



Technical Report No. 61

PROFILES OF AQUACULTURE IN MICHIGAN

by

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and
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IN
MICHIGAN

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Sea Grant Technical Report Number 61

Michigan Sea Grant Program
a Cooperative Effort of the
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PREFACE

The information in this report was obtained from a descriptive survey of the 1975 Michigan aquaculture industry. The survey was conducted by Michigan State University and the Michigan Sea Grant Program* in an attempt to document specific physical, biological and economic aspects of the Michigan industry. Data for this report was contributed by Michigan aquaculture operators through mail-administered questionnaires, telephone and personal interviews. In total 81% of all licensed operators responded to the questionnaires and 26% were personally interviewed. The assistance and hospitality of the contributing operators is appreciated. Not included in the report are fish dealers or agents, the existing bait-fish industry, and state hatcheries. This report is based upon a Master of Science thesis, "Aquaculture in Michigan - Descriptive Profiles" by the senior author.

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Profiles of
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INTRODUCTION AND SUMMARY

The Michigan aquaculture industry:

- is basically composed of two major types of operations: fee-fishing and fish production.
- is characterized by small firms operated mainly as a hobby, providing primarily non-monetary returns to their owners.
- concentrates on producing rainbow trout.
- generally produces low or negative returns for the investor.

This report begins with profiles of the operation of fish production and fee-fishing enterprises in Michigan in 1975. This is followed by analyses of the monetary costs and returns of different size classes of both kinds of enterprises. Finally, some of the problems and concerns expressed by operators and a brief analysis of the outlook for the future are presented.

About 100 aquaculture firms are scattered throughout Michigan. Roughly half specialize in growing fish and half providing fee-fishing in catch-out ponds. In 1975 the industry produced about 550,000 pounds of fish, worth about \$700,000, mostly for live-stocking private waters or fee-fishing operations. About 40% of the fish were grown by the largest 11% (four firms) of the production firms.

After subtracting variable costs and fixed costs, most firms had too little

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revenue left to fully pay for the operator's labor and normal returns for his invested capital. As a rule, larger firms tended to provide the better rates of return. However, some firms in each size class were much more profitable (or less unprofitable) than others, implying that some have superior managerial ability or other advantages. The data suggest that an investment of around \$100,000 for production firms and \$30,000 for fee-fishing firms would be required to "break even" under average circumstances. Profitable fee-fishing firms also have better locations.

While the worldwide outlook for aquaculture seems promising, Michigan's industry appears to have some significant barriers. Despite abundant water in Michigan, few sites have large volumes of water suitable for raising trout. Current water quality regulations require costly water quality monitoring, and perhaps treatment facilities, for larger operators. Several permits are required. Capital investment funds for the industry are difficult to obtain. Markets for most of the products are poorly developed, and market expansion appears to be difficult at present. Finally, diseases and environmental hazards increase the risk of any venture.

EXTENT OF AQUACULTURE IN MICHIGAN

In 1975 there were 117 licensed fish production or fee-fishing operations in Michigan. Of the 83 counties, 57 had at least one aquaculture operation. About 40% of these primarily produce fish, about 36% primarily offer fee-fishing and the remainder engaged in neither in 1975 for various reasons, or refused to answer (5%). Both fish production and fee-fishing operations were most concentrated in Michigan's northern Lower Peninsula (see Figure 1).

While the number of licensed operations is large compared to other states, the volume of production is small. The 1975 Michigan industry produced approximately 550,000 pounds of fish (92% rainbow trout), worth approximately \$700,000. These figures are small when compared to Idaho's estimated 1973 production of 19.22

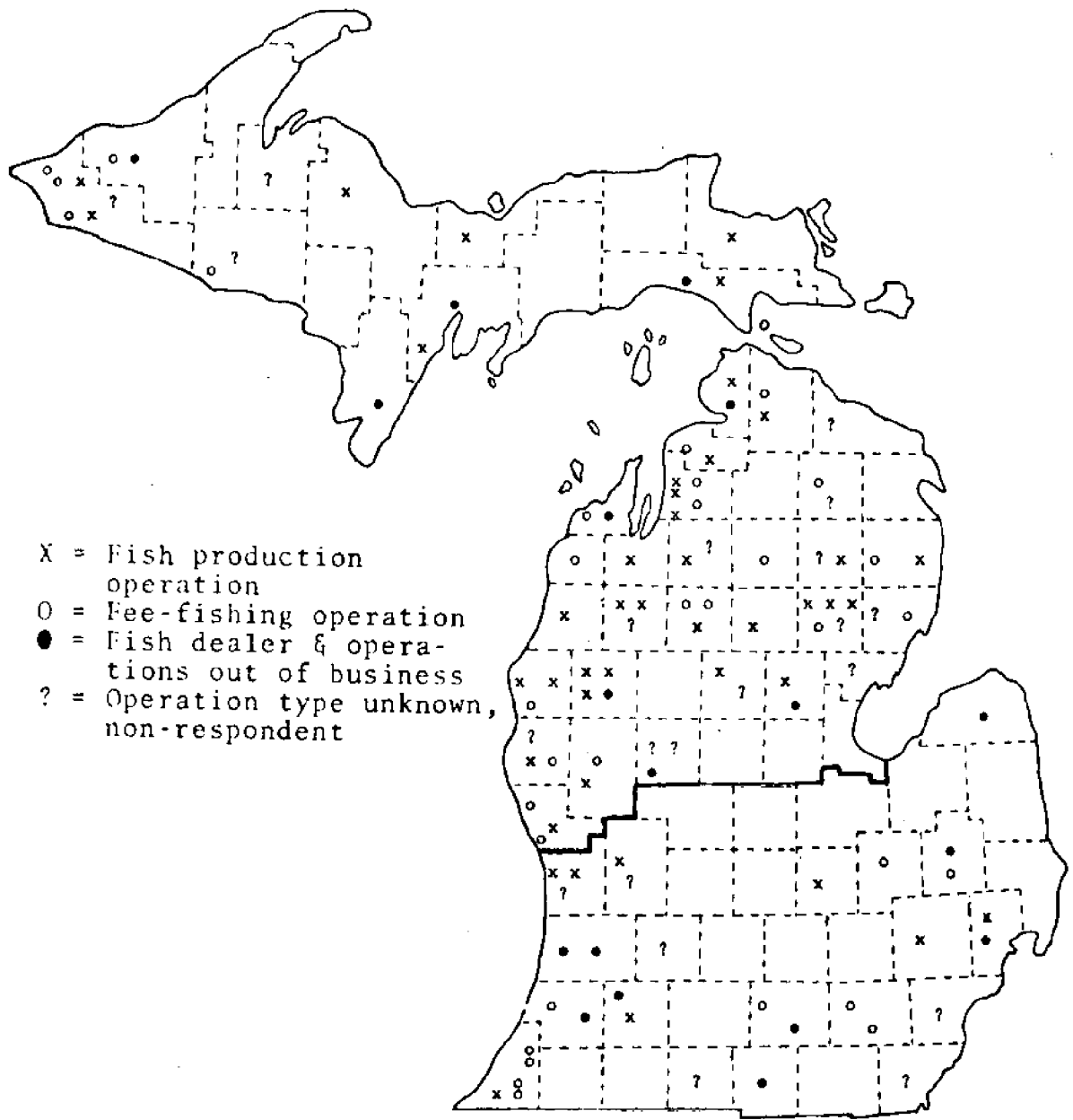


Figure 1. Locations of 1975 licensed Michigan aquaculture operations.

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

Item	Size of Operation			Average
	Large	Medium	Small	
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.

million pounds of trout and catfish worth approximately \$25 million.

FISH PRODUCTION PROFILES

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 annual gross income between \$10,000 and \$40,000. Small operations are those with annual gross income 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 operations category was composed of three operations which were similar and one operation which was very large. Specific physical, biological and business data for fish production operations are presented in Table 1.

Most 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. The remaining 8% was composed of mainly brook and brown trout with some operators experimenting with hybrid sunfish, walleyes, bass and catfish. 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 10 ounces to one pound). This estimate varied with water temperature, strain of fish and feeds.

Fish

Most producers started with fish eggs, either produced from their own brood stock (50%) or purchased outside the state (50%). None of the responding operators produced eggs for sale. Large and medium-size operators tended to produce or purchase more fish eggs than did small operators. The large number of eggs reported for medium-size operations was due to one operator greatly expanding his production in 1975.

Two operators started their operations with fingerlings instead of eggs, and some operators purchased fingerlings during the year. These fingerlings were purchased from other, usually larger, fish production operations in Michigan, and were used to augment existing stocks. Large and medium-size operations tended to handle more fingerlings than did small operations. The large average number of fingerlings at medium-size farms was due to one operator expanding his production.

All responding operators produced market-size fish ("growers") 9 to 14 inches in length. The number and weight of growers per operation varies greatly with the size of the operation. This difference is reflected in the different annual gross returns for each size of operation.

Facilities

Ponds accounted for 85% of the total fish culture area. Pond shapes and sizes varied but most were of earthen construction. Other ponds were constructed with concrete sides and earth or gravel bottoms. Their average depth was 3 feet. 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.

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). 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 fish were 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.

Fingerling sales tended to be a more important market source for medium and small operations than for 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 at production operations was a more important source of income for medium and small operations than for large operations.

Market size processed fish sales was generally an important market source only for large operations. Most processed fish were sold dressed, 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.

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. Spring and well water temperatures varied from 43°F to 50°F. Pond water temperatures varied considerably, depending on the source and season, and ranged between 45°F to 65°F. Flow rates also varied but were usually above 75 gpm per well or spring. Most 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 lost part of his stock because of silt in his water supply.

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.

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. Conversion (dry weight of feed per wet weight gain of fish) at medium and large operations tended to be lower than at small operations. The unfavorably high feed conversion rates at many of the operations in all three size categories indicates that greater feed efficiency might be obtained, thus reducing feeding costs.

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.

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 and kingfishers), ducks, mink and otter.

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.

FEE-FISHING PROFILE

Fee-fishing operations comprised approximately 36% (34 operations) of the responding operators. Large and small fee-fishing operations, as used in this report, 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. 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. The busiest months for business were June, July and August, followed by May and September. Specific physical, biological and business data for fee-fishing operations is presented in Table 2.

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

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.

catchable-size fish, 9 inches or longer, which were purchased from fish production operations in Michigan. One operator produced his own fish for stocking. Large operations generally stocked 7 to 8 times as many fish per operating year as did small operations. Rainbow trout was the most common fish species stocked. Some operators in the southern part of the state were experimenting with catfish and hybrid sunfish.

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. 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 also provided fish cleaning, bagging and icing for a nominal additional charge. A few firms provided food and beverage, picnic areas and/or camping.

Business Activities:

About 75% of the paying customers in 1975 were composed of families with children. The remainder were individual adult fishermen and special groups. The average number of customers and 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%.

Most operations charged the customer on the basis of the length or weight of the fish caught. A few 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.

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.

Most 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.

Feeds:

All respondents used commercially prepared fish feed (pellets). Most 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.

Disease:

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

Mortalities:

Most 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.

Management:

Most 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.

COSTS AND RETURNS OF FISH PRODUCTION OPERATIONS¹

Average returns to labor, management and investment were low for all three sizes of operations. In particular, the average annual return of small operations was not sufficient to cover annual operating costs. Large operators were the only group 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 larger scale operations are more profitable than smaller operations. Insufficient data exist to precisely determine the optimum size of operation. A few operators, however, suggested that an investment of approximately \$75-100,000 may be necessary to break even, assuming proper management and market conditions. The reader is cautioned when reviewing the costs and returns. A great deal of variability existed among all three sizes of operations with some operations within each size category being much more profitable than others. The average costs and returns should be used only as a guide.

Revenue:

Total annual gross revenues ranged upward from \$2,000 and averaged \$20,684 (Table 3). 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 produced an average of 55,875 pounds of growers

¹ Information on the costs and returns of each individual operation was recorded based on a "typical year" of business and not any one particular business year (1975 prices were used). Various components of the costs and returns tables are discussed in Appendix A - Understanding Costs and Returns.

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

Item	Size of Operation			Average
	Large	Medium	Small	
Number of samples	4	4	5	13
(1) Gross revenue	\$92,875	\$27,000	\$6,020	\$20,084
<u>Variable costs</u>				
Feed	31,250	8,125	2,500	7,007
Fish	1,750	1,187	770	878
Utilities	3,575	1,150	150	752
Labor	10,000	550	0	1,197
Chemicals	48	212	100	124
Transportation	8,750	3,375	465	2,103
Maintenance	2,938	1,325	640	1,062
Misc. advertising	3,175	1,087	29	639
Interest on operating capital	5,285	766	209	890
(2) Total variable costs	65,571	17,777	4,863	14,652
<u>Fixed costs</u>				
License fees	204	5	5	26
Insurance	1,281	406	130	324
Legal bookkeeping	650	237	5	134
Taxes	2,263	744	298	622
Depreciation	6,325	2,100	1,400	2,103
(3) Total fixed costs	10,723	3,492	1,838	3,209
<u>Opportunity costs</u>				
(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
<u>Summary</u>				
Return to labor, management and investment	16,581	5,731	-681	2,823
(1 less 2 and 3)				
Return to labor and management	10,737	2,331	-2,806	-29
(1 less 2, 3 and 6)	(\$5,967	work hour)		
Return to investment	993	-1,869	-3,733	-2,745
(1 less 2, 3, 4 and 5)	(1.4% return)			

* Less than 1%.

(fish 9-14 inches in length) and marketed 75% of this production (41,906 pounds), accounting for nearly 70% of a large operation's average annual gross income (refer to Table 1). Medium-size operations produced an average of 13,500 pounds of growers and sold about 80% of this production, accounting for 64% of average annual gross income. Small operations produced an average of 9,100 pounds of growers and sold approximately 44% of this production, accounting for 80% of 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:

Variable costs averaged \$14,652, about 82% of the total annual costs. Feed was the largest single variable expense for all sizes of operations. Greater feed efficiency can probably be obtained by many operators through careful analysis of feed types used, feeding rates and methods. Transportation costs were the second largest variable expense, being higher for medium and large operations. Labor costs were an important variable cost for large operations, but were less important for medium and small operations. Only large operations employed significant amounts of labor. Fish and maintenance costs were important variable costs for small operations. The major reason for this was that some 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:

Fixed costs averaged only \$3,209, only 18% of the total annual costs (Table 3). Equipment and facilities depreciation was the major fixed cost item. Taxes and insurance costs were the other important fixed costs. Higher tax and insurance costs for medium-size operations is attributed to the larger

acreage held by these farms.

Operator's labor:

Operator's labor time per year varied considerably from operation to operation. In this analysis an average of 1,000 hours of labor per year is assumed for operators. 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 management:

This opportunity cost was based on 10% of the annual gross returns. This cost averaged \$2,068.

Total Investment:

Total investment varied considerably among operations. 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. This opportunity cost averaged \$2,852 (Table 3).

COSTS AND RETURNS OF FEE-FISHING OPERATIONS¹

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 large operators were greater, but still provided only low returns to labor and management. Neither size operation recorded a positive return to investment. Insufficient data existed to precisely determine the optimum size of operation.

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

Item	Size of Operation		Average
	Large	Small	
Number of samples			
(1) Gross revenue	\$17,525	\$2,297	\$3,041
Variable Costs			
Feed			
Fish	3,100	430	665
Utilities	3,750	1,127	1,358
Labor	1,725	86	235
Chemicals	1,250	0	37
Transportation	68	29	32
Maintenance	300	105	122
Misc. advertising	750	100	157
Interest on operating capital	650	33	87
(2) Total variable costs	262	43	61
Fixed costs	11,905	1,953	2,754
License fees	5	5	5
Insurance	400	40	72
Legal bookkeeping	18	46	43
Taxes	200	150	154
Depreciation	1,000	500	555
(3) Total fixed costs	1,623	741	829
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	3,997	-397	58
(1 less 2 and 3)			
Return to labor and management	2,297	-1,253	-886
(1 less 2, 3 and 6)	(\$2,307 work hour)		
Return to investment	-1,256	-4,127	-3,806
(1 less 2, 3, 4 and 5)			

* Less than 1%.

However, large scale operations appear to 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.

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. Larger operations were apparently in more advantageous locations.

Variable Costs:

Average variable costs (\$2,754) accounted for 77% of average total costs (Table 4). Fish and feed were the largest variable expense items. Small operators paid higher prices for the smaller quantities of fish needed to stock their ponds. Utility and labor costs were major variable cost items for large operations. Chemicals, 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). Equipment and facilities depreciation was the major fixed cost item. Taxes and insurance cost were the other major fixed cost items, especially for large operations.

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, they 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 for both groups (Table 4).

Operator's Management:

This opportunity cost was calculated at 10% of the annual gross revenues and averaged \$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. The opportunity cost of investment capital was assumed to be 8.5%, so investments costs for large and small operations were \$1,700 and \$856, respectively.

CURRENT PROBLEMS AND 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. Most of 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, marketing, insurance, increasing production costs, cooperation and assistance, and public relations. Three of the most common concerns, regulations, financing and marketing are discussed below.

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 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. They are also required to monitor their water and submit monthly readings on various water quality parameters. Many operators feel that these requirements hinder the development and expansion of their operations. Many stated that the cost of monitoring their water would be prohibitive and would force them to keep production below 20,000 pounds or leave the industry altogether.

Most 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."

Financing:

Financing was a major concern of many 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.

Marketing Difficulties:

Marketing was a major concern of many production operators. At present, each operator secures his own markets. Most of these markets are irregular, varying from year to year. This arrangement can put the operator at a disadvantage, especially if he has a surplus of fish which must be sold to make room for younger fish. Operators who want to increase production are faced with a similar problem - 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 Michigan. The sale of market-size processed fish, sold to local restaurants, supper clubs, supermarkets, wholesale and retail outlets, may represent the only major market sources for increased future 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. A market source that might be further developed in the future would be the wholesaling of live fish to processors for processing and distribution. Contractual arrangements might be made between producers and buyers for specific quantities of fish over a given time period. While not fool-proof, this market arrangement would reduce the risk for both producer and buyer, and add some stability to the market.

OUTLOOK FOR THE FUTURE

On a world-wide basis, aquaculture is expected to continue to increase in importance. Total world fish production through aquaculture, presently 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 in 1976 and again in 1977. 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.

Most fish production and fee-fishing operators view their operation as a "hobby" which provides them with many returns, including aesthetic rewards, self-satisfaction, fish for the family table, as well as economic returns. Many, especially fee-fishing operations, will probably continue to operate as such, despite higher operating costs. 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. An operator's "ability" to increase his production depends not only upon his markets, but also upon such items as water use permits, effluent discharge guidelines, financing and production potential.

Prospective Michigan aquaculture operators are faced with basically the same situation. 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 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. Additional permits may be necessary depending on the particular situation. He will need to consider several locational factors. An adequate water supply is perhaps the most important. 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. They should be located as near to "natural stopping places" as possible.

Existing fish production and fee-fishing operators may be able to reduce their operating costs through more careful management. 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 and schedules. The survey indicated that the more profitable operators of both fish production and fee-fishing firms prepared detailed production schedules, feeding schedules, inventory records and purchase and sales records. These operators were also familiar with tax laws and the financial affairs of their business.

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 were typical of many cooperatives: limited interest, direction and management, and in-fighting among members. In the future, however, a carefully operated and managed marketing cooperative could prove beneficial. 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 (especially pond-raised fish) through advertising, improving public relations, encouraging helpful and needed legislation and reducing operating costs through collective purchase of needed materials and equipment.

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.

REFERENCES

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 others interested in the industry, are an encouraging sign for the continued development and improvement of aquaculture both world-wide and in the United States. While there are many studies that involve or are related to aquaculture, the following list includes only those studies that appear to have relevance to the Michigan industry.

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APPENDIX A - UNDERSTANDING COSTS AND RETURNS²

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.

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).

² This section adapted from 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.