A SURVEY OF LIVE-BAIT DEALERS IN MICHIGAN

Thesis for the Degree of M. S.

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George Howard Lauff

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This is to certify that the

thesis entitled

"A Survey of Live-Bait Dealers in Michigan"

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H R Hunt

Major professor

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A SURVEY OF LIVE-BAIT DEALERS IN MICHIGAN

By

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A THESIS

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INTRODUCTION

Michigan has many hundreds of miles of rivers and thousands of lakes. Its waters, beaches, and vacation lands attract people from all areas. The wealth of water and its fishery resources has gained Michigan wide renown and the state has become of great importance as a resort area. During certain periods of the year, the fish in its waters attract over a million tourists and resident anglers. Since many anglers prefer to fish with live bait, the demand has given rise to an industry concerned with the collecting, raising, and selling of such baits as minnows, adult insects, insect nymphs and larvae, and worms of various kinds.

Coincident with this increasing demand for bait and the efforts to supply it has arisen the problem of seasonal shortages of certain types of bait and perhaps the over exploitation of a valuable natural resource. As a result, it has become necessary to enact legislation to control the collection and sale of live bait. Since the chief demands are for minnows and insect larvae, it is these baits which are regulated by state legislation.

The first official report of the minnow shortage in Michigan was made in 1933 by Hubbs of the Institute for Fisheries Research in his reply to the Department of

Conservation concerning their inquiries regarding the status of minnows. He reported that observations indicated a considerable depletion of the bait minnow stock had taken place. Streams near fishing lakes had a minnow population well below that which would be expected. He noted, however, that streams hidden from view and those streams that were comparatively inaccessible had a much larger minnow supply. Even at that time, bait dealers were often forced to travellong distances to obtain an adequate supply of minnows. He blamed unregulated and wasteful methods of handling for the depleted stock and suggested bait minnow culture as one of the possible solutions.

Despite legislation, native minnow resources could not satisfy the increasing demand for live bait. The shortage continued and became more acute. Bait dealers asked for help concerning pond construction, pond culture and propagation of bait minnows. In 1947, a series of experiments were conducted at state fish hatcheries which determined that bait minnows could be propagated successfully (Yoder, 1950). A program was inaugurated by the state in which minnow fry were offered for sale at a price to cover only the costs involved. The northern creek chub, Semotilis atromaculatus atromaculatus, and the white sucker, Catostomus commersonnii commersonnii,

were selected since results of Washburn's survey (1946) indicated a preference for these species. Adult breeding stock was collected and the eggs taken and hatched. Fry were distributed when the egg sac had been absorbed sufficiently to allow them to become free swimming. This program is in operation at the present time.

This thesis represents a summarization of the data collected during the survey of Michigan live-bait dealers conducted during the spring and summer of 1950 by the Institute for Fisheries Research, Michigan Department of Conservation, in cooperation with Michigan State College, to determine the importance and extent of the live bait business in the state and to study practices and problems common to the dealers. Data gathered as a result of the survey were used to evaluate the state's program of supplying minnow fry for propagation purposes and to assist in the formulation of legislation that would give increased protection to live bait resources.

DEFINITION OF MINNOWS

The true minnows belong to the family Cyprinidae. Carbine (1941) states that the name "minnow" is commonly, but erroneously applied to small fish of all species. The mud minnow, sucker, and the top minnow, three species which are used as bait, belong to other families. Young specimens of game and food fish, which should be called fry or fingerlings, are often spoken of improperly as minnows, e.g., perch minnows and pike minnows. The true minnows are distinguished from all other fishes by their possession of the following characters:

1. There are no teeth on the jaws.
2. There are no scales present on the head.
3. There are no spiny rays in the fins.
4. The single dorsal fin has less than ten rays.

The commercial minnow law, Act 165, P.A. 129, states that "minnows shall be defined as chubs, shiners, suckers, (when of a size ordinarily used for bait in hook and line fishing), dace, stonerollers, muddlers, and mud minnows. Wigglers shall be defined as May-fly nymphs or larvae. Commercial purposes shall be construed to mean offering for sale, selling, giving or furnishing to others".

LIVE-BAIT DEALERS

Classification

There are two legal classifications of live-bait dealers in the state of Michigan: the retail dealer and the wholesale dealer. Regulations and provisions for operation are essentially similar with the exception that wholesale dealers may offer bait for resale. Another general classification can be readily observed, however. It may be termed a socio-economic grouping.

Marginal dealers: This group is characterized by small dealers, operating from roadside stands, back porches, or basements. The total investment is very small, perhaps no more than the price of a wash tub, a pop cooler, or a stock tank. They are in operation only when bait is readily available and their operation is definitely seasonal in nature. Patronage is usually limited and quite sporatic. There is no regular income, livelihood being derived from both bait sales and odd jobs. Resort owners operating a few cabins or a boat livery are in this classification.

Part-time dealers: A majority of the live bait dealers fall into this category. The major portion of their total income is derived from some full-time occupation but off hours and week-ends are spent collecting

bait. A part of a basement or garage may be divided off to provide a small shop. A line of fishing tackle and equipment is usually stocked. Business may be either seasonal or year around. Gas stations, general stores, and other such establishments which often handle bait and fishing supplies are included in this grouping.

Large seasonal dealers: Dealers of this type are found in an area which supports a large summer resort population. The dealer devotes his full time and energies to his business during its operation which is typically from mid-June until Labor Day. While in operation, a fairly complete line of supplies and equipment is stocked. The place of business is usually of a permanent nature and an effort is made to attract trade.

Permanent dealers: Dealers in this grouping operate a bait business in conjunction with a fairly large sporting goods store or tackle shop. The bait department is built as a part of the store and some live bait is available throughout the year even though the range or selection will not equal that of the summer season.

Growth of the Live Bait Business

Since the regulation of live bait sales was effected in 1930 (Act 165, P.A. 129), the growth in the number of licensees has increased rapidly. In 1940 (Act 337,

P.A. 1939) provision was made for both a retail and a wholesale license. Wholesale license sales were relatively constant from their initiation in 1941 until 1945. In 1946, the sale of both wholesale and retail bait licenses increased; wholesale license sales had more than tripled and retail license sales had nearly doubled by 1949. A graphic representation of the growth of license sales is illustrated by Chart I.

Carbine (1940) estimated that 50 per cent of the fishermen relied on bait dealers for their live bait. A comparison of bait license sales and fish license sales indicates an approximate ratio of one bait dealer license for 600 fish licenses. This could be construed to mean that one bait dealer would serve approximately 300 fishermen.

There is an apparent correlation between the number of bait licensees and the number of fishing licenses sold (Chart II). The first resident fishing license was required in 1927 for the taking of any trout, excepting mackinaw trout. In 1933, a general resident license was required for all fishing. The rapid rate of increase of licenses sold is shown on the chart. The sudden reduction in sale of both bait licenses and fishing licenses during the war years, 1940-1945, may possibly have been caused by several factors. The decline might be contributed to transportation difficulties due to war-time restriction, to high war time employment in industry, or to an engagement

Chart I: Bait License Sales in Michigan: 1939-1950

BAIT LICENSES/

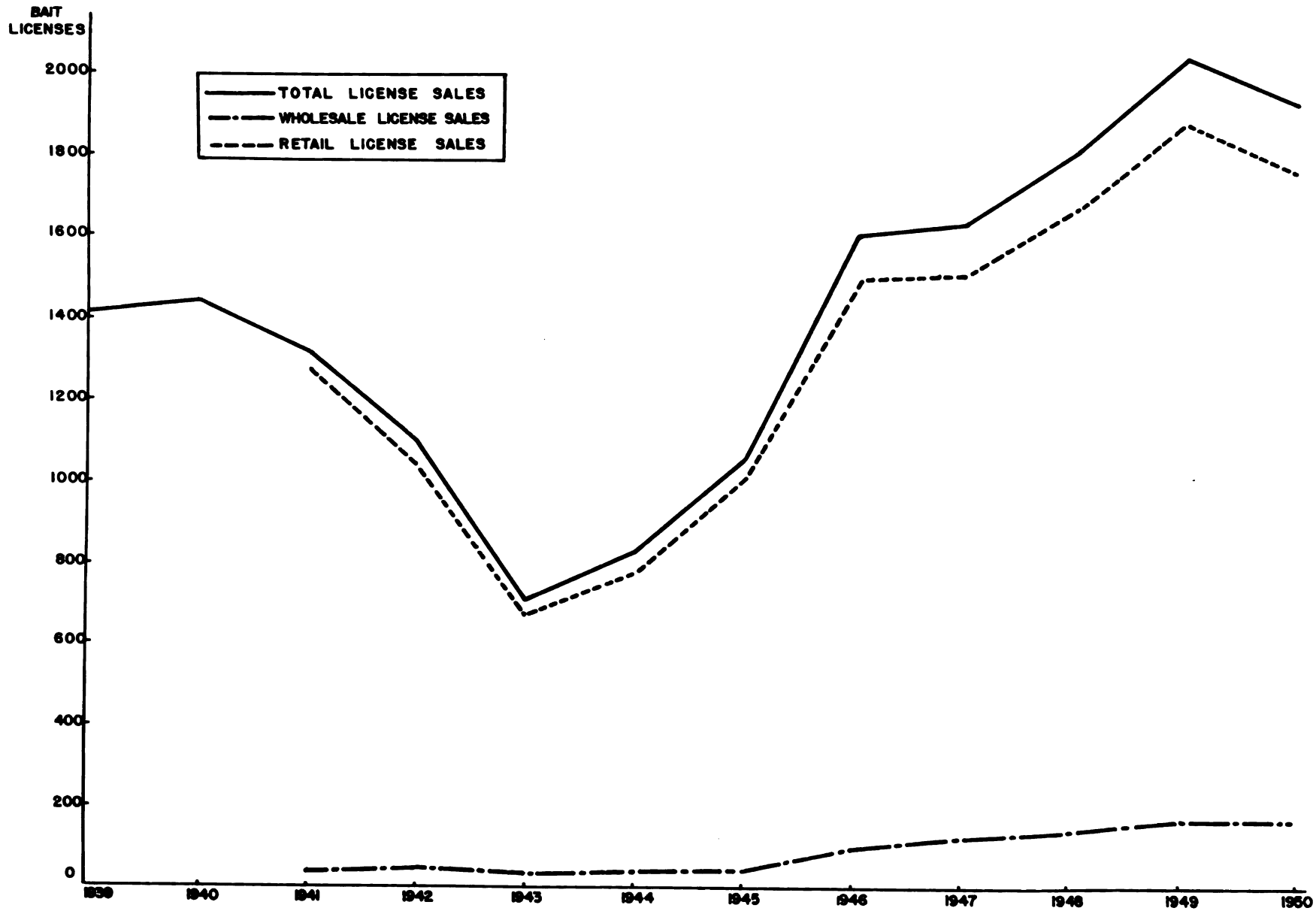
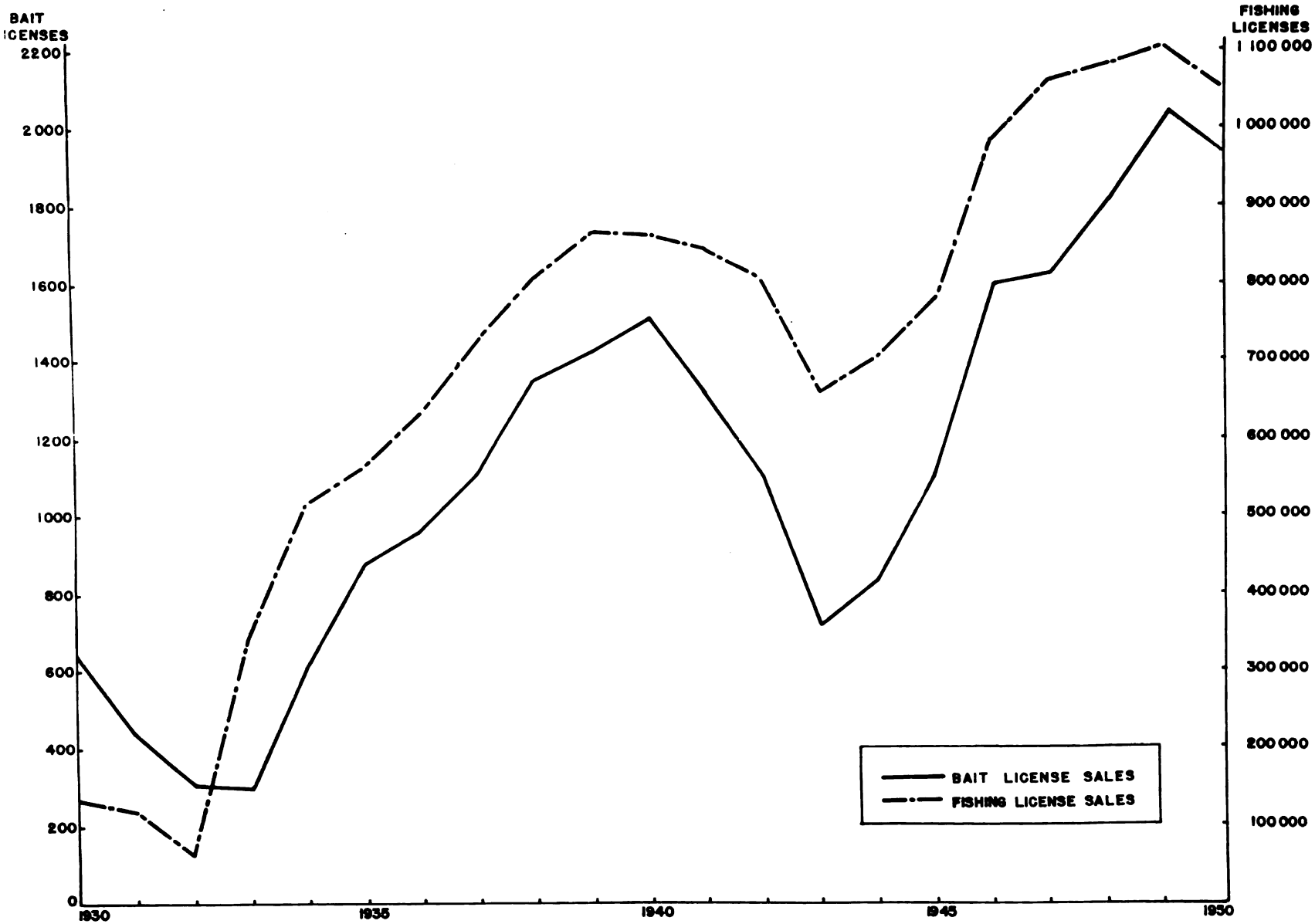

BAIT LICENSES
2000
1800
1600
1400
1200
1000
800
600
400
200
0
TOTAL LICENSE SALES
WHOLESALE LICENSE SALES
RETAIL LICENSE SALES
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950

Chart II: Comparison of Bait License Sales and Fishing License Sales in Michigan: 1930-1950


BAIT
ICENSES
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
FISHING
LICENSES
1 100 000
1 000 000
900 000
800 000
700 000
600 000
500 000
400 000
300 000
200 000
100 000
1930
1935
1940
1945
1950
BAIT LICENSE SALES
FISHING LICENSE SALES

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fisherm

live ba

in active military service. Trends in both bait and fishing license sales are similar and it may be assumed that the increase in sales of fishing licenses and the consequent demand for live bait by the increased population of fishermen suggested favorable business opportunities in live bait sales.

LIVE-BAIT DEALER SURVEY

The purpose of this survey was as follows:

1. To determine the importance and extent of the live bait business in Michigan.

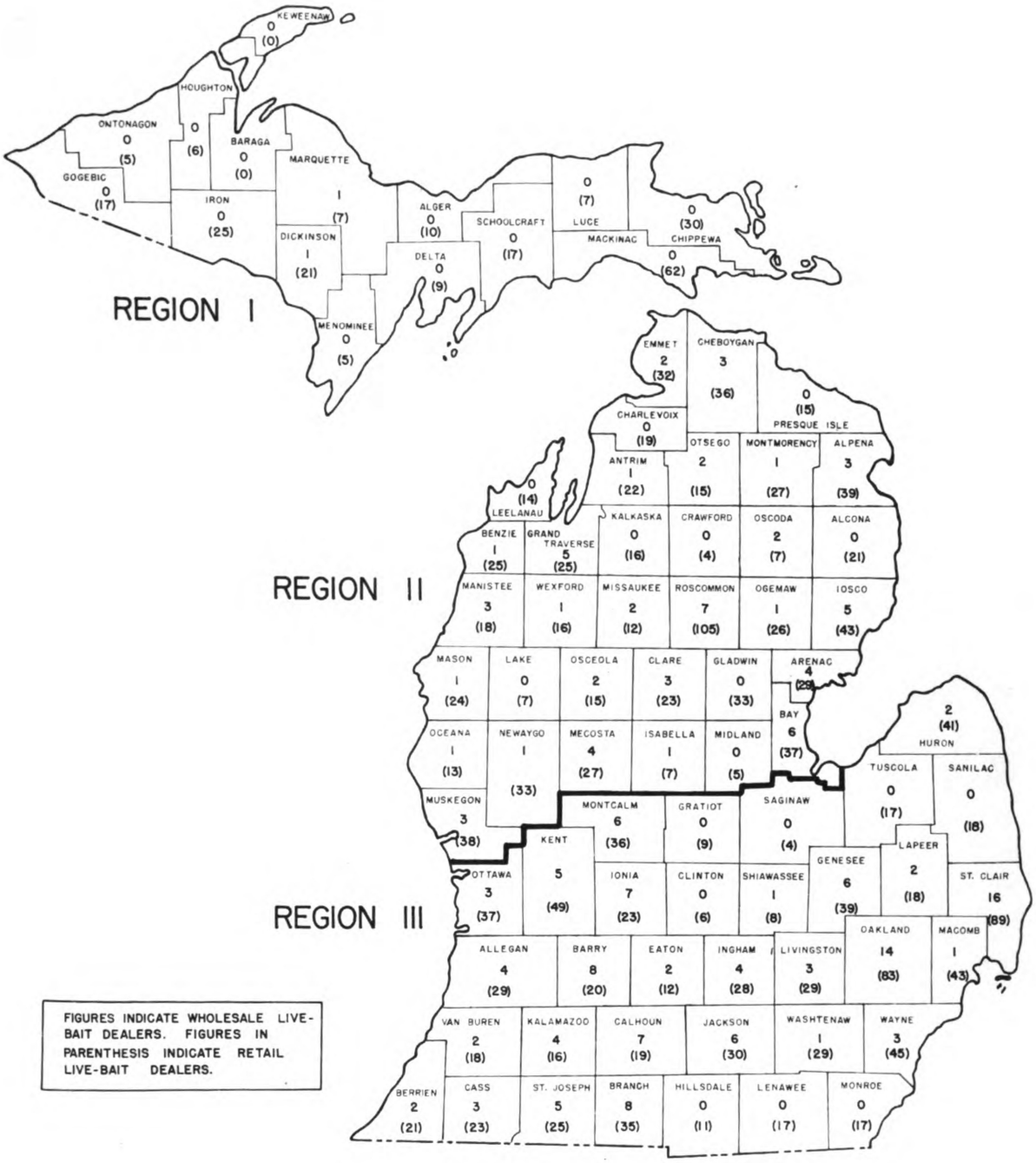
2. To study some of the problems and practices common to bait dealers.

Data gathered during the survey were used to evaluate the state's program of supplying minnow fry for propagation purposes and to assist in the formulation of legislation that would give increased protection to live bait resources.

The dealers contacted were among those who had obtained either a wholesale or a retail minnow license during the period January 1, 1949 to April 13, 1950. The statewide concentration of dealers was determined by plotting the number of licenses sold in each county as indicated by the Department of Conservation's list of minnow dealers licensed for that period. The number of wholesale dealers and the number of retail dealers were determined and are indicated on Chart III.

Sixteen per cent of the retail dealers and 30 per cent of the wholesale dealers were contacted to allow a complete coverage of the state in the allocated time. A larger percentage of wholesalers were contacted since it

Chart III: Distribution of Wholesale and Retail Live-Bait Dealers in Michigan (January 1, 1949-April 13, 1950)


KEWEENAW
0
(0)
HOUGHTON
0
(6)
ONTONAGON
0
(5)
BARAGA
0
(0)
GOGEBIC
0
(17)
IRON
0
(25)
MARQUETTE
1
(7)
DICKINSON
1
(21)
MENOMINEE
0
(5)
ALGER
0
(10)
SCHOOLCRAFT
0
(17)
DELTA
0
(9)
LUCE
0
(7)
MACKINAC
0
(30)
CHIPPEWA
0
(62)
REGION I
EMMET
2
(32)
CHEBOYGAN
3
(36)
PRESQUE ISLE
0
(15)
CHARLEVOIX
0
(19)
ANTRIM
1
(22)
OTSEGO
2
(15)
MONTMORENCY
1
(27)
ALPENA
3
(39)
LEELANAU
0
(14)
BENZIE
1
(25)
GRAND TRAVERSE
5
(25)
KALKASKA
0
(16)
CRAWFORD
0
(4)
OSCODA
2
(7)
ALCONA
0
(21)
REGION II
MANISTEE
3
(18)
WEXFORD
1
(16)
MISSAUKEE
2
(12)
ROSCOMMON
7
(105)
OGEMAW
1
(26)
IOSCO
5
(43)
MASON
1
(24)
LAKE
0
(7)
OSCEOLA
2
(15)
CLARE
3
(23)
GLADWIN
0
(33)
ARENAC
4
(29)
OCEANA
1
(13)
NEWAYGO
1
(33)
MECOSTA
4
(27)
ISABELLA
1
(7)
MIDLAND
0
(5)
BAY
6
(37)
2
(41)
HURON
TUSCOLA
0
(17)
SANILAC
0
(18)
MUSKEGON
3
(38)
MONTCALM
6
(36)
GRATIOT
0
(9)
SAGINAW
0
(4)
KENT
5
(49)
LAPEER
2
(18)
GENESEE
6
(39)
ST. CLAIR
16
(89)
OTTAWA
3
(37)
IONIA
7
(23)
CLINTON
0
(6)
SHIAWASSEE
1
(8)
REGION III
OAKLAND
14
(83)
MACOMB
1
(43)
ALLEGAN
4
(29)
BARRY
8
(20)
EATON
2
(12)
INGHAM
4
(28)
LIVINGSTON
3
(29)
VAN BUREN
2
(18)
KALAMAZOO
4
(16)
CALHOUN
7
(19)
JACKSON
6
(30)
WASHTENAW
1
(29)
WAYNE
3
(45)
BERRIEN
2
(21)
CASS
3
(23)
ST. JOSEPH
5
(25)
BRANCH
8
(35)
HILLSDALE
0
(11)
LENAWEE
0
(17)
MONROE
0
(17)
FIGURES INDICATE WHOLESALE LIVE-BAIT DEALERS. FIGURES IN PARENTHESIS INDICATE RETAIL LIVE-BAIT DEALERS.

was believed that they would be more familiar with existing conditions of supply and demand of the bait industry.

Those dealers to be contacted were selected at random from the Department of Conservation's list of licensed minnow dealers. A total of 60 wholesale contacts and 328 retail dealer contacts were made from the beginning of the survey, June 7, 1950 until its completion, September 12, 1950. The survey was conducted on a personal interview basis with the proprietor or a person closely associated with the business. The mimeographed form that was used is shown in Chart IV.

Chart IV: Form Used in the Live-Bait Dealer Survey

Name _____ Address _____
Location _____ County _____

BUSINESS
Type: wholesale _____ retail _____ both _____
Size: large _____ small _____ part-time _____ seasonal _____
Bait only _____ bait, tackle, etc. _____
Years in business _____
Radius served _____

EQUIPMENT
Transportation size condition tank size type of aeration
Truck:
Trailer: _____
_____: _____

Collection number size
Seines:
Glass traps: _____
Hook and line: _____
Wire traps: _____
Holding tanks: _____
_____: _____

Real estate
_____:
_____:
Total value of equipment: . . . . . $_____

BAITS
Minnow species Perch Bass Pike Decoy
Main species
_____: _____
_____: _____
_____: _____
Regional sp.
_____: _____
_____: _____
Seasonal sp.
_____: _____
_____: _____

Other baits yes no source
Worms:
Red:
Night crawlers: _____
_____: _____
Crickets: _____
Wrigglers: _____
_____: _____
_____: _____

Availability
General: _____
Specific: _____
Seasonal: _____

Radius of collection: _____

SOURCE OF MINNOWS yes no
Collectors:
Collect own: _____
Out-of-state sources: _____
Wholesalers: _____
Raise own: _____

PRIVATE PONDS
Number _____ Average size _____ Total area _____
Source of water _____
Species number feed or fertilizer production
_____: _____
_____: _____
_____: _____
Success:
Percentage of own supply: _____ surplus _____
Remarks on ponds: _____
_____

HOLDING FACILITIES number size
Tanks: _____
Source of water: _____
Percent fish loss _____ chlorine _____ aeration _____
Feeding: _____
Treatment: _____

MINNOW SALES
Number per person: _____
Number per container: _____
Types of containers percent
Minnow pails: _____
Cans: _____
Buckets: _____
_____: _____

INCOME
Gross from live bait only: $_____
Percentage of total sales: _____
Total gross sales: $_____

LITERATURE

There have been two other minnow dealer surveys made in Michigan. Carbine, (1940) interviewed 65 dealers during the period 1937-1939 to determine minnow loss and methods of collecting, handling, and holding.

Shortly before the state undertook the demonstration experiment for determining the practicality of bait minnow culture, Washburn (1946) conducted a postcard questionnaire concerning the scarcity of bait minnows and the advisability of the demonstration program proposed. He concluded from the 37 per cent returns that minnow dealers recognized that an acute shortage of bait existed and were in favor of the program to study methods of propagation of these fish.

DISCUSSION OF RESULTS OF THE SURVEY

In the discussion that follows, reference is made to the division of the state into "regions". These regions are indicated on Chart III. This division of the state, which is utilized by the Department of Conservation, has been followed because each of the three regions generally represents differences in soil, agriculture, vegetation, and population density.

Region I is an area that is sparsely populated in comparison to the other regions of the state. Poor soils and a short growing season limit agriculture. Vegetation is a mixture of conifers and more tolerant deciduous trees. Tourist trade is an important part of the economy of the area.

Region II is intermediate between regions I and III in most respects. Fruit farming, dairy farming, and other agricultural practices are carried on as soil types and the length of the growing season will permit. Population is more dense than the northern region and industrial concerns are more numerous. Vegetation varies from mostly deciduous forms in the southern portions of the region to a mixture of conifers and deciduous trees or pure conifer stands at the northern limits. This area has centers which are widely known as tourist resorts.

Region III is characterized by greater industrialization than the other regions. General farming as well as specialized agricultural practices are conducted. Soils in this area are generally more fertile than northern soils. Tourist trade is of some significance in this area but not to the extent it realizes in the two northern regions of the state.

In the discussion of the results of the survey, percentages or averages given are representative of the state unless otherwise indicated in the text. Figures that are representative of the regions are given in charts that accompany the text. Percentages and averages are arithmetic means calculated from data obtained by survey contacts which were a random sample of the live-bait dealers in the state at the time the survey was conducted.

Business Operation

Under the provisions of Act 337, P.A. 1939, a dealer purchasing a wholesale license may also operate a retail establishment. Nearly 70 per cent of the wholesale dealers were following this practice. Some, however, apparently were not aware of the provisions of the act since they purchased both the retail and wholesale license.

Over half of the wholesale dealers contacted (Chart V) had a gross sale of live bait totaling $2000.00 or more

Chart V: Business Operations of Michigan Live-Bait Dealers

	Region I	Region II	Region III	State
Percentage of wholesale licensees operating as wholesalers only	-	23.5%	34.3%	30.8%
Percentage of dealers having a gross sale of live bait over $2000 per year	0% -	22.0%* 52.9%**	27.3% 57.1%	21.7% 55.7%
Percentage of dealers operating part-time	94.6% -	60.2% 41.2%	60.4% 45.7%	64.6% 44.2%
Percentage of dealers operating seasonally	67.6% -	39.0% 29.4%	31.7% 14.3%	39.2% 19.2%
Percentage of dealers handling only live bait	54.1% -	31.7% 64.7%	17.3% 45.7%	27.8% 51.9%
Average number of years in the live bait business	3.4 -	6.4 10.7	5.6 8.5	5.7 9.2
Average service radius in miles	4.8 -	9.6 47.2	10.0 45.5	9.2 46.1
Average collection radius in miles	7.8 -	19.2 53.4	16.6 30.6	16.6 38.1

* Retail dealers
**Wholesale dealers

per year. Less than one quarter of the retail dealers obtained that volume of sales.

Part-time operators were found to be most prevalent, with 65 per cent of the retail dealers working at some other occupation throughout the year. Forty-four per cent of the wholesale dealers were in this category. Four out of every ten retail dealers operated seasonally as compared to two out of ten wholesale dealers.

The majority of the wholesale dealers in the state handle only live bait. Over 70 per cent of the retail dealers handle fishing tackle, sporting equipment, or other materials in addition to live bait.

The average retail bait dealer has been in business for 5.7 years as compared to 9.2 years for the average wholesale dealer.

The radius of collection for the average retail dealer is 16.6 miles, exceeding the radius of service which is 9.2 miles. The average radius of collection for wholesale dealers is 38.1 miles as compared to a service radius of 46.1 miles.

Equipment

Transportation Equipment:

Trucks, trailers, autos, and boats are utilized in transporting bait from lakes and streams and of these,

trucks are by far the most common. Thirty-six per cent of the retail dealers used trucks (Chart VI) as compared to 75 per cent of the wholesale dealers. The auto was next most important means of transportation for retail dealers, followed by auto trailers, and boats. Wholesale dealers utilized auto trailers more than either boats or autos. Factors that determine the type of vehicle used in the transportation of bait are: the ability of the dealer to invest in a special vehicle for bait purposes, the quantity of bait that is transported, and the distance that the bait is transported.

Tanks and containers of every size, shape, and description are used. Metal stock tanks six to eight feet in length are common. Tanks of sheet metal or wood construction are sometimes built to utilize all available space on truck or trailer beds. Use of metal having a natural light reflective quality is advisable in tank construction. Light colored paint may be applied to dark tanks to decrease heating from the sun. Tanks may be insulated with commercial materials or a small cooling unit may be installed. Smaller containers such as barrels, garbage cans, pails, and wash tubs are used.

Despite the fact that they are aware of the oxygen needs of fish, many dealers have no provisions for adequate aeration on their transportation equipment. Manual dipping

Chart VI: Types of Equipment Used by Michigan Live-Bait Dealers

	Region I	Region II	Region III	State
Percentage of dealers using trucks for transportation of live bait	18.9% -	46.3%* 76.5%**	31.7% 74.3%	36.1% 75.0%
Percentage of dealers using trailers for transportation of live bait	10.8% -	5.7% 0%	11.5% 17.1%	9.0% 11.5%
Percentage of dealers using boats for transportation of live bait	27.0% -	18.7% 5.9%	21.6% 11.4%	21.1% 9.6%
Percentage of dealers having an aeration device on transportation equipment	8.1% -	28.5% 58.8%	23.0% 71.4%	23.4% 67.3%
Percentage of dealers operating seines	73.0% -	65.9% 70.6%	48.9% 65.7%	58.9% 67.3%
Percentage of dealers operating glass traps	0% -	41.5% 76.5%	40.3% 62.9%	35.8% 67.4%
Percentage of dealers operating wire traps	37.8% -	5.7% 5.9%	5.0% 8.6%	9.4% 7.7%
Percentage of dealers operating hook and line	5.4% -	11.4% 11.8%	25.9% 25.7%	17.4% 21.2%

* Retail dealers
**Wholesale dealers

of the water or the splashing of water during transit are relied upon to provide oxygen.

In transporting minnows with or without the aid of some mechanical means of aeration, consideration must be given to water temperature, air temperature, number and size of minnows to be carried, and the distance to be traveled. Without some device to provide aeration, there is seldom any margin of safety to allow for accidents such as flat tires or motor trouble, not to mention providing time for catching a load of bait after arriving at the desired collection area.

Aeration devices were present on one fourth of the vehicles used in the transportation of minnows by retail dealers; two thirds of the vehicles operated by wholesale dealers possessed such equipment. Small gasoline motors with pump attachments were in wide use. Some dealers attached small water pumps beneath the hood of the truck and operated the pump from the fan belt. This proved to be a convenient, neat arrangement that is economical to install and less vulnerable to mechanical failure than gasoline motor types. Compressed air from pressure tanks or spare tires is used as a means of aeration. Funnel arrangements which force air into the water while the vehicle is in motion are sometimes employed. The use of oxygen tablets in small containers is common practice.

Collection Equipment:

Equipment that may be used for taking minnows in Michigan is defined by law (Act 165, P.A. 1929). Seines are most widely used, followed by glass traps, hook and line, and wire traps (Chart VI). Dip nets are seldom used other than for lake emerald shiners (Notropis atherinoides acutus). There has been considerable controversy concerning minnow injury caused by seining practices. It remains, however, the most widely used means for taking minnows throughout the state. The use of seines is most prevalent in the northern portions of the state where they are the chief means of taking minnows.

Glass traps are employed widely in southern areas of the state and used very little in the Upper Peninsula. They are used with varying degrees of success, dependent upon the skill and experience of the trapper. Glass traps have the advantage of not injuring the minnow, a serious fault of the seine and the wire trap. Experimental traping in trout streams has shown that trout are not readily taken by glass traps, a fact which has opened many waters to the bait dealer which otherwise would have remained closed (Carbine, 1943; Washburn, 1945; Yoder, 1948).

Considerable use of hook and line for taking bait minnows was also noted in the southern portions of the state. This method is employed while tending glass traps

and is especially productive for the larger size minnows.

Wire traps are commonly utilized in northern areas of the state but seldom in the southern waters.

Bait Minnows

Common Bait Species:

Bait minnows are offered for sale in four ways; (1) stream run, (2) size, (3) species, and (4) species and size. Some dealers have a straight price for their minnows which gives a customer a distribution of sizes and species as they were captured from the stream. No sorting is involved. One of the more common methods of presenting minnows for sale is to sort them according to size. Since most fishermen prefer minnows within a certain size range when angling for a specific game fish, the size of the minnow and the name of the game fish for which they serve as bait has become almost synonomous. Minnows measuring up to three inches in length are commonly referred to as perch, speck, or crappie minnows; minnows from three to five inches in length are called bass or walleye minnows while larger minnows are called pike minnows. Sorting of this nature is accomplished by hand in most cases.

Fishermen may express a desire for a definite species of minnow. To supply these requires sorting by hand whereas minnows may be sorted to size by a mechanical fish sorter.

The most frequently used division is a combination of size and species. This method, too, involves hand sorting. Loss can be kept to a minimum if care in handling is exercised. Dealers who present minnows sorted in this manner for sale are better able to meet the demands of specialized anglers who prefer a certain species of minnow. On the whole, it leads to more satisfied customers.

Large suckers, golden shiners, and chubs are often utilized as decoy minnows in winter spearing to lure large predatory fish into spearing position. These minnows usually are larger in size than pike minnows used for bait during the regular fishing season. Large suckers are also cut into strips and used as bait for lake trout in areas where these fish are found.

Muddlers are sold by few bait dealers; they are a bait that some trout fishermen prefer over all others. Since muddlers are not plentiful and are difficult to capture, they generally are high in price.

The cost of bait minnows varies from area to area and from week to week, depending upon the competition and availability. Localities were noted in which minnows could be purchased for only one-half the cost ordinarily

expected. Several dealers were located in the area but a policy of under-selling had developed and often minnows were retailed for the usual wholesale price. The reverse situation is also true: isolated dealers may charge prices far in excess of those expected. The practice of under or over-selling is not the general rule, however. Most dealers have arrived at a reasonable price that they attempt to maintain as long as availability of the minnows continues. As bait minnows become difficult to obtain, more effort is expended in their capture with a consequent increase in price that is passed on to the angler.

Minnow populations available to bait dealers fluctuate. Minnows are generally available in the spring and fall but warm water temperatures during the summer months force them into waters where they are inaccessible. Heavy rains may cause water levels in streams to rise and the water may become heavily laden with silt, making glass trapping and seining impossible. Fluctuation in barometric pressure is believed to have an influence on the trapping of minnows.

It is difficult to arrive at a specific price for each size class and species of bait minnow because of variations induced by competition and availability. The range of prices by species and size class is given in Chart VII. The species are listed in order of their

Chart VII: Price Range of Minnows in Michigan

(Spring and Summer, 1950)

Species	Retail price range per dozen			Wholesale price range per 1,000		
	Perch	Bass	Pike	Perch	Bass	Pike
REGION I						
Creek chub	.25-.50	.40-1.00	.75-3.00	Retail dealers do not commonly pur-		
White sucker	.25-.50	.50-1.00	1.00-3.00	chase live bait from wholesalers.		
Common shiner	.25-.50	.40-1.00	.75-1.50	Only two wholesale dealers were		
Long nosed dace	.25-.50	.45-.50	-	present in the region at the time of		
Mud minnow	.25-.35	.45-.60	.60-.75	the survey. Neither was contacted.		
Northern red-bellied dace	.25	-	-			
Golden shiner	.30	.60	.75			
Fathead	.30	-	-			
Lake emerald and other lake shiners	.20-.40	-	-			
Decoy minnows (all species)	.50-.75 each					
REGION II						
Creek chub	.10-.35	.30-.85	.50-1.50	3.50-7.50	20.00-40.00	40.00-50.00
White sucker	.10-.35	.30-.85	.50-1.50	3.50-7.50	20.00-40.00	40.00-50.00
Common shiner	.10-.35	.30-.85	.60-1.50	3.50-7.50	20.00-40.00	40.00-50.00
Long nosed dace	.10-.35	.40-.50	.60-.75	-	25.00	-
Golden shiner	.25-.50	.40-.70	.60-1.20	-	-	-
Fathead	.10-.25	-	-	5.00	-	-
Lake Emerald shiner	.10-.25	.35	-	2.00-6.00	-	-
Muddlers	.40	.75-1.00	-	-	-	-
Decoy minnows (all species)	.15-.50 each				-	
REGION III						
Creek chub	.15-.25	.35-1.00	.60-1.80	3.00-10.00	20.00-30.00	30.00-60.00
White sucker	.15-.25	.35-1.00	.60-1.50	-	-	60.00
Common shiner	.15-.25	.35-.75	.60-1.80	3.00-10.00	20.00-30.00	30.00-60.00
Golden Shiner	.20-.25	.50-1.00	.60-1.80	8.00-10.00	30.00-40.00	50.00-70.00
Fathead	.20-.25	-	-	7.00-10.00	-	-
Lake emerald shiner	.10-.35	-	-	3.00-6.00	-	-
Decoy minnows (all species)	.15-1.00 each				-	

prominence in the region. The species sold are largely determined by availability, locally or from wholesale sources, and by the demands of the fishermen. Three species which are common in all three regions of the state are the northern creek chub, white sucker, and the common shiner, Notropis cornutus.

Lake Emerald Shiners:

The readily accessible supply of lake emerald shiners in certain areas in the Great Lakes has provided a seemingly inexhaustable supply of small minnows. They are an attractive, bright minnow which some anglers claim to be more readily taken by fish than darker bait minnows. Although these minnows are not particularly hardy on the hook and are easily injured in handling, their abundance has nearly excluded any species that might be cultured to compete in this size class. In areas more remote from the Great Lakes, fatheads, golden shiners, and numerous species of other shiners commonly found in streams are used.

Specific areas along the Great Lakes have been fortunate enough to have a year-around supply of lake emeralds with few periods of scarcity such as experienced in many other localities. Port Huron is the center of lake emerald shiner activity in the state and the minnow supply from that source supports a large number of

wholesale bait dealers, some among the largest in the state. Minnows are transported along the eastern shore line of the state, ranging far inland or across the state except for the months of July and August when inland lakes and streams are too warm for the use of the lake emerald shiner.

Mortality of lake emerald shiners is generally quite high since they are easily injured in handling and are sensitive to water temperatures. Following delivery from a wholesaler, retail dealers may suffer 100 per cent minnow mortality in a three day period. Most bait dealers operating on the Great Lakes during the summer months expect a mortality from 33 per cent to 50 per cent. This is a variable dependent upon the holding facilities, most of which are live boxes located in the lake or river. If care is exercised by the wholesaler in handling, allowing as little rehandling as possible, minnow loss can be reduced.

Generally, lake emeralds are not counted when sold. Prices range from less than one cent apiece upward. The customer may in many cases receive a scap net of minnows which will severely over-crowd his minnow bucket and the minnows usually are dead when the angler arrives at his fishing site.

Since lake emerald shiners are not tolerant of high water temperatures, they are not a minnow that should be used in many of the inland lakes and streams during the summer months. Lake emerald shiners are utilized extensively as a winter bait in such areas since they are easily held in cold water and require little or no care during this time.

Lake emerald shiners are usually captured by one of two methods. The most wide-spread method is seining which must be carried out carefully or considerable scaling and injury may result. Dip nets of commercial types or of camouflage netting are used if shiners are present in water near boat docks or pilings. This method is less injurious to fish than seining since there is not the same likelihood of mechanical injury involved.

Once the minnows have been collected, they are transported by pails or tubs to tanks on carrying vehicles. Wholesale dealers may use large live boxes in the vicinity for storage or the minnows may be placed in a delivery truck which can either deliver them directly to the retail dealers or take them to reserve holding ponds. The increased handling involved in placing minnows in live boxes or in storage ponds increases the mortality rate. If the wholesaler has a rapid turn over, these injured minnows may be passed on to retail dealers who suffer the loss.

Live boxes used for storage are usually provided with some screening device which will allow the smaller minnows to escape. The box is generally of heavy construction to withstand the buffeting of wave action. The location of the live box in the lake or river is of considerable importance, particularly if heavily loaded with minnows. Boxes placed in areas where there is no current may not receive adequate aeration. In contrast, the placing of a box in a current that is too strong will cause minnows to become weak from fighting the current. Holding in close confines without food will cause minnows to loose condition which eventually results in increased mortality.

Some dealers have established routes with definite customer stops. Other dealers are competing for retail outlets on a first come first serve basis. This practice may result in the loss of a complete truck load of minnows if a wholesaler is unfortunate enough to be on a route traveled earlier by another dealer.

Minnows are usually sold by the gallon. A pail is employed and the minnows are netted from the tank and transferred to the tanks of the retail dealer. If the wholesale dealer fears he may lose his load of bait, "bargin" rates or extra large measures may be given.

In some instances, retail dealers are forced to purchase a certain amount of minnows or go without any at all. This practice often results in overloading the tanks of the retail dealer. Since the supply of lake emeralds may fluctuate, retail dealers experience periods when no minnows are available. As a precaution against this, retailers may purchase from two or more wholesale dealers to insure a supply in the event one wholesaler cannot make delivery.

The abundant supply of lake emerald shiners has counteracted their high rate of mortality expected in the ordinary conditions of wholesale and retail live bait sales. They are not a hardy minnow and are easily injured in handling, they are not temperature tolerant, and they lose condition quickly in holding. Their low cost and the fact that many anglers prefer them has excluded other species that might otherwise compete in this size class.

Availability of Minnows

No definite conclusions could be determined from the survey concerning the availability of bait minnows. Dealers in a specific area would state that minnows were generally abundant. Yet, another dealer contacted in that same area would claim poor availability of bait

minnows. The varability in most cases was probably due to differences in the collecting techniques employed by dealers as well as knowledge of the streams and lakes available to the taking of bait minnows.

Areas such as Roscommon County, Mackinaw County, Oakland County and St. Clair County that support a large tourist population or have a high population of resident fishermen were noted to suffer from minnow shortage in all size classes. Otherwise, pike minnows were said to be least abundant. In areas where lake emerald shiners were not available, perch minnows were sometimes scarce. The bass and walleye minnows were never particularly difficult to obtain.

Suckers are seldom abundant. In most instances, the scarcity of suckers is not caused by a low native population in streams and lakes but is due to the fact that legal methods for their capture are not satisfactory. Suckers may be seined but will rarely enter glass traps; this fact alone makes those in trout waters unavailable to bait dealers.

Availability of all species is in part seasonal, minnows being more abundant in the spring and fall but less plentiful in the warm summer months when the demand for minnows is greatest. During the survey it was noted that dealers who had private ponds or lakes had fewer

problems but rarely was the supply available from their ponds alone adequate to fill demands. Holding ponds or a combination holding and rearing pond that was stocked when the native minnow population was high generally provided the best solution to the problem of minnow availability.

Sources of Minnows

Minnows are obtained by dealers by the following means: (Chart VIII)

1. Purchase from licensed wholesale live-bait dealers
2. Purchase from out-of-state sources
3. Purchase from unlicensed collectors
4. Collection from natural habitats
5. Pond propagation
6. Any combination of the above

Collection from natural habitats such as lakes and streams is the most common practice. Over 95 per cent of the wholesale dealers utilize this source to obtain all or a portion of their minnows. Seven out of ten retail live-bait dealers also collect their own minnows. However, if the supply available is not sufficiently large to meet the demand, the dealer is obliged to resort to the purchase of minnows. Sixty per cent of the retail dealers purchase part or all of their minnows from

Chart VIII: Sources of Bait Minnows for Commercial Sale

	Region I	Region II	Region III	State
Percentage of dealers obtaining minnows from collectors	10.8% -	1.6%* 0%**	9.4% 0%	6.4% 0%
Percentage of dealers collecting their own minnows	91.9% -	75.6% 94.1%	59.7% 97.1%	70.2% 96.1%
Percentage of dealers obtaining minnows from out of state sources	2.7% -	0% 0%	0% 0%	0.3% 0%
Percentage of dealers obtaining minnows from wholesalers	13.5% -	62.6% 47.1%	73.4% 31.4%	61.5% 36.5%
Percentage of dealers raising all or a portion of the minnows used	10.8% -	7.3% 17.6%	9.4% 22.9%	8.7% 21.2%

* Retail dealers
**Wholesale dealers

wholesale live-bait dealers. Wholesale dealers may also purchase minnows from other wholesalers to meet existing demands. This is particularly true in the case of lake emerald shiners because access to sources of supply is usually limited to specific areas.

A very small percentage of minnows are purchased from out-of-state sources. It is largely restricted to the western portion of the Upper Peninsula where mud minnows, Umbra limi, are imported from Wisconsin to meet the demand for a walleye bait.

Approximately 5 per cent of the dealers purchased some minnows from unlicensed collectors who operate in violation of the law.

The percentage of dealers who raise all or a portion of their minnows is approximately one half of those owning or having access to private ponds or lakes. Very few dealers were noted who were able to raise their total supply of minnows. In many instances, failure could be attributed to improper pond construction or poor selection of water supply.

Private Ponds

There are approximately 1180 private ponds in Michigan that are used to raise or hold bait minnows. The average number of ponds per wholesale dealer is 1.35;

retail dealers average 0.46 ponds each. As indicated in Chart IX, 22 per cent of the retail minnow dealers and 40 per cent of the wholesale dealers in the state own or have access to private ponds.

There is a wide range in size and suitability of ponds. Those that were constructed specifically for holding purposes are usually small. In many holding ponds, as well as in successful rearing ponds, the minnows are collected only with considerable difficulty since no provision for draining the ponds was provided.

During the course of the survey, minnow dealers who had purchased minnow fry from the state for propagation purposes were contacted in order to evaluate the success of the program. Dealers who stocked minnow fry in suitable ponds usually meet with success. In nearly every case in which attempts at minnow propagation failed, the cause could be attributed to unsatisfactory pond construction or poor water supply.

Dams were noted to be poorly constructed and were frequently washed-out. Screening of water inlets and outlets was in most cases inadequate to keep small minnow fry in the pond. Predatory fish which were sometimes present removed the fry soon after they were stocked. In many instances, minnow fry were placed in ponds where little food was available. Water temperatures were often too low to permit an acceptable rate of growth.

Chart IX: Data Concerning the Use of Minnow Ponds in Michigan

	Region I	Region II	Region III	State
Percentage of dealers having private ponds	27.0% -	22.8%* 41.2%**	19.4% 40.0%	21.7% 40.4%
Average number of private ponds per dealer	.35 -	.57 1.71	.39 1.17	.46 1.35
Percentage of dealers considering their ponds successful for raising minnows	50.0% -	25.0% 42.9%	44.4% 57.1%	37.1% 52.5%
Percentage of dealers considering their ponds successful for holding minnows	80.0% -	85.7% 85.7%	63.0% 42.9%	74.4% 56.9%

* Retail dealers
**Wholesale dealers

The program fills an important need since it provides dealers with highly desired creek chub and white sucker fry which otherwise would not be available. The demand for fry will undoubtedly continue and increase as bait dealers accept minnow culture as a solution to the minnow shortage and provide adequate facilities for minnow propagation.

Holding Facilities

Many types of tanks are utilized in holding minnows for sale; metal stock tanks are most common. Little uniformity in size is found since tanks are purchased as needed and usually are second-hand to make initial cost as low as possible. Metal tanks are often replaced with cement or cement-block type tanks which can be constructed in any desired size or shape. In addition, these tanks improve the overall appearance of the establishment. Cement tanks can be partitioned into various sized compartments readily, they are easily cleaned, and generally offer more flexible utilization than standard stock watering tanks.

In permanent tank installations, complete drainage is possible by removable plugs in the floor of the tanks. In the survey it was noted that many dealers failed to install drains in larger tanks. Overflow pipes are usually

found to be located near the top of the tank. However, tanks having a device whereby overflow water is taken from the bottom rather than the top have the advantage of obtaining a more complete change of water in addition to removal of some bottom sediment and debris.

Smaller operators employ wash tubs, pop coolers or pails for holding purposes. Facilities of this type are not adequate for the purpose since they must necessarily hold only a few minnows. Nearly constant attendance is required to keep water changed or aerated.

Dealers having access to nearby lakes or streams may employ "live boxes" or "live screens" for holding minnows. These devices are box-like structures of metal screen of a combination of metal screen and wood. Holding facilities of this nature are widely used by small bait dealers and resort operators in the northern areas of the state where bait sales are small and seasonal. Considerable loss was noted in this type of holding structure. This loss may result from mechanical injury from contact with screening, buffeting by waves or current, fatigue from constant presence of a strong current, warm water temperatures, or low oxygen supply.

Sources of water commonly utilized for holding facilities are wells, springs, city supply or water pumped from rivers or lakes. Temperature extremes, presence of

toxic chemicals or industrial waste, and constancy of flow must be considered in selection of the source of water supply. In urban areas where chlorine or some other chlorinated compound has been added to the water, a filtering system may be installed. In some instances, where the amount of chlorine contained in the water ~~was~~ is not great, the chlorine can be eliminated by spraying the water into the tank in the form of a mist or fine spray.

Aeration is accomplished by use of jets that spray water into the holding tanks with considerable force. Water can be allowed to splash into the tank from the inflow pipe or dribbled in through holes in a pipe hung over the tank. In some instances, a circulating pump is employed. The amount of water that enters the tank should be controlled as an economic measure.

Minnow Loss

A wide variation in the percentage of minnows lost due to transportation, handling, and holding was noted in the survey. Greatest loss occurred in the various species of shiners, especially lake emerald shiners. Handling techniques, improper tempering of the minnows, and adverse holding water temperatures were indicated as major causes of mortality.

Most dealers found golden shiners difficult to handle and hold without high mortality. Trouble was experienced in holding all species due to injury or scaling in seining and handling which was followed by fungus infection. Considerable mortality was noted in species that were captured during their spawning season. Females apparently became egg-laden and died.

Average Percentage of Minnow Loss

	Region I	Region II	Region III	State
Retail dealers:	21.7	14.4	16.6	16.4
Wholesale dealers:	—	9.2	8.0	8.4

Wholesale dealers incurred a smaller percentage loss than retail dealers. Better handling techniques, equipment, and knowledge of tempering and treatment may account for this difference. The percentage of mortality as indicated by the results of the survey are considerable lower than generally estimated. Observations made during the survey suggested that many dealers suffered bait minnow mortality that was substantially greater than that stated during the interview.

Holding Tank Care

Cleaning:

The majority of the bait dealers have no specific policy for preventing disease in minnow holding tanks.

Among dealers who employ some method of cleaning and disease prevention, the scrubbing of tanks with a salt and water solution is most common. Commercial soaps, bleaches, and cleaning agents are often used, as well as boric acid, baking soda, or vinegar. Tank cleaning may vary among the bait dealers from as often as once each week to only once or twice a season.

Painting of holding tanks is carried out by some dealers who rely on this means of keeping tanks clean rather than occasional washing or scrubbing. Tanks may be repainted as often as six times a season. Paints of almost every type are used but a preference of aluminum paint for metal tanks and asphalt paint for cement tanks was noted. Commercial rubberized paints with fungus repellent qualities are sometimes used.

Treatment:

The addition of salt to water in holding tanks is the most widely used treatment for minnows. Few dealers, however, are aware of the proper concentrations to be used. A handful or two of salt may be placed in a tank and the treatment is considered completed. Salt and mercurochrome in combination is sometimes used. There is no flushing to remove the salt solution or the sloughed-off ectoparasites.

Copper sulfate, potassium permanganate, and formalin are used by some dealers. Treatments are made in a haphazard manner and value of such procedure is doubtful.

In some instances, an effort is made to remove weak or infected minnows as soon as they are noted but more often they are allowed to remain in the tank for considerable periods.

The recognized malachite green treatment for fungus is seldom practiced. Dealers who are aware of the treatment and who would attempt to use it are not able to obtain malachite green from local sources or from nearby cities.

Feeding:

The policy of feeding minnows held in holding tanks during summer is not usually practiced. The turn-over of minnows is sufficiently fast that feeding is not necessary.

Dealers who do feed use several different types of food. The most widely used are cracker crumbs, dog food, and oatmeal. Others are bread, worms, toast crumbs, soybean meal, corn meal, cooked oatmeal and corn meal, meat scraps, cream of wheat, Pablum, chicken mash, and chick starter.

Minnow Sales

In order to supply a greater percentage of their patrons, a small number of the dealers in the state limit

the number of minnows to be sold to one customer. Fishermen are offered a refund for the return of any minnows that are not used. This practice, however, is the exception rather than the rule.

CHART X

Minnow Sales Practices

	Region I	Region II	Region III	State
Percentage of dealers limiting minnow sales:	0 ---	4.1* 0**	2.9 0	3.3 0
Percentage of dealers limiting the number of minnows per container:	97.3 ---	99.2 100.0	95.7 100.0	97.3 100.0
Average percentage of sales made to fishermen using commercial minnow pails:	78.7 ---	81.6 68.5	76.6 70.5	78.9 69.8

* Retail dealers; ** wholesale dealers

Nearly all dealers in the state attempt to limit the number of minnows sold in any one container. In most instances, the number is too great. The number varies with the type and size of the container, the size of the minnow, and the distance to be traveled. Fishermen are usually urged to purchase oxygen tablets to supply additional oxygen to the water in the event of some emergency.

Commercial type minnow pails are used by eight out of ten fishermen purchasing minnows. Rental of minnow pails is sometimes permitted. Other containers of all

kinds are employed as substitutes for minnow pails: tin cans, bottles, crocks, or nearly any other vessel that will hold water.

Other Live Baits

Chart XI indicates forms of live bait, other than minnows, which are handled by live-bait dealers. A description and a brief life history are given for the larval and nymphal forms since they are generally not well known. Material for descriptions and life histories has been taken largely from Morgan (1930), Matheson (1947), and Comstock (1949).

Night crawlers and the earthworm, or common garden worm, are the most common live bait. The nymphal form of the Mayfly called "wigglers" is the most important aquatic representative. Wigglers are in great demand as an ice fishing bait and some dealers are successful in holding them for summer sales. The combination of wigglers and night crawlers constitute, in some instances, a major portion of all live bait sales.

Other forms of live bait have varying degrees of importance depending upon the type of fishing in the area, the demand for a specific bait, and the availability of that bait. The common live baits are obtained by the following means:

Chart XI: Live Bait Other Than Minnows Sold by Live-Bait Dealers in Michigan

Form and name of live bait	Region I	Region II	Region III
Worms:			
Night crawlers	*	*	*
Red worms	X	*	*
Earth worms	*	*	*
Leeches:			
Leech		X	X
Crustaceans:			
Crayfish		*	*
Insects:			
Adult forms:			
Grasshopper		X	X
Cricket		*	X
Larval forms:			
Cornborer		*	*
Meal worm		X	X
White grub		*	*
Caddis		X	*
Wax worm		X	X
Golden rod grub		X	*
Catalpa worm		X	*
Hellgrammite		X	*
Sand borer			X
Wood borer			X
Rat-tailed maggot			X
Nut weevil			*
Nymphal forms:			
Wiggler	X	*	*
Frogs:			
Grass frog		*	*
Mice:			
Field mouse			X

X Sold by some dealers
* Commonly sold

1. Collection by the dealer, his family, or his hired help.
2. Purchase from wholesalers or collectors.
3. A combination of the above.

Some of the live bait forms listed are "speciality" items handled by only a few dealers in an area. In many cases, these items are not plentiful or are otherwise difficult to obtain.

EUROPEAN CORN BORER:

Order: Lepidoptera
Family: Pyralididae
Pyrausta nubilalis

The European corn borer came into the United States sometime before 1917. The adults are pale yellowish moths with a wing expanse of about 25 to 30 millimeters. The species pass the winter as a larvae in burrows in corn-stalks, stubble, or cobs, or in the stems of other host plants, as dahlias and gladiolus. In the spring they pupate in the burrows and the adults emerge in two or three weeks, from late May to early June. Females lay their eggs in small masses on the under sides of leaves. The eggs hatch in a week or ten days and the larvae usually burrow into the host plant. The larvae of this brood mature in July and the adults emerge in August; the females oviposit mostly on corn. The eggs hatch and larvae burrow into the stalks or the developing ears where they

hibernate in their burrows. There are two strains of this insect, one with two generations a year, as outlined above, and the other with but one generation.

MEAL WORM:

Order: Coleoptera
Family: Tenebrionidae
Tenebrio molitor
Tenebrio obscurus

The meal worms are a common pest in mills, granaries, and wherever grain is stored. The adult of *T. molitor* is shining brownish-black in color and about 15 mm. long. The females lay their eggs in cereals, flour, or any kind of grain. The mature larva is a hard, shining, yellowish, cylindrical worm closely resembling a wireworm. The entire life cycle from egg to adult requires three or four months. In warm places it breeds throughout the year. A closely related species with similar habits, *T. obscurus*, is about the same size but is opaque black in color.

After reaching the full larval size, larvae may pupate at once or may remain for months without any visible change. When the larvae are ready to pupate they become sluggish. Within a few hours the larval skin splits and the white, naked pupae frees itself of the old larval skin. When the pupae is mature, the colorless adult emerges. With time, the white changes to brown and the brown grows darker until the characteristic adult color is obtained.

WHITE GRUB:

Order: Coleoptera
Family: Scarabaeidae
Phyllophaga sp.

The adult May beetles are comparatively large insects, robust, pale reddish, brownish to almost black. They appear in May, June, and July. During the day they remain hidden under grass or debris, or in some place of concealment. At night they come out to feed on plant foliage.

The life cycles of most of the species are quite similar. The females enter the soil and deposit each egg in a ball of earth some inches below the surface. There seems to be a preference for sod land, especially in high areas or near wooded tracts. The eggs hatch in three or four weeks and the young "white grubs" appear. These larvae are thick, fleshy grubs, with well-developed legs. The caudal segments of the abdomen are very large and appear black because of the dirt in the intestine. The grubs feed upon decaying vegetation and the roots of grass and other plants. At the approach of winter, they burrow deeper into the soil and hibernate. The next spring they come near the surface and feed actively all summer. The following winter is passed as before and the next spring the grubs again come near the surface to feed. This time, however, it is only for a short period which is followed

by the formation of rough oval pupal cells in the ground. Pupation takes place during the summer and the adults emerge from the pupal skins but remain in the cells until the following spring. The emergence of the adult beetle completes the three year cycle.

CADDIS:

Order: Trichoptera

The caddis flies are moth-like insects which are common in the vicinity of streams, ponds, and lakes. The body wall and wings of the adult are clothed with hair. Eggs are laid either in water or upon objects above the water from which the larvae can drop into the water.

The larvae of most caddis flies are somewhat caterpillar-like in shape and build portable cases in which they live. The cases of different species differ greatly in form and in materials used in their construction. The larvae drag the cases about, projecting only the front end of the body and the legs from the case when they travel.

When full-grown, caddis worms do not leave the water to transform as do nearly all other aquatic larvae. When about to pupate, some of the case-building species change the form and material of their cases and nearly all of them partly close their cases so as to keep out intruders and silt. Some provision is made for the entry

of water for respiration. When the adult insect reaches the surface of the water, its wings expand instantly and are fitted for flight.

WAX WORM:

Order: Lepidoptera
Family: Pyralididae
Galleria mellonella

The bee moth is a common pest in apiaries. The adult female enters a hive at night to lay its eggs. The larvae feed on the wax, making silk-lined tunnels in the combs. Pupation takes place in tough cocoons within the hive.

GOLDEN ROD GRUB:

Order: Lepidoptera
Family: Gelerchiidae
Gnorimoschema gallaesolidaginis

There are two kinds of conspicuous galls which are enlargements of the stems of golden-rods. One is spindle-shaped and caused by the moth *G. gallaesolidaginia*. The eggs are laid on the old plants in the fall and hatch in the spring. The young larvae crawl to a new shoot and bore down into it causing the growth of the gall. The larvae become full-grown about the middle of July. Then, before changing to pupae, a passage-way is eaten through the wall of the gall at its upper end, and the opening is closed with a plug of silk so formed that it can be pushed out by the adult moth when it is ready to emerge.

Order: Diptera
Family: Trypetidae
Eurosta solidaginis

The round golden-rod gall that is a common sight on the stems of the plant during late summer and winter is produced by the larva of *E. solidaginis*. The species passes the winter as mature larvae within the gall. Before the larvae hibernate, a tunnel is cut to the surface of the gall, but a tiny cap is left for protection. Pupation takes place in May. The adults emerge and the females lay their eggs in the apical rosette of leaves of the young plants. The larvae burrow down the stem and the gall develops. There is only one generation a season.

CATALPA WORM:

Order: Lepidoptera
Family: Sphingidae
Ceratomia catalpae

The adult form of the catalpa worm is a moth which ranges from New Jersey and southern Pennsylvania southward to Florida and westward through the Mississippi Valley wherever its food-plant is found. The larvae, like all moth larvae, have chewing mouth parts, three jointed thoracic legs, and five pairs of abdominal prolegs which bear hooks at the ends. The larvae feed upon various species of catalpa and have in recent years been charged with doing considerable damage to these trees by denuding them of foliage.

HELLGRAMMITE:

Order: Neuroptera
Family: Sialidae
Corydalus cornutus

The larvae of this insect, commonly known as "hellgrammites", live under stones in the swift part of rapid streams. They are predacious insects, feeding upon mayfly nymphs, stonefly larvae, and the larvae of other aquatic insects. When full grown they are two or three inches long with dark brown, rough looking skin, and large jaws. Their bodies are flattened and sprawling with a tuft of white hairlike gills at the base of each of the lateral appendages on the first seven abdominal segments. In May and June when they are about three years old, they crawl out on shore and under a log or stone to pupate. The pupa is at first pale-colored and soft but it gradually darkens. The adults emerge about ten days after pupation.

The adults have cinnamon brown bodies and gray-white spotted wings which measure four or five inches from tip to tip when fully spread. The female has short, stubby mandibles but those of the male are tusk-like and more than three times the length of the head. As adults, the dobsonflies are short-lived and although they possess strong mouth parts, they probably eat nothing. The eggs are laid on stones or sticks overhanging the water and the

newly hatched larvae drop into the water to begin their larval life.

GROUND BORER:

Order: Coleoptera
Family: Trogidae
Trox sp.

The adults are oblong, convex insects with the surface of the body and wing covers usually very rough, and covered with a crust of dirt. They are small or of medium size, most commonly measuring from 8 mm. to 12 mm. in length. These beetles feed upon dried, decomposing animal matter; many species are found about the refuse of tanneries, slaughter houses, and upon the hoofs and hair of decaying animals.

Larvae are one half to three quarters of an inch long, white bodied, with a black or brown chitinized head. They are similar to the European corn borer larvae in appearance. Little is known about the life history.

WOOD BORER:

Order: Coleoptera
Family: Cerambycidae

The adult beetles are of medium or large size, graceful in appearance, and often beautiful in color. They possess long antennae which accounts for the common name, "long-horned beetles". So far as is known, both the adults and larvae are vegetarians.

The larvae are borers, living within the solid parts of trees and shrubs, or beneath bark. They are white or yellowish grubs. The body is soft, and tapers slightly from head to tail; the jaws are powerful and well adapted for the burrowing habit. The larval state usually lasts two or three years. The pupal state is passed within the burrow made by the larva.

RAT-TAILED MAGGOT:

Order: Diptera
Family: Syrphidae
Eristalis tenax

The drone fly is a rather large, bee-like fly which frequents flowers and feeds on nectar and pollen. They are commonly seen flying about polluted ponds, liquid manure, and such places, where eggs are deposited. The larvae of several species that live in water as well as some that live in rotten wood are known as "rat-tailed maggots" because of the long tail-like tube which can be extended to the surface when the larvae is immersed in water. This tube is composed of two segments, one of which can be slipped over the other; a rosette of hairs at its tip keeps water out of the air tube. The body of the larvae is about half an inch long. The larval skin contracts to form the dark horn pupal case from which the adult fly emerges.

NUT WEEVIL:

Order: Coleoptera
Family: Curculionidae
Belaninus sp.

These insects have larval forms that are common in nuts and acorns of some of the chestnuts and oaks, hazel nuts, hickory nuts, and others. The adult beetle is yellow, spotted and mottled with rich brown shades. They possess the prolongation of the head as a distinct snout with the biting mouth parts as the tip of the snout which is typical of this family. The eggs are laid in a hole in a nut that the female has drilled with its beak. The grubs feed in the nuts and drop to the ground with them, where they cut their way out and enter the soil. The grubs pupate the following summer and the adults emerge in August.

WIGGLER:

Order: Ephemerida

Mayflies spend nearly all of their lives as nymphs in the water. The nymphs, "wigglers", are of various shapes and sizes but all agree in having seven pairs of gills on the abdomen, two or three slender tail filaments, and but a single claw on each foot. Wigglers live in every aquatic situation except foul water. These nymphs are abundant from March to late June and adults are emerging and swarming at this time.

As winged insects, their lives last only a few hours or days at most, during which time they do not feed. Adults have large front wings and small hind wings except in some very small species in which hind wings are absent. The adults have either two or three tail filaments which are longer than those of the nymph. The mating flight usually takes place in late afternoon or twilight. During this flight the males mate with the females which almost immediately lay their eggs in the water and die upon the surface.

Income, Gross Sales, and Investment

The income, gross sales of live bait, and the value of equipment for the three regions of the state express an interesting relationship. The percentage of the total income of bait dealers located in the more northern portions of the state is largely derived from sales of live bait. Bait dealers in southern counties sell a greater volume of live bait yet it is a smaller percentage of the total income since sales of fishing tackle and other equipment are considerable (Chart XII). The average percentage of the total income derived from live bait for retail dealers in region I is 60 per cent, falling to 47 per cent in region III. In contrast, the average gross sales from live bait increased from $300.00

to $1800.00 in these same regions. Likewise, the average total value of equipment used in the live bait business increased from $150.00 in region I to $1000.00 in region III. The percentage of retail dealers having special housing for their bait business ranged from 3 per cent in region I to 35 per cent in region III. Values determined for wholesale live-bait dealers are comparable and parallel the regional differentiation noted for retail bait dealers.

An estimate of the total gross sales of live bait in the state, based on the state averages for both retail and wholesale dealers, would approximate 3.8 million dollars per year. Approximately half of that amount is derived from sales of minnows while the remainder is from sale of all other live bait. The importance of live bait cannot be placed on a dollar basis alone since it is closely linked with tourist trade and with the sales of sporting equipment and other items.

Chart XII: Data Concerning Income, Gross Sales, and Investment of Michigan Live-Bait Dealers

	Region I	Region II	Region III	State
Average percentage of the total income of the business derived from live bait	60.7% -	57.3%* 81.6%**	47.4% 74.4%	53.1% 76.8%
Average gross sales from live bait only	$325 -	$1533 $2735	$1837 $4344	$1525 $3811
Average total value of equipment used in the live bait business	$149 -	$747 $2661	$998 $3112	$790 $2965
Percentage of dealers having special housing for live bait	2.7% -	18.7% 29.4%	34.5% 22.9%	24.1% 25.0%

* Retail dealers
**Wholesale dealers

SUGGESTIONS ON COMMON PROBLEMS

Minnow Transportation Units for Vehicles

Consideration should be given to the following factors in planning and construction of minnow transportation units:

1. Type of vehicle available for the installation of the unit
2. Size and number of compartments in the unit
3. Removal of minnows from the unit
4. Construction and operational cost of the unit

Vehicles ordinarily used in transporting minnows are trucks, autos, auto trailers, and boats. The size of the vehicle and the space available for the transportation unit must be considered as well as the portability of the unit if the vehicle must serve other needs. The size of the unit is determined by available space and the number of minnows to be carried. Division of the unit into compartments depends upon the extent of sorting at the time of collection or before delivery to retail outlets. Small compartments will aid in minimizing water surge, water loss, and minnow damage. Large transportation units should be provided with drains to permit the water level to be lowered for easy access to the minnows. In consideration of construction and operational costs of the unit, the

permanence of the construction as well as the maintenance required should be taken into account.

Most of the available knowledge concerning fish transportation units has been made available through experimental work carried on by the Fish and Wildlife Service and state conservation agencies. There are apparently two factors which govern the degree of success of transportation units: aeration and cooling of the water.

Aeration is required to replenish the oxygen supply in water used in fish transportation units. Legislation has been enacted in many states which requires the installation of some device on such units to maintain the oxygen content in the water. Copeland (1947) classifies methods of aeration as follows:

1. Aeration by circulation of water through a Venturi valve
2. Aeration by spraying
3. Aeration by forced air, i.e., by the use of air compressors
4. Aeration by introduction of "canned" oxygen

The circulation of water may be effected by the installation of a water pump driven by a small gasoline engine or other means. Considerable experimental work has proved conclusively that the mixing of natural atmospheric oxygen with water is superior to other methods of aeration

(Copeland, 1947). The results of these experiments have indicated the desirability of the introduction and use of a special mechanism known as a Venturi valve placed between the water pump and the intake of the tank. As water is drawn to the pump, air and water are mixed at the valve, saturating the water with oxygen and changing the water to a white, milky color.

In aeration by spraying water into fish transportation units, water from near the bottom of the tank is removed through a large, screened outlet and sprayed back into the tank from the top of the unit. This permits the water to absorb oxygen and release carbon dioxide as it passes through the air. The water may also be cooled by evaporation. The cost of operation for these methods is about the same as for compressed air. They are subject to mechanical failure and only relatively clean water should be used. Trouble caused by clogged screens and pipes may be reduced by the installation of a drain on the side of the tank near the bottom rather than on the bottom. Heavier debris can then be avoided. Pressure of the spray system should be kept low since high pressures may cause injury to the fish. Wilson (1950) found seven pounds sufficient.

Aeration by forced air requires the use of a compressor driven by a small gasoline engine. Air is forced

into equalizing tanks and released through carborundum stone which breaks the air into fine bubbles that are released into the water. Aeration by forced air is not as efficient in eliminating carbon dioxide as the water spray method and it may assist in raising water temperature through the induction of warm air. Stubblefield (1949) has described Lefevre's aeration unit in which water is cooled and is circulated and constantly changed by means of a hollow rotating propeller operated in the center of the tank. Fresh air is brought into an air tube located in the propeller and then diffused through the water by means of veins at the heel or along the edges of the propeller blades.

The canned-oxygen method is probably the most simple to install and mechanical failures are unlikely. Oxygen is released directly through a carborundum stone. Wilson (1950) states that it has a negligible effect upon the water temperature. The disadvantages are that carbon dioxide is not eliminated efficiently and there is the possibility of charging the water too highly. Generally, operation costs are greater than for other methods.

As water holds more oxygen at a low temperature than at a high temperature, any process which will keep the temperature low as is consistent with the well-being of the fish will increase the number of fish that can be safely carried. Crushed ice can be placed in compartments

on the exterior of the tank and at the same time covering the intake and exit water pipes. Ice compartments may be constructed on top the unit so as to allow melted ice water to drop into the compartment below. Both cooling of the water and aeration may be effected in this manner. Water may be cooled by evaporation as in the spray system. Small refrigeration units may be installed or the material used in tank construction can be chosen to provide insulation qualities.

A number of materials can be used in tank construction and several methods of assembling the material are satisfactory. Weight of the completed tank and the water contained in it must be consistent with the load-limits of the vehicle used to transport it. Demountable tanks should be fairly light in weight to facilitate handling. The design of the tank should be such that it can be mounted forward of the rear wheels of the vehicle to reduce splash and surge, minimizing water loss and damage of fish.

Wood can be used in the construction of tanks. It is fairly light and provides some insulation. It requires constant maintenance. Welded sheet metal can be used but it is heavy and also requires painting and rust prevention. Wilson (1950) found that a tank made from 24 S-T aluminum alloy and riveted together to be highly satisfactory. The

tank required more work than welded tanks but the result was a strong, light, flexible unit. The aluminum material used in its construction is a good reflector. Aluminum-colored tanks were noted to run considerably lower temperatures than one painted black or green.

Copeland (1947) and Stubblefield (1949) have presented plans and construction details for large transportation units suitable for wholesale purposes. Smaller units are described by Copeland (1947) and Wilson (1950). Basic designs are good but variations can be planned to fill the requirements of individual dealers.

Handling of Minnows

Greatest minnow loss occurs in handling and holding minnows. A survey conducted in 1948 by the Minnesota Bureau of Fisheries Research determined that minnows are often killed during seining operations (Dobie, Meehan, and Washburn, 1948). Some are crushed in the net, and the small ones are often left stranded on the beach. Some are killed by slow and careless handling during sorting. The loss is extremely high when "soft" minnows like the golden shiner are handled during hot weather. Rough handling often causes injuries through which fungus is able to start its growth.

Prevention of injury must start at the time of collection. Seines should be landed on sand or hard bottom whenever possible to prevent roily water. A seine containing minnows should be bagged loosely and floated to deeper water where the minnows can be dipped into floating live boxes. The seine should never be pulled up on shore when it contains minnows.

The likelihood of mechanical injury to minnows is not great when glass traps are used. Wire screen traps and plastic screen traps may result in scaling or other injury. Traps should be attended frequently and floating live boxes or other portable holding facilities should be available in the stream when the minnows are captured. Every precaution should be exercised to prevent injury.

Fish have no means of adapting themselves to rapid changes in water temperature. If minnows are to be transferred from water having a temperature appreciably different than another, the change should be accomplished by mixing the two waters slowly, allowing at least 20 minutes for each 10 degrees F. change in temperature. A sudden change in water temperature may cause shock which will prove fatal to the minnows. Care must be exercised in placing minnows taken from the stream into the carrying truck and also when placing the minnows in the holding tanks.

Removal of minnows from the carrying tank is best accomplished by lowering the water level. Minnows may then be gathered quickly and easily with a scap net. It was noted on the survey that this provision for allowing controllable drainage of tanks is often omitted.

Holding Facilities

The preferred type of holding tank construction is cement. Tanks should be painted with an asphaltum paint to provide a smooth finish and to prevent toxic substances in the cement from entering the water. Tanks should be sufficiently deep to prevent injury to minnows from aeration jets but the depth should be such that the minnows can be readily collected. The size of the tanks should be such that all minnows can be sold within a few days since periodic cleaning is recommended. Additional minnows should not be added until all the others have been sold and the tanks drained and cleaned.

Large drainage plugs should be installed at the time of tank construction. Plugs, together with a sloping floor, will facilitate draining and cleaning. Overflow water should be taken from the bottom of the tank rather than the top. Individual overflows should be present to prevent the spread of disease from tank to tank. Minnows should not be transferred from one holding

tank to another. Scap nets or other equipment should be sterilized often to prevent disease transmission.

Following the removal of minnows from a holding tank, the tank should be drained, cleaned, and sterilized. This can best be accomplished by scrubbing the sides and bottom of the tank with a solution of sodium hypochlorite. One-half pint of bleach (Hilex or Chlorox) in 15 gallons of water is suitable (Dobie, 1948). Following this treatment, all traces of chlorine must be rinsed away before refilling the tank for use.

During the survey it was noted that dealers operating in urban areas were sometimes required to use city water which had been chlorinated. Rodgers (1949) explains a simple method for neutralizing chlorine. Baking powder or similar tin cans with covers are used as containers for a quantity of sodium thiosulphate. A number of holes are punched in the top and the bottom of each can. Strings are attached to the cans and the cans are then submerged in the middle of the tank. The strings enable the cans to be removed easily for refilling and provide a means of shaking the can if the action of the fish indicate that too little of the chemical is dissolved in the water. The quantity to be used and the period between refilling should be determined by trial tests with a few minnows.

Fungus disease is often present in the tanks of dealers who are suffering a high minnow mortality. Death is probably caused by the direct effect of the fungus infection or by injury which has been followed by fungus infection. Dead minnows should be removed and destroyed. Minnows that have become infected and those exposed to the disease should be treated and placed in a sterilized holding tank. All nets and tools should be sterilized.

The treatment most widely recommended by biologists is a 10 second dip in a 1:15000 malachite green solution which is the equivalent of 1/8 ounce in 15 gallons of water (Dobie, Meehan, and Washburn, 1948). The solution should be discarded after 100 pounds of minnows have been treated or at the end of the day.

The addition of salt to holding tanks for the control of external parasites is common practice. It is a fairly effective treatment but some parasites survive and the treatment must be repeated frequently. It is, however, the only treatment which should be applied in the absence of definite knowledge regarding the cause of the mortality. Davis (1946) states that the common hatchery practice is to distribute salt throughout the trough, having first turned off the water supply. When fish begin to show signs of distress, the water is then turned on again. Fish (1938) suggests determining the volume of water

contained in a trough drawn down to a predetermined depth. For each 60 cubic inches of water in the trough at this depth, one ounce of finely ground salt is dissolved in a pail half full of water. To administer the salting, shut off the inflow, drain the trough to the predetermined depth, and spread the salt solution evenly over the trough. When the weaker fish begin to suffer, the inflow is resumed at the maximum rate the fish will withstand to permit a rapid replacement of the salt water. These treatments are difficult for most bait dealers to apply correctly since the water source available generally is not adequate for rapid removal of the salt solution. Salting in this manner becomes more expensive, less effective, and more difficult as the size of the tank increases. Davis (1946) suggests that a better method is to dip the fish for a short time in a 3 per cent salt solution.

The general salt solution treatment and the malachite green dip for fungus will control disease epidemics in holding tanks in the majority of instances. Disease prevention and control should follow recommended treatments rather than hit and miss methods. Should a high mortality rate continue, a trained biologist should be contacted or a few infected fish should be preserved in a ten per cent formalin solution or in alcohol and sent to the nearest pathologist.

Minnow Sorting and Sales

Minnows that are offered for sale are generally segregated by size and species. In instances, minnows sorted in this manner demand a higher price than unsorted minnows. There is no single type of sorting device in general use. Sorting may be accomplished from a dip net held at the water surface, from boxes attached inside holding tanks, or with tubs and miscellaneous containers.

Minnows can be easily sorted to size by the use of mechanical fish graders which are no more than wooden or metal boxes with a bottom or sides of dowels or rods so spaced as to allow the escape of small minnows which can pass between the rods. The fish remaining can be placed in the next larger grader and so on. Bengard (1951) presented a design for metal fish graders which should work well in minnow operations.

A sorting table of the type suggested by Topel (1947) can be used to advantage in sorting minnows by species or by size. The design was patterned after an ordinary four-legged, flat-topped table, to which side-boards containing openings cut flush with the table top were added. The table top was covered with sheet metal and held in place by quarter round molding. Flaps of light rubber at the openings were used to control the ejection of fish into the containers below the table. The construction of

the table is simple, and a number of minnows can be sorted in a short time. Injury is held to a minimum since fish are not handled but pushed on the film of water always present on the table during operation.

The practice of selling small minnows wholesale by the gallon is common. Considerable loss may be involved since this procedure necessitates measuring of minnows in a nearly dry state. Dobie (1948) states that minnows may be weighed by first filling a metal basket half full of water, weighing the basket and water, and then adding the fish and reweighing. The difference in weight is the weight of the minnows. Little injury occurs during weighing. By counting the number of minnows in a pound, it is possible to determine the number of fish sold. Fish may be sold by numbers, pounds, or by gallons, allowing eight pounds to the gallon.

Minnow Ponds

Within the past few years, attempts at minnow culture have prompted construction of many ponds throughout the state. Small natural lakes and ponds have been used as well as ponds formed by dammed streams or creeks. Many articles have been written concerning all aspects of pond propagation. Planning and construction has been covered in detail. Despite the available literature, most

minnow dealers have resorted to their own ideas of pond construction and many have been sadly disappointed with the results. Wherever possible, the services of an engineer or someone experienced in fish pond construction should be employed in order to make best possible use of material at hand.

The general considerations and suggestions discussed are presented to indicate those problems which most often occur.

Pond Requirements:

There are three requirements generally considered for a good minnow pond site: (1) a topsoil or subsoil that contains a sufficient amount of clay to hold water, (2) a water supply that will provide an adequate supply of water but not an excessive amount, and (3) a topography that can be converted into a pond economically (Lawrence, 1949).

Considerations of the topsoil and subsoil types are necessary in determining pond locations. Since a pond is nothing more than a bowl for collecting and holding water, its bottom and dam must be composed of clay soils which are best adapted to reduce seepage to a minimum. If there is doubt as to the type of soil present, a County Agricultural Agent may be contacted. If seepage occurs after the pond construction is completed, the

fault may be corrected by bringing in clay or commercial soil-sealing compounds to cover the bad spots. Duncan (1947) believes that water loss through seepage can be corrected by careful application of a water repellent material like bentonite. Each job will require study of soil type and other conditions since they will affect the amount of bentonite required as well as the method of application.

A suitable source of water must be available to the pond site. It must be sufficient to fill the pond and maintain the water level with little fluctuation. From the fish management point of view, any overflow is waste. The ideal water supply is one that keeps the pond full without running over. It should be only moderately hard, slightly alkaline, and have a temperature high enough to promote rapid growth.

Springs and artesian wells furnish a good source of water since they are usually easily controlled and generally free from pollution. Most springs are a steady, dependable source which have enough flow to keep a small pond well supplied but not so much as to cause trouble. Water from artesian wells may need to be aerated before it enters the pond.

Natural water supplies like creeks or streams may be used to satisfy water requirements but they should not

be subject to excessive flooding. They should also have a well vegetated watershed which will permit the stream to remain fairly clear from silt even during rains. In addition to being subject to changes in volume and turbidity, the water may be polluted or the temperature may fluctuate greatly. Undesirable species of fish may be present and successful screening to prevent their entry into ponds is expensive.

Surface run-off from lands may be used to provide water to ponds. The type of soil, vegetation, and steepness of the slope will effect the surface run-off. Drainage area ratios per-acre-of-pond should be determined by some qualified individual and these should be closely followed when selecting pond sites in order to provide sufficient water.

Topography refers to the surface features of the area. It should provide a place where a pond can be made with a small dam or by little excavation of soil. The ideal topography for a single pond is bowl shaped with an opening where a dam can be placed. If an extensive pond system is planned, the area should be relatively flat and large enough to include all ponds and buildings. The topography should slope gently downward from the upper end to provide drainage for the ponds. The main object is to select a site of sufficient size and of slope such

that ponds will be completely drainable, preferable independently, and can be constructed without moving or hauling an excessive amount of dirt.

It is particularly advisable that a qualified engineer be contacted to aid in making a survey to determine the volume, depth, and area of the pond. Schaeperclaus (1933) states that the relatively high productivity of the pond is due - in greater part - to its shallowness, which allows the penetration of light down to its very bottom and at the same time facilitates the rapid warming up process of the whole mass of water. Based upon these theoretical considerations, the depth of the water has quite often been calculated too low, with resulting bad shore infringements. Ponds located in areas where the winter is cold must necessarily be relatively deep to prevent winter kill.

A seining or catch basin should be constructed at the outlet to simplify collection of the minnows during draining or marketing operations.

Aquatic Plants:

Higher aquatic plants are not desirable in minnow ponds. They do not provide food to any appreciable degree. The shelter provided fry is not needed in minnow ponds and they often become difficult to control, taking over large areas of the pond while making minnow collection difficult.

Since there are three different types of higher aquatic plants, control measures differ. Submerged plants may be controlled by fertilization of the water to develop heavy planktonic growth which cuts off the sunlight vital to the growth of the plants. The addition of nigrosine, a black aniline dye, affords promise of controlling these coarse weeds in addition to encouraging the development of water bloom algae (Surber and Everhart, 1950).

Rooted vegetation with floating leaves requires that the leaf stems be cut below the water surface. Repeated cuttings reduce the vitality of the plant and prevents recouperation. Cornell (1949) found that certain species of floating aquatic plants could be eradicated with 2, 4-D. Surber (1947) experienced some success with certain plant-growth regulators which were used as herbicides.

Emergent vegetation may be most easily controlled by poisoning or hand-pulling. Since these plants grow only in shallow water, a pond that is correctly built will limit them to a narrow band around the margin. Spraying with 2, 4-D has proven effective (Surber, 1947; Cornell, 1949; and Snow, 1949). Solutions of copper sulfate or sodium arsenite may be used. Care must be exercised in the use of chemicals that are toxic to fish and advice from a trained biologist should be sought.

Fertilization:

The purpose in the application of fertilizer, other than to control higher aquatic vegetation, is to increase the production of planktonic forms which serve as food for minnows. Both manure and various commercial fertilizers are used. Applications should begin in the early spring and continue as often as needed to keep up the bloom. Henderson (1949) used manganese in addition to the major fertilizing elements (nitrogen, phosphorus, potassium, and calcium) to help in causing and maintaining water blooms in hard-water ponds. It is sometimes very difficult to obtain water blooms by the use of fertilizers alone in these ponds.

A general rule of thumb that is followed in fertilization is to keep the water colored so that the hand is not visible at the depth of one foot. Fertilization should be done at the optimum rate since an excess is not only expensive but may also endanger the oxygen supply.

Poisoning:

Many ponds and lakes used in minnow culture operations have no outlet to allow drainage. If predatory fish have gained entrance through the water supply or by accidental introduction in stocking, it is necessary that they be removed. Removal in these ponds is limited to poisoning. Probably the most important recent development

in poisoning has to do with the forms in which rotenone is available. Forms generally used are simple powdered derris or "cube" form, a wettable rotenone paste, and emulsifiable rotenone (Solman, 1950). The best procedure, as outlined in "Propagation of Minnows and Other Bait Species" is to apply 1.32 pounds of 6 per cent rotenone powder per acre-foot of water (0.5 p.p.m.). The powder must be mixed with water to form a thin batter and spread evenly over the pond.

Investigations in Ontario have found emulsified rotenone very effective, presumably more so than rotenone in derris powder. Rotenone kills fish in low concentrations (0.025 p.p.m.) and at such concentrations it is not toxic to most aquatic invertebrates (Smith, 1950).

SUMMARY

1. The majority of the retail live-bait dealers in Michigan are part-time operators having a gross sale of live bait less than $2000.00 per year. Over 70 per cent handle various supplies in addition to live bait. Approximately one-half of the wholesale dealers operate full-time, dealing only in live bait, and having a gross sale over $2000.00 per year.

2. Two-thirds of all minnow transportation units operated by wholesale bait dealers are furnished with aeration devices as compared to one-quarter of the units operated by retail dealers that are so equipped.

3. Seines and glass traps are employed for minnow collection by most bait dealers. Overall, the seine is more widely used but the use of the glass trap is generally more common in southern portions of the state. Wholesale dealers use glass traps to a greater extent than retail dealers, a fact which may account, in part, for the lower percentage of minnow loss incurred by wholesale bait dealers.

4. The cost of bait minnows varies from area to area, and from week to week, depending upon the competition and availability. The creek chub, white sucker, and common shiner are preferred species.

5. The abundance and availability of lake emerald shiners has excluded any species which might be cultured to compete successfully in the perch minnow size class.

6. Availability of minnows is variable, depending upon the experience of the bait dealer and the season of the year. Areas supporting a large tourist population or a high population of resident fishermen suffer from minnow shortage in all size classes. Otherwise, pike minnows are least abundant.

7. Over 95 per cent of the wholesale dealers and 70 per cent of the retail bait dealers utilize natural live bait resources in varying degrees. Sixty-five per cent of the retail dealers purchase some or all of their minnows from wholesale dealers. Over 20 per cent of the retail dealers and 40 per cent of the wholesale dealers own or have access to ponds, yet less than 10 per cent of the retailers and less than 25 per cent of the wholesale dealers raise minnows. Very few dealers raise their total minnow supply.

8. There are estimated to be 1180 private ponds in Michigan used to raise or hold bait minnows. Over half the ponds are considered unsuitable for the propagation of minnows.

9. Direct or indirect effects of mechanical injury, improper tempering of minnows, and adverse holding

water temperatures are major causes of minnow mortality. Wholesale dealers incurred 8 per cent minnow mortality while retail bait dealers suffered 16 per cent loss. The total percentage of minnow mortality indicated by survey results is substantially less than that estimated by observations made during the survey.

10. There is no general policy concerning holding tank care involving cleaning, disease treatment, and feeding. Accepted practices, if followed at all, are conducted in a haphazard manner and value of such procedure is doubtful.

11. The combination of wigglers and night crawlers constitute, in some instances, a major portion of all live bait sales.

12. An estimate of the total gross sales of live bait in Michigan for a year would approximate 3.8 million dollars. However, the importance of live bait can not be placed on a cash basis since it is closely allied with several other enterprises.

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