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THE POTENTIAL FOR COMMERCIAL HARVEST OF
UNDERUTILIZED FISH IN INLAND LAKES IN MICHIGAN

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THE POTENTIAL FOR COMMERCIAL HARVEST OF UNDERUTILIZED FISH IN INLAND LAKES IN MICHIGAN

By

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ABSTRACT

THE POTENTIAL FOR COMMERCIAL HARVEST OF UNDERUTILIZED FISH IN INLAND LAKES IN MICHIGAN

By

Richard Paul O'Neal

The purpose of this study is to identify the species of underutilized fish and bodies of water in Michigan with the potential for commercial exploitation.

The primary species of underutilized fish in inland lakes in Michigan are carp (Cyprinus carpio), white sucker (Catostomus commersoni), yellow bullhead (Ictalurus natalis), brown bullhead (Ictalurus nebulosus) and black bullhead (Ictalurus melas). The white sucker is the primary commercial species in 54.9%, bullhead in 24.9% and carp in 20.2% of the designated inland waters of the state.

A total of 116,694 acres may be available for the commercial harvest of underutilized fish in Michigan's inland waters. The total acreage for each region of the state is as follows: Region I - 37,277 acres; Region II - 63,868 acres; and Region III - 15,549 acres. Based on preliminary biomass estimates, these waters support 7,996,425 pounds of rough fish. Or by region: Region I - 1,453,803 pounds (using an average of 39 pounds per acre); Region II - 4,023,684 pounds (using an average of

63 pounds per acre); and Region III - 2,518,938 pounds (using an average of 162 pounds per acre). Natural lakes account for 78.8% (91,976 acres) of the designated waters in the state while impoundments account for the remaining 21.2% (24,718 acres).

Other information discussed includes methods of harvest used in inland lakes, rough fish programs in other states, a review of the literature on rough fish management and some important aspects concerning this type of management.

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INTRODUCTION

Underutilized fish are abundant in many inland lakes, rivers and impoundments in Michigan. Presently, management of underutilized fish in Michigan's inland waters is limited to removal projects using chemicals. This resource should be utilized if possible and commercial rough fish harvest by mechanical methods may be an alternative to management with chemicals. Many other states have had programs of this nature for years and continue to have them at the present time.

Recent interest in the development of markets for underutilized fish has initiated studies of their relative abundance in Michigan waters. Galloway and Kevern (1976) examined the abundance of suckers in the Great Lakes in relation to potential commercial harvest. Because of limited information, they recommended that a commercial fishery be established on a small scale and then gradually expanded if the stocks can support the fishing pressure. Investigations were conducted in the 1940's to determine the feasibility of commercial sucker harvest in inland lakes in Michigan. Crowe (1949) demonstrated that suckers can be harvested from inland lakes with benefits to game fish populations.

The carp, Cyprinus carpio, is another species being considered for commercial exploitation. Since its introduction into Michigan waters in 1885 (Peterson and Drews 1957), the carp has become very abundant throughout the state. As Sigler (1958) noted, carp are probably more abundant than are any other freshwater fish in the United States.

They are generally regarded by fishery biologists as being detrimental to game fish and their habitat. Feeding carp may destroy aquatic vegetation and increase water turbidity (Threinen and Helm 1954).

Bullheads are other underutilized fish that might be considered for commercial harvest in inland lakes. A study is presently being conducted on Lake St. Helen, Michigan, to assess the results of a commercial bullhead harvest (Schnicke, personal communication).

The objective of this study is to identify the species of fish and bodies of water in Michigan that have the potential for commercial exploitation of underutilized fish. The discussion includes: information compiled on contaminants in fish; identification, description and available species of fish for each body of water with the potential for commercial harvest; preliminary estimates of biomass for underutilized fish in inland waters; a summary of the literature on commercial harvest techniques used in inland lakes; and management considerations with a summary of the literature on rough fish management.

SELECTION, DESCRIPTION AND LOCATION OF LAKES AND RIVERS

The lakes and rivers included in this study were recommended by Michigan Department of Natural Resources fishery biologists in each district of the state. Most of these lakes are larger than 500 acres and contain substantial populations of rough fish. It should be noted that production of fish will vary in different locations of the state. Generally, production will be lowest in the Upper Peninsula of Michigan and greatest in the southern part of the state. Therefore, sustained yields of rough fish in northern Michigan may not be comparable to those in southern Michigan.

Each of the lakes included in this study was classified according to regions and districts established by the Michigan Department of Natural Resources (Table 1). The description of each body of water (see discussion section) includes a discussion of the major commercial species, their lengths, percentage of the total fish population (based on weight unless otherwise stated), and estimated standing crop when available. The major commercial species in each lake was indicated by the district fishery biologists, and the remaining information comes from fishery survey records and other publications. Chemical and tainting problems have been included where information was available. The physical description of each lake was made from contour maps obtained from the Michigan United Conservation Clubs.

Department of Natural Resources fishery survey records were available for most of the lakes and rivers included in this study. The most recent of these have been included in Appendix A. These surveys may or may not provide an accurate indication of the true proportion of rough fish in each lake. Some of these surveys were conducted to evaluate the entire fish population, while others were more selective for a specific

species. Survey methods also vary from lake to lake and year to year making comparisons among them difficult. The common fishery survey methods used by the Michigan Department of Natural Resources are experimental gill nets, trap nets, fyke nets, seines and electrofishing gear. There is also seasonal variation in these surveys. Carp and bullhead are most easily netted in the spring and fall months, and less susceptible to capture in the summer. Suckers are most easily netted during the spring spawning season.

Table 1. Inland lakes and rivers in Michigan with the potential for commercial harvest of underutilized fish.

Lake No.	Region[1]	District[1]	County	Lake or River
1	I	1	Houghton	Otter Lake
2	I	2	Iron	Chicagon Lake
3	I	2	Iron	Perch Lake
4	I	3	Alger	Au Train Lake
5	I	3	Alger	Au Train Power Basin
6	I	3	Delta	Moss Lake
7	I	3	Marquette	Sundstrom Lake
8	I	4	Luce	Blind Sucker Flooding
9	I	4	Luce	Muskallonge Lake
10	I	4	Mackinac	Brevoort Lake
11	I	4	Mackinac	Manistique Lake
12	I	4	Mackinac	South Manistique Lake
13	I	4	Schoolcraft	Gulliver Lake
14	I	4	Schoolcraft	Indian Lake
15	II	5	Alpena	Seven Mile Pond
16	II	5	Cheboygan	Munro Lake
17	II	5	Emmet	French Farm Lake
18	II	5	Presque Isle	Grand Lake
19	II	6	Newaygo	Hess Lake
20	II	6	Newaygo	Hardy Pond
21	II	6	Newaygo	Fremont Lake
22	II	6	Manistee	Manistee Lake
23	II	6	Mason	Pere Marquette Lake
24	II	7	Alcona	Bamfield Pond
25	II	7	Crawford	Lake Margrethe
26	II	7	Iosco	Cooke Pond
27	II	7	Iosco	Foote Pond
28	II	7	Iosco	Loud Pond
29	II	7	Iosco	Tawas Lake
30	II	7	Iosco	Van Etten Lake
31	II	7	Missaukee	Missaukee Lake
32	II	7	Oscoda	Mio Pond
33	II	7	Roscommon	Houghton Lake
34	II	7	Roscommon	Higgins Lake
35	II	7	Roscommon	Lake St. Helen
36	II	7	Ogemaw	Sage Lake
37	II	8	Gladwin	Secord Lake
38	II	8	Gladwin	Wixom Lake
39	II	8	Midland	Sanford Lake
40	III	9	Montcalm	Whitefish Lake
41	III	9	Muskegon	Mona Lake
42	III	9	Muskegon	Muskegon Lake
43	III	9	Muskegon	White Lake
44	III	9	Ottawa	Lake Macatawa
45	III	11	Genesee	Holloway Reservoir
46	III	12	Barry	Thornapple Lake
47	III	12	Cass	Indian Lake

Table 1. (Cont'd.)

Lake No.	Region[1]	District[1]	County	Lake or River
48	III	12	Kalamazoo	Morrow Pond
49	III	12	St. Joseph	Mud Hole
50	III	12	St. Joseph	Sturgis Impoundment
51	III	13	Branch	Marble Lake
52	III	13	Branch	Union Lake
53	III		Eaton, Jackson and Ingham	Grand River
54	III		Lenawee, Monroe	River Raisin
55	III	13	Wayne	Flat Rock Impoundment
56	III	13	Washtenaw	Ford Lake
57	III	14	Macomb	Stony Creek Impoundment
58	III	14	Oakland	Kent Lake
59	III	14	Oakland	Tipsico
60	III	14	Washtenaw	Belleville

1. Classification of regions and districts used by the Michigan DNR Fisheries Division.

UNDERUTILIZED FISH IN MICHIGAN LAKES

Species of Fish Currently Underutilized

For this discussion, an underutilized (rough, coarse, commercial or trash) fish is one that is low in sport or commercial demand. Bullhead and suckers are sometimes considered important in local areas of the state; in those specific locations they were not considered an underutilized species.

The major underutilized or commercial species of fish in Michigan's inland lakes are carp, white sucker, yellow bullhead, brown bullhead and black bullhead. All of the lakes included in this study contain at least one of these species as the major commercial fish. Other species of rough fish common in Michigan's inland lakes include channel catfish, freshwater drum, redhorse, longnose sucker, spotted sucker, northern hog sucker, bowfin, quillback, longnose gar, shortnose gar, goldfish, gizzard shad and alewife (Table 2). In general, these species were not as abundant as the major commercial species but sometimes they formed a substantial portion of the fish population.

Estimation of Biomass

A number of attempts have been made to provide fish biomass estimates in Michigan lakes. These estimates were summarized by Schneider (1973). Schneider (1973) provided adjusted estimates of fish biomass for these lakes based upon information that the original estimates were too low due to incomplete recovery of fish after poisoning. For lakes and ponds less than ten feet deep Schneider (1973) assumed 100% recovery of fish and the original estimates were not adjusted. For lakes greater than ten feet deep he assumed 60% recovery and the original estimates were adjusted accordingly. To be consistent with Schneider's (1973) methods, the same adjustments have been applied to estimates of fish

biomass for 16 lakes recently poisoned by the Michigan Department of Natural Resources (Tables 3, 4, 5).

All lakes for which biomass estimates are available were classified according to three regional areas of the state: Region I - Upper Peninsula, Region II - northern half of the Lower Peninsula, Region III - southern half of the Lower Peninsula. One estimate was determined for each region of the state by using the average biomass for all lakes in that region (Tables 3, 4, 5). Average standing crops for each of the regions are as follows: Region I - 59.1 pounds per acre, Region II - 95.8 pounds per acre, and Region III - 245.6 pounds per acre.

Twenty-five lakes in this study with potential for commercial harvest have fishery survey records indicating the percentage of biomass that rough fish contribute to the total fish population (Table 6). Using a state-wide average, rough fish generally account for 66% of the standing crop of fish in these lakes. After applying this percentage to the total estimated standing crops, the following estimates of rough fish standing crops were determined for each region of the state: Region I - 39 pounds per acre, Region II - 63 pounds per acre and Region III - 162 pounds per acre.

Only a few of the lakes for which biomass estimates are available contain large populations of rough fishes, therefore, these biomass estimates may not accurately represent the lakes included in the present study. However, the estimates given here should provide a preliminary indication of the biomass of fish in Michigan lakes. It should be emphasized that the estimates will be subject to change as new information becomes available.

Table 2. Common and scientific names of under-utilized fish in Michigan lakes and streams[1].

White Sucker	*Catostomus commersoni*
Longnose Sucker	*Catostomus catostomus*
Quillback	*Carpiodes cyprinus*
Northern Hog Sucker	*Hypentelium nigricans*
Buffaloes	*Ictiobus* spp.
Spotted Sucker	*Minytrema melanops*
Redhorses	*Moxostoma* spp.
Yellow Bullhead	*Ictalurus natalis*
Brown Bullhead	*Ictalurus nebulosus*
Black Bullhead	*Ictalurus melas*
Channel Catfish	*Ictalurus punctatus*
Carp	*Cyprinus carpio*
Goldfish	*Carassius auratus*
Freshwater Drum	*Aplodinotus grunniens*
Bowfin	*Amia calva*
Longnose Gar	*Lepisosteus osseus*
Shortnose Gar	*Lepisosteus platostomus*
Gizzard Shad	*Dorosoma cepedianum*
Alewife	*Alosa pseudoharengus*

1. Names taken from Bailey et al. (1970).

Table 3. Lakes in Region I with biomass estimates.

County	Lake	Type of lake	Area (acres)	Pounds per acre
From Schneider (1973)[1]				
Gogebic	Marsh	bass	65.0	52.0
Gogebic	Katherine	bass	48.0	10.0
Gogebic	Cub	bass	28.0	62.0
Marquette	Swanzy	trout	15.0	52.0
Luce	Holland	trout	5.3	137.0
Menominee	Linnbeck	trout	5.1	48.0
Marquette	Twin	trout	5.0	17.0
Lakes recently treated by the Michigan DNR[2]				
Baraga	Parent	-	215.0	38.0
Marquette	Brocky	-	105.0	47.5
Marquette	Johnson	-	85.7	125.8
Alger	Island	-	34.0	102.3
Ontonagon	Courtney	-	33.0	28.3
Luce	Pratt	-	24.0	92.5
Chippewa	Soldier	-	18.8	51.9
Baraga	Alberta	-	17.0	21.7
Average				59.1

1. Adjusted biomass estimates by Schneider (1973).
2. These estimates have been adjusted to be consistent with Schneider's (1973) estimates.

Table 4. Lakes in Region II with biomass estimates.

County	Lake	Type of lake	Area (acres)	Pounds per acre
From Schneider (1973)[1]				
Osceola	Center	trout	38.8	284
Grand Traverse	Sand No. 3 (1969)	bass	14.9	73
Ogemaw	Jewet (1958)	bass	12.9	100
Otsego	Ford (1946)	trout	10.7	204
Wexford	Cadillac	bass	1,150.0	25
Grand Traverse	Fife (1950)	bass	619.0	80
Crawford	Howe	bass	13.4	63
Ogemaw	South Pond	bass	1.3	58
Montmorency	East Twin	bass	830.0	48
Otsego	Big Bear	bass	362.0	100
Ogemaw	Devoe	trout	130.0	57
Ogemaw	Grebe	bass	72.5	192
Cheboygan	North Twin	bass	27.1	36
Grand Traverse	Sand No. 2 (1971)	bass	17.3	12
Ogemaw	Lodge	bass	17.2	121
Otsego	Booth	bass	16.0	37
Grand Traverse	Sand No. 3 (1971)	bass	14.9	241
Montmorency	East Fish	trout	13.5	50
Alcona	Clear	bass	11.3	195
Alcona	Obrien	trout	10.4	45
Otsego	Ford (1971)	trout	10.2	40
Oscoda	N. Basin Twin	bass	7.8	87
Newaygo	Kimes No. 3	trout	6.8	228
Otsego	Fitzek	trout	6.2	32
Ogemaw	Scaup	bass	5.8	45
Oscoda	Pike No. 4	trout	4.6	73
Otsego	Pond No. 4	bass	1.6	113
Lakes recently treated by the Michigna DNR[2]				
Crawford	Shupac	-	109.0	92
Montcalm	Sage	-	51.0	87
Crawford	Kneff	-	13.0	57
Average				95.8

1. Adjusted biomass estimates by Schneider (1973).
2. These estimates have been adjusted to be consistent with Schneider's (1973) adjusted estimates.

Table 5. Lakes in Region III with biomass estimates.

County	Lake	Type of lake	Area (acres)	Pounds per acre
From Schneider (1973)[1]				
Kent	Belmont No. 2	bass	6.4	239
Calhoun	Emerald	bass	5.6	159
Kent	Belmont No. 1	bass	4.4	305
Kent	Belmont No. 3	bass	2.5	233
Clinton	Burke	trout	1.8	100
Washtenaw	Whitmore	bass	677.0	57
Washtenaw	Sugarloaf	bass	180.0	95
Hillsdale	Bear	bass	117.0	90
Washtenaw	Cassidy (1964)	bass	46.2	145
Kalamazoo	Wintergreen	bass	39.3	360
Oakland	Deep	trout	14.8	63
Washtenaw	Walsh	bass	10.2	153
Washtenaw	Third Sister	bass	10.0	145
Van Buren	Pond No. 24	bass	33.7	184
Washtenaw	Lower Loch Alpine	bass	12.5	190
Washtenaw	Upper Loch Alpine	bass	10.9	301
Washtenaw	Dix Pond	bass	1.2	128
Kalamazoo	Debruin's	bass	0.8	301
Washtenaw	Rash Pond	bass	0.2	96
Lakes recently treated by the Michigan DNR[2]				
Ionia	Long	-	356.0	185
Montcalm	Rainbow	-	155.0	217
Oakland	Crescent	-	97.0	180
Kent	Big Brown	-	85.0	162
Kent	Long	-	47.0	115
Genesee	Thread[3]	-	65.0	699
Wayne	Flat Rock Impoundment[3]	-	154.0	378
Washtenaw	Ford Impoundment[3]	-	975.0	759
Washtenaw	Belleville Impoundment[3]	-	1,270.0	784
Ottawa	Macatawa[3]	-	1,780.0	300
Average				245.6

1. Adjusted biomass estimates by Schneider (1973).
2. These estimates have been adjusted to be consistent with Schneider's (1973) adjusted estimates.
3. Estimates not adjusted.

Table 6. Percentage (based on weight) of rough fish in the catch from 25 inland lakes in Michigan[1].

Region	County	Lake	% of rough fish in the catch
I	Houghton	Otter	78.73
I	Iron	Chicagon	84.91
I	Alger	Au Train	64.74
I	Alger	Au Train Power Basin	64.64
I	Delta	Moss	59.66
I	Marquette	Sundstrom	71.89
I	Luce	Muskallonge	86.15
I	Mackinac	Brevoort	57.39
I	Schoolcraft	Gulliver	76.79
II	Alpena	Seven Mile Pond	69.74
II	Newaygo	Hess	30.14
II	Newaygo	Hardy Pond	39.14
II	Missaukee	Missaukee	26.30
II	Roscommon	Houghton	33.20
II	Roscommon	St. Helen	43.21
II	Ogemaw	Sage	33.37
III	Ottawa	Macatawa	96.01
III	Genesee	Holloway Reservoir	68.31
III	Barry	Thornapple	77.78
III	Kalamazoo	Morrow Pond	70.86
III	St. Joseph	Sturgis Impoundment	75.24
III	Branch	Union	85.48
III	Wayne	Flat Rock Impoundment	83.29
III	Washtenaw	Ford Impoundment	86.75
III	Washtenaw	Belleville Impoundment	98.00
	Average		66.47

1. All figures obtained from Michigan DNR lake fishery surveys except for Lake Macatawa - See Trimberger (1974). Refer to Appendix A for more detailed information.

Contaminants in Underutilized Fish

A limited amount of data on contaminants in fish is available for inland lakes in Michigan. Recent information has become available through the Michigan Department of Natural Resources on heavy metals, chlorinated hydrocarbons and impairment of flavor in fish (Grant 1977; Hesse and Evans 1972; Hesse and Willson 1972; Lundgren 1976, 1978; Willson 1973; Willson and Hesse 1973; Schrouder 1972). This information is included in the discussion section for each appropriate lake.

In Michigan, contaminant problems in inland waters are generally most prevalent in large streams and impoundments, especially below areas with substantial municipal development. Most of these rivers and impoundments are in the southern portion of the state.

As a criterion for this study, any lake with evidence that contaminants are present in the flesh of fish was eliminated as a present potential source of underutilized fish. Several lakes and rivers with large populations of underutilized fish have been included in the discussion as potential future sources for commercial harvest. The fish in these lakes are considered to be unmarketable at the present time because of chemical contamination or tainting. They may become marketable if these problems are reduced to within the desired limits of acceptability.

Heavy Metals

Fish have the capacity to accumulate certain contaminants from their environment. Some evidence suggests that certain heavy metals, in addition to mercury, may accumulate in the flesh of commercially valuable rough fishes. Hess and Evans (1972) found that mercury was concentrated greatest by predatory species of fish while zinc, chromium, copper, manganese and nickel tended to be highest in bottom feeders. Their findings

indicated that increasing levels of heavy metals in water and sediments may cause similar increases in fish.

Mercury is the only heavy metal for which the U.S. Food and Drug Administration has established tolerance limits in fish and seafoods. Canadian officials have set tollerance limits for four other metals in marine and freshwater animals (Table 7).

Chlorinated Hydrocarbons

Chlorinated hydrocarbon pesticides and polychlorinated biphenyls are two other groups of contaminants that may limit the value of commercial fishes. The U.S. Food and Drug Administration has set tolerance limits in fish and seafoods for DDT, dieldrin and polychlorinated biphenyls (Table 7).

Impairment of Flavor

Tainting of fish by organic compounds may substantially reduce the value of a commercial fishery. A large variety of organic compounds are capable of imparting objectionable tastes and odors to the flesh of fish. These materials are sometimes capable of impairing flavor at concentrations far below levels otherwise considered detrimental to aquatic organisms (Shumway and Palensky 1973).

The rate of flavor impairment may vary with the type of chemical and exposure time. Shumway and Palensky (1973) found that rainbow trout (Salmo gairdneri) exposed to high concentrations of various chemicals (pyridine, butanethiol, 2,4 - dichlorophenol and o-cresol) appeared to obtain maximum off-flavor in 33.5 hours or less. Substantial increases in off-flavor occurred at high concentrations of butanethiol and 2,4 -dichlorophenol after only 15 minutes of exposure.

Where tainting is a problem, the off-flavor may be eliminated or reduced by transferring the fish to freshwater ponds. This method

does not always reduce the off-flavor in fish (Shumway and Palensky 1973).

Shumway and Palensky (1973) determined the clearing rate of flavor impairment in rainbow trout for varying concentrations of 2,4 - dichlorophenol. Off-flavor values for trout exposed to 100 ppb of 2,4 - dichlorophenol were substantially reduced after 6.5 hours in fresh water, and returned to normal after 33.5 hours of exposure. At 10 ppb, flavor impairment was gone after 6.5 hours exposure to fresh water. At 1 ppb, little or no change occurred in the off-flavor index with exposure to fresh water.

Table 7. United States and Canadian tolerance limits for heavy metals and hydrocarbons in fish and seafoods[1].

Metal or Compound	Tolerance limit (ppm)	Official
Mercury	0.5	Canada and U.S.
Arsenic	5.0	Canada
Lead	10.0	Canada
Copper	100.0	Canada
Zinc	100.0	Canada
DDT	5.0	U.S.
Dieldrin	0.3	U.S.
PCB	5.0	U.S.

1. Taken from Hesse and Evans (1972), and Hesse and Willson (1972).

DISCUSSION

Region I

Region I has 37,277 surface acres of inland waters that might provide a commercial source of underutilized fish. Of these, 4,400 acres (11.8%) are impounded waters while the remaining 32,877 acres (88.2%) are natural lakes (Table 8). The 14 lakes and impoundments range in size from 786 surface acres to 10,130 surface acres. Based on an average estimated standing crop of 39 pounds per acre, these waters support a biomass of 1,453,803 pounds of rough fish.

White suckers are the predominant commercial species in this region of the state; in 89.9% of the listed waters, suckers are designated as the major commercial species (Table 8). In the remaining 10.1% of the designated waters black bullhead and brown bullhead are the predominant commercial species. Carp and other underutilized fish are not important commercial species in this are of the state.

All of the designated waters in Region I are less than 30 feet deep with the exception of Chicagon Lake (maximum depth of 115 feet). Nearly all of the lakes in this area have inlet and outlet streams, some of which support sucker spawning runs in the spring months. Gravel sediments are characteristic spawning sites of suckers in these lakes and have been included in the discussion where they occur.

Information is not available on toxic materials and tainting of fish in this region. Industrial and chemical pollution is generally considered light in this area of the state and probably presents no major problem to a fishery.

Table 8. Distribution of lakes by major commercial species and type of lake for Region I[1].

Lake No.	County	Lake	Acres	Major commercial Species		Type of lake	
				Suckers	Bullhead	Impoundment	Natural
1	Houghton	Otter	890		890		X
2	Iron	Chicagon	1,100	1,100			X
3	Iron	Perch	994	994			X
4	Alger	Au Train	830[2]	830	Pr.		X
5	Alger	Au Train Power Basin	1,000[2]		1,000	X	
6	Delta	Moss	1,080[2]		1,080		X
7	Marquette	Sundstrom	2,400[2]	2,400		X	
8	Luce	Blind Sucker Flooding	1,000[2]	1,000		X	
9	Luce	Muskallonge	786	Pr.	786		X
10	Mackinac	Brevoort	4,230	4,230	Pr.		X
11	Mackinac	Manistique	10,130	10,130			X
12	Mackinac	S. Manistique	4,001	4,001			X
13	Schoolcraft	Gulliver	836	836			X
14	Schoolcraft	Indian	8,000	8,000			X
	Totals		37,277	33,521	3,756	4,400	32,877
	% of total			89.9	10.1	11.8	88.2

1. Pr. - Designates other species that may add substantially to a commercial harvest.

2. Approximate size.

Otter Lake (Lake No. 1)

Otter Lake is located in the northern part of Houghton County. Black bullhead are the major commercial species in this lake, but suckers are also present. In 1970 and 1977 state surveyes, bullhead provided 35.3% and 56.24% of the catch, averaging in size from 10.1 to 6.9 inches, respectively. In 1977 suckers and bullhead accounted for 78.73% of the catch.

Otter Lake is 890 surface acres in size with a maximum depth of 29 feet. The major portion of the lake has a gently sloping bottom and the sediments are composed primarily of sand and clay.

Chicagon Lake (2)

Chicagon Lake, Iron County, may provide a commercial supply of white suckers. State survey records from 1968 to 1971 show that suckers accounted for 41% to 85% by weight, of the catch with average sizes of 18.0 to 16.5 inches, respectively.

Chicagon Lake is 1,100 surface acres in size with maximum depth of 115 feet. The central, deeper portion of the lake has a gently sloping bottom and three extensive areas of shallow water are located at the north, west and south ends of the lake. Wagner Creek flows into the lake at the southeast end while Chicagon Creek flows out at the north end.

Perch Lake (3)

Perch Lake, Iron County, may provide a supply of suckers to a commercial fishery. State crews netted 1,600 pounds of suckers during the 1976 spawning season

Perch Lake is 994 acres in size with a maximum depth of 14 feet. A small island is located in the central part of the lake. Wolf Creek, Kidney Creek and the Perch River are three streams associated with the lake.

Au Train Lake (4)

Au Train Lake, Alger County, may primarily support a sucker fishery in the spring, but black bullhead are also considered underutilized. A 1972 state fishery survey showed that suckers, black bullhead and a few carp accounted for 64.74% of the catch. The average size for suckers was 18.3 inches and for black bullhead, it was 10.6 inches.

Au Train Lake is 830 surface acres in size with a maximum depth of 30 feet. Most of the lake is less than 20 feet deep. The Au Train River, Buck Bay Creek and Cole Creek flow into the lake at the south and southeastern shores. The Au Train River flows out of the lake at the north end. Survey crews have encountered occasional snags while fishing with seines.

Au Train Power Basin (5)

Au Train Power Basin, Alger County, is an impoundment of the Au Train River. Black bullhead are the primary commercial species in this impoundment, but suckers are also present. State surveys in 1975 and 1977 show that black bullhead and suckers together accounted for 54.41% and 64.64% of the catch. In 1975, the average size for bullhead was 11.0 inches while in 1978, it was 8.1 inches. For suckers the average sizes were 17.0 and 17.8 inches in 1975 and 1978 respectively.

This impoundment is approximately 1,000 surface acres in size and is infested with old tree stumps. A contour map of the basin is not available. Joes Creek, Johnson Creek, Slapneck Creek and the Au Train River are streams associated with this basin.

Moss Lake (6)

Moss Lake, Delta County, contains mostly bullhead, but suckers and carp are also present. These three species accounted for 59.66% of the

catch in a 1977 state survey. Bullhead averaged only 6.2 inches in length. This lake occasionally winterkills and the fish population is probably limited due to the extreme shallow nature of the lake.

Moss Lake is 1,080 acres in size with a maximum depth of 5 feet. Apparently, there is a hole in the south-central area of the lake where state crews caught most of their fish, but this hole is not evident on the contour map. Several small creeks flow into the lake along the northeast shoreline. Bull Run Creek flows out of the lake at the southeast end.

Sundstrom Lake (Dead River Storage Basin) (7)

Sundstrom Lake, Marquette County, may primarily support a sucker fishery but black bullhead are also common. Suckers and bullhead comprised 71.89% of the catch in a 1972 state survey. Suckers averaged 11.5 inches and bullheads averaged 6.0 inches in length.

Sundstrom Lake is approximately 2,400 surface acres in size and water levels are usually at their lowest level in late August. A contour map of the lake is not available. The Dead River flows into the basin at the west end, and out at the east end. The Little Dead River flows into the basin at the southeast end. Various other small streams are associated with this impoundment.

Blind Sucker Flooding (8)

Blind Sucker Flooding, Luce County, has a moderate supply of suckers available to a commercial fishery. A state survey in 1966 showed that 31.25%, by number, of the catch was white sucker, ranging in size from 6.0 to 23.0 inches.

Blind Sucker Flooding is a 1,000 acre impoundment of the Blind Sucker River. A contour map of the basin is not available. The Dead Sucker River flows into the basin at the west end and the Blind Sucker River flows out at the northeast end.

Muskallonge Lake (9)

Muskallonge Lake, Luce County, may provide a harvest of brown bullhead and white suckers. These two species accounted for 86.15% of the catch in a 1977 state survey. The suckers had an average size of 19.2 inches while the bullhead averaged 8.6 inches. The bullhead were reported to be in poor condition.

This lake is 786 surface acres in size with a maximum depth of 20 feet. Most of the lake is less than 15 feet deep with extensive areas of bottom and submergent vegetation. A small, deeper area lacking vegetation is located in the south-central area of the lake. A large portion of the south shoreline consists of gravel sediments. Trout Creek flows into the lake on the southwest side.

Brevoort Lake (10)

Brevoort Lake, Mackinac County, may provide a harvest of bullhead and suckers. In May and July, 1976, these two species accounted for 39.18% and 57.39% of the catch. Brown bullhead (predominant species of bullhead) averaged 11.3 and 10.6 inches, respectively. White suckers averaged 16.9 and 17.1 inches.

Brevoort Lake is 4,230 surface acres in size with a maximum depth of 30 feet. The largest portion of the lake is less than 20 feet deep. Large areas of rubble can be found along the north and southeast shorelines of the lake. The Brevoort River and Silver Creek flow into a bay at the northwest end of the lake while the Cut River and Massey Creek flow in at the northeast end. The Brevoort River flows out of the lake at the south end.

Manistique Lake (11)

Manistique Lake, Mackinac County, may provide a commercial harvest of suckers. In two state surveys in April 1977, white sucker and redhorse

together accounted for 53.32% and 64.55%, by number, of the catch, ranging in size from 12.0 to 20.0 inches.

This lake is 10,130 surface acres in size with a maximum depth of 20 feet. Several small islands are found in the central portion of the lake. Gravel and rock sediments are present around the islands and various locations along the entire shoreline. The Portage River, Helmer Creek and Mud Creek flow into the lake at the southeast and northeast ends. The Manistique River flows out of the lake at the west end.

South Manistique Lake (12)

South Manistique Lake, Mackinac County, may provide a harvest of suckers. In 1971 and 1975, white suckers and a few redhorse and bullhead accounted for 85.68% and 40.67%, by number, of the catch.

This lake is 4,001 acres in size with a maximum depth of 29 feet. The largest portion of the lake is less than 20 feet deep, composed primarily of sand and muck sediments. One spawning bed is known to occur at the north shoreline of the largest bay, on the west side of the lake. The Shoepac River flows into the lake at the west end and Portage Creek is an outlet at the north end.

Gulliver Lake (13)

Gulliver Lake, Schoolcraft County, may supply a harvest of white suckers. In various surveys, suckers have accounted for 66.59% to 76.79% of the catch, averaging from 17.0 to 17.4 inches in length.

Gulliver Lake is 836 surface acres in size with a maximum depth of 28 feet. Gravel sediments occur along the entire northwest shoreline and part of the east shoreline. Major spawning beds are located in rubble sediments in the east-central part of the lake in about 10 feet of water.

Gents Creek provides an inlet at the north end of the lake while Gulliver Lake Outlet is located at the south end.

Indian Lake (14)

Indian Lake, Schoolcraft County, may provide a commercial harvest of white suckers. In two state surveys white suckers accounted for 41.26% and 63.16%, by number, of the catch, ranging in size from 12.6 to 17.5 inches. A lesser number of redhorse were caught.

Indian Lake is 8,000 surface acres in size with a maximum depth of 15 feet. Extensive areas of submergent and emergent vegetation are located in the north section of the lake. Several small areas of boulders and gravel are located along the southwest and northeast shorelines, and the central area of the lake. The Indian River and several other creeks flow into the lake at the north, west and south ends. The Indian River provides an outlet at the east end.

Region II

Region II has 63,868 surface acres of water that might supply a commercial fishery for underutilized species. Of these, 49,108 acres (76.9%) are natural lakes while the remaining 14,760 acres (23.1%) are impounded waters (Table 9). Most of the 26 lakes and impoundments in this region are less than 40 feet deep, and range in size from 500 surface acres to 20,044 surface acres. Based on an average estimated standing crop of 63 pounds per acre, these waters support a biomass of 4,023,684 pounds of rough fish. In addition to the above mentioned waters, one river may potentially provide a commercial harvest of carp.

White sucker, bullhead and carp are the major commercial species in Region II. Suckers are the primary commercial species in 47.1% of the designated waters, bullhead are the primary species in 37.1% of the

Table 9. Distribution of lakes by major commercial species and type of lake for region II.

Lake No.	County	Lake	Acres	Major commercial species			Type of lake	
				Suckers	Bullhead	Carp	Impoundment	Natural
15	Alpena	Seven Mile Pond	1,530	1,530	Pr.		X	
16	Cheboygan	Munro	694		694			X
17	Emmet	French Farm	585		585		X	
18	Presque Isle	Grand	5,660	5,660				X
19	Newaygo	Hess	755[2]		Pr.	755		X
20	Newaygo	Hardy Pond	2,000[2]	Pr.		2,000	X	
21	Newaygo	Fremont	790[3]			790		X
22	Manistee	Manistee	1,000[3]	1,000		Pr.		X
23	Mason	Pere Marquette	600[3]	600		Pr.		X
24	Alcona	Bamfield Pond	953	953			X	
25	Crawford	Margrethe	1,920	1,920				X
26	Iosco	Cooke Pond	1,942	1,942			X	
27	Iosco	Foote Pond	1,824	1,824			X	
28	Iosco	Loud Pond	937	937			X	
29	Iosco	Tawas	1,670			1,670		X
30	Iosco	Van Etten	1,320	1,320				X
31	Missaukee	Missaukee	1,880	1,880	Pr.			X
32	Oscoda	Mio Pond	944	944			X	
33	Roscommon	Houghton	20,044		20,044			X
34	Roscommon	Higgins	9,600	9,600				X
35	Roscommon	St. Helen	2,390		2,390			X
36	Ogemaw	Sage	785			785		X

Table 9. (Cont'd.)

Lake No.	County	Lake	Acres	Major commercial species			Type of lake	
				Suckers	Bullhead	Carp	Impoundment	Natural
37	Gladwin	Secord	815	Pr.		815	X	
38	Gladwin	Wixom	1,980	Pr.		1,980	X	
39	Midland	Sanford	1,250			1,250	X	
	Totals		63,868	30,110	23,713	10,045	14,760	49,108
	% of total			47.1	37.1	15.8	23.1	76.9

1. Pr. - Designates other species that may add substantially to a commercial harvest.

2. Approximate size.

3. Drowned rivermouth lake with connecting channel to Lake Michigan.

waters, and carp are the primary species in the remaining 16% of the designated waters (Tabel 9). Other rough fish found in this region of the state are redhorse, bowfin, channel catfish, quillback, garpike, alewife and freshwater drum. These species are usually found in much lower numbers than the three primary species.

Few studies have been conducted for the accumulation of toxic materials or off-flavor in fish from this region of the state. Of the lakes included in this study, taint tests have been conducted on only Manistee Lake and Pere Marquette Lake. The most recent tests conducted on these lakes reveal no off-flavor present in the fish. An investigation to determine the presence of heavy metals in fish was conducted on the Tittabawassee River, but not specifically on any of the designated impounded waters of this river (See Sanford Lake).

Seven Mile Pond (15)

Seven Mile Pond, Alpena County, is an impoundment at the confluence of the Thunder Bay River and Lower South Branch of the Thunder Bay River. Suckers and brown bullhead are the important rough fish in this lake accounting for 69.74% of the catch in 1976. Suckers averaged 16.1 inches in length and bullhead averaged 9.5 inches.

This impoundment is 1,530 acres in size with a maximum depth, just above the dam, of 30 feet Most of the lake is less than 10 feet deep with bottom sediments composed of sand and muck. Submergent vegetation, stumps and deadheads occur throughout the lake.

Munro Lake (16)

Munro Lake, Cheboygan County, has an abundant bullhead and white sucker population. In 1962 and 1968 state surveys, these two species accounted for 79.32% and 52.04% of the catch. Black bullhead ranged in

size from 9.5 to 11.3 inches, brown bullhead from 5.5 to 7.8 inches and white sucker from 12.4 to 18.1 inches. Bowfin were also present in the catch.

Munro Lake is 694 acres in size with a maximum depth of 15 feet. A large portion of the lake is less than 6 feet deep and the bottom has a gently sloping contour. Two small creeks are associated with the lake. This lake occasionally winterkills.

French Farm Lake (17)

French Farm Lake, Emmet County, may provide a moderate harvest of brown bullhead. In 1960 and 1968 state surveys, bullhead accounted for 31.68% and 75.1%, by number, of the catch. The fish ranged in size from 5.2 to 11.2 inches.

French Farm Lake is an impoundment of French Farm Creek. It is 585 acres in size but only about 10% of the lake is greater than 5 feet deep. A series of springs are located at the north end of the lake and French Farm Creek flows out at the southwest end.

Grand Lake (18)

Grand Lake, Presque Isle County, may provide a supply of white suckers to a commercial fishery. A state survey in 1976 showed that 37.66%, by number, of the catch was white suckers. During a coarse fish removal project in the winter of 1945 to 1946, 6,645 suckers weighing 13,290 pounds were harvested with trap nets by commercial fishermen (Crowe 1946).

Grand Lake is 5,660 surface acres in size with a maximum depth of 25 feet. Several islands are scattered throughout the lake. Gravel sediments can be found in various locations along the entire shoreline of the lake, and around the islands. Several creeks flow into the lake

in various locations, and Grand Lake Outlet is located at the northwest end of the lake.

Hess Lake (19)

Hess Lake, Newaygo County, has an abundant carp population, and a population of bullhead. These two species accounted for 30.14% of the catch in a 1969 state survey. Bowfin and quillback were also present in the catch.

Hess Lake is 755 acres in size with a maximum depth of 29 feet. The greatest portion of the lake is less than 10 feet deep. A public fishing site is located at the northwest end of the lake.

Hardy Pond (20)

Hardy Pond, Newaygo County, is an impoundment of the Muskegon River. Carp, white sucker and redhorse are the important rough fish in this lake. These three species accounted for 39.14% of the catch in a 1975 state survey. White suckers and redhorse averaged 16.3 inches in length, and carp averaged 10.5 inches in length. Channel catfish were present in the catch in small numbers.

Hardy Pond is approximately 2,000 acres in size. A contour map of the lake is not available. Several small creeks flow into the pond along its northwest shore.

Fremont Lake (21)

Fremont Lake, Newaygo County, has a very productive carp population. Based on a small sample size, carp and white sucker accounted for 14.47%, by number, of the catch in a 1972 state survey. On the same day, the surveyors saw a large school of 1971 year-class carp along the shoreline of the lake. This lake was chemically treated in 1957 to determine the size of the carp population, but a report is not available.

Fremont Lake is 790 surface acres in size with a maximum depth of 88 feet. The bottom contour is quite irregular in some places. Several small creeks flow into the lake at various locations. Brooks Creek flows out of the lake at the south end.

Manistee Lake (22)

Manistee Lake, Manistee County, may provide a commercial supply of carp and suckers. This lake is approximately 1,000 surface acres in size. Neither a contour map nor a state fishery catch record is available for this lake.

Manistee Lake has a history of receiving substantial amounts of industrial and municipal wastes (Grant 1977). From the mid-1960's through 1967, tainting of fish was evident in Manistee Lake. Complaints of off-flavored fish decreased in 1968, but in the fall of 1969, chinook salmon (Oncorhynchus tshawytscha) from the south end of the lake were judged to have an off-flavored taste. Taint tests conducted in 1976 revealed no off-flavor in Manistee Lake fish (Lundgren 1976). Taint tests probably should be conducted on Manistee Lake fish before they are sold commercially.

Pere Marquette Lake (23)

Pere Marquette Lake, Mason County, is approximately 600 acres in size. This lake may provide a commercial harvest of carp and suckers. Neither a contour map nor a state fishery catch record is available for this lake.

Taint tests conducted on northern pike (Esox lucius) and white suckers from Pere Marquette Lake showed no evidence of off-flavor (Lundgren 1976).

Alcona Pond (Bamfield Pond - 24)

Alcona Pond, Alcona County, is a 953 acre impoundment of the Au Sable River. This pond contains suckers, carp and a few bullhead which may be harvested commercially. State surveys in 1962 and 1972 showed that these species account for 73.41% and 36.45%, by number, of the catch. Average lengths of the fish in the 1972 survey are as follows: white sucker - 11.9 inches, redhorse - 25.8 inches, black bullhead - 11.8 inches, brown bullhead - 11.2 inches and carp - 13.3 inches. Bowfin were also present in the catch.

Lake Margrethe (25)

Lake Margrethe, Crawford County, may furnish a commercial harvest of white suckers. Two state surveys in 1971 show that suckers accounted for only 0.69% and 0.49%, by number, of the catch, and averaged only 13.5 inches in length. These figures probably do not reflect the true proportion of suckers in the fish population of the lake.

Lake Margrethe is 1,920 acres in size with a maximum depth of 65 feet. Extensive areas of submergent vegetation occur in the two large bays at the north end of the lake. Portage Creek flows out of the lake at the northwest end.

Cook Pond (26)

Cook Pond, Iosco County, is an impoundment of the Au Sable River. This impoundment contains suckers, redhorse, a few carp and some bullhead. Suckers, redhorse and bullhead accounted for only 14.77%, by number, of the catch in a 1972 state survey. The average lengths for these fish are as follows: white sucker - 13.0 inches, redhorse - 19.1 inches, black bullhead - 12.7 inches, and brown bullhead - 10.8 inches. Bowfin were also present in the catch.

Cooke Pond is 1,942 surface acres in size. Heavy growths of rooted aquatic vegetation occur in the upper end of the impoundment. Netting efforts by state crews were hampered by limited shoal areas in the impoundment. State crews also noted that strong currents were present in the area near the dam. Two small creeks flow into the impoundment on its north shoreline.

Foote Pond (27)

Foote Pond, Iosco County, is an impoundment of the Au Sable River. This impoundment contains suckers, redhorse, a few carp and some bullhead. These species accounted for 7.0% and 11.48%, by number of the catch in 1969 and 1970 state surveys. Bowfin were also present in the catch.

Foot Pond is 1,824 surface acres in size with a maximum depth of about 14 feet. Snags have been noted to be a problem and limited shoal areas have hampered fishing efforts by state crews in the upper portion of the impoundment.

The Au Sable River below Foote dam may provide a harvest of carp. Carp are known to aggregate below the dam in June (Schnicke, personal communication). Netting records are not available for this river.

Loud Pond (28)

Loud Pond, Iosco County, is a 937 acre impoundment of the Au Sable River. This impoundment contains suckers, redhorse, a few carp and some bullhead. Neither a contour map nor a state fishery record is available for this impoundment. Barker Creek flows into the impoundment on its north shoreline.

Tawas Lake (29)

Tawas Lake, Iosco County, may provide a commercial harvest of carp. Yellow bullhead, black bullhead, brown bullhead, bowfin, garpike and

alewife are other species of fish found in this lake. Carp and bullhead accounted for 20.17%, by number, of the catch in a 1962 state survey.

Tawas Lake is 1,670 surface acres in size with a maximum depth of 5 feet. Extensive areas of emergent vegetation occur throughout the lake. Silver Creek and Tuttle Creek enter the lake on its northeast shore and several other small creeks enter along the northwest shoreline. The Tawas River flows out of the lake at the southwest end.

Van Etten Lake (30)

Van Etten Lake, Iosco County, may be a source of carp, suckers and bullhead. These species accounted for 11.9%, by number, of the catch in a 1962 state survey. Suckers ranged in size from 10.0 to 20.0 inches, bullhead from 7.0 to 14.9 inches and carp from 15.0 to 20.0 inches. Freshwater drum and bowfin were also present in the catch.

In a demonstration netting project in 1948, commercial fishermen harvested 661 suckers, 667 redhorse, 182 bullhead, 2,686 freshwater drum and 129 carp in 39 trap net lifts from Van Etten Lake (Table 16; Crowe 1949).

Van Etten Lake is 1,320 acres in size with a maximum depth of 33 feet. Most of the lake is from 15 to 25 feet deep. The Pine River and several other creeks flow into the lake in various places while Van Etten Creek flows out of the lake at the south end.

Missaukee Lake (31)

Missaukee Lake, Missaukee County, contains suckers, yellow bullhead and brown bullhead. In 1975 and 1976 state surveys, these three species accounted for 27.29% and 26.30% of the catch.

Missaukee Lake is 1,880 surface acres in size with a maximum depth of 27 feet. A large portion of the lake is less than 10 feet deep with extensive areas of submergent vegetation. Gravel sediments can be

located along the island at the north end of the lake, and along the east shoreline.

Mio Pond (32)

Mio Pond, Oscoda County, is a 944 acre impoundment of the Au Sable River. This lake contains a large population of white sucker, a few carp and some bullhead. A 1970 state survey showed that these three species accounted for 52.32%, by number, of the catch. In the same survey, many additional suckers were shocked but not picked up. The average sizes of these fish are as follows: white sucker - 16.1 inches, brown bullhead - 10.4 inches and carp - 24.7 inches. Bowfin were also present in the catch. Chemical reclamation was proposed for this pond in the spring of 1977.

Houghton Lake (33)

Houghton Lake, Roscommon County, may provide a harvest of bullhead. Brown bullhead accounted for 33.2% of the catch in a 1972 state survey, and averaged 10.5 inches in length. White sucker, carp, bowfin and longnose gar were also present in the catch.

Houghton Lake is 20,044 surface acres in size with a maximum depth of 21 feet. The bottom contour is quite irregular. Denton Creek, Spring Brook Creek and Knappen Creep flow into the lake at the southeast end. Backers Creek flows in on the east shoreline and the Muskegon River flows out at the northwest end of the lake.

Higgins Lake (34)

Higgins Lake, Roscommon County, may provide a harvest of white suckers. Survey records from 1938 to 1954 (Laarman 1976), indicate the presence of white suckers in the lake, but more detailed surveys are not available.

Higgins Lake is 9,660 acres in size with a maximum depth of 135 feet. Flynns Island and a sunken island can be located in the west arm of the lake, and another sunken island can be located in the east arm. Gravel sediments occur around all of the islands and various locations around the lake shoreline. Known spawning beds occur on the south shore of the west arm, and around Flynns Island. The Cut River flows out of the lake at the south end of the east arm.

Lake St. Helen (35)

Lake St. Helen, Roscommon County, may provide a commercial harvest of bullhead. White suckers and carp are also present in the lake. These three species accounted for 43.21% of the catch in a 1976 state survey. The average sizes for these fish are as follows: bullhead - 8.9 inches, white sucker - 18.3 inches, and carp - 20.5 inches.

This lake is 2,390 acres in size with a maximum depth of 25 feet. Most of the lake is from 5 to 10 feet deep. Cameron Creek and Russell Creek flow into the lake at the west end, while the South Branch of the Au Sable River flows out at the northeast end.

Sage Lake (36)

Sage Lake, Ogemaw County, may provide a harvest of carp and bullhead. These two species accounted for 33.37% of the catch in a 1965 state survey. Bowfin were also present in the catch.

Sage Lake is 785 acres in size with a maximum depth of 80 feet. The bottom contour is quite uneven and several islands are located in the main section of the lake. Gravel sediments are found in a few places around the shoreline of the lake and the islands. The Au Gres Creek flows into the lake on the north shoreline, and the Au Gres River flows out of the lake at the southwest end.

Secord Lake (Secord Dam Backwater - 37)

Secord Lake, Gladwin County, is an impoundment of the Tittabawassee River. Carp and suckers are the important rough fish in this lake, but bullhead and channel catfish are also present. Two state surveys in 1967 showed that these species accounted for 5.44% to 9.7%, by number, of the catch. These figures probably do not represent the true proportion of these species in the fish population. Carp ranged in size from 20.7 to 25.5 inches, white sucker from 12.8 to 20.0 inches, bullhead from 7.9 to 11.4 inches and one channel catfish was 10.4 inches in length.

This impoundment is 815 surface acres in size with a maximum depth of 40 feet. Gravel sediments can be located in the main section of the lake, just above the dam. The dam impounds two sections of the Tittabawassee River and several other small streams.

Wixom Lake (38)

Wixom Lake, Gladwin County, is an impoundment of the Tittabawassee River. This lake contains primarily carp and suckers, but bullhead and channel catfish are also present. These species accounted for 21.19%, by number, of the catch in a 1967 state survey. Suckers ranged in size from 12.4 to 23.7 inches, bullhead from 6.4 to 12.3 inches, channel catfish from 9.9 to 12.2 inches and carp from 15.9 to 22.4 inches.

Wixom Lake is 1,980 surface acres in size with a maximum depth of 40 feet. Several streams and bays are associated with this lake.

Sanford Lake (39)

Sanford Lake, Midland County, is an impoundment of the Tittabawassee River. This impoundment contains primarily carp, but bullhead and channel catfish are also present. These species accounted for 13.89%, by number, of the catch in a 1967 state survey. Carp ranged in size

from 9.7 to 21.1 inches, channel catfish from 5.3 to 19.2 inches and brown bullhead from 5.2 to 7.6 inches.

Sanford Lake is 1,250 acres in size with a maximum depth of 20 feet. An area with gravel sediments is located about midway up the impoundment from the dam. Varity Creek and Black Creek flow into the lake on its western shoreline.

Toxic material surveys have not been conducted on any of the impoundments of the Tittabawassee River. However, one study of toxic materials in fish flesh was conducted in Midland County, just above and below the city of Midland (downstream from all of the designated impoundments). Results showed that no fish samples exceeded the heavy metals limits set by the U.S. Food and Drug Administration, or by Canadian officials (Hesse and Evans 1972; Appendix B). The fish were analyzed for cadmium, nickel, lead, mercury, chromium, arsenic, copper, and zinc. These results may provide some indication of the environmental conditions in the Tittabawassee River, but bear no direct evidence on any of the designated impoundments.

Region III

Region III has 15,549 surface acres of water that might provide a commercial harvest of underutilized fish species. Of these, 5,558 acres (35.7%) are impounded waters and 9,991 acres (64.3%) are natural inland lakes (Table 10). Several of these lakes are drowned rivermouth lakes which have connecting channels to Lake Michigan and may support spawning runs of suckers in addition to the resident rough fish population. The individual bodies of water range in size from 154 surface acres to 4,150 surface acres, and in depth from 16 to 70 feet. Several of the larger rivers in this region of the state may also support potential sources of underutilized fish. Based on an average estimated

Table 10. Distribution of lakes by major commercial species and type of lake for Region III[1].

Lake No.	County	Lake	Acres	Major commercial species			Type of lake	
				Suckers	Bullhead	Carp	Impoundment	Natural
40	Montcalm	Whitefish	500[3]		500			X
42	Muskegon	Muskegon	4,150[2,3]	Pr.		4,150		X
43	Muskegon	White	2,000[3]	Pr.		2,000		X
44	Ottawa	Macatawa	1,780[3]	Pr.		1,780		X
45	Genesee	Holloway Reservoir	1,973			1,973	X	
46	Barry	Thornapple	409	409			X	
47	Cass	Indian	480[2]			480		X
49	St. Joseph	Mud Hole	500[2]	Pr.		500	X	
50	St. Joseph	Sturgis Impoundment	500[2]	Pr.		500	X	
51	Branch	Marble	780		780			X
52	Branch	Union	525	Pr.		525	X	
55	Wayne	Flat Rock Impoundment	154			154	X	
57	Macomb	Stony Creek Impoundment	497	Pr.		497	X	
58	Oakland	Kent	1,000			1,000	X	
59	Oakland	Tipsico	301		301			X
	Totals		15,549	409	1,581	13,559	5,558	9,991
	% of total			2.6	10.2	87.2	35.7	64.3

1. Pr. - Designates other species that may add substantially to a commercial harvest.

2. Approximate size.

3. Drowned rivermouth lake with connecting channel to Lake Michigan.

standing crop of 162 pounds per acre, these waters support a biomass of 2,518,938 pounds of rough fish.

Carp and suckers are the primary commercial species in 89.8% of the designated waters in this region of the state (Table 10). White suckers are the most abundant type of sucker in this region but redhorse, longnose suckers, spotted suckers and northern hog suckers are also present in smaller numbers. A combination of yellow bullhead, black bullhead and brown bullhead are the primary species in the remaining 10.2% of the designated waters in this region. Other underutilized species of fish found in this region are as follows: freshwater drum, bowfin, quillback, longnose gar, shortnose gar, goldfish, gizzard shad and alewife.

Tainting problems are evident in Mona Lake, Ford Lake, Belleville Lake and the Grand River below large municipalities. Polychlorinated biphenyl contamination is evident in fish from Morrow Pond, an impoundment of the Kalamazoo River. Certain areas of the River Raisin contain fish with high levels of heavy metals in their flesh.

The evident contamination problems found in these lakes and rivers indicate that similar chemical problems may occur in other lakes, and expecially river impoundments, in Region III. River impoundments account for 35.7% of the commercially fishable waters in this region. Chemical contamination could reduce this figure substantially. Before commercial fisheries are established in impoundments in Region III, tests should be conducted to determine if contaminants are present in the fish. Impoundments that account for a major portion of the commercial waters in Region III are as follows: Impoundments of the St. Joseph River - Mud Hole, Sturgis Impoundment and Union Lake; Impoundments of the Huron River - Flat Rock Impoundment, Ford Lake, Kent Lake and Belleville Lake; Stony

Creek Impoundment; and Thornapple Lake, an impoundment of the Thornapple River. Holloway Reservoir, an impoundment of the Flint River, is surrounded by a buffer zone from any large municipality and probably does not have serious contaminant problems.

Whitefish Lake (40)

Whitefish Lake, Montcalm County, may provide a commercial harvest of yellow bullhead. In a 1971 state survey yellow bullhead accounted for 37.94%, by number, of the catch, averaging 11.0 inches in length.

Whitefish Lake is 500 surface acres in size with a maximum depth of 54 feet. The bottom contour is uneven except for the deeper, central portion of the lake. Two streams flow into the lake at the southeast and southwest ends. One stream flows out at the north end of the lake.

Mona Lake (41)

Mona Lake, Muskegon County, may provide a harvest of carp and suckers. Bullhead and channel catfish are also present in the lake. These four species accounted for 13.58%, by number, of the catch in a 1977 state survey. Suckers ranged in size from 10.6 to 24.5 inches, carp from 11.5 to 31.6 inches, bullhead from 5.2 to 12.6 inches, and channel catfish from 9.5 to 23.2 inches in length. Freshwater drum, bowfin, quillback, longnose gar, goldfish and gizzard shad were also present in the catch.

Mona Lake is 695 acres in size with a maximum depth of 42 feet. The central portion of the lake has a gently sloping bottom contour. Black Creek and Little Black Creek enter the lake at the northeast end. An outlet to Lake Michigan is located at the west end of Mona Lake.

Severe tainting of white sucker, carp, channel catfish and northern pike is evident in Mona Lake (Lundgren 1976). Severely contaminated lake

sediments and presently occurring municipal and industrial contaminants from Black Creek and Little Black Creek are suspected as the cause of this tainting. Until this problem is resolved, a fishery in this lake may not be worthwhile, unless the off-flavor can be cleansed from the fish in holding ponds.

Information on toxic materials is not available for this lake, but tests probably should be conducted before a fishery is established, in view of the evident chemical contamination.

Muskegon Lake (42)

Muskegon Lake, Muskegon County, contains primarily carp and suckers, but bullhead are also present in small numbers. In 1967 and 1975 state surveys, these three species accounted for 29.78% and 14.03%, by number, of the catch. Average sizes for the fish in the 1975 survey are as follows: white sucker - 15.1 inches, redhorse - 16.2 inches, carp - 24.2 inches, and brown bullhead - 9.6 inches. Bowfin, gizzard shad, freshwater drum, quillback, longnose gar, goldfish and alewife were also present in the catch.

Muskegon Lake is 4,150 acres in size with a maximum depth of 70 feet. Several channels of the Muskegon River flow into the lake at the northeast end and a channel to Lake Michigan is located at the west end.

Taint tests conducted on white sucker, redhorse and northern pike showed no evidence of reduced fish palatability in Muskegon Lake (Lundgren 1976).

White Lake (43)

White Lake, Muskegon County, contains primarily carp and suckers but bullhead are also present in small numbers. These three species accounted for 14.46%, by number, of the catch in a 1965 state survey. White suckers

ranged in length from 11.0 to 20.0 inches, redhorse from 10.5 to 25.0 inches, carp from 30.0 to 35.5 inches and bullhead from 9.0 to 13.5 inches. Catfish, freshwater drum, bowfin, longnose gar, gizzard shad and alewife were also present in the catch.

White Lake is about 2,000 surface acres in size with a maximum depth of 70 feet. The White River flows into the lake at the northeast end, and an outlet to Lake Michigan is located at the west end.

Taint tests conducted on white suckers captured off Long Point in White Lake were judged to be of low palatability (Lundgren 1976). However, carp, white sucker, northern pike, smallmouth bass (Micropterus dolomieui), and largemouth bass (Micropterus salmoides) from other areas of the lake did not show the presence of off-flavor. No specific reason is known for the presence of off-flavor in suckers captured off Long Point, but additional tests probably should be conducted before a fishery is established.

Information on toxic materials is not available for this lake, however, public concern of contamination has arisen because of recent discharges by chemical companies located on White Lake. The Michigan Department of Natural Resources should be contacted for more recent information on this matter.

Lake Macatawa (44)

Lake Macatawa, Ottawa County, may supply carp, suckers and some bullhead to a commercial fishery. These species accounted for 44.5%, by number, of the catch in a 1976 state survey. Average lengths for the fish in this survey are as follows: white sucker - 16.6 inches, redhorse - 18.1 inches, carp - 20.5 inches, yellow bullhead - 9.3 inches, black bullhead - 8.1 inches, and brown bullhead - 9.4 inches. Catfish, freshwater

drum, quillback, bowfin, gar pike, goldfish and gizzard shad were also present in the catch.

In June 1974, the large 200 acre marsh at the mouth of the Black (Macatawa) River was treated with chemicals to remove the spawning population of carp. As a result of the treatment, 600,000 pounds (300 pounds per acre) of carp were removed from the lake. The average size carp was 18.9 inches in length and weighed 4.8 pounds. In addition to carp, 14,500 pounds of gizzard shad, 9,214 pounds of alewives, 280 pounds of suckers, 125 pounds of bullhead, 375 pounds of bowfin, and a few freshwater drum and longnose gar were also removed.

Lake Macatawa has a history of commercial fishing and large numbers of carp have been removed from the lake. The average catch per seine haul has ranged from 1,315 pounds in 1938 to 9,524 pounds in 1939 (Table 11). Some of these were winter operations where seining hauls were conducted under the ice.

Lake Macatawa is 1,780 acres in size with a maximum depth of 40 feet. The eastern section of the lake has a fairly uniform depth but the western section has an irregular bottom contour. Pine Creek and the Black River flow into the lake on its north and northeast ends. An outlet to Lake Michigan is located at the west end of the lake. Several areas of Lake Macatawa are known to have aggregations of carp during the winter months. The best known areas are where warm water discharges are located.

Holloway Reservoir (45)

Holloway Reservoir, Genesee County, is an impoundment of the Flint River. Carp are the important rough fish in this reservoir but bullhead, channel catfish and white sucker are also present. These species accounted for 68.31% of the catch in a 1976 state survey. Average lengths of the

Table 11. Carp fishing in Lake Macatawa, 1927-1942[1].

Year	No. of hauls	Carp		Bass		Other Game Fish		Coarse Fish	
		Total No. pounds	Average No. pounds per haul	Total No. pounds	Average No. pounds per haul	Total No. pounds	Average No. pounds per haul	Total No. pounds	Average No. pounds per haul
1927	21	127,200	6,057	677	32	1,052	50	777	37
1928	15	91,535	6,102	132	9	1,392	93	9,963	664
1935	22	45,202	2,054	9,473	430	59,544	2,661	1,327	60
1936	13	43,073	3,313	970	74	27,635	2,125	2,477	190
1937	16	23,007	1,438	4,160	260	14,506	906	8,276	517
1938	11	14,467	1,315	798	72	9,283	844	12,143	1,104
1939	25	238,191	9,524	4,499	179	8,949	357	23,681	946
1940	16	67,599	4,225	595	37	1,514	94	2,316	144
1941	19	58,839	3,096	2,413	127	185	9	474	25
1942	13	19,236	1,479	507	39	685	63	329[2]	25

1. Trimberger, personal communication.

2. Plus 1,457 pounds of freshwater drum.

fish in this survey are as follows: carp - 13.6 inches, white sucker - 15.3 inches, bullhead - 8.0 inches, and channel catfish - 14.9 inches. Bowfin were also present in the catch.

The upper portion (650 acres) of this reservoir was chemically treated in 1976 to eradicate the dominant carp population. An estimated 160,000 pounds (346 pounds per acre) of carp were removed in this treatment. In a pre-treatment survey, 126 carp had an average weight of 1.07 pounds each.

Holloway Reservoir is 1,973 acres in size. The upper portion of the reservoir (above Mt. Morris Road) is 650 acres in size and contains a predominant carp population. This portion of the reservoir is shallow and contains many stumps. The lower portion of the reservoir is deeper and contains a larger proportion of game fish. Water levels in this reservoir have been lowered to assist in chemical treatment operations. This technique may be helpful to netting operations by commercial fishermen.

Holloway Reservoir is surrounded by a green belt and receives very little municipal or industrial waste. Accumulation of toxic materials and tainting in fish flesh are not likely to be problems in this reservoir (Shepherd, personal communication).

Thornapple Lake (46)

Thornapple Lake, Barry County, contains primarily suckers, but bullhead and carp are also present. These species accounted for 77.78% of the catch in a 1966 state electrofishing survey.

Thornapple Lake is 409 surface acres in size with a maximum depth of 31 feet. The central portion of the lake has a fairly uniform depth of 20 to 30 feet. High Bank Creek, Mud Creek and the Thornapple River

flow into the lake on its eastern end. The Thornapple River flows out of the lake at the west end.

Indian Lake (47)

Indian Lake, Cass County, may provide a commercial harvest of carp. Carp and bullhead accounted for only 4.34%, by number, of the catch in a 1964 state survey. This figure probably does not represent the true proportion of carp in the fish population. In the same survey, chemical reclamation was recommended to eradicate the large carp population. The average lengths of carp and bullhead were 22.0 inches and 8.0 inches, respectively. Shortnose gar were also present in the catch.

Indian Lake is 480 surface acres in size. A contour map of the lake is not available. One stream flows out of the lake and into the Dowagiac River.

Morrow Pond (48)

Morrow Pond, Kalamazoo County, is about a 1,000 acre impoundment of the Kalamazoo River. Carp and suckers are the dominant rough fish in this pond, but bullhead and channel catfish are also present. State surveys in 1969 and 1973 showed that these species accounted for 54.0% and 70.86% of the catch. Bowfin and longnose gar were also present in the catch. A contour map of the pond is not available.

Morrow Pond is one of the areas on the Kalamazoo River that is considered to have a good fish population. Taint tests were conducted on carp, white sucker, smallmouth bass and black crappie (Pomoxis nigromaculatus) from this pond in 1971. Consistently high flavor ratings were given for all of these species (Schrouder 1972). Concentrations of mercury, chromium, nickel, lead, zinc, copper, cadmium, and arsenic in fish flesh were below tolerance limits set by the U.S. Food and Drug Administration and Canadian officials (Hesse and Evans 1972; Appendix B).

Polychlorinated biphenyl (PCB) contamination of fish is evident in the Kalamazoo River basin. Carp and suckers from Morrow Pond exceeded the U.S. Food and Drug Administration's tolerance limit of 5 mg/kg in fish tissues (Hesse and Willson 1972; Appendix C). The cities of Battle Creek and Kalamazoo are believed to be the probable sources of contamination. Fish from Morrow Pond will probably not be marketable until contamination by PCB's is lowered to within the U.S.F.D.A.'s tolerance limits.

Mud Hole (49)

The Mud Hole, St. Joseph County, is a 500 acre impoundment of the St. Joseph River. Carp and suckers are the important rough fish in this impoundment. These two species accounted for 18.32%, by number, of the catch in a 1975 state survey. Average lengths of fish collected in this survey are as follows: white sucker - 11.8 inches, redhorse - 20.5 inches, spotted sucker - 14.5 inches, and carp - 16.9 inches. Longnose gar were also present in the catch.

A contour map of this impoundment is not available. Stumps and turbidity have hindered netting efforts by state crews in the past.

Information on toxic materials and tainting in fish is not available for this river. Tests probably should be conducted to determine if there are problems of this nature before any fishery is established.

Sturgis Impoundment (50)

Sturgis Impoundment, St. Joseph County, is about a 500 acre impoundment of the St. Joseph River. Carp and suckers are the predominant rough fish in this impoundment, but bullhead and channel catfish are also present. These species accounted for 75.24% of the catch in a 1975 state netting survey. Average lengths of fish caught in this survey are as follows: white sucker - 14.9 inches, redhorse - 18.8 inches, spotted

sucker - 14.5 inches, carp - 15.7 inches, bullhead - 9.8 inches and channel catfish - 11.8 inches.

A contour map of the impoundment is not available. State crews have had difficulty in locating suitable netting sites in this impoundment, probably because of stumps.

Information on toxic materials and tainting in fish is not available for the St. Joseph River at the present time. Tests probably should be conducted to determine if there are chemical problems before any fishery is established.

Marble Lake (51)

Marble Lake, Branch County, may provide a commercial harvest of bullhead. Suckers and carp are present in small numbers. Two surveys in 1970 show that these species accounted for 16.25% and 42.22%, by number, of the catch. Bullhead and white suckers averaged 10.7 inches and 22.2 inches in length, respectively.

Marble Lake is 780 surface acres in size with a maximum depth of 60 feet. The bottom contour is quite uneven. Gravel sediments can be located in various places around the shoreline of the lake, especially along the southeast shoreline. Several streams flow into the lake around its perimeter, and the Coldwater River flows out of the lake at the northwest end.

Union Lake (52)

Union Lake, Branch County, is an impoundment of the St. Joseph River. Carp and suckers are the primary commercial species in the impoundment, but bullhead are also present in small numbers. These species accounted for 60.62% and 77.46% of the catch in two 1972 state surveys. Bowfin were also present in the catch.

Union Lake is 525 acres in size with a maximum depth of 16 feet. Gravel sediments can be found in the old riverbed which is located adjacent to the northwest shoreline of the lake. The upper portion of the reservoir is shallow and contains many stumps. Most of the lower part of the impoundment is greater than 5 feet deep.

Grand River (53)

About 57 miles of the Grand River in Eaton, Jackson and Ingham Counties may provide a commercial harvest of carp. Suckers and bullhead are also present in the river. State surveys in Jackson and Eaton Counties in 1970 showed that these species accounted for 88.13% and 84.20%, by number, of the catch. Carp ranged in size from 8.0 to 21.0 inches, suckers from 6.0 to 19.0 inches, and bullhead from 4.0 to 12.0 inches. Bowfin and goldfish were also present in the catch. A chemical treatment has been proposed for the Grand River from Jackson to Grand Ledge to remove the large carp population.

Thirty-two fish samples were collected in 1970 to test for the accumulation of heavy metals in Grand River fish from Jackson to Lake Michigan. Carp, suckers, bullhead and bass were used to test for the accumulation of copper, nickel, zinc, chromium, cadmium, and mercury. None of the samples exceeded tolerance limits established by the U.S. Food and Drug Administration or Canadian officials (Hesse and Evans 1972; Appendix B).

Tests were also conducted for the accumulation of DDT, dieldrin and polychlorinated biphenyls on the sample of 32 fish. Although there was an absence of critical contamination, the highest levels of chlorinated hydrocarbon insecticides and polychlorinated biphenyls in fish were generally located below the metropolitan areas of Jackson, Lansing and Grand Rapids (Willson and Hesse 1973; Appendix C).

In 1971, taint tests were conducted on northern pike, carp, white suckers, and catfish captured from the Grand River in and around large metropolitan areas. Results showed that the metropolitan areas of Jackson, Lansing and Grand Rapids have adversely affected the palatability of resident fish species in the Grand River within and below these population centers (Willson 1973). Until the problem can be resolved, a fishery in the Grand River may not be worthwhile, unless the off-flavor can be cleansed from the fish in holding ponds.

River Raisin (54)

The entire River Raisin is a potential commercial source of carp. Some bullhead and suckers are also present in this stream. State surveys in Lenawee and Monroe counties in 1971 showed that these species accounted for 76.5% and 89.81% of the catch. Carp ranged in size from 4.0 to 25.0 inches, suckers from 3.0 to 23.0 inches and bullhead from 5.0 to 10.0 inches.

In 1971, carp, bullhead, crappie, northern pike, rock bass (Ambloplites rupestris), largemouth bass and smallmouth bass were tested for the accumulation of zinc, copper, nickel, lead, mercury, chromium, cadmium, and arsenic. Of the 25 samples tested, 2 samples had concentrations of mercury that either equalled or exceeded the .5 ppm tolerance limit established by the U.S. Food and Drug Administration (Hesse and Evans 1972; Appendix B). These two samples were taken in the following locations: Lenawee County below Blissfield (T6S, R5E, S29), and Monroe County at highway M-50 (Dundee) (T6S, R7E, S9).

Information on tainting, hydrocarbon pesticides or polychlorinated biphenyls is not available at the present time for the Raisin River.

Flat Rock Impoundment (55)

Flat Rock Impoundment, Wayne County, is an impoundment of the Huron River. Carp are the primary rough fish in this impoundment but buffalo, white sucker, channel catfish, gizzard shad and goldfish are also present. Flat Rock Impoundment and 15 miles of the Huron River were chemically treated in 1974 to remove the rough fish population. Removal estimates are as follows: carp - 320 pounds per acre, white sucker - 60 pounds per acre, buffalo - 4 pounds per acre, channel catfish - 4 pounds per acre, gizzard shad - 32 pounds per acre and goldfish - 12 pounds per acre. Carp, suckers and channel catfish accounted for a total of 334 pounds per acre.

Flat Rock Impoundment is 154 surface acres in size. Submergent vegetation and deadheads are scattered throughout the impoundment. An additional 27 miles of the Huron River, above and below the impoundment, may support a commercial fishery.

Ford Lake (56)

Ford Lake, Washtenaw County, is an impoundment of the Huron River. Carp are the primary rough fish in this lake, but bullhead, white sucker and channel catfish are also present. This impoundment was chemically treated in 1973 to remove the predominant carp population. Removal estimates are as follows: carp - 751.2 pounds per acre, white sucker - 3.3 pounds per acre, bullhead - 5.0 pounds per acre, a total of 759.5 pounds per acre. A state survey in 1975 showed that white sucker, yellow bullhead and channel catfish accounted for 23.46% of the catch. Carp are still present in the population and accounted for 59.51% of the catch in September, 1973 (four months after the chemical treatment).

Ford Lake is 975 surface acres in size with a maximum depth of about 30 feet. Gravel sediments can be located in the immediate area

of the dam, around the island, and various other places around the shoreline of the lake.

Tainting problems are evident in fish from Ford Lake (Lundgren 1978). Tainting was evident in fish from the following sections of Ford Lake: upper section - walleye (Stizostedion vitreum), largemouth bass and white suckers; middle section - walleye; lower section - largemouth bass. Ford Lake will be considered a potential source of rough fish for the future. It will not be considered a potential source at the present time.

Stony Creek Impoundment (57)

Stony Creek Impoundment, Macomb County, has a substantial population of carp, suckers and bullhead. These species accounted for 60.83% and 80.87%, by number, of the catch in 1969 and 1968 state surveys. Average sizes of the fish caught in the 1968 survey are as follows: white sucker - 14.1 inches, redhorse - 15.5 inches, carp - 20.0 inches, and brown bullhead - 8.4 inches.

Stony Creek Impoundment is 497 acres in size with a maximum depth of 23 feet. The bottom sediments are composed of gravel, sand, organic and clay materials interspersed throughout the impoundment. Four creeks enter the lake along the north shoreline and Stony Creek flows out at the southern end. An access site is located near the dam on the southern end of the lake.

Kent Lake (58)

Kent Lake, Oakland County, is an impoundment of the Huron River. This impoundment has an abundant carp population. Some suckers and bullhead are also present in the lake. A state survey in 1976 showed that these species accounted for 19.73%, by number, of the catch. Carp only accounted for 3.89%, by number, of the catch. This figure probably does

not represent the true proportion of carp in the fish population. Average sizes of fish in this catch are as follows: carp - 19.0 inches, white sucker - 17.0 inches, yellow bullhead - 9.5 inches, and brown bullhead - 7.5 inches. Bowfin were also present in the catch.

Kent Lake is 1,000 surface acres in size with a maximum depth of 38 feet. Most of the impoundment is less than 10 feet deep. A boat launching ramp is located on the southeast end of the lake. A sewage treatment plant is located on the southeast end of the lake and might be a potential source of contaminants.

Tipsico Lake (59)

Tipsico Lake, Oakland County, may provide a commercial harvest of yellow bullhead. In a 1976 state survey, yellow bullhead accounted for 90.66%, by number, of the catch and averaged 7.0 inches in length. Bowfin were also present in the catch.

Tipsico Lake is 301 surface acres in size with a maximum depth of 27 feet. The major portion of the lake has a gently sloping bottom contour. One stream flows out of the lake and one stream enters the lake on the north end. A large marsh area is located at the south end of the lake where another stream enters.

Belleville Lake (60)

Belleville Lake, Wayne County, is an impoundment of the Huron River. Carp are the primary rough fish in this lake but suckers, bullhead and channel catfish are also present. In 1973, this impoundment was chemically treated to remove the predominant carp population. Approximately one million pounds of fish were killed. An estimated 760 pounds per acre of carp and 24 pounds per acre of suckers were removed from the lake. Some bullhead and channel catfish were also killed. Up to the present time,

carp have not reached the high numbers that were present in this impoundment in 1973, but the population is rebuilding itself and a partial chemical treatment is expected in about 1982 (Spitler, personal communication).

A state survey in 1976 showed that carp, white sucker, channel catfish and bullhead accounted for 16.51%, by number, of the catch. Average sizes of the fish in this catch are as follows: carp - 20.2 inches, white sucker - 14.2 inches, bullhead - 8.5 inches, and channel catfish - 14.5 inches.

Belleville Lake is 1,270 surface acres in size with a maximum depth of about 20 feet. Gravel sediments can be located in various places along the shoreline of the lake, and along the entire old river channel. Several small creeks flow into the lake along its north shoreline.

Tainting problems are evident in fish from Belleville Lake (Lundgren 1978). Tainting was evident in fish from the following locations: middle section - walleye and largemouth bass, lower section - white sucker. Belleville Lake will be considered a potential source of rough fish for the future. It will not be considered a potential source at the present time.

All Regions

A total of 116,694 surface acres of inland waters supporting an estimated 7,996,425 pounds of rough fish may be available for commercial harvest in Michigan (Table 12). Natural lakes account for 78.8% of these waters while the remaining 21.2% are impounded waters. The white sucker is the predominant commercial species in 54.9% of the total waters listed, most of which are located in Region I and Region II. Bullhead are the primary commercial species in 24.9% of the designated waters. Houghton Lake (20,044 acres) accounts for the largest portion

of the bullhead waters and is located in Region II. The carp is the primary commercial species in 20.2% of the waters in Regions II and III.

In addition to the waters listed above, four lakes (3,940 acres) and two rivers (Raisin and Grand) located in Region III, should be considered as potential future sources of underutilized fish (unavailable at the present time because of contaminant problems).

Table 12. Estimates of total underutilized fish biomass, and distribution of lakes by major commercial species and type of lake for all three Michigan regions.

Region	Major[1] commercial species			Type[1] of lake		Total acres	Estimated pounds per acre of rough fish	Estimated total biomass (pounds)
	Suckers	Bullhead	Carp	Impoundment	Natural			
I	33,521	3,756	-	4,400	32,877	37,277	39	1,453,803
II	30,110	23,713	10,045	14,760	49,108	63,868	63	4,023,684
III	409	1,581	13,559	5,558	9,991	15,549	162	2,518,938
Total	64,040	29,050	23,604	24,718	91,976	116,694		7,996,425
% of Total	54.9	24.9	20.2	21.2	78.8			

1. Figures represent acres of water.

METHODS OF HARVEST USED IN INLAND LAKES

A variety of methods are available for the capture of underutilized fish in inland lakes. Impounding gears, which retain captured fish alive, are the preferred methods for inland lake fisheries. Live capture methods allow the separation of commercial species from game species, which can be returned to the water with minimum damage. This is an important consideration in managing Michigan lakes where recreational fisheries are emphasized.

Gillnetting has been used for the commercial harvest of rough fish in some instances (Jester 1976; Johnsen and Hasler 1977). The fishery manager may choose to use gillnetting as a harvest technique where the danger to game fish is considered to be small.

Seines

Seining probably has been the most widely used method employed in capturing carp. A variety of lengths, depths and mesh sizes have been used in various seine operations.

In Wisconsin, where considerable effort has been employed in carp fishing, seining is considered the most effective method of carp control (Miller 1952). Seines are considered efficient because of their mobility. They can be transported to large carp concentrations where an entire school can be captured in one haul. Wisconsin seines are typically suspended nets with manila rope as the bottom line. This type of net allows easy passage of the bottom line over aquatic vegetation.

Wisconsin fishermen have used seines ranging from 200 feet to over 1 mile in length, and from 6 to 50 feet in depth. Mesh size usually ranges from 2 1/2 to 5 1/2 inch stretch measure. A carp 8.1 inches in length and 0.3 pounds in weight can be captured with 2 1/2 inch mesh (Table 13).

Table 13. Age, weight and length of young carp caught in various sizes of mesh in Wisconsin[1].

Mesh[2] (inches)	Length (inches)	Weight (pounds)	Age limit (years)
5.5	16.5	2.4	3.0
4.5	14.1	1.6	3.0
4.0	12.5	1.1	3.0
3.5	10.6	0.7	2.0
3.0	9.0	0.4	2.0
2.5	8.1	0.3	2.0

1. Taken from Miller (1952).

2. Stretch measure.

The conditions for which the seine is used will partly determine the mesh size. The smaller the mesh the more resistance to pull by water and vegetation. Larger mesh sizes are usually used in river currents. Fish size and spawning periodicity may also determine mesh size. Miller (1952) states that a 3 1/2 inch mesh is usually used where a good catch of carp occurs every three years. This size mesh will capture carp 18 months and older.

In 1,400-acre East Okoboji Lake, Iowa, seining was used as an effective method of rough fish removal (Rose and Moen 1953). In this study a 2,500 foot, 5 inch stretch mesh seine was used to remove rough fish from East Okoboji Lake from 1940 to 1951 (Table 14). Average catches per seine haul of buffalo, carp, and freshwater drum ranged from 1,608 pounds (1951) to 7,283 pounds (1940) in the 12-year period.

Ricker and Gottschalk (1941) used seines in a coarse fish removal study at Bass Lake, Indiana. Two seines were employed: one was 1,000 feet long and 20 feet deep with 3 inch stretch mesh; the other was 800 feet long and 8 feet deep with 3 inch mesh. Ricker and Gottschalk (1941) concluded that the smaller seine was less costly and less difficult to use than the large seine. The smaller net could be pulled more times per day resulting in a larger number of fish caught (Table 15).

Lake Macatawa, Ottawa County, Michigan, has an extensive history of carp seining operations that began in 1927. Average catches per seine haul have ranged from 1,315 pounds (1938) to 9,524 pounds (1939) (Table 11).

Other devices sometimes assist seining operations. Barges and winches are sometimes used for transporting and retrieving the large seines after they have been set (Peterson 1958; Ricker and Gottschalk

Table 14. Average catch (pounds) of rough fish per seine haul in East Okoboji Lake, 1940 - 1951[1].

Year	Species			Total
	Buffalo	Carp	Freshwater drum	
1940	5,142	523	1,618	7,283
1941	3,964	469	352	4,785
1942	2,652	848	308	3,808
1943	2,412	653	267	3,332
1944	1,409	1,211	240	2,860
1945	847	1,409	302	2,558
1946	2,959	1,180	245	4,384
1947	1,584	463	401	2,448
1948	1,001	1,811	973	2,115
1949	994	850	158	3,002
1950	36	1,116	372	2,024
1951	167	927	514	1,608

1. Taken from Rose and Moen (1953).

Table 15. Mean number of rough fish caught, the standard deviation, and the average weight in pounds for each species of fish in the large and small seine[1].

Species	Large Seine			Small Seine		
	Mean No.	S.D.	Average Wt.	Mean No.	S.D.	Average Wt.
Carp	28.1	31.1	8.5	38.8	41.7	6.5
Quillback	18.4	26.6	2.2	2.5	2.4	2.1
Buffalo	4.6	10.1	6.1	3.9	4.6	7.6
Gar Pike	1.2	-	2.2	3.5	-	2.1

1. Taken from Ricker and Gottschalk (1941).

1941). In lakes with soft, muddy bottoms, pans may be attached along the bottom line to act as skis for easier movement (Miller 1952). By using light webbing and fastening weights to the center of the slack webbing, rolling of the nets in river currents can be prevented (Peterson 1958).

Trap Nets and Fyke Nets

Trap nets have been used in several rough fish removal projects. Suckers have been the major species taken with this method.

In the 1940's, sucker removal and demonstration netting projects were carried out on certain large lakes in Michigan (Crowe 1949). In these projects, suckers were harvested with commercial trap nets (small "subs") with the following dimensions: crib - 4 feet by 6 - 8 feet by 8 - 10 feet, with 300 foot leads and 2 1/2 inch stretch mesh. The average catch per lift of suckers ranged from 8 (Mullet Lake, Table 16) to 134 (348 pounds, Burt Lake, Table 17). The nets were usually lifted once every three days but occasional seven-day sets were made. The nets were generally set near stream mouths (Crowe 1947), over either sand and gravel or plain sand sediments. Water depth ranged from 4 to 12 feet (Crowe 1946).

Johnson (1977) used trap nets to harvest suckers on 605-acre Wilson Lake, Lake County, Minnesota. During May 21 to June 3, 1966, 5,369 adult white suckers weighing 15,600 pounds (85% of the estimated biomass of suckers) were harvested.

Grice (1958) used fyke nets to remove trash fish and panfish from 45 ponds in Massachusetts. A total of 127,430 pounds of panfish and trash fish were removed from the ponds during 1951-1956. Grice's fyke nets were D-framed, heart-lead bonneted wingnets. The leads were 100 to

Table 16. Catches of underutilized fish from certain large inland lakes in Michigan, during 1947 and 1948[1].

County	Lake	Date	No. of Lifts	Species[2]							Total
				Suckers	Bullhead	Freshwater drum	Redhorse	Burbot	Bowfin	Carp	
Cheboygan	Burt	11/7/47-5/10/48	144	11,795	1,770	-	-	395	259	11	14,230
				(82)	(12)	-	-	(3)	(2)	(<1)	(99)
Cheboygan	Mullet	11/1/47-1/17/48	20	164	274	-	-	-	62	-	500
		3/26/48-4/29/48		(8)	(14)	-	-	-	(3)	-	(25)
Cheboygan	Black	11/7/47-4/23/48	87	831	406	-	282	9	18	-	1,546
				(9)	(5)	-	(3)	(<1)	(<1)	-	(18)
Alcona	Hubbard	11/19/47-12/30/47	58	5,347	224	-	-	3	-	-	5,574
		4/5/48-4/29/48		(92)	(4)	-	-	(<1)	-	-	(96)
Iosco	Van Etten	3/26/48-4/28/48	39	661	182	2,686	667	2	8	129	4,335
				(17)	(5)	(69)	(17)	(<1)	(<1)	(3)	(111)
		Total	348	18,798	2,856	2,686	949	409	347	140	26,185

1. Taken from Crowe (1949).

2. Upper figure - total number caught, lower figure - number caught per lift.

Table 17. Catches of suckers from sucker removal and demonstration netting projects in certain large Michigan lakes.

County	Lake	Date	No. of lifts	No.[1] caught	Pounds[1] caught	% of catch
Cheboygan	Burt[2]	3/21-5/13/47	55	7,367 (134)	19,154 (348)	83
Cheboygan	Carp[2]	4/7-5/23/47	74	8,991 (122)	22,477 (304)	65
Alcona	Hubbard[2]	4/18-5/22/47	48	5,468 (114)	14,217 (296)	89
Cheboygan	Mullet[2]	3/28-5/13/47	18	675 (38)	1,755 (97)	24
Presque Isle	Grand[3]	1945 and 1946	76	6,645 (87)	13,290 (175)	61
Montmorency	East Twin[4]	1936 and 1937	-	2,041	4,338	-
Cheboygan	Black[4]	1939 and 1940	-	7,225	16,256	-
Otsego	Big Bear[4]	1940-1943	-	5,778	10,400	-

1. Upper figure - total number, lower figure - catch per lift.

2. Taken from Crowe (1947).

3. Taken from Crowe (1946).

4. Taken from Crowe (1949).

200 feet long, 5 to 10 feet deep with 2 inch stretch mesh. The pots were composed of 1 1/2 inch mesh with a frame 5'6" wide and 4'6" high. The wings were 32 feet long, 9 to 10 feet deep with 1 1/2 inch mesh. The bonnets spanned 28 feet between the wings and were made of 1 1/2 inch mesh.

Trawls

Trawls usually are not used for commercial fishing in inland waters (Lagler 1956). Trawl nets probably could be adapted for fishing large inland lakes that are relatively free of obstructions. A special trawl is used routinely for harvesting rough fish in a large Wisconsin lake.

Fish Traps

The wood fish trap may be an effective method for capturing rough fish in certain situations. Fish traps used in the Wisconsin carp fishery are constructed of 1 by 4 or 2 by 4 inch boards driven vertically into the lake or stream bottom and spaced about 1 1/2 inches apart (Miller 1952). Stones must be placed along the bottom of the boards to prevent the fish from rooting their way out. To be effective, the fish trap must completely shut off the entrance to a stream bay or marsh.

Rose and Moen (1951) used a fish trap in a carp removal project on 1,260-acre Lost Island Lake, Iowa. A permanent trap was constructed at an inlet to Lost Island Lake and operated for 6 years. The total pounds of carp captured in this fish trap ranged from 24,344 pounds (1945) to 113,245 pounds (1946) (Table 18).

Baiting

Baiting may prove to be a successful way of concentrating large numbers of commercial fishes in inland lakes. Buck et al. (1960) performed carp baiting experiments with sour corn in three Illinois lakes.

Table 18. Total weight removed, pounds per acre removed and average weight of carp removed with a permanent trap from Lost Island Lake, 1944 - 1949[1].

Year	Total removed	Pounds per acre removed	Average Weights
1944	-	-	1.8
1945	24,344	19.3	2.0
1946	113,245	80.8	2.0
1947	68,538	54.3	2.3
1948	30,785	25.2	4.5
1949	24,492	19.4	6.0
1950	29,870	23.6	10.0

1. Taken from Rose and Moen (1951).

Results showed that sour corn seemed to repel most other fishes so that large numbers of carp, and possibly catfishes, could be concentrated and killed with small losses of game fish. Buck et al. (1960) suggested that in the largest lake (Slocum Lake - 225 acres), control of carp would require several treatments in each of several widely separated areas. A natural cove or channel would be the best baiting area but the authors indicated that carp might be lured to enclosures made with seines or chicken wire. If a channel is present, the fish could be lured into the channel, then the channel could be quickly closed off and seined (poisoning with rotenone was used by Buck et al. 1960).

Any current in the lake should be used to distribute the scent of the bait (Buck et al. 1960). Low concentrations of carp were obtained when baiting one of the smaller lakes because available currents were not used to distribute the scent. Large scent bags (burlap sacks filled with bait) may also be used to help attract the fish. With continuous baiting, carp can be reconcentrated at fairly short intervals of time. Buck et al. (1960) suggests that best use of the technique would be to establish permanent, continuously baited areas where carp could be captured as often as they could be concentrated. At 225-acre Slocum Lake, 5,871 pounds of carp were attracted to the baited area and killed there within 36 to 48 hours following a first treatment with rotenone (Table 19).

Relatively large numbers of catfish and lesser numbers of bullhead were also killed in the Slocum Lake baiting experiment. Buck et al. (1960) suggest that these two species may also be attracted to bait, but effective comparisons were not possible because of inadequate data.

Baits other than corn that might prove more effective, or economical, might be oats, soybean cake, cottonseed cake, bread or dried milk, either singly or in combination (Buck et al. 1960).

Table 19. Numbers, weights and pounds per acre of fish recovered by chemically treating an area baited with corn at Slocum Lake (225 acres) following listed baiting periods[1].

	1956				1957			
Baiting Periods	7/20-7/23		8/3-8/20		7/15-7/28		7/29-7/31	
No. applications and total wt. of corn (pounds)	2-400		6-1300		9-1090		1-336	
Species	No.	lbs.	No.	lbs.	No.	lbs.	No.	lbs.
Largemouth bass	5	5	0	0	0	0	0	0
Bluegill	93	19	20	1	-	tr.	-	tr.
Misc. Sunfishes	-	11	0	0	75	4	14	1
Crappies	97	24	5	1	22	1	0	0
Channel catfish	19	17	323	174	755	362	74	35
Bullhead	182	30	290	48	28	7	10	3
Carp	967	1,808	2,525	5,800	523	1,692	3,727	5,871
Totals	1,363	1,914	3,164	6,024	1,403	2,066	3,825	5,910
Pounds per acre of lake								
Carp		8.0		25.8		7.5		26.1
Channel catfish		tr.		0.8		1.6		0.2
Others		0.4		0.2		tr.		-
Totals		8.4		26.8		9.1		26.3

1. Taken from Buck et al. (1960).

Ultrasonic Tracking and Sonar

Ultrasonic tracking may be useful in locating large aggregations of commercial fishes in inland lakes. Johnsen and Hasler (1977) used ultrasonic tracking equipment to find large aggregations of carp in 9,736-acre Lake Mendota, Wisconsin. By knowing where these aggregations were, commercial fishermen harvested 102,294 pounds of carp and bigmout buffalo with only 57,743 feet of gill net while fishing through the ice (January 29 through March 9, 1976). Some net avoidance was observed by instrumented fish. The authors indicated that seining before freeze-up may have been more efficient than gillnetting through the ice.

Carp in Lake Mendota aggregated in the same two locations in autumn and winter, in two consecutive years. Both areas were from 5 to 7 meters deep, located near large beds of macrophytes. In both years, instrumented fish arrived at the aggregation areas with relative synchrony within 2 to 12 days (December 20-21, 1974; November 22 through December 2, 1975). Fish made their most extensive movements during the time interval just prior to arrival at the aggregation areas. These rapid movements followed turnover and occurred when the lake temperature was below 8^{o} C. The aggregations of fish in this study represented only carp larger than 3 kg (Johnsen and Hasler 1977). It was not known if the aggregations were composed of all carp from the lake, or only the larger carp. Smaller carp were observed under the ice in marshes.

Sonar may also help to locate large aggregations of commercial fishes. The literature on this method was not available for inclusion in the present study, but the University of Wisconsin has experimented with sonar in detecting large schools of fish (Peterson 1958). Strand and Scidmore (1969) have investigated sonar as an aid to under-ice rough fish seining.

Other Helpful Methods

Inland lake operations harvesting large amounts of rough fish usually require mechanical aids for moving nets and transporting fish. In addition to barges and winches used in pulling seines, elevators (Peterson 1958) and crane lifted nets (Spitler 1976 - for dead fish) have been used to load fish onto trucks. Fish pumps might also be adapted for this type of work.

Holding ponds may be necessary to retain fish until they can be transported to market. Often large quantities of rough fish are captured in a short period of time and holding ponds offer a quick means of disposal (Miller 1952). Live cribs may assist in saving time for sorting and separating out game fish (Peterson 1958). A 10 foot wide by 61 foot long live crib used in Wisconsin was capable of holding 80,000 pounds of carp.

Optimal Fishing Seasons

Winter aggregations and spawning runs of rough fishes have successfully aided commercial fishermen in capturing large numbers of fish in inland waters. In Wisconsin, carp seining operations must be carried out in the spring and fall to be effective in control efforts (Miller 1952). Carp form large aggregations in the fall which usually disperse after spring ice-out (Miller 1952; Jonsen and Hasler 1977). After ice-out, they scatter for a short period until spawning time. Large numbers of carp usually spawn in marshy or shallow weedy areas of a lake (Scott and Crossman 1973). After spawning, they again scatter until fall turnover. Spawning usually begins in May and may extend to August in the Great Lakes Region depending on water temperatures (Swee and McCrimmon 1966). Spawning usually begins in earnest when water temperatures reach 62.6 F (17 C).

In Michigan, suckers have usually been harvested with trap nets in the fall and spring. Crowe (1949) studying sucker removal projects in Michigan, noted that the poorest fishing occurred in mid-winter under heavy ice cover. In general, fishing was fairly good for suckers prior to ice formation, followed by very poor fishing and a second production peak after the break-up. There was some indication that the best period had already passed when netting was resumed in the spring.

White suckers usually spawn from early May to early June. Adults usually migrate from lakes into gravelly streams when the water temperature reaches 50 F (10 C), but they also spawn on lake margins, or quiet areas in the mouth of blocked streams (Scott and Crossman 1973) Seining may be a useful method of capture for suckers where large numbers of spawners could be captured in a single haul. Artificially concentrating suckers by baiting has not been attempted.

All three species of bullhead, the yellow, black and brown bullhead, usually spawn from May to June when water temperatures reach about 70 F (21.1 C) (Scott and Crossman 1973). Information is not available concerning the best times of the year of best methods for capturing bullhead. Presently, however, Gary Schnicke of the Michigan Department of Natural Resources is initiating a commercial harvest of bullhead on Lake St. Helen in Michigan. His study should provide some insight into the effectiveness of bullhead harvest in inland lakes.

Problems in Netting

Netting problems often occur in inland lakes where extensive areas of aquatic macrophytes or other obstructions occur. Obstructions are especially a problem in impoundments where flooded waters often contain many old tree stumps. Seining operations in impoundments will be restrict-

ed to areas free of obstructions. Trap nets may be more versatile in impoundments, but stumps will still present a problem.

Some of the methods previously discussed may aid in successfully fishing impoundments. Baiting trap nets, or baiting areas free of obstructions may help catch large numbers of rough fish in impoundments. Currents are usually prevalent in impoundments which can greatly aid in distributing the scent of the bait. Fish traps may be useful in impoundments where they can be set in shallow areas where rough fish are known to spawn.

MANAGEMENT CONSIDERATIONS

The removal of abundant rough fish populations from inland lakes has been a common management tool for many years. As of 1952, at least forty states and provinces were conducting programs for commercial or rough fish harvest through commercial fishing, state supported operations, or state supervised volunteers (Schneberger 1952). Many of these control efforts continue at the present time.

The most obvious benefits of removing rough fish from inland lakes are in improving water clarity, increasing fish forage base and reducing damage to rooted aquatic vegetation. These benefits may be desirable in themselves, or they may be indicative of improved conditions for game and panfish populations. Several studies have attempted to measure the effects of rough fish removal on game and panfish populations (Crowe 1946, 1947, 1949; Grice 1958; Johnson 1977; Moyle et al. 1950; Rawson and Elsey 1950; Ricker and Gottschalk 1941; Rose and Moen 1951, 1953).

From 1939 to 1948, sucker removal projects were carried out by the Michigan Institute for Fisheries Research on certain large inland lakes in Michigan with overabundant sucker populations (Tables 16, 17; Crowe 1946, 1947, 1949). As a result of these investigations, Crowe (1949) recommended that suckers can be harvested from inland lakes where investigation indicates that conditions warrant the effort and where local fishing is not adequate to utilize the crop. In the lakes where suckers had become the dominant species, removal was beneficial to the game species and brought about more favorable balances in the fish community. He also noted that in certain selected large lakes, suckers probably can be harvested even though they do not occupy a dominant position in the fish community.

Johnson (1977) measured the response of walleye and yellow perch (Perca flavescens) populations to removal of white suckers from a Minnesota lake in 1966. His results indicated that percid populations may benefit by the removal of white suckers in relatively infertile lakes where the number of species is low. In a 7-year period following intensive removal of adult white suckers, catches of adult white suckers remained far below pre-removal catches, but juvenile suckers increased about 17-fold, yellow perch increased about 15-fold, and the standing crop of walleye increased about one-third. There was some indication that recruitment of the very abundant immature suckers would restore, to some degree, the adult population. The changes in the structure of the fish community were related to changes in the food web.

Rawson and Elsey (1950) harvested suckers from 320-acre Pyramid Lake, Alberta, in an attempt to improve the rainbow trout population. Removal of about 27,000 longnose suckers and 6,000 mountain whitefish produced no detectable improvement in the survival of rainbow trout in the 5-year harvest period (1940-1945), or the three years which followed. Six species of fish were present in the lake: mountain whitefish, rainbow trout, eastern brook trout, lake trout, longnose sucker and lake chub. The authors noted that the increased survival of young suckers may have nullified the expected decrease in food competition. They also suggested that the removal of coarse fish from cold, trout-producing lakes may not prove as helpful as it had been in certain warm-water lakes.

Rose and Moen (1953) found an increase in game fish populations in 1,400-acre East Okoboji Lake, Iowa, following intensive removal of rough fish. During the management period, the average catch per seine haul of rough fish decreased while the average catch per seine haul of game

fish increased. Buffalo, carp and freshwater drum were the primary species of rough fish harvested; yellow perch, crappie, bullhead and bluegill were the primary species of fish that benefited from the harvest. White bass and walleye catches increased somewhat toward the end of the management period. The authors concluded that where carrying capacities of fish are high, as in the lakes of northern Iowa and where rough fish are strongly dominant, reduction must be extensive and continued in order to effect significant increases in game fish populations.

Ricker and Gottschalk (1941) noted improved game fish populations after removing coarse fish from 1,600-acre Bass Lake, Indiana. Forty-five tons of carp, twenty tons of quillback and six tons of buffalo were removed from the lake in 1935 and 1936. Catch indices showed a reduction in the number of rough fish from 1935 to 1936 and an increase in the number of game fish for the same period. The major species of game fish benefiting from the operation were walleye, striped bass, smallmouth bass, bluegill and black crappie. Consistent with the improved game fish populations, water clarity improved and increased growth of aquatic vegetation occurred in Bass Lake. Up to 1940, there had been no significant reversion to conditions existing prior to 1935.

Rose and Moen (1951) found an increase in the growth of black bullhead after removal of carp from 1,260-acre Lost Island Lake, Iowa. Annual removal ranged from 19.3 to 80.8 pounds per acre of carp from 1945 to 1950. During the same period angler catch limits on bullhead were removed. As a result of these experimental practices, the average catch of bullhead decreased, but the average weight and length of bullhead increased throughout the management period (from 1.5 inches and 0.1 ounces to 10.4 inches and 10.1 ounces). The changes in growth were related to competition for food between the carp and bullhead.

Grice (1958) attempted to improve game fish populations in 45 Massachusetts ponds by removing panfish and trash fish with fyke nets from 1951 to 1956. These experments did not improve game fish populations. The predominant species of game fish tested in these experiments were chain pickeral and largemough bass. Fyke netting usually increased the growth of the species being thinned, which in most ponds was panfish. Apparently, young, rapidly growing panfish, rather than game fish filled the void left by harvesting. Removal of trash fish from these ponds ranged from 1 to 146 pounds per acre annually.

It should be noted that in 28-acre Duck Pond, substantial increases in bullhead growth were achieved after thinning operations.

Moyle et al. (1950) in comparing 25 years of catch data from 14 rough fish lakes in southern Minnesota, concluded that removing an average of 92 pounds per acre per season had no permanent effect in reducing the size of carp and buffalo populations. They found, in general, that rough fish lakes in Minnesota support 375 pounds per acre of fish, of which 280 pounds are rough fish, largely carp. The annual poundage increment of rough fish (96.6 pounds per acre) in southern Minnesota waters is approximately one-third of the standing crop of rough fish (281 pounds per acre). The authors believe, in general, that rough fish have no effect on the total poundage of game fish in southern Minnesota lakes. The average weight of game and forage fish was 101.1 pounds per acre in game fish lakes, and 93.4 pounds per acre in rough fish lakes.

In an earlier discussion, Moyle (1949) noted that much of the early work on rough fish control in Minnesota resulted only in harvesting the annual growth of the rough fish population. More intensive operations, however, did result in temporary marked reductions in the size of carp populations in certain lakes.

In summary of the literature: Johnson (1977), Rose and Moen (1951), and Rose and Moen (1953) found that continuous, intensive removal efforts resulted in improved game fish populations. Ricker and Gottschalk (1941) noted that benefits to game fish populations lasted for at least two years after two years of consecutive annual harvest of rough fish. Crowe (1949) found improved angling of game fish and a reduction in the relative size of the sucker population after netting operations. Moyle (1949) noted temporary, marked reductions in the size of carp populations after intensive removal operations. In contrast, Grice (1958) found no improvement in game fish populations after removal of trash fish and panfish from 45 Massachusetts ponds. Rawson and Elsey (1950) found no increase in a rainbow trout population following removal of longnose suckers. In reviewing 25 years of catch data, Moyle et al. (1950) noted no permanent reductions in rough fish populations subjected to removal operations.

The question arises whether stable, desirable populations of game fish can be achieved through intensive removal of rough fish. The literature indicates that this type of management has increased game fish populations in some instances. The success of the type of management depends upon a variety of factors including: species composition, water quality, type of lake, intensity of removal and post-removal management.

Variation in interspecific interactions may account for the success of sucker removal operations. A difference may be implied in the opposite results obtained by Johnson (1977), and Rawson and Elsey (1950). Removal of suckers appear to benefit the warm-water fish population but not the cold-water trout population.

Variation is also present in the reproductive response of different species of fish to increased harvest. Neese et al. (1957) found that increased reproduction did not occur after 5 years of heavy exploitation of a carp population. Mraz and Cooper (1957) found no relationship between the density of adult carp and the number of young surviving to the end of the first summer. In contrast, Johnson (1977), and Rawson and Elsey (1950) noted high recruitment of suckers after removal operations.

Changes in water quality may lead to conditions more favorable to rough fish than to game fish. When this occurs it will be necessary to improve water quality before any favorable improvement in game fish populations can be achieved through rough fish management. Water quality deterioration and changes in species compositions resulted in the establishment of a large carp population in Lake Macatawa, Michigan. Recommendations were made to improve the water quality and reduce the rough fish population in that lake (Trimberger, personal communication).

Some lakes may have characteristics principally suited to rough fish, as was noted by Moyle (1949) for Minnesota lakes. Lakes of this type may not be desirable for game fish management and could be used as a commercially harvestable source of fish protein.

Most lakes subject to rough fish management will probably require continuous, or at least intermittent, removal operations. Compensatory recruitment can easily restore a sucker population (Mraz and Cooper 1957). The potential egg deposition of one female carp of 4 to 5 pounds may exceed 200,000 eggs. Impoundments, and inland lakes with tributary streams are subject to re-invasion by rough fish from outside sources, possibly allowing a quicker re-establishment of the rough fish population.

If good game fish populations can be established through rough fish removal, angling intensity for game fish probably will increase. Intensive angling for game fish can give a competitive advantage to the lightly exploited rough fish population. Continuous removal of rough fish may be necessary to partially offset this imbalance in the fishery.

Another tool that might be useful in this type of management is predator stocking programs. Only recently has predator stocking been investigated as a possible tool in rough fish management programs (Wisconsin is presently conducting a study on this subject - Hacker, personal communication). Stocking game fish after intensive removal operations could help game fish fill the void left by removal, and possibly stop the resurgence of rough fish populations.

Chemical control is usually the alternative method of controlling rough fish populations in inland lakes. Many biologists feel that chemical control, rather than mechanical control, is a much more efficient way of controlling over-abundant rough fish populations. From 1971 to 1976 in Michigan, 84 lakes (11,801 acres) and 10 streams (264 acres) were chemically treated, some of these for rough fish control (Reynolds, personal communication). Chemical control of lakes and streams in Michigan has been a very successful management tool, attracting more fishing than any other form of present management (marsh management - maintenance trout stocking - stocking predators, Trimberger 1975).

Perhaps another form of management, mechanical rough fish management, should be introduced into inland lakes in Michigan. There is, after all, a tremendous waste of fish protein in chemical reclamation projects. It is obviously desirable to utilize this resource if at all possible, an idea shared by most Department of Natural Resources district fishery

biologists in Michigan. There is, however, some reluctance by biologists in Michigan to attempt rough fish removal projects with commercial crews. This reluctance partly results from an uneasiness in allowing commercial fishermen into inland waters, partly due to unfavorable public reaction, and partly because they are not sure this type of management will work effectively. Very few rough fish removal projects have been attempted in Michigan. The only attempts that have been conducted, from personal communication and the literature, were those of Crowe (1946, 1947, 1949), and another on Lake Macatawa, Ottawa County, from 1927 to 1942. Recently, Lake Macatawa has been chemically treated.

As noted earlier, several states currently have rough fish control programs. Minnesota annually nets about seven million pounds of rough fish from their inland lakes (Hennagir 1975). Carp, buffalo, perch, suckers, redhorse, freshwater drum, bowfin, burbot, tullibee, gar pike, goldeyes, bullhead and turtles are target species for removal operations. About 225 inland lakes are fished by commercial contract crews using seines and hoopnets. Another 150 lakes, where commercial operations are reluctant to net, are fished by state netting crews (Hennagir 1975).

From 1976 to 1977, about 4.5 million pounds of rough fish were harvested by contract fishermen and state netting crews in Minnesota (Appendix D). Carp, bullhead, buffalo, freshwater drum (sheepshead) and sucker accounted for the largest portion of the catch.

Minnesota's policy states that rough fish will be harvested for the best use of this natural protein resource and for the benefit of sport fish. None of their lakes are harvested for their maximum sustainable yield of rough fish (Hennagir, personal communication).

Since 1934, Wisconsin has had an extensive commercial fishery for rough fish in their inland waters. Presently, one state crew and 20

contract crews operate in their inland waters. In 1974, 1975 and 1976, 3,412,410, 3,254,295 and 6,441,299 pounds, respectively, were harvested from Wisconsin's inland waters (Hacker, personal communication; Appendix D). Carp, freshwater drum (sheepshead) and buffalo accounted for the largest portion of the total catch. Bullhead, bowfin, burbot, gar, quillback, suckers and gizzard shad are other underutilized fish taken in Wisconsin.

Michigan has 56 lakes and impoundments (116,694 acres) with the potential for commercial harvest of underutilized fish. This figure is much smaller than those given for Minnesota (375 rough fish lakes) and Wisconsin (137,708 acres alone in Lake Winnebago). It is evident that an inland lake commercial fishery for underutilized fish in Michigan would not be as extensive as those in Minnesota and Wisconsin.

SUMMARY

The primary species of underutilized fish in Michigan's inland lakes are carp, white sucker, yellow bullhead, brown bullhead and black bullhead. The white sucker is the primary commercial species in 54.9% (mostly in Regions I and II), bullhead in 24.9% (scattered throughout the state), and carp in 20.2% (all in Regions II and III) of the designated inland waters in the state. Other species of rough fish common in Michigan's inland lakes are channel catfish, freshwater drum, redhorse, longnose gar, shortnose gar, goldfish, gizzard shad and alewife.

A total of 116,694 acres may be available for the commercial harvest of underutilized fish in Michigan's inland waters. The total acreage for each region of the state is as follows: Region I - 37,277 acres, Region II - 63,868 acres, Region III - 15,549 acres. Based on preliminary biomass estimates, these waters support 7,996,425 pounds of rough fish. Or by region: Region I - 1,453,803 pounds (using an average of 39 pounds per acre), Region II - 4,023,684 pounds (using an average of 63 pounds per acre), Region III - 2,518,938 pounds (using an average of 162 pounds per acre). Natural lakes account for 78.8% (91,976 acres) of the designated waters in the state while impoundments account for the remaining 21.2% (24,718 acres). Four lakes (3,940 acres) and two large rivers (the Raisin and Grand) located in Region III, should be considered as potential future sources of underutilized fish (unavailable at the present time because of contaminant problems).

Seines are the most common type of gear used in inland lake rough fish management. Other methods which have been used include gill nets, trap nets, fyke nets, trawls and fish traps. Further investigation should be conducted on baiting rough fish as a means to concentrate them

for capture. Ultrasonic tracking and sonar are useful aids for locating large aggregations of rough fish in inland lakes.

Harvesting rough fish from inland lakes has been a common management tool in the United States for many years. The literature indicates that intensive rough fish removal has been used to obtain certain conditions in inland lakes including increased forage base, increased growth of aquatic plants, and increased water clarity; several studies have indicated achievement of increased populations of game fish. The success of this type of management depends on a variety of factors including species composition, water quality, type of lake, and intensity and periodicity of removal. Predator, or game fish stocking and limits on angling may be necessary to maintain desirable populations of game fish. Mechanical harvest may be an alternative, at least in some situations, to the present form of rough fish control in Michigan, chemical control.

APPENDICES

APPENDIX A

FISHERY SURVEY DATA FOR 60 INLAND LAKES AND RIVERS IN MICHIGAN

This data was compiled from Michigan Department of Natural Resources inland lake fishery surveys. The table includes the lake number (as designated in Table 1 of the text); the name of the lake or river; the effort expended (in feet - ft., lift - l., acres seined, or electro-shocking - shock, by hour) and date of survey; the total catch (game and rough fish combined), upper figure - total number caught, lower figure - total weight caught; the species of rough fish (abbreviated - see below); the percentage, by number, of the catch; the percentage, by weight, of the catch; and the range or average size of the fish.

Abbreviated names of fish used in Appendix A:

White Sucker	Wh. Su.	Black Bullhead	Bl. Bh.
Longnose Sucker	Lgn. Su.	Channel Catfish	Ch. Cat.
Quillback	Quillb.	Carp	Carp
Northern Hog Sucker	N. Hgsu.	Goldfish	Goldf.
Buffalo	Buff.	Freshwater drum	Fw. Dr.
Spotted Sucker	Sp. Su.	Bowfin	Bowf.
Redhorses	Redh.	Longnose Gar	Lgn. Gar
Yellow Bullhead	Y. Bh.	Shortnose Gar	Shn. Gar
Brown Bullhead	Br. Bh.	Gizzard Shad	G. Shad
		Alewife	Alew.

Table A1. Fishery survey data for 60 inland lakes and rivers in Michigan.

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
1	Otter	Gill-150 ft. Fyke-10 1. 7/22/77	706 (254.8)	Wh. Su. Redh. Bl. Bh. Total	.57 4.82 60.06 65.45	2.16 20.33 56.24 78.73	14.8 15.3 6.9
		Gill-525 ft Fyke-8 1. Trap-8 1. 8/10-14/70	660 (415.4)	Wh. Su. Redh. Bl. Bh. Total	5.76 1.82 38.03 45.61	12.21 3.88 35.30 51.39	15.3 14.7 10.1
2	Chicagon	Gill-500 ft. 11/3/71	40	Wh. Su.	22.50	-	16.4
		Gill-750 ft. 8/27-28/68	228 (80)	Wh. Su.	7.89	41.17	18.0
		Gill-1,875 ft. Trap and Fyke-20 1. 5/5,9/68	3,574 (2322.4)	Wh. Su.	20.54	84.91	18.0
3	Perch	Gill-150 ft. Fyke-15 1. Trap-6 1. 5/10-13/76	1,397 plus 1,600[1]	Wh. Su. Br. Bh. Total	- 0.43 0.43	1,600[1] 1,600[1]	17.3 12.5

1. Designates pounds.

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
4	Au Train	Gill-25 1. Fyke-4 1. Trap-4 1. Seine-2 Acre 6/19-23/72	1,069 (645.6)	Wh. Su. Bl. Bh. Carp Total	17.21 14.12 0.37 31.78	39.84 18.70 6.20 64.74	18.3 10.6 25.0
5	Au Train Power Basin	Gill-10 1. Fyke-4 1. Seine-less than 1 acre 6/7-8/77	960 (420)	Wh. Su. Bl. Bh. Total	3.54 80.31 83.85	14.31 50.33 64.64	17.8 8.1
		Gill-625 ft. Fyke-5 1. Seine- ? 5/20-22/75	519 (480.4)	Wh. Su. Bl. Bh. Total	2.3 66.28 68.58	5.64 47.77 53.41	17.0 11.0
6	Moss	Gill-1,000 ft. Fyke-4 1. Trap-2 1. 7/27/77	284 (116.1)	Suckers Bl. Bh. Carp Bowf. Total	1.06 76.41 1.76 0.70 79.93	6.35 30.16 23.15 6.46 66.12	18.1 6.2 25.3 22.1
7	Sundstom (Dead River Storage Basin)	Gill, Trap and Fyke-26 1. 6/27-30/72	1,008 (278.2)	Wh. Su. Bl. Bh. Total	48.31 14.68 62.99	65.56 6.33 71.89	11.5 6.0

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
8	Blind Sucker Flooding	Gill-625 ft. 6/21/66	125	Wh. Su.	31.25	-	6.0-23.0
9	Muskallonge	Trap-4 1.	332	White Su.	5.72	32.23	19.2
		Fyke-8 1.	(151.7)	Br. Bh.	75.90	53.92	8.6
		8/11-12/77		Total	81.62	86.15	
10	Brevoort	Fyke and	1,005	Wh. Su.	5.57	39.14	17.1
		Trap-33 1.	(209.7)	Br. Bh.	9.55	17.95	10.6
		7/20-22/76		Bl. Bh.	0.10	0.30	9.3
				Bowf.	0.10	2.00	22.8
				Total	15.32	59.39	
		Gill-625 ft.	669	Wh. Su.	6.13	1.88	16.9
		Fyke-17 1.	(501.9)	Br. Bh.	47.53	37.30	11.3
		5/13-14/76		Bowf.	0.45	-	18.3
				Total	54.11	39.18	
11	Manistique	Trap-41 1.	3,106	Wh. Su.	49.97	-	12.0-20.0
		4/21-25/77		Redh.	2.96	-	14.0-20.0
				Br. Bh.	0.39	-	6.0-8.0
				Total	53.32	-	
		Trap-28 1.	4,997	Wh. Su.	62.23	-	-
		4/19-24/77		Redh.	2.28	-	-
				Br. Bh.	0.04	-	-
				Total	64.55		

Table A1. (Cont'd)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
12	S. Manistique	Trap-16 1. 5/2-9/75	1,099	Wh. Su.	39.03	-	-
				Redh.	0.82	-	-
				Bl. Bh.	0.82	-	-
				Total	40.67	-	
		Trap and Fyke-16 1. 4/13-26/71	2,180	Wh. Su.	82.20	-	-
				Redh.	3.07	-	-
				Br. Bh.	0.41	-	-
				Total	85.68	-	
13	Gulliver	Fyke-10 1. 5/26/77	226	Wh. Su.	79.65	76.79	17.4
		Gill-250 ft. Fyke-24 1. Trap-8 1. 5/27-28/76	683 (938.9)	Wh. Su.	51.24	66.08	17.0
				Br. Bh.	0.89	0.51	10.0
				Total	52.13	66.59	
		Gill-2 1. Fyke and Trap-44 1. 6/26-28/76	897 (1,084.6)	Wh. Su.	59.08	71.09	17.2
				Br. Bh.	0.67	0.44	11.1
				Total	59.75	71.53	
14	Indian	Trap-2 1. 5/3-5/72	38	Wh. Su.	63.16	-	12.6-17.5
				Redh.	5.26	-	14.5-14.8
				Br. Bh.	2.63	-	12.2
				Total	71.05	-	

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
		Trap-9 1. 4/27-5/5/71	509	Wh. Su. Bl. Bh. Total	41.26 0.17 41.43	- - -	- -
15	Seven Mile Pond	Gill-2,000 ft. Trap-39 1. 6/15-25/76	1,074 (758.9)	Wh. Su. Br. Bh. Total	17.04 39.38 56.42	44.59 25.15 69.74	16.1 9.5
16	Munro	Gill-1,250 ft. 7/24/68	196	Wh. Su. Bl. Bh. Br. Bh. Bowf. Total	16.33 5.10 30.61 0.51 52.55	- - - - -	12.4-18.1 9.5-11.3 5.5-7.8 21.3
		Trap-28 1. 10/9-10/62	4,298	Wh. Su. Bullhead Bowf. Total	6.84 72.48 1.16 80.48	- - - -	14.9 9.0 20.5
17	French Farm	Gill-750 ft. 7/18/68	241	Br. Bh.	75.10	-	5.2-11.0
		Trap-13 1. 11/22-24/60	606	Br. Bh.	31.68	-	5.5-11.2
18	Grand	Trap-154 1. 4/20-5/7/76	3,250	Wh. Su. Y. Bh. Carp Bowf. Total	37.66 0.92 0.12 0.52 39.22	- - - - -	- - - -

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
19	Hess	Gill-2,375 ft.	722	Bullhead	10.80	19.13	9.7
		Fyke-6 1.	(392)	Carp	0.97	11.06	24.5
		Shock-1.25 hr.		Bowf.	2.22	19.39	23.0
		5/20-21/69		Quillb.	0.55	0.67	10.3
				Total	14.54	50.20	
20	Hardy Pond	Gill-4,000 ft.	648	Wh. Su.	11.26	38.98	16.3
		7/29/75	(339.3)	Redh.	3.24	-	16.3
				Ch. Cat.	0.15	0.03	4.2
				Carp	0.15	0.15	10.5
				Total	14.80	39.14	
21	Fremont	Gill-1,000 ft.	76	Wh. Su.	5.26	-	16.6
		5/4/72		Carp	9.21	-	15.0
				Total	14.47		
22	Manistee	No Records					
23	Pere Marquette	No Records					
24	Bamfield Pond	Gill-1,440 ft.	384	Wh. Su.	27.86	-	11.9
		Trap-8 1.		Redh.	4.17	-	25.8
		Shock-300 min.		Bl. Bh.	2.34	-	11.8
		6/12-14/72		Br. Bh.	1.04	-	11.2
				Carp	1.04	-	13.3
				Bowf.	5.21	-	23.5
				Total	41.66	-	

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
		Fyke and Trap-8 1, 5/17-18/62	316	Wh. Su.	14.87	-	-
				Redh.	49.37	-	-
				Br. Bh.	7.59	-	-
				Carp	1.58	-	-
				Bowf.	4.43	-	-
				Total	77.84	-	
25	Margrethe	Trap-8 1. 8/13/71	202	Wh. Su.	0.49	-	13.5
				Br. Bh.	0.49	-	10.5
				Total	0.98	-	
		Trap-7 1. 7/21-27/71	144	Wh. Su.	0.69	-	17.8
26	Cooke Pond	Gill-960 ft.	413	Wh. Su.	3.39	-	13.0
		Trap-8 1.		Redh.	0.24	-	19.1
		Shock-4 hrs.		Bl. Bh.	7.51	-	12.7
		5/22-24/72		Br. Bh.	3.63	-	10.8
				Bowf.	6.29	-	23.4
				Total	21.06	-	
27	Foote Pond	Gill-1,440 ft.	174	Wh. Su.	1.15	-	15.0
		Trap-8 1.		Bl. Bh.	0.57	-	13.0
		Shock-2.5 hrs.		Br. Bh.	9.19	-	12.2
		5/15-17/72		Carp	0.57	-	14.8
				Bowf.	4.60	-	23.0
				Total	16.08	-	

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
		Trap and Fyke-10 1. 7/2-3/69	428	Wh. Su.	0.23	-	-
				Redh.	0.70	-	-
				Bullhead	6.07	-	-
				Bowf.	1.63	-	-
				Total	8.63	-	
28	Loud Pond	No Records					
29	Tawas	Fyke and Trap-10 1. 5/29-30/62	570	Y. Bh.	8.07	-	-
				Bl. Bh.	0.35	-	-
				Br. Bh.	5.79	-	-
				Carp	5.96	-	-
				Bowf.	2.10	-	-
				Gar	6.32	-	-
				Alew.	1.23	-	-
				Total	29.82	-	
30	Van Etten	Fyke and Trap-14 1. 5/29-30/62	1,966	Wh. Su.	2.29	-	10.0-20.0
				Redh.	3.51	-	10.0-20.0
				Y. Bh.	1.58	-	8.0-14.9
				Br. Bh.	4.27	-	7.0-14.9
				Carp	0.25	-	15.0-20.0
				Fw. Dr.	1.22	-	15.0-20.0
				Bowf.	0.20	-	15.0-20.0
				Total	13.32	-	
31	Missaukee	Gill-1,250 ft. Trap-8 1. 6/29-7/1/76	1,191 (692)	Wh. Su.	3.27	15.03	16.1
				Bullhead	18.22	11.27	8.3
				Total	21.49	26.30	

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
		Gill-1,750 ft.	670	Wh. Su.	1.34	8.47	18.3
		Trap-16 1.	(253.1)	Y. Bh.	3.73	-	8.7
		6/12-13/75		Br. Bh.	12.89	18.82	9.9
				Total	17.96	27.29	
32	Mio Pond	Gill-2,000 ft.	1,294	Suckers	41.11	-	16.6
		Fyke-15 1.		Br. Bh.	8.27	-	10.4
		Trap-1 1.		Carp	2.94	-	24.7
		Shock-10 hrs.		Bowf.	1.08	-	21.8
		7/6-21/70		Total	53.40	-	
33	Houghton	Trap-20 1.	800	Wh. Su.	1.25	-	17.1
		6/1,2/72	(509.6)	Br. Bh.	35.37	33.20	10.5
				Carp	0.87	-	21.2
				Bowf.	0.75	-	23.8
				Lgn. Gar	0.25	-	24.7
				Total	38.49	33.20	
34	Higgins	No Records					
35	St. Helen	Gill-9,375 ft.	1,333	Wh. Su.	8.12	15.93	18.3
		Trap-68 1.	(1,681)	Bullhead	49.14	20.54	8.9
		5/3-10/76		Carp	1.42	6.74	20.5
				Bowf.	4.95	17.85	24.0
				Total	63.63	61.06	

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
36	Sage	Gill- ?	204	Bullhead	19.12	9.03	-
		Trap-4 1.	(117.1)	Carp	1.47	24.34	-
		Fyke-4 1.		Bowf.	2.94	18.43	-
		6/1-2/65		Total	23.53	51.80	
37	Secord	Gill-2,000 ft.	103	Wh. Su.	3.88	-	12.3-20.0
		7/17-20/67		Bl. Bh.	0.97	-	12.8
				Br. Bh.	3.88	-	7.9-11.4
				Ch. Cat.	0.97	-	10.4
				Total	9.70	-	
		Trap-9 1.	147	Wh. Su.	1.36	-	10.3-19.0
		7/11-20/67		Carp	4.08	-	20.7-25.5
				Total	5.44	-	
38	Wixom	Gill-2,000 ft.	368	Wh. Su.	6.25	-	12.4-17.2
		8/2-9/67		Redh.	1.63	-	13.2-23.7
				Y. Bh.	3.53	-	6.4-12.3
				Br. Bh.	5.16	-	6.8-10.8
				Ch. Cat.	1.36	-	9.9-12.2
				Carp	3.26	-	15.9-22.4
				Total	21.19	-	
39	Sanford	Gill-2,250 ft.	216	Br. Bh.	1.85	-	5.2-7.6
		8/9-15/67		Ch. Cat.	8.33	-	5.3-19.2
				Carp	3.70	-	9.7-21.1
				Total	13.89	-	

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
40	Whitefish	Gill-2 l.	369	Wh. Su.	2.17	-	21.2
		Fyke-6 l.		Y. Bh.	37.94	-	11.0
		4/20-22/71		Total	40.11	-	
41	Mona	Gill-8 l.	1,606	Wh. Su.	0.93	-	10.6-19.7
		Fyke-10 l.		Redh.	0.50	-	13.2-24.5
		Trap-8 l.		Lgn. Su.	0.06	-	20.9
		5/10-11/77		Carp	3.80	-	11.5-31.6
				Y. Bh.	0.19	-	9.4-11.2
				Bl. Bh.	5.35	-	5.2-14.0
				Br. Bh.	0.93	-	10.3-12.6
				Ch. Cat.	1.87	-	9.5-23.2
				Fw. Dr.	0.06	-	31.1
				Bowf.	2.43	-	20.2-25.1
				Quillb.	0.75	-	12.4-21.7
				Lng. Gar	0.25	-	33.7-39.2
				Goldf.	10.65	-	4.1-13.2
				G. Shad	20.24	-	10.0-19.7
				Total	48.01	-	
42	Muskegon	Gill-475 ft.	178	Wh. Su.	1.68	-	15.1
		Trap-2 l.		Redh.	1.68	-	16.2
		4/24/75		N. Hgsu.	0.56	-	10.8
				Carp	1.68	-	24.2
				Br. Bh.	8.43	-	9.6
				Bowf.	4.49	-	26.8
				G. Shad	0.56	-	10.5
				Total	19.08	-	

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
		Gill-555 ft.	2,438[2]	Wh. Su.	5.04	-	-
		Trap-794 1.		Redh.	3.86	-	-
		Fyke-66 1.		N. Hgsu.	0.04	-	-
		Shock-17 hrs.		Carp	19.69	-	-
		1967		Y. Bh.	0.33	-	-
				Bl. Bh.	0.04	-	-
				Br. Bh.	0.78	-	-
				Fw. Dr.	0.08	-	-
				Quillb.	0.20	-	-
				Bowf.	0.94	-	-
				Lgn. Gar	0.53	-	-
				Goldf.	0.16	-	-
				G. Shad	22.07	-	-
				Alew.	6.11	-	-
				Total	59.87	-	
43	White	Gill-24 1.	3,430	Wh. Su.	1.89	-	11.0-20.0
		Trap-96 1.		Redh.	5.53	-	10.5-25.0
		Shock-60 min.		Carp	4.63	-	30.0-35.5
		6/2-11/65		Bullhead	2.15	-	9.0-13.5
				Catfish	0.26	-	20.0-37.5
				Fw. Dr.	0.03	-	17.7
				Bowf.	0.76	-	18.0-28.0
				Lng. Gar	0.23	-	32.0-33.0
				G. Shad	0.06	-	12.5-13.5
				Alew.	37.15	-	6.5-8.0
				Total	52.69	-	

2. At least 2,000 more fish were counted.

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
44	Macatawa	Gill-6 1.	609	Wh. Su.	15.60	-	16.6
		Trap-5 1.		Redh.	0.33	-	18.1
		Fyke-1 1.		Sp. Su.	0.16	-	16.1
		10/19/76		Carp	3.45	-	20.5
				Y. Bh.	1.48	-	9.3
				Bl. Bh.	6.07	-	8.1
				Br. Bh.	13.96	-	9.4
				Ch. Cat.	3.45	-	17.1
				Fw. Dr.	0.66	-	9.5
				Quillb.	7.22	-	15.0
				Bowf.	0.49	-	25.5
				Gar	0.33	-	20.2
				Goldf.	1.64	-	12.1
				G. Shad	7.22	-	7.7
				Total	62.02	-	
45	Holloway Reservoir	Fyke-24 1. 6/22-25/76	778 (419.5)	Wh. Su.	0.39	0.74	15.3
				Bullhead	0.26	0.21	8.0
				Ch. Cat.	5.53	14.37	14.9
				Carp	28.41	52.99	13.6
				Bowf.	0.26	0.71	19.0
				Total	34.85	69.02	

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
46	Thornapple	Shock-3.33 hrs. 4/25,26/66	407 (244.2)	Wh. Su.	18.92	41.91	14.6
				Redh.	14.50	21.54	11.8
				Bullhead	1.72	-	9.1
				Carp	0.74	14.33	27.0
				Total	35.88	77.78	
47	Indian	Seine-9.6 acre 6/1,2/64	6,028	Bullhead	1.97	-	8.0
				Carp	2.37	-	22.0
				Shn. Gar	0.02	-	17.5
				Total	4.36	-	
48	Morrow Pond	Shock-1 hr. 6/14/73	255 (66.4)	Wh. Su.	24.31	42.47	-
				Redh.	7.84	7.20	-
				Bullhead	0.39	0.29	-
				Carp	1.96	20.90	-
				Total	34.50	70.86	
		Gill-1,500 ft. 10/31,31/69	81 (131.3)	Wh. Su.	60.49	26.50	-
				Redh.	1.23	1.71	-
				Br. Bh.	2.47	-	-
				Ch. Cat.	1.23	1.04	-
				Carp	4.94	24.75	-
				Lng. Gar	1.23	3.43	-
				Bowf.	13.58	38.84	-
				Total	85.18	96.27	

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
49	Mud Hole	Fyke-4 1. Shock-1.5 hrs 8/8/75	322	Wh. Su. Redh. Sp. Su. Carp Lgn. Gar Total	5.90 1.86 0.31 10.25 2.48 21.11	- - - - - -	11.8 20.5 14.5 16.9 28.5
50	Sturgis Impoundment	Fyke-12 1. 8/6,7/75	633 (468.2)	Wh. Su. Redh. Sp. Su. Bullhead Ch. Cat Carp Total	7.90 13.11 0.32 0.63 0.32 3.79 26.07	8.70 49.79 0.53 0.60 0.40 15.22 75.24	14.9 18.8 14.5 9.8 11.8 15.7
51	Marble	Fyke and Trap-37 1. 5/4/70	2,589	Wh. Su. Bullhead Shn. Gar Bowf. Total	0.46 15.79 0.15 0.19 16.59	- - - - -	22.2 10.7 18.0 23.6
		Fyke-2 1. Trap-2 1. 4/28,29/70	135	Wh. Su. Bullhead Carp Total	0.74 37.04 4.44 42.22	- - - 	- 7.3 -

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
52	Union	Fyke-2 1.	87	Wh. Su.	2.30	13.27	-
		7/19/72	(22.6)	Redh.	6.90	29.65	-
				Bullhead	2.30	4.87	-
				Carp	2.30	12.83	15.7
				Total	13.80	60.62	
		Shock-0.33 hr.	110	Redh.	44.54	21.97	-
		7/19/72	(71.0)	Carp	7.27	55.49	-
				Bowf.	0.91	7.75	-
				Total	52.72	85.48	
53	Grand River	Fyke- ?	500	Wh. Su.	9.40	-	6.0-19.0
		Shock- ?		Redh.	0.80	-	11.0-16.0
		Sum.-1970		N. Hgsu.	0.40	-	8.0-11.0
		Jackson Co.		Bullhead	10.80	-	4.0-12.0
				Carp	68.80	-	8.0-29.0
				Bowf.	3.00	-	12.0-21.0
				Total	87.20	-	
		Gill-125 ft.	312	Wh. Su.	2.56	-	7.8-10.9
		Shock-2.75 hrs.		Redh.	0.64	-	9.9-10.8
		5/13/70		Bl. Bh.	0.32	-	-
		Eaton Co.		Carp	84.61	-	9.1-21.0
				Goldf.	11.54	-	6.8-8.8
				Total	99.67	-	

Table Al. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
54	Raisin River	Shock-3.67 hrs. 8/17-25/71 Lenawee Co.	260 (122.6)	Wh. Su.	27.69	23.90	4.0-16.0
				Redh.	16.54	7.50	3.0-14.0
				N. Hgsu.	11.15	5.95	5.0-11.0
				Bullhead	0.77	1.55	5.0-6.0
				Carp	6.92	37.60	13.0-25.0
				Total	63.07	76.50	
		Shock-2.67 hrs. 8/26-31/71 Monroe Co.	617 (502.9)	Wh. Su.	12.48	7.46	3.0-15.0
				Redh.	15.88	34.70	8.0-23.0
				N. Hgsu.	1.46	0.70	6.0-13.0
				Y. Bh.	0.32	0.20	9.0
				Bl. Bh.	0.16	0.02	4.0
				Br. Bh.	0.16	0.14	10.0
				Carp	23.01	46.59	4.0-25.0
				Total	53.47	89.81	
55	Flat Rock Impoundment	Chemical Treatment 9/19/74 Figures in pounds per acre		Wh. Su.	-	6.00	-
				Buff.	-	4.00	-
				Ch. Cat	-	4.00	-
				Carp	-	320.00	-
				G. Shad	-	32.00	-
				Goldf.	-	12.00	-
				Total	-	378.00	
		Shock-1.5 hrs. 9/20/72	158	Wh. Su.	2.53	-	13.4
				Carp	17.09	-	16.3
				G. Shad	23.42	-	11.7
				Total	43.04	-	

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
56	Ford	Fyke and Trap-16 1. 5/20-22/75	1,595 (624.2)	Wh. Su.	0.06	0.32	-
				Y. Bh.	34.67	23.04	8.2
				Ch. Cat.	0.12	0.10	-
				Total	34.85	23.46	
		Fyke-2 1. 9/21/73	257 (77.3)	Wh. Su.	0.39	0.52	-
				Y. Bh.	10.89	7.24	6.5
				Carp	63.42	59.51	-
				Total	74.70	67.27	
		Chemical Treatment 5/10/73 Figures in pounds per acre		Wh. Su.	-	3.30	-
				Bullhead	-	5.00	-
				Carp	-	751.20	-
				Total	-	759.50	
57	Stony Creek Impoundment	Gill-750 ft. Fyke-6 1. 7/15,16/69	166	Wh. Su.	10.84	-	16.9
				Y. Bh.	3.61	-	8.1
				Bl. Bh.	18.67	-	9.9
				Carp	27.71	-	20.6
				Total	60.83		
		Fyke and Trap-12 1, 4/19/68	627	Wh. Su,	10.69	-	14.1
				Redh,	0.64	-	15.5
				Br. Bh.	46.89	-	8.4
				Carp	22.65	-	20.0
				Total	80.87	-	

Table A1. (Cont'd.)

Lake No.	Name of lake	Effort and date	Total Catch	Species	% by No. of the catch	% by Wt. of the catch	Range or size
58	Kent	Fyke and Trap-57 1. 3/8-26/76	2,108	Wh. Su.	2.94	-	17.0
				Y. Bh.	11.34	-	9.5
				Br. Bh.	1.56	-	7.5
				Carp	3.89	-	19.0
				Bowf.	0.33	-	20.0
				Total	20.06	-	
59	Tipsico	Fyke and Trap-22 1. 5/3-7/76	2,978	Y. Bh.	90.66	-	7.0
				Bowf.	0.50	-	24.9
				Total	91.16	-	
60	Belleville	Fyke-12 1. 7/21-23/76	926	Wh. Su.	2.81	-	14.2
				Bullhead	2.16	-	8.5
				Ch. Cat.	4.21	-	14.5
				Carp	7.23	-	20.2
				Total	16.51	-	
		Chemical Treatment 10/5/73 Figures in pounds per acre		Suckers	-	24.00	-
				Carp	-	760.00	-
				Total	-	784.00	-

APPENDIX B

HEAVY METALS IN FISH FROM THE GRAND RIVER, KALAMAZOO RIVER (MORROW POND), RAISIN RIVER AND TITTABAWASSEE RIVER

The data compiled in this table was taken from Hesse and Evans (1972). Abbreviations used for heavy metals are as follows:

Cu	copper
Ni	nickel
Zn	zinc
Cr	chromium
Cd	cadmium
Hg	mercury
Pb	lead
As	arsenic

Table B1. Heavy metals in fish from the Grand River, Kalamazoo River (Morrow Pond), Raisin River and Tittabawassee River[1].

Station	Species	Metals (ppm)							
		Cu	Ni	Zn	Cr	Cd	Hg	Pb	As
Grand River, Jackson to Grand Haven, July 1970									
1	Carp	0.3	< 0.4	8.0	< 0.05	< 0.05	-	-	-
	Bass	0.2	< 0.4	11.0	< 0.05	< 0.05	-	-	-
	Bullhead	0.2	< 0.4	9.0	< 0.05	< 0.05	-	-	-
2	Carp	0.4	< 0.4	11.0	< 0.05	< 0.05	-	-	-
3	Carp	0.1	< 0.4	11.0	< 0.05	< 0.05	-	-	-
4	Carp	0.3	< 0.4	8.0	< 0.05	< 0.05	-	-	-
5	Carp	0.3	< 0.4	11.0	< 0.05	< 0.05	-	-	-
	Sucker	0.2	< 0.4	8.0	< 0.05	< 0.05	-	-	-
6	Carp	0.3	< 0.4	11.0	< 0.05	< 0.05	-	-	-
	Sucker	1.1	< 0.4	12.0	0.5	< 0.05	-	-	-
7	Carp	0.2	< 0.4	11.0	< 0.05	< 0.05	-	-	-
8	Carp	0.1	< 0.4	11.0	< 0.05	< 0.05	-	-	-
	Sucker	0.2	< 0.4	8.0	< 0.05	< 0.05	-	-	-
	Bass	1.8	< 0.4	8.0	0.5	< 0.05	-	-	-
	Bullhead	1.8	< 0.4	12.0	1.0	0.12	0.35	-	-
9	Carp	0.3	< 0.4	11.0	< 0.05	< 0.05	-	-	-
10	Carp	0.1	< 0.4	13.0	< 0.05	< 0.05	-	-	-
	Sucker	0.4	< 0.4	9.0	< 0.05	< 0.05	0.2	-	-
11	Carp	0.3	< 0.4	12.0	< 0.05	< 0.05	-	-	-
12	Carp	0.3	< 0.4	8.0	< 0.05	< 0.05	-	-	-
13	Carp	0.4	< 0.4	8.0	< 0.05	< 0.05	-	-	-
	Sucker	0.2	< 0.4	12.0	< 0.05	< 0.05	-	-	-
14	Carp	1.0	< 0.4	13.0	< 0.05	< 0.05	-	-	-
	Sucker	0.0	< 0.4	9.0	< 0.05	< 0.05	-	-	-
15	Pike	0.2	< 0.4	12.0	0.2	< 0.05	0.45	-	-
21	Carp	0.3	< 0.4	12.0	< 0.05	< 0.05	-	-	-

Table B1. (Cont'd.)

Station	Species	Metals (ppm)							
		Cu	Ni	Zn	Cr	Cd	Hg	Pb	As
	Sucker	0.0	< 0.4	12.0	< 0.05	< 0.05	0.0	-	-
	Catfish	0.4	< 0.4	12.0	< 0.05	< 0.05	0.45	-	-
22	Carp	0.3	< 0.4	8.0	< 0.05	< 0.05	-	-	-
	Sucker	0.0	< 0.4	8.5	< 0.05	< 0.05	-	-	-
24	Carp	0.6	< 0.4	20.0	< 0.05	< 0.05	-	-	-
	Sucker	0.0	< 0.4	23.0	< 0.05	< 0.05	-	-	-
Kalamazoo River, Morrow Pond, July 1971									
M4	Carp	0.3	< 0.2	8.0	-	< 0.1	0.0	-	< 0.5
	Whitesucker	0.3	< 0.2	5.0	-	< 0.1	0.12	-	< 0.5
	Northern pike	0.3	< 0.2	10.0	-	< 0.1	0.4	-	< 0.5
Tittabawasee River, Midland and Saginaw Counties, July 26 - 29, 1971									
3	Carp	0.5	< 1.0	8.0	< 0.1	< 0.1	0.05	< 1.0	< 1.0
	Rock bass	0.3	< 1.0	8.0	-	< 0.1	0.25	< 1.0	-
	Crappie	3.6	< 1.0	13.0	< 0.1	< 0.1	0.17	< 1.0	< 1.0
	Redhorse	2.2	< 1.0	16.0	< 0.1	< 0.1	0.07	< 1.0	< 1.0
4	Smallmouth bass	-	< 1.0	16.0	< 0.1	< 0.1	0.27	< 1.0	< 1.0
	Rock bass	-	< 1.0	19.0	< 0.1	< 0.1	0.33	< 1.0	< 1.0
	White bass	-	< 1.0	19.0	< 0.1	< 0.1	0.27	< 1.0	< 1.0
	Northern pike	0.7	< 1.0	5.8	< 0.1	< 0.1	0.27	< 1.0	< 1.0
	Redhorse	0.5	< 1.0	7.0	< 0.1	< 0.1	0.07	< 1.0	< 1.0
	Crappie	0.5	< 1.0	13.0	-	< 0.1	< 0.01	< 1.0	-
	Carp	0.5	< 1.0	2.0	-	< 0.1	0.23	< 1.0	-
5	Carp	0.5	< 1.0	20.0	< 0.1	< 0.1	0.10	< 1.0	< 1.0
6	Carp	0.5	< 1.0	2.0	-	< 0.1	0.03	< 1.0	-

Table B1. (Cont'd.)

Station	Species	Metals (ppm) Cu	Ni	Zn	Cr	Cd	Hg	Pb	As
7	Carp	0.5	< 1.0	12.0	< 0.1	< 0.1	0.05	< 1.0	< 1.0
8	Carp	0.4	< 1.0	2.0	-	< 0.1	0.05	< 1.0	-
9	Carp	0.4	< 1.0	8.0	-	< 0.1	0.33	< 1.0	-
River Raisin, August 1971									
A	Crappie	< 0.2	< 0.2	6.2	< 0.1	< 0.1	0.03	< 1.0	< 0.5
	Bullhead	< 0.2	< 0.2	7.0	< 0.1	< 0.1	0.01	< 1.0	< 0.5
B	Northern pike	< 0.2	< 0.2	5.1	< 0.1	< 0.1	0.30	< 1.0	< 0.5
	Largemouth bass	< 0.2	< 0.2	7.8	< 0.1	< 0.1	< 0.01	< 1.0	< 0.5
2	Rock bass	< 0.2	< 0.2	7.0	< 0.1	< 0.1	0.35	< 1.0	< 0.5
6	Bullhead	< 0.2	< 0.2	6.0	< 0.1	< 0.5	0.12	< 1.0	< 0.5
7	Rock bass	< 0.2	< 0.2	6.0	< 0.1	< 0.1	0.12	< 1.0	< 0.5
	Smallmouth bass	< 0.2	< 0.2	5.7	< 0.1	< 0.1	0.09	< 1.0	< 0.5
9	Smallmouth bass	< 0.2	< 0.2	4.9	< 0.1	< 0.1	0.03	< 1.0	< 0.5
10	Rock bass	< 0.2	< 0.2	4.9	< 0.1	< 0.1	0.06	< 1.0	< 0.5
	Smallmouth bass	< 0.2	< 0.2	5.9	< 0.1	< 0.1	0.03	< 1.0	< 0.5
11	Carp	< 0.2	< 0.2	7.0	< 0.1	< 0.1	0.21	< 1.0	< 0.5
13	Carp	< 0.2	< 0.2	13.0	< 0.1	< 0.1	0.13	< 1.0	< 0.5
14	Northern pike	< 0.2	< 0.2	4.0	< 0.1	< 0.1	0.38	< 1.0	< 0.5
	Smallmouth bass	< 0.2	< 0.2	5.6	< 0.1	< 0.1	0.38	< 1.0	< 0.5
16	Northern pike	< 0.2	< 0.2	6.2	< 0.1	< 0.1	0.18	< 1.0	< 0.5
18	Northern pike	< 0.2	< 0.2	4.0	< 0.1	< 0.1	0.38	< 1.0	< 0.5
19	Northern pike	< 0.2	< 0.2	4.9	< 0.1	< 0.1	0.02	< 1.0	< 0.5
	Rock bass	< 0.2	< 0.2	5.4	< 0.1	< 0.1	0.50	< 1.0	< 0.5
20	Carp	< 0.2	< 0.2	7.0	< 0.1	< 0.1	0.04	< 1.0	< 0.5
21	Rock bass	< 0.3	< 0.2	5.9	< 0.1	< 0.1	0.03	< 1.0	< 0.5
23	Northern pike	< 0.2	< 0.2	4.8	< 0.1	< 0.1	0.65	< 1.0	< 0.5

Table B1. (Cont'd.)

Station	Species	Metals(ppm)							
		Cu	Ni	Zn	Cr	Cd	Hg	Pb	As
24	Rock bass	< 0.2	< 0.2	7.0	< 0.1	< 0.1	0.18	< 1.0	< 0.5
	Smallmouth bass	< 0.2	< 0.2	4.9	< 0.1	< 0.1	0.41	< 1.0	< 0.5
26	Smallmouth bass	< 0.2	< 0.2	5.8	< 0.1	< 0.1	0.12	< 1.0	< 0.05

1. Taken from Hesse and Evans (1972). Also consult the same reference for station descriptions.

APPENDIX C

CONCENTRATIONS OF CHLORINATED HYDROCARBON INSECTICIDES AND POLYCHLORINATED BIPHENYLS IN FISH FROM THE GRAND RIVER AND THE KALAMAZOO RIVER

The data compiled for this table was taken from Willson and Hesse (1973), and Hess and Willson (1972).

Table C1. Concentrations (mg/kg wet weight) of chlorinated hydrocarbon insecticides and polychlorinated biphenyls (PCB's) measured in fish from the Grand River (Jackson to Grand Haven, Michigan, July, 1970), and the Kalamazoo River (Morrow Pond, July, 1971).

Station[1]	Species	% fat	Dieldrin	DDE	TDE	DDT	Total DDT	Estimated PCB	Total DDT Corrected
Grand River (Willson and Hesse 1973)									
1	Carp	1.07	0.004	0.008	0.006	0.022	0.036	< 0.010	0.036
2	Carp	1.80	0.002	0.038	0.075	0.026	0.140	0.111	0.097
3	Carp	2.24	0.022	0.052	0.255	0.054	0.361	0.475	0.233
4	Carp	1.64	0.016	0.078	0.176	0.097	0.351	0.333	0.220
5	Carp	0.82	0.003	0.012	0.043	0.019	0.074	0.105	0.046
6	Carp	0.952	0.004	0.010	0.026	0.010	0.046	0.065	0.029
7	Carp	0.827	0.002	0.061	0.060	0.024	0.145	0.098	0.118
8	Carp	1.313	0.005	0.074	0.200	0.109	0.383	0.228	0.292
9	Carp	6.74	0.005	0.074	0.225	0.119	0.418	0.226	0.305
10	Carp	1.584	0.004	0.046	0.116	0.046	0.208	0.116	0.151
11	Carp	0.599	0.005	0.198	0.123	0.040	0.361	0.135	0.301
12	Carp	1.520	0.008	0.607	0.445	0.184	1.236	0.369	1.043
13	Carp	0.731	0.003	0.077	0.106	0.053	0.236	0.120	0.189
14	Carp	1.055	0.002	0.085	0.136	0.063	0.284	0.167	0.221
21	Carp	3.521	0.002	0.058	0.098	0.047	0.193	0.336	0.098
22	Carp	1.305	0.002	0.052	0.077	0.058	0.187	0.334	0.076
24	Carp	3.856	0.005	0.104	0.164	0.071	0.339	0.168	0.272
4	White sucker	0.690	0.002	0.022	0.064	0.043	0.129	0.215	0.063
5	White sucker	0.590	0.002	0.020	0.059	0.028	0.107	0.177	0.051
6	White sucker	0.725	0.005	0.027	0.045	0.033	0.105	0.063	0.083
8	White sucker	1.641	0.005	0.022	0.042	0.023	0.087	0.067	0.062
10	White sucker	1.178	0.005	0.046	0.148	0.092	0.286	0.150	0.209
13	Whtie sucker	0.776	0.005	0.052	0.134	0.099	0.285	0.192	0.187
14	White sucker	1.722	0.007	0.064	0.188	0.130	0.382	0.211	0.272
21	White sucker	2.578	0.013	0.071	0.213	0.186	0.470	0.781	0.115
22	White sucker	0.657	0.003	0.050	0.067	0.065	0.182	0.217	0.103

Table C1. (Cont'd.)

Station[1]	Species	% fat	Dieldrin	DDE	TDE	DDT	Total DDT	Estimated PCB	Total DDT Corrected
24	White sucker	1.488	0.008	0.062	0.105	0.079	0.246	0.456	0.080
1	Bullhead	0.335	< 0.001	0.030	0.006	0.013	0.049	< 0.010	0.049
8	Bullhead	0.710	0.002	0.010	0.015	0.010	0.035	0.014	0.029
1	Bass	0.509	< 0.001	0.007	0.006	0.014	0.027	< 0.010	0.027
8	Bass	1.061	0.005	0.064	0.062	0.040	0.166	0.107	0.127
21	Catfish	6.105	0.010	0.355	0.454	0.561	1.370	1.169	0.740
15	Pike	1.555	0.004	0.342	0.404	0.278	1.024	0.392	0.788
Kalamazoo River, Morrow Pond (Hesse and Willson 1972)									
M4	Carp	1.49	0.006	0.065	0.105	-	0.212	5.07[2]	-
	White sucker	0.38	0.004	0.033	0.048	-	0.152	5.50[2]	-
	Northern pike	1.25	0.015	0.231	0.317	-	0.598	17.60[2]	-

1. Refer to Willson and Hesse (1973) for station descriptions.
2. Based upon Aroclor 1254.

APPENDIX D

THE COMMERCIAL HARVEST OF ROUGH FISH FROM INLAND LAKES IN MINNESOTA AND WISCONSIN

The data presented in this table was provided by Vern Hacker from the Wisconsin Department of Natural Resources, and Floyd Hennagir from the Minnesota Department of Natural Resources.

Table D1. Species and volumes (pounds) of rough fish harvested from inland lakes in Minnesota and Wisconsin.

Species	Minnesota	Wisconsin		
	1976	1974	1975	1976
Carp	2,247,760	1,571,254	1,233,755	3,411,323
Buffalo	940,846	325,443	798,679	1,319,215
Bullhead	1,129,621	21,400	19,960	6
Sheepshead	175,462	1,436,527	1,140,290	1,597,339
Suckers/Redhorse	141,226	16,689	13,694	12,925
Perch	16,437			
Burbot	662	11,831	515	10,841
White bass	5,505			
No. cisco	7,378			
Bowfin	6,247	6,150	9	14
Gar		500	213	70
Quillback		17,266	47,180	89,566
Gizzard Shad		4,350		
TOTAL	4,671,144	3,412,410	3,254,295	6,441,299

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LIST OF REFERENCES

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