FISHERIES DIVISION
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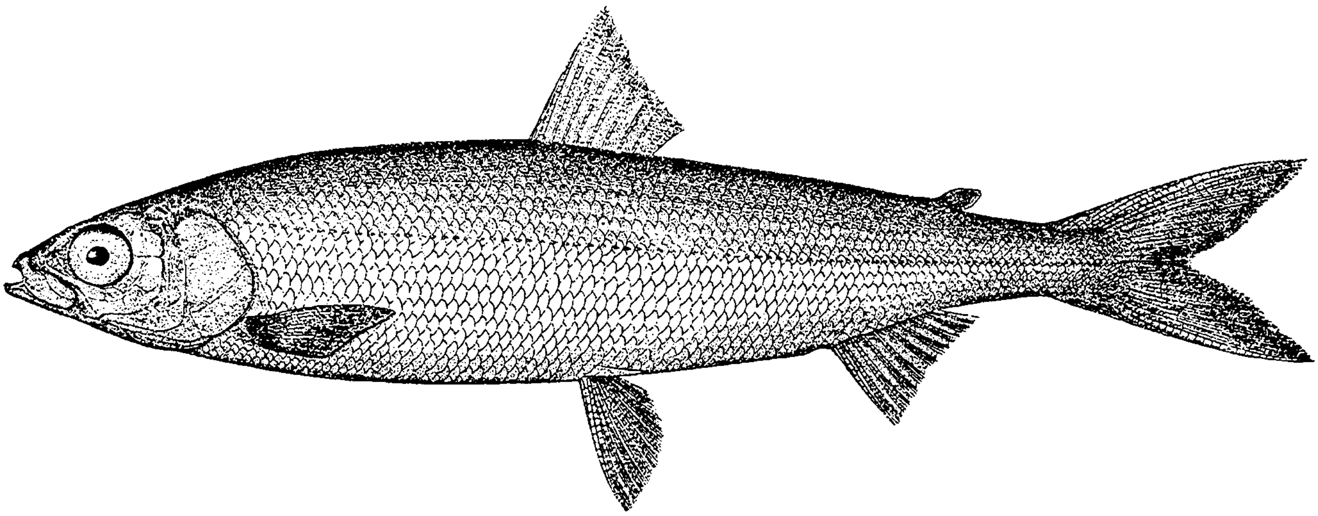

THE CISCO OR LAKE HERRING.
Coregonus Artedi, Lesueur.
Drawing by H. L. Todd, from No. 33958, U. S. National Museum, collected at Nearfield Bay, Wisconsin, by J. W. Milner.

DNR

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


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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.

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*Michigan Department of Natural Resources*
*Fisheries Research Report No. 2014, 1995*

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

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*Abstract.*—Lake herring *Coregonus artedi* 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 artedi* 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

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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 |
| Allegan | 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 First | Capture year Last | Status | Lake description: 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 First | Capture year Last | Status | Lake description: Area (acre) | Maximum depth (ft) | Oxygen-thermal[1] | Alkalinity (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 First | Capture year Last | Status | Lake description: 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 | | Status | Lake description | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | First | Last | | 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 |
| | Sporley | 45,46N | 24W | 5,31,32 | 1941 | 1955 | E | 76 | 41 | 2 | 19 |
| Montmorency | 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 |
| | Muskellunge | 31N | 2E | 4 | 1952 | — | — | 113 | 46 | 3 | 151 |
| Newaygo | Nichols | 15,16N | 13W | 5,6,31,32 | 1926 | 1937 | — | 158 | 57 | 2 | 124 |
| | Pickerel | 12N | 12,13W | 1,12,6 | 1952 | 1984 | S | 318 | 73 | 2 | 117 |
| Oakland | 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 |
| | 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 |
| Ogemaw | Devoe | 23N | 3E | 11,12 | 1931 | 1946 | E | 130 | 53 | 3 | 164 |
| | Grousehaven | 23N | 3E | 1 | 1931 | 1946 | E | 88 | 55 | 3 | 127 |
| Roscommon | Higgins | 24N | 3,4W | many | 1887 | 1987 | S | 9,440 | 141 | 1 | 102 |
| Schoolcraft | 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 | — |
| | Pickerel | 1S | 4E | 8 | 1948 | 1982 | D | 24 | 56 | 3 | — |
| | South | 1S | 3E | 10,15,16 | 1973 | 1987 | S | 816 | 83 | 2 | — |

[1]Schneider (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<br>62 ft.<br>2<br>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<br>70 ft.<br>4<br>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<br>81 ft.<br>4<br>— | Classified eutrophic in Schaedel (1978) regional water quality report. Probably herring habitat deterioration. |
| Marquette | Sporley | 45,46N | 24W | 5,31,32 | 76 acres<br>41 ft.<br>2<br>19 ppm | Treated with fish toxicant in 1955 to create habitat free of competition for trout. |
| Ogemaw | Devoe | 23N | 3E | 11,12 | 130 acres<br>3<br>164 ppm | Apparently smelt and alewife introduced into lake. Competition or predation may have been cause. |
| Ogemaw | Grousehaven | 23N | 3E | 1 | 88 acres<br>3<br>127 ppm | Apparently alewife introduced into lake. Competition or predation may have been cause. |
| Barry | Gull | 1N,1S | 9,10W | many | 2,030 acres<br>110 ft.<br>2<br>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<br>63 ft.<br>3<br>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<br>65 ft.<br>3<br>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<br>64 ft.<br>2<br>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<br>48 ft.<br>3<br>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<br>37 ft.<br>2<br>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<br>64 ft.<br>4<br>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<br>82 ft.<br>4<br>— | 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. |

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