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Making Plans for Commercial Fish Culture in Michigan

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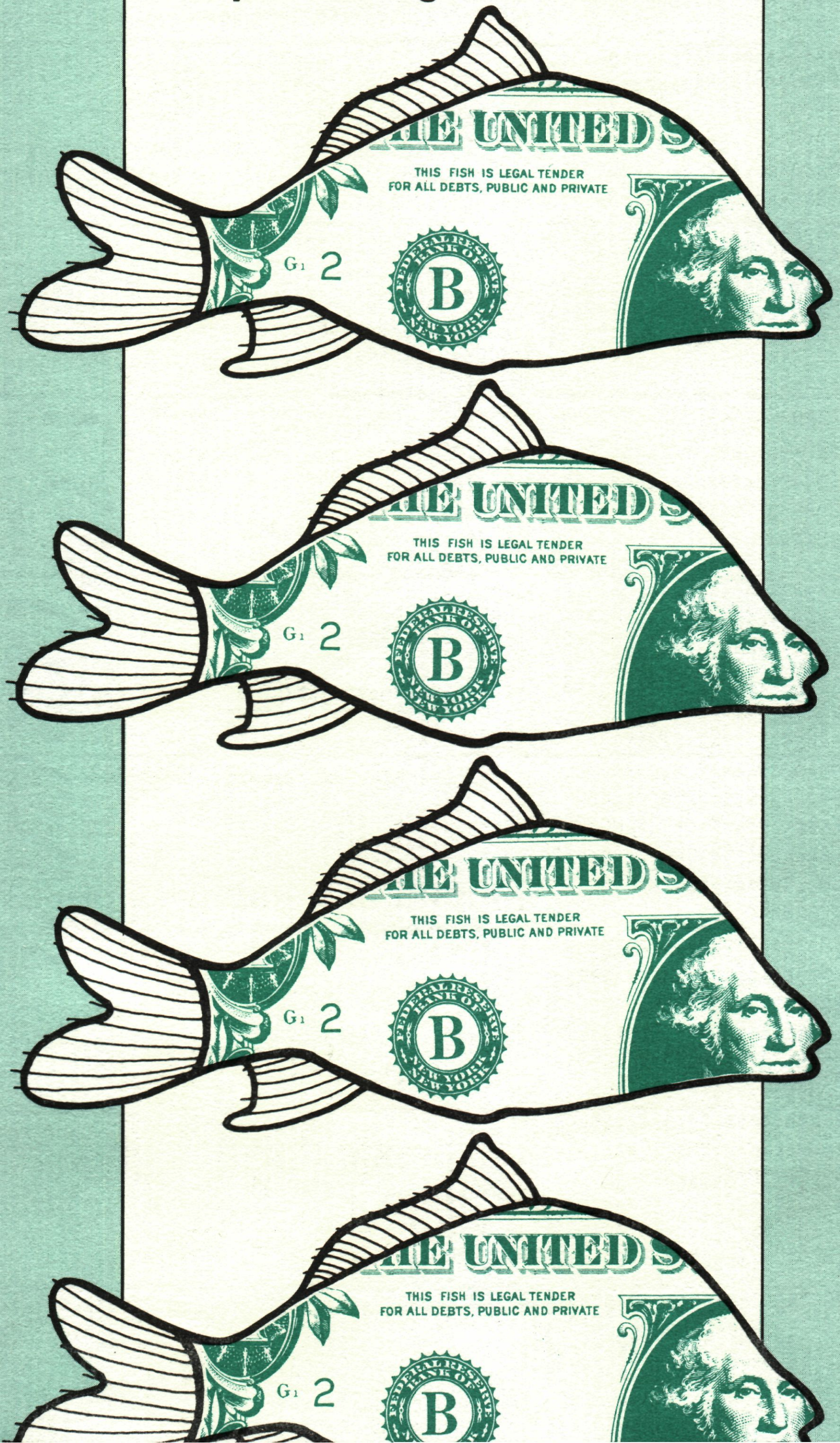

Introduction

Fish culture is not a new concept. Japanese, Chinese, Romans, Egyptians, and Mayan Indians farmed fish for food and recreation prior to 2000 BC. Ponds were constructed and fish were raised much in the same manner as fish are raised today.

Both freshwater and saltwater fish are currently raised commercially throughout the world. Other aquatic products, such as shrimp, crayfish, oysters, clams, worms, crickets, frogs and some plants are also raised commercially. **Aquaculture** is the general term used to describe the propagation and rearing of aquatic animals in controlled or selected environments. Although aquaculture is increasing in popularity in this country, the vast majority of fisheries food products eaten in the United States are imported or captured wild stocks from natural waters.

In Michigan, there are about 75 licensed fish breeders (aquaculturists) who produce fish for recreational stocking, food, or fee-fishing. About half of these produce rainbow trout. In 1975, 550,000 lbs. of rainbow trout were produced worth about $700,000 in Michigan. Estimated production levels and value more than doubled by 1980.

In the Great Lakes region, aquaculture is a viable enterprise. Wisconsin ranks fifth in U.S. trout production. Minnesota bait fish farmers produce fish worth more than a million dollars annually. Many other species of fish are also produced in the region for stocking recreational and fee-fishing ponds.

Aquaculture products can be an answer to the growing problem of world dietary animal protein shortages. Fish convert feed into flesh about two times more efficiently than chickens and five to ten times more efficiently than beef cattle. Feed conversion rates of fish are higher than other common commercial livestock because: a) fish can utilize foods that are less usable by most land animals and b) they require less energy from their foods. Moreover, fish can use the entire pond, from top to bottom, for living space while terrestrial animals are confined to the ground.

Consequently, the proper combination of fish species, control of the environment, and careful feeding can result in annual yields approaching 6,250 pounds per acre compared to approximately 1,000 pounds per acre yield from beef cattle production. The potential for increased production and the lure of high profits have accelerated the interest in fish farming and other types of aquaculture.

What Kind of Fish Can I Grow?

Here is a list of candidate fish and other aquatic animals and their current potential for culture in Michigan.

Candidates	Current Michigan culture potential	Comments
Rainbow trout Brook trout	high high	for food and stocking private lakes and ponds
Largemouth bass Smallmouth bass Bluegill Sunfish & hybrids	high high high high	for stocking private lakes and ponds
Baitfish	high	for Michigan bait industry
Brown trout Crappie Carp Aquarium fishes	moderate moderate moderate moderate	limited markets
Walleye Yellow perch Channel catfish Sturgeons Striped bass Eel	low low low low low low	either fingerlings or brood stock unavailable on commercial scale locally, climate inappropriate, or culture techniques not developed
Crayfish Aquatic plants	low low	limited bait market limited marketability for water lily, watercress, and wild rice
Prawns, turtles worms, frogs, mussels, lobsters shrimps, clams, salamanders, etc.	???	either culture techniques not developed, not appropriate for this climate/ water type, or markets don't exist

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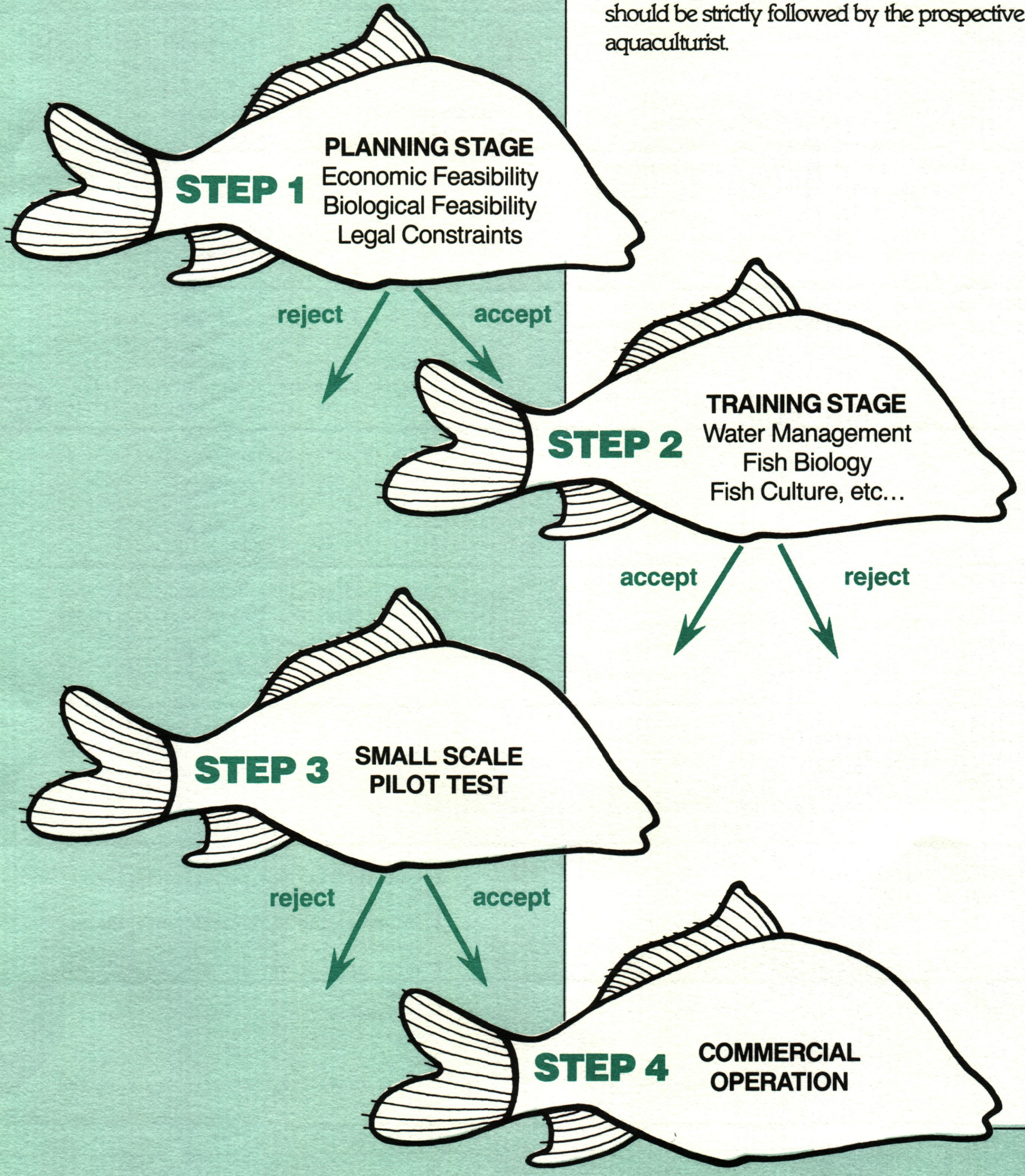
Establishing a Commercial Fish Culture Enterprise

Establishing a commercial fish culture enterprise involves a four step process which should be strictly followed by the prospective aquaculturist.

Figure 1. Flow diagram showing the processes to be followed.



STEP I: PLANNING STAGE

An extensive planning stage is necessary before making any large capital investment. This step is especially important when deciding on the feasibility of establishing a costly aquaculture venture. Planning involves a detailed evaluation of the biological, economic and legal feasibility of raising a particular fish or group of fishes. Biological and economic considerations are of equal importance. Legal constraints can also severely limit aquaculture in certain areas.

Economic Feasibility

An economic case study of trout production can serve as an example of the economic constraints facing the potential fish farmer. During the period from September 1980 to August 1981, U.S. trout producers in 14 surveyed states sold 42.9 million pounds of trout, down 11% from the previous year. Idaho producers sold 85% of the total during the period and dominated the industry. They sold their product for 61 cents a pound, down from 68 cents a pound the previous year. Producers in other states, who market their product in fee/recreational and fresh forms, sold their products for an average of $1.77 a pound ($1.34-$2.46 a pound). Production costs were about $33.1 million with purchased feed accounting for the largest share at about $20 million (60%).

Total revenue for sales of all trout was about $38.5 million dollars. While the returns may appear favorable, the returns based on capital investment in facilities were minimal.

The outlook is clouded by the dominance of Idaho producers. Three large producer-processors who control the major portion of the frozen and processed trout market, have depressed prices to reduce their inventories. Fortunately, producers in other areas have seen prices increase and they expect prices for fresh and live trout to continue to climb.

In Michigan we estimate that it will cost approximately $150,000-$200,000 to start a trout production farm capable of supporting the operators' full income requirements. Lower levels of investments will usually limit income and may result in negative returns. Although the initial investment may seem high, it is in line with investments required to start any type of new agribusiness (a tractor can cost as much). Current trout producers who aggressively market their products have no difficulty in selling all their fish at $1.50-$1.75 a pound.

Other types of operations cost less. Starting a fee-fishing operation will require an initial investment of $30,000-$50,000. A bait minnow farm will require $60,000-$80,000 initial investment.

Economic feasibility analysis: An aquaculture venture is economically feasible if a fish or aquaculutre product can be produced at a cost competitive to other sources and can be sold at a reasonable profit. Economic considerations are divided into **demand, finance, production and marketing.**

Product **demand** is the relationship between the amount of product that consumers will purchase, the selling price, the price of competing products, the size of the consuming population, and the income of the consuming population. Many fish and aquaculture products command high prices as luxury food items, but these items are characteristically in short supply. Since demand for luxury foods is normally limited, increased production would result in reduced product revenues. Other fish and aquaculture products which command lower prices must compete with meat products. Until aquacultural products can compete favorably with the price of chicken and hamburger, the size of the fish-consuming public will remain relatively low. In 1982, less than 50% of the population ate fish while average per capital consumption was only 13-14 pounds.

Finance is also a very important economic consideration. Private sector financing is generally conservative. Rarely will the private sector be persuaded to finance projects where risks are high, profits uncertain, and past experiences to guide decisions unavailable. Public financial assistance does not currently include specific programs for aquaculture; however some U.S. Department of Agriculture programs have been extended to include aquaculture. Additional public financial assistance sources may become available pending the passage of aquaculture oriented legislation. Consequently, the current outlook for financing an aquacultural venture is dim but the future holds promise.

Production economics involve various direct costs which can be divided into system costs, production costs and processing costs. These factors can be outlined as follows:

1. **System costs**
   a. **Initial facilities investment**
      1. **land**
      2. **construction costs (ponds, raceways, wells)**
      3. **buildings and equipment (tanks, filters, pumps)**
      4. **alternative power sources (solar, electrical, fossil fuel)**
   b. **Maintenance**
   c. **Depreciation**
   d. **Taxes**
   e. **Interest on working capital**
   f. **Insurance**

2. **Production costs**
   a. **Fish stocks**
   b. **Chemicals (disease control, water chemistry analysis)**
   c. **Feed**
   d. **Labor**
   e. **Water pumping, heating, oxygenation**
   f. **Energy (operation and transport)**
   g. **Miscellaneous supplied**
   h. **Harvesting**
      1. **equipment (nets, lifts, tractor)**
      2. **labor**
      3. **holding and/or transport facilities**
3. **Processing costs (if applicable to product)**
   a. **Direct cost to producer**
   b. **Shipment to processing facilities**

Aquaculture ventures can be extremely labor intensive. The cost of labor can be the most limiting factor in terms of production costs for large U.S. firms. Less labor intensive aquaculture ventures are normally limited by high feed costs. Poor understanding of the nutritional requirements of fish and other aquatic animals results in rigid diet formulations. This causes costs of diets to skyrocket if a particular necessary ingredient becomes scarce.

Processing is a production cost if existing processing facilities are not available to the producer or if the producer is unable to sell the product to a processor at a reasonable profit. Processing costs as well as the multitude of state and federal regulations governing processing can be a significant constraint to perspective aquaculturists.

Marketing involves the movement of goods from producers to consumers. For aquaculture industries, marketing can be a significant problem.

Ideally the marketing network for food items involves processors, distributors, and outlets. Although a producer can bypass processors and distributors, bypassing these intermediaries will increase costs and risk. Because of the additional risk involved, it is best to work through an established marketing network that can adapt to a new aquacultural product.

Establishing a market network for a new aquacultural product requires a continuous, year-round supply of marketable fish. Until a year round production system can be assured, a processor will be hesitant to invest in expansion or conversion of existing equipment to handle the new product. Processors prefer to contract for products from producers on a strict schedule to avoid slack production periods. Market development will be restricted if supplies are seasonal.

Unfortunately, the temperatures in temperate climates like Michigan restrict growth rates and promote seasonal yields. Year-round supplies can only be obtained by holding marketable sized animals to meet processor demand or by raising the aquatic animals in controlled temperature systems. Both methods result in added production costs.

Distributors transfer food products from processors to outlets or producers to outlets when live fish are sold for recreational usage. Problems associated with distribution include quantity and quality of the distributed product. Inadequate product handling and storage of food products can result in a consumer preference for well processed frozen imported aquaculture products. Improper handling of live fish results in fish deaths, impaired taste, and ultimately, reduced sales.

Market outlets for aquacultural products range from recreational fish ponds (live fish) to retail food stores and restaurants (processed food items). Outlets for processed aquacultural food items will purchase their products based on quality and costs. Consequently, imported products can often out-compete domestic sources because of established processing and distribution facilities and reduced labor costs.

Determining the economic feasibility of an aquacultural venture is complex. A professional economist should design and perform the initial analysis. But before an economist is hired, it is advisable to determine the biological feasibility of raising the desired fish or aquaculture products in a particular area.

Not all fish or aquaculture products are suitable for culture in certain areas. Environmental constraints such as water quality, water temperatures, and the length of the growing season dictate where an aquatic organism can be raised commercially.

Biological Feasibility

Water supply is a critical factor when determining site selection for an aquaculture facility. Desirable water supply characteristics include: 1) relatively constant flow; 2) constant or acceptable water temperatures; 3) high levels of dissolved oxygen; 4) low levels of harmful gases; 5) low siltation levels; 6) limited possibilities of introducing diseases or wild fishes; and 7) no chemical or organic pollution sources. Based on these characteristics, water supply sources can generally be ranked from most to least desirable as springs, wells, streams, lakes and reservoirs, respectively.

Surface runoff and ground water are usually an unacceptable source of water for commercial production ponds because of seasonal water level fluctuations and possible pollution. However, they may be acceptable for a fee-fishing operation.

Any potential water supply source should be adequately tested, both in terms of quantity and quality, before any costs for facilities are made. Raising shrimp, lobsters, or other marine animals inland, although technically possible, would be costly due to production costs required to maintain a suitable saltwater environment and the constraints on disposal of salt-laden waste water.

Water temperature and/or the length of the **growing season** often limit the commercial production of aquatic organisms. The body temperature of an aquatic organism is approximately the same as the water temperature. Temperature, in turn, affects its activity and growth. Therefore, the water temperature must be at levels which promote growth during a significant portion of the year to enable commercially economic production of the animal.

The levels of temperature which promote growth differ with different types of aquatic animals. For example, trout require lower water temperatures than channel catfish for optimum growth.

Temperatures below the optimum levels prolong the time required to raise an aquatic organism to market size and raise production costs. Temperatures above the optimum level for growth will stress the aquatic organism and results in reduced growth, disease and often death. Water temperatures is one reason that production of catfish for the food market is severely limited in the Great Lakes region. The growing season (water temperatures above 65°F) is too short and requires at least 3-4 years to produce a harvestable catfish. Only 18-24 months are required to produce a harvestable catfish in the southeast where the growing season is longer. Also eggs, fingerlings, feed and other production supplies are not locally available. In addition, commercial fisheries for catfish in Saginaw Bay and western Lake Erie currently supply the local demand at a price that would be difficult if not impossible to meet using a catfish culture system.

Biological Constraints

Although fish and aquaculture products in general have higher feed conversion rates than most terrestrial animals, not all fishes are suitable for intensive culture. Additional biological constraints limit which aquatic organisms can be raised at high densities commercially. Lack of knowledge of the reproductive biology, nutrition, and diseases of specific aquatic organisms represent the major biological constraints to culture of certain aquatic animals.

The **reproductive biology** of culturable aquatic organisms must be well understood before commercial production is undertaken. Control over reproductive biology is essential for commercial culture. Culture of wild captured stocks, though probably not legal, is entirely dependent on the unpredictable availability of wild fry or seed. Control over the reproductive biology of a desired aquatic organism allows the aquaculturist to produce offspring at desired times and in desired numbers. For example, lack of reproductive control is one of the major constraints limiting shrimp culture in coastal areas.

Nutritional requirements represent a major factor in determining the suitability of an aquatic species for aquaculture. As mentioned, the price of feeds based on rigid formulations can fluctuate severely with availability. This problem cannot be avoided unless the nutritional requirements of an aquatic organism are understood to allow for ingredient substitution. The nutritional requirements of fish and aquatic animals are not well understood even for fish like trout and channel catfish, currently under intensive commercial culture. Some fish and aquatic animals require natural feeds such as algae, insects, minnows, etc. If these animals are raised commercially, their natural feeds must be raised as well. For example, because walleyes do not accept commercial feeds, intensive production of walleyes in the Great Lakes area is limited.

A third biological constraint to aquaculture is **disease resistance and control.** When aquatic animals are raised intensively, they are crowded into a limited area which tends to promote the spread of disease. If diseases cannot be identified and treated quickly, the entire stock can be lost in a few days. The potential of disease-caused disasters to aquaculture makes knowledge of diseases and their control mandatory.

Scientific advances in the areas of reproductive control, nutrition, and disease control will improve the potential for aquaculture of established and new aquatic species. Selective breeding and advanced systems technology will also help eliminate many of the biological constraints on aquacultural development.

Legal Constraints

Various local, state, and federal laws can also restrict potential aquacultural development. These laws fall into a variety of categories including: 1) land use laws, 2) access laws, 3) water use laws, 4) environmental laws, 5) transport laws, 6) health and safety laws, and 7) permit procedures and requirements.

Currently, the number of permits required to establish an aquacultural business in Michigan are minimal; however, the permit process requires considerable planning and may take a year to complete. Obtaining permits to release effluents from aquaculture facilities may be denied due to the character of the water system receiving them.

If the economic, biological, and legal aspects of the planning stage indicate that the aquaculture venture is feasible, the prospective aquaculturist can proceed to Step 2.

STEP 2: TRAINING STAGE

Production of fish or aquaculture products requires a different set of technical and managerial skills than other agricultural activities. Before a would-be aquaculturist can successfully grow aquatic organisms, that person needs specialized training in water quality management, aquatic weed control, parasite and disease control, nutrition and feeds, cultural techniques, marketing, and processing skills. Although an informed aquaculturist can minimize the potential risks associated with raising aquatic organisms, the untrained fish farmer continually faces the possibility of unpredictable disaster.

The necessary technical and managerial skills required for aquaculture can be gained in either of two ways. The first method is that the prospective aquaculturist can obtain the necessary training by enrolling in selected college level courses or by attending special workshops. Either alternative for obtaining the necessary skills is costly and time consuming. The second method is to hire a fisheries biologist trained in aquaculture. Many large scale commercial ventures have succeeded because professional aquaculturists were hired to perform the technical and managerial functions. However, hiring a trained aquaculturist is often undesirable because of cost and/or the desire on the part of the potential aquaculturist to perform the labor.

Working for an aquaculture firm is also highly advisable. First hand, experiential learning will give the potential aquaculturist insight into the daily workings of an aquaculture operation.

Regardless of the method used to obtain technical and managerial skills, they are necessary in the developmental process for establishing a commercial aquaculture venture. Once the skills are acquired, the prospective aquaculturists can proceed to Step 3.

STEP 3: PILOT TEST

A small scale pilot test is desirable, particularly when evaluating a new species or culture technique, to determine the validity of estimates made during the planning stage. If the initial planning stage studies overestimate the biological feasibility, the products acceptability, or the economic outlook has changed, losses can be minimized by testing the estimates with a small pilot test. A small pilot project also permits the new aquaculturist to develop practical managerial skills.

Failures resulting from lack of experience can be greatly minimized by obtaining experience during a pilot test. However, small pilot operations can not be used to directly analyze economic feasibility because of economy of scale. Many inputs, such as feed, chemicals, fish, equipment, etc., can be purchased at a discount when ordered in bulk. Many attempts at large scale commercial fish culture have failed because of undercapitalization and the inability to take advantage of the economies of scale.

Only after the pilot project verifies the feasibility of the proposed commercial aquacultural venture and the skills of the aquaculturists have been obtained and developed, should a full scale commercial operation be undertaken (Step 4).

STEP 4: LARGE-SCALE COMMERCIAL OPERATION

The size and nature of a commercial aquaculture venture will depend on the results obtained from steps 1, 2 and 3. Based on the complexity and involvement required to complete steps 1-3, few people interested in establishing a commercial aquacultural operation ever pass steps one and two.

A few people interested in aquaculture progress to stage three and decide to restrict the size of their operation. A small scale operation can often provide a rewarding supplemental income by rearing fish for stocking recreation ponds or fee fishing lakes.

Very few potential aquaculturists proceed to step four, a large-scale commercial operation. Large-scale commercial aquacultural industries are often regionally located in areas where biological requirements can be best met, where markets for fish products are established, processing and distribution networks are available and the price of a culture species can compete favorably with prices of captured wild fishes. The lack of an established national network of processors, distributors, and markets will continue to limit the growth of large scale commercial aquaculture outside their established regional areas in the near future.

THE FUTURE OF AQUACULTURE IN MICHIGAN AND THE U.S.

Although the potential for aquaculture is theoretically very high, a number of factors, such as water pollution, threaten the future expansion of aquaculture. However, the interest in aquaculture, the anticipated funding and developmental support through the U.S. Departments of Agriculture and Commerce (Sea Grant Program) and advances in technology and scientific knowledge will have a positive effect on the potential for aquaculture in Michigan and the U.S.

In summary, some critical factors to consider are:

A. **Economics**
- **Is there a high demand and sufficient market for your product?**
- **Are sufficient capital or "high-risk" loans available for your operation?**
- **What is the cost of land purchase and pond or raceway construction?**
- **What are the finance interest and tax rates?**
- **What is the cost of maintaining facilities, purchasing equipment, and providing energy?**
- **What is the cost of purchasing fish stocks, fish feed, and chemicals?**
- **What are the processing and shipping costs?**

B. **Biological**
- **Is there a continuous supply of high-quality water available?**
- **Is the water temperature optimum and the length of the growing season sufficient?**
- **Is the species selected for rearing adaptable to culture conditions?**
- **Do you have an adequate knowledge of the reproductive biology, nutritional requirements and common diseases of the species?**
- **Is there an adequate supply of eggs, fingerlings, or brood stock available?**

C. **Legal**
- **What are the federal, state, and local laws that affect aquaculture?**
- **What are the permit procedures and license requirements necessary for aquaculture operations?**

Additional Readings:

1. National Research Council, Committee on Aquaculture. 1978. **Aquaculture in the United States: Constraints and Opportunities** National Academy of Sciences. 123 pp.
2. Shang, Y.C. 1981 **Aquacultural economics: basic concepts and methods of analysis** Westview Press. (Boulder, CO) 153 p.
3. Bardach, J.E., J.H. Ryther and W.P. McLarney. 1972. **Aquaculture: the farming and husbandry of freshwater and marine-organisms** John Wiley and Sons, Inc. New York. 868 p.
4. Stevenson, J.P. 1980. **Trout Farming Manual** Scholium International Publishers (Great Neck, NY) 186 p.
5. Brown, E. and J.B. Gratzek. 1980. **Fish Farming Handbook** AVI Publ. Co. (Westport, CT) 391 p. Publishers. NY
6. Dupree, H.K. and J.V. Huner. 1984. **Third report to the fish farmers.** U.S. Fish and Wildlife Service. Washington, D.C.
7. Roberts, R.J. and C.J. Sheperd. 1974. **Handbook of Trout and Salmon Disease.** Scholium International Publishers, (Great Neck, NY) 169 p.
8. Stickney, R.R. 1979. **Principles of Warmwater Aquaculture** John Wiley and Sons, Inc. NY 375 p.
9. Leitritz, E., and R.C. Lewis. 1976. **Trout and Salmon Culture** University of California, Division of Agricultural Science Publ. No. 4100.
10. Joint Subcommittee on Aquaculture. 1983. **National Aquaculture Development Plan** Volumes I and II, Washington, DC

For more information on raising fish commercially, fee-fishing pond management, or pond management for recreational fishing, contact:

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