

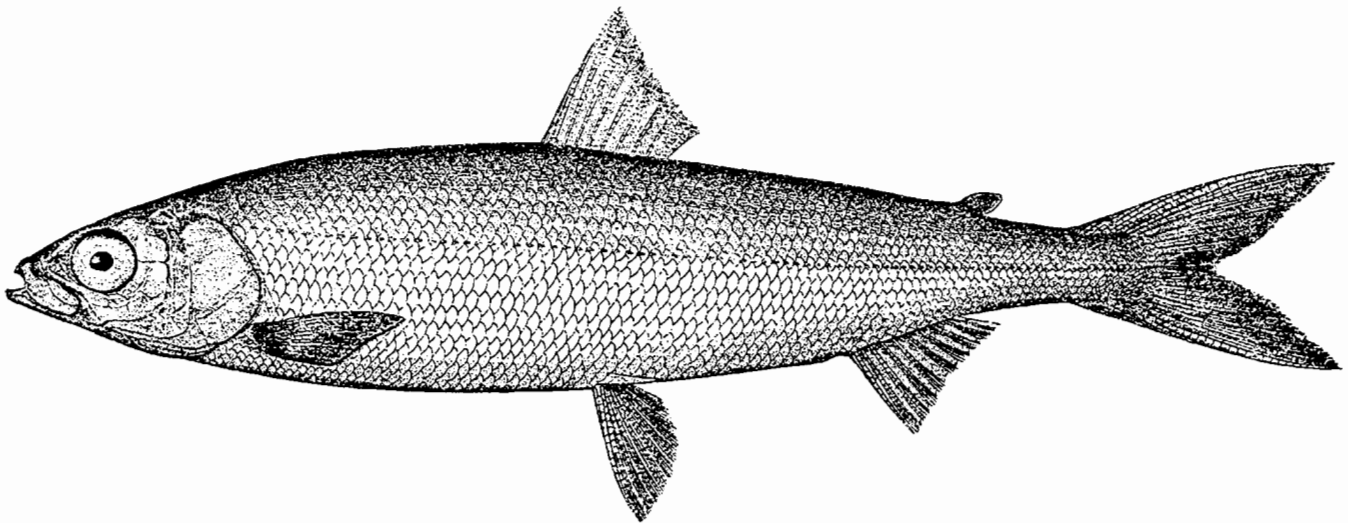
FISHERIES DIVISION
RESEARCH REPORT

Number 2014

July 25, 1995

**Distribution and Abundance of the Lake Herring
(*Coregonus artedii*) in Michigan**

W. C. Latta



THE CISCO OR LAKE HERRING.

Coregonus Artedi, Lesueur.

Drawing by H. L. Todd, from No. 33958, U. S. National Museum, collected at Nearfield Bay, Wisconsin, by J. W. Milner.



**STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES**

**MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FISHERIES DIVISION**

**Fisheries Research Report 2014
July 25, 1995**

**DISTRIBUTION AND ABUNDANCE OF LAKE HERRING
(*COREGONUS ARTEDI*) IN MICHIGAN**

W. C. Latta

The Michigan Department of Natural Resources, (MDNR) provides equal opportunities for employment and for access to Michigan's natural resources. State and Federal laws prohibit discrimination on the basis of race, color, sex, national origin, religion, disability, age, marital status, height and weight. If you believe that you have been discriminated against in any program, activity or facility, please write the MDNR Equal Opportunity Office, P.O. Box 30028, Lansing, MI 48909, or the Michigan Department of Civil Rights, 1200 6th Avenue, Detroit, MI 48226, or the Office of Human Resources, U.S. Fish and Wildlife Service, Washington D.C. 20204.

For more information about this publication or the American Disabilities Act (ADA), contact, Michigan Department of Natural Resources, Fisheries Division, Box 30028, Lansing, MI 48909, or call 517-373-1280.

Cover graphic—Goode, George Brown 1884. The Fisheries and Fishery Industries of the United States. Section I, Natural History of Useful Aquatic Animals. U. S. Government Printing Office, Washington.

Distribution and abundance of lake herring (*Coregonus artedii*) in Michigan

W. C. Latta

Institute for Fisheries Research
203 Museums Annex Bldg.
1109 N. University
Ann Arbor, MI 48109-1084

Abstract.—Lake herring *Coregonus artedii* are, or have been, present in at least 153 lakes in Michigan. A large fraction (49%) of the lakes are in a band across the southern part of the state extending from Oakland County southwest to Cass County, in moraines left by the Wisconsin glacier. Many of the remaining herring lakes are in counties contiguous to the Great Lakes; few are found in interior counties. Although herring lakes vary in size between 20 and 18,770 acres, three-fourths of them are larger than 100 acres. Most of the lakes are oligotrophic and 79% have alkalinities of 105 ppm or greater. The status of the herring populations is unknown in 51 of the lakes. In the remaining 102 it was judged that the population is stable in 80 lakes, declining in 8, and extirpated in 14. Of the latter, it appeared extirpation of herring was caused by habitat deterioration in 6 lakes, competition or predation from other fishes in 4, treatment of the lake with a fish toxicant in 1, and unknown in 3. All herring lakes in Michigan should be protected from eutrophication and any proposed fish introductions should be evaluated.

The lake herring or cisco *Coregonus artedii* is widely distributed in northern North America from upper Mississippi River and Great Lakes basins north to Labrador and northwest to Mackenzie River drainage. It occurs mainly in lakes but also in large rivers and coastal waters of Hudson Bay (Lee et al. 1980). The southern most populations occur in Michigan and Indiana. The lake herring, a member of the trout family, is a slender, silvery fish usually 8 to 12 inches in length. It requires cool, well oxygenated water and is normally found in a water layer where the temperature is 20°C or less and the dissolved oxygen is 3.0 mg/l or more. Frey (1955) called this the "cisco layer." McLain and Magnuson (1988) have defined this layer with a lower temperature (17°C) and a higher oxygen concentration (4 ppm). Maturity

is usually attained at age 3 or 4 and some individuals may live for 12 years or more. Spawning takes place in shallow water in late fall or early winter. Corresponding to its pelagic habitat, it mainly consumes zooplankton. Scott and Crossman (1973) and Becker (1983) provide excellent life history summaries.

In Michigan, the lake herring is classified as a threatened species (Bailey and Smith 1991). However, no systematic effort has been made to evaluate its status in Michigan's inland lakes although in Great Lakes waters its abundance has been monitored frequently (Fleischer 1992). The objective of this study was to tabulate the lakes in Michigan which have, or had, a lake herring population and determine if each population was stable, declining or extirpated.

Methods

The names and locations of lakes containing lake herring populations were obtained from several sources: the collection records from the Fish Division, Museum of Zoology, The University of Michigan; the gill-netting records for 1886-1892 of the Michigan Fish Commission entitled "Examination of Interior Lakes"; the files on fishing regulations from the Fisheries Division, Michigan Department of Natural Resources (MDNR) where in the past many lakes containing lake herring were listed as open to fishing with gill nets during the fall; the lists and notes compiled by district fishery biologists of the MDNR; and the files, notes and memories of other agency and academic fish biologists in the state of Michigan. For this analysis, only records in which lake herring were identified by a person with recognized taxonomic skills were considered valid. Although many lakes reported as containing herring in the Michigan Fish Commission records of the late 1800s were accepted, twelve lakes were rejected because subsequent netting did not capture any herring. Identification was questionable in many of these early records. In more recent records, lake herring have been reported present in several lakes where no actual specimens have been recorded; these records have been discarded. Also the fish populations of many Michigan lakes, especially private ones, have not been adequately sampled and are essentially unknown. Listed for each lake by county was: name, location (town, range and section), year of first and last capture of lake herring, status of the population (either stable, declining or extirpated), area and depth of lake, oxygen-thermal classification, and alkalinity (bound carbon dioxide) of the water. Most of this information was obtained from the lake survey files of the Fisheries Division, MDNR. The oxygen-thermal classification follows Schneider (1975) in which there are 6 types:

- (1) Stratified lakes with at least 2 ppm dissolved oxygen (DO) at all depths,
- (2) Stratified lakes in which DO falls to 2 ppm in the hypolimnion,

- (3) Stratified lakes in which DO falls to 2 ppm between the 5-foot level of the thermocline and the top of the hypolimnion,
- (4) Stratified lakes in which DO falls to 2 ppm between the bottom of the epilimnion and the 5-foot level of the thermocline,
- (5) Unstratified lakes,
- (6) Lakes subject to frequent severe, fish kills (DO falls to near zero throughout the lake).

Only 1 through 5 are applicable to the lake herring lakes.

Status of the lake herring populations were defined as follows: stable if after the initial collection at least two samples were taken and there was no significant decrease in catch per effort; declining if more than two samples suggested a decrease; and extirpated if more than two samples failed to capture a lake herring. Obviously these status ratings are subjective. Lake herring are difficult to catch because of their cold-water temperature preference and pelagic habits. They are seldom caught except in gill nets. In several lakes, herring have not been captured in 20 or more years, however, they were considered as stable populations because either no netting had been done, the sampling gear was inappropriate (trap nets, electrofishing), or there were no reports of herring die-offs in the files. In addition, I asked each district fishery biologist to review my ratings for the herring lakes under their management and I corrected for their judgments in the few cases necessary.

Results and Discussion

Lake herring are, or have been, present in at least 153 lakes in Michigan (Table 1). There are many private and public lakes which have not been surveyed which presumably contain herring. The extreme example is Oakland County which with 16 has the largest number of herring lakes per county in the state (Figure 1). According to Humphrys et al. (1962), there are 175 lakes 25 acres or larger in Oakland County. To date, about 92 of these lakes, or 53% of them, have been adequately sampled. The proportion of herring lakes (16) to lakes

surveyed (92) implies there may be another 14 lakes in the county with herring populations. This fraction is probably too high to extrapolate statewide, but suggests there are many lakes containing herring not yet sampled. Lakes with herring occur in 41 of Michigan's 83 counties. A large fraction of the lakes, 49%, are in southern Michigan in a band which extends from Oakland County southwest to Cass County. Dorr and Eschman (1970) identify most of this band as an area of abundant kettle-hole lakes in the moraines left by the retreating Wisconsin glacier. Another group of herring lakes are those in the counties contiguous to the Great Lakes. These lakes were formed in glacially scoured depressions by the receding water level of the ancient Great Lakes. Few herring lakes are found in the interior counties. In the tabulation of herring lakes (Table 1) the size varies between 20 and 18,770 acres. Of the 153 lakes, 23% are between 10 and 100 acres, 54% are between 100 and 1,000 acres, and 23% are larger than 1,000 acres in size. Using Humphrys et al. (1962) numbers for the size distribution of all Michigan lakes, only 2% are larger than 1,000 acres, 16% are between 100 and 1,000 acres, and 82% are between 10 and 100 acres. As might be expected, herring occur more frequently in the larger lakes. Of the 1,120 lakes in Michigan larger than 100 acres, about 10% are known to contain herring.

More than three-fourths of the lakes with herring are classified as hardwater (Table 1). Hooper (1956) used alkalinity to classify Michigan lakes as follows: 0-19 ppm calcium carbonate-very soft; 20-39 ppm-soft; 40-104 ppm-medium; and 105 and greater ppm-hard. For the herring lakes, 6% were very soft, 2% soft, 13% medium, and 79% hard. Schneider (1975) found 20% of the 1,620 Michigan lakes sampled were very soft, 8% soft, 25% medium and 47% hard.

Judging from Schneider's (1975) oxygen-thermal classification, more than half of the herring lakes can be considered oligotrophic with a large volume of cold, well oxygenated water. For the herring lakes in Table 1, 13% were oxygen-thermal type 1-- the coldest most oxygenated lakes, 42% were type 2, 32% type 3, 7% type 4, and 6% type 5. Type 4, the warmest,

and least oxygenated type of stratified lake, provides marginal habitat for lake herring. Type 5, the unstratified lakes, can also be marginal depending upon climatic variations.

Of the 153 lakes containing herring the population status was unknown in 51 or about 33%. For the remaining 102 lakes, 14 (14%) of the populations were believed to be extirpated and 8 (8%) declining. The lakes with extirpated populations, and the apparent reasons for extirpation, are given in Table 2. For those lakes where the apparent reason for extirpation could be identified, habitat deterioration (the disappearance of the cisco layer) was presumed in 6 lakes. In 4 lakes, it appears that predation or competition most likely from rainbow smelt *Osmerus mordax* in 3 lakes, or alewife *Alosa pseudoharengus* in 1 lake, caused the demise of the herring. One lake was treated with a fish toxicant by MDNR as part of a fish management plan, and in 3 lakes reasons for disappearance of herring could not be identified. There did not appear to be any relationship between herring extirpation and lake size, depth, or alkalinity, however, the oxygen-thermal classifications usually reinforced the judgments of habitat deterioration.

For those 8 lakes with declining populations, the reasons for the declines could not be identified in 6 lakes. In the remaining 2 lakes, the change in one was attributed to habitat deterioration and in the other to a combination of toxicant treatment and competition-predation.

Although trout have been stocked in many herring lakes as a common fishery management practice, in none of the lakes which have lost herring was loss attributed to trout stocked. Clady (1967) suspected a decline in the Birch Lake herring population was related to stocked rainbow trout *Oncorhynchus mykiss*, however, in an earlier study Leonard and Leonard (1949) concluded that trout were neither predators nor competitors of herring in Birch Lake. Both Christie (1974) and Crowder (1980) attributed the decline of lake herring in the Great Lakes to competition-predation of rainbow smelt. Rudstam (1984) speculated the decline of herring in Sparkling Lake, Wisconsin might be due to the introduction of smelt but also noted the establishment of walleye *Stizostedion vitreum*

and muskellunge *Esox masquinongy* populations in the lake. Alewife can also be detrimental to lake herring survival (Crowder 1980).

Management Implications

The lake herring in Michigan was extirpated in 14% of the inland lakes where it existed and declining in another 8%. Because of the lack of sampling and the difficulty of catching herring, these are undoubtedly minimal estimates. However, the multiple, isolated, inland lake populations are probably much more viable than the Great Lakes populations. In Michigan, the lake herring is classified as a threatened species. This classification would appear to be more applicable to the Great Lakes where, the herring is considered threatened in lakes Erie and Michigan, rare in Huron and abundant only in Superior (Todd and Smith 1992), than in inland populations. The most common cause of extirpation in inland lakes is eutrophication with loss of the cisco layer. Becker (1983) declared "the greatest challenge to the management of cisco populations in inland lakes is stopping or reversing the eutrophication process." The next greatest cause of extirpation is introduction of smelt or alewife into lakes which through competition and/or predation is detrimental to herring. Obviously, any lake with a herring population

should be protected from eutrophication and any proposed fish introductions. This species, because of its sensitivity to temperature and oxygen changes, is an excellent indicator of environment deterioration from eutrophication or climatic warming which could narrow the cisco layer.

Acknowledgments

I want to thank the following district fishery biologists of the Michigan Department of Natural Resources who provided me with names of lakes with lake herring populations and also reviewed my final list: Raymond P. Juetten, William B. Ziegler, Dell H. Siler, Steven J. Scott, Stephen C. Swan, Leo Mrozinski, Dave Smith, James P. Baker, Richard O'Neal, Gary L. Towns, Joan Duffy, and Elizabeth Hay-Chmielewski. In addition, Gerald R. Smith, Curator of Fishes, Museum of Zoology, University of Michigan provided a list of lakes with herring from the fish collection catalogue. I appreciate also the leads and lake names provided by other Michigan fish biologists knowledgeable about lake herring. The manuscript was reviewed by James C. Schneider and Reeve M. Bailey. Logistical support was provided by the Institute for Fisheries Research, Michigan Department of Natural Resources.



Figure 1.—Geographic distribution of lake herring in Michigan: number of lakes containing herring in each county is shown.

Table 1.—Lakes in Michigan which have (or had) a population of the lake herring with population status and lake description. Status: Stable = S, Declining = D, Extirpated = E.

County	Lake	Town	Range	Section	Capture year		Status	Lake description			
					First	Last		Area (acre)	Maximum depth (ft)	Oxygen-thermal ¹	Alkalinity (ppm)
Alger	AuTrain	46N	20W	many	1951	1989	S	830	30	5	120
	Deer	47N	27W	7,8,17,18	1953	1983	D	243	75	1	8
Allcgan	Green	4N	11W	2,3,10,11	1952	1990	S	309	69	2	149
Alpena	Beaver	29,30N	5E	2,11,35	1925	1987	S	665	77	3	150
Alcona	Hubbard	27,28N	7,8E	many	1925	1967	S	8,850	87	3	158
Antrim	Bellaire	29,30N	7,8W	many	1931	1987	S	1,775	95	1	160
	Elk	28,29N	8,9W	many	1888	1990	S	7,730	192	1	140
	Intermediate	30,31N	7,8W	many	1931	1986	S	1,515	82	2	157
	Torch	29,30,31N	8,9W	many	1888	1991	S	18,770	285	1	133
Barry	Big Cedar	2N	9W	34,35	1890	1959	S	82	35	—	188
	Little Cedar	2N	9W	26	1962	—	—	37	42	2	175
	Barlow	3N	10W	5,8	1951	1977	S	187	63	2	127
	Gull	1N, 1S	9,10W	many	1886	1954	E	2,030	110	2	116
	Long	1N	8W	10,15	1988	—	—	60	43	2	135
	Lime	2N	10W	16	1946	—	—	20	38	3	146
	Fish	2N	10W	16,21	1946	1973	S	165	56	2	165
Benzie	Lake Ann	27N	13W	22,23,26,27	1950	1992	S	527	75	2	151
	Crystal	26,27N	15,16W	many	1940	1989	S	9,711	162	1	106
Branch	Bartholomew	7S	5W	7	1948	—	—	75	56	3	174
	Coldwater	7S	6W	many	1886	1967	S	1,610	92	3	127
	Long	7S	6W	13,14,23,24	1886	1941	—	123	45	3	162
	Marble	6,7S	5W	many	1941	1986	S	780	60	3	148
Cass	Baldwin	8S	13W	9,16	1887	1990	S	266	55	3	164
	Birch	7S	13W	5,6,7,8	1887	1990	S	295	95	1	122
	Bunker	5S	14W	11,14	1949	—	—	107	58	3	—
	Curtis	7S	14W	21	1948	—	—	22	—	—	—
	Day	7S	14W	22	1948	—	—	23	25	—	—
	Donnell	6S	14W	35,36	1887	1947	E	246	63	3	149

Table 1.—Continued:

County	Lake	Town	Range	Section	Capture year		Status	Lake description			
					First	Last		Area (acre)	Maximum depth (ft)	Oxygen- thermal ¹	Alkalinity (ppm)
Cass	Harwood	6S	13W	24	1953	1990	S	122	55	2	171
	Long	8S	13W	9,10,15,16	1887	1950	S	241	44	3	222
	Shavehead	7S	13W	19	1887	1983	S	289	70	3	171
Charlevoix	Charlevoix	32,33,34N	6,7,8W	many	1926	1990	S	17,260	102	2	133
	Walloon	33,34N	5,6W	many	1890	1977	S	4,320	100	2	112
Cheboygan	Burt	35,36N	3W	many	1887	1975	S	16,700	73	2	133
	Douglas	37N	3W	many	1959	1977	S	3,395	84	2	126
	Mullett	35,36,37N	1,2W	many	1887	1989	S	16,630	147	1	138
	Twin Lakes - 2, 3, 4	36,37N	1E	2,3,34,35	1968	1992	S	201	73	2	155
Chippewa	Hulbert	45N	6,7W	1,2,6,7,12	1940	1953	S	557	74	1	85
	Monacle	47N	3W	11,14	1976	1981	D	146	55	2	13
Dickinson	Mary	39N	28,29W	19,24,25,30	1945	1986	S	86	83	2	162
	Louise	39N	28W	19,30	1950	1956	S	80	57	2	121
Gogebic	Clark	44N	40W	many	1966	1985	S	890	75	2	—
	Crooked	44,45N	40W	many	1938	1969	—	566	60	3	70
	Gogebic	46,47,48N	42,43W	many	1938	1992	S	12,800	37	5	25
	Loon	44N	40W	15,22	1966	1983	S	375	55	—	Trace
	Norwood	43N	38W	23,24	1961	—	—	120	60	1	4
	Taylor	44,45N	38W	3,34	1960	1972	S	110	39	2	13
	Thousand Island	44N	41W	many	1969	1975	S	1,079	81	2	50
Grand Traverse	Bridge	26N	12W	20	1950	—	—	32	39	3	110
	Cedar Hedge	26N	12W	4,5,8,9	1967	1977	S	155	69	3	92
Grand Traverse	Duck	26N	12W	many	1950	1991	S	1,930	98	1	126
	Green	25,26N	12W	many	1947	1989	S	1,987	102	2	133
Hillsdale	Bear	7S	3W	8	1945	—	—	117	53	4	150
	Carpenter	7S	4W	5	1886	1994	—	34	70	3	132
	Hemlock	6,7S	4W	4,5,32	1886	1985	S	146	65	2	137
	Long	7S	4W	5,8,17	1886	1976	—	213	45	3	171

Table 1.—Continued:

County	Lake	Town	Range	Section	Capture year			Lake description			
					First	Last	Status	Area	Maximum depth	Oxygen-thermal ¹	Alkalinity
					(acre)	(ft)	(ppm)				
Hillsdale	Middle Sand	6S	3W	19,30	1886	1927	—	65	38	—	—
	North Sand	6S	3W	18,19	1992	—	—	65	40	—	—
	South Sand	6S	3W	30,31	1886	—	—	80	32	—	—
	Wilson	7S	3W	5,8	1963	—	—	92	60	2	139
Houghton	Otter	52N	34W	many	1925	1970	D	890	29	1	56
	Portage	53,54,55N	32,33,34W	many	1930	1988	—	9,641	54	—	—
	Torch	55N	32,33W	many	1971	1988	S	2,750	123	1	—
Iosco	Loon	23N	5E	3,4,9,10	1931	1981	S	417	128	2	109
Iron	Smoky	43N	37W	21,28,32,33	1938	1987	S	558	68	3	16
Isabella	Coldwater	15N	5W	29,30,31	1952	1966	E	294	65	3	180
	Littlefield	16N	5W	17,18,20	1950	1960	E	550	62	2	168
Jackson	Brown's	3S	1W	21,22,27,28	1889	1988	S	210	35	3	161
	Swain's	4S	3W	3,4	1889	1940	E	70	64	2	125
	Vandercook	3S	1W	22,23,26,27	1889	1988	S	144	42	3	239
Kalamazoo	Howard	4S	11W	33,34	1962	1991	S	109	46	—	134
	Indian	3,4S	10W	many	1888	1965	S	758	69	3	129
	Little Paw Paw	3,4S	12W	5,6,31,32	1943	1969	D	126	56	3	171
Kalkaska	Big Blue	28N	5W	22	1930	1992	S	114	86	2	137
	Big Twin	28N	5,6W	13,18	1930	1993	S	215	90	2	95
	North Blue	28N	5W	22	1930	1955	S	55	78	2	147
Kent	Murray	7,8N	9W	4,33,34	1927	1990	S	320	72	3	139
	Ziegenfuss	9N	9W	11,14	1891	1971	S	80	40	2	—
Keweenaw	Desor	64N	37W	1,2,3,4	1929	—	—	1,050	55	—	—
	Fanny Hooe	59N	28W	32,33,34	1926	1952	E	235	48	3	47
	Richie	65N	35W	1,11,12,13	1929	—	—	520	37	—	—
	Sargent	66N	34W	many	1929	—	—	368	45	—	—
	Siskiwit	64N	35W	many	1929	—	—	4,560	142	—	—

Table 1.—Continued:

County	Lake	Town	Range	Section	Capture year		Status	Lake description			
					First	Last		Area (acre)	Maximum depth (ft)	Oxygen-thermal ¹	Alkalinity (ppm)
Lake	Little Bass	20N	14W	27,34	1953	—	—	54	45	3	120
Leelanau	Big Glen	28,29N	14W	many	1949	1979	S	4,865	130	1	135
	Little Traverse	29N	13W	10,11,12,13,14,15	1970	—	—	640	54	2	136
	North Lake Leelanau	30,31N	12W	many	1949	1988	S	2,950	121	1	145
	South Lake Leelanau	29N	12W	many	1967	1988	S	5,370	62	2	149
Livingston	Appleton	1N	5E	2	1956	1991	D	55	38	3	155
	Bass	1N	5E	21,28	1952	1977	—	184	73	2	179
	Bennett	4N	5E	1,2	1968	1979	—	133	58	4	239
	Chemung	2N	5E	many	1942	1956	E	313	70	4	123
	Crooked	1N	6E	22	1943	1970	S	38	53	3	227
	Fish	1N	6E	27	1972	—	—	32	44	2	125
	Limekiln	1N	6E	26,27	1970	—	—	26	35	—	—
	Ore	1N	5E	12,13,18	1890	1953	E	234	81	4	—
	Portage	1N,1S	4,5E	many	1880	1967	S	644	84	4	168
	Runyan	4N	6E	9,10	1979	—	—	200	55	2	110
	Sandy Bottom	1N	6E	27	1970	—	—	53	42	—	—
	Zukey	1N	5E	21,22,27,28	1985	—	—	155	44	4	222
Luce	North Manistique	45N	11,12W	many	1926	1989	S	54	45	3	120
Mackinac	Brevoort	41,42N	5W	many	1979	1986	S	4,230	30	5	78
	Big Manistique	44,45N	11,12W	many	1936	1987	S	10,130	20	5	87
	South Manistique	43,44N	11,12W	many	1926	1988	S	4,001	29	5	85
Manistee	Pine	21N	14W	21,22,27,28	1932	1989	S	159	58	2	107
	Portage	23N	16W	many	1948	1976	S	2,110	60	2	120
Marquette	First Pine	51,52N	28W	28	1927	—	—	—	—	—	—
	Independence	51N	27W	many	1953	1988	S	1,986	32	5	44
	Ives	51N	28W	4	1927	—	—	—	—	—	—
	Lake Ann	52N	29W	25	1927	—	—	—	—	—	—
	Mountain	51,52N	28W	31	1927	—	—	—	—	—	—

Table 1.—Continued:

County	Lake	Town	Range	Section	Capture year			Lake description			
					First	Last	Status	Area (acre)	Maximum depth (ft)	Oxygen- thermal ¹	Alkalinity (ppm)
Marquette	Rush	52N	28,29W	19,24	1927	—	—	—	—	—	—
	Silver Lake Basin	49N	28W	many	1954	1987	S	1,000	70	1	8
Montmorency	Sporley	45,46N	24W	5,31,32	1941	1955	E	76	41	2	19
	Lake Avalon	31N	4E	4,5,8,9	1939	1990	D	372	74	2	118
	Long	31,32N	4E	5,29,32	1955	1990	S	296	82	2	140
Newaygo	Muskellunge	31N	2E	4	1952	—	—	113	46	3	151
	Nichols	15,16N	13W	5,6,31,32	1926	1937	—	158	57	2	124
Oakland	Pickerel	12N	12,13W	1,12,6	1952	1984	S	318	73	2	117
	Lake Angelus	3N	9,10E	many	1890	1952	S	413	92	2	120
	Cass	2,3N	9E	many	1890	1992	S	1,280	120	2	179
	Cedar Island	3N	8E	26,27,34,35	1971	1994	—	144	72	2	188
	Commerce	2N	8E	10,15,16	1890	1968	—	288	66	3	151
	Deer	4N	9E	19,20,29,30	1890	1989	S	137	63	2	154
	Dunham	3N	7E	18	1890	1976	S	110	125	2	—
	Green	2N	9E	8	1961	1970	S	165	72	2	109
	Hammond	2N	9,10E	1,6	1957	—	—	75	112	2	82
	Loon	3N	9E	11	1944	1972	S	243	73	3	188
	Maceday	3,4N	9E	many	1890	1991	S	220	110	1	158
	Orchard	2N	9E	10,11,14,15	1890	1976	S	788	111	3	93
	Oxbow	3N	8E	22,23,26,27	1970	—	—	269	72	3	—
	Schoolhouse	3N	9E	11,12	1950	—	—	37	49	2	137
	Townsend	4N	9E	33	1951	—	—	26	55	2	191
Ogemaw	Union	2N	8,9E	1,5,6	1930	1973	S	465	110	3	102
	Upper Pettibone	3N	7E	10,15	1945	—	—	42	55	2	161
Roscommon	Devoe	23N	3E	11,12	1931	1946	E	130	53	3	164
	Grousehaven	23N	3E	1	1931	1946	E	88	55	3	127
Schoolcraft	Higgins	24N	3,4W	many	1887	1987	S	9,440	141	1	102
	Gulliver	41,42N	14W	many	1940	1983	S	836	26	5	93

Table 1.—Continued:

County	Lake	Town	Range	Section	Capture year		Status	Lake description			
					First	Last		Area (acre)	Maximum depth (ft)	Oxygen-thermal ¹	Alkalinity (ppm)
Schoolcraft	Indian	41,42N	16,17W	many	1937	1988	S	8,000	15	5	74
St. Joseph	Corey	6S	12W	many	1887	1966	D	630	80	4	105
	Klinger	7,8S	11W	1,2,35,36	1887	1983	S	830	72	1	110
	Middle (Tamarack)	7S	10W	31	1957	—	—	75	48	2	179
	Pleasant	6S	12W	9,10,16	1887	1985	—	262	40	3	127
	Thompson	7S	10W	28,29,32,33	1887	—	—	153	30	3	185
Van Buren	Wolf	2S	13W	13,14	1927	1945	E	26	37	2	188
Washtenaw	Baseline	1N,1S	5E	5,6,31,32	1890	1943	E	254	64	4	205
	Blind	1S	3E	1	1946	1985	S	68	80	2	171
	Bruin	1S	3E	1,2	1954	1971	—	123	48	3	105
	Halfmoon	1S	3,4E	1,6	1942	1983	E	236	82	4	—
	Pickrel	1S	4E	8	1948	1982	D	24	56	3	—
	South	1S	3E	10,15,16	1973	1987	S	816	83	2	—

¹Schneider (1975) classification

Table 2.—Lakes in Michigan in which the lake herring population has been extirpated with presumed reason(s) for demise. Lake characteristics, in order, are size of lake in acres, maximum depth in feet, oxygen-thermal classification, and alkalinity in parts per million.

County	Lake	Town	Range	Section	Lake characteristics	Reason(s) for extirpation
Isabella	Littlefield	16N	5W	17,18,20	550 acres 62 ft. 2 168 ppm	Presumed extirpated per L. E. Mrozinski, 1979, MDNR lake survey files. Rainbow smelt planted by local residents in 1950s became well established. Competition or predation may have been cause.
Livingston	Chemung	2N	5E	many	313 acres 70 ft. 4 123 ppm	Loss of oxygen in thermocline reported in 1960s-70s. Probably lake herring habitat deterioration.
Livingston	Ore	1N	5E	12,13,18	234 acres 81 ft. 4 —	Classified eutrophic in Schaedel (1978) regional water quality report. Probably herring habitat deterioration.
Marquette	Sporley	45,46N	24W	5,31,32	76 acres 41 ft. 2 19 ppm	Treated with fish toxicant in 1955 to create habitat free of competition for trout.
Ogemaw	Devoe	23N	3E	11,12	130 acres 3 164 ppm	Apparently smelt and alewife introduced into lake. Competition or predation may have been cause.
Ogemaw	Grousehaven	23N	3E	1	88 acres 3 127 ppm	Apparently alewife introduced into lake. Competition or predation may have been cause.
Barry	Gull	1N,1S	9,10W	many	2,030 acres 110 ft. 2 116 ppm	Presumed extirpated per J. L. Dexter, Jr., in 1991 lake status report, MDNR. Numerous species of salmonids and smelt stocked in lake. Competition or predation may have been cause.

Table 2.—Continued:

County	Lake	Town	Range	Section	Lake characteristics	Reason(s) for extirpation
Cass	Donnell	6S	14W	35,36	246 acres 63 ft. 3 149 ppm	Reported present in 1887 and 1947. Listed as herring lake by MDNR, 1944. None taken in extensive netting with gill nets in 1956. Reason unknown.
Isabella	Coldwater	15N	5W	29,30,31	294 acres 65 ft. 3 180 ppm	District fishery biologist, MDNR, noted in 1953 lack of oxygen in thermocline. Probably herring habitat deterioration.
Jackson	Swain's	4S	3W	3,4	70 acres 64 ft. 2 125 ppm	Presumed extirpated per G. L. Towns, in 1991 unpublished lake status report, MDNR. Last seen (one individual) in 1940. Reason unknown.
Keweenaw	Fanny Hooe	59N	28W	32,33,34	235 acres 48 ft. 3 47 ppm	Last seen in 1952 (two individuals in gill net). Lake treated with fish toxicant in 1963. No herring found in sample of dead fish. Reason unknown.
Van Buren	Wolf	2S	13W	13,14	26 acres 37 ft. 2 188 ppm	Received outfall from Wolf Lake Fish Hatchery, MDNR, which contributed eutrophication and other fishes. Cause may have been competition, predation or habitat deterioration.
Washtenaw	Baseline	1N,1S	5E	5,6,31,32	254 acres 64 ft. 4 205 ppm	Regional agency reported water quality problems (Schaedel 1978). Repeated fish kills. Probably herring habitat deterioration.
Washtenaw	Halfmoon	1S	3,4,E	1,6,	236 acres 82 ft. 4 —	Presumed extirpated per M. P. Herman in 1992 lakes status report, MDNR. Die-off investigated in 1968 (Colby and Brooke 1969). Probably herring habitat deterioration.

Literature Cited

- Bailey, R.M., and G.R. Smith. 1991. Names of Michigan fishes. Michigan Department of Natural Resources, Fisheries Division pamphlet, Lansing.
- Becker, G.C. 1983. Fishes of Wisconsin. The University of Wisconsin Press, Madison.
- Christie, W.J. 1974. Changes in fish species composition of the Great Lakes. Journal Fisheries Research Board of Canada 31:827-854.
- Clady, M.D. 1967. Changes in an exploited population of the cisco, *Coregonus artedii*, LeSueur. Papers Michigan Academy of Science, Arts, and Letters 52:85-99.
- Colby, P.J., and L.T. Brooke. 1969. Cisco (*Coregonus artedii*) mortalities in a southern Michigan lake, July 1968. Limnology and Oceanography 14:958-960.
- Crowder, L.B. 1980. Alewife, rainbow smelt and native fishes in Lake Michigan: competition or predation? Environmental Biology of Fishes 5:225-233.
- Dexter, J.L. 1991. Gull Lake, Barry County (T1N, R9W, Sec. 31, 36), Kalamazoo County (T1N, R9-10W, Sec. 6, 7, 8, 17, 18, 20, 1, 2, 12). Michigan Department of Natural Resources, Status of Fishery Resource Report 91-4, Lansing.
- Dorr, J.A., Jr. and D.F. Eschman. 1970. Geology of Michigan. The University of Michigan Press, Ann Arbor.
- Fleischer, G.W. 1992. Status of coregonine fishes in the Laurentian Great Lakes. Polish Archives Hydrobiology 39:247-259.
- Frey, D.G. 1955. Distributional ecology of the cisco, *Coregonus artedii*, in Indiana. Investigations of Indiana Lakes and Streams 4:177-228.
- Herman, M.P. 1992. Halfmoon Lake, Washtenaw County (T1S, R3E, Sec. 1,6) Surveyed May, 1991. Michigan Department of Natural Resources, Status of the Fishery Resource Report 92-9, Lansing.
- Hooper, F.F. 1956. Some chemical and morphometric characteristics of southern Michigan lakes. Papers Michigan Academy Science, Arts, and Letters 41:109-130.
- Humphrys, C.R., J. Tsolakides, J.A. Donnan and J. Colby. 1962. Selected data from lake inventory bulletins 1-83. Michigan State University, Department of Resource Development, Water Bulletin 16, East Lansing.
- Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina Biological Survey 1980-12, Raleigh.
- Leonard, J.W., and F.A. Leonard. 1949. An analysis of the feeding habits of rainbow trout and lake trout in Birch Lake, Cass County, Michigan. Transactions American Fisheries Society 76:301-314.
- McLain, A.S., and J.J. Magnuson. 1988. Analysis of recent declines in cisco (*Coregonus artedii*) populations in several northern Wisconsin lakes. Finnish Fisheries Research 9:155-164.
- Rudstam, L.G. 1984. Long term comparison of the population structure of the cisco (*Coregonus artedii* LeSueur) in smaller lakes. Wisconsin Academy of Science, Arts and Letters 72:185-200.
- Schaedel, A.L. 1978. Water quality in southeast Michigan: inland lakes. Southeast Michigan Council of Governments, Environmental Background Paper Number 33e, Detroit.

Schneider, J.C. 1975. Typology and fisheries potential of Michigan lakes. Michigan Academician 8:59-84.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Bulletin 184, Ottawa, Ontario.

Todd, T.N. and G.R. Smith. 1992. A review of differentiation in Great Lakes ciscoes. Polish Archives Hydrobiology 39:261-267.

Report approved by Paul W. Seelbach
James S. Diana, Editor
James C. Schneider, Editorial Board Reviewer
Alan D. Sutton, Graphics
Marlene D. Reynolds and Barbara A. Diana, Word Processing
Kathryn L. Champagne, DTP