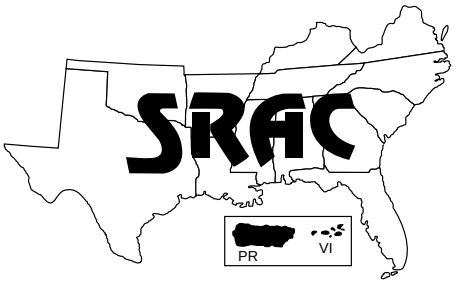
SRAC Publication No. 441

Southern
Regional
Aquaculture
Center



November 1998

Aquaculture: Realities and Potentials When Getting Started

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The outlook for aquaculture in this country is bright. Health-conscious consumers are increasing their consumption of fish and shellfish, and ocean fish catches are declining and are subject to contamination scares. Thus, there is an increased demand for farm-raised fish.

Southern states have a long growing season and other resources that have contributed to the establishment of large catfish, baitfish and crawfish aquaculture industries. While prospects for fish farming in the South in general are very good, the potential for individual success varies widely.

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 like they are working blindfolded and without sleep until they become comfortable using water quality test equipment, water color changes and feeding response as their "eyes" to detect early warnings of problems. Nighttime work is done throughout the warm months and includes checking dissolved oxygen levels and running aeration equipment as needed.

As with any other business, finding and keeping good help also is a challenge. Workers must be capable of making the right decisions when the farmer/manager is unavailable. Also, finding and developing good markets for the product takes considerable time and energy. A good fish farmer works to earn and maintain the trust of buyers while continuing to search for new marketing opportunities.

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

- Unusually hot, cold or cloudy weather can stress fish and bring on disease.
- Fish can be affected by off-flavor problems that make 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.

Because fish farming overlaps with public issues such as wildlife conservation, food safety and water quality, a fish farmer must be ready to endure a gauntlet of regulations and permitting procedures.

- Fish-eating birds are protected by federal law and can be killed in limited number only after obtaining a permit or written permission.
- Approved drugs and treatments for fish diseases are in short supply.
- Many states have or are drafting laws to control water withdrawal and discharges from fish farms.

Regulations requiring water conservation and reuse for crop irrigation are likely to become increasingly common for aquaculture in the future. (Refer to Southern Regional Aquaculture Center [SRAC] Publication 465.)

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However, in spite of the problems, established fish farmers enjoy a great way of life. Their work and lifestyle are rewarding experiences. 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 several years 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, 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 and 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 warmwater finfish. Crawfish are produced in much shallower levee pond structures. (Refer to SRAC Publications 100, 101 and 240.)

Watershed ponds are standing water impoundments built by damming ravines or small valleys. From 5 to 30 acres of watershed is needed to supply the water for 1 surface acre 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. (Refer to SRAC Publication 102.)

> *"After I got into it, I realized the producers I visited early on weren't as dumb as I had thought and I wasn't as smart."*

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. Main disadvantages are quick spread of disease and greater vulnerability to theft, disturbance and moderately low oxygen levels. (See SRAC Publications 160-166.)

Raceways and flow through tanks are long channels or tanks through which fresh water flows continuously and is then discarded. 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 artesian water or water 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.

Recirculating systems are tank systems in which water is filtered and reused. Filtration is conducted by large beds of bacteria, known as biofilters. Main advantages of recirculating systems are that ideal growing temperatures can be maintained year-round and they can be located anywhere. Main disadvantages are lack of reliability, high production costs and need for constant attention. Biofilters can be killed by chemicals that are used for disease treatments. They also can die unexpectedly without any apparent reason. More research and development work appears necessary before recirculating systems will be economical for most applications. At present these systems are being used successfully in some hatchery systems and for broodstock conditioning and production of very high value species. (See SRAC Publications 451-454.)

Location is everything

Much time, effort and money have been wasted trying to force fish farms to fit in impractical locations. First and foremost, a fish farm needs abundant, good quality water. To raise just 1,000 pounds of catfish requires about 244,000 gallons (0.75 acre-feet) of water. This is in a typical levee pond that is drained once every 5 to 10 years. Raising the same amount of catfish in a raceway requires an enormous amount of water—roughly 65 times as much 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 do use water from lakes and creeks but problems with fish parasites and invasion by trash fish are a constant battle. 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 agent or aquaculture Extension specialist can assist in determining how best to test the suitability of water for fish farming.

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 need to 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 well often must be abandoned because corrective measures are costly. Levee ponds generally are built only in areas with less than 5 percent slope; about 1/2 percent is ideal. (See SRAC Publications 100 and 101 for more information on levee ponds.)

Areas with more than 5 percent slope are generally better suited for watershed type ponds. SRAC Publication 102 has more information on watershed ponds. The county 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 can 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 escape of fish or discharge of water. Contact a county Extension agent or aquaculture Extension 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.

What to grow?

Like any other business, fish farms must produce, at a profit, a marketable product. Fish farmers located outside of major aquaculture areas must work doubly hard to be sure that their resources are suitable for what they wish to produce and to build their own markets from the ground up. Ideas for developing markets are contained in SRAC Publication 350, *Small Scale Marketing of Aquaculture Products*. In major aquaculture areas, there are processors and other established markets for certain products.

Many prospective fish farmers want to concentrate all their time and effort on growing fish, but often it is the marketing of their product that determines success or failure. This is especially true if new markets will have to be developed for the final product. This has even been true for those selling to established processing plants. A new fish farmer must consider what to do if the intended processor goes bankrupt, as many have. Consequently, plan to spend a considerable amount of time and energy developing primary and secondary markets for products, and be ready for all possibilities.

Catfish are the major aquaculture product in the South. Production is centered in Mississippi, Arkansas, Alabama and Louisiana, although smaller industries exist in most other southern states. Catfish production is divided into fingerling production and food fish production. Many producers specialize in one or the other. Key requirements for levee pond catfish farms include 25 gallons per minute of water for each surface acre of pond and land suitable for levee ponds as described in the previous section. The investment needed ranges from $3,000 to $5,000 per surface acre, 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, excluding land costs. (Refer to SRAC Publications 180 and 181 and video V001 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 of water per surface acre of pond. Flat sites are needed to allow economical pond construction. The hand labor needed to empty and reset traps daily during the harvest season may be difficult to obtain outside of major crawfish production areas. An investment of approximately $90,000 is required for a 40-acre crawfish farm, excluding land costs. (Refer to SRAC Publications 240-242 and video V003.)

Baitfish production 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. The investment required for a 160-acre baitfish farm is $720,000. (See SRAC Publications 120-122 and video V019.)

Largemouth bass, bluegill and other sport fish fingerlings are widely produced for stocking recreational fishing ponds. Key requirements include land and water resources suitable for levee or watershed ponds. Special skills are required to handle, protect and provide food for very young fish. Experience in producing large fish is usually obtained before the production of fingerlings is attempted. (See SRAC Publications 140-142, 200 and 201.)

Rainbow trout farming in the South centers in the Smoky Mountains of North Carolina, Tennessee and northern Georgia where water from mountain streams is diverted to flow through concrete raceways and tanks. A small farm is considered to be one with a water flow of 500 gallons per minute. The establishment cost required for such a small farm is approximately $26,000 excluding land costs. (See SRAC Publications 220-223 and V005.)

Striped bass, hybrid striped bass and red drum for food are newly developing species for fish culture. Farms are concentrated along coastal areas. Levee pond culture predominates with some interest in flow through and recirculating systems. Water should have an alkalinity of 100 mg/1 or more. (See SRAC Publications 300-303, 320-324 and videos V006 and V002.)

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. Requirements vary from species to species and information may be difficult to obtain.

Other species may be feasible for individual situations. Some species, however, may never be developed beyond the experimental stage. Many types of fish and shellfish are uneconomical or impossible to produce because of lack of proven feeds or fingerling rearing techniques or other technical problems. Tried and proven forms of fish farming are the best methods for beginners. There is no easy money to be made in aquaculture. If someone offers something that sounds too good to be true, it probably is.

Reasons to start small

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.

More time is available 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.

Design of ponds and facilities can be improved. 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 important factor in aquaculture is water quality. Dissolved oxygen levels in water can drop quickly and suffocate fish. Wastes produced by fish can build up, harm their delicate gills and lead to other problems. 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 Publications 370, 371 and 462-464.)

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.

Do your homework

As you make plans, you will find it to your advantage to ask some hard questions. 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 Resources Conservation Service professionals, businessmen 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.

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

Following are some questions that must be asked before a major investment in a fish farm is made.

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 and road access conditions for the type of production facility to be built?
- 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.

Marketing

- Who are your planned customers?
- How much will they buy from you, how frequently and at what 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.

Seedstock, feed and specialized supplies

- How will you obtain a reliable supply of fingerlings or other seedstock at a reasonable price?
- Can you afford the extra investment in time and money needed to develop your own seedstock 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. The county Extension agent should be able to provide fact sheets or other assistance in preparing business plans. (Also see SRAC Publication 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.

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.

Think like a banker

Take the plunge into aquaculture only after careful planning. Sample enterprise budgets that are available through the Cooperative Extension Service are a good starting point. Read them carefully and make all changes needed to fit your situation. Other financial statements required for business proposals are discussed in SRAC Publication 381.

Raising nontraditional species will require an original budget. First, consider the *income* your fish farming operation will produce. Generally this means estimating the amount 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 machinery. 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 are already purchased. 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 break-even cost for what you produce. To obtain these critical numbers, organize the information into an enterprise budget format. 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 opera-

Figure 2. An enterprise budget format.

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.

tion 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. SRAC Publication 350 discusses many of these alternatives. Be creative—time spent finding and developing specialty markets can yield good returns.

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

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 the 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 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, the site conditions are right, and reliable markets exist or can be developed.

In return for their efforts, fish farmers enjoy an independent, countryside 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 are likely to offer the SRAC publications listed, as well as other fact sheets tailored to fish farming conditions in your state. 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 aquaculture Extension specialists who are accessible through the Extension office.

The county Natural Resources Conservation Service offices offer 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.

Bacteria – Microscopic animal life, some kinds of which are responsible for the decay of dead materials and wastes.

Biofilters – Plates, beads or other media that provide a large surface area upon which bacteria can grow using fish waste products as food. The bacteria break down ammonia and nitrite into forms much less harmful to fish. A component of recirculating systems.

Dissolved oxygen – 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 bad 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 plants (phytoplankton).

Raceways – Long channels through which large amounts of new water flow continuously and are then discarded. 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 than can lead to fish kills, especially in watershed ponds. During summer, a cold bottom layer of water lacking in oxygen develops. In fall, 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 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, chlorides and harmful substances like iron and hydrogen sulfide, also affect quality. Water quality can change quickly in fish farming situations and must be checked regularly on site.

Managing Iowa Fisheries

Getting Started in Aquaculture Enterprises

Introduction

Aquaculture, or fish farming, is the rearing of aquatic organisms under controlled or semi-controlled conditions. Although aquaculture was developed in China more than 3,500 years ago, fish farming only recently has become a specialized agricultural business in the United States. For the past two decades, aquaculture has been the fastest growing sector in agriculture. Common in many supermarkets today are fresh channel catfish, produced mainly by fish farms in the South, and trout from the Northwest. Recent emphasis on agricultural diversification has led many Iowans to consider fish as a potential crop.

Current Status

The number of private fish hatchery licenses issued in Iowa has doubled within the past 10 years. In 1988, the Iowa Department of Natural Resources issued 69 commercial permits to 62 Iowans and seven out-of-state fish producers. Most are located in eastern and southeastern Iowa where the soil and topography lends itself to the construction of farm ponds. Notable exceptions are several trout hatcheries, which need a constant supply of cold water from springs or wells, in central and northeast Iowa.

A survey of Iowa aquaculturists found that most operations produce fish for stocking purposes. However, many fish were reared for human consumption, and some operators generate income from ponds where members of the public pay to fish. Channel catfish were the most commonly reared fish for stocking and direct food use. Largemouth bass and bluegill were second in importance, sold exclusively for stocking purposes.

Other species common to Iowa's aquaculture business, in decreasing order of importance, were walleye, grass carp, fathead minnows, crappie, trout, smallmouth bass, northern pike, buffalo, wipers, and crayfish. "Wipers" is a common name given to a hybrid bass produced by breeding a white bass female with a striped bass male. Many producers in eastern and southern states consider farm-reared wipers comparable to striped bass, whose dwindling numbers along the Atlantic coast and Gulf of Mexico resulted in a ban on their commercial harvest several years ago.

About one-fourth of the Iowa aquaculturists surveyed indicated they were new to fish farming. Most seemed optimistic about the future of their operation but found the work to be more difficult than they had anticipated. In response to increased interest in aquaculture, several regional junior colleges and universities offer vocational or supplemental adult classes in fish farming.

Production Considerations

The widely accepted idea that Fish + Water + Food = Money is a misconception. Sound planning and collection of available information can help a prospective fish farmer decide whether or not to pursue this venture, and it can prevent expensive mistakes. Important factors to consider before pursuing a fish production are:

- water,
- rearing facilities,
- species to produce,
- feeds and feeders,
- disease and treatment,
- harvesting, and
- marketing.

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Pm-1352h | August 1992

The following comments are not meant to encourage or discourage fish farming, but to provide factors on which to base a sound decision.

Water

The most serious threat to profitable fish production is poor water quality and lack of an acceptable quantity of water. Without adequate quantities of good quality water, fish production may be costly or impossible.

Three basic sources provide water for fishing operations: 1) wells, 2) springs, and 3) surface runoff. The preferred source is a deep well or spring; however, the most common source for most operations is the use of surface runoff. Surface water makes fish rearing difficult because the source often is polluted and contains wild fish populations with associated diseases.

Water from wells and springs is free of unwanted fish; however, both sources may be low in oxygen and require aeration. Well water also may be high in iron, carbon dioxide, or nitrogen gas, all of which can be toxic to fish, and must be removed before use. See table 1 for a description of those factors that affect water quality.

Portable test kits and meters can identify water quality parameters. For initial testing of important water parameters, several laboratories are available on a fee basis.

Water quantity is as important as water quality. For a pond culture, approximately 13 gallons/minute/pond surface acre should be available for flushing or refilling a pond. Several inches of water can evaporate from a pond during one year. Runoff water supplies make ponds difficult to manage because water may not be available when needed, such as in midsummer, or too much water may flush fish from the pond. For a raceway culture, enough water should be available to completely change the water in a raceway one to two times per hour.

Rearing facilities

Ponds: Many first-time fish farmers have an existing pond in which they would like to grow fish. This can work well, but a few guidelines must be followed:

- The pond bottom and water should be analyzed for pesticide contamination.
- The pond should be at least 8 feet deep to protect fish from summer drought and winterkill.
- The bottom should be uniform and free of stumps to simplify harvest.
- The pond should possess a screened outlet to prevent fish from escaping.
- The pond should be free of all unwanted fish.

If a pond is constructed for personal use only, no other special features are needed. For commercial use, the following pond features are recommended:

- The soil should be at least 20 percent clay below pond bottom.
- The pond should be drainable within 7 to 10 days.
- The facility may have a concrete harvest basin with water supply.
- The area must be accessible to vehicles.
- The pond must be at least 4 feet deep in the shallow end and 10 feet deep at the harvest end.
- The facility must have an overflow if it is built on a substantial floodplain.

Cages: Small wire enclosures, about 4' x 4' x 8', float in existing ponds and are anchored to the shore or a dock by rope or cable. Fish reared in cages are easy to observe, feed, and harvest; however, disease treatment is difficult without removing the fish from the cage or treating the whole pond.

Raceways: Raceways are used by commercial producers interested in the intensive (concentrated) culture of fish, such as the rainbow trout and channel catfish. Water usually is obtained from a spring or stream and is passed through the raceway using gravity, a “once-through” or “open” system. Raceways are arranged in a series on slightly sloping terrain, thus taking advantage of gravity to move the water through each unit. Raceway dimensions vary, but generally a length:width:depth ratio of 30:3:1 provides favorable characteristics. Most raceways are 3 to 6 feet wide and 20 to 100 feet long, but they also can be circular.

Raceway construction or purchase can be expensive and a **large** supply of good quality water is required. Raceways are constructed of concrete, block, tile, bricks, wood, or other durable materials, or they can be earthen. Earthen raceways may be less expensive to construct than other types; however, the high volume of fast-moving water cause varying degrees of erosion. Thus, raceways are not often used. They often require daily cleaning to maintain a good environment.

Table 1. Factors that affect water quality.

Water parameter (when to check)	Recommended levels	Importance
Oxygen (daily)	Minimum: 4-5 ppm Maximum: not to exceed 150% saturation for 4-6 hours	Main cause of fish stress and death during high production.
pH (daily)	Minimum: 6.5 Maximum: 8.5	Fish do not grow well outside these ranges; a good indicator of water quality.
Alkalinity/ total hardness (weekly)	Minimum: 20 ppm Maximum: 400 ppm	Acts as buffer against water pH changes, affects behavior of chemicals in water and fish survival.
Iron (annually)	Maximum: 0.5 ppm or below	Kills young fish by suffocation, commonly found in wells and springs.
Ammonia (weekly)	Maximum: 0.012 ppm (trout) : 0.12 ppm (catfish)	Excess causes gill damage, reduced growth, and death; toxicity affected by pH.
Temperature range	Trout: 45°F-60°F Catfish: 65°F-85°F	Outside these ranges reduced growth occurs and extremes may cause stress.

Production in raceways is greater than that of ponds or cages as a result of the continual exchange of freshwater, which removes the wastes. Production is based, in part, on the amount of water flowing through the raceways, yields are measured in pounds per gallon per minute (lb./gal./min.). Yields exceeding 82 lb./ gal./min. have been obtained in very intensive raceway production.

Water reuse systems: A closed reuse system recirculates water rather than passing it through the system only once. Less water is needed for this system than for ponds or open raceways. Most reuse systems are located indoors, which allows the grower to maintain control over the water, such as temperature. Reuse systems have additional advantages; however, their major disadvantage is the start-up cost.

Closed reuse systems have four parts: the culture chambers, a primary settling chamber, a biological filter, and a final clarifier or secondary settling chamber. Each unit is important to the system, although some closed systems do not contain all four components. Components may be separate units or they may be arranged in combinations that make the system appear to have only one or two units. Components may be large or relatively small, but each must be in proper proportion to one another if the system is to perform properly.

Production rates in closed reuse systems vary considerably depending upon the type of system and the user's expertise. Yields can range from 0.25 to 0.8 pounds per gallon (lb./gal.), although these figures can be misleading. Large-scale reuse systems are not recomended for persons with little experience in aquaculture.

Species to produce

Many species are produced commercially in Iowa; however, channel catfish, rainbow trout, large-

mouth bass, and bait fish are most common. The choice remains with the fish farmer, although available rearing facilities, potential market, water supply, and water temperature should influence the decision. Catfish, bait fish, and bass prefer 70°F to 85°F water temperatures while trout do best in 45°F to 65°F water. The most important factor to remember is that the growing time from egg to finished food product will be at least two years in Iowa. Bait fish and small stocking fish require less time and effort to produce, however, competition in this market is intense both from in-state and out-of-state producers.

Feeds and feeding

The fish farmer must have a knowledge of fish nutrition and be able to manipulate natural foods (plankton) along with formulated dry diets. Good commercial feeds are available for a variety of fish, and for particular species, such as channel catfish, trout, and salmon. The fish farmer must know how water temperature, water quality, feed quality, feed size, and feeding frequency affect eating habits, especially if feeding species other than channel catfish, trout, and salmon.

A good aquaculture program requires fish be fed 3 to 5 percent of their body weight 6 to 7 days per week, and at the same time and place in the pond or raceway. With good management practices, a pond can produce 1,500 to 2,000 pounds of channel catfish per acre of water.

Disease and treatment

The aquatic environment contains a variety of disease organisms and, thus, potential for disease problems. Disease can be caused by anything that produces stress; such as low dissolved oxygen and other water quality problems, handling, poor feed or feeding practices, drastic temperature fluctuations, and crowding. Bacterial and parasites are the most common disease-causing organisms, which can result in the death of many fish. However, fish usually will give the attentive fish farmer advance signs of a potential problems. Common indicators of fish stress and disease include reduced feeding activity, lazy swimming, and the appearance of dead fish.

The best control for disease is prevention. This is accomplished through proper management, maintenance of good water quality, and insistence that the newly acquired fish be free of stress and disease.

Even with these precautions, disease may occur and chemical treatment may be necessary. Before selecting a chemical, the culturist must identify the disease and know how the chemical, water, fish and disease will respond to the treatment. Chemical treatments can be expensive, are no panacea, and may cause higher mortality than the disease outbreak. Experience indicates disease problems and fish loss will continue to reoccur until the stress factor (crowding, poor water quality, handling, etc.), which precedes a disease outbreak, has been identified and removed. The fish farmer must know which chemicals are legal to use and their correct application.

Harvest

Harvest is an important aspect of fish farming and is often given low priority. Any damage to salable fish during harvest or transport can lead to a lower fish value, or fish death, and a complete loss. Harvesting techniques are similar for all species; however, scaled fish (walleye, bait fish, bass) are more prone to injury and require careful handling.

The time of harvest can be affected by market availability, the size of the fish needed, and weather. In general, fish handled in cool water are stressed less than those handled in warm water. Fish also should not be fed 24 to 36 hours prior to harvest to reduce fish stress and fouling of hauling tanks. Harvest during hot weather can cause “off flavor,” oxygen depletions, fish loss, and generally poor quality fish. Common equipment needed include seines, holding facilities, graders, dip nets, scales, boats, hauling units, aeration equipment, tractors, and trailers.

Marketing

This last section should be first in the minds of all potential fish farmers. Before fish rearing facilities are built or fish are stocked in existing ponds, a fish farmer **must** know where to sell the product.

The three types of fish commonly produced—food fish, small fish for stocking, and bait fish—appeal to different markets. Food fish are sold to area consumers and must be processed, either at a central plant, which are limited in Iowa, or at the farm. These fish also are sold live wholesale or retail to local customers or haulers. Food fish can be sold to lake owners as catchable fish or harvested from the production pond by anglers for a fishing fee. Fish raised for stocking fish or bait can be sold to local pond owners and

anglers, but often transportation of these fish over a large area is necessary.

A final consideration is when to sell. Due to similar growing seasons, many producers sell fish at the same time. This can create an over-supply and lower prices. Fish farmers can be flexibile by adjusting stocking dates or fingerling size at stocking, partial harvesting, or harvesting during an off-season.

Fish farming is similar to the production of other livestock. A successful operation requires technical expertise. If you're considering fish farming, look at all points discussed above, then discuss your situation with an experienced fish producer. This should help ensure a satisfying and profitable investment in fish.

Legal Considerations

The Department of Natural Resources and the Department of Inspection and Appeals should be contacted as soon as possible to determine permits needed for an aquaculture operation. The following laws and regulations are summarized for convenience. In addition to these laws, local zoning, health, and other regulations may apply.

These licenses are available from the Department of Natural Resources: 900 East Grand, Des Moines, Iowa 50319.

Aquaculture unit license: Needed to operate a hatchery, to engage in the business of propagating fish in private waters, or to hold fish for commercial purposes. The state conservation officer in your area must approve the application before a license can be issued. The licensee is allowed to possess, propagate, buy, sell, deal in, and transport fish produced from breeding stock lawfully acquired.

Operators must secure breeding stock from licensed private fish hatcheries in Iowa or from lawful sources outside the state. The Department of Natural Resources can provide a list of licensed Iowa fish hatcheries and a list of conservation officers for each county.

When purchasing fish, keep the bill of sale that allows possession to spawn, rear, and harvest fish. Additionally, anyone bringing fish or fish eggs into Iowa that are not native must submit an application to the DNR and receive a permit prior to transporting the fish into the state. The DNR may require certification that the source of fish or fish eggs is disease-free.

Bait dealers license: This license is required if minnows, frogs, or clams are sold for fish bait. The license also allows the licensee to obtain bait from lakes and streams where permitted.

NPDES permit: This permit, from the National Pollutant Discharge Elimination System (NPDES), is needed for discharge of "used" water. Generally, only relatively large operations or flow-through hatcheries will need an NPDES permit.

Water withdrawal permit: This permit is required if withdrawal from a groundwater or surface water source is in excess of 25,000 gallons per day.

Water storage permit: The permit is needed if natural runoff is captured and stored (e.g., a dam across a waterway) and the permanent storage is in excess of 18 acre feet.

Well construction permit: This permit is required prior to construction of new water wells.

Floodplain development permit: This permit may be needed if a fish farm is constructed on the flood plain of a stream or if a dam is constructed across a waterway or stream.

The Department of Inspection and Appeals requires a permit to operate a processing plant or slaughterhouse where fish are killed or dressed for food. Persons planning to raise fish for food should contact: Department of Inspection and Appeals, Lucas State Office Building, Des Moines, Iowa 50319.

Fish Farming Publications

Numerous publications are available on aquaculture. Suggested reading materials and sources are:

• *Aquaculture Magazine Annual Buyer's Guide.* Address purchase requests to Aquaculture Magazine, P.O. Box 2329, Asheville, N.C. 28802

• *Fish Hatchery Management*. Piper, et al. 1983. American Fisheries Society and the U.S., Fish and Wildlife Service, Washington, D.C.

• *The Freshwater Aquaculture Book: A Handbook for Small Scale Fish Culture.* McLarney, W. 1984 Harley and Marks, Inc.

• *A Guide to Approved Chemicals in Fish Production and Fishery Resource Management*, National Fisheries Laboratory, U.S. Fish & Wildlife Service, La Crosse, Wis. 54602

• *Northern Aquaculture.* 4611 William Head Road, Victoria, British Columbia V8X 3W9 Canada

• *Progressive Fish-Culturist*. American Fisheries Society, 5410 Grosvenor Lane, Suite 110, Bethesda, Md. 20814-2199

• *Third Report to the Fish Farmers*. U.S. Fish and Wildlife Service. Covers warm water aquaculture. Purchase from Superintendent of Documents, U.S. Printing Office, Washington D.C. 20402, pub. #S/N 024-010-000654-4

• *Water Quality in Ponds for Aquaculture*. Boyd, C.E. 1990. Alabama Agricultural Experiment Station, Auburn University, Ala.

Other Sources for Information

For more information about aquaculture contact the following offices or agencies:

• U.S. Department of Agriculture's Soil Conservation Service for information on soil suitability for pond construction and engineering expertise.

• Local Iowa State University Extension Office for general information on aquaculture.

• Department of Agriculture and Land Stewardship for marketing aspects of fish farming. Contact: Agricultural Diversification Bureau, Marketing Division, Wallace Building, Des Moines, Iowa 50319

• Investment Division, Office of the Treasurer of Iowa, for information on low interest loans available through the Linked Program for Horticulture and Alternative Crops. Contact: Office of Treasurer, State Capitol Building, Des Moines, Iowa 50319

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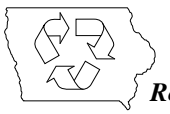

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Cooperative Extension Service, Iowa State University of Science and Technology and the United States Department of Agriculture cooperating. Robert M. Anderson, Jr., director, Ames, Iowa. Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914.