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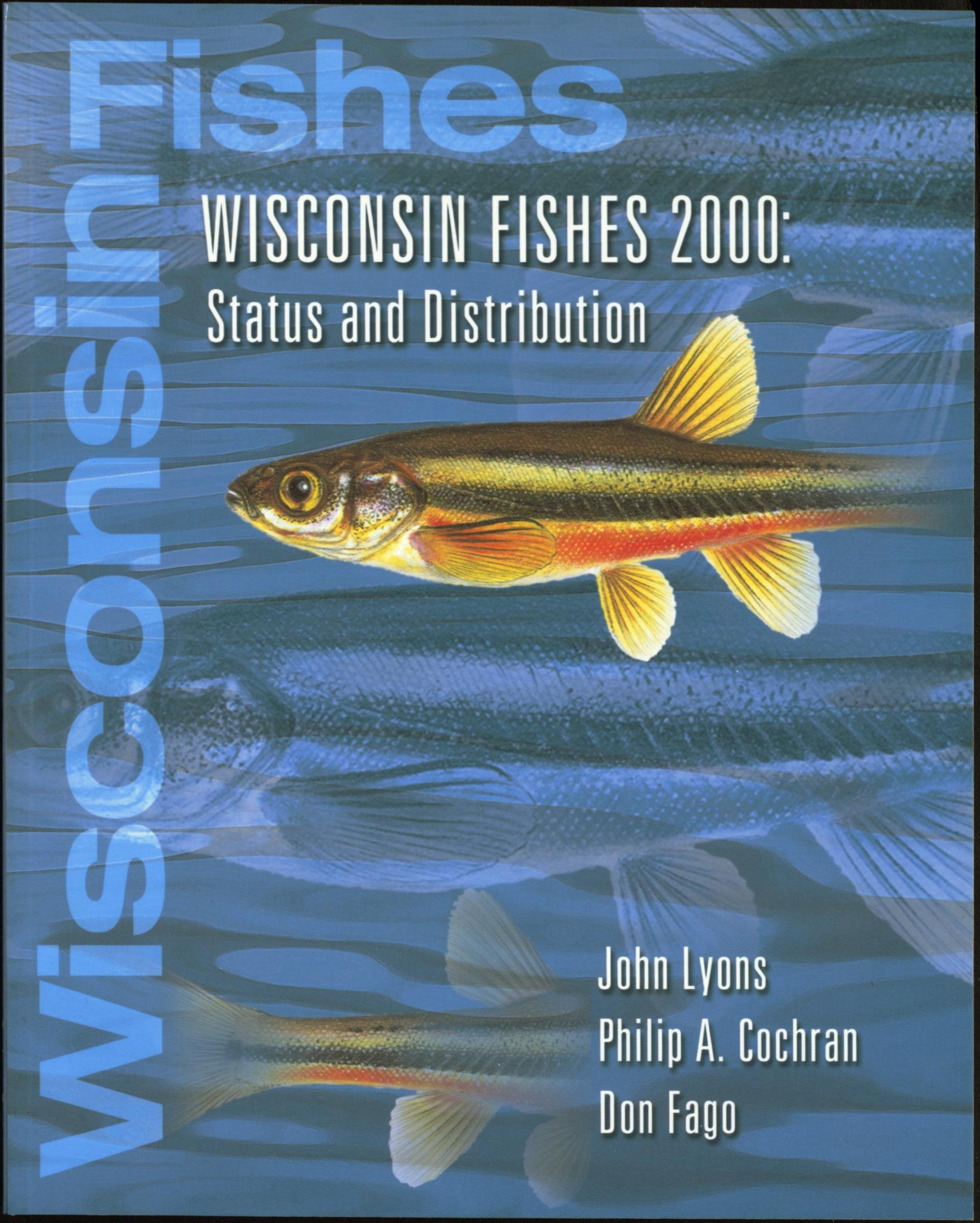

WISCONSIN FISHES 2000:
Status and Distribution

John Lyons
Philip A. Cochran
Don Fago

Color Plate 1. Southern brook lamprey adult (top) and ammocoete (bottom) captured 11 May 1999 from Wedges Creek, Clark County. Photograph by John Lyons.

Color Plate 2. Two channel shiners captured 9 June 1999 from the Mississippi River, Pool 11, Grant County. Photograph by John Lyons.

Color Plate 3. Spawning male kokanee salmon captured 22 December 1999 from Florence Lake, Langlade County. Photograph by John Lyons.

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Color Plate 5. White perch young of the year (top) and adult (bottom) captured 9 October 1995 from Lake Superior. Photograph by John Lyons.

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Color Plate 7. Round goby captured 24 May 1999 from Superior Harbor, Douglas County. Photograph by John Lyons.

Color Plate 8. Detail of round goby's fused pectoral fins. Photograph by John Lyons.

Wisconsin Fishes 2000

Status and Distribution

Color Plates

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Wisconsin Fishes 2000

Status and Distribution

John Lyons
Wisconsin Department of Natural Resources

Philip A. Cochran
St. Norbert College

Don Fago
Wisconsin Department of Natural Resources

University of Wisconsin Sea Grant Institute
Madison, Wisconsin

University of Wisconsin Sea Grant Institute
1975 Willow Drive, Second Floor
Madison, WI 53706-1177

Phone (608) 263-3259
Fax: (608) 262-0591
Email: linda@seagrant.wisc.edu

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Contents

Summary

Since the original publication of George C. Becker's landmark *Fishes of Wisconsin* in 1983, many changes have occurred in the Wisconsin fish fauna. Currently, 147 native species are recognized, one more than in Becker (1983). Two additional native species, southern brook lamprey (*Ichthyomyzon gagei*) and channel shiner (*Notropis wickliffi*), have been found in the state, and one former native species, longjaw cisco (*Coregonus alpenae*), is now considered merely a distinctive form of shortjaw cisco (*Coregonus zenithicus*). Hybrid northern redbelly X finescale dace (*Phoxinus eos X Phoxinus neogaeus*) may represent an additional unisexual clonal species, but genetic analyses of Wisconsin populations are required for confirmation. Six native species — ghost shiner (*Notropis buchanani*), ironcolor shiner (*Notropis chalybaeus*), creek chubsucker (*Erimyzon oblongus*), deepwater cisco (*Coregonus johannae*), blackfin cisco (*Coregonus nigripinnis*), and shortnose cisco (*Coregonus reighardi*) — are extirpated from the state. Two species thought by Becker (1983) to be extirpated, skipjack herring (*Alosa chrysochloris*) and black redhorse (*Moxostoma duquesnei*), have been rediscovered but are rare. Three endangered species, striped shiner (*Luxilus* (formerly *Notropis*) *chrysocephalus*), pallid shiner (*Notropis amnis*), and slender madtom (*Noturus exilis*), have declined greatly in distribution and abundance and are now nearly extirpated. Fourteen non-native species are currently established in the state, with kokanee salmon (*Oncorhynchus nerka*), threespine stickleback (*Gasterosteus aculeatus*), white perch (*Morone americana*), ruffe (*Gymnocephalus cernuus*), and round goby (*Neogobius melanostomus*) newly reported since Becker's (1983) book. At least 19 additional non-native species have been reported from state waters but are not currently established; 2 of these, red shiner (*Cyprinella* (formerly *Notropis*) *lutrensis*) and pink salmon (*Oncorhynchus gorbuscha*) had been tentatively considered by Becker (1983) to be established. The scientific names of 16 native and 2 non-native Wisconsin fishes have been changed, and several others may be changed in the future.

Illustrations and Photographs

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Introduction

The publication of George C. Becker's monumental *Fishes of Wisconsin* in 1983 was a major landmark in Wisconsin ichthyology. However, even as this book was being published, substantial new information was being gathered about the fishes of the state. From 1975–1980, the Wisconsin Department of Natural Resources (WDNR) sampled fish from nearly 5000 sites on over 1700 lakes, rivers, and streams as part of a statewide fish distribution survey (FDS) under the direction of Don Fago. Only portions of these collections were included in Becker (1983). Unfortunately, the FDS was terminated with just 45% of the waters in the state adequately surveyed. Summaries of FDS results were published by Fago (1982, 1983, 1984a, 1984b, 1985a, 1985b, 1986, 1992). As a result of the FDS, Fago (1988) created the "Master Fish File," a comprehensive database that now includes over 22,000 Wisconsin fish collections from 1900 to the present. This database is updated regularly and can be accessed through the WDNR web site (*www.dnr.state.wi.us*).

Following the end of the FDS and the publication of *Fishes of Wisconsin*, many additional studies of Wisconsin waters were carried out, adding greatly to our knowledge of the taxonomic status, distribution, and abundance of Wisconsin fishes. Several noteworthy studies about native species were published, including the discovery (Cochran 1987) and analysis of variation and distribution (Cochran and Gripentrog 1992, Lyons et al. 1997) of southern brook lamprey (*Ichthyomyzon gagei),* rediscovery of skipjack herring (*Alosa chrysochloris*) (Thiel 1985, Fago 1993) and black redhorse (*Moxostoma duquesnei*) (Fago and Hauber 1993), documentation of the decline in distribution and abundance of slender madtom (*Noturus exilis*) (Lyons 1996a), and analysis of morphological variation and distribution in slimy sculpin (*Cottus cognatus*) (Lyons 1990). The initial establishment and spread was reported for four non-native species: threespine stickleback (*Gasterosteus aculeatus*) (Johnston 1991), white perch (*Morone americana*) (Cochran and Hesse 1994), ruffe (*Gymnocephalus cernuus*) (Simon and Vondruska 1991, Pratt et al. 1992), and round goby (*Neogobius melanostomus*) (Charlebois et al. 1997, Steingraeber 1999). Occurrence and abundance trends were presented for the entire fish assemblage from certain waters, including the Bois Brule River system, Douglas County (DuBois and Pratt 1994); Devils Lake, Sauk County (Lillie and Mason 1986); Lake Mendota and other lakes near Madison (Lyons 1989a, Lathrop et al. 1992, Magnuson and Lathrop 1992); the Mississippi River (Held 1983a and 1983b, Sylvester and Broughton 1983, UMRCC 1983, Eckblad 1986, Fremling et al. 1989, Burkhardt et al. 1997, Torreano 1998); Sparkling Lake, Vilas County (Lyons 1987); the St. Croix River basin (Fago and Hatch 1993); Lake Superior (Hansen 1994, Hoff and Bronte 1999); and the Trout River, Vilas County (Lyons 1988). Factors that influenced the distribution of fish species and assemblages across broad regions of the state were analyzed by Lyons et al. (1988, 1996), Lyons (1989b, 1991, 1992, 1996b), Johnson and Jennings (1998), and Newall and Magnuson (1999) for streams and rivers, and by Tonn and Magnuson (1982), Rahel (1984), Brazner (1997), Brazner and Beals (1997), and Jennings et al. (1999) for lakes.

In this publication we have updated the information in Becker (1983) on the occurrence, taxonomic status, distribution, and abundance of fishes in Wisconsin. We have also briefly summarized nomenclatural changes.

Figure 1. Map of Wisconsin, showing the major rivers and lakes mentioned in the text.

Materials and Methods

We compiled information for this update from many different sources, including data and specimen collections held by government agencies, colleges and universities, and private individuals. All told, we considered information from about 3500 locations on 1200 Wisconsin streams, rivers, and lakes sampled from 1981 through 1999. For new distribution records we relied on published literature, the Master Fish File, and voucher specimens or photographs deposited in the fish collection of the University of Wisconsin Zoological Museum (UWZM) in Madison or the WDNR Research Center in Monona. A portable sea lamprey assessment trap (Schuldt and Heinrich 1982) operated below the DePere Dam on the Lower Fox River (Brown County) from 1979 to the present provided especially useful information on exotic species and trends in fish abundance (Cochran 1994, Cochran and Hesse 1994, Cochran and Marks 1995), although it was relatively inefficient at collecting large, deep-bodied species. We accepted unpublished records without specimens or photographs if they had been observed by one of the authors or by a biologist that we judged competent to identify Wisconsin fishes.

We have used common and scientific names from the most recent American Fisheries Society list of fish names (Robins et al. 1991a, 1991b, Kendall 1997), and we have indicated where these names differ from those in Becker (1983). The American Fisheries Society list will be updated soon and will probably include name changes for several Wisconsin species to match the nomenclature proposed by Mayden et al. (1992), so we list these alternative names in parentheses.

We defined three categories of Wisconsin fishes. Native species are those that had established populations in the state prior to European settlement in the early 1800s. Most of these fishes are able to complete their whole life cycle in Wisconsin waters, but two, American eel (*Anguilla rostrata*) and skipjack herring (*Alosa chrysochloris*), spend only part of their lives in Wisconsin and spawn outside the state (Becker 1983). Non-native species were not present prior to European settlement and entered Wisconsin because of human activities subsequent to settlement, either through intentional or accidental introductions or through modifications of waterways that allowed them to bypass natural barriers. An example of the latter is the construction of the Welland Canal, which circumvented the barrier at Niagara Falls and permitted the invasion of the sea lamprey (*Petromyzon marinus*) and alewife (*Alosa pseudoharengus*) from Lake Ontario into the upper Great Lakes. We split non-native species into two categories: "established species," with one or more self-sustaining populations in the state as of 1999, and "transient species," which are not self-sustaining in the state. Some transient non-natives, such as the rainbow sharkminnow (*Epalzeorhynchos frenatum*) or striped bass (*Morone saxatilis*), are known only from a single individual; others, such as the grass carp (*Ctenopharyngodon idella*) or Atlantic salmon (*Salmo salar*), are represented by several records because they have been regularly stocked in Wisconsin or nearby states.

The following species accounts are divided into the three categories of native, established non-native, and transient non-native fishes. Species are listed by category and then alphabetically by scientific name within family, with families ordered taxonomically according to Robins et al. (1991a). Note that this taxonomic order differs from that of Becker (1983), reflecting an improved understanding of phylogenetic relationships.

Each species account includes a brief update of the current status of each species treated in Becker (1983), emphasizing any significant new information since then on taxonomy, distribution, and abundance. For status we used a five-level classification: secure – highly unlikely to disappear from the state within the foreseeable future; special concern – probably secure, but with either evidence of recent declines or uncertainty about trends in distribution or abundance; threatened – likely to become endangered in the foreseeable future; endangered – continued existence as a viable component of the Wisconsin biota in jeopardy; extirpated – no records from the state over at least the last 20 years. Threatened and endangered species have been legally designated by Wisconsin state law, whereas special concern species are listed informally by the WDNR.

Each species account also defines current abundance as either common – consistently captured in large numbers when the appropriate sampling technique is used in the right habitat; occasional – captured sporadically, usually not in large numbers; or uncommon – taken infrequently and always in small numbers. We also briefly summarize current distribution patterns. See figure 1 for a map of many of the rivers and lakes mentioned in the text.

For those native and established non-native species newly confirmed in the state since Becker (1983), the species account is more detailed, including a photograph, distribution map, discussion of identifying features and taxonomic status, and information (if available) on reproduction, growth, feeding, population dynamics, interactions with other species, and management issues.

Overview of Changes in the Wisconsin Fish Fauna

Becker (1983) provided accounts of 157 species (with separate accounts for two nominal subspecies of lake trout (*Salvelinus namaycush*)), of which 146 were native and 11 were established non-natives by our criteria (table 1). Nine of the native species, skipjack herring (*Alosa chrysochloris*), ghost shiner (*Notropis buchanani*), ironcolor shiner (*Notropis chalybaeus*), creek chubsucker (*Erimyzon oblongus*), black redhorse (*Moxostoma duquesnei*), longjaw cisco (*Coregonus alpenae*), deepwater cisco (*Coregonus johannae*), blackfin cisco (*Coregonus nigripinnis*), and shortnose cisco (*Coregonus reighardi*), were considered extirpated. Becker (1983) excluded two species previously reported from the state, pallid sturgeon (*Scaphirhynchus albus*) (Priegel and Wirth 1971) and blue catfish (*Ictalurus furcatus*) (Greene 1935), because of an absence of valid records. He also listed 10 transient non-native species that had been introduced into state waters without success.

Based on our analyses, as of 1999, we recognize 147 native species, 14 established non-native species, and a minimum of 19 transient non-native species (table 1). Two new native species have been recognized, southern brook lamprey (*Ichthyomyzon gagei*) and channel shiner (*Notropis wickliffi*). One former native species, the extirpated longjaw cisco (*Coregonus alpenae*), is now considered merely a distinctive form of shortjaw cisco (*Coregonus zenithicus*). Hybrid northern redbelly X finescale dace (*Phoxinus eos X Phoxinus neogaeus*) could represent an additional unisexual clonal species, but genetic analyses of Wisconsin populations are lacking for confirmation. Two species thought by Becker (1983) to be extirpated, skipjack herring (*Alosa chrysochloris*) and black redhorse (*Moxostoma duquesnei*), have been rediscovered but are rare. Six species, ghost shiner (*Notropis buchanani*), ironcolor shiner (*Notrpois chalybaeus*), creek chubsucker (*Erimyzon oblongus*), deepwater cisco (*Coregonus johannae*), blackfin cisco (*Coregonus nigripinnis*), and shortnose cisco (*Coregonus reighardi*), are still considered extirpated. Three endangered species, striped shiner (*Luxilus* (formerly *Notropis*) *chrysocephalus*), pallid shiner (*Notropis amnis*), and slender madtom (*Noturus exilis*), have declined greatly in distribution and abundance since the late 1970s and are nearly extirpated from the state. Five of the 14 established non-native species are new: kokanee salmon (*Oncorhynchus nerka*) (the lake-dwelling form of the sockeye salmon; considered a transient non-native by Becker (1983)), threespine stickleback (*Gasterosteus aculeatus*), white perch (*Morone americana*), ruffe (*Gymnocephalus cernuus*), and round goby (*Neogobius melanostomus*). The 20 transient non-native species listed in this publication include 9 listed by Becker (1983), 9 not listed previously from the state (including the blue catfish (*Ictalurus furcatus*)), and 2 tentatively considered established by Becker (1983), the red shiner (*Cyprinella* (formerly *Notropis*) *lutrensis*) and pink salmon (*Oncorhynchus gorbuscha*).

Robins et al. (1991a) and Kendall (1997) changed the scientific names of 16 native and 2 non-native Wisconsin fishes from those used in Becker (1983). Mayden et al. (1992) proposed additional name changes for five species and two families (table 2). Three of the Mayden et al. (1992) species names and both family names are likely to be accepted in the next version of the American Fisheries Society list of North American fish names.

TABLE 1 — FISHES RECORDED FROM WISCONSIN WATERS AS OF 1999.

Common Name	Scientific Name	Category in Becker (1983)
NATIVE SPECIES		
LAMPREYS	PETROMYZONTIDAE	
Chestnut Lamprey	*Ichthyomyzon castaneus*	Native
Northern Brook Lamprey	*Ichthyomyzon fossor*	Native
Southern Brook Lamprey	*Ichthyomyzon gagei*	Not known
Silver Lamprey	*Ichthyomyzon unicuspis*	Native
American Brook Lamprey	*Lampetra appendix*	Native
STURGEONS	ACIPENSERIDAE	
Lake Sturgeon	*Acipenser fulvescens*	Native
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*	Native
PADDLEFISHES	POLYODONTIDAE	
Paddlefish	*Polyodon spathula*	Native
GARS	LEPISOSTEIDAE	
Longnose Gar	*Lepisosteus osseus*	Native
Shortnose Gar	*Lepisosteus platostomus*	Native
BOWFINS	AMIIDAE	
Bowfin	*Amia calva*	Native
MOONEYES	HIODONTIDAE	
Goldeye	*Hiodon alosoides*	Native
Mooneye	*Hiodon tergisus*	Native
FRESHWATER EELS	ANGUILLIDAE	
American Eel	*Anguilla rostrata*	Native
HERRINGS	CLUPEIDAE	
Skipjack Herring	*Alosa chrysochloris*	Native
Gizzard Shad	*Dorosoma cepedianum*	Native
MINNOWS	CYPRINIDAE	
Central Stoneroller	*Campostoma anomalum*	Native
Largescale Stoneroller	*Campostoma oligolepis*	Native
Redside Dace	*Clinostomus elongatus*	Native
Lake Chub	*Couesius plumbeus*	Native
Spotfin Shiner	*Cyprinella spiloptera*	Native
Gravel Chub	*Erimystax x-punctatus*	Native
Brassy Minnow	*Hybognathus hankinsoni*	Native

Common Name	Scientific Name	Category in Becker (1983)
Mississippi Silvery Minnow	*Hybognathus nuchalis*	Native
Striped Shiner	*Luxilus chrysocephalus*	Native
Common Shiner	*Luxilus cornutus*	Native
Redfin Shiner	*Lythrurus umbratilis*	Native
Speckled Chub	*Macrhybopsis aestivalis*	Native
Silver Chub	*Macrhybopsis storeriana*	Native
Pearl Dace	*Margariscus margarita*	Native
Hornyhead Chub	*Nocomis biguttatus*	Native
Golden Shiner	*Notemigonus crysoleucas*	Native
Pallid Shiner	*Notropis (Hybopsis) amnis*	Native
Pugnose Shiner	*Notropis anogenus*	Native
Emerald Shiner	*Notropis atherinoides*	Native
River Shiner	*Notropis blennius*	Native
Ghost Shiner	*Notropis buchanani*	Native
Ironcolor Shiner	*Notropis chalybaeus*	Native
Bigmouth Shiner	*Notropis dorsalis*	Native
Blackchin Shiner	*Notropis heterodon*	Native
Blacknose Shiner	*Notropis heterolepis*	Native
Spottail Shiner	*Notropis hudsonius*	Native
Ozark Minnow	*Notropis nubilus*	Native
Rosyface Shiner	*Notropis rubellus*	Native
Sand Shiner	*Notropis stramineus (ludibundus)*	Native
Weed Shiner	*Notropis texanus*	Native
Mimic Shiner	*Notropis volucellus*	Native
Channel Shiner	*Notropis wickliffi*	Not recognized[1]
Pugnose Minnow	*Opsopoeodus emiliae*	Native
Suckermouth Minnow	*Phenacobius mirabilis*	Native
Northern Redbelly Dace	*Phoxinus eos*	Native
Southern Redbelly Dace	*Phoxinus erythrogaster*	Native
Finescale Dace	*Phoxinus neogaeus*	Native
Bluntnose Minnow	*Pimephales notatus*	Native
Fathead Minnow	*Pimephales promelas*	Native
Bullhead Minnow	*Pimephales vigilax*	Native
Blacknose Dace	*Rhinichthys atratulus*	Native
Longnose Dace	*Rhinichthys cataractae*	Native
Creek Chub	*Semotilus atromaculatus*	Native
SUCKERS	CATOSTOMIDAE	
River Carpsucker	*Carpiodes carpio*	Native
Quillback	*Carpiodes cyprinus*	Native
Highfin Carpsucker	*Carpiodes velifer*	Native
Longnose Sucker	*Catostomus catostomus*	Native
White Sucker	*Catostomus commersoni*	Native
Blue Sucker	*Cycleptus elongatus*	Native

Common Name	Scientific Name	Category in Becker (1983)
Creek Chubsucker	*Erimyzon oblongus*	Native
Lake Chubsucker	*Erimyzon sucetta*	Native
Northern Hog Sucker	*Hypentelium nigricans*	Native
Smallmouth Buffalo	*Ictiobus bubalus*	Native
Bigmouth Buffalo	*Ictiobus cyprinellus*	Native
Black Buffalo	*Ictiobus niger*	Native
Spotted Sucker	*Minytrema melanops*	Native
Silver Redhorse	*Moxostoma anisurum*	Native
River Redhorse	*Moxostoma carinatum*	Native
Black Redhorse	*Moxostoma duquesnei*	Native
Golden Redhorse	*Moxostoma erythrurum*	Native
Shorthead Redhorse	*Moxostoma macrolepidotum*	Native
Greater Redhorse	*Moxostoma valenciennesi*	Native
BULLHEAD CATFISHES	ICTALURIDAE	
Black Bullhead	*Ameiurus melas*	Native
Yellow Bullhead	*Ameiurus natalis*	Native
Brown Bullhead	*Ameiurus nebulosus*	Native
Channel Catfish	*Ictalurus punctatus*	Native
Slender Madtom	*Noturus exilis*	Native
Stonecat	*Noturus flavus*	Native
Tadpole Madtom	*Noturus gyrinus*	Native
Flathead Catfish	*Pylodictis olivaris*	Native
PIKES	ESOCIDAE	
Grass Pickerel	*Esox americanus*	Native
Northern Pike	*Esox lucius*	Native
Muskellunge	*Esox masquinongy*	Native
MUDMINNOWS	UMBRIDAE	
Central Mudminnow	*Umbra limi*	Native
TROUTS	SALMONIDAE	
Cisco/Lake Herring	*Coregonus artedi*	Native
Lake Whitefish	*Coregonus clupeaformis*	Native
Bloater	*Coregonus hoyi*	Native
Deepwater Cisco	*Coregonus johannae*	Native
Kiyi	*Coregonus kiyi*	Native
Blackfin Cisco	*Coregonus nigripinnis*	Native
Shortnose Cisco	*Coregonus reighardi*	Native
Shortjaw Cisco	*Coregonus zenithicus*	Native[2]
Pygmy Whitefish	*Prosopium coulteri*	Native
Round Whitefish	*Prosopium cylindraceum*	Native

Common Name	Scientific Name	Category in Becker (1983)
Brook Trout	*Salvelinus fontinalis*	Native
Lake Trout	*Salvelinus namaycush*	Native
TROUT-PERCHES	PERCOPSIDAE	
Trout-perch	*Percopsis omiscomaycus*	Native
PIRATE PERCHES	APHREDODERIDAE	
Pirate Perch	*Aphredoderus sayanus*	Native
CODFISHES	GADIDAE	
Burbot	*Lota lota*	Native
KILLIFISHES	CYPRINODONTIDAE (FUNDULIDAE)	
Banded Killifish	*Fundulus diaphanus*	Native
Starhead Topminnow	*Fundulus dispar*	Native
Blackstripe Topminnow	*Fundulus notatus*	Native
SILVERSIDES	ATHERINIDAE	
Brook Silverside	*Labidesthes sicculus*	Native
STICKLEBACKS	GASTEROSTEIDAE	
Brook Stickleback	*Culaea inconstans*	Native
Ninespine Stickleback	*Pungitius pungitius*	Native
SCULPINS	COTTIDAE	
Mottled Sculpin	*Cottus bairdi*	Native
Slimy Sculpin	*Cottus cognatus*	Native
Spoonhead Sculpin	*Cottus ricei*	Native
Deepwater Sculpin	*Myoxocephalus thompsoni*	Native
TEMPERATE BASSES	PERCICHTHYIDAE (MORONIDAE)	
White Bass	*Morone chrysops*	Native
Yellow Bass	*Morone mississippiensis*	Native
SUNFISHES	CENTRARCHIDAE	
Rock Bass	*Ambloplites rupestris*	Native
Green Sunfish	*Lepomis cyanellus*	Native
Pumpkinseed	*Lepomis gibbosus*	Native
Warmouth	*Lepomis gulosus*	Native
Orangespotted Sunfish	*Lepomis humilis*	Native
Bluegill	*Lepomis macrochirus*	Native
Longear Sunfish	*Lepomis megalotis*	Native
Smallmouth Bass	*Micropterus dolomieu*	Native
Largemouth Bass	*Micropterus salmoides*	Native

Common Name	Scientific Name	Category in Becker (1983)
White Crappie	*Pomoxis annularis*	Native
Black Crappie	*Pomoxis nigromaculatus*	Native
PERCHES	PERCIDAE	
Crystal Darter	*Ammocrypta (Crystallaria) asprella*	Native
Western Sand Darter	*Ammocrypta clara*	Native
Mud Darter	*Etheostoma asprigene*	Native
Rainbow Darter	*Etheostoma caeruleum*	Native
Bluntnose Darter	*Etheostoma chlorosoma*	Native
Iowa Darter	*Etheostoma exile*	Native
Fantail Darter	*Etheostoma flabellare*	Native
Least Darter	*Etheostoma microperca*	Native
Johnny Darter	*Etheostoma nigrum*	Native
Banded Darter	*Etheostoma zonale*	Native
Yellow Perch	*Perca flavescens*	Native
Logperch	*Percina caprodes*	Native
Gilt Darter	*Percina evides*	Native
Blackside Darter	*Percina maculata*	Native
Slenderhead Darter	*Percina phoxocephala*	Native
River Darter	*Percina shumardi*	Native
Sauger	*Stizostedion canadense*	Native
Walleye	*Stizostedion vitreum*	Native
DRUMS	SCIAENIDAE	
Freshwater Drum	*Aplodinotus grunniens*	Native

ESTABLISHED NON-NATIVE SPECIES

LAMPREYS	PETROMYZONTIDAE	
Sea Lamprey	*Petromyzon marinus*	Established
HERRINGS	CLUPEIDAE	
Alewife	*Alosa pseudoharengus*	Established
MINNOWS	CYPRINIDAE	
Goldfish	*Carassius auratus*	Established
Common Carp	*Cyprinus carpio*	Established
SMELTS	OSMERIDAE	
Rainbow Smelt	*Osmerus mordax*	Established
TROUTS	SALMONIDAE	
Coho Salmon	*Oncorhynchus kisutch*	Established?

Common Name	Scientific Name	Category in Becker (1983)
Rainbow Trout	*Oncorhynchus mykiss*	Established
Kokanee/Sockeye Salmon	*Oncorhynchus nerka*	Transient
Chinook Salmon	*Oncorhynchus tshawytscha*	Established?
Brown Trout	*Salmo trutta*	Established
STICKLEBACKS	GASTEROSTEIDAE	
Threespine Stickleback	*Gasterosteus aculeatus*	Not known
TEMPERATE BASSES	PERCICHTHYIDAE (MORONIDAE)	
White Perch	*Morone americana*	Not known
PERCHES	PERCIDAE	
Ruffe	*Gymnocephalus cernuus*	Not known
GOBIES	GOBIIDAE	
Round Goby	*Neogobius melanostomus*	Not known

TRANSIENT NON-NATIVE SPECIES

HERRINGS	CLUPEIDAE	
American Shad	*Alosa sapidissima*	Transient
MINNOWS	CYPRINIDAE	
Grass Carp	*Ctenopharyngodon idella*	Transient
Red Shiner	*Cyprinella lutrensis*	Established?
Rainbow Sharkminnow	*Epalzeorhynchos frenatum*	Not known
Rudd	*Scardinius erythrophthalmus*	Transient
Tench	*Tinca tinca*	Transient
CHARACINS	CHARACIDAE	
"Pacu" or "Pirapatinga"	*Colossoma* or *Piaractus* sp.	Not known
Red? Piranha	*Pygocentrus nattereri?*	Not known
BULLHEAD CATFISHES	ICTALURIDAE	
Blue Catfish	*Ictalurus furcatus*	Not known[3]
LONGWHISKERED CATFISHES	PIMELODIDAE	
Redtail Catfish	*Phractocephalus hemioliopterus*	Not Known
TROUTS	SALMONIDAE	
Cutthroat Trout	*Oncorhynchus clarki*	Transient
Pink Salmon	*Oncorhynchus gorbuscha*	Established?

Common Name	Scientific Name	Category in Becker (1983)
Atlantic Salmon	*Salmo salar*	Transient
Arctic Grayling	*Thymallus arcticus*	Transient
LIVEBEARERS	POECILIIDAE	
Western Mosquitofish	*Gambusia affinis*	Not listed
Guppy	*Poecilia reticulata*	Transient
TEMPERATE BASSES	PERCICHTHYIDAE (MORONIDAE)	
Striped Bass	*Morone saxatilis*	Not known
CICHLIDS	CICHLIDAE	
Oscar	*Astronotus ocellatus*	Not known
"Tilapia"	*Tilapia* or *Oreochromis* sp.	Transient

[1] Becker (1983) considered *Notropis wickliffi* to be a subspecies of *Notropis volucellus*.

[2] The longjaw cisco *(Coregonus alpenae)* was considered a valid native species by Becker (1983) but is now considered a synonym of the shortjaw cisco *(Coregonus zenithicus)*.

[3] Becker (1983) considered early reports of the blue catfish *(Ictalurus furcatus)* from Wisconsin waters to be erroneous.

Table 2 – Changes in Scientific Names for Wisconsin Fishes since Becker (1983).

Common Name	Becker (1983)	Robins et al. (1991) Kendall (1997)	Mayden et al. (1992)
NATIVE SPECIES			
Spotfin Shiner	*Notropis spilopterus*	*Cyprinella spiloptera*	*Cyprinella spiloptera*
Gravel Chub	*Hybopsis x-punctata*	*Erimystax x-punctatus*	*Erimystax x-punctatus*
Striped Shiner	*Notropis chrysocephalus*	*Luxilus chrysocephalus*	*Luxilus chrysocephalus*
Common Shiner	*Notropis cornutus*	*Luxilus cornutus*	*Luxilus cornutus*
Redfin Shiner	*Notropis umbratilis*	*Lythrurus umbratilis*	*Lythrurus umbratilis*
Speckled Chub	*Hybopsis aestivalis*	*Macrhybopsis aestivalis*	*Extrarius aestivalis*
Silver Chub	*Hybopsis storeriana*	*Macrhybopsis storeriana*	*Macrhybopsis storeriana*
Pearl Dace	*Semotilus margarita*	*Margariscus margarita*	*Margariscus margarita*
Pallid Shiner	*Notropis amnis*	*Notropis amnis*	*Hybopsis amnis**
Sand Shiner	*Notropis stramineus*	*Notropis stramineus*	*Notropis ludibundus**
Pugnose Minnow	*Notropis emiliae*	*Opsopoeodus emiliae*	*Opsopoeodus emiliae*
Cisco/Lake Herring	*Coregonus artedii*	*Coregonus artedi*	*Coregonus artedi*
Black Bullhead	*Ictalurus melas*	*Ameiurus melas*	*Ameiurus melas*
Yellow Bullhead	*Ictalurus natalis*	*Ameiurus natalis*	*Ameiurus natalis*
Brown Bullhead	*Ictalurus nebulosus*	*Ameiurus nebulosus*	*Ameiurus nebulosus*
KILLIFISHES	CYPRINODONTIDAE	CYPRINODONTIDAE	FUNDULIDAE*
Starhead Topminnow	*Fundulus notti*	*Fundulus dispar*	*Fundulus dispar*
TEMPERATE BASSES	PERCICHTHYIDAE	PERCICHTHYIDAE	MORONIDAE*
Smallmouth Bass	*Micropterus dolomieui*	*Micropterus dolomieu*	*Micropterus dolomieu*
Crystal Darter	*Ammocrypta asprella*	*Ammocrypta asprella*	*Crystallaria asprella**
Western Sand Darter	*Ammocrypta clara*	*Ammocrypta clara*	*Etheostoma clarum*
Bluntnose Darter	*Etheostoma chlorosomum*	*Etheostoma chlorosoma*	*Etheostoma chlorosoma*
ESTABLISHED NON-NATIVE SPECIES			
Rainbow Trout	*Salmo gairdneri*	*Oncorhynchus mykiss*	*Oncorhynchus mykiss*
TRANSIENT NON-NATIVE SPECIES			
Red Shiner	*Notropis lutrensis*	*Cyprinella lutrensis*	*Cyprinella lutrensis*

We followed Robins et al. (1991) and Kendall (1997), but recognize that several of the Mayden et al. (1992) names (indicated by an asterisk) are likely to be adopted in the next version of the American Fisheries Society list of North American fish names.

Species Accounts

Native Species

Lampreys – Petromyzontidae

Chestnut Lamprey ***Ichthyomyzon castaneus***: Secure. Occasional to locally common in the St. Croix and Red Cedar Rivers; uncommon in the Mississippi, Wisconsin, Fox, and Wolf Rivers and their larger tributaries. Becker (1983) and Fago (1983, 1992) provided a number of records of this species from the upper Black River drainage. However, Lyons et al. (1997) re-examined their specimens and made several new collections and concluded that all records from above Lake Arbutus, Clark County, were actually southern brook lampreys.

Northern Brook Lamprey ***Ichthyomyzon fossor***: Secure. Occasional in streams and small rivers in the central and northern parts of the state, particularly in the Chippewa, middle Wisconsin, Wolf, and Menominee drainages. Becker (1983) and Fago (1992) listed several records for this species from the Wisconsin River drainage above Merrill, Lincoln County, but Lyons et al. (1997) determined that all of these were actually southern brook lampreys. Fago (1986) reported two records of the northern brook lamprey from the St. Croix River drainage, but Lyons et al. (1997) examined the specimens and concluded that they could not be identified to species with certainty. Recent collections from these two localities have yielded only the southern brook lamprey and chestnut lamprey. Cochran (1984) documented the first occurrence of the northern brook lamprey in the Illinois River drainage of southeastern Wisconsin, at a single site on the Mukwonago River, Waukesha County. Until the 1960s northern brook lampreys were common in some Lake Superior tributaries, especially the Bois Brule River, Douglas County (Churchill 1945, UWZM specimens). Their distribution and abundance there have been greatly reduced by lampricide treatments designed to eliminate sea lamprey, although a few small populations may persist (Schuldt and Goold 1980, DuBois and Pratt 1994).

Southern Brook Lamprey ***Ichthyomyzon gagei***: Secure. Occasional to locally common in streams and rivers of the St. Croix, upper Black, and upper Wisconsin drainages. New since Becker (1983). See color plate 1 and the distribution map in figure 2.

The southern brook lamprey's geographic range was believed to be limited to the southern United States. It was unexpected, therefore, when Cochran (1987) reported this species from the St. Croix River drainage of Wisconsin and Minnesota, over 900 km north of the nearest previously reported population in southern Missouri. Because of the possibility that the widely disjunct northern populations represented a distinct species, subsequent reports on their geographic distribution, biology, and taxonomy (Cochran and Pettinelli 1988, Cochran and Gripentrog 1992, Lyons 1992, Lyons et al. 1997) sometimes referred to the northern lampreys provisionally as *Ichthyomyzon* cf. *gagei*. Recent morphological (Lyons et al. 1997) and molecular genetic (Mundahl et al. 1997) analyses, however, point to the conservative conclusion that the northern lampreys are conspecific with *Ichthyomyzon gagei* from the southern United States. In the account that follows, information on southern populations has been used to supplement what is known about *Ichthyomyzon gagei* in Wisconsin.

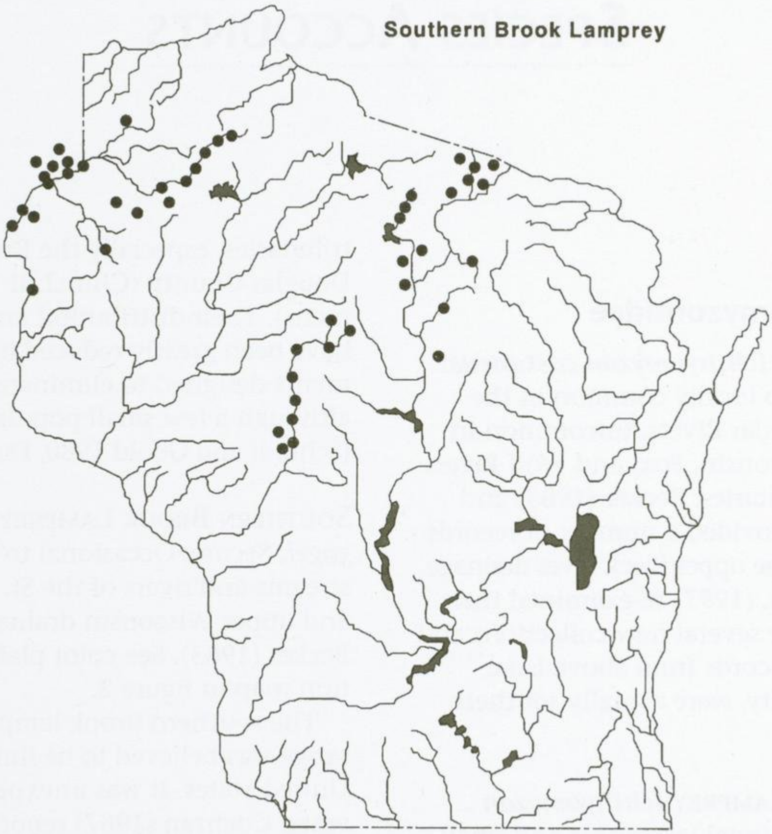

Figure 2. Map of the distribution of southern brook lamprey in Wisconsin.

Description: The southern brook lamprey, a nonparasitic species, is thought to be an evolutionary derivative of the parasitic chestnut lamprey (*Ichthyomyzon castaneus*) (Hubbs and Trautman 1937). Both possess a single dorsal fin more or less divided by a shallow notch into two lobes, and they have a similar number of trunk myomeres. Extreme counts of 48 and 59 trunk myomeres have been reported for southern brook lampreys by Hall and Moore (1954) and Dendy and Scott (1953), but the range of 52–56 reported by Page and Burr (1991) is more typical. In addition, both species typically possess at least some circumoral teeth that are bicuspid. For example, among 100 southern brook lampreys from throughout the southeastern United States, Dendy and Scott (1953) found the number of bicuspid circumoral teeth to range from 0 to 10, with a mean of 5.5. Unlike the chestnut lamprey, the southern brook lamprey has an oral disc narrower than its head, and it does not achieve a maximum length greater than approximately 160 mm. The southern brook lamprey can be distinguished from the northern brook lamprey (*Ichthyomyzon fossor*) most easily by its bicuspid circumoral teeth. In addition, its teeth are generally more strongly developed than the short, blunt teeth of the northern brook lamprey. Large ammocoetes of the two species can be distinguished by their lateral line pores; those of the southern brook lamprey are much darker than their background.

Southern brook lampreys from Wisconsin and Minnesota appear similar to those from the southern United States (color plate 1) (Cochran 1987, Lyons et al. 1997). However, spawning males from the two regions differ in the average relative length of their urogenital papillae, a feature found by Kott et al. (1988) to be of general use in distinguishing among male nonparasitic lampreys. Breeding males from the southern United States had urogenital papillae that averaged 27.6% of their branchial lengths (Kott et al. 1988), whereas those from the northern United States averaged only 17.6% (Sneen and Cochran 1990). More recent analysis (Lyons et al. 1997) confirmed the difference in mean urogenital papilla length and also revealed that southern brook lampreys from the northern United States have a greater median number of bicuspid circumoral teeth (7 vs. 6), a greater mean branchial length (10.7% of total length vs. 10.4%), a greater mean eye length (1.5% of total length vs. 1.2%), a greater mean tail length (30.4% of total length vs. 29.2%), and a smaller mean snout length (5.8% of total length vs. 6.7%). Although these differences are statistically significant, overlap in the distribution of individual measurements is extensive enough that it is often impossible to place a particular specimen into one of the two groups with certainty. The 99 preserved lampreys from Wisconsin examined by Lyons et al. (1997) had a mean total length of 121 mm, whereas 51 specimens from Minnesota averaged 110 mm (Cochran and Pettinelli 1988). For the Minnesota specimens, however, it was found that preservation resulted in a reduction of mean total length by 7.6% from that of living animals.

Mundahl et al. (1997) used analyses of random amplified polymorphic DNA to compare southern brook lampreys from Minnesota with those from the southern United States and with the chestnut lamprey, the presumed ancestor to both groups. The two groups of brook lampreys were similar to each other, much more so than either was to the chestnut lamprey, and Mundahl et al. (1997) concluded that they resulted from the same speciation event rather than representing two independent offshoots from the chestnut lamprey.

Distribution, Status, and Habitat: The geographic range of the southern brook lamprey is centered in the southern United States, where it is found in river systems that drain to the Gulf of Mexico from northern Florida, Georgia, Tennessee, and Kentucky, west to southern Missouri, eastern Oklahoma, and Texas (Rohde and Lantéigne-Courchene 1980). The disjunct northern range was initially known to include only tributaries of the St. Croix River above St. Croix Falls in Wisconsin and Minnesota (Cochran 1987, Cochran and Pettinelli 1988, Cochran and Gripentrog 1992), and that understanding was reflected in the ranges plotted by Page and Burr (1991) and Etnier and Starnes (1993). However, Lyons et al. (1997) showed that the range in Wisconsin was much wider than first suspected, also encompassing parts of the Black and Wisconsin River drainages. In 1996, a southern brook lamprey was captured from the St. Croix River below St. Croix Falls in Washington County, Minnesota (Konrad Schmidt, Native Fish Conservancy, St. Paul, MN, personal communication). Southern brook lampreys are now known from numerous locations within the St. Croix River drainage, the Black River drainage above Lake Arbutus, and the Wisconsin River drainage above Wausau (figure 2). Previously collected specimens from these areas had been misidentified as *I. castaneus* or *I. fossor* (Lee et al. 1980, Becker 1983, Fago 1992).

Although the southern brook lamprey is apparently easy to overlook within its range in Wisconsin, it is common at many localities, and its status seems secure. The species was formerly given special concern status by the WDNR, but this was because of uncertainties concerning its taxonomic status and distribution, not concerns about abundance. One of the southern brook lamprey's strongholds is the Namekagon River, which receives protection as part of the United States Wild and Scenic River Program.

In the southern United States, the southern brook lamprey inhabits streams of small to medium size (Rohde and Lantéigne-Courchene 1980). Some are of relatively high gradient

(Boschung 1989), whereas others are typified by slow to moderate current (Pierson et al. 1989). In the north, southern brook lampreys have been found not only in small streams less than two meters wide but also in rivers as large as the St. Croix, where they inhabit nearshore areas along channels greater than 100 m wide. Throughout its range, this species tends to be found where the water is shallow (less than one meter), clear, and in many cases, stained (Dendy and Scott 1953, Swift et al. 1977, Cochran 1987, Cochran and Pettinelli 1988). Water temperatures in some streams inhabited by southern brook lampreys in the southern United States may reach at least 26°C for short periods (Beamish 1982), but in 19 such streams estimated annual mean temperatures ranged from 14.6°C to 20.9°C (Beamish et al. 1994). In the north, southern brook lampreys have been collected not only in warm-water streams but also in waters cold enough to support trout.

Streams that flow through localized areas of high gradient contain the complete range of habitats used by southern brook lampreys throughout their life cycle. Spawning occurs in the vicinity of gravel bars and riffles, although relatively deep areas with swift current over boulders and rocks provide crevices that are sometimes used for spawning (Cochran and Gripentrog 1992) and possibly for overwintering. Regions of slower current and finer substrate downstream or in side channels and backwaters provide habitat for the burrowing ammocoetes, although ammocoetes have also been reported from silt pockets behind obstructions in main channels (Suttkus 1961).

Biology: The biology of southern brook lampreys in the Upper Midwest is not yet well known. However, they have been studied extensively in the southern United States (Beamish 1982, 1993, Beamish and Jebbink 1994, Beamish and Legrow 1983, Beamish and Thomas 1983, 1984, Beamish and Medland 1988, Beamish et al. 1994, Dendy and Scott 1953, Hall and Moore 1954, Medland and Beamish 1991, Moshin and Gallaway 1977).

Spawning by southern brook lampreys in the southern United States generally peaks in mid-April (Beamish 1993) but can occur as late as late May (Pierson et al. 1989). Southern brook lampreys were found spawning in Minnesota in late May and early June at water temperatures of 17–21°C (Cochran and Pettinelli 1988) and in Wisconsin at 15–22°C (Cochran and Gripentrog 1992). A cool spring in 1997 apparently delayed spawning in the Namekagon River in Sawyer and Bayfield Counties; at sites where no adults were observed during the period 29–31 May, spawning was observed 6–11 June, with a few stragglers as late as 13 June. In 1998, a more typical spring, spawning occurred at the same sites by 26 May. Aggregations of as many as 40 individuals of both sexes move gravel with their oral discs to create spawning pits, typically on gravel bars or just above riffles. Spawning sometimes occurs in cavities beneath boulders or other cover objects, often in reaches that are deeper and faster than where spawning occurs in the open. Southern brook lampreys sometimes form mixed spawning aggregations with chestnut lampreys (Cochran and Gripentrog 1992). Beamish (1982) found that some individuals in Alabama migrated upstream at least one km to spawn. Females from Minnesota contained 0–1254 eggs (Cochran and Pettinelli 1988), but they may already have spawned some eggs; Dendy and Scott (1953) and Beamish and Thomas (1983) reported a range of 1000–3264 oocytes in females from the southern United States prior to spawning. Fecundity in the south increases with total length, but both fecundity and egg size vary among localities (Beamish et al. 1994). At any particular locality, the spawning period is brief (< 1 week) and ends abruptly (Cochran and Pettinelli 1988). Where dozens of spawning lampreys are found on one day, only a few dead or moribund stragglers might be found two days later. The collection of an adult male on 23 June 1989 in the Moose River, Douglas County (St. Croix River drainage) (UWZM 9736), suggests that spawning may be delayed in this and other relatively cold streams.

The biology of larval southern brook lampreys in the north has not been examined, but some information is available for those in the southern United States. Larvae are most abundant where fine sediment (<0.15 mm in diameter) contributes at least 40% to the dry weight of the substrate and very coarse sand (1.0–2.0 mm) at least 8% (Beamish and Jebbink 1994). Ammocoetes feed primarily on phytoplankton and organic detritus (Moshin and Gallaway 1977); the recent implication that they feed on invertebrates (Winemiller 1991, 1992) is inaccurate. The larval period lasts roughly three or four years (Beamish 1982, Beamish and Medland 1988). Moshin and Gallaway (1977) reported seasonal changes in condition (weight at a given length) of ammocoetes from a Texas stream, possibly related to seasonal differences in quality and quantity of food. Beamish (1982) reported that the ammocoetes he studied in Alabama grew at an even rate throughout the year, so that annuli were not recognizable in their statoliths (Beamish and Medland 1988), but he subsequently identified annuli in larvae from one Alabama creek out of the twenty southern streams that he examined (Beamish 1993). Annuli were induced in larvae held under a seasonal thermal regime simulating that of a northern stream (Medland and Beamish 1991). We suspect that ammocoetes in the relatively harsh, seasonal Wisconsin climate will be found to display annuli in their statoliths, and it would not be surprising if they take longer to complete the larval phase than those in the south. Sex ratio in 20 populations of larvae in the southeastern United States ranged from 9% to 49% male (Beamish 1993), and the ratio apparently varied with environmental factors.

Beamish and Thomas (1984) described stages in the metamorphosis of southern brook lampreys in Alabama, with mature adults assigned to stage 8. Seven transforming individuals collected in St. Croix River tributaries in late October had reached stages 5–7.

Adult southern brook lampreys have been collected along with over thirty other fish species in Wisconsin and Minnesota. Frequent ecological associates include common shiners (*Luxilus cornutus*), longnose dace (*Rhinichthys cataractae*), hornyhead chubs (*Nocomis biguttatus*), johnny darters (*Etheostoma nigrum*), and mottled sculpins (*Cottus bairdi*). In the southern United States, southern brook lampreys may occur with other species of brook lampreys, but in Wisconsin and Minnesota their distribution is apparently complementary to northern brook lamprey (*Ichthyomyzon fossor*) and American brook lamprey (*Lampetra appendix*) (Lyons et al. 1997). The distribution pattern in Wisconsin and Minnesota implies that barriers to upstream movement may have prevented northern and American brook lampreys from successfully colonizing areas now occupied by southern brook lampreys. It would appear that southern brook lampreys reached the upper Mississippi River basin first, but that they have been replaced wherever the other species have managed to colonize.

Importance and Management: Although no information is available on the predators of southern brook lampreys, brown trout (*Salmo trutta*) and other gamefishes are known to prey on northern brook lampreys in Wisconsin (Cochran et al. 1992), and they undoubtedly capture southern brook lampreys as well, especially during the spawning season when adult lampreys are most exposed.

Some human activities may indirectly benefit southern brook lampreys. As noted by Cochran and Pettinelli (1988), they often occur in microhabitats associated with bridge crossings (in one case bridge reconstruction had occurred only a few years previously). In the Namekagon River, groups of adults can be predictably located during the spawning season where boulders and cobble have been arranged in V-shaped chutes that point downstream and provide deeper water for passing canoes. The lampreys take advantage of crevices along the upstream faces of these structures.

SILVER LAMPREY ***Ichthyomyzon unicuspis***: Secure. Uncommon to occasional in the Mississippi River and the lower reaches of its largest tributaries, with a large population below the Prairie du Sac Dam on the Wisconsin River. Also occasional in the Lake Winnebago – Fox River – Wolf River system and Green Bay.

AMERICAN BROOK LAMPREY ***Lampetra appendix***: Secure. Occasional to locally common in cold to coolwater streams and small rivers of the southern two-thirds of the state. Fago (1983, 1984a, 1985b, 1992) provided many new records of this species from tributaries of the Mississippi, Chippewa, and Wisconsin Rivers in the western portion of the state, indicating that this species is much more widespread than previously believed. Similarly, Fago (1985b, 1992) and Cochran et al. (1993) provided many new records from the Lake Michigan basin in northeastern Wisconsin. The captures of a specimen (UWZM 10729) from Lancaster Brook, Brown County, in 1996 and another from its tributary Thornberry Creek in 1999 support the hypothesis that the American brook lamprey used the Wisconsin River-Fox River connection to disperse into the Lake Michigan drainage, in addition to the routes suggested by Bailey and Smith (1981). Cochran (1984) and Fago (1984b) documented the presence of American brook lamprey in the Mukwonago River, Waukesha County, the first record from the Wisconsin portion of the Illinois River drainage. Lyons et al. (1997) provided an up-to-date distribution map for this species.

Sturgeons – Acipenseridae

LAKE STURGEON ***Acipenser fulvescens***: Special concern. Generally uncommon in the larger rivers of the state and in nearshore areas of the Great Lakes, but locally common within the Lake Winnebago-Fox River-Wolf River system. Statewide, populations appear to be stable. Cochran (1995) reported lake sturgeon in the lower Fox River, Brown County, and observations in subsequent years revealed groups of fish apparently engaged in spawning behavior where they had not been reported since newspaper accounts in the late 1800s (Cochran and Pecora, manuscript in review). In 1983, an effort began to re-introduce lake sturgeon into the St. Louis River, a tributary of Lake Superior that forms the Minnesota/Wisconsin border near the city of Superior, Douglas County (Schramm et al. 1999). Lake sturgeon had been eliminated from this river and adjacent areas of Lake Superior by the early 1900s because of overexploitation, water pollution, and habitat alteration. From 1983–1994, 736,000 lake sturgeon fry, 128,000 fingerlings, and 500 yearlings of the Lake Winnebago strain were stocked. After stocking began, a population of lake sturgeon developed in the river, in Duluth-Superior Harbor, and in western Lake Superior, with stocked fish reported as far east as the Apostle Islands and as far north as the Canadian border. No spawning of stocked fish has yet been reported, which is not surprising given that female lake sturgeon may take 15–20 years or more to mature. In the early 1990s, programs began to re-introduce lake sturgeon into two river segments from which they had been extirpated — the Wisconsin River between Wisconsin Rapids, Wood County, and Stevens Point, Portage County (Tim Larson, WDNR, Poynette, personal communication), and the Wolf River between the Balsam Row Dam, Shawano County, and Keshena Falls, Menominee County (Ron Bruch, WDNR, Oshkosh, personal communication). Lake sturgeon have also been stocked into several lakes in the Wolf River system of Menominee County where they had not been found historically: Upper Bass Lake, Neopit Millpond, and Legend Lake. However, it is too early to judge the success of any of these introductions.

SHOVELNOSE STURGEON ***Scaphirhynchus platorhynchus***: Secure. Occasional in the Mississippi, lower Wisconsin, lower Chippewa, and lower Red Cedar Rivers.

Paddlefishes – Polyodontidae

PADDLEFISH ***Polyodon spathula***: Threatened. Uncommon in the Mississippi River and the lower reaches of its largest tributaries, although there are small areas within the Wisconsin, Black, and Chippewa Rivers where paddlefish are locally common. Graham (1997) reported that paddlefish populations in Wisconsin were increasing, presumably based on an unpublished U.S. Fish and Wildlife Service survey of biologists and commercial fishermen. Lyons (1993) documented the disappearance of paddlefish from the Wisconsin River above the Prairie du Sac Dam, Sauk/Columbia Counties, and made the first crude population estimates for the large paddlefish concentration below the dam: 3600 to 4720 individuals greater than 5 kg in 1988 and 1989. Runstrom (1996) provided more accurate and precise population estimates of from 540 to 1714 individuals during 1993 and 1994. Zigler et al. (1999) documented diel movement and habitat use patterns of adult paddlefish in Pool 8 of the Mississippi River. Jennings and Wilson (1993) published the first evidence for successful spawning by paddlefish in Wisconsin waters based on the occurrence of yearling paddlefish in the lower Black River at Mississippi River Pool 8 in LaCrosse County. In 1997, federal government biologists captured single newly hatched larval paddlefish from the Chippewa River in Dunn County and in Buffalo/Pepin Counties, and from the Wisconsin River in Iowa County. Another larval paddlefish was collected from the Chippewa River at the Dunn County site in 1998 (Ann Runstrom, U.S. Fish and Wildlife Service, Onalaska, WI, personal communication).

Gars – Lepisosteidae

LONGNOSE GAR ***Lepisosteus osseus***: Secure. Occasional in lakes and rivers of the southern two-thirds of the state.

SHORTNOSE GAR ***Lepisosteus platostomus***: Secure. Occasional in the Mississippi River and the lower reaches of its largest tributaries as well as the Lake Winnebago – Fox River – Wolf River system and Green Bay.

Bowfins – Amiidae

BOWFIN ***Amia calva***: Secure. Occasional in lakes and rivers of the southern two-thirds of the state; uncommon in the northern third.

Mooneyes – Hiodontidae

GOLDEYE ***Hiodon alosoides***: Endangered. Uncommon in the Mississippi River and the lower reaches of its largest tributaries. Recent trends in abundance are uncertain. The few confirmed records since Becker (1983) are from the lower Wisconsin River in Sauk and Crawford Counties and its tributary the Kickapoo River in Crawford County (Fago 1992, WDNR unpublished data) and from the Mississippi River in Pools 11, 9, 8, 5A, and 4 (EMTC 1998; Greg Seegert, EA Science, Engineering, and Technology, Deerfield, Illinois, personal communication; Schmidt, personal communication; WDNR unpublished data and photographs).

MOONEYE ***Hiodon tergisus***: Secure. Occasional in the Mississippi River and the lower reaches of its larger tributaries, the Lake Winnebago – Fox River – Wolf River system, and lower Green Bay.

Freshwater eels – Anguillidae

AMERICAN EEL ***Anguilla rostrata***: Special concern. Uncommon in the larger rivers of the state and the Great Lakes. Statewide population trends are uncertain. Cochran (1981) reported an unusually small (157 mm total length) American eel from the Blackhoof River, Minnesota, in the Lake Superior basin. This specimen must have accessed the Blackhoof River from the St. Louis River, which forms the Wisconsin-Minnesota border near Superior, Douglas County. All other eels reported from Wisconsin have been much larger, from 350 mm to more than 1000 mm (Becker 1983). Although

Cochran (1981) assumed that this American eel had swum all the way from the ocean, an alternative possibility is that it arrived in ballast water from an oceangoing ship that had visited Duluth-Superior Harbor. Ballast water transport of fish has been blamed for the arrival of several non-native fishes in the Great Lakes, including the ruffe (*Gymnocephalus cernuus*) in Duluth-Superior Harbor. X-radiography of the Blackhoof River specimen allowed vertebral count estimates (< 110) that are more consistent with those of American eels than with those of the European eel *(Anguilla anguilla)*, but the possibility remains that the Blackhoof River eel was picked up along the U.S. coastline by an oceangoing vessel and then transported inland. We have records of several adult eels from Lake Superior and Lake Michigan since Becker (1983); these eels probably arrived by swimming from the ocean.

Herrings – Clupeidae

SKIPJACK HERRING ***Alosa chrysochloris***: Endangered. Uncommon in the Mississippi River and Lake Michigan. This species was believed by Becker (1983) to be extirpated because no specimens had been reported from the state since about 1950. However, in 1984, a commercial fisherman captured a specimen from Mississippi River Pool 10 near Prairie du Chien, Crawford County (Thiel 1985). From 1986 to 1996, a few additional specimens were encountered in Pools 8, 5, and 4 (EMTC 1998, WDNR unpublished data), usually during years with higher than normal flows when upstream movement in the Mississippi was presumably easier. In 1989 a skipjack herring was captured by a commercial fisherman from Green Bay in Kewaunee County; in 1991 another was taken from Lake Michigan in Kenosha County; and in 1992 a third was encountered in Lake Michigan in Door County (Fago 1993). These were the first records of this species from the Great Lakes basin. Since 1995 there have been an average of one or two skipjack herring seen per year in the WDNR monitoring of the commercial fishery in Green Bay and Lake Michigan (Steve Hogler, WDNR, Mishicot, personal communication). The skipjack herring probably entered Lake Michigan via canals that connect with the Mississippi River basin at Chicago. All skipjack herring in Wisconsin waters are believed to be migrants from established populations further to the south.

GIZZARD SHAD ***Dorosoma cepedianum***: Secure. Common in the Mississippi River and the lower reaches of its larger tributaries, the Lake Winnebago – Fox River – Wolf River system, and Green Bay. Uncommon to occasional in bays and harbors of Lake Michigan.

Minnows—Cyprinidae

CENTRAL STONEROLLER ***Campostoma anomalum***: Secure. Common in rocky streams in the southern half of the state, and occasional in streams of the lower portions of the Chippewa and St. Croix drainages in northwestern Wisconsin.

LARGESCALE STONEROLLER ***Campostoma oligolepis***: Secure. Common in rocky streams in the northern half of the state, although absent from the Lake Superior basin; uncommon to occasional in streams of the southern half of the state.

REDSIDE DACE ***Clinostomus elongatus***: Special concern. Uncommon to occasional in coolwater streams in the southern two-thirds of Wisconsin. Redside dace appear to have generally stable populations in the state. They are more widespread than indicated by Becker (1983) in the upper Wisconsin River drainage, upper Kickapoo River system (tributary to lower Wisconsin River), and upper Eau Claire River system (Chippewa River drainage)(Fago 1992, WDNR unpublished data). Additional populations have recently been discovered in the Eau Galle River, St. Croix County, its tributary Cady Creek, Pierce County (Chippewa River drainage), and the Rush River, St. Croix and Pierce Counties (Mississippi

River tributary) (Fago 1992; Schmidt, personal communication; WDNR unpublished data). However, redside dace populations have apparently disappeared from Syfestad, Deer, Fries Feeder, and Flynn Creeks, Dane County (Rock River drainage)(WDNR unpublished data). Reasons for these disappearances are uncertain, but in Deer and Fries Feeder Creeks, loss of redside dace was associated with expansion of piscivorous brown trout (*Salmo trutta)* populations into the headwater habitats used by the redside dace.

LAKE CHUB ***Couesius plumbeus***: Secure. Uncommon to occasional in nearshore areas of the Great Lakes and the lower reaches of tributaries.

SPOTFIN SHINER ***Cyprinella spiloptera***: Secure. Common in larger streams and rivers throughout Wisconsin, although absent from the Lake Superior basin; uncommon to occasional in inland lakes.

GRAVEL CHUB ***Erimystax x-punctatus***: Endangered. Uncommon in lower Turtle Creek and localized areas of the Pecatonica, Sugar, and Rock Rivers in southern Wisconsin. Populations appear to be stable. Surveys in the mid-1980s revealed no major changes in distribution or relative abundance since the mid-1970s (WDNR unpublished data). In 1991, the WDNR stocked gravel chubs into the Rock River at Janesville, Rock County, but this attempt to establish a new population was apparently unsuccessful.

BRASSY MINNOW ***Hybognathus hankinsoni***: Secure. Occasional in small streams and beaver ponds statewide.

MISSISSIPPI SILVERY MINNOW ***Hybognathus nuchalis***: Secure. Uncommon to occasional in the Mississippi River and the lower reaches of its larger tributaries. Torreano (1998) indicated that this species had declined greatly in abundance in Mississippi River Pool 8 since the 1940s. However, long-term trends for this species in Wisconsin are difficult to determine. We and others (EMTC 1998; Seegert, personal communication) have found the Mississippi silvery minnow to vary dramatically in abundance from year to year in the Mississippi River. Periods of low numbers are more common than periods of relatively high numbers. In most years the species is uncommon, but in some years it is encountered regularly.

STRIPED SHINER ***Luxilus chrysocephalus***: Endangered. Uncommon in a small area of the Milwaukee River north of the city of Milwaukee. In recent years this species has declined so much that it is nearly extirpated from the state. Historically, the striped shiner was sporadically distributed in low numbers across southern and eastern Wisconsin, with a stronghold in the Milwaukee River drainage (Lake Michigan basin). By the mid-1970s it had disappeared from many localities and become less common in the Milwaukee River drainage but still persisted in moderate numbers in the lower part of the drainage in Milwaukee and Ozaukee Counties (12 localities; >100 specimens) and was rare (single individuals) at four other localities in southeastern Wisconsin (Fago 1982 and 1984b, Becker 1983, WDNR unpublished data). During the mid-1990s, WDNR crews resampled all Wisconsin striped shiner sites in southeastern Wisconsin (some on multiple occasions), plus many other sites in the region, and were able to collect only one individual (released) from the Milwaukee River, Ozaukee County. The cause of this precipitous decline in distribution and abundance is unknown but may relate to the cumulative impacts of many years of poor agricultural practices plus the increasing urban development of watersheds in southeastern Wisconsin.

COMMON SHINER ***Luxilus cornutus***: Secure. Common in streams, small rivers, and lakes throughout the state.

REDFIN SHINER *Lythrurus umbratilis*: Threatened. Uncommon in small to medium-sized rivers at widely scattered localities in the southern two-thirds of Wisconsin. Recent trends in abundance are uncertain. Since Becker (1983), redfin shiners have been collected in small numbers from the Milwaukee River, Ozaukee County, and its tributary Cedar Creek, Washington County; the Suamico River, Brown County (Green Bay tributary); Willow Creek, the Pine River, and Austin Creek, Waushara County (Fox River drainage); the Hay River, Dunn County (Chippewa River drainage); Seeley Creek, Sauk County (Wisconsin River drainage); and the Crawfish River, Dodge County and Sugar River, Green County (Rock River drainage) (Fago 1992, WDNR unpublished data).

SPECKLED CHUB *Macrhybopsis aestivalis*: Threatened. Uncommon in the Mississippi, lower Wisconsin, and Wolf Rivers. Abundance appears to be stable. Most speckled chub sites mapped by Becker (1983) also yielded speckled chubs when sampled in the 1980s or 1990s. In 1994 and 1995, several specimens were collected from the Wolf River (Fox River drainage), Shawano County (WDNR unpublished data, UWZM 11072), constituting the first record of this species from the Great Lakes basin. We believe that the Wolf River specimens represent a previously unknown native population rather than a recent introduction. The Wolf River has not been thoroughly sampled for nongame fishes and has extensive areas of shallow, shifting-sand bottom that are ideal habitat for the speckled chub. Moreover, the speckled chub, although widespread in the Mississippi and lower Wisconsin Rivers, is a rare, small, and difficult-to-catch species, and it seems highly unlikely that it would be transported by anglers to the Wolf River for use as bait. We hypothesize that the speckled chub entered the Great Lakes basin long before European settlement of Wisconsin through a natural but sporadic high-water connection between the Wisconsin and Fox Rivers that formerly existed at Portage, Columbia County (Becker 1983, Durbin 1997). Speckled chub occur in the Wisconsin River at Portage (Becker 1983, Fago 1992), and if they were able to move into the Fox, there would have been no natural barriers to prevent them from reaching the Wolf River. Alternatively, the speckled chub could have reached the Fox River more recently via the Portage Canal, which was built to connect the Wisconsin and Fox Rivers about 160 years ago.

SILVER CHUB *Macrhybopsis storeriana*: Special concern. Uncommon to occasional in the Mississippi, lower Wisconsin, Pecatonica, and Sugar Rivers and the lower reaches of their tributaries. There are relatively few records of silver chubs since Becker (1983), but the species may be more common than collection data suggest. Silver chubs occupy large river habitats that are difficult to sample. They are found mainly in deeper areas of the main channel and large side channels of the Mississippi and lower Wisconsin Rivers (Becker 1983, WDNR unpublished data), although juveniles are sometimes captured in backwaters (UWZM specimens). Statewide population trends are uncertain. Fago (1992) mapped a highly disjunct 1969 record of silver chub from the North Fork of the Jump River, Price County (Chippewa River drainage), far upstream from any other populations of this species. We consider this record erroneous. No specimens are extant. The habitat in the North Fork of the Jump River – a medium-sized, shallow, infertile, stained-water stream – is atypical for the silver chub. The North Fork Jump River collection was attributed to University of Wisconsin–Stevens Point students. However, Becker (1983) was a professor at the university during that period, taught ichthyology, and was in charge of the fish collection, yet made no mention of this record.

PEARL DACE *Margariscus margarita*: Secure. Occasional to locally common in low-gradient streams, beaver ponds, and small lakes in the northern half of Wisconsin; uncommon to occasional in the southern half.

HORNYHEAD CHUB ***Nocomis biguttatus***: Secure. Common in rocky warmwater streams and rivers statewide.

GOLDEN SHINER ***Notemigonus crysoleucas***: Secure. Occasional in inland lakes and low-gradient streams statewide.

PALLID SHINER ***Notropis (Hybopsis) amnis***: Endangered. Uncommon in the Mississippi River. In recent years the pallid shiner has declined to the point that it is nearly extirpated from the state. In the 1940s, the pallid shiner was common in the Mississippi River and occurred occasionally in the lower reaches of tributaries (Becker 1983, Torreano 1998, UWZM specimens). It had disappeared from the tributaries and become uncommon in the Mississippi River by the 1970s (Fago 1992). In 1976, the FDS collected a total of 235 pallid shiners from 23 locations in Mississippi River Pools 10, 11, and 12, Grant and Crawford Counties, and in 1979 they caught 2 specimens from 2 locations in Pool 9, Crawford County (WDNR unpublished data). During 1995–1999 the WDNR sampled all 25 of these locations (5 on multiple occasions) plus other nearby sites in the Mississippi River and its tributaries, and caught only one pallid shiner, in Cassville Slough in Pool 11, Grant County, in 1999 (UWZM 11215). The capture site had been sampled for pallid shiner five times previously without success during 1995–1998. During intensive annual seining (>50 collections per year) from 1989–1996, a total of 16 pallid shiners were collected from Mississippi River Pool 8, and 1 from Pool 4 (EMTC 1998).

The recent decline in pallid shiner numbers was associated with an increase in the abundance of channel shiners (*Notropis wickliffi*). Pallid and channel shiners are similar in appearance and occupy the same general habitat types in the Mississippi River (see channel shiner account), although they are found together relatively infrequently. In a seining survey of 47 sites in Pools 3–10 of the Mississippi River during 1944–48, 467 pallid shiners were captured from 36 sites (77%) and 74 channel shiners were captured from 15 sites (32%), but the two species co-occurred at only 5 sites (11%) (Torreano 1998, UWZM specimens). In 1976 and 1979, the FDS seined 126 sites in Pools 9–12 and collected 245 pallid shiners from 25 sites (20%) and 91 channel shiners from 22 sites (17%), but the two species were found together at only 2 sites (2%) (WDNR unpublished data). During our seining surveys of Pools 9–12 in 1995–99, we made 62 collections from 47 sites and captured a single pallid shiner at 1 site (2%) and 1975 channel shiners in 34 collections (55%) from 27 sites (57%) (WDNR unpublished data). No channel shiners were captured with the pallid shiner.

PUGNOSE SHINER ***Notropis anogenus***: Threatened. Uncommon in lakes and small low-gradient rivers at widely scattered localities statewide. Population trends are uncertain. A new pugnose shiner locality discovered since Becker (1983) is the Manitowish River system, Iron and Vilas Counties (Chippewa River drainage), with records from the Manitowish River, Manitowish Lake, and the Trout River (Lyons 1988, WDNR unpublished data, UWZM 9804, 11192). However, the species has apparently been eliminated from Rock Lake and Lake Ripley, Jefferson County (Rock River drainage), where it had been found during the mid-1970s (Dave Marshall, WDNR, Dodgeville, personal communication; WDNR unpublished data). The disappearance of pugnose shiners from these lakes may have been caused by loss of habitat from lakeshore development and destruction of native littoral-zone macrophyte communities. Pugnose shiners typically inhabit the well-vegetated shallow margins of lakes and streams and are highly sensitive to environmental modifications (Becker 1983, Lyons 1989a, 1992).

Emerald Shiner ***Notropis atherinoides***: Secure. Common in large rivers, a few large inland lakes, nearshore areas of Lake Superior, and the lower reaches of their tributaries. Uncommon in nearshore areas of Lake Michigan.

River Shiner ***Notropis blennius***: Secure. Common in the Mississippi River and the lower reaches of its larger tributaries. Occasional in Lake Winnebago. Uncommon at single locations on the Rock River (Fago 1982) and its tributary the Oconomowoc River (UWZM 9092) in southeastern Wisconsin.

Ghost Shiner ***Notropis buchanani***: Extirpated. Becker (1983) and Fago (1992) also considered this species to be extirpated. We have encountered no confirmed records of its recent occurrence in Wisconsin waters. Reports that the species persists in low numbers in Mississippi River Pools 11 and 12 (UMRCC 1983, Eckblad 1986) are unsubstantiated, and we consider them erroneous.

Ironcolor Shiner ***Notropis chalybaeus***: Extirpated. Becker (1983) considered this species to be extirpated from Wisconsin, and we concur. We resampled the two historic localities for the species in the state, Blake Creek, Waupaca County (Fox River drainage), and the Fox River, Columbia County, as well as many other nearby sites, and failed to collect specimens.

Bigmouth Shiner ***Notropis dorsalis***: Secure. Occasional to common in small streams and uncommon in rivers in the southern two-thirds of Wisconsin.

Blackchin Shiner ***Notropis heterodon***: Secure. Occasional to locally common in lakes and low-gradient streams statewide; largely absent from southwestern Wisconsin, and most frequently encountered in northern Wisconsin. Lyons (1989a) documented the loss of this species and the blacknose shiner (*Notropis heterolepis*) from Lake Mendota, Dane County, and Pewaukee Lake, Waukesha County, where they were both once common. He also noted the apparent disappearance of blackchin and blacknose shiners from Lake Wingra, Dane County, but recent intensive sampling indicates that small populations of both species still persist there (Center for Limnology, University of Wisconsin–Madison, unpublished data, courtesy of John Magnuson). Blackchin and blacknose shiners may have been eliminated from Rock Lake and Lake Ripley, Jefferson County, since the mid-1970s (Marshall, personal communication; WDNR unpublished data). The blackchin and blacknose shiner are sensitive to habitat modifications and environmental degradation of their preferred habitats, which are well-vegetated, nearshore areas of lakes and slow-moving streams (Becker 1983, Lyons 1989a and 1992). The littoral zones of all five lakes have been greatly altered over the last 35 years (Lyons 1989a, WDNR unpublished data).

Blacknose Shiner ***Notropis heterolepis***: Secure. Occasional to locally common in lakes and low-gradient streams statewide; largely absent from southwestern Wisconsin, and most frequently encountered in northern Wisconsin. See blackchin shiner (*Notropis heterodon*) account above.

Spottail Shiner ***Notropis hudsonius***: Secure. Occasional to locally common in large rivers, a few large inland lakes, and nearshore areas of the Great Lakes.

Ozark Minnow ***Notropis nubilus***: Threatened. Uncommon in scattered streams of southern Wisconsin and the upper Red Cedar drainage in northwestern Wisconsin. Abundance appears to be stable. Since Becker (1983), there are multiple records of the Ozark minnow from the Platte River system, Grant County, and the Galena River system, Lafayette County (Mississippi River tributaries) and the Apple River, Lafayette County, and the Turtle River system, Rock County (Rock River drainage) (WDNR unpublished data). The Red Cedar River drainage localities have not been sampled since the late 1970s.

Rosyface Shiner *Notropis rubellus*: Secure. Occasional to common in rocky streams over most of the state, but absent from the St. Croix and Lake Superior drainages

Sand Shiner *Notropis stramineus (ludibundus)*: Secure. Occasional to common in sandy areas of large streams and rivers statewide.

Weed Shiner *Notropis texanus*: Special concern. Uncommon in large rivers and the lower reaches of their tributaries and in a few large shallow lakes. Statewide, populations appear to be generally stable. Since Becker (1983), small numbers of weed shiners have been collected from tributaries of the Wolf River and Lake Poygan, Waushara, Waupaca, and Outagamie Counties (Fox River drainage); tributaries and sloughs of the Wisconsin River in Sauk and Iowa Counties; the Mississippi River in Pools 11, 10, 9, 8 and 4; the lower reaches of the Black River in Trempealeau and LaCrosse Counties; the Buffalo River in Buffalo County (Mississippi River tributary); and tributaries of the Red Cedar River system in Barron, Washburn, and Sawyer Counties (Chippewa River drainage) (Fago 1983, 1984a, and 1992; WDNR unpublished data). Wiener et al. (1984) reported the occurrence of the weed shiner in Garth Lake, Oneida County (Wisconsin River drainage), and Fago (1992) mapped WDNR Fisheries Management reports from Camp Four Creek, Price County, and Long Lake, Iron County (Chippewa River drainage). If valid, these records would represent major upstream range extensions (> 150 km) for the species in each drainage. However, we consider these records erroneous. None are supported by preserved specimens, and the habitat at each site seems inappropriate for the weed shiner, which prefers sloughs, side channels, backwaters, floodplain lakes, and other slow-moving areas associated with medium to large warmwater rivers (Becker 1983). Garth Lake is small and infertile with no stream connection; Camp Four Creek is small, swampy, and coldwater; and Long Lake is medium-sized and mesotrophic with only a small outlet. We suspect that the three records were based on misidentified blackchin shiners (*Notropis heterodon*), which look very similar to weed shiners and commonly occur in the type of habitats that these three localities represent.

Mimic Shiner *Notropis volucellus*: Secure. Common in medium- to large-sized inland lakes and medium-sized rivers. Uncommon in small streams, large rivers, and nearshore areas of the Great Lakes. The taxon that Becker (1983) and Fago (1992) considered to be the mimic shiner has recently been split into two species – the "true" mimic shiner and the closely related channel shiner (*Notropis wickliffi*) (see channel shiner account for details). Mayden and Kuhajda (1989) and Hrabik (1997) have further argued that the currently recognized mimic shiner may be a complex of several cryptic species. It has been difficult to determine with certainty the exact distribution of the mimic shiner in Wisconsin. Many records of "mimic" shiners are not supported by specimens, and even when specimens are available, some cannot be identified with certainty. We are particularly unsure about the distribution and abundance of mimic shiners in the state's largest rivers. Mimic shiners appear to be almost completely replaced by channel shiners in the Wisconsin River below the Prairie du Sac Dam, Sauk/Columbia Counties; the Chippewa River below Eau Claire, Eau Claire County; and the Mississippi River, although a few mimic shiners apparently do occur in these river reaches (Greene 1935; WDNR unpublished data; Seegert, personal communication; UWZM 1284). Greene (1935), who distinguished between mimic and channel shiners, reported only mimic shiners from the St. Croix River below St. Croix Falls, Polk County, but some more recent collections appear to contain possible mimic X channel shiner hybrids (Bob Hrabik, Missouri Department of

Conservation, Jackson, personal communication; UWZM 836, 10984).

Channel Shiner *Notropis wickliffi*: Secure. Occasional to common in the Mississippi, lower Wisconsin, and lower Chippewa Rivers. Possibly present in the lower St. Croix River. Newly recognized from the state since Becker (1983). See color plate 2 and the distribution map in figure 3.

Description: Very similar to the mimic shiner (*Notropis volucellus*); see description of mimic shiner in Becker (1983), color plate 2, and systematic notes below. Maximum size observed in Wisconsin 59 mm standard length (SL)(74 mm total length).

Systematic Notes: This species was first described as a subspecies, *N. volucellus wickliffi*, of the mimic shiner by Trautman (1931). The range of this subspecies included the Mississippi River in Wisconsin, and Greene (1935) distinguished the channel mimic shiner and the northern mimic shiner *(N. v. volucellus)* in his monograph on the distribution of Wisconsin fishes. Jenkins (1976) was the first to propose that the channel shiner be given full species status but gave no supporting data. Becker (1983) disagreed, noting the great difficulty in distinguishing channel and mimic shiners, and he did not separate the two forms in his account of the mimic shiner. However, subsequent authors documented consistent morphological and genetic

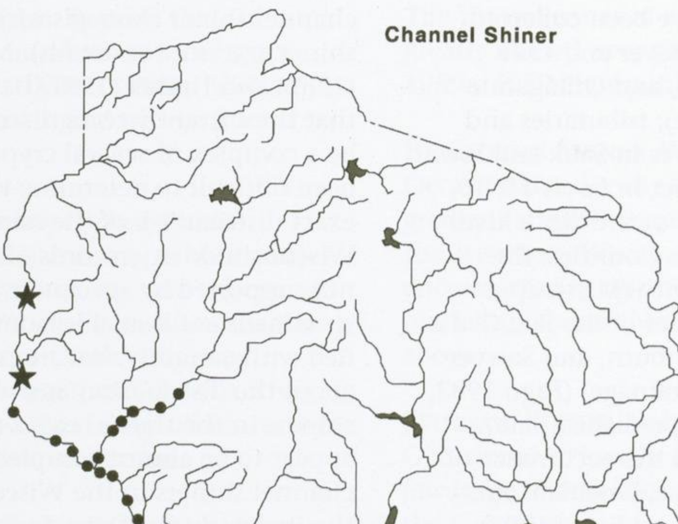

Figure 3. Map of the distribution of channel shiner (solid circles) in Wisconsin. The stars indicate localities for possible channel shiner X mimic shiner hybrids.

differences between the two forms (Mayden and Kuhajda 1989, Gong 1991, Etnier and Starnes 1993, Hrabik 1996 and 1997, Eisenhour 1997), and the current consensus among ichthyologists is that channel and mimic shiners are discrete species (Robins et al. 1991a, Mayden et al. 1992).

Channel shiners and mimic shiners are very difficult to distinguish, and there has been disagreement in the literature over which characteristics best separate the two species. Trautman (1931 and 1981) used a combination of pigment patterns, body proportions, and scale shape and number, with the channel shiner being a paler, more robust species with fewer and less elongated lateral line scales. However, his characteristics overlapped substantially between the two species and could not be used unequivocally to separate all specimens. A variety of additional morphological characteristics were also found to differ statistically between the two species, including number of pectoral fin rays, scale rows above and below the lateral line, and vertebrae, but overlap was extensive (Gong 1991, Hrabik 1996, 1997, Eisenhour 1997).

The most useful characteristics for separating channel and mimic shiners related to pigment patterns on the dorsal surface; these were best seen in well-preserved adults. In Tennessee, channel shiners had a dark, thin, continuous, post-dorsal stripe, and this stripe was lacking, faint, or interrupted in mimic shiners (Etnier and Starnes 1993). Mimic shiners usually had a predorsal blotch; channel shiners lacked the blotch but sometimes had a predorsal stripe. Mimic shiners had posterior dorso-lateral scales that were most heavily pigmented near their posterior margins, compared with more continuously distributed pigment in channel shiner scales. In Illinois, Eisenhour (1997) found similar differences between the two species in distribution of pigment on posterior dorso-lateral scales. He also noted that channel shiners and mimic shiners from northern Illinois often had a postdorsal stripe, but mimic shiners from southern Illinois usually did not. Northern Illinois mimic shiners often had a predorsal blotch or stripe, but channel shiners and southern Illinois mimic shiners typically did not. For the upper Mississippi River basin, Hrabik (1996, 1997) reported that channel shiners usually lacked a postdorsal stripe, and that mimic shiners sometimes had this stripe, the opposite of the pattern found by Etnier and Starnes (1993) in Tennessee. Mimic shiners usually also had a thin or striated predorsal stripe, which channel shiners lacked. Hrabik (1997) postulated that the discrepancies between studies existed because the currently recognized mimic shiner and channel shiner were actually each a complex of two or more taxa.

We examined morphological and pigment characteristics of Wisconsin specimens of channel and mimic shiners. Generally, the specimens that we identified as channel shiners tended to have relatively deeper and thicker bodies, longer dorsal fins, and less elongated lateral-line scales than mimic shiners. These differences were most apparent in large adults and difficult to quantify in smaller specimens. Channel shiners tended to lack a complete predorsal stripe, but 6 of 20 specimens from Mississippi River Pool 11 had a faint or striated complete stripe (UWZM 10978, 11004, 11213). Mimic shiners usually had a predorsal stripe, but it was often faint, and it was incomplete in one individual from the Peshtigo River, Marinette County (UWZM 10993). Complete postdorsal stripes occurred in about 40% of channel shiners and 90% of mimic shiners. Pigment distribution on posterior dorsolateral scales was continuous in about 60% of channel shiners and concentrated posteriorly in about 80% of mimic shiners.

We suggest the following combination of characteristics to distinguish channel and mimic shiners in Wisconsin (best seen in preserved specimens):

Channel Shiner—Predorsal stripe usually absent or incomplete, faint if complete; posterior dorso-lateral scales either continuously pigmented or with pigment concentrated posteriorly; postdorsal stripe usually absent or incomplete, faint if complete; specimens over 45 mm SL typically with body depth contained less than 4.5 times in SL, body width contained less than 1.7 times in depth, dorsal fin height contained less than 2.5 times in predorsal length, and anterior lateral line scales from 2–3 times as tall as wide.

Mimic Shiner—Predorsal stripe present, often faint but rarely incomplete; posterior dorsolateral scales usually with pigment concentrated posteriorly; postdorsal stripe usually present and complete, often well-pigmented; specimens over 45 mm SL typically with body depth contained more than 4.5 times in SL, body width contained more than 1.7 times in depth, dorsal fin height contained more than 2.5 times in predorsal length, and anterior lateral line scales more than 3 times as tall as wide.

We recommend a "weight of evidence" approach to identify specimens that meet criteria for both species. Even then, some fish will be impossible to identify with certainty. We tentatively consider specimens from the lower St. Croix River (UWZM 836, 10984) that met about half of the mimic shiner and half of the channel shiner criteria to be possible hybrids. We caution, however, that genetic analyses planned for the near future may alter our definitions of channel and mimic shiners and invalidate much of the taxonomic information presented here (Hrabik, personal communication).

Channel and mimic shiners are easily confused with other small shiner species, especially sand shiners (*Notropis stramineus*), and are best separated from them by the shape of the anterior scales in the lateral series. Channel and mimic shiners have elevated scales about two to three times as tall as they are wide with a nearly vertical posterior profile. Sand shiners have less elongated scales that are usually less than two times as tall as they are wide with a more triangular or rounded posterior profile. Channel and mimic shiners usually have eight anal fin rays and sand shiners seven, although in our Wisconsin samples about 4% of sand shiners (N=81) have eight anal rays and about 8% of channel shiners (N=167) have seven anal fin rays. Mimic shiners with seven anal rays are rare (< 1%).

Distribution, Status, and Habitat: In Wisconsin, the channel shiner occurs throughout the Mississippi River, the Chippewa River upstream to Eau Claire, Eau Claire County, and the Wisconsin River up to the Prairie du Sac Dam, Columbia/Sauk Counties (figure 3). It is likely that the species also occurs in the lower reaches of tributaries to these rivers. Possible channel X mimic shiner hybrids have been found in the lower St. Croix River, but whether "pure" channel shiners occur there is unknown.

The channel shiner is widespread and locally common within its Wisconsin range. This species had been given special concern status by the WDNR, but this was based on uncertainty about taxonomic status and distribution – not abundance. During the mid- to late 1990s, we encountered hundreds of channel shiners at many localities in Mississippi River Pools 9–12 and in the lower Wisconsin River. Relatively few "mimic" shiners were caught in these areas either by the FDS or by us during the mid-1970s through mid-1980s (WDNR unpublished data), suggesting that channel shiner populations have increased over the last 15–20 years in southern Wisconsin. See also the pallid shiner (*Notropis amnis*) account. Reasons for this change are unknown.

The channel shiner is a large-river specialist and seems to prefer certain habitats within these rivers. In the Wisconsin and Chippewa Rivers, channel shiners were most commonly found in shallow shoreline areas of the main channel with moderate current and mixed sand/gravel/cobble substrate. They were rarely encountered in extensive areas of shifting, pure-sand bottoms, which are especially common in the lower Wisconsin River, or backwater areas with little current and silt substrate. In the Mississippi River, the largest catches of channel shiners came from the shorelines of side channels and sloughs with moderate current and mixed silt/sand substrate. They were less common along the edge of the main channel where the current was stronger and the bottom sandier and rarely captured from backwater or lentic areas with little current and deep silt substrate.

Biology: Very little is known about the biology of the channel shiner, in large part because of its confusing taxonomy (Hrabik 1996). A spawning season from June through August was suggested for Ohio (Trautman 1981) and Tennessee (Etnier and Starnes 1993). However, no other information about reproduction, life history, diet, growth, or population dynamics is available.

Importance and Management: The relationship of channel shiners to other species or to human society is unknown. However, given their abundance, channel shiners undoubtedly serve as forage for predatory fishes in the Mississippi, lower Chippewa, and lower Wisconsin Rivers.

Pugnose Minnow *Opsopoeodus emiliae*: Special concern. Generally uncommon in large rivers and associated lakes and impoundments in the southern two-thirds of Wisconsin, although pugnose minnows can be locally common in backwaters and sloughs of the Mississippi River (Seegert, personal communication; WDNR unpublished data). Statewide population trends appear to be stable. Fago (1986) provided the first records of this species from the St. Croix River in Polk and St. Croix Counties. Fago (1992) mapped three pre-1972 records of pugnose minnow from the upper Wisconsin River drainage, two in Portage County and one in Oneida County, more than 150 km upstream of other known populations. However, examination of the database used to generate these maps indicates that these records were probably based on erroneous reports. The Oneida County record was attributed to Greene (1935), yet it is not mentioned in that publication. The two Portage County records were attributed to collections by University of Wisconsin–Stevens Point students during the 1960s. However, Becker (1983) was a professor at the university during that period, taught ichthyology, and was in charge of the fish collection, yet made no mention of these records.

Suckermouth Minnow *Phenacobius mirabilis*: Secure. Occasional in moderate- to high-gradient streams in the Mississippi basin portion of the southern third of Wisconsin. Fago (1992) referenced a collection by the FDS in 1979 of suckermouth minnows from the South Branch of the Little Wolf River, Waupaca County (Fox River drainage), which, if valid, would represent the first record of this species from the Lake Michigan basin. However, a re-examination of collection data from this site indicates that suckermouth minnows actually were not captured, and the report from Fago (1992) was based on an error in the FDS database.

Northern Redbelly Dace *Phoxinus eos*: Secure. Occasional to common in low-gradient streams, beaver ponds, and small lakes in the northern half of Wisconsin; uncommon to occasional in the southern half.

Southern Redbelly Dace *Phoxinus erythrogaster*: Secure. Common in moderate- to high-gradient streams in the southern half of the state.

Finescale Dace *Phoxinus neogaeus*: Secure. Occasional to locally common in low-gradient streams, beaver ponds, and small lakes in the northern half of Wisconsin. Historically the finescale dace reached the southern edge of its range in the state in a disjunct group of 11 localities in the headwaters of the Fox River and Rock River drainages (Greene 1935). In 1998 we resampled these localities but failed to collect any finescale dace. The widespread channelization and intensive watershed agriculture that exists in these drainages may have contributed to the disappearance of the species. Fago (1985b) reported an FDS collection of finescale dace from one site on the Mullet River, Sheboygan County (Lake Michigan basin). This record is at least 750 kilometers by water from the nearest extant populations in the headwaters of the Wolf River.

NORTHERN REDBELLY DACE X FINESCALE DACE HYBRID ***Phoxinus eos X P. neogaeus***: Secure. These hybrids occur occasionally in northern Wisconsin in small boggy streams and beaver ponds (Becker 1983, WDNR unpublished data, UWZM 10340), but their exact distribution and abundance in the state is poorly documented. Many northern redbelly-finescale dace hybrid populations from eastern North America and Minnesota consist entirely of females and reproduce clonally (Dawley et al. 1987, Schlosser et al. 1998). Whether such clonal populations occur in Wisconsin is unknown, but it seems likely that they do, based on their common occurrence elsewhere. In the clonal populations, sperm from a male of one of the parental species, usually northern redbelly dace, is necessary to initiate egg development, but no genetic material from the male is incorporated into the egg. Clonal populations appear to be able to persist indefinitely. By some definitions, these clonal hybrids could be considered a separate unisexual species, distinct from the two parental species (Dawley et al. 1987). Some hybrid populations in eastern North America consist of multiple clonal lineages (i.e., they resulted from multiple hybridization events), whereas in Minnesota all hybrids within a drainage system belonged to a single clone (Dawley et al. 1987, Schlosser et al. 1998). Clonal hybrids in Minnesota differed from parental species in physiological tolerance to low dissolved oxygen and in trophic ecology (Schlosser et al. 1998).

BLUNTNOSE MINNOW ***Pimephales notatus***: Secure. Common in streams, rivers, and inland lakes statewide. Uncommon in the largest rivers and nearshore areas of the Great Lakes.

FATHEAD MINNOW ***Pimephales promelas***: Secure. Common in small streams, beaver ponds, and small lakes throughout Wisconsin. Widely used as bait; therefore stray individuals may be encountered almost anywhere.

BULLHEAD MINNOW ***Pimephales vigilax***: Secure. Occasional to common in the Mississippi, lower Wisconsin, lower Black, and lower Chippewa Rivers and the lower reaches of their tributaries. Uncommon to occasional in localized areas of the Sugar, Fox (Illinois), Fox (Green Bay), and Wolf Rivers.

BLACKNOSE DACE ***Rhinichthys atratulus***: Secure. Common in rocky streams and small rivers statewide.

LONGNOSE DACE ***Rhinichthys cataractae***: Secure. Common in rocky streams and small rivers statewide, except for southeastern Wisconsin, where absent. Occasional in rocky, turbulent areas of Great Lake shorelines.

CREEK CHUB ***Semotilus atromaculatus***: Secure. Common in streams and uncommon in rivers statewide.

Suckers – Catostomidae

RIVER CARPSUCKER ***Carpiodes carpio***: Secure. Occasional to locally common in the Mississippi, lower Wisconsin, lower Black, lower Chippewa, and Sugar Rivers and the lower reaches of their tributaries.

QUILLBACK ***Carpiodes cyprinus***: Secure. Occasional to common in the larger rivers in the southern half of the state; uncommon in the St. Croix River in northwestern Wisconsin. The *C. "cyprinus"* that is found in Wisconsin may be taxonomically distinct from the *C. cyprinus* that is found in the eastern United States; therefore the Wisconsin form may require a new scientific name (Henry Bart, Tulane University, New Orleans personal communication).

HIGHFIN CARPSUCKER ***Carpiodes velifer***: Secure. Occasional in the Mississippi River and the lower reaches of its largest tributaries.

LONGNOSE SUCKER ***Catostomus catostomus***: Secure. Uncommon to occasional in the Great Lakes, entering tributaries in the spring to spawn. Occasional in the upper Menominee drainage in northeastern Wisconsin. Greene (1935) and Becker (1983) reported disjunct records of longnose sucker from the extreme upper part of the Menominee and Peshtigo River drainages (Lake Michigan basin) but could only speculate on its status and abundance there. All other confirmed records of the species from Wisconsin were from Lake Michigan and Lake Superior and the lower reaches of their tributaries. Fago (1992) mapped the widespread occurrence of longnose sucker further downstream in the Menominee drainage in the Brule River, Forest and Florence Counties, where the species appears to be well-established and self-sustaining (Tom Theumler, WDNR, Peshtigo, personal communication). Strays from the Brule population are sometimes found in the upper part of the Menominee River proper in Florence and Marinette Counties (UWZM 11082; Seegert, personal communication). The Brule River population is isolated from contact with the longnose sucker population in Lake Michigan by a series of dams and, historically, by several impassable waterfalls. It is the only confirmed self-sustaining inland population in Wisconsin.

WHITE SUCKER ***Catostomus commersoni***: Secure. Common in streams, rivers, and lakes statewide, as well as nearshore areas of the Great Lakes. Uncommon in the state's largest rivers.

BLUE SUCKER ***Cycleptus elongatus***: Threatened. Uncommon to occasional in the Mississippi River and the lower reaches of its largest tributaries. Generally, populations are stable. Since Becker (1983), there have been numerous collections of small numbers of blue suckers from the Mississippi River, lower Wisconsin River, lower Chippewa River, lower Red Cedar River (tributary of lower Chippewa River), and lower St. Croix River (WDNR unpublished data). Young-of-the-year and yearlings have been collected from Mississippi River Pool 9 (Vernon County) in 1979 and 1980 (McInerny and Held 1988) and Pool 10 and Pool 12 (Grant County) in 1998 (UWZM 11029, 11067). Historically, there are reports of blue suckers that exceeded 11 kg in weight from the Mississippi River system, but in the last 70 years individuals greater than 5 kg have been encountered only rarely (Burr and Mayden 1999). On 18 September 1998, a blue sucker that weighed 7.3 kg was collected from the Red Cedar River in Dunn County (WDNR unpublished data and photograph). Burr and Mayden (1999) provide a detailed up-to-date summary of the taxonomy and biology of the blue sucker.

CREEK CHUBSUCKER ***Erimyzon oblongus***: Extirpated. Becker (1983) and Fago (1992) considered this species to be extirpated, and we concur. Recent sampling of the Des Plaines River system, Kenosha County, where creek chubsuckers formerly occurred, has failed to yield specimens (WDNR unpublished data).

LAKE CHUBSUCKER ***Erimyzon sucetta***: Special concern. Uncommon in low-gradient streams and lakes in southeastern and east-central Wisconsin and in sloughs and backwaters of the lower Wisconsin River, although the species may be locally common in a few southeastern Wisconsin lakes. Abundance in the state appears to be stable. Since Becker (1983), small numbers of lake chubsuckers have been taken from numerous sites in southeastern Wisconsin and a few sites along the lower Wisconsin River (Fago 1982, 1984b, and 1992; WDNR unpublished data).

NORTHERN HOG SUCKER ***Hypentelium nigricans***: Secure. Common in medium to large rocky rivers statewide, although absent from the Lake Superior basin.

SMALLMOUTH BUFFALO ***Ictiobus bubalus***: Secure. Occasional to locally common in the Mississippi, lower Wisconsin, lower Black, and lower Chippewa Rivers.

BIGMOUTH BUFFALO ***Ictiobus cyprinellus***: Secure. Occasional to locally common in rivers and lakes in southern and western Wisconsin from the Rock through the lower Chippewa drainages.

BLACK BUFFALO ***Ictiobus niger***: Threatened. Uncommon in the Mississippi, lower Wisconsin, Pecatonica, and Sugar Rivers. Abundance trends are uncertain. Since Becker (1983), small numbers of black buffalo have been captured from Mississippi River Pools 4, 8, and 12, and the Grant River, Grant County, just upstream from Mississippi River Pool 11; the Wisconsin River above and below the Prairie du Sac Dam, Columbia, Dane, Sauk, Iowa, and Crawford Counties; and the Pecatonica River, Green County, and Sugar River, Rock County (Rock River drainage) (EMTC 1998, WDNR unpublished data and photographs).

SPOTTED SUCKER ***Minytrema melanops***: Secure. Uncommon to occasional in the Mississippi River and the lower reaches of its tributaries including the Wisconsin River as far upstream as the mouth of the Lemonwier River, Juneau County (UWZM 10975). Also occasional in the upper Fox and Wolf Rivers and some of their tributaries. Fago (1992) reported the collection of this species by the FDS in 1979 at two sites on the East Fork of the Chippewa River, Bayfield County, more than 250 km upstream from the nearest other populations, which occurred in the lower Chippewa River. We attribute the presence of spotted sucker in the East Fork of the Chippewa River to bait-bucket introductions.

SILVER REDHORSE ***Moxostoma anisurum***: Secure. Occasional to locally common in rivers throughout the state.

RIVER REDHORSE ***Moxostoma carinatum***: Threatened. Uncommon to occasional in localized areas of the largest rivers in the state, including the Mississippi, Black, Chippewa, St. Croix, Fox (Illinois), Fox (Green Bay), and Wolf. Abundance appears to be stable. Becker (1983) feared that a 1976 WDNR poisoning of the upper Rock River system to eradicate common carp (*Cyprinus carpio*) might eliminate an isolated river redhorse population in the Rock River at Watertown, Dodge County. FDS personnel had removed some of the river redhorse from the site before the poisoning and then restocked them there afterwards. Fortunately, the population still persists, as two small adult river redhorse were collected at the site in 1995 (WDNR unpublished data). Fago (1984b) reported several FDS collections from the Fox River, Waukesha, Racine, and Kenosha Counties, the first records from the Illinois River drainage of Wisconsin. Fago (1992) reported FDS collections of river redhorse from the Wolf River in Shawano and Waupaca Counties (Fox River drainage), the first record of this species from the Great Lakes basin of Wisconsin. In 1996, two individuals were collected from the Little Wolf River, Waupaca County (Fox River drainage), and in 1997 one was taken from the Fox River, Green Lake County (WDNR unpublished data and photographs). Fago (1992) mapped a highly disjunct, unverified report of river redhorse from the Milwaukee River drainage (Lake Michigan basin), but there were no extant specimens nor was there supporting locality or collection information in the WDNR database. We consider this record erroneous and believe that it was probably based on a misidentified greater redhorse, a species that is very similar in appearance to the river redhorse and occurs widely in the Milwaukee River drainage.

Black Redhorse ***Moxostoma duquesnei***: Endangered. Uncommon in the Wisconsin River and the lower reaches of its tributary the Eau Claire River in central Wisconsin. This species was believed by Becker (1983) and Fago (1992) to be extirpated from Wisconsin, with the last verified record from 1928. Then in 1992, small numbers of black redhorse were collected from the Wisconsin River at Wausau, Marathon County, and from the extreme lower end of the Eau Claire River, which enters the Wisconsin River just south of Wausau (Fago and Hauber 1993). Additional specimens have been collected from the Wisconsin and lower Eau Claire Rivers since 1992, most recently in 1998 (WDNR unpublished data and photos). However, extensive sampling further upstream in the Eau Claire River, in other nearby Wisconsin River tributaries, and in the Wisconsin River at many locations above and below Wausau failed to produce black redhorse.

There are unsubstantiated reports of a single black redhorse from the Wisconsin River below Stevens Point, Portage County, in 1993 (Fred Copes, University of Wisconsin–Stevens Point, personal communication), the Chippewa River, Dunn County, in 1974 (WDNR unpublished data), and Mississippi River Pool 4 in 1993 (WDNR unpublished data). The Stevens Point fish is plausible as a stray from the Wausau population 65 km upstream, although we sampled the reported location in 1997 and 1998 without capturing any black redhorse. The Chippewa River and Mississippi River records seem much less likely and are probably erroneous. Extensive sampling of both rivers over many years has never yielded confirmed black redhorse specimens (UMRCC 1983, Fremling et al. 1989, Fago 1992, EMTC 1998, WDNR unpublished data). Furthermore, the black redhorse is easily confused with the golden redhorse, which occurs in both rivers. However, black redhorse are found in the upper reaches of two Minnesota tributaries to the Mississippi River (Underhill 1988), so the occurrence of a stray in the Mississippi or Chippewa Rivers is possible.

Golden Redhorse ***Moxostoma erythrurum***: Secure. Common in rocky rivers throughout the state, although there are no recent records from the Lake Superior basin (Fago 1992, WDNR unpublished data).

Shorthead Redhorse ***Moxostoma macrolepidotum***: Secure. Common in rivers throughout the state.

Greater Redhorse ***Moxostoma valenciennesi***: Threatened. Uncommon in lakes and rivers in scattered localities throughout much of Wisconsin; absent from the southwestern portion of the state and the Lake Superior basin. Greater redhorse can be locally common during spawning on rocky riffles in rivers (personal observations; Seegert, personal communication). Abundance appears to be stable or increasing slightly. Recent collections indicate that the greater redhorse is more widespread than previously thought (figure 4). Fago (1985b, 1986, 1992) mapped numerous new records from the FDS, including the first records from the Sheboygan River and Twin River drainages (Lake Michigan basin). Sampling since 1980 has documented a broad distribution of greater redhorse in the upper Chippewa River drainage (Lyons 1988, WDNR unpublished data and photos). Collections of greater redhorse from the Mukwonago River in 1994 (UWZM 10521) and Genesee Creek in 1997 (UWZM 11007), Waukesha County, constitute the first records from the Illinois River drainage in Wisconsin.

Bullhead Catfishes – Ictaluridae

Black Bullhead ***Ameiurus melas***: Secure. Occasional to common in inland lakes, streams, and rivers statewide.

Yellow Bullhead ***Ameiurus natalis***: Secure. Occasional to common in inland lakes, streams, and rivers statewide, except the Lake Superior basin, where it is uncommon.

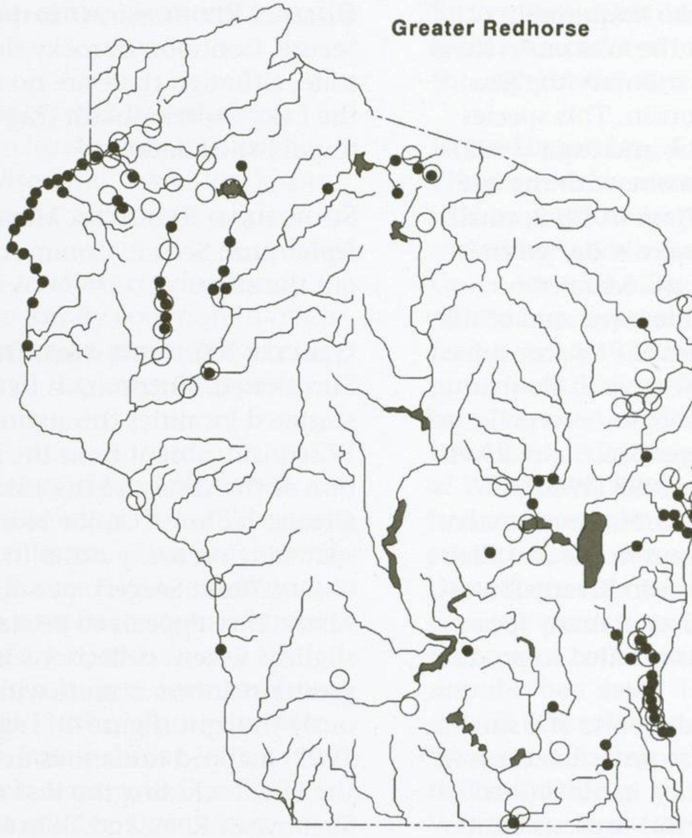

Figure 4. Map of the distribution of greater redhorse in Wisconsin. Open circles are records from Becker (1983); solid circles are subsequent records.

Brown Bullhead ***Ameiurus nebulosus***: Secure. Occasional to locally common in inland lakes; uncommon in streams and rivers. Absent from the Lake Superior basin.

Channel Catfish ***Ictalurus punctatus***: Secure. Occasional to common in rivers in the southern half of the state; uncommon in inland lakes and Lake Michigan. Uncommon to occasional in rivers in northwestern Wisconsin; absent from the Lake Superior basin and north-central and northeastern Wisconsin.

Slender Madtom ***Noturus exilis***: Endangered. Uncommon at a few localities in the Rock River drainage in southern Wisconsin. In recent years the slender madtom has declined to the point where it is nearly extirpated from the state. The FDS captured 245 slender madtoms from 27 sites on 16 streams in the Rock River drainage during the mid-1970s (Fago 1982). All of these sites were resampled (some multiple times) in the early 1990s along with many other sites in southern Wisconsin, but only 115 slender madtoms were taken from 11 sites on four streams (Lyons 1996a). Only 6 sites yielded more than one slender madtom.

A combination of factors was responsible for the loss of the species. At the Rock River in Watertown, Dodge County, Lyons (1996a) suggested that channel dewatering from inappropriate hydroelectric dam operation caused the slender madtom's demise. A WDNR poisoning of the upper Rock River system in 1976 to remove common carp (*Cyprinus carpio*) substantially reduced slender madtom abundance at this site (catch rate decline from 0.9 per 100 m electroshocked in 1976 prior to poisoning to 0.05 per 100 m in 1977; WDNR unpublished data) and may have made extirpation more likely. This same poisoning may have eliminated a population at a site on the Oconomowoc River, a Rock River tributary, just downstream of the city of Oconomowoc in Waukesha County. However, the data here are limited; the FDS caught one slender madtom in 1975, but the only follow-up sample was in 1994 when no slender madtoms were captured. Fish kills from agricultural runoff probably eliminated slender madtoms from six sites on five tributaries to the Pecatonica River in Iowa and Lafayette Counties (Lyons 1996a). Causes of the species' disappearance from the remaining seven sites, located on five streams in four southeastern counties, were uncertain but appeared not to be related to dewatering, poisoning, or agricultural fish kills.

STONECAT ***Noturus flavus***: Secure. Occasional in rocky streams in the southern half of Wisconsin; uncommon within a few scattered areas in the northern half.

TADPOLE MADTOM ***Noturus gyrinus***: Secure. Occasional in low-gradient streams and rivers statewide. Uncommon in shallow lakes.

FLATHEAD CATFISH ***Pylodictis olivaris***: Secure. Uncommon to occasional in the Mississippi River, the lower reaches of its largest tributaries, and the Pecatonica, Sugar, Fox (Green Bay), and Wolf Rivers.

Pikes – Esocidae

GRASS PICKEREL ***Esox americanus***: Secure. Occasional in low-gradient streams and lakes of southeastern Wisconsin and north-central Wisconsin (introduced) and in backwaters, sloughs, and tributary mouths of the lower Wisconsin River and Mississippi River Pools 10 and 11. Two recently published distribution maps for this species contain errors. The map in Fago (1982) for the Rock River drainage had unlabeled triangular symbols that did not correspond to grass pickerel; only the circles were valid (Fago 1992). The pre-1972 map of Fago (1992) shows grass pickerel localities from several streams in the Lake Superior basin, the Chippewa River, Pepin County, and the outlet of Lake Winnebago, Winnebago County (Fox River drainage), based on unpublished accounts of "pickerel" from 1908 from these waters. However, no specimens are extant, Greene (1935) and Becker (1983) did not recognize these records, and grass pickerel do not occur in these waters now. We believe these records are erroneous and actually apply to northern pike or walleye, which in the past were sometimes called pickerel and which are currently known from these localities (see also DuBois and Pratt 1994 for a similar argument). Recent collections in 1996 and 1998 from the Lemonweir River, Juneau County (UWZM 10742, photograph), have extended the known natural range of grass pickerel over 100 km upstream in the Wisconsin River drainage. Introduced populations (Becker 1983) occur about 300 km further upstream in the headwaters of the Wisconsin River drainage in Oneida County (UWZM 9789) and adjacent parts of the Manitowish River system (Chippewa River drainage), Vilas County (Lyons 1988, Fago 1992).

NORTHERN PIKE ***Esox lucius***: Secure. Occasional to common in streams, rivers, and inland lakes statewide. Uncommon in nearshore areas of the Great Lakes.

MUSKELLUNGE ***Esox masquinongy***: Secure. Occasional in lakes and rivers in the northern half of the state; widely stocked. A few populations are maintained by stocking lakes and rivers in southern Wisconsin. Uncommon in harbors and bays of the Great Lakes. Becker (1983) noted the taxonomic confusion regarding this species, which continues today. Traditionally, the species had been divided into three subspecies based mainly on pigmentation patterns, and two of these subspecies were thought to occur in Wisconsin. However, the genetic validity and exact historical distribution of these forms was never clearly established. In Wisconsin, the barred form, *E. m. immaculatus*, was considered to be native to the Mississippi River basin, and the spotted form, *E. m. masquinongy*, was thought to have occurred in the Great Lakes and the lower reaches of their tributaries, perhaps including Lake Winnebago (Greene 1935). "Pure" spotted-form muskellunge had become rare by the mid-1900s owing to habitat loss and perhaps introgression with the barred form, which was widely stocked throughout the state. Recently, spotted forms have been cultured in Wisconsin and stocked in Green Bay and the St. Louis River, Douglas County (Lake Superior tributary), but it is too early to determine if successful natural reproduction of stocked fish has occurred (WDNR unpublished data).

LeBeau (1992) proposed a different muskellunge taxonomy. He recognized two distinct species, the riverine muskellunge *E. masquinongy* and the lacustrine muskellunge or maskinonge *E. lacustris*. For Wisconsin, LeBeau (1992) listed the historical range of the lacustrine muskellunge as lakes and rivers that lacked northern pike in the headwaters of the Flambeau River (Chippewa River drainage) and Wisconsin River drainages. Included in this range were many well-known muskellunge fishing waters in Oneida and Vilas Counties, such as Minocqua, Tomahawk, and Trout Lakes. The riverine muskellunge was found in the Great Lakes and their tributaries, and in the Mississippi, St. Croix, Black, Wisconsin, and Chippewa River drainages, exclusive of the range of the lacustrine muskellunge. Included in this range were many famous muskellunge waters in Sawyer County in the headwaters of the Chippewa drainage, such as Lac Courte Oreilles and the Chippewa Flowage. Stocking and habitat changes have greatly confused current distribution patterns, with lacustrine muskellunge now much more widespread and riverine muskellunge generally reduced in range. LeBeau's (1992) taxonomy has proven to be controversial and has not been accepted by many other muskellunge specialists. Thus, we list only a single species from Wisconsin waters.

Mudminnows – Umbridae

CENTRAL MUDMINNOW ***Umbra limi***: Secure. Common in low-gradient streams, beaver ponds, and small lakes statewide.

Trouts – Salmonidae

LONGJAW CISCO ***Coregonus alpenae***: No longer considered a valid species; believed now to be merely a form of the shortjaw cisco (*Coregonus zenithicus*) (Todd et al. 1981, Robins et al. 1991a).

CISCO/LAKE HERRING ***Coregonus artedi***: Special concern. Uncommon to locally common in a few deep inland lakes scattered around the state, but concentrated in northern Wisconsin. Common in Lake Superior and uncommon in northern Lake Michigan. In several inland lakes there have been recent population declines, but in Lake Superior the population has increased from the record lows of the 1960s. The cisco has experienced major, well-documented abundance fluctuations in Lake Mendota, Dane County, since the 1970s. Believed extirpated from the lake in the 1960s and 1970s, cisco produced two large year-classes in the lake in the late 1970s, and by the early and mid-1980s the species was abundant in the pelagic zone (Rudstam et al. 1987). However, an especially long and warm summer in 1987 led to a major die-off of cisco (Vanni et al. 1990), which require cold, well-oxygenated water, and by the 1990s the species was uncommon (Center for Limnology, University of Wisconsin–Madison unpublished data, courtesy of John Magnuson). Cisco have also declined in abundance or disappeared from a number of small lakes in Vilas County, probably because of increased predation from introduced muskellunge (*Esox masquinongy*), rainbow smelt (*Osmerus mordax*), and walleye (*Stizostedion vitreum*) (Rudstam 1984, McLain and Magnuson 1988, Hrabik et al. 1998).

Becker (1983) emphasized the confusing and uncertain taxonomy of *Coregonus artedi* and the closely related bloater (*Coregonus hoyi*), deepwater cisco (*Coregonus johannae*), kiyi (*Coregonus kiyi*), blackfin cisco (*Coregonus nigripinnis*), shortnose cisco (*Coregonus reighardi*), and shortjaw cisco (*Coregonus zenithicus*), which are limited to the Great Lakes. However, some progress in understanding their status and relationships has been made (Todd and Smith 1992, Webb and Todd 1995). Phylogenetic analysis of Todd and Smith (1992) indicated that *Coregonus artedi* from inland lakes differed more from *Coregonus artedi* from the Great Lakes than *Coregonus artedi* from the Great Lakes differed from the other five Great Lakes ciscoes. Overall, studies of Great Lakes ciscoes have shown statistically significant morphological and genetic differences among the six currently recognized taxa, but these differences are generally smaller than those normally used to distinguish species (Todd and Smith 1980, 1992, Todd et al. 1981, Webb and Todd 1995).

LAKE WHITEFISH *Coregonus clupeaformis*: Secure. Occasional in Trout Lake, Vilas County, and possibly Lake Lucerne, Forest County. Occasional to common in the Great Lakes, sometimes entering the lower reaches of tributaries during fall spawning. Fago (1992) mapped pre-1972 records of this species based on unpublished accounts from 1908 of "whitefish" from Big Green Lake, Green Lake County (Fox River drainage), and Bear Lake, Barron County (Chippewa River drainage). However, no specimens are extant, Greene (1935) and Becker (1983) did not recognize these records, and lake whitefish apparently do not occur in these lakes now. We believe these records are erroneous and actually apply to cisco, which have been found in both lakes (WDNR unpublished data). A mapped 1908 record of "whitefish" from Bear Lake, Portage County (Fox River drainage) (Fago 1992), was based on an unsuccessful introduction of lake whitefish (WDNR unpublished data). A single lake whitefish was captured from the St. Croix River, St. Croix County, in 1967, but the source of this fish is unknown (WDNR unpublished data).

BLOATER *Coregonus hoyi*: Secure. Common in Lake Superior and Lake Michigan. The bloater has had a major increase in abundance in Lake Michigan since the 1970s (Kitchell and Crowder 1986, Brandt et al. 1991) and supports a commercial fishery.

DEEPWATER CISCO *Coregonus johannae*: Extirpated. Formerly found in Lake Michigan and Lake Huron, the deepwater cisco is now extinct (Robins et al. 1991a). The deepwater cisco disappeared before its taxonomic status could be studied in detail.

KIYI *Coregonus kiyi*: Special Concern. Uncommon to occasional in Lake Superior; extirpated from Lake Michigan. The kiyi appears to have a stable population in Lake Superior, but abundance data are limited (Joan Bratley, Chuck Bronte, and Mike Hoff, U.S. Geological Survey, Ashland, WI, unpublished data and personal communications).

BLACKFIN CISCO *Coregonus nigripinnis*: Extirpated. In Wisconsin, formerly found in Lake Michigan. Populations still exist in lakes in Canada.

Robins et al. (1991a) expressed doubt that the blackfin cisco was a valid species because Todd and Smith (1980) had reported that nominal blackfin cisco from Lake Superior, which were considered a separate subspecies from the Lake Michigan population by Koelz (1929), were actually referable to shortjaw cisco (*Coregonus zenithicus*). However, later phylogenetic analyses by Todd and Smith (1992) of the Lake Michigan subspecies of blackfin cisco indicated that it was relatively distinct from shortjaw cisco. The taxonomic status of

Canadian populations of blackfin cisco has apparently not been studied in detail.

Shortnose Cisco ***Coregonus reighardi***: Extirpated. Formerly found in Lake Michigan, Lake Huron, and Lake Erie, the shortnose cisco is now extinct (Robins et al. 1991a).

Todd and Smith (1980) questioned whether the shortnose cisco was a valid species after their analyses indicated that what had been considered the Lake Superior subspecies of the shortnose cisco was in fact actually a form of the shortjaw cisco (*Coregonus zenithicus*). However, subsequent phylogenetic analyses indicated that the Lake Michigan and Lake Huron subspecies of the shortnose cisco was more distinctive (Todd and Smith 1992, Webb and Todd 1995).

Shortjaw Cisco ***Coregonus zenithicus***: Special concern. Uncommon in Lake Superior; extirpated from Lake Michigan. Numbers of shortjaw cisco in Lake Superior may be decreasing (Bratley, Bronte, and Hoff, unpublished data and personal communications).

Pygmy Whitefish ***Prosopium coulteri***: Special concern. Pygmy whitefish are uncommon in Lake Superior around the Apostle Islands, Ashland and Bayfield Counties (Brately, Bronte, and Hoff, unpublished data and personal communications). Recent abundance trends are uncertain.

Round Whitefish ***Prosopium cylindraceum***: Secure. Occasional in Lake Superior and northern Lake Michigan, sometimes entering the lower reaches of tributaries in small numbers during fall spawning.

Brook Trout ***Salvelinus fontinalis***: Secure. Common in cold streams and spring ponds in the northern half of Wisconsin; uncommon to occasional in the southern half. Widely stocked. A Great Lakes form of the brook trout, the "coaster," was once common, but now it is rare and possibly extirpated from Wisconsin waters (Becker 1983, DuBois and Pratt 1994, Newman et al. 1997). However, whether coasters are genetically distinct from native inland populations is uncertain and the subject of ongoing studies. The WDNR has given the coaster special concern status.

Lake Trout ***Salvelinus namaycush***: Secure. Common in the Great Lakes, but sustained by stocking in Lake Michigan. Inland, extant naturally-reproducing populations have been confirmed in Trout Lake, Vilas County, and Big Green Lake, Green Lake County, although the Big Green Lake population is probably introduced (WDNR unpublished data). The Trout Lake population has declined and is now supplemented by stocking (WDNR unpublished data), and abundance trends in Big Green Lake are unknown. In Wisconsin waters of Lake Superior, the abundance of naturally produced lake trout adults has increased from the record low levels of the early 1960s, and stocking has been discontinued (Hansen et al. 1995; Mike Hansen, University of Wisconsin–Stevens Point, personal communication). No significant natural reproduction of lake trout has been observed in Lake Michigan in recent years, and stocking is required to maintain the species in the lake (Holey et al. 1995). Lake trout are also maintained by stocking in a few deep Vilas County lakes. Lyons (1984) provided evidence that Trout Lake (Chippewa River drainage) and Black Oak Lake (Wisconsin River drainage), Vilas County, were the only Mississippi River basin waters in Wisconsin with native populations of lake trout. Other early records of lake trout from the basin (Greene 1935) were attributed to introductions.

Becker (1983) prepared accounts for two subspecies, "lean" lake trout *S. n. namaycush*, found in inland lakes and inshore areas of Lake Superior and Lake Michigan, and siscowet *S. n. siscowet*, found in deeper waters of Lake Superior. He also briefly discussed another form, the humper, from Lake Superior. Siscowet also occurred in Lake Michigan but have been extirpated (Brown et al. 1981), and only the lean lake trout remains there, maintained by regular stocking. Burnham-Curtis and Smith (1994), Krueger and Ihssen (1995), and Burnham-Curtis and Bronte (1996) documented osteological, genetic, and ecological differences among lean, siscowet, and humper lake trout from Lake Superior. The systematics of lake trout in Lake Superior is currently an area of active research, but most ichthyologists believe that distinctions among the three forms are not sufficient to warrant subspecific designation (Mary Burnham-Curtis, U.S. Geological Survey, Ann Arbor, MI, personal communication).

Trout-perches – Percopsidae

TROUT-PERCH ***Percopsis omiscomaycus***: Secure. Common in the Great Lakes. Occasional in large rivers and a few large deep lakes in the northern half of Wisconsin; uncommon in the Mississippi and Wisconsin Rivers and in Lakes Winnebago and Poygan, Winnebago and Waushara Counties (Fox River (Green Bay) drainage), in the southern half.

Pirate Perches — Aphredoderidae

PIRATE PERCH ***Aphredoderus sayanus***: Special concern. Uncommon in low-gradient streams and rivers in southern Wisconsin and in a small area of the upper Wisconsin River drainage in northern Wisconsin, where it may have been introduced. Abundance appears to be stable. The only significant new pirate perch localities since Becker (1983) were in Big Roche a Cri Creek, Adams County, in 1988, Narrows Creek, Sauk County, in 1989, and the Little Yellow River, Juneau County, in 1995 (Wisconsin River drainage) (UWZM 9475, WDNR unpublished data).

Codfishes – Gadidae

BURBOT ***Lota lota***: Secure. Occasional to common in the Great Lakes, and occasional in coolwater streams and rivers and deep lakes throughout much of Wisconsin. Absent from the southeastern portion of the state.

Killifishes – Cyprinodontidae (Fundulidae)

BANDED KILLIFISH ***Fundulus diaphanus***: Special concern. Uncommon to occasional in lakes and their inlet and outlet streams over much of the state. Most frequently encountered in the St. Croix River drainage in northwestern Wisconsin, where Fago (1986) reported many new records. Absent from southwestern Wisconsin. The banded killifish has become less common in southern Wisconsin in recent years. Lyons (1989a) documented the disappearance of banded killifish from Lakes Mendota and Monona, Dane County, and Pewaukee Lake, Waukesha County. Recent sampling suggests that the species has declined greatly in abundance and possibly disappeared from Oconomowoc Lake, Waukesha County (WDNR unpublished data), and Rock Lake and Lake Ripley, Jefferson County (Marshall, personal communication). Shoreline development and modification of littoral-zone habitats may have caused the loss of banded killifish.

STARHEAD TOPMINNOW ***Fundulus dispar***: Endangered. Uncommon in a few lakes and low-gradient rivers in the Fox River drainage (Illinois) of southeastern Wisconsin and in tributary mouths and floodplain ponds of the lower Wisconsin and lower Black Rivers in the southwestern portion of the state. Abundance trends are unclear. The species is more widespread in the lower Wisconsin River drainage than Becker (1983) indicated, with small numbers of individuals observed as far downstream as the Big Green River, Grant County (WDNR unpublished data). Ray Katula, an accomplished aquarist who specializes in Wisconsin's native fishes, discovered a new population of starhead topminnows in the Black River in Jackson County (Schmidt, personal communication). However, the Coon Creek, Rock County, population of the starhead topminnow may be gone (Fago 1982), and a 1995 resampling of the Sugar River tributary locality in Rock County failed to yield specimens (WDNR unpublished data).

Blackstripe Topminnow ***Fundulus notatus***: Secure. Occasional in low-gradient streams and rivers in southeastern Wisconsin, with a few records from backwaters of the lower Wisconsin River in southwestern Wisconsin.

Silversides – Atherinidae

Brook Silverside ***Labidesthes sicculus***: Secure. Common in lakes and in backwaters and sloughs of large rivers in southern and northwestern Wisconsin.

Sticklebacks – Gasterosteidae

Brook Stickleback ***Culaea inconstans***: Secure. Common in low-gradient streams, beaver ponds, and small lakes throughout the state.

Ninespine Stickleback ***Pungitius pungitius***: Secure. Common in the Great Lakes; occasional in tributary mouths during spring spawning. Uncommon in one or more deep lakes in north-central Wisconsin. Lyons (1984) documented the capture of three individuals of this species in 1968 from Trout Lake, Vilas County (Chippewa River drainage) — the first record of ninespine stickleback from the Mississippi River basin in Wisconsin and the only confirmed Wisconsin records outside of Lake Michigan and Lake Superior. However, no ninespine stickleback have been taken from Trout Lake since 1968 despite extensive sampling, indicating that the species has probably been extirpated. In 1995, ninespine stickleback were reported from Lake Tomahawk, Oneida County (Wisconsin River drainage) (Gene Hatzenbeler, University of Wisconsin–Stevens Point, personal communication), but the origin and status of this population is unknown.

Sculpins – Cottidae

Mottled Sculpin ***Cottus bairdi***: Secure. Common in coldwater streams and deep lakes statewide; uncommon to occasional in nearshore areas of the Great Lakes.

Slimy Sculpin ***Cottus cognatus***: Secure. Common in the Great Lakes, occasionally moving into the lower reaches of tributaries when water temperatures are cold. Inland, the slimy sculpin is found in a few cold streams that are scattered around the state but concentrated in southwestern Wisconsin and in Trout Lake, Vilas County, and Big Green Lake, Green Lake County. New inland records were documented by Lyons (1984) for Trout Lake (Chippewa River drainage); by Fago (1985b) for Kriwanek Creek, Manitowoc County (Twin River drainage, Lake Michigan basin; see also Kinziger 1998); and by Fago (1986) and Lyons (1990) for the Namekagon River system (St. Croix River drainage). Lyons (1990) summarized distribution and morphological variation of slimy sculpin in the north-central United States.

Spoonhead Sculpin ***Cottus ricei***: Secure. Common in Lake Superior; uncommon in northern Lake Michigan. Spoonhead sculpin were considered extirpated from Lake Michigan by the 1980s but reappeared in the northern half of the lake in low numbers in 1990 (Potter and Fleischer 1992).

Deepwater Sculpin ***Myoxocephalus thompsoni***: Secure. Common in the deeper waters of the Great Lakes.

Temperate Basses – Percichthyidae (Moronidae)

White Bass ***Morone chrysops***: Secure. Occasional to common in large rivers and large lakes in the southern two-thirds of the state.

Yellow Bass ***Morone mississippiensis***: Secure. Uncommon to occasional in the Mississippi and lower Wisconsin Rivers, the Yahara River and Madison lakes (Rock River drainage), the Fox River (Illinois), Lake Winnebago, and Lake Poygan, Winnebago and Waushara Counties (Fox River (Green Bay) drainage). The Yahara River and Madison lakes populations may have been introduced.

Sunfishes – Centrarchidae

Rock Bass ***Ambloplites rupestris***: Secure. Common in lakes and rivers statewide.

Green Sunfish ***Lepomis cyanellus***: Secure. Occasional to common in streams, small rivers, and small lakes in the southern half of the state; uncommon in the northern half.

Pumpkinseed ***Lepomis gibbosus***: Secure. Common in lakes and low-gradient streams throughout the state; occasional in rivers.

Warmouth ***Lepomis gulosus***: Secure. Uncommon to occasional in lakes and large rivers statewide, with a concentration of populations in the southeast. Fago (1992) documented FDS collections from five lakes in Bayfield County, the first Wisconsin records from the Lake Superior basin.

Orangespotted Sunfish ***Lepomis humilis***: Secure. Occasional in the rivers of the southern third of Wisconsin; most abundant in backwaters and sloughs of the Mississippi River. Fago (1984b) documented two occurrences of orangespotted sunfish from the Milwaukee River, Ozaukee County, the first records of this species from the Great Lakes basin in Wisconsin.

Bluegill ***Lepomis macrochirus***: Secure. Common in ponds, lakes, and rivers throughout the state.

Longear Sunfish ***Lepomis megalotis***: Threatened. Uncommon in a handful of small lakes and low-gradient rivers in the eastern and northern thirds of the state. Abundance trends are uncertain. Longear sunfish in the Milwaukee River system, a former stronghold, appear to be declining (Tim Ehlinger, University of Wisconsin–Milwaukee, personal communication; WDNR unpublished data). The only populations remaining are found upstream of the city of West Bend, Washington County, and contain few individuals, some of which are hybrids with other *Lepomis* species. New localities since Becker (1983) in the Chippewa River drainage include the Trout River, Vilas County (Lyons 1988), Lake Winter and Beverly Lake, Sawyer County (Fago 1992), and the West Fork Chippewa River, Sawyer County (UWZM 9753). In other drainages there are new records for the Yellow River, Washburn County (Bell Museum of Natural History 24235, University of Minnesota, Minneapolis), in the St. Croix River drainage; Genesee Creek, Waukesha County (UWZM 11006), in the Illinois River drainage; and Leigh Flowage, Oconto County (Fago 1992), in the Oconto River drainage (Lake Michigan basin). However, 1997 and 1998 sampling of Winter Lake failed to yield specimens, and the Beverly Lake population was found to contain numerous hybrids (Ehlinger, personal communication). Longear sunfish from Wisconsin had been considered the northern subspecies *L. m. peltastes*, but Jennings and Philipp (1992) showed with a genetic analysis that northern and central longear sunfish *L. m. megalotis* could not be reliably distinguished.

Smallmouth Bass ***Micropterus dolomieu***: Secure. Common in lakes, streams, and rivers statewide, as well as nearshore areas of the Great Lakes.

Largemouth Bass ***Micropterus salmoides***: Secure. Common in ponds, lakes, and low-gradient rivers throughout the state.

White Crappie ***Pomoxis annularis***: Secure. Occasional in lakes and large rivers in the southern half of the state; uncommon at a few localities further north.

Black Crappie ***Pomoxis nigromaculatus***: Secure. Occasional to common in lakes and large rivers statewide.

Perches — Percidae

Crystal Darter ***Ammocrypta (Crystallaria) asprella***: Endangered. Uncommon in the Mississippi River and the lower reaches of its largest tributaries. Distribution and abundance in the state appear to be stable. Sampling in the 1990s found crystal darters in all river reaches where they had been reported by Becker (1983). Only one collection had been known from the lower Wisconsin River, made in 1962 by Becker, and the species was thought to have been extirpated from this system (Fago 1992). However, in 1998 and 1999 single individuals were collected from three localities on the Wisconsin River in Grant, Richland, and Iowa Counties (UWZM 11076, 11077, and photos). Fago (1986) provided the first records from the lower St. Croix River. In 1998, a WDNR crew collected a single specimen from the LaCrosse River (LaCrosse County) about 23 km above Mississippi River Pool 8 (Mary Temp, WDNR, LaCrosse, personal communication). Recent reports document the presence of crystal darter in the Mississippi River in Pools 8, 5, 5A, and 4 (UMRCC 1983; EMTC 1998; Bell Museum of Natural History specimens, University of Minnesota, Minneapolis; WDNR unpublished data).

Western Sand Darter ***Ammocrypta clara***: Special concern. Uncommon to occasional in the Mississippi, lower Wisconsin, lower Black, lower Chippewa, lower St. Croix, Wolf, and Menominee Rivers, and the lower reaches of their larger tributaries. This species seems to have a stable abundance in the state. Fago (1986) confirmed the presence of the western sand darter in the lower St. Croix River drainage, and Fago (1992) documented several new records in the Wolf River system (Fox River drainage). Recent collections have extended the species range upstream in the Wisconsin River to just below the mouth of the Lemonweir River, Juneau County (UWZM 10976). Western sand darters were collected in 1993 (University of Michigan Museum of Zoology 224173) and in 1997 (UWZM 10989) from separate locations in the Menominee River above the Grand Rapids Dam, where the river forms the boundary between Marinette County, Wisconsin, and Menominee County, Michigan. These are the first records from this drainage and the first known from Michigan. Becker (1965, 1983) attributed the presence of the western sand darter in the Lake Michigan basin to a cross-over from the Wisconsin River basin within the last 160 years via a canal at Portage, Columbia County. However, the presence of the western sand darter in the Menominee River, more than 350 km from Portage and upstream from three dams on the Menominee River (which were in place by the late 1800s), argues for a much earlier cross-over via the natural but sporadic high-water connection between the Wisconsin and Fox Rivers that formerly existed at Portage (see speckled chub account).

Mud Darter ***Etheostoma asprigene***: Special concern. Uncommon in the Mississippi River and the lower reaches of its largest tributaries. Abundance trends are uncertain. The mud darter often occurs in relatively deep, silty habitats that are difficult to sample, and it may be more widespread and abundant than currently believed. Recent collections have extended its range about 50 km upstream in the Wisconsin River, to just below the mouth of the Baraboo River, Columbia County (WDNR unpublished data). A 1998 collection (Bell Museum of Natural History 30283, University of Minnesota, Minneapolis) confirms the continued presence of the mud darter in the lower reaches of the St. Croix River, where it had not been reported since the 1920s (Greene 1935, Fago 1986).

RAINBOW DARTER *Etheostoma caeruleum*: Secure. Occasional to common in rocky streams and small rivers in the southern two-thirds of the state, mainly in the Mississippi River basin. The only Wisconsin records from the Great Lakes basin are from western tributaries of the lower Wolf River drainage and the headwaters of the Fox River drainage. Many of the Fox River drainage populations appear to have been eliminated (Becker 1983, WDNR unpublished data), probably because of the intensive agriculture that dominates the watersheds in this area.

BLUNTNOSE DARTER *Etheostoma chlorosoma*: Endangered. Uncommon in Mississippi River Pool 11, Grant County. Becker (1983) published records from the 1940s of bluntnose darter from Mississippi River Pool 8 and Pool 9, and a 1976 FDS record from Pool 11. Fago (1992) noted an additional 1976 FDS record from Pool 11. No bluntnose darters have been seen in Pool 8 or Pool 9 since the 1940s despite substantial sampling (UMRCC 1983, Fremling et al. 1989, EMTC 1998), although a specimen was taken in 1997 from Pine Creek, Minnesota, near where it enters Pool 8 (Bell Museum of Natural History 29263, University of Minnesota, Minneapolis). From 1995 through 1999, the two Pool 11 sites plus many others in the vicinity were resampled by WDNR personnel, and in 1996 three bluntnose darters were captured from one of the 1976 sites (UWZM 10790).

IOWA DARTER *Etheostoma exile*: Secure. Occasional to common in lakes and low-gradient streams and rivers throughout the state.

FANTAIL DARTER *Etheostoma flabellare*: Secure. Common in rocky streams and small rivers in the southern half of the state, uncommon to occasional in the northern half, and absent from the Lake Superior basin.

LEAST DARTER *Etheostoma microperca*: Special concern. Uncommon in small lakes and low-gradient streams widely scattered around the state; most frequently encountered in the southeast and northwest. Statewide abundance trends are uncertain. Fago (1992) provided several new records from the upper St. Croix and Chippewa drainages, and Lyons (1988) documented a disjunct population in the Trout River, Vilas County (Chippewa River drainage). In 1992, Konrad Schmidt (personal communication) captured a single least darter from Bakken Lake, Sauk County, the first record of the species from the lower Wisconsin River drainage in 30 years. However, the least darter may have disappeared from Allen Creek, Rock Lake, and Lake Ripley, Jefferson County, and Otter Creek, Rock County (Rock River drainage), perhaps because of watershed and shoreline development (Marshall, personal communication; WDNR unpublished data). The least darter is relatively sensitive to environmental perturbations (Lyons 1992).

JOHNNY DARTER *Etheostoma nigrum*: Secure. Common in ponds, lakes, streams, and rivers throughout Wisconsin, as well as in sheltered nearshore areas of the Great Lakes.

BANDED DARTER *Etheostoma zonale*: Secure. Occasional to common in streams and rivers in the southern two-thirds of Wisconsin.

YELLOW PERCH *Perca flavescens*: Secure. Common in ponds, lakes, and rivers throughout the state. Also common in harbor and river mouths of Lake Superior and throughout Green Bay, but currently uncommon in southern Lake Michigan. The population of yellow perch in southern Lake Michigan has declined precipitously in recent years, forcing closure of the commercial fishery (WDNR unpublished data). The population in Green Bay has also decreased, but yellow perch abundance remains high enough to permit the commercial fishery there to continue.

LOGPERCH *Percina caprodes*: Secure. Common in lakes and rivers statewide plus nearshore areas of the Great Lakes.

Gilt Darter ***Percina evides***: Threatened. Uncommon to occasional in the St. Croix River, the Chippewa River in Rusk and Sawyer Counties, the Black River in Jackson County, and the lower reaches of their larger tributaries. The gilt darter has a stable distribution and abundance in the state. Sampling in the 1990s revealed healthy populations of gilt darters in all river reaches where they had been reported by Becker (1983). New populations were discovered in the Jump and lower Flambeau Rivers, Rusk County (Chippewa River drainage) (UWZM 9535, 9538, 10217, 10998). An apparent gilt darter X blackside darter hybrid was collected in 1998 from the Chippewa River, Rusk County (UWZM 11089). In 1996, an attempt was made to re-establish gilt darters in a stretch of the Namekagon River, Washburn County (St. Croix River drainage), where they had last been seen in the 1920s, but it is too early to determine the success of this effort (WDNR unpublished data).

Blackside Darter ***Percina maculata***: Secure. Common in streams and rivers in all areas of the state except the Lake Superior basin, where absent.

Slenderhead Darter ***Percina phoxocephala***: Secure. Occasional in the larger rivers of the state, mainly in the Mississippi River basin. The only Wisconsin records from the Great Lakes basin are from the Wolf River drainage. Since Becker (1983), several new localities have been documented for this species in the upper Chippewa, upper Wisconsin, and Wolf Rivers drainages (Fago 1992; UWZM 9527, 9530, 9754, 9802, 11052).

River Darter ***Percina shumardi***: Secure. Occasional in the Mississippi River and the lower reaches of its largest tributaries and in the Lake Winnebago – Fox River – Wolf River system. Becker (1983) thought that this species dispersed from the Mississippi River basin into the Lake Michigan basin via the Portage canal that connected the Wisconsin and Fox Rivers drainages. Both he and Fago (1992) plotted records in the Fox River drainage as far downstream as Lake Winnebago. Recently, the known range of this species has been extended to include the lower Fox River and at least a portion of Green Bay. Five individuals were electrofished or caught in the sea lamprey assessment trap below the DePere Dam on the Fox River (Brown County) during the period 1980–1991 (Cochran unpublished data, University of Wisconsin–Green Bay Richter Museum of Natural History 1634). Brazner (1997) reported a single specimen from an unspecified location in Green Bay.

Sauger ***Stizostedion canadense***: Secure. Common in the Mississippi River and the lower reaches of its largest tributaries, and uncommon to occasional in the Lake Winnebago – Fox River – Wolf River system and lower Green Bay.

Walleye ***Stizostedion vitreum***: Secure. Common in lakes and rivers throughout the state as well as nearshore areas of the Great Lakes. Widely stocked.

Drums – Sciaenidae

Freshwater Drum ***Aplodinotus grunniens***: Common in the Mississippi River and the lower reaches of its largest tributaries, the Yahara River and Madison lakes (Rock River drainage), Pewaukee Lake (Fox River (Illinois) drainage), and the Lake Winnebago – Fox River – Wolf River system. Uncommon in nearshore areas of Lake Michigan. The population in Pewaukee Lake may have been introduced.

Established Non-native Species

Lampreys — Petromyzontidae

Sea Lamprey ***Petromyzon marinus***: Secure. Common in the Great Lakes and many of their tributaries in the northern half of the state. Native to the Atlantic Ocean and its tributaries in northeastern North America and Europe. The abundance of the sea lamprey, a parasitic species that kills many salmonids in the Great Lakes, is suppressed well below potential levels in Wisconsin by a combination of the application of a selective toxicant that kills ammocoetes (juveniles) and the maintenance of barriers that prevent access by adults to spawning streams. Sea lampreys require cool or cold streams with good environmental quality in order to spawn successfully. As pollution controls have improved water quality in many rivers, there has been concern that new spawning habitat would become available for this undesired species (Ferreri et al. 1995). A navigation lock on the lower Fox River, Brown County, was permanently sealed in 1987–1988 to prevent sea lamprey access to the large Fox River drainage, a somewhat controversial action, since no sea lampreys had yet been collected from the river (Cochran 1994). However, the timing of the lock closure proved fortuitous, as sea lampreys were first collected from the lower Fox River in 1991. A total of six specimens have now been collected, the most recent in 1998 and 1999.

Herrings – Clupeidae

ALEWIFE ***Alosa pseudoharengus***: Secure. Common in Lake Michigan and uncommon to occasional in Lake Superior. Sometimes found in the lower reaches of tributary streams during the spring. The population in Lake Michigan has declined substantially from peak levels of the 1960s. Native to the neashore Atlantic Ocean and its tributaries in northeastern North America.

Minnows — Cyprinidae

GOLDFISH ***Carassius auratus***: Secure. Uncommon to occasional in a few localities in southeastern and east-central Wisconsin. Widely kept as a pet, and individuals released from home aquaria or washed out of ornamental ponds may be encountered elsewhere in the state. Native to temperate regions of Asia. Becker (1983) indicated that established populations of this species were restricted to southeastern Wisconsin, with a single individual having been collected from as far north as Winnebago County. Fago's (1985b, 1992) records were also concentrated in southeastern Wisconsin, but he mapped localities in the Manitowoc River drainage in Calumet County and the West Twin River in Manitowoc County. We have recent records from a pond and its outlet stream near Green Bay in Brown County (Cochran unpublished data). A goldfish was found in the nest of a Forster's tern (*Sterna forsteri*) on Kidney Island (Renard Isle) in Green Bay in 1988 (Jonas and Erdman, manuscript in preparation), and single goldfish were collected in 1994 from the Fox River in Brown County (Cochran unpublished data) and from Green Bay (Brazner 1997).

COMMON CARP ***Cyprinus carpio***: Secure. Common in lakes and rivers in the southern two-thirds of the state; uncommon in the northern third. Common in harbors and bays of Lake Michigan, but uncommon in Lake Superior. Native to temperate areas of Asia.

Smelts — Osmeridae

RAINBOW SMELT ***Osmerus mordax***: Secure. Common in the Great Lakes and a few inland lakes in northern Wisconsin. Native to nearshore marine and adjacent freshwater habitats throughout much of the Nearctic region, including the Pacific, Arctic, and Atlantic coasts of northern North America. Since Becker (1983), additional inland reports of rainbow smelt have come from Mississippi River Pool 8; Whitefish Lake, Douglas County (St. Croix River drainage); Beaver Dam Lake, Barron County, Sparkling Lake, Vilas County, and Crystal Lake, Vilas County (Chippewa River drainage) (Lyons 1984 and 1987, McLain and Magnuson 1988, Fago 1992, Hrabik et al. 1998, WDNR unpublished data). The Mississippi River record is erroneous (DuWayne Gebken, WDNR, Madison, personal communication), and the Crystal and Sparkling Lake records are for recently established populations (McLain and Magnuson 1988, Hrabik et al.

1998). Rainbow smelt are blamed for the extirpation of cisco from Sparkling Lake and declines in the yellow perch population in Crystal Lake. The status of the rainbow smelt populations in Beaver Dam and Whitefish Lakes is unknown. Abundance of rainbow smelt in the Great Lakes has declined substantially from peak levels of the 1960s and 1970s (WDNR unpublished data).

Trouts – Salmonidae

Coho Salmon *Oncorhynchus kisutch*: Secure. Common in the Great Lakes and many of their tributaries. Native to the Pacific slope of northwestern North America and northeastern Asia. In Wisconsin, Lake Michigan populations are supported completely by stocking; consistent successful natural reproduction in tributaries has not occurred. However, self-sustaining populations have become established in several Lake Superior tributaries, most notably in the Bois Brule River, Douglas County (DuBois and Pratt 1994), and Whittlesey Creek systems, Ashland and Bayfield Counties (WDNR unpublished data). As a result, coho salmon are no longer stocked in the Wisconsin waters of the Lake Superior basin (Peck et al. 1999).

Rainbow Trout *Oncorhynchus mykiss*: Secure. Common in the Great Lakes and many of their tributaries; occasional to locally common in many inland coldwater streams throughout the state. Native to the Pacific slope of northwestern North America and northeastern Asia. In Wisconsin, Lake Michigan populations are supported completely by stocking; successful natural reproduction in tributaries has been very limited, with only Little Scarboro Creek, Kewaunee County (Kewaunee River drainage), consistently producing rainbow trout that survive to migrate to the lake (Ed Avery, WDNR, Waupaca, unpublished data). Self-sustaining populations have become established in several Lake Superior tributaries, with the Bois Brule River producing by far the most recruits to Lake Superior (DuBois and Pratt 1994). Nearly all inland stream populations are maintained by stocking. We know of only two self-sustaining populations, Drew Creek/Florence Lake, Langlade County, and the West Branch of the White River, Waushara County (both in the Fox River drainage), but there may be others.

Kokanee/Sockeye Salmon *Oncorhynchus nerka*: Secure. Occasional to common in two small lakes and their inlets on the border of Langlade and Menominee Counties in northeastern Wisconsin (Fox River drainage). This species is native to the Pacific slope of northern North America and northern Asia, but it has been widely introduced outside its range. Becker (1983) noted the capture of a kokanee salmon from an unspecified Langlade County lake in 1976 but had no other information on the status of the species in Wisconsin. More recent data indicate that the species has become established in the state. See color plate 3 and the distribution map in figure 5. Unless specific to Wisconsin, information in this account is taken from Scott and Crossman (1973), Moyle (1976), Wydoski and Whitney (1979), Morrow (1980), and Simpson and Wallace (1982).

Description: The kokanee salmon is a freshwater form of the anadromous sockeye salmon. Kokanee are much smaller than adult sockeye salmon and rarely exceed 500 mm total length (TL) and 1.6 kg in weight. The largest confirmed Wisconsin specimens have been about 430 mm TL and 0.9 kg, but there are unverified reports of angler catches of fish up to 550 mm (WDNR unpublished data). Kokanee have a typical salmon/trout shape but can be easily distinguished from other salmonids. Unlike other Wisconsin trout and salmon, kokanee have no or very few spots on their body and fins as adults. They are bright silver except during spawning, when their sides and back turn a distinctive bright or purplish red and their heads often take on a dark greenish shade (color plate 3). Males also develop a distinctive "hump" in the dorsal area behind the head and the tip of their lower jaw becomes hooked upward to form

Figure 5. Map of the distribution of kokanee salmon in Wisconsin.

a "kype." Kokanee can also be distinguished from other salmonids by their combination of 13 or more anal fin rays, fewer than 155 lateral-line scales, and 28 or more gill rakers on the first gill arch.

Distribution, Status, and Habitat: Kokanee were apparently first brought to Wisconsin in the late 1950s, when a private individual stocked them into a spring pond that drained into Drew Creek, Langlade County (Fox River drainage) (WDNR unpublished data). Kokanee soon escaped into Drew Creek and moved downstream into Florence Lake, Langlade County, and from there through a 1-km connecting channel into Upper Bass Lake, Menominee County, where they became established (figure 5). Upper Bass Lake drains into the West Branch of the Wolf River, but no kokanees have been taken downstream from the lake (Doug Cox, Menominee Indian Tribe of Wisconsin, Environmental Services Department, Keshena, personal communication).

The exact abundance of kokanee in Wisconsin waters is uncertain. Anecdotal accounts from anglers and limited scientific sampling suggest that kokanee are common year-around in Upper Bass Lake, but seasonal in Florence Lake and Drew Creek. Local residents say that mature kokanee migrate into Florence Lake from Upper Bass Lake for spawning, but that otherwise kokanee are absent from the lake. Most fish arrive in October and remain until their post-spawning death in early winter, but some individuals may reach the lake as early as mid-summer. We have seen kokanee adults in Drew Creek only on 22 October 1997, although sampling of the creek has been limited. The movement and distribution of larval and juvenile kokanee is unknown.

The specific habitat of kokanees in Wisconsin is unstudied, but data from other regions indicate that juvenile and adult fish inhabit pelagic areas of lakes that are cold (10–18˚C) and well-oxygenated (> 5 mg/l). Interestingly, neither Florence (8.8 m maximum depth) nor Upper Bass (15.5 m) Lakes are particularly deep, but they do thermally stratify and retain cold subsurface water throughout the summer. On 21 July 1999 dissolved oxygen concentrations were low in Florence Lake at depths deeper than about 4 m, but there was a stratum from 2 to 3.5 m with temperatures from 15.0–17.3˚C and oxygen levels from 5.0 to 9.5 mg/l (WDNR unpublished data). The spawning habitat of the kokanee is shallow gravel shoals in lakes and streams. In Wisconsin, spawning fish have been observed along a shallow gravel shoreline near a spring in the northwest corner of Florence Lake and in Upper Bass Lake at the mouth of the shallow inlet from Florence Lake (WDNR unpublished data; Runstrom, personal communication).

Biology: The biology of kokanees has not been investigated in detail in Wisconsin but has been well-studied elsewhere. Kokanees feed primarily on pelagic zooplankton, but in some places they also eat significant numbers of benthic invertebrates. Kokanee typically have a four-year life span, but this can vary from two to eight years depending on growth rate, with slower-growing individuals typically living longer. Growth rate varies greatly among lakes depending on food supply and other environmental conditions. Sexual maturity may be reached anywhere from 200 to 380 mm TL, with faster-growing fish maturing at an earlier age and larger size. Spawning fish that we have seen in Drew Creek and Florence Lake have ranged from 275–365 mm TL and 0.2–0.4 kg (N=11; UWZM 11012, 11221); spawning fish from Upper Bass Lake have ranged from 301 to 416 mm TL (N=9; Runstrom, personal communication). Local anglers report a strong peak in spawners every four years in Florence Lake, indicating a four-year life cycle. Like other Pacific salmon, kokanee die after their first and only spawning. Some kokanee populations spawn as early in the year as August, whereas others spawn as late as the following April. Wisconsin populations appear to spawn from October through at least December. Ripe adults were taken on 4 October and 16 November 1994, from Upper Bass Lake (Runstrom, personal communication) and on 22 October 1997, from Drew Creek (UWZM 11012). Local anglers say that spawning in Florence Lake usually peaks in November just before the lake freezes and that by December most kokanee that are caught are spawned out and dying. On 20 December 1999, all nine kokanee captured from Florence Lake were spawned out and several showed signs of the tissue decay that is a precursor to death (UWZM 11221). However, the former WDNR fish manager for the area reports having seen spawning in Florence Lake in "late winter" (Max Johnson, WDNR, Antigo, memo on file). Fecundity of Wisconsin kokanee has not been determined, but elsewhere, females typically lay from 200 to 1800 eggs in one or more redds constructed in gravel shoals. Soon after hatching in late winter or early spring, fry move into the pelagic zone of lakes, where they remain until they mature several years later.

Importance and Management: Kokanees support popular sport fisheries and are valuable forage for larger salmonids in many lakes in western North America. Consequently, they have been widely stocked outside their native range and have been the subject of numerous fisheries management activities and research studies. Only limited fishing for kokanee takes place in Wisconsin because neither Florence nor Upper Bass Lake has public access. Moreover, Upper Bass Lake lies entirely within the Menominee Indian Reservation and is not open to fishing by the public (Cox, personal communication). The role of kokanee as a forage species in Wisconsin is unknown.

There are no reports of kokanee introductions negatively influencing native fish populations, but all studies are from the western U.S. and Canada, where the native fauna is very different from that of Wisconsin. The possible impact of kokanees on the native fauna of Wisconsin is uncertain, but the possibility for harm must be considered. As pelagic planktivores, kokanees have the potential to influence strongly zooplankton communities and thus compete with other zooplantivorous fishes for food. Some native Wisconsin lake fishes, such as yellow perch (*Perca flavescens*), have pelagic larval stages that feed on zooplankton, and competition with or predation by kokanee could influence their survival. Also of concern is the potential for kokanee to disrupt brook trout spawning activities and disturb brook trout (*Salvelinus fontinalis*) redds in streams. We strongly urge that kokanees be prevented from expanding their range in Wisconsin.

Chinook Salmon ***Oncorhynchus tshawytscha***: Secure. Common in Lake Michigan and its tributaries; occasional in Lake Superior and its tributaries. Native to the Pacific slope of northwestern North America and northeastern Asia. In Wisconsin, Lake Michigan populations are supported completely by stocking, as consistent successful natural reproduction in tributaries has not occurred. However, self-sustaining populations have become established in a few Lake Superior tributaries, most notably the Bois Brule River, Douglas County (DuBois and Pratt 1994). As a result chinook salmon are no longer regularly stocked in the Wisconsin waters of the Lake Superior basin (Peck et al. 1999).

Brown Trout ***Salmo trutta***: Secure. Common in many coldwater streams and small rivers and in the Great Lakes and their tributaries. Native to Europe, parts of western Asia, and the Atlas Mountains in northwestern Africa. In Wisconsin, many inland streams have self-sustaining populations, but brown trout are also widely stocked in streams and a few deep lakes. In Lake Michigan, populations are supported almost completely by stocking; recruitment of brown trout from tributaries is insignificant. However, self-sustaining anadromous populations exist in several Lake Superior tributaries, the largest being the Bois Brule River, Douglas County (DuBois and Pratt 1994).

Sticklebacks — Gasterosteidae

Threespine Stickleback ***Gasterosteus aculeatus***: Secure. Common in Lake Michigan and the lower reaches of its tributaries; occasional in Lake Superior and its tributaries. This species has a broad circumpolar distribution in the northern hemisphere in both fresh and coastal marine waters, but its known range prior to 1980 did not include the Great Lakes above Niagara Falls (Burgess and Lee 1980). In 1980, threespine sticklebacks were collected at Manitoulin Island in northern Lake Huron (Gibson 1982), presumably having arrived there via a bait bucket release (Stedman and Bowen 1985). Since then, a series of papers have documented the spread of the species through Lake Huron and into the Lake Michigan and Lake Superior basins (Fleisher and Brazo 1985, Stedman and Bowen 1985, Johnston 1991). See color plate 4 and the distribution map in figure 6.

Description: Throughout its vast range, the threespine stickleback name is applied to what may actually be a complex of related species (Burgess and Lee 1980). Threespine sticklebacks possess 3 dorsal fin spines (rarely 2 or 4), a feature that distinguishes them from Wisconsin's native sticklebacks, the brook stickleback (*Culaea inconstans*) with 5 (4–6) and the ninespine stickleback (*Pungitius pungitius*) with 9 (8–11). The most posterior third spine of the threespine stickleback is very short (color plate 4). The prominent bony keel along each side of the caudal peduncle is shorter but wider than the keel of the ninespine stickleback. The sides of the threespine stickleback are more or less covered with a series of bony plates. Most of the upper Great Lakes specimens that have been examined

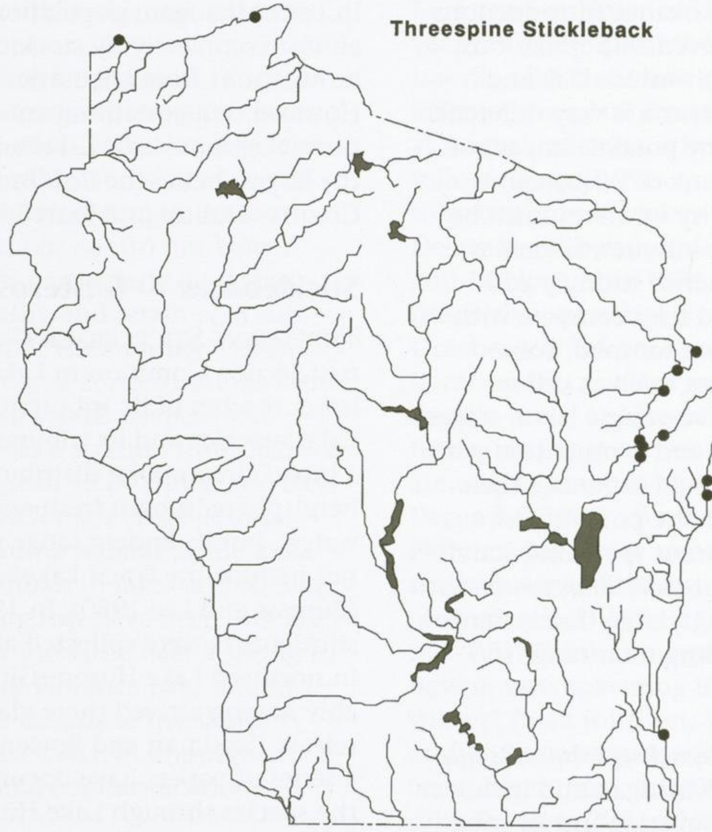

Figure 6. Map of the distribution of threespine stickleback in Wisconsin.

are the fully plated (*trachurus*) morph typical of the east coast of North America (Gibson 1982, Stedman and Bowen 1985), but some partly plated, intermediate specimens were observed by Fleischer and Brazo (1985). Eleven individuals from Lake Michigan tributaries in Wisconsin averaged 59 mm TL (range: 50–71 mm); 8 specimens from a Lake Superior tributary averaged 52 mm (range: 49–58 mm) (Cochran, unpublished data).

Distribution, Status, and Habitat: The native range of the threespine stickleback includes much of the east and west coasts of North America and the Pacific coast of Asia, as well as Iceland, parts of Greenland, and much of Europe (Burgess and Lee 1980, Page and Burr 1991). Freshwater populations may occur some distance inland from coastlines, especially in eastern North America, where the species is native to the St. Lawrence River and Lake Ontario. As discussed above, threespine sticklebacks spread to the Lake Superior and Lake Michigan drainages after being introduced to Lake Huron (figure 6). In the Lake Superior drainage, they were reported from the Thunder Bay Harbor, Ontario, by Momot and Stephenson (1996), and they were collected in Minnesota in 1994 in Taconite Harbor and later in the St. Louis River estuary on the border with Wisconsin (Hirsch 1998). In 1999 threespine sticklebacks were collected in "surf pools" of Lake Superior near Grand Marais, Minnesota (Schmidt 1999). In addition, we have specimens from Wisconsin collected on 5 June 1998 at the mouth of Saxine Creek, Bayfield County

(UWZM 11218). In northern Lake Michigan, threespine sticklebacks were found in 1994 in beach pools along the shoreline of Beaver Island (Swinehart 1996). In the western Lake Michigan basin, they were reported by Johnston (1991) from Milwaukee Harbor, Milwaukee County (collected in 1986), and from an unnamed Lake Michigan tributary, Kewaunee County (1989), as well as from several locations in Illinois (1988 and 1989). Jonas and Erdman (manuscript in preparation) found the remains of 40 threespine sticklebacks in 1988 in a tern nesting colony on Kidney Island (Renard Isle) in Green Bay. In 1990 and 1991, eight specimens were collected from five sandy beach and coastal wetland sites along the southern and western shoreline of Green Bay, including locations in Brown, Oconto, and Marinette Counties in Wisconsin and Delta County in Michigan (Brazner 1997, Brazner and Beals 1997). We also have specimens collected from the lower Fox River, Brown County, 12 km upstream from Green Bay (17 June 1994, UWZM 11216 and 19–29 May 1996, UWZM 11217) and in an unnamed creek tributary to Lake Michigan at Two Creeks Park, Manitowoc County (19 May 1999, UWZM 11163).

Local abundance of threespine sticklebacks may fluctuate erratically (Cochran and WDNR unpublished data). Ten specimens collected in a sea lamprey assessment trap on the lower Fox River in May 1996 were the first collected in 18 years of spring trapping, but none were collected during the subsequent 3 years. Specimens were easily collected on 5 June 1998 at the mouth of Saxine Creek, where none were found on 3 June 1997. Dense schools were observed in Milwaukee Harbor in the late spring and early summer of 1996, but none were encountered there in late summer.

Our review of collection data for threespine sticklebacks in the upper Great Lakes suggests that habitat use may vary seasonally. Collections in autumn and early May have tended to occur offshore at relatively great depths (e.g., 27–55 m, Stedman and Bowen 1985), whereas collections from mid-May to July have occurred in tributary streams or shallow, protected habitats inshore. Movement into shallow habitat in late spring and summer is probably associated with spawning (Stedman and Bowen 1985). Prior to the decline of the rainbow smelt sport fishery in the Green Bay system, we received reports of threespine sticklebacks being collected by smelt netters who seined Green Bay tributary streams during the spring. We sampled likely habitat in the lower reaches of several Lake Michigan tributaries in Kewaunee and Door Counties in October 1998 without finding threespine sticklebacks.

Most of the threespine sticklebacks that we have collected in Wisconsin in Great Lakes tributaries in May and June occurred at water temperatures of 13.5–16°C. However, a specimen was taken in the Fox River on 17 June 1994 at 27°C.

Biology: The threespine stickleback is one of the best-studied of all fishes, and several books deal extensively with its biology (Wootton 1976, 1984, Bell and Foster 1994). Relatively little is yet known, however, about the ecology of this species in the upper Great Lakes.

Several predators and parasites have been found to attack threespine sticklebacks in the upper Great Lakes. Jonas and Erdman (manuscript in preparation) reported that threespine sticklebacks were the most common fish species found discarded around Forster's (*Sterna forsteri*) and common tern (*Sterna hirundo*) nests on Kidney Island (Renard Isle) in Green Bay during 1988. Observations of nestling terns with bleeding about the mouth indicated that they had been wounded by the sticklebacks' spines (T. C. Erdman, University of Wisconsin–Green Bay, personal communication). Several threespine sticklebacks have been recovered from lake trout (*Salvelinus namaycush*) stomachs. Hudson et al. (1994) found that 5 of 110 threespine sticklebacks sampled in Lake Huron were infected by the parasitic copepod *Ergasilus nerkae*, but this parasite was much more common on ninespine sticklebacks (*Pungitius pungitius*).

The threespine stickleback often occurs with native sticklebacks. Threespine (UWZM 11218), ninespine (UWZM 11220), and brook (UWZM 11219) sticklebacks were collected in the same seine haul at Saxine Creek. Threespine and brook sticklebacks were collected together in small streams in Kewaunee and Manitowoc Counties and in the same reach of the Fox River (Cochran and WDNR unpublished data). Threespine and ninespine sticklebacks were collected together at two locations in Lake Huron (Hudson et al. 1994). Although several authors have suggested the potential for competition between threespine and native sticklebacks (Stedman and Bowen 1985, Hirsch 1998), we are unaware of data to test that hypothesis in the upper Great Lakes. Wootton (1984) reviewed studies of resource use by threespine and ninespine sticklebacks where they co-occur in other areas and found that diets often differed on the basis of food type or food size and there was no evidence that food was limiting even when diet overlap was high. Moreover, competition for space by nesting males was apparently avoided through a tendency for male ninespine sticklebacks to establish territories in denser algal growth.

Importance and Management: The threespine stickleback does not seem to have aroused the same level of concern as other recent invaders to Wisconsin waters. It is native to part of the Great Lakes basin, where it has long coexisted with many of the same species native to the upper Great Lakes. Efforts to minimize the spread of other exotic species within the Great Lakes may be too late to have much effect on the threespine stickleback, which seems to be less confined to river mouths or bays than ruffe (*Gymnocephalus cernuus*) or white perch (*Morone americana*).

Another non-native species of stickleback, the fourspine stickleback (*Apeltes quadracus*), has been reported from the Lake Superior drainage at Thunder Bay, Ontario (Holm and Hamilton 1988, Momot and Stephenson 1996). It is native to the northeastern coast of North America and probably reached Lake Superior via ballast water transfer. The fourspine stickleback apparently has not spread far since its initial discovery, but it may eventually appear in Wisconsin.

Temperate Basses – Percichthyidae (Moronidae)

White Perch *Morone americana*: Secure. Common in the lower Fox River and Green Bay, several Lake Michigan river mouths, and Duluth-Superior Harbor. This euryhaline species is native to the Atlantic coast of North America (Burgess 1980). It is thought to have invaded Lake Ontario through the Mohawk River and Erie Barge Canal (Scott and Christie 1963) and was established in western Lake Erie by 1975 (Busch et al. 1977). Beginning in 1983, the white perch was reported from locations throughout Lake Huron (Johnson and Evans 1990), and in 1988 was collected in the Lake Michigan drainage in Illinois (Savitz et al. 1989) and the Green Bay/lower Fox River system in Wisconsin (Cochran and Hesse 1994). The presence of fish of several age classes in Fox River collections in 1989 and 1990 suggested that the species may have been established for several years prior to its initial discovery in 1988 (Cochran and Hesse 1994). Possibly as the result of ballast water transfer, white perch were collected in Duluth-Superior Harbor in the Lake Superior drainage in 1986 (Johnson and Evans 1980). See color plate 5 and the distribution map in figure 7.

Description: The white perch (color plate 5) is similar in appearance to the closely related white bass (*Morone chrysops*) and yellow bass (*Morone mississipiensis*). White perch have been captured together in Wisconsin with white bass but not with yellow bass. The body depth of the white perch peaks just before or at the beginning of the spiny dorsal fin; the body of the white bass is deepest below the middle of the spiny dorsal fin and remains fairly uniform throughout the length of the fin. The body of the yellow bass peaks toward the middle or end

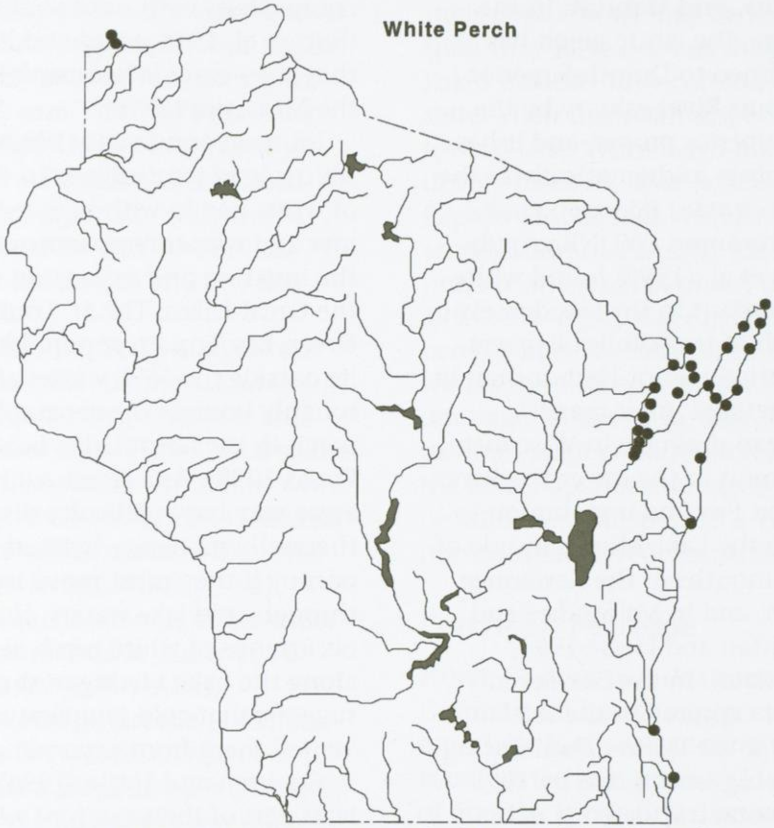

Figure 7. Map of the distribution of white perch in Wisconsin.

of the spiny dorsal fin, and the peak is less pronounced than that of the white perch, giving the yellow bass a more rounded dorsal profile. All sizes and ages of white bass and yellow bass have dark horizontal lines along their sides. Young white perch may have similar dark lines but adults do not. Rather, the adults are dark green-brown or olive on the back, whitish on the belly, and unmarked silver-green on the sides, sometimes with a brassy tinge. Spawning white perch may display a bluish-lavender cast on their chins. Conversely, white bass are typically silver-white on their sides, and yellow bass are silver-yellow. The spiny dorsal fin is more firmly connected to the soft dorsal fin in the white perch and yellow bass than in the white bass. When the spiny dorsal fin of a fresh white perch or yellow bass is manually pulled erect, the soft dorsal fin also rises, but when the spiny dorsal fin of a white bass is pulled erect, the soft dorsal fin remains relaxed. All three species have three anal fin spines, but in the white perch and yellow bass the second and third spines are roughly equal in length, whereas in the white bass the second spine is distinctly intermediate in length between the first and third. The white perch and yellow bass have 8–10 soft rays behind the anal spines and the white bass has 11–13. Finally, the white bass has one or two patches of teeth on the rear of its tongue; these are absent in the white perch and yellow bass (Page and Burr 1991).

White perch in the Great Lakes do not get as big as white bass, but they are similar in maximum size to yellow bass. The largest white perch measured from the Fox River was a female of 260 mm TL that weighed 261 g. The largest male was 245 mm and 207 g.

Distribution, Status, and Habitat: In the Lake Superior drainage, the white perch has apparently been confined to Duluth-Superior Harbor and the St. Louis River estuary by the cold waters of Lake Superior proper, and it has not increased in numbers as dramatically as the ruffe (*Gymnocephalus cernuus*) (Sierszen et al. 1996) although it is common (WDNR unpublished data). Brazner et al. (1998) found white perch to be more abundant in the less densely vegetated outer marsh of the Allouez Bay wetland within the Duluth-Superior Harbor than in the more densely vegetated inner marsh.

In the Lake Michigan drainage in Wisconsin, white perch are common in the lower Fox River and throughout Green Bay and uncommon to occasional in bays on the Lake Michigan side of Door County, in the mouths of the Kewaunee and West Twin Rivers, and in Milwaukee and Racine Harbors (Cochran and Hesse 1994, WDNR unpublished data). In the Fox River, white perch were first captured in the sea lamprey assessment trap at the DePere Dam during the 1989 spring trapping season and by 1993 made up 24% of the total trap catch (Cochran and Hesse 1994). They have remained a conspicuous component of the lower Fox River fauna since then, constituting 37% of the lamprey trap catch in 1998, but they are only occasionally captured during yearly electrofishing samples upstream from the dam. In the early 1990s white perch began to be captured in large numbers during WDNR trawling in Green Bay. Now white perch occur throughout Green Bay and typically constitute 10 to 35% of annual trawl catches (WDNR unpublished data). The first records for the Door County bays, the Kewaunee and West Twin Rivers, and Milwaukee and Racine Harbors are from 1997 or later (Tim Kroeff, WDNR, Sturgeon Bay, personal communication; Steve Hogler, WDNR, Mishicot, personal communication; Jim Thompson, WDNR, Milwaukee, personal communication), suggesting that white perch have only recently invaded these localities. White perch have invaded the Mississippi River drainage in Illinois through connections with Lake Michigan in Chicago (Burr et al. 1996, Laird and Page 1996), and thus they may enter Wisconsin's inland waters via the Mississippi River.

Johnson and Evans (1990) discussed the possible role of temperature in the range expansion of white perch, with higher-than-average summer and winter temperatures coinciding with the invasion and expansion of white perch in the Great Lakes. The St. Louis River estuary and Green Bay/Fox River populations in Wisconsin lie outside the –5°C winter air isotherm that roughly bounds the geographic range of white perch in the Great Lakes basin (Johnson and Evans 1990). As a result, white perch in these areas may have difficulty dispersing from the thermally moderate habitats they presently occupy if they must move long distances through cold lake waters. However, the recent occurrence of white perch at several localities along the Lake Michigan shoreline of Wisconsin suggests that cold temperatures have not prevented them from expanding their range.

Cochran and Hesse (1994) thought that at least part of their catch of white perch at the DePere Dam represented the result of an upstream spawning migration from Green Bay. However, trapping was extended throughout the summer and fall seasons of 1993 and 1994 and revealed that some white perch remain in the river in the vicinity of the dam during the summer. In many weeks, white perch were one of the most numerous species in the catch. Although no fish were collected during the fall of 1993, white perch were collected during limited sampling in October 1992 and as late as mid-November 1994.

Biology: Much of what is known about the biology of white perch in the Great Lakes is based on work done in Lake Ontario and Lake Erie (e.g., Schaeffer and Margraf 1986a, 1986b, and 1987, Parrish and Margraf 1990). In the Fox River, increased trap catches at the DePere Dam typically occurred in mid- to late May as water temperature first reached 18°C, apparently reflecting the beginning of the upstream spawning run. There was some suggestion that males moved upriver slightly ahead of females, and males as small as 112 mm TL freely expressed milt (Cochran and Hesse 1994). Preliminary analysis of ages from scale samples indicated that growth was rapid, especially early in life, and comparable with white perch from Lake Erie. Growth in later life slowed and few fish exceeded 210 mm TL.

White perch in Lake Erie feed primarily on benthic and planktonic invertebrates and small fish (Parrish and Margraf 1990, Schaeffer and Margraf 1886a). Sierszen et al. (1996) used stable isotope analyses to characterize the diet of white perch in the St. Louis River estuary and inferred that they may become piscivorous by the time they reach 250 mm in length. Naze (1998) reported that the stomachs of some adult white perch in Green Bay contained as many as 12 juvenile yellow perch (*Perca flavescens*).

Little has been reported about the predators of white perch in the Great Lakes. Ogle et al. (1996) mentioned that a black crappie (*Pomoxis nigromaculatus*) from the St. Louis River estuary had eaten a white perch.

Importance and Management: Cochran and Hesse (1994) listed three concerns about the colonization of Wisconsin's waters by white perch: (1) its potential to compete with more desirable species, especially yellow perch (*Perca flavescens*) (Schaeffer and Margraf 1986a) and white bass (*Morone chrysops*), (2) its potential impact as a predator of fish eggs, especially those of walleye (*Stizostedion vitreum*) (Schaeffer and Margraf 1987), and (3) its potential to interbreed with white bass. Additional concerns have arisen about the potential impact of white perch as a predator on yellow perch in Green Bay (Naze 1998). The potential benefit of white perch as a panfish for anglers in Green Bay is largely negated by their high body burdens of PCBs (Naze 1998).

It is important to limit the dispersal of white perch into Wisconsin's inland waters, where their populations may be less easily confined than they have been in the peripheral Great Lakes habitats they currently occupy in the state. Their upstream dispersal in the Fox River toward Lake Winnebago may have been fortuitously blocked, or at least delayed, when the Rapide Croche lock was sealed early in 1988 in anticipation of a similar movement by sea lampreys (*Petromyzon marinus*) (Cochran and Hesse 1994). However, it is now possible that white perch will eventually reach Wisconsin's inland waters from Illinois via the Mississippi River drainage. In the meantime, regulations that prohibit anglers from harvesting white perch in the Lake Superior drainage (one specimen may be killed for transport to a WDNR office) may prevent inadvertent transfers within this system.

Perches – Percidae

RUFFE ***Gymnocephalus cernuus***: Secure. Common in nearshore areas of Lake Superior, especially harbors and river mouths. This species is native to fresh and brackish water in portions of Eurasia. It was first discovered in the St. Louis River, a tributary to Lake Superior that feeds the Duluth-Superior Harbor, in 1987, although subsequent examination of previously collected samples revealed that specimens had been collected as early as 1986 (Pratt 1988, Pratt et al. 1992). Ruffe apparently were transported to this continent in the ballast water of an oceangoing vessel that traveled from a Eurasian port to load grain in the Duluth-Superior Harbor. On the basis of genetic similarity between North American ruffe and those from the Danube River, Stepien et al. (1998) concluded that the Black Sea basin was a likely source. See color plate 6 and the distribution map in figure 8.

Description: The following description has been adapted largely from Pratt (1988) and Jensen et al. (1996). Ruffe resemble small (TL usually < 20 cm) yellow perch (*Perca flavescens*) in body shape, except that the prominent spiny and soft dorsal fins are continuous and the small mouth is slightly downturned (color plate 6). Moreover, ruffe have no scales on their heads and possess 5–10 spines on the posterior edge of each preopercle, along with a sharp spine on the posterior edge of the gill cover. The eyes are large and high on the head, with a tapetum lucidum in the retina that gives them a glassy look. A well-developed system of subsurface canals is present on the head. Rows of black spots on the membranes between the 11–16 dorsal fin spines suggest the spiny dorsal fin of the sauger (*Stizostedion canadense*). The anal fin has two spines, and each pelvic fin has one. The sides and back vary from gray-green, brown-green, or olive-green to yellowish-gold with irregular dark spots. Simon and Vondruska (1991) described larval ruffe from the St. Louis River estuary and provided characteristics to distinguish them from native percids.

Distribution, Status, and Habitat: From the St. Louis River at the border of Wisconsin and Minnesota, ruffe spread into Duluth-Superior Harbor and moved east along the north and south shores of Lake Superior. Along the south shore, ruffe were collected from the mouths of the Amnicon, Brule, and Iron Rivers by 1991 (Pratt et al. 1992), and by 1994 they had spread along the entire Wisconsin shoreline of Lake Superior (figure 8) and into the Upper Peninsula of Michigan as far as the Ontonagon River (Jensen et al. 1996). Along the north shore, they reached as far as Two Harbors, Minnesota, by 1995 (Jensen et al. 1996). A disjunct population discovered in 1991 at Thunder Bay, Ontario, is thought to have been established by transfer of fish from the St. Louis River via ballast water (Pratt et al. 1992). Similarly, ruffe collected near

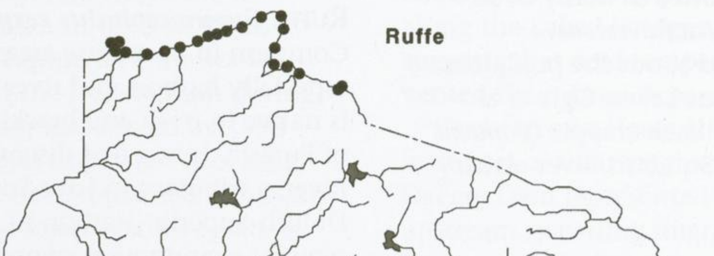

Figure 8. Map of the distribution of ruffe in Wisconsin.

Alpena, Michigan, in northern Lake Huron in 1995 and 1996 are thought to have resulted from ballast water discharge (Jensen et al. 1996). Fuller et al. (1999) indicated that reports of ruffe established in Lake Michigan (Page and Burr 1991) were erroneous, but it would not be unexpected for this species to eventually spread to the Lake Michigan basin.

Five age classes of ruffe were present in the St. Louis River estuary by 1988 (Pratt 1988). After 1990, ruffe became the most numerous fish species collected in bottom trawl and trap samples from the estuary (Bronte et al. 1998, Edwards et al. 1998), with estimates of approximately two million mature fish in Duluth-Superior Harbor (Selgeby 1994). It was also one of the most abundant fishes at the mouths of the Sand, Flag, Iron, Amnicon, and Bois Brule Rivers (Jensen et al. 1996).

In its native range, the ruffe is found in a variety of habitats, including streams, rivers, ponds, lakes, and brackish water (Pratt 1988, Ogle 1998). Although it tends to be found in the deeper, more slowly moving reaches of running waters and has been found as deep as 73 m in a lake in Norway, Pratt (1988) concluded that bottom type was more important than depth in its effect on ruffe distribution. Soft mud bottoms where vegetation is sparse or absent apparently are the preferred foraging habitat. The ruffe often thrives under eutrophic conditions (Ogle 1998).

Selgeby (1994) indicated that ruffe in the St. Louis River estuary are closely associated with the bottom. Although they occupy all habitats in the estuary, they apparently prefer channels of intermediate depth (3–5 m) by day and move to shallower water to feed at night. Movement from rivers into deeper water in lakes may occur at the onset of winter (Pratt 1988). They are found in the deepest channels (8–18 m deep) at the time of ice-out, then move to shallower water to spawn. Brazner et al. (1998) found ruffe to be relatively uncommon in shallow, heavily vegetated habitat, which may provide some native species a refuge from competition with the ruffe as it becomes numerically dominant in more open areas.

Ruffe in the Great Lakes seem to be most common in or near river mouths. The cold water of Lake Superior may slow their dispersal, but Selgeby (1994) noted that ruffe were caught in Lake Superior as populations in the St. Louis River increased.

Biology: Shortly after ruffe were discovered in the Great Lakes, Pratt (1988) provided a review of their biology based on the Eurasian literature. In 1997, an International Symposium on the Biology and Management of Ruffe was held in an attempt to integrate information from Europe and Asia with what was being revealed by North American studies (Gunderson et al. 1998). As noted below, reviews of the literature on selected aspects of the biology of this species are sometimes in disagreement with respect to details. This may reflect the ruffe's apparent adaptability to a broad range of habitats over its extensive range, and it is consistent with recent findings of extensive genetic variation among populations from different geographic locations (Stepien et al. 1998).

Reproduction by ruffe in Europe was reviewed briefly by Pratt (1988), Simon and Vondruska (1991), and Ogle (1998). It is a nonguarding, open substrate, phyto-lithophil (Balon et al. 1977) that intermittently spawns adhesive, demersal eggs at water temperatures between 10°C and 18°C on hard bottoms of sand, clay, or gravel that sometimes have vegetation or plant debris. Females produce from 13,000 to 200,000 eggs per season (Jensen et al. 1996), although the latter figure would be achieved only by very large individuals. Egg diameter typically falls in the range 0.5–1.0 mm (Pratt 1988), although Ogle (1998) reported extremes of 0.34 and 1.3 mm. Pratt (1988) stated that eggs usually hatch in 9–14 days, but Fairchild and McCormick (1996) observed hatching in 5–6 days at 16 C, and Ogle (1998) concluded that hatching occurs after 5–12 days at 10–15°C.

In the St. Louis River estuary, Pratt (1988) first found ruffe in spawning condition on 30 April at a water temperature of 11°C. Fish in spawning condition were collected through early June, with some evidence that at least some females in June were producing a second batch of eggs. Brown et al. (1998) found females in spawning condition at water temperatures of 5–18°C from late April to late June, depending on the year. They concluded that peak spawning occurred from mid-May through early June at 12–14°C, after walleye *(Stizostedion vitreum)* and yellow perch *(Perca flavescens)* had already spawned. They also inferred that ruffe spawn only once in a season, with older fish spawning earlier than younger fish. Larval ruffe have been collected from late May until early July (Simon and Vondruska 1991, Brown et al. 1998). Pratt (1988) found nearly all fish to be mature at age 1, but Selgeby (1994) reported that the proportion of yearlings that were mature declined as the population increased.

Ruffe in the St. Louis River estuary fed primarily on benthic organisms from May to October (Ogle et al. 1995). Age-0 fish shifted from a diet of mostly cladocerans and copepods in early summer to a diet of mostly chironomid larvae in late summer and autumn. Small (< 120 mm TL) adults continued to eat many microcrustaceans but fed primarily on chironomids and other macroinvertebrates. Large adults fed primarily on chironomids, burrowing mayflies, and caddisflies. Few fish had consumed fish or fish eggs. Selgeby (1998), however, found that ruffe taken in Lake Superior in early winter had consumed substantial quantities of lake herring (*Coregonus artedi*) eggs in addition to burrowing amphipods, mysids, and chironomids. Sierszen et al. (1996) used stable isotope techniques to analyze ruffe diet and concluded that it may be broader than indicated by Ogle et al. (1995), with plankton being consumed in addition to benthos. A recent laboratory study (Fullerton et al. 1998) has shown that both ruffe and yellow perch (*Perca flavescens*) prefer soft-bodied invertebrates to hard-bodied forms, a pattern consistent with previous findings in the field. Ruffe were able to consume 5% of their body mass per day at 20°C over a substrate of sand, but they were much less efficient over cobble.

Ruffe seem well-adapted to be active at low light levels, as suggested by their well-developed system of neuromasts in subsurface canals on the head, along with a tapetum lucidum in the retina. Ogle et al. (1995) concluded that adult ruffe generally moved into shallower water at night to feed. However, adult ruffe that stayed in deeper water fed throughout the 24-hour period. Experiments have shown that ruffe in the dark detect prey at greater distances than yellow perch *(Perca flavescens)* and swim faster while searching for food (Janssen 1997).

Predation on ruffe in the St. Louis River estuary was discussed by Selgeby (1994), Ogle et al. (1996), and Mayo et al. (1998). In diet samples collected during 1989–1991, ruffe (mostly age-0 or small age-1 fish) occurred in 6.7% of the burbot (*Lota lota*), 5.8% of the bullheads (*Ameiurus* species), 4.7% of the smallmouth bass (*Micropterus dolomieu*), 2.6% of the northern pike (*Esox lucius*), 2.6% of the black crappies (*Pomoxis nigromaculatus*), 1.3% of the yellow perch (*Perca flavescens*), and none of the walleye (*Stizostedion vitreum*) examined (Ogle et al. 1996). Large yellow perch (> 20 cm) and brown bullheads (*Ameiurus nebulosus*) ate primarily smaller ruffe, whereas northern pike ate larger ruffe and consumed increasing numbers between 1989 and 1992 as the ruffe population increased. In early 1992, 5 of 18 walleye that had eaten fish contained ruffe, and consumption of ruffe by all predators combined increased from almost none in 1989 to over 20% of all fish prey in 1992 (Selgeby 1994). During the period 1991–1994, predators were estimated to have consumed as much as 47% of the ruffe biomass within a single year (Mayo et al. 1998). However, this increased predation did not stop the ruffe population from expanding. Most of the predation during 1991–1994 was by northern pike, but like the other predatory fishes in the system, northern pike selected against ruffe in favor of native prey species. Adaptations for living in dimly lit habitat may help ruffe avoid some predators, and their prominent spines may make them less preferable to predators than soft-rayed fishes or those with smaller spines.

After ruffe became established in Loch Lomond in Scotland, they became the primary prey for cormorants and herons (Adams and Maitland 1998). It can be expected that cormorants, herons, and other avian piscivores in Great Lakes coastal habitats will incorporate ruffe into their diets as ruffe become available.

Importance and Management: Based on what was known of ruffe biology in Europe and Asia, the invasion of North America by ruffe raised many concerns (Pratt et al. 1992, Busiahn 1993). The ruffe quickly proliferated where introduced in Europe and was reported to decrease the abundance of more desirable native species through competition or predation on eggs. The ruffe has a tendency to stunt and provides little value for recreation or food in Europe. Because of its wide habitat tolerance and high reproductive capacity, it is thought to be capable of expanding its range throughout the Great Lakes and into inland waters across much of North America. Its thermal requirements are similar to those of the broadly distributed yellow perch (*Perca flavescens*).

Initial field work in the St. Louis River estuary suggested the potential for ruffe to compete with trout-perch (*Percopsis omiscomaycus*) and yellow perch (Ogle et al. 1995). Stable isotope analysis revealed a high similarity in diet between ruffe and juvenile yellow perch, and increased ruffe numbers may conceivably result in a competitive bottleneck that leads to slow growth by young yellow perch (Sierszen et al. 1996). Laboratory experiments indicated that ruffe were more aggressive but less active than yellow perch (Savino and Kolar 1996), and it was not apparent that either species would have a competitive advantage under all conditions. Although some fish species declined during the time that ruffe increased in abundance in the St. Louis River estuary (Selgeby 1992), it is not clear that factors other than ruffe were not responsible, and at least some sport fish populations are thriving despite increased ruffe abundance (Horns 1996, Sierszen et al. 1996, Bronte et al. 1998).

Management of the ruffe initially focused on biological control through increased stocking of walleye (*Stizostedion vitreum*), northern pike (*Esox lucius*), and muskellunge (*Esxo masquinongy*) from 1989 through 1993 coupled with regulations to reduce sport harvest of these potential ruffe predators. As discussed above, this did not prevent the ruffe population from expanding, at least during the initial years (Hirsch 1998). Predator biomass did not increase substantially during the enhancement period, perhaps because predators were free to leave the system, and predators may actually have favored ruffe by feeding preferentially on native species (Mayo et al. 1998). The Aquatic Nuisance Species Task Force, a federal board created by the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, appointed a Ruffe Control Committee to develop a control program to prevent or delay the spread of ruffe and confine it to its current range in Lake Superior (Busiahn 1993). Although the control program was initially intended to include the use of piscicides in some situations (field tests showed that the lampricide TFM killed a high percentage of ruffe with little mortality to native fishes), this facet of control proved controversial. Instead, attempts have been made to slow the spread of ruffe by assisting the shipping industry in developing voluntary guidelines for handling ballast water in the Great Lakes and by regulating the possession and transportation of ruffe by anglers. To minimize the possibility of inadvertent bait bucket transfers, it is illegal to seine minnows for use as bait in Lake Superior or its tributaries in Wisconsin, and there is no open season for anglers to harvest ruffe. A single specimen may be killed and transported to a WDNR office. Investigations of piscicides (Dawson et al. 1998) and of antigens that might be used to disrupt reproduction (Flynn et al. 1998) have not ruled out these potential control tactics.

Gobies — Gobiidae

Round Goby *Neogobius melanostomus*: Secure. Perhaps locally common in Superior Harbor of Lake Superior and Milwaukee Harbor and Sturgeon Bay of Lake Michigan. This species is native to the Black and Caspian Seas and adjacent waters in Europe and Asia, but it has also become established in Poland. It was first found in North America in 1990 in the St. Clair River, the outlet of Lake Huron. Presumably round gobies reached North America via the ballast water of ships from Europe or Asia, as has been proposed for ruffe and several invertebrate species in the Great Lakes. However, the Eurasian source for populations in the Great Lakes is unknown (Stepien and Dillon 1999). From the St. Clair River, round gobies spread rapidly around the Great Lakes and were first recorded from Lake Superior in 1995 in Duluth-Superior Harbor, where the species appears to have become established. In 1999, specimens were captured from Milwaukee Harbor and Sturgeon Bay in Wisconsin waters of Lake Michigan. Round gobies have been common in harbor areas of southern Lake Michigan near the Illinois-Indiana border since 1993. See color plates 7 and 8 and the distribution map in figure 9. Unless otherwise noted, information in this account is taken from Charlebois et al. (1997).

Description: The round goby is a bottom-dwelling fish with a relatively large rounded head, a subterminal mouth, large fan-like pectoral fins, no visible lateral line, and a mottled olive and brown color (becoming jet black in parental males) (color plate 7). Round gobies look superficially like sculpins but can be easily distinguished by their pelvic fins, which are fused together to form a sucking disk (color plate 8). No other Wisconsin fish has this characteristic. The maximum size of round gobies in the Great Lakes can exceed 250 mm TL, but most adult specimens are 45–125 mm TL (MacInnis and Corkum 2000).

Distribution, Status, and Habitat: As of 1999, round gobies had been found in Wisconsin in Duluth-Superior Harbor, Milwaukee Harbor, and Sturgeon Bay (Edwards et al. 1998; Steingraeber 1999; Thompson, personal communication; *Green Bay News-Chronicle*, 6 August 1998; WDNR unpublished data). The abundance of round gobies at these sites is difficult to determine, but anecdotal reports from WDNR fisheries biologists and anglers indicate that they are locally common in shallow rocky areas near shore and that a wide range of sizes is present. We have collected several individuals by electroshocking rock riprap along the shoreline of Duluth-Superior Harbor (UWZM 11187). Abundance of round gobies in deeper waters is unknown. Trawling and trapping surveys in Duluth-Superior Harbor have captured few specimens (Edwards et al. 1998). However, these techniques are likely to underestimate goby numbers, and underwater observation may be the best method to determine population size (Wicket and Corkum 1998a).

In the Great Lakes, round gobies have been seen or captured most commonly from the bottom in areas of complex structure. They seem to prefer areas with large cobble rock and macrophytes, although they are capable of using a wide range of habitats. In the St. Clair River and southern Lake Michigan, juveniles are often found feeding in areas of open sand bottom, especially at night. During summer, round gobies are most frequently encountered near shore at depths of less than 5 m, but they have also been observed in shipwrecks and rocky reefs offshore in water more than 10 m deep (Wickett and Corkum 1998a). During winter, round gobies move into water deeper than 3 m, and in their native range, they have been found as deep as 60 m. Spawning round gobies establish nests in cavities under rocks or logs or within shipwrecks or other artificial structures (Wickett and Corkum 1998b).

Biology: Round gobies in the Great Lakes eat a variety of benthic animals, primarily invertebrates,

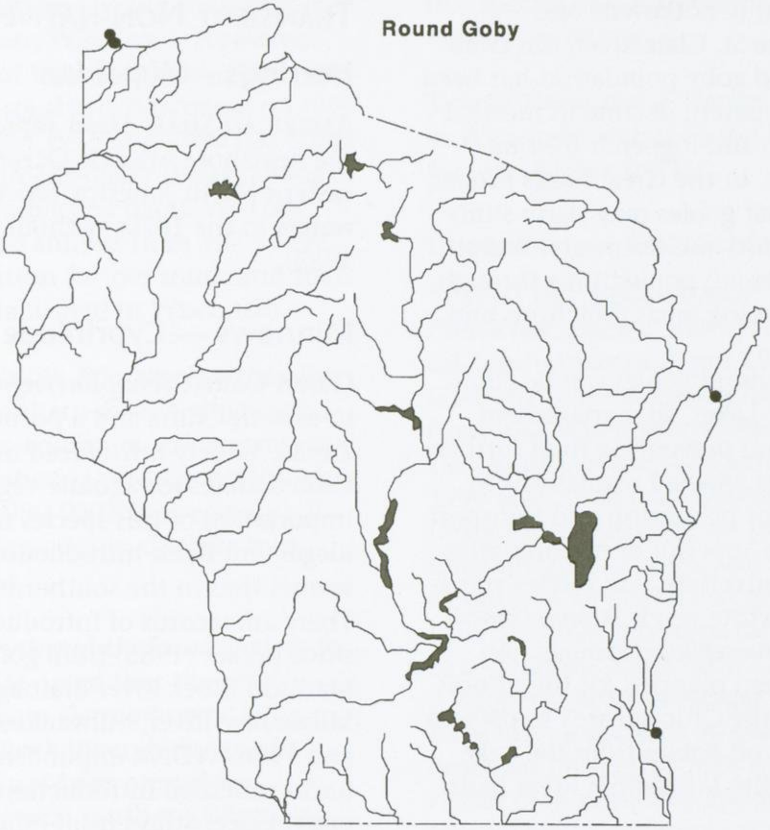

Figure 9. Map of the distribution of round goby in Wisconsin.

including the non-native zebra mussel (*Dreissena polymorpha*). Only limited age and growth information is available for round gobies from the Great Lakes, but in their native range, round gobies typically live up to four years, with males growing faster and reaching a larger size than females. Males are 100–130 mm TL after their first year and up to 250 mm at four years, compared with 40–90 mm and 90–140 mm for females. In the Great Lakes, females become mature in their first year (MacInnis and Corkum 2000) and males in their second or third. Males establish and aggressively guard a cavity nest (e.g., Wickett and Corkum 1998b) over an extended period from mid-May through late July when water temperatures are 9–26°C. Males attract females to their nests by producing sounds. Mature females contain from 80 to 600 eggs and lay these eggs among several nests; single nests may contain 600 to 10,000 eggs from multiple females (MacInnis and Corkum 2000). Eggs hatch in two to three weeks depending on temperature, and fry remain in the nest, guarded by the male, for four to nine days before dispersing. Round gobies can tolerate a wide range of environmental conditions, including temperatures from –1 to 30°C and dissolved oxygen concentrations less than 1 mg/l.

Importance and Management: There are fears that round gobies may have major effects on Great Lakes fish communities. Round gobies are larger and more aggressive than many native benthic species and may compete with them for food or habitat. Round gobies may also eat the eggs of other fishes, especially lake trout

(*Salvelinus namaycush*) (Chotkowski and Marsden 1999). In the St. Clair River, the establishment of the round goby population has been associated with an apparent decline in mottled sculpin (*Cottus bairdi*) and logperch (*Percina caprodes*) populations. In the Great Lakes proper, there are concerns that gobies may harm slimy sculpin (*Cottus cognatus*) and deepwater sculpin (*Myoxocephalus thompsoni*) populations through competition for spawning areas (MacInnis and Corkum 2000).

It is unlikely that round gobies can be eliminated from the Great Lakes, so management efforts have focused on preventing their further spread. Wisconsin has enacted regulations to prohibit the capture or possession and transport of bait fish from Lake Superior or its tributaries in order to curtail inadvertent bait bucket transport of round goby, white perch *(Morone americana)*, and ruffe *(Gymnocephalus cernuus)*. An electric barrier has been planned for the Illinois Waterway System in the Chicago area to prevent the movement of round gobies from the Lake Michigan basin into the Mississippi River basin (Steingraeber 1999).

Round gobies may have some value in the Great Lakes. They serve as food for larger predatory fishes and water snakes (King et al. 1999), but their importance relative to the native species they may displace is unknown. Round gobies consume zebra mussels (*Dreissena polymorpha*), but whether they eat enough to help control zebra mussel populations has not been determined. Where they are common, round gobies are easily caught by anglers, and provide some sport. However, possession of round gobies by anglers in Wisconsin is prohibited. (One may be kept for transport to a WDNR office for identification.) Also, many anglers see round gobies as a nuisance that interferes with their fishing for other more desirable species such as yellow perch (*Perca flavescens*). In their native range, round gobies are regularly eaten, and in some areas they support a commercial fishery.

Transient Non-native Species

Herrings – Clupeidae

American Shad ***Alosa sapidissima*****:** Native to the nearshore Atlantic Ocean and tributaries of eastern North America. Stocked into Wisconsin waters in the 1870s without success (Becker 1983).

Minnows — Cyprinidae

Grass Carp ***Ctenopharyngodon idella*****:** Native to eastern China and a portion of southwestern Russia. Widely introduced in the southern United States for aquatic vegetation control. Importation of this species into Wisconsin is illegal, but illicit introductions have occurred at several sites in the southern part of the state. There are records of introduced populations since Becker (1983) from golf course ponds near Madison (Rock River drainage) in 1988 and the Milwaukee River, Milwaukee County, in 1983 and 1996 (WDNR unpublished data), but other undocumented introductions have probably taken place. Strays from established populations further south are seen on rare occasions in the Mississippi River; we have reports from 1986 in Pool 5A and 1985, 1990, and 1994 in Pool 4, but this list is probably incomplete (EMTC 1998, WDNR unpublished data; Schmidt, personal communication). There is no evidence of successful reproduction in Wisconsin waters. Whenever possible, populations discovered in Wisconsin have been eliminated with fish toxicants to prevent their possible spread and establishment.

Red Shiner ***Cyprinella lutrensis*****:** Native to the Mississippi basin of the central United States, with populations in central Illinois and Iowa. Becker (1983) noted the first Wisconsin record of the red shiner, based on two specimens collected in 1973 from the Menominee River, Grant County (Mississippi River basin), in extreme southwestern Wisconsin. He speculated that this species, which is tolerant of a wide range of environmental conditions, would soon become established in southern Wisconsin. However, extensive sampling of the Menominee River site and many others in southern Wisconsin on several occasions between 1975 and 1999 has failed to yield further specimens (Fago 1985a, Lyons et al. 1988, WDNR unpublished data). We conclude that the two red shiners from 1973 were strays from a population further south and that the species is not established in Wisconsin.

Rainbow Sharkminnow ***Epalzeorhynchos frenatum*****:** Native to southern Asia. A single specimen of this common aquarium species was captured from Lake Waubesa, Dane County (Rock River drainage), in 1980 (WDNR specimen). It was undoubtedly released into the lake by a tropical fish hobbyist.

Rudd ***Scardinius erythrophthalmus*****:** Native to Europe. Becker (1983) noted that the rudd had been reported from Oconomowoc Lake, Waukesha County (Rock River drainage), in 1916–1918 and had not been seen since. However, in 1988, several southern Wisconsin bait dealers began selling rudd (WDNR unpublished data). By 1989, these sales had been stopped by new regulations, but in the interim many rudd had been used as bait. The rudd is very similar in appearance to the native golden shiner, a popular bait species, so it was difficult to track where rudd had been sold and used. Single rudd were reported in 1988 from Lake Winnebago, Winnebago County (Fox River drainage), and the Fox River, Racine County (Illinois River drainage), and in 1991 from North Lake, Waukesha County (WDNR unpublished data), and three rudd were captured from Sturgeon Bay, Door County, in 1994 (Kroeff, personal communication and photograph), but no reports have been confirmed since then. The Sturgeon Bay rudd were unusually large (approximately 350 mm TL), and we speculate that they were survivors from a bait bucket release in 1988. Rudd sold in 1988 averaged 75–150 mm TL (WDNR unpublished data). We conclude that this species has not become established in Wisconsin waters.

Tench ***Tinca tinca*****:** Native to Europe. Stocked in Wisconsin waters in the late 1800s without success (Becker 1983).

Characins — Characidae

"Pacu" or "Pirapatinga" ***Colossoma*** **or** ***Piaractus*** **species:** Native to large rivers in tropical South America. Since 1994, specimens of at least one of these genera have been reported from four Wisconsin waters: Lake Columbia, Columbia County (Wisconsin River drainage), in 1994 and 1999; Lake Delavan, Walworth County (Rock River drainage), in 1996; the Rock River, Rock County, in 1998; and the Fox River, Brown County, in 1995 (WDNR unpublished data). Pacu are often mistaken for piranha, so a report of a "piranha" from Glen Lake, St. Croix County (Chippewa River drainage), in 1994 may also have been a pacu. In all cases, our records are based on photographs or eyewitness descriptions rather than preserved specimens, and it has been impossible to determine the exact species present. All pacu records were undoubtedly the result of tropical fish hobbyist introductions. The species is unable to survive Wisconsin winters in natural waters, but the most recent pacu from Lake Columbia, which receives heated water from a power plant, may have survived as long as nine years (Larson, personal communication).

Red? Piranha ***Pygocentrus nattereri*****?:** Native to tropical South America. A single specimen of this aquarium species was found in 1993 in a gravel pit near Janesville, Rock County (Rock River drainage) (Don Bush, WDNR, Newville, personal communication). This record was undoubtedly the result of a tropical fish hobbyist introduction.

Bullhead Catfishes — Ictaluridae

BLUE CATFISH ***Ictalurus furcatus***: Native to large rivers in the southern and central United States, with good numbers as far north as central Illinois and reports of single individuals from the Mississippi River not far south of the Wisconsin border. Becker (1983) concluded that Greene's (1935) report of blue catfish from the Wisconsin portion of the Mississippi River was based on misidentified channel catfish and did not believe that the blue catfish had ever occurred in the state. However, since Becker (1983), blue catfish have been stocked into Yellowstone Lake, Lafayette County (Rock River drainage), in the mid-1980s by the WDNR (Gene Van Dyck, WDNR, Dodgeville, personal communication) and the lower St. Croix River by the Minnesota Department of Natural Resources in 1977 (Phillips et al. 1982). In 1978, a single blue catfish was captured from Mississippi River Pool 4 (Phillips et al. 1982). There is no evidence that these introductions were successful, although there are occasional unconfirmed angler reports of blue catfish from the St. Croix and Mississippi Rivers.

Longwhiskered Catfishes — Pimelodidae

REDTAIL CATFISH ***Phractocephalus hemioliopterus***: Native to tropical South America. In 1998, a single 5.4 kg specimen of this aquarium species was captured by a commercial fisherman from Mississippi River Pool 9 (Mike Kaminski, Iowa Department of Natural Resources, Manchester, personal communication). This record was undoubtedly the result of a tropical fish hobbyist introduction.

Trouts – Salmonidae

CUTTHROAT TROUT ***Oncorhynchus clarki***: Native to the Rocky Mountains and the Pacific slope of northwestern North America. Stocked into a Washington County lake in 1959 without success (Becker 1983).

PINK SALMON ***Oncorhynchus gorbuscha***: Native to the Pacific slope of northwestern North America and northeastern Asia. Becker (1983) chronicled the appearance and spread of the pink salmon in Wisconsin and noted that successful reproduction had been reported from five Wisconsin Lake Superior tributaries. Emery (1981) and Kwain and Lawrie (1981) documented additional records from Lake Michigan. By the early 1980s it seemed as if pink salmon were well on their way to becoming established in Wisconsin. However, during the mid- to late 1980s, pink salmon populations in both Lake Michigan and Lake Superior declined dramatically, and now the species is rarely seen in Wisconsin (WDNR unpublished data). The Lake Superior streams where reproduction was reported have not had significant spawning runs of pink salmon since the late 1970s (e.g., DuBois and Pratt 1994). The few individuals that occasionally occur in Wisconsin waters appear to be strays from established populations in the Upper Peninsula of Michigan. Interestingly, the state sport fishing record for pink salmon was broken in 1999 with the capture of a 2.8 kg specimen from Lake Michigan in Kewaunee County (WDNR unpublished data).

ATLANTIC SALMON ***Salmo salar***: Native to the Atlantic Ocean and its tributaries in northeastern North America and Europe. Stocking of Atlantic salmon began in Wisconsin in the late 1800s and has continued sporadically almost up to the present, but no successful natural reproduction of the species has ever been documented in the state. The WDNR has not stocked Atlantic salmon since the early 1980s, but Minnesota and Michigan have stocked the species more recently in the Great Lakes basin, and there have been a few reports of Atlantic salmon captured by anglers from the Wisconsin waters of Lake Michigan, Lake Superior, and some of their tributaries during the 1990s. At present, at least one aquaculture facility in central Wisconsin is raising Atlantic salmon in outdoor ponds for sale as food (*Capital Times*

(Madison), 13 December 1999), raising the possibility of escapees being encountered in inland waters.

ARCTIC GRAYLING ***Thymallus arcticus***: Native to northwestern North America and historically found in streams in Michigan in the Lake Huron, Lake Michigan, and Lake Superior basins and in a Lake Nipigon tributary in Ontario in the Lake Superior basin. Arctic grayling were stocked into a number of Wisconsin waters between the late 1800s and mid-1900s without success. Recently, we heard rumors of arctic grayling being caught by anglers from a specific reach of Waupee Creek, Oconto County (Oconto River drainage, Lake Michigan basin), but a thorough sampling of this reach on 25 April 1997, failed to yield specimens. The fishes we did collect here suggested that water temperatures were too warm to support the cold-loving arctic grayling.

Livebearers—Poeciliidae

WESTERN MOSQUITOFISH ***Gambusia affinis***: Native to the south-central United States, with populations occurring as far north as central Illinois. Becker (1983) did not note the occurrence of this species from Wisconsin, but there are several reports of at least one stocking of this species into Wisconsin waters prior to 1948 (Krumholz 1948, Dees 1961, Fuller et al. 1999). Nothing has been published on where or when the stocking took place, and there are no reports of specimens being captured from Wisconsin waters. We conclude that the mosquitofish did not become established in Wisconsin.

GUPPY ***Poecilia reticulata***: Native to Trinidad and northern South America. Becker (1983) reported catching numerous individuals of this common aquarium species from a pond in Washington County. These fish were undoubtedly the result of tropical fish hobbyist introductions, and there is no evidence that the guppy became established in the state.

Temperate Basses –Percichthyidae (Moronidae)

STRIPED BASS ***Morone saxatilis***: Native to the Atlantic Ocean and its tributaries in eastern North America. In 1996, a single striped bass was caught by an angler from the Fox River, Kenosha County (Illinois River drainage)(Doug Welch, WDNR, Kansasville, personal communication). This specimen was apparently a stray from a stocking made further downstream in the drainage in Illinois. Striped bass X white bass (*Morone chrysops*) hybrids have been stocked in Lake Columbia, Columbia County (Wisconsin River drainage), since the mid-1980s. The heated water in this power plant cooling lake allows the hybrids to survive over the winter, although no reproduction has been observed (Larson, personal communication).

Cichlids — Cichlidae

OSCAR ***Astronotus ocellatus***: Native to tropical South America. Specimens of this common aquarium species have been captured by anglers from Lake Waubesa, Dane County (Rock River drainage), in 1988 and Mississippi River Pool 11 in 1993 (WDNR unpublished data). These records were undoubtedly the result of tropical fish hobbyist introductions.

"TILAPIA" ***Tilapia* or *Oreochromis* sp.**: Native to Africa and adjacent southwestern Asia. A specimen of one of these genera, which are both common in aquaculture and occasional in the aquarium hobby, was reported from a marsh adjacent to Lake Winnebago in 1965 (Becker 1983), but there is no evidence of establishment of a population.

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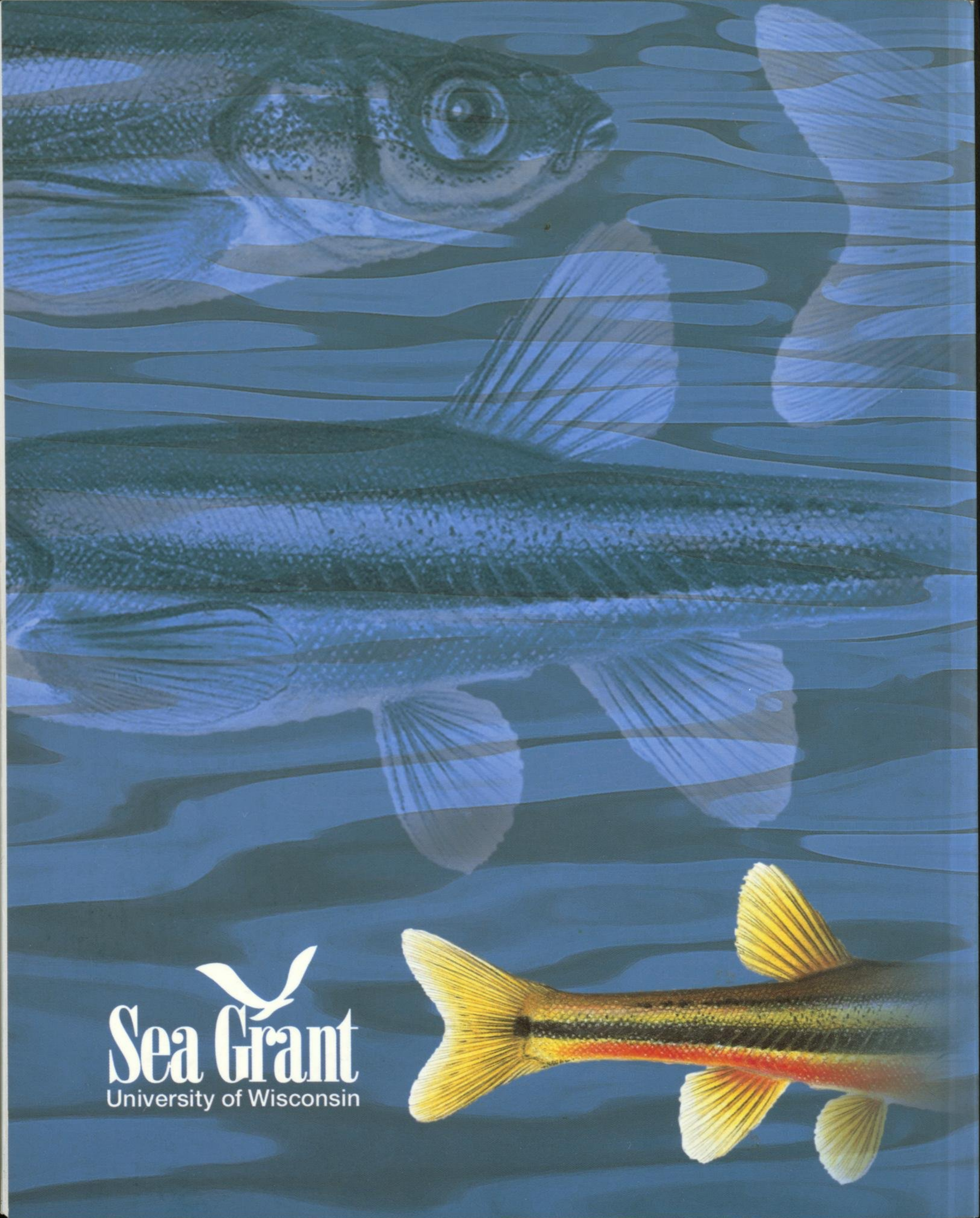
Index to Species by Scientific Name

John Lyons is a research scientist for the Wisconsin Department of Natural Resources in Monona and the adjunct curator of fishes at the University of Wisconsin Zoological Museum in Madison, positions he has held since 1985. He received his B.S. in biology from Union College in Schenectady, New York, and his M.S. and Ph.D. in zoology from the University of Wisconsin-Madison. His research has focused on the ecology, taxonomy, and management of fishes in Wisconsin and Mexico. Mailing address: Wisconsin Department of Natural Resources, 1350 Femrite Drive, Monona, WI 53716-3736. E-mail: lyonsj@dnr.state.wi.us.

Philip A. Cochran has been a professor of biology at St. Norbert College in DePere, Wisconsin, since 1984 but will move to a new position as a professor of biology at St. Mary's University of Minnesota in Winona in summer 2000. He earned his B.A. in biology from St. Mary's University of Minnesota, his M.S. in fisheries biology from the University of Minnesota, and his Ph.D. in zoology from the University of Wisconsin-Madison. His research has included studies of the ecology and distribution of fishes, amphibians, and reptiles, with an emphasis on lampreys. Mailing address: Division of Natural Sciences, St. Norbert College, DePere, WI 54115-2099. E-mail: cochpa@sncac.snc.edu. Mailing address as of August 2000: Biology Department, St. Mary's University of Minnesota, Winona, MN 55987.

Don Fago is a research scientist for the Wisconsin Department of Natural Resources in Monona and has been with the WDNR since 1970. He obtained his B.S. and M.S. in fishery biology from the University of Washington in Seattle. His research interests include nongame fishes, radio telemetry, and computer programming, including geographic information systems and database management. Mailing address: Wisconsin Department of Natural Resources, 1350 Femrite Drive, Monona, WI 53716-3736. E-mail: fagod@dnr.state.wi.us.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