AQUACULTURE IN MICHIGAN - DESCRIPTIVE PROFILES

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ABSTRACT

AQUACULTURE IN MICHIGAN - DESCRIPTIVE PROFILES

By

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A descriptive survey of the 1975 Michigan aquaculture industry was conducted in an attempt to document specific physical, biological, and economic characteristics of the existing industry. The survey indicated that there were basically two major types of operations: fish production operations comprising approximately 40% of the total number of licensed operations, and fee-fishing operations comprising 36% of the total number of licensed operations. The other operations consisted of fish dealers or agents, operations which were just starting or had closed, and operators who preferred not to answer the questionnaires. The majority of both types of operations were small in size and were operated as a "hobby", providing a secondary source of income and (primarily) non-monetary returns to the owners. Rainbow trout was the most common species found at both types of operations. The majority of the fish produced at production operations were sold as *live* fish for stocking in private waters. Average returns to labor, management and investment were low for both fish production and fee-fishing operations. Average returns to labor and management were $10,737, $2,331 and -$2,806 for large, medium-size and small fish production operations, respectively, and were $2,297 and -$1,253 for large and small fee-fishing operations, respectively. Insufficient data were available to precisely determine the optimum-scale of operations for both types of operations. The data suggest, however, that larger-scale operations may be more profitable than smaller operations, assuming proper management. Common concerns of both fish production and fee-fishing operators were regulations affecting their operations and lack of financing, marketing and information assistance.

AQUACULTURE IN MICHIGAN - DESCRIPTIVE PROFILES

By

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I. INTRODUCTION

A. Aquaculture is the art and science of cultivating and propagating water-dwelling organisms in a controlled environment (Gilbertson, 1971). Recorded aquaculture practices date back as far as 2,000 years ago, where in China, goldfish were raised for ornamental purposes. Since 1000 B.C. fish have been raised for human consumption.

Today, aquaculture practices are being expanded and intensified throughout the world, including the United States. In the U.S. the expansion of aquaculture has been attributed to a number of factors, including: increasing overexploitation, regulation and control of natural fish stocks; degradation of natural aquatic environments by various forms of pollution which negatively affect commercially valuable fish stocks; and a decreasing annual domestic fish catch.

An increasing awareness of aquaculture, its importance, and its potential has prompted some governments, including Canada and the State of Idaho, to evaluate their own aquaculture industries. These studies and resulting reports provide both historical perspective and "a feel" for the industry, its scope and its direction, to existing aquaculture operators, resource managers, extension workers, policy makers and administrators. Problems and needs of the industry are brought forth, a necessary aspect in any attempt to develop and improve the aquaculture industry.

In Michigan, however, very little is known about the extent of existing aquaculture operations and their physical, biological, economic and social aspects. Additionally, there is increasing interest on the part of private entrepreneurs to become engaged in aquaculture enterprises in the state. Increasing interest in aquaculture and the existing lack of relevant information concerning aquaculture in Michigan prompted this study.

B. The goal of this study was to collect and disseminate pertinent information concerning the current Michigan aquaculture industry. Our concentration has been on two major components of the existing industry: fish production operations and fee-fishing operations. Not included in the report are fish dealers or agents, the existing bait-fish industry, and state hatcheries.

The objectives of the study were to determine:

(1) Physical and biological characteristics of the existing operations, i.e., facilities, water, fish, feeds, mortalities, disease, etc.

(2) Business and economic characteristics of the existing operations, i.e., costs and returns, markets, employment, etc.

(3) Current factors affecting the Michigan industry in general.

It is hoped that the information contained within this report will prove useful to aquaculture operators, extension workers, natural resource planners, policy makers and managers in future attempts to develop and improve aquaculture in Michigan.

C. The balance of the report is composed of seven sections. The second section is a review of recent aquaculture articles and reports that may have relevance to the Michigan industry. The third section is a review of the methodology used in conducting this study. In Sections IV and V more detailed profiles (physical, biological and economic characteristics) of fish production and fee-fishing operations are presented. Costs and returns information for both fish production and fee-fishing operations are presented in Section VI. Section VII discusses some of the problems and needs of the existing industry. The last section presents outlooks for the industry and some concluding remarks.

D. In 1975, the Michigan Department of Natural Resources licsned 117 aquaculture operations in the state. These operations were scattered throughout the state, with at least one operation in 57 of the 83 counties in Michigan. The highest concentration of both fish production and fee-fishing operations existed in the northern Lower Peninsula, which includes the counties north of a line from Muskegon to Bay City (dark line on Figure 1).

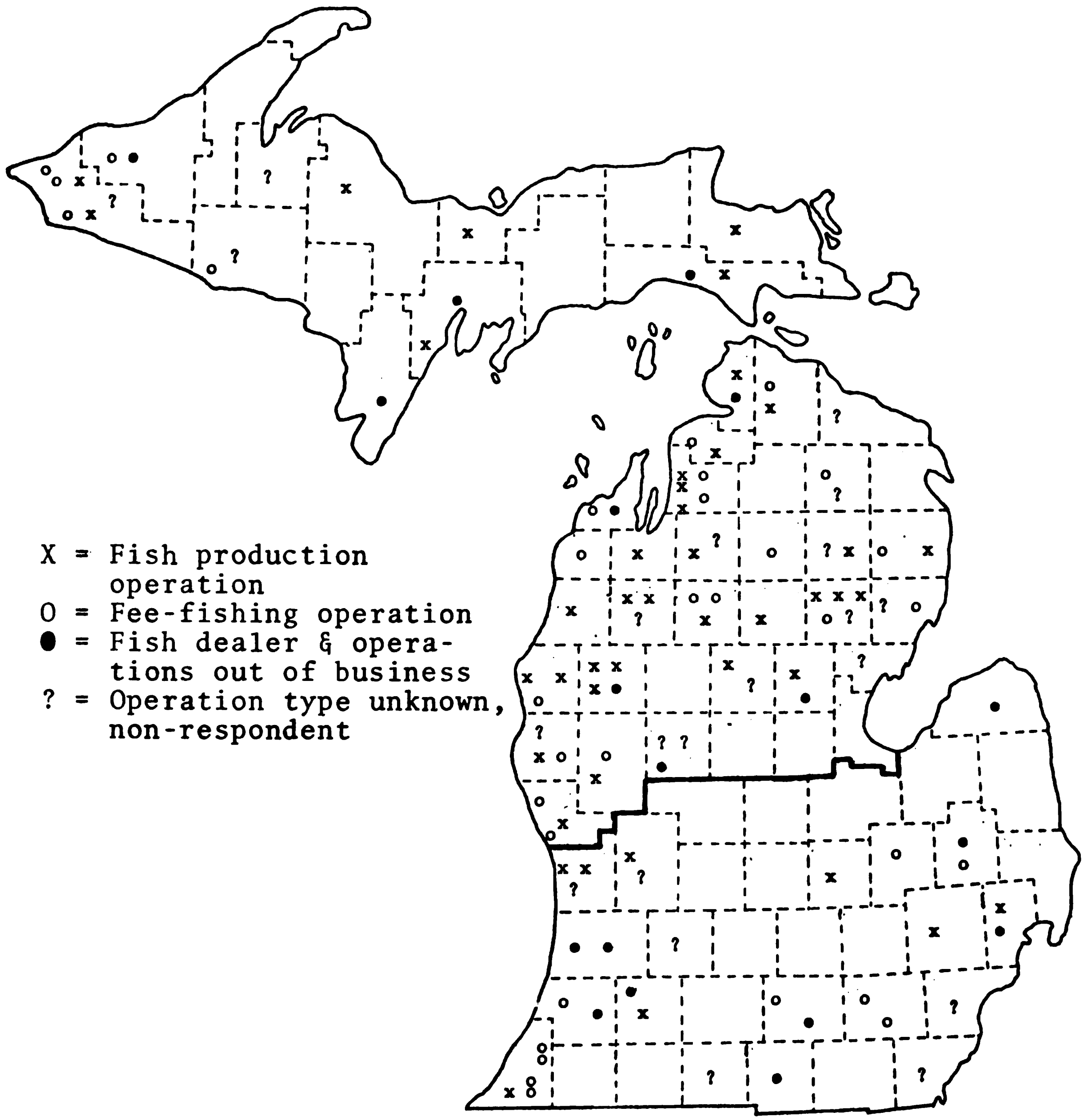

Figure 1. Locations of 1975 licensed Michigan aquaculture operations.

Basically, there are two different types of aquaculture operations in the state. The first is mainly a fish production enterprise, in which fish eggs, either taken from personal brood stock or purchased, are hatched and the resultant fry are raised to fingerlings or market-size fish and sold. Some production operations, however, start with fingerlings rather than eggs. Fish production operations accounted for approximately 40% (38 operations) of the total number of responding operations. The second type of operation is a fee-fishing enterprise. Here, either fingerlings or large-size fish (9 to 14 inches) are usually purchased from fish production operations and stocked. One operator, however, raised his own stock. Customers are allowed to catch fish on a paying basis, either by weight or the length of the fish. This type of operation accounted for 36% (34 operations) of the responding operations.

The remaining 24% of the responding operations consisted of: 9 operations (9%) which had gone out of business; 4 operations (4%) that were just starting operations; 6 operations (5%) that preferred not to answer the questionnaires; and 4 operations (4%) which were primarily fish dealers or agents.

The most common fish species cultured at production operations or stocked at fee-fishing operations in Michigan is trout, predominantly rainbow trout. Some fee-fishing operations, however, offer catfish, bass and bluegill fishing. In addition, some production operators were experimenting with the culture of black bass, hybrid sunfish, bluegills, and walleyes.

The Michigan aquaculture industry is quite small compared to Idaho's industry, especially in terms of volume of production. The 1973 Idaho industry produced an estimated 19.22 million pounds of trout and catfish worth approximately $25 million. The 1975 Michigan industry produced an estimated 550,000 pounds of trout (92% rainbow trout) worth approximately $700,000. The bulk of this production was sold as live fish for stocking private waters or for use in fee-fishing operations.

Most of the fish farms and fee-fishing operations are family owned and operated and employ very little outside help. In addition, the majority of the operations are considered by their owners to be "hobbies", providing secondary sources of income to their owners.

II. LITERATURE REVIEW

Awareness of aquaculture has increased considerably in the last ten years. A number of state and federal agencies, colleges and universities, and governments have undertaken various studies involving or relating to aquaculture. These studies, which provide information needed by existing fish farmers and other persons interested in the industry, are an encouraging sign for the continued development and improvement of aquaculture in the U.S. While there are many studies that involve or are related to aquaculture, the author has chosen to review four studies that appear to have relevance to the Michigan industry.

Klontz and King (1975) discussed the aquaculture industry in Idaho, which is one of the largest in the U.S. and is based primarily on rainbow trout farming. In 1973, the commercial food fish industry in Idaho produced an estimated 19.22 million pounds of rainbow trout and channel catfish, worth an estimated gross value of $25 million. This amounted to nearly 90% of the total U.S. production of processed rainbow trout and nearly 70% of the U.S. commercial production of both processed and live trout. Almost all of this production was exported out of Idaho. The Idaho industry in 1973 directly employed 302 persons, of whom approximately 50% were involved in raising fish per se with the other 50% involved in processing operations.

The Idaho industry is highly concentrated geographically. In 1974, the Idaho Fish and Game Commission issued 72 permits to commercially raise fish, with the majority of the permits issued in three counties near the towns of Buhl and Twin Falls, in south-central Idaho. There were in addition five major egg producers, six trout and catfish processing plants, and at least 16 fee-fishing operations.

Aquaculture in Idaho is expected to grow and, by 1977, fish production and gross dollar values are expected to double the 1973 figures. The primary reason for the large growth of this industry in Idaho is the availability of large quantities of water optimally suited for raising rainbow trout.

Several factors influencing the future growth of Idaho's food fish industry were delineated. These included: marketing practices; increasing production costs; water resources development; federal and state regulations regarding interstate shipment of live fish and/or their products; and fish husbandry practices. The report suggested a "symphonic orchestration" of the major segments of the food fish industry, namely, production and processing, sales and marketing. The need for coordination within the food fish industry and federal and state involvement in terms of financial and manpower assistance was also mentioned.

MacCrimmon, Stewart and Brett (1974) discussed the aquaculture industry in Canada. In 1972, there were 163 licensed private hatcheries and 113 licensed private commercial trout ponds. These private fish farmers produced approximately 1 million pounds, of which approximately 27% was sold as live fish and 73% was sold for human consumption. Sale of live fish was typically made on a local or regional basis and fish for human consumption were typically sold to restaurants or local customers. Very little of the production was exported. Salmonid species, particularly rainbow trout, were the major species cultured by private operators.

The report recognized that many factors, including favorable government policies, adequate and relevant research, legal status, government-industry cooperation, marketing, pollution control, relevant information dissemination, and capital and operating funds, must be considered in any attempt to aid aquaculture enterprises. G. I. Pritchard, of the Department of Environment, Fisheries and Marine Service, Canada, states in the report:

> The key to successful aquaculture will be found in innovation. The confluence of different fields of science and technology, the flowing together of information and expertise from many sources seems essential for innovation and surely this should be the situation that exists in Canada. There is plenty of demand for research and the generation of new ideas, but there is little room for isolation. The multi-disciplined approaches look most

> promising. It is the blend of biological, physical and social sciences of business acumen with environmental concerns, that is creating the most exciting ideas and developmens.

Brown, Holema and Hudson (1973) discussed the trout fee-fishing industry in Georgia. In 1972, a survey of 11 of an estimated 15 trout fee-fishing enterprises in Georgia revealed that the average operator had been in business 3.5 years, had 1.75 acres of ponds, sold more than 7,400 pounds of trout (predominantly rainbow trout), and collected approximately $5,000 in gross revenue. The study found that most of Georgia's trout industry is centered in the resort area of northeast Georgia, where more than 1,200 customers visited the average fee-fishing operation in 1972.

Georgia fee-fishing operations were basically of two types: (1) Those that grow trout from fingerlings to maturity in raceways or ponds. When the trout are of catchable size, they are transferred to small ponds where they are fished for by patrons. (2) Those that stock small ponds with catchable size trout purchased from a supplier. The operator orders fish on an "as needed" basis and has a large turnover. He is not interested in increasing trout size, so only enough feed is required to maintain body weight.

All fee-fishing operators charged customers by the pound of live trout caught, averaging $1.55 per pound. Most operators cleaned the fish and packed them in ice for a nominal additional charge. The average total catch per fisherman weighed approximately 6 pounds and cost him $10.10.

Gross incomes ranged from $1,300 to $25,000 per year and averaged $12,254. Total annual costs averaged $7,243, with variable costs accounting for 98% of the total annual costs. The cost of fish was the major variable expense, accounting for 97% of the annual variable costs and 95% of the total annual costs. Average annual net income for family labor and management was approximately $5,000 for 120 to 150 operating days per year.

Gilbertson (1971) discussed the economic feasibility of aquaculture in the United States. He indicated that interest in aquaculture as an alternative way of obtaining fish supplies has increased as the commercial catch of freshwater fish has declined. The potential for increasing fish production exists, and food and protein needs will increase substantially in the future based on population growth projections. He states:

> However, neither the need for protein nor the large potential production capacity of aquaculture is sufficient to ensure that a viable fish-farming industry will develop. Whether this will occur depends partly upon the effective demand for fish, which is a function of prices, tastes, preferences, market distribution facilities, competition with other foods and income levels.

Gilbertson suggests that the potential demand for the increased amount of fish that could be produced in aquaculture facilities is not particularly strong. He states:

Fish is not a staple in the U.S. diet; the demand for fish is not growing rapidly; and if fish farmers increase production substantially, industry returns may decline. The nature of the product may be such that the demand for aquaculturally produced fish can be expanded by modern merchandising and marketing techniques. Indeed, it seems evident that if aquaculture is to develop into an industry even roughly comparable to the poultry industry of the South, a substantial amount of market development effort will be necessary. If a viable industry develops, it will probably consist of larger firms (or large producer cooperatives) which can handle the complex production and merchandising techniques that may be required to raise and market food fish.

III. METHODOLOGY

A two-phase survey was conducted in an attempt to collect the needed data and information and fulfill the stated objectives.

Phase I

Phase I was conducted from March to June 1976. A one-page pretested questionnaire (Appendix A) was mailed to each of the 117 licensed aquaculture operators existing in the state in 1975. With respect to his 1975 operation, each operator was requested to:

(1) indicate his primary aquaculture business activity (fish production, fee-fishing, fish dealer or agent).

(2) indicate his secondary aquaculture business activity.

(3) indicate the total gross income received from his aquaculture activities.

(4) indicate the percent of the total gross income received that was represented by each aquaculture business activity conducted.

Fifty-four (54) operators responded to Questionnaire I within 30 days. Operators who had not responded within 30 days were sent a reminder and another copy of the questionnaire. This mailing yielded 16 additional responses. Operators who had not responded to either mailing were surveyed via telephone. In total, 95 operators responded to Questionnaire I.

The responses obtained through this questionnaire were used to classify each individual operation into one of three categories: fish production, fee-fishing, or fish dealer. The operations in each category were then stratified into two or three sub-categories, based on annual gross incomes.

Phase II

Phase II was conducted during June and July 1976. A sample (non-random) was drawn from each of the sub-categories established in Phase I. If a sub-category had many members (10 or more operations), a sample size of at least 20% was selected. Sub-categories with fewer members were completely sampled. The selected operations were then visited and the owner interviewed. Each owner was requested to provide information about his 1975 operation in the following major areas (Appendices B and C):

A. Background information
B. Fish
C. Facilities
D. Business activities
E. Water
F. Feeds
G. Disease
H. Mortalities
I. Management
J. Information assistance
K. Present problems and needs
L. Future plans
M. Costs and returns

A total of 31 operations, or 26% of all licensed operations, were interviewed. One large fish production operator declined to complete Questionnaire II. The missing information was completed based on the data from two similar operations. All figures reported in this thesis are based on the assumption that this operation was sampled. The information received through the interviews was evaluated and consolidated into this thesis.

Many difficulties are inherent in conducting a study of this type and in reporting the results. Perhaps the greatest difficulty encountered was the variability found among the operations, both fish production and fee-fishing. Each individual operation differs in some ways from other operations and the reader is requested to keep this in mind, especially when reviewing the physical, biological, business characteristics and costs and returns.

IV. FISH PRODUCTION PROFILE

A. Background Information

Fish production operations comprised approximately 40% (38 operations) of the responding operations. Large, medium, and small operations, as used in this report, are defined on the basis of annual gross incomes received by the operations. Large operations are those that recorded an annual gross income greater than $40,000. Medium operations are those with an annual gross income between $10,000 and $40,000. Small operations are those with an annual gross income of less than $10,000. The majority (63%) of the responding operations were small. Medium and large operations accounted for 26% and 11%, respectively, of the total fish production operations that responded. The large operation category was composed of three operations which were similar and one operation which was very large.

The majority of the fish production operations have been managed by the existing owner for 9 to 14 years. Large operations are usually the primary occupation of their owners and employ limited full or part-time help. Smaller operations tend to be a secondary occupation of their owners and were family operated, employing no full or part-time help.

Rainbow trout comprised 92% of the total production by weight in 1975. Operators estimated that it takes approximately 1.5 to 2.0 years to produce a market-size trout (9 to 14 inches in length with a live weight of 3/4 pound to one pound). This estimate varied with water temperature, strain of fish and feeds. Two operators estimated their complete production costs at $0.80 to $0.90 per pound of trout.

B. Fish

Eggs

Approximately 80% (9 operations) of all production operators who responded started with fish eggs. These eggs were either produced from the owner's brood stock (50%) or purchased outside the state (50%). The number of eggs per operation ranged from 13,000 to 1,500,000 and averaged 205,868 (Table 1). Medium and large operations tended to produce or purchase more fish eggs than did small operations. The large number of eggs reported for medium-sized operations was due to one operator greatly expanding his egg production in 1975. The majority of the operators used either incubators or troughs.

Fingerlings

Thirty-five percent (3 operations) of the responding production operators purchased additional fingerlings. These fingerlings were purchased from other, usually larger, fish production operations in Michigan, and were

Table 1. Physical, biological and business characteristics of fish production operations, Michigan, 1975

Item	Size of Operation: Large	Medium	Small	Average
Number of samples	4	4	5	13
Facilities				
Average culture area (acres)	4.11	3.30	1.39	2.18
Range (acres)	*	0.62-10.90	0.07-4.02	0.07-10.90
Eggs				
Average number of eggs/year	511,250	450,000	53,250	205,868
Range	*	100,000-1,100,000	13,000-100,000	13,000-1,500,000
Fingerlings				
Average number of fingerlings/year	235,000	112,500	27,750	71,868
Range	*	75,000-150,000	6,000-75,000	6,000-600,000
Market-size fish (growers)				
Average number of growers/year	165,000	48,750	27,400	47,502
Range	*	30,000-75,000	5,000-100,000	5,000-270,000
Average total weight of growers/year (lb)	55,875	13,500	9,100	15,181
Range (lb)	*	11,000-16,000	1,500-30,000	1,500-91,500
Markets (average % of total annual gross income)				
Fingerling sales	6	11	11	11
Market-size *live* fish sales	67	71	76	74
Market-size processed fish sales	25	3	0	3
Fee-fishing sales	2	15	13	12
	100%	100%	100%	100%
Feed conversion (dry weight of feed/wet weight gain of fish)				
Average	1.5	1.7	2.6	2.2
Range	*	1.5-2.2	2.0-3.7	1.1-3.7
Selling price of market-size *live* fish				
Average (dollars/lb)	1.30	1.60	1.20	1.31
Range (dollars/lb)	*	1.00-2.00	0.80-1.80	0.80-2.00

*Data not included to avoid revealing individual information.

used to augment an operation's stock. Two operators (20%) started their operations with fingerlings instead of eggs. The number of fingerlings per operation ranged from 6,000 to 600,000 and averaged 71,868 (Table 1). Medium and large operations tended to handle more fingerlings than did small operations. The large average number of fingerlings at medium-sized farms was due to one operator expanding his production.

Market-Size Fish

All responding operators produced market-size fish (growers) 9 to 14 inches in length. The number of growers on hand or produced per operation ranged from 5,000 to 270,000 and averaged 47,502 (Table 1). The weight of these fish ranged from 1,500 pounds to 91,500 pounds and averaged 15,181 pounds (Table 1).

The number and weight of growers per operation greatly decreased, going from large to small operations. This difference is reflected in the different annual gross returns for each size of operation (Table 3).

C. Facilities

Ponds were the most common fish culture facility used, accounting for 85% of the total fish culture area. Pond shapes and sizes varied but most were of earthen construction and averaged 3 feet deep. Other ponds were constructed with concrete sides and earth or gravel bottoms. In addition to ponds, most operations used one or two raceways and/or cement or metal tanks. The amount of surface culture area varied considerably among operations. Surface area per operation ranged from 0.07 acres to 10.90 acres and averaged 2.18 acres (Table 1). In general, there was a decrease in the amount of surface culture area going from large to small operations.

D. Business Activities

In 1975, fish producers of all sizes had one major market (sale of market-size *live* fish) and one or more minor markets (sale of fingerlings, market-size processed fish or fee-fishing).

The sale of market-size *live* fish (growers), on the average, accounted for 74% of an operation's annual gross income (Table 1). From 50% to 85% of the growers produced at each operation were sold for stocking in private waters (farm ponds, fishing clubs, private lakes, etc.) within Michigan. The remaining percentage was sold to intermediate fish dealers, fee-fishing operations and other fish production operations. The selling price per pound of *live* market-size trout varied between $0.80 and $2.00, and averaged $1.31.

The sale of fingerlings, on the average, accounted for 11% of an operation's annual gross income (Table 1). This market source tended to be more important to medium and small operations than to large operations. Most of the fingerlings were sold for stocking in private waters within Michigan. Otherwise they were sold to fee-fishing operations and other fish production operations. Approximately 90% of the fingerlings were sold within Michigan.

Fee-fishing, on the average, accounted for 12% of an operation's annual gross income (Table 1). Again, this market was more important to medium and small operations than to large operations.

The sale of market-size processed fish, on the average, accounted for 3% of an operation's annual gross income. This market source tended to be dominated by large operations. An average of 25% of a large operation's annual gross income came from this source, compared to averages of 3% and 0% for medium and small operations, respectively. The majority (80%) of the processed fish were sold dressed and were sold directly to supper clubs and restaurants. The selling price per pound of dressed trout ranged from $1.45 to $2.00 and averaged $1.75.

E. Water

Water supply sources were fairly evenly distributed between natural wells (artesian), pump wells, springs, creeks and rivers. Natural wells and especially pump wells were mainly used in hatchery operations. Water temperatures varied considerably, depending on the source, and ranged between 45 to 65 F. Flow rates also varied but were usually above 75 gpm per well or spring. The majority of the used water was discharged into small rivers or creeks. The larger farms usually settled their water in a settling pond before discharging.

Very few serious water quality or supply problems were encountered in 1975. One operator encountered siltation of his water supply (river) and lost part of his stock.

Approximately 50% of the operations aerated their water sometime during the year: 25% of all operations aerated their water all of the time. None of the respondents recycled their water.

F. Feeds

All of the respondents used commercially prepared fish feed (pellets), administered by hand. Most farms fed at least once daily, except in the winter, when fish were fed once every 2 to 3 days. Smaller fish were usually fed 2 to 3 times per day during the summer months. Very few operators used feeding schedules, with the majority of the operators feeding each pond or raceway until the fish stopped actively taking the feed. Common feed brands used were Mastermix, Glenco and Purina. The specific feed brand used by an operator usually depended on its availability and personal evaluation of its past performance. Many of the operators mentioned that they had to try two or three different brands of feed before finding the brand that was best suited to their operation.

Feed conversions varied considerably from operation to operation. Conversions (dry weight of feed/wet weight gain of fish) at medium and large operations tended to be lower than at small operations, ranging from 1.1 to 2.2 and averaging 1.6 (Table 1). Conversions on small farms ranged from 2.0 to 3.7 and averaged 2.6. The unfavorably high feed conversion rates at small operations indicates that greater feed efficiency might be obtained, thus reducing feeding costs.

G. Disease

None of the respondents encountered any major fish disease problems. Problems, including bacterial gill infection and fin rot, were common but were treated and caused only minor losses.

H. Mortalities

Mortalities varied considerably from operation to operation. Egg mortalities ranged from 25% to 100% and averaged approximately 50%. The mortality for fish, 1 to 6 inches in length, was 5% to 10% for all operations. Mortality for fish larger than 6 inches ranged from 1% to 10%. The major cause of mortality among the large fish was predation by birds (herons, kingfishers, etc.).

I. Management

Record keeping activities were usually minimal, especially at the smaller operations. Purchase and sales records were commonly kept. Stock inventory, growth rates, feeding rates and water quality records were occasionally kept by the larger operations, on a monthly basis. In general, the larger operators tended to keep more and better records regarding their operations. In addition, the operators of the more profitable operations in all three size categories closely managed all aspects (feeding, mortalities, costs, etc.) of their operation.

V. FEE-FISHING PROFILE

A. Background Information

Fee-fishing operations comprised approximately 36% (34 operations) of the responding operators. Large and small fee-fishing operations, as used in this thesis, are defined on the basis of annual gross incomes received. Large operations recorded annual gross incomes greater than $10,000 and small operations recorded annual gross incomes of less than $10,000. The majority (91%) of the operations were small in size. Fee-fishing operations were located throughout Michigan, with no heavy concentration in any one area. Most of the fee-fishing operations have been operated by the present owner for an average of ten years. Almost all of the operations were family-run enterprises, providing a secondary source of income and requiring very little or no part-time help. Large operations usually provided the primary occupation for their owners and limited help was employed.

Most of the operations were open to the public for 6 to 8 months per year, although some operations remained open throughout the year. The busiest months for business were June, July and August, followed by May and September.

B. Fish

Almost all of the respondents stocked their ponds or raceways at least once a year, with the majority stocking 3 to 8 times per year. Most operations stocked catchable-size fish, 9 inches or longer, which were purchased from fish production operations in Michigan. On the average, small operations stocked 2,580 fish per year and large operations stocked 19,000 fish per year (Table 2). Rainbow trout was the most common fish species stocked at Michigan fee-fishing operations.

C. Facilities

Earthen ponds were the most common fishing facility used by fee-fishing operators. In addition, raceways, usually made of concrete sides and earthen bottoms, were used for fishing by some operators. Most operations had two or more ponds, but would allow fishing in only one or two ponds. Total water surface area among all operations ranged from 0.11 acres to 4.03 acres and averaged 0.96 acres (Table 2). Total surface area used for fishing ranged from 0.02 acres to 1.51 acres and averaged 0.45 acres, or 47% of the average total water surface area. Large operations, on the average, had 5 times the amount of total water surface area and approximately twice the amount of surface area actually fished than small operations.

Almost all respondents provided fishing equipment, usually free-of-charge, to their customers. Most operations

Table 2. Physical, biological and business characteristics of fee-fishing operations, Michigan, 1975

Item	Size of Operation		Average
	Large	Small	
Number of samples	2	6	8
Facilities			
Average culture area (acres)	3.52	0.72	0.96
Range (acres)	*	0.11-1.95	0.11-4.03
Average area fished (acres)	0.76	0.42	0.45
Range (acres)	*	0.07-1.01	0.02-1.51
Fish			
Average number of fish stocked/year	19,000	2,580	4,029
Range	*	1,000-5,000	1,000-28,000
Business			
Average number of paying fishermen/year	1,750	464	577
Range	*	335-1,000	335-2,000
Average charge per customer (dollars/customer)	10.50	4.63	5.15
Range (dollars/customer)	*	3.50-6.00	3.50-14.00

*Data not included to avoid revealing individual information.

also provided fish cleaning, bagging and icing for a nominal additional charge. Other services and facilities occasionally provided included food and beverage, picnic areas and camping.

D. Business Activities

Approximately 75% of the paying customers in 1975 were composed of families with children. The remaining percentage was composed of individual adult fishermen and special groups.

The number of paying customers per operation ranged from 335 to 2,000 and averaged 577 (Table 2). Charges per customer ranged from $3.50 to $14.00 and averaged $5.15. The average number of customers and the average charge per customer were greater for large operations than for small operations. This large difference is probably due to geographic locational factors. The percentages of paying customers who were not residents of Michigan varied among operations from 12% to 56%.

The majority of the operations charged the customer on the basis of the length of the fish caught. This charge ranged from $0.10 to $0.17 per inch and was usually graduated (the longer the fish, the higher the charge per inch). Other operators charged their customers by the weight of the fish caught. This charge ranged from $1.50 to $2.00 per pound. In addition, some operators charged by the inch for smaller fish and by the pound for larger fish.

Additional charges for services (fish cleaning, bagging, icing, etc.) and facilities offered to the customers accounted for less than 5% of the total annual gross returns.

E. Water

The major water supply sources used by fee-fishing operators were natural wells (artesian), springs, creeks and rivers. Pump wells were used by only a few operations. Almost all of the operators discharged used water into creeks or small rivers.

The majority of the operations indicated that they did not encounter any serious water quality or supply problems. Two operations, however, lost most of their stock due to poisoning, caused by careless chemical spraying on adjoining agricultural land.

F. Feeds

All respondents used commercially prepared fish feed (pellets). Most operators fed the fish daily during the summer months and two to three times per week during the winter. Some operators fed less during the peak fishing season in an attempt to ensure hungrier and more aggressive fish for their customers. Most operators used feed only to maintain body weight, and not to increase the weight of the fish.

G. Disease

None of the respondents encountered any serious disease problems. Most operators tried to guard against diseases by buying only healthy fish. Some operations encountered bacterial gill infections and fin rot, but these were usually treated early and caused no serious losses.

H. Mortalities

The majority of the operators reported an annual mortality of 5% to 10% for fish 9 inches and longer. Most of this mortality was caused by hooked and released fish and predation by birds (herons and kingfishers). All operations required that each hooked and landed fish be kept by the customer in order to guard against large mortalities.

I. Management

The majority of the operators limited their record keeping activities to purchases and sales records only. Large operations usually kept water quality and fish inventory records on a weekly or monthly basis.

VI. COSTS AND RETURNS

Information on the costs and returns of each individual operation was recorded based on a "typical year" of business and not necessarily on last year's (1975) business. Costs and returns were computed separately for each size of fish production and fee-fishing operation (Tables 3 and 4). The various components of the costs and returns tables as discussed by Smith (1973) are presented below.

Gross revenue. The total annual value of all goods and services sold before any deductions. Annual gross revenues were computed as indicated by the operators.

Variable costs. These include all costs that vary as the volume of business varies. Feed, fish, utilities, labor, chemicals, maintenance, and miscellaneous and advertising costs were computed as indicated by the operator. Transportation expenses were based on yearly mileage, computed at $0.15 per mile. Interest on borrowed operating capital was computed at 9% per annum based on a 6-month production period for fish production operations and a 3-month period for fee-fishing operations.

Fixed costs. These are all costs that remain constant regardless of the volume of business. License, insurance, legal bookkeeping, and property tax costs were computed as indicated by the operator. Equipment and facilities were depreciated by the straight-line method with a 10% salvage value.

Opportunity costs

Operator's labor. The estimated value of the operator's time, or the amount the operator could have earned working for someone else. An hourly wage rate of $3.50 (as used by Kelsey, 1976) was used in this analysis for both fish production and fee-fishing operators.

Operator's management. The estimated value of the operator's management (decision-making and risk) or the amount that he could have earned managing another similar business. This opportunity cost was arbitrarily assumed to be 10% of the annual gross returns as used by Smith (1973).

Total investment. The estimated fair return (interest) to the total investment, regardless of actual debt, arbitrarily computed at 8.5% annual compound interest rate.

Return to labor, management and investment. Earnings for the owner's time, skill, risk, decision-making and money invested in his business. All costs have been subtracted except the operator's labor, management and total investment. This return is available to pay interest and principal on actual debts, to support the operator's family and to pay income taxes.

Return to operator's labor and management. This is what the operator earned for his time, skill, risk, and decision-making invested in the business. All costs (including the opportunity cost of total investment), except the operator's labor and management, have been subtracted.

Return to investment. This is what the total investment earned in the business. All costs except the opportunity cost of investment have been subtracted.

A. Fish Production Operations

Revenue

Total annual gross revenues for all respondents ranged upward from $2,000 and averaged $20,684 (Table 3). Average annual gross revenue for large, medium and small operations was $92,875, $27,000 and $6,020, respectively.

In general, the large differences in annual gross incomes were related to the volumes of production and sale of market-size *live* fish for each size of operation. Large operations, on the average, produced 55,875 pounds of growers (fish 9-14" in length) and marketed 75% of this production or approximately 41,906 pounds, accounting for approximately 70% of a large operation's average annual gross income. Medium-size operations, on the average, produced 13,500 pounds of growers and sold approximately 80% of this production, accounting for 64% of a medium-size operation's average annual gross income. Small operations, on the average, produced 9,100 pounds of growers and sold approximately 44% of this production,

Table 3. Average cost and returns of fish production operations, Michigan, 1975

Item	Size of Operation							
	Large		Medium		Small		Average	
Number of samples	4		4		5		13	
(1) Gross revenue	$92,875		$27,000		$6,020		$20,684	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
Variable costs								
Feed	31,250	47.7	8,125	45.7	2,500	51.4	7,007	47.8
Fish	750	1.1	1,187	6.7	770	15.8	878	6.0
Utilities	3,375	5.1	1,150	6.5	150	3.1	752	5.1
Labor	10,000	15.3	550	3.1	0	0	1,197	8.2
Chemicals	48	*	212	1.2	100	2.1	124	*
Transportation	8,750	13.3	3,375	19.0	465	9.6	2,103	14.3
Maintenance	2,938	4.5	1,325	7.4	640	13.2	1,062	7.2
Misc. advertising	3,175	4.8	1,087	6.1	29	*	639	4.4
Interest on operating capital	5,285	8.1	766	4.3	209	4.3	890	6.1
(2) Total variable costs	65,571	100.0	17,777	100.0	4,863	100.0	14,652	100.0
Fixed costs								
License fees	204	1.9	5	*	5	*	26	*
Insurance	1,281	11.9	406	11.6	130	7.1	324	10.1
Legal bookkeeping	650	6.1	237	6.8	5	*	134	4.2
Taxes	2,263	21.1	744	21.3	298	16.2	622	19.4
Depreciation	6,325	59.0	2,100	60.1	1,400	76.2	2,103	65.5
(3) Total fixed costs	10,723	100.0	3,492	100.0	1,838	100.0	3,209	100.0
Opportunity costs								
(4) Operator's labor ($3.50/hr)	6,300		4,900		2,450		3,500	
(5) Operator's management (10% of gross)	9,288		2,700		602		2,068	
(6) Total investment (8.5% interest)	5,844		3,400		2,125		2,852	
Summary								
Return to labor, management and investment (1 less 2 and 3)	16,581		5,731		-681		2,823	
Return to labor and management (1 less 2, 3 and 6)	10,737 ($5.96/ work hour)		2,331 ($1.66/ work hour)		-2,806		-29	
Return to investment (1 less 2, 3, 4 and 5)	993 (1.4% return)		-1,869		-3,733		-2,745	

*Less than 1%.

accounting for 80% of a small operation's average annual gross income.

The large differences in the selling prices of live fish between large, medium and small operations cannot be clearly explained. Most likely, however, this difference is due to the individual market arrangements that each operator has with his buyers.

Variable Costs

On the average, variable costs accounted for 82% of the total annual costs, averaging $14,652 (Table 3). Variable costs for large, medium and small operations accounted for 86%, 84% and 73%, respectively, of the total annual costs.

Feed was the largest single variable expense for all sizes of operations, averaging 47.7%, 45.7% and 51.4% of annual variable costs for large, medium and small operations, respectively. Greater feed efficiency can probably be obtained by smaller operators through careful analysis of feed types used, feeding rates and methods.

Transportation costs were the second largest variable expense, averaging 14.3% of annual variable costs. This cost was higher for medium and large operations, averaging 19.0% and 13.3%, respectively, of the annual variable costs.

Labor costs were an important variable cost for large operations, averaging 15.3% of the total annual variable costs. Labor costs were less important for medium and small operations as these operations employed very little or no paid labor.

Fish and maintenance costs were important variable costs for small operations, averaging 15.8% and 13.2%, respectively, of the annual variable costs. The major reason for this was because some smaller operators purchased additional fingerlings to augment their stock.

Utility, chemical, advertising and interest on operating capital were minor variable expenses for all sizes of operations.

Fixed Costs

On the average, fixed costs accounted for 18% of the total annual costs (Table 3). Fixed costs accounted for 14%, 16% and 27% of total annual costs for large, medium and small operations, respectively.

Equipment and facilities depreciation was the major fixed cost item, accounting for 59.0%, 60.1% and 76.2% of the total fixed costs for large, medium and small operations, respectively.

Taxes and insurance costs were the other major fixed costs, averaging 19.4% and 10.1% for all sizes of operations (Table 3). Higher tax and insurance costs for medium-size operations is attributed to the larger acreage held by these farms.

Opportunity Costs

Operator's labor. Operator's labor time per year varied considerably from operation to operation. In this thesis an average of 1,000 hours of labor per year is used. Yearly averages of labor hours for large, medium and small operations are 1,800, 1,400 and 700, respectively. An hourly wage rate of $3.50 is assumed.

On the average, this cost amounted to $3,500 per year (Table 3). Operator's yearly labor costs for large, medium and small operations were $6,300, $4,900 and $2,450, respectively.

Operator's management. This opportunity cost was based on 10% of the annual gross returns, amounting to $9,288, $2,700 and $602 for large, medium and small operations, respectively (Table 3). On the average, this cost was $2,068.

Total investment. Total investment varied considerably from individual operation to operation. Items included in computing the total investment were: necessary land, ponds and raceways, hatchery, truck, hauling tank, nets and seines, aerators, incubators, wells and pumps. Total investment values for large, medium and small operations were estimated to be $68,750, $40,000 and $25,000, respectively. An 8.5% annual return to total investment is assumed.

On the average, this opportunity cost amounted to $2,852 (Table 3). Opportunity costs for total investment for large, medium and small operations were $5,844, $3,400 and $2,125, respectively.

Returns to the Firm

Average returns to labor, management and investment were low for all three sizes of operations (Table 3). In particular, the average annual return of small operations was not sufficient to cover annual operating costs. Returns to labor and management were positive for both large and medium-sized operations. Based on labor requirements of 1800 hours and 1400 hours for large and medium-sized operations, respectively, large operators received $5.96 per work hour and small operators received $1.66 per work hour for their labor and management. Large operators were the only operators to receive a positive return to investment, averaging 1.4%. This is a relatively low return when compared to other businesses.

The data suggest that, on the average, larger scale operations may be more profitable than smaller operations. Insufficient data exist to precisely determine the optimum size of operation. The few operations surveyed, however, suggest that an investment of approximately $100,000 may be necessary to break even, assuming proper management and market conditions.

The reader is again cautioned when reviewing the cost and returns. As stated earlier, a great deal of variability existed among the operators in all three sizes of operations. Some operations within each size category were more profitable than others. The average cost and returns should be used only as a guide.

B. Fee-Fishing Operations

Revenue

Total annual gross revenues for all respondents ranged from $1,000 to $20,000 and averaged $3,641 (Table 4). Average annual gross revenues of large operations were approximately 8 times greater than small operations. This large difference was due to the greater number of paying customers and the higher charge per customer at large operations. The locational advantages of the larger fee-fishing operations was probably the main reason for this difference.

Variable Costs

On the average, variable costs accounted for 77% of the total annual costs, averaging $2,754 (Table 4). Variable costs for large and small operations accounted for 88% and 73%, respectively, of the total annual costs.

Fish cost was the largest single variable expense item, averaging 49.3% of annual variable costs. This cost was greater for small operations than for large operations, averaging 57.7% of annual variable costs. The reason for this difference is probably due to higher prices paid by small operators for the smaller quantities of fish needed to stock their ponds.

Feed cost was the second major variable expense item. On the average, feed costs accounted for 24.1% of the annual variable costs. This cost accounted for a slightly

Table 4. Average costs and returns of fee-fishing operations, Michigan, 1975

Item	Size of Operation					
	Large		Small		Average	
Number of samples	2		6		8	
(1) Gross revenue	$17,525		$2,297		$3,641	
	Dollars	Percent	Dollars	Percent	Dollars	Percent
Variable costs						
Feed	3,100	26.0	430	22.0	665	24.1
Fish	3,750	31.5	1,127	57.7	1,358	49.3
Utilities	1,775	14.9	86	4.4	235	8.5
Labor	1,250	10.5	0	0	37	1.3
Chemicals	68	*	29	1.5	32	1.2
Transportation	300	2.5	105	5.4	122	4.4
Maintenance	750	6.3	100	5.1	157	5.7
Misc. advertising	650	5.5	33	1.7	87	3.2
Interest on operating capital	262	2.2	43	2.2	61	2.2
(2) Total variable costs	11,905	100.0	1,953	100.0	2,754	100.0
Fixed costs						
License fees	5	*	5	*	5	*
Insurance	400	24.6	40	5.4	72	8.7
Legal bookkeeping	18	1.1	46	6.2	43	5.2
Taxes	200	12.3	150	20.2	154	18.6
Depreciation	1,000	61.6	500	67.5	555	66.9
(3) Total fixed costs	1,623	100.0	741	100.0	829	100.0
Opportunity costs						
(4) Operator's labor (1000 hrs/yr · $3.50/hr)	3,500		3,500		3,500	
(5) Operator's management (10% of gross)	1,753		230		364	
(6) Total investment (8.5% interest)	1,700		856		944	
Summary						
Return to labor, management and investment (1 less 2 and 3)	3,997		-397		58	
Return to labor and management (1 less 2, 3 and 6)	2,297 ($2.30/ work hour)		-1,253		-886	
Return to investment ((1 less 2, 3, 4 and 5)	-1,256		-4,127		-3,806	

*Less than 1%.

larger portion of the annual variable costs of large operations than for small operations.

Utility and labor costs were major variable cost items for large operations, averaging 14.9% and 10.5%, respectively, of the annual variable costs.

Chemical, transportation, maintenance, advertising and interest on borrowed operating capital were minor variable cost items for both sizes of operations.

Fixed Costs

On the average, fixed costs accounted for 23% of the total annual costs (Table 4). Fixed costs for large and small operations averaged 22% and 27%, respectively, of the total annual costs.

Equipment and facilities depreciation was the major fixed cost item, averaging 61.6% and 67.5% of the annual fixed costs for large and small operations, respectively.

Taxes and insurance cost were the other major fixed cost items, especially for large operations. On the average, these two items represented 36.9% and 25.6% of annual fixed costs for large and small operations, respectively.

Opportunity Costs

Operator's labor. Operator's labor time per year varied considerably from operation to operation. Since most of the operations were family-run enterprises, labor requirements were usually met from within the owner's immediate family (including spouse and children). In general, most operations were open for business 6 to 8 hours per day, 5 to 7 days per week for 150 to 240 days per year. Based on the above information, labor requirements were estimated at approximately 1000 hours per operating year. At an hourly wage rate of $3.50, this opportunity cost amounted to $3,500 (Table 4). This estimate is the same for both large and small operations.

Operator's management. This opportunity cost was calculated at 10% of the annual gross revenues and amounted to $1,753 and $230 for large and small operations, respectively (Table 4). On the average, this cost was $364.

Total investment. Total investment varied considerably from individual operation to operation. Items included in computing the total investment were: necessary land, ponds, buildings, fishing equipment, aerators, wells, pumps, refrigerator-freezer, lawn mower and advertising signs. Total investment values for large and small operations were $20,000 and $10,000, respectively. An 8.5% return to total investment is assumed.

Costs for total investment for large and small operations were $1,700 and $856, respectively (Table 4).

Returns to the Firm

Average returns to labor, management and investment were low for both sizes of operations (Table 4). In particular, the average annual return of small operations was not sufficient to cover annual operating costs. Returns to labor and management were positive only for large operations. Based on an annual labor requirement of 1000 hours, large operators received only $2.30 per work hour for their labor and management. The data indicate that large operators are accepting lower returns to labor and management than assumed in the analysis. Neither size operation recorded a positive return to investment. Insufficient data exist to precisely determine the optimum size of operation. The data suggest, however, that larger scale operations may be more profitable than smaller operations, assuming proper management and location. Again, the reader is reminded that some operations are more profitable than others. Not all had negative returns.

VII. CURRENT CONCERNS OF THE MICHIGAN INDUSTRY

The Michigan aquaculture industry, like many other "small-scale" industries, has its problems and needs. These problems not only hinder development and improvement of the industry, but have in some cases actually forced operators out of business. Mostly, these problems are a result of the "newness" of the aquaculture industry and a lack of general understanding of what aquaculture is, what it does and how it operates. Many of these problems are also shared by aquaculture industries in other states.

Common concerns expressed by Michigan operators included: regulations, financing, insurance, marketing, increasing production costs, cooperation and assistance, and public relations. Two of the most common concerns, regulations and financing, are discussed below.

(1) Regulations. Regulations directly affecting aquaculture operations were a common concern expressed by operators throughout the state. In particular, many operators expressed concern over the existing water use regulations and NPDES (National Pollutant Discharge Elimination System) guidelines. Basically, NPDES guidelines require that all aquaculture operations with 20,000 pounds or greater of fish over a 30-day period, apply for a NPDES permit. Presently, those operations with less than the

above amount are not required to have this permit. Operators with permits are required to have their discharge water meet specific Michigan water quality standards and guidelines which are patterned after national guidelines. Operators, in addition, are required to monitor their water and submit monthly readings on various water quality parameters. Many operators feel that this permit hinders the development and expansion of their operations. Many stated that the costs of monitoring their water would be prohibitive and would force them to keep production below 20,000 pounds or leave the industry altogether.

The majority of the operators also felt that permit issuing procedures, whether for expansion, construction of a new facility, or for other reasons, are too complicated and should be simplified. These operators believe in the protection of the aquatic environments from which they derive their incomes. They feel, however, that regulations should be "reasonable."

(2) Financing. Financing was another major concern of the existing operators. At present, very few lending institutions offer loans to operators, and those that do, do so on a haphazard basis. This situation is unfortunate but understandable, in view of the "newness" and limited understanding of the aquaculture industry by lending institutions. As aquaculture becomes more "capital intensive" steps should be taken to secure adequate loans for existing and prospective operators. Without sufficient

capital, the existing industry cannot expand and improve operations. Lack of financing also hinders entry by new operators into the industry.

VIII. OUTLOOK AND CONCLUSIONS

On a world-wide basis, aquaculture is expected to continue to increase in importance. Total world fish production through aquaculture, which presently is slightly over six million tons, is expected to double by 1985. In the United States, aquaculture activities are also expected to increase. Frost and Sullivan, a New York based marketing research firm, recently completed a four-month study of fishing activities in the U.S. The firm estimated that by 1982 fish raised in captivity will total 848 million pounds, or about 15% of the total edible U.S. catch, up from 130 million pounds, or 5% of the catch in 1974. The firm also estimates that annual sales of fish raised on farms could total $374 million by 1982 compared with $54 million in 1974.

Policy makers, at both state and federal levels, are also beginning to take a more active interest in aquaculture. Recently, a bill was introduced into Congress to encourage the development of aquaculture in the United States. This bill (HR. 14695) was introduced into the House of Representatives on July 2, 1976, by 22 members of the Subcommittee on Fisheries and Wildlife Conservation and the Environment of the House Committee on Merchant Marine and Fisheries. Various leaders of the nation's commercial aquaculture industry are providing input into this legislation and reaction to its contents has been generally favorable. Highlights of the bill include: the development of a National Aquaculture Plan; loan guarantee program; insurance program; disaster loan program; research grants to federal and state agencies, universities, regional commissions, private businesses and corporations and individuals; extension and educational services; and the formation of a Federal Interagency Committee on Aquaculture. This legislation and its modifications, which have not yet been finalized or approved, could take great strides in developing and improving aquaculture throughout the United States, hopefully for both large and small operators alike.

If aquaculture continues to grow and develop as predicted, what role will Michigan operators assume? This question is very difficult to answer.

For the majority of the fish production and fee-fishing operators, their operation exists as a "hobby" which provides them with many returns (aesthetic, self-satisfaction, fish for the family table, etc.) besides economic returns. Most likely, many of these operations (fee-fishing operations in particular) will continue to operate as such. Higher operating costs (feed costs, fish costs, etc.) will probably not discourage these operators. In the future, their primary markets (fishing clubs, private lake owners, recreationists) should continue to exist. Higher operating costs can rather easily be offset by slightly increasing the selling price or charge per customer.

Larger operators or operators who want to expand their operations will be faced with a somewhat different situation. For these operators a number of concerns must be considered and resolved. One major concern involves an operator's "ability" to increase his production. Here, water use permits, effluent discharge guidelines, financing, production potential and marketing all become important.

Another concern is where to market the increased production. Presently, most of Michigan's fish production is marketed to individuals not connected with the aquaculture industry for stocking in private waters. It is doubtful that this market can absorb large quantities of increased production, at least in-state. The sale of market-sized processed fish is another existing market. These fish are sold to local restaurants and supper clubs, and wholesale and retail outlets. In the future, these may represent the only major market sources for the increased production. These markets, however, usually demand large, dependable and uniform supplies. In addition, these Michigan markets may receive increasing attention from the larger aquaculture industries in other states, particularly Idaho.

Existing fish production and fee-fishing operators may be able to reduce their operating costs through more careful management of their operations. In particular, feeds and feeding, which represent the largest single cost item, should be carefully monitored. Operators who are experiencing high feed conversion rates (rates greater than 2.0/1.0) should experiment with different feed brands and feeding rates.

Existing fish production operators should give serious consideration to cooperative action, especially for marketing their production. A Michigan fish producers cooperative was formed several years ago, but met with little success and was dissolved. The reasons for its failure are typical of many cooperatives: limited interest, direction, management, and in-fighting among members. In the future, however, a carefully operated and managed marketing cooperative could prove beneficial to Michigan fish producers. Dependable markets could be established by the cooperative by combining the production of its members. This should also reduce marketing costs. Cooperative action could take an active role in the promotion of fish consumption through advertising, improving public relations, encouraging helpful and needed legislation and reducing operating costs through collective purchase of needed materials and equipment.

Prospective Michigan aquaculture operators are faced with basically the same situation as operators who want to expand their operations. Again, a number of concerns must be considered and resolved.

If a prospective operator is planning to build a new facility, he will be faced with the unsavory task of obtaining the necessary permits and licenses. Construction permits, water use permits (if taking water from a creek, stream or river), and a fish breeders license will have to be obtained. An extension report detailing the existing aquaculture regulations, permits and licenses will be forthcoming in the next year and should prove useful to new and existing operators. Operators who are planning to buy an existing facility must obtain a fish breeders license.

Financing must also be considered by new operators. As aquaculture becomes more "capital intensive" this factor should be given increased attention. It is hoped that as aquaculture grows in importance, lending institutions will make low interest loans more accessible to both prospective and existing operators. At present, however, adequate capital is difficult to obtain.

Locational factors should also be considered by new operators. An adequate water supply is perhaps the most important locational factor to consider. Transportation and the distances to market sources must also be considered. Fee-fishing operators should consider locating in areas readily accessible to recreationists and travelers. These operations should be located as near to "natural stopping places" as possible.

The future of Michigan aquaculture is uncertain and poses a challenge to existing and prospective operators alike. Many of the previously mentioned concerns must be resolved through both individual and collective action before any serious development can take place.

APPENDICES

APPENDIX A

PRELIMINARY SURVEY, QUESTIONNAIRE I

MICHIGAN AQUACULTURE SURVEY LIC. NO.______________

1. Please indicate which of the categories below best describes your aquaculture business in 1975. (Mark only one box.)

   ☐ Primarily fish production (actually raise fish for a large portion of their life, for example from egg or fingerling to market-size fish).

   ☐ Primarily fee-fishing

   ☐ Primarily a fish dealer or agent (buy and sell fish including eggs, fingerlings or market-size fish not produced by your operation)

   ☐ Other (please describe)

2. During 1975, did you also participate in any categories other than the one checked above? If so, please mark the appropriate boxes below.

   ☐ Fish production

   ☐ Fee-fishing

   ☐ Fish dealer or agent (for fish not produced by your operation)

   ☐ Other (please describe)

3. Please mark the box below that best estimates your 1975 GROSS INCOME from aquaculture.

   ☐ $0.00 - $5,000

   ☐ $5,001 - $10,000

   ☐ $10,001 - $20,000

   ☐ $20,001 - $40,000

   ☐ Greater than $40,000

4. Please indicate the approximate percent of your 1975 aquaculture GROSS INCOME that came from each appropriate category.

   Fish production: ________%

   Fee-fishing: ________%

   Fish dealer or agent: ________%

   Other (please describe): ________%

   ____

   100 %

Cooperative Extension Service, Michigan State University and U.S. Department of Agriculture Cooperating, Fisheries and Wildlife Department.

APPENDIX B

QUESTIONNAIRE II - FISH PRODUCTION OPERATIONS

1975 MICHIGAN AQUACULTURE SURVEY
Michigan Sea Grant Program
Michigan State University
Department of Fisheries and Wildlife

FISH PRODUCTION QUESTIONNAIRE

LIC. NO.________

A. BACKGROUND INFORMATION:

Facility Name:____

Address:____

County:____

Phone No.:____________________ Year your present operation started:__________

Please indicate your general stage of business in 1975 (mark only one box).

☐ Starting
☐ Operating (maintaining same volume of fish production)
☐ Expanding (increasing volume of fish production)
☐ Contracting (decreasing volume of fish production)

Was aquaculture your primary occupation in 1975? ☐ YES ☐ NO

If NO, please list your primary occupation:______________________________

____

How many months did you operate in 1975? __________number of months

How many full and part-time paid employees did you employ in 1975?

Full-time: number ______ man-months worked _____
Part-time: number ______ man-months worked _____

B. FISH PRODUCTION:

Eggs:

Did you produce fish eggs from your own brood stock in 1975? ☐ YES ☐ NO

If YES, please complete this table.

FISH SPECIES	APPROXIMATE NUMBER OF EGGS PRODUCED

Did you buy fish eggs in 1975? ☐ YES ☐ NO

If YES, please complete this table.

FISH SPECIES	APPROXIMATE NUMBER OF EGGS BOUGHT

Please indicate what percent (%) of the eggs you bought in 1975 were produced in Michigan. _______%

Fingerlings (1-6" long):

Did you produce fingerlings from the eggs that you either produced or bought in 1975? ☐ YES ☐ NO

If YES please complete this table:

FISH SPECIES	APPROXIMATE NUMBER OF FINGERLINGS PRODUCED

Did you buy fingerlings in 1975? ☐ YES ☐ NO

FISH SPECIES	NUMBER OF FINGERLINGS BOUGHT

Please indicate what percent (%) of the fingerlings you bought in 1975 were produced in Michigan. ______%

GROWERS (6" and larger):

In 1975, did you produce market-size fish (growers) from the fingerlings that you either produced or bought?

☐ YES ☐ NO

If YES, please complete this table.

FISH SPECIES	APPROXIMATE NUMBER OF MARKET-SIZE FISH PRODUCED	APPROXIMATE WEIGHT OF MARKET-SIZE FISH PRODUCED

FACILITIES

Please indicate the type of fish raising units you used in 1975.

Unit	Number	Total Area (Acres)	Total Volume (cu. ft.)	Type of Construction (earthen, concrete, etc.)
Ponds:				
Raceways:				
Tanks:				
Incubators:				

Other (please specify): ____________________

C. BUSINESS ACTIVITIES:

Please indicate the approximate percent (%) of your total 1975 AQUACULTURE GROSS INCOME that came from each of the following sources. (If 0% for a source, please indicate 0%).

____% EGG SALES

____% FINGERLING SALES

____% MARKET-SIZE LIVE FISH SALES

____% MARKET-SIZE UNPROCESSED FISH SALES

____% MARKET-SIZE PROCESSED FISH SALES

____% FEE FISHING

____% OTHER (Please describe) ____________________

100 %

For each income source that you indicated above, please fill in the appropriate sections below.

EGG SALES:

FISH SPECIES SOLD	APPROXIMATE NUMBER OF EGGS SOLD	DOLLAR VALUE OF EGGS SOLD

What percent of the eggs that you sold in 1975 were sold within Michigan? _____%

FINGERLING SALES:

FISH SPECIES SOLD	APPROXIMATE NUMBER OF FINGERLINGS SOLD	DOLLAR VALUE OF FINGERLINGS SOLD

Please indicate the percent (%) you sold to the following buyers in 1975:

____% other operators like yourself

____% fee-fishing operators

____% individuals not connected with the aquaculture industry (private farm ponds)

____% fish wholesalers or retailers

____% other (please describe) ______________________________

100 %

What percent (%) of the fingerlings that you sold in 1975 were sold within Michigan?

____%

MARKET-SIZE LIVE FISH SALES

FISH SPECIES SOLD	APPROXIMATE NUMBER OF FISH SOLD	APPROXIMATE WEIGHT OF FISH SOLD	DOLLAR VALUE OF FISH SOLD

Please indicate the percent (%) you sold to the following buyers:

____% Individual consumers

____% Directly to restaurants

____% Intermediate fish dealers (wholesalers)

____% Fish markets or retail outlets

____% Other (please describe)____________________

100 %

What percent (%) of the live market-size fish that you sold in 1975 were sold in Michigan? _____%

MARKET-SIZE UNPROCESSED FISH SALES:

FISH SPECIES SOLD	APPROXIMATE NUMBER OF FISH SOLD	APPROXIMATE WEIGHT OF FISH SOLD	DOLLAR VALUE OF FISH SOLD

Please indicate the percent (%) you sold to the following buyers:

____% Individual consumers

____% Directly to restaurants

____% Intermediate fish buyers (wholesalers)

____% Fish markets or retail outlets

____% Other (please describe)____________________

100 %

MARKET-SIZE PROCESSED FISH SALES

FISH SPECIES SOLD	APPROXIMATE NUMBER OF FISH SOLD	APPROXIMATE WEIGHT OF FISH SOLD	DOLLAR VALUE OF FISH SOLD

What percent (%) of the processed fish that you sold in 1975 were processed in the following ways?

____% Dressed only ____ Price per pound

____% Boned ____ Price per pound

____% Filleted ____ Price per pound

Please indicate the percent (%) you sold to the following buyers:

____% Individual consumers

____% Directly to restaurants

____% Intermediate fish buyers (wholesalers)

____% Fish markets or retail outlets

____% Other (please describe)________________________________

100 %

What percent (%) of the processed market-size fish that you sold in 1975 were initially sold within Michigan? ____%

FEE-FISHING:

FISH SPECIES SOLD	APPROXIMATE NUMBER OF FISH SOLD	APPROXIMATE WEIGHT OF FISH SOLD	DOLLAR VALUE OF FISH SOLD

Please indicate your method of charging the customer for the fish caught (mark appropriate box).

☐ According to the weight of the fish caught Price charged________

☐ According to the length of the fish caught Price charged________

☐ Other (please describe)________________________________

____

____

D. WATER:

Please indicate your operation's major 1975 water supply sources and the percent of the total supply and average flow by each source.

Sources	Percent of total water supplied	Average flow (gpm)
Natural wells (artesian)	____%	____
Pump wells	____%	____
Springs	____%	____
Stream or Creek	____%	____
River	____%	____
Other (please describe) ________ ________________	____%	____

Please indicate your immediate water discharge site (mark appropriate box).

☐ INLAND LAKE ☐ SMALL STREAM OR CREEK
☐ RIVER ☐ OTHER (Please describe)____________________
____

In 1975 did you have any serious water quality and/or supply problems? ☐ YES ☐ NO

If YES, please specify problems encountered:____________________
____
____

Did you artificially aerate your water? ☐ YES ☐ NO

In 1975 did you apply any type of water quality treatment (settling, chemical treatment, etc.) before discharging your water? ☐ YES ☐ NO

If YES, please specify treatment used:____________________
____
____

Did you recycle any portion of your water before discharging? ☐ YES ☐ NO

If YES, what percent (%) of the total water used was recycled? ____%

E. FEEDS

In your 1975 operation, did you use any "fish feeds" (commercial pellets, live feeds, etc.)? ☐ YES ☐ NO

If YES, please indicate each type of feed used, i.e., pellets, live feeds, etc. and the frequency of feeding for each fish species fed.

FISH SPECIES	TYPE OF FEED	FREQUENCY OF FEEDING DAILY	WEEKLY	MONTHLY

What percent (%) of the total feeds used in 1975 were purchased within Michigan?

_____%

Please indicate your method/s of feeding (mark appropriate box/es).

☐ MANUAL FEEDING (HAND FEEDING)
☐ DEMAND FEEDING
☐ AUTOMATIC FEEDING
☐ OTHER (Please describe)_______________

F. DISEASE:

In 1975, did you have any major fish disease problems? ☐ YES ☐ NO

If YES, please specify the disease problems and the fish species affected: _______

G. MORTALITIES:

Please indicate the average fish mortality (approximate number of fish lost) that your operation encountered in 1975 by fish species and fish size.

FISH SIZE	APPROXIMATE NUMBER OF FISH LOST	FISH SPECIES
EGGS		
1-3"		
3-6"		
6-9"		
9-12"		
12-16"		
larger than 16"		

H. MANAGEMENT:

Please indicate the type of records you kept and the frequency of recording for your operation in 1975. (Mark appropriate box/es.)

TYPE OF RECORD					
FISH INVENTORY	☐ NONE	☐ DAILY	☐ WEEKLY	☐ MONTHLY	☐ YEARLY
FISH MORTALITY	☐ NONE	☐ DAILY	☐ WEEKLY	☐ MONTHLY	☐ YEARLY
FEEDING RATES	☐ NONE	☐ DAILY	☐ WEEKLY	☐ MONTHLY	☐ YEARLY
WATER QUALITY	☐ NONE	☐ DAILY	☐ WEEKLY	☐ MONTHLY	☐ YEARLY

OTHER (Please describe)____

____

I. INFORMATION ASSISTANCE:

In 1975 did you request any of the following types of aquaculture information? (Mark appropriate box/es.)

☐ NONF
☐ FISH CULTURE PRACTICES
☐ FISH FARM MANAGEMENT
☐ FISH FARM LEGISLATION
☐ FISH MARKETING
☐ FISH FARM FINANCING
☐ OTHER (Please describe)____________

____

From whom did you request the information? (Mark appropriate box/es.)

☐ County Extension agent
☐ Other operators
☐ DNR personnel
☐ Education centers (colleges, etc.)
☐ National organizations
☐ Other (please specify)____________

____

J. PRESENT NEEDS AND PROBLEMS:

What do you consider to be the major needs and problems affecting your operation in specific and the Michigan Aquaculture industry in general?

____

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K. FUTURE PLANS

What are the future plans for your aquaculture operation?

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APPENDIX C

QUESTIONNAIRE II - FEE-FISHING OPERATIONS

1975 MICHIGAN AQUACULTURE SURVEY
Michigan Sea Grant Program
Michigan State University
Department of Fisheries and Wildlife

FEE FISHING QUESTIONNAIRE

LIC. NO.________

A. BACKGROUND INFORMATION:

Facility Name:

Address:

County:

Phone No.: Year your present fee-fishing operation started?_____

Was your operation primarily leased by a fishing club or group in 1975?

☐ YES ☐ NO

Please indicate your general stage of business in 1975 (mark only one box).

☐ Starting

☐ Operating (maintaining some acreage or fish stocking density devoted to fee-fishing)

☐ Expanding (increasing the acreage or fish stocking density devoted to fee-fishing)

☐ Contracting (decreasing the acreage or fish stocking density devoted to fee-fishing)

How many months of the year was your fee-fishing operation open to customers in 1975? __________months

Was your fee-fishing operation your primary occupation in 1975?

☐ YES ☐ NO

If NO, please list your primary occupation:________________________________

____

How many full and part-time paid employees did you employ in 1975?

Full-time: number _______ man-months worked _______

Part-time: number _______ man-months worked _______

B. FISH

Did you stock your pond/s in 1975? ☐ YES ☐ NO

If YES, please indicate the fish species you stocked in 1975, and the approximate number stocked by sizes.

APPROXIMATE NUMBER STOCKED

FISH SPECIES	1-3"	3-6"	6-9"	9-12"	12-16"	16" and over

What percent (%) of the total number of fish you stocked in 1975 did you purchase in Michigan? ______%

Did you stock your ponds more than once per operating year? ☐ YES ☐ NO

If YES, how often (times/year) do you stock your pond/s? _______ number of stockings/year

C. FACILITIES:

Please indicate the type of fish holding or raising units you used in your 1975 operation.

UNIT	TOTAL NUMBER	TOTAL AREA (acres or sq. ft.)	TOTAL VOLUME (cu. ft.)	TYPE OF CONSTRUCTION (concrete, earthen, etc.)
PONDS				
RACEWAYS				
TANKS				

What was the total number of ponds, the total area and volume that was actually fished by your fee-fishing customers in 1975?

UNIT	TOTAL NUMBER	TOTAL AREA (acres or sq. ft.)	TOTAL VOLUME (cu. ft.)
PONDS			

Besides fee-fishing, did you provide any of the following services or facilities in 1975? (Mark appropriate boxes)

- ☐ Picnic area
- ☐ Camping (tents, trailers, car and truck campers, etc.)
- ☐ Lodging (other than camping)
- ☐ Fishing supplies (poles, reels, bait, etc.)
- ☐ Food and beverage
- ☐ Fish cleaning
- ☐ Frozen fish sales
- ☐ Souvenir shop
- ☐ Fish food for visitors to use in feeding the fish
- ☐ Other (please describe)______________________________

D. BUSINESS ACTIVITIES:

Please indicate the approximate number and/or weight of each fish species caught from your operation by paying fishermen in 1975.

FISH SPECIES	APPROXIMATE TOTAL NUMBER OF FISH CAUGHT	APPROXIMATE TOTAL WEIGHT OF FISH CAUGHT

Please indicate your method of charging the customer for the fish caught. (Mark one box.)

- ☐ According to the weight of the fish caught Price charged $_______
- ☐ According to the length of the fish caught Price charged $_______
- ☐ Other (please describe)______________________________

On approximately how many occasions did people fish at your operation in 1975? One occasion is one fishing visit by one person. (Mark appropriate box.)

- ☐ less than 100 occasions
- ☐ 100-500 occasions
- ☐ 500-1000 occasions
- ☐ 1000-1500 occasions
- ☐ 1500-2000 occasions
- ☐ 2000-3000
- ☐ over 3000

What percent (%) of the total number of people who fished at your operation in 1975 belonged to the following categories?

_____% individual adult fishermen

_____% families with children

_____% special groups (Boy Scouts, school groups, etc.)

_____% other (please explain)

____

100 %

Approximately what percent (%) of the people who fished at your operation in 1975 were not residents of Michigan?

_____%

If you provide other services and facilities besides fee-fishing, what percent of your total gross income from services, facilities and fee-fishing in 1975 was represented by fee-fishing only?

Fee-fishing _____%

E. WATER:

Please indicate your operation's major 1975 water supply sources and the percent of the total supply and average flow represented by the appropriate source.

	Percent of total water supplied	Average Flow (gpm)
Natural wells (artesian)	____%	____
Pump wells	____%	____
Springs	____%	____
Stream or creek	____%	____
River	____%	____
Other (please describe)	____%	____
______________________	100	

Please indicate your immediate water discharge site (mark appropriate box).

☐ Inland lake ☐ Small stream or creek

☐ River ☐ Other (please describe) ______________

____

In 1975, did you have any serious water quality and/or supply problems?

☐ YES ☐ NO

If YES, please specify problems encountered:________________________________

____

____

F. FEEDS AND FERTILIZER:

In your 1975 operation, did you use any "fish feeds" (commercial pellets, live feeds, etc.)?

☐ YES ☐ NO

If YES, please indicate each type of feed used, i.e., pellets, live feeds, etc. and the frequency of feeding.

FREQUENCY OF FEEDING
(Mark appropriate box)

FEED TYPE	DAILY	WEEKLY	MONTHLY

In 1975, did you use any type of fertilizer in your fish ponds? ☐ YES ☐ NO

If YES please describe the type of fertilizer used:____________________________

____

G. DISEASE

In 1975 did you have any major fish disease problems? ☐ YES ☐ NO

If YES please specify the disease problems and the fish species affected.

FISH SPECIES	DISEASE PROBLEM

H. MORTALITIES:

Please indicate the average fish mortality (approximate number of fish lost) that your operation encountered in 1975 by fish species and size.

FISH SIZE	APPROXIMATE NUMBER OF FISH LOST	FISH SPECIES
1-3"		
3-6"		
6-9"		
9-12"		
12-16"		
larger than 16"		

I. MANAGEMENT

Please indicate the type of records you kept and the frequency of recording for your operation in 1975. (Mark appropriate box/es.)

TYPE OF RECORD	FREQUENCY OF RECORDING				
FISH INVENTORY	☐ NONE	☐ DAILY	☐ WEEKLY	☐ MONTHLY	☐ YEARLY
FISH MORTALITY	☐ NONE	☐ DAILY	☐ WEEKLY	☐ MONTHLY	☐ YEARLY
FEEDING RATES	☐ NONE	☐ DAILY	☐ WEEKLY	☐ MONTHLY	☐ YEARLY
WATER QUALITY	☐ NONE	☐ DAILY	☐ WEEKLY	☐ MONTHLY	☐ YEARLY

OTHER (please describe): ____________________

____

J. INFORMATION ASSISTANCE:

In 1975, did you request any of the following types of aquaculture information? (Mark appropriate box/es.)

- ☐ None
- ☐ Fish culture practices
- ☐ Fish-farm management
- ☐ Fish-farm legislation
- ☐ Fish marketing
- ☐ Fish-farm financing
- ☐ Other (please describe)____________

____

From whom did you request the information? (Mark appropriate box/es.)

- ☐ County Extension Agent
- ☐ Other operators
- ☐ MDNR Personnel
- ☐ Educational centers
- ☐ National Organizations
- ☐ Other (please describe)

____

____

K. PRESENT NEEDS AND PROBLEMS:

What do you consider to be the major needs and problems affecting both your operation in specific and Michigan aquaculture industry in general?

L. FUTURE PLANS:

What are the future plans for your aquaculture operations?

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REFERENCES

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