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Making Plans for Commercial Aquaculture in the North Central Region

Donald L. Garling
Michigan State University

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Abstract
Aquaculture 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 related aquatic products raised commercially are shrimp, crayfish, oysters, clams, worms, crickets, frogs, and some plants. Aquaculture is the general term used to describe the propagation and rearing of aquatic animals and plants 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 are captured wild stocks from natural waters.

Disciplines
Aquaculture and Fisheries | Operations and Supply Chain Management

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North Central Regional
Aquaculture Center

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Making Plans for Commercial Aquaculture in the North Central Region

by D. L. Garling, Fish Culture Specialist, Michigan Cooperative Extension Service,
Department of Fisheries and Wildlife, Michigan State University,
East Lansing, MI

AQUACULTURE

Aquaculture 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.

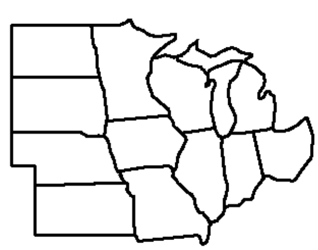
Both freshwater and saltwater fish are currently raised commercially throughout the world. Other related aquatic products raised commercially are shrimp, crayfish, oysters, clams, worms, crickets, frogs, and some plants. *Aquaculture* is the general term used to describe the propagation and rearing of aquatic animals and plants 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 are captured wild stocks from natural waters.

In the North Central Region (NCR), aquaculture is a viable enterprise. Fish are produced for recreational stocking, food, or fee-fishing. Minnesota bait fish farmers produce fish worth more than 30 million dollars annually. Wisconsin, Missouri, and Michigan each annually produce trout worth 1.5 to 2 million dollars. Many other species of fish are produced in the region including Atlantic, chinook, and coho salmon, perch, walleye, hybrid striped bass, largemouth and smallmouth bass, sunfish and sunfish hybrids, channel catfish, and carp.

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, top to bottom, for living space, while terrestrial animals are confined to the ground.

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.

Aquaculture, however, is a highly specialized form of agriculture. It is a high risk enterprise. One is trying to grow animals that one cannot see easily in their water environment. Water management may not be a familiar subject. Consequently, to increase potential for success, it is important to research carefully and plan any proposed aquaculture venture.



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ESTABLISHING A COMMERCIAL FISH CULTURE ENTERPRISE

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

STEP 1: 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 also can 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 September 1989 to August 1990, United States trout producers in 15 surveyed states sold 56.8 million pounds of food-size trout, valued at 64.5 million dollars. Idaho producers sold 70 percent of the total during the period and dominated the industry. They sold their product for 81 cents a pound, up from 77 cents a pound the previous year. Producers in other states, who marketed their product as food-size trout, sold their product for an average of $1.91 a pound ($1.22-$3.65 a pound). In the NCR, average sale price for food-sized trout was $2.34 ($1.95 to $2.67) in 1990.

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

In the NCR we estimate that it will cost at least $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 may cost as much). Current trout producers who aggressively market their products have no difficulty in selling their fish.

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 aquaculture product can be produced at a cost competitive with other sources and can be reasonably profitable. Here, economic considerations are divided into demand, finance, production, and marketing.

Demand

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 that command lower prices must compete with meat products. Until aquacultural products can compete favorably with the price of chicken and hamburger, the number of the fish-consuming people will remain relatively low. In 1990, less than 50 percent of the population ate fish, while average per capita consumption was 15.5 pounds.

Finance

Finance is a very important 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 United States 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. Thus, the current outlook for financing an aquacultural venture is dim — though the future holds promise.

Production

Production economics involves various direct costs that 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 (eggs, fry, fingerlings)
   b. Chemicals (disease control, water chemistry analysis)
   c. Feed
   d. Labor
   e. Water pumping, heating, oxygenation
   f. Energy (operation and transport)
   g. Miscellaneous supplies
   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 United States 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

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 usually best to work through an established marketing network that can adapt to a new aquacultural product. Unfortunately, when aquaculture is beginning to develop in an area, an established marketing network may not be available. Many small producers may have to process and market their own products to take advantage of the value that these steps add to the 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. To avoid slack production periods, processors prefer to contract for products from producers on a strict schedule. Market development will be restricted if supplies are seasonal.

Unfortunately, the temperatures in the climates found in most of the NCR 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

Distributors transfer food products from processors to outlets, or, when live fish are sold for recreational use, from producers to outlets. Problems associated with distribution include quantity and quality of the distributed product. Both inadequate product handling and inappropriate storage of food products can result in 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

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 outcompete 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 every area. 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

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.

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 for quantity and quality, before any cost analysis for facilities is made. Raising shrimp, lobsters, or other marine animals inland, although technically possible, would be costly because of production costs required to maintain a suitable saltwater environment and the constraints on disposal of salt-laden waste water.

Water temperature and growing season

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 thus affects its activity and growth. Therefore, to enable commercially economic production of the animal, the water temperature must be appropriate for promoting growth during a significant portion of the year.

Each type of aquatic animal requires a specific growth-promoting water temperature. 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 result in reduced growth, disease and often death. Water temperature is one reason that production of catfish for the food market is severely limited in the northern part of the NCR. The growing season (water temperatures above 65° F) is too short. Up to three years may be required to produce a marketable catfish (only 18-24 months is required to produce a harvestable catfish in the Southeast where the growing season is longer). In addition, eggs, fingerlings, feed, and other production supplies are not locally available. Since shipping costs for fresh and frozen catfish from the primary culture areas are extremely low (about 3 cents per pound in 1990), local supplies of catfish must either meet specific demands for specialty niche markets or compete in price with southern produced catfish.

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 represents the major biological constraint on the culture of certain aquatic animals.

Reproductive biology

The reproductive biology of cultured 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, which may be illegal in some NCR states, is entirely dependent on the unpredictable availability of wild fry or seed. Control over the reproductive biology of a desired 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

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 — so as to allow for ingredient substitution. The nutritional requirements of fish and aquatic animals are not well understood — even for fish such as trout and channel catfish, currently under intensive commercial culture. Some fish and aquatic animals require natural feeds such as algae, insects, and minnows. If these animals are raised commercially, their natural feeds must be raised as well. For example, because walleye fry do not readily accept commercial feeds, intensive production of walleye as food fish in the Great Lakes area is limited at this time.

Disease resistance and control

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 help eliminate many of the biological constraints on aquacultural development.

Legal Constraints

Various local, state, and federal laws can restrict potential aquacultural development. These laws fall into a number 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.

The number of permits required to establish an aquacultural business varies from state to state in the NCR; you will need to contact your state aquaculture coordinator to determine the specific permit requirements. The permit process requires considerable planning and may take a year or more to complete. As an example, permits to release effluents from an aquaculture facility may be denied if the water system receiving them is a high quality trout stream. Choosing an alternate site where effluents can be discharged into a less sensitive receiving system may facilitate obtaining the necessary effluent permits.

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 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, such skills are necessary in the process of establishing a commercial aquaculture venture. Once the skills are acquired, the prospective aquaculturist 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. In case the initial planning stage studies overestimate the biological feasibility or the product's 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, and fish equipment 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 consequent 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. Because of the complexity of analysis and the involvement required to complete steps 1-3, few people interested in establishing a commercial aquacultural operation 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 help diversify their farming activities and 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 best be 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 THE NCR 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, widespread interest in aquaculture, the anticipated funding and developmental support through the U.S. Departments of Agriculture (Regional Aquaculture Centers and Land Grant Programs) and Commerce (Sea Grant Program), and advances in technology and scientific knowledge will have a positive effect on the potential for aquaculture in the NCR and the United States.

Aquaculture Check List

Under the right conditions, fish farming can be a rewarding and profitable business opportunity. Like other forms of farming, fish production involves substantial capital investment and many risks. Growing fish requires specialized training and daily attention. If you are considering fish farming, this check list can help you determine whether a fish farming enterprise is feasible for your particular situation. The check list does not cover all possibilities, so answering "yes" to most of the questions will not guarantee your success. Answering "no" to many of the questions will not mean automatic failure. The check list does present many of the most important considerations. To have a good probability of success, most of your answers should be in the "yes" column.

Market

Yes	No	
☐	☐	Is there an established market for your fish?
☐	☐	Is there a market for your fish when you plan to sell them?
☐	☐	Will fish be available year-round if so required by the market?
☐	☐	Are other fish products available at prices lower than your profitable selling price that will out-compete you in the market?
☐	☐	Do you have an alternative marketing strategy on which to fall back?

Management

Yes	No	
☐	☐	Do you have land with suitable water supplies and sites for fish culture development?
☐	☐	Do you have the machinery and equipment needed to raise, process, and market fish?
☐	☐	Do you have the necessary financial resources ($75,000 for fee fishing to $250,000+ for an intensive fish farm) to invest?
☐	☐	Are estimates of costs and returns available for the fish farming available for your area?
☐	☐	Is the profit potential from raising fish higher than that of other possible investments?
☐	☐	Will the expected profit be adequate compensation for your labor, management, and risk?
☐	☐	Are financial institutions willing to loan money for fish farming in your area?
☐	☐	Will investment and operating capital interest rates permit a reasonable profit?
☐	☐	Is fish farming the best alternative for the land you intend to use?
☐	☐	Can you afford to forego income until you sell your first crop?
☐	☐	Are you able to absorb occasional losses?
☐	☐	Are you willing and able to devote the daily time and effort required?

Physical Factors

Yes	No	
☐	☐	Do you have enough water to raise the fish you would like to grow?
☐	☐	Do you have water of the quality necessary to raise the fish you would like to grow?
☐	☐	Does the land have appropriate topography for the construction of ponds or raceways?
☐	☐	Will the soil hold water?
☐	☐	Is the area protected from flooding?
☐	☐	Can you build a water retention area to remove fish wastes?
☐	☐	Can you discharge water from your site?
☐	☐	Do you live close enough to the site to allow frequent and timely observations of the fish?
☐	☐	Is the site easily accessible year round for you and transport trucks?

Production Factors

Yes	No	
☐	☐	Are eggs or fingerlings available from local dealers at competitive prices?
☐	☐	Can you raise your fish from eggs to produce your own fingerlings?
☐	☐	Are high quality fish feeds readily available at competitive prices?
☐	☐	Do you have a suitable area to store feeds?
☐	☐	Do you have a source of the drugs and chemicals needed?
☐	☐	Is dependable labor available?
☐	☐	Are dependable diagnostic services available locally?
☐	☐	Are you aware of universities, government agencies, or professional fish culturists that can provide you educational and technical services?

Risks — Are you equipped to handle the following problems:

Yes	No	
☐	☐	Poor water quality?
☐	☐	Fish disease and parasites?
☐	☐	Poachers and vandals?
☐	☐	Potential chemical contamination?
☐	☐	Business management and taxation?

These are the elements essential to a successful fish farming enterprise:

- Large volumes of high quality water.
- Suitable water quality.
- Sufficient financial resources.
- Established markets.
- Appropriate management skills and time.

If a potential fish farmer lacks any one of these elements, his or her chance for success is very limited.

WHAT FISH CAN YOU GROW IN YOUR STATE?

Here is a list of candidate fish and other aquatic animals and their current potential for culture in the North Central Region (NCR). You should consult your state's fish culture extension specialist for specific information about the best aquatic animals to raise in your state.

Candidate	Current NCR Culture Potential	Comments
Chinook Salmon Coho Salmon Atlantic Salmon Rainbow Trout Brook Trout Brown Trout	low to high	For food and stocking (trout) private lakes and ponds: These fish require high quality, cold water. They can be raised in raceways where large volumes of water are available or in deep pens in cold water lakes where winter ice thaws in place instead of breaking up. Egg supply may be a problem in the future.
Largemouth Bass Smallmouth Bass Bluegill Sunfish Hybrid Sunfish Crappies	moderate to high	For stocking private lakes and ponds: market may be saturated in some areas. For food: potential increases with longer growing season in the southern (NCR) .
Baitfishes	moderate to high	For local bait fish industry demand and especially for periods of seasonal supply shortages.
Walleye Yellow Perch Striped Bass Hybrids	moderate	For stocking private lakes and for food: Fingerling or broodstock supply limited, culture techniques under development.
Crayfish	moderate	For bait and food: culture techniques under development.
Common Carp Aquarium Fishes Goldfish	low to moderate	limited markets
Grass Carp	low to high	For aquatic plant control: illegal to possess diploids or any grass carp in some NCR states.
Channel Catfish	low to high	For food and stocking: difficult to compete with supplies from the southern states. Require warm waters for food fish growth, only available in the southern NCR.
Aquatic Plants (wild rice, water cress, water lily, etc)	low	For food or ornamental water gardening: limited markets.
Tilapia	low	For food: limited market, usually raised in experimental recirculating systems.
Prawns (freshwater shrimp) Freshwater Lobsters Frogs Salamanders Freshwater Pearls Marine Shrimp	????	Either culture techniques are not developed, not appropriate for this climate/water salinity, may be illegal to import into some states, or markets poorly defined or don't exist.

Additional Readings:

Some of these suggested readings may be out-of-print and will be available only through your local library on Interlibrary Loan.

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Information on fish farming in the North Central Region of the United States is limited. Your State's Cooperative Extension Service can help you further decide if fish farming is a viable option for you.

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