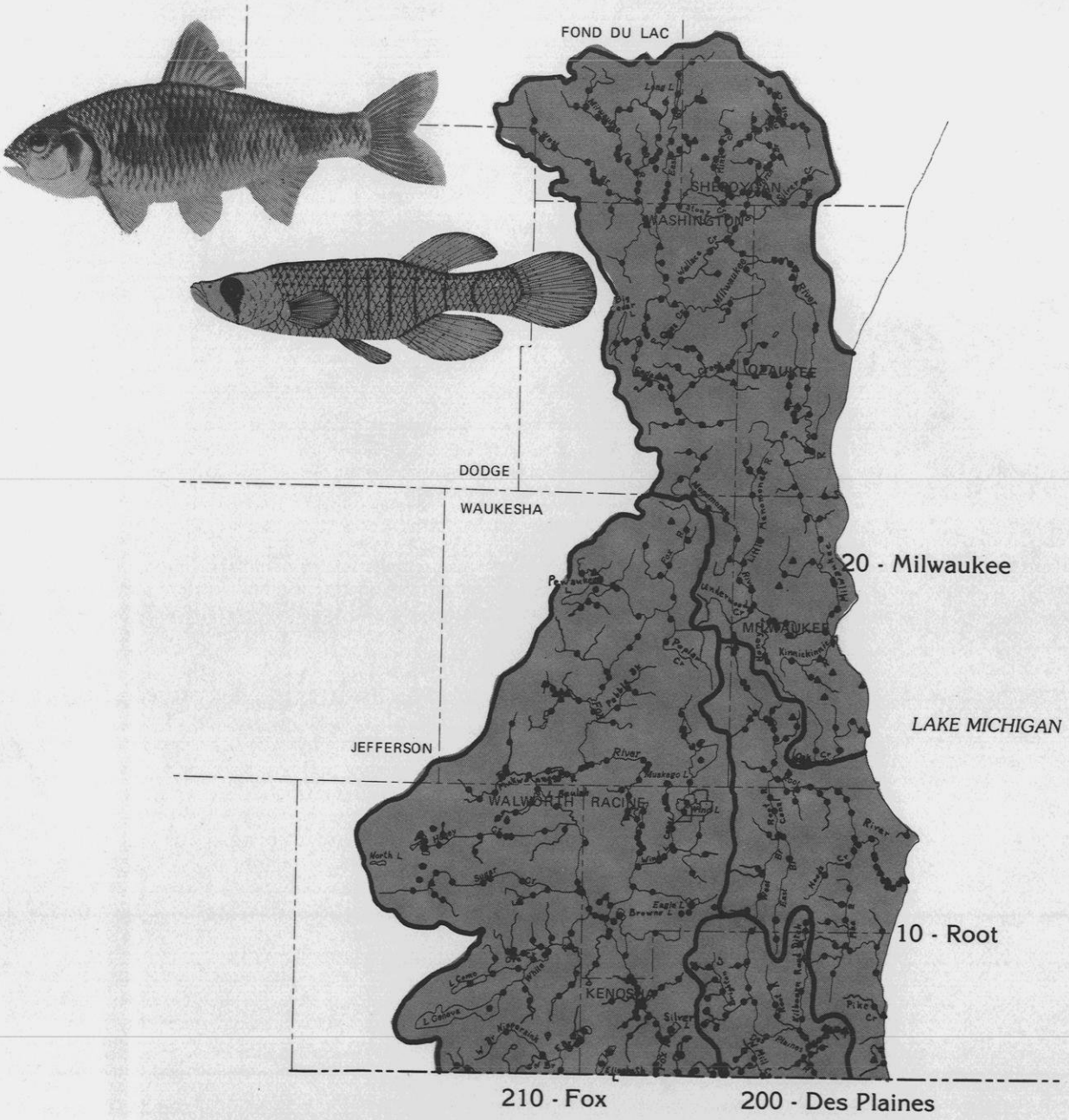
Distribution and relative abundance of fishes in Wisconsin: IV. Root, Milwaukee, Des Plaines, and Fox River basins. No. 147 1984

Fago, Don

Madison, Wisconsin: Wisconsin Department of Natural Resources, 1984



DISTRIBUTION AND RELATIVE ABUNDANCE OF FISHES IN WISCONSIN

IV. Root, Milwaukee, Des Plaines, and Fox River Basins

Technical Bulletin No. 147
DEPARTMENT OF NATURAL RESOURCES
Madison, Wisconsin 53707

1984

COVER: *Striped shiner and starhead top minnow.*

This report is dedicated to the nongame fish, whose interrelationship in the aquatic ecosystem is generally not well documented or appreciated.

PREFACE

Little attention has been given to nongame fish species which comprise over 75% of the 150 fish species in Wisconsin waters. Yet many of those species play a major role in maintenance of sport fish populations so vital to recreational and economic interests in the state. In essentially disregarding these species, their right to exist and their role in maintaining community stability through species diversity have been overlooked. The nongame fish not only make up the majority of fish species in Wisconsin but are also more abundant than sport fish species in both total number and total biomass.

Further attention by either research or management to nongame fish species must be preceded by an inventory of what we have and where we have it. In 1974 the Bureau of Research of the Wisconsin Department of Natural Resources (DNR), with inputs from field fish management personnel, began a statewide assessment of the distribution and relative abundance of fish species, emphasizing but not limited to nongame species. This assessment was begun using a basin approach to delineate location of sampling stations on the over 7,200 lakes (over 350,000 ha) and 11,000 streams (over 68,000 km) within the state. The 3 major basins (Mississippi River, Lake Michigan, and Lake Superior) were further divided into 30 minor basins.

The last report on the distribution of fish species throughout the state was made by C. W. Greene (1935) for the 1900-31 period. He covered about 1,400 sampling stations. Since then, other collectors, notably Dr. George Becker (1959, 1964a, 1964b, 1966, 1983), Professor Marlin Johnson (Johnson and Becker 1970), and the students at the University of Wisconsin at Madison (including McNaught 1963) and Stevens Point, have added appreciably to knowledge of regional distribution of Wisconsin fishes.

The need to update our knowledge of statewide fish distribution is most clearly evident from the dearth of information available on nongame species in most watersheds for preparing environmental impact assessments and reports and department master plans. In addition, both federal and state law now require the establishment of an endangered and threatened species list. Furthermore, the Wisconsin Department of Natural Resources has been directed to "conduct research on endangered and threatened species of this state and shall implement programs directed at conserving, protecting, restoring, and propagating selected state endangered and threatened species to the maximum extent practicable." (Chap. 29.415, Wis. Stats.)

Field collecting under the research study initiated in 1974 was essentially terminated in 1980 due to reduced funding, with only limited sampling after that time. Of the 30 river basins in the state, sampling has now been completed in 15 and nearly completed in Basin 400. Only scattered samples were taken in the other 14 basins. These samples inventoried about 45% of the state.

The results of the work so far completed on fish distribution are being published in a series of separate bulletins dealing with one or more minor basins. Reports on the following are now available: Greater Rock River basin (Fago 1982), Black, Trempealeau, and Buffalo river basins (Fago 1983), and Red Cedar River basin (Fago 1984a). The bulk of the data presented refers primarily to collections made during the Bureau of Research study. However, other fishery biologists and managers have made numerous collections over the years, and their published and unpublished records, when available to us, are included. Therefore, data from as early as 1900 are available for some basins, permitting comparisons between historical and current records.

This series of reports, however, constitutes only an overview of a voluminous mass of data now permanently stored in computer files. For the field manager or investigator, the greatest value of this study lies in the availability of fish data on specific waters or on waters in close proximity to those of immediate concern. Data now in computer files (over 16,900 collections) have already, in over 200 cases, proven to be very useful to DNR personnel in several bureaus and to other state and federal agencies, environmental consultants, and students. They have used the data for various purposes: e.g., to make assessments on past as well as potential changes in the aquatic environment, indicate water quality through fish species composition, and determine ranges in Wisconsin for particular fish species.

Sufficient data were collected during the research study to recommend the revision of Wisconsin's endangered and threatened fish species lists in 1979 and again in 1982. The first revision added 15 species to both lists and removed 3 from the endangered list. The second revision added 2 to the endangered list and removed 1 from the endangered and 3 from the threatened list.

The bulk of the preserved fish collections are curated at the Milwaukee Public Museum, further enhancing the value and significance of this study. There they are used by scientists and educators interested in taxonomy, systematics, and natural history. They also are serving as a baseline collection from which to determine changes in fish community structure and environmental loads of pollutants and toxicants.

This report deals with 4 separate basins in southeastern Wisconsin—the Root, Milwaukee, Des Plaines, and Fox river basins.

DISTRIBUTION AND RELATIVE ABUNDANCE OF FISHES IN WISCONSIN

IV. Root, Milwaukee, Des Plaines, and Fox River Basins

By
Don Fago

Technical Bulletin No. 147
DEPARTMENT OF NATURAL RESOURCES
Box 7921, Madison, Wisconsin 53707

1984

ABSTRACT

A statewide survey of the inland waters of Wisconsin was initiated in 1974 by the Bureau of Research, Wisconsin Department of Natural Resources, to establish a comprehensive data base on the distribution and relative abundance of all fish species. The Root, Des Plaines, and Fox river basins were sampled from 1974 through 1981, and the Milwaukee River basin from 1973 through 1981 at a total of 532 stations by research personnel, at 121 stations by fish management personnel, and at 23 stations by other collectors. An additional 92 stations were partially sampled by fish management personnel and other collectors.

A total of 42 species was collected from the Root River basin, 67 from the Milwaukee River basin, 43 from the Des Plaines River basin, and 85 from the Fox River basin. Included were the endangered striped shiner and starhead topminnow and the threatened longear sunfish. Eight species on the Department's watch list were also collected.

Data from recent collections for the Root, Milwaukee, Des Plaines, and Fox river basins were compared with data from the 1900-28 and the 1951-73 periods. Seven species were collected which had not been previously reported from the Root River basin, 11 from the Milwaukee River basin, 11 from the Des Plaines River basin, and 10 from the Fox River basin. Fourteen species have apparently been extirpated from the Root River basin, 6 from the Milwaukee River basin, 7 from the Des Plaines River basin, and 4 from the Fox River basin.

This report includes numerous tables, distribution maps of the species, and discussion on many aspects of fish distribution in the 4 basins. The continued use of this data base for the preparation of environmental impact assessments, for the development of master plans for the aquatic resource, and for research on nongame species, fish communities, and ecosystems is therefore recommended.

CONTENTS

STUDY AREA

Root River Basin

The Root River basin (10) is located in the extreme southeastern portion of Wisconsin (Fig. 1). It is in the Lake Michigan basin and encompasses parts of the following counties: Kenosha, Milwaukee, Racine, and Waukesha. This basin includes the Root River, Barnes Creek, Kenosha South Creek, Pike Creek, Pike River, and 4 unnamed creeks, all of which flow directly into Lake Michigan. The watershed contains an area of approximately 679 km^2 (Holmstrom 1982). Within this area, we have defined 42 streams with a total length of 282 km (Table 1)*. Of these, 26 are unnamed creeks and ditches. There are 21 lakes** in the basin, with a total area of 42 ha and an average size of 3 ha.

The average annual precipitation within the Root River basin is 79 cm (76-81 cm) (Skinner and Borman 1973). The average gradient for the Root River (70 km in length) is 96 cm/km. The average discharge of the Root River at State Hwy. 38, which includes 95% of its drainage area, is 4 m^3/sec. The average discharge of the Pike River near Racine, which includes 75% of its drainage area, is 1 m^3/sec. The combined drainage areas with discharge data contain 87% of the entire Root River basin (U.S. Geol. Surv. 1981). We determined from the data collected at our sampling stations on the Root River that the bottom is composed primarily of sand, gravel, silt, and muck, with lesser amounts of clay and rubble.

The dominant land use (67%) in the basin is agriculture, primarily row crops and pasture; 24% is urban. The population within the basin in 1975 was over 180,000 people, a 134% increase since 1950 (Southeast. Wis. Reg. Plann. Comm. 1978).

*These were defined through a water mileage system that divided the state into 3 major and 30 minor basins (Fago 1984b).

**Lakes in this report refer to naturally occurring lakes as well as impoundments (bodies of water with dams at their outlet) unless otherwise specified.

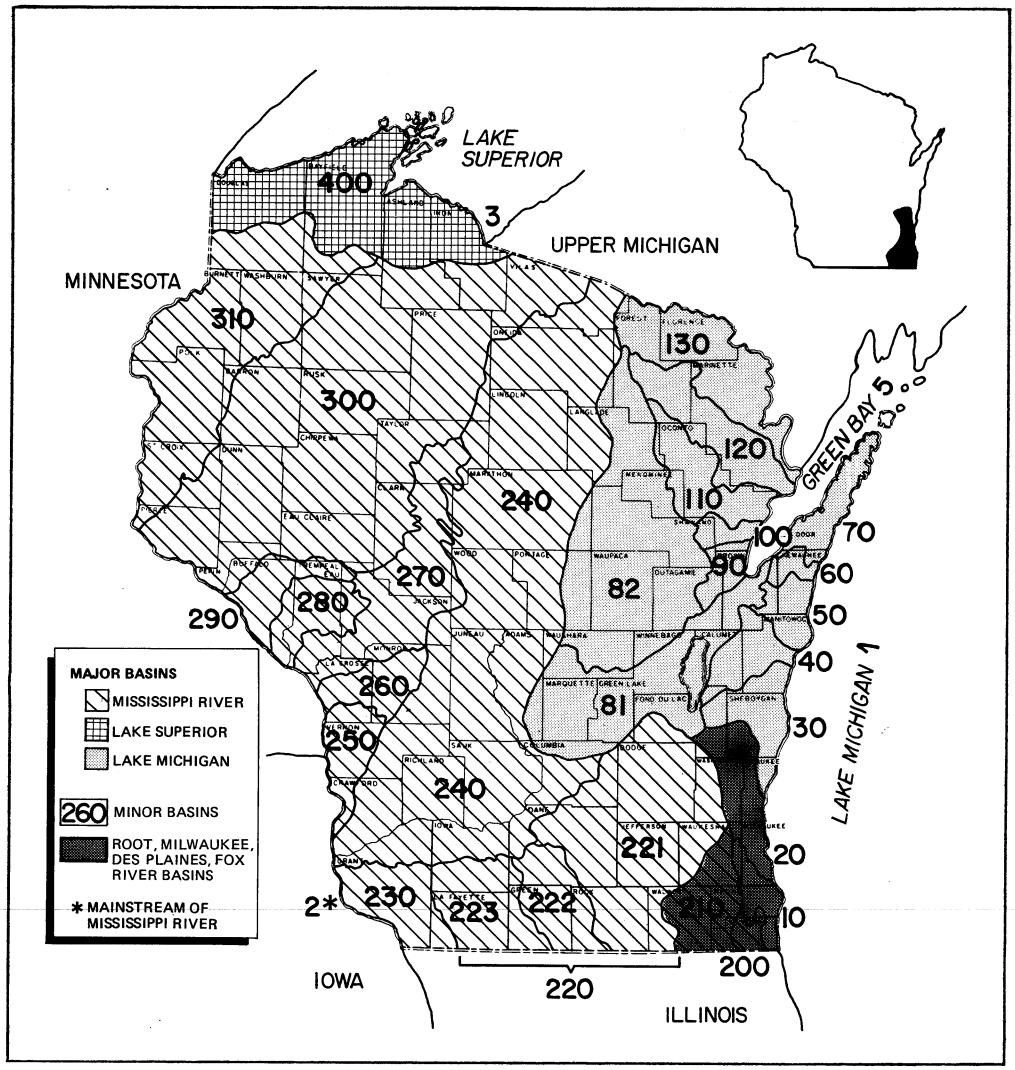
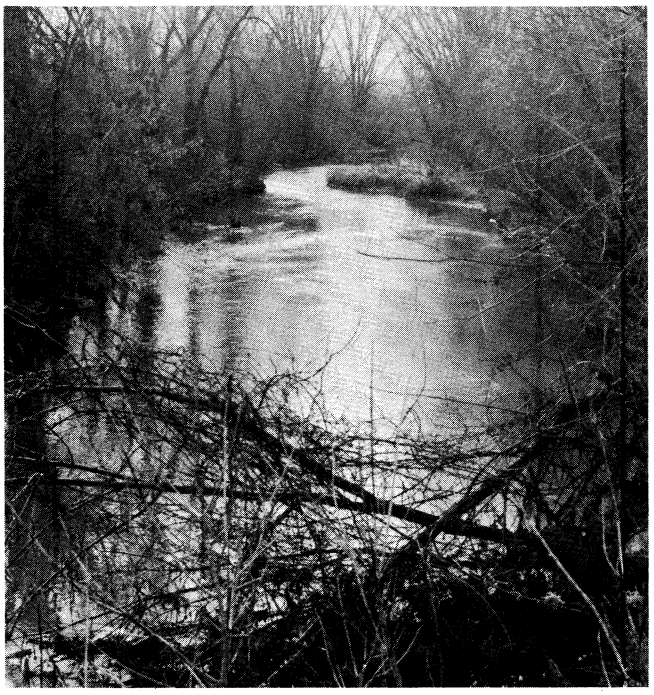


FIGURE 1. *Major and minor river basins in Wisconsin.*

TABLE 1. *Land area, streams, and lakes of the Root, Milwaukee, Des Plaines, and Fox river basins.*

	Root River Basin	Milwaukee River Basin	Des Plaines River Basin	Fox River Basin
Land area (km^2)	679	2,340	332	2,440*
Streams				
Total number	42	132	30	157
(Unnamed creeks or ditches)	(26)	(85)	(22)	(92)
Total length (km)	282	959	151	933
Lakes/impoundments**				
Total number	21	121	20	102
Area (ha)	42	1,782	276	9,168
No. dams	8	53	14	51

*Drainage area in Wisconsin.
**Impoundments are bodies of water with dams at their outlets.



Pike River (Root River basin) at County Trunk A, 4.5 miles from its mouth.

Root River at 6th Street in the City of Racine, 1.6 miles from its mouth.

Milwaukee River Basin

The Milwaukee River basin (20) is located adjacent to the northeastern edge of the Root River basin (Fig. 1). It is in the Lake Michigan basin and encompasses parts of the following Wisconsin counties: Fond du Lac, Milwaukee, Ozaukee, Sheboygan, Washington, and Waukesha. This basin includes the Milwaukee River, Fish Creek, and Oak Creek all of which flow directly into Lake Michigan. It contains an area of approximately 2,340 km^2 (Holmstrom 1982). Within this area we have defined 132 streams with a total length of 959 km (Table 1). Of these, 85 are unnamed creeks or ditches. There are 121 lakes with a total area of 1,782 ha. However, only 8 lakes are over 40 ha in size.

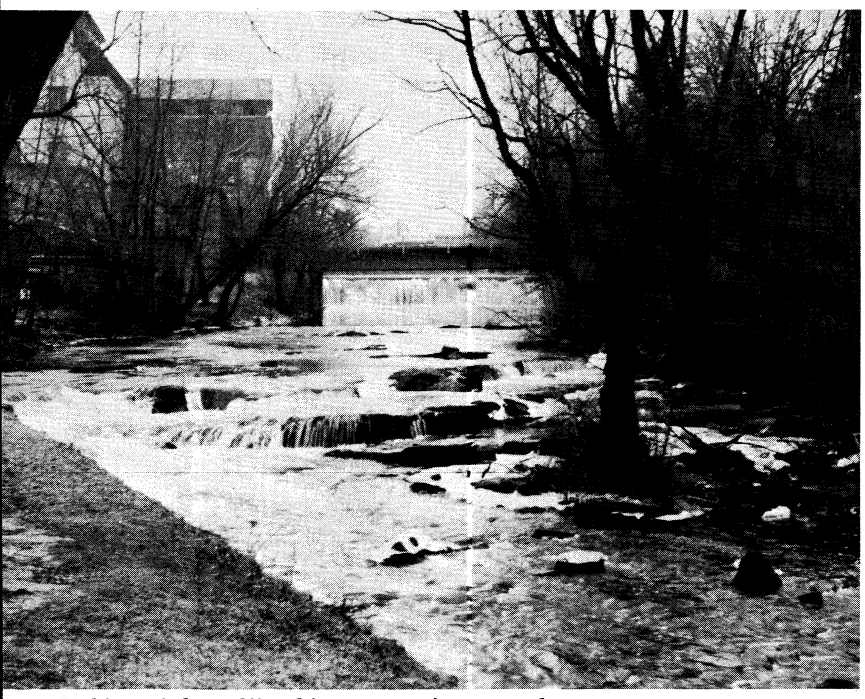
The average annual precipitation is between 74 and 76 cm for the basin (Skinner and Borman 1973). The average gradient for the Milwaukee River (164 km in length) is 95 cm/km. The combined average discharge of the Milwaukee River at Milwaukee, the Menomonee River at Wauwatosa, and the Kinnickinnic River at Milwaukee, which includes 96% of the entire Milwaukee River drainage area (excludes the Oak and Fish creek watersheds), is 15 m^3/sec. The average discharge of Oak Creek (includes 95% of its basin) is 0.6 m^3/sec. (U.S. Geol. Surv. 1981). We determined that the Milwaukee River bottom is composed primarily of sand, gravel, and rubble, with lesser amounts of silt, muck, and boulders.

The dominant land use (63%) is agriculture, primarily row crops, hay, and pasture; approximately 22% is urban. The population within the basin in 1975 was over 1,025,000 people, a 25% increase from 1950 (Southeast. Wis. Reg. Plann. Comm. 1978).

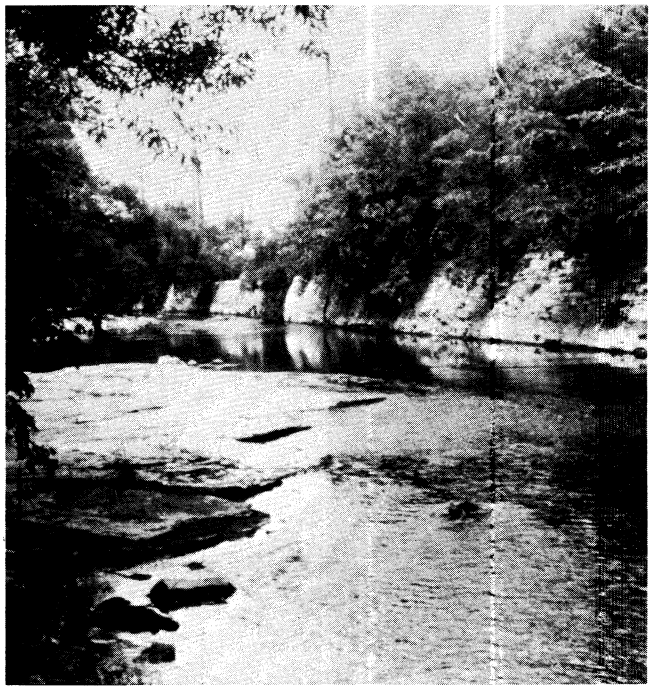
Des Plaines River Basin

The Des Plaines River basin (200) is located adjacent to the western edge of the Root River basin (Fig. 1). It is in the Mississippi River basin and encompasses parts of the following Wisconsin counties: Kenosha and Racine. The basin includes all tributaries to the Des Plaines River in Wisconsin and Mill

Milwaukee River at Highway 100, 15.2 miles from its mouth—looking at habitat of the greater redhorse, currently on the watch list.



Habitat of the redfin shiner, a species currently on the watch list, in Cedar Creek (Milwaukee River basin) in City of Cedarburg.



Menomonee River (Milwaukee River basin) at Hawley Road.

Creek which flows into the Des Plaines River in Illinois. This watershed contains an area of approximately 332 km^2 (Holmstrom 1982). Within this area we have defined 30 streams with a total length in Wisconsin of 151 km (Table 1). Of these, 22 are unnamed creeks or ditches. There are 20 lakes with a total area of 276 ha. However, only 2 lakes are over 40 ha in size.

The average annual precipitation is between 79 and 81 cm for the basin (Skinner and Borman 1973). The average gradient for the Des Plaines River (35 km in length) is 74 cm/km. The average discharge at Russell, Illinois (approximately 1/2 mile south of the Wisconsin-Illinois border) is 3 m^3/sec (U.S. Geol. Surv. 1981). This includes the entire portion of the Des Plaines River basin in Wisconsin. We determined that the river's stream bottom is composed primarily of silt, muck, and sand, with lesser amounts of clay.

The major land use (77%) is agriculture which is dominated by row crops; approximately 7% of the land is urban. The 1975 population in the basin was about 16,000, an increase of 105% since 1950 (Southeast. Wis. Reg. Plann. Comm. 1978).

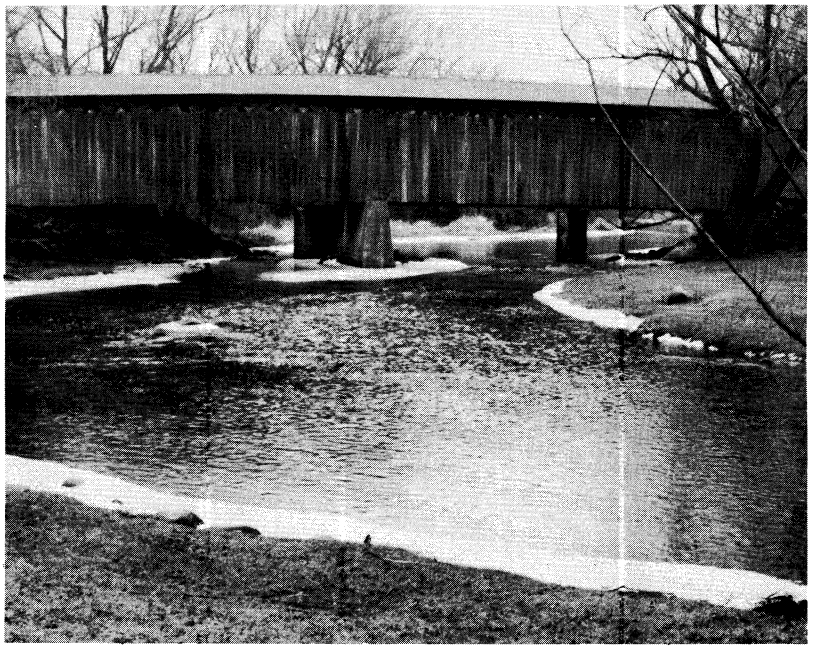
Fox River Basin

The Fox River basin (210), adjacent to the western edge of the Des Plaines, Root, and Milwaukee river basins (Fig. 1), is in the Mississippi River basin and encompasses parts of the following Wisconsin counties: Jefferson, Kenosha, Milwaukee, Racine, Walworth, and Waukesha. This basin includes those portions that are in Wisconsin of the Fox River, Nippersink Creek, North Branch Nippersink Creek, Trevor Creek, and an unnamed outlet to Camp Lake. The watershed in Wisconsin contains an area of approximately 2,440 km^2 (Holmstrom 1982). Within this area, we have defined 157 streams with a total length in Wisconsin of 930 km (Table 1). Of these, 92 are unnamed creeks and ditches. There are 102 lakes in the basin, with a total area of 9,178 ha. Of these, 20 are over 80 ha in size.

The average annual precipitation within the Fox River basin is 79 cm (74-81 cm) (Wisconsin DNR 1972). The average gradient for the Fox River (129 km in length) is 28 cm/km. The average discharge at Wilmot, which includes 96% of the basin's drainage area, is 15 m^3/sec (U.S. Geol. Surv. 1981). We determined that the stream bottom is composed of primarily sand, silt, muck, and gravel, with limited areas of rubble, detritis, boulder, and clay.

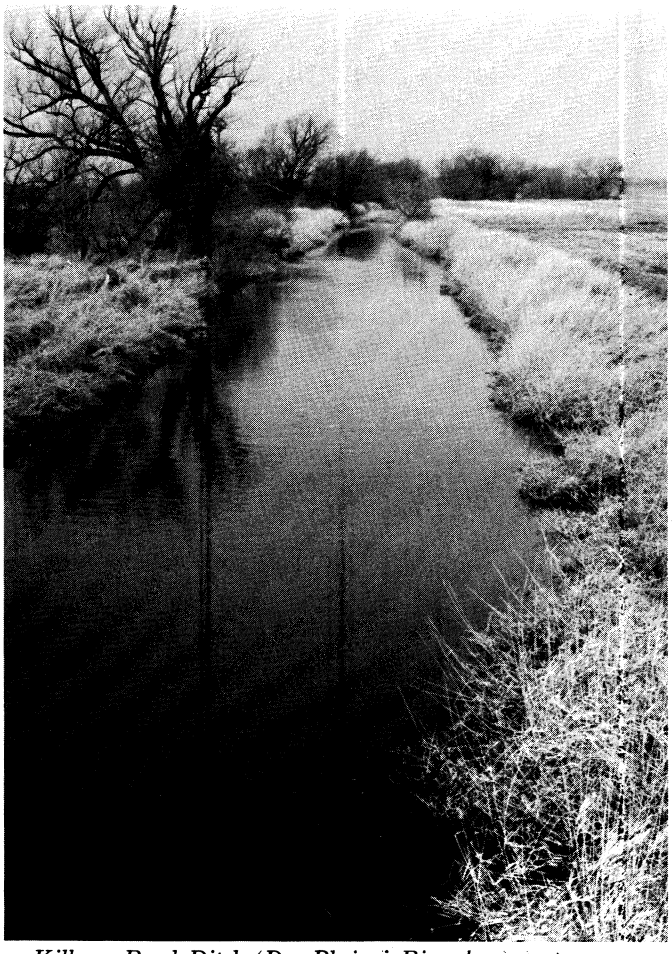
The dominant land use (64%) is agriculture, primarily dairy farming, row crops, and hay. Approximately 13% of the land is urban. The 1975 population of the basin was 225,000 which has increased 134% since 1950 (Southeast. Wis. Reg. Plann. Comm. 1978 and Wisconsin DNR 1972).

Underwood Creek (Milwaukee River basin) at end of 106 Street in City of Milwaukee. This concrete-lined creek is being sampled with a Tiny Tiger pack shocker.

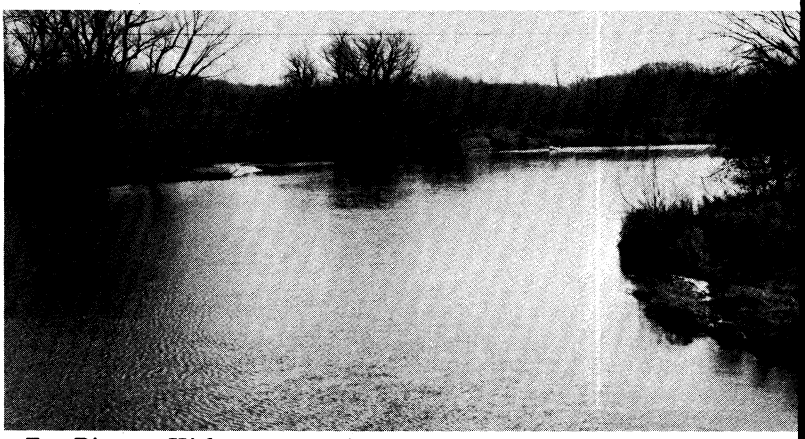


Cedar Creek at covered bridge northwest of Cedarburg.

Des Plaines River at County Trunk C in Kenosha County.

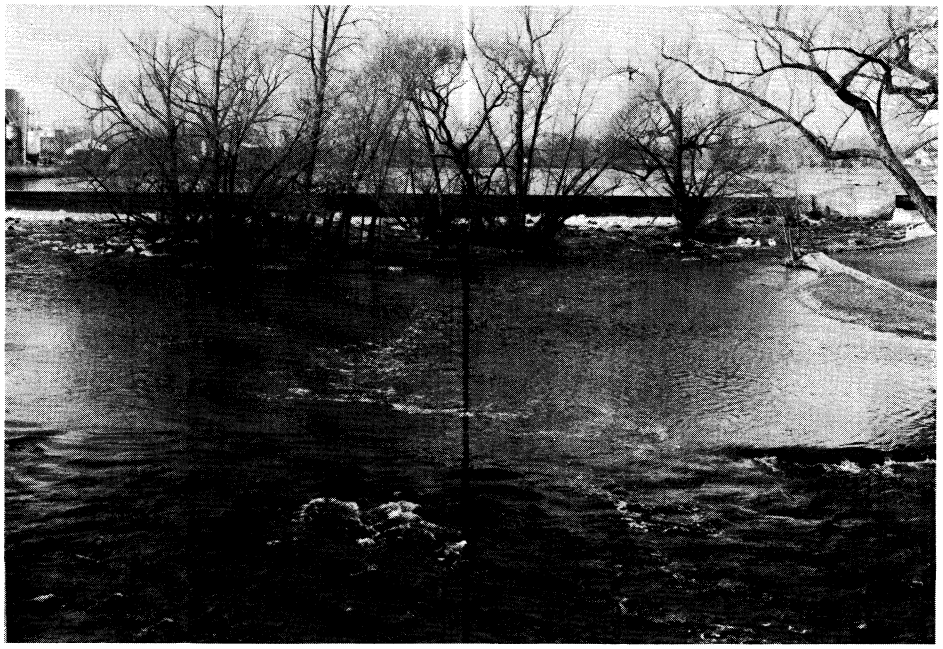


Kilborn Road Ditch (Des Plaines River basin) at Highway 50, looking upstream at habitat of the pirate perch.



Fox River at Highway 83 south of Rochester.

Muskego Creek (Fox River basin) at Highway 83.



White River (Fox River basin) at Burlington. Habitat of the river redhorse.

METHODS

Data Sources and Time Periods

All collections are divided into 3 time periods: 1900-28, 1951-73, and 1974-81 (1973-81 for the Milwaukee). The earlier records provide the basis for assessment of changes over time in distribution of fish species within the basins of the Root, Milwaukee, Des Plaines, and Fox rivers.

If a location was sampled within a time period more than once, only 1 collection is used in the counts of number of stations sampled and number of stations at which a species was taken.

Stations were classified in one of two ways, except for the 1900-28 period, depending on how the samples were taken: complete (those in which all species collected were recorded and identified), and partial (those in which sampling effort and/or species identification were incomplete and therefore did not yield adequate assessment of total species composition).

1900-28 Period. All collections were made between 1900 and 1928, except for 3 in the Fox River basin (2 in 1941 and 1 in 1946), with 53% taken during 1923-28. Collections from this time period were made at 19 stations in the Root River basin, 43 in the Milwaukee River basin, 3 in the Des Plaines River basin, and 31 in the Fox River basin by a number of collectors. They included A. Cahn (1927), H. V. Ogden, G. Wagner, Schultz, C. Tarzwell, C. L. Turner, and several collectors at the Milwaukee Public Museum (names taken from original field notes). Most specimens from these collections were verified by Dr. Carl Hubbs or Dr. C. W. Greene and cited by Greene (1935).

The stations sampled were located on 11 streams in the Root River basin, 13 streams and 4 lakes in the Milwaukee River basin, 2 streams and 1 lake in the Des Plaines River basin, and 12 streams and 5 lakes in the Fox River basin (Table 2). Thoroughness of sampling effort was unknown, and therefore calculation of percent occurrence of each species was not attempted (Table 5).

1951-73 Period.* Complete collections from this period were made at 10 sampling stations on 2 streams in the Root River basin, 31 stations on 4 streams and 2 lakes in the Milwaukee River basin, 5 stations on 3 streams in the Des Plaines River basin, and 63 stations on 30 streams and 3 lakes in the Fox River basin (Table 2). An additional 5 partial collections in the Root River basin, 11 in the Milwaukee River basin, 5 in the Des Plaines River basin, and 54 in the Fox River basin increased the number of streams sampled by 4, 0, 0, and 8 and lakes by 1, 10, 5, and 34 in the Root, Milwaukee, Des Plaines, and Fox river basins, respectively. The data from these partial samples were kept separate in Table 2 and not included in the percentages of total stations sampled presented in Table 5. These additional 75 stations came from written records provided by DNR fish management personnel.

The complete samples from the Root, Milwaukee, Des Plaines, and Fox river basins (72% taken between 1966 and 1972) were collected by the following: Dr. George Becker and his students (unpubl. data)—32 stations, Prof. Marlin Johnson (unpubl. data)—32 stations, Dr. G. Seeburger and students (1975)—22 stations, Milwaukee Public Museum (unpubl. data)—12 stations, Dr. O. Amin et al. (1973)—10 stations, and Dr. C. Norden (unpubl. data)—1 station.

Total occurrences are defined as the sum of the number of species taken at each station. For example, if a collector took 10 species at one station, 20 at another, and 30 at another, the total species occurrences would be 60. This information has been calculated for collections since 1951, and reveals the volume of data from both complete and partial samples used (Table 3). For the earliest period, only a grand total of occurrences was calculated (Table 5). Total occurrences increased from 835 for the 1900-28 period to 1,350 for the 1951-73 period for the Root, Milwaukee, Des Plaines, and Fox river basins. During 1951-73, 50% of the grand total of occurrences for these 4 basins were accounted for by Dr. Becker, Prof. Johnson, and their students. They also collected 75 of the 80 species reported

*1951-72 for Milwaukee River basin.

TABLE 2. *Summary of stream and lake sampling efforts in the Root, Milwaukee, Des Plaines, and Fox river basins, 1900-81.*

	Root (10)			Milwaukee (20)			Des Plaines (200)			Fox (210)		
	1900-28	1951-73	1974-81	1900-28	1951-72	1973-81	1900-28	1951-73	1974-81	1900-28	1951-73	1974-81
Streams												
No. sampled	11	2*(4)**	27(1)	13	4	59(1)	2	3	15(1)	12	30(8)	64(1)
No. stations	19	10 (4)	68(6)	39	29(1)	197(14)	2	5	39(7)	21	50(20)	176(12)
Lakes/ impoundments												
No. sampled	0	0 (1)	0(5)	4	2(10)	28(19)	1	0(5)	11(1)	5	3(34)	50(1)
No. stations	0	0 (1)	0(5)	4	2(10)	39(22)	1	0(5)	11(1)	10	13(34)	146(25)
Total no. stations	19	10 (5)	68(11)	43	31(1)	236(36)	3	5(5)	50(8)	31	63(54)	322(37)

*Complete samples.
**Partial samples.

TABLE 3. *List of collectors with number of species taken and total occurrences from samples for the Root, Milwaukee, Des Plaines, and Fox river basins.*

	Root (10)				Milwaukee (20)				Des Plaines (200)				Fox (210)			
	1951-73		1974-81		1951-72		1973-81		1951-73		1974-81		1951-73		1974-81	
Source of Data*	No. Species	Total Occurrences	No. Species	Total Occurrences	No. Species	Total Occurrences	No. Species	Total Occurrences	No. Species	Total Occurrences	No. Species	Total Occurrences	No. Species	Total Occurrences	No. Species	Total Occurrences
Research 0	-	-	42	412(76)**	-	-	66	1,568(66)	-	-	38	347(61)	-	-	79	2,930(85)
Fish Mgt. 1	7	16(31)	25	131(24)	8	46(13)	56	714(30)	11	12(14)	17	22(4)	17	241(28)	64	478(14)
Becker 2	-	-	-	-	39	185(54)	-	-	12	34(38)	-	-	32	137(16)	-	-
Johnson 3	-	-	-	-	37	94(27)	-	-	23	43(48)	-	-	54	188(22)	-	-
Seeburger 4	-	-	-	-	-	-	-	-	-	-	-	-	41	199(23)	-	-
Mil. Pub. Mus. 5	-	-	-	-	16	19(6)	29	87(4)	-	-	-	-	33	71(8)	29	46(1)
UW-Madison 6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3(t)
Sport fish. 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4(t)
Norden 12	-	-	-	-	-	-	-	-	-	-	-	-	30	30(3)	-	-
UW-Parkside 13	18	35(69)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ENCAP 14	-	-	-	-	-	-	-	-	-	-	31	179(31)	-	-	-	-
Bio Test 15	-	-	2	2(t)	-	-	-	-	-	-	7	22(4)	-	-	-	-
Grand total of occurrences		51		545		344		2,364		89		570		866		3,461

*Collectors identified at end of Appendix A Table 16.
**Total occurrences are defined as the sum of the number of species collected at each station; percent of total occurrences in parentheses.
t = less than 0.5%.

for this time period (Table 3 and Append. A Table 20).

1974-81 Period.* Complete collections from this period were made at 68 stations (all sampled between 1975 and 1979) on 27 streams in the Root River basin, 236 stations (99% between 1973 and 1979) on 59 streams and 28 lakes in the Milwaukee River basin, 50 stations (90% in 1979 and 1980) on 15 streams and 11 lakes in the Des Plaines River basin, and 322 stations (92% between 1978 and 1980) on 64 streams and 50 lakes in the Fox River basin (Table 2). There were an additional 11 partial collections in the Root River basin, 36 in the Milwaukee River basin, 8 in the Des Plaines River basin, and 37 in the Fox River basin which increased the number of streams by 1, 1, 1, and 1 and lakes by 5, 22, 1, and 1, in the Root, Milwaukee, Des Plaines, and Fox river basins, respectively.

For all four river basins, the number of complete samples increased an average of more than 680% over the 1951-73 period with 676 stations sampled. DNR research personnel sampled 532 (79%); DNR fish management personnel, 121 (18%); Milwaukee Public Museum, 12 (2%); and ENCAP, Inc., D.W. Greenfield (1980), 11 (2%). The 92 partial samples were collected by fish management personnel, Bio Test Inc. (Wis. Elec. Power Co. 1975), and sport fishermen.

Total occurrences increased from 1,350 for the 1951-73 period to 6,945 for the Root, Milwaukee, Des Plaines, and Fox river basins, an average increase of more that 680%. Research personnel recorded 76% of these (Table 3). We also collected 93 of the 96 species found in all four basins (for list of species taken by all other collectors see Append. A Table 20).

Collection Methods and Gear**

We used six types of electrofishing gear, depending on the size of the body of water. The types of gear and percentage of stations where each was used were: boom shocker (4%), minishocker (2%), stream shocker (42%), DC battery-powered backpack (2%), gasoline-powered backpack (1%), and longline shocker (12%). Small mesh seines were used at 37% of the stations, primarily in lakes and large rivers.

All generators produced direct current, with the boom shocker and minishocker permitting a choice of several pulse rates and frequencies. The boom shocker also produced alternating current and it was used occasionally when the DC unit was inoperative. For more information concerning the boom and stream shocking equipment, see Novotny and Priegel (1971, 1974).

The minishocker consisted of a 5-m flat bottom boat with one boom in the bow and used the same 5 hp T&J gasoline powered generator as the stream shocker. It required only 1 person sitting on a chair in the bow to collect the fish, in contrast to 2 people standing in the boat using the boom shocker. The battery-powered backpack used a 12-volt deep cycle battery and pulsed the DC at several frequency and pulse rates. The development and production of this unit, like all the electric fishing gear used, was a joint project between Wisconsin DNR and Instrumentation Systems Center, UW-Madison. The seines were 1.2-m and 9.1-m bag seines with 4.8-mm delta mesh.

Sampling Effort

We established sampling locations based on habitat diversity, distance between stations, and accessibility. The length of a sampling station was approximately 100 m for all electrofishing gear except for the boom and minishockers. Boom shocker and minishocker stations averaged 2.4 km. Area seined averaged 365 m^2. Distance between stations on the main stems of the Root, Milwaukee, Des Plaines, and Fox rivers averaged 4.4 km. There was an average of 1 station/3 km for the total length of all sampled streams with 1 or more complete stations. On sampled lakes in the Milwaukee and Fox basins, there was an average of 1 station/47 ha of water.

Complete collections were made on 64% of the streams and none of the lakes in the Root River basin; 45% of the streams and 23% of the lakes in the Milwaukee River basin; 50% of the streams and 55% of the lakes in the Des Plaines River basin; and 41% of the streams and 49% of the lakes in the Fox River basin (Tables 1 and 2). While these percentages are relatively low, the streams that were sampled comprised 90%, 85%, 85%, and 78% of the total length of all streams in the Root, Milwaukee, Des Plaines, and Fox river basins, respectively. The sampled lakes comprised 0%, 72%, 77%, and 95%, respectively, of the total surface area for all lakes in each basin.

Figure 2 shows the locations of 533 of the 676 complete and 52 of the 92 partial stations. Only one dot per lake was shown and dots were eliminated that would overlap another dot.

Data Handling

Data collected at the sampling stations were recorded in pencil on Form 8100-46 (Append. A Fig. 5), and included station and species information, and ecological data. This form is made of polyethylene paper, is virtually unaffected by salt and fresh water, and is resistant to tearing, discoloration, and rotting.

In order to handle the data on over 1,400 collections from the Root, Milwaukee, Des Plaines, and Fox river basins, dating from 1900, Cobol and Mark IV computer programs were developed through a cooperative effort with the DNR's Bureau of Information Management to organize, store, and retrieve the data. Some programs are used to update the Fish Master File, which contains all data on the stations in the 4 basins as well as on 15,500 additional stations throughout the state.

Other programs are used to help in the analysis of the data. One analysis uses a Cobol program to organize the data by species, and lists all stations for each species. This listing, based on a water mileage system developed for this study, was organized in 2 ways (Figs. 3a and 3b):

(1) All stations on a river are listed until a tributary of the river is reached (Fig. 3a). All stations on that tributary are then listed before going back to the confluence of the tributary with the original river. This procedure is followed for all tributaries in the basin of the first tributary before going back to the original river.

(2) All stations on a river are listed before going back to the first tributary of the original river and listing all stations on the tributary (Fig. 3b). This procedure is followed for all tributaries in the basin of the first tributary before going to the second tributary of the original river.

The program for both of these methods can be restricted to one or more of the following criteria: particular minor basins, a sub-basin or part of a sub-basin, individual collectors, dates, township and range (by entire township or contiguous townships), counties, water types, and selected species. At each station, the stream name along with water type, number of fish taken, collector,

*1973-81 for the Milwaukee River basin and 1 collector of Phil Cochran in the Fox River basin in 1982.

**Only the methods and gear employed by DNR research personnel are described; fish management personnel used similar equipment.

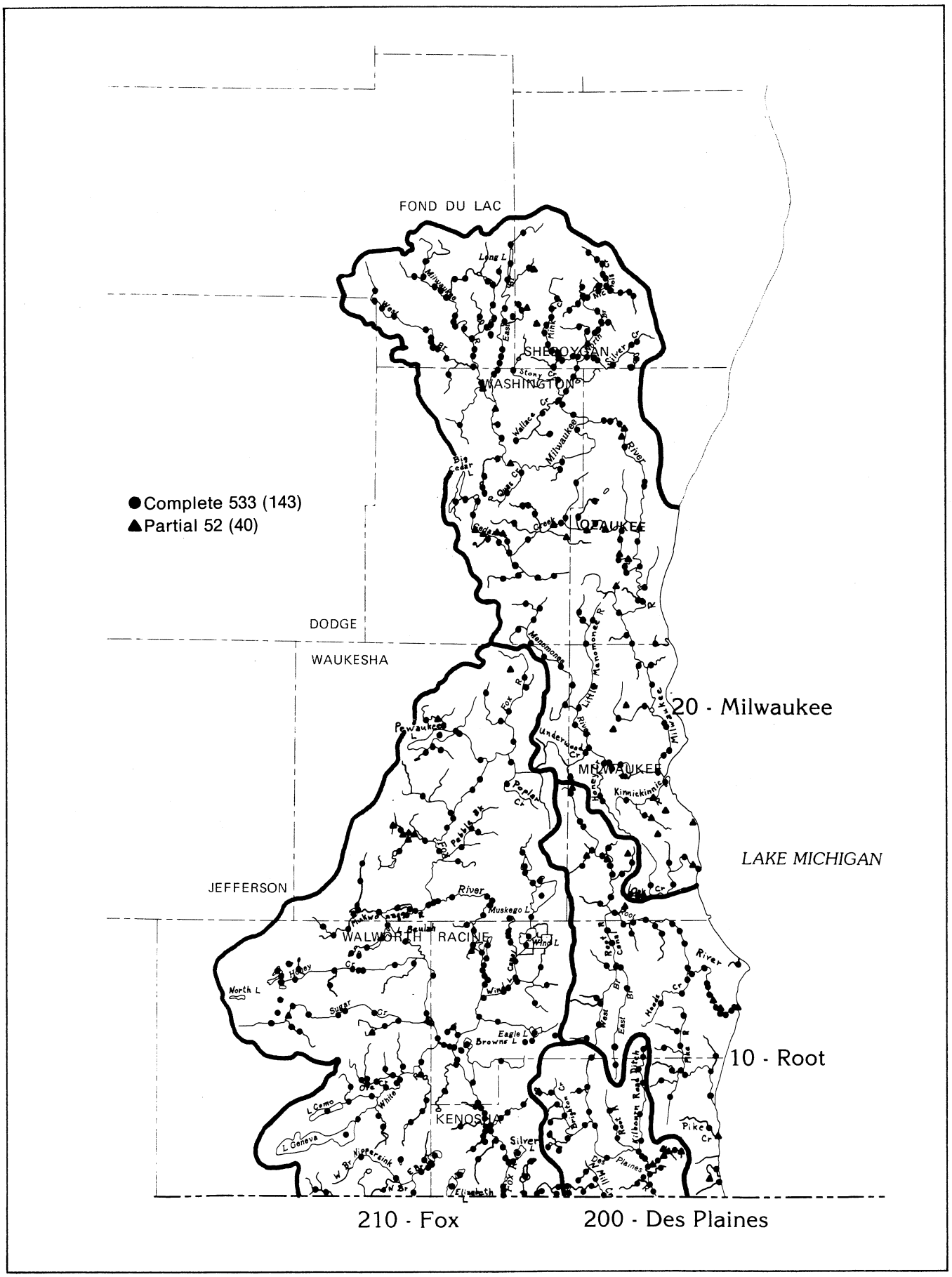


FIGURE 2. *Location of 768 sampling stations in the Root, Milwaukee, Des Plaines, and Fox river basins. (Due to lack of space, 183 stations, indicated in parentheses, are not shown.)*

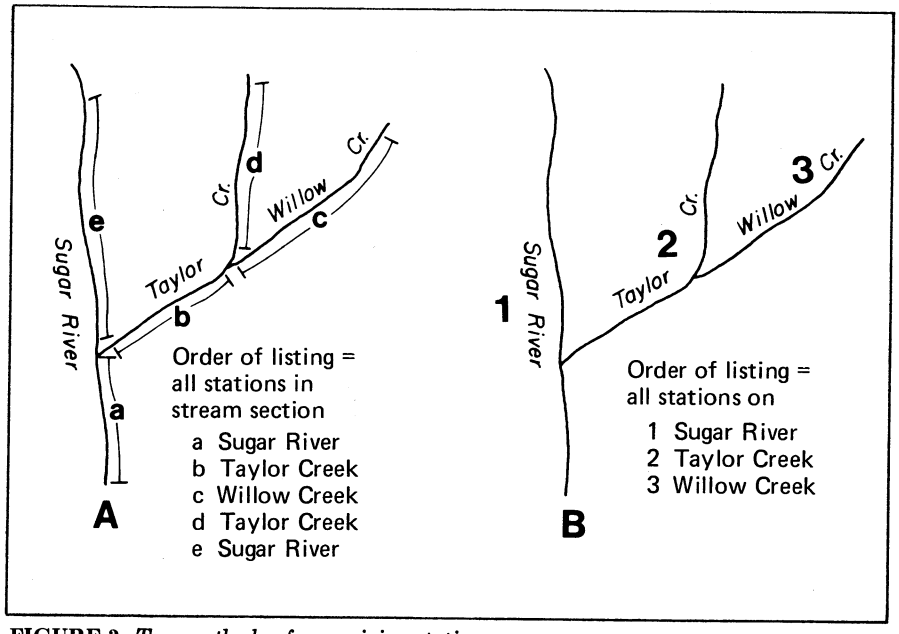


FIGURE 3. *Two methods of organizing stations on computer printouts.*

gear, effort, date, township description, and county are listed. An example of the Cobol listing for one species is shown in Appendix A Figure 6. At the end of each species listing, the total number of stations, total number of specimens, average number of fish/station, and number of stations for each collector is computed. At the end of the printout, a summary table is given that lists each species, the number stations at which it was taken, the percent of the total stations possible, grand total of species occurrences, totals for each collector, and totals for number of species and hybrids (Append. A Fig. 7).

Another type of analysis uses a Mark IV program to organize the data by stations, and lists for each station all information (number of specimens of each species, and the total number of species, hybrids, and unspecified categories). The program can be restricted to the same criteria cited above for the Cobol program, and the listing can be organized the same 2 ways (Fig. 3). However, only the Mark IV listing can be restricted to gear, or any of the 10 ecological variables. This program can be organized in still different ways, including: (1) by county and then alphabetically by name of stream or lake, (2) by county and then by basin, or (3) by township, range, and section. An example of the Mark IV listing is shown in Appendix A Figure 8.

A water mileage system was devised to permit computer analysis of the data and still allow easy recognition of the location by persons wishing to use the data. This was accomplished by using the town, range, section, quarter section, and county along with basin numbers, a series of mileages, and the name of the body of water. A Master Stream and Lake File containing this information has been generated by this study for most streams and lakes in Wisconsin. Mark IV computer programs are available to obtain a variety of listings—such as streams and/or lakes in each basin listed alphabetically.

An example of a page of the water mileage system from a computer printout of the Master Stream and Lake File is shown in Appendix A Figure 9. An example of a page of the Master Fish File which uses the water mileage system to organize the biological and environmental data is included in Appendix A Figure 8. A detailed explanation of the system as exemplified in these figures is presented in Fago (1984b).

Fish Identification and Enumeration

In order to reduce the volume of specimens taken back to the laboratory, larger fish were identified to species in the field and were usually returned to the water. Generally all others were preserved in 10% Formalin for later identification in the laboratory (principally using the unpublished keys of Dr. G. Becker).

At least a few stonerollers at each station (except for 6 stations in the Milwaukee River basin) were keyed to species. The remainder were left as stonerollers (*Campostoma* spp.). Research personnel identified all fish for the 1974-81 period except for some specimens of 25 species (indicated by an asterisk in Append. A Table 20) collected by fish management personnel, Bio Test Inc., or sport fishermen. For the 1951-73 period, all species records are based upon the collectors' identification. The common and scientific names of fish species cited in this report (Table 4) follow names established by American Fisheries Society's Committee on Names of Fishes (Robins 1980). All hybrids and specimens not keyed to species, except stonerollers, were not dealt with in this report.

At each station, the number of specimens for each species was counted to 98 and recorded on Form 8100-46 (Append. A Fig. 5). However, at many stations there were more than 98 specimens taken for certain species. They were recorded as 99. Therefore, the number of specimens recorded in Tables 6, 12, and 13 for some species is substantially lower than the number actually captured. Furthermore, there were up to 6 stations for certain species at which the number taken was unknown, further underestimating the total number of specimens.

Questionable specimens were sent to Dr. George Becker at the University of Wisconsin-Stevens Point for verification.

Endangered, Threatened, and Watch Species

The State of Wisconsin currently has 8 species on its endangered list*, 6 species on its threatened list*, and 18 species on its unofficial watch list. These 3 categories are defined as follows:

Endangered: Any species or subspecies in danger of becoming extirpated. Its continued existence as part of the state's wildlife resources is in jeopardy.

Threatened: Any species or subspecies which appears likely, within the foreseeable future, to become endangered.

Watch: Species or subspecies that may or may not be holding their own at the present time. They will be under special observation to identify conditions that could cause further decline, or any factors that could help to ensure their survival in the state.

*Chap. NR 27, Wis. Admin. Code.

TABLE 4. *List of common and scientific names of fish species cited in this report.*

Computer No.	Common Name	Scientific Name
	Lampreys	Petromyzontidae
A03	Northern brook lamprey	*Ichthyomyzon fossor*
A05	American brook lamprey	*Lampetra appendix*
	Gars	Lepisosteidae
D01	Longnose gar	*Lepisosteus osseus*
	Bowfins	Amiidae
E01	Bowfin	*Amia calva*
	Freshwater eels	Anguillidae
F01	American eel	*Anguilla rostrata*
	Herrings	Clupeidae
G01	Alewife	*Alosa pseudoharengus*
G02	Gizzard shad	*Dorosoma cepedianum*
	Trouts	Salmonidae
I04	Cisco or lake herring	*Coregonus artedii*
I14	Coho salmon	*Oncorhynchus kisutch*
I16	Chinook salmon	*Oncorhynchus tshawytscha*
I19	Rainbow trout	*Salmo gairdneri*
I21	Brown trout	*Salmo trutta*
I22	Brook trout	*Salvelinus fontinalis*
I23	Lake trout	*Salvelinus namaycush namaycush*
	Smelts	Osmeridae
J01	Rainbow smelt	*Osmerus mordax*
	Mudminnows	Umbridae
K01	Central mudminnow	*Umbra limi*
	Pikes	Esocidae
L01	Grass pickerel	*Esox americanus vermiculatus*
L02	Northern pike	*Esox lucius*
L03	Muskellunge	*Esox masquinongy*
	Minnows and carps	Cyprinidae
M06	Central stoneroller	*Campostoma anomalum*
M07	Largescale stoneroller	*Campostoma oligolepis*
M08	Goldfish	*Carassius auratus*
M09	Redside dace	*Clinostomus elongatus*
M12	Common carp	*Cyprinus carpio*
M14	Brassy minnow	*Hybognathus hankinsoni*
M15	Mississippi silvery minnow	*Hybognathus nuchalis*
M19	Hornyhead chub	*Nocomis biguttatus*
M20	Golden shiner	*Notemigonus chrysoleucas*
M22	Pugnose shiner	*Notropis anogenus*
M23	Emerald shiner	*Notropis atherinoides*
M27	Striped shiner	*Notropis chrysocephalus*
M28	Common shiner	*Notropis cornutus*
M29	Bigmouth shiner	*Notropis dorsalis*
M30	Pugnose minnow	*Notropis emiliae*
M31	Blackchin shiner	*Notropis heterodon*
M32	Blacknose shiner	*Notropis heterolepis*
M33	Spottail shiner	*Notropis hudsonius*
M35	Rosyface shiner	*Notropis rubellus*
M36	Spotfin shiner	*Notropis spilopterus*
M37	Sand shiner	*Notropis stramineus*
M38	Weed shiner	*Notropis texanus*
M39	Redfin shiner	*Notropis umbratilis*
M40	Mimic shiner	*Notropis volucellus*
M41	Suckermouth minnow	*Phenacobius mirabilis*
M42	Northern redbelly dace	*Phoxinus eos*
M43	Southern redbelly dace	*Phoxinus erythrogaster*
M45	Bluntnose minnow	*Pimephales notatus*
M46	Fathead minnow	*Pimephales promelas*
M47	Bullhead minnow	*Pimephales vigilax*
M48	Blacknose dace	*Rhinichthys atratulus*
M49	Longnose dace	*Rhinichthys cataractae*
M50	Creek chub	*Semotilus atromaculatus*
M51	Pearl dace	*Semotilus margarita*
	Suckers	Catostomidae
N06	Quillback	*Carpiodes cyprinus*
N09	White sucker	*Catostomus commersoni*
N11	Creek chubsucker	*Erimyzon oblongus*
N12	Lake chubsucker	*Erimyzon sucetta*
N13	Northern hog sucker	*Hypentelium nigricans*
N17	Spotted sucker	*Minytrema melanops*
N18	Silver redhorse	*Moxostoma anisurum*
N19	River redhorse	*Moxostoma carinatum*
N21	Golden redhorse	*Moxostoma erythrurum*
N22	Shorthead redhorse	*Moxostoma macrolepidotum*
N23	Greater redhorse	*Moxostoma valenciennesi*
	Bullhead catfishes	Ictaluridae
O05	Black bullhead	*Ictalurus melas*
O06	Yellow bullhead	*Ictalurus natalis*
O07	Brown bullhead	*Ictalurus nebulosus*
O08	Channel catfish	*Ictalurus punctatus*
O09	Slender madtom	*Noturus exilis*
O10	Stonecat	*Noturus flavus*
O11	Tadpole madtom	*Noturus gyrinus*
	Pirate perches	Aphredoderidae
P01	Pirate perch	*Aphredoderus sayanus*
	Trout-perches	Percopsidae
Q01	Trout-perch	*Percopsis omiscomaycus*
	Killifishes	Cyprinodontidae
S01	Banded killifish	*Fundulus diaphanus*
S02	Blackstripe topminnow	*Fundulus notatus*
S03	Starhead topminnow	*Fundulus notti*
	Silversides	Atherinidae
T01	Brook silverside	*Labidesthes sicculus*
	Sticklebacks	Gasterosteidae
U01	Brook stickleback	*Culaea inconstans*
U02	Ninespine stickleback	*Pungitius pungitius*
	Temperate basses	Percichthyidae
V01	White bass	*Morone chrysops*
V02	Yellow bass	*Morone mississippiensis*
	Sunfishes	Centrarchidae
W04	Rock bass	*Ambloplites rupestris*
W05	Green sunfish	*Lepomis cyanellus*
W06	Pumpkinseed	*Lepomis gibbosus*
W07	Warmouth	*Lepomis gulosus*
W08	Orangespotted sunfish	*Lepomis humilis*
W09	Bluegill	*Lepomis macrochirus*
W10	Longear sunfish	*Lepomis megalotis*
W11	Smallmouth bass	*Micropterus dolomieui*
W12	Largemouth bass	*Micropterus salmoides*
W13	White crappie	*Pomoxis annularis*
W14	Black crappie	*Pomoxis nigromaculatus*
	Perches	Percidae
X07	Rainbow darter	*Etheostoma caeruleum*
X09	Iowa darter	*Etheostoma exile*
X10	Fantail darter	*Etheostoma flabellare*
X11	Least darter	*Etheostoma microperca*
X12	Johnny darter	*Etheostoma nigrum*
X14	Banded darter	*Etheostoma zonale*
X15	Yellow perch	*Perca flavescens*
X16	Logperch	*Percina caprodes*
X18	Blackside darter	*Percina maculata*
X22	Walleye	*Stizostedion vitreum vitreum*
	Drums	Sciaenidae
Y01	Freshwater drum	*Aplodinotus grunniens*
	Sculpins	Cottidae
Z01	Mottled sculpin	*Cottus bairdi*

RESULTS AND DISCUSSION

Findings are presented individually for the Root, Milwaukee, Des Plaines, and Fox river basins. This is followed by a discussion of differences between the basins for selected species, including those on the Wisconsin DNR endangered, threatened, or watch lists. Unless otherwise indicated, findings refer only to the 1974-81 period (1973-81 for Milwaukee River basin).

ROOT RIVER BASIN (10)

Species Found

Over 10,000 specimens representing 42 species were identified in samples from the Root River basin (Tables 5 and 6). This included one watch species, the lake chubsucker. Distribution maps for all species are presented in Appendix B: each map shows the location of stations where the species was collected. An index to the maps is contained in Table 5 and after Appendix B.

Reproducing Populations

In the Root River basin 39 species are believed to have reproducing populations. The presence of reproducing populations of 3 other species (rainbow trout, brook trout, and chinook salmon) is questionable since all collections can be attributed to stocking (R. Piening, pers. comm.).

Common and Rare Species

The 5 most common species (caught at the highest percentage of complete stations) were white sucker (81%), creek chub (76%), fathead minnow (69%), green sunfish (63%), and black bullhead (41%) (Table 5). The 5 most numerous species (most specimens caught) were white sucker (2,300), creek chub (1,800), fathead minnow (970), green sunfish (770), and bigmouth shiner (740) (Table 6). The black bullhead was the 13th most numerous species.

Of the 18 rarest species (those caught at 3 or fewer of all the stations, Table 7), all but 5 (alewife, gizzard shad, chinook salmon, sand shiner, and stonecat) were also represented by the smallest total numbers of specimens (Table 6).

Differences Between Time Periods

Seven species of fish collected during the 1974-81 period have not been previously reported for this basin (Table 8).

Fourteen species are apparently no longer present in the Root River basin, for they were last taken before 1929 (Table 9). This seems to indicate that the aquatic environment has been dramatically changed since the early 1900's. In fact, of all the 11 basins for which technical bulletins have been prepared, only the Sugar River basin comes close to this number of extirpated species. The Sugar basin had 11 extirpated species, although its area was 2.8 times larger than the Root River basin. As in other basins, some of these species may have been rare even in the early 1900's, for they were reported from only 1 or 2 stations.

Thirteen species that we collected were not taken between 1929 and 1973 from this basin (Table 10).

One of the most important results of this study was the documentation of changes in the known distribution of species within the Root River basin in 1974-81 as compared to previous periods (Table 11). These changes have ranged from decreases in the number of stations for 19 species to increases for 27 species, and no change for 3 others. The decreases ranged from 33% for the northern pike to 100% for 14 species. The increases ranged from 100% for 4 species to 5,100% for the creek chub (average = 910%), and were due primarily but perhaps not entirely to increased sampling effort in 1974-81. There were 25 more streams with at least 1 complete station as compared to 1951-73 and 16 more streams compared to 1900-28 (Table 2). When the total number of complete stations sampled in the 1974-81 period was compared with 1951-73 and 1900-28 periods, there were increases of 580% and 260%, respectively.

Species Diversity

Only 4 stations in the Root River basin had 15 or more species and none of the stations sampled by research personnel had 20 or more species (Fig. 4). The average number of species taken per station was 7.

MILWAUKEE RIVER BASIN (20)

Species Found

Over 39,000 specimens representing 67* species were identified in samples from the Milwaukee River basin (Tables 5 and 12). This included the endangered striped shiner, the threatened longear sunfish, and 5 watch species. Distribution maps for all species are presented in Appendix B.

Reproducing Populations

In the Milwaukee River basin 64 species are believed to have reproducing populations. The presence of reproducing populations of 3 other species (rainbow trout, coho salmon, and chinook salmon) is questionable since all accounts can be attributed to stocking (R. Schumacher, pers. comm.).

*On 2 August 1983 one grass carp *(Ctenopharyngodon idella)* was taken near the Hambolt Ave. bridge (M. Holey, pers. comm.). This additional species is not taken into account in this report.

TABLE 5. *Number of stations and percent of total stations at which each species was collected in the Root, Milwaukee, Des Plaines, and Fox river basins, 1900-81.*

Map No.	Species	Root (10)					Milwaukee (20)				
		1900-28	1951-73		1974-81		1900-28	1951-73		1974-81	
		No. Stn.	No. Stn.	Percent Total	No. Stn.	Percent Total	No. Stn.	No. Stn.	Percent Total	No. Stn.	Percent Total
2	Northern brook lamprey	0	0	-	0	-	0	0	-	0	-
1	American brook lamprey	0	0	-	0	-	0	0	-	0	-
1	Longnose gar	0	0	-	0	-	0	0	-	0	-
2	Bowfin	0	0	-	0	-	0	0	-	0	-
-	American eel (W)[1]	0	0	-	0	-	1	0	-	0	-
3	Alewife	0	1	11	2(1)*	3	0	0	-	0	-
3	Gizzard shad	0	0	-	2	3	0	0	-	0	-
4	Cisco or lake herring	0	0	-	0	-	0	0	-	0	-
4	Coho salmon	0	0	-	0	-	0	0	-	1(1)	t**
5	Chinook salmon	0	0	-	3	4	0	0	-	2	1
6	Rainbow trout	0	0(1)	-	2(5)	3	0	0(2)	-	3(2)	1
7	Brown trout	0	0(1)	-	2(1)	3	0	0(2)	-	3(2)	1
8	Brook trout	0	0	-	0	-	0	0	-	8	3
8	Lake trout	0	0	-	0	-	0	0	-	0	-
5	Rainbow smelt	0	0	-	1	1	0	0	-	0	-
9	Central mudminnow	10	3(2)	33	22(2)	32	6	3	10	93(6)	39
10	Grass pickerel	6	1	11	1	1	1	0	-	0	-
11	Northern pike	3	0		2	3	1	8(9)	26	76(26)	32
10	Muskellunge	0	0	-	0	-	0	0	-	0	-
-	Stonerollers	0	0	-	0	-	0	6	19	6	3
12	Central stoneroller	0	0	-	0	-	0	1	3	27	11
13	Largescale stoneroller	9	0	-	0	-	22	5	16	8	3
14	Goldfish	0	0(2)	-	15(5)	22	0	0	-	15(8)	6
-	Redside dace (W)	1	0	-	0	-	5	0	-	0	-
15	Common carp	2	2(5)	22	18(7)	26	2	7(6)	23	42(26)	18
16	Brassy minnow	1	0	-	0	-	4	1	3	2	1
-	Mississippi silvery minnow	0	0	-	0	-	0	0	-	0	-
17	Hornyhead chub	6	0	-	0	-	16	11	35	50(4)	21
18	Golden shiner	4	1	11	21	31	1	5	16	35(8)	15
19	Pugnose shiner (W)	0	0	-	0	-	0	0	-	7	3
20	Emerald shiner	1	0	-	2	3	1	1	3	1	t
21	Striped shiner (E)	0	0	-	0	-	5	14	45	10	4
22	Common shiner	8	0	-	23	34	10	26	84	94(9)	40
23	Bigmouth shiner	0	1	11	24	35	0	0	-	0	-
24	Pugnose minnow (W)	0	0	-	0	-	0	0	-	0	-
25	Blackchin shiner	1	0	-	1	1	1	0	-	17	7
26	Blacknose shiner	8	0	-	0	-	4	0	-	17(1)	7
27	Spottail shiner	1	0	-	0	-	1	5	16	5	2
28	Rosyface shiner	0	0	-	0	-	9	5	16	1	t
29	Spotfin shiner	0	0	-	0	-	3	6	19	25(1)	11
30	Sand shiner	0	0	-	2	3	0	14	45	22	9
-	Weed shiner (W)	0	0	-	0	-	0	0	-	0	-
31	Redfin shiner (W)	7	0	-	0	-	8	10	32	2(4)	1
32	Mimic shiner	0	0	-	0	-	5	3	10	3(1)	1
33	Suckermouth minnow	0	0	-	0	-	0	0	-	0	-
34	Northern redbelly dace	2	0	-	1	1	1	1	3	16	7
35	Southern redbelly dace	7	0	-	4	6	16	1	3	16	7
36	Bluntnose minnow	15	1	11	12	18	27	21	68	93(12)	39
37	Fathead minnow	1	3	33	47	69	9	8	26	63(2)	27
38	Bullhead minnow	0	0	-	0	-	0	0	-	0	-
39	Blacknose dace	8	0	-	4	6	12	2	6	56	24
39	Longnose dace	0	0	-	1	1	1	0	-	0	-
40	Creek chub	15	1	11	52	76	25	5	16	107(1)	45

*Number in parentheses indicates partial stations. They were kept separate since not all of the fish from the station were adequately keyed to species.

**t = less than 0.5%.

[1]E = Endangered, T = Threatened, W = Watch.

TABLE 5 *(Cont.)*

Map No.	Species	Des Plaines (200) 1900-28 No. Stn.	Des Plaines (200) 1951-73 No. Stn.	Des Plaines (200) 1951-73 Percent Total	Des Plaines (200) 1974-81 No. Stn.	Des Plaines (200) 1974-81 Percent Total	Fox (210) 1900-28 No. Stn.	Fox (210) 1951-73 No. Stn.	Fox (210) 1951-73 Percent Total	Fox (210) 1974-81 No. Stn.	Fox (210) 1974-81 Percent Total
2	Northern brook lamprey	0	0	-	0	-	0	0	-	1	t
1	American brook lamprey	0	0	-	0	-	0	0	-	1	t
1	Longnose gar	0	0	-	0	-	0	4	6	9(5)	3
2	Bowfin	1	0(2)	-	4(1)	8	2	3(12)	5	13(9)	4
-	American eel (W)[1]	0	0	-	0	-	0	0	-	0	-
3	Alewife	0	0	-	0	-	0	0	-	0	-
3	Gizzard shad	0	0	-	0	-	0	0	-	0	-
4	Cisco or lake herring	0	0	-	0	-	2	0	-	2(2)	1
4	Coho salmon	0	0	-	0	-	0	0	-	0	-
5	Chinook salmon	0	0	-	0	-	0	0	-	0	-
6	Rainbow trout	0	0	-	0	-	1	1(2)	2	0(3)	-
7	Brown trout	0	0	-	0	-	0	0(3)	-	4(13)	1
8	Brook trout	0	0	-	0	-	1	0(2)	-	0(3)	-
8	Lake trout	0	0	-	0	-	0	0	-	0(1)	-
5	Rainbow smelt	0	0	-	0	-	0	0	-	0	-
9	Central mudminnow	2	4(1)	80	34(3)	68	5	15(7)	23	77(7)	24
10	Grass pickerel	3	1	20	7	12	7	11	17	56(3)	17
11	Northern pike	0	1(5)	20	26(7)	52	5	4(36)	6	52(22)	16
10	Muskellunge	0	0	-	0	-	0	0	-	0(1)	-
-	Stonerollers	0	1	20	0	-	0	18	28	0	-
12	Central stoneroller	0	0	-	6	12	4	2	3	46(3)	14
13	Largescale stoneroller	0	0	-	1	2	2	0	-	1	t
14	Goldfish	0	0	-	0	-	0	0	-	1	t
-	Redside dace (W)	0	0	-	0	-	0	0	-	0	-
15	Common carp	0	1(4)	20	24(6)	48	4	12(31)	19	83(18)	26
16	Brassy minnow	0	0	-	0	-	3	1	2	3	1
-	Mississippi silvery minnow	0	0	-	0	-	1	0	-	0	-
17	Hornyhead chub	2	1	20	2	4	6	20	31	43(1)	13
18	Golden shiner	1	4	80	34	68	3	8	13	75(2)	23
19	Pugnose shiner (W)	0	0	-	0	-	0	3	5	10(1)	3
20	Emerald shiner	0	0	-	0	-	0	12	19	43	13
21	Striped shiner (E)	0	0	-	0	-	4	0	-	1	t
22	Common shiner	1	3	60	11(1)	22	8	38	59	83(2)	26
23	Bigmouth shiner	0	0	-	5	10	0	18	28	25	8
24	Pugnose minnow (W)	0	0	-	0	-	0	1	2	4(3)	1
25	Blackchin shiner	0	0	-	3(1)	6	3	5	8	28(3)	9
26	Blacknose shiner	1	0	-	1(1)	2	4	9	14	46(4)	14
27	Spottail shiner	0	0	-	0	-	2	8	13	36(1)	11
28	Rosyface shiner	0	0	-	0	-	1	2	3	8	2
29	Spotfin shiner	0	0	-	10	20	1	6	9	77	24
30	Sand shiner	0	0	-	8(1)	16	0	2	3	55	17
-	Weed shiner (W)	1	0	-	0	-	1	0	-	0	-
31	Redfin shiner (W)	1	2	40	0	-	0	1	2	0	-
32	Mimic shiner	0	0	-	0	-	5	1	2	33	10
33	Suckermouth minnow	0	0	-	0	-	0	1	2	18	6
34	Northern redbelly dace	2	0	-	1	1	1	1	3	16	7
35	Southern redbelly dace	7	0	-	4	6	16	1	3	16	7
36	Bluntnose minnow	15	1	11	12	18	27	21	68	93(12)	39
37	Fathead minnow	1	3	33	47	69	9	8	26	63(2)	27
38	Bullhead minnow	0	0	-	0	-	0	0	-	0	-
39	Blacknose dace	8	0	-	4	6	12	2	6	56	24
39	Longnose dace	0	0	-	1	1	1	0	-	0	-
40	Creek chub	15	1	11	52	76	25	5	16	107(1)	45

(Cont. on next page)

TABLE 5 *(Cont.)*

Map No.	Species	Root (10) 1900-28 No. Stn.	Root (10) 1951-73 No. Stn.	Root (10) 1951-73 Percent Total	Root (10) 1974-81 No. Stn.	Root (10) 1974-81 Percent Total	Milwaukee (20) 1900-28 No. Stn.	Milwaukee (20) 1951-73 No. Stn.	Milwaukee (20) 1951-73 Percent Total	Milwaukee (20) 1974-81 No. Stn.	Milwaukee (20) 1974-81 Percent Total
41	Pearl dace	0	0	-	0	-	3	1	3	17	7
42	Quillback	0	0	-	0	-	0	0	-	0	-
43	White sucker	12	5(4)	56	55(8)	81	22	21(5)	68	148(31)	63
-	Creek chubsucker	0	0	-	0	-	0	0	-	0	-
44	Lake chubsucker (W)	0	0	-	3	4	0	0	-	3(4)	1
45	Northern hog sucker	1	0	-	0	-	2	0	-	0	-
45	Spotted sucker	0	0	-	0	-	0	0	-	0	-
46	Silver redhorse	0	0	-	0	-	2	0	-	1	t
47	River redhorse (W)	0	0	-	0	-	0	0	-	0	-
48	Golden redhorse	1	0	-	0	-	2	3	10	14(1)	6
49	Shorthead redhorse	0	0	-	0	-	0	2	6	4	2
50	Greater redhorse (W)	0	0	-	0	-	4	1	3	13(1)	6
51	Black bullhead	5	1	11	28	41	8	15	48	102(2)	43
52	Yellow bullhead	0	0	-	0	-	0	2	6	56(1)	24
53	Brown bullhead	0	1	11	1	1	0	0	-	6	3
54	Channel catfish	0	0	-	0	-	0	0	-	1	t
-	Slender madtom (E)	0	0	-	0	-	0	0	-	0	-
55	Stonecat	0	1	11	2	3	4	3	10	27(1)	11
56	Tadpole madtom	2	0	-	0	-	2	10	32	19(1)	8
57	Pirate perch (W)	0	0	-	0	-	0	0	-	0	-
-	Trout-perch	1	0	-	0	-	0	0	-	0	-
58	Banded killifish	0	0	-	0	-	2	1	3	10(1)	4
59	Blackstripe topminnow	0	0	-	0	-	0	0	-	7(2)	3
60	Starhead topminnow (E)	0	0	-	0	-	0	0	-	0	-
61	Brook silverside	0	0	-	0	-	0	0	-	0	-
62	Brook stickleback	6	0	-	23(1)	34	15	5	16	60(1)	25
-	Ninespine stickleback	0	0	-	0	-	1	0	-	0	-
63	White bass	1	0	-	0	-	0	0	-	0	-
63	Yellow bass	0	0	-	0	-	0	0	-	0	-
64	Rock bass	5	0	-	1	1	13	10	32	53	22
65	Green sunfish	2	5	56	43	63	6	10	32	118(3)	50
66	Pumpkinseed	1	2	22	8	12	5	13	42	92(1)	39
67	Warmouth	0	0	-	3	4	0	0	-	1	t
68	Orangespotted sunfish	0	0	-	0	-	0	0	-	2	1
69	Bluegill	0	3	33	12	18	2	3	10	74(2)	31
70	Longear sunfish (T)	2	0	-	0	-	5	4	13	10	4
71	Smallmouth bass	0	0	-	0	-	6	3	10	8(1)	3
72	Largemouth bass	1	1	11	20(4)	29	6	3(7)	10	81(24)	34
73	White crappie	3	0	-	7	10	0	0	-	0	-
74	Black crappie	1	0	-	2	3	4	4	13	33(2)	14
75	Rainbow darter	0	0	-	0	-	0	0	-	0	-
76	Iowa darter	3	0	-	6	9	1	0	-	25	11
77	Fantail darter	0	0	-	0	-	18	1	3	31	13
78	Least darter (W)	11	0	-	0	-	7	1	3	7	3
79	Johnny darter	11	2	22	15	22	24	4	13	76(2)	32
80	Banded darter	0	0	-	0	-	0	0	-	0	-
81	Yellow perch	0	0(1)	-	8(5)	12	3	2(11)	6	59(15)	25
82	Logperch	0	0	-	0	-	5	2	6	21	9
83	Blackside darter	2	0	-	5	7	5	5	16	18	8
84	Walleye	0	0	-	0	-	0	0(4)	-	1(8)	t
84	Freshwater drum	0	0	-	0	-	0	0	-	0	-
85	Mottled sculpin	0	0	-	0	-	2	0	-	27	11
	No. of species	40	22		42		55	51		67	
	Total no. of occurrences (Sum of number of species taken at each station)	187	51		545		376	344		2,369	

*Number in parentheses indicates partial stations. They were kept separate since not all of the fish from the station were adequately keyed to species.

**t = less than 0.5%.

[1]E = Endangered, T = Threatened, W = Watch.

TABLE 5 *(Cont.)*

Map No.	Species	Des Plaines (200) 1900-28 No. Stn.	1951-73 No. Stn.	1951-73 Percent Total	1974-81 No. Stn.	1974-81 Percent Total	Fox (210) 1900-28 No. Stn.	1951-73 No. Stn.	1951-73 Percent Total	1974-81 No. Stn.	1974-81 Percent Total
41	Pearl dace	0	0	-	0	-	0	0	-	0	-
42	Quillback	0	0	-	0	-	1	0	-	18	6
43	White sucker	2	2(3)	40	20(5)	40	12	34(32)	53	129(17)	40
-	Creek chubsucker	2	0	-	0	-	0	0	-	0	-
44	Lake chubsucker (W)	1	1(5)	20	2(2)	4	4	9(17)	14	38(6)	12
45	Northern hog sucker	0	0	-	0	-	2	5(1)	8	11	3
45	Spotted sucker	0	3	60	1	2	0	0	-	0	-
46	Silver redhorse	0	0	-	0	-	0	0	-	7	2
47	River redhorse (W)	0	0	-	0	-	0	0	-	7	2
48	Golden redhorse	0	0	-	0	-	1	0	-	17	5
49	Shorthead redhorse	0	0	-	0	-	0	0	-	8	2
50	Greater redhorse (W)	0	0	-	0	-	0	0	-	0	-
51	Black bullhead	1	2	40	31	62	3	8	13	62	19
52	Yellow bullhead	2	1	20	16	32	3	10	16	56(1)	17
53	Brown bullhead	0	0	-	1	2	1	0	-	27	8
54	Channel catfish	0	0(1)	-	0	-	0	1(14)	2	21(4)	7
-	Slender madtom (E)	0	0	-	0	-	1	0	-	0	-
55	Stonecat	0	0	-	0	-	2	5	8	19	6
56	Tadpole madtom	1	2	40	10	20	3	7	11	16	5
57	Pirate perch (W)	1	3	60	6(4)	12	0	0	-	0	-
-	Trout-perch	0	0	-	0	-	0	0	-	0	-
58	Banded killifish	0	0	-	0	-	2	4	6	44(2)	14
59	Blackstripe topminnow	1	5	100	12	24	1	3	5	12	4
60	Starhead topminnow (E)	0	0	-	0	-	2	2	3	7	2
61	Brook silverside	0	0(1)	-	0(1)	-	2	12(2)	19	63(7)	20
62	Brook stickleback	0	0	-	15(1)	30	4	13(3)	20	39(4)	12
-	Ninespine stickleback	0	0	-	0	-	0	0	-	0	-
63	White bass	0	0	-	0	-	1	1	2	7(1)	2
63	Yellow bass	0	0	-	0	-	0	0	-	2	1
64	Rock bass	1	0	-	0	-	7	7	11	43(1)	13
65	Green sunfish	2	3	60	43	86	0	19	30	127(3)	39
66	Pumpkinseed	1	0	-	23	46	10	20	31	172	53
67	Warmouth	0	0	-	4(1)	8	1	2	3	44	14
68	Orangespotted sunfish	0	0	-	0	-	0	3	5	20	6
69	Bluegill	0	0	-	26(1)	52	7	26	41	176(1)	55
70	Longear sunfish (T)	1	0	-	0	-	3	2	3	5	2
71	Smallmouth bass	0	0	-	0	-	5	1(5)	2	38(5)	12
72	Largemouth bass	1	1(5)	20	6(4)	12	13	17(30)	27	170(22)	53
73	White crappie	0	0	-	4	8	1	1	2	23(1)	7
74	Black crappie	1	0	-	22	44	4	18	28	67(1)	21
75	Rainbow darter	0	0	-	0	-	4	7	11	12	4
76	Iowa darter	0	1	20	14	28	1	2	3	33	10
77	Fantail darter	0	0	-	0	-	6	12	19	30(2)	9
78	Least darter (W)	1	0	-	1	2	4	3	5	12	4
79	Johnny darter	2	2	40	11(1)	22	10	41	64	94(3)	29
80	Banded darter	0	0	-	0	-	2	13	20	14	4
81	Yellow perch	1	0(5)	-	13(1)	26	7	12(27)	19	146(21)	45
82	Logperch	0	0	-	0	-	1	4	6	31	10
83	Blackside darter	1	3	60	10	20	0	3	5	17	5
84	Walleye	0	0(1)	-	0(1)	-	1	1(17)	2	14(12)	4
84	Freshwater drum	0	0	-	0	-	0	1	2	2(1)	1
85	Mottled sculpin	0	0	-	0	-	0	4	6	6(1)	2
	No. of species	29	30		42		62	70		85	
	Total No. of occurrences (Sum of number of species taken at each station)	38	89		570		234	866		3,461	

TABLE 6. *Number of specimens and number of stations for each species collected in the Root River basin, 1974-81.*

Common Name	No. Specimens*	No. Stations** <99	>98	"Unknown"
White sucker	2,300	52	10	1
Creek chub	1,800	43	9	
Fathead minnow	970	43	4	
Green sunfish	770	41	2	
Bigmouth shiner	740	19	5	
Common carp	530	21	3	1
Bluntnose minnow	460	9	3	
Johnny darter	350	13	2	
Common shiner	280	22	1	
Largemouth bass	250	22	1	
Goldfish	240	19	1	
Central mudminnow	240	24		
Black bullhead	180	28		
Brook stickleback	170	24		
Golden shiner	160	21		
Rainbow trout	140	6	1	
Blacknose dace	120	3	1	
Alewife	100	2	1	
Sand shiner	84	2		
Chinook salmon	74	3		
Gizzard shad	68	2		
Bluegill	64	12		
Stonecat	60	2		
Blackside darter	50	5		
Yellow perch	32	13		
Iowa darter	29	6		
Brown trout	17	3		
Pumpkinseed	15	8		
White crappie	15	7		
Lake chubsucker	13	3		
Rock bass	12	1		
Southern redbelly dace	9	4		
Black crappie	7	2		
Warmouth	6	3		
Emerald shiner	3	2		
Blackchin shiner	3	1		
Rainbow smelt	2	1		
Grass pickerel	2	1		
Northern pike	2	2		
Northern redbelly dace	1	1		
Longnose dace	1	1		
Brown bullhead	1	1		
Smallmouth bass	1	1		
Total	10,371	499	44	2

*Rounded to 2 significant figures for each species.
** < 99 = 98 or fewer specimens taken/station.
>98 = 99 or more specimens taken/station.
Unknown = counts of specimens were not made.

TABLE 7. *List of species collected at 5 or fewer stations from the Milwaukee and Fox river basins and at 3 or fewer stations from the Root and Des Plaines river basins (1974-81).*

Root (10)	Milwaukee (20)	Des Plaines (200)	Fox (210)
Alewife	Coho salmon*	Largescale stoneroller	Northern brook lamprey
Gizzard shad	Chinook salmon*	Hornyhead chub	American brook lamprey
Chinook salmon*	Rainbow trout*	Blacknose shiner	Cisco or lake herring
Brown trout	Brown trout	Spotted sucker	Rainbow trout*
Rainbow smelt	Brassy minnow	Brown bullhead	Brook trout*
Grass pickerel	Emerald shiner	Brook silverside	Lake trout*
No. pike	Spottail shiner	Least darter	Muskellunge*
Emerald shiner	Rosyface shiner	Walleye*	Largescale stoneroller
Blackchin shiner	Mimic shiner		Goldfish
Sand shiner	Silver redhorse		Brassy minnow
No. redbelly dace	Shorthead redhorse		Striped shiner
Longnose dace	Channel catfish		No. redbelly dace
Lake chubsucker	Warmouth		Yellow bass
Brown bullhead	Orangespotted sunfish		Longear sunfish
Stonecat			Freshwater drum
Rock bass			
Warmouth			
Black crappie			

*Naturally reproducing population questionable.

TABLE 8. *Fish species collected for the first time during the 1974-81 period from the Root, Milwaukee, Des Plaines, and Fox river basins.*

Root (10)	Milwaukee (20)
Gizzard shad	Coho salmon*
Chinook salmon*	Chinook salmon*
Rainbow smelt	Brook trout
Sand shiner	Goldfish
Longnose dace	Pugnose shiner
Lake chubsucker	Lake chubsucker
Warmouth	Brown bullhead
	Channel catfish
	Blackstripe topminnow
	Warmouth
	Orangespotted sunfish

Des Plaines (200)	Fox (210)
Central stoneroller	Northern brook lamprey
Largescale stoneroller	American brook lamprey
Bigmouth shiner	Lake trout*
Blackchin shiner	Muskellunge*
Spotfin shiner	Goldfish
Sand shiner	Bullhead minnow
Brown bullhead	Silver redhorse
Brook stickleback	River redhorse
Warmouth	Shorthead redhorse
Bluegill	Yellow bass
White crappie	

*Naturally reproducing population questionable.

TABLE 9. *Fish species apparently no longer present in the Root, Milwaukee, Des Plaines, and Fox river basins.*

Last Period Recorded	Root (10)	Milwaukee (20)	Des Plaines (200)	Fox (210)
1900-28	Largescale stoneroller Redside dace Brassy minnow Hornyhead chub Blacknose shiner Spottail shiner Redfin shiner Northern hog sucker Golden redhorse Tadpole madtom Trout-perch White bass Longear sunfish Least darter	American eel Grass pickerel Redside dace Longnose dace Northern hog sucker Ninespine stickleback	Weed shiner Creek chubsucker Rock bass Longear sunfish	Mississippi silvery minnow Weed shiner Slender madtom
1951-73			Redfin shiner Channel catfish	Redfin shiner

TABLE 10. *Fish species reported prior to 1929 but not collected again until 1974-81.*

Root (10)	Milwaukee (20)	Des Plaines (200)	Fox (210)
Northern pike	Blackchin shiner	Blacknose shiner	Cisco or lake herring
Emerald shiner	Blacknose shiner	Pumpkinseed	Largescale stoneroller
Common shiner	Silver redhorse	Black crappie	Striped shiner
Blackchin shiner	Iowa darter	Least darter	Quillback
No. redbelly dace	Mottled sculpin		Golden redhorse
So. redbelly dace			Brown bullhead
Blacknose dace			
Brook stickleback			
Rock bass			
White crappie			
Black crappie			
Iowa darter			
Blackside darter			

Common and Rare Species

The 5 most common species (caught at the highest percentage of complete stations) were white sucker (63%), green sunfish (50%), creek chub (45%), black bullhead (43%), and common shiner (40%) (Table 5). The 5 most numerous species (most specimens caught) were white sucker (4,600), common shiner (3,400), creek chub (3,100), central mudminnow (2,500), and bluntnose minnow (2,300) (Table 12).

Of the 14 rarest species (those caught at 5 or fewer of all the stations, Table 7), all but 2 (brown trout and spottail shiner) were also represented by the smallest number of specimens (Table 12).

Differences Between Time Periods

Eleven species of fish that we collected have not been previously reported for this basin (Table 8).

Six species are apparently no longer present in the Milwaukee River basin (Table 9). The American eel, grass pickerel, redside dace, longnose dace, northern hog sucker, and ninespine stickleback were taken only before 1932. All of these species, except the redside dace, may have been rare for they were reported from only 1 or 2 stations.

The blackchin shiner, blacknose shiner, silver redhorse, Iowa darter, and mottled sculpin were not taken between 1929 and 1972 from this basin (Table 10).

As in the Root River basin, one of the most important results of this study was documentation of changes in the known distribution of species within the Milwaukee River basin in 1973-81 as compared to previous periods (Table 11). These changes have ranged from decreases in the number of stations for 10 species to increases for 50 species, and no change for 2 others. The decreases ranged from 29% for the striped shiner to 100% for 6 species. The increases ranged from 57% for the sand shiner to 3,200% for the central mudminnow (average = 960%). The reasons for the increases generally are the same as for the Root River basin. In 1973-81 there were 55 more streams and 26 more lakes with at least 1 complete station compared to 1951-72 and 46 more streams and 24 more lakes

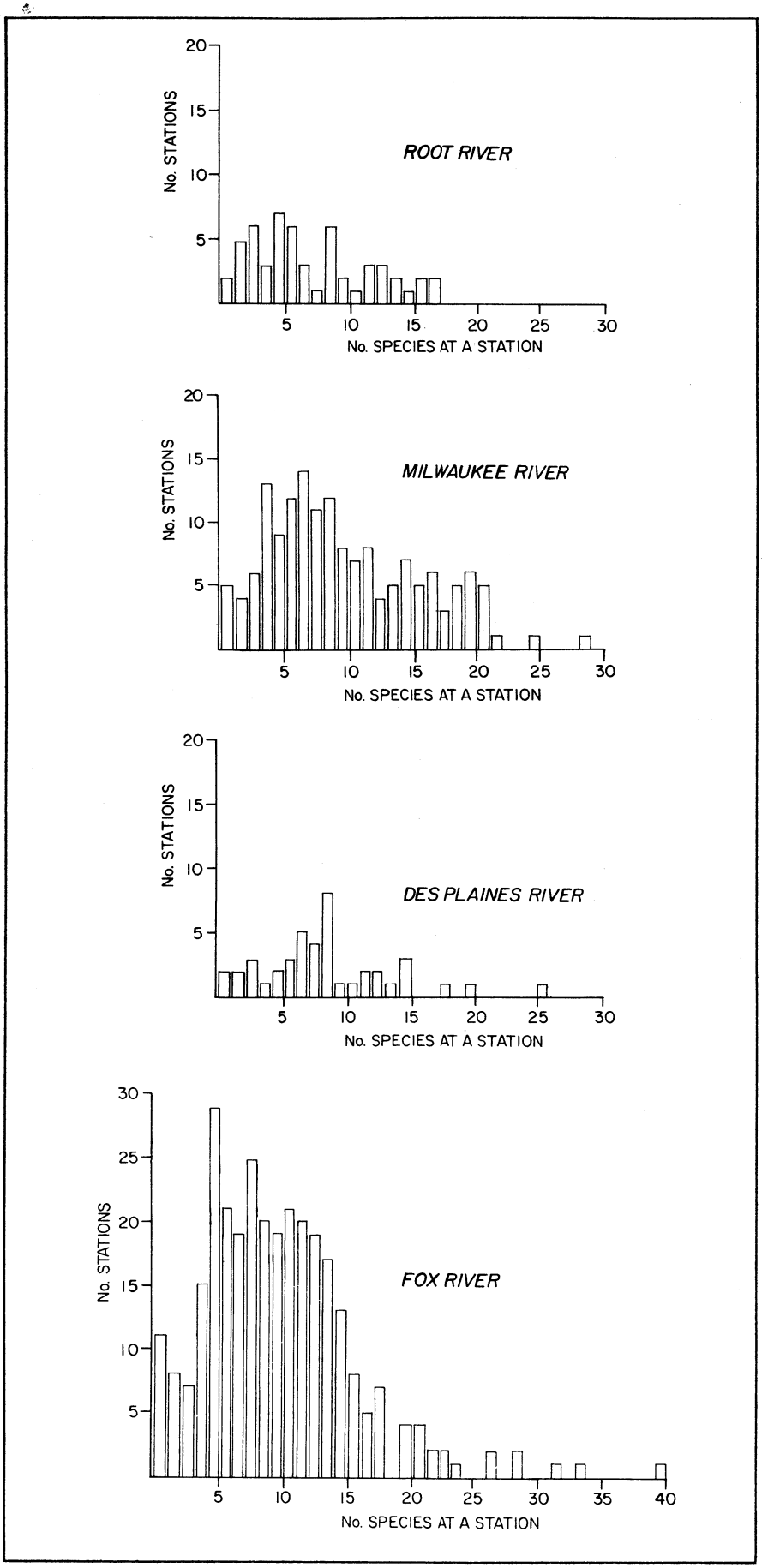


FIGURE 4. *Number of stations at which varying numbers of species were taken in the Root, Milwaukee, Des Plaines, and Fox river basins.*

compared to 1900-28 (Table 2). When the total number of complete stations sampled in the 1973-81 period was compared with the 1951-73 and 1900-28 periods, there were increases of 2,900% and 5,500%, respectively.

Species Diversity

There were 14 stations (9%) sampled by research personnel that had 20 or more species, 1 of which had 29 species (Fig. 4). The average number of species taken per station was 11.

DES PLAINES RIVER BASIN (200)

Species Found

Over 7,000 specimens representing 42 species were identified in samples from the Des Plaines River basin (Tables 5 and 13). This included the pirate perch which is on the watch list. Distribution maps for all species are presented in Appendix B.

Reproducing Populations

In the Des Plaines River basin 39 species are believed to have reproducing populations. The presence of reproducing populations of the rainbow trout, brook trout, and walleye are questionable since all records can be attributed to stocking (R. Piening, pers. comm.).

Common and Rare Species

The 5 most common species (caught at the highest percentage of complete stations) were green sunfish (86%), central mudminnow (68%), golden shiner (68%), fathead minnow (64%), and black bullhead (62%) (Table 5). The 5 most numerous species (most specimens caught) were green sunfish (690), golden shiner (670), bluegill (660), central mudminnow (550), and fathead minnow (510) (Table 13). The black bullhead was the 6th most numerous species.

Of the 8 rarest species (those caught at 3 or fewer of all the stations, Table 7), all but 3 (hornyhead chub, blacknose shiner, and brook silverside) were also represented by the smallest total number of specimens (Table 13).

TABLE 11. *Percent change in occurrence over the next most recent period in which each species was collected in the Root, Milwaukee, Des Plaines, and Fox river basins, 1900-81.**

Species	Root (10)	Milwaukee (20)	Des Plaines (200)	Fox (210)
Northern brook lamprey	-	-	-	-
American brook lamprey	-	-	-	-
Longnose gar	-	-	-	250
Bowfin	-	-	150	47
American eel	-	-100	-	-
Alewife	200	-	-	-
Gizzard shad	-	-	-	-
Cisco or lake herring	-	-	-	100
Coho salmon	-	-	-	-
Chinook salmon	-	-	-	-
Rainbow trout	600	150	-	0
Brown trout	200	150	-	470
Brook trout	-	-	-	50
Lake trout	-	-	-	-
Rainbow smelt	-	-	-	-
Central mudminnow	380	3,200	640	280
Grass pickerel	0	-100	500	440
Northern pike	-33	510	450	85
Muskellunge	-	-	-	-
Central stoneroller	-	2,600	-	2,400
Largescale stoneroller	-100	60	-	-50
Goldfish	900	-	-	-
Redside dace	-100	-100	-	-
Common carp	260	420	500	130
Brassy minnow	-100	100	-	200
Miss. silvery minnow	-	-	-	-100
Hornyhead chub	-100	390	100	120
Golden shiner	2,000	760	750	860
Pugnose shiner	-	-	-	270
Emerald shiner	100	0	-	260
Striped shiner	-	-29	-	-75
Common shiner	190	300	300	120
Bigmouth shiner	2,300	-	-	360
Pugnose minnow	-	-	-	300
Blackchin shiner	0	1,600	-	500
Blacknose shiner	-100	350	100	460
Spottail shiner	-100	0	-	360
Rosyface shiner	-	-80	-	300
Spotfin shiner	-	330	-	1,200
Sand shiner	-	57	-	2,700
Weed shiner	-	-	-100	-100
Redfin shiner	-100	-40	-100	-100
Mimic shiner	-	33	-	3,200
Suckermouth minnow	-	-	-	1,700
No. redbelly dace	-50	1,500	-	50
So. redbelly dace	-43	1,500	-	500
Bluntnose minnow	1,100	400	700	510
Fathead minnow	1,500	710	970	430
Bullhead minnow	-	-	-	-
Blacknose dace	-50	2,700	-	220
Longnose dace	-	-100	-	-
Creek chub	5,100	2,100	330	190
Pearl dace	-	1,600	-	-
Quillback	-	-	-	1,700
White sucker	600	590	400	120
Creek chubsucker	-	-	-100	-
Lake chubsucker	-	-	-33	69
Northern hog sucker	-100	-100	-	83
Spotted sucker	-	-	-67	-
Silver redhorse	-	-50	-	-
River redhorse	-	-	-	-
Golden redhorse	-100	400	-	1,600
Shorthead redhorse	-	100	-	-
Greater redhorse	-	1,300	-	-
Black bullhead	2,700	590	1,500	690
Yellow bullhead	-	2,800	1,500	470
Brown bullhead	0	-	-	2,600
Channel catfish	-	-	-100	67
Slender madtom	-	-	-	-100
Stonecat	100	830	-	280
Tadpole madtom	-100	100	400	130
Pirate perch	-	-	230	-
Trout-perch	-100	-	-	-
Banded killifish	-	1,000	-	1,100
Blackstripe topminnow	-	-	140	300
Starhead topminnow	-	-	-	250
Brook silverside	-	-	0	400
Brook stickleback	300	-	-	170
Ninespine stickleback	-	-100	-	-
White bass	-100	-	-	700
Yellow bass	-	-	-	-
Rock bass	-80	430	-100	530
Green sunfish	760	1,100	1,300	580
Pumpkinseed	300	620	2,200	760
Warmouth	-	-	-	2,100
Orangespotted sunfish	-	-	-	570
Bluegill	300	2,400	-	580
Longear sunfish	-100	150	-100	150
Smallmouth bass	-	200	-	620
Largemouth bass	2,300	950	67	310
White crappie	130	-	-	2,300
Black crappie	100	780	2,100	280
Rainbow darter	-	-	-	71
Iowa darter	100	2,400	1,300	1,600
Fantail darter	-	3,000	-	170
Least darter	-100	600	0	300
Johnny darter	650	1,900	500	140
Banded darter	-	-	-	8
Yellow perch	1,200	470	180	330
Logperch	-	950	-	680
Blackside darter	150	260	230	470
Walleye	-	130	0	44
Freshwater drum	-	-	-	200
Mottled sculpin	-	1,300	-	75

*Data in Table 5 were used in these calculations.

TABLE 12. *Number of specimens and number of stations for each species collected in the Milwaukee River basin, 1973-81.*

Common Name	No. Specimens*	No. Stations** <99	>98	"Unknown"
White sucker	4,600	162	13	4
Common shiner	3,400	83	20	
Creek chub	3,100	91	16	1
Central mudminnow	2,500	87	11	1
Bluntnose minnow	2,300	96	9	
Brook stickleback	1,800	52	9	
Green sunfish	1,700	117	3	1
Blacknose dace	1,400	48	8	
Bluegill	1,400	69	7	
Black bullhead	1,400	98	5	1
Hornyhead chub	1,300	48	6	
Fathead minnow	1,200	62	3	
Johnny darter	1,100	75	3	
Largemouth bass	1,100	103	1	1
Stonerollers	990	8	9	1
Pumpkinseed	830	91	2	
Common carp	700	58	3	7
Rock bass	690	53		
Yellow perch	590	73	1	
Mottled sculpin	590	26	1	
Northern pike	570	101	1	
Fantail darter	530	30	1	
Spotfin shiner	470	25	1	
Logperch	410	19	2	
Northern redbelly dace	380	14	2	
Sand shiner	380	21	1	
Yellow bullhead	360	57		
Golden shiner	340	42	1	
Pearl dace	330	17		
Stonecat	320	28		
Iowa darter	300	23	2	
Goldfish	280	20	2	1
Southern redbelly dace	240	16		
Central stoneroller	160	27		
Walleye	140	8	1	
Blackchin shiner	120	17		
Black crappie	120	35		
Brown trout	110	4	1	
Blacknose shiner	95	18		
Golden redhorse	83	15		
Striped shiner	82	10		
Blackstripe topminnow	80	9		
Blackside darter	73	18		
Smallmouth bass	67	9		
Spottail shiner	51	5		
Tadpole madtom	51	20		
Longear sunfish	46	10		
Greater redhorse	44	14		
Banded killifish	42	11		
Largescale stoneroller	41	8		
Lake chubsucker	33	7		
Brook trout	32	8		
Pugnose shiner	31	7		
Redfin shiner	30	6		
Shorthead redhorse	23	4		
Rainbow trout	13	5		
Least darter	13	7		
Brown bullhead	11	6		
Mimic shiner	7	4		
Brassy minnow	4	2		
Coho salmon	3	2		
Chinook salmon	3	2		
Orangespotted sunfish	3	2		
Rosyface shiner	2	1		
Channel catfish	1	1		
Emerald shiner	1	1		
Silver redhorse	1	1		
Warmouth	1	1		
Total	39,217	2,218	145	18

* Rounded to 2 significant figures for each species.

** < 99 = 98 or fewer specimens taken/station.
> 98 = 99 or more specimens taken/station.
Unknown = counts of specimens were not made.

TABLE 13. *Number of specimens and number of stations for each species collected in the Des Plaines River basin, 1974-81.*

Common Name	No. Specimens*	No. Stations** <99	>98	"Unknown"
Green sunfish	690	43		
Golden shiner	670	32	2	
Bluegill	660	23	4	
Central mudminnow	550	35	2	
Fathead minnow	510	30	2	
Black bullhead	480	30	1	
Common carp	370	29	1	
White sucker	290	25		
Common shiner	270	11	1	
Spotfin shiner	270	9	1	
Pumpkinseed	270	23		
Bluntnose minnow	260	15	1	
Yellow perch	250	13	1	
Northern pike	230	32	1	
Sand shiner	230	7	1	
Stonerollers	200	2	1	
Black crappie	170	21	1	
Johnny darter	170	12		
Iowa darter	160	13	1	
Largemouth bass	160	10		
Creek chub	130	13		
Blackstripe topminnow	110	12		
Brook silverside	99		1	
Blackside darter	87	10		
Brook stickleback	86	16		
Hornyhead chub	61	2		
Bigmouth shiner	49	5		
Blacknose shiner	48	2		
Tadpole madtom	44	10		
Yellow bullhead	37	16		
Lake chubsucker	32	4		
Blackchin shiner	25	4		
Central stoneroller	20	6		
Warmouth	15	5		
Pirate perch	9	6		
Grass pickerel	8	6		
Bowfin	6	5		
Least darter	6	1		
Spotted sucker	5	1		
White crappie	5	4		
Brown bullhead	3	1		
Walleye	3	1		
Largescale stoneroller	1	1	—	—
Total	7,749	546	22	0

* Rounded to 2 significant figures for each species.
** < 99 = 98 or fewer specimens taken/station.
> 98 = 99 or more specimens taken/station.
Unknown = counts of specimens were not made.

Differences Between Time Periods

Eleven species of fish that we collected have not been previously reported for this basin (Table 8).

Six species are apparently no longer present in the Des Plaines River basin (Table 9). The weed shiner, creek chubsucker, rock bass, and longear sunfish were taken only before 1932, and the redfin shiner and channel catfish were most recently taken in the 1951-73 time period. These species were apparently rare in earlier years, for they had been reported from only 1 or 2 stations. It is doubtful if a reproducing population of the channel catfish ever existed.

The blacknose shiner, pumpkinseed, black crappie, and least darter were not taken between 1929 and 1973 from this basin (Table 10).

Again, one of the most important results of this study was documentation of changes in the known distribution of species within the Des Plaines River basin in 1974-81 as compared to previous periods (Table 11). These changes ranged from decreases in the number of stations for 8 species to increases for 26 species, and no change for 3 others. The decreases ranged from 33% for the lake chubsucker to 100% for 6 species. The increases ranged from 67% for the largemouth bass to 2,200% for the pumpkinseed (average = 670%). The reasons for the increases are generally the same as for the other 2 basins. In 1974-81 there were 12 more streams and 11 more lakes with at least 1 complete station compared to 1951-73 and 13 more streams and 10 more lakes compared to 1900-28 (Table 2). When the total number of complete stations sampled in the 1974-81 period is compared with the 1951-73 and 1900-28 periods, there were increases of 900% and 1,600%, respectively.

Species Diversity

There were only 2 stations sampled by research personnel that had 20 or more species, 1 of which had 26 species, and only 6 had 15 or more species (Fig. 4). The average number of species taken per station was 9.

FOX RIVER BASIN (210)

Species Found

About 58,000 specimens representing 85 species were identified in samples from the Fox River basin (Tables 5

TABLE 14. *Number of specimens and number of stations for each species collected in the Fox River basin, 1974-81.*

Common Name	No. Specimens*	No. Stations** <99	>98	"Unknown"
Bluntnose minnow	7,000	155	39	
Bluegill	5,300	156	21	
Yellow perch	3,100	152	15	
White sucker	3,000	133	8	5
Common carp	2,500	81	15	5
Common shiner	2,400	71	14	
Largemouth bass	2,400	188	4	
Brook silverside	2,300	57	12	1
Pumpkinseed	2,100	169	3	
Creek chub	1,900	75	3	
Spotfin shiner	1,600	70	7	
Central stoneroller	300(1,300)[a]	49(10)	(10)	
Sand shiner	1,500	47	8	
Central mudminnow	1,300	79	5	
Green sunfish	1,300	128	2	
Mimic shiner	1,200	25	8	
Hornyhead chub	1,200	42	2	
Johnny darter	1,100	95	2	
Blacknose shiner	1,000	45	5	
Fantail darter	830	29	3	
Golden shiner	820	73	4	
Bigmouth shiner	760	23	2	
Black crappie	740	66	2	
Blackchin shiner	700	29	2	
Blacknose dace	680	31	1	
Black bullhead	570	60	2	1
Fathead minnow	570	69		
Southern redbelly dace	520	9	3	
Brook stickleback	520	42		1
Emerald shiner	500	42	1	
Spottail shiner	500	36	1	
Banded killifish	500	45	1	
Northern pike	470	70	1	3
Walleye	460	24	2	
Brown trout	440	14	3	
Yellow bullhead	370	56	1	
Quillback	350	18		
Warmouth	350	44		
Smallmouth bass	330	43		
Logperch	310	31		
Suckermouth minnow	270	17	1	
Rock bass	260	46		
Lake chubsucker	250	44		
Brown bullhead	220	26		1
Iowa darter	210	33		
Channel catfish	200	24	1	
Banded darter	200	13	1	
Rosyface shiner	200	8		
Grass pickerel	190	59		
Stonecat	160	19		
Blackstripe topminnow	160	12		
White crappie	150	23	1	
Golden redhorse	140	17		
Cisco or lake herring	120	3	1	
Tadpole madtom	120	16		
Brook trout	110	2	1	
River redhorse	110	6	1	
Pugnose shiner	97	11		
Mottled sculpin	92	6	1	
Longear sunfish	91	5		
Rainbow darter	90	12		
Northern hog sucker	76	11		
Blackside darter	70	17		
Pugnose minnow	66	7		
Orangespotted sunfish	65	20		
Bullhead minnow	60	10		
Rainbow trout	54	3		
Starhead topminnow	52	7		
Bowfin	47	21		1
Shorthead redhorse	43	8		
Least darter	42	12		
Silver redhorse	37	7		
Longnose gar	32	12		2
White bass	16	8		
Largescale stoneroller	13	1		
Muskellunge	11	1		
Northern redbelly dace	11	3		
American brook lamprey	4	1		
Yellow bass	4	2		
Freshwater drum	4	3		
Lake trout	3	1		
Brassy minnow	3	3		
Northern brook lamprey	2	1		
Goldfish	1	1		
Striped shiner	1			
Total	57,847(1,300)	3,244(10)	209(10)	21

*Rounded to 2 significant figures for each species.
** <99 = 98 or fewer specimens taken/station.
>98 = 99 or more specimens taken/station.
Unknown = counts of specimens were not made.
[a]Number in parentheses is for stonerollers not keyed to species.

and 14). This includes the endangered striped shiner and starhead topminnow, the threatened longear sunfish, and 5 watch species. Distribution maps for all species are presented in Appendix B.

Reproducing Populations

In the Fox River basin 81 species are believed to have reproducing populations. The presence of reproducing populations of 4 other species (rainbow trout, brook trout, lake trout, and muskellunge) is questionable since all accounts can be attributed to stocking (R. Piening, pers. comm.).

Common and Rare Species

The 5 most common species (caught at the highest percentage of complete stations) were bluntnose minnow (57%), bluegill (55%), pumpkinseed (53%), largemouth bass (53%), and yellow perch (45%) (Table 5). The 5 most numerous species (most specimens caught) were bluntnose minnow (7,000), bluegill (5,300), yellow perch (3,100), white sucker (3,000), and common carp (2,500) (Table 14). The pumpkinseed and largemouth bass were the 9th and 7th most numerous species.

Of the 15 rarest species (those caught at 5 or fewer of all the stations, Table 7), all but 4 (cisco or lake herring, rainbow trout, brook trout, and longear sunfish) were also represented by the smallest total number of specimens (Table 14).

Differences Between Time Periods

Ten species of fish that we collected have not been previously reported for this basin (Table 8).

The Mississippi silvery minnow, weed shiner, redfin shiner, and slender madtom are apparently no longer present in the Fox River basin (Table 9). However, they may have been rare even in the early 1900's for they were reported from only 1 or 2 stations.

Six species that we collected were not taken between 1929 and 1973 from this basin (Table 10).

As in the 3 other basins, one of the most important results of this study was the documentation of changes in the known distribution species within the Fox River basin in 1974-81 as compared to previous periods (Table 11). These changes ranged from decreases in the number of stations for 6 species to increases for 72 species, and no change for 1 other. The decreases ranged from 50% for the largescale stoneroller to 100% for 4 species. The increases ranged from 8% for the banded darter to 3,200% for the mimic shiner (average = 590%). The reasons for the increases are, again, generally the same as for the other 3 basins. In 1974-81 there were 34 more streams and 47 more lakes with at least 1 complete station compared to 1951-73 and 52 more streams and 45 more lakes compared to 1900-28 (Table 2). When the total number of complete stations sampled in the 1974-81 period was compared with the 1951-73 and 1900-28 periods, there were increases of 400% and 900%, respectively.

TABLE 15. *Fish species collected in only one of the four basins, 1974-81.**

Root (10)	Milwaukee (20)	Des Plaines (200)	Fox (210)
Alewife	Coho salmon*	Spotted sucker	No. brook lamprey
Gizzard shad	Redfin shiner	Pirate perch	Am. brook lamprey
Rainbow smelt	Pearl dace		Longnose gar
Longnose dace	Greater redhorse		Cisco or lake herring
			Lake trout*
			Muskellunge*
			Pugnose minnow
			Suckermouth minnow
			Bullhead minnow
			Quillback
			No. hog sucker
			River redhorse
			Starhead topminnow
			White bass
			Yellow bass
			Rainbow darter
			Banded darter
			Freshwater drum

* Naturally reproducing population questionable.

Species Diversity

Twenty stations (6%) sampled by research personnel in the Fox River basin had 20 or more species and 6 stations had more than 25 species (Fig. 4). The average number of species taken per station was 10.

DIFFERENCES BETWEEN BASINS (10, 20, 200, 210)

Of the 85 species found in the Fox River basin, 18 were not found in the Root, Milwaukee, or Des Plaines river basins (Table 15). Of the 42 species found in the Root River basin, 4 were not captured in the 3 other basins. Of the 67 species found in the Milwaukee River basin, 4 were not taken in the other 3. Of the 42 species found in the Des Plaines River basin, only the spotted sucker and pirate perch were not captured in the 3 other basins.

ENDANGERED SPECIES

Two endangered species were found in the Fox River basin, 1 in the Milwaukee River basin, and none in the 2 other basins (Table 16). A total of 83 **striped shiners** were taken at 11 stations in 5 streams in the Milwaukee River basin and 1 specimen in Wind Lake in the Fox River basin (Append. B Map 21). Previously, this species had been reported from 18 stations in 3 streams and 1 millpond in the Milwaukee River basin and from 4 stations in 2 rivers and 1 lake in the Fox River basin. We sampled the Kinnickinnic, Fox, and White rivers (which previously contained striped shiners) but did not find any striped shiners. It appears that the striped shiner is near extirpation in the Fox River basin. A total of 52 **starhead topminnows** were captured at 7 stations in 2 rivers and 3 lakes in the Fox River basin (Append. B Map 60). It had been reported from 1 of these rivers and 2 of these lakes in the past.

Habitat characteristics for the 2 endangered species are shown in Table 17.

TABLE 16. *Endangered species collected in the Root (10), Milwaukee (20), Des Plaines (200), and Fox (210) river basins during 1974-81 and records from stations in other Wisconsin basins since 1974.*

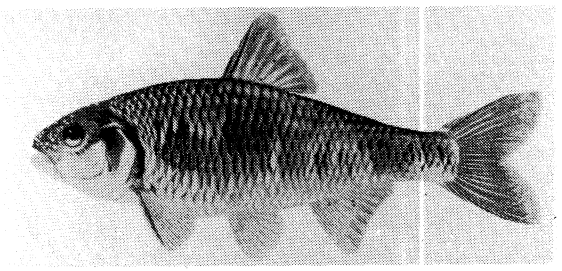
Species	Basin	Body of Water	County	No. Stations	No. Fish	Avg. No. Fish/Station	No. Records From Other Basins*
Striped shiner	20	Milwaukee R.	Milwaukee	2	17		2 (30,221)
		Milwaukee R.	Ozaukee	4	46		
		Pigeon Cr.	Ozaukee	1	16		
		Cedar Cr.	Ozaukee	1	1		
		Stony Cr.	Washington	1	1		
		Mink Cr.	Sheboygan	1	1		
	210	Wind L.	Racine	1	1		
			Total	11	83	8	
Starhead topminnow	210	Fox R.	Waukesha	1	1		2 (222,270)
		Mukwonago R.	Waukesha	2	20		
		Lower Phantom L.	Waukesha	2	24		
		Upper Phantom L.	Waukesha	1	4		
		L. Beulah	Waukesha	1	3		
			Total	7	52	7	

* Basin numbers shown in parentheses (see Fig. 1).

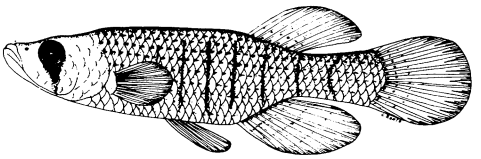
TABLE 17. *Characteristics of aquatic habitat for selected species collected in the Root, Milwaukee, Des Plaines, and Fox river basins, 1974-81.*

Species	Stream Width (m)	Avg. Stream Depth (m)	Velocity*	Turbidity*	Cond. (μmhos)	Temp. (F)
ENDANGERED						
Striped shiner	20-50	0.5	moderate	slightly turbid	600-780	61-77
Starhead topminnow	47% of stations in littoral zone of lakes with abundant aquatic vegetation			clear	350-750	48-78
THREATENED						
Longear sunfish	20-60	0.5-10	moderate	clear to slight	350-850	47-77
WATCH						
Pugnose shiner	94% of stations in littoral zone of lakes with abundant aquatic vegetation			clear to slight	100-450	75-83
Pugnose minnow	all stations in littoral zone of lakes with abundant aquatic vegetation			slight to moderate	450-650	76-79
Lake chubsucker	50% of stations in littoral zone of lakes with abundant aquatic vegetation			slight	280-1,300	50-82
River redhorse	30-60	0.3-1.0	moderate	turbid	500-650	74-79
Greater redhorse	30-60	0.1-1.0	moderate	slight	520-770	62-78
Pirate perch	2-5	0.2-0.8	moderate	moderate	340-760	63-75
Least darter	65% of stations in littoral zone of lakes with aquatic vegetation			clear to slight	225-725	58-78

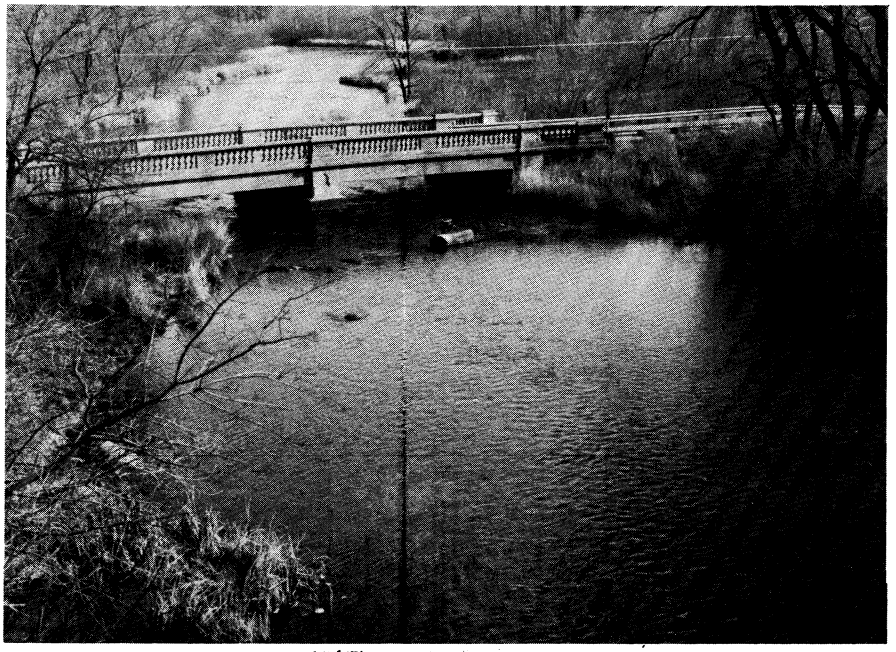
* Terms are defined in Fago (1984b).



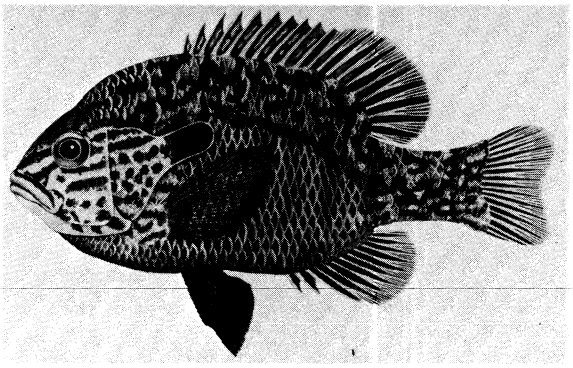
The striped shiner, whose range has been virtually restricted to 5 small-to-medium-size rivers in the Milwaukee River basin, is an endangered species in Wisconsin.



The starhead topminnow, an endangered species in Wisconsin, prefers sloughs and backwaters of well-vegetated lakes.



Mukwonago River (Fox River basin) looking downstream from railroad trestle 2 miles from its mouth. Forty species of fish were taken at this location including the starhead topminnow, on the endangered list, and the longear sunfish, on the threatened list.



The longear sunfish, a threatened species in Wisconsin, prefers medium to larger rivers and lakes.

THREATENED SPECIES

The **longear sunfish** was the only threatened species caught in the Milwaukee and Fox River basins; no threatened species were taken in the 2 other basins (Table 18). A total of 137 specimens at 15 stations were captured in 3 rivers and 1 lake in the Milwaukee River basin and 3 rivers in the Fox River basin (Append. B Map 70). The species had been previously collected from all 4 basins: 2 stations in the Root River, 8 stations and 1 millpond in the Milwaukee River, 1 station in the Des Plaines River, and a total of 5 stations from 3 rivers in the Fox River basin. It appears as if this species has been extirpated from the Root and Des Plaines river basins. Habitat for this species is shown in Table 17.

WATCH SPECIES

A total of 8 watch species were taken in these 4 basins (10, 20, 200, 210) (Table 19). The **pugnose shiner** was captured at 18 stations from 7 lakes in the Milwaukee and 10 lakes and 1 river in the Fox River basins (Append. B Map 19). This species was previously reported from only 3 stations on 2 rivers and 1 lake in the Fox River basin. The **pugnose minnow** was caught at a total of 7 stations from 4 lakes in the Fox River basin (Append. B Map 24). It was previously reported from only Bassett Creek in the Fox River basin. The **redfin shiner** was captured at a total of 6 stations from 3 streams and 1 pond in the Milwaukee River basin (Append. B Map 31). Previously, this species was reported from a total of 28 stations from 4 streams in the Root

TABLE 18. *Threatened species collected in the Root, Milwaukee, Des Plaines, and Fox river basins during 1974-81 and records from stations in other Wisconsin basins since 1974.*

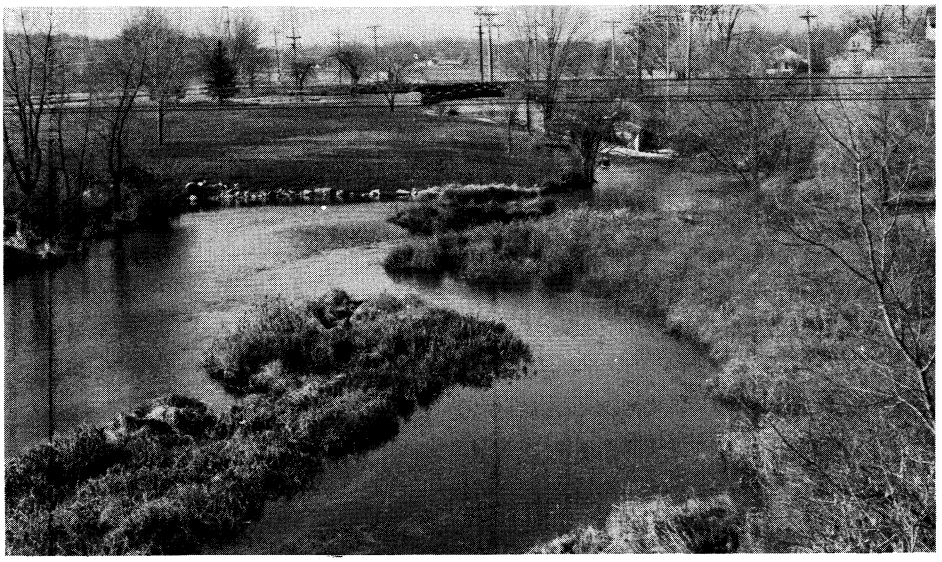
Species	Basin	Body of Water	County	No. Stations	No. Fish	Avg. No. Fish/Station	No. Records From Other Basins*
Longear sunfish	20	Milwaukee R.	Ozaukee	3	17		7 (82,90,100,
		Milwaukee R.	Washington	2	6		300)
		E. Br. Milwaukee R.	Washington	1	2		
		E. Br. Milwaukee R.	Fond du Lac	1	9		
		Mauthe L.	Fond du Lac	1	1		
		W. Br. Milwaukee R.	Fond du Lac	2	11		
	210	Fox R.	Racine	1	1		
		Fox R.	Waukesha	1	1		
		White R.	Walworth	1	3		
		Mukwonago R.	Waukesha	2	86		
			Total	15	137	9	

* Basin numbers shown in parentheses (see Fig. 1).

River basin, the Des Plaines River, and Muskego Creek in the Fox River basin. Apparently, it is now extirpated from these 3 basins. The **lake chubsucker** was taken at 57 stations from 3 streams in the Root River basin, 3 streams and 4 lakes from the Milwaukee River basin, 2 streams and 2 lakes in the Des Plaines River basin, and 10 streams and 18 lakes in the Fox River basin (Append. B Map 44). This species was previously collected at 17 stations from 1 creek in the Milwaukee River basin, 1 creek and 1 lake from the Des Plaines River basin, and 5 streams and 2 lakes in the Fox River basin.

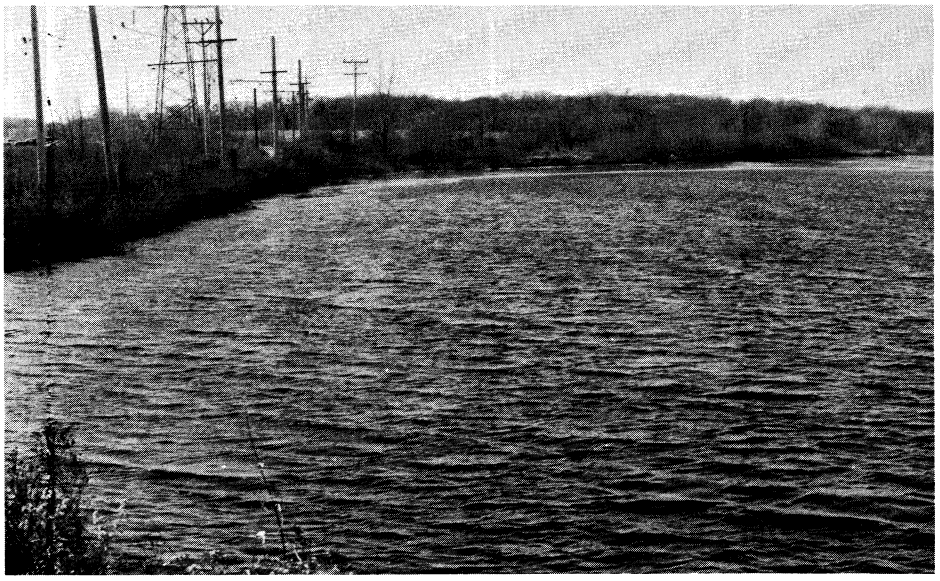
The **river redhorse** was taken at 7 stations from 2 rivers in the Fox River basin (Append. B Map 47). This species had not been reported in any of the 4 basins. The **greater redhorse** was taken at 14 stations from 4 streams in the Milwaukee River basin (Append. B., Map 50), it was previously taken from 5 stations on 4 streams in this same basin. The **pirate perch** was caught at 10 stations from 5 streams in the Des Plaines River basin (Append. B Map 57). This species was previously reported from a total of 3 stations on 3 streams in this basin. The **least darter** was captured at 20 stations from 4 streams and 3 lakes in the Milwaukee River basin, Paddock Lake in the Des Plaines River basin, and 4 streams and 7 lakes in the Fox River basin (Append. B Map 78). Previously, this species was caught at a total of 27 stations from 7 streams in the Root River basin, 7 streams from the Milwaukee River basin, the Des Plaines River, and 6 streams in the Fox River basin. This species has apparently been extirpated from the Root River basin.

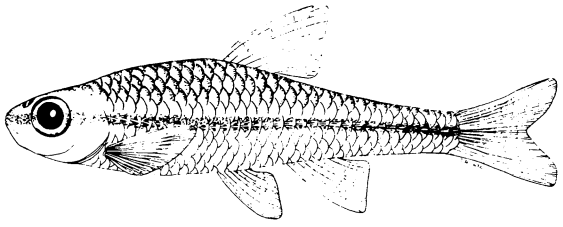
Habitat characteristics for all of the watch species except the redfin shiner are shown in Table 17.



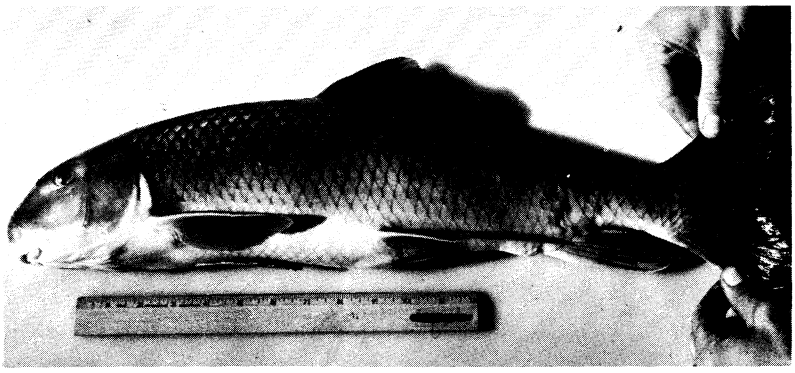
Mukwonago River looking upstream from railroad trestle in the City of Mukwonago. Lower Phantom Lake is in the background. (above)

Habitat of the starhead topminnow in Lower Phantom Lake. (below)





The pugnose shiner, a species presently on the watch list, prefers clear, weedy lakes. When this study began, it was on Wisconsin's endangered list.



The greater redhorse, presently on the watch list, inhabits larger rivers and lakes. When this study began, it was on Wisconsin's endangered list.

TABLE 19. *Watch species collected in the Root, Milwaukee, Des Plaines, and Fox river basins during 1974-81 and records from stations in other Wisconsin basins since 1974.*

Species	Basin	Body of Water	County	No. Stations	No. Fish	Avg. No. Fish/Station	No. Records From Other Basins*
Pugnose shiner	20	Forest L.	Fond du Lac	1	4		43 (81,82,221, 300,310)
		Big Cedar L.	Washington	1	1		
		Lucas L.	Washington	1	3		
		Silver L.	Washington	1	5		
		Crooked L.	Sheboygan	1	14		
		Mauthe L.	Fond du Lac	1	3		
		Tittle L.	Fond du Lac	1	1		
	210	Elizabeth L.	Kenosha	1	1		
		L. Mary	Kenosha	1	1		
		Benedict L.	Kenosha	1	27		
		Cross L.	Kenosha	1	53		
		Silver L.	Kenosha	1	1		
		Waubeesee L.	Racine	1	2		
		L. Kec-Nong-Ga-Mong	Racine	1	1		
		Mukwonago R.	Waukesha	1	1		
		Upper Phantom L.	Waukesha	1	5		
		L. Beulah	Walworth	1	1		
		Lulu L.	Walworth	1	4		
			Total	18	128	7	
Pugnose minnow	210	Camp L.	Kenosha	2	4		117 (2,81,82, 240,221,240, 270,280,300, 310)
		Center L.	Kenosha	1	3		
		Wind L.	Racine	3	57		
		Tichigan L.	Racine	1	2		
			Total	7	66	9	
Redfin shiner	20	Cedar Cr.	Ozaukee	3	16		21 (82,90,221, 222,240,300)
		Cedarburg Pond	Ozaukee	1	12		
		N. Br. Milwaukee R.	Washington	1	1		
		Wallace Cr.	Washington	1	1		
			Total	6	30	5	
Lake chubsucker	10	W. Br. Root R. Canal	Racine	1	11		38 (30,81,82,221)
		Un. Cr.	Milwaukee	1	1		
		Un. Cr.	Milwaukee	1	1		
	20	Cedar Cr.	Washington	1	3		
		N. Br. Cedar Cr.	Washington	1	1		
		Hasmer L.	Washington	1	2		
		Tilly L.	Washington	1	18		
		Mayfield Pd.	Washington	1	1		
		Crooked L.	Sheboygan	1	3		
		Un. Cr.	Fond du Lac	1	5		
	200	Lower Pleasant Prairie Dit.	Kenosha	1	4		
		Paddock L.	Kenosha	1	25		
		Hooker L.	Kenosha	1	1		
		Un. Cr.	Kenosha	1	2		
	210	Pleasant L.	Walworth	1	1		
		Rockland L.	Racine	1	19		
		Fox R.	Waukesha	1	2		
		Elizabeth L.	Kenosha	1	2		
		E. Br. Nippersink Cr.	Walworth	1	5		
		Tombeau L.	Walworth	1	4		
		Benedict L.	Kenosha	1	2		
		Rock L.	Kenosha	1	3		
		Camp L.	Kenosha	2	21		
		Center L.	Kenosha	1	1		
		Silver L.	Kenosha	1	5		
		Peterson Cr.	Kenosha	1	1		
		Honey Cr.	Walworth	3	5		
		Spring Cr.	Walworth	1	6		
		Mill L.	Walworth	2	16		
		L. Kec-Nong-Ga-Mong	Racine	1	1		

(Cont. on next page)

TABLE 19 *(Cont.)*

Species	Basin	Body of Water	County	No. Stations	No. Fish	Avg. No. Fish/Station	No. Records From Other Basins*
Lake chubsucker cont.		L. Denoon	Waukesha	1	10		
		Muskego Canal	Waukesha	1	1		
		Mukwonago R.	Waukesha	6	41		
		Lower Phantom L.	Waukesha	3	24		
		Upper Phantom L.	Waukesha	1	1		
		L. Beulah	Walworth	5	38		
		Un. Cr.	Walworth	1	3		
		Eagle Spring L.	Waukesha	2	25		
		Lulu L.	Walworth	1	2		
		Genesee Cr.	Waukesha	1	3		
		Pewaukee L.	Waukesha	1	2		
		Un. Ditch	Waukesha	1	4		
			Total	57	326	6	
River redhorse	210	Fox R.	Kenosha	3	3		64 (2,82,221,222, 240,270,300, 310)
		Fox R.	Racine	3	103		
		White R.	Racine	1	2		
			Total	7	108	15	
Greater redhorse	20	Milwaukee R.	Milwaukee	1	3		83 (5,40,50,82, 100,110,,221, 240,300,310)
		Milwaukee R.	Ozaukee	7	22		
		Milwaukee R.	Washington	1	1		
		Cedar Cr.	Ozaukee	1	9		
		N. Br. Milwaukee R.	Washington	1	5		
		N. Br. Milwaukee R.	Sheboygan	2	2		
		W. Br. Milwaukee R.	Fond du Lac	1	2		
			Total	14	44	3	
Pirate perch	200	Des Plaines R.	Kenosha	1	1		15 (240,250,270, 280,290)
		Jerome Cr.	Kenosha	3	29		
		Un. Ditch	Kenosha	1	1		
		Kilbourn Road Ditch	Kenosha	3	3		
		Kilbourn Road Ditch	Racine	1	4		
		Salem Br.	Kenosha	1	1		
			Total	10	39	4	
Least darter	20	N. Br. Cedar Cr.	Washington	1	2		68 (82,221,222, 270,300,310)
		Wallace Cr.	Washington	1	1		
		Green L.	Washington	1	4		
		Silver Cr.	Washington	1	1		
		Silver L.	Washington	1	1		
		Un. Cr.	Sheboygan	1	1		
		Long L.	Fond du Lac	1	3		
	200	Paddock L.	Kenosha	1	6		
	210	Fox R.	Waukesha	1	7		
		Benedict L.	Kenosha	1	2		
		Rock L.	Kenosha	1	1		
		Center L.	Kenosha	1	1		
		White R.	Walworth	1	1		
		Sugar Cr.	Walworth	1	10		
		L. Geneva	Walworth	2	3		
		Waubeesee L.	Racine	1	11		
		L. Kec-Nong-Ga-Mong	Racine	1	1		
		Mukwonago R.	Walworth	1	4		
		L. Beulah	Walworth	1	1		
			Total	20	61	3	

RECOMMENDATIONS

CONTINUING USE OF FISH DISTRIBUTION DATA

The data in both the Master Fish and Master Stream and Lake files* are available and should be used by interested persons when preparing environmental impact assessments, forming master plans, and planning future research studies.

FUTURE RESEARCH STUDIES

This series of reports on fish distribution does not deal generally with the ecological data collected during the 1974-81 period. Analysis of these data should be the subject of another study. The species composition of fish communities and their relationship to the ecological data collected are two other subjects for study.

The potential integration of the data compiled by the study with data collected by other researchers on, for example, water quality, open up further areas for study and analysis.

*See section on Data Handling in this report and Fago (1984b) for explanation of these files.

PROTECTION OF ENDANGERED AND THREATENED SPECIES AND THEIR HABITAT

Striped Shiner. This endangered species has been nearly extirpated from the Fox River basin. Any manipulation of the aquatic environment in the Milwaukee River basin where populations of this species are known to occur should be done with great care to preserve its habitat. This is virtually the sole remaining area for this species in Wisconsin, since there are only two other locations in Wisconsin where a total of 2 specimens were taken.

Starhead Topminnow. The lakes and streams in the Mukwonago area have the best known populations of this endangered topminnow in Wisconsin. Any manipulations of this aquatic environment should take the presence of this species into account.

Longear Sunfish. This threatened sunfish is believed to have been extirpated from both the Root and Des Plaines river basins. Management of the aquatic habitat in the areas of the Milwaukee and Fox river basins where populations of the longear sunfish are known to occur should take the presence of this species into account.

UPDATING PRESENT RECORDS

District fish management personnel should in the course of routine surveys preserve at least 1 specimen of each endangered, threatened, and watch species they observe (except paddlefish, lake sturgeon, and American eel) and notify the Bureau of Research. Such collections will permit continuing reassessment of the endangered and threatened species lists as required by law and of the watch list as well.

COMPLETION OF THIS SURVEY

Completion of a statewide survey has not been achieved due to funding reduction; only 45% of the state has been covered. When additional funds become available for investigations of endangered, threatened, and/or nongame species, high priority should be accorded to completion of the surveys in compliance with the legislative mandate.

LITERATURE CITED

AMIN, OMAR M., JOSEPH S. BALSANO, AND KATHY A. PFALZGRAF
1973. *Lernaea cyprinacea* Linn. (Copepoda: Crustacea) from Root River, Wisconsin, Fishes. Am. Midl. Nat. 89(2):484-87.

BECKER, GEORGE C.
1959. Distribution of central Wisconsin fishes. Trans. Wis. Acad. Sci., Arts, and Lett. 48:65-102.
1964a. The fishes of Lakes Poygan and Winnebago. Trans. Wis. Acad. Sci., Arts, and Lett. 53:29-52.
1964b. The fishes of Pewaukee Lake. Trans. Wis. Acad. Sci., Arts, and Lett. 53:19-27.
1966. Fishes of southwestern Wisconsin. Trans. Wis. Acad. Sci., Arts, and Lett. 55:87-117.
1983. Fishes of Wisconsin. Univ. Wis. Press, Madison. 1052 pp.

CAHN, A. R.
1927. An ecological study of southern Wisconsin fishes, the brook silverside (*Labidesthes sicculus*) and cisco (*Leucichthys artedi*), in relation to the region. Ill. Biol. Monogr. 11:1-151.

ENCAP, INC. - D. W. GREENFIELD
1980. Habitat evaluation of the upper Des Plaines River and adjacent wetlands, 1979-80. Final Rep. Part 3. filed at U.S. Environ. Prot. Agency, Reg. V, 250. S. Dearborn, Chicago, IL. pp. 69-88.

FAGO, DON
1982. Distribution and relative abundance of fishes in Wisconsin. I. Greater Rock River basin. Wis. Dep. Nat. Resour. Tech. Bull. No. 136. 120 pp.
1983. Distribution and relative abundance of fishes in Wisconsin. II. Black, Trempealeau, and Buffalo river basins. Wis. Dep. Nat. Resour. Tech. Bull. No. 140. 120 pp.
1984a. Distribution and relative abundance of fishes in Wisconsin. III. Red Cedar River basin. Wis. Dep. Nat. Resour. Tech. Bull. No. 143. 69 pp.
1984b. Retrieval and analysis system used in Wisconsin's statewide fish distribution survey. Wis. Dep. Nat. Resour. Res. Rep. No. 126. 35 pp.

GREENE, C. W.
1935. The distribution of Wisconsin fishes. Wis. Conserv. Comm., Madison. 235 pp.

HOLMSTROM, B. K.
1982. Drainage area data for Wisconsin streams. U. S. Geol. Surv. and Wis. Dep. Transp. Div. Highw., Madison.

JOHNSON, M. AND G. BECKER
1970. Annotated list of the fishes of Wisconsin. Wis. Acad. Sci., Arts, and Lett. 58:265-300.

MCNAUGHT, D. C.
1963. The fishes of Lake Mendota. Trans. Wis. Acad. Sci., Arts, and Lett. 52:37-55.

NOVOTNY, D. W. AND G. R. PRIEGEL
1971. A guideline for portable direct current electrofishing systems. Wis. Dep. Nat. Resour. Tech. Bull. No. 51. 22 pp.
1974. Electrofishing boats improved design and operational guidelines to increase the effectiveness of boom shockers. Wis. Dep. Nat. Resour. Tech. Bull. No. 73. 48 pp.

PEARSE, A. S.
1921. The distribution and food of the fishes of three Wisconsin lakes in summer. Univ. Wis. Stud. in Sci. No. 3:1-61.

ROBINS, C. R., ED.
1980. A list of common and scientific names of fishes from the United States and Canada. (4th ed.) Am. Fish. Soc. Spec. Publ. No. 12. 176 pp.

SEEBURGER, G.
1975. Fishes of Walworth county. Univ. Wis.-Stevens Point Mus. Nat. Hist. Rep. on the Fauna and Flora of Wisconsin. No. 10. 16 pp.

SKINNER, E. L. AND R. G. BORMAN
1973. Water resources of Wisconsin—Lake Michigan basin. Hydrol. Invest. Atlas HA-432. U.S. Geol. Surv. Washington D.C.

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION
1978. A regional water quality management plan for southeastern Wisconsin 2000. Vol. 1, Inventory Findings. Plann. Rep. No. 30. 438 pp.

U.S. GEOLOGICAL SURVEY
1981. Water resources data Wisconsin/water year 1980. Prepared in cooperation with the State of Wisconsin. 413 pp.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES
1972. Pollution investigation survey/Fox (Illinois) River. 43 pp.
1976. Drainage basin report/southeastern Wisconsin river basins. 136 pp.

WISCONSIN ELECTRIC POWER COMPANY
1975. Environmental report, Pleasant Prairie power plant units 1 and 2. Vol. 1., Chap. 2.7, pp. 1-28.

APPENDIX A. Supplementary Data

TABLE 20. *List of species used in this report from the Root, Milwaukee, Des Plaines, and Fox river basins by collectors other than DNR research personnel.*

Species	Root (10)		Milwaukee (20)		Des Plaines (200)		Fox (210)	
	1951-73	1974-81	1951-72	1973-81	1951-73	1974-81	1951-73	1974-81
Northern brook lamprey	-	-	-	-	-	-	-	6
Longnose gar*	-	-	-	-	-	-	2	1
Bowfin*	-	-	-	-	1	1,14	1,3,5	1
Alewife*	13	1	-	-	-	-	-	-
Cisco or lake herring*	-	-	-	-	-	-	-	1
Coho salmon	-	-	-	1	-	-	-	-
Rainbow trout*	1	1	1	1	-	-	1,5	1
Brown trout*	1	1	1	1	-	-	1	1
Brook trout*	-	-	-	1	-	-	1	1
Lake trout*	-	-	-	-	-	-	-	1
Central mudminnow*	1,13	1,15	3,5	1,5	1,2,3	14,15	1,3,4,5	1
Grass pickerel	13	-	-	-	3	-	2,3,4,5,12	1,5
Northern pike*	-	1	1,2,3,5	1	1,3	1,14,15	1,2,5,12	1,5,8
Muskellunge*	-	-	-	-	-	-	-	1
Stonerollers	-	-	3	5	3	-	3,5	-
Central stoneroller	-	-	2	1	-	-	4	1
Largescale stoneroller	-	-	2	-	-	-	-	-
Goldfish*	1	1	-	1	-	-	-	-
Common carp*	1,13	1	1,2,3,5	1	1,2	1,14,15	1,2,3,4,5,12	1,8
Brassy minnow	-	-	3	-	-	-	3	1
Hornyhead chub	-	-	2,3,5	1,5	3	-	3,4,5,12	1,5
Golden shiner	13	1	2,3	1	3	14	2,3,4,5,12	1,5
Pugnose shiner	-	-	-	1	-	-	2,3,5	1
Emerald shiner	-	-	2	-	-	-	2,3,4,12	1
Striped shiner	-	-	2,3	-	-	-	-	-
Common shiner	-	1	2,3,5	1,5	2,3	1,14	2,3,4,5,12	1
Bigmouth shiner	13	1	-	-	-	14	3,4,5	1
Pugnose minnow	-	-	-	-	-	-	3	1
Blackchin shiner	-	-	-	1	-	1,14	2,4,12	1,5
Blacknose shiner	-	-	-	1	-	1	2,3,4,5,12	1
Spottail shiner	-	-	2,3	-	-	-	2,3,5	1
Rosyface shiner	-	-	2,3	-	-	-	3,4	-
Spotfin shiner	-	-	2,3	1	-	14	3,4	1
Sand shiner	-	-	2,3	1,5	-	1,14	2,3	1
Redfin shiner	-	-	2,3	1	2,3	-	3	-
Mimic shiner	-	-	2,3	1	-	-	2	1,5
Suckermouth minnow	-	-	-	-	-	-	3	1
Northern redbelly dace	-	-	3	1	-	-	5	1
Southern redbelly dace	-	-	3	1,5	-	-	4	1
Bluntnose minnow	13	1	2,3,5	1,5	3	1,14	2,3,4,5	1,5
Fathead minnow	13	1	2,3	1,5	2,3	14	3,4,5,12	1
Bullhead minnow	-	-	-	-	-	-	-	1,5
Blacknose dace	-	1	3	1,5	-	-	3,4,5	1
Creek chub	13	1	2,3	1,5	2,3	14	3,4,5	1
Pearl dace	-	-	3	1	-	-	-	-
White sucker*	1,13	1	1,2,3,5	1,5	1,3	1,14,15	1,2,3,4,5,12	1,5
Lake chubsucker*	-	-	-	1,5	1,3	1,14	1,2,3,4,12	1,5
Northern hog sucker*	-	-	-	-	-	-	1,3,4	1

(Cont. on next page)

TABLE 20 *(Cont.)*

Species	Root (10)		Milwaukee (20)		Des Plaines (200)		Fox (210)	
	1951-73	1974-81	1951-72	1973-81	1951-73	1974-81	1951-73	1974-81
Spotted sucker	-	-	-	-	2,3	-	-	-
Golden redhorse	-	-	2,3	1	-	-	-	-
Shorthead redhorse	-	-	2,5	-	-	-	-	-
Greater redhorse	-	-	2	1,5	-	-	-	-
Black bullhead	13	1	2,3,5	1,5	3	14	2,3,4,5	1,5
Yellow bullhead	-	-	2,5	1,5	3	14	2,3,4,5,12	1,5
Brown bullhead	13	-	-	1	-	-	-	5
Channel catfish*	-	-	-	-	1	-	1,3	1,8
Stonecat	13	-	2,5	1,5	-	-	4	5
Tadpole madtom	-	-	2,3	1,5	2,3	14	2,3,5	1,5
Pirate perch*	-	-	-	-	2,3	15	-	-
Banded killifish	-	-	3	1,5	-	-	2,4,12	1
Blackstripe topminnow	-	-	-	1	2,3	14	3,4	-
Starhead topminnow	-	-	-	-	-	-	3,12	-
Brook silverside*	-	-	-	-	1	1	1,2,3	1,5
Brook stickleback*	-	1,15	2,3	1,5	-	14,15	1,3,4,5	1
White bass	-	-	-	-	-	-	2	1
Rock bass	-	-	2,3,5	1,5	-	-	2,3,4,12	1,5
Green sunfish	13	1	2,3,5	1,5	3	14	2,3,4,5,12	1,5
Pumpkinseed	13	1	2,3	1,5	-	14	2,3,4,5,12	1,5
Warmouth	-	-	-	1	-	1,14	3,12	5
Orangespotted sunfish	-	-	-	-	-	-	3,12	1,5
Bluegill	13	1	2	1	-	1,14	2,3,4,5,12	1,5
Longear sunfish	-	-	2,3,5	1	-	-	3,12	-
Smallmouth bass*	-	-	2,3	1	-	-	1,4	1,5
Largemouth bass*	13	1	1,2	1,5	1,2	1,14,15	1,2,3,4,5,12	1,5
White crappie	-	1	-	-	-	14	3	1,5
Black crappie	-	-	2	1,5	-	14	2,3,4,5,12	1,5
Rainbow darter	-	-	-	-	-	-	3,4,5,12	-
Iowa darter	-	-	-	1	3	14	3,5	1
Fantail darter	-	-	3	1,5	-	-	3,4,5,12	1,6
Least darter	-	-	3	1	-	-	3,4	-
Johnny darter	13	1	2,3	1,5	3	1,14	2,3,4,5,12	1,5
Banded darter	-	-	-	-	-	-	3,4	1,6
Yellow perch*	1	1	1,2	1,5	1	1,14	1,2,12	1,5
Logperch	-	-	2,5	1	-	-	3,4,12	1,5
Blackside darter	-	1	2,3,5	1,5	2,3	14	3,4,12	-
Walleye*	-	-	1	1	1	1	1,2	1,8
Freshwater drum*	-	-	-	-	-	-	2	1
Mottled sculpin*	-	-	-	1,5	-	-	3	1

*Records of this species collected by Fish Management, students, and sport and commercial fishermen are based upon their identification.

KEY TO COLLECTOR'S CODE

1 = All Fish Management collections
2 = Dr. George Becker and his students
3 = Professer Marlin Johnson and his students
4 = Dr. George Seeburger and his students
5 = Milwaukee Public Museum
6 = UW-Madison students (P. Cochran, pers. comm.)
[7 = Commercial fishermen]
[8 = Sport fishermen]
[9 = Upper Mississippi River Conservation Commission (UMRCC)]
[10 = N.U.S. Corporation, Pittsburg, PA]
[11 = U.S. Fish and Wildlife]
12 = Dr. Carroll Norden and his students
13 = Dr. Omar Amin and his students
14 = ENCAP, Inc., Dekalb, IL
15 = Bio Test, Inc., Chicago IL

[ ] = Collector not used in this report.

DEPARTMENT OF NATURAL RESOURCES — FISH OR STREAM DATA INPUT — FORM 8100-58 REV. 4-81

1 ADD
2 CHANGE
3 DELETE

F OR S

☐ SEQUENCE __ __ __ __ __ __ __ ☐ MAJOR BASIN __ MINOR BASIN __ __ __

CC1 MB MILES __ __ __ __ . __ __

ORDER MILEAGES 1) __ __ __ __ . __ __ 2) __ __ __ __ . __ __ 3) __ __ __ __ . __ __

4) __ __ __ __ . __ __ 5) __ __ __ __ . __ __ 6) __ __ __ __ . __ __

7) __ __ __ __ . __ __ 8) __ __ __ __ . __ __ 9) __ __ __ __ . __ __

10) __ __ __ __ . __ __ 11) __ __ __ __ . __ __

REPORT LOCATION ☐

STATION MILEAGE __ __ __ __ . __ __

NAME __

DAM OR JAR CODE __ WATERTYPE __ LANDLOCKED SEQUENCE NUMBER __ __

	TOWNSHIP	RANGE	SEC.	1/16	1/4	COUNTY
STREAM OR LAKE LOCATION	__ __ __	__ __ __	__ __	__ __	__ __	__ __
STATION LOCATION	__ __ __	__ __ __	__ __	__ __	__ __	__ __

SOURCE OF DATA __ __ GEAR __ EFFORT __ __ DATE __ __ / __ __ / __ __ (MO / DAY / YR) HOUR __ __

WIDTH L __ __ __ M __ __ __ U __ __ __ DEPTH L __ __ . __ M __ __ . __ U __ __ __

VELOCITY __ TEMPERATURE __ __ CONDUCTIVITY __ __ __ __ TURBIDITY __

BOTTOM TYPES	__ __	__ __	__ __	__ __	__ __	__ __	__ __	__ __
AQUATIC VEG.	__	__	__	__	__	__	__	__
STRM. BANK VEG.	__ __	__ __	__ __	__ __	__ __	__ __	__ __	__ __

FISH SPECIES

1) __ __ __ __ __	2) __ __ __ __ __	3) __ __ __ __ __	4) __ __ __ __ __
5) __ __ __ __ __	6) __ __ __ __ __	7) __ __ __ __ __	8) __ __ __ __ __
9) __ __ __ __ __	10) __ __ __ __ __	11) __ __ __ __ __	12) __ __ __ __ __
13) __ __ __ __ __	14) __ __ __ __ __	15) __ __ __ __ __	16) __ __ __ __ __

MORE DATA ON BACK: ☐ YES

17) __ __ __ __ __	18) __ __ __ __ __	19) __ __ __ __ __	20) __ __ __ __ __
21) __ __ __ __ __	22) __ __ __ __ __	23) __ __ __ __ __	24) __ __ __ __ __
25) __ __ __ __ __	26) __ __ __ __ __	27) __ __ __ __ __	28) __ __ __ __ __
29) __ __ __ __ __	30) __ __ __ __ __	31) __ __ __ __ __	32) __ __ __ __ __
33) __ __ __ __ __	34) __ __ __ __ __	35) __ __ __ __ __	36) __ __ __ __ __
37) __ __ __ __ __	38) __ __ __ __ __	39) __ __ __ __ __	40) __ __ __ __ __
41) __ __ __ __ __	42) __ __ __ __ __	43) __ __ __ __ __	44) __ __ __ __ __

FISH ONLY

FIGURE 5. *Examples of field collection form (8100-46).*

```
MINOR=223SELECTION=223                                    SOURCE=NOT 40 81 94 95 99        MILE ON                    PAGE  43
MIN. MONTH =     MAX. MONTH =      MIN. YEAR = 1950  MAX. YEAR = 1973   COUNTY = OR < 72

X12   JOHNNY DARTER                                  ETHEOSTOMA NIGRUM                                  DATE RUN 11/09/83

                ----------O R D E R  M I L E A G E S----------                                                      N86006A
BASIN   MBM        1       2/7      3/8      4/9      5/10     6/11     MILE  LAKE OR STREAM NAME          WT NO SD GEF --DATE--TWRRNGSECQTQTCO

2 223 1434.8R  156.9L                                                  139.1  PECATONICA R                  2  2 46 5    6/27/60  2N 3E12SESE33
2 223 1434.8R  156.9L                                                  182.4  PECATONICA R -MIFFLIN         2 11 46 5    8/15/62  5N 1E27SESE25
2 223 1434.8R  156.9L    72.8R                                         30.5  RICHLAND CR                   2    61 5   11/28/65  1N 8E 7SENE23
2 223 1434.8R  156.9L    72.8R    27.OR                                 1.8E TWIN GROVE BR                 2    61 5   10/20/64  1N 8E29NWNE23
2 223 1434.8R  156.9L   102.8R    13.8Y                                 1.3  BUCKSKIN SCHOOL CR            2    61 5    7/ 5/65  2N 7E 5SWSW23
2 223 1434.8R  156.9L   105.8R                                         30.2  E BR PECATONICA R             2 44 46 5    6/30/60  4N 5E26SESE33
2 223 1434.8R  156.9L   105.8R                                         40.3  E BR PECATONICA R             2 27 46      6/30/60  4N 5E 4SENE25
2 223 1434.8R  156.9L   105.8R                                         53.4  E BR PECATONICA R             2    61 5   10/15/64  5N 5E 4NWNW25
2 223 1434.8R  156.9L   105.8R                                         58.3  E BR PECATONICA R             2  3 61 5    8/ 1/69  6N 5E22  SE25
2 223 1434.8R  156.9L   105.8R    10.9L                                 .5  WHITESIDE CR                  2  3 46      6/30/60  2N 5E 3SESW33
2 223 1434.8R  156.9L   105.8R    10.9L    1.6R                         1.9  APPLE BR                     2    61 5   10/ 7/65  3N 5E32  NE33
2 223 1434.8R  156.9L   105.8R    10.9L    1.6R                        3.3E APPLE BR                     2 19 46      6/29/60  3N 5E30SESE33
2 223 1434.8R  156.9L   105.8R    15.OR                                5.3  DOUGHERTY CR                  2    61 5   10/ 6/64  3N 6E19NWSE23
2 223 1434.8R  156.9L   105.8R    19.2L                                 .3  MUD BR                        2 24 46      6/29/60  3N 5E22  SW33
2 223 1434.8R  156.9L   105.8R    19.2L                                3.7  MUD BR                        2    61 5   10/ 1/64  3N 5E2ONWNW33
2 223 1434.8R  156.9L   105.8R    19.2L                                9.6  MUD BR                        2 24 46      6/29/60  3N 4E15NENW33
2 223 1434.8R  156.9L   105.8R    19.7L                               6.1E YELLOWSTONE R                 2  5 46      6/29/60  3N 5E 8SENE33
2 223 1434.8R  156.9L   105.8R    19.7L                               17.O  YELLOWSTONE R                2  9 46      6/28/60  4N 4E23SESE33
2 223 1434.8R  156.9L   105.8R    25.4R                                1.3  SAWMILL CR                    2    61 5   10/ 7/64  3N 5E 2NESE33
2 223 1434.8R  156.9L   105.8R    25.4R                               6.5E SAWMILL CR                    2    61 5   10/ 6/64  4N 6E2OSESW23
2 223 1434.8R  156.9L   105.8R    27.5L                                1.O  UN CR                         2 27 46      6/28/60  4N 5E27NWSE33
2 223 1434.8R  156.9L   105.8R    33.5R                                 .9  GORDON CR                     2    61 5   10/ 1/64  4N 5E13NWSW25
2 223 1434.8R  156.9L   105.8R    44.2L    6.1R                        6.3  CONLEY LEWIS CR               2  1 61 5    8/ 1/69  6N 4E34SWNE25
2 223 1434.8R  156.9L   139.5L                                         1.2  AMES BR                       2  3 46      6/27/60  2N 3E11SESE33
2 223 1434.8R  156.9L   141.OR                                          .4  OTTER CR                      2  2 46      6/27/60  2N 4E 6SENW33
2 223 1434.8R  156.9L   153.4L                                         5.1  BONNER BR                     2  7 46      8/15/62  3N 2E11SENW33
2 223 1434.8R  156.9L   159.OR                                         9.9  MINERAL POINT BR              2  3 46 5    8/15/62  4N 2E1O  NE25
2 223 1434.8R  156.9L   159.OR                                        13.7  MINERAL POINT BR              2  1 46      8/ 9/62  5N 2E36SWNE25
2 223 1434.8R  156.9L   159.OR    8.8L                                 8.3  SUDAN BR                      2  4 46      8/14/62  5N 2E29SWSE25
2 223 1434.8R  156.9L   159.OR    8.8L    10.6R                         .4  PEDLER CR                     2  2 46      8/14/62  5N 2E21SWNE25
2 223 1434.8R  156.9L   172.9L                                         1.5  JONES BR                      2    45      7/11/62  4N 1E23SWSE33


NUMBER OF STATIONS WITH FISH =   31     NUMBER OF STATIONS WITH 1-98 FISH =   2O   NUMBER OF STATIONS WITH 99 OR MORE FISH =   O
TOTAL NUMBER OF FISH =    221          AVERAGE NUMBER OF FISH = 11.1  (ESTIMATE)
PERCENT OF TOTAL NUMBER OF STATIONS = 79.49                NUMBER OF STATIONS WITH A " " = 11
# STATIONS/SD:  SD-11=  O     SD-14,16=  O  SD-15,17,19=  O  SD-23-33=  O     SD-4O=  O  SD-45,46= 19     SD-5O=  O  SD-55,56=  O
                SD-61= 12       SD-66=  O       SD-72=  O     SD-75=  O     SD-76=  O     SD-77=  O     SD-78=  O     SD-8O=  O
                SD-83=  O       SD-86=  O       SD-88=  O     SD-89=  O     SD-94=  O     SD-98=  O     SD-99=  O     SD-36=  O

                     TOTAL NUMBER OF SPECIES OCCURRENCES    31
```

FIGURE 6. *Sample listing for a species using the Cobol program (listing method B, Figure 3, used here).*

MINOR=223SELECTION=223 SOURCE=NOT 40 81 94 95 99 MILE ON PAGE 50

A86006 DATE RUN 11/09/83

		NUMBER OF STATIONS	PERCENT OF TOTAL STATIONS
I21	BROWN TROUT	1	2.56
KO1	CENTRAL MUDMINNOW	4	10.26
MO5	STONEROLLERS	13	33.33
MO6	CENTRAL STONEROLLER	19	48.72
MO7	LARGESCALE STONEROLLER	4	10.26
M12	COMMON CARP	5	12.82
M14	BRASSY MINNOW	5	12.82
M19	HORNYHEAD CHUB	21	53.85
M23	EMERALD SHINER	1	2.56
M28	COMMON SHINER	28	71.79
M29	BIGMOUTH SHINER	5	12.82
M35	ROSYFACE SHINER	17	43.59
M36	SPOTFIN SHINER	16	41.03
M37	SAND SHINER	14	35.90
M41	SUCKERMOUTH MINNOW	8	20.51
M43	SOUTHERN REDBELLY DACE	18	46.15
M45	BLUNTNOSE MINNOW	29	74.36
M46	FATHEAD MINNOW	6	15.38
M48	BLACKNOSE DACE	2	5.13
M5O	CREEK CHUB	27	69.23
M76	COMMON SHINER X ROSYFACE SHINER	1	2.56
NO2	SUCKERS	1	2.56
NO4	REDHORSES	1	2.56
NO6	QUILLBACK	1	2.56
NO9	WHITE SUCKER	29	74.36
N13	NORTHERN HOG SUCKER	10	25.64
N15	BIGMOUTH BUFFALO	3	7.69
N18	SILVER REDHORSE	9	23.08
N21	GOLDEN REDHORSE	8	20.51
N22	SHORTHEAD REDHORSE	13	33.33
OO8	CHANNEL CATFISH	1	2.56
O1O	STONECAT	5	12.82
SO2	BLACKSTRIPE TOPMINNOW	1	2.56
UO1	BROOK STICKLEBACK	12	30.77
WO4	ROCK BASS	5	12.82
WO5	GREEN SUNFISH	6	15.38
WO8	ORANGESPOTTED SUNFISH	5	12.82
WO9	BLUEGILL	10	25.64
W11	SMALLMOUTH BASS	14	35.90
W12	LARGEMOUTH BASS	6	15.38
XO7	RAINBOW DARTER	2	5.13
X1O	FANTAIL DARTER	13	33.33
X12	JOHNNY DARTER	31	79.49
X14	BANDED DARTER	5	12.82
X15	YELLOW PERCH	3	7.69
X18	BLACKSIDE DARTER	7	17.95
X19	SLENDERHEAD DARTER	4	10.26
X22	WALLEYE	1	2.56
ZO1	MOTTLED SCULPIN	7	17.95

TOTAL NUMBER OF SPECIES OCCURRENCES 441

# STATIONS/SD:	SD-11=	0	SD-14,16=	0	SD-15,17,19=	0	SD-23-33=	0	SD-40=	0	SD-45,46=	283	SD-50=	0	SD-55,56=	0					
	SD-61=	158	SD-66=	0	SD-72=	0	SD-75=	0	SD-76=	0	SD-77=	0	SD-78=	0	SD-80=	0					
	SD-83=	0	SD-86=	0	SD-88=	0	SD-89=	0	SD-94=	0	SD-98=	0	SD-99=	0	SD-36=	0					

TOTAL NUMBER OF SPECIES OCCURRENCES 441

TOTAL NUMBER OF STATIONS	
(WITH MILE RULE)	39
(WITHOUT MILE RULE)	42
TOTAL NUMBER OF SPECIES	45
TOTAL NUMBER OF HYBRIDS	1

FIGURE 7. *Sample summary report for species listing shown in Figure 6.*

```
NOV 23, 1983                    FISH MASTER FILE                                                                    MILE OFF                PAGE 1
  SEQ. JAR WT  ----------O R D E R  M I L E A G E S---------                                                                          STATION LOCATION
BASIN    MBM       1      2/7     3/8     4/9     5/10    6/11      MILE  ----STREAM OR LAKE NAME----          SD G EF --DATE-- TWNRNGSECQTQTCO


2 222              1N      10E      27      SW 54                        +  SUGAR R -OXBOW                     46 5     8/ 0/63   1N10E27NWSW54

        SP=04 HY=00 UNSP=00  FISH  M20  +  005  +  S02  +  W08  +

2 222  1434.8R  156.9L      .7R     6.9R                                 2.3   E FORK RACCOON CR               61 5    12/12/65   1N12E31NWSE54

        SP=13 HY=00 UNSP=02  FISH  M04  +  M05  +  M14  +  M28  +  M29  +  M41  +  M43  +  M45  +  M50  +
                                   N09  +  U01  +  X10  +  X12  +  X14  +  X18  +

2 222  1434.8R  156.9L      .7R     6.9R                                 2.4   E FORK RACCOON CR               11 2 06  5/15/74   1N12E31SWNE54

        SP=15 HY=01 UNSP=01  FISH  A05  4  I21 10  L02  6  L07  1  M05  6  M12  1  M28  1  M29  1  M45 13
                                   M50  2  N09 28  W05  3  W09  1  X10 11  X12 25  X14  2  Z01  6

2 222  1434.8R  156.9L      .7R     6.9R    2.7R                         1.5   UN CR (CHAMBERLIN SPRINGS)      71 5    10/ 5/77   1N12E29SWNW54

        SP=08 HY=00 UNSP=00  FISH  M06  1  M29 27  M43 10  M48 29  M50 99  N09  3  U01  5  X12 11

2 222  1434.8R  156.9L      .7R     6.9R    2.7R                         3.8   UN CR                           11 3 06  5/15/74   1N12E21NWNW54

        SP=07 HY=00 UNSP=01  FISH  M05 99  M43 19  M46  4  M48 75  M50 53  N09 30  U01  8  X12  2

2 222  1434.8R  156.9L      .7R     6.9R                                 3.2   E FORK RACCOON CR               11 2 05  11/ 5/75   1N12E31NENW54

        SP=17 HY=00 UNSP=01  FISH  A05  2  K01  6  L01  2  M05 33  M28  2  M45 11  M46  3  M48 20  M50 16  (006     030   0      40)
                                   N09 47  W05 10  W09  6  X07  1  X10 30  X12 25  X14  2  X18 10  Z01 27  (1 49       3  0001      )
                                                                                                           (ET F1 G2 H5 I2           )
                                                                                                           (D3 FT K4 M2 O1           )

2 222  1434.8R  156.9L      .7R     6.9R                                 3.3   E FORK RACCOON CR               61 5     6/10/65   1N12E31NENW54

        SP=07 HY=00 UNSP=01  FISH  M05  +  M28  +  M39  +  M43  +  M45  +  M50  +  N09  +  X10  +

2 222  1434.8R  156.9L      .7R     6.9R                                 7.8   E FORK RACCOON CR               11 2 06  5/15/74   1N11E12SESW54

        SP=16 HY=00 UNSP=01  FISH  I21  2  K01  2  M05 99  M09  1  M43 99  M45 99  M46  5  M48 79  M50 99
                                   N09 99  U01 99  W05  5  W08  1  X10 99  X11 46  X12 61  Z01  2

2 222  1434.8R  156.9L      .7R                                         10.7   RACCOON CR                      11 2 06  7/ 0/74   1N11E35SENW54

        SP=19 HY=00 UNSP=01  FISH  L02  8  M05 15  M12  7  M19  6  M28 32  M36 27  M45 54  M46  6  M50  3
                                   N09 11  005  1  006 13  010  2  U01  2  W04  2  W05  2  W06  1  X12  3
                                   X14  4  X18  4

2 222  1434.8R  156.9L      .7R                                         10.7   RACCOON CR                      61 5     6/10/65   1N11E35SENW54

        SP=12 HY=00 UNSP=00  FISH  K01  +  L02  1  M39  +  M45  +  N09  +  005  +  006  +  S02  +  U01  +
                                   W05  +  X12  +  X18  +
```

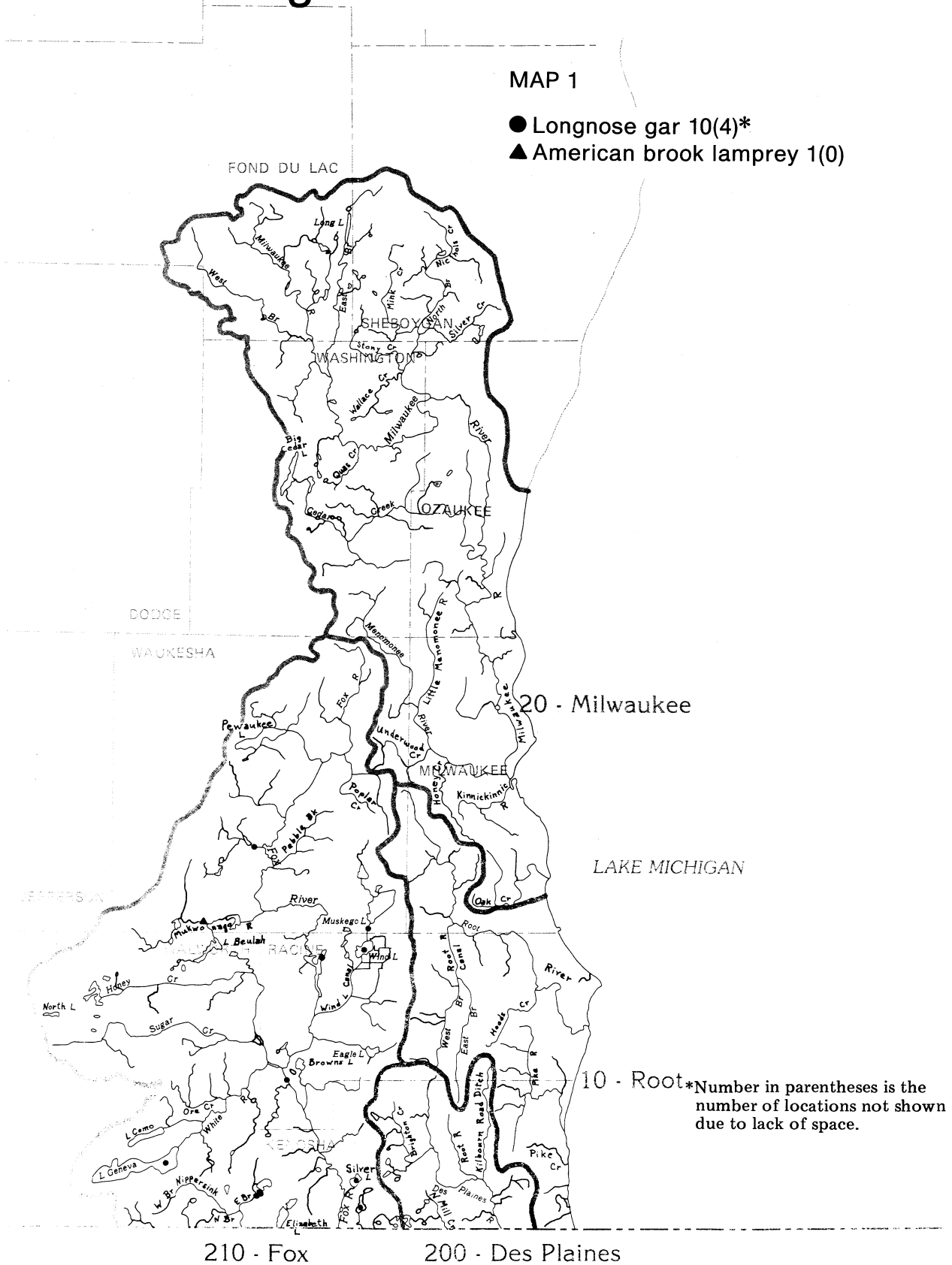
FIGURE 8. *Sample page from the Master Fish File using a Mark IV program (listing method A, Figure 3, used here).*

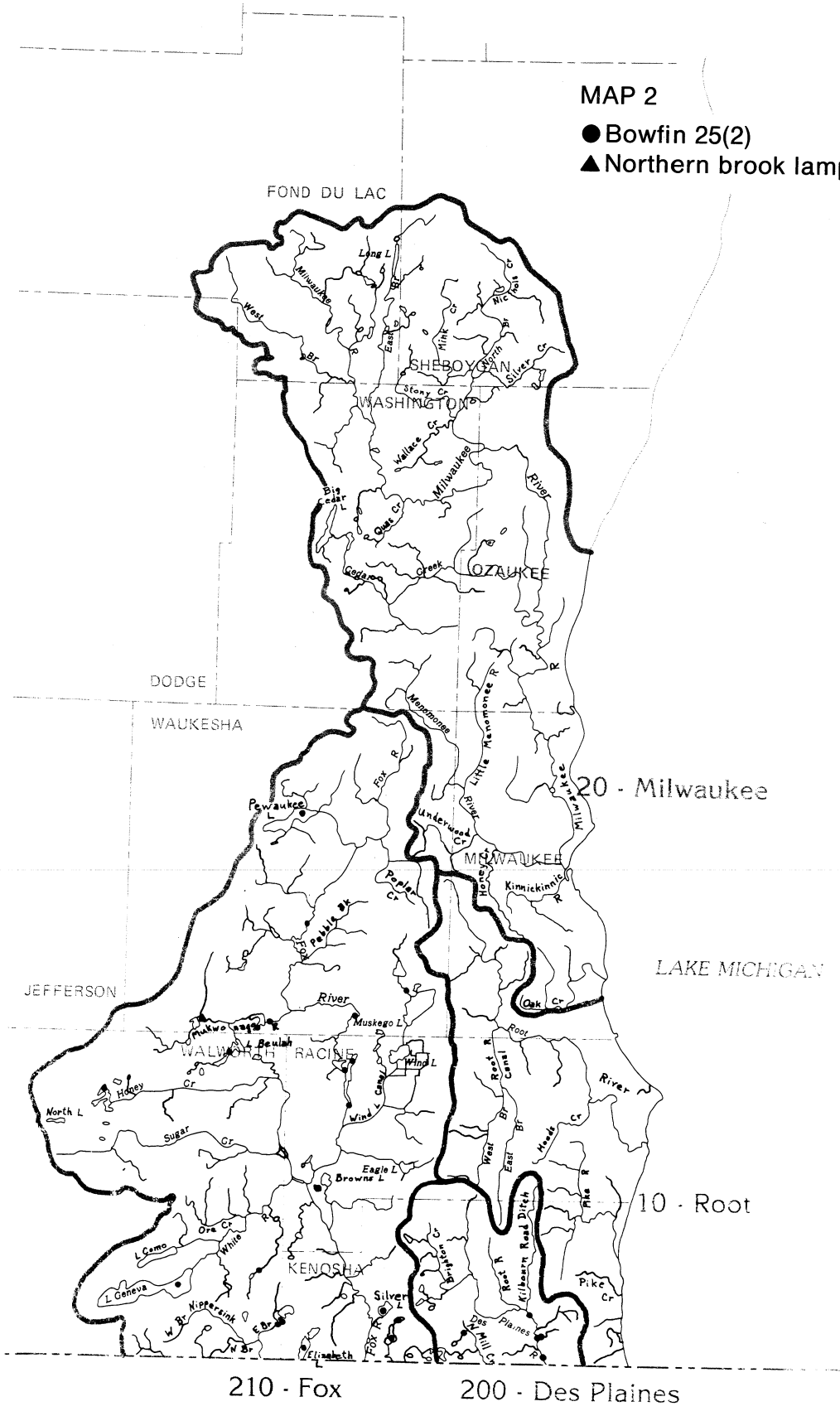
NOV 29, 1983 STREAM & LAKE FILE - MASTER PAGE 1

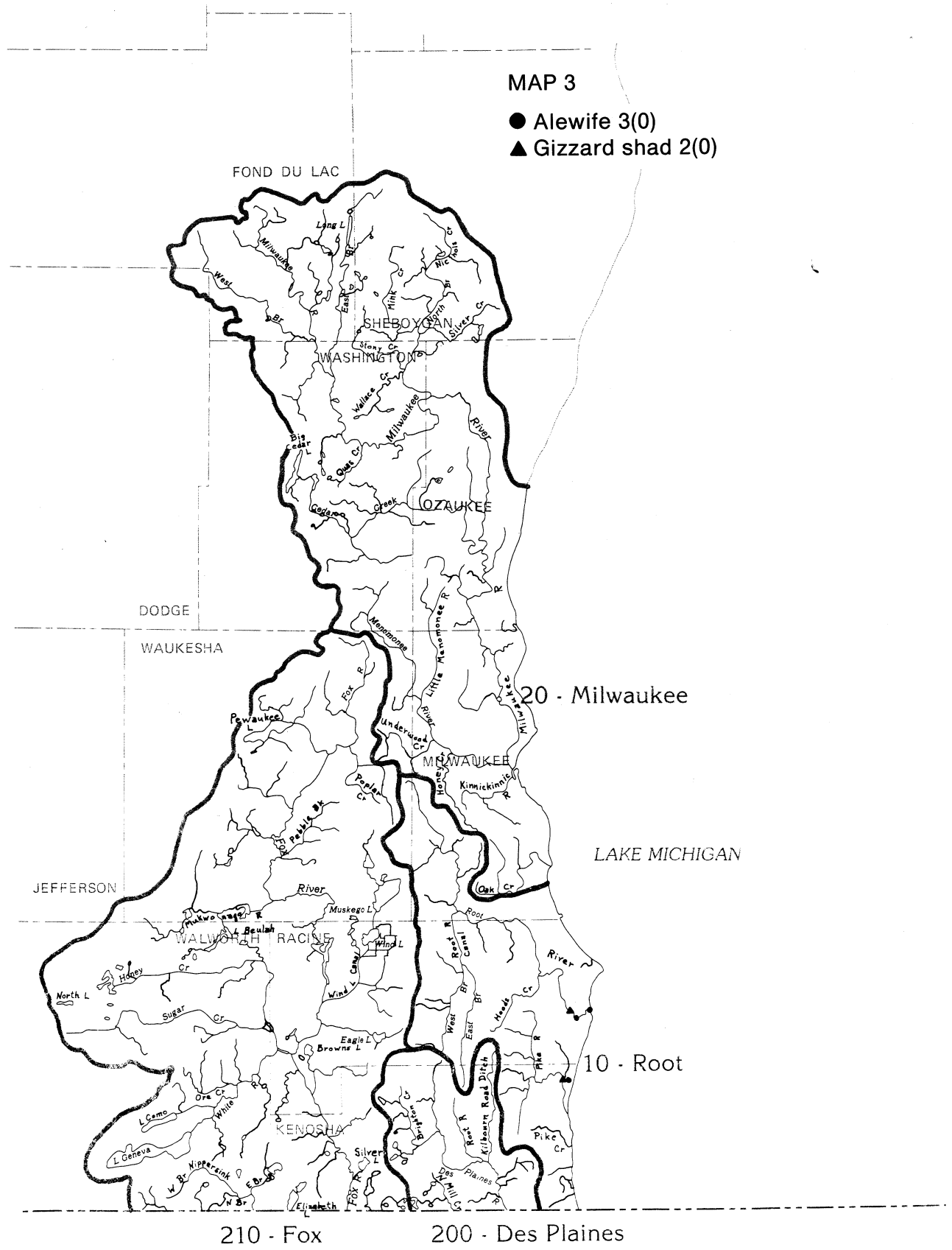
BASINS MAJ	MIN	MB. MI.	ORDER MILEAGES 1	2	3	4/8	5/9	6/10	7/11	MI OR ACRES	STREAM OR LAKE NAME	D C	WL TST	WN	RNG	SEC	QTQT	64CO
2	222 62640									17	GOOSE POND	0	6N		8E	13	NENE	13
2	222 62650									33	L HARRIETT	0	5N		9E	9	NWNW	13
2	222 62660									10	MORSE POND	0	6N		8E	3	SESW	13
2	222 62670									12	MORTENSON POND	0	5N		9E	26	NWSE	13
2	222 62680										SUGAR R -OXBOW	0	1N		10E	27	NWSW	54
2	222 62690									8	VERONA GRAVEL PIT #12 (EAST	0	6N		8E	22	SENW	13
2	222 62700	1434.8R	156.9L	.7R						11	RACCOON CR	2	46N		1E	22		80
2	222 62710	1434.8R	156.9L	.7R	6.9R					7	E FORK RACCOON CR	2	46N		1E	8		80
2	222 62720	1434.8R	156.9L	.7R	6.9R	1.4					E FORK RACCOON CR WI-IL BD	6	1N		12E	31	SESW	54
2	222 62730	1434.8R	156.9L	.7R	6.9R	2.7R				4	UN CR (31-3,CHAMBERLIN SPR.	2	1N		12E	31	SWNE	54
2	222 62740	1434.8R	156.9L	.7R	9.5						RACCOON CR WIS-ILL BD	6	1N		11E	35	SESE	54
2	222 62750	1434.8R	156.9L	.7R	11.4						DAM-RACCOON CR-MILLPOND		1N		11E	34	NENE	54
2	222 62760	1434.8R	156.9L	.7R	11.7R					3	UN CR	2	1N		11E	27	SWSE	54
2	222 62770	1434.8R	156.9L	.7R	11.7R	.3R				3	UN CR	2	1N		11E	27	NWSE	54
2	222 62780	1434.8R	156.9L	9.2R						76	SUGAR R	2	28N		11E	11		80
2	222 62790	1434.8R	156.9L	9.2R	10.7						SUGAR R WIS-ILL BD	6	1N		10E	36	SESW	54
2	222 62800	1434.8R	156.9L	9.2R	10.8L					9	GREEN DRAINAGE SYSTEM	2	1N		10E	36	SESW	54
2	222 62810	1434.8R	156.9L	9.2R	10.8L	6.4R				1	UN CR	2	1N		9E	25	SENE	54
2	222 62820	1434.8R	156.9L	9.2R	11.2R					3	UN DITCH	2	1N		10E	36	NWSW	54
2	222 62830	1434.8R	156.9L	9.2R	11.2R	.7R				1	UN DITCH	2	1N		10E	36	NENW	54
2	222 62840	1434.8R	156.9L	9.2R	11.7R					2	UN DITCH	2	1N		10E	35	SENE	54
2	222 62850	1434.8R	156.9L	9.2R	16.0L					6	UN DITCH	2	1N		10E	28	NESW	54
2	222 62860	1434.8R	156.9L	9.2R	18.8L						SUGAR R -W CHANNEL	2	1N		10E	20	SWNE	54
2	222 62870	1434.8R	156.9L	9.2R	18.8L	.5L				1	UN DITCH	2	1N		10E	20	SWNW	54
2	222 62880	1434.8R	156.9L	9.2R	19.8R					13	TAYLOR CR	2	1N		10E	18	SESE	54
2	222 62890	1434.8R	156.9L	9.2R	19.8R	1.8R				10	WILLOW CR (NORTH)	2	1N		10E	7	NESW	54
2	222 62900	1434.8R	156.9L	9.2R	19.8R	1.8R	6.7R			4	UN CR	2	1N		10E	11	SWNE	54

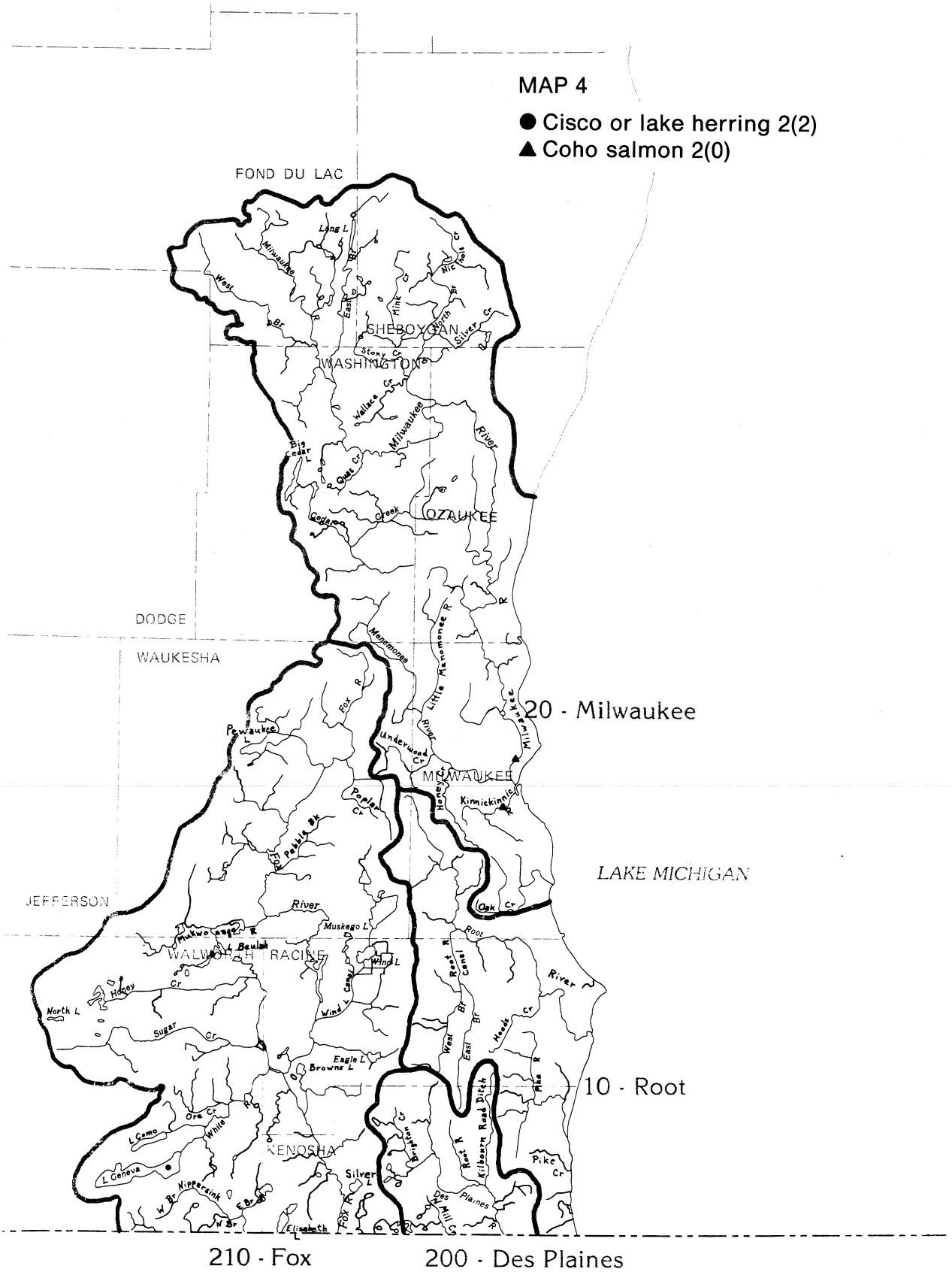
FIGURE 9. *Sample page from the Master Stream and Lake File.*

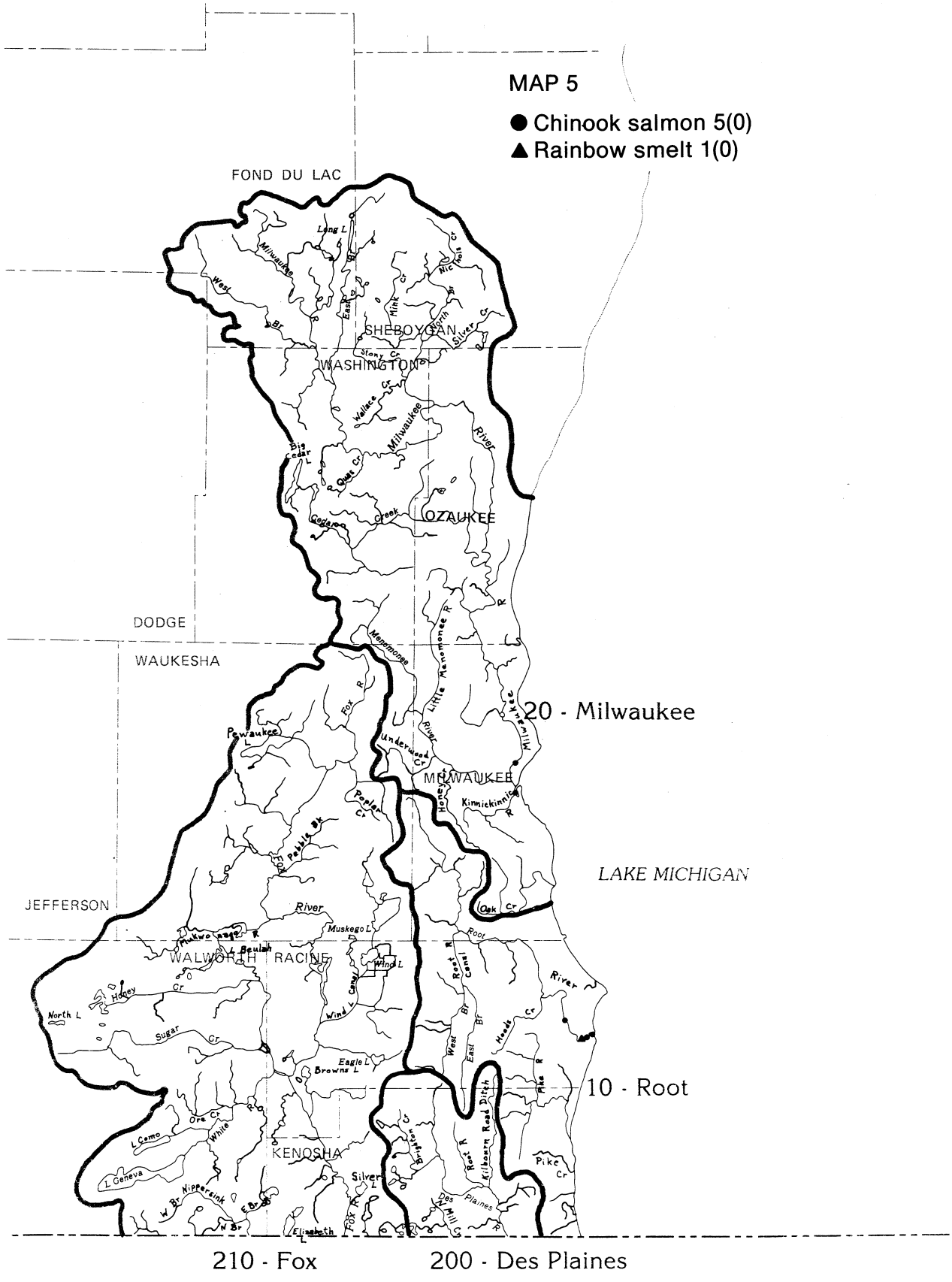
APPENDIX B. Distribution Maps For All Species Collected During 1975-82

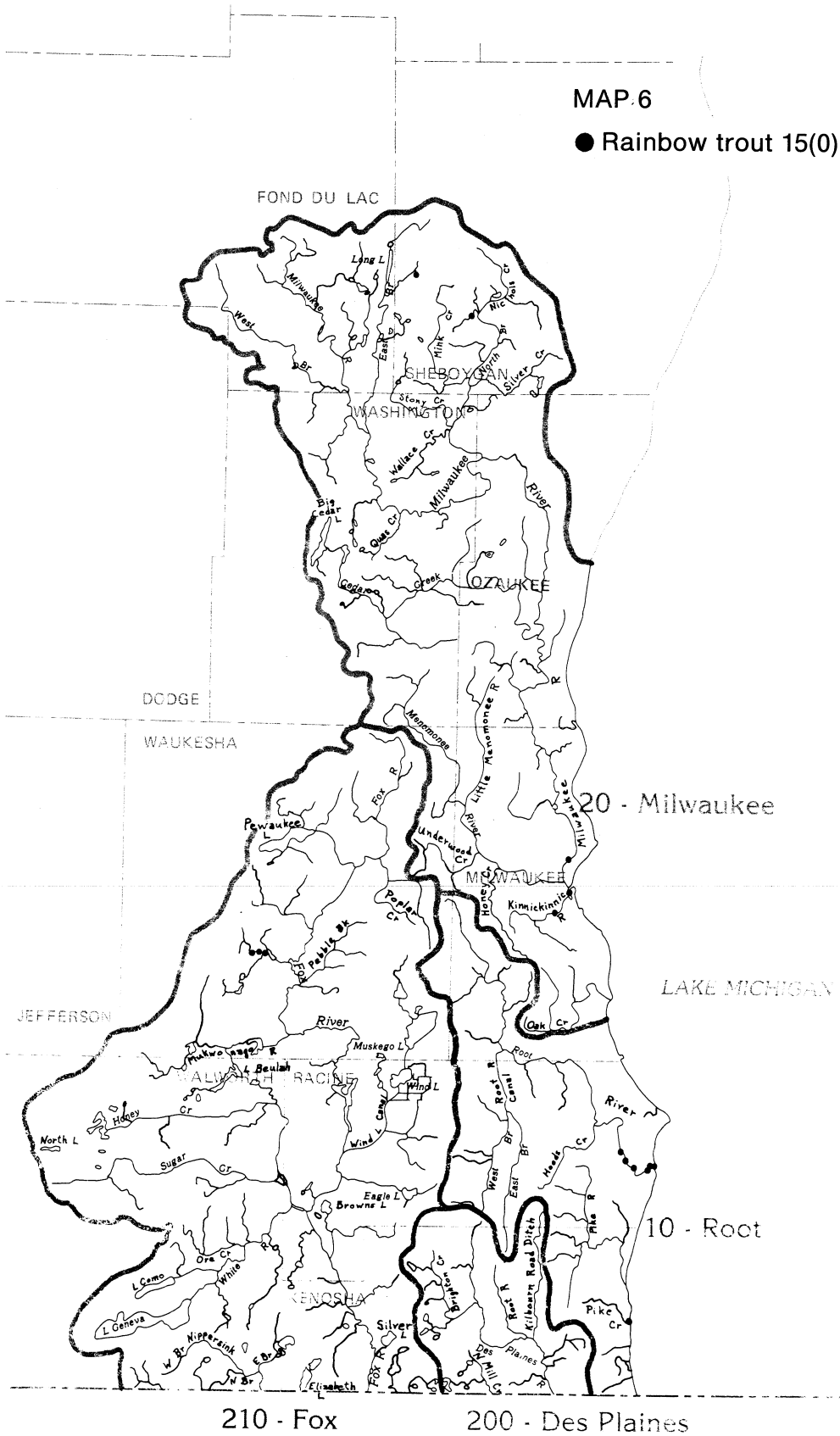


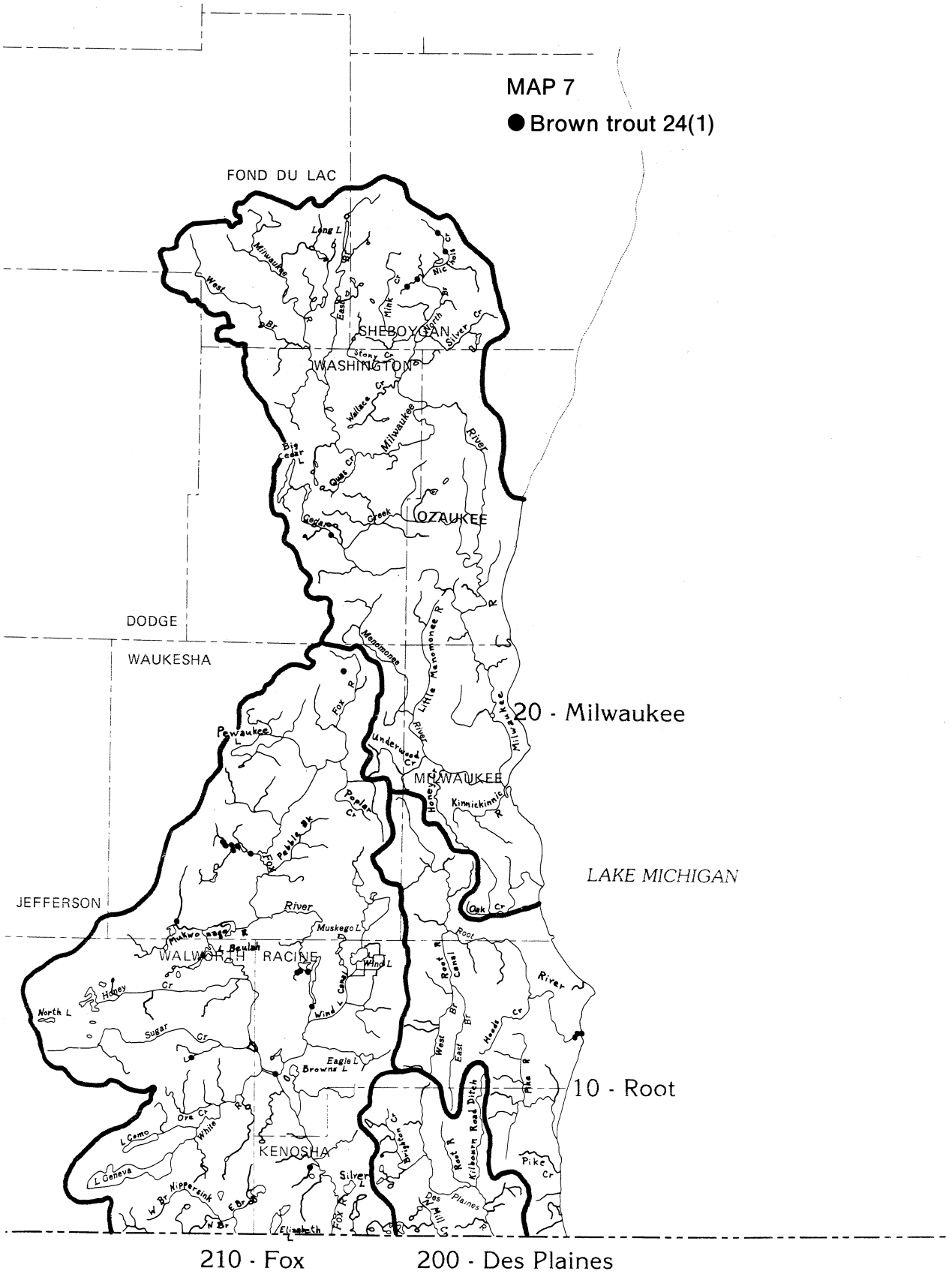

MAP 2
● Bowfin 25(2)
▲ Northern brook lamprey 1(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

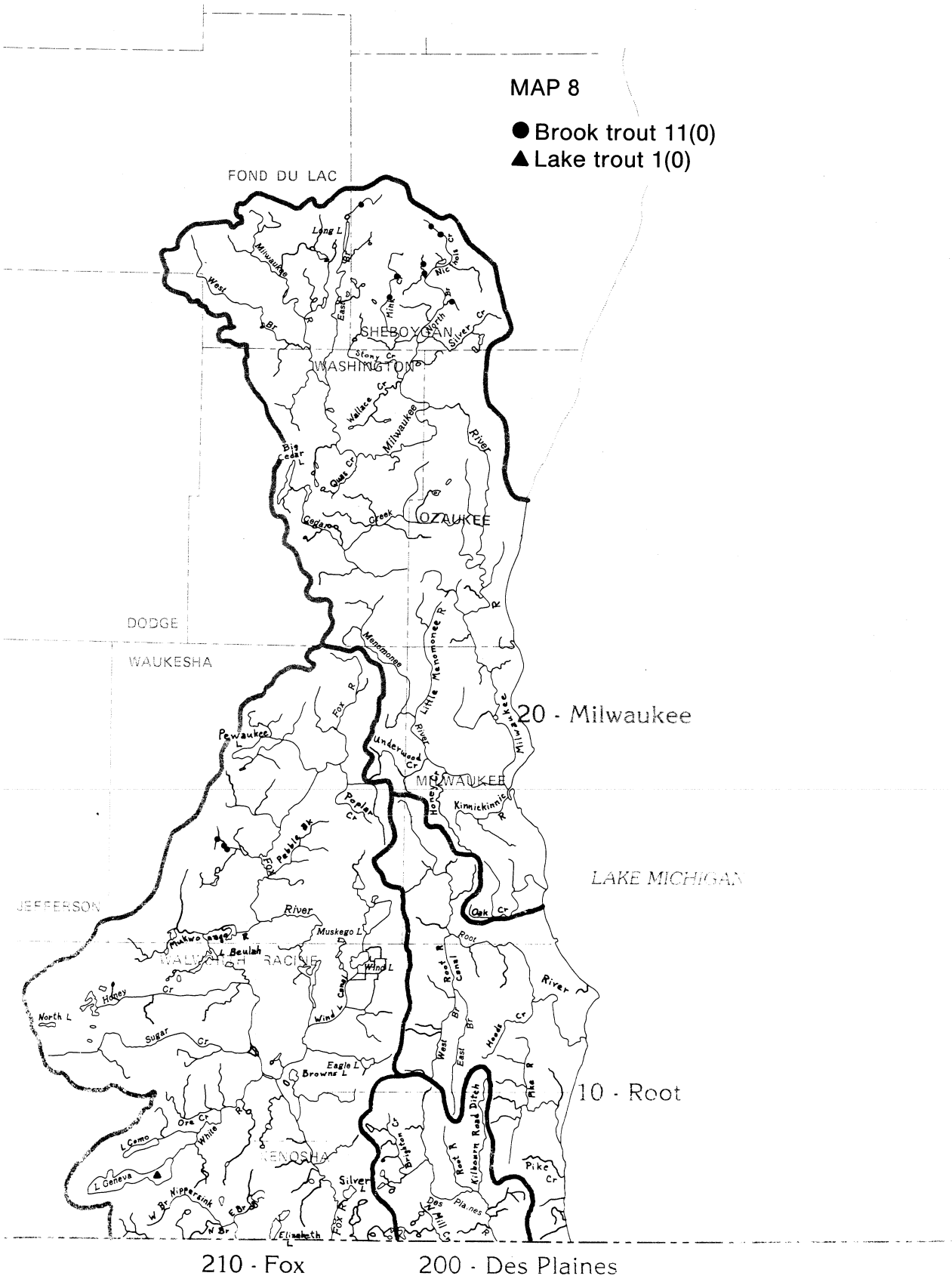

MAP 3
● Alewife 3(0)
▲ Gizzard shad 2(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

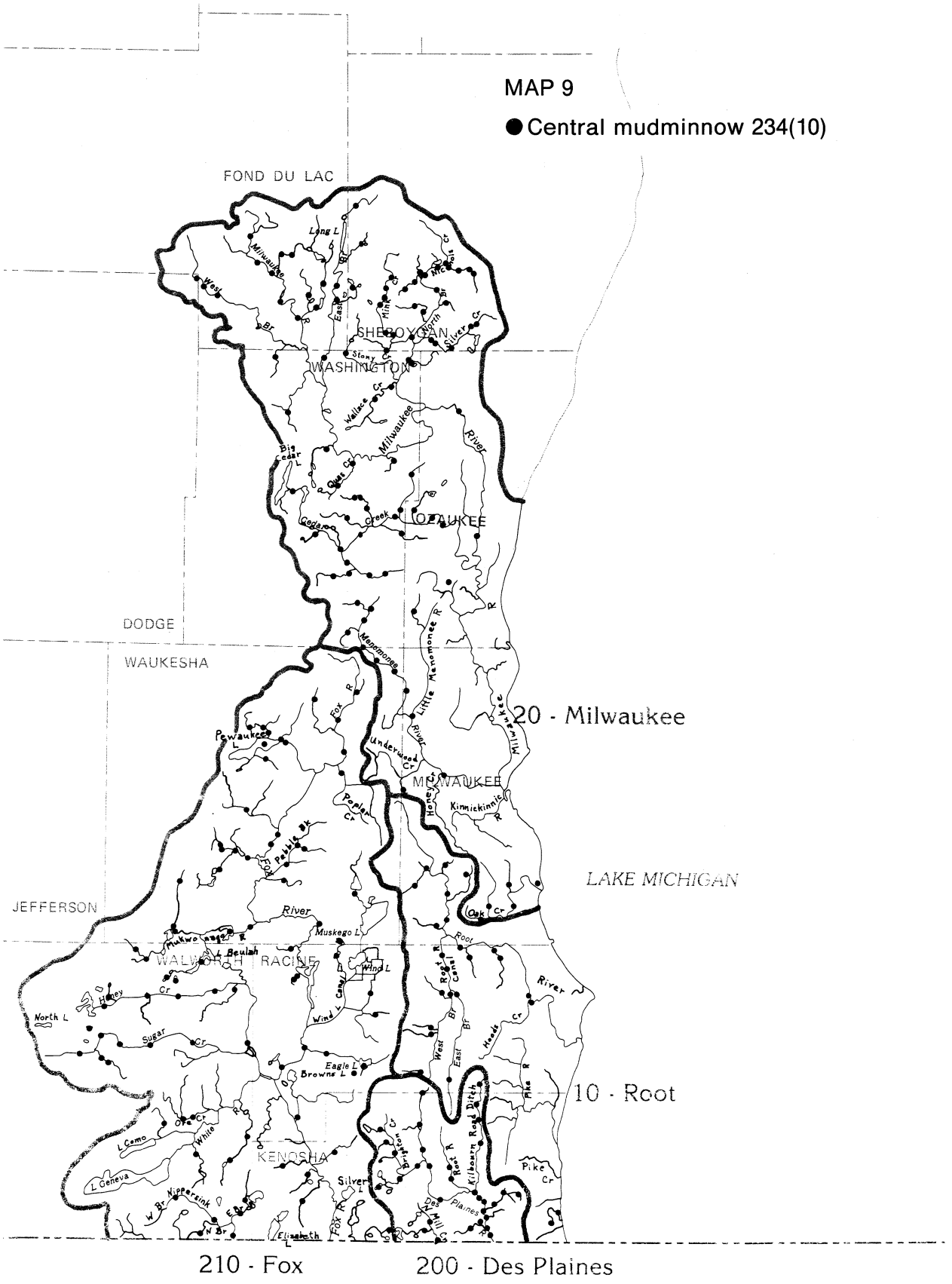

MAP 4
● Cisco or lake herring 2(2)
▲ Coho salmon 2(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

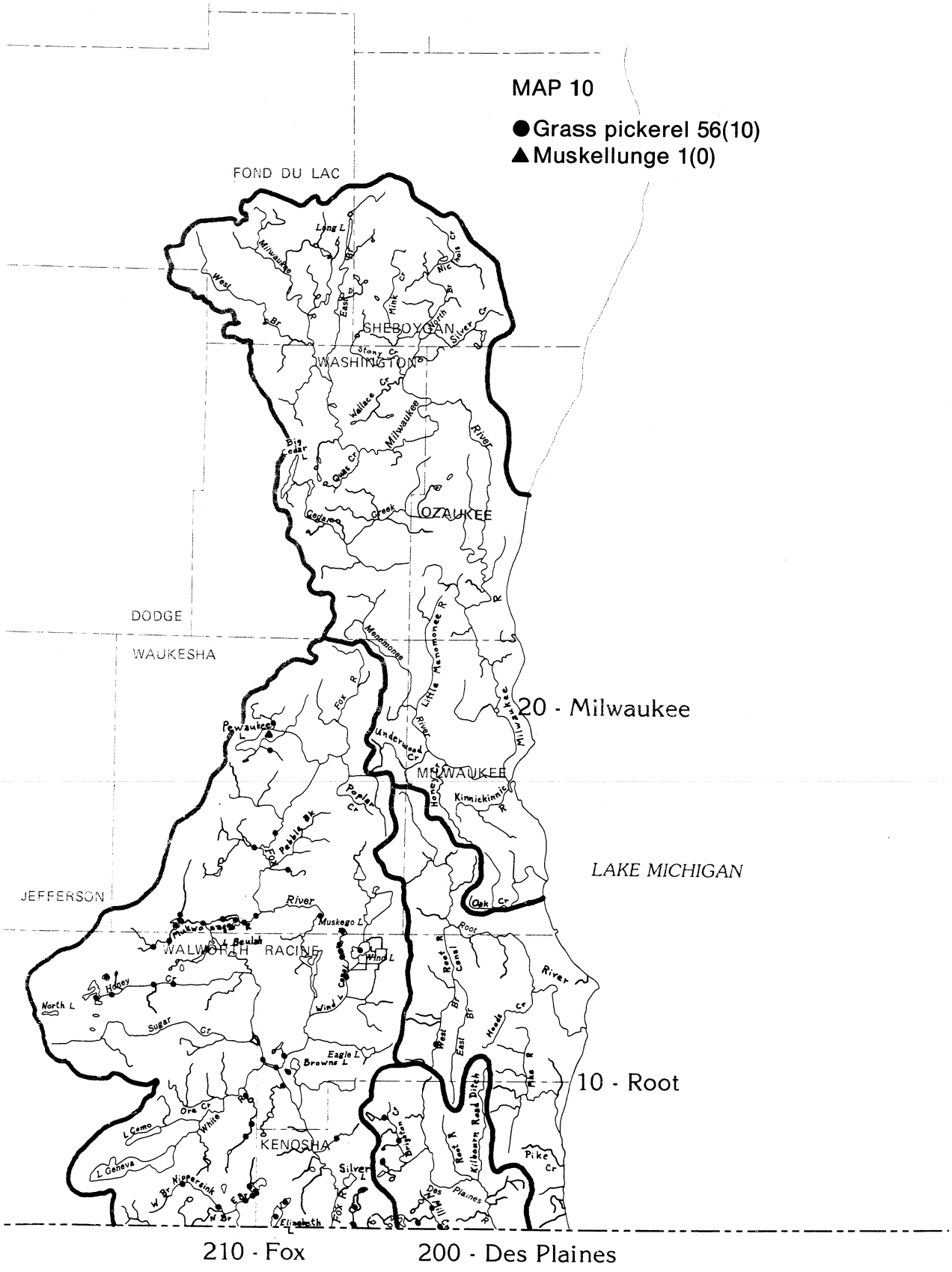

MAP 5
● Chinook salmon 5(0)
▲ Rainbow smelt 1(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
20 - Milwaukee
MILWAUKEE
LAKE MICHIGAN
JEFFERSON
WALWORTH
RACINE
10 - Root
KENOSHA
210 - Fox
200 - Des Plaines

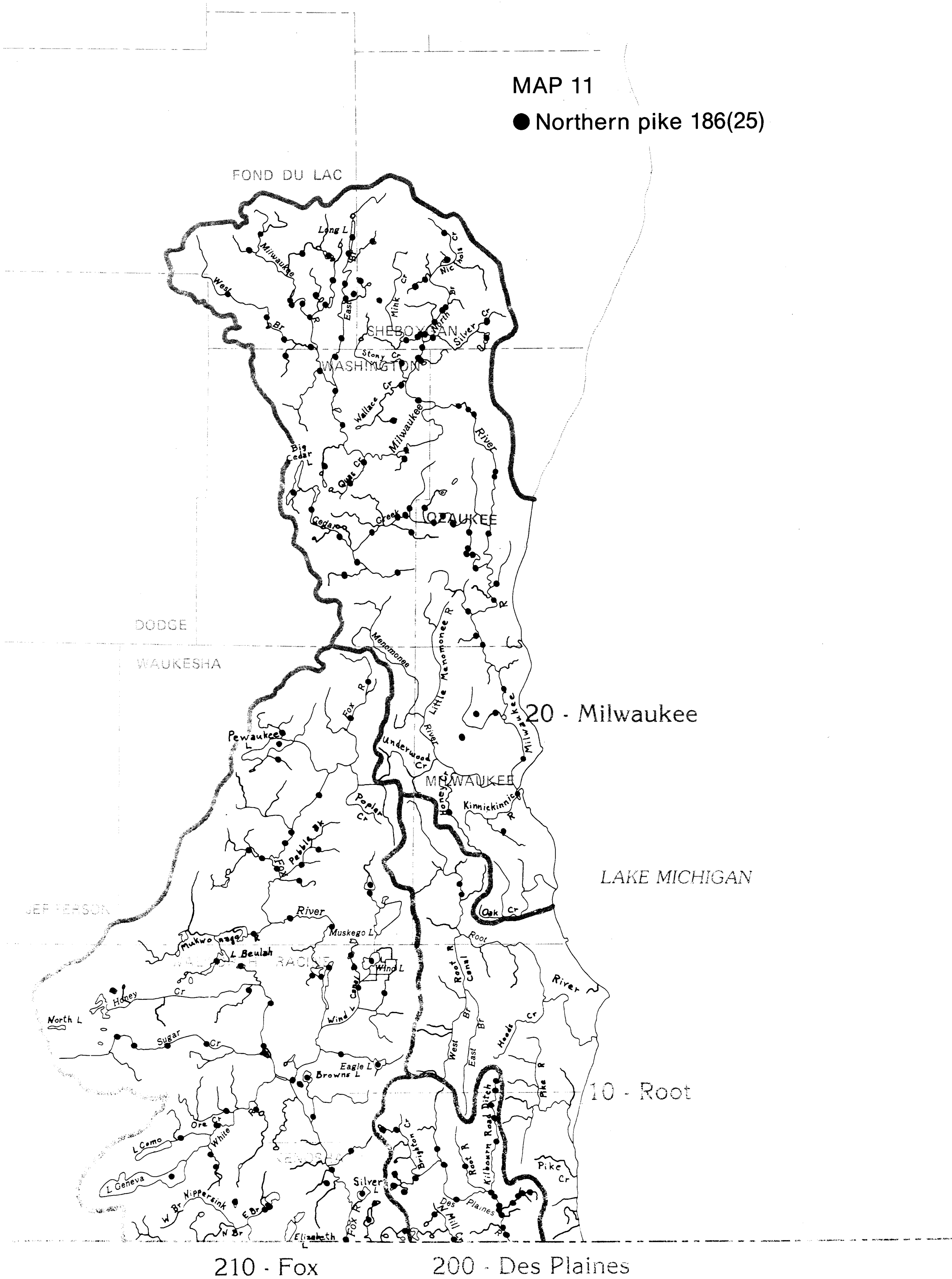

MAP 6
● Rainbow trout 15(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

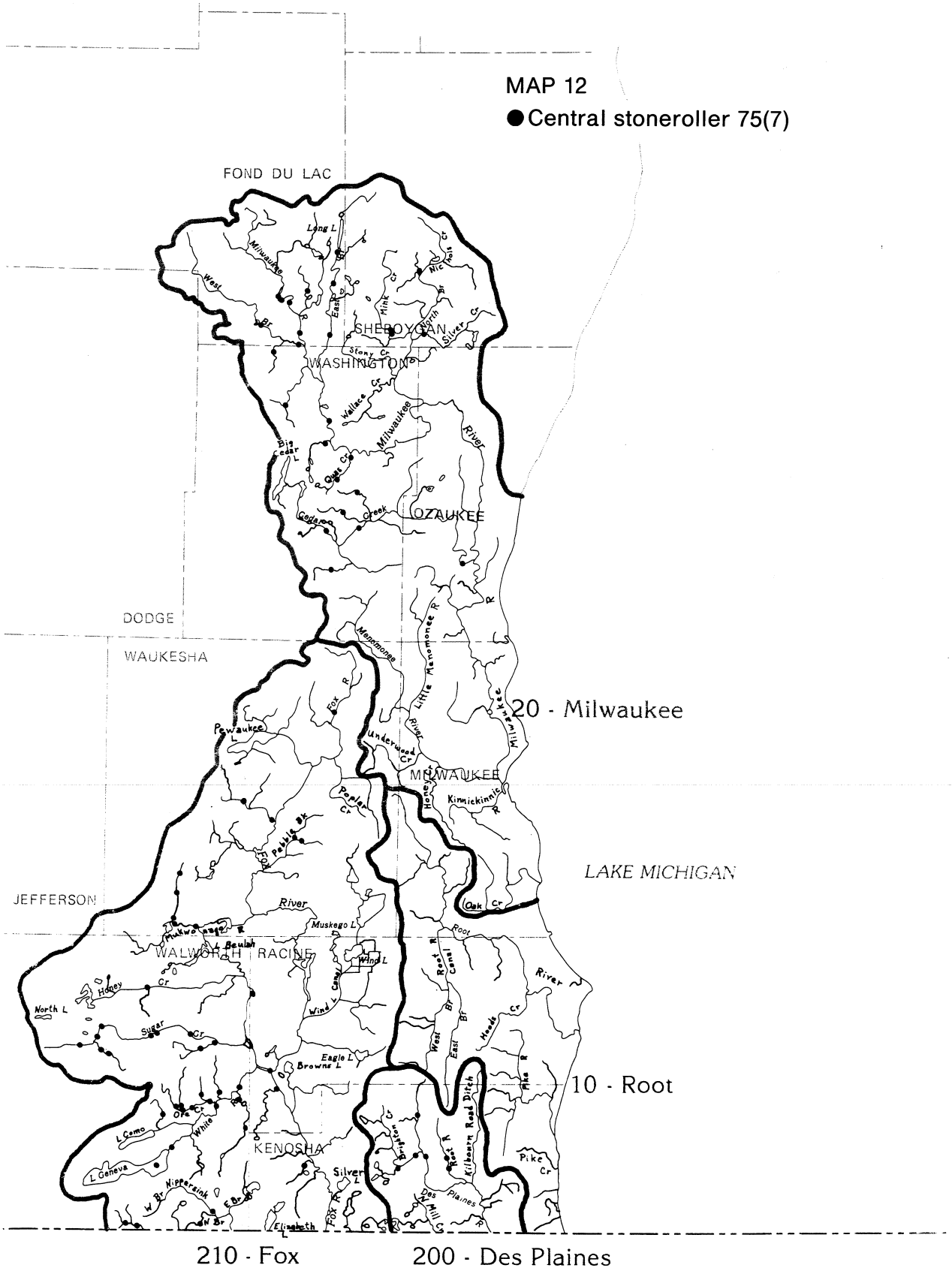

MAP 7
● Brown trout 24(1)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

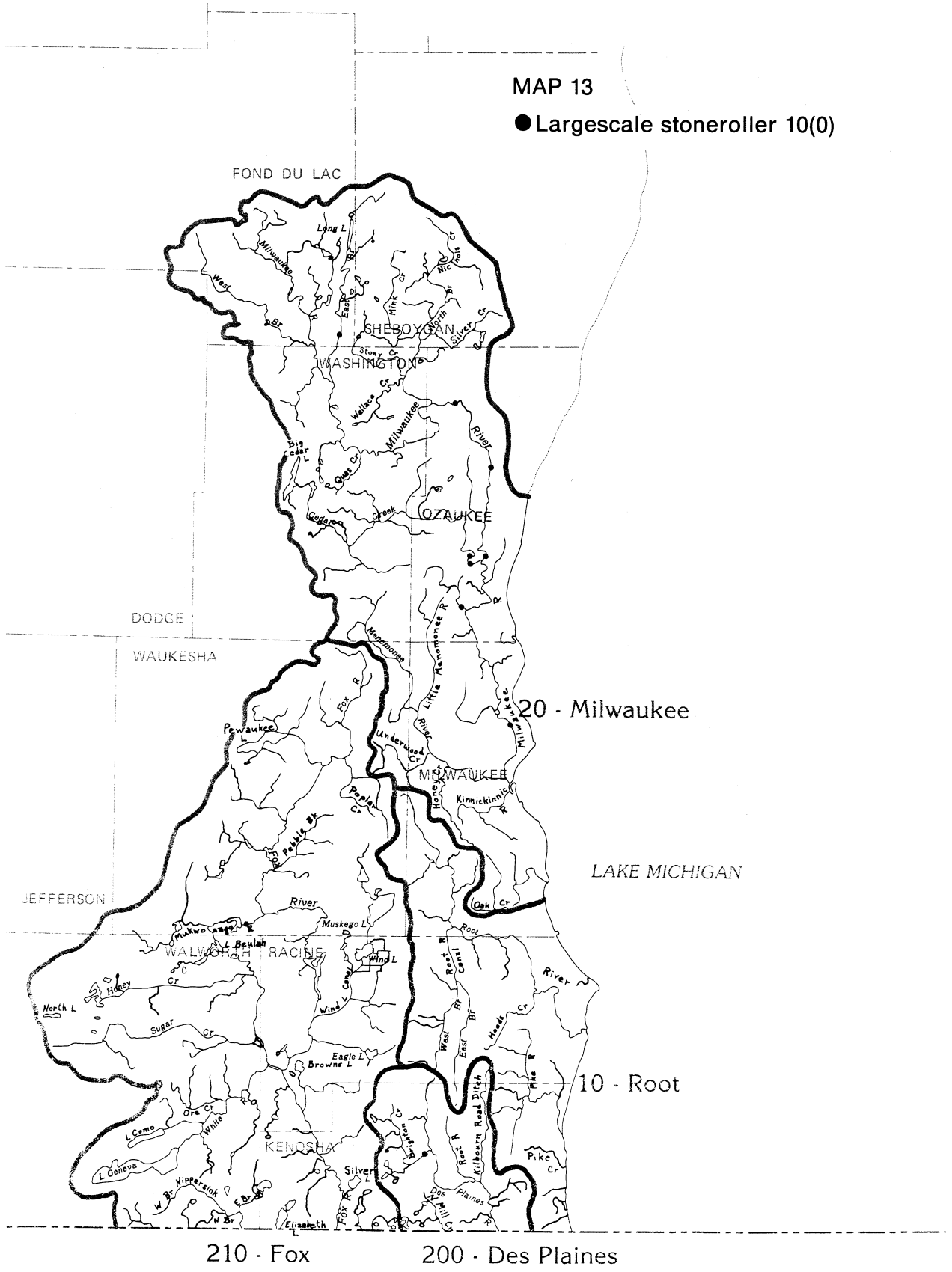

MAP 8
● Brook trout 11(0)
▲ Lake trout 1(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
20 - Milwaukee
MILWAUKEE
LAKE MICHIGAN
JEFFERSON
10 - Root
210 - Fox
200 - Des Plaines

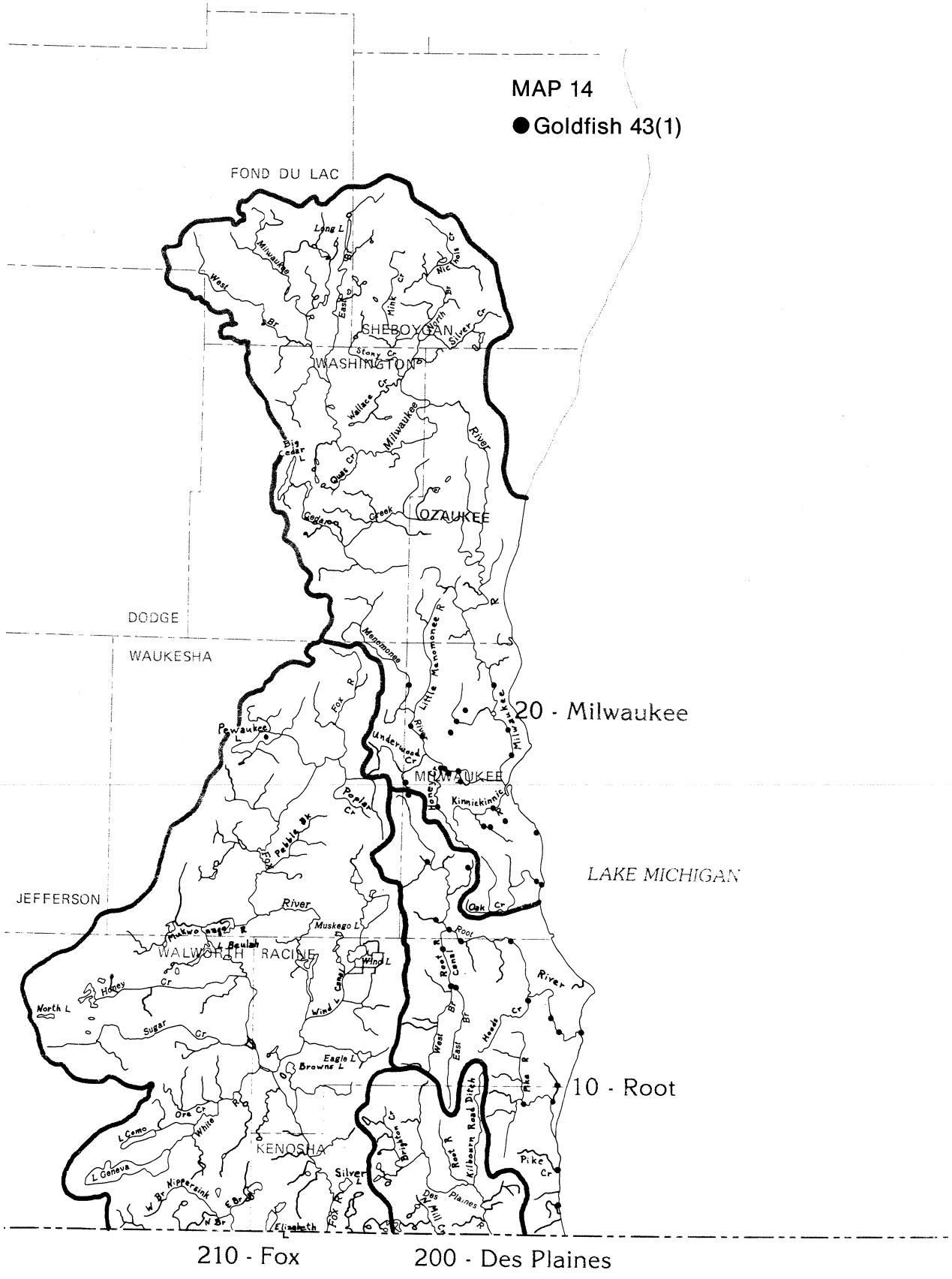

MAP 9
● Central mudminnow 234(10)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

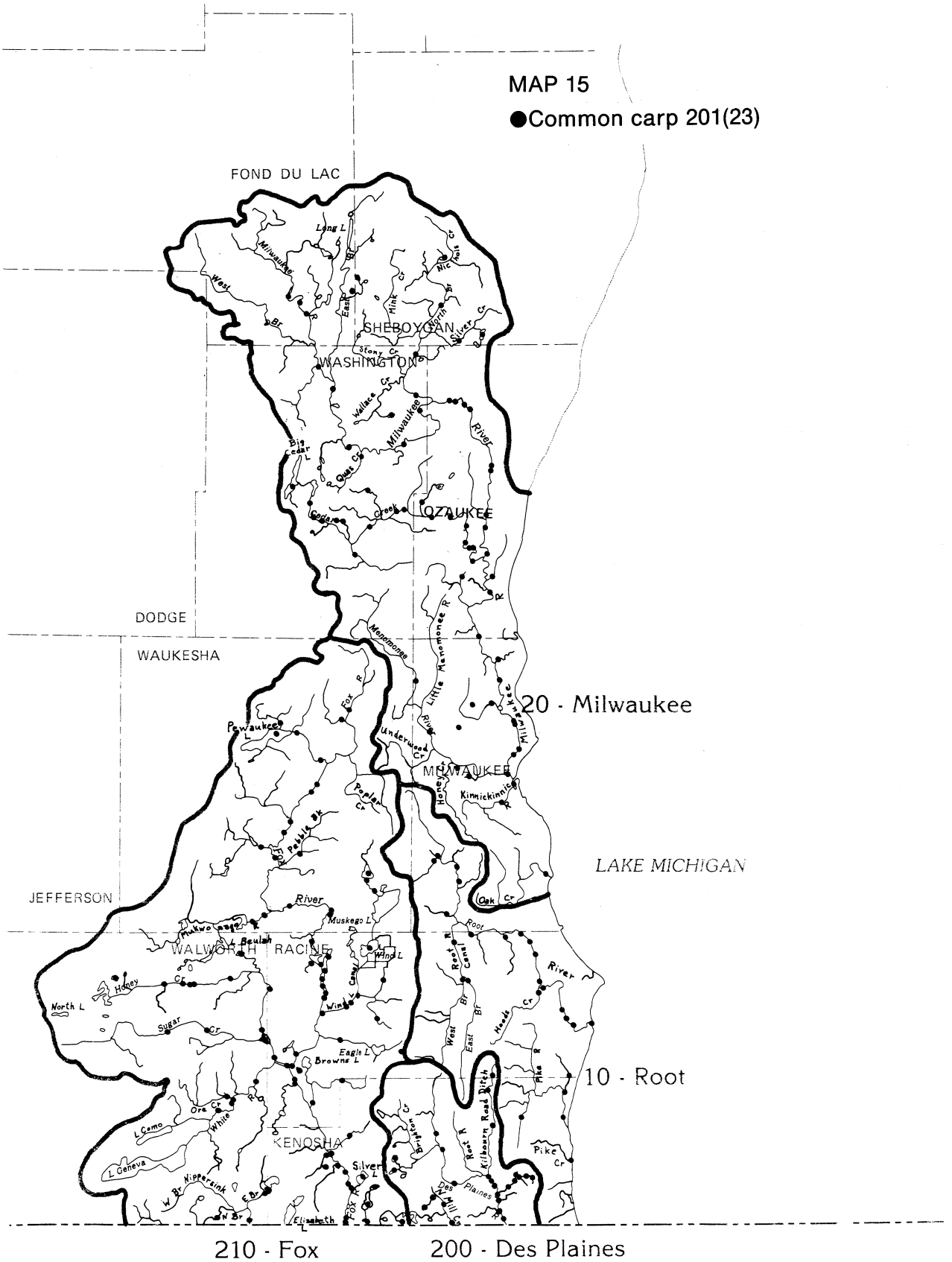

MAP 10
● Grass pickerel 56(10)
▲ Muskellunge 1(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

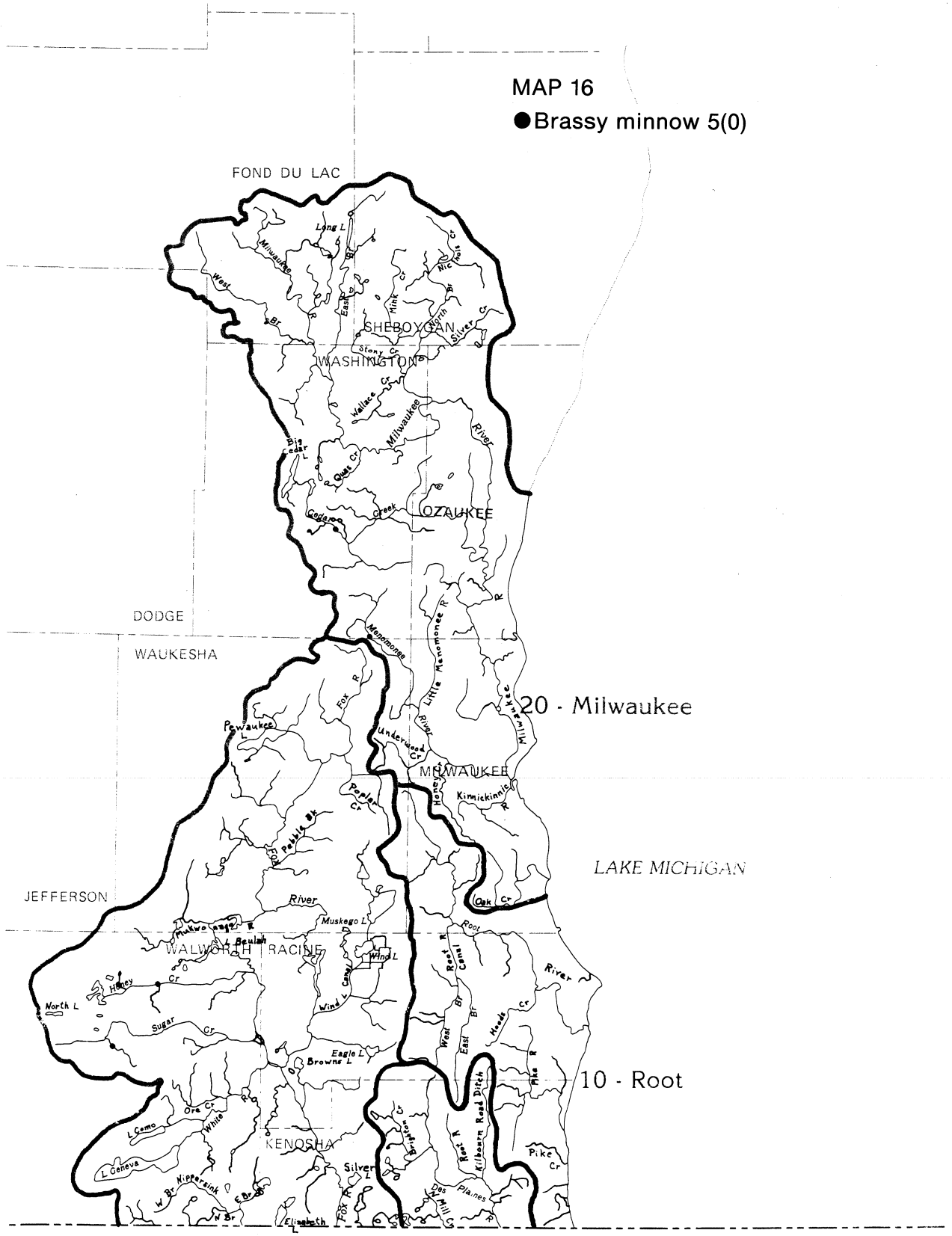

MAP 11
● Northern pike 186(25)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
RACINE
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines


MAP 12
● Central stoneroller 75(7)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines


MAP 13
● Largescale stoneroller 10(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

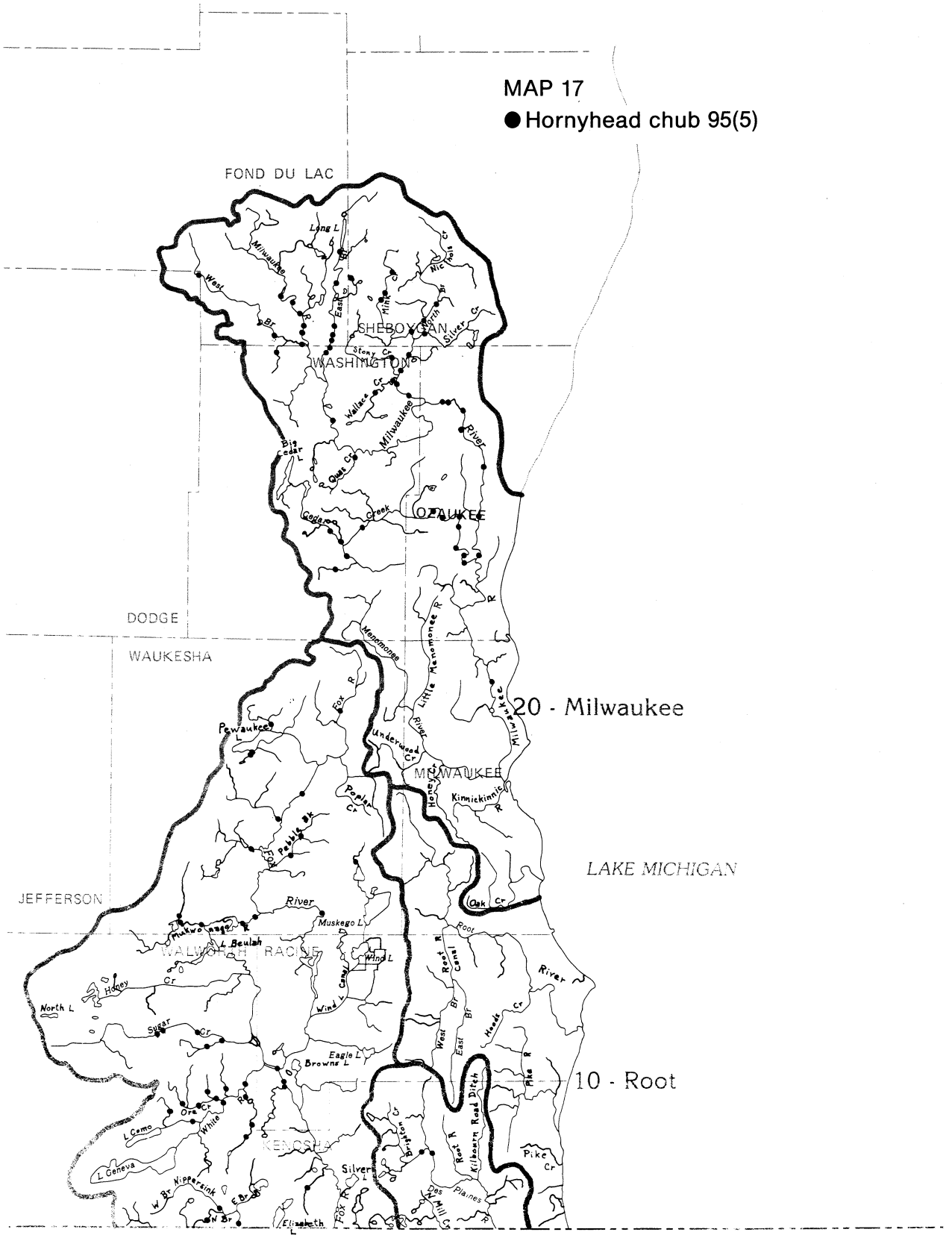

MAP 14
● Goldfish 43(1)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

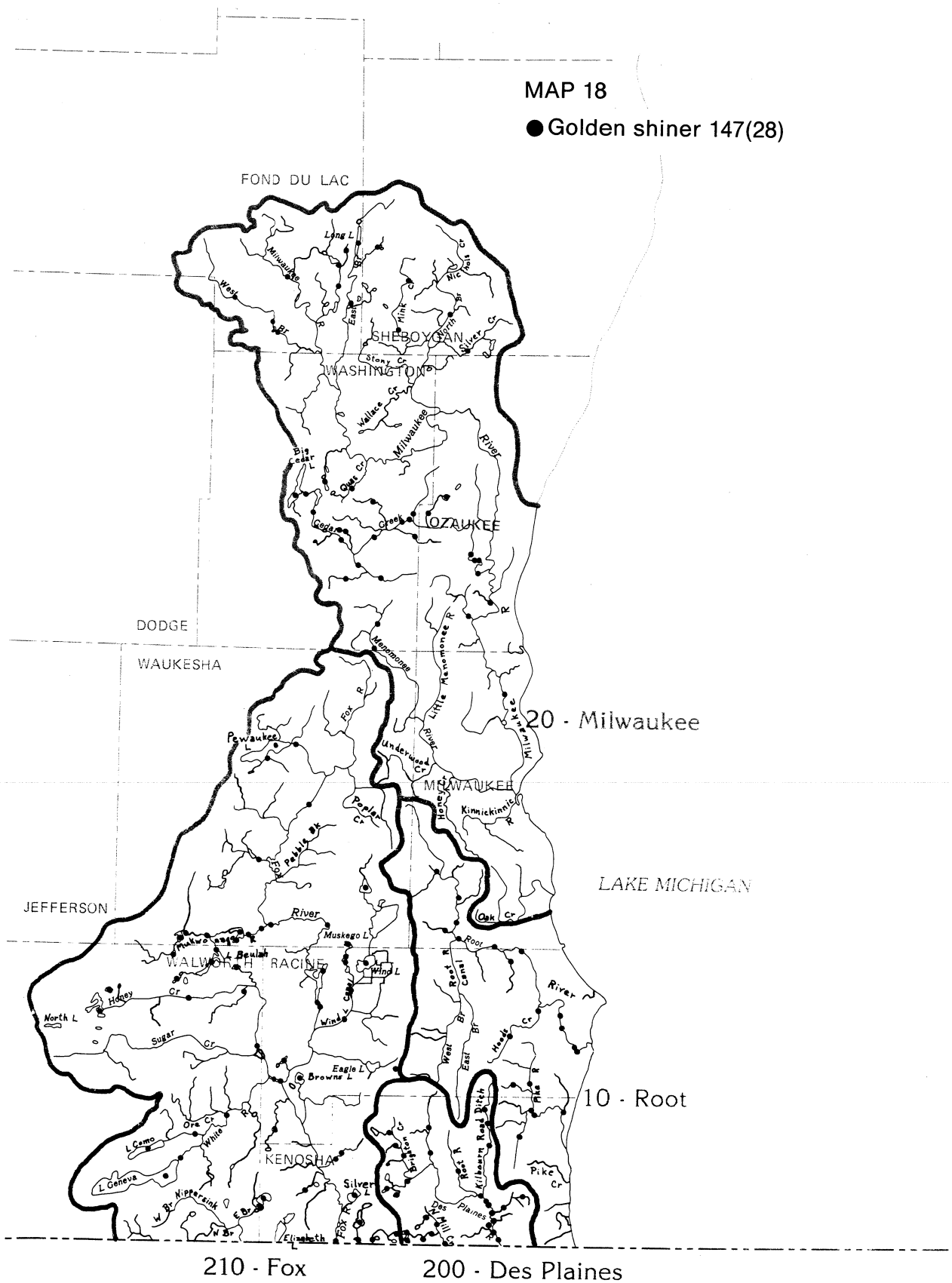

MAP 15
●Common carp 201(23)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
20 - Milwaukee
MILWAUKEE
LAKE MICHIGAN
JEFFERSON
WALWORTH
RACINE
10 - Root
KENOSHA
210 - Fox
200 - Des Plaines

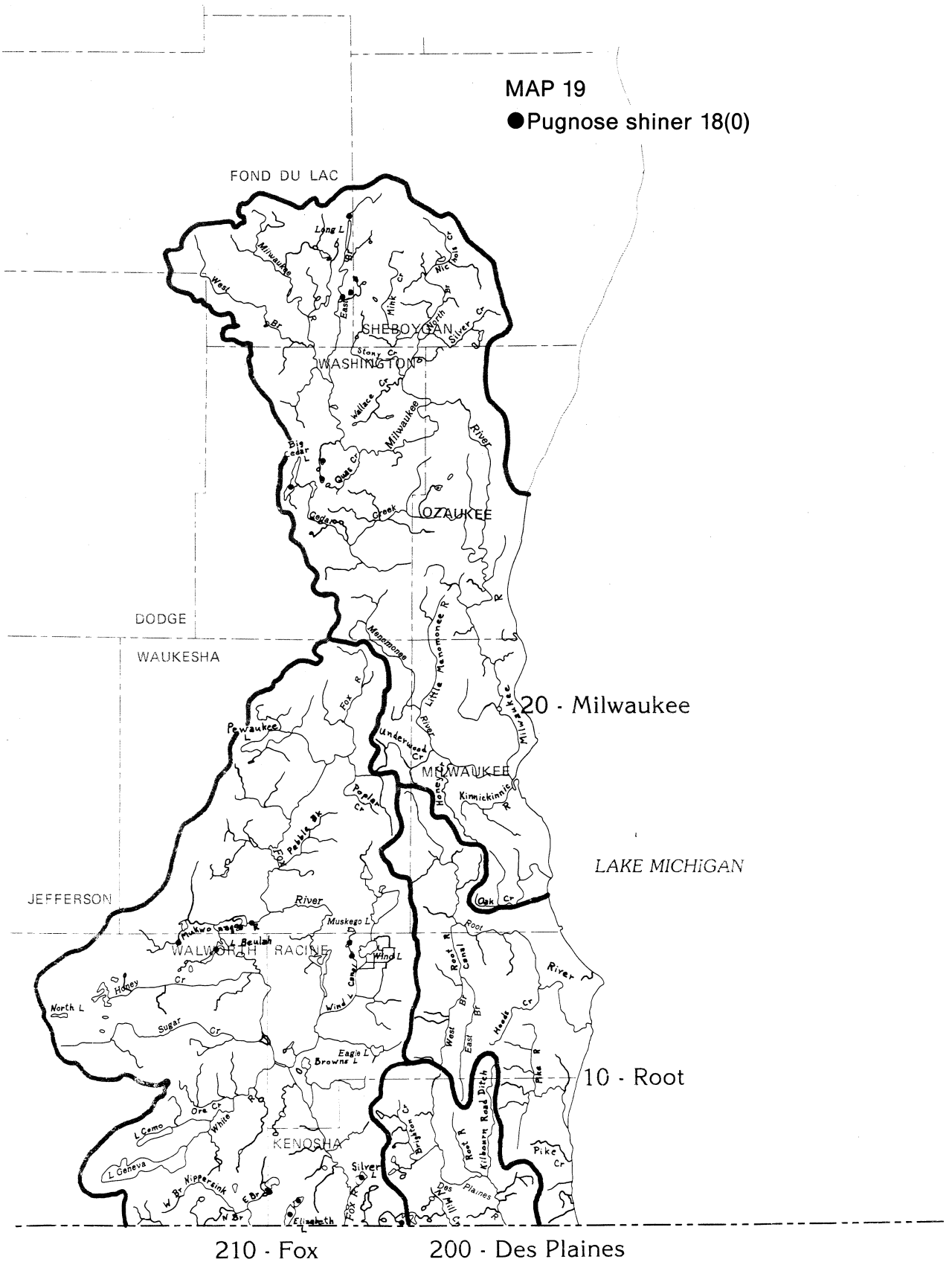

MAP 16
● Brassy minnow 5(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

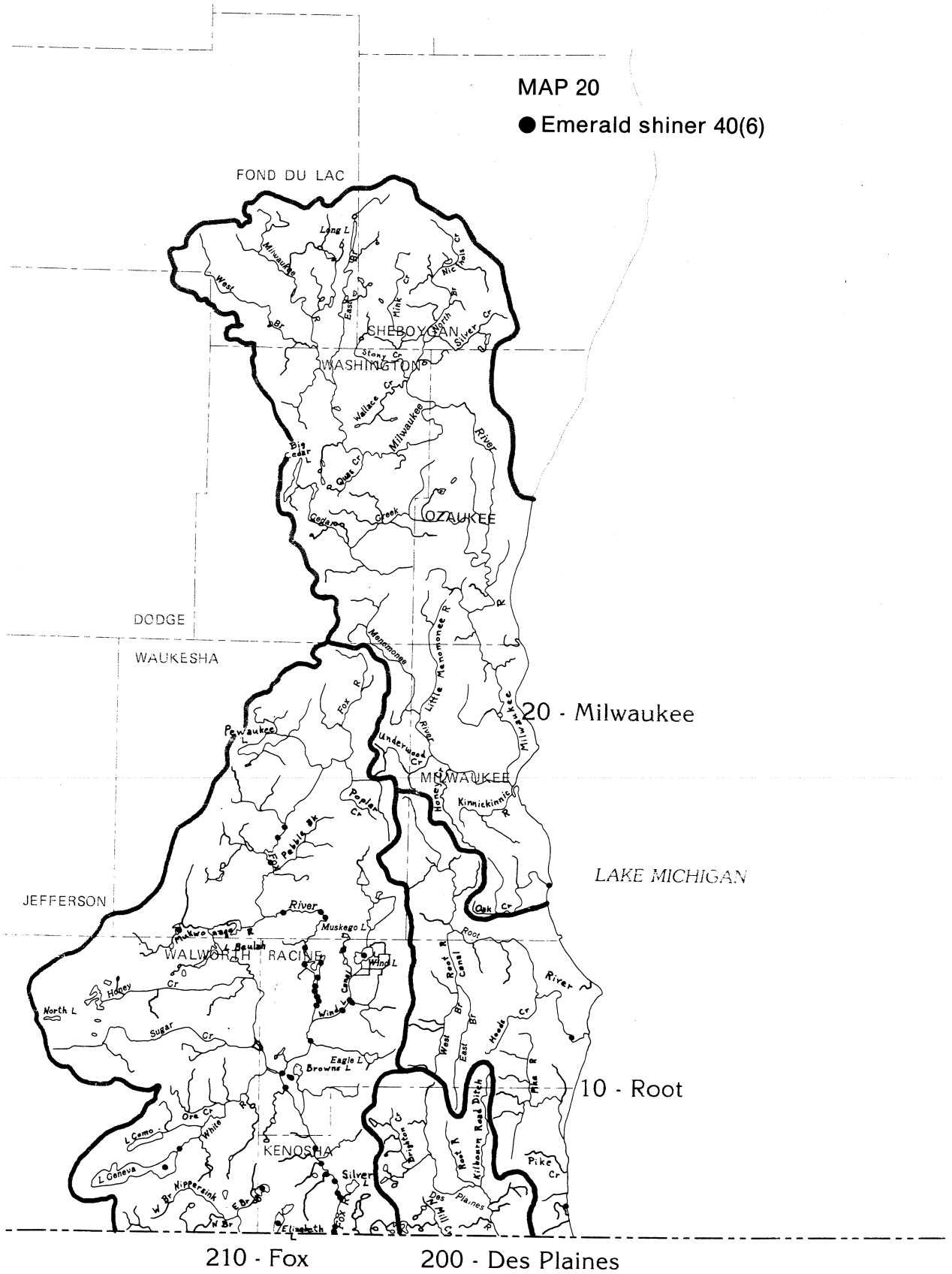
MAP 17

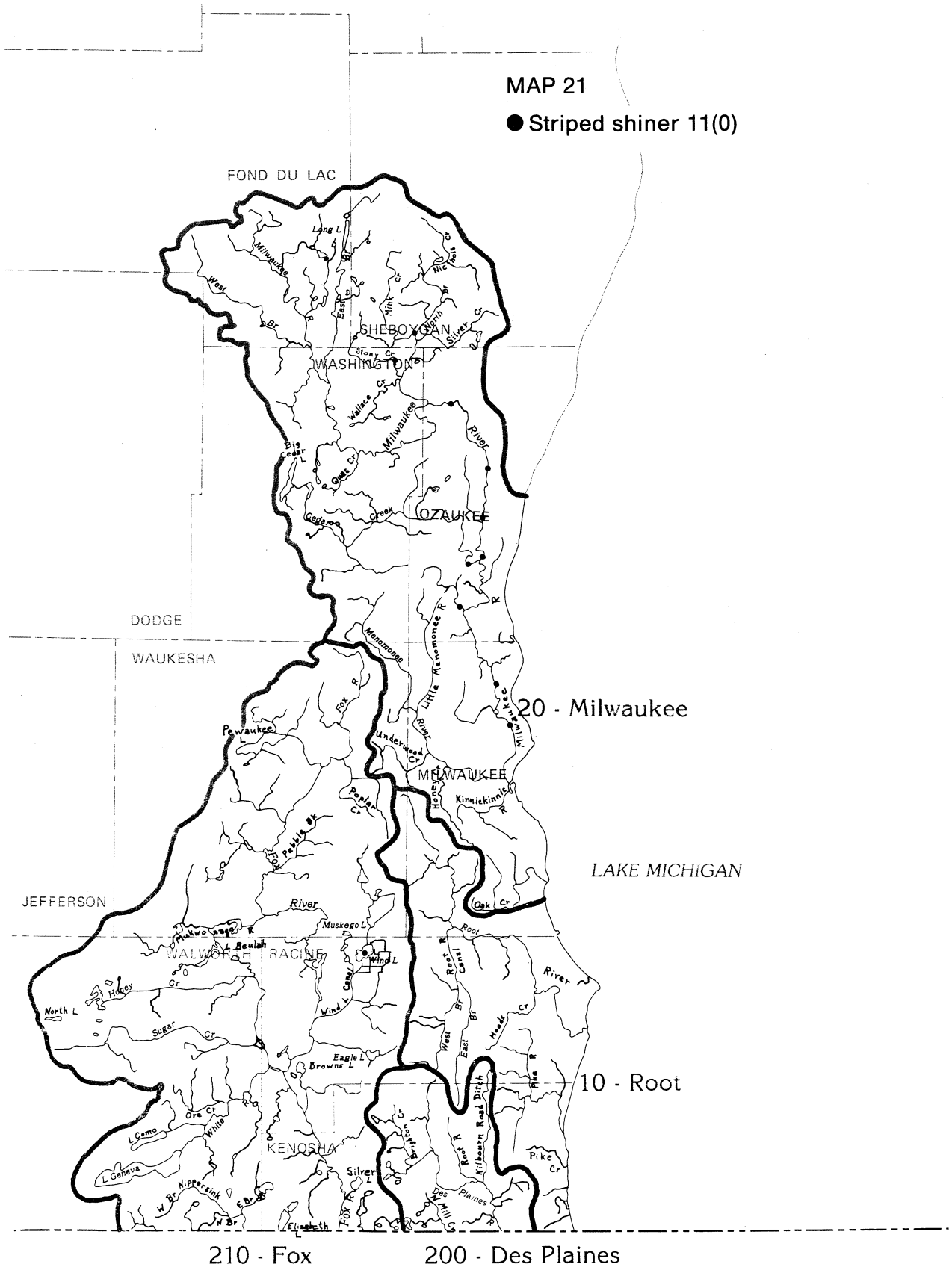
● Hornyhead chub 95(5)

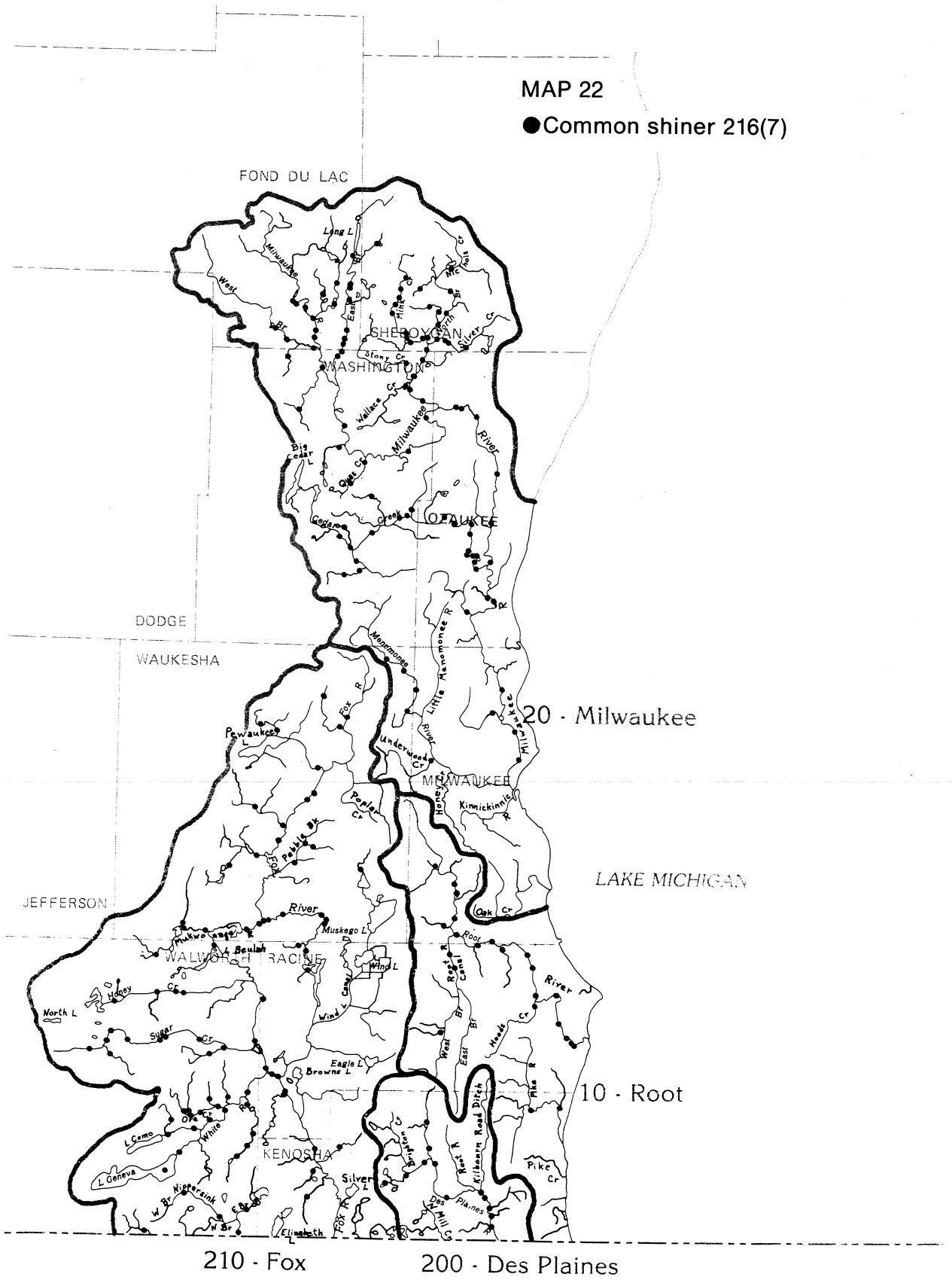


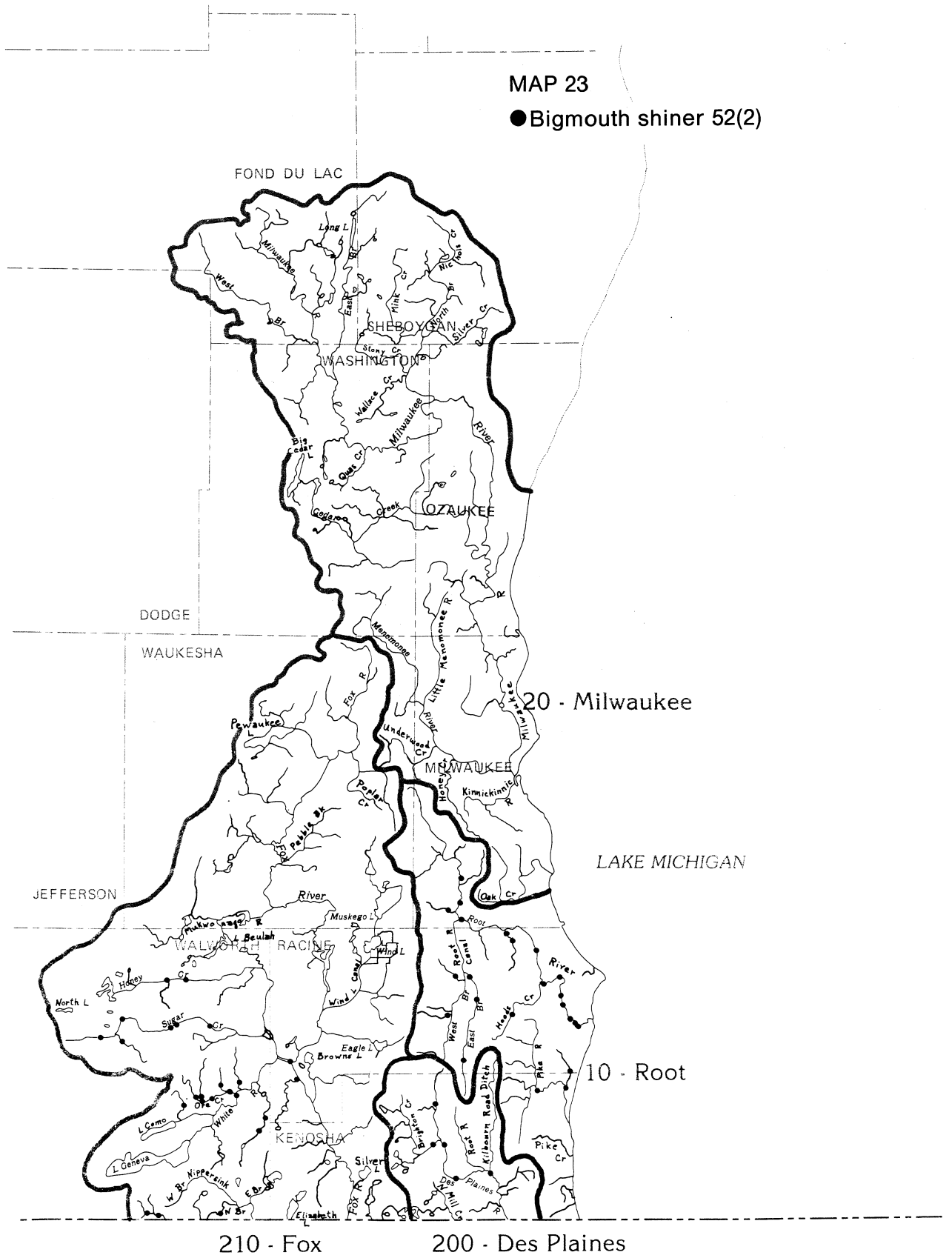

MAP 18
● Golden shiner 147(28)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

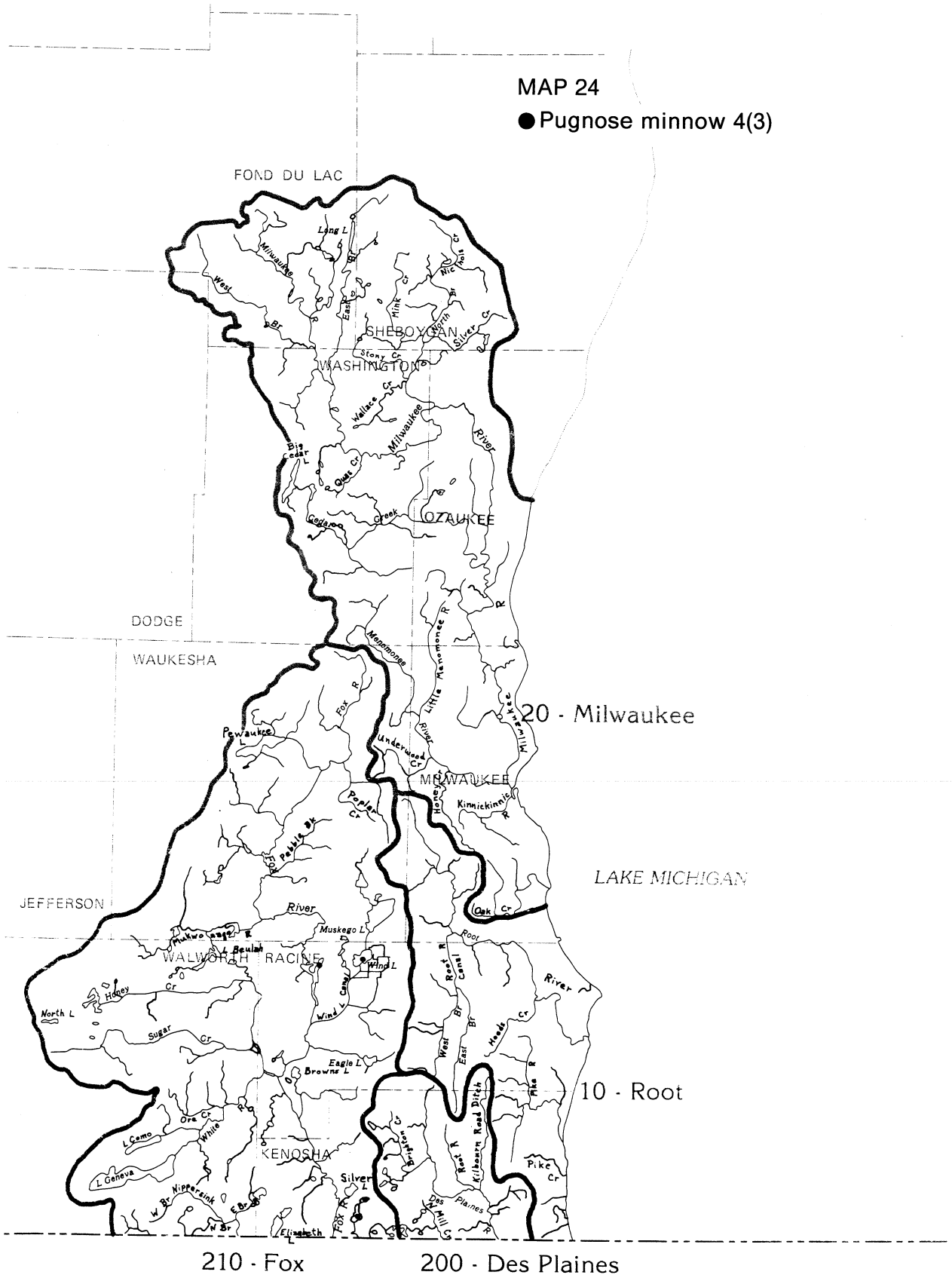

MAP 19
●Pugnose shiner 18(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKEE
WAUKESHA
MILWAUKEE
LAKE MICHIGAN
JEFFERSON
WALWORTH
RACINE
KENOSHA
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

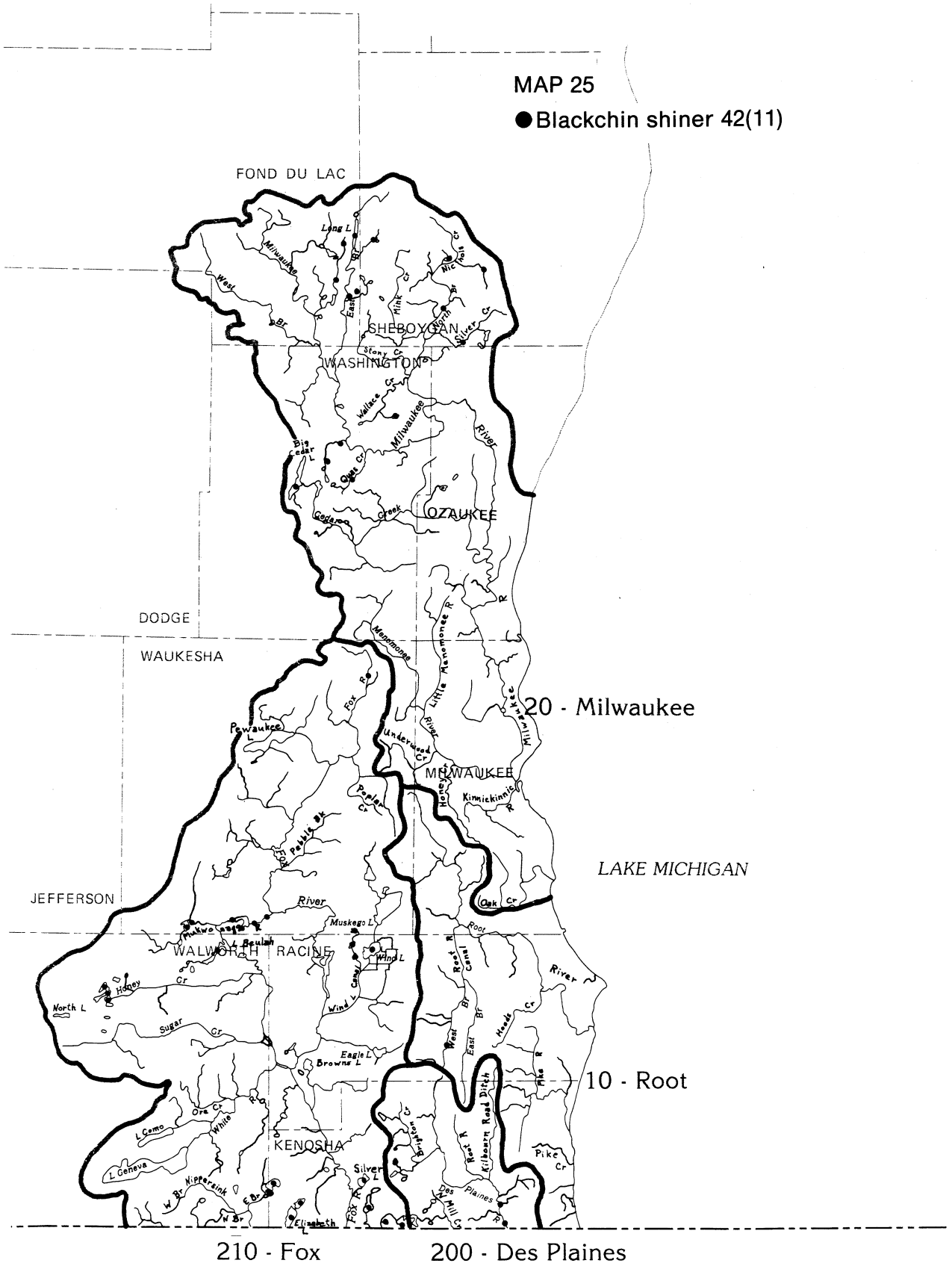

MAP 20
● Emerald shiner 40(6)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines


MAP 21
● Striped shiner 11(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines


MAP 22
●Common shiner 216(7)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

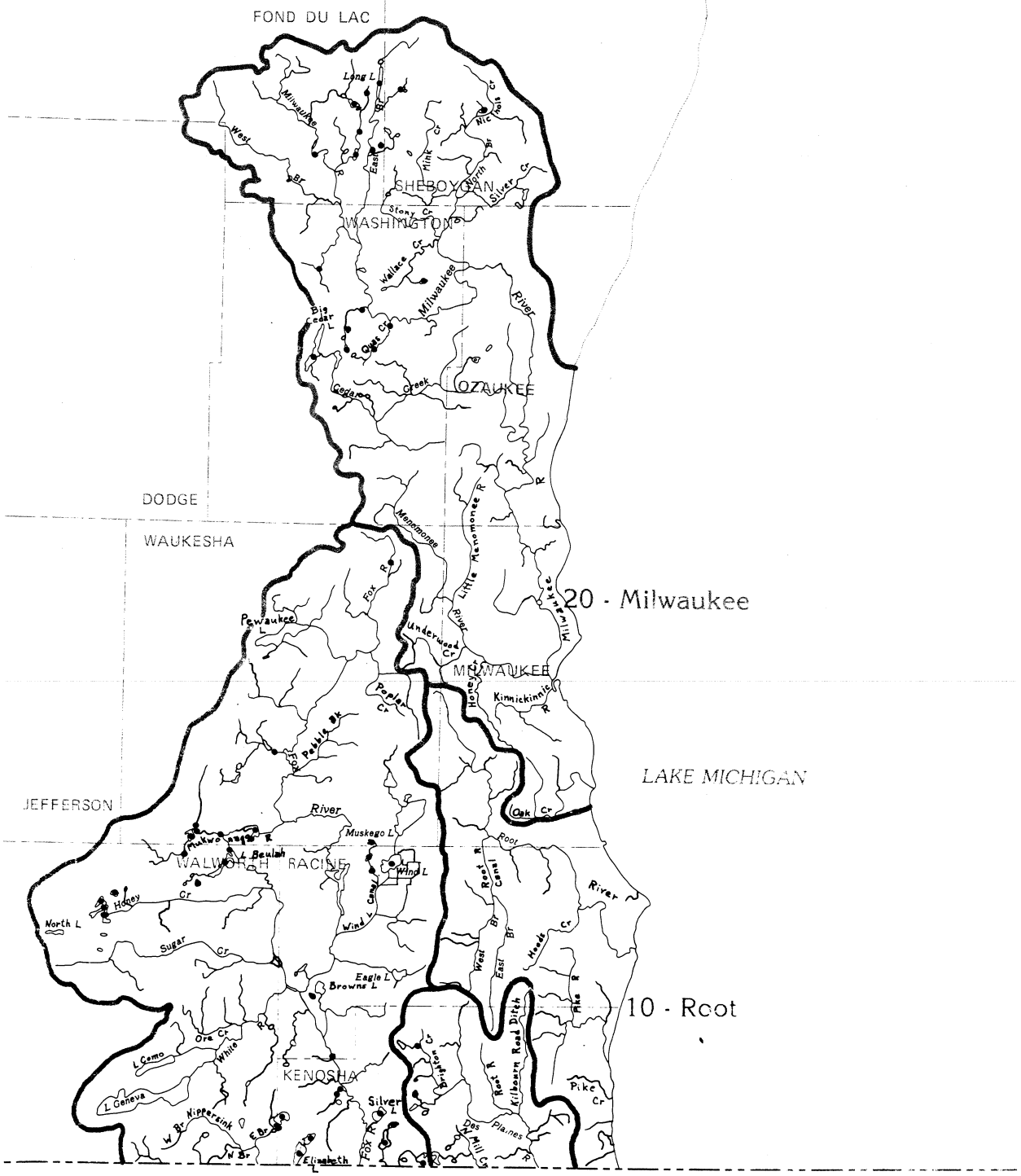

MAP 23
●Bigmouth shiner 52(2)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
JEFFERSON
WALWORTH
RACINE
KENOSHA
MILWAUKEE
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

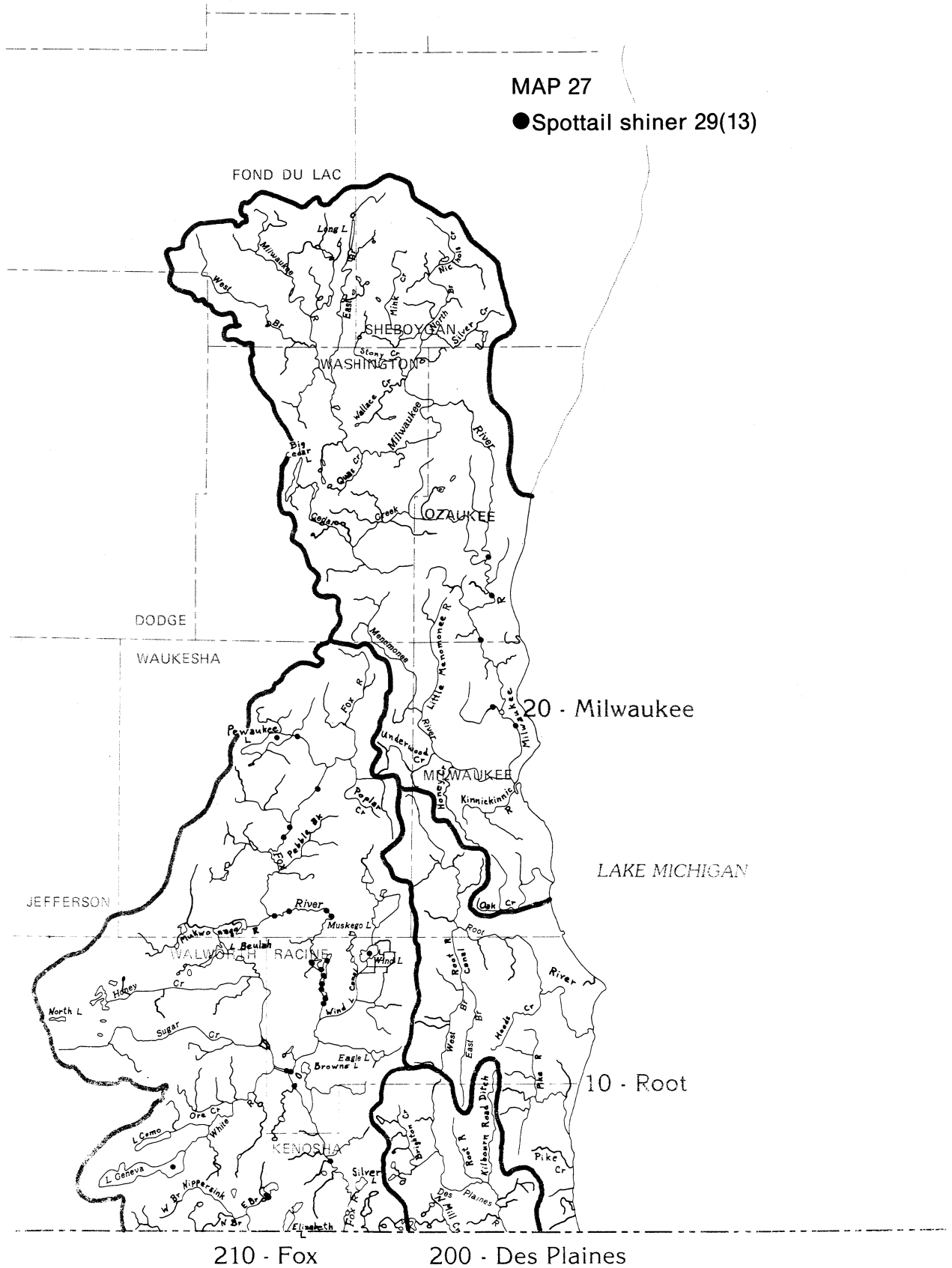

MAP 24
● Pugnose minnow 4(3)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

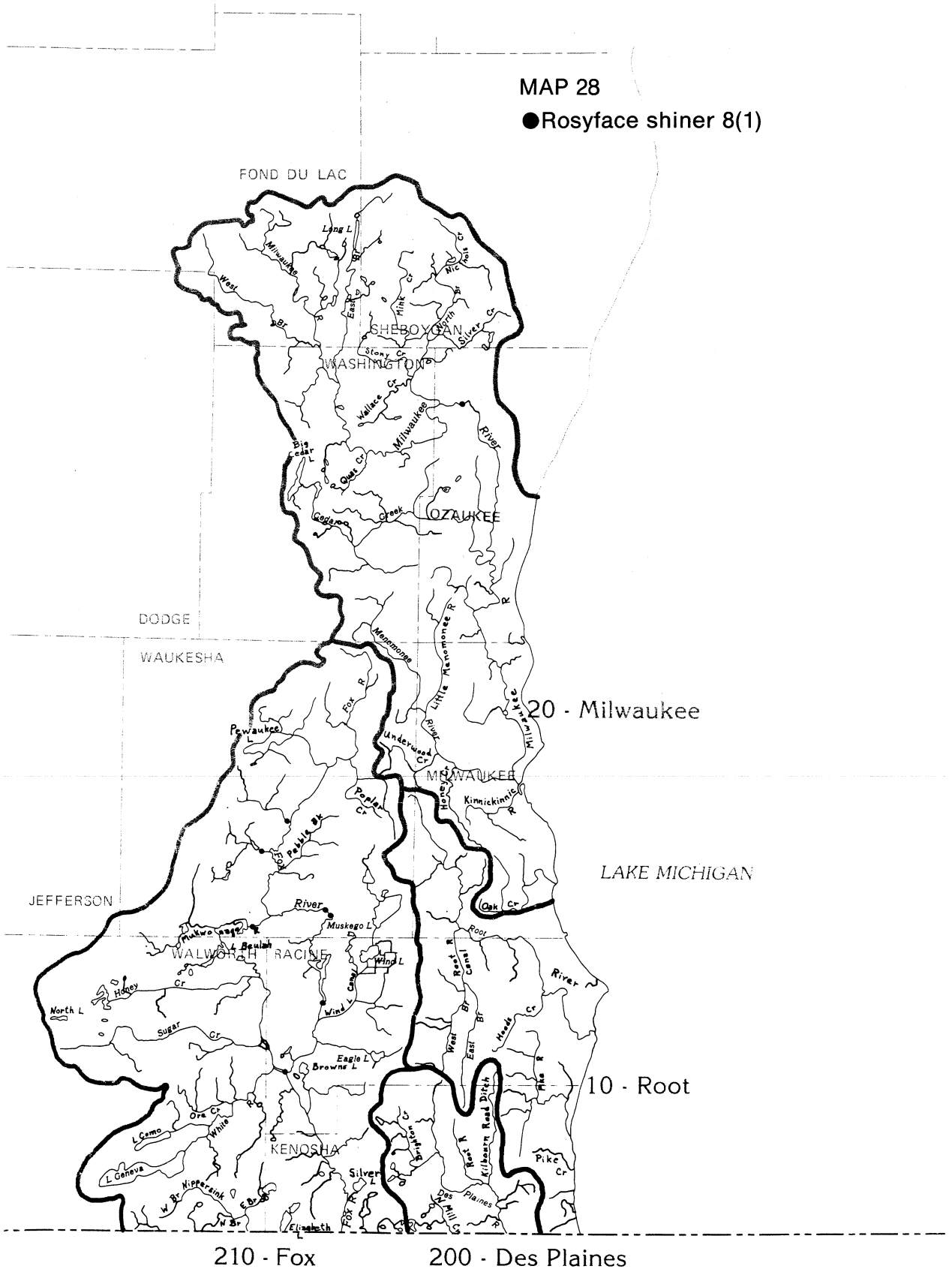

MAP 25
● Blackchin shiner 42(11)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
20 - Milwaukee
MILWAUKEE
LAKE MICHIGAN
JEFFERSON
WALWORTH
RACINE
10 - Root
KENOSHA
210 - Fox
200 - Des Plaines

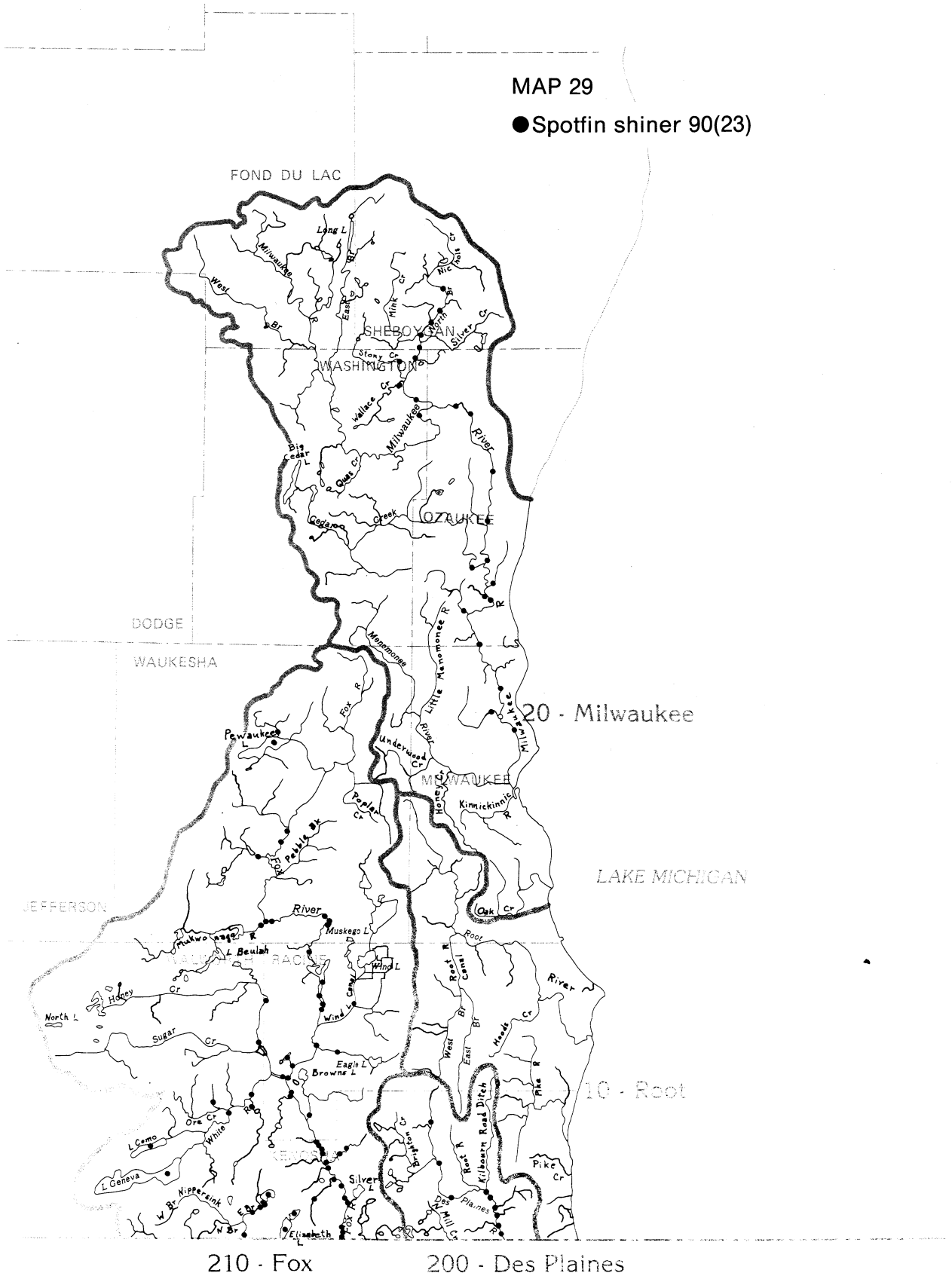
MAP 26

● Blacknose shiner 52(18)



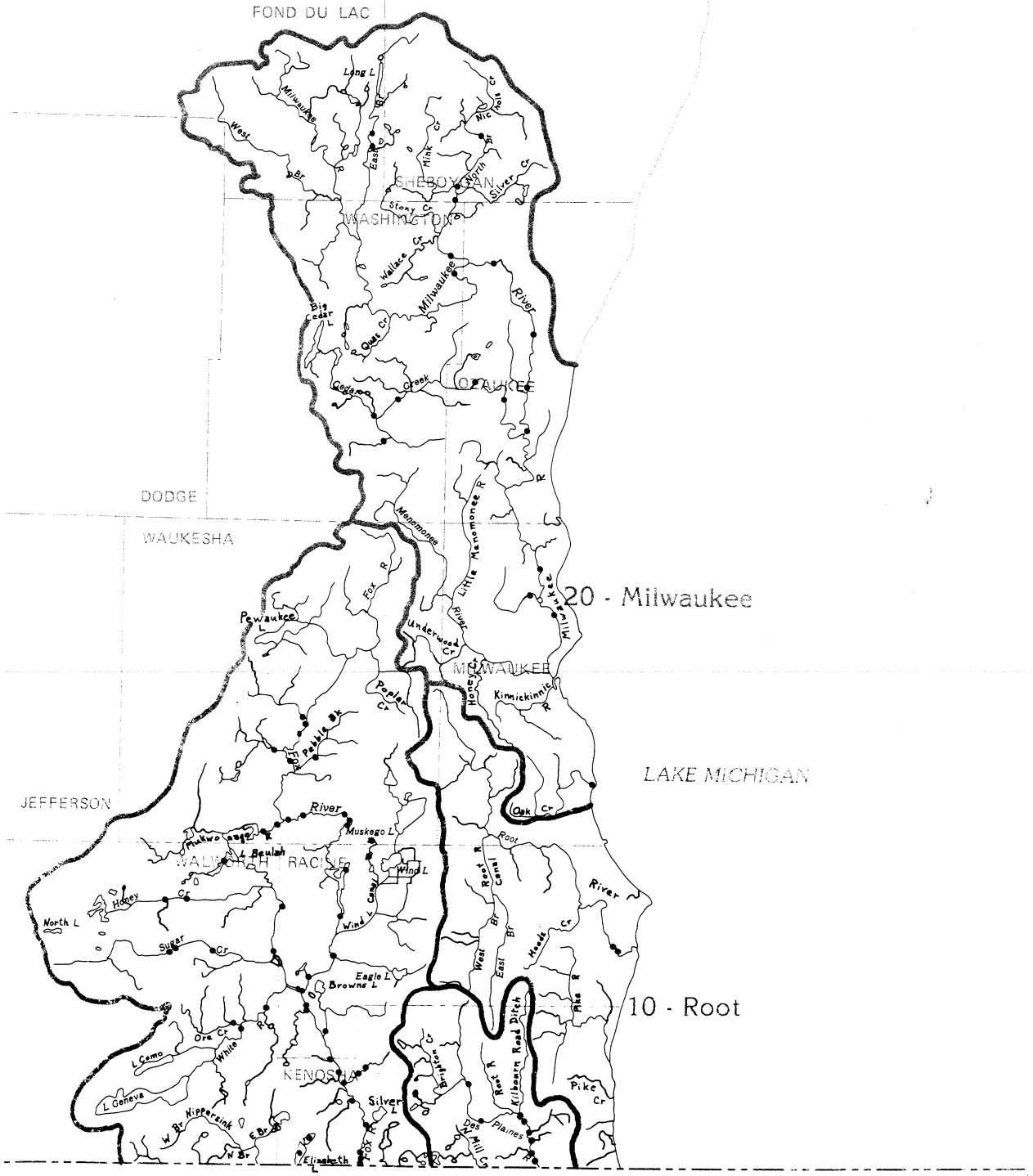

MAP 27
●Spottail shiner 29(13)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
20 - Milwaukee
MILWAUKEE
LAKE MICHIGAN
JEFFERSON
WALWORTH
RACINE
10 - Root
KENOSHA
210 - Fox
200 - Des Plaines

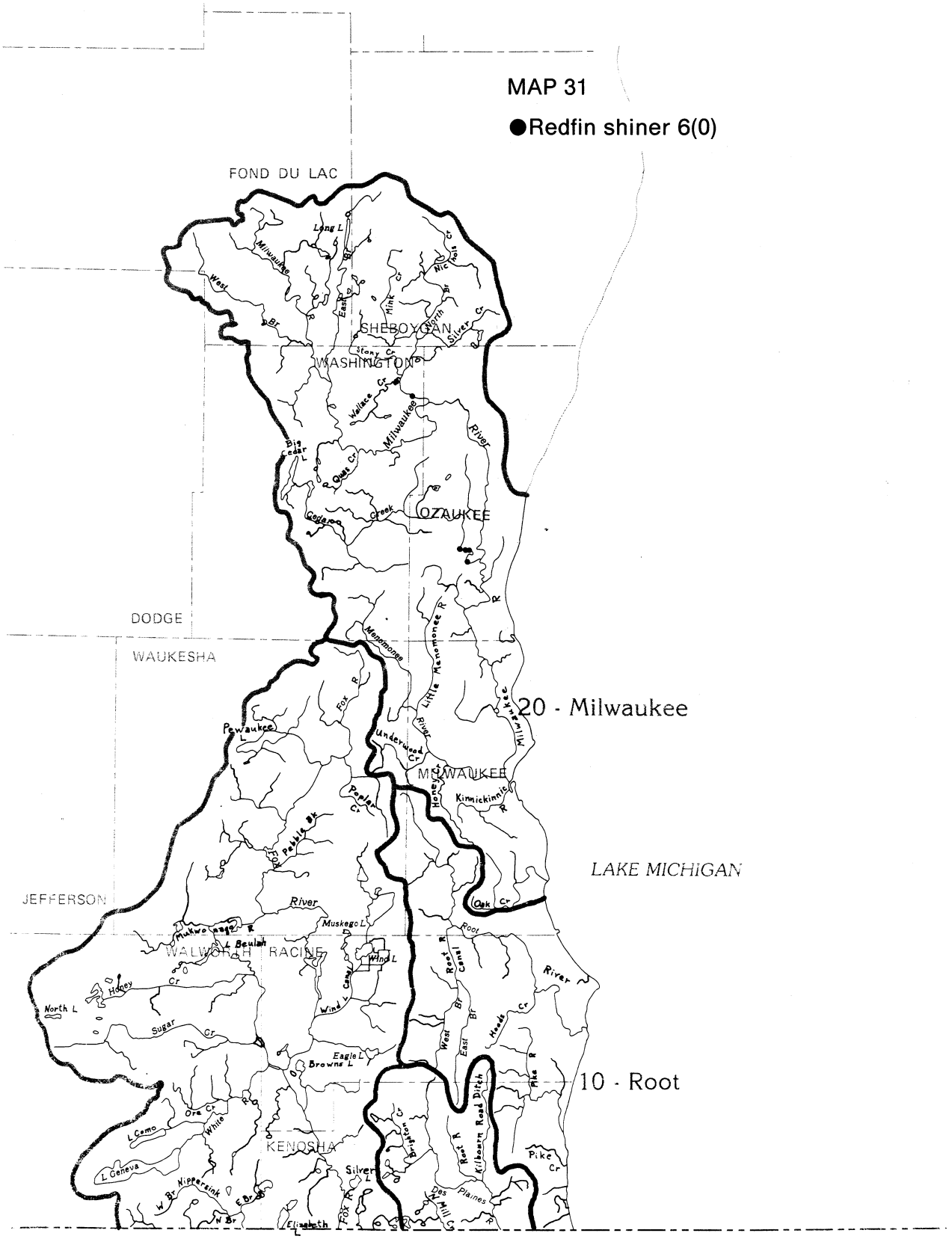

MAP 28
●Rosyface shiner 8(1)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

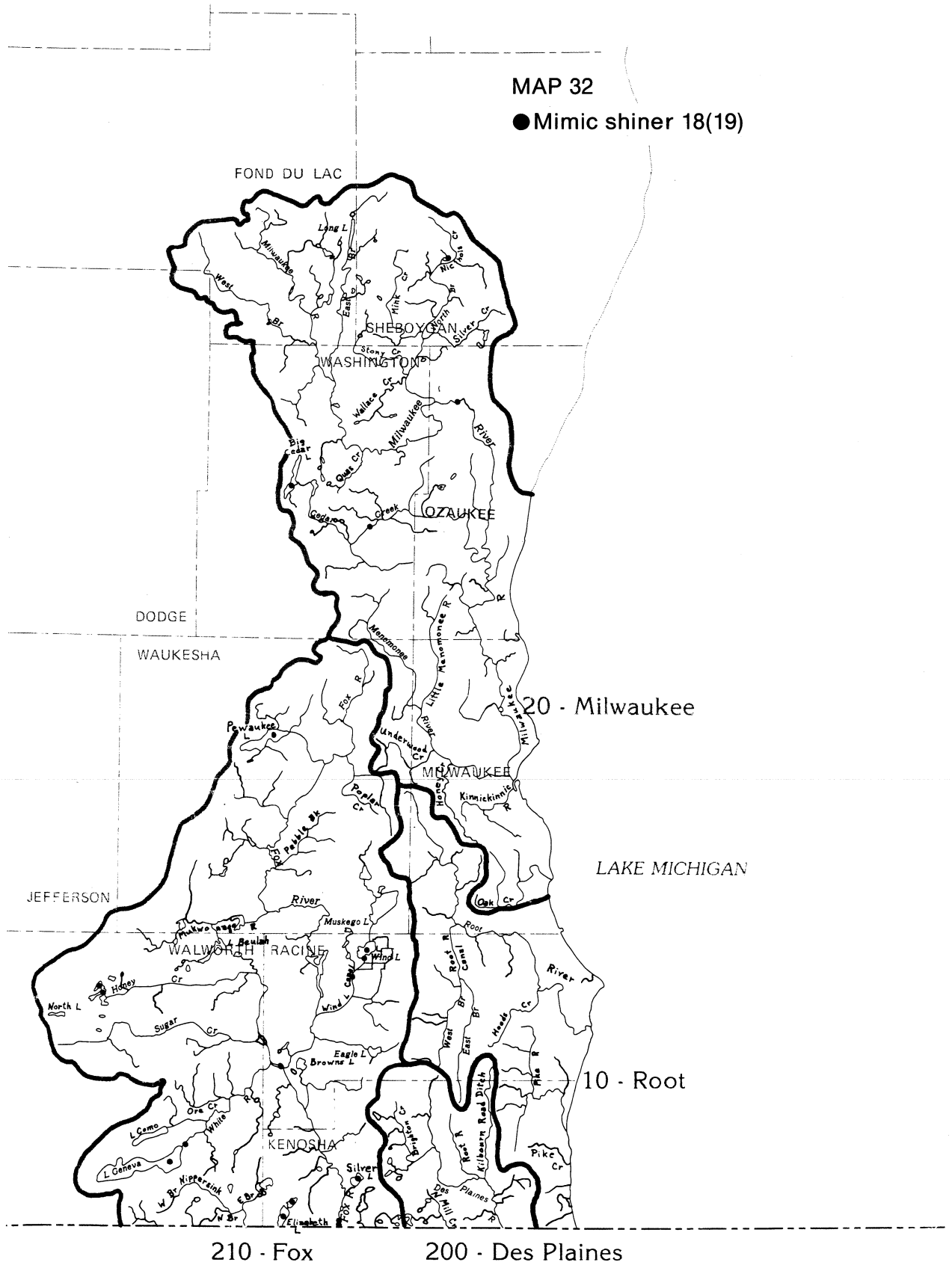

MAP 29
●Spotfin shiner 90(23)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
JEFFERSON
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

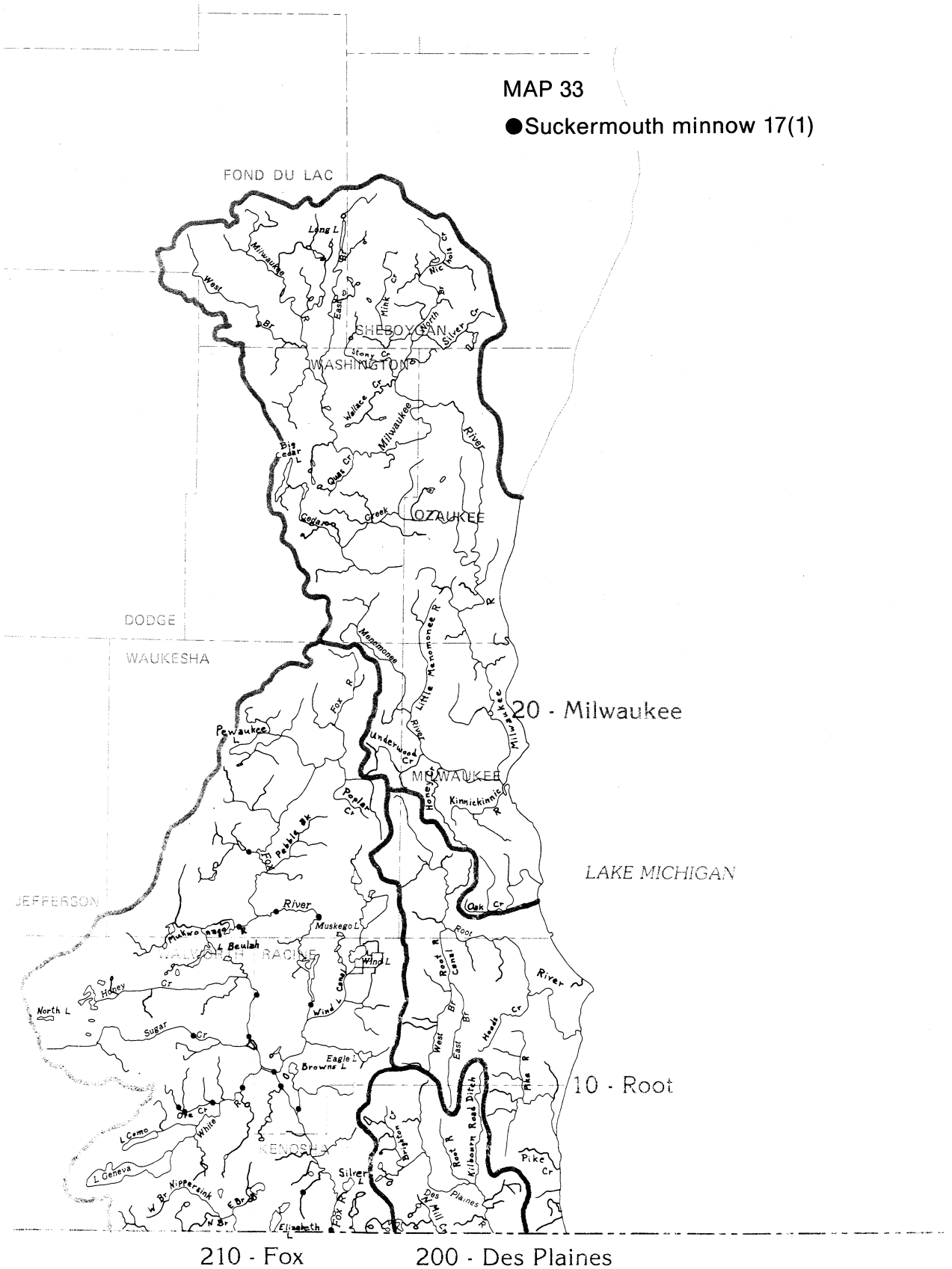
MAP 30

● Sand shiner 78(10)



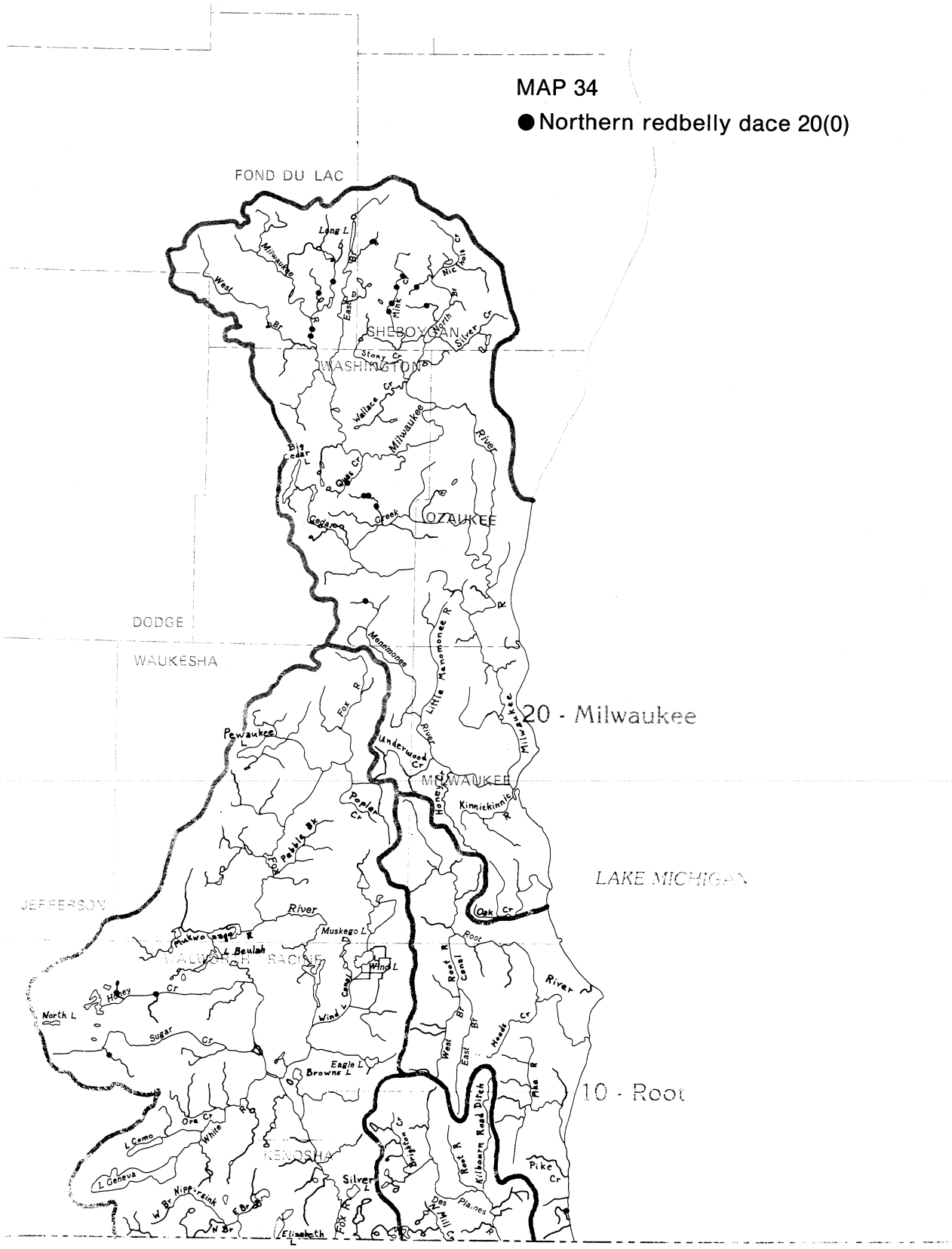

MAP 31
●Redfin shiner 6(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines
Long L
Milwaukee R
West Br
East Br
Mink Cr
Nic Pool
North Br
Silver Cr
Stony Cr
Wallace Cr
Big Cedar L
Oak Cr
Cedarburg Creek
Menomonee R
Little Menomonee River
Underwood Cr
Honey Cr
Kinnickinnic R
Pebble Br
Oak Cr
Muskego L
Beulah L
Wind L
Wind L Canal
Root R Canal
Root River
Honey Cr
North L
Sugar Cr
Eagle L
Browns L
West Br
East Br
Hoods Cr
Ora Cr
White R
L Como
L Geneva
W Br Nippersink
E Br
N Br
Elizabeth L
Fox R
Silver L
Brighton
Root R
Kilbourn Road Ditch
Pike R
Pike Cr
Des Plaines R
Mill Cr

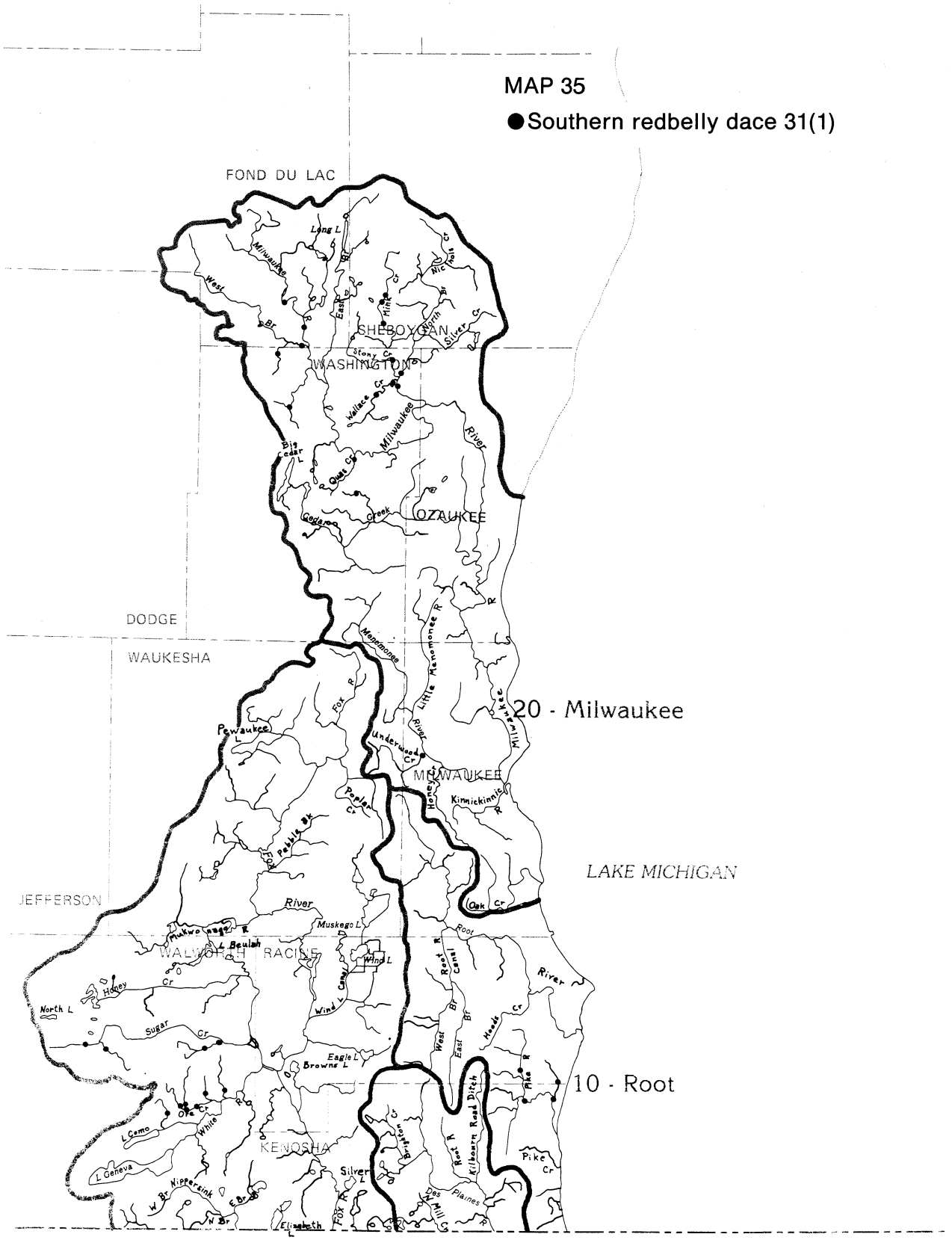

MAP 32
● Mimic shiner 18(19)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

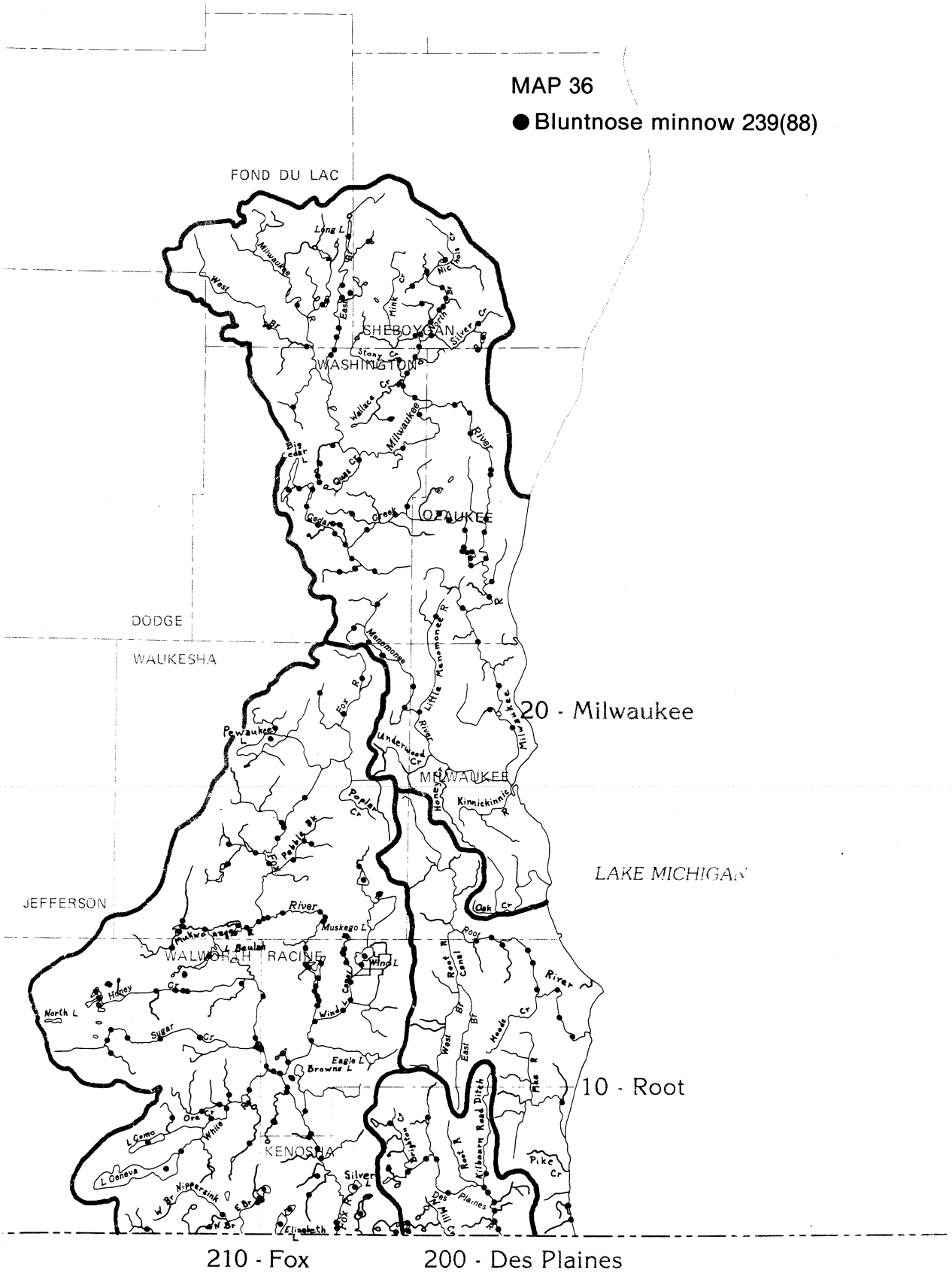

MAP 33
●Suckermouth minnow 17(1)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

MAP 34

● Northern redbelly dace 20(0)

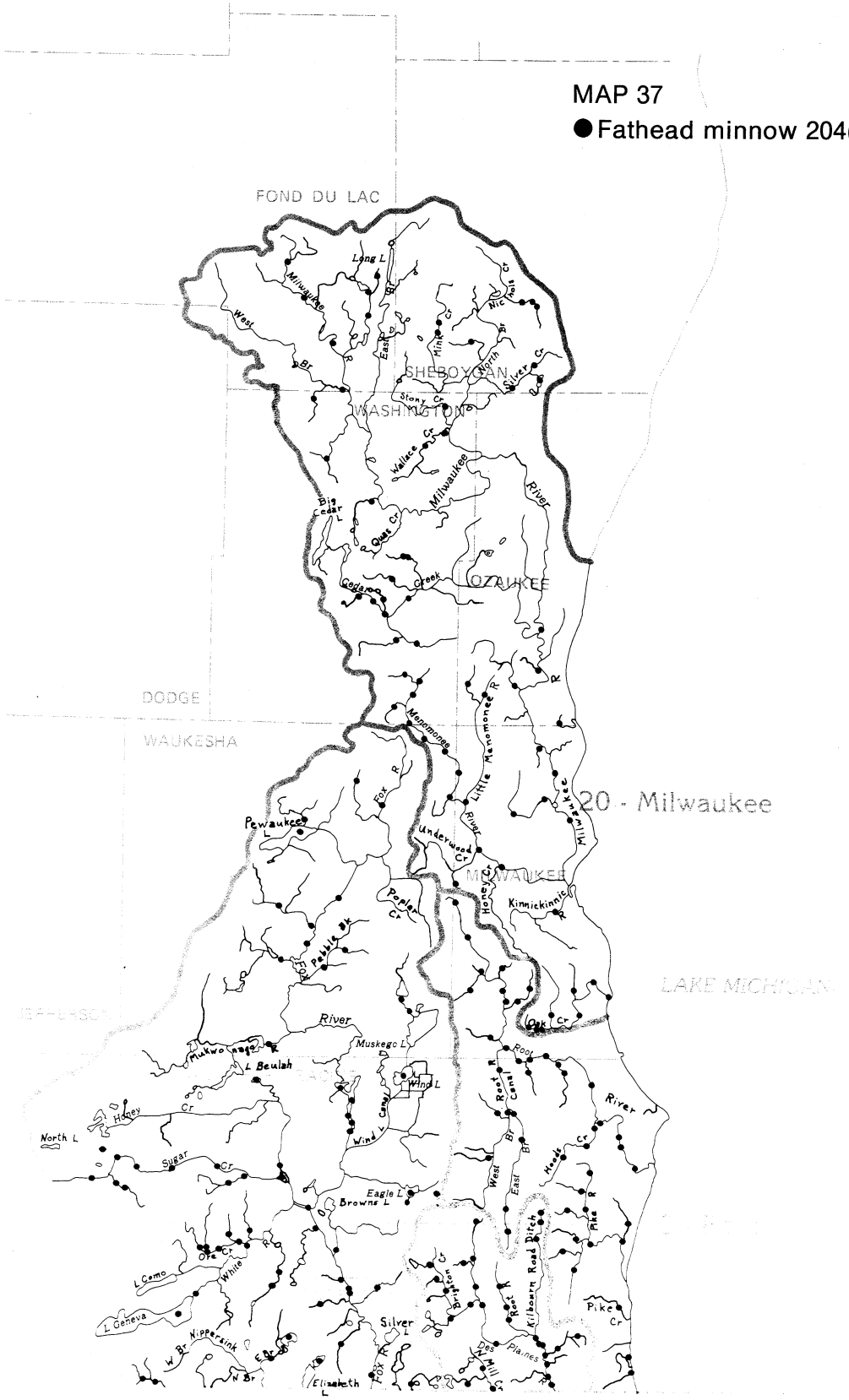



MAP 35
● Southern redbelly dace 31(1)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
20 - Milwaukee
MILWAUKEE
LAKE MICHIGAN
JEFFERSON
WALWORTH
RACINE
10 - Root
KENOSHA
210 - Fox
200 - Des Plaines


MAP 36
● Bluntnose minnow 239(88)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

MAP 37

● Fathead minnow 204(9)

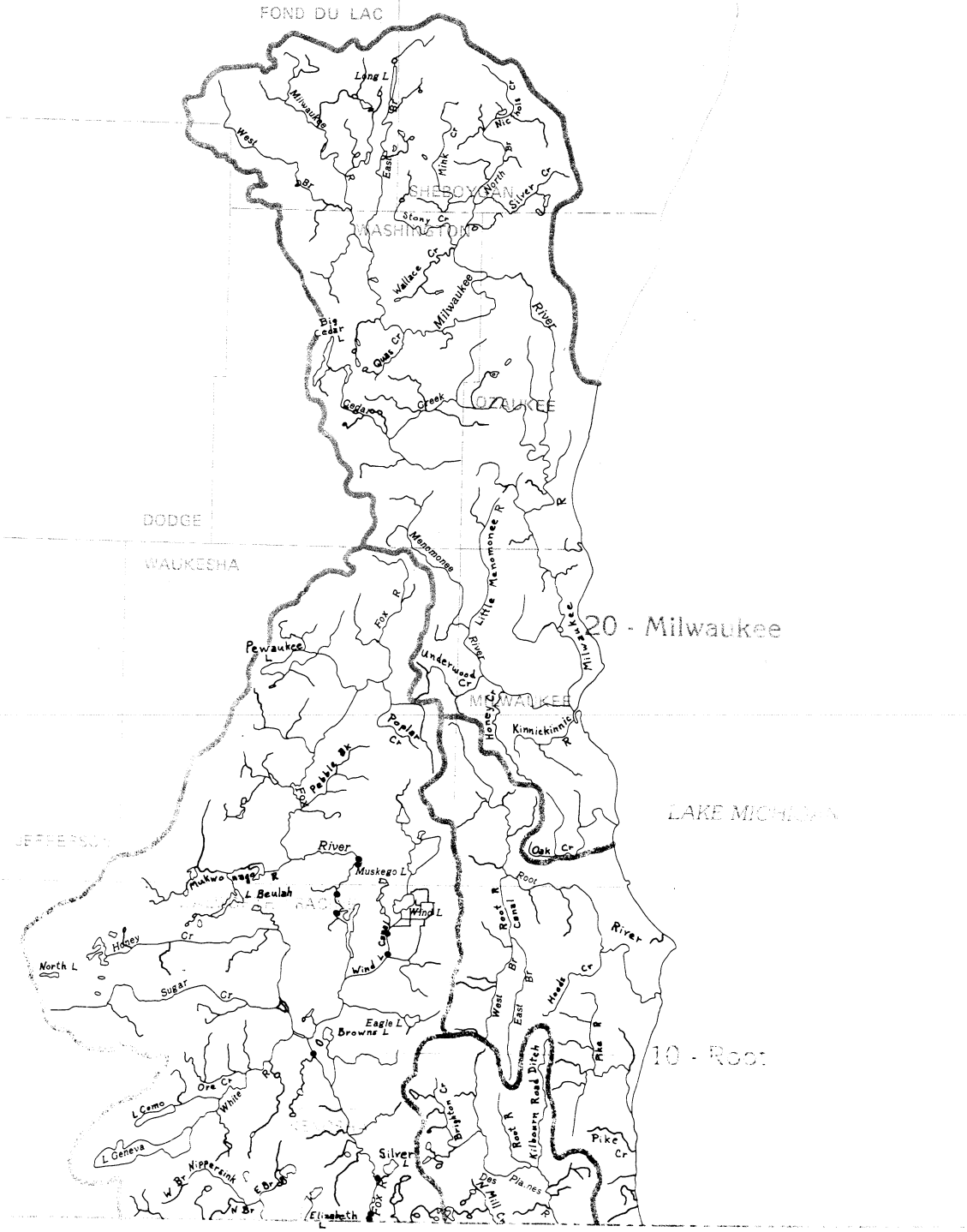


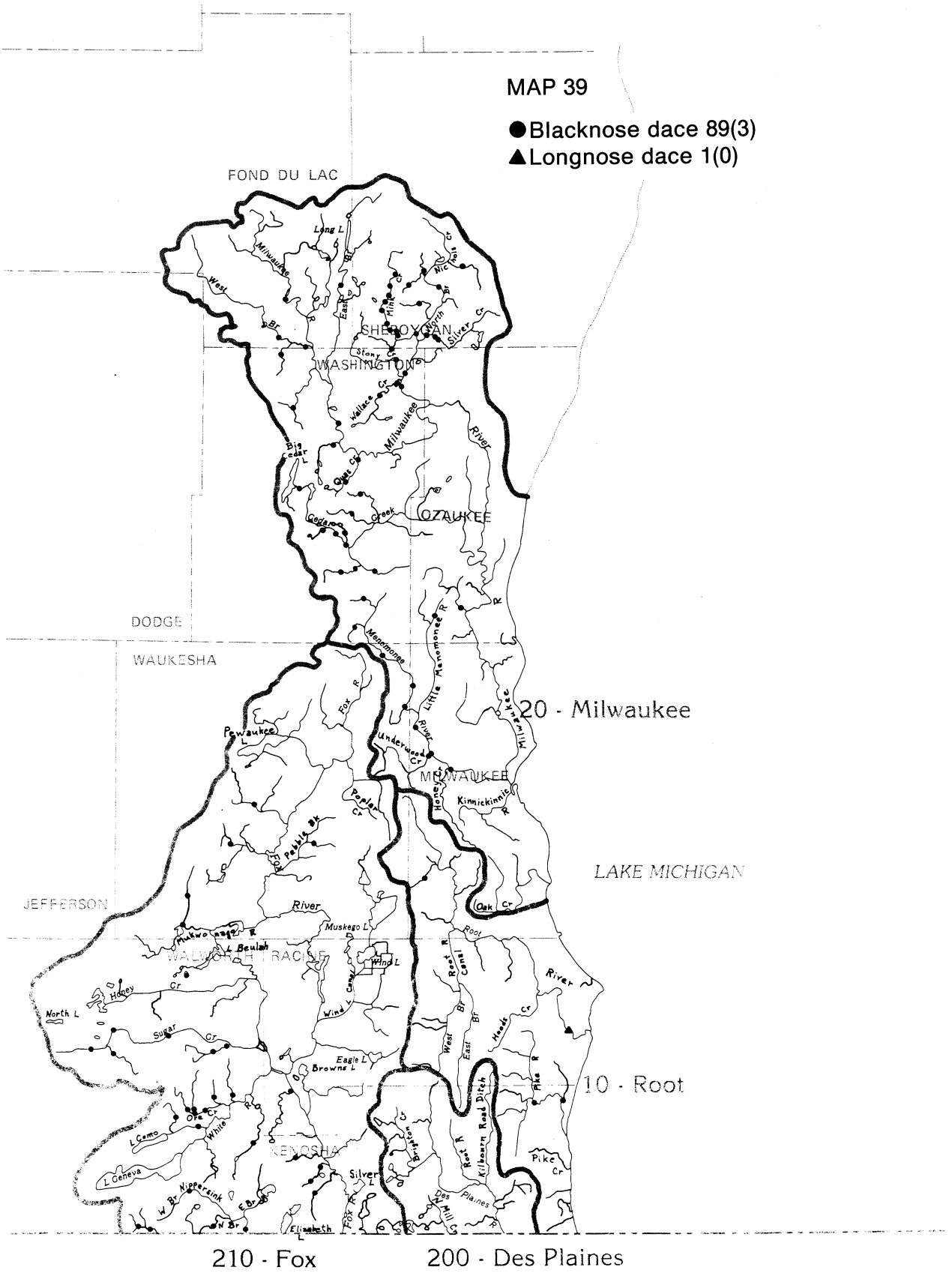
20 - Milwaukee

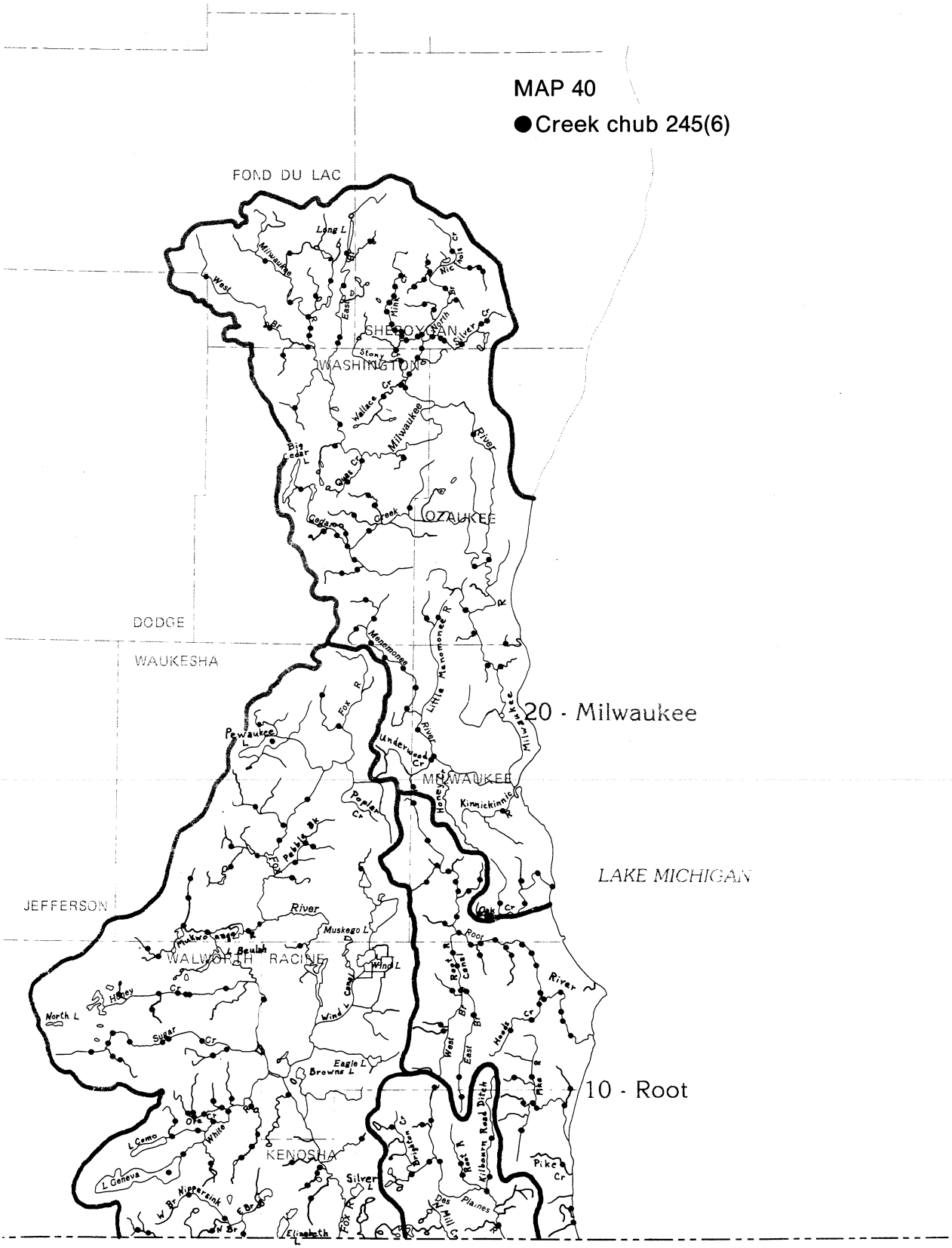
210 - Fox

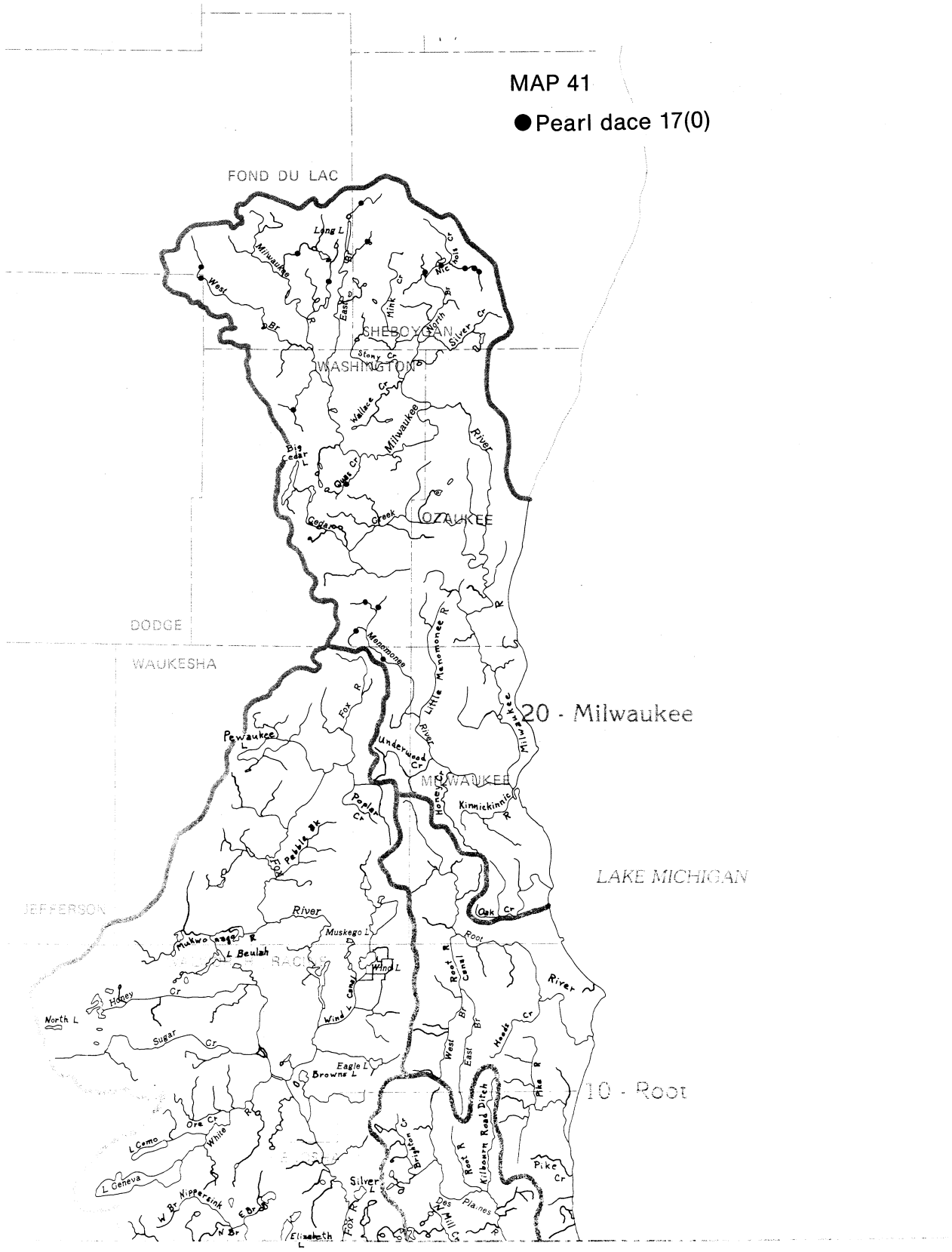
MAP 38

●Bullhead minnow 10(0)



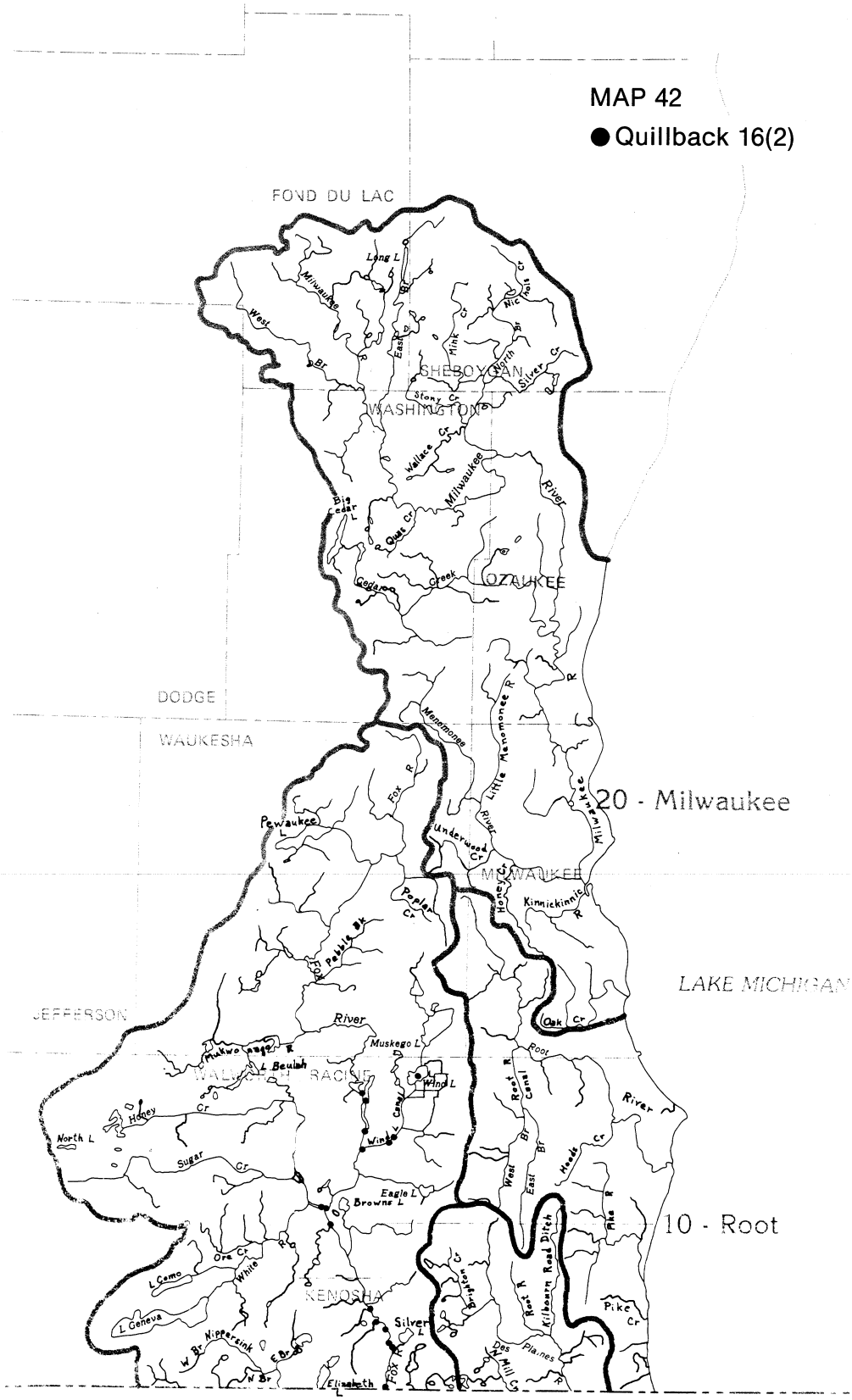

MAP 39
●Blacknose dace 89(3)
▲Longnose dace 1(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

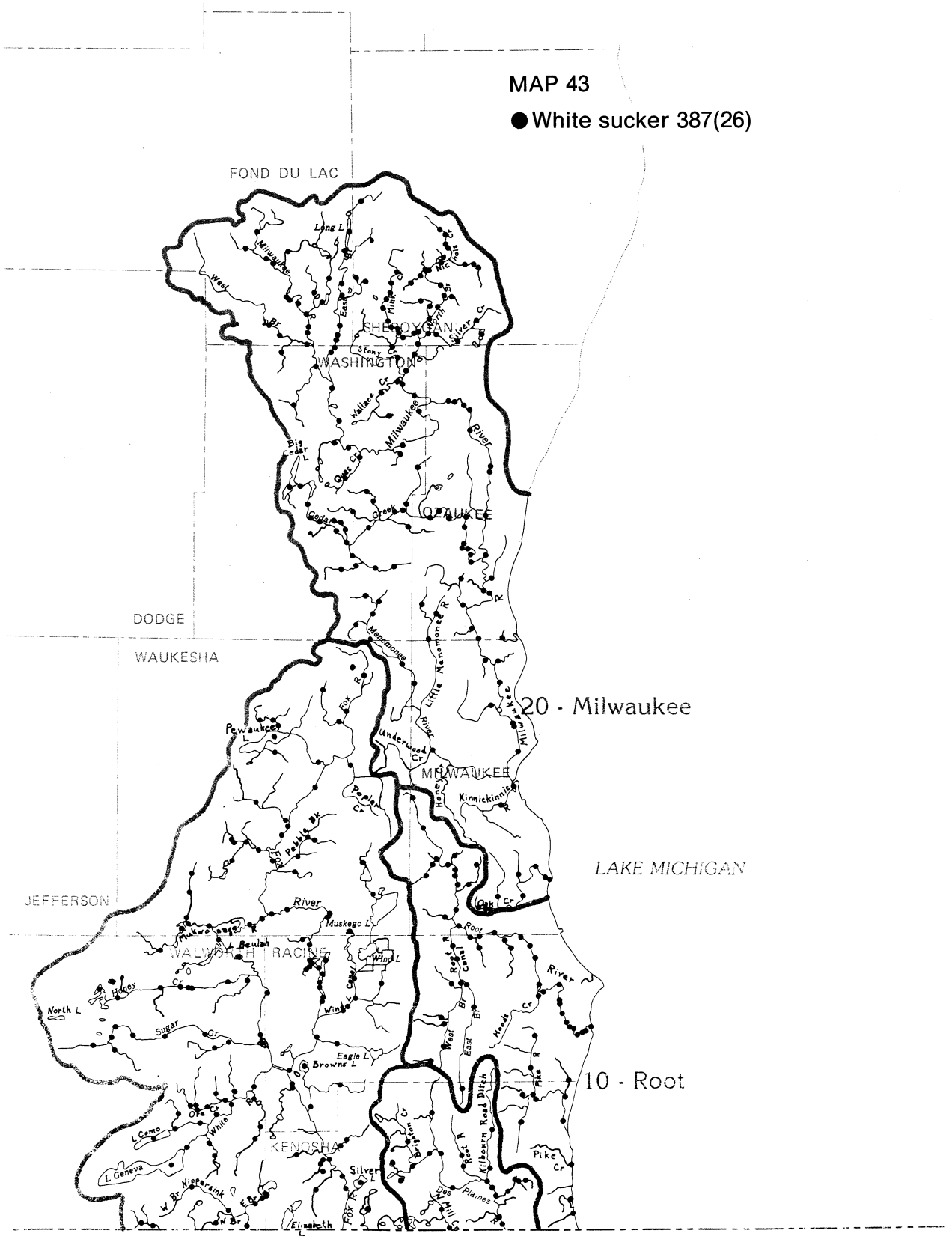

MAP 40
● Creek chub 245(6)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKEE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

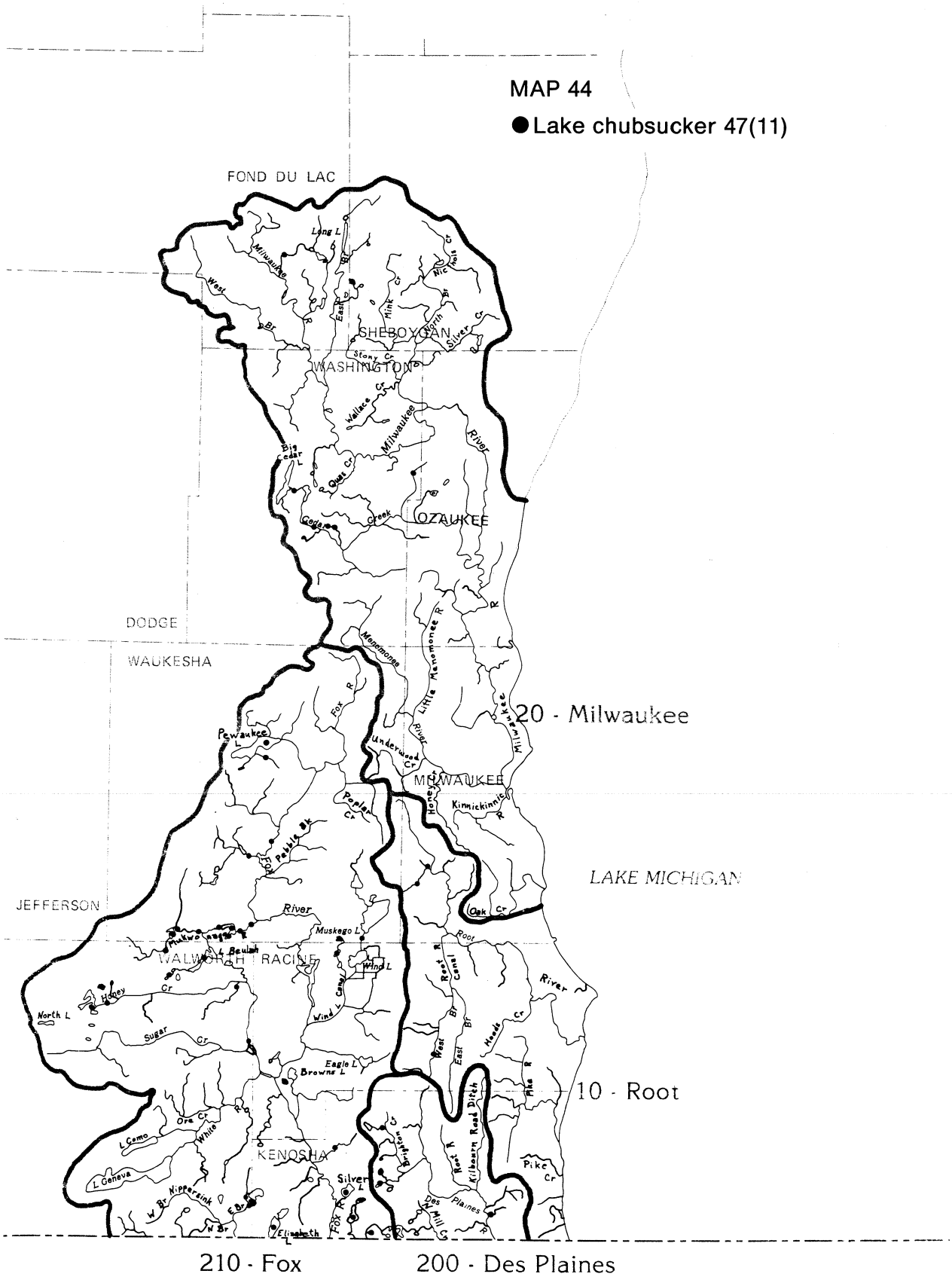

MAP 41
● Pearl dace 17(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
RACINE
LAKE MICHIGAN
Long L
Milwaukee
West Br
East Br
Mink Cr
Nic Pool
North Br
Silver Cr
Stony Cr
Wallace Cr
Milwaukee River
Big Cedar L
Quer Cr
Cedar Creek
Menomonee R
Little Menomonee River
Fox R
Pewaukee L
Underwood Cr
Honey Cr
Kinnickinnic R
Poplar Cr
Pebble Bk
North Br Fox River
Muskego L
Mukwonago R
L Beulah
Wind L
Wind L Canal
Root R Canal
Root River
Oak Cr
Honey Cr
North L
Sugar Cr
Eagle L
Browns L
West Br
East Br
Hoods Cr
Pike R
Ore Cr
White R
L Como
L Geneva
W Br Nippersink
E Br
N Br
Elizabeth L
Silver L
Fox R
Root R
Kilbourn Road Ditch
Pike Cr
Des Plaines River
Mill Cr
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

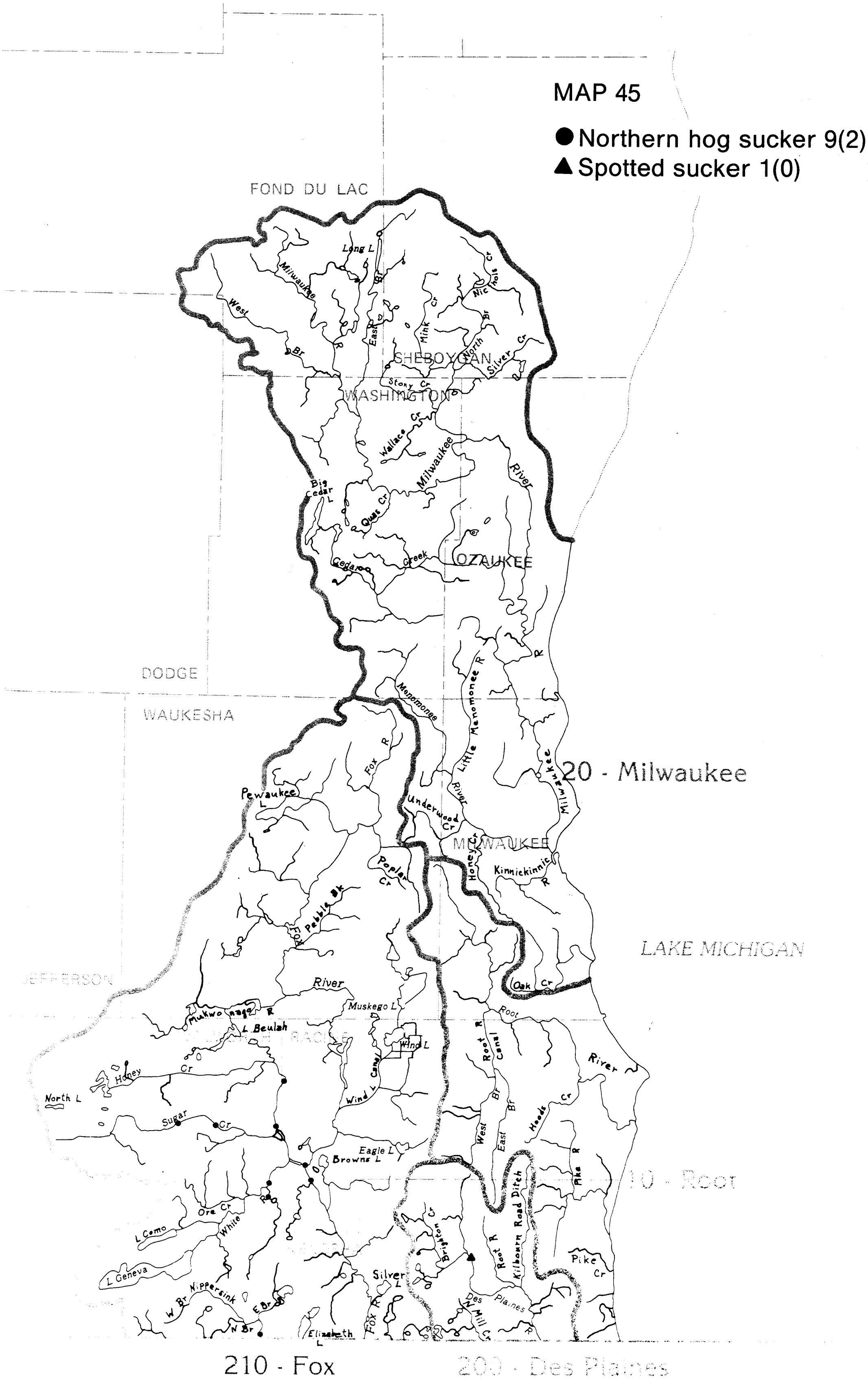
MAP 42

● Quillback 16(2)




MAP 43
● White sucker 387(26)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

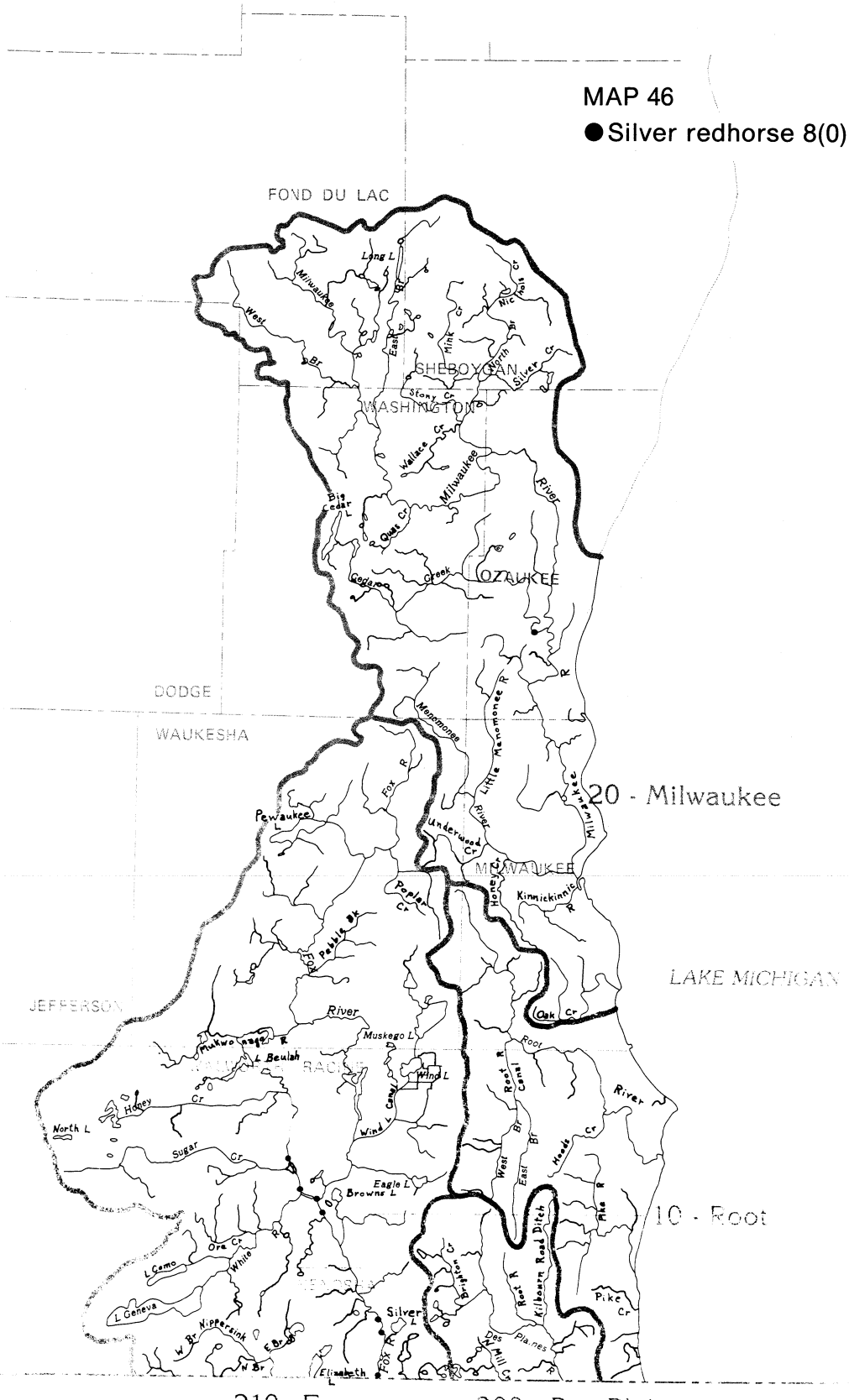

MAP 44
● Lake chubsucker 47(11)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

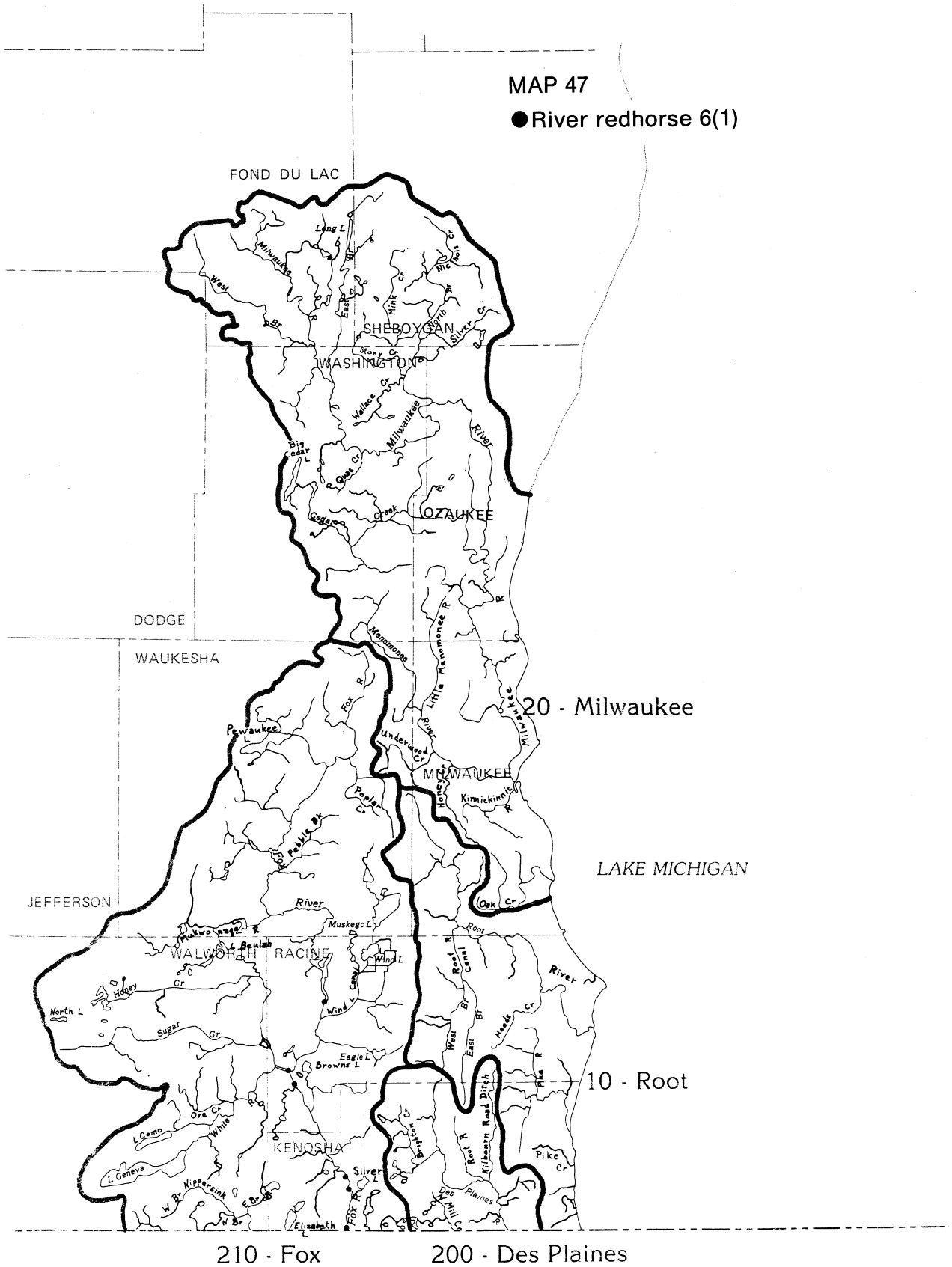


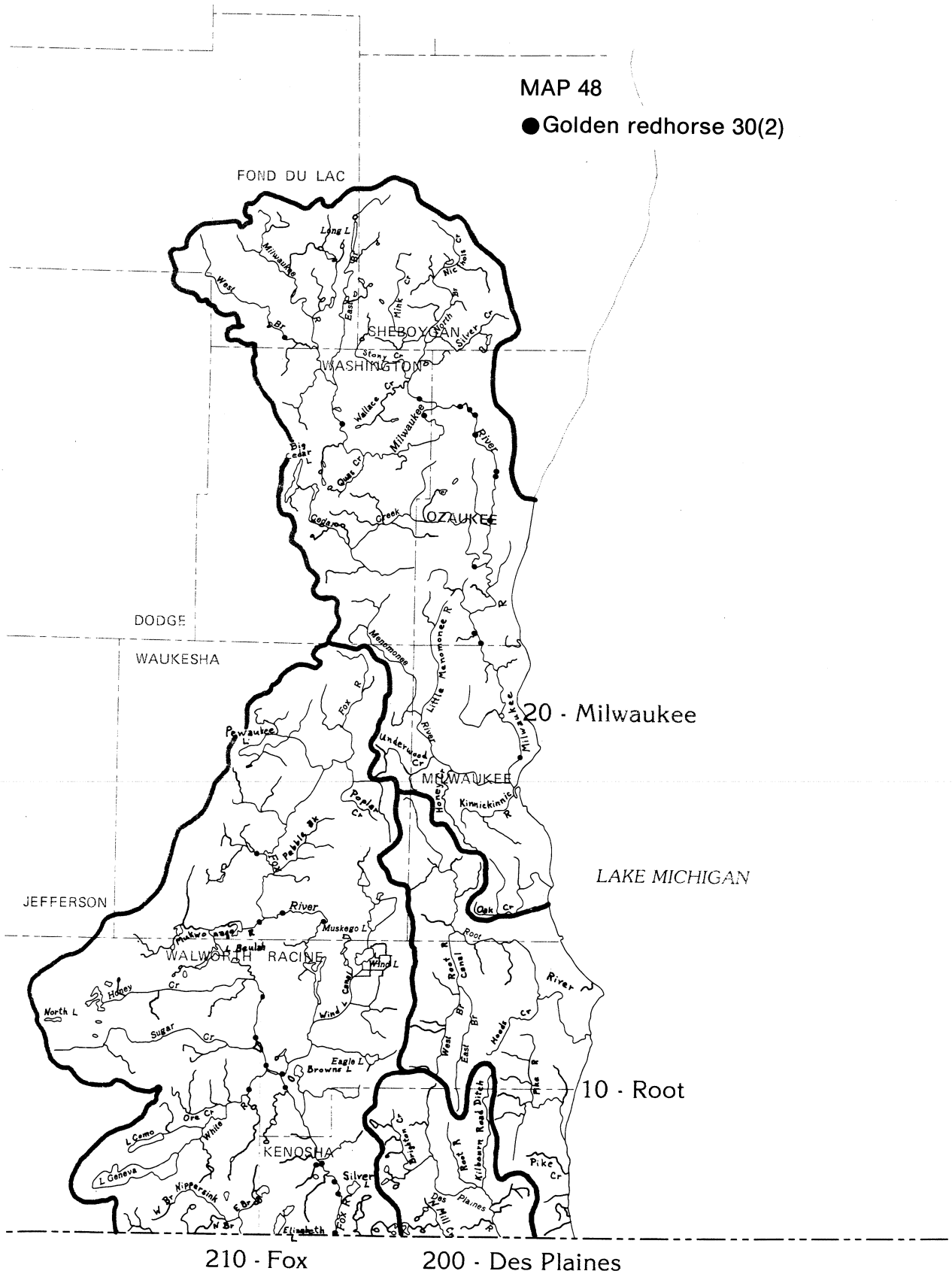
MAP 45
● Northern hog sucker 9(2)
▲ Spotted sucker 1(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines
Long L
Milwaukee R
West Br
East Br
Mink Cr
Nichols Cr
North Br
Silver Cr
Stony Cr
Wallace Cr
Milwaukee River
Big Cedar L
Quas Cr
Cedar Creek
Menomonee R
Menomonee
Little Menomonee River
Fox R
Pewaukee L
Underwood Cr
Honey Cr
Kinnickinnic R
Poplar Cr
Pebble Bk
Fox River
Mukwonago R
L Beulah
Muskego L
Wind L
Wind L Canal
Root R Canal
Root River
West Br
East Br
Hoods Cr
Pike R
Oak Cr
North L
Honey Cr
Sugar Cr
Eagle L
Browns L
Ore Cr
White R
L Como
L Geneva
W Br Nippersink
E Br
N Br
Elizabeth L
Silver L
Fox R
Brighton Cr
Root R
Kilbourn Road Ditch
Des Plaines R
Mill Cr
Pike Cr

MAP 46

● Silver redhorse 8(0)

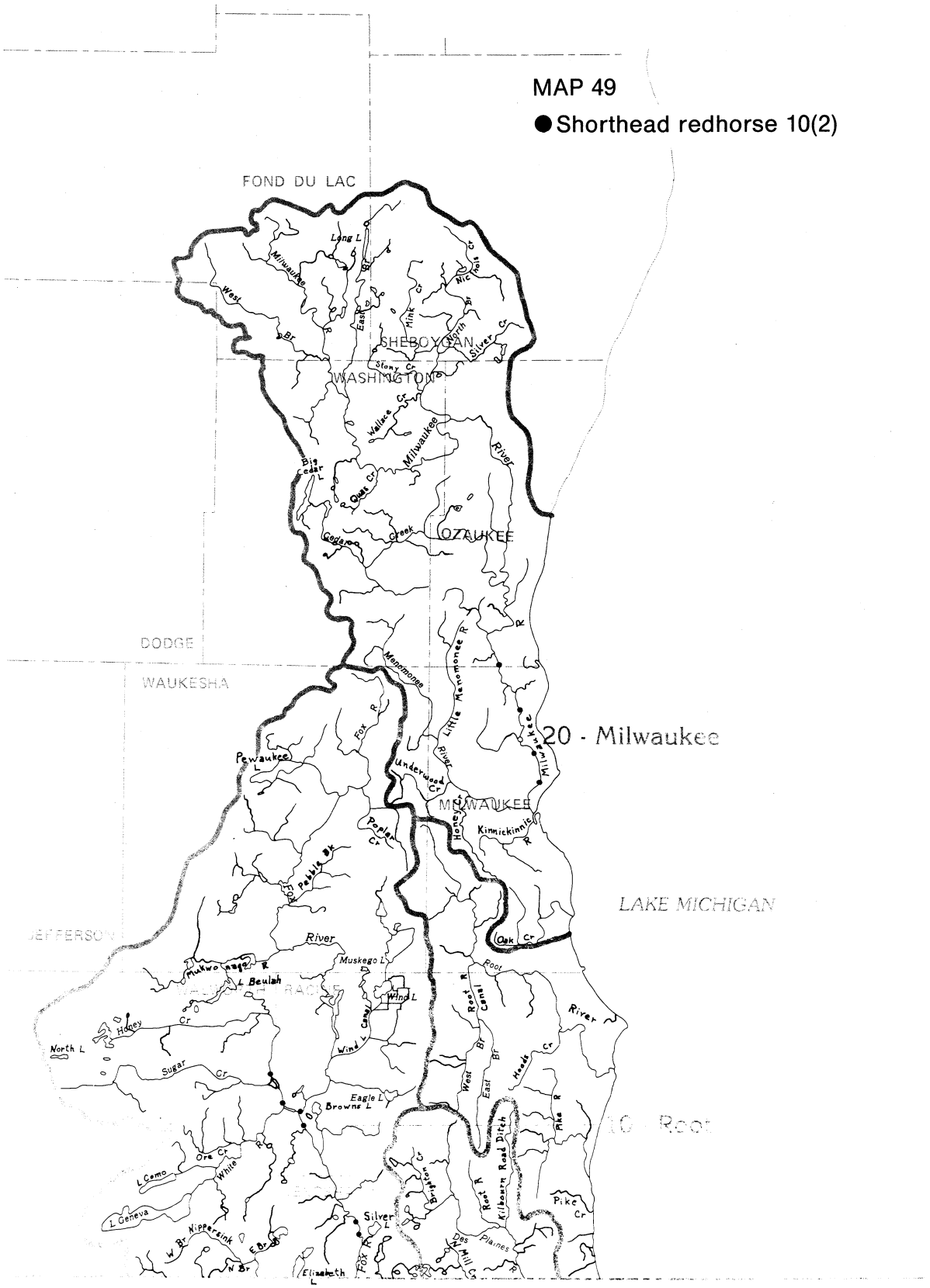



MAP 47
● River redhorse 6(1)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines
Long L
Milwaukee
West Br
East
Mink
Nichols Cr
North Br
Silver Cr
Stony Cr
Wallace Cr
Milwaukee River
Big Cedar L
Quat Cr
Cedarburg Creek
Menomonee R
Little Menomonee River
Underwood Cr
Honey
Kinnickinnic R
Pewaukee L
Fox R
Poplar Cr
Pebble Br
Fox River
Muskego L
Mukwonago R
L Beulah
Wind L
Wind L Canal
Root R Canal
Root River
Oak Cr
Hoods Cr
West Br
East Br
Pike R
Pike Cr
Kilbourn Road Ditch
Honey Cr
North L
Sugar Cr
Eagle L
Browns L
L Como
Ora Cr
Whitewater Cr
L Geneva
W Br Nippersink
E Br
W Br
Elizabeth L
Fox R
Silver L
Des Plaines R
Mill Cr


MAP 48
● Golden redhorse 30(2)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

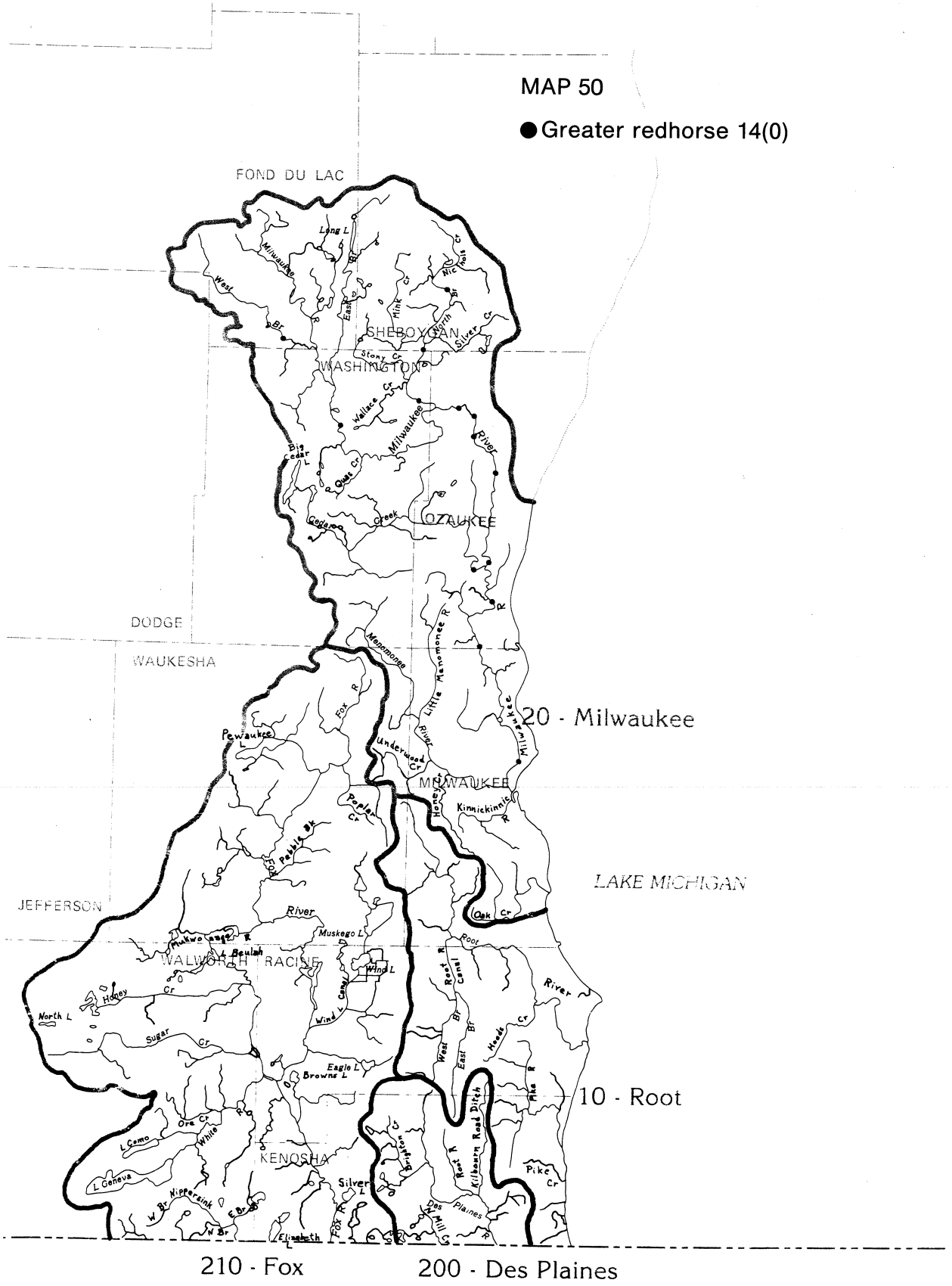
MAP 49

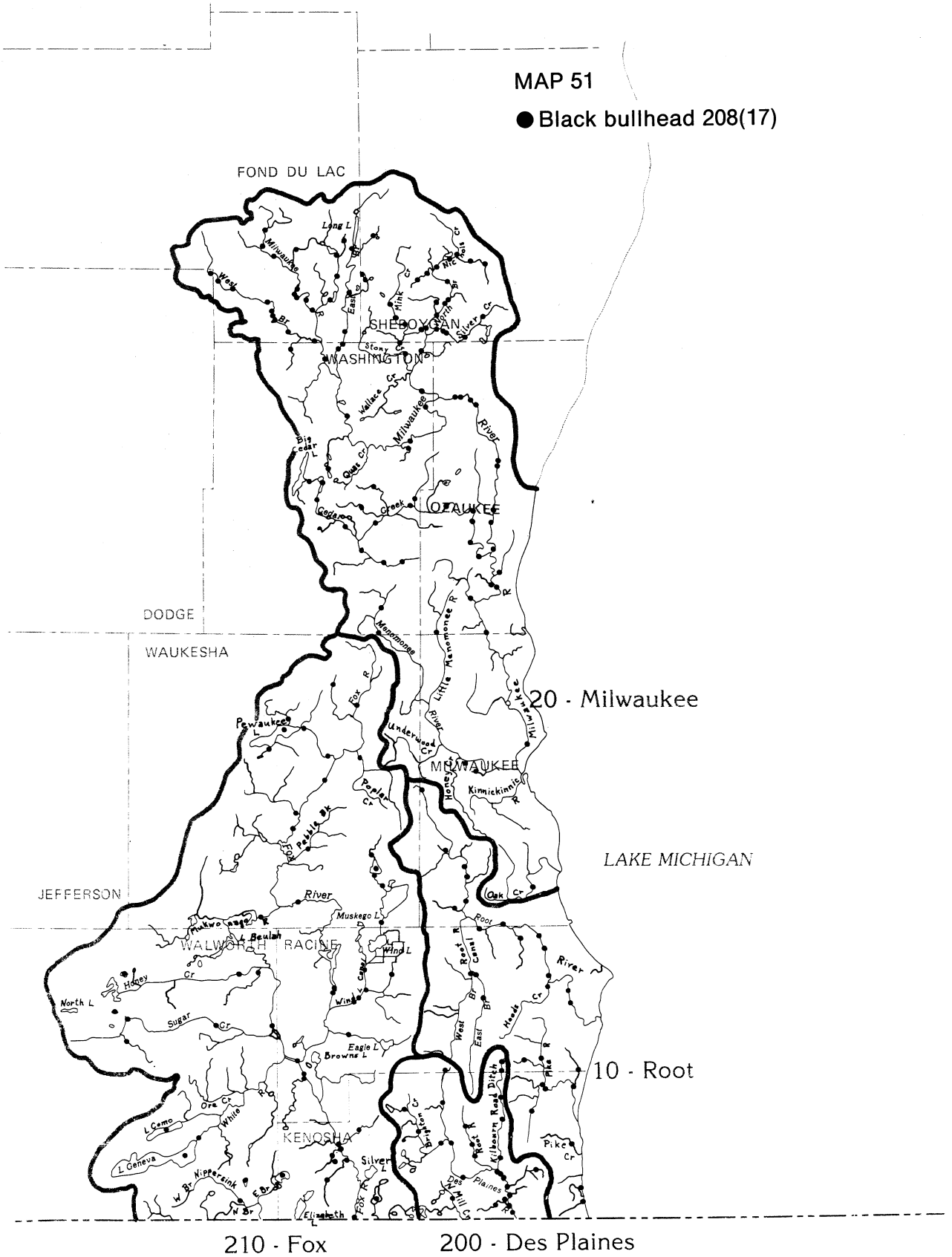
● Shorthead redhorse 10(2)

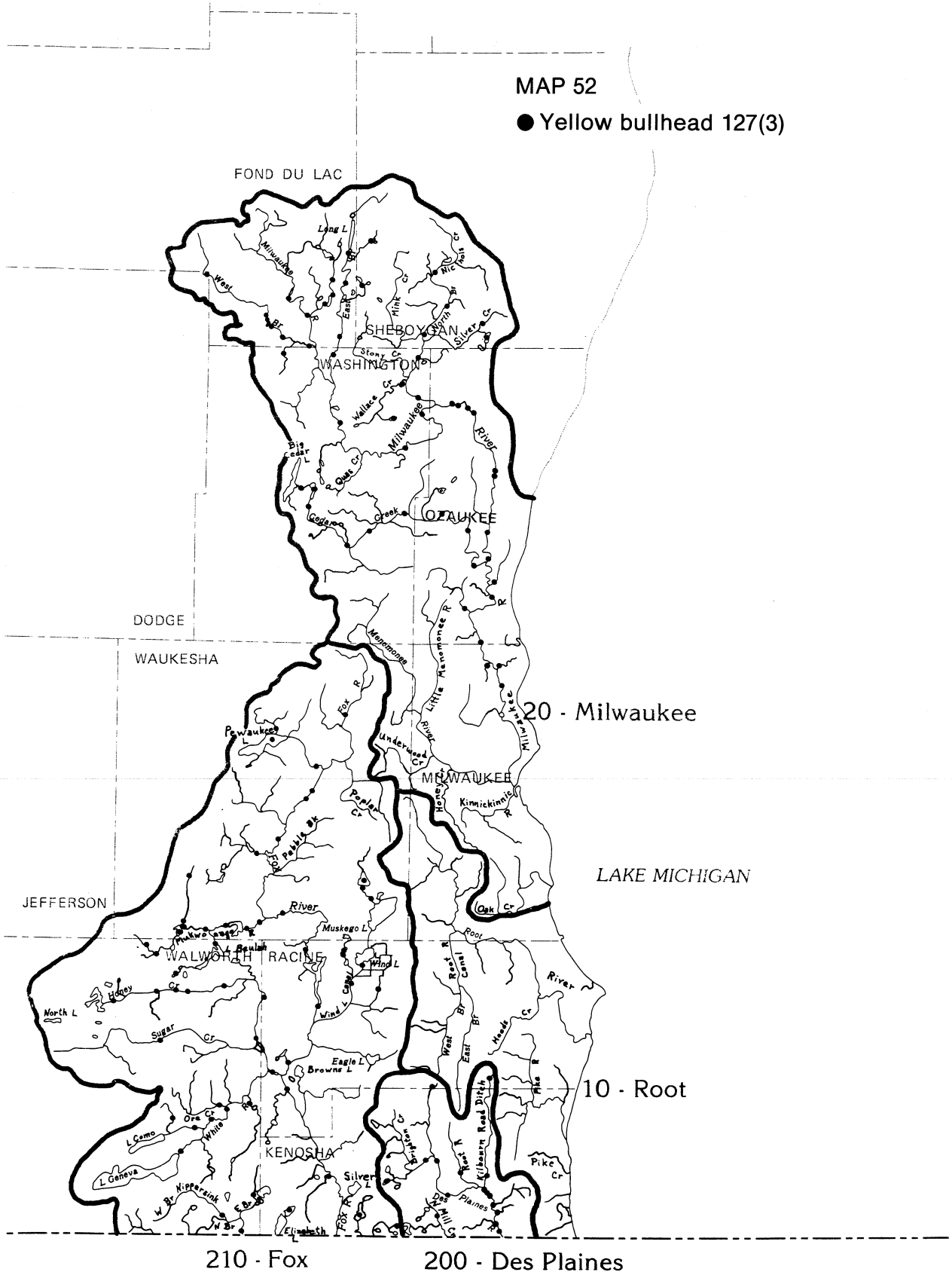


MAP 50

● Greater redhorse 14(0)

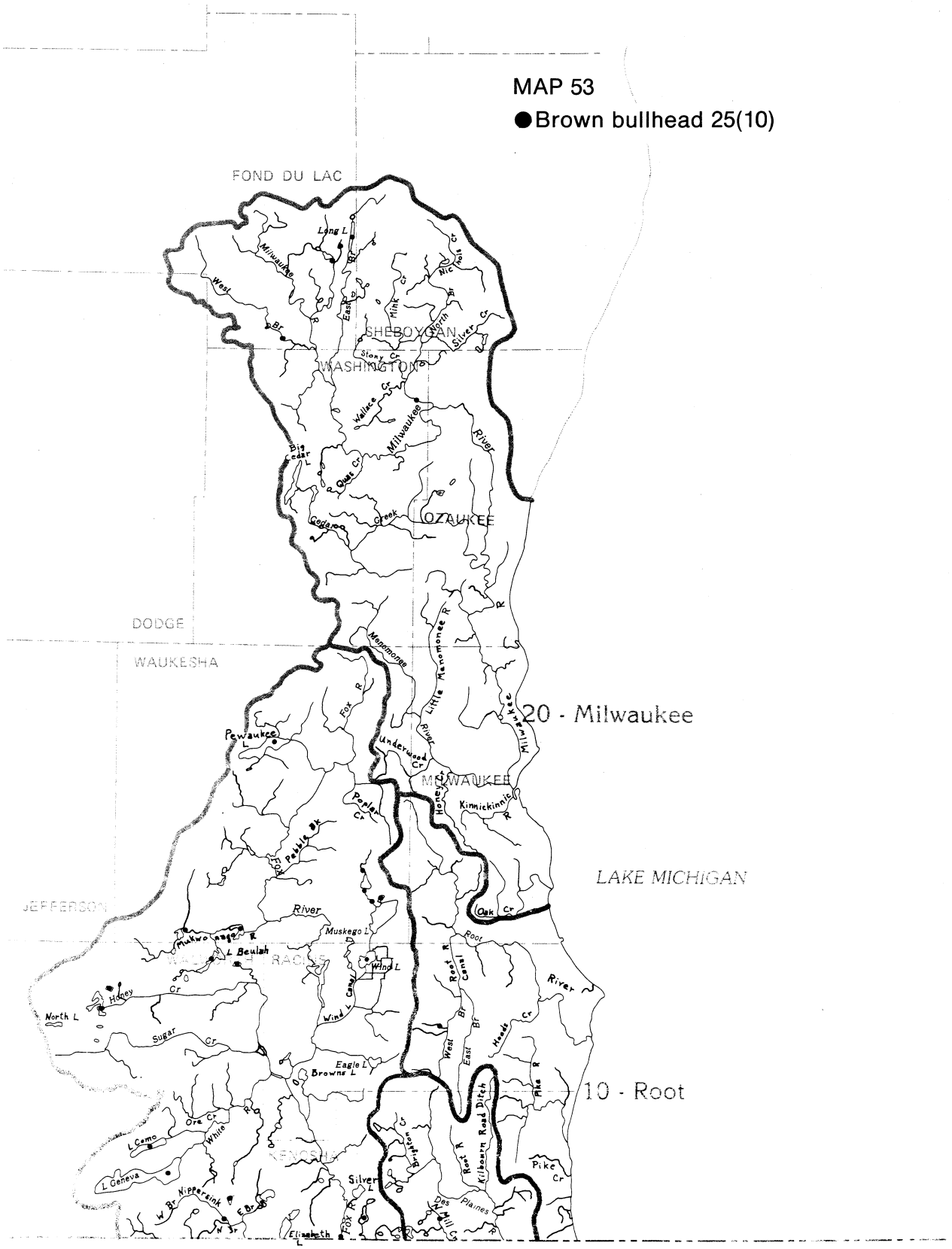


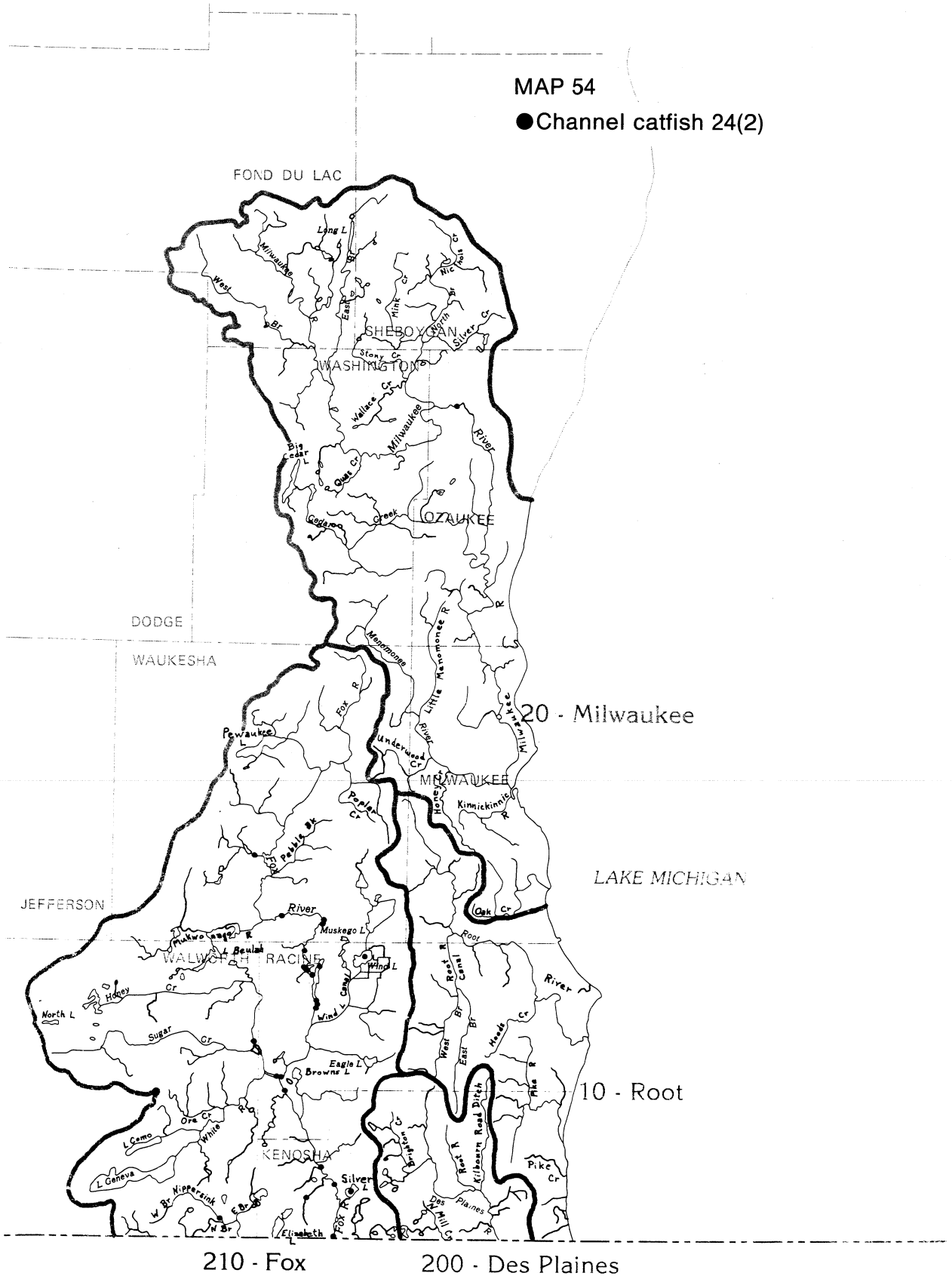

MAP 51
● Black bullhead 208(17)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

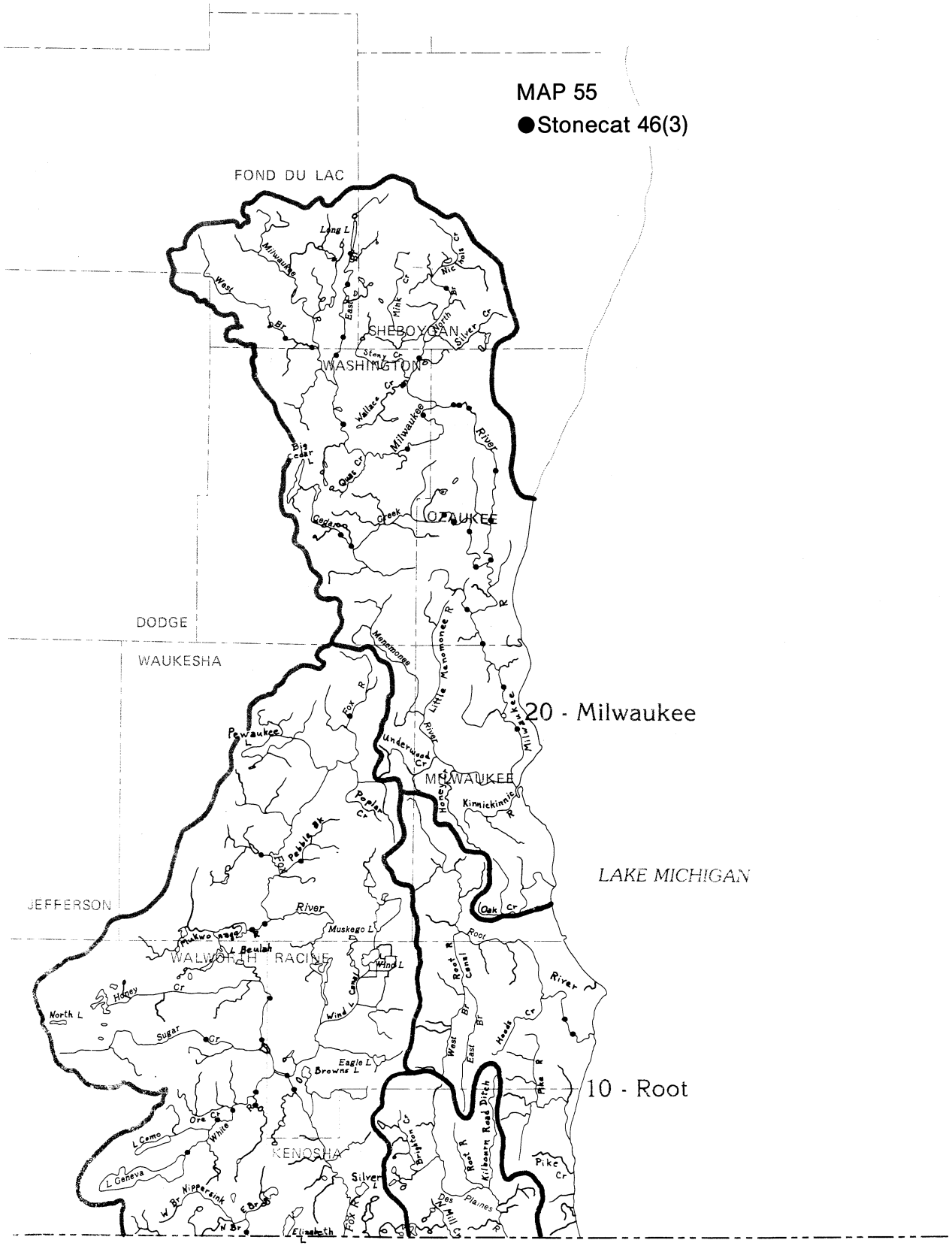

MAP 52
● Yellow bullhead 127(3)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

MAP 53

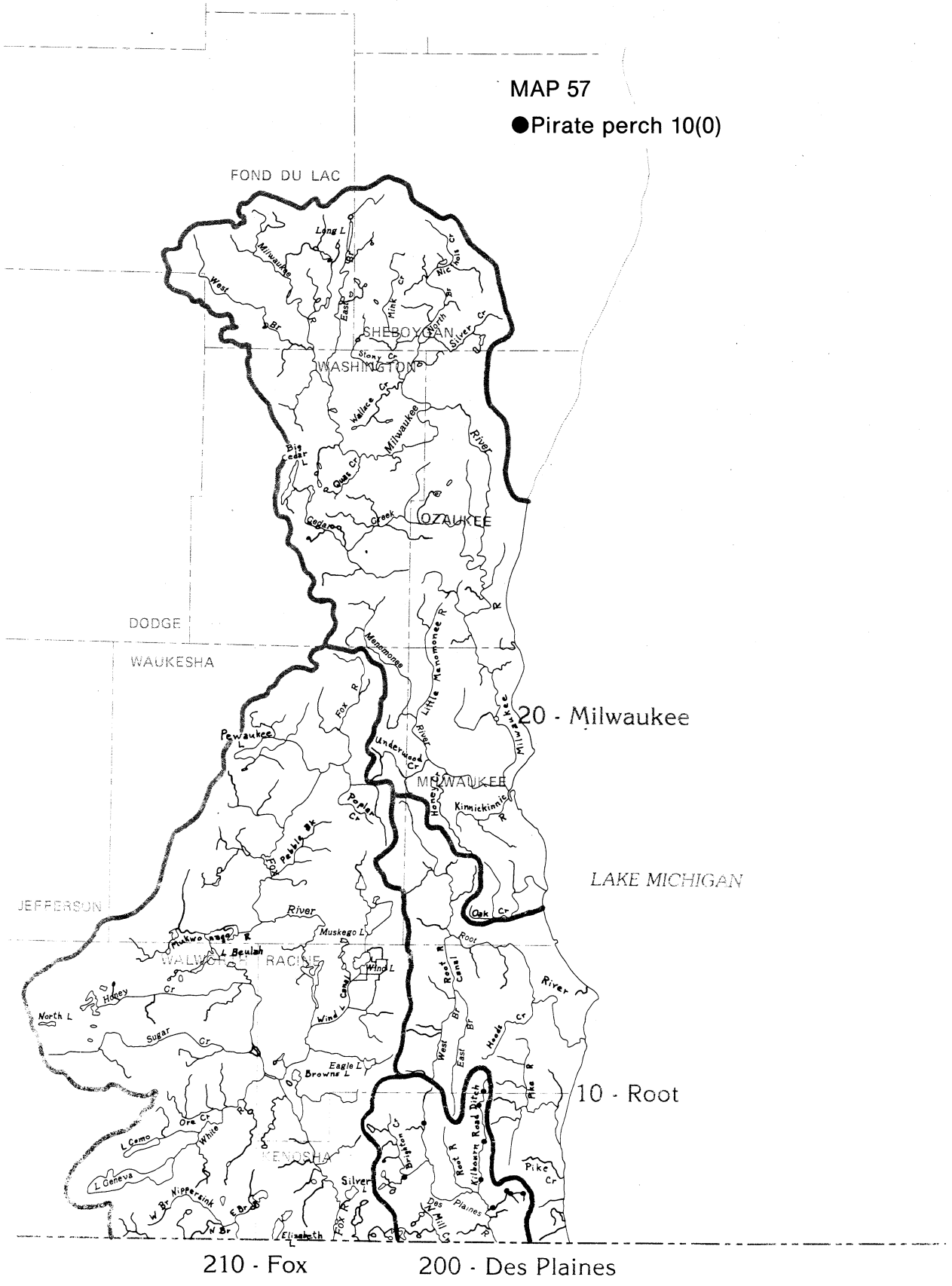
● Brown bullhead 25(10)

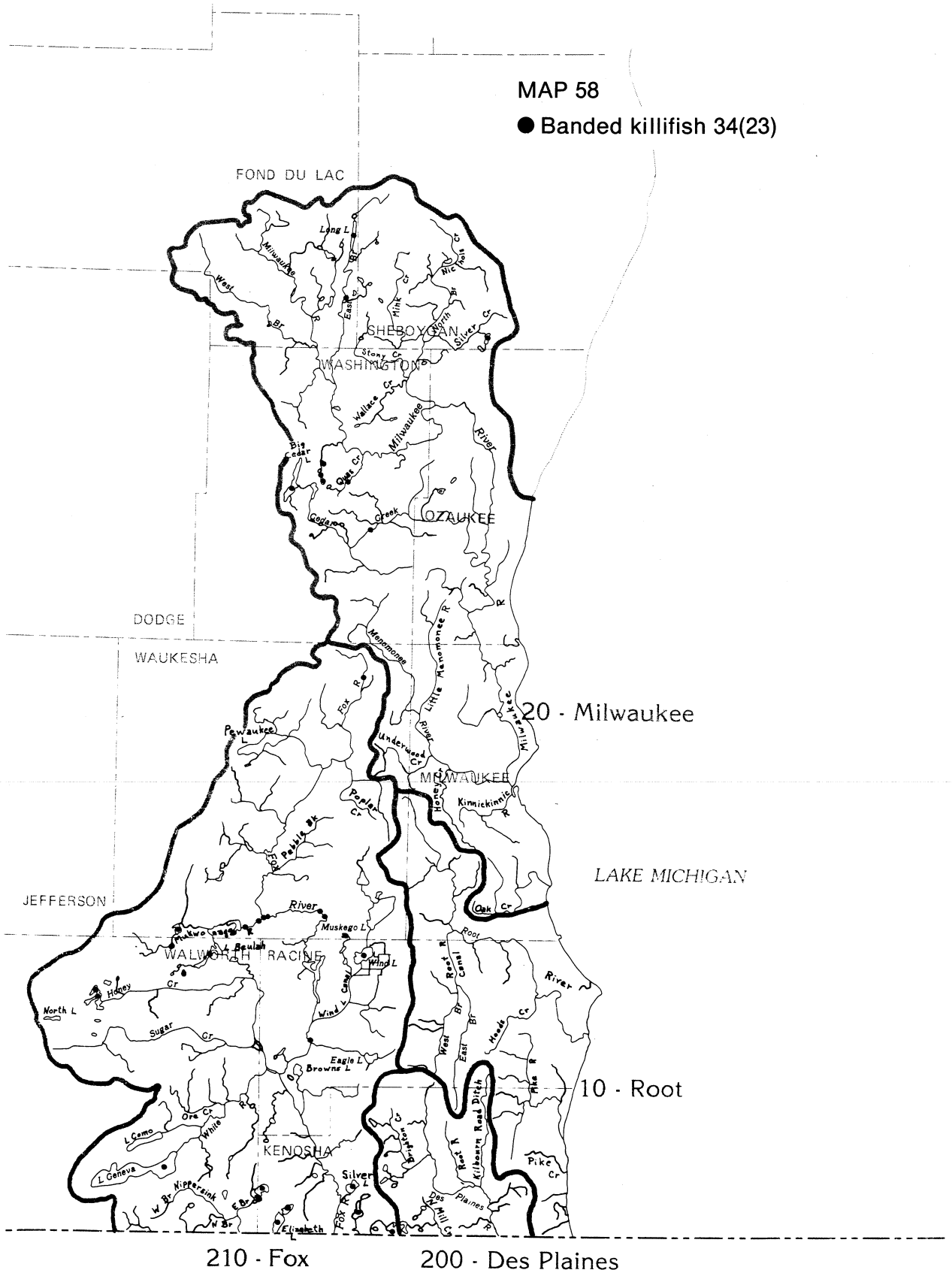


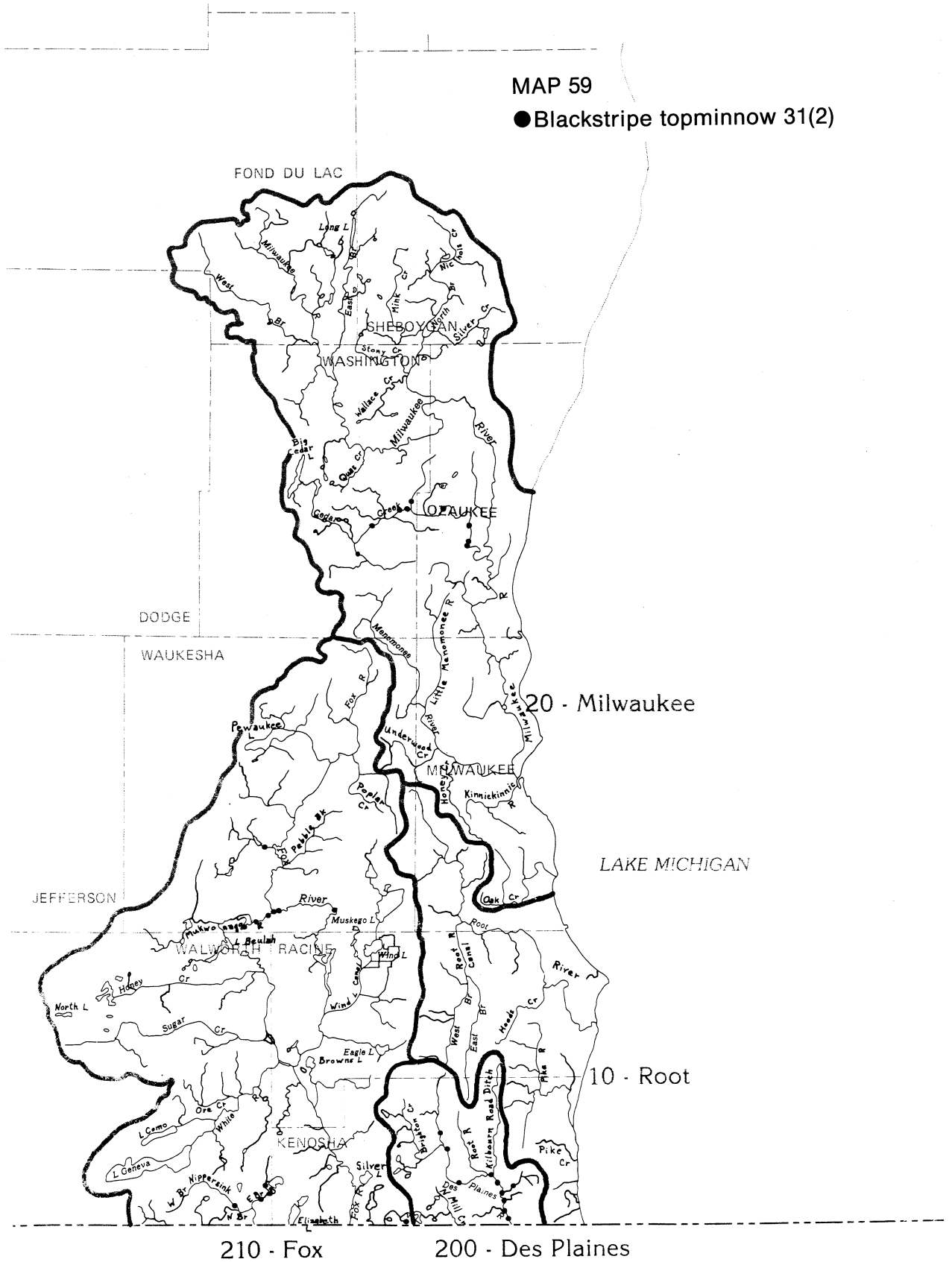

MAP 54
●Channel catfish 24(2)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

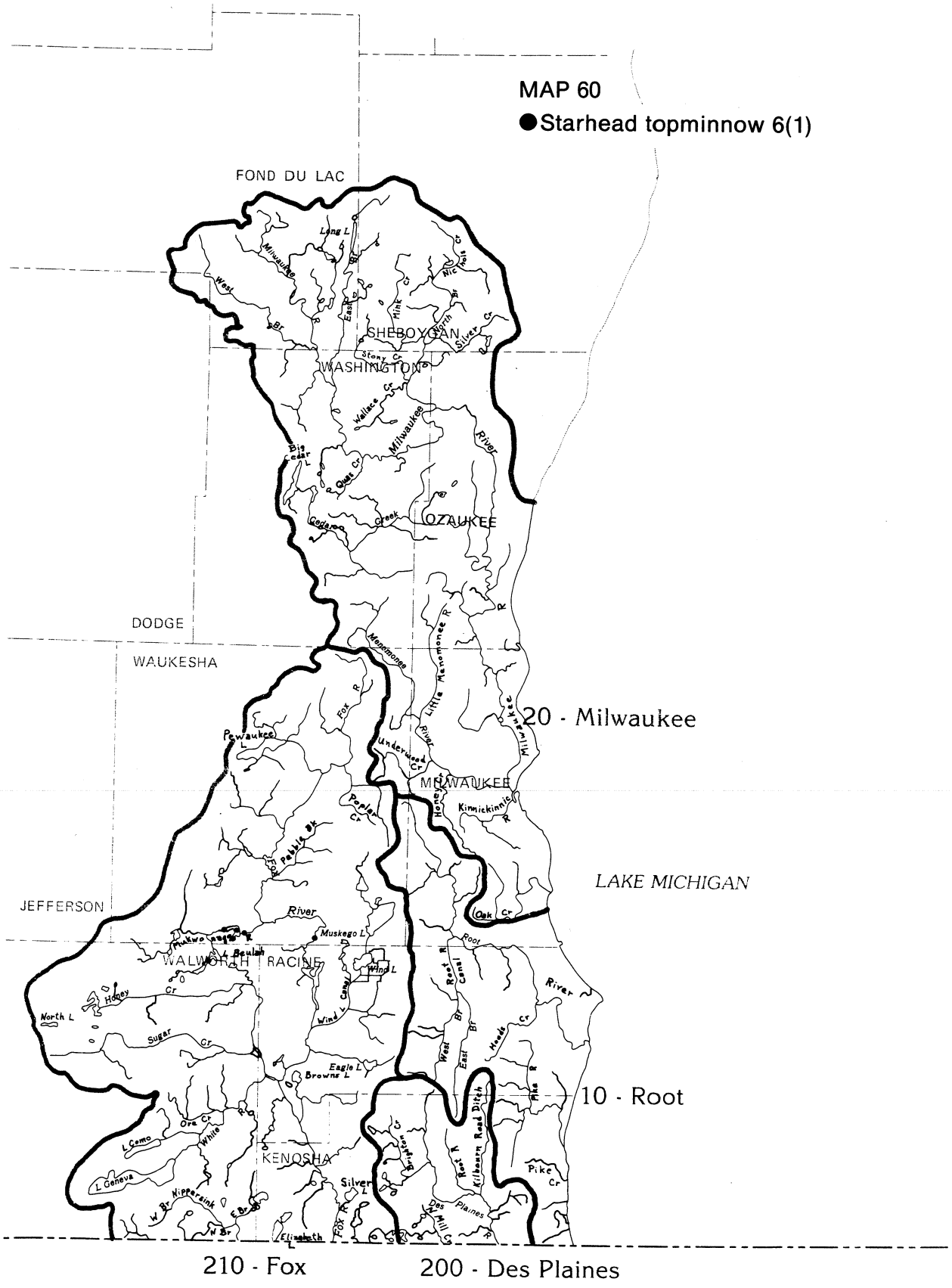

MAP 55
●Stonecat 46(3)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines


MAP 56
● Tadpole madtom 44(2)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
20 - Milwaukee
MILWAUKEE
LAKE MICHIGAN
JEFFERSON
WALWORTH
RACINE
10 - Root
KENOSHA
210 - Fox
200 - Des Plaines


MAP 57
●Pirate perch 10(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

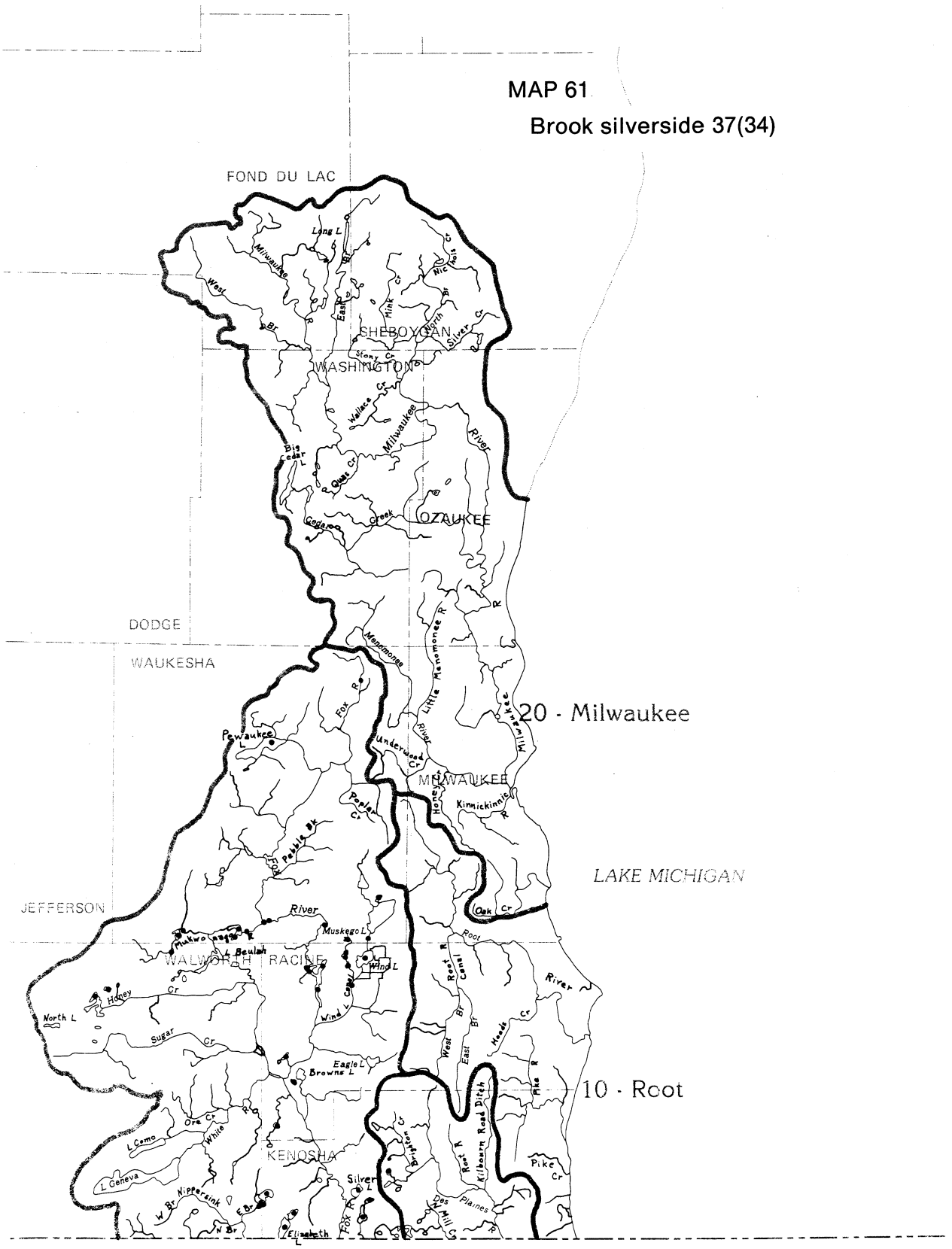

MAP 58
● Banded killifish 34(23)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

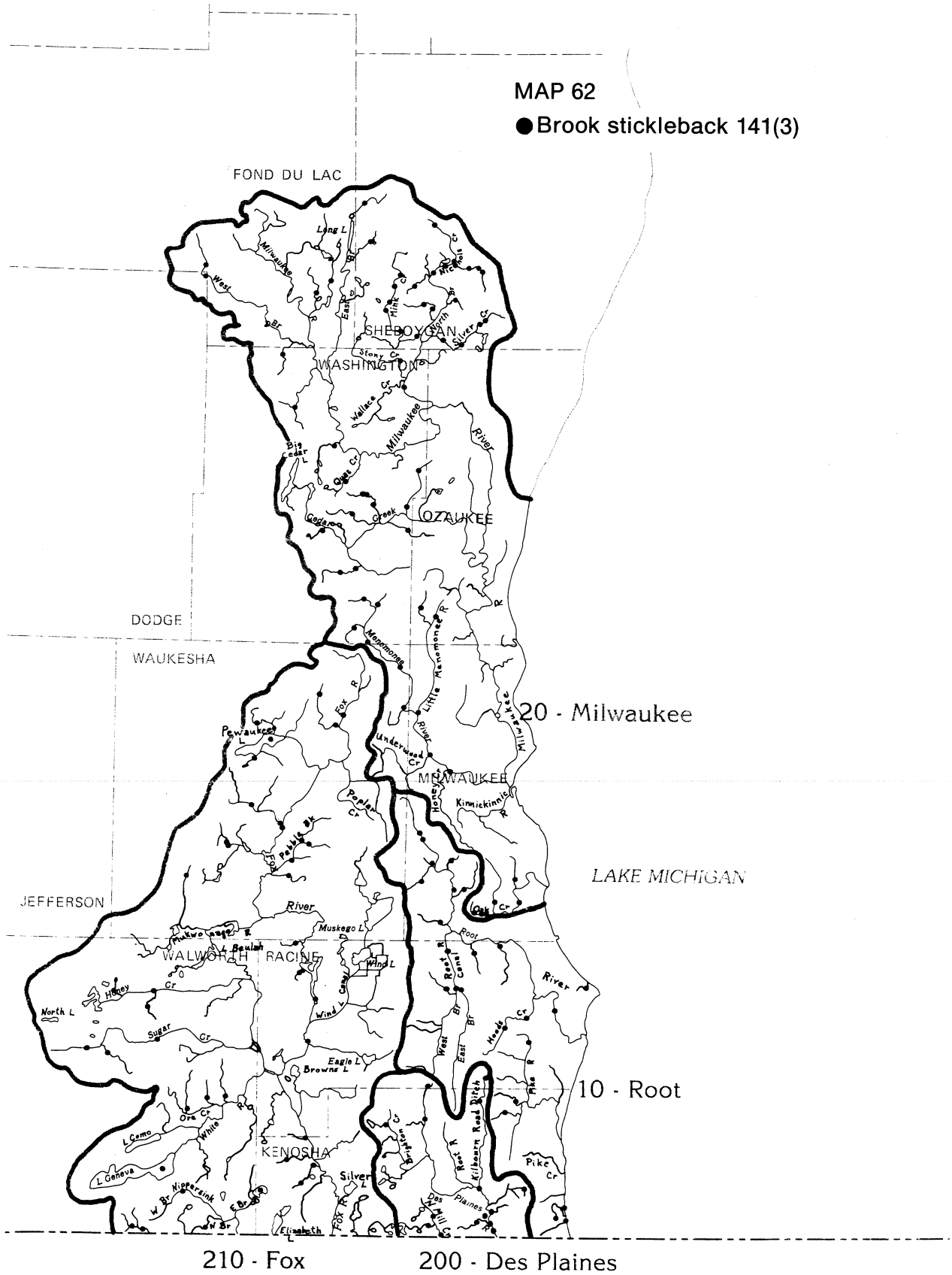

MAP 59
●Blackstripe topminnow 31(2)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

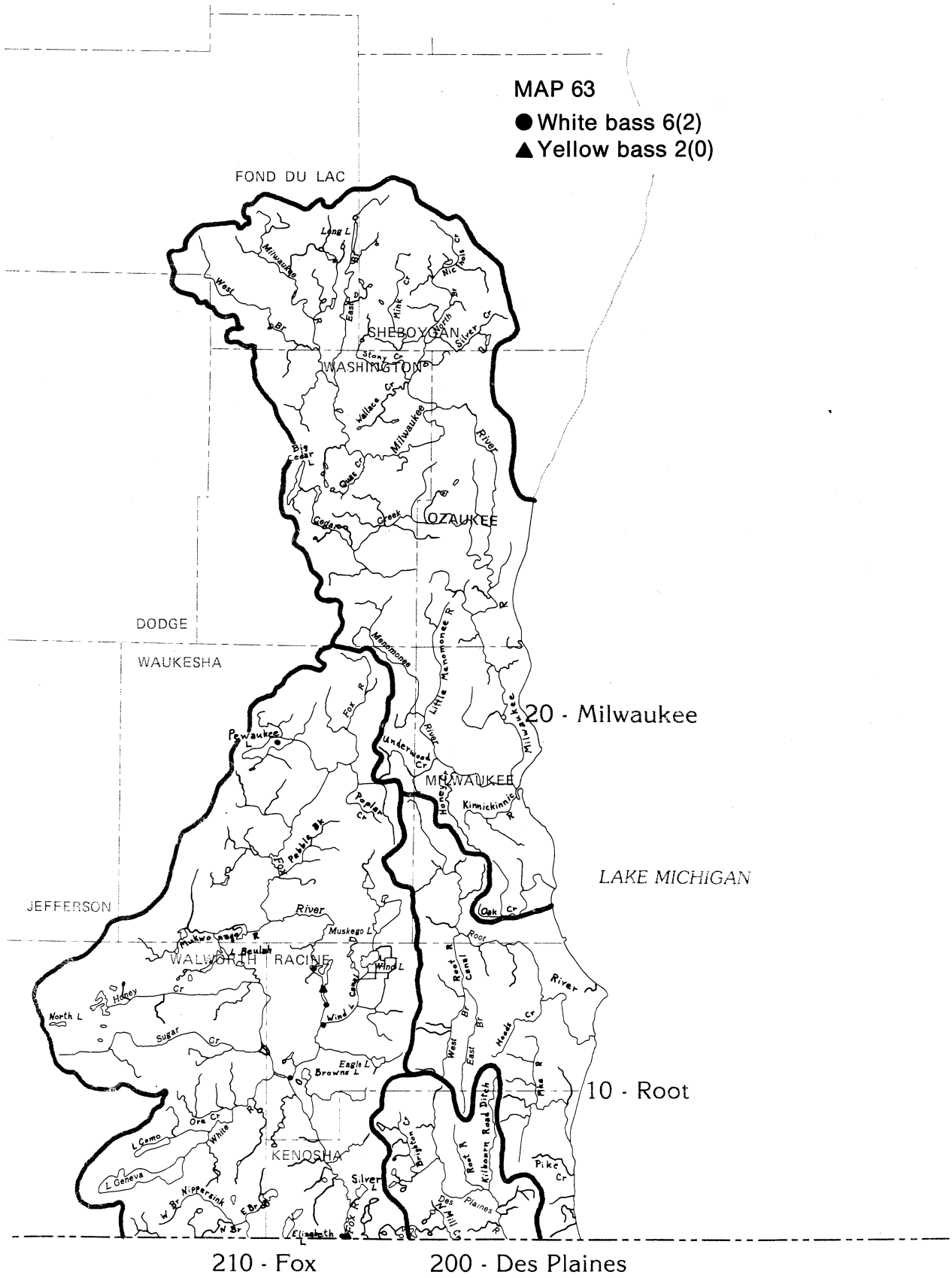

MAP 60
● Starhead topminnow 6(1)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

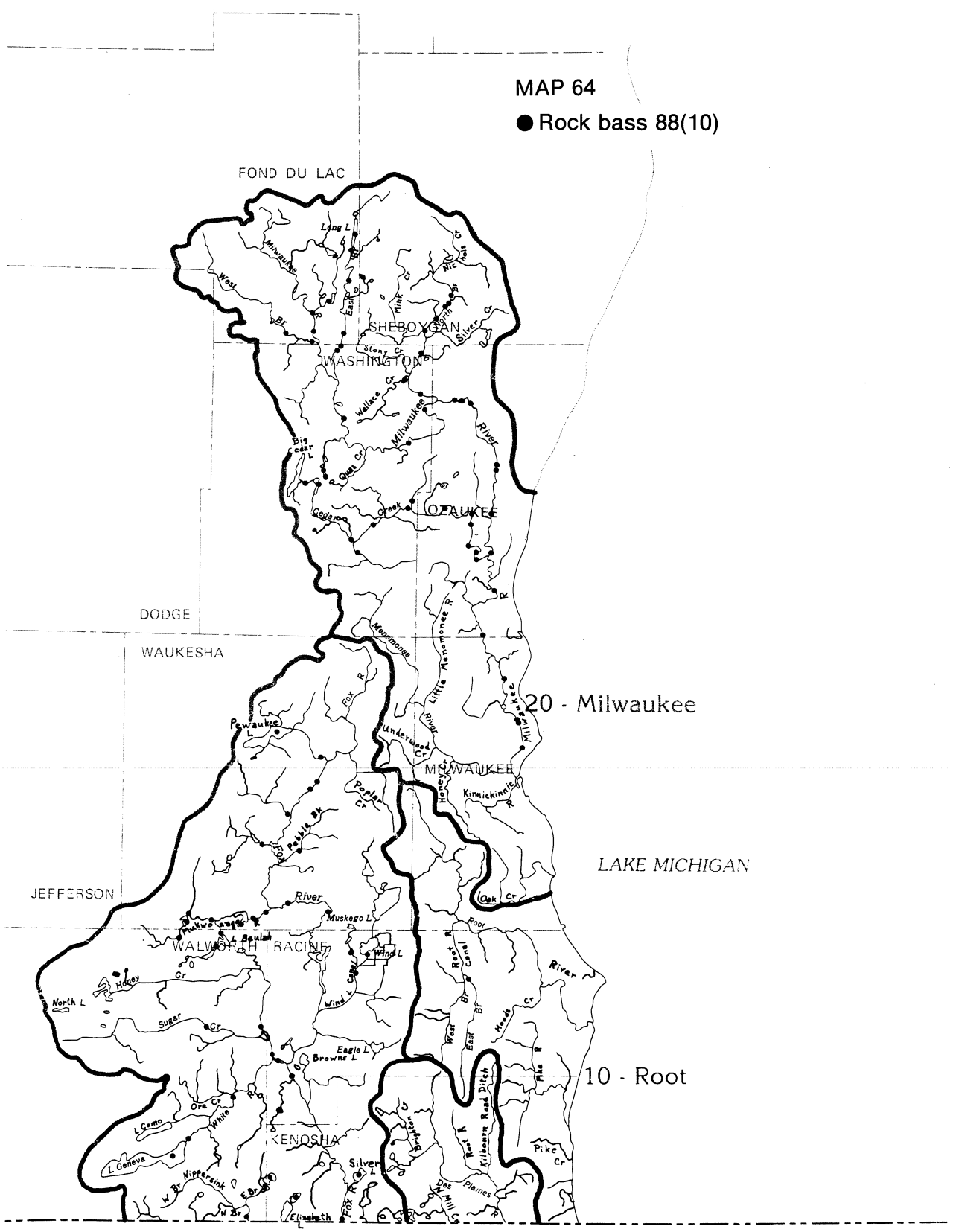
MAP 61

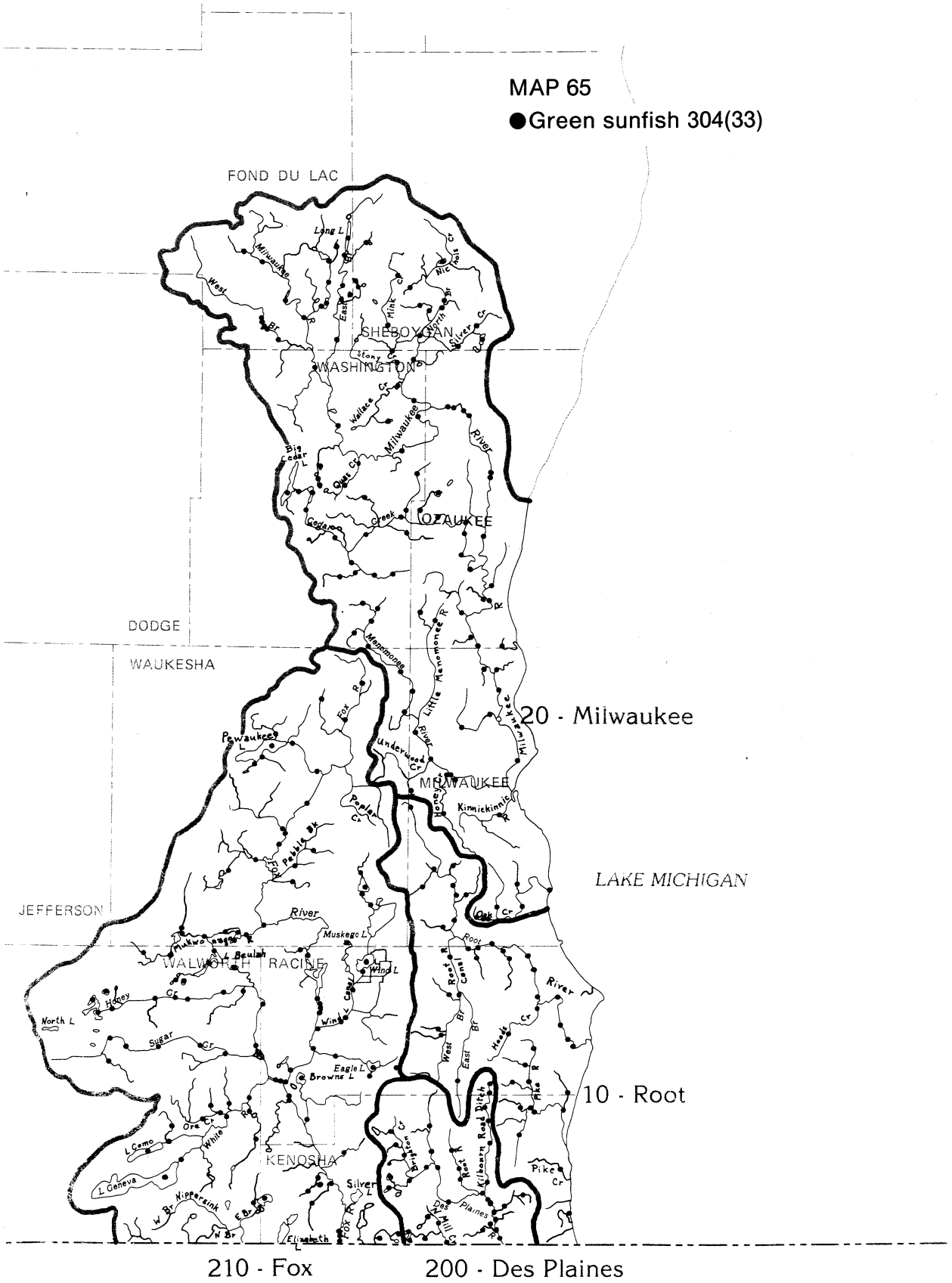
Brook silverside 37(34)

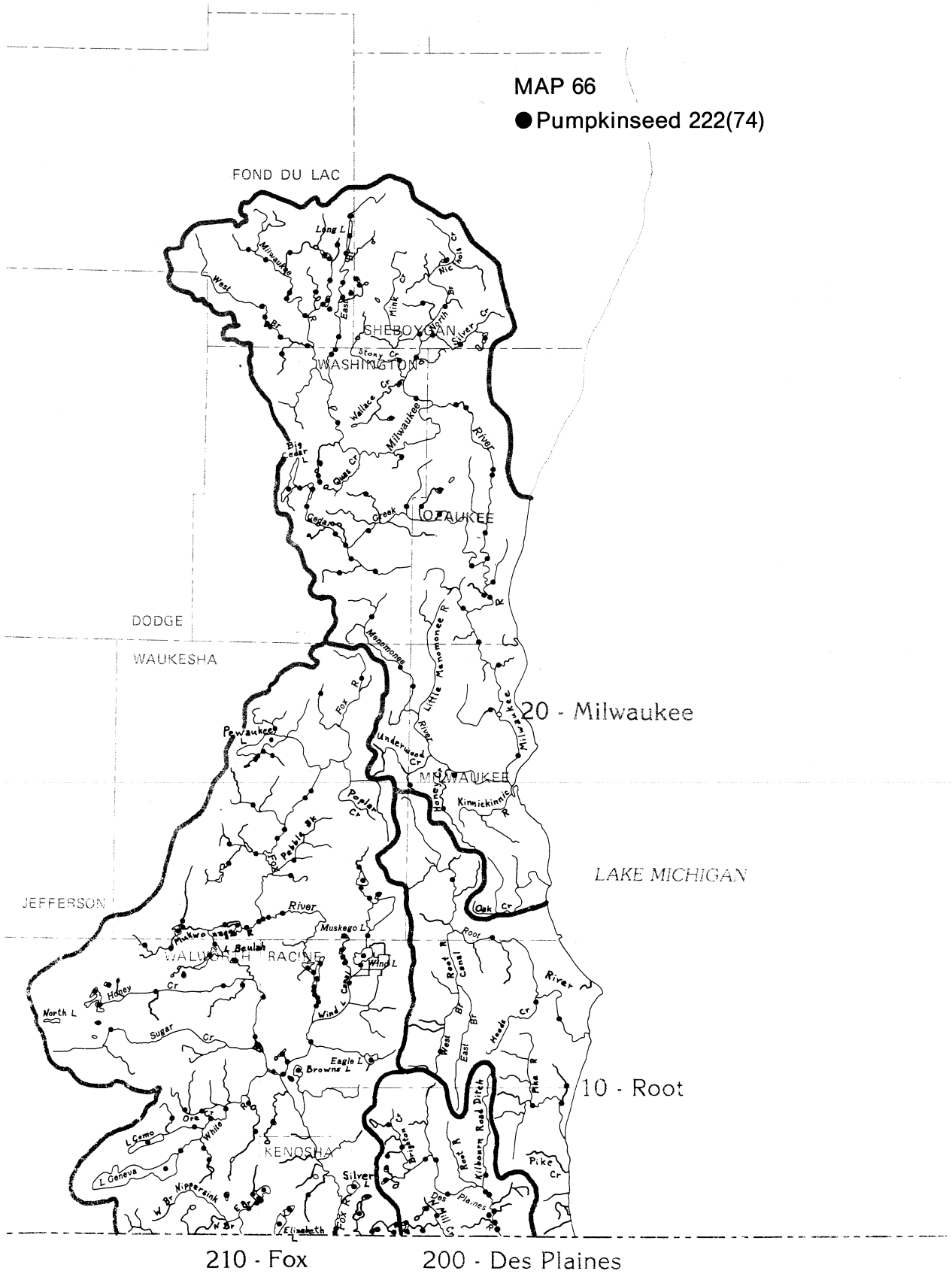


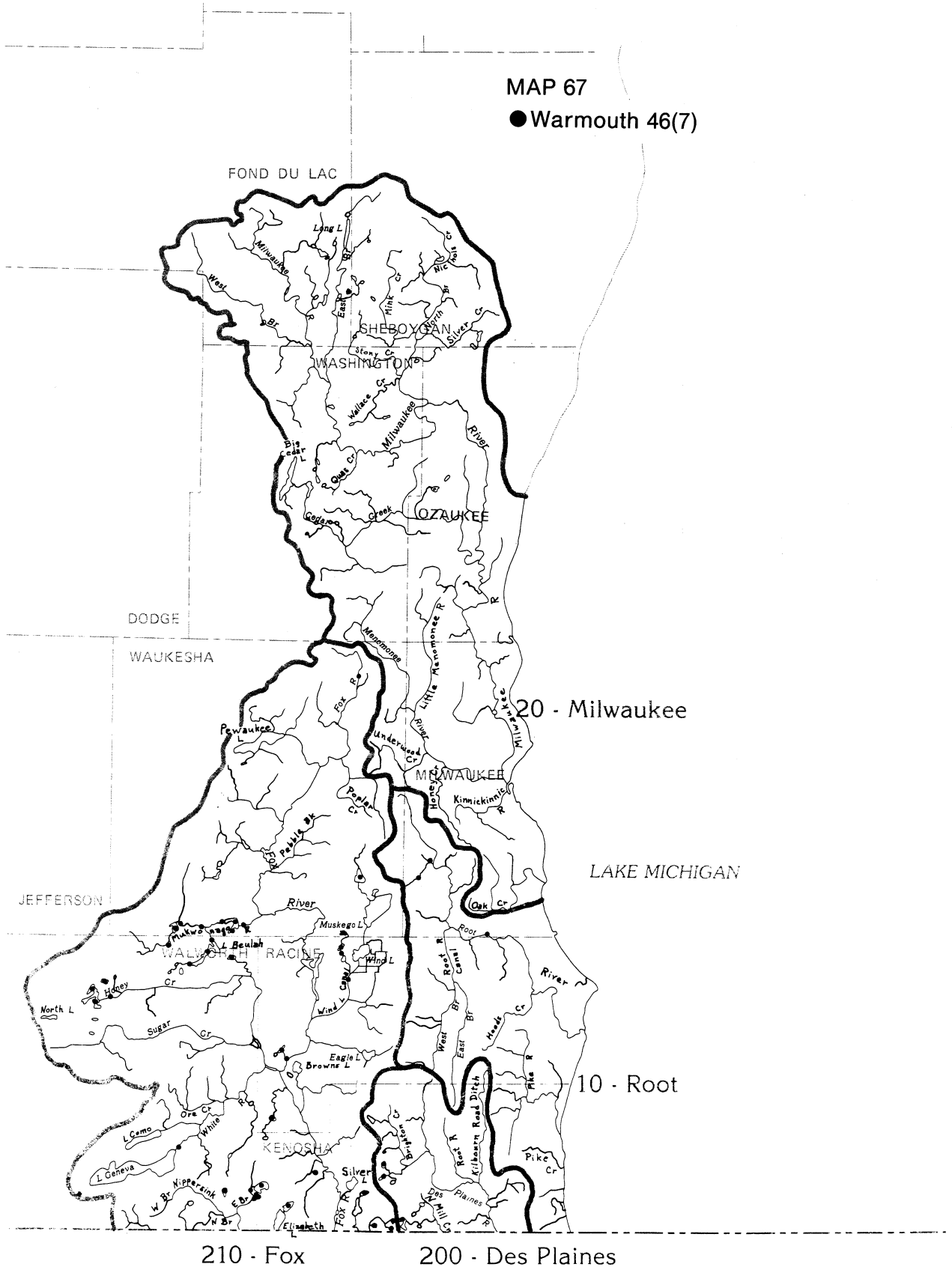

MAP 62
● Brook stickleback 141(3)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

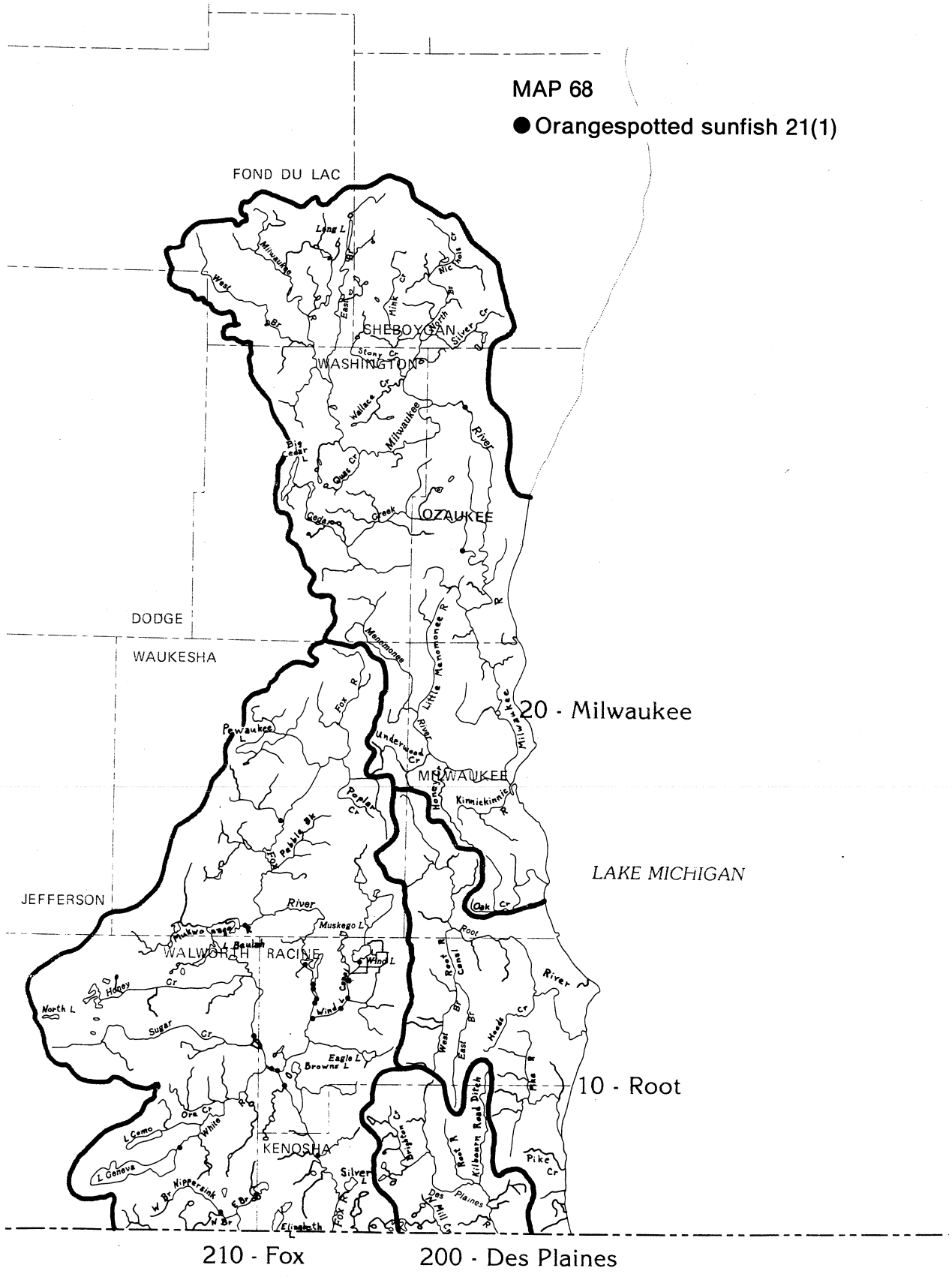

MAP 63
● White bass 6(2)
▲ Yellow bass 2(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

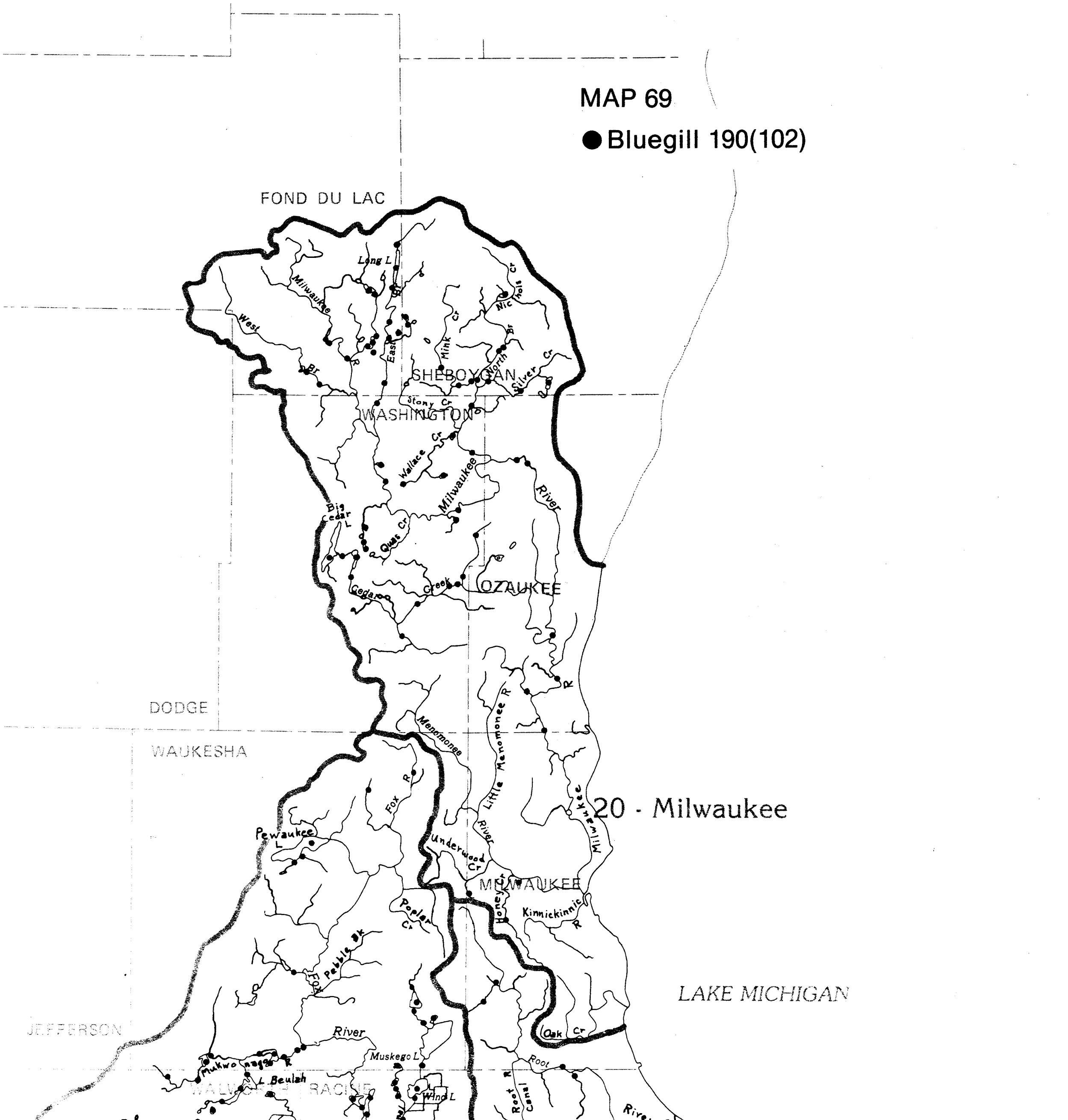

MAP 64
● Rock bass 88(10)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

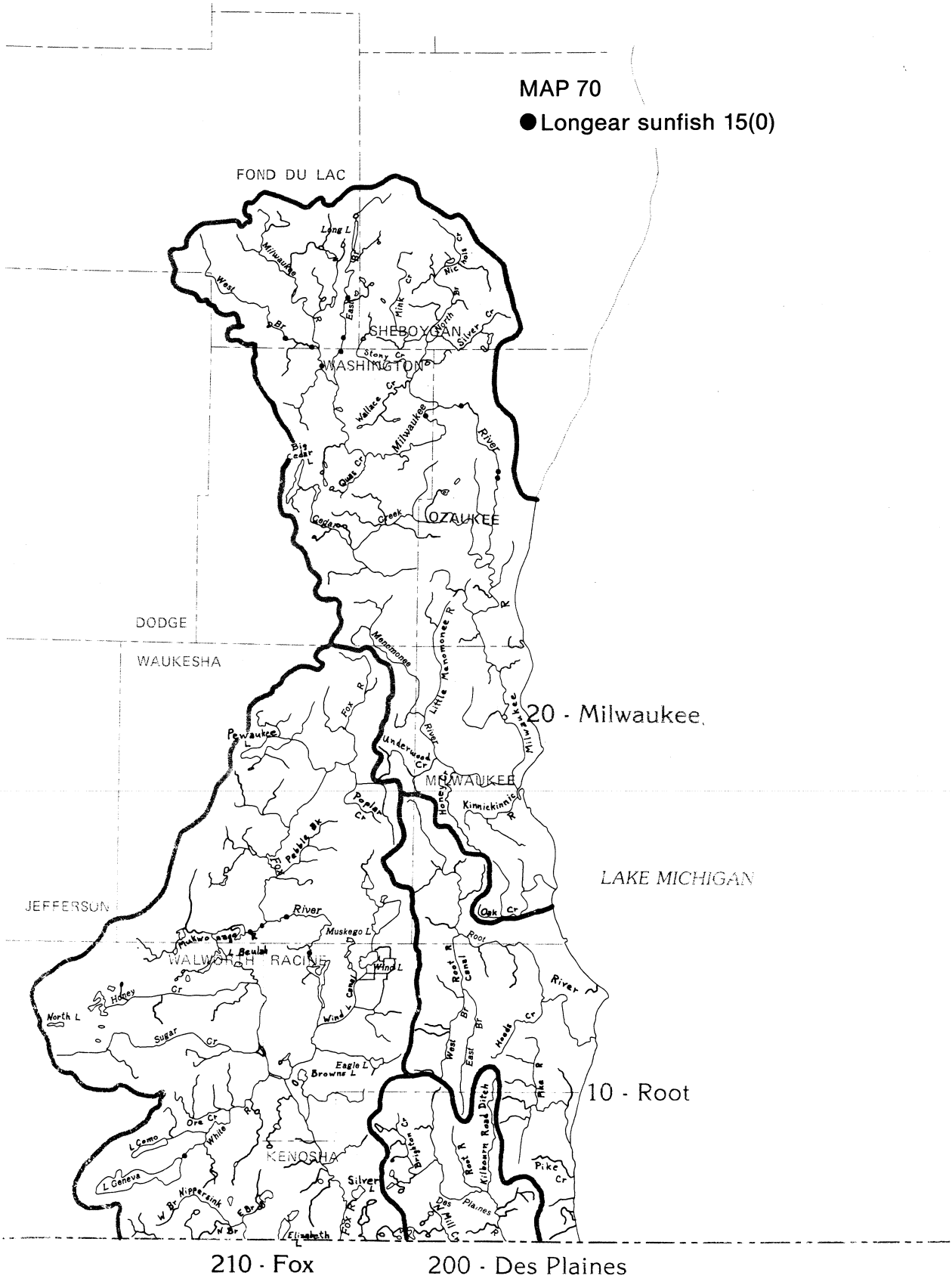

MAP 65
●Green sunfish 304(33)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

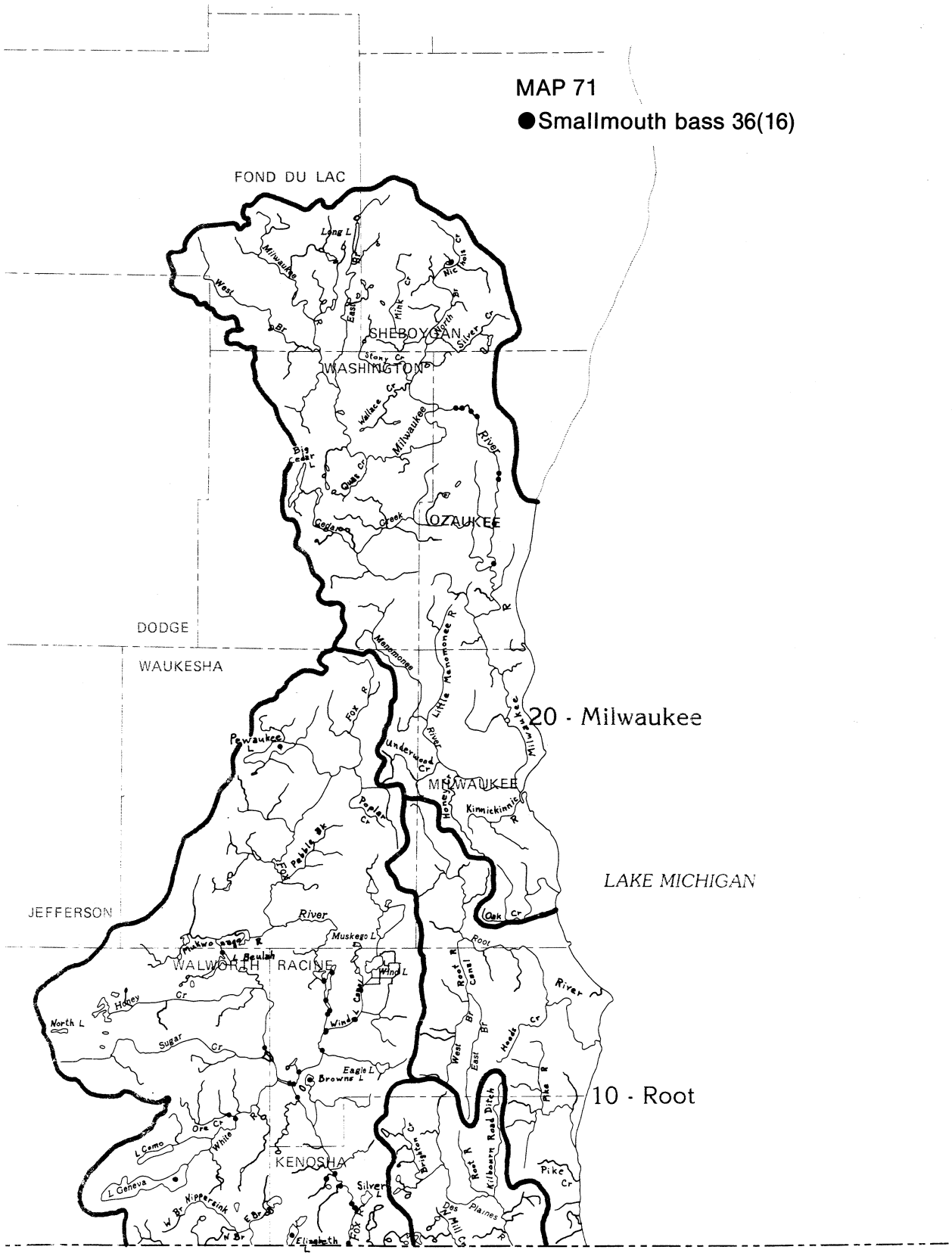

MAP 66
● Pumpkinseed 222(74)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

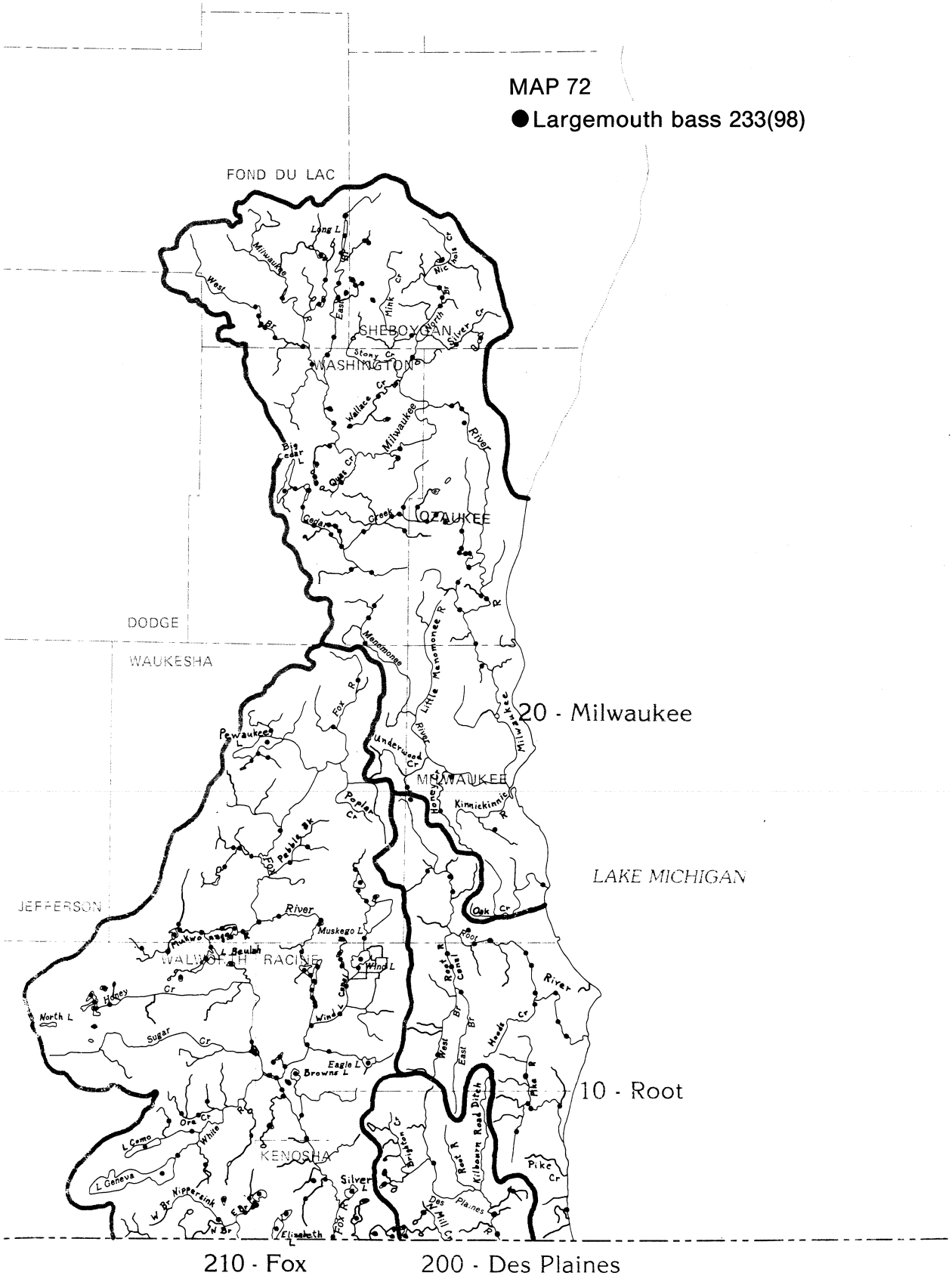

MAP 67
● Warmouth 46(7)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
20 - Milwaukee
MILWAUKEE
LAKE MICHIGAN
JEFFERSON
WALWORTH
RACINE
10 - Root
KENOSHA
210 - Fox
200 - Des Plaines


MAP 68
● Orangespotted sunfish 21(1)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines


MAP 69
● Bluegill 190(102)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines
Long L
Milwaukee R
West Br
East Br
Mink Cr
North Br
Nichols Cr
Silver Cr
Stony Cr
Wallace Cr
Milwaukee River
Big Cedar L
Quas Cr
Cedar Creek
Menomonee
Little Menomonee River
Underwood Cr
Honey Cr
Kinnickinnic R
Oak Cr
Pewaukee L
Fox R
Poplar Cr
Pebble Bk
River
Muskego L
Mukwonago
L Beulah
Wind L
Canal
Honey Cr
North L
Sugar Cr
Eagle L
Browns L
Root R
Canal
West Br
East Br
Hoods Cr
Pike R
Root River
Ore Cr
White R
L Como
L Geneva
W Br Nippersink
E Br
N Br
Elizabeth L
Silver L
Brighton Cr
Kilbourn Road Ditch
Des Plaines R
Pike Cr

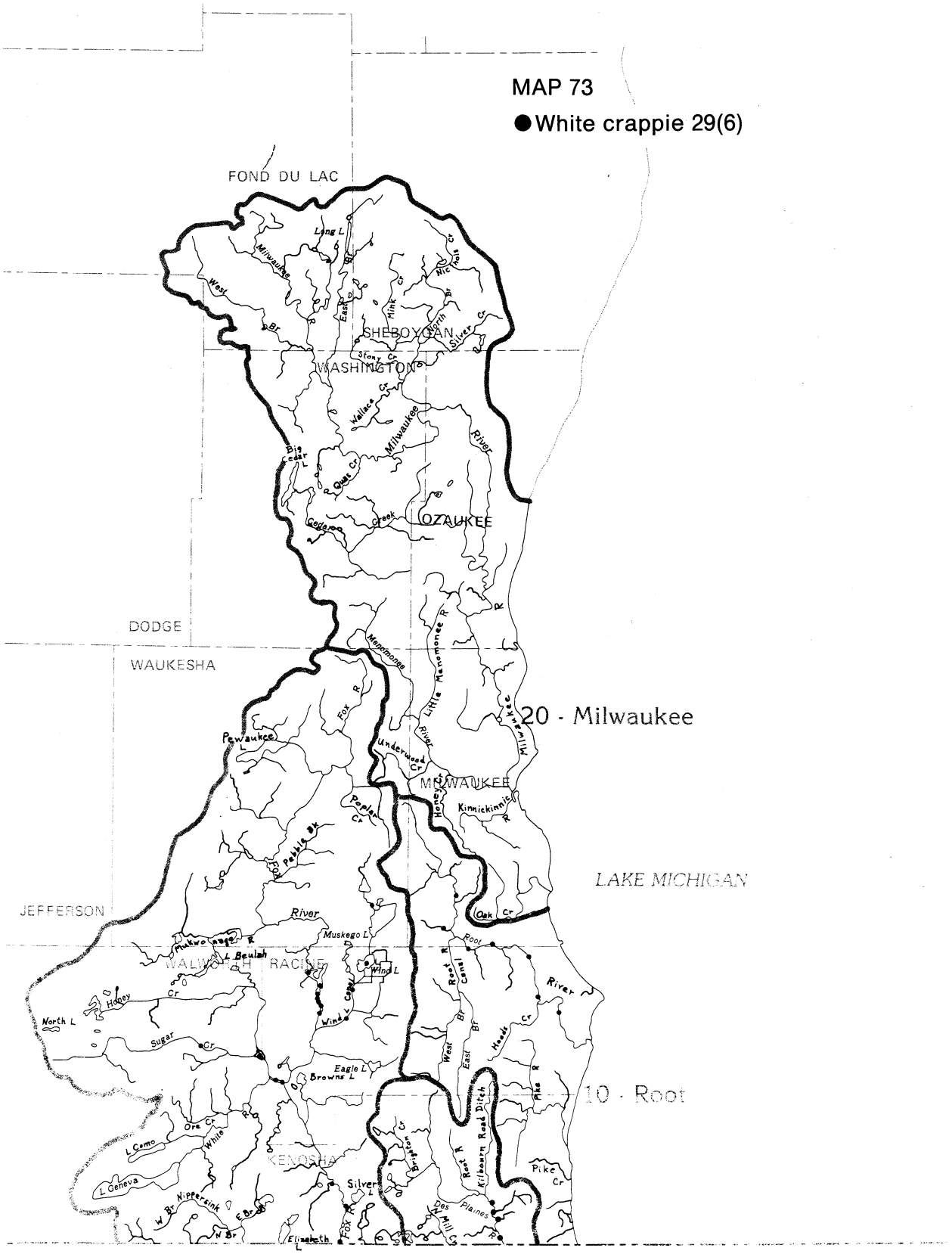

MAP 70
● Longear sunfish 15(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

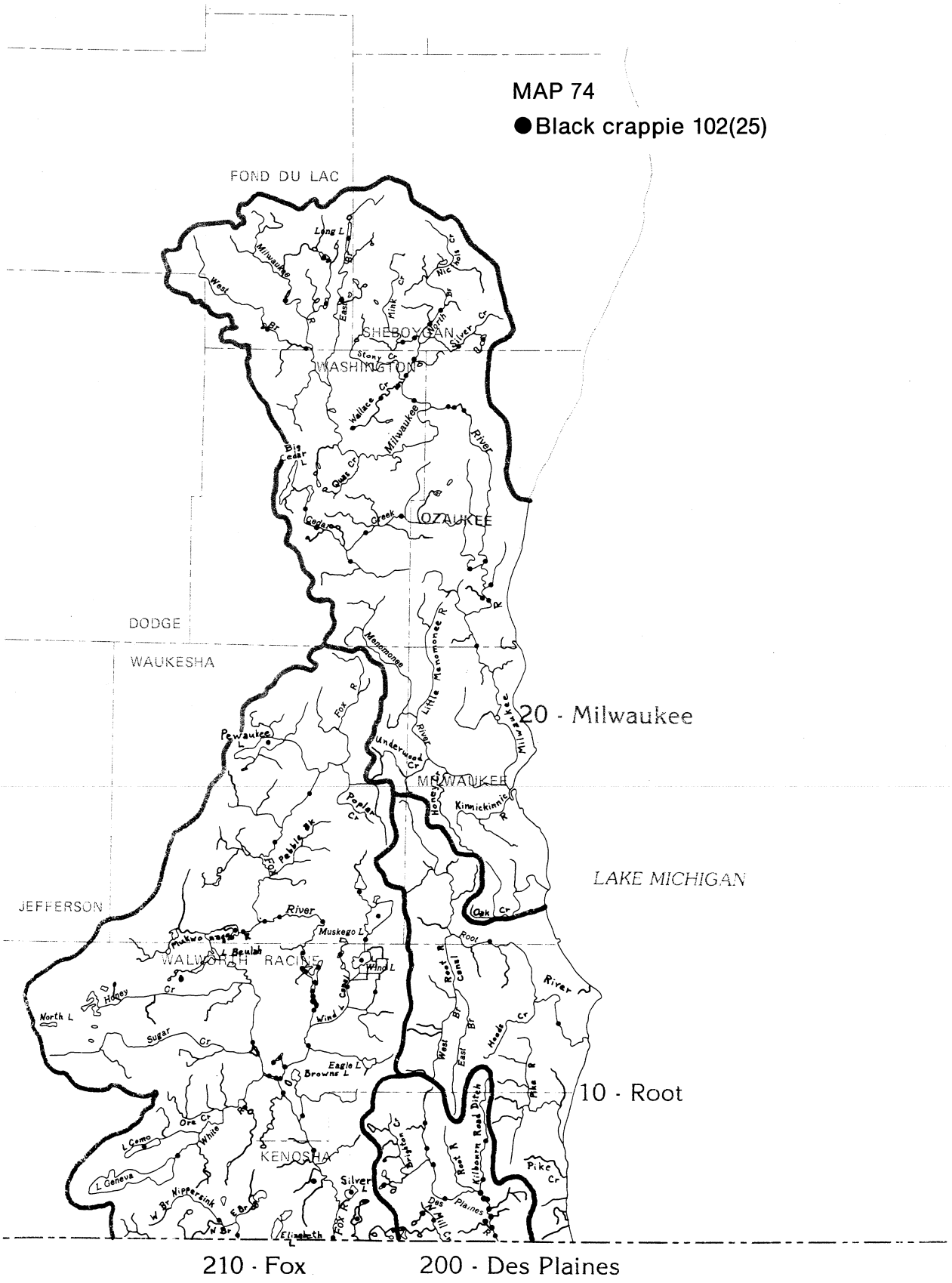

MAP 71
●Smallmouth bass 36(16)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
20 - Milwaukee
MILWAUKEE
LAKE MICHIGAN
JEFFERSON
WALWORTH
RACINE
10 - Root
KENOSHA
210 - Fox
200 - Des Plaines


MAP 72
● Largemouth bass 233(98)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

MAP 73

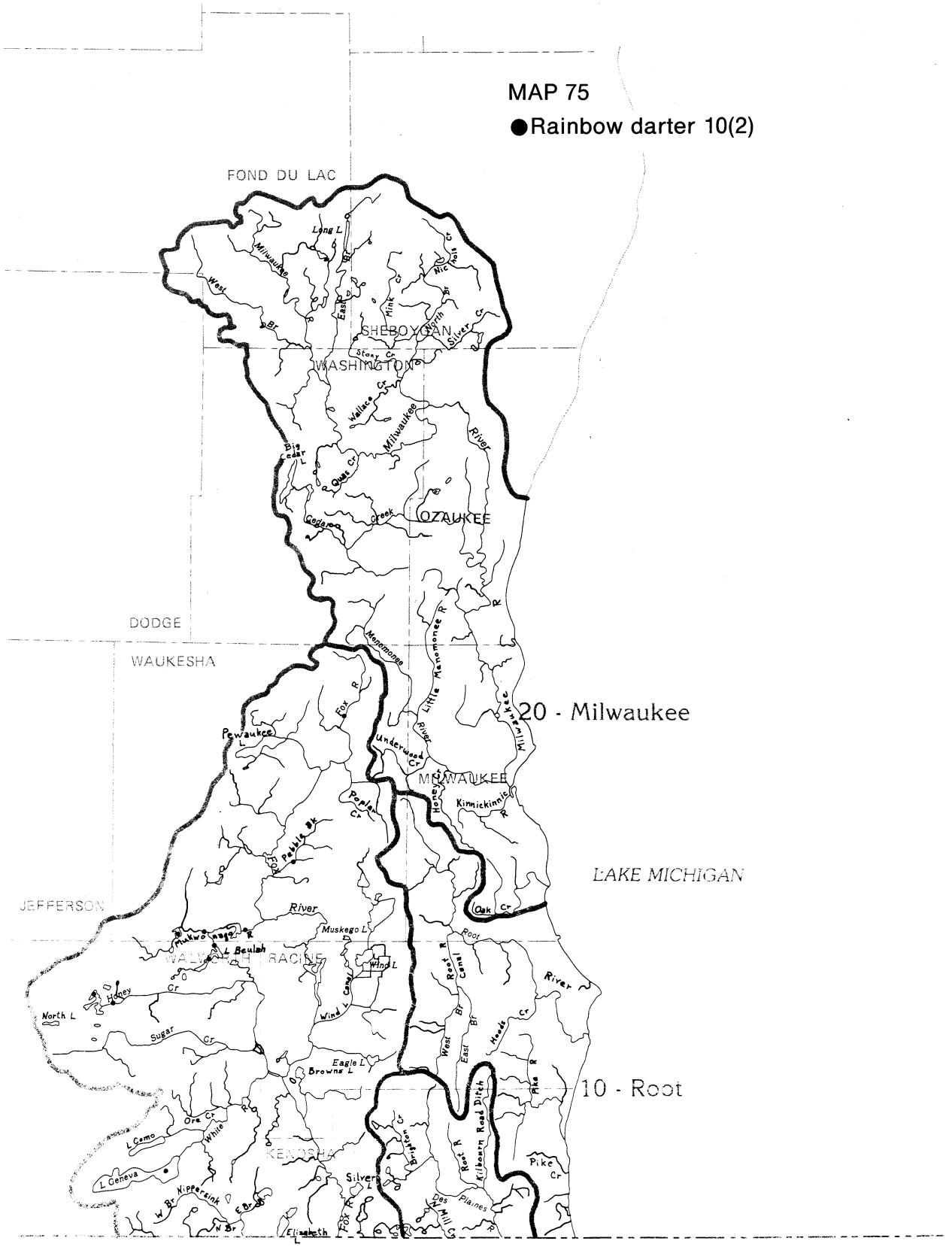
● White crappie 29(6)

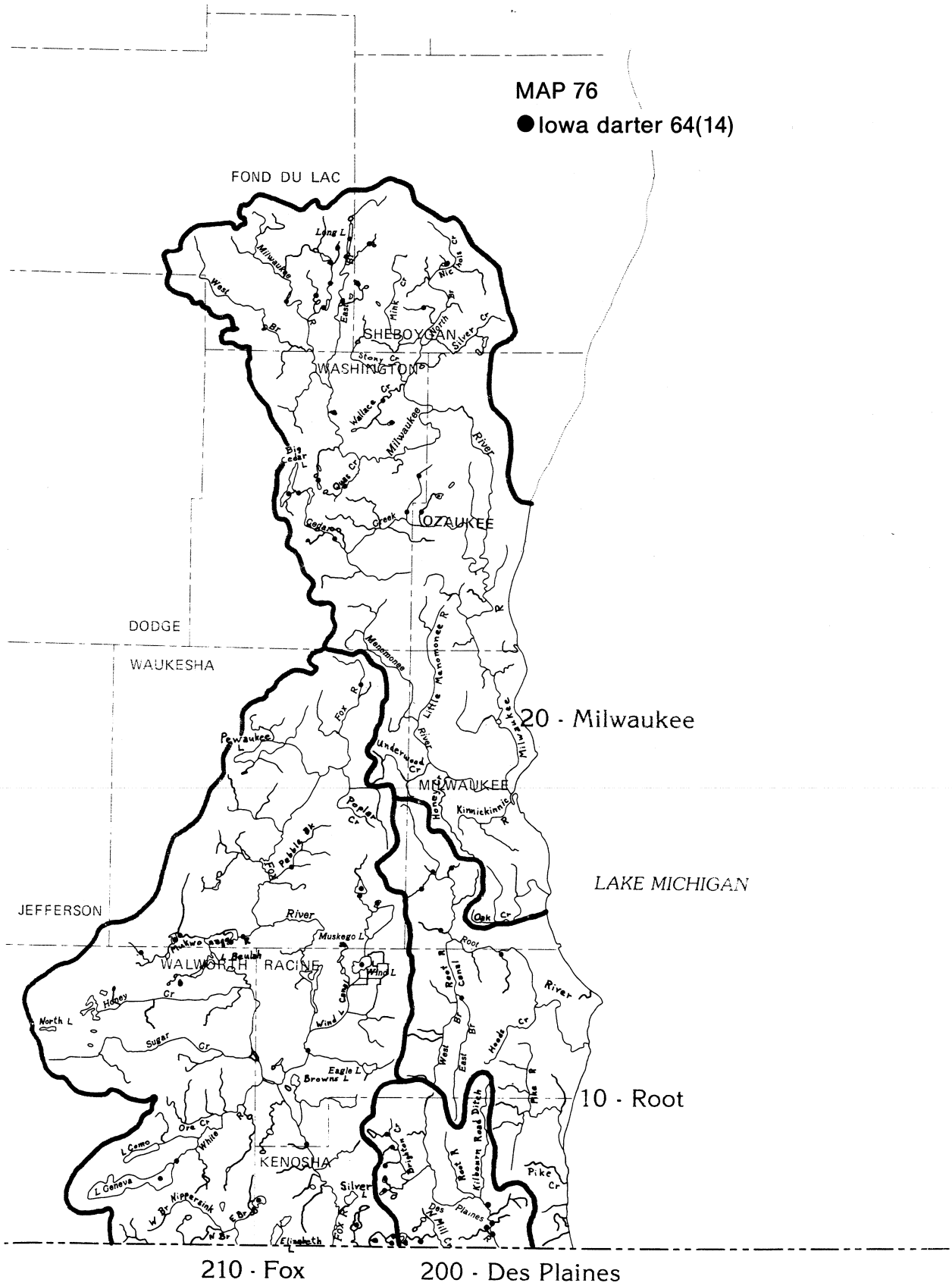


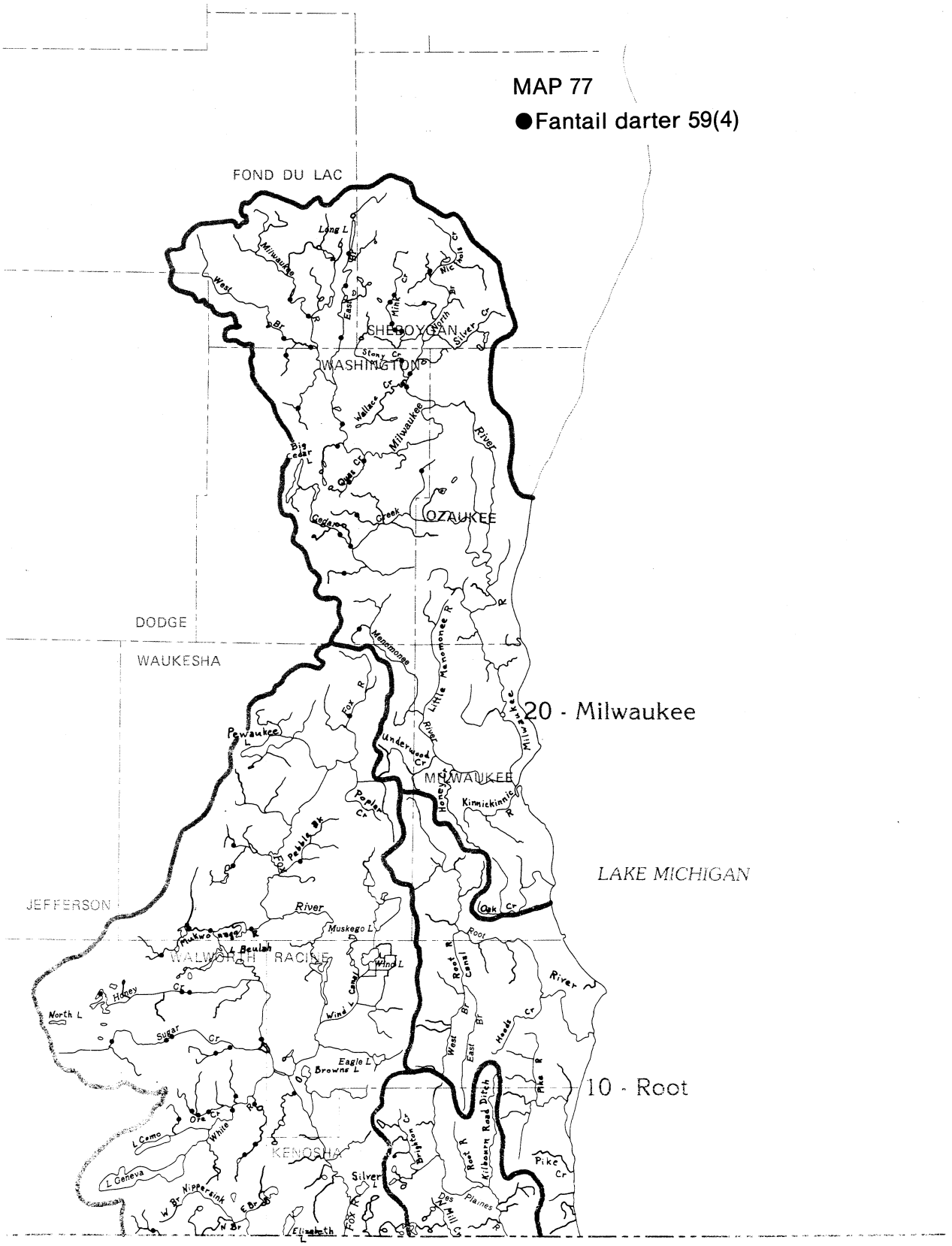

MAP 74
● Black crappie 102(25)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKEE
WAUKESHA
20 - Milwaukee
MILWAUKEE
LAKE MICHIGAN
JEFFERSON
WALWORTH
RACINE
10 - Root
KENOSHA
210 - Fox
200 - Des Plaines

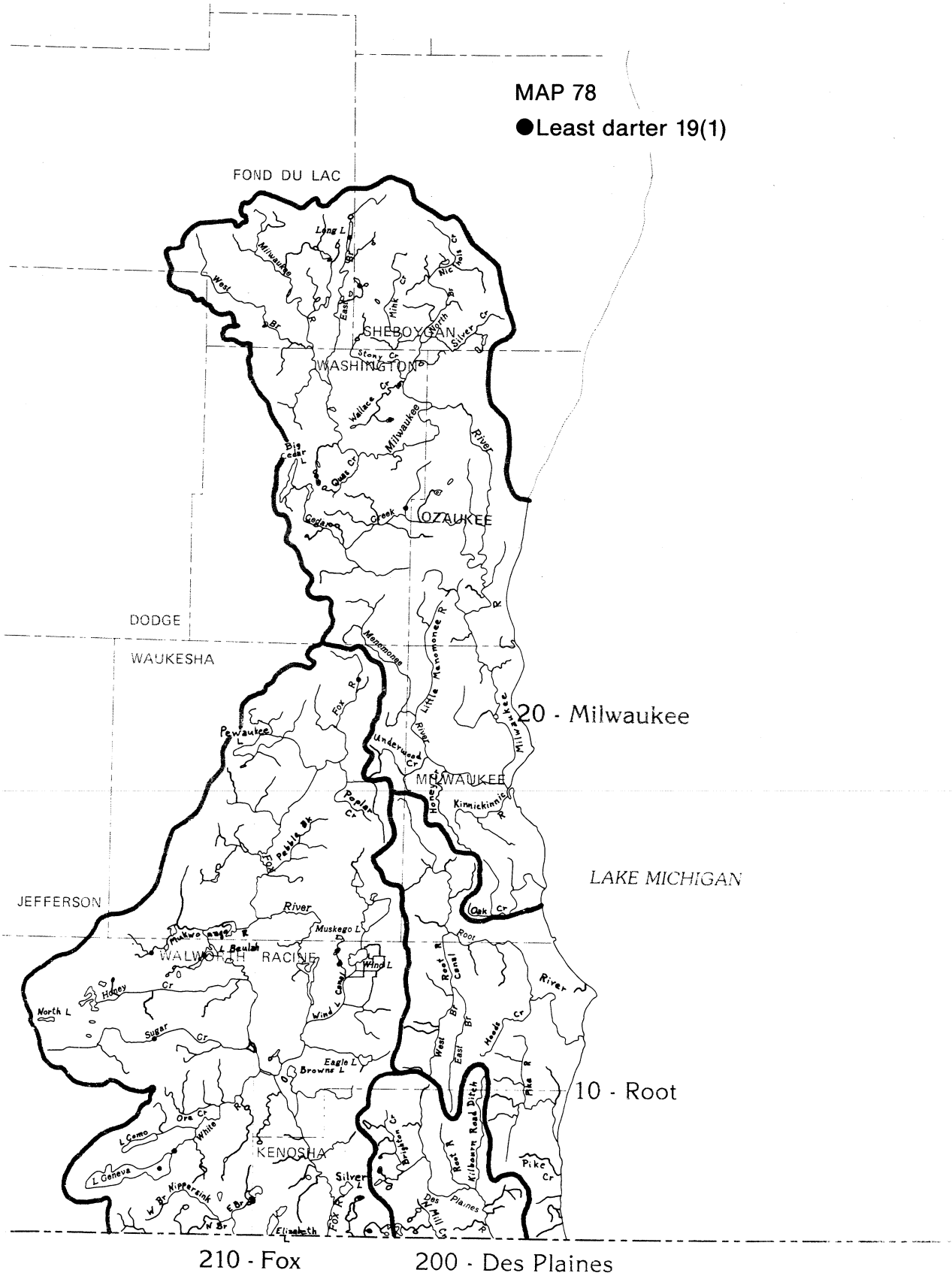
MAP 75

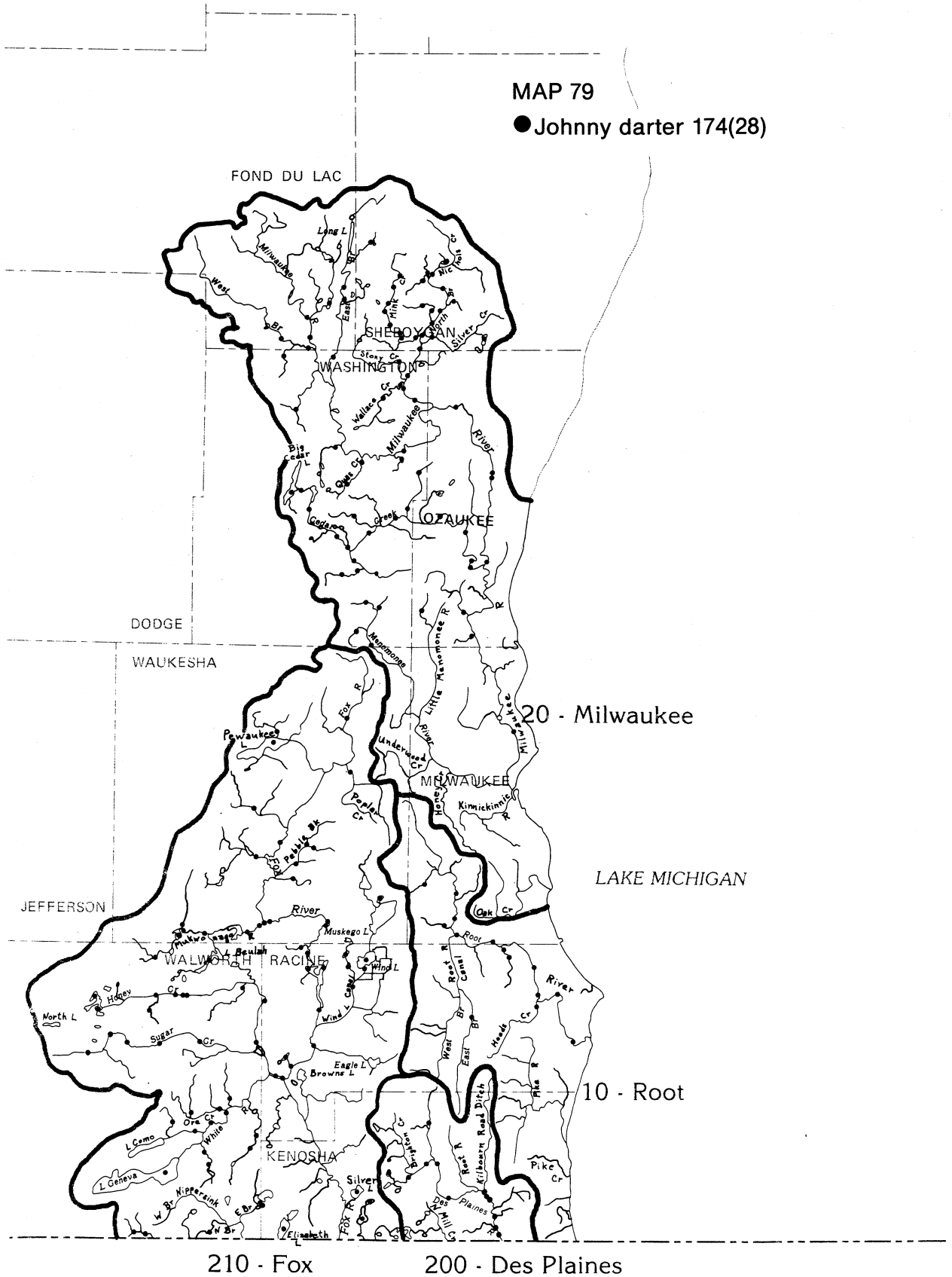
● Rainbow darter 10(2)

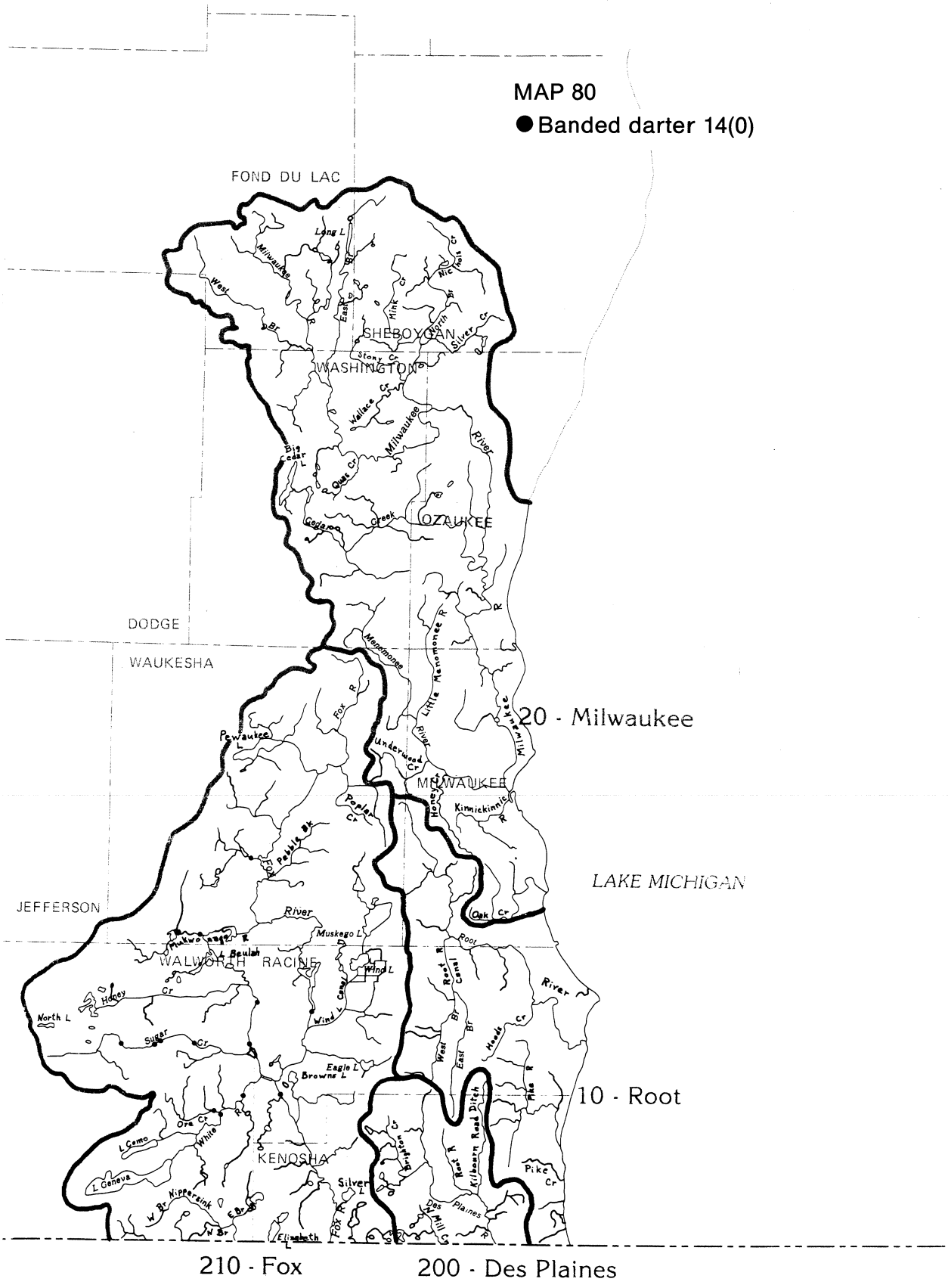



MAP 76
● Iowa darter 64(14)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines


MAP 77
●Fantail darter 59(4)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKEE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

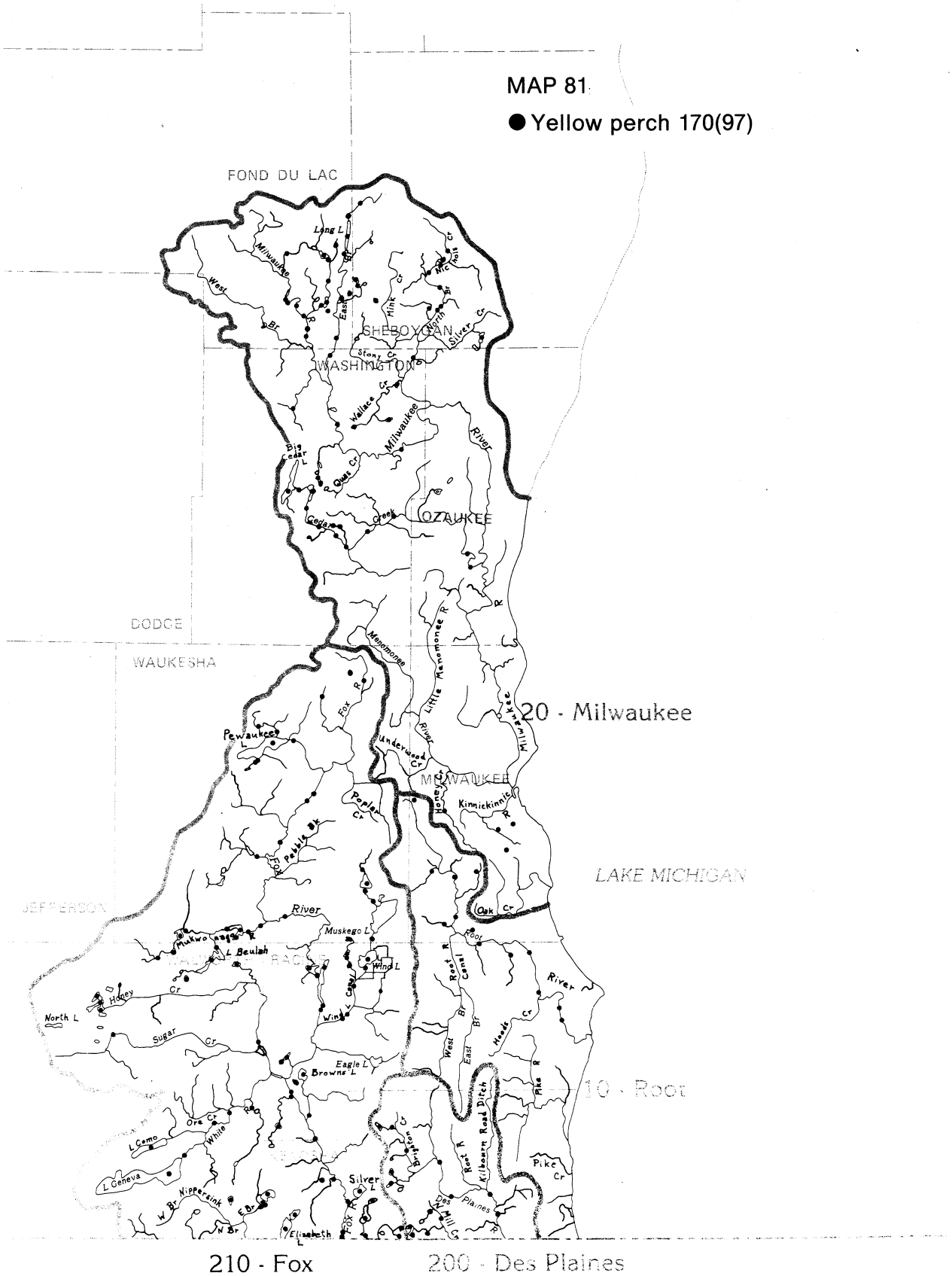

MAP 78
●Least darter 19(1)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

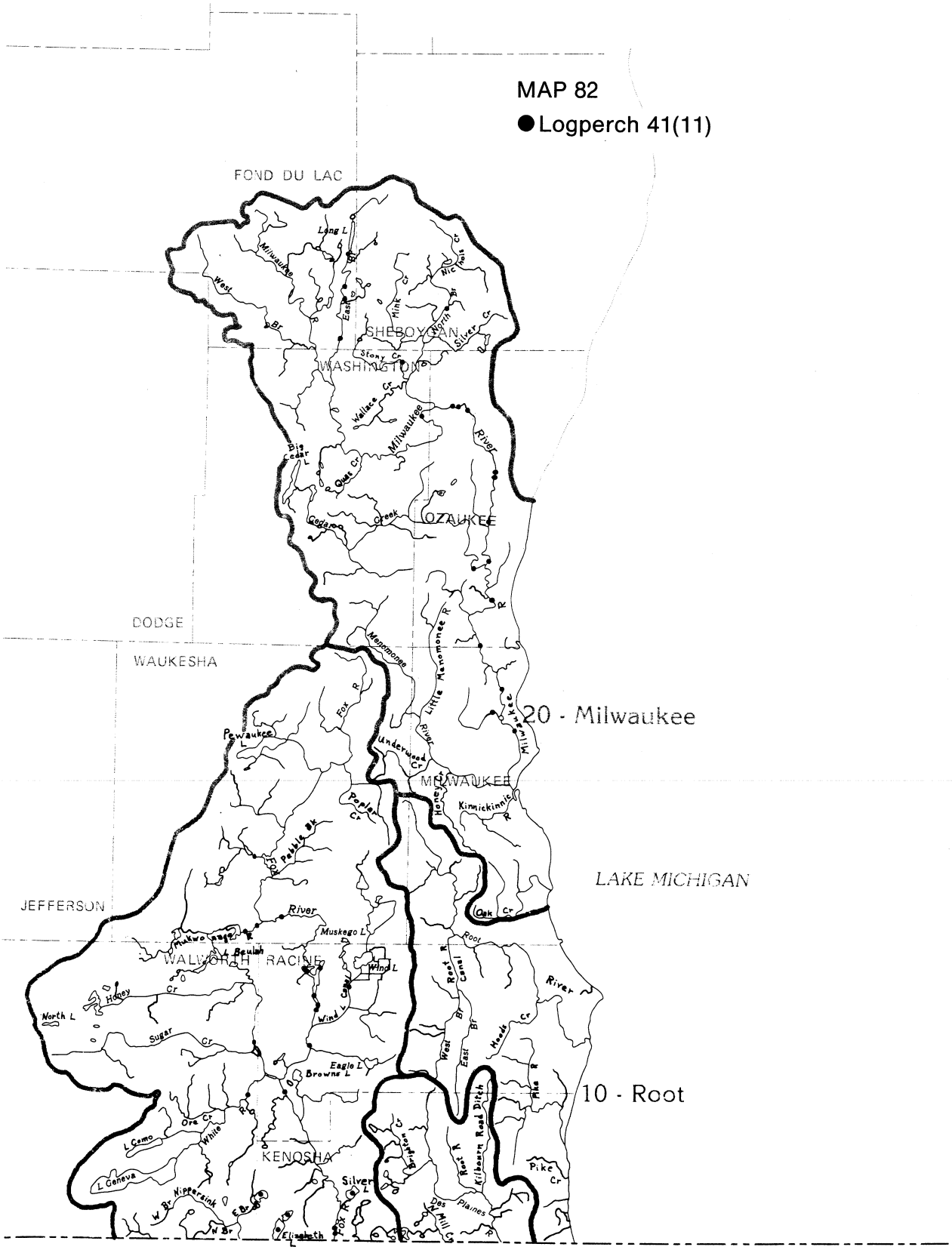

MAP 79
● Johnny darter 174(28)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

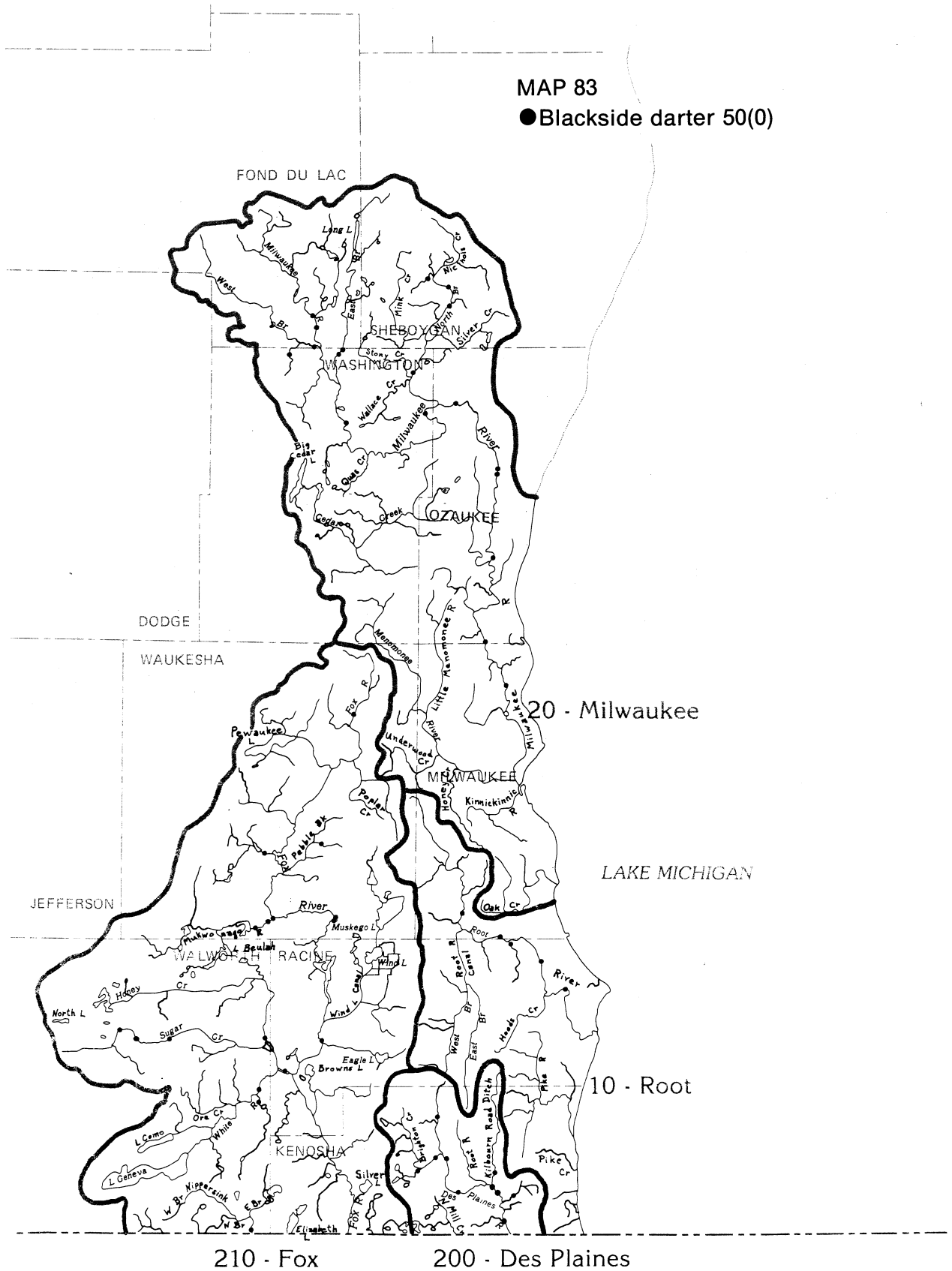

MAP 80
● Banded darter 14(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

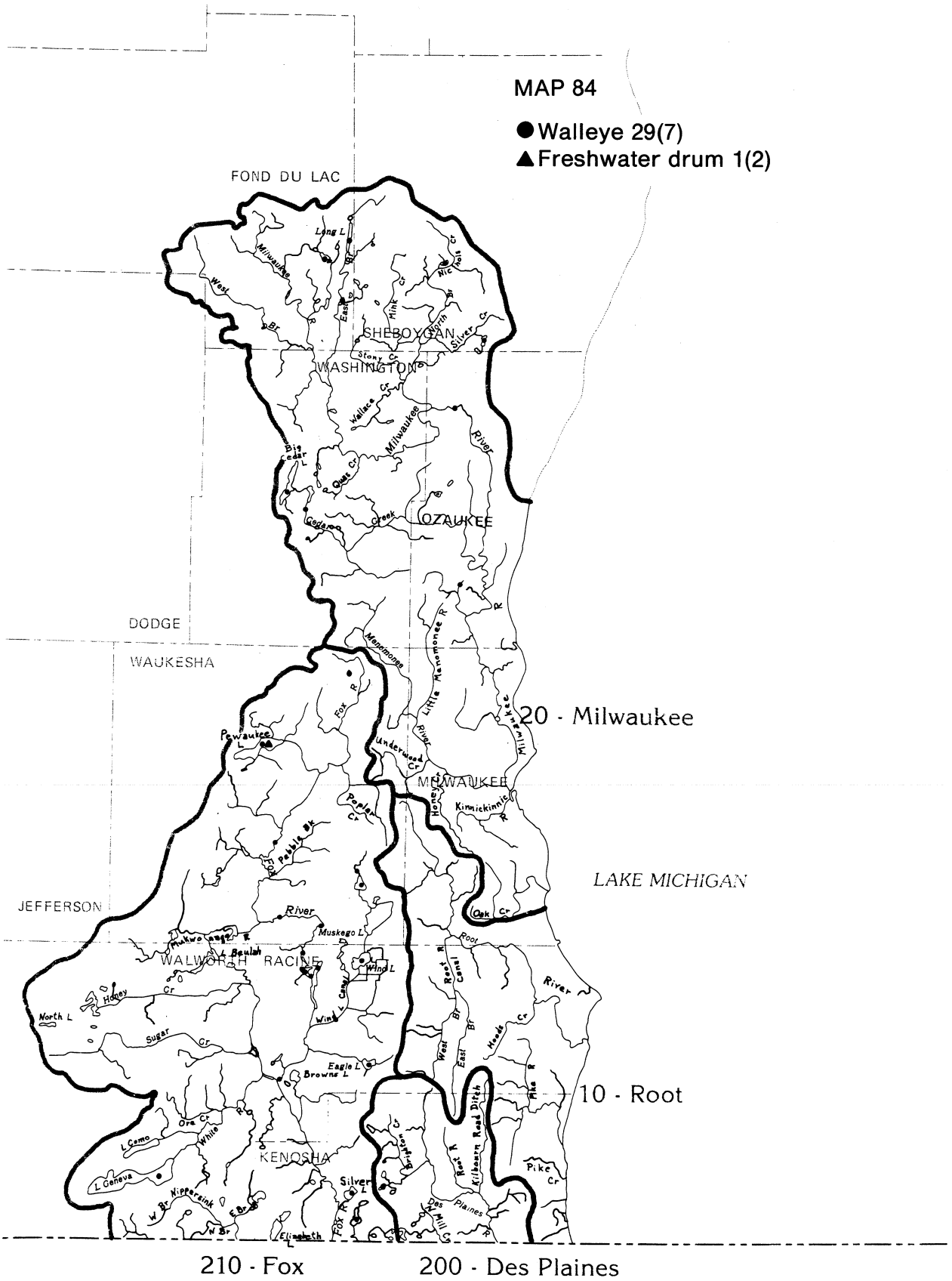
MAP 81

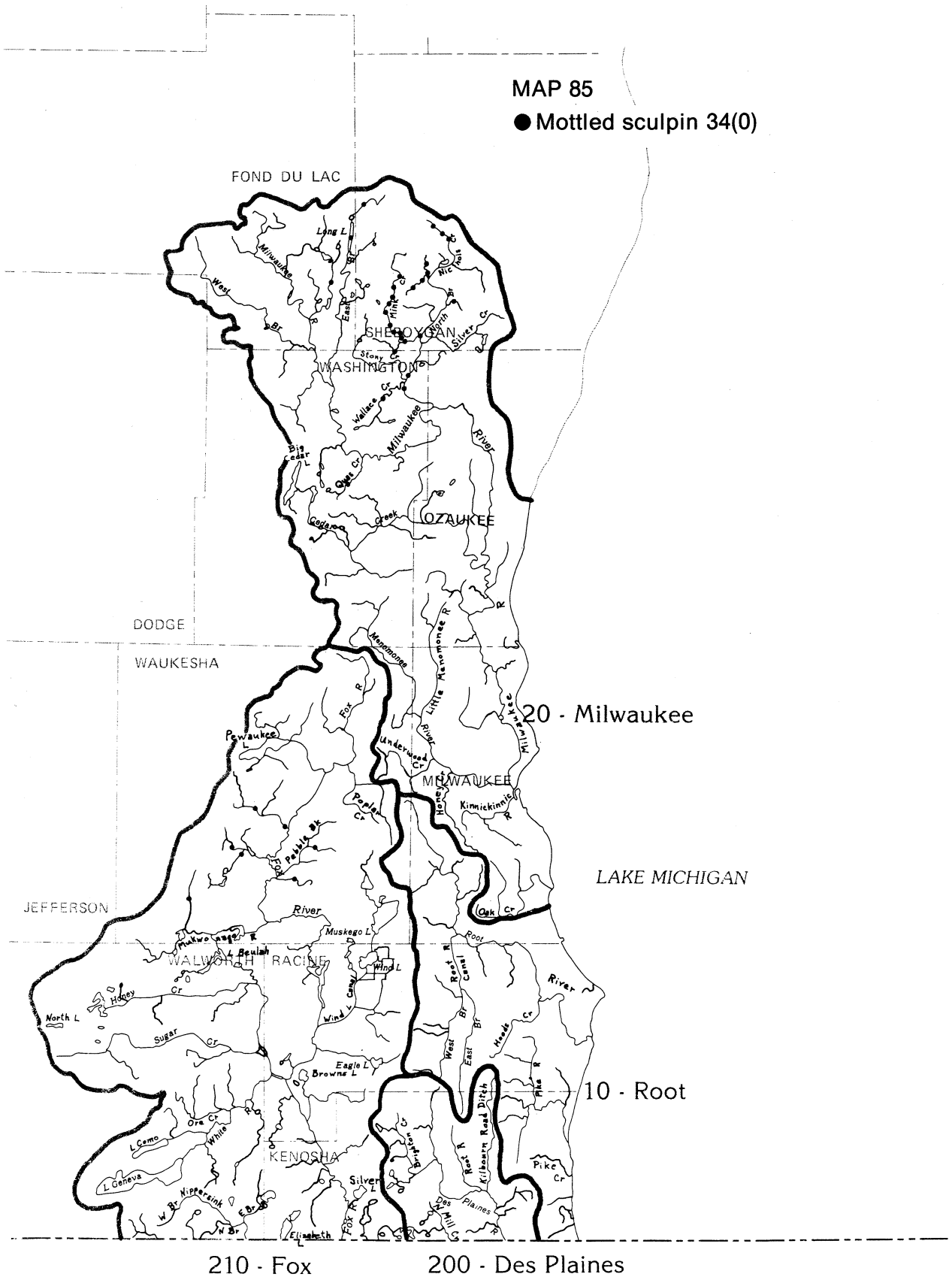
● Yellow perch 170(97)




MAP 82
● Logperch 41(11)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines


MAP 83
●Blackside darter 50(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
20 - Milwaukee
MILWAUKEE
LAKE MICHIGAN
JEFFERSON
WALWORTH
RACINE
10 - Root
KENOSHA
210 - Fox
200 - Des Plaines


MAP 84
● Walleye 29(7)
▲ Freshwater drum 1(2)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines


MAP 85
● Mottled sculpin 34(0)
FOND DU LAC
SHEBOYGAN
WASHINGTON
OZAUKEE
DODGE
WAUKESHA
MILWAUKEE
JEFFERSON
WALWORTH
RACINE
KENOSHA
LAKE MICHIGAN
20 - Milwaukee
10 - Root
210 - Fox
200 - Des Plaines

INDEX TO MAPS

METRIC-ENGLISH AND ENGLISH-METRIC CONVERSIONS

1 km = 0.6214 mile
1 km^2 = 0.3861 $miles^2$
1 ha = 2.47 acres
1 cm = 0.3937 inches (0.328 ft)
1 m^3 = 35.21 ^{3}

1 ft = 30.48 cm
1 mile = 1.609 km
1 acre = 0.4047 ha

ACKNOWLEDGMENTS

The study of the distribution of fish in the Root, Milwaukee, Des Plaines, and Fox river basins spans a decade and represents the efforts and cooperation of a number of people.

One requiring special thanks is David Siegler for his work throughout the study, particularly in heading a field sampling crew, in coding the raw data for entry into the computer, in drafting the base maps, and in proofing the tables and figures. Another is Dale Becker for his work as principal fish taxonomist and as a member of the sampling crew. Another member of the crew was Keith Otis who replaced Mr. Becker as principal taxonomist in July 1978. Three other individuals, Fred Hagstrom, Ken Kahler, and Jim Kreitlow, are recognized for their work in the field as crew leaders and in the laboratory. Credit is given to Richard Tollefson, who along with Mr. Siegler, prepared the 85 species maps. Summer employes who helped with the strenuous field work were Roger Cohn, Paul Johnson, Al Kaas, Douglas Leschisin, Dan Lynch, Mike Meyers, Tom Meyer, John Nichols, Kurt Osterby, Eric Polzin, Tom Rosin, Don Samuelson, Peter Segerson, Paul Sims, George Van Dahm, and Kurt Welke.

I am particularly indebted to Dr. George Becker who shared not only his skills in fish taxonomy with members of this study, but also data from fish collections that he and his students had made. Credit is given to District Fish Management personnel who assisted by sending us fish from their stream and lake surveys and copies of their reports.

Lyle Christenson and Anne Forbes critically reviewed this manuscript. Photographs were taken by the author except where noted.

Permission to use several fish photographs and drawings from "Fishes of Illinois" by Philip Smith was kindly granted by the University of Illinois Press (©/1979 by the Board of Trustees of the University of Illinois).

This investigation was financed in part by the Wisconsin Department of Natural Resources, Federal Aid in Fish Restoration Act under Dingell-Johnson project F-83-R, Study 501 (formerly 216), and Federal Endangered Species Act of 1973 under Wisconsin Project E-1.

About the Author

Don Fago is a fisheries biologist with the Bureau of Research who has been in charge of the statewide fish distribution study since its inception in 1974 (DNR, 3911 Fish Hatchery Road, Madison, Wisconsin 53711).

Production Credits

Ruth L. Hine, Editor
Susi Nehls, Donna Mears, Copy Editors
Richard Burton, Graphic Artist
Sheila Mittelstaedt, Susan J. Hoffman, and Christine Trevorrow, Word Processors

TECHNICAL BULLETINS (1981-84)

No. 119 A successful application of catch and release regulations on a Wisconsin trout stream. (1981) Robert L. Hunt

No. 120 Forest opening construction and impacts in northern Wisconsin. (1981) Keith R. McCaffery, James E. Ashbrenner, and John C. Moulton

No. 121 Population dynamics of wild brown trout and associated sport fisheries in four central Wisconsin streams. (1981) Ed L. Avery and Robert L. Hunt

No. 122 Leopard frog populations and mortality in Wisconsin, 1974-76. (1981) Ruth L. Hine, Betty L. Les, and Bruce F. Hellmich

No. 123 An evaluation of Wisconsin ruffed grouse surveys. (1981) Donald R. Thompson and John C. Moulton

No. 124 A survey of Unionid mussels in the Upper Mississippi River (Pools 3 through 11). (1981) Pamella A. Thiel

No. 125 Harvest, age structure, survivorship, and productivity of red foxes in Wisconsin, 1975-78. (1981) Charles M. Pils, Mark A. Martin, and Eugene L. Lange

No. 126 Artificial nesting structures for the double-crested cormorant. (1981) Thomas I. Meier

No. 127 Population dynamics of young-of-the-year bluegill. (1982) Thomas D. Beard

No. 128 Habitat development for bobwhite quail on private lands in Wisconsin. (1982) Robert T. Dumke

No. 129 Status and management of black bears in Wisconsin. (1982) Bruce E. Kohn

No. 130 Spawning and early life history of yellow perch in the Lake Winnebago system. (1982) John J. Weber and Betty L. Les

No. 131 Hypothetical effects of fishing regulations in Murphy Flowage, Wisconsin. (1982) Howard E. Snow

No. 132 Using a biotic index to evaluate water quality in streams. (1982) William L. Hilsenhoff

No. 133 Alternative methods of estimating pollutant loads in flowing water. (1982) Ken Baun

No. 134 Movement of carp in the Lake Winnebago system determined by radio telemetry. (1982) Keith J. Otis and John J. Weber

No. 135 Evaluation of waterfowl production areas in Wisconsin. (1982) LeRoy R. Petersen, Mark A. Martin, John M. Cole, James R. March, and Charles M. Pils

No. 136 Distribution and relative abundance of fishes in Wisconsin. I. Greater Rock river basin. (1982) Don Fago

No. 137 A bibliography of beaver, trout, wildlife, and forest relationships with special reference to beaver and trout. (1983) Ed Avery

No. 138 Limnological characterstics of Wisconsin lakes. (1983) Richard A. Lillie and John W. Mason

No. 139 A survey of the mussel densities in Pool 10 of the Upper Mississippi River (1982). Randall E. Duncan and Pamella A. Thiel

No. 140 Distribution and relative abundance of fishes in Wisconsin. II. Black, Trempealeau, and Buffalo river basins. (1983) Don Fago

No. 141 Population dynamics of wild trout and associated sport fisheries in two northern Wisconsin streams. (1983) Ed L. Avery

No. 142 Assessment of a daily limit of two trout on the sport fishery at McGee Lake, Wisconsin. (1984) Robert L. Hunt

No. 143 Distribution and relative abundance of fishes in Wisconsin. III. Red Cedar river basin. (1984) Don Fago

No. 144 Population ecology of woodcock in Wisconsin. (1984) Larry Gregg

No. 145 Duck breeding ecology and harvest characteristics on Grand River Marsh Wildlife Area. (1984) William E. Wheeler, Ronald C. Gatti, and Gerald A. Bartelt

No. 146 Impacts of a floodwater-retarding structure on year class strength and production by wild brown trout in a Wisconsin coulee stream. (1984) Oscar M. Brynildson and Clifford L. Brynildson

Copies of the above publications and a complete list of all technical bulletins in the series are available from the Bureau of Research, Department of Natural Resources, Box 7921, Madison, WI 53707.

Department of Natural Resources
Box 7921
Madison, Wisconsin 53707