PRESETTLEMENT FISH COMMUNITIES OF IOWA'S NATURAL (GLACIAL) LAKES

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INTRODUCTION

In 2019, I received a grant from the Iowa DNR's Wildlife Diversity Program to identify the presettlement fish communities of Iowa's natural lakes of glacial origin (glacial lakes).[1] The final report was submitted to Iowa DNR in April 2020. The purpose of the project was to provide information to allow the Iowa DNR Fisheries Bureau to create a more species-rich and ecologically stable fish community following lake restoration projects at Iowa's shallow glacial lakes. Iowa DNR's program for restoring shallow glacial lakes has historically used a low diversity stocking approach that was limited to popular game fish such as Northern Pike *Esox lucius* and Yellow Perch *Perca flavescens*. Iowa DNR biologists suspect that this approach has resulted in a low return in terms of angling success and has contributed to poor water quality conditions due to eventual and relatively rapid overabundance of non-desirable fish species such as Common Carp *Cyprinus carpio* and bullheads *Ameiurus* spp. With better knowledge of the species that comprised the presettlement fish communities of Iowa's glacial lakes, Iowa DNR could implement a high diversity stocking approach for restored natural lakes.

Despite the long history of fisheries work in the state, a summary of Iowa's presettlement lake fish species had not been attempted, possibly because truly pre-settlement fish data for Iowa lakes do not exist. The earliest systematic fish surveys on northern Iowa's glacial lakes were conducted in the early 1890s, about 40 years after European settlement of these areas (Schwieder 1990).[2] Thus, my attempt to describe the pre-settlement fish community of Iowa's glacial lakes defaulted to characterizing the historical fish community that existed in Iowa's glacial lakes while filtering-out species whose presence was likely due to intentional introductions.

[1] Iowa Department of Natural Resources Wildlife Diversity Program Small Project Grant #19CRDWBKKINK-0103.

[2] Although European settlement of Iowa was well underway in the 1830s, northwest Iowa, where many of Iowa's natural (glacial) lakes occur, was the last portion of the state to be settled (Schwieder 1990).

Photos by the author unless otherwise indicated.

John Olson retired from the Iowa DNR, where he worked for 30 years in the Water Quality Assessment Section, in 2017. He has been involved with stream fish survey work in Iowa since attending Iowa State University, where he participated in a statewide survey of Iowa fishes from 1981–84. He has a degree in Animal Ecology from Iowa State with an emphasis in fisheries biology. He assisted with fish surveys while at Iowa DNR, and he continues to pursue his interest in Iowa (and, occasionally, Minnesota) fishes in retirement.

My review of the literature revealed several studies that compared late 19th or early 20th century lake fish communities to later 20th century communities (e.g., Clady 1976; Lyons 1989; Pierce et al. 2001). In general, these studies used historical fish community data as a baseline to evaluate changes, for example, in lake littoral zone fish communities over time. My review of the literature, however, did not reveal an attempt to identify presettlement fish communities for a lake or group of lakes.

METHODS

My approach for determining which fish species occurred in Iowa's natural lakes prior to European settlement of the state was primarily historical. Fish survey data and reports from 1890 to 1947 for 32 lakes of glacial origin in northern Iowa and southwestern Minnesota were considered "historical." I used the following factors to determine which species were likely part of the presettlement fish communities of these lakes: (1) the frequency of occurrence of species in the 10 of the 32 lakes (four in southwest Minnesota and six in Iowa) that had pre-1900 fish survey data, (2) the likelihood that either 19th century Mississippi River fish rescue (transplanting) operations or early fish culture activities in the state of Iowa could explain the pre-1900 occurrence of a species in the lakes, and (3) whether the species is considered native or introduced to the portion of the state where Iowa's natural (glacial) lakes occur.

HISTORICAL FISH SURVEYS OF IOWA'S GLACIAL LAKES

The oldest fish data for Iowa's natural lakes comes from Seth Eugene Meek who, while a professor at Coe College in Cedar Rapids, Iowa, in the late 1880s and early 1890s, conducted extensive fish surveys in Iowa under the auspices of the US Fish Commission (USFC). Meek sampled a variety of fish habitats in Iowa, including streams, rivers, glacial lakes, and river bayous. His summaries of these surveys (Meek 1892, 1894) provide the historical baseline fish survey information for the state. A contemporary of Meek's, Ulysses Orange Cox, conducted a survey of lakes in southern Minnesota in the mid-1890s (Cox 1896). Similar to Meek's work in Iowa, Cox's work in Minnesota was directed by the USFC.

There was relatively little fish survey activity in Iowa in the approximately 30 years following the work of Meek in the early 1890s. The first 20th century fish survey of Iowa's natural lakes was conducted by Austin P. Larrabee of the University of Iowa. He surveyed the lakes of the Okoboji lakes region in Dickinson County in northwest Iowa during summers of 1921, 1922, 1924, and 1925 (Larrabee 1926). Next, as part of the development of Iowa's 25-year conservation plan (Crane and Olcott 1933), an exten-

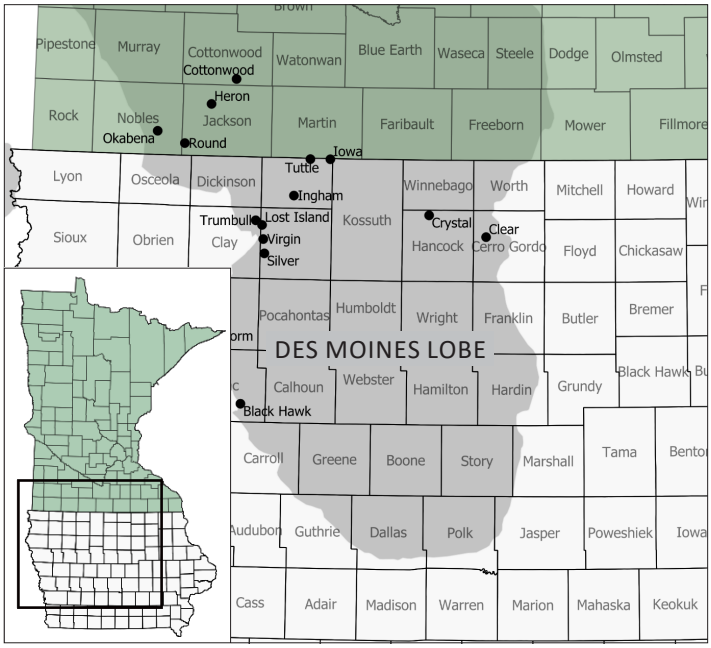

Figure 1. The portions of southern Minnesota and northern Iowa covered by the Des Moines Lobe of the Wisconsinan Glacier that was present in the area from approximately 12,000 to 30,000 year before present. The locations of the glacial lakes with historical data (1890–1947) for fish communities are indicated for all counties except Dickinson County, Iowa (see Figure 2).

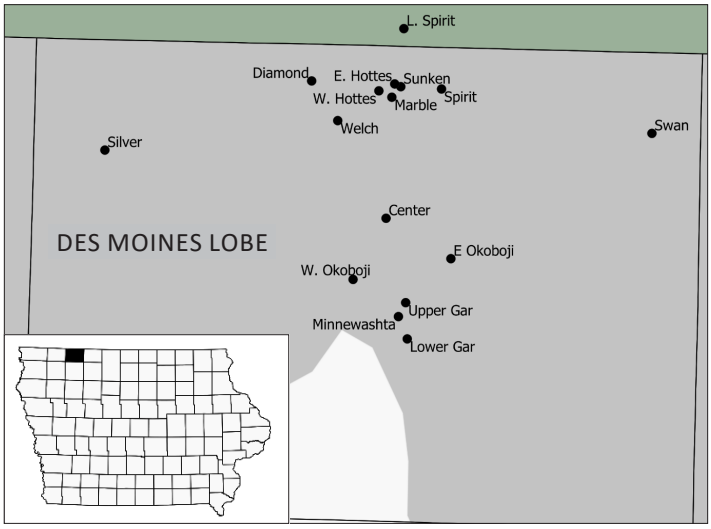

Figure 2. The portions of Dickinson County, Iowa, covered by the Des Moines Lobe of the Wisconsinan Glacier and locations of the glacial lakes with historical (1890–1950) data for fish communities. Spirit, East Okoboji, and West Okoboji lakes are the largest in what is known as the Iowa Great Lakes region.

sive fish survey of Iowa lakes and streams, mostly in the northern half of Iowa, was conducted in 1932 by renowned ichthyologist and then curator of fishes at the University of Michigan Museum of Zoology, Carl L. Hubbs, and his assistant, J. Clark Salyer. Although their work in Iowa remains unpublished, a set of typed field notes exists for the approximately 65 fish collections they made on Iowa streams and lakes in the summer of 1932, including at 19 of Iowa's natural lakes (Salyer 1932). About 10 years later in 1941, Raymond E. Johnson, then a student of Hubbs at Michigan, conducted a fish survey of the fish fauna in the lakes of the Okoboji Lakes region in Dickinson County. Similar to the work in Iowa in 1932 by Hubbs and Salyer, Johnson's work was never published, but a set of typed field notes survives (Johnson 1941). The catalog of Iowa State University's Collection of Fishes was reviewed for additional information on fishes of Iowa's glacial lakes.

For purposes of characterizing Iowa's presettlement fish communities, the historical fish data for Iowa's glacial lakes was divided into pre-1900 and post-1900 periods. The pre-1900 period includes fish survey data from ten glacial lakes: six lakes in northern Iowa that were surveyed by Meek (1892, 1894), and four lakes in southwestern Minnesota that were surveyed by Cox (1896) (Table 1). For several reasons, the sampling history, location, and physical setting of four lakes of glacial origin in southwest Minnesota made them appropriate for identifying native fish species of Iowa lakes: (1) their proximity to Iowa's glacial lakes (Figure 1); (2) they are in river basins that drain from Minnesota to Iowa (Little Sioux River and Des Moines River basins) and in the same river basins as the majority of the pre-1900 Iowa lakes; (3) they are in the same Level IV ecoregion (Des Moines Lobe-47b) as the Iowa lakes; and (4) their physical characteristics (e.g., surface areas and mean depths) are within the range of the Iowa glacial lakes (Table 1).

The post-1900 period includes fish data from the 28 glacial lakes in Iowa that were sampled, in part, by Larrabee (1926), Salyer (1932), Johnson (1941), and records for which preserved specimens exist up through 1947 in the fish collection of Iowa State University. The physical characteristics of all 32 glacial lakes with fish data for the years 1890 to 1947 are summarized in Figure 3. The year 1900 was chosen as a break point for the historical data due to (1) the increasing spread of Common Carp (introduced in the early 1880s) across the state after 1900 and (2) the acceleration of fish plantings that began in the mid-1870s as part of Iowa's Mississippi River fish rescue program (Carlander 1954). The upper boundary of the historical period was set just before 1950 (1947) in an attempt to avoid the post-1950 advent of boat electrofishing and to thus keep sample gear type similar (i.e., seines) over the entire 1890 to 1947 historical period.

Lacking any truly pre-settlement information, the pre-1900 lake dataset was the best available for identifying candidate species for the characterizing the presettlement fish community of Iowa's glacial lakes. The post-1900 lake dataset was used to determine the frequencies of occurrence of species found in the pre-1900 period in the post-1900 period. A comparison of the two datasets was used to identify fish species common in glacial lakes in the post-1900 period but that were not reported in the pre-1900 period. All candidate species for the presettlement fish communities of Iowa's glacial lakes come from the species found in the six lakes in northern Iowa sampled by Meek (1892, 1984) and the four lakes in southwestern Minnesota sampled by Cox (1896).

CONFOUNDING FACTORS

Even by 1890, human-caused impacts to Iowa's glacial lakes existed. Agricultural development of the landscape was well un-

Table 1. Physical characteristics of the 10 glacial lakes with pre-1900 data on fish communities from northern Iowa (Meek 1892, 1894) and southwestern Minnesota (Cox 1896).

Lake Name*	County	State	Major River Drainage	River Basin	Surface Area (acres)	Max. Depth (feet)	Mean Depth (feet)
Clear[C]	Cerro Gordo	Iowa	Upper Mississippi	Iowa-Cedar	3,664	18.1	10.1
Cottonwood[B]	Cottonwood	Minnesota	Upper Mississippi	Des Moines	155	10	8
East Okoboji[A]	Dickinson	Iowa	Missouri	Little Sioux	1,835	22	10
Heron[B]	Jackson	Minnesota	Upper Mississippi	Des Moines	2,641	5	3
Okabena[B]	Nobles	Minnesota	Missouri	Little Sioux	776	16	8
Round[B]	Jackson	Minnesota	Missouri	Little Sioux	930	9	8
Silver[C]	Dickinson	Iowa	Missouri	Little Sioux	1,066	9.8	6.5
Spirit[C]	Dickinson	Iowa	Missouri	Little Sioux	5,366	22.5	15.9
Storm[A]	Buena Vista	Iowa	Upper Mississippi	Des Moines	3,097	13	8
West Okoboji[C]	Dickinson	Iowa	Missouri	Little Sioux	3,900	138.9	36.6

*Sources/references for measurements of surface area, maximum depth, and mean depth:
[A]Bachmann et al. 1980
[B]Minnesota DNR, Lake Finder (https://www.dnr.state.mn.us/lakefind/index.html)
[C]Iowa DNR lake mapping: 2008, 2009, 2015, 2019; available online at "Iowa DNR, Where to Fish"

Table 2. Depth categories used to summarize percent occurrences of fish species from the 32 glacial lakes in northern Iowa and southwestern Minnesota with historical (1890–1947) fish data.

Depth Category	Mean Depth	No. of Lakes
Shallow	< 5 feet	13
Mid-depth	5 to 10 feet	12
Deep	> 10 feet	7

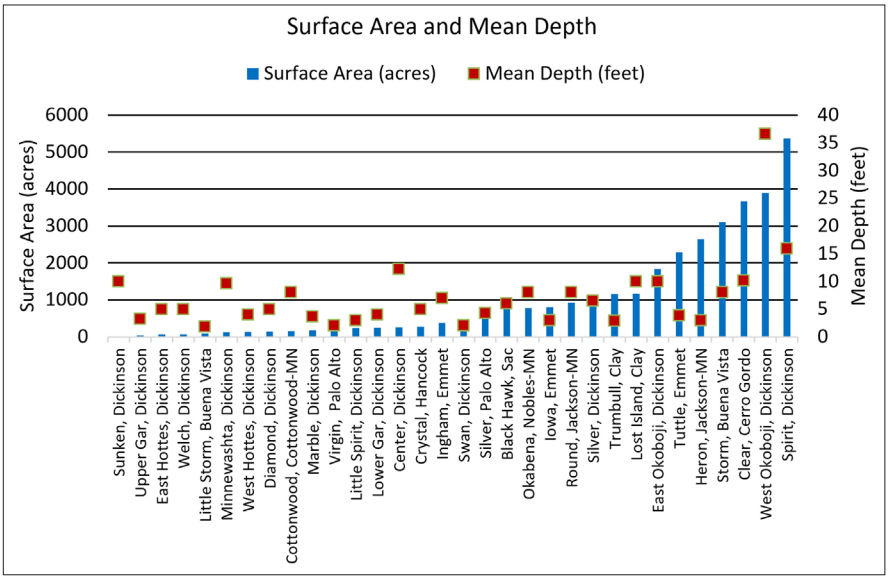

Figure 3. Surface areas and mean depths of the 32 glacial lakes in northern Iowa and southwestern Minnesota with historical data from 1890–1947 for fish communities. X-axis labels: lake name, Iowa county name, and (for Minnesota lakes) state abbreviation.

derway, and the Common Carp, which had been intentionally introduced into state waters in the early 1880s (Bernstein and Olson 2001), was spreading rapidly and was beginning to be perceived as the invasive species that it turned out to be (Lincoln 1902). Fortunately, the arrival of Common Carp in Iowa's glacial lakes seems to have been delayed somewhat, possibly until after 1900 (based on information in Larrabee 1926), thus possibly delaying significant carp-related alterations to Iowa's pre-settlement fish communities. Once established, however, the ability of this prolific, fast growing, and large species to directly (through feeding) or indirectly (through increased turbidity) suppress growth of aquatic macrophytes profoundly altered and degraded the aquatic habitats of Iowa's shallow glacial lakes.

The 32 lakes in this dataset (28 in Iowa and 4 in Minnesota) have a wide range of physical characteristics. Surface areas range from 15 to over 5,300 acres, and mean depths range from 1.8 feet to over 36 feet (Figure 3). Physical characteristics, especially mean depth, influence lake water quality, aquatic habitat, and overall ecological stability and, through these factors, influence the composition of the fish community. Due to the importance of mean depth, presettlement lake fish communities were approximated for three mean depth categories in the 32 lakes: shallow (mean depths less than 5 feet), middle depth (mean depths from 5 to 10 feet), and deep (mean depths greater than 10 feet) (Table 2). In the context of Iowa and Minnesota lakes with fish data over the 1890–1947 period, these groupings provide at least an approximation of whether the fish species were typical of Iowa's shallow, middle-depth, and/or deep glacial lakes. Choosing a mean depth to separate the shallow,

Table 3. Fish species collected by Meek (1892, 1894) and Cox (1896) from the 10 glacial lakes in northern Iowa and southwestern Minnesota sampled prior to 1900.

Rank	Common Name	Family	Scientific Name	No. of the 10 lakes found:
1	Yellow Perch	Percidae	*Perca flavescens*	10
2	Northern Pike	Esocidae	*Esox lucius*	8
3	Golden Shiner	Leuciscidae	*Notemigonus crysoleucas*	7
4	Banded Killifish	Fundulidae	*Fundulus diaphanus*	7
5	Black Bullhead	Ictaluridae	*Ameiurus melas*	7
6	Walleye	Percidae	*Sander vitreus*	5
7	Spottail Shiner	Leuciscidae	*Notropis hudsonius*	5
8	Fathead Minnow	Leuciscidae	*Pimephales promelas*	5
9	Iowa Darter	Percidae	*Etheostoma exile*	4
10	Johnny Darter	Percidae	*Etheostoma nigrum*	4
11	Blacknose Shiner	Leuciscidae	*Notropis heterolepis*	4
12	Bluegill	Centrarchidae	*Lepomis macrochirus*	3
13	Black Crappie	Centrarchidae	*Pomoxis nigromaculatus*	3
14	Largemouth Bass	Centrarchidae	*Micropterus nigricans*	3
15	Smallmouth Bass	Centrarchidae	*Micropterus dolomieu*	3
16	Bigmouth Buffalo	Catostomidae	*Ictiobus cyprinellus*	2
17	Bluntnose Minnow	Lecuciscidae	*Pimephales notatus*	2
18	Pumpkinseed	Centrarchidae	*Lepomis gibbosus*	2
19	White Bass	Moronidae	*Morone chrysops*	2
20	Longnose Gar	Lepisosteidae	*Lepisosteus osseus*	2
21	Green Sunfish	Centrarchidae	*Lepomis cyanellus*	1
22	Orangespotted Sunfish	Centrarchidae	*Lepomis humilis*	1
23	White Sucker	Catostomidae	*Catostomus commersonii*	1
24	Spotfin Shiner	Leuciscidae	*Cyprinella spiloptera*	1
25	Northern Rock Bass	Centrarchidae	*Ambloplites rupestris*	1
26	Common Shiner	Leuciscidae	*Luxilus cornutus*	1
27	Tadpole Madtom	Ictaluridae	*Noturus gyrinus*	1
28	Smallmouth Buffalo	Catostomidae	*Ictiobus bubalus*	1
29	Trout-Perch	Percopsidae	*Percopsis omiscomaycus*	1
30	Northern Sunfish	Centrarchidae	*Lepomis peltastes*	1
31	Blackchin Shiner	Leuciscidae	*Notropis heterodon*	1
31	Brook Silverside	Atherinopsidae	*Labidesthes sicculus*	1
33	Fantail Darter	Percidae	*Etheostoma flabellare*	1
34	Rainbow Darter	Percidae	*Etheostoma caeruleum*	1
35	Sauger	Percidae	*Sander canadensis*	1

Table 4. Occurrence in 28 Iowa glacial lakes of 14 fish species not reported in the 10 lakes in northern Iowa and southwestern Minnesota lakes in the pre-1900 period (1890–1894) but reported in three or more lakes during the post-1900 period (1926–1947).

	Common Name	Scientific Name	No. of the 28 lakes reported, post-1900
1.	White Crappie	*Pomoxis annularis*	19
2.	Common Carp [I]	*Cyprinus carpio*	13
3.	Brassy Minnow	*Hybognathus hankinsoni*	8
4.	Freshwater Drum	*Aplodinotus grunniens*	8
5.	Sand Shiner	*Notropis stramineus*	7
6.	Red Shiner	*Cyprinella lutrensis*	6
7.	Shorthead Redhorse	*Moxostoma macrolepidotum*	6
8.	Brown Bullhead	*Ameiurus nebulosus*	5
9.	Bigmouth Shiner	*Notropis dorsalis*	4
10.	Bullhead Minnow	*Pimephales vigilax*	4
11.	Channel Catfish	*Ictalurus punctatus*	4
12.	Yellow Bullhead	*Ameiurus natalis*	4
13.	Logperch	*Percina caprodes*	3
14.	Shortnose Gar	*Lepisosteus platostomus*	3

Table 5. Fish species reported in pre-1900 surveys at 10 lakes in northern Iowa and southwestern Minnesota by Meek (1892, 1894) and Cox (1896) that were likely part of the presettlement fish communities of Iowa's glacial lakes. Species are listed by the number of lakes they occurred in of the 10 lakes sampled during the pre-1900 period.

Rank	Common Name	Scientific Name	Nomenclature of Meek (1982, 1894)	No. of lakes:
1.	Yellow Perch	*Perca flavescens*	[same]	10
2.	Northern Pike	*Esox lucius*	*Lucius lucius*	8
3.	Golden Shiner	*Notemigonus crysoleucas*	[same]	7
4.	Banded Killifish	*Fundulus diaphanus*	*F. zebrinus*	6
5.	Black Bullhead	*Ameiurus melas*	[same]	6
6.	Walleye	*Sander vitreus*	*Stizostedion vitreum*	5
7.	Spottail Shiner	*Notropis hudsonius*	[same]	5
8.	Fathead Minnow	*Pimephales promelas*	[same]	5
9.	Iowa Darter	*Etheostoma exile*	*E. iowae*	4
10.	Johnny Darter	*Etheostoma nigrum**	[same]	4
11.	Blacknose Shiner	*Notropis heterolepis*	*N. cayuga*	4
12.	Bluegill	*Lepomis macrochirus*	*L. pallidus*	3
13.	Blackchin Shiner	*Notropis heterodon*	*[same]*	1

*As Scaly Johnny Darter, *E. n. eulepis*. Despite Underhill's (1963) dismissal of the scaly subspecies of Johnny Darter, the scaly form is, and historically has been, limited to the larger glacial lakes in Iowa.

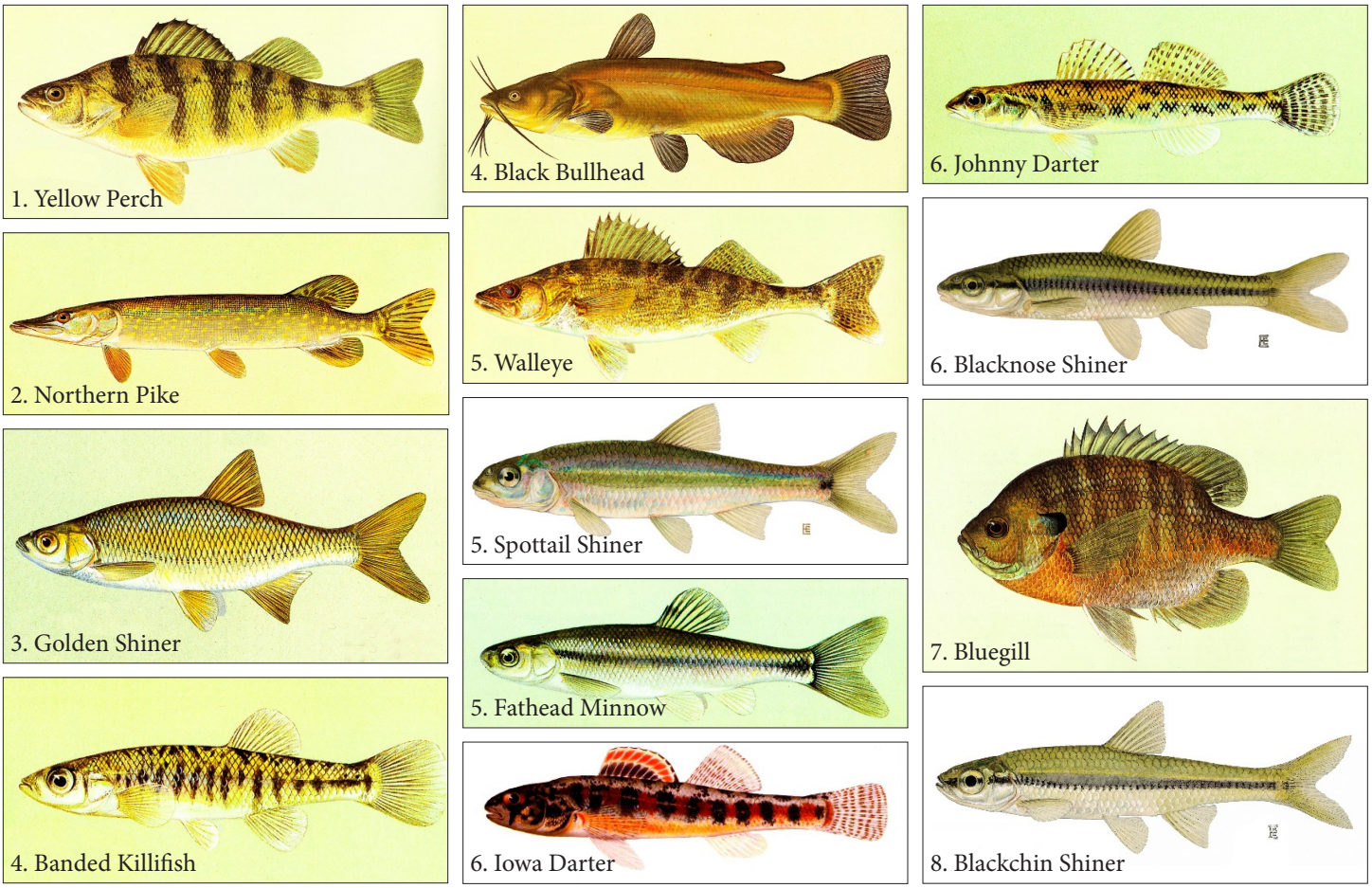

Figure 4. The thirteen fish species believed to have been part of the presettlement fish community of Iowa's natural (glacial) lakes. Species are ranked by frequency of occurrence. Illustrations by Maynard Reece (in Harlan et al. 1987; used with permission), except Spottail, Blacknose, and Blackchin shiners, by Ellen Edmondson (in Edmondson and Crisp 1926-39; used with permission).

middle-depth, and deep lake categories was challenging and was ultimately arbitrary, but an attempt was made choose mean depth breakpoints that had at least some limnological basis (i.e., thermal stratification of deep lakes) and that resulted in a roughly similar number of lakes in each category.

These 32 lakes occur in two major North American river drainages: 20 lakes are in the Missouri River drainage, and 12 are in the Upper Mississippi River drainage. Overall, the fish faunas of the Missouri and Mississippi drainages vary considerably. Most of Iowa's approximately 140 native fish species are believed to have reached post-glacial Iowa via the Mississippi River valley from southern or other glacial refugia, while fewer species are believed to have used the Missouri river route (Menzel 1987). Considerable mixing of the Upper Mississippi and Missouri drainage fish faunas seems evident and is believed due, in part, to flood-related inter-drainage connections in the headwaters of the upper Little Sioux (Missouri drainage) and upper Des Moines (Mississippi River drainage) river basins in southwestern Minnesota (Bailey and Allum 1962). These inter-drainage connections appear to have allowed fish to move from one major basin to the other. This movement has resulted in a mixing of the fish faunas of the Missouri and Upper Mississippi drainages in northwest Iowa and southwest Minnesota. Thus, when attempting to identify presettlement fish communities of Iowa's glacial lakes, the differences in the composition of the fish faunas of the Missouri and Upper Mississippi drainages do not appear to be a significant factor.

RESULTS

Species reported in the historical period (1890–1947): A total of 71 fish species were reported from the 32 glacial lakes in northern Iowa and southwestern Minnesota from 1890–1947. A total of 35 species were reported by Meek (1892, 1894) and Cox (1896) from 10 glacial lakes in northern Iowa and southern Minnesota in the pre-1900 period (Table 3). Due to the increasing impact on lake populations related to fish stockings from Iowa's Mississippi River fish rescue program and from state hatchery introductions after 1900, results of the pre-1900 surveys of Meek and Cox provide the best available picture of the presettlement fish community of Iowa's glacial lakes.

A total of 36 species was reported from 28 of Iowa's glacial lakes in the post-1900 period (1926–1947) that were not reported by Meek (1892, 1894) or Cox (1896) from the 10 pre-1900 lakes. Fish species reported only in the post-1900 period at three or more of the 28 lakes during the post-1900 period are summarized in Table 4. At least in part, Iowa's fish rescue program and/or its early fish culture program are likely responsible for the post-1900 appearance of these species in Iowa's glacial lakes and for the relatively high reporting frequencies of some of these species in the post-1900 period, e.g.,

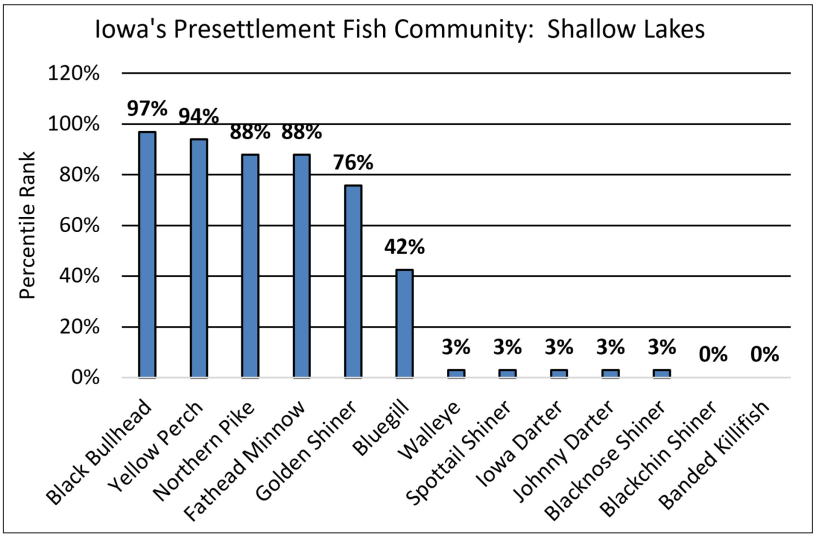

Figure 5. Percentile rankings of the 13 presettlement fishes of Iowa glacial lakes based on reported occurrence in 13 shallow glacial lakes (mean depth < 5 feet) in northern Iowa and southwestern Minnesota from 1890–1947.

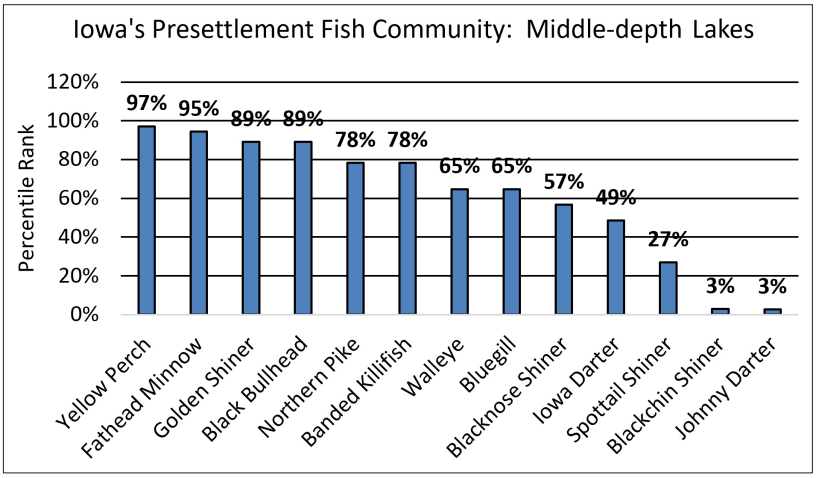

Figure 6. Percentile rankings of the 13 presettlement fishes of Iowa glacial lakes based on reported occurrence in 12 middle-depth glacial lakes (mean depth from 5 to < 10 feet) in northern Iowa and southwestern Minnesota from 1890–1947.

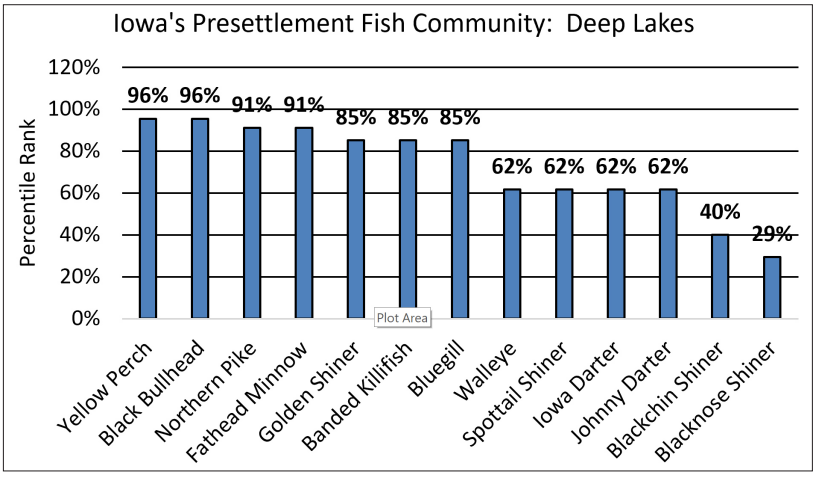

Figure 7. Percentile rankings of the 13 presettlement fishes of Iowa glacial lakes based on reported occurrence in seven deep glacial lakes (mean depth > 10 feet) in northern Iowa from 1890–1947.

White Crappie *Pomoxis annularis:* 68%, Common Carp *Cyprinus carpio:* 46%, and Freshwater Drum *Aplodinotus grunniens:* 29%.

The post-1900 appearance of several species in Iowa's glacial lakes is not surprising (e.g., the introduced Common Carp and common species in the Mississippi River such as Freshwater Drum and Shorthead Redhorse *Moxostoma macrolepidotum*). The lack of several ictalurid species in Iowa's glacial lakes during the pre-1900 period—especially catfish species (Brown *Ameiurus nebulosus* and Yellow *A. natalis* bullheads and Channel Catfish *Ictalurus punctatus*)—is surprising. Most, if not all, of the species in Table 4 were likely introduced into Iowa's glacial lakes as part of the Mississippi River fish rescue plantings. For example, both Johnson (1941) and Bailey (1953) stated that populations of Brown Bullhead in Iowa lakes were probably introduced from such plantings.

THE PRESUMPTIVE PRESETTLEMENT FISH COMMUNITY OF IOWA'S GLACIAL LAKES

I identified 13 fish species that likely occurred in Iowa's presettlement glacial lakes (Table 5, Figure 4). The available distributional and historical information for these 13 species suggest that they were not planted or stocked as part of either fish rescue, fish culture, or other human-related fish management activities into the 10 pre-1900 lakes surveyed by Meek (1982, 1894) or Cox (1896). Frequency of occurrence in the pre-1900 lakes was a primary factor in selecting the presettlement species.

Figures 5, 6, and 7 present the occurrence rankings of these 13 fish species in 13 shallow, 12 middle-depth, and seven deep natural (glacial) lakes, respectively, in northern Iowa and southwestern Minnesota.

SOURCES OF UNCERTAINTY

Several sources of uncertainty exist regarding selecting species that likely were members of the presettlement fish community of Iowa's glacial lakes. The late 19th and early 20th century plantings of fishes via Iowa's fish rescue operations and early fish culture activities were done with good intentions, i.e., to increase the supply of food fish. These programs, however, altered the presettlement distribution of Iowa's fish species before Iowa's earliest fish surveys were conducted in the late 1800s. Thus, determining which species were naturally occurring in an Iowa lake (or stream or river) is difficult. Sampling bias also introduces uncertainty. All sampling includes error, and the sampling of lake fishes with common sense minnow seines in the late 19th century no doubt resulted in underreporting of the number of species present. An additional source of uncertainty is misidentification of rare species and attempts of subsequent authors to resolve these misidentifications.

Figure 8. An early 1900s Iowa fish rescue crew seining a backwater of the Mississippi River. Photo from Hinshaw (1915).

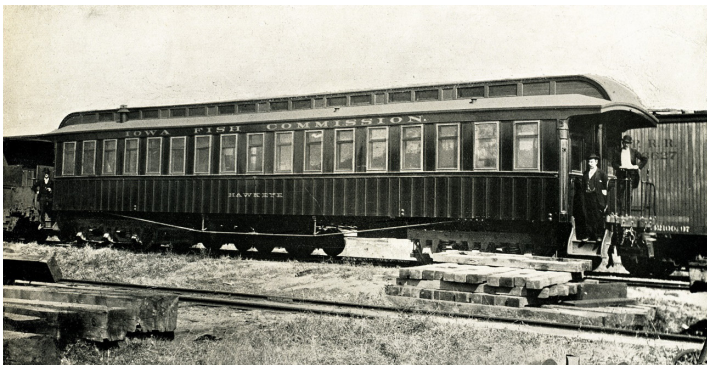

Figure 9. Iowa's first state-owned fish car, the "Hawkeye," purchased by the state of Iowa in the late 1890s (Delavan 1897). Prior to purchasing this car, the state relied on the generosity of the railroad companies for use of one of their cars for transporting rescued fishes. Photo from Lincoln (1902).

1. **Fish Rescue:** Iowa conducted state-sponsored "fish rescue" operations that began in the mid-1870s and continued into the mid-20th century (Carlander 1954). The establishment of railroad lines across Iowa in the 1870s made this program possible. As a result, Iowa's presettlement fish communities were forever altered, and the presettlement distributions of Iowa's native species were forever obscured. Originated and promoted as the best use of the resource by a member of Iowa's first fish commission, B.F. Shaw (Shaw 1878), "fish rescue" involved spring and summer removal (seining) of fishes from bayous and overflow pools of large rivers (primarily the northern Iowa portion of the Upper Mississippi River) and transportation via rail of the fishes captured to Iowa's inland waters, including the glacial lakes of north-central and northwest Iowa (Figures 8 and 9).

   As part of his fisheries work in Iowa in 1932 for Iowa's 25-year Conservation Plan (Crane and Olcott 1933), University of Michigan ichthyologist Carl Hubbs, along with his assistant, J. Clark Salyer, conducted an evaluation of Iowa's fish rescue program (Hubbs 1932). Although Hubbs approved of the program overall, many of his comments were negative. He found "a considerable ignorance" of species identification, and he used the Orangespotted Sunfish *Lepomis humilis* to demonstrate that ignorance. He reported that he could not find anyone where rescued fishes were being sorted that realized that they were sending a species of sunfish (Orangespotted Sunfish) to be stocked in inland waters "that never reaches a legal or catchable size" (Hubbs 1932). Regarding the movement of Orangespotted Sunfish to inland waters, Hubbs stated that "we believe that the wholesale spread of this runt fish into interior waters has been a very serious mistake." Hubbs made recommendations regarding which species should be returned to the Mississippi River and which species should be stocked inland in Iowa, including Channel Catfish, Northern Pike, Walleye, White Bass *Morone chrysops*, Largemouth Bass *Micropterus salmoides*, and Bluegill, which he called the "most desirable fish for inland distribution." He felt that Pumpkinseed, Green Sunfish, and Warmouth *Lepomis gulosus* also "seemed worth planting." He agreed with those in charge of fish rescue operations that "predator fish" such as gar and Bowfin *Amia ocellicauda* (formerly *A. calva*) should be thrown on the bank.

   Evidence suggests that the four glacial lakes in southwest Minnesota that were sampled in 1894 by Cox (1896) were less—or possibly not—affected by early fish rescue activities. Although Iowa Fish Commissioner B.F. Shaw (1884) mentioned that fish rescue programs were being adopted by other states along the Mississippi River, he did not identify specific states. Anfinson (2003), however, notes that Missouri and Illinois began rescuing Mississippi River fishes in the 1880s and that Wisconsin began its program in 1895, but he does not mention a pre-1900 fish rescue program in Minnesota. Anfinson continues that the USFC (aka US Bureau of Fisheries) began Mississippi River fish rescue operations in 1899 and that it would come to dominate fish rescue operations on the river. Carlander (1954) summarized Mississippi River fish rescue stations established by the USFC for all upper river states (Iowa, Illinois, Minnesota, Missouri and Wisconsin). Her summary suggests that the earliest of Minnesota's 11 fish rescue stations was established at Homer [near Winona] in 1911.

2. **Early fish culture:** As described in the Fourth Biennial Report of the State Fish Commission of Iowa (Shaw 1882), a new fish hatching-house was established by the Iowa Legislature in 1880—about 10 years before Meek's initial lakes surveys in Iowa—between Spirit and East Okoboji lakes in Dickinson County in northwest Iowa. In early 1881, Shaw and his assistant fish commissioner experimented with propagating native fishes. They concluded that "the result of our operations satisfied us that we can hatch pike, bass, buffalo, and perch and the like with very little trouble." Also, "most of our native fish can be artificially propagated under favorable circumstances to any extent desired, and that depleted waters can be restocked" (Shaw 1882). In the next (fifth) biennial report of the state fish commission, Shaw (1884), again mentions that he and his assistant conducted some "experimental" work with artificial propagation of native species in spring 1882, including "wall-eyed pike, bass, perch, pickerel, and buffalo." These statements introduce the possibility that at least some of the species of game fishes and food fishes reported for Spirit Lake by Meek (1894) (e.g., Largemouth Bass) were introduced via the new Spirit Lake hatchery.

Table 6. Species reported from the 10 pre-1900 lakes that were not considered part of the presettlement fish community of Iowa's glacial lakes but that have at least some evidence of a presettlement presence. Illustrations by Maynard Reece (in Harlan et al. 1987; used with permission).

Species and Illustration	No. of pre-1900 records	Lakes	Rationale for possibly considering species as presettlement
 Longnose Gar *Lepisosteus osseus*	2	Spirit Okabena-MN	No known pre-1900 fish rescue in MN; only select species were part of early fish culture at Lake Okoboji region lakes.
 Bluntnose Minnow *Pimephales notatus*	2	Clear Silver (Dickinson Co., IA)	Not usually considered a lakes species (Page and Burr 2011). Occurrence possibly due to stream connections.
 White Sucker *Catostomus commersonii*	1	Okabena-MN	Presence in Okabena suggests presettlement occurrence; otherwise, lack of presettlement reports.
 Bigmouth Buffalo *Ictiobus cyprinellus*	2	Okabena-MN Round-MN	Gathering information on spring runs of buffalo (*Ictiobus* spp.) was reason for Cox's (1896) survey.
 Pumpkinseed *Lepomis gibbosus*	2	Spirit Okabena-MN	Possibly pre-settlement but just as likely a rare species prior to 1900 in NW Iowa and SW Minnesota.
 Smallmouth Bass *Micropterus dolomieu*	3	Clear Spirit West Okoboji	Native occurrence in the Missouri River basin of northwest IA and southwest MN is uncertain(Cross et al. 1986); possibly introduced to Lake Okoboji region via early fish culture.

3. **Sampling lake fish assemblages:** The fish communities reported in the historical surveys of Meek (1892, 1894), Cox (1896), Salyer (1932), and Johnson (1941) should be viewed as rough approximations of the communities that actually existed in the glacial lakes they sampled. Characterizing fish assemblages of lake systems is inherently difficult due to habitat heterogeneity and especially water depth. The thoroughness of inventories of lake fishes depends on many factors such as season, growth of aquatic vegetation, time of day sampling was conducted, and the selectivity of the sampling gear(s).

   Because all these studies were conducted before the advent of electrofishing and use of other collection methods in Iowa waters,[3] the primary sampling gear used in the lake studies during the period 1890–1947 was the seine. Meek, Cox, and Larrabee all mention seining as their collection method. They all, however, would occasionally include anecdotal mentions of rare species or common sport fish species associated with the lakes they sampled. In his survey of the fishes of the Lake Okoboji region, Larrabee (1926) mentioned that seines were commonly used but that hook-and-line sampling was also used. He also examined fishes in live bait boxes and catches of local fishers, and he incorporated local information on fishes. Regarding the abundance of larger fishes, Meek (1892) commented that "it was often difficult to reach satisfactory conclusions by the use of ordinary collecting seines." Not surprisingly, the use of a seine to sample a well-vegetated lake of several hundred acres or more, with water depths often much deeper than seines can effectively sample, will not provide a complete list of the species present. Regardless of this significant short-

[3] Based on information in Harrison (1955), boat-mounted electrofishing was first evaluated on Iowa waters in the early to mid-1950s.

coming, the largely seining-based information provided on fish communities in Iowa's glacial lakes prior to 1950 is the best and only information available.

OTHER POSSIBILITIES FOR PRESETTLEMENT FISH SPECIES

Just under half (17) of the 35 fish species reported from the 10 pre-1900 lakes in northern Iowa and southwestern Minnesota (Table 2) lacked evidence of a presettlement presence in the glacial lakes and were rejected for inclusion to the potential presettlement fish community of Iowa's glacial lakes. Most of these species had only one pre-1900 report from the 10 lakes, and those single reports were often from Iowa lakes and were attributable to human activity (e.g., early fish rescue activities or early fish culture activities). Several species that occurred at low frequencies in the pre-1900 lakes, however, could not be eliminated from pre-settlement consideration due to a fish rescue or fish culture-related explanation (Table 6). Several, if not all, of these species may have been part of the presettlement fish communities of Iowa's glacial lakes.

CONCLUSIONS

Although the process involved several types of uncertainty, the identification of a presumptive presettlement fish community for Iowa's glacial lakes (Table 5) provides guidance for implementing a high diversity fish stocking program for lake restoration projects in Iowa. The influence of mean depth on the historical occurrence frequency of presettlement species suggests that stocking at restored glacial lakes should be focused on species that tend to occur at relatively high frequencies in the depth category of the restored lake (see Figures 5, 6, and 7).

The group of 13 species that I identified as the presettlement fish community of Iowa's natural lakes is not what I expected when I began this project. I had presumed that the presettlement community would be dominated by environmentally sensitive species. I did not anticipate that the environmentally tolerant Black Bullhead and Fathead Minnow would be two of the most frequently found species in the 10 lakes sampled before 1900, yet that is exactly what the pre-1900 sampling results suggest. That either the Black Bullhead or Fathead Minnow would be stocked into a post-restoration shallow lake as part of a high-diversity stocking approach seems unlikely. The presence of only one centrarchid species (Bluegill) in the presettlement community of Iowa's glacial lakes also seems unlikely. My expectations included the presence of a centrarchid top predator such as Largemouth Bass or Smallmouth Bass and an additional littoral zone *Lepomis* such as Pumpkinseed. The low frequency of pre-1900 occurrence for Smallmouth Bass and Pumpkinseed may simply reflect the presettlement absence or rarity of these species in the Missouri River drainage where six of the 10 pre-1900 lakes occur.

In terms of the literature on Iowa fishes, relatively little attention has been given to the influence of either Iowa's approximately 75-year (1875–1950) Mississippi River fish rescue program or its early fish culture activities on the distribution of Iowa fish species. Other than brief specific mentions (e.g., Bailey and Harrison (1945) attributing Yellow Bass *Morone mississippiensis* in Iowa's Clear Lake to Mississippi River fish rescue operations), these subjects have largely been ignored. Although the history of Iowa's fish rescue programs, both on the Mississippi River and on inland rivers, is described in detail by several authors (e.g., Aitken 1938 and Carlander 1954), these topics are not addressed in two reports on the distribution of Iowa fishes: Cleary (1956) and Menzel (1987). As demonstrated by this report, both fish rescue and early fish culture influenced the presettlement distribution of fish species in Iowa's glacial lakes. This topic, especially as related to fish distribution in Iowa's streams and rivers, would appear to deserve further attention.

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