young fish from the time of hatching up to 1 inch in length.

Levee ponds — Standing water impoundments built by excavating the pond area to a shallow depth and using the soil obtained to build a perimeter of levees or dikes. These should be built so they can be drained by gravity.

Off flavor — Aquatic animals can absorb and take on flavors from the water in which they live. These musty, muddy, or otherwise undesirable flavors usually come from substances put out by certain species of microscopic algae (phytoplankton) and bacteria.

Plankton — Microscopic or minute visible aquatic plants and animals that drift with the movement of water. Phytoplankton are the microscopic plants suspended in the water column that typically give pondwater a greenish color. Zooplankton are tiny animals of microscopic or less than pinhead size.

Raceways — Long channels through which large amounts of new water flow continuously and is then discarded or used in irrigation. Usually built of concrete, these also can be earthen channels or long tanks constructed of other materials.

Recirculating systems — Tank systems that rely on biofilters to break down harmful fish waste products so water can be reused.

Seine — A long net used to capture fish.

Turnover — Mixing of top and bottom water that can lead to fish kills, especially in watershed ponds. During summer, a cold bottom layer of water lacking in oxygen develops. In fall and spring, the bottom and top layers can suddenly mix or turn over.

Watershed ponds — Impoundments built by damming streams or small valleys. Runoff from the surrounding land of higher elevation (the watershed) fills the ponds.

Water quality — The degree of suitability of water for growing fish and other aquatic organisms. Water high in dissolved oxygen and low in animal wastes such as ammonia is generally considered to be of high quality. Other factors, such as alkalinity, hardness, chlorides, and harmful substances like iron and hydrogen sulfide, also affect quality. Critical water quality factors, such as dissolved oxygen, can change quickly in fish farming situations and must be checked regularly on site.

For more information about aquaculture in Oklahoma, see your Extension county Extension educator.

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