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River Raisin Assessment

Kenneth E. Dodge

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EXECUTIVE SUMMARY

This is one of a series of river assessments to be prepared by the Fisheries Division of the Michigan Department of Natural Resources (MDNR) for Michigan rivers. This report describes the characteristics of the River Raisin and its biological communities.

River assessments are prepared to provide a comprehensive reference for citizens and agency personnel who desire information about a particular fisheries resource. These assessments will provide an approach to identifying opportunities and solving problems related to aquatic resources in watersheds. It is hoped that this river assessment will increase public awareness of the River Raisin and its challenges and serve to promote a sense of public stewardship and advocacy for the resources of the watershed. The ultimate goal is to increase public involvement in the decision making process to benefit the river and its resources.

This document consists of four parts: an introduction, a river assessment, management options, and public comments and responses. The river assessment is the nucleus of the report. The characteristics of the River Raisin and its watershed are described in twelve sections: geography, history, geology and hydrology, channel morphology, soil and land use patterns, biological communities, special jurisdictions, recreational use, dams and barriers, water quality, fishery management, and citizen involvement.

The management options section of the report identifies a variety of challenges and opportunities. These management options are categorized and presented following the organization of the main sections of the river assessment. It must be stressed that the options listed are not necessarily recommended by MDNR, Fisheries Division. They are intended to provide groundwork for public discussion and comment.

The River Raisin and its tributaries form a network draining approximately 1,070 square miles of southeastern Michigan and northwestern Ohio. The basin contains portions of the following Michigan counties: Hillsdale, Jackson, Washtenaw, Lenawee, and Monroe. A small portion of Fulton County, Ohio is also in the watershed. Major tributaries of the River Raisin include the South Branch, Wolf Creek, Macon Creek, Black Creek, and Saline River.

For purposes of discussion, the River Raisin mainstem is divided into three sections. The first section is from the headwaters in the extreme northwestern portion of the watershed downstream to Tecumseh. The second is the low-gradient, meandering mid-section of the mainstem from Tecumseh downstream to Dundee. The final section is from Dundee downstream to the mouth at Lake Erie.

Streams in the upper portion of the watershed above Tecumseh have moderately stable flows. However, flow stability decreases in streams in the middle and most downstream portions of the watershed primarily because of less permeable soil type coupled with intensive agricultural land use. Stream channelization, removal of floodplains and wetland retention areas, and installation of artificial surface and tiled drainage systems to facilitate agriculture have reduced flow stability throughout the watershed. Water withdrawals for agricultural irrigation aggravate natural low flow situations during droughts, particularly in the upstream portion near Brooklyn, Manchester, and Clinton. Water withdrawals for municipal use also reduce stream flows. The communities of Adrian, Blissfield, Deerfield, and Dundee rely on the River Raisin for public water supply. Flooding is a recurring problem in the lower watershed in Monroe and Frenchtown townships and the City of Monroe. Much flooding is attributable to ice jams in the lower river and periodic high levels of Lake Erie.

The average gradient of the River Raisin mainstem is 3.2 feet per mile. However, gradient is not uniform throughout. The highest average gradient (5.7 feet per mile) is from the headwaters to Highway M-50 in Tecumseh. The lowest average gradient (1.3 feet per mile) is in the mid-portion of the river between Tecumseh and Dundee. The mainstem of the River Raisin is mostly low-gradient channel, 92 miles (62 %) having gradient less than three feet per mile. Fish and other aquatic animals are typically most diverse and productive in river gradient between 10 and 70 feet per mile. This highly desirable gradient class is found in only 7.5 miles (5%) of the mainstem in the extreme headwaters of the watershed and in localized areas near Brooklyn, Manchester, and Tecumseh. Much of this high-gradient habitat has been inundated by dams in Brooklyn, Manchester (2 dams), and Tecumseh (3 dams). These dams and their impoundments have eliminated and fragmented some of the best fish habitat on the river.

The channel of the mainstem has been adversely altered over the years by agricultural activities. Flow instability and resulting erosion have caused the channel to be excessively narrow in the middle portion where stream banks with high clay content are resistant to erosion. Conversely, the channel is excessively wide below the confluence of the mainstem and Saline River, downstream from Dundee. The substrate from this point downstream to the mouth at Lake Erie is composed of gravel, cobble, rock, and limestone bedrock. Therefore, during high flow, the less erosion-resistant stream banks are eroded. Agricultural activities including channelization and drainage have decreased the hydraulic diversity of tributary streams throughout the watershed. Intensive agricultural land use has caused woody cover to be sparse in many portions of the mainstem and major tributaries. Woody cover creates excellent fish habitat and provides good substrate for production of aquatic insects and other fish food organisms.

Land use is the primary factor causing decline of fisheries resources in stream ecosystems. The River Raisin watershed has the highest percentage of agricultural land use (92%) of any watershed in Michigan. Intensive agricultural land use coupled with fine particle soil types has degraded the river system by decreasing flow stability, altering natural channel morphology, and creating severe erosion and sedimentation problems. Channelization, drainage of wetlands, and installation of surface and tiled artificial drainage courses to facilitate agriculture have also decreased flow stability and altered temperature regimes.

Based on biological surveys conducted during the past thirty years and early twentieth century University of Michigan records, the River Raisin watershed is known to have contained at least ninety fish species. Although present fish species diversity remains high, certain species are declining and potamodromous fishes have been virtually eliminated by the cooling water intake at the Detroit Edison Monroe Power Plant near the mouth. A series of six low-head dams in Monroe and Waterloo Dam at the western edge of the city also create barriers to upstream migration of potamodromous fish. Silt-tolerant fish species have increased, whereas fishes requiring clean gravel substrate or clear water with aquatic vegetation at some point in their life cycles have declined. Dams have inundated high-gradient areas with gravel, cobble, and rock substrates. These high-gradient areas are of critical importance to certain species as spawning habitat and for the production of aquatic insects and other macroinvertebrates that are important fish food organisms. Agricultural activities have reduced flow stability and increased sediment load in streams throughout the watershed. Mussel species have declined primarily as a result of increased sediment loading resulting from agriculture and urban development. Introduced pest species including zebra mussels, rusty crayfish, Eurasian milfoil, curlyleaf pondweed, and purple loosestrife have had negative effects on native fishes and macroinvertebrates. Wetland drainage and filling primarily to facilitate agriculture have negatively affected populations of fish, amphibians, and reptiles.

The River Raisin watershed has great potential for recreational use because of its proximity to population centers in the watershed and in the heavily populated surrounding area of southeastern

Michigan and northwestern Ohio. The mainstem is canoeable from Brooklyn to the mouth, although logjams between Adrian and Deerfield make canoe travel difficult in localized areas. Bona fide access to the river is only fair, and assured public access to impoundments is needed at Sharon Hollow, Manchester, Clinton, and Tecumseh (Red Millpond). Small access sites are needed on the mainstem downstream of the Ford Dam in Manchester, upstream of the Clinton Impoundment, downstream of Tecumseh, east of Adrian, and in southern Palmyra Township. Public parcels of property at Ida-Maybee Road and downstream of Dundee should be developed to facilitate canoe access and shore fishing. Very little land in the intensively agricultural River Raisin watershed is in public ownership. The acquisition of more public property would benefit recreational users. Legislative adoption of a recreational rather than commercial definition of navigability would benefit canoeists.

According to two independent sources, there are about sixty dams in the River Raisin watershed. Twenty-two of these dams, including the six low-head dams in Monroe, are on the mainstem and 38 are on tributaries. Dams fragment habitat of fish and other aquatic organisms. Spawning runs of potamodromous and river fish species are blocked by dams. Northern pike populations have decreased particularly in southern Michigan because the installation of lake-level control structures (dams) on lake outlets has eliminated access to pike spawning habitat. Dams disrupt normal downstream drift of aquatic insects and other invertebrates, sediment, and woody debris. Fish are killed outright or injured passing over dams. None of the dams in the River Raisin watershed has effective fish passage facilities. Dams were generally constructed in areas of highest stream gradient. This enables the dam builders to create the highest possible drop (greatest potential energy) while minimizing the amount of inundated land. These high-gradient river areas are essential spawning habitats for several fish species and highly productive areas for aquatic insects and other fish food organisms. Dams also alter the natural flow and temperature regimes of rivers. Many of the impoundments in the River Raisin watershed are shallow, sediment-laden, and choked with aquatic vegetation. They provide poor quality habitat for sport fish species and have only modest recreational value.

The Detroit Edison Monroe Power Plant at the mouth of the River Raisin presents a formidable obstacle to upstream and downstream migration of potamodromous fish. This power plant's cooling water requirement of up to 3000 cfs greatly exceeds the River Raisin annual mean flow of 741 cfs. Therefore, during all but high flow periods, the entire flow of the River Raisin is processed through the power plant as cooling water. Besides the available River Raisin stream flow, Lake Erie water is drawn upstream to the plant through the river channel. This process essentially reverses the flow of the river and forces it to "flow" upstream. The processed cooling water is then returned to Lake Erie through a separate outlet channel to Plum Creek Bay that is out of the River Raisin watershed. Impingement of adult and juvenile fish and entrainment of larval fish and fish eggs at the power plant are significant problems. Unless the cooling water intake situation at the power plant is altered, potamodromous fisheries management in the lower River Raisin is impractical.

Point source water pollution from industrial and municipal sources in the watershed has been dramatically abated over the past thirty years. Pollution from point sources will continue to be reduced in the future as municipal wastewater treatment plants upgrade their facilities and technology and industrial discharge permits are tightened.

The greatest remaining factor that degrades water quality in the watershed is nonpoint source pollution resulting from agriculture. Recent studies have shown conclusively that implementing best management practices on farmland can significantly reduce runoff, erosion, and delivery of sediment, nutrients, and agricultural chemicals to watercourses.

The lower River Raisin has been identified by the International Joint Commission as one of Michigan's fourteen Areas of Concern (AOC) due to polychlorinated biphenyl (PCB) and heavy metal contamination of fish and sediments. The AOC includes the most downstream 2.6 mile portion of the river and the immediate Lake Erie area extending one mile north and south of the river mouth and one-half mile lakeward. Problems that exist in the River Raisin AOC are heavy metals (zinc, chromium, copper) and PCB contamination of sediments and water column, sediment from nonpoint agricultural sources outside the AOC, and a fish consumption advisory concerning carp and white bass.

Fishery management of the mainstem and major tributaries has been neglected. Past municipal and industrial point source pollution, excess turbidity from intense agricultural land use, lack of assured public access, and a very poor public image of the river particularly from Tecumseh to Dundee have combined to discourage fishery management. Enhancement and promotion of angling opportunities on southern Michigan rivers are one of few remaining frontiers available to fishery managers.

The greatest impediment to beneficial change in the River Raisin watershed is the poor public image of the river and its major tributaries. This negative public image and perception of the river must be improved to motivate people to take pride in the river and advocate habitat protection and enhancement of water quality and recreational opportunities. An improved public image of the river would serve to foster an ethic of public stewardship that would act to drive all other beneficial changes. Direct involvement of local citizens with the River Raisin and its watershed is the only way to improve public image and erase negative perceptions.

INTRODUCTION

This river assessment is one of a series of documents being prepared by the Fisheries Division, Michigan Department of Natural Resources, for rivers in Michigan. We have approached this assessment from an ecosystem perspective, as we believe that fish communities and fisheries must be viewed as parts of a complex aquatic ecosystem. However, this assessment is admittedly biased towards aquatic systems.

As stated in the Fisheries Division Strategic Plan, our aim is to develop a better understanding of the structure and functions of various aquatic ecosystems, to appreciate their history, and to understand changes to the system. Using this knowledge we will identify opportunities that provide and protect sustainable fishery benefits while maintaining, and at times rehabilitating, system structures or processes.

Healthy aquatic ecosystems have communities that are resilient to disturbance, are stable through time, and provide many important environmental functions. As system structures and processes are altered in watersheds, overall complexity decreases. This results in a simplified ecosystem that is unable to adapt to additional change. All of Michigan's rivers have lost some complexity due to human alterations in the channel and on the surrounding land; the amount varies. Therefore each assessment focuses on ecosystem maintenance and rehabilitation. Maintenance involves either slowing or preventing the losses of ecosystem structures and processes. Rehabilitation is putting back some of the structures or processes.

River assessments are based on ten guiding principles of the Fisheries Division. These are: 1) recognize the limits on productivity in the ecosystem; 2) preserve and rehabilitate fish habitat; 3) preserve native species; 4) recognize naturalized species; 5) enhance natural reproduction of native and desirable naturalized fishes; 6) prevent the unintentional introduction of exotic species; 7) protect and enhance threatened and endangered species; 8) acknowledge the role of stocked fish; 9) adopt the genetic stock concept, that is protecting the genetic variation of fish stocks; and 10) recognize that fisheries are an important cultural heritage.

River assessments provide an organized approach to identifying opportunities and solving problems. They provide a mechanism for public involvement in management decisions, allowing citizens to learn, participate, and help determine decisions. As well these projects provide an organized reference for Fisheries Division personnel, other agencies, and citizens who need information about a particular aspect of the river system.

The nucleus of each assessment is a description of the river and it's watershed using a standard list of topics. These include:

Geography - a brief description of the location of the river and it's watershed; a general overview of the river from its headwaters to its mouth. This section sets the scene.

History- a description of the river as seen by early settlers and a history of human uses and modifications of the river and the watershed.

Geology and Hydrology - patterns of water flow over and through the landscape. This is the key to the character of a river. River flows reflect watershed conditions and influence temperature regimes, habitat characteristics, and perturbation frequency.

Channel Morphology - the shape of the river channel: width, depth, sinuosity. River channels are often thought of as fixed, aside from changes made by people. However, river channels are dynamic, constantly changing as they are worked on by the unending, powerful flow of water. Diversity of channel form affects habitat available to fish and other aquatic life.

Soils and Land Use Patterns - in combination with climate, soils and land use determine much of the hydrology and thus the channel form of a river. Changes in land use often drive change in river habitats.

Biological Communities - species present historically and today, in and near the river; we focus on fishes, however associated mammals and birds, key invertebrate animals, threatened and endangered species, and pest species are described where possible. This topic is the foundation for the rest of the assessment. Maintenance of biodiversity is an important goal of natural resource management and essential to many of the goals of fishery management. Species occurrence, extirpation, and distribution are also important clues to the character and location of habitat problems.

Special Jurisdictions - stewardship and regulatory responsibilities under which a river is managed.

Recreational Use - types and patterns of use. A healthy river system provides abundant opportunities for diverse recreational activities along its mainstem and tributaries.

Dams and Barriers - affect almost all river ecosystem functions and processes, including flow patterns, water temperature, sediment transport, animal drift and migration, and recreational opportunities.

Water Quality - includes temperature, and dissolved or suspended materials. Temperature and a variety of chemical constituents can affect aquatic life and river uses. Degraded water quality may be reflected in simplified biological communities, restrictions on river use, and reduced fishery productivity. Water quality problems may be due to point-source discharges (permitted or illegal) or to non-point source land runoff.

Fishery Management - goals are to provide diverse and sustainable game fish populations. Methods include management of fish habitat and fish populations.

Citizen Involvement - an important indication of public views of the river. Issues that citizens are involved in may indicate opportunities and problems that the Fisheries Division or other agencies should address.

Management Options follow and list alternative actions that will protect, rehabilitate, and enhance the integrity of the watershed. These options are intended to provide a foundation for discussion, setting priorities, and planning the future of the river system. Identified options are consistent with the mission statement of Fisheries Division.

Copies of the draft assessment were distributed for public review beginning late fall, 1997. Three public meetings were held January 26, 1998 in Adrian, January 27, 1998 in Monroe, and January 29, 1998 in Manchester. Written comments were received through February 27, 1998. Comments were either incorporated in this assessment or responded to in this section.

A fisheries management plan will be written after completion of this assessment. This plan will identify options chosen by Fisheries Division, based on our analysis and comments received, that the Division is able to address.

Individuals who review this assessment and wish to comment should do so in writing to:

Michigan Department of Natural Resources
Fisheries Division
301 E. Louis Glick Hwy.
Jackson, Michigan 48909-7946

Comments received will be considered in preparing future updates of the River Raisin Assessment.

RIVER ASSESSMENT

Geography

The River Raisin and its tributaries form a network draining approximately 1,070 square miles of southeastern Michigan and northwestern Ohio (Shepherd 1974; Figure 1). The basin contains portions of Hillsdale, Jackson, Washtenaw, Lenawee, and Monroe counties in Michigan. A small portion of Fulton County in Ohio is also in the river basin. The highest point in the watershed is in northeastern Hillsdale County at an area known locally as Bundy Hill. Along with the River Raisin, the Grand, Kalamazoo, and Maumee watersheds originate in this general area. The River Raisin mainstem originates in Section 27 of Woodstock Township (T5S, R1E) in Lenawee County at an elevation of approximately 1050 feet. From this point the river flows to the northeast until it reaches Manchester, where the river turns south and meanders in a southerly direction until it reaches the town of Blissfield. From Blissfield the river flows east until it enters Lake Erie at Monroe at an elevation of 572 feet. The total length of the mainstem is about 150 miles and the total drop from the headwaters to the mouth is about 480 feet. Major tributaries include the South Branch of the River Raisin, Wolf Creek (a tributary of the South Branch), Macon Creek, Black Creek, and Saline River.

The two most noteworthy topographic features of the basin, the rugged Irish Hills and the lake district, are both in the highland area of the northwestern part of the basin. The eastern portion of the watershed is relatively flat with poorly drained clay soils. This old lake plain portion is productive and intensively used farmland.

For purposes of discussion throughout the assessment, the River Raisin mainstem is divided into three distinct portions: headwaters to Tecumseh, Tecumseh to Dundee, and Dundee to Monroe (Figure 2). The rationale for selecting these three distinct portions involves significant differences in surficial geology, soil type and land use patterns, gradient, and composition of bottom sediments. These differences are discussed in detail in **Geology and Hydrology, Biological Communities,** and **Fishery Management.**

History

The River Raisin and its watershed were formed as a result of the retreat of the last glacier (Wisconsin of the Pleistocene Epoch). The river was formed by melt water of the Saginaw and Huron-Erie lobes of the ice sheet. As the glacier went through several advances and retreats, direction of flow and outlet location changed many times (Russell and Leverett 1915). At its earliest stage, the ancestral River Raisin drained land that lies to the west of the present river course. The westward flowing River Raisin joined the Huron River just north of Jackson. At that time, the Raisin and Huron were headwater tributaries to the Grand River that flowed westward to the Mississippi River (MWRC 1965). The modern River Raisin had its beginnings when the ice front retreated from the most easterly land-laid moraine (Defiance Moraine). The glacier melted so rapidly that the first in a series of glacial lakes (Lake Maumee) was formed. The shoreline of Lake Maumee followed the eastern border of the Defiance Moraine. The River Raisin gradually extended itself eastward as new and lower glacial lakes established themselves. Finally, about 10,000 years ago the Great Lakes assumed their present levels and the River Raisin assumed its present course. The modern topography and soils are the result of post-glacial erosion and soil formation processes acting upon glacial deposits (Albert et al. 1986).

The earliest evidence of human occupation in the basin dates to the Paleo-Indian period over 10,000 years ago when Indian people entered the area to hunt mastodon and other now-extinct game (B. Mead, Office of the State Archaeologist, personal communication). Not much is known about the Early and Middle Archaic periods (7000-2000 BC). During much of this time the levels of the Great Lakes were much lower than they are at present. Therefore, camps of Archaic peoples may be buried under sediments along the shores of lakes and rivers or may be underwater. Sites from this period are most common in the southern half of the Lower Peninsula. Excavations of these sites reveal that people were learning to more efficiently use plants and animals available to them in seasonal cycles (RRWC 1988). Besides fish and game, nuts and other plant foods became important in their diet.

By 2,000 BC, lake levels were again high and camps and burial places of late Archaic period peoples (2000-500 BC) are found throughout the state. Although late Archaic peoples had not yet learned the art of pottery making, some of the burials of this period contain striking artifacts. Hooks, gaffs, and spears were used to take fish. Hunters used spears and darts thrown with an atylatyl (spear thrower) to take game. Stone axes were used to shape wood and copper was mined and used to make spear points, knives, and other useful items.

By 500 BC, local people were experimenting with growing crops and making pottery (B. Mead, Office of the State Archaeologist, Department of State, personal communication). This was the beginning of the Woodland period. Squash and sunflowers were cultivated and could be stored for the winter along with nuts and dried meat.

In the Late Woodland period (AD 600- AD 1700), several important technological advances were developed. Gill nets allowed exploitation of whitefish, lake trout, and other fishes during spawning runs. These fish could then be smoked, dried, or frozen for use in winter. The bow and arrow replaced the spear thrower for hunting. Corn horticulture became practical in southern Michigan when varieties were developed that could mature quickly in a short growing season. The earliest corn in Michigan was found in Monroe County and dates to about AD 700. By AD 1000 the effect of this agricultural adaptation was reflected in increased density and number of villages and burial sites of the late Woodland period. In southern Michigan, agricultural groups such as the Miami and Potawatomi tribes built large stockade villages near their farms. Women worked the land and men hunted.

In the River Raisin area, it is uncertain which native peoples were the original residents, but in the eighteenth and early nineteenth centuries Potawatomi and refugee Wyandot lived in southeastern Michigan (B. Mead, Office of the State Archaeologist, Department of State, personal communication). The River Raisin afforded native people an important canoe portage. From the westernmost extremity of the main branch of the River Raisin (Goose Creek) by a relatively short portage, one could access the Grand, Kalamazoo, and Maumee rivers. Records exist of Indians making these portages without leaving the canoe in periods of high water when wetlands were navigable (before agricultural drainage) (Zeisler 1939).

The first Europeans to enter the River Raisin watershed were the French explorer Sieur de-LaSalle and his party who ascended the Detroit River in 1679. According to legend, early French explorers noticed the luxuriant grapevines that festooned the trees lining the banks and named the river “Riviere aux Raisins” that became River Raisin (RRWC 1988).

The influx of Europeans brought diseases that were devastating to the Native Americans. From 1600 to about 1825, the Indians lost one-third to one-half of their population through epidemics of European diseases (Tanner 1986). A major epidemic of smallpox inflicted heavy losses among Potawatomi and Wyandot in 1752. Another localized epidemic of smallpox affected Wyandot along the Detroit River in 1787-88. In 1813-14 an epidemic of whooping cough or possibly typhoid swept the Michigan territory (Tanner 1986).

During the early and mid-eighteenth century, French woodsmen, fur traders, and voyagers traveled through the River Raisin watershed trading with Indians and taking goods to trading posts and missionaries. The first permanent European settlement in the watershed was founded at the site of what is now Monroe, in the early 1780s. French families from Detroit who were disgruntled with British rule settled along the River Raisin in narrow “ribbon” farms extending perpendicular from both river banks. The early name of this settlement was Frenchtown.

Frenchtown was the site of one of the largest military battles of the War of 1812. More American casualties occurred here than in any other single battle during that conflict. After the surrender of General Hull in Detroit on August 16, 1812 and surrender of the local militia on the River Raisin at Frenchtown, the British briefly occupied the area. After the British burned the fortified blockhouse and left, a small detachment of Canadian militia was stationed at Frenchtown to monitor movements of the Americans. A new American army recruited in Kentucky in August of 1812 quickly routed the Canadian militia and 200 Potawatomi Indians on January 18, 1813 and reoccupied Frenchtown. The British counterattacked on January 22, 1813 with a force of 600 British and Canadian soldiers, 800 Indians, and six cannon (Anonymous 1985). The American force at Frenchtown totaled approximately 1000 troops and militia. The Canadians and Indians flanked a portion of the American force. An American retreat quickly developed into a disastrous rout. Of the 400 Americans who ran, nearly 220 were killed and another 150 were captured. The rest of the Kentucky militia who had continued to fight, surrendered on orders of the American general who had been captured. The victorious British withdrew quickly due to heavy casualties and news that more American troops were near. The American wounded were left behind in homes of settlers. After British guards left on the morning of January 23, 1813, pro-British Indians returned and plundered homes and the wounded for valuables. The defenseless American wounded who could not walk were murdered. Bodies were tossed into burning houses. Americans who could walk were taken to Detroit and ransomed. Over 60 unarmed American wounded were killed in this action that came to be known as the “Massacre of the River Raisin”. “Remember the Raisin” became a battle cry of the American troops and militia for the rest of the conflict.

After the end of hostilities between the British, Americans, and Indians, white settlers began entering southern Michigan. Indian lands were ceded to the American government, and reservations were established. A Potawatomi reservation was established near the present town of Dundee in 1807, when much of southeastern Michigan was ceded to the United States government. This reservation was eliminated in 1827 and many southeastern Michigan Indians were removed to western reservations in Iowa, Kansas, and Oklahoma in the late 1830s. A small Potawatomi reservation remains near Athens in southwestern Calhoun County.

A detailed description of the River Raisin before settlement by Europeans could not be found. The brief descriptive passages attributed to early French explorers and missionaries (Sieur-de-LaSalle, Father Hennepin, and Charlevoix) mention meadows, marshes, thick hardwood forests, clear waters, and the abundance of game animals and waterfowl (Bulkley 1913). Charles Lanman in 1837 described the river as a small stream winding through a considerable portion of thickly timbered woods (Zeisler 1949a) and an anonymous traveler in 1822 described the river as navigable only one mile upstream of Monroe in low water. This observer also mentioned the rapid, clear water and availability of excellent sites for dams and mills. Tree species mentioned included oaks, black walnut, elm, hickory, butternut, basswood, ash, wild cherry, sugar maple, and whitewood (tulip poplar). During high water periods the mainstem was deemed navigable for a long distance (70-80 miles) into the interior (Zeisler 1950).

Settlement of the watershed by people of European descent began in earnest in the 1820s and 1830s. Most of these early settlers came from New York and New England. The port of Monroe was influential in this westward movement. Many later settlers traveled by boat from Buffalo to Monroe and then to Chicago and points further west by way of the Michigan Southern Railroad. Settlement of the area brought rapid change. Land had to be cleared for farming. Today only small woodlot remnants are in forest cover. The last portion of the watershed to be settled was the extreme southeastern portion of Lenawee County (Ogden and Riga townships) (Bonner 1909). This area was a swamp with flat topography and soils composed of muck and clay. Immense cottonwoods, soft maples, and hickory trees covered this swampy land that was originally thought to be worthless. After the swamp had been ditched and tiled, these townships became excellent producers of farm products including sugar beets.

The early settlers needed dams to create water power for mills to saw lumber and grind flour. The river and its tributaries provided many favorable locations for the construction of dams. Towns often were developed near these dams and mills along the river. The Waterloo Dam located a short distance upstream from Monroe was built in 1820. This dam fragmented the habitat of the River Raisin and disrupted spawning runs of potamodromous (fish that migrate from fresh water lakes up fresh water rivers to spawn) fishes.

The State archaeological site file maintained by the Bureau of History lists 654 archeological sites by township in the basin (Table 1). Most of these archeological sites are Indian camps, cemeteries, burial mounds, and storage pits; French homesteads and mills; and American towns, mills, dumps, cemeteries, and churches.

There are three registered archaeological sites listed on the National Register of Historic places and State Register of Historic Sites. These include Walker Tavern in T5S, R2E, Lenawee County that served as a road house from 1843-1865, the River Raisin Battlefield in the City of Monroe that was the battlefield and massacre site in 1813; and the Navarre-Anderson Post in the City of Monroe, a trading post built in 1796 (B. Mead, Office of the State Archaeologist, Department of State, personal communication).

Geology and Hydrology

Geology

The following description of the physical characteristics and geology of the River Raisin watershed is from a 1975 report by the U.S. Geological Survey, "Water Resources of the River Raisin Basin", (Knutilla and Allen 1975).

> "The River Raisin basin is characterized by hilly to moderately undulating topography in the western and northwestern parts and by relatively flat terrain in the southeast. The two topographically different areas are divided by a series of ancient beaches that cross the basin in a southwest to northeast direction. These beaches, formed by glacial lakes, are marked by a local steepening of the land surface. Sands and clays laid down in the glacial lakes make up the surface deposits in the southeastern part of the basin. Areas to the northwest are underlain principally by morainal deposits.
>
> "Altitudes in the northwest range from 1,000 to 1,100 feet above sea level, but exceed 1,200 feet in several places. Altitudes gradually decrease to about 600 feet above sea level in the south and east and to 572 feet at the mouth of the River Raisin.

> "The River Raisin rises in the rugged Irish Hills (Lenawee County) and lake district in the western part of the basin. In this area the drainage system is not well developed and the stream flows through a series of interconnected lakes or in wide swampy valleys. Through the central part of the basin the stream valley is well defined having cut into the supporting plain 30 or more feet. The major tributaries in this part of the basin are Goose Creek, Iron Creek, Evans Creek, South Branch River Raisin, and Black Creek.
>
> "The River Raisin in its eastward course over glacial lake bed is characterized by low banks from Blissfield to its mouth and by wide meanders in a low, broad, flood plain from Blissfield northeast to Dundee. Drainage in much of the southeastern area is aided by artificial drains connected to tributaries of the River Raisin. Major tributaries in this part of the basin are the Little Raisin River, Macon Creek, and Saline River.
>
> "There are 429 lakes and ponds in the River Raisin basin, ranging in size from 800 acres (Lake Columbia, an artificial lake) to less than an acre (Humphrys and Green 1962). Most lakes are in morainal and outwash areas to the west and northwest. Elsewhere, lakes are widely scattered and generally small in size.
>
> "Glacial deposits [Figure 3] are classified according to the type of materials of which they are composed and the way they were deposited. Lake bed deposits consist principally of clays and sands which were deposited in former glacial lakes. Till plains and moraines consist of various combinations of clay, silt, sand, and gravel. These materials were deposited directly by glacial ice and its melt waters.
>
> "The thickness of the glacial deposits is important in determining the potential of the deposits for development of a groundwater supply. Thicker deposits can store larger quantities of water and the probability of encountering water-bearing materials is greater than from thin glacial deposits. Drift thickness ranges from about 50 to 300 feet. The drift is thickest in the northeastern and southwestern parts of the basin and thinnest in the eastern part".

The upstream (northwestern) portion of the watershed is dominated by permeable and semi-permeable geology and soils. Therefore, the mainstem and tributaries in this glacial moraine area have more stable flows and more ground water recharge than streams in the southeastern Lake Maumee portion, where surficial geology and soils are dominated by less permeable features. As with soil type, less permeable geology types lead to streams with more "flashy" natures characterized by rapid, intense water level fluctuations after rain events. Impermeable geology and soil types also permit less ground water recharge and lead to higher summer and lower winter water temperatures.
Information from the Geographical Information System "ERDAS" database was used to present geology, soil type, and land use information about the watershed (Tables 2,3,4; Figure 4). This system has a resolution of 1 km square and data are given as percent coverage (e.g., percentage of the watershed in agriculture, etc.). Drainage areas in acres are approximate.

It is important to note that percentages of land use, soils, and geology are expressed as cumulative figures. In other words, the values given for a specific site include the entire watershed above that point. Although this method yields cumulative values for land use, soil type, and geology type in the entire watershed above the sample site, it masks significant differences in various portions. In the basin there are drastic soil and geology differences between the glacial moraine topography (northwestern portion of the basin) and the old Lake Maumee lake plain to the southeast.

Climate

The Great Lakes have less influence on climate of the watershed than on the west side of the state. Winds are usually westerly so Lake Erie has little influence on the weather. However, during periods of high water in Lake Erie, strong easterly winds can cause ice jams at the river mouth and flooding of low shoreline areas (Albert et al. 1986).

Michigan lies in the westerly wind belt. Westerly winds are characterized by a procession of high and low atmospheric pressure centers during much of the year that ensures the day to day changeability typical of Michigan weather. The River Raisin watershed is in the warmest portion of the state and has a mean annual temperature between 48 and 49 degrees (Eichenlaub 1990). The watershed is also in the driest portion of the state receiving from 30 to 32 inches of precipitation per year (Sommers 1977). The average annual snowfall is less than 40 inches. The watershed has low levels of warm season surface runoff resulting from high average air temperatures and greater evaporation. Evaporation exceeds precipitation by more than 80% during the growing season. Total annual surface runoff in the watershed is lower than in most of the rest of the state.

Annual Stream Flow

The United States Geological Survey (USGS) operates three gauging stations on the mainstem and one station on the South Branch of the River Raisin (Figure 2). Mean annual discharge of the mainstem at the station two miles upstream from Manchester (Sharon Valley Rd.) was 107 cubic feet per second (cfs) (Blumer et al. 1996). At Tecumseh, a USGS gauging station has been discontinued. For this station's period of continuous operation (1957 to 1980), the mean annual discharge was 182 cfs. There is a gauging station on the South Branch of the River Raisin in Adrian, near the bridge on State Highway M 52. The mean annual discharge of the South Branch at this location was 154 cfs. The next downstream gauging station on the mainstem is at Academy Road about three miles east of the city of Adrian. This station is downstream from the confluence of the South Branch with the mainstem. Mean annual discharge at this station was 340 cfs. The most downstream gauging station on the mainstem is located about one mile below the bridge on Ida-Maybee Road. This site is about twelve miles upstream from the river mouth at Lake Erie. At this location, mean annual discharge was 741 cfs.

The typical annual flow pattern of surface water fed streams shows seasonal high flows in March and April and base flows during July through October (Figure 5). Graphs of all gauging stations in the watershed would show similar pattern, since flow at all gauge stations is characterized by high surface water and low ground water components.

Seasonal Flow

Flow, arguably the most characteristic physical attribute of stream ecosystems, plays a central role in stream ecology (Poff and Ward 1989). Flow stability is critical to support balanced and diverse fish communities (Richards 1990). Flow stability is an important component of habitat suitability for many fish species (Hay-Chmielewski et. al. 1995).

Richards (1990) ranked 119 streams in the Great Lakes basin according to flow stability using seven indices. Rankings ranged from 1 (least stable) to 119 (most stable). The average rank for the River Raisin, using flow data from the most downstream USGS gauge near Monroe, was 32. Richards classified the River Raisin as variable regarding flow stability. He further determined that large areas of high flow variability are found in the western and central Lake Erie drainages, probably as a result of intense agricultural land use in association with fine-grained, heavy, impermeable soils.

Flow patterns can be depicted by flow duration curves for various gauge locations in a watershed. Flow duration curves show the percentage of days during the period of record when water flows exceed a given level. For example, the 10% exceedence value is the discharge that has been exceeded 10% of the time in the given period (usually a given water year- October to September). Flow duration curves for the mainstem near Manchester, Tecumseh, Adrian, and Monroe and for the Saline River near Saline show a similar pattern (Figure 6).

When comparing exceedence values for streams of varying sizes, it is necessary to standardize values so direct comparisons can be made (Beam and Braunscheidel 1996). One method of accomplishing this standardization is to plot the flows and percentage exceedences on a logarithmic scale (Figure 6). A second method used to facilitate comparison of widely different flows entails dividing exceedence values by median exceedence to arrive at a factor and displaying this factor in figures. This factor represents the magnitude of discharge variance from the median flow at each exceedence range. For exceedence flow under 50% (5%, 10%, and 25% in the figures), the smaller the standardized value, the more stable the stream. For example, (5% exceedence)/ (50% exceedence) = standardized discharge factor at the 5% exceedence level. If this factor is equal to 2, then the flood flow is twice the median flow. The standardized discharges at the 5% exceedence level for four mainstem River Raisin gauge stations are: Manchester- 3.0, Tecumseh- 4.4, Adrian- 5.0, and Monroe- 8.0 (Figure 7). Stream flow becomes less stable proceeding downstream on the mainstem. The South Branch of the River Raisin at Adrian has a standardized discharge factor at 5% exceedence of 5.8, i.e., flood flow is 5.8 times greater than median flow. This indicates an unstable system. For comparison, the most stable streams in Michigan have 5% exceedence (high) flows that are less than twice their median flows (Au Sable at Grayling-1.7, Manistee River at Sherman-1.7, Jordan River at East Jordan-1.4).

In analyzing low flow regimes, the higher the ratio between each exceedence rate and the median discharge for exceedences over the 50% rate (75%, 90%, and 95%), the less variation in stream flow (Figure 8). For the USGS stations on the River Raisin mainstem, the standardized 95% exceedence ranges from 0.32 at Tecumseh to 0.21 at Monroe and Manchester. Adrian falls between these values. The value of the 95% exceedence factor at Manchester (0.21) is believed to be artificially low as a result of irrigation in the upper portion of the watershed. Again as a comparison, the Au Sable River at Grayling has a 95% exceedence factor of 0.70 indicating extremely stable stream flow.

Another index of flow stability is the ratio of the maximum mean monthly flow to the minimum mean monthly flow or the ratio of high to low monthly flow yields (Figure 9). High values of these ratios indicate unstable flows dominated by surface runoff, whereas low values indicate stable flows dominated by ground water. Ratio values of 1.0-2.0 indicate very stable conditions (trout streams), 2.1-5.0 indicate stable cool water and warm water rivers, 5.1-10.0 indicate flashy (less stable) warm water rivers, and > 10.0 indicate very-flashy warm water rivers (P. Seelbach, Michigan Department of Natural Resources, Fisheries Division, personal communication). The values of these ratios on the mainstem range from 4.2 at Tecumseh to 7.9 at Monroe and 8.8 on the South Branch at Adrian. This indicates that the mainstem above Tecumseh is fairly stable. However, the mainstem below Tecumseh and the tributaries in the southeastern portion of the basin have somewhat flashy flow characteristics. The most stable river systems in the state have high yield: low yield ratios of about 1.5. Conversely, the most unstable systems have ratios greater than 25.

Daily Flow

Daily hydrographs show the mean daily discharge at a particular station over time. The daily hydrograph of the mainstem near Monroe for water year 1983 (October, 1982 through September, 1983) shows that daily water flow is not particularly stable (Figure 10). Also, the lack of a large ground water component of flow is apparent.

Daily flow stability is often adversely affected by hydroelectric dams and lake-level control structures. In the early to mid-twentieth century there were a number of small hydroelectric dams on the mainstem. However, only one of these hydroelectric facilities (Sharon Mill Dam upstream from Manchester) remains functional and it is operated only intermittently and in a run-of-the-river mode. In recent years there have been plans to reinstate power generation at the Ford (downstream) Dam in Manchester and the dam at Brooklyn. However, that has not yet happened.

Drainage for agriculture including “channel improvement” (straightening and deepening surface drains) and the installation of tiled sub-surface drainage systems decreases stability of flow. In natural streams, daily flow changes are generally gradual. Channel “improvement” to benefit agriculture increases peak flows after rain events by getting water off the land and into the stream more quickly. In natural systems, flow gradually tapers off after a rain event due to gradual release of water from the surrounding soils (Beam and Braunscheidel 1996). Artificially “improved” drainage systems reduce this period required for stream flow to return to normal levels, thereby making the stream more flashy.

Computerized real-time stream flow information is available from the USGS. Use of these data can aid management decisions, contaminant spill and movement evaluations, and the scheduling of water sampling. Canoeists and anglers also find this information helpful. Flow information from the River Raisin site near Manchester is available on the Internet.

Flooding

Flood-prone area maps have been prepared for the basin by the United States Geological Survey. These maps can be obtained from the USGS and from MDEQ, Land and Water Management Division. The flood-prone areas shown on these maps have a 1 in 100 chance of being inundated during any year. If a National Flood Insurance Program flood study has been adopted by the local government entity, this study supersedes the less-detailed flood-prone area maps. Flood Insurance Rate Maps for use in administering the National Flood Insurance Program have been prepared for the River Raisin basin. Generally, these maps depict the flood hazard areas inundated by 100-year and 500-year floods. These maps are available from the Federal Emergency Management Agency, MDEQ Land and Water Management Division, and affected local governmental units.

The Federal Emergency Management Agency data on flood insurance policies for River Raisin watershed units of government reveal that since 1978, flooding has not been a serious problem above Palmyra. However, flooding has been serious in the lower watershed in Blissfield and Dundee, and particularly in Monroe and Frenchtown townships, and the City of Monroe. However, it should be noted that much of the flood damage in Frenchtown township occurred outside this watershed.

The greatest flood of the lower river since 1937, occurred in 1982. A peak discharge of 15,300 cfs was recorded during this flood event on March 16, 1982. Other significant floods were on May 19, 1945 and March 29, 1950 when the discharge peaked at 12,900 cfs. Newspaper accounts of the 1945 and 1950 flood events left no doubt that they were greater than any previous floods known to the oldest residents at that time.

Much of the flooding in the City of Monroe and in Monroe, Raisinville, and Frenchtown townships is attributable to Lake Erie. High Great Lakes water levels resulting from years of above normal precipitation and strong onshore winds cause flooding as far as 1.5 miles inland. Major flooding along the shoreline occurred during 1972 and 1973 when Lake Erie was at record high levels. The 1972 and 1973 floods had about a 100-year frequency. Areas immediately next to the River Raisin are flooded during spring break-up when ice jams back-up stream flow before it reaches Lake Erie. Ice jams have created the worst flooding conditions during historic flooding events dating back to 1887.

Consumptive Water Use, Irrigation

In recent years there have been significant increases in irrigation withdrawals. Short periods of below normal rainfall have resulted in a number of water use complaints generating concerns about effects of consumptive water uses on stream flows during severe droughts. A report entitled "Effects of Consumptive Water Use on Drought Flows in the River Raisin" was prepared by the MDNR, Engineering-Water Management Division (Fulcher et al. l986). This study was designed to evaluate effects of consumptive water uses on stream flows in the River Raisin watershed.

Study results show that consumptive water uses cause significant reductions in stream flow in the River Raisin watershed and the most severe effects were during drought conditions. For example, if all consumptive water uses are allowed to continue, there would be no flow in the river near Manchester during droughts. These reductions in base flow would significantly alter the river throughout its entire course.

Seasonal irrigation water withdrawals in 1984 varied greatly (Table 5a). Irrigation is by far the major water use in the watershed during summer months when stream flow is low. In 1984, 71% of irrigation withdrawals were taken from surface water sources. There were 10,135 acres of farmland reported under irrigation during 1984. The areas of largest agricultural acreage under irrigation included the northwestern portion of the watershed (Norvell-Manchester townships) and the southern portion (Palmyra-Fairfield townships) (Fulcher et al. 1986).

Thirteen public water supply systems were identified in 1984. Total water withdrawals were 13.4 cfs, the largest continuous annual water use in the watershed. However, nine of these thirteen systems use ground water primarily from wells. About half of the total public supply water withdrawn in the watershed is from ground water sources. Communities that rely on surface water sources include Adrian (Lake Adrian) and Blissfield, Dundee, and Deerfield (River Raisin). Effects of consumptive water losses at selected locations show that this use decreases stream flow substantially (Table 5b).

The 1986 report predicted that reduced stream flows caused by drought conditions coupled with consumptive water use would have a significant effect on the River Raisin’s water quality. Reduced water volume would be insufficient to provide dilution rates necessary to meet National Pollution Discharge Elimination System (NPDES) permit stipulations. Low stream flows coupled with irrigation withdrawals would also restrict recreational uses and reduce aesthetic values. The authors further recommended that stream flow estimates used in the NPDES calculations be lowered to reflect consumptive water uses. Another recommendation was that planning to minimize water use conflicts and resource damage during drought periods should begin immediately. According to Jerry Fulcher, one of the report’s authors, the report’s recommendations have been virtually ignored. The riparian doctrine concerning water use rights prevails, and agricultural irrigation has actually increased.

Drought conditions occurred in Michigan in late spring and summer of 1988. Table 6 presents flow measurements for selected stream locations in the watershed on June 21 and July 13, 1988 during the peak of drought conditions. As was predicted in the 1986 report, the flow at the downstream dam in Manchester was 0 cfs on July 13. Also, many of the locations on tributary streams had no stream flow on July 13. Severe low flow problems occur during droughts on all of these tributaries listed in Table 6 and in the mainstem at Manchester and Norvell. Many of the other tributaries, particularly downstream from Adrian, that were not studied during the drought period in 1988 also experience low flow. Low flow is definitely a problem during years with low precipitation, particularly in smaller tributaries in the eastern portion of the River Raisin watershed. Water withdrawals, primarily for agricultural irrigation, exacerbate this problem.

Channel Morphology

Gradient

Gradient is defined as the drop in elevation over a specified length of river. It is usually expressed in feet per mile. Gradient has a major controlling influence on river habitat. Steeper gradients allow faster water flows with accompanying changes in depth, width, channel meandering, and sediment transport (Knighton 1984).

Gradient is an extremely important factor that dictates the quality of fisheries habitat in streams. Trautman (1942) extensively studied effects of gradient on smallmouth bass populations in Ohio streams. He developed the following relation between stream gradient and smallmouth bass population densities: 0-2 ft/mi- smallmouth bass absent; 2-4 ft/mi- low smallmouth bass populations; 4-5 ft/mi- moderate smallmouth populations; 5-7 ft/mi- high smallmouth populations; 7-20 ft/mi- very high populations; 20-25 ft/mi- moderate smallmouth populations; > 25 ft/mi- low smallmouth populations. The best smallmouth bass habitat (gradient of 7-20 ft/mi) is characterized by deep, clean pools interspersed with riffle areas with cobble and rock bottom. Results of a 1984 MDNR survey validated Trautman’s observations (Towns 1985). Smallmouth bass populations were highest in the higher gradient river segments near Manchester and near Monroe (rock substrate) and lowest in the low-gradient mid-section near Blissfield.

Channel flow characteristics and hydraulic diversity can be predicted based on gradient. Gradient classes and their channel characteristics are listed below (G. Whelan, MDNR, Fisheries Division, personal communication). Hydraulic diversity refers to the variety of water velocities and depths found in the channel for each gradient class. Fish and other aquatic life are typically most diverse in river gradient between 10.0 and 69.9 feet per mile (G. Whelan, Fisheries Division, MDNR, unpublished data; Trautman 1942). Unfortunately such gradients are uncommon in Michigan because of the low-relief landscape.

Gradient class	Channel characteristics
0.0 - 2.9 ft/mi	mostly run habitat with low hydraulic diversity
3.0 - 4.9 ft/mi	some riffles with modest hydraulic diversity
5.0 - 9.9 ft/mi	riffle-pool sequences with good hydraulic diversity
10.0 - 69.9 ft/mi	well established, regular riffle-pool sequences with excellent hydraulic diversity
70.0 - 149.9 ft/mi	chute and pool habitats with only fair hydraulic diversity
> 150 ft/mi	falls and rapids with poor hydraulic diversity

River gradients are not uniformly distributed throughout the river (Figure 11a). They reflect the topography and geology type over which the river flows. Low gradients are generally found across flat areas such as the old Lake Maumee lake plain area in the central and southeastern portions of the watershed. High gradient stream stretches are found in the hilly northwestern headwater's portion of the basin and where the glacial moraines drop to meet the old lake plain in Tecumseh.

Average gradient of the mainstem is 3.2 feet per mile. Total drop of the mainstem from the headwaters to the mouth at Lake Erie is about 475 feet. The total length is 149 miles. The highest average gradient on the mainstem is from the headwaters to Highway M-50 in Tecumseh. Average gradient in this section is 5.7 feet per mile, indicating good hydraulic diversity and good fish habitat. Lowest average gradient on the mainstem is in the reach from Tecumseh to Dundee. Average gradient in this sluggish mid-section of the river is only 1.3 feet per mile. In the most downstream portion of the mainstem, Dundee to Lake Erie, average gradient increases to 3.0 feet per mile as the stream flows over a limestone bedrock base.

The mainstem is mostly low gradient channel with 92 miles (62%) under three feet per mile (Figure 12, Table 7). The most desirable gradient class (10.0 to 69.9 ft/mi) is found in only 7.5 miles (5%). This high quality habitat is concentrated in the extreme headwaters of the watershed and in localized areas near Brooklyn, Manchester, and Tecumseh. Except in the extreme headwaters above Mercury Lake where the stream is very small, many of the highest gradient portions have been inundated by dams in Brooklyn (1 dam), Manchester (2 dams), and Tecumseh (3 dams) (Figure 11b.). Early settlers were adept at determining the best locations for dams to harness water power. Unfortunately, these dams and impoundments created have eliminated and fragmented some of the best fish habitat on the river.

Gradient in the three major segments of the mainstem can be characterized as follows (Figure 12):

<u>*Headwaters to Tecumseh*</u>
This 54 mile portion has 6.5 of the total 7.5 miles of highest gradient class habitat on the entire mainstem. This high gradient habitat is concentrated in the extreme headwaters and in relatively short stream stretches near Brooklyn, Manchester, and Tecumseh. Fair to good gradients (3.0 to 9.9 ft/mi) characterize 62% (33.5 miles) of this stream segment and poor gradient (< 3.0 ft/mi) is found on only 26% (14 miles).

<u>*Tecumseh to Dundee*</u>
This 69 mile middle portion of the river is almost entirely low gradient (< 3.0 ft/mi) habitat. The two mile section of good to excellent river gradient is located immediately below the most downstream of the three impoundments in Tecumseh (Globe Mill Pond). Because of the low gradient, stream flow is sluggish particularly during normal and low flow periods.

<u>*Dundee to Lake Erie*</u>
Gradient increases in this 25 mile lower portion of the river. A total of 44% has fair to good gradient (3.0 - 9.9 ft/mi). The highest gradient is nearest to the mouth at Lake Erie. The stream bed in most of this downstream section is composed of limestone bedrock. This rock bottom in combination with increased gradient produces improved game fish habitat compared to the low-gradient middle section.

Channel Cross Section

Unless altered by human use, such as channelization or construction of an artificial concrete stream bed, natural channel cross sections are not normally uniform. Unstable flows generally create channels that are wide and shallow during normal flow periods. Abnormal sediment loads also modify channel cross section. Bridges, culverts, bank erosion, channel modification, and armored substrates cause deviations from expected channel form.

To assess channel characteristics, measured channel width can be compared to the average width of rivers with the same discharge using data from Leopold and Maddock (1953) and Leopold and Wolman (1957) (cited by Hay-Chmielewski et al. 1995). Expected width is log (width in feet) = 0.741436 + 0.498473 log (mean daily discharge in cfs). The calculated expected width is then compared to the measured channel width at a measured flow as close as possible to the mean daily discharge. Channels where measured width greatly exceeds expected width are often the result of greatly fluctuating flows or excessive sediment loading, whereas excessively narrow channels are usually the result of armored stream banks or dredging.

The analysis of expected width compared to measured width was calculated at four locations on the mainstem and one location each on the South Branch and Saline River (Table 8). Data were available only at USGS gauge locations. This lack of information reduced the usefulness of these width comparisons, since USGS gauges are often located at bridges where measured widths may not be representative of that particular river segment. Additional widths at mean flow data are needed on streams throughout the watershed to permit a more detailed analysis of expected widths versus measured widths.

At all locations, except Ida-Maybee Road about halfway between Dundee and Monroe, the measured channel widths were more narrow than the expected widths. At Tecumseh and Adrian on the mainstem and at both tributary stations this is probably the result of high clay content in the stream banks. Clay banks are resistant to erosion and streams running through clay soil generally have U-shaped channels (Knighton 1984). The excessively narrow channel at the Manchester gauge site is more difficult to explain. Perhaps this is an anomaly caused by the location of the USGS width measurement. USGS discharge measurements are not necessarily made at the same cross section every visit. This explains why the USGS width measurement at mean flow (28 ft) could be exceeded by the width measurement taken at low flow during a 1984 MDNR survey (35 ft).

Besides width comparisons, the hydraulic diversity of a channel can be indexed using the Shannon-Weiner diversity index to characterize predictability of hydraulic conditions in randomly chosen portions of a cross-section (Whittaker 1975) (cited by Hay-Chmielewski et al. 1995). The greater the number of different velocities and depths, the larger the number of species or life stages or both (i.e., spawning, young-of-the-year, juvenile, adult, etc.) that can be supported in a stream segment (Rozich 1996). To calculate this diversity index, counts of cross section data points were used. Velocity was in intervals of 0.5 ft/s and depth in intervals of 0.5 ft. The diversity index ranges from 0.0 representing constant depth and constant velocity across the channel as in a flume to values greater than 3.0 representing a highly diverse channel. Channel width diversity index values between 0.0 and 1.50 are considered to have poor hydraulic diversity. Diversity index values of 1.51 to 2.00 indicate channels with fair hydraulic diversity, 2.01 to 2.50 indicate good hydraulic diversity, and above 2.51 indicate excellent hydraulic diversity.

Shannon-Weiner index values for channel diversity are calculated for nine locations on the mainstem, one location on Wolf Creek, one on the South Branch, one on Black Creek, and two on the Saline River (Table 8). Locations on the mainstem received fair to good ratings of hydraulic diversity. However, all locations selected on the tributaries received poor hydraulic diversity ratings. As with channel width analysis, additional cross section data are needed for a complete and accurate analysis of cross section hydraulic diversity information on streams throughout the River Raisin watershed. Most of the locations where data were available were either USGS gauge stations (current and retired) or miscellaneous measurement stations. Since these measurements are often taken at or near bridges, they are not always representative of specific stream reaches.

A narrative description of the cross sections of various segments of the River Raisin mainstem follows. Topographic maps, aerial photographs, data collected during the MDNR 1984 survey, and the author's knowledge of the stream provided the material to develop these general descriptions. More detailed descriptions could be prepared after extensive field observations.

Headwaters to Tecumseh
The extreme headwater segment upstream from Mercury Lake has been channelized. Therefore, the channel is narrow and less diverse then would be expected in a natural channel. The stream runs through a heavily wooded corridor and gradient is fairly steep. Bottom substrate is a combination of sand and gravel.

Downstream from Mercury Lake, the mainstem flows through a series of small lakes and connecting wetlands until it leaves the Onsted State Game Area and crosses US-12 west of Cambridge Junction. Stream gradient is low and water velocity is slow. The substrate is a mixture of sand and silt. Stream banks are not well defined in the wetland areas and bank vegetation is composed of brush and emergent aquatic vegetation.

Below US-12, the mainstem has a short portion of higher gradient habitat before it flows into a long, narrow wetland area connected to Vineyard Lake. The stream is channelized between US-12 and M-50 next to Michigan International Speedway and has less channel diversity than normal. Stream banks are poorly defined in the wetland area upstream from Vineyard Lake.

From Vineyard Lake the mainstem meanders through wetlands created by an impoundment at Brooklyn. This is a high gradient portion of the stream that has been inundated by the impoundment. Flow is sluggish through these wetlands and bottom type is a mixture of sand and silt. Downstream from Brooklyn, the River Raisin enters a large wetland area that is roughly at the same elevation as the Norvell Lake Dam. Banks in this 3.5 mile wetland area are low, poorly defined, and heavily vegetated with wetland shrubs, emergent aquatic vegetation, and purple loosestrife. Stream flow is slow and the bottom is fairly firm in most locations. Substrate is a combination of sand and silt. The impoundment created by the Norvell Dam is about two miles long. Submergent aquatic vegetation is extremely heavy in this shallow, silty impoundment. Eurasian milfoil and curlyleaf pondweed produce extensive mats that seriously limit recreational use. The lake association has requested a permit to lower the lake level during fall and winter of 1998 in an attempt to control submergent aquatic vegetation.

The river meanders through a strip of bottomland hardwoods from Norvell Dam to Tecumseh, except for impoundments at Sharon Hollow, Manchester (2), and Clinton. The banks are steep but not excessively high, and bank vegetation, except for tree roots, is absent under dense canopy. In more open areas the immediate stream banks are covered with dense growth of shrubs and grasses. Stream flow and gradient are increased over more upstream lake and wetland areas and pools and a few riffle areas are present. Bottom substrates are composed of varying amounts of sand, gravel, silt, and cobble, with gravel and sand the dominant materials.

The Sharon Hollow, Clinton, and upstream Manchester impoundments are shallow and sediment-laden with dense emergent and submergent aquatic vegetation. The Sharon Hollow Impoundment is essentially reduced to the stream channel flowing through shallow water over silt and sand deposits. This impoundment has a heavy growth of emergent aquatic vegetation over 75% of the surface. The Clinton and upstream Manchester impoundments have dense growths of emergent and submergent aquatic vegetation. The downstream Manchester Impoundment is silt-laden and shallow in the upstream portion; however, deep water near the dam prohibits weed growth. The mainstem at

Manchester is one of the highest gradient areas of the entire river. Unfortunately, much of this valuable high gradient habitat has been lost under the two Manchester impoundments.

Tecumseh to Dundee

At Tecumseh there is a series of three dams. Similar to the Manchester area, Tecumseh is one of the highest gradient stretches of the entire mainstem. Much of the high gradient habitat at Tecumseh is also lost under impoundments. The most upstream impoundment at Tecumseh (Red Millpond) is extremely shallow, silt-laden, and vegetation-choked particularly in the upstream end. This impoundment was treated with rotenone in 1955 to control abundant populations of carp and suckers. Benefits of this treatment were short-lived.

Tecumseh is the approximate location where the River Raisin mainstem drops from the morainal, northwest portion of the watershed to the old lake plain southeast portion. From Tecumseh to Dundee the average gradient is only 1.3 ft/mi. This low gradient and sluggish stream flow in combination with sand, silt, and clay soils has resulted in an extreme meandering course. The River Raisin has been described as the world's most crooked river (RRWC 1988).

Immediately downstream from Tecumseh the mainstem meanders through a fairly broad band of bottom land hardwoods. This strip of trees along both banks becomes increasingly narrow and interspersed with open farm fields as the river continues to Dundee. Extensive logjams primarily of dead elms are common. These logjams in the past have forced the river to cut new channels that resulted in tremendous erosion and sediment loads. Old oxbows cut off by the river creating a new channel are common between Tecumseh and Dundee.

In the old lake plain portion of the mainstem, the banks are steep and high. Bank vegetation is sparse particularly in areas with dense tree canopy. There is evidence of significant flow fluctuation, since vegetation is sparse even where the tree canopy is more open. Bottom substrates are composed of sand, silt, and clay with lesser amounts of gravel. This stretch is primarily run habitat with a few deeper pools and very few riffles. The Shannon-Weiner diversity index values for mainstem locations in the old lake plain (Tecumseh to Dundee) section are higher than expected. This diversity is a factor of varying depths in the cross-sections measured. Stream velocities were uniformly low across the channels. However, presence of deeper water creates more volume of fish habitat and enhances fish management options. High clay content in the banks causes channels to be more narrow than expected.

Dundee to Lake Erie

For a distance of approximately two river miles downstream from Dundee the channel is very similar to the description given for the channel from Tecumseh to Dundee. At the confluence of the mainstem and Saline River, the channel of the mainstem stops meandering and becomes excessively wide. This is caused by an abrupt change in the stream's bed from a clay, sand, and silt mixture to a gravel, cobble, and bedrock composition. These bottom sediments are more resistant to erosion. Therefore, the stream is forced to cut into the banks during high flow periods and the stream becomes excessively wide. In combination with a gravel and bedrock substrate the gradient increases. This creates excellent habitat for smallmouth bass and they are abundant in the lower river.

The stream banks in this most downstream portion are lower than banks in the Tecumseh to Dundee segment. The banks are less heavily wooded than in upstream areas and the immediate banks are generally covered with grasses and shrubs. In Monroe, a portion of the river is lined by concrete retaining walls. Several areas between the Ida-Maybee Road crossing and downtown Monroe have many small "islands" covered with grasses and marsh vegetation. Local residents refer to these islands as "dots". The river below Ida-Maybee Road is primarily run habitat with deeper riffle areas and few pools except behind the dams.

Soil and Land Use Patterns

Soil Information

In combination with climate, soil and land use patterns determine much of the hydrology and thus the channel form of a river. Changes in land use often drive change in river habitats. The texture and particle size of the soil determine the rate water can flow through it. For example, water will percolate very rapidly through gravel but very slowly through clay. This influence on runoff is reflected in the pattern of stream flow. In regions where dominant soil types are permeable, stream flow is fairly uniform throughout the year. In regions where soils are primarily impermeable clays, stream flow tends to be erratic and streams are said to be flashy with rapid, intense flow fluctuations. The parent material of soils in the River Raisin watershed is from the most recent stage of Pleistocene glaciation (Wisconsin stage) and the lacustrine deposits of the ancestral Great Lakes associated with it (MWRC 1965). This glacial veneer is composed of a great variety of mineral materials arranged in many topographic expressions under all conditions of drainage and modified by long-term variations in cover and climate. Therefore, there are many different soil associations as classified by parent material, texture, soil profile development, and glacial origin (MWRC 1965; Table 9; Figure 13). Soil data can be further characterized by particle size that determines soil permeability and ground water versus surface water flow components.

Soil Type Information, ERDAS

Soil type information from the ERDAS database (Table 3) along with information from Figure 13 and Table 9 (MWRC 1965) yields important observations. The upstream northwestern portion of the River Raisin watershed is dominated by sandy loams, loams, and clay loam soils that have moderate to high filtration rates. Streams in this portion of the watershed have more stable flows and some ground water recharge. In the old lake plain southeastern portion of the River Raisin basin, soils are primarily clays, clay loams, and silty clays with low to very low permeability and slow infiltration rates. Therefore, the mainstem of the River Raisin becomes more flashy in its lower reaches, although the upstream portion of the watershed acts to moderate this tendency. Tributaries such as Macon Creek and the Little Raisin River that have watersheds almost entirely composed of soils with low permeability have very flashy flow characteristics after rain events. The influence of agricultural water withdrawal enhances this flashy character and makes these streams extremely difficult to manage for sport fish. Detailed soil information and maps are available in county soil surveys published by the United States Department of Agriculture, Natural Resource Conservation Service (NRCS).

Land Use Information

Land use is the primary factor causing a decline of fishery resources in stream ecosystems (Schlosser 1991). Agriculture is the overwhelmingly dominant land use in the River Raisin basin. According to ERDAS data roughly 94% of the total land mass of the river basin is devoted to agricultural use (Table 4). The percent of land used for agriculture increases as the river continues downstream. For example, agricultural use from Tecumseh upstream in the river basin is about 85% of the total available land mass, whereas agricultural land use in the entire river basin is about 94%. Agricultural land use approaches 100% in the Black and Macon Creek sub-watersheds. The River Raisin watershed has the highest percentage of agricultural land use (92%) of any watershed in Michigan according to the Michigan Inventory Resource Information System (MIRIS) land cover database (Gooding 1995). Lenawee and Monroe counties rank among the top ten counties in Michigan in the production of corn, winter wheat, soybeans, potatoes, sugar beets, and truck vegetables.

The pattern of increasing agricultural land use in more downstream areas of the watershed is evident when information from major sub-basins is studied (Figures 14 and 15). Land use within a 50 meter riparian zone from each bank is significantly different from land use within the entire sub-basin (Figures 15 and 16). In most sub-basins land use is much less agricultural and more forested in the 100 meter wide stream corridor than in the entire sub-basin. This reflects the presence of the wooded stream corridor.

Nonpoint source pollution caused by intensive agricultural land use is the most serious water quality problem in the River Raisin watershed and creates the most limiting factor on fish and aquatic invertebrate populations. Tillage of soils increases erosion and sediment loading to streams. Many fish and macroinvertebrate species are intolerant of high sediment loads. According to Smith et al. (1981) such silt-intolerant fish species have declined and silt-tolerant fishes have increased in the River Raisin watershed. Erosion and resulting downstream sedimentation often blanket gravel substrates, the silt and sand eliminating spawning and food producing areas. Drainage improvement to promote agriculture results in wetland destruction, stream channelization, and the construction of new surface and underground (tiled) drainage passages. Destruction of wetlands eliminates spawning, nursery, and feeding habitats for many fish species and other animals. Wetlands also serve important functions in providing high water quality. These wetland functions include acting as a sediment and nutrient filter during and after precipitation events and stabilizing stream flow and promoting ground water recharge by acting as storage reservoirs during high flow periods. Stream channelization creates shallow, uniform channels with much less diversity of depth, velocity, and bottom substrates. Less diverse channels support less diverse biota as critical habitats for reproduction and survival of aquatic species are eliminated. The overhead canopy is often destroyed or greatly reduced during the channelization process. This leads to increased summer water temperatures that can eliminate certain fisheries management options. Channelization also results in the drastic decrease of instream woody debris thereby limiting instream cover for fish and other aquatic organisms. In many agricultural streams, the absence of woody debris causes a reduction in heterogeneity of depth, substrate, and current velocity resulting in wide, shallow streams with little structural complexity and affording poor habitat for many aquatic species (Schlosser 1991). The construction of artificial surface and subsurface drainage channels decreases flow stability in the stream and can increase stream temperatures during low flow periods. Agricultural land use produces increased inputs of agricultural chemicals to the stream. These chemicals include fertilizers that add nutrients to the system and pesticides and herbicides that are toxic to many aquatic organisms.

Before settlement and intensive clearing for agriculture in the mid-1800s, the River Raisin watershed was predominately deciduous forest interspersed with smaller areas of wetlands and prairies. According to ERDAS data, only slightly more than 2% of the basin remains in hardwood forest. The remaining forested land is composed of small, isolated woodlots and narrow, wooded corridors along the immediate stream and river banks. However, forest land use has increased in recent years as marginal farm land primarily in the northwestern portion of the watershed reverts to brush and eventually to hardwood forest (Allan et al. 1997). The major tree species of commercial value are oaks, maples, walnut, cherry, and tulip poplar (Bill Hoppe, MDNR, Forest Management Division, personal communication). Private woodlot management throughout the basin is not intensive; major products are firewood, mixed hardwood saw logs, and veneer logs. Sycamores and cottonwoods are abundant along streams and American elms were abundant until the onset of Dutch elm disease.

Urban land use remains relatively low in the River Raisin watershed and ranges from 2% (ERDAS) to 3% (MIRIS) of the total basin land area (Table 4). However, urban land use in the basin will continue to increase particularly in the Adrian, Monroe, Tecumseh, and Saline vicinities as people from the Detroit and Ann Arbor metropolitan areas move into the watershed. Urban development increases the percentage of impervious land area (roads, parking lots, roofs, etc.) thereby transporting water from the land to the receiving stream more quickly. This results in decreased flow stability and an increased flashy character of the stream. Detrimental effects of decreased flow stability were discussed in **Geology and Hydrology,** *Daily Flow*. Urban runoff water also contains pollutants including grease and oil, salt, heavy metals, bacteria, and lawn and garden chemicals that are transported to the stream.

The remaining land use categories from the ERDAS database (Table 4) are water, forested wetlands, and non-forested wetlands. These categories account for a very small percentage of the total land use. As expected, all of these natural land use categories follow a similar pattern of being higher in the extreme upstream portion of the watershed and much lower to non-existent after the river enters the old Lake Maumee lake plain southeastern portion of the basin.

Besides overall land use data, streamside vegetation can play a particularly important role in mitigating adverse effects of changing land use. At the land and water interface, riparian vegetation regulates temperature, runoff, and the flow of water and nutrients from upstream sources (Roth 1994). In addition, forested riparian vegetation contributes organic litter, an energy source for instream trophic webs, and large woody debris that serves as habitat structure and influences the development of channel morphology (Karr and Schlosser 1978, Naiman et al. 1993) (cited by Roth 1994).

The removal of native vegetation increases the potential for overland and channel erosion. This causes increased siltation that obliterates the clean gravel surfaces required by many fish species as spawning habitat (Berkman and Rabeni 1987) (cited by Roth 1994). Habitat alteration is cited as a contributing cause in 73% of fish species extinctions in North America during the 20th century (Miller et al. 1989) (cited by Roth 1994).

Land use in a 50 meter riparian zone on each bank (100 meters total width) for each of seven sub-basins of the River Raisin watershed was investigated by Roth (1994) using the MIRIS digital database (Figure 16). As expected, agricultural land use of the riparian zone increases greatly and wetland land use decreases greatly as the river continues downstream in the watershed. Forested and urban land uses in the riparian zone do not appear to be related to location in the watershed. Surprisingly, percentage of land in forest cover in the riparian zones was higher in the Black Creek and Saline River sub-basins than in the Upper Raisin and Goose Creek sub-basins. This indicates that immediate riparian zones remain somewhat wooded even though the more downstream sub-basins considered as a whole are intensely agricultural.

Biological Communities

Original Fish Communities

The fish communities of the Great Lakes region are of relatively recent origin. Ice flows covered this entire region during the Wisconsin glaciation, and exposure from the ice flows dates only from 14,000 years ago at the southern edge of the region to 9,000 years ago in the northern portion of the basin (Bailey and Smith 1981). During glacier advancement and retreat, various lakes created by melt water provided refuges for fishes. Movement of these fishes was through open water channels connecting peripheral ice-free refuges with newly created aquatic habitat. Species distribution patterns suggest colonization of the Great Lakes by 122 species solely from Mississippi basin refuges, 14 species only from Atlantic drainage refuges, and dual refuges for at least 18 species.

Bailey and Smith (1981) identified 125 fish species as native and still present in Lake Erie tributaries, four species as native but extirpated, seven species as recently colonized by way of canals, and ten species as being introduced. All fish species, their common and scientific names, and their status in the River Raisin watershed are listed (Table 10).

A description of the fish community at the time of European settlement (early 1800s) is not available. However, early anecdotal accounts relating primarily to potamodromous fishes do exist. Potamodromous fish are species that migrate from freshwater lakes up freshwater rivers to spawn. The Indians called the River Raisin "Nummasepee" or river of sturgeon for the vast quantities of lake sturgeon ascending the river in spring (Wing 1890; Bulkley 1913). Indians and early settlers speared lake sturgeon from large rocks in the lower river during these spring spawning runs (Zeisler 1943).

Muskellunge were abundant in western Lake Erie including Maumee Bay in the first half of the nineteenth century (Clark 1964). Therefore, it seems feasible that muskellunge populations may have existed in the Michigan tributaries of Lake Erie (Seelbach 1988). Indeed there is anecdotal evidence that the River Raisin supported spawning runs of muskellunge (Zeisler 1949b.). Besides lake sturgeon and muskellunge, the River Raisin also received spawning runs of other potamodromous fishes including pickerel (walleye), white bass, pike, mullet (white suckers), and possibly whitefish and lake trout (Wing 1890).

The lower River Raisin became well known for smallmouth bass fishing during the middle of the nineteenth century. At that time, it was said to produce the finest bass fishing to be found in the country and bass fishermen came to Monroe from Chicago and other Midwestern cities. Besides smallmouth bass, anglers took walleye, perch, rock bass, bullheads, and sunfish as well as other species from the river (Wing 1890). Ice fishing was also a popular pastime on the lower River Raisin and on portions of Lake Erie near the mouth.

The first paper mill in Monroe was established in 1834, and Monroe became an important paper mill town in the mid to late 1800s. During the early 1900s eight paper mills operated in Monroe. Pollution from these paper mills and other industrial and municipal discharges into the River Raisin at Monroe and upstream locations was affecting fish populations. In the 1920s, a landmark lawsuit concerning industrial water pollution was litigated in Monroe. W. C. Sterling operated a carp pond business in the extensive marshes between the city of Monroe and Lake Erie. Carp (introduced) were caught in Lake Erie during the summer and stored and fattened on cracked corn in the ponds until spring when they were shipped live by rail to New York City and sold to Jewish people. Many of the fish died during the holding period or in transit and the company lost money every year.

Mr. Sterling thought that paper mill effluent was killing the carp. He also blamed paper mill effluent for destroying wild rice and wild celery beds in the marsh. This change in marsh vegetation led to the demise of his elite duck hunting club (the Monroe Marsh Club). Therefore, Mr. Sterling filed suit for damages (dead carp) and requested an injunction prohibiting the operation of the paper mills until the discharge problem was corrected (DeVries 1927).

The judge ruled that riparian owners throughout the length of a river had a right to the stream's water in its original condition. The paper mills were ordered to compensate Mr. Sterling for damages. However, the judge did not order the paper mills to cease polluting the River Raisin. The judge ruled that the prosperity of the City of Monroe depended largely upon the defendant's eight mills, seven that were built before the plaintiff established the carp pond business. The judge further ruled that the paper mills employed 3000 people representing an investment of $15,000,000 (1920s dollars) and could not be operated profitably without discharging the wastes into the river. On the other hand, the carp pond business represented an investment of $10,000 and employed less than five workers. Both sides appealed to the Supreme Court that upheld the lower court's ruling. The decision in this lawsuit set a legal precedent that economic considerations could outweigh environmental damages caused by pollution.

Factors Affecting Fish Communities

European settlers caused dramatic changes to the River Raisin and its watershed that resulted in significant changes to fish communities. The effects of dam construction, intense agriculture, urban land use, municipal and industrial discharges, water withdrawal, drainage, and lake-level control structures on the river system are discussed in detail elsewhere in this report. However, a brief summary of the effects of settlement and development of the watershed is appropriate.

Fish require several types of habitat throughout their life cycle. Stream fishes often require very diverse habitats for spawning, feeding, and escape cover. Also, habitat requirements can vary widely for juvenile versus adult fish and for winter versus summer seasons. Fish also require the freedom to move from one habitat to another (Schlosser 1991). If any one specific habitat is lacking or if the ability to move between required habitats is restricted, the species cannot continue to exist in that area.

Construction of dams during the early period of European settlement blocked spawning runs of potamodromous species. Potamodromous fishes were also concentrated below dams during subsequent runs and made more vulnerable to harvest (Trautman 1981). Early settlers were adept at selecting high gradient areas to construct dams and mills. These sites became town locations. Water powered mills for sawing lumber and grinding flour were of paramount importance to early settlers. These high gradient areas often provide critical spawning areas for fish and provide the best sport fish habitat. Dams can alter temperature patterns and flow regimes of rivers thereby creating conditions that cannot be tolerated by many fish species and favor large, adult, warmwater fishes such as carp (Cushman 1985). Therefore, original species diversity was reduced.

At the time of European settlement (early 1800s) the vast majority of the River Raisin watershed was forested. Land was cleared primarily for agriculture and only small woodlots remain of the original hardwood forests. With clearing of the forests came wetland drainage and stream channelization to facilitate agriculture. Detrimental effects of intensive agriculture and on natural stream habitats and biological communities were discussed in **Soil and Land Use Patterns,** *Land Use Information*.

Urban water use also affects both water quality and quantity in the river basin. Many homes use ground water from individual wells. Not all of this water is returned to the watershed and the water that is returned generally is warmer and more nutrient-laden than in its original condition.

Many lakes in the upper portion of the watershed have lake-level control structures. These lowhead dams disrupt movements of fish and often prevent fish from reaching spawning habitat. Adjustments of lake-level control structures to favor lake residents can be detrimental to the stream. When lake levels are deemed too high, boards are removed from the structure and the stream channel is subjected to excessively high flows. This can result in bank erosion and increased sediment loads. Conversely, when lake levels are abnormally low, flow from the lake to the stream is limited or blocked completely, exacerbating low flow conditions in the stream. Lake levels are often dropped in the fall to reduce ice damage to riparian seawalls and beaches. This can result in damage to wetland areas around the lake shore. If a lake level is not restored early enough in the spring, spawning habitat for early spawning fish, such as northern pike, is unavailable. Seasonal low water levels act to encourage dredging and filling that destroys wetland spawning habitat.

Before implementation of the Federal Clean Water Act in the 1970s, point source discharges of industrial and municipal wastes created severe problems downstream from towns in the watershed. Although point source pollution problems have been reduced significantly, Smith et al. (1981) reported that effects of pollution from municipalities remained clearly evident in their 1978 fish collections. On the River Raisin mainstem, one-third of the fish species were eliminated below

Clinton and Tecumseh and about one-half of the fish species were unable to survive immediately below Adrian. Changes in habitat are partly responsible for this reduction in species diversity.

Besides changes in fish communities resulting from European settlement and related human activities in the watershed, fish communities have often been altered by the intentional stocking of fish (Table 11) or the inadvertent introduction of exotic species (Table 10) (Smith et. al 1981).

Present Fish Communities

Based on biological surveys (Shepherd 1974; Smith et al. 1981; Towns 1985; Kosek and Jones 1994) and earlier University of Michigan records (Smith et al. 1981) the River Raisin watershed is known to contain at least 90 fish species (Table 10). These surveys were conducted with a variety of methods: seining (Smith et al. 1981); electrofishing (Shepherd 1974; Kosek and Jones 1994); and rotenone (Towns 1985). Distributions of individual fish species vary from essentially basin-wide (common shiner) to isolated areas (silver shiner) (Appendix 1). Many native species remain abundant in the watershed whereas others have declined primarily as a result of habitat changes.

Eleven non-indigenous fish species have been introduced in the watershed (Table 10). These introductions include both planned fish stocking and unintentional introduction and migration. Except for carp and goldfish, the ranges of these species have remained limited (Appendix I).

The first comprehensive fish survey of the River Raisin drainage was conducted in 1978 by Dr. Gerald R. Smith and personnel from the University of Michigan (Smith et al. 1981). This survey was an inventory of fishes in the drainage with special reference to threatened species and critical habitats. Fish collections were made at 160 locations and 240 habitat samples were analyzed. Of the 81 species previously recorded from the River Raisin basin, 67 were taken in the 1978 survey. Three species (orangespotted sunfish, chinook salmon, and creek chubsucker) were collected for the first time in the basin. Previously reported fish species not taken in the 1978 survey fall into three categories: (1) species possibly extirpated from the drainage, (2) peripheral species whose occurrence in the basin is based on few documented records, and (3) fish species not easily collected using seines. Smith compiled a comparison of fish species from the 1978 survey, based on their abundance and frequency of occurrence (Figure 17). Note the correlation between abundance and geographical distribution in the basin. Species that are abundant generally have widespread distribution in the watershed whereas the distributions of uncommon species are much more restricted.

Thirteen species were abundant in the 1978 survey. These 13 species made up two-thirds of the total sample of 50,000 specimens. Abundant species include five species of shiners (common, spotfin, striped, redfin, and blacknose) and four other minnow species (bluntnose minnow, stoneroller, creek chub, and blacknose dace), plus white sucker, brook silverside, johnny darter, and bluegill. Bluntnose minnow was the most abundant species.

Thirty-seven species represented by 30 to 1000 specimens collected from 10 to 100 habitat samples in the 1978 survey were regarded as common. They include most of the sunfishes, darters, and catfishes plus three suckers, nine minnows, sculpins, pike, pickerel, and mudminnow. Most are sufficiently widespread in the watershed to be regarded as stable. These warmwater species would be expected to be common in the basin.

Seven species were regarded as restricted but not rare, based on their relative abundance and very localized geographical distribution in the watershed. These species included silver shiner, sand shiner, emerald shiner, gizzard shad, spottail shiner, banded killifish, and brook stickleback. The restricted distributions of these species result from specific habitat requirements.

Thirteen rare species represented by one to eleven individuals and taken in only one to five habitat samples included seven species that are common or abundant elsewhere in the state. These are bowfin, longnose gar, chinook salmon, goldfish, silver redhorse, logperch, and walleye. The other six rare species require brief discussion.

The brindled madtom is restricted to clean waters with riffles in several drainages in southeast Michigan. It is an indicator of good water quality, and has probably declined as a result of increased sediment loads caused by agriculture. The orangespotted sunfish is a warmwater species that has invaded Lenawee, Monroe, and Washtenaw counties in recent years. Although it is still rare, its distribution is spreading. The black redhorse is a southern species in Michigan that requires clear water with clean gravel or rubble riffles. Similar to other clear riffle species, the black redhorse appears to be declining because of increased sediment loads resulting from agriculture. The greater redhorse was taken at only one station during the 1978 survey. It appears to be declining in abundance and distribution in the basin. The creek chubsucker was taken at only two localities during the 1978 seining survey. The creek chubsucker is one of the rarest species in the state, known from only nine localities in the southern tier of counties. The southern redbelly dace is a rare headwater species requiring cool, clean water with stable flow. It is known from fewer than a dozen localities in Lenawee and Washtenaw counties.

There are no rare or extinct northern fish species in the River Raisin drainage. Most of the rare or extinct species are southern forms near the northern edge of their range; e.g., creek chubsucker. Many also appear to be species that are intolerant of siltation (southern redbelly dace, bigeye chub, silver shiner, brindled madtom) (Trautman, 1981).

The Michigan Natural Features Inventory (MNFI) is part of the Natural Heritage Program, MDNR, Wildlife Division. MNFI is a comprehensive source of existing data on Michigan's endangered, threatened, or otherwise significant plant and animal species, plant communities, and other natural features (Table 12). The fish species on this list include the black redhorse, brindled madtom, and pugnose shiner (all of special concern); and the creek chubsucker, eastern sand darter, silver shiner, and southern redbelly dace (all threatened). The eastern sand darter has apparently been eliminated from the River Raisin watershed (C. Latta, MDNR, Fisheries Division, personal communication). Smith et al. (1981) list bigeye chub, lake herring, pugnose shiner, and brook trout (introduced) as species previously found in the River Raisin watershed that have possibly been extirpated from the drainage.

Species diversity in the lower drainage is based primarily on the large volume of water and siltation or pollution tolerant species. These fishes are not declining and are not in danger in Michigan because their habitat is increasing. Species that make up the diversity in the upper drainage, on the other hand, include several that are threatened by the loss of critical or favorable habitat. These include silver shiner, rosyface shiner, river chub, hornyhead chub, black redhorse, greater redhorse, and brindled madtom. The rainbow and fantail darters, though characteristic of smaller waters, are similarly threatened by pollution and siltation. Smith et al. (1981) present an extensive analysis of habitat preferences of various fish species in the watershed. This excellent material and accompanying figures is well worth investigating.

An extensive fisheries survey of the River Raisin mainstem and selected tributaries using a rotenone survey technique was conducted during August, 1984 (Towns 1985; Figure 18). During this survey, over 83,000 fish representing 61 species were collected (Figure 19). As in the earlier University of Michigan seining survey (Smith et al. 1981), the bluntnose minnow was the most numerous species. However, when fish less than three inches long were disregarded, the northern hog sucker was the most numerous species. Common carp accounted for 28.3% by weight but only 1.9% by number of the total catch. Estimates of total standing crop of fish in the River Raisin varied between stations from 128 to 703 pounds per acre. The River Raisin mainstem from east of Adrian to Dundee had a lower standing crop and a higher proportion of carp, redhorse species, and suckers than the rest of the river.

Species associated with Lake Erie were not found even at the most downstream station. This finding was in marked contrast to the results of rotenone surveys of other southern Michigan rivers (Nelson and Smith 1981, Towns 1984). In the River Raisin, the cooling water intake at the Detroit Edison Monroe Power Plant, lowhead dams in the city of Monroe, and the Waterloo Dam deter upstream migration of fish from Lake Erie.

For purposes of additional fish community and habitat information, the mainstem of the River Raisin can be divided into three segments (Figure 2). A description of these segments, their habitats, and their fish populations follows:

Headwaters to Tecumseh

This upstream northwestern portion of the watershed is characterized by glacial geological features including moraines, ground moraines (till plains), and outwash and glacial channels. Permeable soils (loams and sand and gravel mixtures) dominate. Therefore, the mainstem and tributaries in this area have more stable flows and more ground water recharge than streams in the southeastern old lake plain portion of the watershed. The stream gradient of this upstream portion is relatively high for the River Raisin basin, although dams at Tecumseh, Clinton, Manchester, Sharon Hollow, and Brooklyn have inundated much of this high gradient area. Stream flow remains relatively swift in river portions of the upper watershed, and the stream bottom is composed of sand, gravel, cobble, and lesser amounts of silt. Kosek and Jones (1994) ranked habitat in three of four upstream mainstem stations as good to excellent. They noted the varied hydrology and channel morphology in this area (roughly the Norvell Impoundment in Jackson County to the Red Millpond in Tecumseh) and determined that areas immediately below the Sharon Hollow Impoundment and about halfway between Clinton and Tecumseh had the best natural gravel substrate of all stations surveyed.

Species diversity is influenced by volume and diversity of habitat available for fish life and presence of pollution and siltation. Locations in the upper (northwest) portion of the watershed that had a high diversity of fish species had moderate volumes of flow and good water quality. However, some of the species that make up the diversity in the upper drainage are threatened by loss of critical or favorable habitats including areas with clean gravel substrate and free-flowing, vegetated lake outlets.

Historic evidence suggests that in recent years the dominant factor determining changes in the distribution and abundance of fishes is siltation resulting from agricultural runoff (Trautman 1981). Siltation reduces diversity of substrate by covering gravel and rubble. Siltation eliminates favorable fish spawning areas and habitat for benthic food organisms.

Tecumseh to Dundee

This middle portion of the River Raisin watershed is characterized by old lake bed geology. Soils are less permeable with much higher clay content than is present in the upper watershed. Therefore, the mainstem and tributaries are more “flashy”. They are characterized by rapid, intense water level fluctuations after rain events. This leads to instability of river banks and increased erosion, turbidity, and sedimentation. Impermeable geology and soils also permit less ground water recharge leading to higher summer and lower winter water temperatures. Average stream gradient is only 1.3 feet per mile and stream flow is sluggish. Although the stream bed remains relatively firm, the bottom is composed mainly of sand, silt, and clay with lesser amounts of gravel. Kosek and Jones (1994) rated the habitat of this mainstem mid-portion as poor (severely impaired) because of erosion, unstable banks, sedimentation, and lack of coarse substrate favorable for macroinvertebrates.

Standing crop of fish decreased dramatically in this mid-portion (Figure 19; Towns, 1985). Stations 6, 7, and 8 (Figure 18) had signs of severe seasonal flooding and showed the most turbid water conditions on the mainstem. White suckers, redhorse suckers, and carp dominated fish populations. Fish of interest to anglers were few. Black and yellow bullheads, rock bass, and pike were the most numerous sport fish collected in the 1984 MDNR survey. Low gradient makes this portion of the mainstem unsuitable for smallmouth bass. This important sport fish species was absent from the 1984 MDNR survey collection at station 8 downstream from Blissfield and very few smallmouth bass were taken from stations 6 and 7 (Figure 18).

Fish species diversity was lowest in this mid-portion of the River Raisin mainstem. The majority of fish species present in the mainstem above Tecumseh but absent between Tecumseh and Dundee are associated with gravel, riffles, and clean water. These include silver shiner, black redhorse, brindled madtom, rainbow and fantail darter, logperch, and mottled sculpin. Other fish species taken above Tecumseh but not in the mainstem from Tecumseh to Dundee are silt-intolerant species associated with vegetated lakes and rivers. Examples of these species include brown bullhead, bowfin, lake chubsucker, and brook silverside.

Dundee to Lake Erie

The lower River Raisin watershed from Dundee to Lake Erie is characterized by relatively impermeable soils dominated by clay material. The general topography is flat, since the entire land area is an old lake plain. However, stream gradient increases over the low-gradient mid-portion and averages 3.0 feet per mile. This increased gradient results in a more rapid flow. The stream bed is firm in almost all areas and is composed of rock, cobble, sand, and limestone bedrock. The relatively impervious soils and intensive agricultural use with related tiling of fields, wetland drainage, channelization of tributaries, and construction of artificial drainage ditches lend a “flashy” characteristic to the lower River Raisin. During flood periods, the bedrock bottom prevents the river from cutting vertically to accommodate increased flow. Therefore, much of the lower River Raisin is shallow and excessively wide.

The station immediately below the dam at Ida-Maybee Road produced both the highest standing crop (703 lbs/acre) and highest number of species (36) of the twelve mainstem stations sampled during the 1984 MDNR survey (Towns 1985). In contrast to the middle portion of the mainstem, smallmouth bass were abundant in the lower River Raisin.

No fish species primarily associated with Lake Erie were found in the lower River Raisin during the 1984 MDNR survey. The cooling water intake at the Detroit Edison Monroe Power Plant, a series of six lowhead dams in Monroe, and the Waterloo Dam restrict access to the river by Lake Erie fish.

Saline River

The Saline River originates a few miles east of Manchester and flows generally in a southeast direction to a point three miles northeast of Dundee where it joins the River Raisin. Kosek and Jones (1994) rated habitat as poor (severely impaired) in both upper and lower portions of the stream. In the upper portion, the poor rating was due primarily to sedimentation effects. In the mid-portion, the poor habitat rating was due partly to sedimentation but also to extreme flow instability and eroded stream banks. Habitat in the park at Saline was rated excellent. This location immediately downstream from the Saline Impoundment had abundant gravel substrate and good variation in channel morphology.

During the 1978 survey, the Saline River downstream from Milan did not yield any fish (Smith et al. 1981). This was attributed to a severe pollution problem in Milan. During the 1984 MDNR survey, sixteen fish species were found at both Saline River sampling stations below Milan indicating significant recovery. However, total fish numbers were low and numbers of young-of-the-year fish were particularly low. The total standing crop at Day Road, 78 pounds per acre, was the lowest of any sampling site in the River Raisin survey (Towns 1984). However, sport fish (smallmouth bass, rock bass, and yellow bullheads) represented 23% of the collection by weight and no carp were taken. Silver redhorse, golden redhorse, white suckers, and northern hog suckers composed the majority of the non-sport fish collection by weight at this station.

The more upstream station at Sherman Road had a higher standing crop of fish (170 pounds per acre) than at Day Road. However, sport fish, primarily largemouth bass and black and yellow bullheads, made up only 8% of the collection by number. Carp and white suckers accounted for 85% of the catch by weight at this station. Northern hog sucker, smallmouth bass, and rock bass were absent from Sherman Road, but numerous in the Day Road collection. This is due to habitat differences between the two stations. The Sherman Road station is characterized by slow stream velocity and poor substrate, predominately clay, sand, and silt. Conversely, the Day Road station had some gravel and cobble substrates and stream flow was much faster. The Sherman Road station was also closer to the polluting discharges entering the Saline River at Milan that were probably still affecting the river in 1984.

South Branch River Raisin

The South Branch of the River Raisin originates in western Lenawee County near Clayton. This stream flows first in a southeast then northeast arc through the City of Adrian before it enters the River Raisin mainstem at a point roughly four miles northeast of Adrian (Figure 1). Wolf Creek, a major tributary, enters the South Branch on the northern edge of Adrian. Lake Adrian, a reservoir on Wolf Creek, provides the municipal water supply for the City of Adrian.

Kosek and Jones (1994) rated the habitat at four stations on the South Branch. The more upstream stations received habitat ratings of fair to poor. They displayed effects of past dredging, degradation caused by sedimentation, and erosive effects on stream banks caused by flow instability. The more downstream stations located in Adrian city parks received good habitat ratings and were characterized by higher gradient and good to excellent variation in channel morphology and hydrology. However, slow water areas in these stations still had significant deposits of sediment.

Only one station was sampled on the South Branch of the River Raisin during the 1984 MDNR survey. This station was below the Adrian Wastewater Treatment Plant within a mile of the confluence with the River Raisin mainstem. Towns (1985) noted that locations further upstream on the South Branch had stream velocities too slow to allow fish collection with rotenone methods. Although the habitat at this station appeared suitable for smallmouth bass, they were absent. All sport fish common to the mainstem except yellow bullheads and several intolerant forage species were absent or sparse. White suckers clearly dominated the fish population. Towns (1985) concluded that pollution was affecting fish populations in the lower South Branch.

Aquatic Invertebrates

Aquatic invertebrate communities provide an important food source for fish and other animals including birds, mammals, reptiles, and amphibians. Aquatic invertebrates, particularly insects and mussels, also serve as indicator species, and presence or absence of certain aquatic insects reveals much about habitat and water quality in a specific portion of a stream.

University of Michigan entomologist Ethan Bright has compiled a list of macroinvertebrates (primarily insects) found in the River Raisin watershed (Table 13). Much of this information came from a Master's thesis on the distribution of macroinvertebrates in the River Raisin watershed (Schroeder 1994). For those particularly interested in aquatic insects and other macroinvertebrates, this thesis lists presence and relative abundance of 55 species collected at 19 sites. The relation between macroinvertebrate communities and habitat variables are discussed in depth.

Several biological surveys of the River Raisin and major tributaries have been conducted by Surface Water Quality Division, MDNR (now MDEQ). The most recent survey was conducted in July and August of 1993 (Kosek and Jones 1994). During this survey eleven stations were sampled on the River Raisin mainstem, eight on the Saline River, four on the South Branch of the River Raisin, and two on Macon Creek. Macroinvertebrate communities were rated fair (moderately impaired) or good (slightly impaired) throughout the survey area. In general, macroinvertebrate communities on the mainstem tended to rate higher than communities of tributary stream stations. Eight of eleven mainstem stations received good (slightly impaired) overall ratings. However, a station downstream from the Petersburg Waste Water Treatment Plant (WWTP) had a very low fair rating since the community was dominated by tolerant species (Kosek and Jones 1994). Macroinvertebrate communities at both Macon Creek stations were rated as fair although the density and diversity of macroinvertebrates at the downstream station was low and the insect population was dominated by tolerant chironomids (midges). The slightly to moderately impaired ratings of invertebrate communities throughout the watershed related to the lack of intolerant species and reduced abundance of stoneflies, mayflies, and caddisflies. When results of the 1993 biological survey are compared to results of earlier studies (MDNR 1979; Surber 1954; Evans 1973), it is evident that water quality as reflected by macroinvertebrate populations has improved. In particular, point source pollution problems from industrial and municipal discharges have been alleviated to a high degree. Nonpoint source agricultural runoff remains a major factor degrading aquatic habitat particularly in the mainstem below Tecumseh.

Crayfish collected during the 1984 MDNR survey were identified by Dr. Philip Yant, University of Michigan. The northern clearwater crayfish (*Orconectes propinquus*) was taken at all sites on the lower River Raisin (roughly Tecumseh to Monroe) and at the South Branch site. This species is the most widespread Michigan crayfish and is well known from medium-sized rivers. The virile crayfish (*Orconectes virilis*) was collected in the past at the Austin Road site. However, it was not found at this site during the 1984 MDNR survey. This crayfish is a small stream or oligotrophic lake species. *Cambarus robustus* (no common name) was taken at Day Road on the Saline River. This species is widespread in southeastern Michigan. The reported habitat of this crayfish is the extreme headwaters of rocky streams. However, this habitat description certainly does not fit the Day Road site on the Saline River. The rusty crayfish (*Orconectes rusticus*) was collected during the 1984 MDNR survey on the mainstem near Tecumseh (Comfort Road). Although the native range of this species includes the Maumee River drainage, the rusty crayfish had not been previously reported from the River Raisin watershed. The rusty crayfish has been widely introduced into areas outside its native range apparently by bait dealers and unknowing anglers.

Since mussels, unlike fish, have very limited mobility, their distributions are excellent indicators of localized habitat conditions. The River Raisin watershed has been significantly altered from its natural pre-settlement condition. Land use is primarily agricultural leading to increased erosion and sedimentation. Agricultural chemicals are entering the streams. Urbanization has resulted in increased discharge of municipal and industrial wastes. Construction of dams throughout the watershed has inundated high-gradient portions of the stream bed and blocked free movement of fishes. In 1976-1978, mussel collections were made at 26 stations in southeastern Michigan (20 stations in the River Raisin watershed) (Strayer 1979). Many stations, particularly in the headwaters, still contained healthy, diverse mussel populations. However, mussel faunas in lower river stations had been greatly reduced. Although the lower River Raisin below Dundee once held 20 species of mussels, Strayer (1979) found only four living species in his study (Table 14). Strayer speculated that the original mussel fauna was destroyed by pollution, and the river was recolonized with mussels when conditions again became suitable. Van der Schalie (1938) studied mussel populations in the nearby Huron River basin. Much of this excellent reference material pertains to River Raisin mussels as well.

The Michigan Natural Features Inventory lists five mussel species in the River Raisin corridor as endangered. These include the northern riffleshell, purple lilliput, rayed villosa, round hickorynut, and salamander mussel. In addition, the wavyrayed lampmussel is threatened and the purple wartyback is of special concern.

Amphibians and Reptiles

Forty-seven species of amphibians and reptiles have been found in the River Raisin watershed (Table 15). The Michigan Natural Features Inventory lists six species as “of special concern”: Blanding’s turtle, eastern box turtle, spotted turtle, Blanchard’s cricket frog, black rat snake, and eastern massasauga. In addition, the eastern fox snake is threatened, and the Kirtland’s snake and smallmouth salamander are endangered. An excellent series of field guides to Michigan amphibians and reptiles is available from the Cooperative Extension Service of Michigan State University (Holman et al. 1989; Harding and Holman 1990; Harding and Holman 1992).

Mammals

Agriculture is the dominant land use in the River Raisin watershed. Corn, soybeans, and vegetables are major crops. Therefore, the wooded river corridor is very important to many mammalian species (Baker 1983; Table 16). The natural area along the river and tributary streams provides relatively undisturbed habitat for these mammals and offers refuges from the heavily cultivated surrounding land. Raccoons, mink, and muskrats are plentiful. Mink and muskrat populations are stable and raccoon populations are very high and continue to increase. Opossums and skunks are plentiful. Red fox are common and gray fox are increasing in southeastern Michigan. Coyotes have increased from rare to common in southeastern Michigan during the past 25 years. Otters have been extirpated from southeastern Michigan. MDNR Wildlife Division plans to reintroduce otters into the nearby Huron River watershed. However, there are no plans to reintroduce otters into the River Raisin watershed because of intensive agricultural land use and concerns about pesticide and herbicide contamination (R. Anderson, MDNR, Wildlife Division, personal communication). There are small numbers of beaver located primarily in the extreme upstream portion of the watershed. Beaver appear to be increasing in recent years, possibly as a result of low fur prices. The Michigan Natural Features Inventory lists the Indiana bat as endangered.

Birds

The River Raisin watershed is a moderately important area for migrating waterfowl. As part of the Mississippi Flyway, it is used by Canada geese, many species of dabbling and diving ducks, and mute swans. Grebes, coots, gallinules, bitterns, sora, and Virginia rails use lakes and marshes in the watershed. The mud flats in the shallow impoundments provide habitat for lesser yellowlegs, phalaropes, sandpipers, and other shore birds (R. Hoffman, MDNR, WD, personal communication). In the past 20 years, the resident flock of giant Canada geese has increased greatly across southern Michigan. Abundance of these geese has created additional hunting opportunities. Despite additional extended hunting seasons, numbers of geese continue to increase to the point where they have attained nuisance status on golf courses and around lakeside homes.

Bald eagles are seen in the watershed during migration periods in the spring and fall, and there is a confirmed report of a successful eagle nest at the mouth of the River Raisin (M. Thomas, MDNR, Fisheries Division, personal communication). Ospreys have been sighted during migratory movements, but there have not been any documented reports of osprey nesting in recent years.

Loons are occasionally seen during migration periods on lakes in the Irish Hills area. There has been no documented loon nesting in recent years in the River Raisin watershed. Great blue herons, kingfishers, and sandhill cranes are common in the basin. The Michigan Natural Features Inventory lists the king rail as endangered.

Other Natural Features of Concern

MNFI has compiled a list of other natural features, such as insects and plants, that are in the watershed and whose status is "of concern" (Table 12).

Pest Species

Pest species are defined as those species that have been introduced, either accidentally or intentionally, that pose a significant threat to native species or their habitat. Generally, most introduced species do not pose a threat unless they are present in high densities.

According to Morman (1979), sea lamprey ammocoetes have not been found in the River Raisin system. Sea lamprey access to the river is apparently limited by the cooling water intake at the Detroit Edison Monroe Power Plant, the Waterloo Dam, and a series of low-head dams in the city of Monroe. Also, the habitat conditions for sea lamprey are marginal in the River Raisin system due primarily to high water temperature.

As previously mentioned, rusty crayfish were present in the River Raisin watershed during the MDNR 1984 rotenone survey. Potential negative effects of these aggressive crayfish include displacement of native crayfish species, predation upon fish eggs, and reduction of aquatic macrophytes through voracious feeding behavior (Helgen 1990).

Zebra mussels were discovered in Lake St. Clair near the Detroit River in 1988. They spread rapidly to the western end of Lake Erie. By the early 1990s, zebra mussels were creating problems by restricting the intake for the city of Monroe municipal water supply from Lake Erie. Zebra mussels began appearing in Michigan inland lakes as early as 1991. In the headwaters of the River Raisin watershed, zebra mussels were discovered in Clark, Wamplers, and Vineyard Lakes in 1994. Zebra mussels are most probably spread by the activities of boaters and anglers. The microscopic, free-living larvae (called veligers) may be carried in bait buckets, live wells, or bilge water. Adults can attach to boats or can be carried from lake to lake on aquatic vegetation on boat trailers. Researchers have found that pH and calcium concentration are the determining factors that best predict the appearance of zebra mussels in freshwater lakes (Ramcharan et al. 1992). Effects of zebra mussels on inland lakes have not been fully determined. One potential adverse effect is the elimination of native mussels after zebra mussel invasions. Zebra mussels are filter-feeders that remove phytoplankton and other organic material from the water column. As the water becomes less turbid, aquatic vegetation can grow in deeper areas.

Excessive aquatic plants and algae create a nuisance to riparian owners on many of the lakes in the basin. Aquatic vegetation control permits are issued by MDEQ, LWMD for application of aquatic herbicides. Often these chemical treatments are accomplished more for cosmetic purposes, not real problems. During 1995, permits for chemical aquatic weed control in the watershed were issued for Hillsdale County: Lake Somerset; Jackson County: Lake Columbia, Vineyard Lake, Clark Lake (channel); Lenawee County: Iron Lake, Lake Loch Erin, Cambridge Lake, Dewey Lake, Evans Lake; Monroe County: none; Washtenaw County: none (D. Kenaga, MDEQ, Land and Water Management Division, personal communication).

Two submergent aquatic plant species that often form thick mats capable of limiting recreational use of lakes are Eurasian milfoil (*Myriophyllum sp*.) and curlyleaf pondweed (*Potamogeton crispus*). Eurasian milfoil appears to be spreading and out-competing native aquatic plant species in many lakes. Eurasian milfoil is difficult to control using conventional chemicals and mechanical harvesting actually causes milfoil to spread. Traditional chemical control for native plants may promote growth of these more resistant, aggressive exotic plant species. The herbicide Sonar has shown promise in controlling milfoil and curlyleaf pondweed. However, the use of this chemical in Michigan is still considered experimental and is tightly regulated.

Purple loosestrife (*Lythrum salicaria*) is a perennial, emergent wetland plant that deserves mention as a pest species. This exotic plant has become well established in southern Michigan during the past three decades. It has been spread intentionally by home gardeners because of the attractive purple flowers that bloom in late July and early August. Until recently, a summer festival was held in Hillsdale, Michigan in celebration of the plant’s beauty. The plant inhabits wetlands and shallow marshes and out-competes and displaces native sedges, grasses, and smartweeds. Purple loosestrife has negligible value to wildlife species and it displaces plants with much higher wildlife value (R. Anderson, MDNR, WD, personal communication). This noxious plant is very difficult to control since mechanical methods are ineffective and chemical methods often kill non-target species as well as loosestrife. Experiments are now started with biological control including use of fungi and insects. One weevil and two other beetle species have been approved for release in the United States by the USDA Animal and Plant Health Inspection Service. The weevil has been used experimentally for loosestrife control in Wisconsin with good results. However, at this time, purple loosestrife is still spreading in Michigan and waterfowl managers particularly are concerned.

One exotic terrestrial insect species that has the potential to defoliate trees in the River Raisin watershed is the gypsy moth. This insect came from Europe and was first discovered in the United States in 1869. Gypsy moths first appeared in Michigan in 1954, and the first serious outbreaks were in the late 1970s in the central Lower Peninsula. Although there have been no serious outbreaks of gypsy moths in the River Raisin watershed, they have been found in isolated locations and the potential for a serious outbreak in the future is present. Defoliation caused by the gypsy moth caterpillar generally does not kill trees. However, stressed trees or trees that are defoliated for several years in a row can be killed.

Special Jurisdictions

Many agencies and organizations have statutory authority or interest in water quality and land use issues in the River Raisin watershed (Table 17). Several federal agencies administer regulations affecting water quality. The United States Environmental Protection Agency is involved with the development of NPDES (discharge) permits and the Remedial Action Plan (RAP) process for the River Raisin Area of Concern. The International Joint Commission is involved in the RAP process as it stems from Great Lakes Water Quality Agreements. Other federal agencies involved are the Army Corps of Engineers that conducts harbor dredging projects, the Federal Energy Regulatory Commission that licenses hydroelectric facilities, and the United States Department of Agriculture that is involved with conservation measures through the Natural Resources Conservation Service and the Farm Service Agency (Manson et al. 1994).

The primary state agency involved with water issues is the Michigan Department of Environmental Quality that was recently split from the Michigan Department of Natural Resources by Executive Order. MDEQ regulates surface and ground water quality and implements several federal programs including the NPDES permitting system for point source discharge into surface waters. Functions regarding public water supply were recently transferred from the Michigan Department of Community Health to MDEQ by Executive Order. Conservation Districts, local units of state government that operate under Michigan Department of Agriculture oversight, work closely with the USDA Natural Resources Conservation Service to assist landowners with the implementation of agricultural best management practices for nonpoint source water quality improvement. The Michigan Department of Transportation, county and local road commissions, and departments of public works affect water quality through various road salt and dust control applications and road and stream crossing construction and maintenance practices.

On the county administrative level, each of the five Michigan counties has a road commission and drain commission that administer regulations pertaining to storm water runoff and erosion during construction. County health departments address private wells and septic systems, county planning commissions make recommendations for local zoning, and boards of county commissioners act upon lake level petitions according to a variety of state statutes and administrative rules.

Regional agencies offer planning and programming assistance. The River Raisin Watershed Council addresses surface and ground water concerns throughout the basin. Regional planning councils, Region 2 and Southeast Michigan Council of Governments (SEMCOG), assist with issues involving water quality, solid waste management, commercial and residential development, and regional transportation (Manson et al. 1994).

City, village, and township governments are responsible for the majority of land use planning and water supply and treatment issues. Several private organizations address conservation issues. These groups include the Raisin Valley Land Trust and several independent lake associations and sportsmen’s clubs. Many federal laws and state statutes pertaining to environmental protection are administered primarily by Land and Water Management and Surface Water Quality divisions of MDEQ (Table 18).

Navigability

In the administration of laws enacted by Congress for the protection and preservation of navigable waters of the United States, the Army Corps of Engineers has exercised jurisdiction over the River Raisin from its mouth at Lake Erie upstream 2.5 miles to the M.C. (Conrail) Railroad Bridge. However, from 1837 to 1907, the Michigan Legislature by local act on general statute authorized construction of certain facilities including locks, sluices, and slides to enhance passage of boats, canoes, rafts or other watercraft and logs. Therefore, MDNR, Law Enforcement Division by policy has deemed the River Raisin navigable in law from Section 21, T7S, R5E in Lenawee County (roughly 2 miles downstream of Blissfield) to its mouth at Lake Erie (MDNR 1993). MDNR Law Enforcement Division by policy also considers as navigable any stream that provides fishing, is stocked with fish by the state, and has an average flow exceeding 41 cfs, an average width exceeding 30 feet, and an average depth exceeding one foot (MDNR 1993). This would extend legal navigability on the River Raisin upstream beyond the most upstream USGS gauge station near Manchester. From this point upstream to the Village of Brooklyn in Jackson County the mainstem of the River Raisin should be presumed navigable. This portion of the mainstem can be floated by canoe except during extreme low flow periods created by drought and irrigation.

The tributaries of the River Raisin are not as easily categorized according to navigability. None of the tributaries have been legally determined navigable by statute or court decision. The Saline River should be presumed navigable from at least Austin Road Bridge in Section 4 of Saline Township downstream to its confluence with the River Raisin. Other major tributaries are canoeable only during periods of high water in spring. However, lacking a court decision to the contrary, they should be presumed navigable.

There is a great need in the State of Michigan to legally determine navigability of rivers and streams by the recreational use test and abandon the old commercial definitions of navigability. The Michigan Court of Appeals in People vs. Hallden concluded that recreational uses alone could support a finding of navigability. In other words, members of the public have a right to navigate lawfully at any point below high water mark on waters of this state that are capable of being navigated by oar or motor propelled small craft (includes canoes). However, in 1982 this ruling was overturned when the Michigan Supreme Court rejected the recreational use test and cited “the need for a comprehensive legislative solution”. The commercial use and log flotation test continues as the controlling legal test of navigability.

In 1969, MDNR proposed legislation to define a navigable stream. This bill would have defined a navigable stream as any water course that is capable of transporting any boat, canoe, or craft of any kind for any purpose with one or more persons aboard. This bill passed the House with strong support, however, it died in the Senate Committee on Conservation where it met opposition from private interest groups. Several similar attempts over the ensuing years have been squashed by opposition from private interests. The present archaic commercial definition of navigability needlessly restricts public recreational opportunity on thousands of miles of Michigan rivers and streams.

Coastal Zone Designation

Part 325, Great Lakes Submerged Lands, of the Natural Resources and Environmental Protection Act, P.A. 451 of 1994, as amended provides for protection and management of shorelands. This act further designates environmental areas determined by MDEQ and MDNR studies necessary for protection and maintenance of fish and wildlife. The act regulates any dredging, filling, alteration of soils, or construction of structures in these environmental areas.

A marsh on the north side of the mouth of the River Raisin is designated as an environmental area. This marsh, next to the Ford Motor Company plant, is known locally as the Ford Marsh. The area is diked from Lake Erie to protect the marsh from wave action, but the dike has several openings. Ford Motor Company did not appeal the designation of this marsh as an environmental area, although at one time they planned to build another plant on this site. Previously the area was used for exclusive duck hunting by Mr. Ford and guests, and a hunting camp was built on the property.

Corps of Engineers Section 404 Jurisdiction

Sections 10 and 404 of the Federal Clean Water Act give the U.S. Army Corps of Engineers jurisdiction to regulate the dredging and filling of waters of the United States including wetlands. The upstream limit of Federal Section 404 jurisdiction on the River Raisin is the M.C. Railroad Bridge (Conrail) located about 2.5 miles upstream from the river mouth at Lake Erie. Permits issued in the River Raisin mainstem under federal Section 404 jurisdiction generally involve marina and boat dockage facilities and work performed in wetlands. Filling to accommodate industrial and commercial development along the river front also falls under Act 404 jurisdiction.

The State of Michigan has dual jurisdiction over dredging and filling activities by authority of three pieces of state legislation: Part 325 (Great Lakes Submerged Lands), Part 303 (Wetlands Protection), and Part 301 (Inland Lakes and Streams) of the Natural Resources and Environmental Protection Act, P.A. 451 of 1994, as amended. Michigan is one of only two states where the Corps of Engineers has yielded Section 404 authority on regulating certain dredge and fill activities on inland waters to the state (H. Harrington, MDEQ, LWMD, personal communication).

County Drain Commissioners

County drain commissioners have authority to establish designated county drain systems under the Drain Code (PA 40, 1956). There are nearly 3,000 miles of constructed drainage systems flowing into the River Raisin mainstem and tributaries in Monroe and Lenawee Counties (RRWC 1988). Most of the small feeder streams and ditches throughout the basin are designated drains (Table 19). County drain maps are available from the various county drain commission offices.

The Drain Code gives the county drain commissioner authority to assess fees to riparian owners throughout a drainage district to raise funds for construction and maintenance of county drains. This work can involve straightening, widening, deepening, relocating, and removing virtually all in-stream woody debris and other important cover that impedes water flow. Artificial surface or subsurface (tiled) drainage passages are also constructed. Projects conducted under authority of the county drain commissioner generally result in unnatural stream channels with little hydraulic diversity, sparse instream cover and overhead canopy, and uniform fine particle substrate. This is detrimental to populations of fish and aquatic invertebrates. Fisheries management aimed at the creation and enhancement of cover and other habitat factors to favor sport fish populations is severely hampered by activities of drain commissioners. Fisheries habitat structures generally impede flow to some degree and drain commissioners often oppose their installation in county drains.

Work done by county drain commissioners for maintenance or improvement of designated county drains established before 1972, is exempt from permit requirements under Part 301 of the Natural Resources and Environmental Protection Act. Therefore, drain commissioners become accountable only during the formal process required to gather funds required for projects and at the ballot box during elections. Generally drain commissioners in rural counties with extensive agriculture have more leeway and less opposition to drainage projects than do drain commissioners from more urban counties or areas where tourism based on natural resources is a major component of the local economy.

A review of the Drain Code is in progress. The review committee is an appointed board composed of eleven drain commissioners, two non-voting members, and one staff person. A bill to amend the Drain Code has been introduced and is now under review by the House Committee on Agriculture (E. Hay-Chmielewski, MDNR, Fisheries Division, personal communication).

Part 301, Inland Lakes and Streams, P.A. 451, Stream Crossings

The majority of permits issued in the River Raisin basin under Part 301, Inland Lakes and Streams, Natural Resources and Environmental Protection Act, P. A. 451, involve relatively minor projects on lakes in the Irish Hills area. Examples of these projects include seawall installation, beach sanding, and minor dredging and filling to remove mucky areas and create more "upland" property. The projects on the mainstem and tributaries are few and generally involve bridge or culvert crossing construction; dam maintenance; minor dredging, filling, or seawall construction to benefit riparian property; and development of recreational facilities including boat or canoe launches and fishing piers in public parks and recreation areas.

Stream crossings deserve mention because they can create significant problems by impeding stream flow and creating erosion and downstream siltation. There are hundreds of public and private road crossings in the River Raisin basin. Many of these crossings were designed or installed improperly and impede stream flow creating drainage and flooding problems during high water. Other crossings create continuous erosion and siltation problems because of poor design. Stream crossing design and construction should hopefully create fewer problems in the future, since these projects are regulated under Part 301, Inland Lakes and Streams, Act 451 of 1994. To receive permits, these crossings receive engineering review to assure enough volume and correct placement. Construction standards and erosion control methods are also contained in these permits.

Stream crossings also require a permit issued under Part 91, Soil Erosion and Sedimentation Control, Act 451 of 1994. These permits stipulate that erosion control measures are to be taken before, during, and after stream crossing construction. In all Michigan counties in the River Raisin basin, the county road commission is an approved public agency under Act 451. Therefore, they regulate erosion control work on stream crossings performed by the county. Private stream crossings require Act 451 permits from the county enforcing agent (CEA). In all Michigan counties in the River Raisin basin except Washtenaw, the County Drain Commission Office is the CEA. Washtenaw County has a separate Office of Soil Erosion Control.

Federal Energy Regulatory Commission

The Federal Energy Regulatory Commission (FERC) is authorized under the Federal Power Act of 1920, as amended, to license and regulate certain hydroelectric facilities. When a hydroelectric project is being licensed or re-licensed, power and non-power aspects of the project are balanced and the resulting license contains specific articles to protect the natural resources and enhance recreational opportunities in the project area (Hay-Chmielewski et al. 1995). Most FERC licenses are for a 35 year period unless a FERC exemption is issued. This exemption is a perpetual license containing protective measures for natural resources in the project area from both MDNR and the United States Fish and Wildlife Service.

Now there are no active FERC licensed projects in the River Raisin watershed (W. Gruhn, MDNR, Fisheries Division, personal communication). The dam at Sharon Hollow west of Manchester produces a small amount of electricity used for residential heating. This facility operates under a run-of-the-river mode during the heating season. A very small percentage of the normal stream flow goes through the generator and the impoundment is not dropped more than an inch.

Recently there have been rumored plans to reactivate power generation at the downstream dam in Manchester and at the Brooklyn Dam. According to the Maintenance Supervisor at Johnson Controls Inc., owner of the downstream Manchester Dam, there are no plans to reactivate power generation in the near future. The current owner of the Brooklyn Dam, Mr. Lee Koepke (Yesterday Power and Equipment), plans to eventually operate this facility as a museum of power generation. Hydroelectric power would be generated as a demonstration project.

Natural Rivers Designation

The mainstem of the River Raisin and its tributaries have never been under consideration for designation under national and state Natural and Scenic River Programs. However, the mainstem from Brooklyn to Tecumseh is a beautiful stretch of river encompassing several vastly different habitats. This segment of the river deserves consideration for inclusion in the Natural and Scenic Rivers Program.

Recreational Use

The River Raisin watershed has great potential for recreational use because of its proximity to population centers in the surrounding area of southeastern Michigan and northwestern Ohio. Water-based recreational activities in the watershed focus on lakes in the Irish Hills area and to a much lesser degree on the River Raisin mainstem, impoundments, and larger tributaries. The lakes and the river provide opportunities for fishing, swimming, canoeing, motor-boating, sailing, hunting, trapping, nature study, and bird watching. Bona fide access to the river is only fair, and assured access is needed at several locations.

Canoeing

The River Raisin mainstem is canoeable from Swains Park in the Village of Brooklyn to the mouth at Lake Erie. However, a portion of the river between Adrian and Deerfield has many major logjams that make canoe travel difficult to impossible. The River Raisin Watershed Council has worked at removing these logjams for the past several summers using funds obtained from participating units of government. The labor force for this ongoing project has been provided by summer youth work and prison labor. This work continues as funds are available.

The extreme upper portion of the mainstem downstream of Brooklyn is characterized by slower current and extensive marshy areas above Norvell Lake. This provides a peaceful, short canoe trip with excellent opportunities to observe waterfowl and other wildlife. From Norvell Dam to Sharon Hollow Impoundment the river goes through heavily wooded areas and many down trees in the river make progress difficult. Upstream water withdrawals during summer months add to canoeing problems in this segment.

The stream from Sharon Hollow Impoundment downstream to Clinton provides challenging canoeing. Water quality is very good in this section and stream banks are wooded and very scenic. This stretch reminds paddlers of northern Michigan streams. However, there are many "pullovers" created by down trees, although work has been done periodically in this stream segment to remove obstacles. The Village of Manchester sponsors a canoe race each spring from the first bridge downstream from Sharon Hollow Impoundment to the town of Manchester.

The character of the river begins to change at Clinton as the stream leaves the sand and gravel Irish Hills area and enters the intensely cultivated clay, lake plain area. Water quality declines particularly because of high sediment load caused by agriculture. From Clinton to the Red Millpond in Tecumseh, canoeing remains good with limited obstacles and primarily wooded banks. Canoeing use is moderately high in this area of the stream.

Below Tecumseh, the stream is influenced by soil type (clay) and intensive agricultural practices. Also, the presence of many major logjams from Adrian to Deerfield makes canoeing this portion of the river difficult. The logjams are so extensive in some areas that the river is forced to cut new channels through the adjacent uplands.

Downstream from Deerfield, the River Raisin becomes more readily canoeable again with only a few major logjams. A livery is located off Plank Road northeast of Dundee. Although land use next to the river is dominated by intensive agriculture, a narrow wooded corridor lines the stream on both banks through much of the area from Deerfield to Grape. The current is gentle and canoeists enjoy a very quiet and peaceful trip.

Below the dam at Grape, the River Raisin is characterized by broad, shallow areas with a bedrock bottom. At peak recreational times of the year (mid-summer to early fall) the stream is too shallow for easy canoe travel in many locations. Further downstream in Monroe, a series of six low-head "beautification" dams complicate canoe travel. For these reasons, canoeing use decreases in this portion.

Except for peak run-off periods during spring, the major tributaries of the River Raisin are not easily canoeable. Saline River is the exception to this general statement, and it provides limited canoeing recreation throughout the year.

Motor Boat Use

Motor boat use in the upstream portions of the watershed is restricted to the natural lakes in the Irish Hills area and the impoundments on the mainstem. Boating use including water-skiing, high speed pleasure boating, and jet-skiing is extremely heavy during weekends, holidays, and summer evenings in several natural lakes in the Irish Hills tourism area. This high speed boating use discourages anglers and causes them to move to smaller, more quiet lakes and ponds. The mainstem from Tecumseh to below Dundee is large enough to permit motor boat use. However, logjams and the lack of boat launching facilities severely limit this use.

The overwhelming majority of motor boat use on the River Raisin mainstem is downstream of the first low-head dam located about 1,000 feet upstream from the Winchester Bridge in Monroe. This boating use is almost completely involved with access to Lake Erie from several private marina facilities and a public boat launch at Hellenberg Field.

Public Access Sites, Lakes in Basin

There are about thirty public access sites on lakes and impoundments in the River Raisin drainage (Table 20). Goose Lake in Somerset Township of Hillsdale County has a small township access site with a gravel launch ramp and parking for a few cars. Somerset State Game Area in Hillsdale County provides carry-in access to Lombard and Moon Lakes. Lombard Lake is a shallow flooding with a very limited area of deep water. Although it receives some fishing use, this flooding is used primarily by waterfowl hunters. Public access to Moon Lake is poor with facilities limited to an informal path through a wide wetland fringe next to the lake shore. There are no public access sites on lakes in the Washtenaw County portion of the River Raisin watershed.

In Jackson County, Clark Lake has a Columbia Township access site on the west end and a Jackson County Park on the east end. Boats can be launched on the township property, but there is no ramp and parking is extremely limited. Boats can be carried-in and launched on the county park property, but this restricts use to canoes and other small boats. Vineyard Lake has a Jackson County Park with a poor launch ramp and inadequate parking. Norvell Lake has an informal access from Austin Road where the River Raisin enters the impoundment. There is no ramp and parking is limited, but people consistently use this area for launching small boats and shore fishing. Shore fishing access is tolerated at the dam in the Village of Norvell. Mud Lake, immediately north of Wamplers Lake, has a campground that provides a fee launch ramp.

In Lenawee County there are several lakes in the Irish Hills region with public access. MDNR, Parks and Recreation Division operates public boat launching facilities on Allens and Sand lakes. The site on Allens Lake also provides access for small fishing boats through connecting channels to Wolf, Kelly, and Meadow lakes. MDNR, Wildlife Division provides access in the Onsted State Game Area to Cleveland, One Mile, Grassy, and Deep lakes. Except for Deep Lake (gravel ramp), these are carry-in access lakes. Carry-in access is adequate on these small, remote lakes. Wildlife Division has also constructed a small gravel parking lot at Grassy Lake. MDNR, Parks Division operates W. J. Hayes State Park on the east end of 780-acre Wamplers Lake. This park provides an excellent launch ramp and ample parking. Adjacent Round Lake can also be accessed by boat from Wamplers Lake through a channel. A private boat rental facility operates on this channel providing access to both lakes. The state campground on Round Lake has a small boat launch for use by campground residents only and there is a fishing pier. Lake Hudson State Recreation Area administered by MDNR, Parks and Recreation Division provides an excellent launch ramp and parking lot on Lake Hudson. Access to Goose Lake in Cement City can be gained by using a fee launch ramp provided by a campground on the south side of the lake. Killarney Lake has a boat rental business and the motel on the north side of Evans Lake allows public boat launching for a fee. Tiny Demings Lake south of Cadmus has an informal access site that local people have used for many years. Iron Lake south of Wamplers Lake has a small site with a gravel launch ramp. There are no inland lakes in the Monroe County portion of the River Raisin basin.

Ice fishermen are able to gain access to most lakes with or without public access sites. Some lakes receive more angling pressure in the winter than the summer because of informal access during ice cover.

Public Recreational Facilities, River Raisin Mainstem

Public recreational facilities on the mainstem of the River Raisin are discussed starting at the Village of Brooklyn near the headwaters and continuing downstream to the mouth of the river at Lake Erie in Monroe (Figure 20).

The Village of Brooklyn operates Swains Park. Canoes are often launched at the park for trips downstream through a large marsh to Norvell Lake. Shore fishing is permitted and primarily children take advantage of this opportunity.

Sharon Hollow Impoundment can be accessed from the next upstream bridge on Sharon Valley Road. There is state land (Sharonville State Game Area) at this bridge crossing and parking for a few cars. The impoundment is so badly silted and weedy that fishing is neither practical nor productive. A canoe livery is located near the Sharon Hollow dam.

Kirk Park in Manchester is located between the two dams. Although canoe launching in the park is discouraged and the park is signed against boat launching, people still launch there and at the Furnace Street bridge.

A new canoe launch facility has been constructed in Tate Park at Clinton. This facility serves as a put-in site for canoe trips downstream. Tate Park, as well as all the other public facilities mentioned, provides opportunities for shore fishing. There is no public access to the impoundment in Clinton, a short distance upstream from Tate Park. This impoundment can be accessed from the river upstream and local trailer park residents tie-up boats along the impoundment near the dam and fish from shore.

In Tecumseh there is a small carry-in access at the bridge and dam at the Red Millpond. There are small boat launches with ramps on both Globe and Standish Millponds. There is also the Kiwanis Memorial Park on Evans Creek that provides access for shore anglers (mostly children).

In the City of Adrian, there is public frontage by the water treatment plant where small boats or canoes can be launched on Lake Adrian, an impoundment on Wolf Creek. Gas motors are prohibited. Also, in the City of Adrian; Riverside, Island, and Heritage parks afford shore-fishing access to the South Branch of the River Raisin and areas where canoes can be launched and retrieved.

The Village of Blissfield has Clara Bachmayer Memorial Park and Ellis Playground with frontage on the River Raisin. Both these parks provide shore fishing opportunities and areas where canoes are launched and retrieved. Ellis Playground has a ramp to accommodate canoes and small boats. The Blissfield Chamber of Commerce sponsors a canoe race in September. Contestants launch at Blissfield, paddle upstream a few miles, and return downstream to the finish line. Blissfield also conducts the Blissfield River Raisin festival the second weekend of July. Many events and activities are focused on the river.

Although there are no formal public facilities on the river in Deerfield or Deerfield Township, canoes are launched on a small piece of public property near the American Legion and at the wastewater treatment plant. Canoes are also launched in Deerfield at the West River Street Bridge. Near the Village of Petersburg there is Fernstrom Park at the wastewater treatment plant. People frequently use this park for canoe launching and shore fishing.

Wolverine Park in Dundee is located immediately upstream from the dam. A canoe and boat launch ramp was installed recently at this park. Both Wolverine Park and Ford Park on the opposite side of the river provide canoe launching and shore fishing opportunities. Barrier-free fishing piers have been installed at both parks. An additional canoe ramp and parking area was recently constructed downstream of the dam east of M-50.

Monroe County has recently purchased a parcel of property located just east of Dundee on a bend in the river. This parcel has been named West County Park and plans have been formed for development. However, the financial situation of the county does not allow further development at this time. Although access to the river at this park is not yet feasible, there will be access in the future. Both MDNR, Fisheries and Parks and Recreation divisions offer grants that could be used to assist access development.

Raisinville Township owns a 17-acre parcel of property on the southwest side of the junction made by the river and Ida-Maybee Road. Although the township has no immediate intent to develop this parcel, canoes can be launched and retrieved there and shore fishing is available. There is also access near the Raisinville Road bridge. The county owns property behind the County Store Museum that can be used for canoe access and shore fishing. The Ellis Branch Library county property on the south side of the river downstream from Raisinville Road is used for canoe launching and shore fishing. Canoes are also launched from the north side at a bend in the river between Ida-Maybee and Muehleisen roads. This informal access site has also been used for years by shore anglers.

There are several parks located in the City of Monroe. The most upstream of these parcels of public river frontage is Waterloo Park where a new canoe launching facility has been built. This Monroe County park is located on the south side of the river near the old Waterloo Dam. A barrier-free fishing platform has been constructed recently. There is ample shore fishing opportunity at Waterloo Park. Continuing downstream (east) on the River Raisin, the City of Monroe operates Veterans', St. Mary's, Soldiers and Sailors parks, and Hellenberg Field. Veterans' and Soldiers and Sailors parks provide shore fishing opportunity but carry-in boat launching is discouraged. Hellenberg Field provides an excellent launch ramp facility with parking for at least fifty boat and trailer units. This facility is heavily used for boat access to Lake Erie, since it is downstream of the first low-head dam on the River Raisin. Across from Hellenberg Field on the north side of the river, there is extensive private marina development for boat access to Lake Erie. These marinas provide fee launch ramps for public use. There is also extensive private marina development downstream from Hellenberg Field on the south side of the river.

Besides previously discussed formal public access facilities, there are many informal access areas. Many of the bridges on the River Raisin have shoulder areas where two or three cars can be parked. People launch canoes and fish from shore at these informal access points.

Points where bona fide access is needed along the River Raisin include the Sharon Hollow Impoundment, the downstream Manchester Impoundment, the Clinton Impoundment, and the Red Millpond (improved access). It would also be wise to develop bona fide canoe access points downstream from the lower Manchester dam, upstream from the Clinton Impoundment, downstream from Tecumseh, east of Adrian on the River Raisin, and somewhere in southern Palmyra Township. Also, the two undeveloped park properties at Ida-Maybee Road and downstream of Dundee should be developed to facilitate canoe travel and shore fishing.

Besides facilities on the mainstem of the River Raisin, there are publicly owned parcels fronting on the tributaries. The most notable of the facilities are parks on the impoundments of the Saline River at Saline and Milan. These parks provide small boat access to the impoundments and shore fishing as well as canoe access to downstream waters.

Fishing Use

Most fishing in the River Raisin basin is in lakes and ponds of the northwestern portion of the basin. The major sport fish species include largemouth bass, bluegill, black crappie, yellow perch, pumpkinseed sunfish, northern pike, and bullheads. Other significant game fish available naturally in some of the lakes or as a result of MDNR, Fisheries Division stocking include smallmouth bass, rock bass, muskellunge, redear sunfish, rainbow trout, and walleye. Vineyard, Wamplers, and Sand lakes are three of the most heavily fished lakes in the basin. These lakes as well as Clark Lake and Lake Columbia also receive very heavy use from boaters other than anglers. These often-competing forms of recreation include use of sailboats, powerboats for high-speed boating and water-skiing, and jet skis.

Most sport fishing on the mainstem takes place in three general areas: below Brooklyn, from Manchester to Tecumseh, and from the confluence of the Saline River and the mainstem to Monroe (Towns 1985). The river in the headwaters near Brooklyn is greatly influenced by several natural lakes and major sport fish species are largemouth bass, northern pike, and panfish. Below Sharon Hollow Impoundment, stream gradient and velocity increase and substrate becomes a mixture of cobble, gravel, and sand favoring smallmouth bass and rock bass. Fishing pressure on the mainstem from the Sharon Hollow Impoundment to Tecumseh is relatively light, although this portion of the river produces good fishing for smallmouth bass and rock bass. As in most areas of southern Michigan, river fishing is not popular and can almost be classified as a well-kept secret. Part of the problem is the general lack of bona fide public access facilities to streams. Also, people often regard southern Michigan rivers as polluted and the fish as unfit to eat. That river fishing is generally more difficult and physically demanding than lake fishing also makes river fishing less popular with anglers.

Fishing pressure is light from Tecumseh downstream to Dundee. Low sport fish populations, turbid water, a uniform sand and silt substrate, and a history of water pollution combine to deter anglers. Because of the difficulty of canoe travel caused by many logjams, bank fishing near bridges and other informal access points is the most popular angling method. Northern pike and panfish are taken from this middle portion of the River Raisin mainstem. In recent years MDNR, Fisheries Division has stocked channel catfish in this area. As indicated by 1992 rotenone survey results, these stocked channel catfish have been surviving and growing very well (MDNR, Fisheries Division files).

Downstream from Dundee, stream gradient again increases and the bottom substrate becomes primarily cobble, gravel, and bedrock. This creates excellent habitat for smallmouth bass and fishing pressure increases. Pressure can be characterized as light to moderate on much of the lower river. However, the river near the dam at Ida-Maybee Road and at the Waterloo Dam receives moderate to heavy fishing pressure. Areas near dams are characterized by higher than normal standing crops of sport fish and anglers are aware of this. Most of the fishing at these dams is done by bank and wading anglers.

The following factors reduce the probability for success of potamodromous fish management in the River Raisin: the Detroit Edison Monroe Power Plant cooling water intake; the series of six low-head dams in Monroe; and the poorly designed, non-functional fish ladder at the Waterloo Dam. Only the fish ladder could be remedied easily and relatively inexpensively. Future potamodromous fish management in the River Raisin with coolwater species such as walleye and lake sturgeon should not be considered until these barriers are removed.

Salmonid management in the River Raisin should not be considered. Survival of salmonids in western Lake Erie has not been high. Return of steelhead to Lake Erie tributaries has been only about one-sixth the rate of steelhead return to Lake Michigan streams (R. Haas, MDNR, Fisheries Division, personal communication). Production of salmonid fisheries should be made where the probability for creating a successful fishery is greater. One plant of coho salmon in the River Raisin in 1977 produced virtually no return (R. Spitler, MDNR, Fisheries Division, personal communication).

Impoundments on the mainstem of the River Raisin are fished very lightly. Good public access is lacking on several of these impoundments (notably Sharon Hollow, Clinton, the downstream Manchester, and the Red Millpond in Tecumseh). Also, most of the impoundments are too shallow and silt-laden to provide good sport fish habitat and the existing fish populations are dominated by carp and suckers. However, several of the impoundments provide fair fishing for northern pike.

Major tributaries of the River Raisin are very lightly fished. Sucker angling and spearing in the spring provide the majority of the year’s angling on most streams. The impoundment on the Saline River in Saline was treated with rotenone to remove carp and suckers in 1985. Although large numbers of carp and suckers were eliminated, the fish population reverted to dominance by carp and suckers in a few years. Fishing pressure remains moderate on the Saline Impoundment and light on the Saline River upstream and downstream of the impoundment. Anglers on the impoundment catch primarily largemouth bass and crappies.

Public Hunting Lands

Public land available for hunting recreation is extremely limited in the intensively agricultural River Raisin basin (Figure 20). The largest block of state owned land for hunting in the watershed is the Sharonville State Game Area in southeastern Jackson and southwestern Washtenaw counties. About 4300 acres of land is in state ownership administered by MDNR, Wildlife Division.

The topography in the Sharonville State Game Area ranges from gently undulating to moderately hilly. At the time of purchase, most of the land was marginal or sub-marginal farmland, pasture, lowland swamp, and hardwood forest. Hunting on this area is primarily for deer and small game species including rabbits, squirrels, grouse, woodcock, and pheasants. Waterfowl hunting opportunity is limited and includes wood duck hunting along the river and Canada goose hunting in fields. Turkeys were introduced during the winter of 1989. These large game birds have done very well and spring gobbler hunting that opened in 1992 has been excellent both in the game area and on surrounding private land. The Sharonville State Game Area also has a supervised rifle, pistol, and shotgun range. This range is heavily used and a major upgrade of the facilities was completed in 1996. A portion of the game area is also available for organized dog field trials.

The Onsted State Game Area is located in the northwest corner of Lenawee County about five miles northwest of the town of Onsted. At 600 acres, it is one of the state's smallest game areas. About three-fourths of the game area is composed of wetlands. The upland acreage is rolling wooded hills. Game species of most importance are ducks, geese, deer, rabbits, squirrels, pheasants, and woodcock. Turkeys were released on the Onsted State Game Area and spring gobbler hunting was opened in 1996.

The Somerset State Game Area (740 acres) located in the uppermost reaches of the watershed is primarily open water and wetlands. The state took possession of the property in January, 1991, and Wildlife Division has made improvements for parking. Lombard Lake is a 281-acre flooding on the property. This flooding often suffers winterkill and the fish population is dominated by pumpkinseeds, bluegills, bullheads, bowfin, and golden shiners. Access is now limited to carry-in boats, and Wildlife Division has no plans to improve access. MDNR purchased an adjoining parcel of property to the west that provides carry-in access to Blood and Moon lakes. The primary species of interest to hunters are waterfowl, pheasants, deer, rabbits, and squirrels. Wild turkeys were introduced on the Somerset State Game Area, and the area is open to spring gobbler hunting.

The majority of the Lake Hudson State Recreation Area is open to hunting. The land surrounding Lake Hudson provides opportunities for deer and small game hunters and the lake itself provides quality recreation for duck and goose hunters. Lake Hudson was impounded for residential development. When the clay soils would not pass percolation tests to allow drain field construction, the bank foreclosed on the developer and the state purchased the 2000-acre property.

The Monroe County portion of the River Raisin basin is administered by MDNR, Wildlife Division from the Livonia Office. State land in the Monroe County portion of the watershed is limited to the Petersburg State Game Area that comprises about 500 acres of land located two miles southeast of the Village of Petersburg. This small parcel of state property provides opportunities for hunting deer and small game. The lack of public hunting land is a major problem throughout the River Raisin basin. Intensive agricultural use combined with fall plowing limits good wildlife habitat.

Besides state-owned property, public hunting is allowed on private lands leased by MDNR, Wildlife Division under the Hunting Access Program. Unfortunately, very few farms in the River Raisin watershed are enrolled in this program. The restrictions on Sunday firearm hunting in Hillsdale, Lenawee, and Washtenaw counties further curtail opportunities for hunting recreation.

Dams and Barriers

According to two independent sources, there are about 60 dams in the River Raisin watershed (RRWC 1986; Table 21; Figure 21). Twenty-two of these dams, including the six low-head "beautification" dams in the City of Monroe, are on the mainstem and 38 are on tributaries. Besides these dams registered with the State of Michigan, there are many small dams established on tributary streams and drains. These small dams are constructed to create swimming holes, duck ponds, and landscape features. Improper “perched” culvert crossings on small tributaries also impede water flow and fish movement and become, in essence, dams.

Several dams on the mainstem and major tributaries were constructed between 1820 and 1850. These dams were built to harness water power for saw and grist mills to promote settlement of the area. Villages grew up around these initial mill sites at Tecumseh, Brooklyn, Saline, Milan, and other locations.

A second phase of dam construction was from 1900 to 1945 when most of the hydroelectric dams were built or refurbished. Henry Ford and the Ford Motor Company constructed hydroelectric facilities at existing dams and built several new dams in the River Raisin watershed and throughout southeastern Michigan during the two decades before the end of World War II. Small factories constructed at these sites made automobile parts for Detroit area assembly plants. In the 1940s and beyond, Ford Motor Company operated hydroelectric facilities and small auto parts factories at Brooklyn, Sharon Hollow, Manchester (downstream dam), Clinton, Tecumseh, Dundee, Saline, Milan, and Macon. All these hydroelectric facilities except Sharon Hollow have been retired, although plans to reactivate power generation arise periodically.

The generation of hydroelectric power is detrimental to fisheries resources, particularly when the facility is operated in a “peaking” mode. This method creates rapid, severe fluctuations of stream flow that are destructive to channel morphology and fish and aquatic macroinvertebrate populations in downstream areas. Habitat destruction downstream from dams occurs when hydroelectric facilities are operated with little regard for the aquatic environment.

After 1950 several large impoundments were constructed on tributaries in the River Raisin watershed for recreational purposes and to promote residential development. Impoundments created for these purposes include Lake Somerset, Lake Columbia, Lake Hudson, and Lake Loch Erin. Many other dams in the basin built during this more recent period were built as lake-level control structures. Lakes with theses structures include: Clark, Vineyard, Dewey, Goose, Sweezy, Killarney, Cambridge, Evans, and Posey lakes. Detrimental effects of lake-level control structures are discussed in **Biological Communities,** *Factors Affecting Fish Communities*.

Dams have a variety of effects on river systems and their biota. Dams create habitat fragmentation that is detrimental to many fish species. For example, dams block and eliminate spawning runs of potamodromous fish species such as lake sturgeon, walleye, white bass, and muskellunge. Dams also block movements of resident river fish species associated with spawning, feeding, and seasonal habitat requirements. Dams disrupt downstream drift of aquatic insects and other invertebrates. Fish are killed outright or injured passing over dams. None of the dams on the River Raisin mainstem or tributaries have effective fish passage facilities.

Dams are usually constructed in the areas of highest stream gradient. This enables the dam builders to create the highest possible drop (most potential energy) with the least possible amount of inundated land. These high-gradient river areas are essential spawning habitats for several fish species and highly productive areas for aquatic insects and other fish food organisms. Examples of high gradient stream segments that have been eliminated on the River Raisin mainstem include the impounded areas at Brooklyn, Manchester (2 dams), and Tecumseh (3 dams).

Impoundments trap normal downstream transport of sediments and woody debris. Stream velocity drops as it enters an impoundment. Therefore, sediment particles drop out of suspension and are deposited in the upstream portions of reservoirs. This sedimentation degrades habitat and promotes growth of aquatic vegetation. Examples of impoundments that have silted in over the years and support extensive vegetation growth include Norvell Lake, Sharon Hollow Impoundment, both impoundments at Manchester, Clinton Impoundment, and Red Millpond in Tecumseh. Dams also create increased erosion downstream from the impoundment as the normal sediment load of the stream is restored. This increased erosion causes the stream to become either excessively deep or excessively wide depending on the relative resistance to erosion of bank materials and bottom substrate. Reduction of instream woody debris downstream from dams leads to less cover and habitat for fish and aquatic macroinvertebrates and less hydraulic diversity of the stream channel.

Dams also affect water quality and quantity. Sunlight on large surface areas of shallow water over dark, organic bottom materials results in increased water temperatures. This increase in water temperature can have drastic effects on biological communities of the stream. For example, in other areas of the state, thermal effects of impoundments can make trout streams unsuitably warm for these coldwater fish. Increased evaporation from shallow impounded areas can significantly decrease stream flow. Hay-Chmielewski et al. (1995) calculated that the 7363 acres of impoundments on the Huron River could reduce July discharge by as much as 56 cfs or 21% at the mouth. Since impounded areas on the River Raisin are much less than on the Huron, flow reduction caused by evaporation in the Raisin system would be correspondingly reduced.

Dams are rated by hazard type: type 1- dam failure expected to cause loss of life, type 2- dam failure would cause extensive property damage, type 3- dam located in remote area or having very low head. In the River Raisin watershed five dams are classified as hazard type 1: Brooklyn, Manchester Mill (upstream Manchester dam), Ford Manchester (downstream Manchester dam), and Clinton dams on the mainstem, and Lake Adrian Dam on Wolf Creek (Figure 21). Ten dams are classified as hazard type 2 and the remaining 45 dams are hazard type 3 (Table 21).

Potamodromous Fisheries Management-Barriers

The Detroit Edison Power Plant at the mouth of the River Raisin presents a formidable obstacle to both upstream and downstream migration of potamodromous fish species (Figure 22). The Monroe Power Plant is one of the largest fossil-fueled power plants in the United States, and the heat produced during power generation is tremendous. The plant’s cooling water requirement of up to 3,000 cfs greatly exceeds the annual mean flow of the River Raisin of 741 cfs (Blumer et al. 1996). Therefore, during all but the high flow periods of the year, virtually the entire flow of the River Raisin is drawn through the intake canal and processed through the power plant as cooling water. In addition, Lake Erie water is drawn upstream to the plant through the river channel essentially reversing the flow of the river. This processed cooling water is then returned to Lake Erie at an increased temperature through a separate outlet canal to Plum Creek Bay. This feature, part of the plant’s normal operation, certainly deters upstream runs of adult potamodromous fishes. Also, survival of wild downstream migrants and potamodromous fish stocked upstream from the power plant is jeopardized as the fish migrate downstream to Lake Erie. One plant of coho salmon in the River Raisin in 1977 produced virtually no return. Spring walleye and white bass spawning runs are insignificant in the River Raisin, whereas these runs have increased dramatically in other major tributaries to the Western Basin of Lake Erie. The absence of substantial walleye and white bass spawning runs in the River Raisin is probably caused by hydrologic disruptions due to the Monroe Power Plant cooling water intake (W. McCracken, MDNR, Water Quality Division (now MDEQ, SWQD), personal communication). Walleye spawning habitat is good between Monroe and Dundee and a substantial potamodromous spawning run of walleyes could develop. Nursery habitat appears to be good along the western shore of Lake Erie.

Impingement of adult and juvenile fish and entrainment of larval fish and fish eggs at the Monroe Power plant is a significant problem. Several fish impingement studies have been conducted at the plant (Detroit Edison Co. 1976, Jude et al. 1983, A. Nuhfer, MDNR, Fisheries Division, personal communication). For this report, results of Nuhfer's study are used to discuss impingement. These data represent the most recent information available, and Nuhfer's estimates are intermediate between results of the Detroit Edison study and Jude's work. Fish impingement extrapolation estimates were calculated at the Monroe Power Plant from May 16, 1985 to May 6, 1986 (Table 22; A. Nuhfer, MDNR, Fisheries Division, personal communication). Based on these extrapolations of 10,270,000 fish impinged during the study, 91% by number and 94% by weight were gizzard shad. This is very similar to Jude's findings of 95% by weight and number of the total impinged fish being gizzard shad (Jude et al. 1983). Nuhfer found yellow perch (78,246 fish weighing 8,917 pounds) to be the second most abundant species impinged by weight (sixth most abundant by number). White perch was the second most abundant species by number and third most abundant by weight (461,268 fish weighing 6,529 pounds). Nuhfer estimated that 7,374 walleyes weighing 2,194 pounds were impinged during the study. About 1,400 pounds of centrarchids were impinged during the study period. Listed in order of decreasing abundance these sunfish family species were largemouth bass, black crappie, rock bass, pumpkinseed sunfish, bluegill, white crappie, smallmouth bass, green sunfish, and orangespotted sunfish. Channel catfish composed 44% of the 717 pounds of ictalurid species impinged. Sixty-two pounds of northern pike, muskellunge, and mud pickerel and 50 pounds of juvenile salmonids including coho salmon, brown trout, and chinook salmon were impinged. It should be noted that Detroit Edison developed and installed a fish rescue system to collect live juvenile and adult fish from in front of the plant's traveling screens at the cooling water intake and return them to Lake Erie to reduce impingement. However, this "fish pump" system was working during the 1985-86 study.

Larval fish entrainment sampling was conducted at the Detroit Edison Monroe Power Plant from February 14, 1982 to February 13, 1983 (Table 23; Jude et al. 1983). An estimated 4.7 billion fish larvae were entrained during the study. Ninety percent of this larval fish entrainment was from mid-May to the end of June. Gizzard shad (87%) was the overwhelmingly dominant fish species. Freshwater drum ranked second in abundance of fish entrained and white bass and white perch (combined) ranked third. The extrapolated estimate of yellow perch larvae entrained was 128 million (2.7 % of the total fish) and for larval walleye about 29,000. An earlier study, June, 1975 through May, 1976 yielded an extrapolated entrainment estimate of 13 million eggs (Detroit Edison Co. 1976). The overwhelming majority of entrained eggs was from gizzard shad. Goodyear (1978) discussed several factors in the Detroit Edison study design and methods that caused underestimation of impingement and entrainment totals.

After the 1975-76 study, Detroit Edison contracted an engineering firm to study alternative intake designs for reducing impingement and entrainment losses at the Monroe Power Plant (Stone & Webster 1978). In the late 1970s a study group was formulated to recommend methods to reduce detrimental effects of the Detroit Edison Monroe Power Plant cooling water on fish populations. This study group considered three adverse effects of the cooling water intake: impingement, entrainment, and blockage of River Raisin fish migrations. Estimates of monetary damages to fisheries resources attributable to the cooling water intake were substantial. An agreement for measures to mitigate fish and recreation losses attributable to the cooling water intake situation at the Monroe Power Plants needs to be formulated between Detroit Edison and the State of Michigan.

The Monroe Intake Study Group recommended alternative solutions to the cooling water problem that would reduce or mitigate fish losses. These proposed recommendations included design and installation of improved fish screening apparatus, modification of plant operating procedures to reduce or eliminate power generation during periods of peak larval entrainment, diking off a portion of Lake Erie to serve as a recirculating cooling pond, and construction of recirculating cooling ponds adjacent to the plant. Other recommendations included relocation of the cooling water intake to offshore in Lake Erie, development of alternate uses for the heat produced rather than dissipating it in cooling water, and diversion of the River Raisin into the discharge canal or reversing the flow of water by using Plum Creek Bay as the intake canal and the River Raisin for discharge.

Other potential solutions recommended by the Monroe Intake Study Group included agreements to resource tradeoffs with Detroit Edison. These mitigating measures could include the development of public recreational facilities on company owned lands or the direct transfer of certain Detroit Edison properties to the state. Detroit Edison could also mitigate fish losses at the Monroe Power Plant by making direct payments to the state. This money could be used to purchase fish to replace fish losses attributable to the plant, or for projects to benefit fisheries and related recreational and environmental concerns in the River Raisin watershed.

Besides the Monroe Power Plant intake situation, there are other barriers to potamodromous fish migration in the lower River Raisin. The six low-head dams on the mainstem in Monroe, between the mouth at Lake Erie and the Waterloo Dam, were built by the U.S. Civilian Conservation Corps in the 1930s. These dams were built to create aesthetically pleasing pools of water during periods of extreme low flow in summer and early fall. These pools of water were also useful for dilution of sanitary and storm sewer runoff during low flow periods. Although these low-head dams would not create a barrier to upstream migration of salmonids, they do create barriers for ascending coolwater fish species such as walleye during all but extreme high flow periods.

The Waterloo Dam at Veterans' Park on the west edge of Monroe has a height of 12 feet (top of dam to stream bed) and a head of 5 feet (headwater minus tailwater at normal flow). The original dam at this site was constructed during the 1820s of planks and logs. The Waterloo Dam was rebuilt using concrete in 1904 and reconstructed again in 1967. A fish ladder was added to the Waterloo Dam in 1977, but it is poorly designed and only marginally functional. There is very little strategic water flow to attract fish to the ladder. To pass large numbers of fish above the Waterloo Dam (provided that the Monroe Power Plant cooling water intake situation is corrected), the ladder must be rebuilt or the dam removed.

Water Quality

Point Source Pollution

MDEQ by authority of Part 31, Act 451, P.A. 1994, the Natural Resources and Environmental Protection Act, has published General Rules that list designated uses for which all surface waters of the state are protected. As a minimum, all waters of the state are designated and protected for the following uses: agriculture, navigation, industrial water supply, public water supply at the point of water intake, warmwater fish, other indigenous aquatic life and wildlife, and partial body contact. In addition, all waters of the state are designated and protected for total body contact recreation from May 1 to October 31.

Surface Water Quality Division of MDEQ issues NPDES permits. Discharges are regulated to protect minimum water quality standards and the designated uses (Part 4, Water Quality Standards) of the receiving water body. There are 41 NPDES discharge permits issued in the River Raisin watershed (Table 24).

Several segments of the mainstem and major tributaries are on the 1996 draft list of areas where designated uses are not now being attained. These areas of nonattainment include combined sewer overflows (CSOs) at Blissfield and Dundee, input of raw sewage to the South Branch at Clayton, excess sediment from agriculture on the entire length of Wolf Creek, presence of PCB and heavy metal toxic contamination in the City of Monroe, and residual effects of a major manure lagoon spill in the headwaters of Macon Creek in 1994 (J. Wuycheck, MDEQ, SWQD, personal communication). Besides these stream segments on the nonattainment list, several other significant water quality problems exist in the watershed. The City of Adrian has a retention basin to hold excess storm water runoff. During extreme precipitation events, the retention basin overflows. Manchester and Dundee have bulkheaded their outfalls responsible for CSOs. However, both towns still experience occasional problems during high precipitation events. The Village of Petersburg experiences periodic flooding of their wastewater treatment plant during heavy rains. This causes adverse effects below the WWTP outfall to the River Raisin (A. McArthur-Brown, MDEQ, SWQD, personal communication). Also PCB contamination is being monitored in bottom sediments at Adrian and pesticide contamination (alochlor) is present in the River Raisin below Adrian (D. Snell, MDEQ, SWQD, personal communication). Although concentrations of alochlor and other similar pesticides are well below drinking water standards, they are a legitimate cause for concern. Sedimentation from agriculture degrades water quality in the River Raisin mainstem and tributaries throughout the southeastern portion of the watershed. Untreated sewage enters the Saline River at Mooreville between Saline and Milan (B. Wisely, MDEQ, SWQD, personal communication). There are plans to construct a sewer system and wastewater treatment plant in the near future.

Part 31 Rules of Act 451, P.A, 1994 authorized regulation and permitting procedures for storm water runoff from certain construction sites and industrial facilities. At present, about 20 construction site and 60 industrial site storm water permits are issued for facilities in the River Raisin watershed. Construction sites with areas of disturbance over five acres are regulated. A state-certified storm water operator is required to provide erosion control measures on a weekly basis and within 24 hours after a rain event. The state-certified storm water operator must also conduct inspections to assure that storm water control measures are maintained throughout a construction project. The industrial storm water control program regulates industries based on standard industrial classification codes as required by the federal Clean Water Act. This entails managing facilities in such a manner that exposure of contaminants to storm water is eventually eliminated. The provisions requiring the plugging of industrial floor drains and mandating the involvement of a state-certified storm water operator will have a substantial beneficial effect on water quality throughout southern Michigan (T. Torongo, MDEQ, SWQD, personal communication).

Fisheries Division Classification

Fisheries Division has classified all the state's streams by their ability to support fish populations. The categories are: 1) top quality cold water streams that are capable of supporting self-sustaining populations of trout; 2) second quality cold water streams that can contain significant trout populations maintained by stocking or periodic treatment or both; 3) top quality warm water streams that contain self-sustaining populations of warmwater (and coolwater) sport fish; and 4) second quality warm water streams that have sport fish populations limited by pollution, competition, inadequate reproduction, or lack of suitable habitat.

The Beaver-Slater creek system that enters the South Branch a short distance downstream from Adrian and a section of Goose Creek in the extreme headwaters of the watershed are classified as top quality warm water. All other tributary streams in the River Raisin basin are classified as second quality warm water (Figure 23). This classification reflects past problems with water quality and current heavy sediment load combined with warm water temperatures. The relatively low amount of ground water and the extreme "flashy" character of many tributaries also dictate a second quality warm water designation.

The mainstem from Brooklyn to Tecumseh and from the confluence of the Saline River to the mouth should be designated as top quality warm water. These portions of the river support significant self-sustaining populations of smallmouth bass, northern pike, panfish, and many forage species. Water quality is generally good.

Part 201, LUST Sites

Part 201 of Act 451, Public Acts, 1994, the Natural Resources and Environmental Protection Act, authorizes MDEQ to identify, regulate, and clean up sites of environmental contamination and leaking underground storage tanks. There are 55 environmental contamination sites and 142 leaking underground storage tank (LUST) sites in the River Raisin watershed.

County	No. Part 201 Sites	No. LUST sites
Hillsdale	0	1
Jackson	7	7
Washtenaw	11	16
Lenawee	21	67
Monroe	16	51
TOTAL	55	142

Most of these sites are known or expected to have adverse effects on ground water quality. Typical sources of these sites include manufacturing, commercial facilities, mining and oil drilling, oil and gasoline storage tanks, and highway maintenance and salt storage. There are no sites in the watershed that are listed on the national priority list for remedial action under the Federal Comprehensive Environmental Response Compensation and Liability Act of 1980 (Superfund Program).

International Joint Commission, Area of Concern

The International Joint Commission (IJC), a United States-Canada commission created by the Boundary Waters Treaty of 1909, monitors water quality of the Great Lakes under terms of the Great Lakes Water Quality Agreements (GLWQA) of 1972 and 1978. These international agreements foster intergovernmental cooperation to solve pollution problems. The lower River Raisin was identified by the IJC as one of Michigan's fourteen Areas of Concern (AOC). The boundaries of the AOC have been defined as the lower 2.6 miles of the River Raisin downstream from the low-head dam at Winchester Bridge. From the river mouth the AOC extends one-half mile into Lake Erie following the Federal Navigation Channel and along the near shore zone of Lake Erie both north and south for one mile. Problems that exist in the River Raisin AOC are heavy metals (zinc, chromium, copper) and polychlorinated biphenyl (PCB) contamination of sediments, the water column, and biota; sediment input from nonpoint sources outside of the AOC; and a fish consumption advisory on carp and white bass.

The fish contamination and consumption advisory issued by the Michigan Department of Community Health has been identified as the primary impaired use in the River Raisin AOC. There should be no consumption of white bass exceeding 12 inches and all carp from the River Raisin downstream from the Winchester Bridge in Monroe. Women and children should not consume more than six meals per year of white bass less than 12 inches long. The general population should not consume more than one meal per week of white bass from 10 to 12 inches. Women and children should not eat more than one meal per week of carp from the River Raisin upstream of the AOC. The South Branch of the

River Raisin also has fish advisories. Women and children should not consume more than one meal per month of northern pike larger than 22 inches, redhorse suckers larger than 12 inches, and all carp; and not more than one meal per week of redhorse suckers less than 12 inches. The Department of Public Health has also issued a special advisory concerning all inland lakes and reservoirs in Michigan due to widespread airborne mercury contamination throughout the north central United States and Canada. No one should eat more than one meal a week of the following kinds and sizes of fish: rock bass, yellow perch, or crappie over 9 inches in length; and largemouth bass, smallmouth bass, walleye, northern pike, or muskellunge of any size. These fish consumption advisories are published annually by the Michigan Department of Community Health.

A Remedial Action Plan (RAP) for the River Raisin AOC was produced by MDNR (MDNR 1987). While this document gives an excellent overview of environmental problems as well as extensive background material, it does not address several items found in the guidance of the GLWQA. Reference to the fourteen potential impairments to beneficial uses is notably lacking. The River Raisin RAP is now being updated and expanded by local stakeholders and technical experts in partnership with state and federal governments. RAP participants are determining the extent and sources of impairments to beneficial uses of the river's ecosystem and will next focus on remedial measures and resources needed for rehabilitation and protection of the lower River Raisin for the future.

A Public Advisory Committee (PAC) was established to advise the state on the development of RAP documents and the direction of the AOC for the River Raisin. The PAC has 20 members representing municipalities, business and industry, environmental groups, and other stakeholders. The role of the PAC has expanded well beyond the original role of advising the state and now includes activities such as public outreach, lobbying, active participation in RAP documentation, and local leadership of the RAP process (R. Sweet, MDEQ, SWQD, personal communication).

Since the publication of the 1987 RAP, several remedial actions have been taken and additional data have been gathered. Sediment sampling by MDEQ and USEPA continues to characterize and further define contaminant "hot spots". MDNR and MDEQ personnel have continued caged fish studies, fisheries surveys, and biosurveys. MDEQ has investigated landfills, lagoons, and industrial sites of contamination within the AOC. Several Part 201 sites including the Port of Monroe Landfill, Ford Motor Company, and the Consolidated Packaging Company (south plant) have undergone study and clean up procedures have begun.

An area adjacent to the Ford Motor Company Plant downstream from an old discharge pipe was found to have PCB contamination levels greater than 40,000 ppm, the highest levels ever found in the state (R. Jones, MDEQ, SWQD, personal communication). The removal and on site encapsulation of 24,000 cubic yards of contaminated sediment was completed in the fall of 1997 at a cost of $6,000,000. Post remediation site characterization and monitoring have begun.

Water Temperature

Water temperature data for the River Raisin at Sharon Valley Road were collected by MDNR Fisheries using an automatic recording thermometer for the period of 10/12/1989 to 9/28/1990 (T. Zorn, MDNR, Fisheries Division, personal communication). Water temperature was taken every two hours. Summer maximum water temperatures exceeded 80° F on several days and the mean daily temperatures occasionally exceeded 75° F. This temperature is too high to manage the stream for coldwater species such as brown trout. However, these water temperatures on an occasional basis are not too high for smallmouth bass.

Maximum-minimum July water temperatures were taken during 1989-1990 at several locations in the River Raisin watershed (Table 25; K. Wehrly, University of Michigan, School of Natural Resources and Environment, personal communication). When River Raisin maximum-minimum temperature data are compared with data from other Lower Peninsula streams, River Raisin temperatures are in the middle to slightly warm range. Daily water temperature fluctuation of the mainstem and tributaries is fairly low. This indicates a more stable water temperature situation that is beneficial to coolwater species such as smallmouth bass and walleye.

Nonpoint Source Pollution

Nonpoint source pollution is viewed as the major cause of pollution affecting most streams, rivers, and lakes in the United States (Dysart 1985). In the River Raisin watershed, agricultural runoff is the major source of nonpoint source pollution. Increased erosion often accompanying agricultural land use not only depletes soil resources, but also degrades water quality through increased turbidity and sedimentation. As fertilizer use has increased, transport of nutrients from soils to surface waters has increased accelerating eutrophication of surface waters. Increasing use of agricultural pesticides and herbicides has introduced additional toxic substances into surface waters. Soluble nutrients and pesticides are affecting ground water quality in some areas.

Due to the predominance of clay till particularly in the southeastern portion of the River Raisin watershed, runoff is significant after rain events and during snow melt. The runoff during storm events causes both rapid stream level fluctuations and very turbid waters. Erosion in the River Raisin basin is high relative to other areas in Michigan.

An excellent overview of sediment, nutrient, and pesticide transport in the River Raisin and other lower Great Lakes tributaries was presented by David Baker, Water Quality Laboratory, Heidelburg College (Baker 1988). The annual hydrograph, sedigraph, and nutrient chemograph for the River Raisin at Monroe during the 1983 water year are from Dr. Baker's work (Figure 10). The graphs depict the magnitude of the problem caused in the River Raisin watershed (and eventually in Lake Erie) by nonpoint pollution resulting primarily from agricultural runoff.

Nonpoint source pollution also originates from urban sources. Flow characteristics of urban streams are generally flashy due to large amounts of impermeable surfaces such as roads and highways, parking lots, and roofs. Construction projects often lead to increased runoff and erosion. Runoff via storm drains ends up in stream courses. Another problem in urban areas is the unwise and excessive use of fertilizers, pesticides and herbicides on yards and gardens. Pollutants from urban sources include metals, toxic substances, road salt, oils and fuels, and nutrients. Metals, pesticides, and toxic materials can be incorporated into food chains, and eventually lead to harmful effects in fish and other aquatic organisms and consumption advisories for people.

Agricultural Nonpoint Source Pollution Abatement

In 1972 the United States entered into an agreement with Canada, under the auspices of the IJC, to reduce nonpoint source nutrient loading in the Great Lakes. Phosphorus loading, that had already turned a large part of Lake Erie algae-green and commanded media attention coast to coast, was to be reduced by 30% (Baker 1988). Specific nonpoint source pollution abatement projects have been implemented in portions of the watershed.

Section 319 refers to the section of the federal Clean Water Act that provides guidance and funding for states to reduce nonpoint source pollution. As grant administrators of Section 319 watershed projects, MDEQ Nonpoint Source staff work with local agencies to develop watershed plans and obtain voluntary implementation of best management practices to control nonpoint source pollution. As of 1996, over $20 million has been directed through Section 319 to reduce nonpoint source pollution in Michigan. This includes federal grant funds and matching state and local dollars.

River Raisin Main Branch Watershed Project- Section 319 Grant Funds

The River Raisin Watershed Project covered a three year period; October 1, 1991 through December 31, 1994. The project area was a portion of the Middle River Raisin watershed in Lenawee County. Water quality problems targeted included sediment deposition and elevated levels of nitrates, phosphorus, and pesticides. Although pesticide concentrations were well below health advisory levels, they caused public concern particularly in Adrian, Blissfield, Dundee, and Deerfield where public water supplies come directly from Wolf Creek and the River Raisin. Objectives of the River Raisin Watershed Project were to reduce the amount of sediment deposition from both wind and water by 33%, reduce nitrate and phosphorus concentrations by 12%, reduce pesticide concentrations by 40%, and to develop a public awareness of the River Raisin basin and the importance of water quality (LSWCD 1995). Methods to accomplish these goals included implementation of agricultural BMPs, implementation of education and demonstration programs, and development of an extensive water quality database.

The implementation of BMPs involved providing technical and cost-share assistance for establishing field windbreaks and grass filter strips. Cost-share funds from other sources were used to implement other BMPs including conservation tillage, cover crops, livestock exclusion, nutrient and pest management, and erosion control structures. The majority of the 319 grant funds was used to cost-share grass filter strips. The original project goal was to install 185,400 lineal feet of grass filter strips in the project area. At the end of the grant period 443,520 lineal feet of grass filter strips had been installed (LSWCD 1995). The River Raisin Watershed Council contributed $15,000 over the three year period for the installation of filter strips (V. Brighton, RRWC, personal communication). Contracts under the 319 grant required landowners to maintain filter strips for a six year period instead of the typical three year period. The ultimate goal of the Lenawee SWCD is to have grass filter strips along every drain and tributary in Lenawee County and field windbreaks planted on every one-half to one mile in the wind erodible areas.

During the first two years of the project, public education focused on group tours of the project area and slide presentations to service organizations. After the second year, an “Enviroscape” model was purchased and a watershed education coordinator was hired to give presentations to school students and adult groups. This model presents a visual display of runoff and erosion. Erosion control practices can be added to the model and their beneficial effects are readily apparent. Programs were presented to 750 Lenawee County school children and 250 adults in a variety of organizations.

There is no way to calculate the total amount of sediment that was kept out of the rivers and streams as a result of the River Raisin Watershed Project. However, Penn State University research has shown the relative gross effect of filter strips for sediment reduction to be 65%, phosphorus reduction at 75%, and nitrogen reduction at 70%. Using these figures it is estimated that 5,745 tons of sediment and 10,590 pounds of phosphorus were filtered from drains and streams in the project area during the three year period (LSWCD 1995).

Wolf Creek Water Quality Project

The Wolf Creek Water Quality Project was funded through the Clean Water Incentives Program. The Wolf Creek watershed is a 48,000 acre urban and rural watershed located in north central Lenawee County. The watershed encompasses 28,000 acres of farmland and the stream empties into Lake Adrian, the municipal water supply reservoir for the City of Adrian. The two water quality problems identified in the Wolf Creek watershed are sediment loading and agricultural chemical contamination (LSWCD 1991).

One of the objectives of the project was to reduce agricultural chemical levels in the watershed. The comparative data from the 1988 implementation phase to 1990 show a decline in concentrations of eight agricultural chemicals and an increase in the concentration of one chemical entering Lake Adrian (LSWCD 1991). The total concentration of the nine agricultural chemicals declined from 11.40 parts per billion (ppb) in 1988 to 8.13 ppb in 1990. This represents a 28.7% decline in the concentration of agricultural chemicals. The decline in concentrations of agricultural chemicals appears to be a result of implementation of a combination of BMPs and education, especially the use of filter strips and increased use of no-till as a management practice (LSWCD 1991).

The second major objective of Wolf Creek Water Quality Project was to reduce the amount of sediment entering Lake Adrian. Three years after project implementation, the amount of sediment entering Lake Adrian had been reduced by 31%. This encouraging result indicates that a 75% reduction of sediment entering the lake is a realistic goal. The data from this project indicate that no-till has 85.5% less sediment delivery to the stream than chisel plowing as a tillage method (LSWCD 1991). No-till had a phosphorus concentration loading of 25% less and an ammonia nitrogen loading of 80% less than the more conventional chisel plowing system. Also, the no-till study plots had an 86% reduction in gallons of runoff and 54% fewer runoff events than comparable plots cultivated with the chisel plow method.

The data gathered from the Wolf Creek Water Quality Project indicate that BMPs that allow cover to remain on the land have the most immediate effect upon water quality related to sediment loading into the waterways. It follows that if runoff events can be slowed down, reduced, or eliminated, amounts of nutrients and chemicals entering the water system will be reduced.

Fishery Management

Fishery management on the River Raisin mainstem has been neglected. Past municipal and industrial point source pollution, excess turbidity from intensive agricultural use in the watershed, lack of assured public access, and a miserable public image of the river particularly from Tecumseh to Dundee have combined to discourage fishery management. Opportunities for more glamorous fishery management elsewhere in the state emphasizing premier species and waters (e.g., salmonids and the Great Lakes), have been another factor causing fishery managers to neglect southern Michigan rivers. Enhancement of angling opportunities on southern Michigan rivers is one of very few remaining frontiers available to fish managers. A definite potential exists for increasing angling recreation substantially on larger southern Michigan streams including the River Raisin.

Target species for fisheries management in the River Raisin mainstem vary throughout the watershed based upon magnitude and stability of stream flow, bottom substrate composition, and gradient. To be consistent, discussion of fishery management opportunities on the River Raisin mainstem will follow three major sections: headwaters to Tecumseh, Tecumseh to Dundee, and Dundee to Lake Erie.

Headwaters to Tecumseh

This most upstream portion of the watershed is characterized by hilly terrain and permeable soils that reduce runoff during precipitation events and limit turbidity. In the extreme headwater portion of the watershed above Norvell Lake, the mainstem flows through a series of lakes and interconnecting wetlands. In river portions of this lake drainage area, the stream is small and current is generally slow. Bottom substrates are a mixture of sand and silt with lesser amounts of gravel. Sport fish are primarily panfish and largemouth bass and populations are limited by small size of the stream, uniform substrate, and lack of habitat diversity in the stream channel. Lakes in this portion of the watershed generally have good warmwater sport fish populations and past fishery management has focused on the lakes with assured public access. Walleye fingerlings have been stocked in several of these lakes with modest results (Table 11). Recent private stocking in lakes in the Irish Hills area with large fall fingerling walleyes has shown promise. Results of a spring MDNR, Fisheries Division 1996 trap net survey of Vineyard Lake and a 1997 survey of Wamplers Lake to evaluate this walleye stocking were encouraging.

From the Norvell Lake Dam downstream to Tecumseh, stream gradient increases and stream flow is fairly swift. The stream bed is firm in most areas and the bottom is composed of rock, gravel, sand, and lesser amounts of silt. Fish cover is adequate, although some areas would benefit from additional instream woody cover and more pool habitat. Problems include excessive water withdrawal for irrigation near Manchester and the presence of dams in several prime habitat high-gradient areas near Sharon Hollow, Manchester (2 dams), and Tecumseh (3 dams). These impounded areas near Manchester and Tecumseh are the highest gradient areas in the entire watershed.

The mainstem from Manchester to Tecumseh supports a good fishery for smallmouth bass and rock bass, and a modest fishery for northern pike. The impoundments are fished very lightly. Most of these old impoundments are too shallow and silt-laden to provide good sport fish habitat and existing fish populations are dominated by carp and suckers. The Globe Millpond (most downstream Tecumseh impoundment) was drawn down to the river channel in 1986. After restoring the water level, fish were restocked. Besides this original restocking, channel catfish were stocked in the Globe and Standish Impoundments in Tecumseh from 1988 to 1991 by MDNR, Fisheries Division. Netting surveys showed that the channel catfish survived and grew very well in these small impoundments.

Tecumseh to Dundee

The mainstem from Tecumseh to Dundee presents problems for fishery managers. The river drops down from the hilly glacial morainal area and enters the old Lake Maumee lake plain area a short distance downstream from Tecumseh. Soil in this area is composed of finer particles and is much less permeable. Therefore, runoff is increased and stream flow becomes more “flashy”. Bottom substrates are composed of smaller particles such as sand, silt, and clay with very little gravel. The stream gradient in this section, less than two feet per mile, severely restricts smallmouth bass populations (Trautman 1981). Stream velocity is correspondingly sluggish. Intensive agricultural use particularly downstream of Palmyra in combination with the soil types results in high levels of turbidity during all but extreme low flow periods. The habitat in this sluggish, turbid section of the river favors silt-tolerant species such as carp, suckers, and redhorse suckers, and these species dominate the fish population. Recreational access to the river is limited and the public image of the river and its fishery is terrible. Many local residents perceive that fishing in this area is a waste of time and state that they would not eat fish from the River Raisin.

Sport fish species include northern pike, channel catfish, bullheads, and very low densities of smallmouth bass and rock bass. After the MDNR 1984 survey, walleye fry and fingerlings were stocked from 1985 to 1987. Channel catfish were stocked from 1988 to 1991. To evaluate this stocking, three of the 1984 MDNR rotenone survey stations (Russel Road, Academy Road, and East Gorman Road) were duplicated in August, 1992. Channel catfish stocking was successful. A total of 59 channel catfish were taken. In the MDNR 1984 survey only five channel catfish were taken from these three stations (Towns 1985). Only one walleye was collected in 1992. Therefore, it is assumed that walleye stocking in the mid-1980s was not successful. Suitable habitat for walleye spawning is severely limited in this portion. Removal of the dams at Tecumseh would rehabilitate a large portion of high-gradient walleye spawning habitat with suitable substrate. One interesting observation was that smallmouth bass populations had apparently decreased from 1984 to 1992 at the three stations surveyed with rotenone methods. Perhaps the channel catfish were competing with the smallmouth bass and displacing them. The low gradient of this stream portion makes it poorly suited for smallmouth bass.

Another potential management tool for fisheries enhancement in the middle River Raisin is stocking a predator to take advantage of the large available forage base of suckers, redhorse suckers, and minnows and to provide an attractive sport fish. Northern pike and channel catfish are the sport fish species that are probably best suited for the available habitat. The existing northern pike population suffers from lack of spawning habitat. The turbidity and siltation along with drainage of former spawning habitat are factors limiting success of natural reproduction of pike. Stocking northern pike fingerlings to augment the existing population may mitigate the apparent low success of natural reproduction.

Dundee to Lake Erie

The lower River Raisin basin from Dundee to Lake Erie is characterized by relatively impermeable soils with high clay content. The general topography is flat, since the entire land area is in the old lake plain. However, stream gradient increases over the low gradient mid-portion of the mainstem and average gradient is about 3.0 feet per mile. The stream is broad and shallow and the stream bed is composed of cobble, rock, gravel, sand, and limestone bedrock. Fish cover is limited. The dominant sport fish species are smallmouth and rock bass. Other sport fish are northern pike, largemouth bass, bluegills, channel catfish, bullheads, and walleyes. Although smallmouth bass were abundant in the lower River Raisin during the 1984 MDNR rotenone survey, only 12 of 1663 smallmouth bass taken at the three lower stations had attained legal-size (> 12 inches at that time). It was theorized that installation of sturdy cover devices capable of withstanding great flow fluctuations could increase the number of large smallmouth bass in the lower River Raisin (Towns 1985).

A long term study of smallmouth bass population dynamics on the nearby Huron River could yield results applicable to the River Raisin and other southern Michigan streams. River rotenone survey results from southern Michigan rivers have consistently shown that smallmouth bass are abundant in streams with suitable habitat. However, legal-sized smallmouth bass (> 14") are relatively rare. The initial goals of the smallmouth bass study were: to determine results of restrictive angling regulations (catch-and-release), and to evaluate habitat improvement methods designed to alter the size structure of smallmouth bass populations by increasing the number of larger fish. In the catch-and-release study, two similar sections of the Huron River were given different regulations (catch-and-release versus statewide 12 inch minimum size limit at that time) and intensive creel census surveys were conducted. Although results were clouded by voluntary release of most legal-sized smallmouth bass in the section with statewide regulations, numbers of smallmouth bass >12 inches increased significantly in the catch-and-release section (Lockwood et al. 1995). The restrictive regulations were also popular with local anglers. The habitat improvement portion of the smallmouth bass study was eventually deleted due to lack of funds.

Potamodromous fish management in the River Raisin is not practical until the blockages created by the power plant cooling water intake, the six low-head dams, and the Waterloo Dam are eliminated. The dams must either have effective fish passage facilities installed or they must be removed. If these barriers to fish movements are eliminated, rehabilitating spawning runs of potamodromous species such as walleyes, white bass, and perhaps lake sturgeon should be implemented. Creating runs of salmonid species into the River Raisin should not be considered, since success of past salmonid stocking in Lake Erie tributaries of western Lake Erie has been marginal at best. Possible explanations for the poor success of salmonid stocking in Michigan tributaries to Lake Erie include the shallow, warm nature of the western basin of Lake Erie and the presence of a heavy commercial fishery, particularly in Ontario waters of Lake Erie (R. Haas, MDNR, Fisheries Division, personal communication). The extensive commercial fishery for smelt in Lake Erie depletes the forage base for salmonids. Also salmonid juveniles would face the potential of heavy predation by walleye populations in western Lake Erie.

Another fish species that deserves consideration for management in the River Raisin provided that existing impediments to migration are eliminated is muskellunge. There are anecdotal accounts of muskellunge spawning runs in the River Raisin during the mid-nineteenth century. Also, muskellunge were impinged at the Monroe Power Plant cooling water intake during the 1985 impingement study (A. Nuhfer, MDNR, Fisheries Division, personal communication). Seelbach (1988) investigated considerations regarding the reestablishment of muskellunge into southern Michigan river systems. He concluded that habitat characteristics of southern Michigan rivers appear ideal for muskellunge. Muskellunge could use as forage the abundant catostomids and cyprinids that now dominate fish communities in these rivers. Although introductions of muskellunge could be attempted in the River Raisin, there are other southern Michigan rivers that are probably better suited for such experimentation. Muskellunge are sight feeders and are generally found where turbidity is minimal. Because of soil types and extensive agricultural use, turbidity is higher in the River Raisin than in Lake Michigan tributaries. Therefore, it may be more prudent initially to introduce muskellunge into large southern Lake Michigan tributaries. If these introductions are successful, experimental muskellunge stocking could be conducted in the River Raisin.

Citizen Involvement

The greatest impediment to beneficial change in the River Raisin watershed is the poor public image of the river and its major tributaries. Local residents perceive the river as sluggish, excessively turbid, and heavily polluted. It is widely thought that fish populations in the mid-portion of the mainstem and in the larger tributaries are restricted to carp and suckers. People express concerns about eating fish from the River Raisin caused by perceived high levels of pollution and contaminants. The River Raisin mainstem, particularly from Tecumseh to Dundee, is a neglected recreational resource.

Except for the lakes in the Irish Hills resort area, the River Raisin is the dominant aquatic recreational resource in the watershed. The poor public image of the river must be improved to give people incentive to take pride in the river and support protective measures and promote enhancement of water quality and recreational opportunities. An improved public image of the river would act to develop a feeling of public stewardship among area citizens that would help to drive all other beneficial changes.

The River Raisin Watershed Council (RRWC) is the major group concerned with the River Raisin. This council, formed in 1974, is composed of representatives from 5 counties, 6 cities, 10 villages, and 40 townships. The Lenawee and Monroe County Soil Conservation districts are also active participants. An annual budget of approximately $20,000 (1991) is raised by dues from the member units of government.

The River Raisin Watershed Council has concentrated on education and plans to maintain this emphasis in the future. The council has produced an excellent map, fact sheet, and video about the river basin. This video and other visual material along with speakers is available to school districts throughout the basin. The council has worked with the Ecology Center in Ann Arbor to develop and present information on ground water issues to area school students. This material has been placed in 15 local school systems (1991). In 1996 the River Raisin Watershed Council contributed financial support for a two-day ground water educational seminar held in Adrian. A similar seminar was sponsored by the council in Monroe County in 1997.

The council has been active in logjam removal from the River Raisin since the mid-1980s. This work has been accomplished with labor from summer youth employment and prison inmates. The goals of this ongoing project are to open more of the river to recreational canoeing and to prevent future erosion and sedimentation by removing major obstacles to stream flow. In the past, the river has changed course and cut new channels around the worst logjams greatly adding to sediment loads and downstream sedimentation problems.

The River Raisin Watershed Council has provided a total of $25,000 from 1991 through 1995 to the Lenawee County Soil Conservation District to cost-share installation of grass filter strips along small drainage courses (V. Brighton, RRWC, personal communication). In 1996 the Monroe County Soil Conservation District received $5000 from the council to cost share creation of grass filter strips in the Monroe County portion of the watershed (T. VanWagner, LSWCD, personal communication).

The council also is a partner in several litter removal projects along the River Raisin mainstem. Cooperators in these projects include the Monroe County Sheriff's Department and the Adrian Rotary Club. In future the River Raisin Watershed Council plans to give highest priority to education, river cleanups and logjam removal, and nonpoint source pollution abatement with installation and maintenance of additional grass filter strips along small drainage courses (V. Brighton, RRWC, personal communication).

The function and activities of the Public Advisory Committee (PAC) for the Remedial Action Plan process for the river Raisin Area of Concern were discussed in **Water Quality,** *IJC, AOC*.

The Stubnitz Environmental Education Center opened in 1993. This facility is located in Heritage Park on the South Branch of the River Raisin about two miles northeast of Adrian. The mission of the center is to provide all people with a living laboratory for lifelong learning and to instill stewardship for the natural environment (P. Bunch, Stubnitz EEC, personal communication). The funds to construct and equip the center were provided primarily by grants from MDNR and the Stubnitz Foundation. The center provides education throughout the school year to all school systems in the Lenawee Intermediate School District. The Stubnitz Environmental Center is also used by the Hillsdale-Lenawee-Monroe Math and Science Center to present math, science, and technology workshops for school teachers. Many of these focus on aquatic biology and other areas of natural science.

The River Raisin Land Trust is a private organization formed to develop conservation easements designed to protect and conserve natural features in the watershed. Now, activities of this organization are concentrated in the northwestern portion of the watershed (S. Kolon, River Raisin Land Trust, personal communication).

The county Soil and Water Conservation Districts have conducted many studies and projects in the River Raisin watershed in recent years. Major projects on the Middle River Raisin, and Wolf Creek watersheds have been discussed in **Water Quality**. Requests for additional grant funds to continue and expand this work have been made. A Section 319 grant of $300,000 requiring local matching funds, has been awarded for implementation of BMPs, reducing chemical concentrations, and providing education opportunities in the South Branch of the River Raisin watershed. The implementation phase of this Section 319 project began in 1997.

A group of University of Michigan graduate students under the direction of Dr. David Allan, School of Natural Resources and the Environment, has initiated studies in the River Raisin watershed. This watershed was selected since the major focus of these studies is to determine effects of land use practices and stream dynamics in an intensively agricultural watershed. Much of the work of Dr.

Allen and his students will concentrate on bank erosion and sediment loading and their effects upon stream biota.

Many other private organizations are interested in the River Raisin (Table 26). These organizations are largely oriented toward recreational pursuits, primarily hunting and fishing. Besides these groups, most towns along the river have service clubs such as the Rotary, Elks, Moose, Eagles, Lions, etc. that have an interest in the River Raisin. Many of the lake residents in the Irish Hills area have formed lake associations that are concerned with the quality of the environment at particular lakes.

MANAGEMENT OPTIONS

Compared to other southeastern Michigan watersheds such as the Rouge, Clinton, and Huron, the River Raisin watershed has not been particularly affected by urbanization. However, the River Raisin watershed is the most intensely agricultural watershed in Michigan (Gooding 1995). This intense agricultural use coupled with erodible soils leads to severe nonpoint source pollution. The River Raisin mainstem and major tributaries suffer from a poor public image and neglect. The management options presented in this assessment are an attempt to address the most important problems and issues and to identify areas where further investigation is needed.

The identified options are consistent with the mission statement of the MDNR Fisheries Division. This mission is to protect and enhance the public trust in populations and habitat of fishes and other forms of aquatic life, and to promote optimum use of these resources to benefit the people of Michigan. In particular, the division seeks to protect and maintain healthy aquatic environments and rehabilitate those now degraded; provide diverse public fishing opportunities to maximize the value to anglers; and foster and contribute to public and scientific understanding of fish, fishing, and fishery management. The management options listed are categorized and presented following the organization of the major sections of this assessment.

Geology and Hydrology

The upper portion of the River Raisin watershed above Tecumseh has moderately stable stream flows. However, flow stability decreases in the middle and lower portions of the watershed primarily because of less permeable soil types and intensive agricultural use including stream channelization, removal of floodplains and wetland retention areas, and installation of artificial tiled drainage systems. Water withdrawals for agricultural irrigation create severe low flow situations particularly in the upstream portion of the watershed near Brooklyn, Manchester, and Clinton. Water withdrawals for municipal use also effect stream flows. The communities of Adrian, Blissfield, Dundee, and Deerfield rely on the River Raisin system for their public water supplies. Flooding is a recurring problem in the lower watershed in Monroe and Frenchtown townships and the City of Monroe.

Option: Protect and rehabilitate the function of wetlands and floodplains as water retention areas. Develop an inventory of existing wetlands and potential areas for the creation of wetlands with emphasis on riparian areas.

Option: Improve the flood prediction accuracy at several sites in the lower River Raisin. The USGS, National Weather Service, and MDEQ, Land and Water Management Division have identified locations where accuracy of flood predictions needs improvement.

Option: Protect critical ground water recharge areas by identifying them and developing a strategy for protection.

Option: Protect remaining natural lake outlets by preventing the construction of new lake-level control structures, thereby allowing natural fluctuation of water levels needed to maintain wetlands. Operate existing lake-level control structures as fixed-crest structures rather than by opening or closing gates or removing stop-logs. Incorporate minimum flow requirements into the design of fixed-crest structures.

Option: Design and implement agricultural best management practices to reduce cropland runoff and increase retention. Installation of grass filter strips and use of conservation tillage practices are especially important.

Option: Seek legislative authority to control agricultural withdrawal of water for irrigation.

Option: Discourage development in floodplain areas by zoning regulations, tax abatement incentives, and use of conservation easements.

Option: Rehabilitate headwater and tributary flow stability by working with county drain commissioners to incorporate flow patterns into criteria for drain design and maintenance and storm water management.

Option: Rehabilitate flow stability by removing or plugging drain tile fields that are no longer needed for land drainage as land is removed from agricultural use.

Option: Support education on agricultural best management practices and storm water management to reach area school districts, contractors, developers, and farmers.

Channel Morphology

The channel of the River Raisin has been adversely altered over the years. Dams have inundated most high-gradient sections of the mainstem. Flow instability and resultant erosion have caused the channel to be excessively narrow in the middle portion of the mainstem where stream banks with high clay content are resistant to erosive forces. Conversely, the channel is excessively wide below the confluence of the mainstem with the Saline River downstream from Dundee. Bottom substrate from this confluence downstream to the mouth at Lake Erie is composed of gravel, cobble, rock, and limestone bedrock. Therefore, during high flow the less erosion resistant stream banks are eroded. Agricultural activities including channelization and drainage have caused woody cover to be sparse in many portions of the mainstem and major tributaries. Woody cover creates excellent fish habitat and provides good substrate for the production of aquatic insects and other fish food organisms.

Option: Work closely with drain commissioners to protect tributaries from further channelization by developing alternatives to current detrimental drainage practices such as dredging, enclosure, and excessive removal of the tree canopy and bank vegetation.

Option: Rehabilitate rare high-gradient habitats by removing dams no longer used for their original purpose; e.g., retired hydroelectric facilities and dams that are a safety hazard. Dams that created small impoundments that are now shallow, silt-laden, and choked with aquatic vegetation could also be removed. Examples of these impoundments include Brooklyn, Sharon Hollow, upstream Manchester, Clinton, Red Mill, Standish, and Globe.

Option: Rehabilitate recruitment of woody debris by establishing and protecting wooded greenbelts on riparian lands by use of cost-share, conservation easement, and tax abatement incentives. Protect existing instream woody cover by monitoring river cleanups to ensure that enough woody cover remains.

Option: Support adoption and implementation of best management practices on agricultural cropland and with upland construction projects to reduce runoff and erosion and increase water retention over time.

Option: Survey stream segments throughout the watershed to acquire data necessary for the analysis of expected widths versus actual widths and for the investigation of channel hydraulic diversity.

Soils and Land Use Patterns

Intensive agricultural land use coupled with fine particle soil types has degraded the river system by decreasing flow stability, altering natural channel morphology, and creating severe erosion and sedimentation problems. Channelization and dredging of tributaries and installation of tiled drain fields have also decreased flow stability. Agricultural water withdrawal for irrigation exacerbates natural low flow conditions during droughts.

Option: Support adoption and implementation of best management practices on agricultural cropland to reduce the number and magnitude of runoff events. Farmers as businessmen must be given financial incentives to adopt best management practices where direct financial benefits of the practices are unclear.

Option: Support aggressive enforcement of state and local regulations dealing with erosion and sedimentation control, storm water management, dredging and filling, and protection of riparian habitat.

Option: Protect undeveloped riparian lands through land use planning, restrictive zoning, property tax abatement incentives, conservation easements, beneficial changes in the “plat act”, and various agricultural “set aside” programs such as the Conservation Reserve Program.

Option: Protect developed lands through land use planning and zoning guidelines that emphasize protection of critical areas, minimize impervious surfaces, and foster improved storm water management.

Option: Purchase flooding rights as an alternative to dredging streams or drains.

Option: Protect remaining wetlands and advocate construction of additional riparian wetland areas.

Option: Protect and rehabilitate the forested corridor along the river and its tributaries through zoning, land use regulations, property tax incentives, conservation easements, education, etc.

Option: Encourage basin-wide land use planning and adoption of uniform environmentally sound regulations throughout the watershed.

Biological Communities

Although fish species diversity in the River Raisin watershed remains high, certain species are declining and potamodromous fishes have been virtually eliminated. Silt-tolerant fish species have increased in the watershed, whereas fishes requiring clean gravel areas or clear, vegetated areas at some point in their life histories have declined. Dams have inundated high-gradient areas with gravel, cobble, and rock substrates. Channelization of tributaries has reduced flow stability and increased sediment load in streams. Mussel species have declined primarily as a result of increased sediment load in streams. Introduced pest species including zebra mussels, rusty crayfish, Eurasian milfoil, curlyleaf pondweed, and purple loosestrife have had negative effects on native fishes and macroinvertebrates. Wetland drainage and filling has affected populations of fish, amphibians, and reptiles.

Option: Survey historic record to determine pre-settlement fish fauna and species distribution.

Option: Rehabilitate rare, high-gradient areas and fragmented habitats by removal of unnecessary dams.

Option: Rehabilitate populations of potamodromous fish by altering the cooling water intake at the Detroit Edison Monroe Power Plant. Several methods of eliminating this cooling water intake that makes management of potamodromous fishes impractical in the River Raisin are discussed in *Potamodromous Fisheries Management- Barriers*.

Option: Rehabilitate populations of potamodromous fish by removal of the six low-head “beautification” dams in the City of Monroe and removal or installation of effective fish passage facilities at the Waterloo, Grape (Murciak), and Dundee dams.

Option: Rehabilitate gravel habitats through reduction of sediment loads by implementing best management practices relating to agriculture and construction activities.

Option: Preserve stream margin habitats including floodplains, wetlands, and the wooded stream corridor by requiring setbacks and vegetative buffer strips in zoning regulations and by controlling development in the stream corridor through regulations and conservation easements.

Option: Preserve vegetated headwater lake outlets by preventing dredging and construction of lake-level control structures at these areas.

Option: Survey distribution and status of species of concern and develop protection and recovery strategies for these species.

Option: Survey distribution and abundance of aquatic insects and other macroinvertebrates.

Option: Survey distribution and status of mussel populations and develop strategies for protection and recovery of these species. Study effects of zebra mussels on native mussel species.

Option: Study effects of other pest species including rusty crayfish, Eurasian milfoil, purple loosestrife, etc. and develop biologically prudent and economically feasible methods of control.

Option: Survey amphibian and reptile populations and develop protection and rehabilitation strategies for these species.

Special Jurisdictions

County drain commissioners have authority over designated county drains and most lake-level control structures. MDEQ, Land and Water Management Division regulates construction of stream crossings, dredging and filling, and re-routing of streams. Public ownership and management of land in the River Raisin watershed is minimal.

Option: Continue to advocate and work toward legislative adoption of the recreational definition of navigability (a stream is legally navigable if it can be navigated by canoe or small boat).

Option: Protect and rehabilitate the river system by supporting cooperative planning and decision making among all involved levels of government.

Option: Survey stream road crossings, identify negative effects, and implement best management practices. Eliminate "perched" culverts that fragment habitat and create barriers to fish migration; e.g., Miller Road, Lenawee County, T5S, R1E, Sec. 13.

Option: Rehabilitate designated county drains to natural stream status where designation as a drain is no longer appropriate. Encourage drain commissioners to use stream management practices that protect and rehabilitate natural processes rather than traditional practices of straightening, deepening, widening, and enclosing natural streams. Getting water off the land as quickly as possible by any means is no longer environmentally acceptable.

Option: Oppose the resumption of hydroelectric power generation at old hydroelectric facilities, particularly if the facility is to be operated in a "peaking" mode that causes severe flow fluctuations.

Option: Explore natural rivers designation for the River Raisin mainstem between Brooklyn and Tecumseh. This is a beautiful stretch of river with varied habitats and good water quality. Natural rivers designation of this portion of the mainstem would encourage recreational use and promote an ethic of stewardship for the river.

Option: Explore the possibility of putting environmentally sensitive areas in the watershed into public ownership for long-term protection and recreation.

Recreational Use

The River Raisin mainstem and larger tributaries have great potential for recreational use because of their proximity to population centers both in the watershed and in heavily populated surrounding area of southeastern Michigan and northwestern Ohio. However, bona fide access to the river is only fair, and assured public access is needed at several locations. The poor public image of the River Raisin among local people also limits its value as a recreational resource.

Option: Encourage and promote public use of the river by any means possible. The only way to counter the present poor public image of the river is to get people out on the river.

Option: Construct small public access sites particularly in the mainstem from Tecumseh to Dundee and on the lakes in the Irish Hills area. Adequate public access is an essential precursor to any activities aimed to foster pride and a feeling of stewardship toward the river by local citizens.

Option: Encourage canoeing on the mainstem to promote public use and awareness of the river.

Option: Encourage the River Raisin Watershed Council to continue removing major obstacles to navigation on the mainstem between Tecumseh and Dundee. Ensure that this work is accomplished in an environmentally sound manner to allow instream woody cover to remain to the highest extent possible.

Option: Encourage town festivals along the river to promote public awareness and a sense of stewardship for the river.

Option: Protect existing public park systems in communities along the river and promote responsible management and provision of public access to the river and shore fishing facilities at these parks.

Option: Rehabilitate stretches of the mainstem by removing old dams that are no longer used for their original purpose in high-gradient areas near Brooklyn, Manchester, Clinton, and Tecumseh. Develop public parks complete with provision of public access on the reclaimed landscape.

Dams and Barriers

The approximately 60 dams in the River Raisin watershed create habitat fragmentation, block movements of resident and potamodromous fish, inundate valuable areas of high stream gradient, eliminate vegetated stream habitat at lake outlets, trap normal downstream transport of sediment and woody debris, and alter flow and temperature regimes of the river. Many of the impoundments in the River Raisin watershed are shallow, sediment-laden, and choked with aquatic vegetation. They provide very little sport fish habitat.

Option: Protect biological communities of the river by providing upstream and downstream fish passage at dams to mitigate for habitat fragmentation.

Option: Survey and develop an inventory of barriers to fish passage such as improperly placed culverts. Correct these improper crossings.

Option: Rehabilitate free-flowing river conditions, rare high-gradient areas, and fragmented habitats by removing dams that no longer fulfill their original purpose.

Option: Rehabilitate free-flowing river conditions by requiring dam owners to make appropriate financial provisions for future dam removal.

Option: Preserve vegetated headwater lake outlets and natural stream flow regimes by preventing construction of lake-level control structures at these areas. Operate existing lake-level control structures as fixed-crest structures rather than by opening or closing gates or removing stop logs. Incorporate minimum flow requirements into the design of existing fixed-crest lake-level control structures wherever feasible.

Option: Protect the remaining free-flowing nature and connectivity of the river system by preventing construction of new dams and in-line storm water retention basins in the watershed.

Option: Oppose resumption of hydroelectric power generation at old hydroelectric facilities along the river.

Option: Rehabilitate potamodromous fish populations by alteration of the cooling water intake at the Detroit Edison Monroe Power Plant.

Option: If the cooling water intake at the power plant can not be altered, it should be mitigated. Mitigation could involve measures taken to reduce impingement of adult and juvenile fish and entrainment of larval fish and fish eggs. A monetary agreement should be developed to compensate the people of Michigan for fish destroyed at the plant and the loss of recreational fishing opportunity created by the elimination of potamodromous fish runs. These funds could be used to enhance fisheries habitat and recreational benefits in the River Raisin watershed.

Option: The Waterloo Dam should be removed or effective fish passage facilities installed to accommodate upstream and downstream passage of potamodromous and resident fish species, particularly if the cooling water intake situation at the Detroit Edison Monroe Power Plant can be addressed.

Option: Remove the six low-head dams in the City of Monroe to allow movement of potamodromous and resident fish.

Water Quality

Point source water pollution from industrial and municipal sources in the River Raisin watershed has been significantly abated over the past thirty years. Pollution from point sources will continue to be reduced in the future as municipal wastewater treatment plants upgrade their facilities. The greatest remaining factor that degrades water quality in the River Raisin watershed is nonpoint source pollution primarily from agriculture.

Option: Protect and enhance water quality by implementing agricultural nonpoint source best management practices to reduce runoff and erosion. Support necessary incentives to encourage farmers to adopt BMPs and participate in projects managed by the Natural Resource Conservation Service and the local Soil Conservation Districts. Support education at all levels to increase public awareness of agricultural nonpoint pollution problems.

Option: Protect water quality of the river by aggressively adopting storm water management BMPs and enforcing regulations relating to storm water management.

Option: Protect water quality by protecting remaining riparian wetlands, rehabilitating former wetlands, and promoting the construction of new wetlands to act as natural sediment and nutrient filters.

Option: Rehabilitate and protect water quality by supporting the aggressive cleanups of Part 201 sites and LUST sites in the watershed.

Option: Continue to strive for the complete elimination of combined sewer overflows at Adrian, Blissfield, and Dundee and the input of raw sewage to the South Branch at Clayton and at Mooreville on the Saline River.

Option: Seek additional federal and state funding to proceed with the cleanup of PCB hot spots in the Area of Concern and seek funding from the potentially responsible parties.

Option: Existing water temperature data from USGS, MDNR, MDEQ, and other sources should be pooled and evaluated. Survey streams throughout the River Raisin watershed to add to this water temperature database as needed on a priority basis.

Fishery Management

Fishery management of the River Raisin mainstem has been neglected over the years. Past municipal and industrial point source pollution, excess turbidity from intensive agricultural use in the watershed, lack of assured public access, and a very poor public image of the river particularly from Tecumseh to Dundee have combined to discourage fishery management. Enhancement and promotion of angling opportunities on southern Michigan rivers is one of very few remaining frontiers available to fishery managers.

Option: Rehabilitate habitat continuity by removing unnecessary dams. Require both upstream and downstream fish passage facilities at dams that remain.

Option: Rehabilitate the connection to Lake Erie by altering the cooling water intake situation at the Detroit Edison Monroe Power Plant. If this untenable situation cannot be eliminated, it should be mitigated by implementing measures to reduce impingement of adult and juvenile fish and entrainment of larval fish and fish eggs. A monetary settlement should be developed to compensate the people of Michigan for fish destroyed at the power plant and lost fishing opportunity from the elimination of potamodromous fish management in the River Raisin as a viable option. These funds could be used to enhance fishing and other recreational opportunities in the River Raisin watershed and to protect and enhance fisheries habitat.

Option: Provided that the power plant cooling water intake situation is eliminated, the Waterloo Dam should be removed or effective fish passage facilities should be installed to enable upstream runs of potamodromous fish. The six low-head "beautification" dams in the City of Monroe should also be removed to facilitate potamodromous fish runs.

Option: Rehabilitate historic potamodromous fish runs. The fish species best suited are walleye, white bass, channel catfish, and smallmouth bass. Potential rehabilitation of historic runs of lake sturgeon and muskellunge should also be investigated.

Option: Rehabilitate and improve smallmouth bass habitat in the mainstem above Tecumseh and below the confluence of the River Raisin and the Saline River. This work would include rehabilitation of instream woody cover and creation of additional channel diversity. Research from Michigan and other states should be used to design habitat improvement particularly for larger smallmouth bass.

Option: Improve fisheries habitat by increasing flow stability and decreasing erosion by implementing agricultural and storm water best management practices to reduce runoff during precipitation events. Develop a combination of cost-share incentives, education opportunities, tax abatement, and aggressive enforcement when needed to implement these practices.

Option: Improve access to fishery resources by constructing small access sites where needed on the mainstem and on lakes in the northwestern portion of the watershed. Use existing grants to assist in funding the development of these sites.

Option: Continue to stock channel catfish and implement northern pike stocking in the mid-portion of the mainstem between Tecumseh and Dundee. Evaluate results of these stockings.

Option: Improve fish habitat in the River Raisin mainstem below Dundee by cracking spaces and holes in the limestone bedrock substrate or installing cover structures that are capable of withstanding large flow fluctuations.

Citizen Involvement

The greatest impediment to beneficial change in the River Raisin watershed is the poor public image of the river and its major tributaries. This public image and perception of the river must be improved to give people a reason to take pride in the river and to advocate habitat protection and enhancement of water quality and recreational opportunities. An improved public image of the river would promote public stewardship that would act to drive all other beneficial changes. Direct involvement of local citizens with the River Raisin and its watershed is the only way to improve public image and erase negative perceptions.

Option: Support the River Raisin Watershed Council (RRWC), River Raisin Land Trust, Stubnitz Environmental Education Center, and other organizations to promote a public stewardship ethic toward the River Raisin and to build public support for beneficial changes in the watershed.

Option: Support the RRWC, Stubnitz Environmental Education Center, Lenawee Intermediate School District, NRCS, and local Soil and Water Conservation Districts to develop and present educational programs to school children and adult groups in the watershed. These educational programs should focus on benefits of river ecosystems, wetlands, floodplains, instream woody cover, and agricultural best management practices.

Option: Develop and sustain in the public consciousness, the concept that all people who live and work in the watershed have a role in supporting the river ecosystem and can positively affect the river by their actions.

Option: Encourage implementation of river cleanups to give participants a feeling of ownership and pride in the river. Develop guidelines to ensure that these projects are accomplished in an environmentally sound manner; i.e., preserve instream woody cover to the highest practical extent.

Option: Encourage activities to get people out on the river. Once people become acquainted with the river, they will gain respect for the river and a stewardship ethic will develop.

Option: Distribute concise data on fish contaminant concentrations in fish from the River Raisin and provide relative risk management information on eating these fish. This information would combat and eliminate incorrect but widely held perceptions that fish from the River Raisin are highly contaminated and should not be eaten.

Option: Develop and implement river adoption, similar to the highly successful Adopt a Stream program developed by the Huron River Watershed Council. Such programs combine a citizen watch concept with educational information and act to foster citizen involvement and a stewardship ethic.

Option: Encourage formation of a citizen-based organization similar to the Grand River Environmental Action Team (G.R.E.A.T.) to become an advocate for the River Raisin.

Option: Promote a late spring canoe expedition from Brooklyn to Lake Erie to generate public interest and create awareness of the River Raisin. Similar expeditions on the Grand and Huron Rivers were highly successful and received extensive positive media coverage. These river trips have also led to the formation of environmental advocacy groups.

Option: Encourage festivals at towns along the river. Several annual festivals already exist, and these festivals present excellent opportunities to present information to the public and increase awareness and promote interest in the River Raisin.

Option: A core of volunteers should be developed and used to assist the watershed council.

PUBLIC COMMENT AND RESPONSE

The draft assessment was distributed during late fall, 1997. The draft was sent to all district offices of the MDNR and MDEQ in the watershed and selected statewide offices. Copies were distributed to federal, state, and regional agencies as well as all units of local government (townships, villages, and cities) in the watershed. County offices of the Board of Commissioners, Drain Commission, Road Commission, Planning Commission, Parks and Recreation Department, Health Department, NRCS, FSA, and MSU Cooperative Extension Service also received copies. A copy of the draft assessment was sent to the Biology or Science Department of every public high school in the watershed and to all community colleges and universities in the surrounding area. Other organizations receiving copies included the River Raisin Watershed Council, several MUCC offices, the Detroit Edison Company, and several citizen organizations. A letter explaining the purpose of the assessment and requesting review comments was enclosed with all copies.

Copies were sent to public libraries in Adrian (two libraries), Ann Arbor, Blissfield, Brooklyn, Deerfield, Dundee, Manchester, Maybee, Milan, Monroe (2 libraries), Petersburg, Saline, and Tecumseh. It was requested that these copies would be kept in the reference section to assure they would be available. Copies for distribution were available at the Jackson, Ann Arbor, and Lansing Fisheries Division offices. Bound copies of the full assessment were sent to any person or group requesting one. After the complete supply of bound copies was distributed, photocopies of the assessment minus the individual fish species distribution maps (Appendix 1) were sent.

Public meetings to receive comments concerning the draft assessment were held on January 26, 1998, at the Lenawee County Human Services Building in Adrian; January 27, 1998, at Monroe City Hall; and January 29, 1998, at the Manchester Township Hall in Manchester. An MDNR news release was issued on January 15, 1998, regarding the date, time, and location of these public meetings. Every daily and weekly newspaper in the watershed was sent copies of the Executive Summary, Introduction, and Management Options sections of the draft assessment along with notification of the public meetings. Telephone contact was made with all the papers to request their cooperation and provide additional information. A total of approximately fifty people attended the three meetings.

Although the public comment period officially ended on February 27, 1998, comments received up to several weeks after that date were included. All comments received were considered. The suggested change was either incorporated into the final assessment or listed with the reason it was not included.

Introduction

Comment: Various comments were made supporting the watershed assessment process and complimenting the Division on the effort. Reviewers often requested copies of the final assessment.

Response: These comments are acknowledged and appreciated. The final assessment will be distributed similar to the draft. Copies will also be sent to all people who request one.

Comment: Much of the content of this report is good reference material for high school biology students.

Response: One of the goals of the assessment process is to provide an organized reference for people who desire information about a particular aspect of the river system.

Comment: It was difficult to obtain a copy of the draft report. Several people that attended the public meetings had not had an opportunity to read the report. It was suggested at the first public meeting that copies of the Executive Summary should have been distributed at the meetings. In addition, a brief presentation before the public comment period would be helpful.

Response: The distribution the draft assessment was discussed in detail at the beginning of the **Public Comment and Response** section. Although the distribution was extensive, certainly not everyone who desired a copy received one. Suggestions on methods to improve distribution of future draft assessments to the general public would be appreciated.

The person who commented regarding the structure of the meetings attended the first public meeting at Adrian. At that meeting, it was apparent that roughly half of the people had not seen the report. At the remaining meetings (Monroe and Manchester), copies of the **Executive Summary, Introduction,** and **Management Options** were distributed. A thirty-minute presentation tailored to the particular meeting location was given before the public discussion portion.

Comment: "This publication is a comprehensive analysis of the River Raisin from the fish point of view. But fish do not vote, pay taxes, talk, nor read reports. Fish will not be implementing protections and improvements. People are responsible for the causes and the cures. It is people problems that need to be addressed."

Response: This report is an assessment of the River Raisin watershed from primarily a fisheries perspective. However, human activities that continue to affect fish population, habitat, and the general health of the river were discussed at length. The **Management Options** section of the assessment lists activities that people can do to protect and rehabilitate the river and its biological communities. One of the primary goals of the assessment process is to provide an organized approach to assist people in identifying opportunities and solving problems.

Comment: Several errors in spelling, punctuation, and grammar were mentioned.

Response: These errors have been corrected. However: undowteddly a phew wil exkape detecshun?

Geography

No comments were received on this section.

History

Comment: The sentence concerning the ditching and tiling done in Ogden and Riga Townships for agriculture implies that ditching and tiling of wetlands were or are positive actions.

Response: Often landowners and society at large are forced to make value judgments. Activities that benefit a particular land use (such as agriculture) can be detrimental to other concerns. The statement as written is correct. Whether agricultural production is a benefit that justifies related environmental costs depends upon the outlook and interpretation of the reviewer.

Geology and Hydrology

Comment: The water table is dropping in the area surrounding Adrian creating a concern about additional residential development.

Response: Comments on several sections of the draft suggested that increased residential development in portions of the watershed was not discussed adequately. While urbanization is not a major problem when the entire watershed is considered, there are localized areas where residential development has created problems. The most notable of these areas are near Adrian, Tecumseh, and Monroe. An additional discussion of residential development has been added to the final document. Wise land use planning is needed to address potential water supply problems concerned with residential development.

Comment: On page 22 the period of record for USGS gauge stations should be referenced to a USGS publication.

Response: This reference has been added.

Comment: Instead of showing the actual mean monthly discharge for each month (Figure 5), it might be better to show percentages of annual flow during each month.

Response: This comment suggests an alternative method of depicting that stream flow peaks in early spring and is lowest in the late summer. Depicting this concept with actual flow data instead of percentages makes it more readily understood.

Comment: "Figure 6 shows flow duration curves based on record through only 1980. By using the entire period of record for current stations, 16 years of record could be added to the analysis. The period from 1980 to 1996 would add at least one major flood event and a noteworthy drought. We suggest you use all available data. Either of the extreme hydrologic events plus the additional 16 years of data could affect the shape of flow duration curves."

Response: This appears to be an excellent suggestion. However, only one of the five gauge stations would be expected to have significant change when considering all available data. The continuous record stations were discontinued near Tecumseh in 1980 and the Saline River gauge in 1977. Adding an additional 16 years of data to the graph for the River Raisin gauge near Monroe would not be expected to change the graph significantly. The 1980 graph for this gauge is based on 44 years of data. Adding 12 years of data to the 1980 graph of the River Raisin gauge at Adrian (based on 26 years of data) would also not probably produce a significant change in the shape of the flow duration curve. The 1980 graph for the River Raisin gauge at Manchester is based on only 11 years of data. Adding an additional 13 years of data (1985-1997) could make a significant difference. However, the existing figure depicts the concept of flow duration curves very well, and this general concept is more important than the exact shape of the curves.

Comment: A third method of comparing these data (exceedence curves for large and small streams, Figures 6,7,8) is to divide the exceedence discharge values by the drainage area.

Response: This comment suggests an alternative method of standardizing exceedence discharge values for streams of varying size. However, the method used to create the figures and explained in the text is probably more easily understood by readers unfamiliar with hydrology. Also, the method used to develop Figures 7 and 8 is the standard method used in all similar watershed assessments to date.

Comment: "In general, if you really want to show flow instability on a day-to-day basis, consider showing the instantaneous discharge. If you really want to show the effects of hydroelectric flow regulation, show instantaneous rather than daily discharge."

Response: Although instantaneous discharge data (a daily hydrograph) would depict flow variation more dramatically, it is felt that the annual hydrograph (Figure 10) depicts flow variation adequately. Instantaneous flow data would be helpful to depict tremendous artificial flow fluctuation caused by hydroelectric facilities in a peaking mode. Thankfully, the River Raisin is no longer affected by operation of hydroelectric facilities.

Comment: "In the section concerning flooding, we suggest adding a sentence to the effect that if a National Flood Insurance Program flood study has been completed and adopted by the local government entity, the National Flood Insurance Program supersedes the less detailed flood-prone area maps."

Response: This information has been added to the text.

Comment: Page 25, Flooding, 4th paragraph: There is a USGS report that documents the 1982 flooding in the River Raisin watershed. Also, we suggest changing "approximately 1940" to 1937.

Response: The suggested change has been made. A copy of the USGS report mentioned in the comment can be obtained from the U.S. Geological Survey, Water Resources Division, 6520 Mercantile Way, Suite 5, Lansing, MI 48911.

Comment: The report concerning consumptive use and its effects on drought flows in the River Raisin was prepared in 1986. Have the report recommendations been implemented?

Response: According to Jerry Fulcher, one of the authors, there have been little or no changes in water use as a result of this report. Laws concerning irrigation have not been changed (the riparian doctrine prevails), and use of water for agricultural irrigation has increased.

Comment: "Page 27, 2nd paragraph: We suggest changing 'I saw no stream flow' to 'No stream flow was noted'. In addition, how many of the small tributaries listed in Table 6 might have no flow even in wetter years? A good visual might be to add an annual hydrograph for the 1988 water year for one or more of the continuous record gauging stations."

Response: The paragraph has been revised. The implication that many of the small tributaries listed in Table 6 may not have had flow even in wetter years is correct. Stream flow in many of these small tributaries is supported entirely by surface water flow. Low flow (or no flow) conditions during extended periods of minimal precipitation are common in these small streams. Table 6 was derived from actual flow measurements taken throughout the River Raisin watershed during the drought of 1988. The purpose of the table was to depict extreme low flow or complete lack of flow during this particular drought event. The addition of an annual hydrograph for the 1988 water year was not deemed necessary to make this point.

Comment: A map would be helpful in showing the routing of the atypical movement of River Raisin water created by the cooling water intake situation at the Detroit Edison Monroe Power Plant.

Response: This is an excellent suggestion. A sketch has been added (Figure 22).

Comment: "USGS discharge measurements are not necessarily made at the same cross section every visit. For a given stage and condition, the best cross section is selected for each flow measurement. This is why the stream width at a low flow measurement could easily be greater than the width used at median discharge."

Response: This comment explains the apparent anomaly mentioned in the text (width measurement at mean flow was less than width measurement at low flow). The original paragraph has been modified in the final text.

Comment: "Add this option to the Management Options section: Improve the flood prediction accuracy at several sites in the lower portion of the River Raisin. The USGS, National Weather Service, and MDEQ have identified locations where accuracy of flood predictions need improvement."

Response: The suggested option has been added to **Management Options, Geology and Hydrology.**

Comment: "We (USGS) did not find any discussion about the use of real-time stream flow data. The use of these data can aid management decisions, contaminant spill and movement evaluations, and the scheduling of water sampling. This information is widely used by recreationists for canoeing and fishing purposes. About one third of the USGS stream gauging stations in the state, including the River Raisin site near Manchester, are available on the Internet."

Response: This is an excellent suggestion and information concerning the availability of real-time stream flow data has been added to the text.

Channel Morphology

Comment: Natural streams should not be made into "drains" by channelization and dredging.

Response: The negative effects of channelization on natural streams and their inherent biological communities are discussed in detail in **Channel Morphology** and **Special Jurisdictions,** *County Drain Commissioners*. Less disruptive alternatives to traditional drainage practices such as channelization and enclosure need to be developed in cooperation with drain commissioners. The drain code needs to be revised to become more environmentally conscious.

Comment: The islands in the lower river near Monroe are growing. These islands block ice flows and lead to flooding. Therefore, the islands should be removed. Other reviewers supported stabilization of the islands with rock riprap and other techniques to halt erosion.

Response: The islands were created and are maintained by the constant processes of erosion and sedimentation in the lower River Raisin. If the islands were removed, the constant forces that encouraged the creation of the islands would continue. Therefore, islands would probably reform over time. Islands create edge habitat and channel diversity enhancing habitat for fish and other wildlife.

Soil and Land Use Patterns

Comment: Land use is a major public issue that needs to be resolved. The conflict between ownership rights and privileges versus public interest in land use planning and regulation has become a major political issue.

Response: Land use planning and the inherent conflict between private and public interests present major challenges to natural resource managers. In Michigan, land use planning is under the jurisdiction of local governments. This produces a confusing and ineffective patchwork of land use regulations. Enforcement of existing land use regulations is often passive. Comprehensive land use planning is essential to promote wise development and preservation of land and natural resources.

Comment: Money from the Natural Resources Land Trust Fund or other sources should be used to purchase wetlands, floodplains, and riparian wooded areas to be used as nature preserves and parks. Greenbelts along streams should be established and riparians should be encouraged to plant beneficial native trees and shrubs to help combat erosion and benefit wildlife. Wetlands near the river downstream from I-75 near Monroe should be preserved.

Response: The beneficial effects of wetlands, floodplain areas, and a wooded riparian corridor along streams have been discussed at length in the assessment. Public ownership of environmentally sensitive areas is listed as a management option.

Comment: Urban sprawl needs to be identified as a strong threat to this watershed. Agricultural land is being lost to unplanned development.

Response: Urban sprawl and the conversion of prime farmland to residential use are less of a problem in the River Raisin watershed than in more urbanized Lake Erie watersheds such as the Rouge, Clinton, and Huron. However, urban sprawl is becoming an important concern in localized areas near Adrian, Tecumseh, and Monroe. Comprehensive land use planning is needed to promote wise residential and commercial development.

Biological Communities

Comment: The natural features information (Table 12) does not include information from townships in Hillsdale, Jackson, and Washtenaw Counties. Several relevant townships in Lenawee and Monroe Counties are also missing from the table.

Response: The natural features table has been corrected. Additional information on natural features can be obtained from the Natural Features Inventory Section, MDNR Wildlife Division, Lansing.

Comment: A reviewer (high school biology teacher) questions the thoroughness and accuracy of the macroinvertebrate table (Table 13). His students are studying invertebrates and mussels.

Response: The macroinvertebrate table presents the best available information on the River Raisin. However, the title of the table states clearly that this list is preliminary. Management options concerning biological communities include the recommendation of additional studies of aquatic insects and other invertebrates including mussels.

Comment: The fish species distribution maps (Appendix 1) contain inaccuracies particularly concerning the lakes.

Response: The primary emphasis of the fish distribution maps (Appendix) was on streams in the watershed. These maps were made using all available data, particularly the University of Michigan seining and MDNR rotenone survey results along with historic information from the U of M Ruthven Museum of Natural History. However, since data points in the watershed were often widely dispersed, assumptions were made based on best available habitat information and locations of dams and other barriers to fish migration. Several suggested changes to the distribution maps were made.

Fish species distribution in lakes was based on less reliable data and is admittedly incomplete. There was little or no information available for several lakes on the base watershed map. Fish species distributions for these lakes were based on considerations of habitat and fish populations of nearby similar lakes.

Special Jurisdictions

Comment: The legal definition of the term “navigable” and its effects on access and public use issues pertaining to streams and rivers needs to be addressed.

Response: The issue of legal navigability is discussed at length in **Special Jurisdictions.** Legislative adoption of the recreational definition of navigability is advocated in **Management Options**. A proposal to adopt the recreational definition of navigability was added to a recent bill designed to increase penalties for illegal trespass. Unfortunately, this proposal was removed from the bill after opposition from private interests developed.

Comment: Several comments were received supporting the inclusion of the River Raisin mainstem from Brooklyn to Tecumseh in the Natural and Scenic Rivers Program.

Response: Although the mainstem has been impounded at several locations between Brooklyn and Tecumseh, much of the river maintains a natural appearance. People desiring additional information concerning the Natural Rivers Program should contact MDNR, Forest Management Division, 5th Floor, Stevens T. Mason Building, P.O. Box 30452, Lansing, MI 48909-7952.

Comment: The Michigan Department of Agriculture does not “operate” Conservation Districts. This reviewer suggested a revision to more correctly describe the relationship between the Michigan Department of Agriculture and the Conservation Districts.

Response: The text has been revised to correctly describe this relation.

Comment: Several reviewers requested that their addresses, phone numbers, and electronic mail addresses should be added to the table listing governmental agencies (Table 17).

Response: This information is certainly valuable to readers. However, the majority of this information concerning agency addresses, etc. is readily available via phone books, directory assistance, or the Internet.

Comment: EPA reviewers suggested several relatively minor changes be made to the wording in the section regarding Corps of Engineers Section 404 jurisdiction.

Response**:** The suggested changes to increase accuracy were included.

Comment: Clearing of the wooded riparian corridor and brush clearing conducted by drain commissioners needs to be covered in more depth.

Response: Importance of establishment and preservation of a wooded stream corridor, vegetated banks, and instream woody cover is discussed in several sections of the assessment. Destructive effects of traditional practices carried out by drain commissioners and suggestions for mitigation are also discussed in **Special Jurisdictions** and **Management Options**.

Comment: EPA reviewers presented the following option to be added to Management Options. "Seek legislative authority or utilize local initiatives to either expand the jurisdiction and resources of the current River Raisin Watershed Council or create a new entity that has the necessary resources and staff to:
1) Build and maintain the public image of the River Raisin as a natural ecosystem that will simultaneously serve a variety of human needs upon the restoration of some of its natural characteristics. Any environmental results/surveys should be celebrated to keep interest up.
2) Sustain in the public consciousness the concept that all people who live and work in the watershed have a role in detracting from the river ecosystem and can help the river by changing their actions.
3) Assess, plan, and implement measures throughout the watershed to restore the river's natural hydrologic and water quality balances, and restore river-related ecosystems including obtaining and expending funds.
4) Work with and include the needs of all watershed stakeholders including the drain commissioners and municipalities in the context of river system health.
5) Remain extant on a permanent basis to oversee the river system's continued robust health once such a state is achieved."

Response**:** The majority of the objectives of this proposed option are included in **Management Options** in slightly different form. The River Raisin Watershed Council and many agencies and organizations are already working on many of the objectives listed in this proposed option. The key factor stated in the proposed option, and the ingredient that is clearly lacking today, is adequate levels of staff and funding to accomplish what needs to be done. It is probable that inadequate funding levels will continue as people generally oppose increased levels of taxation in any form and larger government. Creation of an additional agency or organization to raise funds and implement projects is not practical in the current political climate.

Recreational Use

Comment: Several reviews stated that lack of public access and logjams impeded use of the river by canoeists and anglers.

Response: These impediments to recreational usage of the river are discussed in the text. Activities to promote recreational use of the river consistent with preserving and rehabilitating its natural character and biological communities should be encouraged.

Comment: The Village of Dundee attempts to make the river a focal point of the community. Barrier-free fishing piers have been constructed recently in parks or both sides of the river. An additional canoe ramp and parking area have been developed downstream of the dam east of M-50. The village president is proud of their recent recreational developments.

Response: The village president and all Dundee citizens should take pride in the community involvement to increase recreational use of the River Raisin.

Comment: Heritage Park on the South Branch in Adrian should be preserved and compatible public use should be encouraged.

Response: The City of Adrian is requesting public comment on a master plan for the future development of Heritage Park. The area near the South Branch will remain in a natural state.

Comment: The second paragraph in Fishing Use includes the statement, "People often regard southern Michigan rivers as polluted and the fish as unfit to eat." This statement could be strengthened by referencing any applicable fish advisories.

Response: Pertinent fish advisories are described in *Water Quality, International Joint Commission, Area of Concern*. These advisories have been updated in the final text. Since the watershed assessments are designed to be updated on a periodic basis, fish advisory information can be added or deleted as necessary in future updates. Current yearly information can be obtained from a brochure published by the Michigan Department of Community Health, available where fishing licenses are sold or by calling 1-800-626-4636.

Dams and Barriers

Comment: The lowhead dams in Monroe should be removed since they form a barrier to upstream migration of fish from Lake Erie. The people in Monroe like the lowhead dams. Removal would necessitate relocation of sanitary sewer lines that are encased in almost every dam. Keep the lowhead dams, since they form a barrier to invasion by gobies and other exotics.

Response: Several comments addressed the lowhead dams in Monroe and these comments revealed a divergence of opinion. Removal of these dams would create both beneficial and detrimental outcomes depending on the point of view of the reviewer. Dam removal was presented in the assessment as a management option to promote public discussion and decision making. Certainly, a comprehensive study of environmental effects (pro and con) and a benefit to cost analysis must be completed before removal of any dams in the watershed. Removal of the lowhead dams would open only a very short additional segment of the River Raisin to invasion of undesirable exotic species or potamodromous fish runs. The Waterloo Dam would continue to act as a barrier to migration further upstream. Also, exotic species often invade upstream areas in the watershed regardless of the presence of barrier dams. Two of the most common methods of dispersal are the movement of boats from affected to unaffected areas of the watershed and transfer in bait buckets.

Comment: The fish ladder at Waterloo Dam is not being properly maintained and is blocked by debris. At one time, the ladder successfully passed fish upstream.

Response: According to the 1997 Dam Safety Inspection Report, the fish ladder is in good condition. The ladder has passed fish upstream as documented by personal observations of reviewers. While it is true that debris is not always removed from the ladder promptly, the ladder's design adds significantly to its inability to pass large numbers of fish upstream. The ladder has insufficient augmented flow to attract fish to the entrance. Therefore, locating the ladder is difficult for fish. Other barriers to migration including the six lowhead dams in Monroe and the cooling water intake at the Detroit Edison Monroe Power Plant further act to deter migration of Lake Erie fish up the river.

Comment: "It is my opinion that fish passage is a concern only when there is a migratory fish population. What is the population? What are the numbers? Where is the benefit/cost analysis?"

Response: It is assumed that this reviewer uses the term "migratory fish population" to describe fish entering and ascending the River Raisin from Lake Erie. However, all fish require several types of habitat throughout their life cycle. Resident stream fish species require very diverse habitats for spawning, nursery, feeding, and escape cover. Also, habitat requirements can vary widely for juvenile versus adult fish and for winter versus summer seasons. Fish require the freedom to move freely from one habitat to another. If this ability to move between required habitats is restricted by barriers including dams, the ability of the fish species to continue to exist in that area is jeopardized. Analysis of benefit to cost ratio and anticipated use of fish passage facilities is required as part of the decision to install them.

Comment: The Village of Dundee uses the water storage capacity behind the dam as a municipal water supply reservoir. Dundee citizens would oppose dam removal. Similar comments were made by reviewers from Adrian (Wolf Creek), Blissfield and Deerfield where the municipal water supply is taken directly from the river. The influence of dams at these locations is particularly important during periods of extreme low flow.

Response: Perhaps dams at Adrian, Blissfield, Deerfield, and Dundee are essential to assure a constant municipal water supply during droughts. This dependence upon dams could possibly be eliminated by redesigning the water withdrawal systems. A comprehensive study of environmental effects and a benefit to cost analysis along with public comment is necessary before the removal of any dams.

Comment: What happens to sediment during and following dam removal?

Response: After engineering studies, dams would be removed in a manner to minimize downstream movement of sediments. Ideally, sediment behind dams can be removed by hydraulic methods or by earth moving machinery before the actual removal of the dam.

Comment: "Riparian owners on the affected impoundments would be expected to oppose dam removals. As a result of removing the dams, riparian landowners would be subjected to accepting the new river location and several years of muck in their front yards as the old river bottom re-establishes itself into the uplands. Who would own this new land? How would it be taxed? Would the MDEQ consider this land as wetlands?"

Response: The reviewer raises important concerns. Clearly, in many cases, riparian owners will oppose dam removals. This opposition will lead to time consuming permitting procedures often culminating in costly court action. However, we must realize that dams are not geologic features in rivers and watersheds. The oldest dam sites in the River Raisin watershed are less than 200 years old. Many of these oldest dams have been rebuilt several times over the ensuing years. There are legal precedents established concerning the reviewer's questions regarding the status of the "new land" created after dam removal.

Comment: "Clearly, the fact that the dams are providing a real function in determining the geomorphology of the river is recognized. The dams are setting the energy guideline, functioning as sediment traps, and most importantly, reducing the upstream erosion by stabilizing the hydraulic guideline."

Response: Geomorphology is the science that treats the general configuration of the earth's surface; specifically the study of the classification, description, nature, origin, and development of landforms and their relation to underlying structures and the history of geologic changes as recorded by these surface features. This definition implies the natural progression of change in the earth's surface over long periods of time. The creation of dams during the last 200 years should be considered as a short term aberration and interruption of long-term natural processes leading to changes in the earth's surface. Dams set the energy gradeline only in that they result in artificial changes to the stream's natural energy gradeline. Dams do indeed serve as sediment traps. This sedimentation leads to premature filling and eutrophication of the impoundments behind the dams. This process often results in shallow impoundments choked with aquatic vegetation that have minimal recreational value. Also, the rapid, turbulent release of water downstream from dams often creates increased erosion. The statement that dams and impoundments reduce upstream erosion may be true in the impounded portion of the stream. However, flooding upstream upland under the impoundment is a very drastic method of curtailing erosion.

Comment: Requiring dam owners to make appropriate financial provisions for future dam removal would be opposed, probably resulting in considerable time and court costs.

Response: This statement is correct. However, in practice when it is generally agreed that a dam should be removed, often the necessary funds are not available. Dam removal must wait for the availability of public funds or grant monies as the dam owner flees and leaves the public holding the bag. This is not right, and could be prevented by requiring dam owners to make financial provisions for future dam removal. The legal principle of requiring the potentially responsible parties to pay for costs is well established.

Comment: "Prior to dam removal, a benefit/cost analysis must be conducted. This analysis must be comprehensive and not just include benefits to fisheries. Further, removal of a single dam will require a new flood insurance study for the entire river."

Response: The reviewer's comments concerning a comprehensive benefit to cost analysis before dam removal are valid. This analysis should consider environmental and social benefits and costs as well as direct costs relating to the dam removal. The final decision should be based on the evaluation of all available information, and public involvement is essential to the decision making process. The removal of a particular dam would require a revised flood insurance study only for the portion of the river that was under the influence of that dam.

Comment: "From what standpoint are culvert placements deemed improper? From a hydraulic standpoint, the culverts may be very proper. If a culvert is perched, then the culvert must be inlet controlled and the invert of the culvert has set the invert of the channel. Before proposing to lower the culvert, a water surface profile analysis should be performed to determine the new equilibrium invert elevations and water surface."

Response: Perched culverts were either placed improperly or result from a stream cutting below the invert of the culvert at the downstream end resulting in a scour hole. Perched culverts are obviously detrimental to movements of fish and aquatic invertebrates. They also create additional maintenance costs to road commissions. As these culverts are replaced, they should be placed at the existing channel bottom or recessed into the channel bed to allow for future downcutting and scouring. This would also allow for a natural stream bottom in the culvert. Other improper culvert crossings create constant erosion and maintenance problems. Fisheries Division prefers bridge or box culvert crossings to corrugated metal pipe culverts. Although it is recognized that initial costs are increased, maintenance costs are reduced. The recommended water profile analysis would be done routinely as part of the engineering involved in proper culvert design.

Comment: The cooling water intake situation at the Detroit Edison Monroe Power Plant should be addressed. The intake should be moved out into Lake Erie.

Response: This alternative was discussed in the text. Use of an offshore velocity cap type of intake was considered by Detroit Edison. Its applicability to the Monroe Power Plant appeared to offer no advantages over the existing intake, since there were no provisions for reducing larval fish entrainment. However, an offshore intake would address the problem of reversing the flow of the river by pumping water upstream from Lake Erie. Detroit Edison states that the existing cooling water intake as modified by the fish diversion system (fish pump) represents site specific best available technology for minimization of impingement losses at the plant.

Comment: Detroit Edison should help pay for fish management and other improvements over the years as mitigation for the cooling water intake situation. Elimination of the Monroe Power Plant cooling water intake is not a viable option. Requiring the utility to pay for fish losses is merely shifting the cost to the electric users and not solving the problem. The cooling water intake kills fish but benefits other life forms. If some use can be made of the "trash" fish destroyed (gizzard shad) in this operation, there is no need to change the method of cooling.

Response: There was a divergence of opinion on this issue as indicated by the preceding comments. However, there is justification and precedent for requiring utility companies to compensate the state for fish losses attributable to their operations. Settlement agreements to mitigate fish losses at the Ludington Pump Storage Facility and at hydroelectric plants on the Manistee, Au Sable, and Muskegon rivers have been developed recently. If settlement agreements can not be formulated, court action could become necessary to develop mitigation measures.

Comment: The real threat to the River Raisin fishery is not Detroit Edison. It is the impairment of beneficial uses cited by the IJC. Edison is not the only reason for these impaired uses.

Response: According to the IJC, the River Raisin fishery has been impaired as follows: loss of fish habitat; restrictions on fish consumption; and degraded fish, phytoplankton, zooplankton, and benthos populations. Certainly, operation of the Monroe Power Plant is not the major reason for these impaired uses. Past and present industrial facilities, landfills, and sediment resulting from agricultural activities in upstream areas are responsible for much of the impairment to beneficial uses in the Area of Concern. However, the cooling water intake at the Monroe Power Plant creates a formidable barrier to potamodromous fish movement between the river and Lake Erie. Impingement and entrainment losses at the plant increase this negative effect.

Comment: "Three studies cited in your report have assessed fish losses at the Monroe Power Plant. The most recent study (May 1985–April 1986) was completed prior to the arrival of the zebra mussel. Depletion of phytoplankton by zebra mussels with the attendant changes in structure of the food chain/web and water clarity has brought about significant changes in the distribution and abundance of fish in Lake Erie. Presently, the number of fish impinged and entrained at the plant would be expected to differ substantially from earlier studies. Observations by plant personnel and other anecdotal information suggest fewer fish are impinged and entrained at the plant today than previous studies would indicate. The gizzard shad is a good example of these changes. Because shad have caused substantial operating problems at the plant in the past, operators visually monitor the number of shad impinged at the plant. They have noted a substantial reduction in shad impingement in recent years. This appears to be related to lesser numbers of shad in Lake Erie because of the reduction in phytoplankton abundance and resultant increase in water clarity of inshore waters. Phytoplankton is the primary diet of yearling and older shad and, like walleye, shad tend to avoid high light intensities seeking areas with higher turbidity and/or depth."

Response: The reviewer makes an excellent point. The invasion of zebra mussels into western Lake Erie waters has had major effects on plankton populations. It is reasonable to conclude that distribution and abundance of fish in these waters have also been affected. The 1985-86 study was used because it provided the most recent information on impingement at Monroe Power Plant. The invasion of zebra mussels and other exotics as well as other potentially important environmental changes occurred after the 1985-86 study was completed. Therefore, new impingement and entrainment studies are needed to provide current information essential in the formulation of a mitigation settlement. Results of future studies can be added to revisions of this assessment. Comments concerning the observed reduction of gizzard shad impinged at the plant combined with the rationale for reduced shad populations in inshore Lake Erie waters seem reasonable. However, a new impingement study is necessary to substantiate or contradict these observations.

Comment: "The company [Detroit Edison] believes your report gives far too much credit to the Monroe Power Plant for the lack of a potamodromous fish spawning run on the River Raisin. To assess whether the Monroe Power Plant sucks up fish migrating up the River Raisin to spawn, the monthly impingement rates from two studies (1982-83 University of Michigan and 1985-86 MDNR) were reviewed. Impingement of potamodromous species during March through May of both study periods (approximately spawning season) was low representing 2-11% of the annual impingement for walleye and 2-4% for white bass. Too few muskellunge were impinged to assess impingement during spawning. Moreover, the seasonal pattern of impingement was consistent with that of non-potamodromous species with low impingement in winter and higher impingement in summer. The seasonal pattern demonstrated by most species mirrors seasonal changes in water temperature in the River Raisin and Lake Erie. There appears to be little evidence from the studies that migrating potamodromous fish are disproportionally affected by the plant."

Response: Certainly there are other factors that limit the potential for potamodromous fish management in the River Raisin besides the Monroe Power Plant. The negative effects of the series of low head dams in Monroe and the Waterloo Dam with its poorly designed fish ladder can not be ignored. However, the cooling water intake at the Monroe Power Plant remains a significant barrier to free movement of fish between Lake Erie and the River Raisin. The upstream pumping of water from Lake Erie and the passage of virtually the entire River Raisin flow through the plant for eventual release to Plum Creek create more of an impediment to free movement between Lake Erie and the river than the actual impingement and entrainment of adult, juvenile, and larval fish.

Comment: "Concern about impingement of potamodromous species should not focus on spawning adults because the low current velocities in the vicinity of the power plant cooling water intake do not challenge the swimming ability of adult fish. Concern should be limited to larval and juvenile fish that may migrate downstream. Downstream migration presumes successful spawning in upstream reaches of the River Raisin. There is reason to doubt, even in the absence of industrial discharges and given removal of the lowhead dams in Monroe, that walleye or other species would be able to successfully spawn in the River Raisin because of siltation resulting from erosion and runoff from the clay loam soils of this primarily agricultural watershed. Presently, even in free-flowing reaches of the River Raisin near Monroe, siltation markedly limits the benthic invertebrate fauna."

Response: While it is true that the River Raisin carries a high sediment load caused by impervious silt and clay soils and enhanced by intensive agricultural land use, this sediment load does not preclude spawning by walleyes, white bass, and other species. Nearby rivers that empty into western Lake Erie receive massive spawning runs of walleye and white bass from the lake. Sediment loads in the rivers, for example the Maumee and Sandusky, appear to be similar to the sediment load of the River Raisin. Also, resident fish including smallmouth bass, rock bass, channel catfish, northern hog suckers, and a wide variety of other species spawn successfully in the lower River Raisin and tributaries. Walleye spawning habitat appears to be excellent in many areas between Monroe and Dundee. If walleye and white bass had free access to the river from Lake Erie, substantial potamodromous spawning runs of these fish would develop.

Comment: "Although not mentioned in your report, it should be noted that Detroit Edison developed and installed a fish rescue system at the Monroe Power Plant to collect live juvenile and adult fish from in front of the travelling screens at the cooling water intake and return them to Lake Erie. At capacity this system, known as the "fish pump" returns approximately 60% of the fish potentially impinged at the plant to the lake. If there were a downstream migration of juvenile potamodromous fish, the fish rescue system would provide a by-pass around the plant for significant numbers of them."

Response: The fish rescue system was not mentioned in the draft assessment because it was working during the 1985-1986 MDNR impingement study. Therefore, the beneficial effects of the "fish pump" were already taken into account in the results of that study. Mention of the fish rescue system has been added to the text.

Comment: "For the last three decades, walleye has been the most important sport fishery in the Michigan waters of Lake Erie. From the near devastation of the mid-1960s, walleye stocks grew to record size in the mid-1980s. Part of that growth was fueled by the abundance of gizzard shad that composed as much as 90% of the walleye diet. Prior to 1950, gizzard shad were relatively uncommon in the western basin of Lake Erie, but by the mid- 1980s gizzard shad were the most common fish. The dramatic increase in gizzard shad probably was the result of increased food supply and the creation of over-winter habitat. Gizzard shad, particularly young-of-the-year, require over-wintering habitat where water temperatures remain above freezing. Historically, shad took refuge in streams tributary to the western basin of Lake Erie in the fall where they remained until spring. This was particularly true of streams that were spring-fed and remained open because the water temperature remained above freezing. Because this type of habitat was limiting, shad in the lake were subject to winter mortality resulting in low recruitment and, consequently, small population size. Construction of power plants increased the available over-wintering habitat in the form of thermal discharges. At the Monroe Power Plant, the discharge canal and thermal plume in Lake Erie are crowded with gizzard shad throughout the winter months (September-May). Higher survival rates of young-of-the-year shad in this discharge, and others like it around Lake Erie, coupled with an abundant food supply are the most probable reasons for the dramatic increase in the abundance of gizzard shad and the walleyes that they support. Any modification of power plant cooling systems at Monroe Power Plant or other generating stations will undoubtedly have a dramatic impact on shad and walleye populations in the western basin of Lake Erie."

Response: Although the reviewer's comments sound reasonable and probably have some merit, the assumed direct relation between more hot water discharges leading to more gizzard shad and eventually more walleyes is certainly not a simple cause and effect relationship. Before the 1970s, the water quality in the western basin of Lake Erie was extremely poor and the lake was commonly referred to as "dead". It is probable that water quality improvements had more to do with the walleye (and gizzard shad) resurgence in Lake Erie than any other single factor. Both walleye and gizzard shad are native to Lake Erie. Historically, walleye thrived in Lake Erie before the construction of power plants with their hot water discharges. The historical abundance of gizzard shad varied considerably, and walleyes thrived in Lake Erie during periods when gizzard shad abundance was low. Hot water discharges do concentrate gizzard shad during the colder portion of the year. This artificial concentration could lead to catastrophic mortalities of shad that would be avoided if the fish were allowed to seek out natural thermal refugia. Gizzard shad abundance has been reduced in the 1990s. A shift from pelagic species such as shad to benthic species such as spottail shiners and silver chubs appears to be occurring as the productivity of the lake decreases. Reduction of phosphorus and other nutrients, and effects of zebra mussels are among the causes of this drop in basic productivity of western Lake Erie waters.

Comment: "On pages 63 through 65 of the report, you describe in some detail the impingement and entrainment studies that have been conducted at Monroe Power Plant as well as interaction between Detroit Edison and MDNR during the late 1970s in pursuit of a possible resolution of the issue. For reasons that are unclear to the company, those discussions were terminated by MDNR without explanation."

Response: A team of MDNR Fisheries Division personnel and other department employees studied impingement and entrainment of fish at the Monroe Power Plant during the 1970s and 1980s. However, every time this team attempted to pursue a particular resolution, follow-through by the department front office was lacking. Ultimately, MDNR personnel decided to concentrate mitigation on the Ludington Pump Storage Facility. Detroit Edison has provided facilities including a parking lot and fishing platforms at the Monroe cooling water discharge canal as part of the Ludington settlement. Now that settlements have been reached regarding the Ludington Pump Storage Facility and hydroelectric dams on the Manistee, Au Sable, and Muskegon rivers, work should be initiated to achieve similar settlements of resource damage issues at the Monroe Power Plant and other power generation facilities. This would require new studies of impingement and entrainment, since biological conditions in western Lake Erie have changed significantly during the past twenty years.

Comment: The company is concerned that a dollar value is assigned to fish losses at the Monroe Power Plant. That information and how it was developed has not been previously shared with the company. The company would like the opportunity to review data and methodology used to develop this estimate and provide a critique and the company's perspective on any such evaluation.

Response: The company's point is valid. The monetary damage estimates presented in the draft assessment represented the best available estimates at that time (1979). However, the use of these fish damage estimates developed with biological data and controversial mathematical models dating back twenty years and more is misleading. Therefore, monetary estimates of fish losses attributable to the Monroe Power Plant have been deleted from the final text. Current estimates using best available data and methodology need to be produced to assist the process of developing a settlement for mitigation of natural resource damages attributable to the operation of the Monroe Power Plant.

Water Quality

Comment: The City of Adrian has periodic CSO events. Raw sewage appears to be dumped into the river frequently.

Response: The retention basin at Adrian has periodic overflows and discharges to surface waters during major precipitation events. The sewage entering surface waters during these overflow events has received primary treatment. Also, occasional power failures at lift stations result in sewage entering the river.

Comment: "Increased levels of fecal coliforms have been documented in the river after major storms. The wastewater treatment facilities and leach fields are over-taxed during storm events with heavy rains and partly treated wastewater is discharged. This issue is national in scope and must be addressed. However, due to the magnitude of storm flows and the escalating cost of pollution control technologies, I do not believe this issue (CSOs) will be resolved for quite some time."

Response: Both the EPA and the state have a policy for eliminating or reducing the magnitude and negative effects of CSOs. NPDES discharge permits require that municipal wastewater treatment systems either separate storm and sanitary sewers or provide adequate treatment of combined sewer wastes. The use of retention basins or short-term detention basins in combination with primary treatment is often selected over complete sewer separation primarily because of cost considerations. Funds are available for CSO elimination from the state revolving fund and ongoing programs will reduce effects of CSOs over time.

Comment: The discussion of point source water quality impairment should reference a map showing the locations of surface water based public water supply systems in the watershed. This would highlight the fact that water pollution has the potential to directly impact human health as well as ecological health, and that both would benefit from pollution prevention and remediation efforts.

Response: The four communities in the watershed that take their municipal water supply directly from surface water sources are Adrian (Wolf Creek) and Blissfield, Deerfield, and Dundee (River Raisin). Adrian, Blissfield, and Dundee are shown on the base watershed map (Figure 1) and all other maps in the assessment. Deerfield is shown on the figure that depicts dam locations (Figure 22). The use of an additional figure to show these four towns was not deemed necessary. This information is also in *Consumptive Water Use, Irrigation*.

Comment: Point source pollution from a sugar beet plant at Blissfield and woolen mills at Clinton caused severe fish kills in the past.

Response: There was documentation of severe fish kills caused by the Blissfield sugar beet plant during the early 1900s. However, the sugar beet plant and the woolen mills at Clinton have been out of business for many years. In general, point source pollution problems are much less severe than in the past. Nonpoint source pollution resulting primarily from agricultural activities poses the most significant challenges to water quality in the watershed today.

Comment: The text states that sediments containing more than 40,000 ppm PCBs will be remediated in an area adjacent to the Ford Motor Company. This clean-up began during the summer of 1997, and its current status should be noted in the text.

Response: The clean-up of the Ford Motor Company "hot spot" was completed in the fall of 1997. The removal of 24,000 cubic yards of contaminated sediment and onsite disposal in a landfill vault was completed at a cost of $6,000,000. This information has been added to the text.

Comment: "The IJC has provided guidelines to delist Areas of Concern. Progress has been made under the River Raisin RAP to implement these guidelines for delisting the River Raisin AOC. Ford Motor Company cleaned up a PCB hot spot in the river, and Detroit Edison Company has contained the Port of Monroe landfill behind an impermeable barrier nearly a mile long from I-75 to the hot water discharge canal. However, Monroe Harbor and the River Raisin estuary are still on the IJC list. Every effort should be made to delist the River Raisin as a Great Lakes AOC using the IJC guidelines and the River Raisin RAP."

Response: Delisting of the River Raisin AOC is premature at this time. Work continues on upland sites (primarily old landfills), and sediment testing this fall will provide final delineation of PCB contamination in the river from the turning basin to the mouth. The area surrounding the PCB "hot spot" will be tested to determine if additional clean-ups are required. Delisting of the River Raisin AOC is a reasonable goal to be achieved over time with continuing rehabilitation.

Comment: "The location and period of record for USGS continuous water temperature data collected in the River Raisin watershed follow: River Raisin near Monroe – 1966-72, 1978-81; River Raisin near Manchester- 1996 to current (not yet available). Also, USGS recorded the water temperature associated with every chemical sample collected between 1978 and 1995 at the River Raisin near Monroe site. The USGS also records the water temperature at the time of most discharge measurements. It would take quite a bit of work, but a long-term temperature database could be established for many sites in the watershed. This sounds like a good project for the watershed council. Water temperature monitoring can be added to any USGS continuous record stream gauging station for $2,000 per year." The MDNR Institute for Fisheries Research has extensive water temperature data available for several streams in the watershed.

Response: Existing water temperature data from USGS, MDNR, and other sources should be pooled and evaluated. A computerized database should be assembled from these data. Then missing information can be determined and additional water temperature studies can be conducted on a priority basis. This is included in **Management Options, Water Quality.**

Comment: Discussion of urban nonpoint source pollution needs to be added. The draft text discusses only agricultural nonpoint pollution.

Response: Although urban nonpoint source pollution is discussed briefly in other sections of the draft text, the reviewer's comment is valid. A brief discussion of urban nonpoint source pollution has been added to the final text.

Comment: Construction activities involving earth disturbance need to be monitored and regulated more effectively. This reviewer expressed concern over control of storm water runoff.

Response: Earth change activities within 500 feet of a lake or stream or involving more than one acre of land are regulated under Act 451, Part 91. Soil erosion and sedimentation control permits are issued by the local unit of government, generally the county drain commissioner, with MDEQ, Land and Water Management Division oversight.

Storm water discharges for construction sites exceeding five acres are regulated under Act 451, Part 31. A state-certified storm water operator is required to inspect site erosion control measures on a weekly basis and within 24 hours after a rain event of enough magnitude to create runoff leaving the site. Oversight of the program is the responsibility of MDEQ Surface Water Quality Division. Municipal storm water permits are issued to cities with population exceeding 100,000. Phase Two of this program will expand the permitting procedure to towns with population exceeding 1000. The municipality is required to submit a storm water management plan designed to minimize storm water effects. This plan should include public education. The storm water manager is a municipal official, and MDEQ, SWQD maintains oversight responsibilities.

Comment: Several reviewers supported the widespread use of agricultural best management practices including education. These BMPs need to be implemented more effectively through educational persuasion and incentives rather than penalties. Farmers should be compensated for taking land out of production for the creation of filter strips and wind breaks.

Response: Agricultural nonpoint source pollution abatement projects and studies show conclusively that widespread adoption of agricultural BMPs would result in significant reduction of erosion and sediment into streams. A combination of education and positive incentives will provide a more effective approach than one of disincentives and penalties. Farmers need to realize that agricultural BMPs are in their own best interest over time.

Comment: "I have a dream. One day the entire watershed down to the last tributary and drainage ditch will be protected by filter strips on both sides."

Response: Agreed! The Lenawee County NRCS office has set a goal to accomplish this feat. The River Raisin Watershed Council continues to fund the establishment of filter strips in Lenawee and Monroe counties.

Comment: Farmers do not deserve all of the blame. Other landowners need to do their part too.

Response: The reviewer makes an excellent point. Misuse, overuse, and improper disposal of fertilizers, herbicides, pesticides, and other chemical products by commercial operators and individual homeowners are serious problems particularly in urban and suburban areas. Education on the proper use of chemicals intended for home use is important.

Comment: Animal wastes are still not being disposed of properly in many instances.

Response: The NRCS and Farm Service Agency (FSA) are actively involved in programs designed to promote the proper disposal and use of animal wastes. These programs include both education and monetary incentives to develop waste management systems.

Comment: The second paragraph on page 71 of the draft text references an enviroscape model that was purchased for educational purposes. The majority of the public does not know what an enviroscape model is. Therefore, it should be described in the text.

Response: A brief description of an enviroscape model has been added to the text. It is an educational tool to visually demonstrate erosion and nonpoint source pollution.

Comment: The correct project title of the project described on page 70 is "River Raisin Main Branch Watershed Project–Section 319 Grant Funds".

Response: The requested correction has been made.

Comment: The section on nonpoint source pollution abatement should include a discussion of section 319 of the Clean Water Act.

Response: A brief discussion of section 319 of the Clean Water Act has been added to the text.

Comment: When roads are plowed, the snow is dumped into the lower river near Monroe along with salts, oils, and other pollutants.

Response: This widespread method of snow removal adds pollutants to rivers and streams in several urbanized areas of the watershed. However, much of this material from impervious surfaces would eventually get to the rivers anyway as the snow melts and water entered storm sewers and drains. Dumping snow directly into the river does cause the pollutants to enter in one large pulse rather than gradually over time.

Comment: Septic system effluent is a problem on lakes and streams.

Response: Septic systems are regulated by county health departments. The effectiveness of these systems can be checked periodically on a complaint basis. Septic systems on new residential or commercial development must meet current standards that are much improved over standards in effect when older residences were built. Proper maintenance of septic systems reduces negative effects.

Comment: Are abnormally low flow situations caused by water withdrawal taken into account when NPDES discharge permits are written?

Response: NPDES permits are written using monthly mean 95% flow exceedence figures over the period of record of applicable USGS stream gauging stations. Abnormal flow situations are taken into account if they are known. Where water withdrawal such as irrigation is relatively constant over a long time, the 95% exceedence figures would include and compensate for irrigation withdrawals. However, problems could occur if irrigation withdrawals increased significantly in a particular area over a short time.

Comment: "The agricultural use of fertilizers, herbicides, pesticides, and other chemicals is creating problems. Chemicals spread on fields are washed into streams via tiled drainage ditches. In this manner, chemicals reach streams faster and in a less diluted condition. A summary and discussion of chemical data is not contained in the report. The USGS has collected chemical, nutrient, and sediment data from 1978 to 1995 at the River Raisin stream gauging station near Monroe. In addition to this periodic sampling, daily sediment records are published for the period of 1966 to 1972 and daily specific conductance records are published for the period of 1978 to 1981. These data were recently analyzed in a comparison study of the River Raisin and Clinton River. Chemical, nutrient, and biological data are being collected at the River Raisin stream gauging station near Manchester. This collection started in 1995 and is scheduled to be completed in 1998. These data will be analyzed in 1998 and 1999."

Response: Chemical, nutrient, and sediment data were mentioned in several sections of the text; and Dr. Baker's work with sediment, nutrient, and pesticide transport in the River Raisin and other Great Lakes tributaries was referenced. A detailed discussion of sediment, nutrient, and chemical data was deemed beyond the scope of this fisheries assessment. For readers who are interested in data relating to chemical, nutrient, and sediment concentrations, Dr. Baker's report is a good reference. Also, USGS personnel can be contacted at U.S. Geological Survey, Water Resources Division, 6520 Mercantile Way, Suite 5, Lansing, MI 48911.

Fishery Management

Comment: A reviewer believes the quality of fishing near Dundee has declined over the years. He used to catch high numbers of rock bass and bluegills.

Response: Bluegills, rock bass, and other game fish are still available at Dundee. Improvements in water quality over the past forty years have doubtlessly improved fish populations near Dundee. For example, the sugar beet plant in Blissfield in the early 1900s caused significant fish kills in the river between Blissfield and Dundee. Luckily, human nature and the natural aging process allow us to remember good days in the past and forget less productive outings. However, for many hunting and fishing endeavors in Michigan the "good old days" are now.

Comment: Potamodromous fish are mentioned throughout the report. However, potamodromous is not in my Funk and Wagnalls, nor could the Monroe Public Library System find the word. I suggest that potamodromous be defined or replaced with a word that can be understood by all.

Response: Potamodromous is defined in the Glossary. However, the reviewer's point is well taken. The first use of the word in the text is now followed by a brief definition.

Citizen Involvement

Comment: A high school biology teacher agreed with the statement that poor public image of the river is a major impediment to full use and appreciation of the river. His students' initial perception of the river is that it is grossly polluted. As the river's image is improved, people will take more pride in the river and an attitude of advocacy and stewardship will develop.

Response: These points are stressed in the text. The only way to improve the river's image with local citizens is to stress education on the river's quality to young people and adults. Also, any activities that get people out on the river and involved are essential.

Comment: More emphasis is needed on developing river partnerships in the Citizen Involvement section.

Response: In this time of reduced staffing and budgets, it is evident that government agencies can not do the job alone. Partnerships are essential. Involving local organizations and area citizens in projects to benefit the river has the added advantage of enhancing stewardship for the river.

Comment: The River Raisin Remedial Action Plan Public Advisory Committee was not included in the Citizen Involvement section or in Table 26. This group has several education and outreach proposals that could be discussed.

Response: This oversight has been corrected. This committee has recently received a grant from the EPA to equip a bus as an environmental laboratory. This mobile lab will be used in conjunction with Monroe Public Schools and projects will be added to the school curriculum. The committee has produced a video series concerning environmental issues in the Monroe area and the Ford Motor Company "hot spot" remediation. These videos are used by the local PBS station.

Comment: Addresses, telephone numbers, and e-mail addresses should be added to the table listing private organizations with an interest in the River Raisin watershed (Table 26).

Response: Information for many of these organizations is readily available from telephone directories or on the Internet. Other less organized groups have constant turnover in their leadership positions. Such information would quickly be out of date and of little use.

Comment: A core of volunteers should be developed and utilized to assist the watershed council.

Response: This suggestion has been added to **Management Options, Citizen Involvement**.
Comment: Include scientific demonstrations at points along the course of river trips mentioned in Management Options, Citizen Involvement.

Response: This was attempted on a large scale during the Huron Riverfest, a similar canoe flotilla organized on the Huron River in 1993. Although the canoe flotilla was an unqualified success, the educational exhibits available at many of the planned stops were not particularly well received, and agency displays were virtually ignored. The voyageur canoes that accompanied the flotilla did create additional interest and media coverage.

Management Options

Comments: The ramifications of the proposed management options should be thoroughly investigated and included as an integral part of the watershed assessment. Cost estimates for each of the options should be provided and funding sources identified.

Response: The management options are a list of alternative actions that will serve to protect, rehabilitate, and enhance the river system. Management options listed are intended to provide a foundation for public discussion, setting of priorities, and embarking on a process of planning the future of the river system. Thorough analysis of all options (90) including a benefit to cost analysis is far beyond the scope of this assessment. Also, benefit to cost estimates developed now could be obsolete by the time the particular option is implemented.

GLOSSARY

ammocete- the larval form of lampreys

base flow- ground water discharge to a stream system

basin- a drainage area, both land and water, from which water flows toward a central collector such as a stream or lake at a lower elevation; synonymous with watershed

benthos- plants and animals living on the bottom of streams, rivers, and lakes

biodiversity- the number and type of biological organisms in a system

biota- animal and plant life

catostomid- species of fish in the Catostomidae family, generally suckers and redhorse sucker species

centrarchid- species of fish in the Centrarchidae family, generally the sunfishes, crappies, and basses

cfs - cubic feet per second, a common measurement of stream or river water flow

channelization- a process of altering natural stream channels by straightening, widening, and deepening to improve drainage

channel morphology- a study of the structure and form of stream and river channels including width, depth, and bottom type

cobble- naturally rounded stones larger than pebbles and smaller than boulders arbitrarily limited to a size of two to ten inches in diameter

conservation easement- an agreement where a landowner receives financial benefits or tax abatements for conducting conservation practices or agreeing not to farm or develop environmentally sensitive portions of the property

conservation tillage- a form of non-inversion tillage that retains protective amounts of residue mulch on the soil surface throughout the year

cyprinid- species of fish in the Cyprinidae family, generally the carp, goldfish, and minnow species

deciduous- vegetation that sheds its foliage annually

ecosystem- a biological community considered together with the non-living factors of its environment as a unit

electrofishing- a process of putting an electric current through water to stun and collect fish

emergent aquatic vegetation- rooted aquatic plants that grow in shallow water with most of the plant protruding above the water surface

entomologist- one who specializes in the study of insects

entrainment- a process of carrying all fish life stages, primarily fish eggs and larval fishes, into a power plant in the cooling process water

eutrophication- a process of becoming increasingly rich in nutrients either as a natural phase in the maturation of a body of water or artificially enhanced by human use such as agriculture or waste disposal

exceedence curves- the probability of a discharge exceeding a given value

exotic species- successfully reproducing organisms transported by humans into regions where they did not previously exist

extirpation- to make extinct, remove completely

fauna- animals of a specific region or time

fixed-crest- a dam that is fixed at an elevation and has no ability to change from that elevation

flashy- streams and rivers characterized by rapid and substantial fluctuations in stream flow

glacial outwash- gravel and sand carried by running water from the melting ice of a glacier and laid down in stratified deposits

glacial till- an unstratified, unsorted glacial drift of clay, sand, gravel, cobble, and boulders

hydraulic diversity- the variability of water depths and velocities in a stream or river channel

hydrograph- a graph of stream discharge plotted against time

hydrology- the science dealing with the properties, distribution, and circulation of water

ictalurid- species of fish in the Ictaluridae family, generally the catfishes, bullheads, and madtoms

impingement- a process of physically capturing juvenile and adult fishes on screens designed to prevent debris from entering a power plant along with process cooling water

impoundment- an artificial body of water created behind a dam

indicator species- a plant or animal species that has very specific habitat requirements; hence, its presence indicates a restrictive habitat requirement is being satisfied

indigenous- a species that is native to a particular area

infiltration- a process of water moving through soil particles

invertebrate- an animal having no backbone or internal skeleton

lacustrine- pertaining to lakes

lake-level control structure- low-head dam placed in the outlet of lakes to control the lake level

loam- a soil consisting of an easily crumbled mixture containing from 7 to 27 % clay, 28 to 50 % silt, and less than 52 % sand

macroinvertebrate- animals without a backbone that are visible to the naked eye

macrophyte- an aquatic plant species that is visible to the naked eye

mainstem- mainstream

meander- a winding, curving stream segment

moraine- a mass of rocks, gravel, sand, clay, etc. carried and deposited directly by a glacier

nonpoint source pollution- pollution to a water course that is not attributable to a single, well-defined source, e.g. sediment resulting from poor agricultural practices

no-till- planting is in narrow slots opened by a narrow chisel, fluted, ripple, or smooth coulter, or other device in undisturbed residue of the previous crop, cover crop, or strawy manure

oligotrophic- lakes that have little plant nutrients and have abundant dissolved oxygen

peaking mode- operational mode for a hydroelectric project that maximizes economic return by operating at maximum capacity during peak demand periods (generally 8 a.m. to 8 p.m.) and reducing operations and discharge during non-peak periods

perched culvert- improperly placed culvert that fragments habitat by creating a significant drop between the culvert outlet and the stream surface

permeable- soils with coarse particles that allow passage of water

point source pollution- pollution to a water course that is attributable to a single, well-defined source, e.g. outfall of a wastewater treatment plant

potamodromous- fish that migrate from fresh water lakes up fresh water rivers to spawn; in the context of this report it refers to fish that migrate into the River Raisin from Lake Erie

riffles- a shallow area extending across the bed of a stream where water flows swiftly so that the surface is broken in waves

riparian- adjacent to or living on the bank of a river; also refers to the owner of stream or lakefront property

rotenone- a natural substance found in roots of plants in the pea family; it is used as a toxicant to all gill breathing animals; it is not toxic to air breathing animals

rubble- large broken pieces of rock in stream and river beds

run-of-the-river- instantaneous inflow of water equals instantaneous outflow of water; this flow regime mimics the natural flow regime of a river on impounded systems

run habitat- fast non-turbulent water

salmonid- species of fish in the Salmonidae family, generally the trout, salmon, and whitefishes

sedimentation- a process of depositing silt, sand, and gravel on a stream or river bottom

Shannon-Weiner diversity index- a probability statistic that measures the number of groups of information in all the information

taxa- groups of organisms constituting one of the categories or formal units in scientific classification

tile- underground enclosed drainage systems generally installed for drainage to facilitate agriculture

topography- the configuration of the earth's surface including its relief and the position of its natural features

tributary- a smaller stream feeding into a larger stream, river, or lake

turbid- water that has large amounts of suspended sediments in the water column

watershed- a drainage area or basin, both land and water, from where water flows toward a central collector such as a stream, river, or lake at a lower elevation; synonymous with basin

wetland- those areas inundated or saturated by surface or ground water at a frequency and duration enough to support types of vegetation typically adapted for life in saturated soil; includes swamps, marshes, and bogs

young-of-the-year- fish that were born during this calendar year

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Table 1.–Number of archaeological sites (654) in the River Raisin drainage, listed by congressional township. Data from: B. Mead, Office of the State Archaeologist, personal communication.

County	Township	Number of sites
Jackson	T2S, R1E	1
	T2S, R2E	1
	T3S, R1E	8
	T3S, R2E	2
	T4S, R1E	10
	T4S, R2E	5
Washtenaw	T3S, R3E	3
	T3S, R5E	6
	T3S, R6E	9
	T4S, R3E	8
	T4S, R4E	4
	T4S, R5E	11
	T4S, R6E	10
Lenawee	T5S, R1E	12
	T5S, R2E	35
	T5S, R3E	20
	T5S, R4E	17
	T5S, R5E	6
	T6S, R1E	14
	T6S, R2E	32
	T6S, R3E	23
	T6S, R4E	13
	T6S, R5E	6
	T7S, R2E	19
	T7S, R3E	18
	T7S, R4E	11
	T7S, R5E	9
	T8S, R2E	5
	T8S, R3E	16
	T8S, R4E	9
	T8S, R5E	2
	T9S, R1E	1
	T9S, R2E	2
Monroe	T5S, R6E	16
	T5S, R7E	10
	T6S, R6E	41
	T6S, R7E	66
	T6S, R8E	109
	T6S, R9E	11
	T7S, R6E	20
	T7S, R7E	7
	T7S, R8E	5
	T7S, R9E	21

Table 2.–Geology data for the River Raisin watershed. Data from: ERDAS database, P. Seelbach, Michigan Department of Natural Resources, Fisheries Division. See Figure 4 for locations. Blanks indicate a value of zero. Numbers are percentages.

Location	Lacustrine clay & silt	Lacustrine sand & gravel	Glacial outwash sand, gravel, & postglacial alluvium	Fine textured glacial till	End moraines fine textured till	Medium textured till	End moraines medium textured till	Coarse textured gravel till	End moraines coarse textured till
a	19.6	3.2	17.4	9.3	49.2	1.3			
b	18.4	12.4	15.6	8.4	44.1	1.2			
c			10.0	34.8	45.1				10.0
1			37.1				1.4	26.7	34.8
2			43.1				0.9	25.9	30.0
3			45.6			2.8	0.8	22.8	27.9
4			44.2		4.7	4.4	0.7	20.7	25.3
5			38.8	6.1	14.1	2.8	0.4	13.2	24.6
6	0.1		29.2	15.5	28.2	1.6	0.3	7.6	17.6
7	0.1	2.0	28.5	15.3	27.9	1.6	0.2	7.4	17.1
8	14.7	7.0	20.6	11.3	27.7	1.1	0.2	5.2	12.2
9	17.1	12.8	18.4	10.1	24.9	1.0	0.2	4.7	10.9
10	25.6	12.0	15.2	8.2	27.0	0.8	0.1	3.3	7.7
11	26.0	12.4	15.0	8.1	26.7	0.8	0.1	3.3	7.6
12	26.3	12.5	14.9	8.1	26.5	0.8	0.1	3.2	7.5
d	63.9	2.8		5.6	27.8				
e	35.8	12.2	1.6	2.8	47.6				
f	53.5				46.5				
g	82.9	4.1			13.0				

Note: The geological groups are expressed as a cumulative figure within the watershed. The geology value given for a specific location includes the entire watershed upstream from that point. For example, the value for location 9 (Dundee) for lacustrine clay & silt means that 17.1% of the geology in the River Raisin watershed upstream from Dundee is lacustrine clay & silt geology.

Table 3.–Soil type data for the River Raisin watershed. Data from: ERDAS database, P. Seelbach, Michigan Department of Natural Resources, Fisheries Division. See Figure 4 for locations. Blanks indicate a value of zero. Numbers are percentages.

	Soil type					
Location	Clayey	Loamy	Loamy on sand/gravel	Sandy	Wet clayey	Wet loamy
a	52.1	2.9	25.4		2.3	17.4
b	46.7	2.6	22.8	1.2	2.0	24.8
c	51.7		6.1		28.7	
1		54.3	39.8			
2		35.0	60.3			
3		30.8	65.1			
4	5.1	28.4	62.8			
5	19.2	17.9	54.3		5.1	0.6
6	32.1	10.3	34.6		13.3	2.7
7	32.1	10.0	33.5		12.9	4.7
8	30.0	7.1	23.9		25.4	6.3
9	26.8	6.3	21.3	1.9	23.5	13.6
10	26.6	4.8	18.7	2.0	23.7	19.4
11	26.3	4.8	18.5	2.0	23.4	20.4
12	26.1	4.7	18.4	2.0	23.3	20.9
d	72.2				19.4	
e	43.3				37.8	1.2
f	27.2		13.2		36.8	22.8
g	13.0				52.0	35.0

Note: Soil type is expressed as a cumulative figure within the watershed. Soil type value given for a specific location includes the entire watershed upstream from that point. For example, the value for location 9 (Dundee) for clayey soils means that 26.8% of the land in the River Raisin watershed upstream from Dundee has clayey soils.

Table 4.–Land use data for the River Raisin watershed. Data from: ERDAS database, P. Seelbach, Michigan Department of Natural Resources, Fisheries Division. See Figure 4 for locations. Blanks indicate a value of zero. Numbers are percentages.

	Land use type					
Location	Urban	Agriculture	Hardwood forest	Water	Forested wetland	Non-forested wetland
a	6.4	91.3	2.3			
b	5.8	91.4	2.9			
c	2.5	94.9	1.2	1.0	0.5	
1	1.8	85.5	0.9	5.9	4.1	1.8
2	1.2	82.2	5.0	4.7	5.2	1.7
3	1.0	83.6	5.1	4.1	4.6	1.5
4	0.9	85.1	4.7	3.7	4.2	1.4
5	2.3	85.1	5.6	2.9	2.9	1.2
6	2.5	89.0	4.0	2.0	1.9	0.7
7	2.5	89.2	3.8	2.0	1.8	0.7
8	1.8	91.9	3.0	1.6	1.3	0.5
9	1.6	92.7	2.6	1.5	1.1	0.4
10	1.9	93.5	2.4	1.0	0.8	0.3
11	1.9	93.6	2.4	1.0	0.8	0.3
12	1.9	93.7	2.3	1.0	0.8	0.3
d		100.0				
e		97.2	1.2	1.6		
f		98.2	1.8			
g		100.0				

Note: Land use type is expressed as a cumulative figure within the watershed. The land use value given for a specific site includes the entire watershed upstream from that point. For example, the value for location 9 (Dundee) for agriculture means that 92.7% of the land in the River Raisin upstream from Dundee is in agricultural land use.

Table 5a.–Seasonal water withdrawals for the River Raisin watershed, 1984. Data from: Fulcher et al. 1986.

Type of withdrawal	Withdrawals (cfs)				
	May	June	July	August	September
Irrigation	4.31	17.83	44.22	32.36	8.92
Self-supplied industrial	10.67	12.40	13.34	14.67	11.02
Public supply	12.64	16.32	15.80	15.80	13.06
Power generation	0	0	0	0	0

Table 5b.–Effects of consumptive use (cfs) on the River Raisin flow at four locations. Data from: Fulcher et al. 1986.

Location	Drainage area square miles	95% exceedence flows before consumptive uses			Consumptive uses			95% exceedence flows after consumptive uses		
		June	July	Aug	June	July	Aug	June	July	Aug
R. Raisin near Manchester	132	25	13	9.8	-5.2	-11	-8.5	20	2	1.3
R Raisin upstream S. Br. R. Raisin	270	49	34	28	-7.7	-18	-13	41	16	15
R. Raisin upstream of Black Creek	467	73	56	45	-8.1	-18	-14	65	38	31
R. Raisin near Monroe	1042	120	64	45	-6.8	-23	-14	110	41	31

Table 6.–Flow measurements taken at various locations in the River Raisin watershed during the 1988 drought. Data from: D. Hamilton, Michigan Department of Environmental Quality, Land and Water Management Division, personal communication. Dashes indicate flow measurement not taken.

			Flow in cubic ft/sec	
Stream	Location	TRS	06/21/88	07/13/88
River Raisin	Wolf Lake Road	04S 02E 08	5.88	5.43
River Raisin	Mill Road	04S 02E 03	1.13	2.96
River Raisin	Sharon Valley Road	03S 03E 33	7.06	4.02
River Raisin	Gage #1756(Manchester)	04S 03E 02	8.51	7.72
River Raisin	Dam at M-52 (Manchester)	04S 03E 01	--	0
Trib. to River Raisin	Austin Road	04S 03E 12	--	1.21
River Raisin	Allen Road	04S 04E 32	18.50	14.30
Iron Creek	Bartlett Road	04S 04E 29	3.36	--
River Raisin	Gage #1757 (Tecumseh)	05S 04E 34	39.00	30.40
S. Br. River Raisin	Adrian	06S 03E 35	12.90	3.38
S. Br. River Raisin	Carleton Road	07S 03E 15	--	2.84
River Raisin	Gage #1756 (Adrian)	06S 04E 32	58.30	44.00
River Raisin	Blissfield	07S 05E 31	60.30	--
Black Creek	Bruce Hwy.	08S 04E 04	--	0.17
River Raisin	Dundee	06S 06E 13	51.40	11.90
N. Br. Macon Creek	Wilcox Road	06S 06E 11	0.19	0
Swamp Raisin Creek	Petersburg Rd.	06S 06E 22	--	0
Swamp Raisin Creek	Larabee Road	06S 05E 27	--	0
Little River Raisin	Petersburg Road	06S 06E 22	--	0
Schroeder Brook	Pocklington Road	06S 05E 14	--	0
Chauncy & Dibble Dr.	Hoaglund Hwy.	06S 05E 14	--	0
Bear Creek	E. Horton Road	08S 04E 04	--	0
Bear Swamp Creek	Oelke Road	05S 06E 36	0	--
N. Br. Macon Creek	Couper Road	05S 06E 26	0	--
N. Br. Macon Creek	Hack Road	05S 06E 05	0.10	--
Saline River	Maple Road (Gage #1764)	04S 06E 18	14.00	11.20
Wolf Creek	Wolf Creek Hwy.	06S 03E 33	--	1.75

Table 7.–Gradient of River Raisin mainstem from Lake Erie to headwaters. Data from: U.S.G.S. topographic maps, P. Seelbach and G. Whelan, Michigan Department of Natural Resources, Fisheries Division.

River miles (cumulative)	Distance in miles (to next upstream point)	Gradient ft/mi	Comments
0	3.07	3.31	Lake Erie to impoundment
3.07	2.98	3.31	Six impoundments
6.05	1.14	4.39	595 ft contour
7.19	1.11	4.49	Raisinville Road
8.31	2.43	2.06	605 ft contour
10.74	0.96	5.19	610 ft contour
11.70	1.32	3.79	615 ft contour
13.02	0.58	8.68	Ida-Maybee Road
13.60	0.16	0.90	Grape Impoundment
13.76	1.61	0.90	Grape Impoundment
15.37	3.80	0.90	River above Grape Impoundment
19.17	2.96	1.69	630 ft contour
22.13	1.51	1.11	635 ft contour
23.64	1.63	1.11	Dundee Impoundment
25.27	10.38	1.11	Above Dundee Impoundment
35.65	3.55	1.41	650 ft contour
39.20	7.74	0.65	655 ft contour
46.94	4.41	1.13	660 ft contour
51.35	6.03	0.96	Below Blissfield Dam
57.37	1.81	0.96	Blissfield Impoundment
59.18	7.86	0.96	675 ft contour
67.04	4.54	1.10	680 ft contour-Penn Central RR
71.57	3.83	1.31	685 ft contour
75.40	5.87	1.70	690 ft contour
81.27	2.86	3.49	Laberdee Road
84.14	4.54	1.32	Suffon Road-710 ft contour
88.68	3.01	1.32	720 ft contour
91.69	1.20	8.33	Mill Highway
92.89	0.73	13.76	730 ft contour
93.62	0.26	38.02	740 ft contour
93.88	0.02	12.27	750 ft contour
93.90	0.02	12.27	760 ft contour
93.92	0.26	12.27	Globe Impoundment
94.18	0.59	12.27	Between Standish & Globe Impds
94.76	0.21	12.27	Standish Mill Pond
94.97	0.54	12.27	Above Standish Impoundment
95.50	0.01	4.29	Below Red Mill Pond
95.52	1.37	4.29	Red Mill Pond-780 ft contour
96.88	0.95	4.29	Above Red Mill Pond
97.83	2.96	3.38	Newburg Road
100.79	1.54	6.51	Clinton-790 ft contour
102.33	0.01	5.15	800 ft contour

Table 7.–Continued.

River miles (cumulative)	Distance in miles (to next upstream point)	Gradient ft/mi	Comments
102.34	0.70	5.15	Clinton Impoundment
103.04	3.17	5.15	820 ft contour
106.21	1.77	5.64	Wilbur Road
107.99	2.90	3.44	Wallace Road
110.89	1.37	7.28	840 ft contour
112.26	1.10	9.13	Austin Road - 850 ft contour
113.36	0.05	21.90	Downstream Manchester Ford Impd.
113.41	1.16	21.90	890 ft contour
114.56	0.16	21.90	Between Manchester Impoundments
114.73	0.01	1.79	Manchester Mill Pond Dam
114.73	0.75	1.79	Manchester Mill Pond
115.48	4.83	1.79	900 ft contour
120.31	0.02	3.25	Sharon Hollow Dam
120.33	1.04	3.25	Sharon Hollow Impoundment
121.37	2.02	3.25	910 ft contour
123.39	3.50	2.86	Pierce Road
126.89	1.38	7.23	920 ft contour
128.27	0.02	1.76	Norvell Dam
128.29	1.94	1.76	Norvell Impoundment
130.24	3.72	1.76	Palmer Road
133.95	0.39	25.77	Case Road
134.34	0.02	4.74	Brooklyn Dam
134.37	4.20	4.74	Brooklyn Impd.-970 ft contour
135.72	1.35	7.41	MIS, contour 980 ft
137.83	2.11	4.74	US-12, contour 990 ft
139.07	1.24	8.06	Miller Hwy., contour 1000 ft
141.18	2.11	4.74	Contour 1010 ft
141.44	0.26	38.46	Sanford Road, contour 1020 ft
142.23	0.79	12.66	Parkhurst Hwy., contour 1030 ft
142.77	0.54	18.52	Contour 1040 ft
143.72	0.95	10.53	Headwater, contour 1050 ft

Table 8.–River Raisin mainstem and major tributary cross-section data summary. Expected width was calculated using average width of rivers with the same mean discharge. Hydraulic diversity index was calculated using the Shannon-Weiner diversity index. Data from: S. Bloomer, United States Geological Survey - gauge data and miscellaneous measurements.

Waterbody	Location	Measured flow (cfs)	Mean flow (cfs)	Actual width (ft)	Expected width (ft)	Hydraulic diversity index	Index rating
River Raisin	Palmer Road	15.3				1.50	poor
River Raisin	Manchester gauge	93	107	28	57	1.73	fair
River Raisin	Wilbur Road	119				2.16	good
River Raisin	Tecumseh M-50	179				2.48	good
River Raisin	Tecumseh gauge	118	182	55	74	2.44	good
River Raisin	Adrian gauge	97	340	63	101	1.51	fair
River Raisin	Blissfield@US-223	180				2.22	good
River Raisin	Dundee@M-50	217				1.67	fair
River Raisin	Ida-Maybee Rd. gauge		741	194	149		
Wolf Creek	Adrian WWTP	8				1.43	poor
S.Br. R.Raisin	Adrian gauge	16	131	44	68	1.17	poor
Black Creek	Jasper	12				1.04	poor
Saline River	Maple Rd. gauge	22	64	32	44	1.00	poor
Saline River	Bigelow Road	30				0.78	poor

Note: Available information for cross section analysis is inadequate in River Raisin watershed. Available flow measurements are taken during extreme low flow periods and actual widths are taken at USGS gauge stations.

Table 9.–Soils of the River Raisin basin. Data from: Michigan Water Resources Commission 1965.

Soil association	Glacial origin	Texture	Natural drainage
Thomas, Wisner, Bono, Toledo	lake bed plains and lacustrine deposits	loams	wet
Nappanee, Hoytville, Pewamo	lake bed plains and lacustrine deposits	clay loams, silty clays, clays	wet
Macomb, Berville, Rimer, Wauseon, Colwood	lake bed plains and lacustrine deposits	clay loams, silty clays, clays	wet
Brady, Sebewa	lake bed plains and lacustrine deposits	loams, sandy loams, loamy sands	wet
Berrien, Plainfield, Allendale, Wauseon, Colwood	lake bed plains and lacustrine deposits	loamy fine sands, fine sandy loams	wet
Blount, Pewamo, Napanee	till plain	clay loams, silty clay loams, clays	imperfect to poor
Morley, Blount, St. Clair, Nappanee	till plain	clay loams, silty clay loams, clays	well to imperfect
Miami, Hillsdale, Brookston	till plain	loams	well to imperfect
Bellefontaine, Hillsdale, Coloma	moraines	sandy loams, loamy sands	dry
Fox, Oshtemo, Bronson	outwash	sandy loams	dry

Table 10.–List of fishes in the River Raisin watershed. Data from: Smith et al. 1981; Towns 1985; C. Latta, University of Michigan, personal communication. Common family names are in bold print. Origin: X = native, C = colonized, I = introduced. Status: O = extirpated, P = recent observations, U = historic record-current status unknown, E = Lake Erie, found in impingement study, Detroit Edison Monroe Power Plant.

Common name	Scientific name	Origin	Status
Lampreys			
Northern brook lamprey	*Ichthyomyzon fossor*	X	P
Silver lamprey	*Ichthyomyzon unicuspis*	X	P
American brook lamprey	*Lampetra appendix*	X	P
Sturgeons			
Lake sturgeon	*Acipenser fulvescens*	X	O
Gars			
Longnose gar	*Lepisosteus osseus*	X	P
Bowfins			
Bowfin	*Amia calva*	X	P
Mooneye			
Mooneye	*Hiodon tergisus*	X	E
Freshwater eels			
American eel	*Anguilla rostrata*	C	U
Herrings			
Alewife	*Alosa pseudoharengus*	C	E
Gizzard shad	*Dorosoma cepedianum*	X	E
Minnows			
Central stoneroller	*Campostoma anomalum*	X	P
Goldfish	*Carassius auratus*	I	P
Spotfin shiner	*Cyprinella spiloptera*	X	P
Common carp	*Cyprinus carpio*	I	P
Striped shiner	*Luxilus chrysocephalus*	X	P
Common shiner	*Luxilus cornutus*	X	P
Redfin shiner	*Lythrurus umbratilis*	X	P
Silver chub	*Macrhybopsis storeriana*	X	E
Hornyhead chub	*Nocomis biguttatus*	X	P
River chub	*Nocomis micropogon*	X	P
Golden shiner	*Notemigonus crysoleucas*	X	P
Bigeye chub	*Notropis amblops*	X	O
Pugnose shiner	*Notropis anogenus*	X	U
Emerald shiner	*Notropis atherinoides*	X	P
Silverjaw minnow	*Notropis buccatus*	X	P
Blackchin shiner	*Notropis heterodon*	X	P
Blacknose shiner	*Notropis heterolepis*	X	P
Spottail shiner	*Notropis hudsonius*	X	P
Silver shiner	*Notropis photogenis*	X	P
Rosyface shiner	*Notropis rubellus*	X	P

Table 10.–Continued.

Common name	Scientific name	Origin	Status
Minnows continued			
Sand shiner	*Notropis stramineus*	X	P
Mimic shiner	*Notropis volucellus*	X	P
Pugnose minnow	*Opsopoeodus emiliae*	X	P
Southern redbelly dace	*Phoxinus erythrogaster*	X	P
Bluntnose minnow	*Pimephales notatus*	X	P
Fathead minnow	*Pimephales promelas*	X	P
Blacknose dace	*Rhinichthys atratulus*	X	P
Creek chub	*Semotilus atromaculatus*	X	P
Suckers			
Quillback	*Carpiodes cyprinus*	X	E
White sucker	*Catostomus commersoni*	X	P
Creek chubsucker	*Erimyzon oblongus*	X	P
Lake chubsucker	*Erimyzon sucetta*	X	P
Northern hog sucker	*Hypentelium nigricans*	X	P
Spotted sucker	*Minytrema melanops*	X	P
Silver redhorse	*Moxostoma anisurum*	X	P
Black redhorse	*Moxostoma duquesnei*	X	P
Golden redhorse	*Moxostoma erythrurum*	X	P
Shorthead redhorse	*Moxostoma macrolepidotum*	X	P
Greater redhorse	*Moxostoma valenciennesi*	X	P
Bullhead catfishes			
Black bullhead	*Ameiurus melas*	X	P
Yellow bullhead	*Ameiurus natalis*	X	P
Brown bullhead	*Ameiurus nebulosus*	X	P
Channel catfish	*Ictalurus punctatus*	X	P
Stonecat	*Noturus flavus*	X	P
Tadpole madtom	*Noturus gyrinus*	X	P
Brindled madtom	*Noturus miurus*	X	P
Pikes			
Grass pickerel	*Esox americanus vermiculatus*	X	P
Northern pike	*Esox lucius*	X	P
Muskellunge	*Esox masquinongy*	X	P
Tiger muskellunge	*E. lucius x E. masquinongy*	I	U
Mudminnows			
Central mudminnow	*Umbra limi*	X	P
Smelts			
Rainbow smelt	*Osmerus mordax*	C	E
Trouts			
Lake herring	*Coregonus artedi*	X	U
Lake whitefish	*Coregonus clupeaformis*	X	O
Coho salmon	*Oncorhynchus kisutch*	I	O

Table 10.–Continued.

Common name	Scientific name	Origin	Status
Trouts continued			
Rainbow trout	*Oncorhynchus mykiss*	I	P
Chinook salmon	*Oncorhynchus tshawytscha*	I	E
Brown trout	*Salmo trutta*	I	E
Brook trout	*Salvelinus fontinalis*	I	O
Lake trout	*Salvelinus namaycush*	X	U
Trout-perches			
Trout-perch	*Percopsis omiscomaycus*	X	E
Cods			
Burbot	*Lota lota*	X	E
Killifishes			
Banded killifish	*Fundulus diaphanus*	X	P
Blackstripe topminnow	*Fundulus notatus*	X	P
Livebearers			
Western mosquito fish	*Gambusia affinis*	I	O
Silversides			
Brook silversides	*Labidesthes sicculus*	X	P
Sticklebacks			
Brook stickleback	*Culaea inconstans*	X	P
Sculpins			
Mottled sculpin	*Cottus bairdi*	X	P
Temperate basses			
White perch	*Morone americana*	C	E
White bass	*Morone chrysops*	X	E
Sunfishes			
Rock bass	*Ambloplites rupestris*	X	P
Green sunfish	*Lepomis cyanellus*	X	P
Pumpkinseed	*Lepomis gibbosus*	X	P
Warmouth	*Lepomis gulosus*	X	P
Orangespotted sunfish	*Lepomis humilis*	C	P
Bluegill	*Lepomis macrochirus*	X	P
Longear sunfish	*Lepomis megalotis*	X	P
Redear sunfish	*Lepomis microlophus*	I	P
Smallmouth bass	*Micropterus dolomieu*	X	P
Largemouth bass	*Micropterus salmoides*	X	P
White crappie	*Pomoxis annularis*	X	P
Black crappie	*Pomoxis nigromaculatus*	X	P
Perches			
Eastern sand darter	*Ammocrypta pellucida*	X	U
Greenside darter	*Etheostoma blennioides*	X	P
Rainbow darter	*Etheostoma caeruleum*	X	P

Table 10.–Continued.

Common name	Scientific name	Origin	Status
Perches continued			
Iowa darter	*Etheostoma exile*	X	P
Barred fantail darter	*Etheostoma flabellare*	X	P
Least darter	*Etheostoma microperca*	X	P
Johnny darter	*Etheostoma nigrum*	X	P
Orangethroat darter	*Etheostoma spectabile*	X	P
Yellow perch	*Perca flavescens*	X	P
Logperch	*Percina caprodes*	X	P
Blackside darter	*Percina maculata*	X	P
Walleye	*Stizostedion vitreum*	X	P
Drums			
Freshwater drum	*Aplodinotus grunniens*	X	E
Gobies			
Round goby	*Neogobius melanostomus*	I	P

Table 11.–Fish stocking in the River Raisin watershed, 1986-1995. Data from: Michigan Department of Natural Resources, Fisheries Division. Significant private plants are included. MP=millpond.

Common name	Stocking location	Years	Numbers	Comments
Hillsdale County				
Channel catfish	Lake Somerset	89	150	Private plant
Hybrid sunfish	Lake Somerset	86,89-90,92	5,725	Private plants
Northern pike	Lake Somerset	86,91-94	1,766	Private plants
Yellow perch	Lake Somerset	86,90,92	3,700	Private plants
Walleye	Lake Somerset	89-94	19,225	Private plants
Jackson County				
Channel catfish	River Raisin	87	200	
Northern pike	Vineyard Lake	87-88	1401	Rearing pond
Walleye	Clark Lake	93,95	7,000	Fall fingerlings
Walleye	Vineyard Lake	86	19,712	Spring fingerlings
Walleye	Vineyard Lake	91-92,94-95	6,000	Fall fingerlings
Lenawee County				
Black crappie	Globe & Standish MP	87	300	Drawdown
Channel catfish	Globe & Standish MP	88-89,91	2700	Augment population
Channel catfish	River Raisin	88-91,95	71,828	Augment population
Fathead minnow	Lake Loch Erin	88	132,000	Private plant
Largemouth bass	Globe & Standish MP	87	87	Drawdown
Largemouth bass	Lake Loch Erin	91,95	4,259	Private plants
Muskellunge	Globe & Standish MP	87	12	
Muskellunge	Lake Hudson	86-87,89-90,93,95	11,596	Broodstock lake
Muskellunge	Lake Loch Erin	89	50	Private plant
Northern pike	Globe & Standish MP	87,88	1,182	Drawdown
Northern pike	Lake Loch Erin	88,89	1,500	Private plant
Rainbow trout	Allens Lake	86-95	34,734	Continued program
Rainbow trout	Deep Lake	87-95	21,808	Continued program
Redear sunfish	Sand Lake	91-92	71,394	Introduction
Redear sunfish	Wamplers Lake	90-91	80,285	Introduction
Tiger muskie	Wamplers Lake	86,88,90	4,800	Continued program
Walleye	Globe & Standish MP	87	28,000	Drawdown
Walleye	Lake Hudson	88	40,000	Introduction
Walleye	Lake Loch Erin	88-90	8,588	Private plants
Walleye	River Raisin	86-87	39,568	Spring fingerlings
Walleye	Sand Lake	86	21,522	Spring fingerlings
Walleye	Sand Lake	91,95	1,223	Fall fingerlings
Walleye	Wamplers Lake	92,94-95	2,980	Fall fingerlings
Monroe County				
none				
Washtenaw County				
Walleye	Saline River Millpond	87	1000	Post-treatment

Table 12.–Natural features of the River Raisin watershed by county of occurrence. Status codes(State or Federal): E=endangered, T=threatened, SC=special concern (rare, may become E or T). County codes: H=Hillsdale, J=Jackson, L=Lenawee, M=Monroe, W=Washtenaw. Blanks occur when no status categories apply. Data from: Michigan Department of Natural Resources, Wildlife Division, Natural Features Inventory, June, 1998.

		State	Fed.	County code				
Common name	Species	status	status	H	J	L	M	W
Vertebrate								
Indiana bat	*Myotis sodalis*	E	E					X
King rail	*Rallus elegans*	E						X
Blanding's turtle	*Emydoidea blandingii*	SC				X		X
Eastern box turtle	*Terrapene carolina carolina*	SC			X	X	X	X
Spotted turtle	*Clemmys guttata*	SC				X		X
Blanchard's cricket frog	*Acris crepitans blanchardi*	SC				X	X	
Black rat snake	*Elaphe obsoleta obsoleta*	SC				X		
Eastern fox snake	*Elaphe vulpina gloydi*	T					X	
Eastern massasauga	*Sistrurus catenatus catenatus*	SC		X	X	X		X
Kirtland's snake	*Clonophis kirtlandii*	E				X		X
Smallmouth salamander	*Ambystoma texanum*	E					X	
Black redhorse	*Moxostoma duquesnei*	SC				X		X
Brindled madtom	*Noturus miurus*	SC						X
Creek chubsucker	*Erimyzon oblongus*	T				X		
Eastern sand darter	*Ammocrypta pellucida*	T				X		
Pugnose shiner	*Notropis anogenus*	SC				X		
Silver shiner	*Notropis photogenis*	T						X
Southern redbelly dace	*Phoxinus erythrogaster*	T				X		
Invertebrate								
Brown walker	*Pomatiopsis cincinnatiensis*	SC				X	X	X
Culvers root borer	*Papaipema sciata*	SC					X	
Duke's skipper	*Euphyes dukesi*	T					X	
Dusted skipper	*Atrytonopsis hianna*	T					X	
Leafhopper	*Flexamia reflexa*	SC				X		
Mitchell's satyr	*Neonympha mitchellii mitchellii*	E	E			X		X
Poweshiek skipper	*Oarisma poweshiek*	T				X		
Regal fritillary	*Speyeria idalia*	E						X
Silphium borer moth	*Papaipema silphii*	T						X
Northern riffleshell	*Dysnomia torulosa rangiana*	E	E				X	
Purple lilliput	*Carunculina glans*	E					X	
Purple wartyback	*Cyclonaias tuberculata*	SC				X		
Rayed villosa	*Villosa fabalis*	E					X	
Round hickorynut	*Obovaria subrotunda*	E				X	X	
Salamander mussel	*Simpsoniconcha ambigua*	E					X	
Wavyrayed lampmussel	*Lampsilis fasciola*	T			X	X		

Table 12.–Continued.

Common name	Species	State status	Fed. status	County code H	J	L	M	W
Plant								
Alleghany plum	*Prunus alleghaniensis var davisii*	SC				X		
American lotus	*Nelumbo lutea*	T					X	
Barens buckmoth	*Hemileuca maia*	SC					X	
Beak grass	*Diarrhena americana*	T				X	X	
Beaked agrimony	*Agrimonia rostellata*	SC				X		
Black haw	*Viburnum prunifolium*	SC				X		
Cup-plant	*Silphium perfoliatum*	T				X	X	
Climbing fumitory	*Adlumia fungosa*	SC				X		X
Davis's sedge	*Carex davisii*	SC				X	X	
Dwarf hackberry	*Celtis tenuifolia*	SC				X		
Edible valerian	*Valeriana ciliata*	T		X		X		
False pennyroyal	*Trichostema brachiatum*	T				X		
Fescue sedge	*Carex festucacea*	SC						X
Frank's sedge	*Carex frankii*	SC				X		
Ginseng	*Panax quinquefolius*	T					X	X
Goldenseal	*Hydrastis canadensis*	T				X		X
Gravel pyrg	*Pyrgulopsis letsoni*	SC						X
Green violet	*Hybanthus concolor*	SC						X
Hairy angelica	*Angelica venenosa*	SC				X	X	X
Hairy-fruited sedge	*Carex trichocarpa*	SC				X		
Jacob's ladder	*Polemonium reptans*	T				X		
Kitten tails	*Besseya bullii*	T			X			
Kentucky coffee-tree	*Gymnocladus dioicus*	SC				X	X	
Knotwood dodder	*Cuscuta polygonorum*	SC				X		
Mat muhly	*Muhlenbergia richardsonis*	T			X			
Prairie buttercup	*Ranunculus rhomboideus*	T						X
Prairie dropseed	*Sporobolus heterolepis*	T			X	X		
Prairie false indigo	*Baptisia lactea*	T						X
Prairie indian-plantain	*Cacalia plantaginea*	T				X		
Prairie rose	*Rosa setigera*	SC				X		
Purple twayblade	*Liparis liliifolia*	SC		X				
Raven's-foot sedge	*Carex crus-corvi*	T					X	
Red mulberry	*Morus rubra*	SC				X		
Sedge	*Carex squarrosa*	SC				X	X	
Seedbox	*Ludwigia alternifolia*	T					X	
Shellbark hickory	*Carya laciniosa*	SC				X	X	
Showy coneflower	*Rudbeckia fulgilda var sullivantii*	SC				X		
Showy orchis	*Galearis spectabilis*	SC				X		X
Small love grass	*Eragrostis pilosa*	SC				X		
Southeastern adder's tongue	*Ophioglossum pycnostichum*	T				X		
Sullivant's milkweed	*Asclepias sullivantii*	T				X	X	
Tall green milkweed	*Asclepias hirtella*	T			X		X	
Toadshade	*Trillium sessile*	T				X		

Table 12.–Continued.

Common name	Species	State status	Fed. status	County code H	J	L	M	W
Plant continued								
Trailing wild bean	*Strophostyles helvula*	SC					X	
Violet wood-sorvel	*Oxalis violacea*	T					X	
Virginia snakeroot	*Aristolochia serpentaria*	T				X		
Virginia water horehound	*Lycopus virginicus*	T				X		
Water willow	*Justicia americana*	T					X	
Whiskered sunflower	*Helianthus hirsutus*	SC				X		
White gentian	*Gentiana flavida*	E						X
White lady-slipper	*Cypripedium candidum*	T		X		X		X
Wild-hyacinth	*Camassia scilloides*	T				X		
Wild rice	*Zizania aquatica var aquatica*	T					X	
Plant Community								
Dry-mesic forest							X	
Hillside prairie					X			
Lakeplain oak openings							X	
Mesic southern forest						X	X	
Prairie fen				X	X	X		X
Southern floodplain forest								X
Champion Tree								
Black ash	*Fraxinus nigra*					X		
Boxelder	*Acer negundo*							X
Ohio buckeye	*Aesculus glabra*					X		
Sycamore	*Platanus occidentalis*					X		
Other Feature								
Great blue heron rookery				X	X	X		

Table 13.–Collected macroinvertebrates of the River Raisin, 1991-1995 - preliminary list. Data from: E. Bright, University of Michigan, School of Natural Resources and Environment, personal communication.

Order	Family	Genus	Species
Non-insect taxa			
Amphipoda	Gammaridae	*Gammarus*	*fasciatus*
Amphipoda	Gammaridae	*Gammarus*	*lacustris*
Amphipoda	Talitridae	*Hyalella*	*azteca*
Annelidae	Haenopidae	*Haemopis*	*sp.*
Cladocera	Daphnidae	*Daphnia*	*sp.*
Gastropoda	Ancylidae	*Laevopex*	*sp.*
Gastropoda	Hydrobiidae	*Amnicola*	*sp.*
Gastropoda	Hydrobiidae	*Pyrgulopsis*	*sp.*
Gastropoda	Lymnaeidae	*Fossaria*	*sp.*
Gastropoda	Lymnaeidae	*Lymnaea*	*sp.*
Gastropoda	Physidae	*Physella*	*sp.*
Gastropoda	Planorbidae	*Gyraulus*	*sp.*
Gastropoda	Vivparidae	*Vivparus*	*sp.*
Hirudinae	various families	various genera	*spp.*
Isopoda	Asellidae	*Asellus*	*sp.*
Mollusca	Pisidiidae	*Pisidum*	*sp.*
Ostracoda	undet. families	undet. genera	*spp.*
Planaria	undet. families	undet. genera	*spp.*
Decapoda	Cambaridae	*Orconectes*	*sp.*
Insect taxa			
Coleoptera	Dytiscidae	*Agabus*	*sp.*
Coleoptera	Dytiscidae	*Oreodytes*	*sp.*
Coleoptera	Elmidae	*Dubiraphia*	*sp.*
Coleoptera	Elmidae	*Macronychus*	*glabratus*
Coleoptera	Elmidae	*Optioservus*	*spp.*
Coleoptera	Elmidae	*Stenelmis*	*spp.*
Coleoptera	Gyrinidae	*Dineutus*	*sp.*
Coleoptera	Helodidae	*Cyphon*	*sp.*
Coleoptera	Hydrophilidae	*Berosus*	*sp.*
Coleoptera	Psephenidae	*Psephenus*	*herricki*
Coleoptera	Psephenidae	*Ectopria*	*sp.*
Copepoda	Cyclopoida	*Cyclops*	*sp.*
Diptera	Anthericidae	*Antherix*	*variegata*
Diptera	Ceratopogonidae	*Culicoides*	*sp.*
Diptera	Chironomidae	many genera	*spp.*
Diptera	Culicidae	*Culex*	*sp.*
Diptera	Psychodidae	*Pericoma*	*sp.*
Diptera	Simulidae	*Prosimulium*	*spp.*
Diptera	Simuliidae	*Simulium*	*spp.*
Diptera	Tabanidae	*Chrysops*	*sp.*
Diptera	Tipulidae	*Hexatoma*	*sp.*

Table 13.–Continued.

Order	Family	Genus	Species
Insect taxa continued			
Diptera	Tipulidae	*Tipula*	*abnormalis*
Ephemeroptera	Baetidae	*Baetis*	*sp.*
Ephemeroptera	Caenidae	*Caenis*	*spp.*
Ephemeroptera	Ephemerellidae	*Ephemerella*	*subvaria*
Ephemeroptera	Ephemerellidae	*Ephemerella*	*invaria*
Ephemeroptera	Ephemeridae	*Ephemera*	*simulans*
Ephemeroptera	Heptageniidae	*Stenacron*	*interpunctatum*
Ephemeroptera	Heptageniidae	*Stenonema*	*pulchellum*
Ephemeroptera	Heptageniidae	*Stenonema*	*terminatum*
Ephemeroptera	Heptageniidae	*Stenonema*	*vicarium*
Ephemeroptera	Leptophlebiidae	*Leptophlebia*	*sp.*
Ephemeroptera	Leptophlebiidae	*Paraleptophlebia*	*sp.*
Ephemeroptera	Siphlonuridae	*Siphlonurus*	*sp.*
Ephemeroptera	Tricorythidae	*Tricorythodes*	*sp.*
Ephemeroptera	Isonychiidae	*Isonychia*	*sayi*
Hemiptera	Belostomatidae	*Belostoma*	*flumineum*
Hemiptera	Corixidae	*Hesperocorixa*	*sp.*
Hemiptera	Corixidae	*Sigara*	*sp.*
Hemiptera	Gerridae	*Gerris*	*remigis*
Hemiptera	Gerridae	*Gerris*	*buenoi*
Hemiptera	Gerridae	*Limnoporus*	*dissortis*
Hemiptera	Gerridae	*Microbates*	*hesperius*
Hempitera	Gerridae	*Trepobates*	*sp.*
Hemiptera	Nepidae	*Renatra*	*fusca*
Hemiptera	Notonectidae	*Notonecta*	*sp.*
Hemiptera	Veliidae	*Rhagovelia*	*obesa*
Hemiptera	Veliidae	*Rhagovelia*	*oriander*
Lepidoptera	Pyralidae	*Paragyractis*	*sp.*
Megaloptera	Corydalidae	*Corydalus*	*cornutus*
Megaloptera	Corydalidae	*Nigronia*	*sp.*
Megaloptera	Sialidae	*Sialis*	*spp.*
Odonata	Aeschniidae	*Boyeria*	*vinosa*
Odonata	Calopterygidae	*Hetaerina*	*americana*
Odonata	Ceonagrionidae	*Argia*	*spicalis*
Odonata	Ceonagrionidae	*Argia*	*tibalis*
Odonata	Coenagrionidae	*Enallagma*	*vesperum*
Plecoptera	Capniidae	*Allocapnia*	*sp.*
Plecoptera	Nemouridae	*Nemoura*	*sp.*
Plecoptera	Perlidae	*Acroneuria*	*abnormis*
Plecoptera	Perlidae	*Perlinella*	*drymo*
Plecoptera	Perlidae	*Agnetina*	*capitata*
Plecoptera	Perlidae	*Perlesta*	*placida*
Plecoptera	Perlodidae	*Isoperia*	*sp.*
Plecoptera	Taeniopterygidae	*Taeniopteryx*	*burksi*
Plecoptera	Taeniopterygidae	*Taeniopteryx*	*nivalis*

Table 13.–Continued.

Order	Family	Genus	Species
Insect taxa continued			
Trichoptera	Brachycentridae	*Brachycentrus*	*numerosus*
Trichoptera	Glossosomatidae	*Glossosoma*	*sp.*
Trichoptera	Helicopsychidae	*Heliopsyche*	*borealis*
Trichoptera	Hydropsychidae	*Cheumatopsyche*	*spp.*
Trichoptera	Hydropsychidae	*Hydropsyche*	*bronta*
Trichoptera	Hydropsychidae	*Hydropsyche*	*simulans*
Trichoptera	Hydropsychidae	*Hydropsyche*	*betteni*
Trichoptera	Leptoceridae	*Ceraclea*	*sp.*
Trichoptera	Leptoceridae	*Mystacides*	*sepulchralis*
Trichoptera	Leptoceridae	*Nectopsyche*	*diarina*
Trichoptera	Limnephilidae	*Neophylax*	*sp.*
Trichoptera	Limnephilidae	*Pycnopsyche*	*sp.*
Trichoptera	Philopotamidae	*Chimarra*	*obscura*
Trichoptera	Phryganeidae	*Ptilostoma*	*sp.*
Trichoptera	Polycentropidae	*Polycentropus*	*sp.*
Trichoptera	Polycentropodidae	*Neureclipsis*	*sp.*
Trichoptera	Psychomyiidae	*Lype*	*diversa*

Table 14.–Distribution and abundance of mussels found in the River Raisin watershed. Data from: Strayer 1979. A = abundant, C = common, R = rare, D = only dead shells found.

Collecting Station (Mussels)	*Amblema costata*	*Cyclonaias tuberculata*	*Elliptio dilatata*	*Fusconaia flava*	*Pleurobema coccineum*	*Alasmidonta calceolus*	*Alasmidonta marginata*	*Pyganodon grandis*	*Utterbackia imbecillis*	*Anodontoides ferussacianus*	*Lasmigona complanata*	*Lasmigona compressa*	*Lasmigona costata*	*Simpsonaias ambigua*	*Strophitus undulatus*	*Actinonaias ligamentina*	*Toxolasma lividus*	*Toxolasma parvus*	*Epioblasma torulosa*	*Ligumia fasiola*	*Lampsilis siliquoidea*	*Lampsilis ovata*	*Ligumia recta*	*Villosa fabilis*	*Villosa iris*	*Ptychobranchus fasciolare*
Monroe County																										
R. Raisin, Monroe St. Monroe		D			D			A			C		D			D		R		D	A				D	
R. Raisin, Telegraph Rd. Monroe		D	D	D				A	D							D		D			A	D		D		D
R. Raisin, Raisinville Rd.	D	D	D	D				A								D					C	D			D	D
R. Raisin, Doty Rd.	D	D	D	D				C								D					C	D				
Macon Ck., Stowell Rd.	D	D	D	D	D	D		D		D				D	D	D	D		D		D		D	D	D	D
Macon Ck., Dundee-Azalia Rd.	D			C	D	D				D											A					
N. Br. Macon Ck., Day Rd.								D		D																
M. Br. Macon Ck., Wilcox Rd.	C			D						D											A					
M. Br. Macon Ck., Petersburg Rd.				D		C				C		C									A					
S. Br. Macon Ck., Wilcox Rd.	A			C		C		D		D											A					
S. Br. Macon Ck., Petersburg Rd.	A			C		R		R		D		C			D						A					
Lenawee County																										
Wolf Ck., Tipton Hwy., Adrian						R				R											A					
Evans Ck., Maumee St., Tecumseh																										
R. Raisin, Evans St., Tecumseh							C	D													A	C				
R. Raisin, Staib Rd.			D	R			C	D				C			D					R	A	C			D	
Goose Ck., Cement City Hwy.																										
Washtenaw County																										
R. Raisin, Austin Rd., Manchester		D	D	D		D	D					D			D						D	D			D	
R. Raisin, Sharon Valley Rd., (downstream)		C	C	C	C	D						C			R					C	C	A			C	
R. Raisin, Sharon Valley Rd., (upstream)		R	R	C	R			D				D								D		C			D	

Table 15.–Amphibians and reptiles in the River Raisin watershed. Data from: Holman et al. 1989; Harding and Holman 1990; Harding and Holman 1992 - range maps.

Common name	Scientific name
Salamanders	
Mudpuppy	*Necturus maculosus maculosus*
Blue-spotted salamander	*Ambystoma laterale*
Spotted salamander	*Ambystoma maculatum*
Small-mouthed salamander	*Ambystoma texanum*
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*
Red-spotted newt	*Notophthalmus viridescens viridescens*
Red-backed salamander	*Plethodon cinereus*
Four-toed salamander	*Hemidactylium scutatum*
Frogs and toads	
Eastern American toad	*Bufo americanus americanus*
Fowler's toad	*Bufo woodhousii fowleri*
Blanchard's cricket frog	*Acris crepitans blanchardi*
Western chorus frog	*Pseudacris triseriata triseriata*
Northern spring peeper	*Pseudacris crucifer crucifer*
Eastern gray tree frog	*Hyla versicolor*
Cope's gray tree frog	*Hyla chrysoscelis*
Green frog	*Rana clamitans melanota*
Bullfrog	*Rana catesbeiana*
Northern leopard frog	*Rana pipiens*
Pickerel frog	*Rana palustris*
Wood frog	*Rana sylvatica*
Turtles and lizards	
Snapping turtle	*Chelydra serpentina*
Common musk turtle	*Sternotherus odoratus*
Spotted turtle	*Clemmys guttata*
Eastern box turtle	*Terrapene carolina carolina*
Blanding's turtle	*Emydoidea blandingii*
Common map turtle	*Graptemys geographica*
Painted turtle	*Chrysemys picta*
Red-eared slider	*Trachemys scripta elegans*
Spiny softshell	*Apalone spinifera*
Five-lined skink	*Eumeces fasciatus*
Snakes	
Kirtland's snake	*Clonophis kirtlandi*
Northern water snake	*Nerodia sipedon sipedon*
Queen snake	*Regina septemvittata*
Brown snake	*Storeria dekayi*
Northern red-bellied snake	*Storeria occipitomaculata occipitomaculata*
Eastern garter snake	*Thamnophis sirtalis sirtalis*
Butler's garter snake	*Thamnophis butleri*
Northern ribbon snake	*Thamnophis sauritus septentrionalis*

Table 15.–Continued.

Common name	Scientific name
Snakes continued	
Northern ringneck snake	*Diadophis punctatus edwardsi*
Eastern hognose snake	*Heterodon platyrhinos*
Blue racer	*Coluber constrictor foxi*
Black rat snake	*Elaphe obsoleta obsoleta*
Eastern fox snake	*Elaphe vulpina gloydi*
Eastern milk snake	*Lampropeltis triangulum triangulum*
Eastern smooth green snake	*Opheodrys vernalis vernalis*
Eastern massasauga rattlesnake	*Sistrurus catenatus catenatus*

Table 16.–List of mammals in River Raisin watershed. Data from: Baker 1983 - range maps. * denotes extirpated from River Raisin watershed.

Common name	Scientific name
Virginia opossum	*Didelphis virginiana*
Masked shrew	*Sorex cinereus*
Short-tailed shrew	*Blarina brevicanda*
Least shrew	*Cryptotis parva*
Eastern mole	*Scalopus aquaticus*
Star-nosed mole	*Condylura cristata*
Keen's bat	*Myotis keenii*
Little brown bat	*Myotis lucifugus*
Indiana bat	*Myotis sodalis*
Silver-haired bat	*Lasionycteris noctivagans*
Big brown bat	*Eptesicus fuscus*
Red bat	*Lasiurus borealis*
Hoary bat	*Lasiurus cinereus*
Eastern cottontail	*Sylvilagus floridanus*
Eastern chipmunk	*Tamias striatus*
Woodchuck	*Marmota monax*
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*
Gray squirrel	*Sciurus carolinensis*
Fox squirrel	*Sciurus niger*
Red squirrel	*Tamiasciurus hudsonicus*
Southern flying squirrel	*Glaucomys volans*
Beaver	*Castor canadensis*
White-footed mouse	*Peromyscus leucopus*
Meadow vole	*Microtus pennsylvanicus*
Woodland vole	*Microtus pinetorum*
Muskrat	*Ondatra zibethicus*
Southern bog lemming	*Synaptomys cooperi*
Norway rat	*Rattus norvegicus*
House mouse	*Mus musculus*
Meadow jumping mouse	*Zapus hudsonius*
Coyote	*Canis latrans*
Gray wolf*	*Canis lupus*
Red fox	*Vulpes vulpes*
Gray fox	*Urocyon cinereoargenteus*
Black bear*	*Ursus americanus*
Raccoon	*Procyon lotor*
Long-tailed weasel	*Mustela frenata*
Least weasel	*Mustela nivalis*
Mink	*Mustela vison*
Wolverine*	*Gulo gulo*
Badger	*Taxidea taxus*
Striped skunk	*Mephitis mephitis*
River otter*	*Lutra canadensis*

Table 16.–Continued.

Common name	Scientific name
Mountain lion*	*Felis concolor*
Lynx*	*Felis lynx*
Bobcat	*Felis rufus*
Elk*	*cervus elaphus*
White-tailed deer	*Odocoileus virginianus*
Moose*	*Alces alces*
Bison*	*Bison bison*

Table 17.–Government agencies with authority in the River Raisin watershed. Data from: Manson et al., 1994.

Level of government	Agency
Federal	International Joint Commission Army Corps of Engineers Environmental Protection Agency United States Geological Survey Federal Energy Regulatory Commission United States Department of Agriculture Natural Resources Conservation Service Farm Service Agency

State	Michigan Department of Environmental Quality
	  Air Quality Division
	  Surface Water Quality Division
	  Environmental Response Division
	  Underground Storage Tank Division
	  Land and Water Management Division
	  Waste Management Division
	Michigan Department of Natural Resources
	  Law Enforcement Division
	  Parks and Recreation
	  Forest Management Division
	  Fisheries Division
	  Wildlife Division
	Michigan Department of Agriculture
	  Natural Resources Conservation Districts
	Michigan Department of Management and Budget

Regional	SEMCOG - Washtenaw, Monroe Co. Region 2 Planning Council-Jackson, Hillsdale, Lenawee Counties River Raisin Watershed Council
County	Drain Commission Road Commission Planning Commission Environmental/Health Office Board of Commissioners Building Inspector, zoning ordinances
Municipal	Township/Village/City Board Zoning Board Planning Commission
Citizen Groups	Conservation groups/clubs Lake associations Service clubs Raisin Valley Land Trust River Raisin Public Advisory Committee

Table 17.–Continued.

Level of government	Agency
County	Hillsdale Jackson Washtenaw Lenawee Monroe
Cities	City of Milan City of Saline City of Adrian City of Tecumseh City of Monroe City of Petersburg
Villages	Village of Brooklyn Cement City Village of Manchester Village of Blissfield Village of Britton Village of Clayton Village of Clinton Village of Deerfield Village of Onsted Village of Dundee
Townships	
Hillsdale County	Somerset Township
Jackson County	Columbia Township Norvell Township Napoleon Township
Washtenaw County	Bridgewater Township Freedom Township Lodi Township Pittsfield Township Manchester Township Saline Township Sharon Township York Township
Lenawee County	Adrian Township Blissfield Township Cambridge Township Clinton Township Deerfield Township

Table 17.–Continued.

Level of government	Agency
Lenawee County continued	Dover Township
	Fairfield Township
	Franklin Township
	Hudson Township
	Madison Township
	Macon Township
	Medina Township
	Ogden Township
	Palmyra Township
	Raisin Township
	Ridgeway Township
	Riga Township
	Rollin Township
	Rome Township
	Seneca Township
	Tecumseh Township
	Woodstock Township
Monroe County	Dundee Township
	Frenchtown Charter Township
	London Township
	Milan Township
	Monroe Charter Township
	Raisinville Township
	Summerfield Township

Table 18.–Statutes administered by Michigan Department of Environmental Quality, Land and Water Management Division, that protect the aquatic resource. N.R.P. Act=Natural Resources and Environmental Protection Act. Data from: Beam and Braunscheidel 1996.

State of Michigan Acts	Previous statute
Public Health Code (1978 PA 386, as amended)	Amendments to Aquatic Nuisance Control Act (PA 86, 1977)
Part 13 N.R.P. Act (1994 PA 451)	Floodplain Regulatory Authority (PA 167, 1968)
Part 91 N.R.P. Act (1994 PA 451)	Soil Erosion & Sedimentation Control Act (PA 347, 1972)
Part 301 N.R.P. Act (1994 PA 451)	Inland Lakes and Streams Act (PA 346, 1972)
Part 303 N.R.P. Act (1994 PA 451)	Wetland Protection Act (PA 203, 1979)
Part 307 N.R.P. Act (1994 PA 451)	Inland Lake Level Act (PA 146, 1961)
Part 309 N.R.P. Act (1994 PA 451)	Inland Improvement Act (PA 345, 1966)
Part 315 N.R.P. Act (1994 PA 451)	Dam Safety Act (PA 300, 1989)
Part 323 N.R.P. Act (1994 PA 451)	Shoreland Protection & Management Act (PA 245, 1970)
Part 325 N.R.P. Act (1994 PA 451)	Great Lakes Submerged Lands Act (PA 247, 1955)
Part 341 N.R.P. Act (1994 PA 451)	Irrigation District Act (PA 205, 1967)

US Federal Acts
Federal Water Pollution Control Act, Section 314 (PL 92-55)
Coastal Zone Management Act (PL 92-583, 1972)
Clean Water Act, Section 404 (PL 95-217)
River and Harbor Act, Section 10 (1899)
Coastal Energy Impact Program (PL 92-538)

Table 19.–Designated drains in the River Raisin watershed by county and township. Data from: county drain commission offices.

Hillsdale County

Somerset Township
- none

Jackson County

Columbia Township
- East Clark Lake Drain
- Imperial Shores Drain
- Kedron Drain
- Lynn Haven Drain
- Nooney Drain
- Palmer and Case Drain
- Plumb Brook Drain
- Sunset View Drain

Grass Lake Township
- Branch Drain
- South Grass Lake Drain

Napoleon Township
- Austin Drain No. 1
- Russell Drain
- Stoney Lake Drain

Norvell Township
- Ashley Swale Drain
- Cobb Lake Drain
- Griffith Lake Drain
- Ladd and Main Drain
- Moore & O'Neil Drain
- Norvell & Manchester Intercounty Dr.
- Sweezy Lake Drain

Washtenaw County

Bridgewater Township
- Arnold Tile
- Boettner Tile
- Br. Village Tile
- Bridgewater #1
- Bridgewater #2
- Bridgewater & Saline
- Carmer Open
- Carmer Tile
- Columbia Lake
- Every & Schmidt
- Saline & Bridgewater
- Saline River
- Feld Kamp & Klager
- Freedom & Bridgewater
- Gadd
- J.J. Knapp
- Joslin Lake
- Macon-Clinton Ext.
- N. Br. Saline & Bridgewater
- Schaffer Lake
- Socks Tile
- Tait Tile
- Van Dusen

Freedom Township
- Bauer
- Branch of J. J. Knapp
- Freedom & Bridgewater
- J. J. Knapp
- Kapp & Dettling
- Freedom & Lodi
- Koebbe

Lodi Township
- Bauer
- Brookview Highlands
- Freedom & Lodi
- Lodi County Estates Sub # 4,5,6
- Pittsfield # 1
- Rouse Pittsfield
- Travis Point South Sub.
- Valley View Estates Sub.
- W. Br. Saline Village Tile
- Wood Outlet

Table 19.–Continued.

Washtenaw County continued

Saline Township
- Bauer
- Biscayne Sub.
- Bridgewater # 1
- Bridgewater # 2
- Bridgewater & Saline
- Brookview Highlands
- Cammett & Luckhardt
- East Horizons
- Feldkamp & Klager
- Golden Acres
- Gross Tile
- Hammond Br. of Weinette
- Hertler-Nissley
- Highcreek Sub.
- Lane & Rentz
- Lenawee & Washtenaw
- Lodi County Estates Sub. #4,5,6
- Mallard Cove Sub.
- Maple Creek Condos.
- McCormick Place
- McMann Tile
- Mel Dan Woods Sub.
- Oak Park Estates Sub.
- Pittsfield # 1
- Pittsfield # 5
- Pittsfield Junction
- Rhodes & Finkbeiner
- Rouse (Saline)
- Saline & Bridgewater
- Saline & Macon
- Saline Mill Pond
- Saline Relief # 1
- Saline River
- Saline Village
- Saline Village Ext.
- Saline/W. Michigan Avenue
- Silo Ridge Sub. # 3,4,5
- State 12 Plaza Br. A & B
- Travis Point South Sub.
- Valleyview Estates Sub.
- W. Br. Saline Village Tile
- W. Br. Weinette
- Weinette
- Wood Outlet
- York & Saline
- York Woods Sub.

Manchester Township
- Cooley Tile
- Half Moon Lake Drain
- Manchester Drain
- Manchester Village Tile
- Iron Lake Level
- Sharon & Manchester Ext.

Pittsfield Township
- Brian Hill
- Columbia Center
- Eberbach
- Hertler-Nissley
- Hickory Groves Estates
- Hunters Ridge Sub.
- Koch & Warner
- Mallard Cove Sub.
- Maple Creek Condos
- McCormick Place
- Pittsfield Junction
- Pittsfield # 1
- Pittsfield # 5
- State 12 Plaza Br. A & B
- Rouse
- Timberview Sub.
- Valley Ranch Bus. Park
- Silo Ridge Sub. #3,4,5
- Warner Creek # 5
- Warner Creek Sub
- Wood Outlet

Sharon Township
- Manchester Drain
- Parks Drain

Table 19.–Continued.

Washtenaw County continued

York Township
- Biscayne Sub.
- County Lanes Sub. # 2
- Craig Drain
- Golden Acres
- Highcreek Sub.
- Hobbs Drain
- Josenhaus Drain
- Koch Warner
- Macon

York Township (continued)
- Mary Drain
- Mel Dan Woods Sub.
- Saline Relief # 1 & Br.
- Saline River Intercounty
- Territorial Road Drian
- Warner
- Wheeler Drain
- York & Saline Drain
- York Woods Sub.

Lenawee County

Adrian Township
- Bailey Tile
- Baker Tile
- Barrus
- Black Creek
- Boyd Tile
- Bulson Tile
- Burnor
- Calvin
- Case
- Cherry Villa
- Coleman Tile
- Cook, A. P.
- Cox Tile
- Derby, Peter
- Dibble, C. A.
- Driscoll Tile
- Elliott
- Fauty
- Fike & Frayer
- Fisk
- Greenwald Tile
- Halstead & Knowles
- Harkness
- Harkness, Branch of
- Hervey Tile
- Kidman
- Kidman, Branch of

Adrian Township (continued)
- Kimball
- Knight Tile
- Lewis
- Lewis Extension
- Marvin
- McConnell
- McDonald
- Older
- Older Tile
- Robbins
- Robinson Tile
- Ryan & Extension
- Slater
- Slater, North Branch
- Sloan
- Spielman
- Springer Tile
- Stevenson Tile
- Stocking Tile
- Thompson
- Titus Tile
- Torry Extension
- Treat
- Turner Tile
- Turner Tile, North Branch
- Turner Tile, West Branch
- Wilson Tile

Table 19.–Continued.

Lenawee County continued

Blissfield Township

- Blissfield & Riga
- Brenot
- Brown & Extension
- Camp
- Cemetery
- Clement
- Crandall # 71
- Driggs Road
- Eddy Extension
- Floodwood Creek
- Forsyth
- Foster
- Fry
- Fry Cut Off
- Goll
- Goodrich
- Goodrich & Bowerman
- Hartley
- Hill or No. 7
- Isley
- Keller & Riga Outlet
- Lamley
- Lamley & Foster
- Langwell
- Little Raisin Jt. Co., S. Br. of
- Marks
- Miller, Van R.
- Pease
- Pollard
- Pollard # 2
- Ricker
- Riga Ditch
- Rouget, Charles
- Scholzen
- Springbrook
- Swamp Raisin Joint County
- Wiley

Cambridge Township

- Bilby Tile
- Bryan Tile
- Cole, L. P.
- Cox Tile
- Driscoll Tile
- Fisk
- Geddes Lake & Extension
- Jessup Tile
- Mann Tile
- Neering
- Onsted Tile
- Onsted-Cambridge #1
- Plumb Brook Joint County
- Reed
- Vanderpool & Rexford
- Wolf Creek

Clinton Township

- Clinton # 2
- Clinton Tile
- Dillingham
- Goheen
- Hatch
- Little Raisin
- Hulett
- Little Raisin, Ext. of N. End
- Little Raisin, North End of
- Macon # 7
- Macon & Clinton Extension Jt. Co.
- Macon Joint County, Middle Branch
- Macon Joint County, South Branch
- McGuire Tile
- Metzger
- Norcross Lake
- Payne
- Pennington
- Rector Tile
- Schnerlia Tile
- Schwartz Tile
- Schwartz Tile, Branch
- Stoner
- VanDeusen Joint County

Table 19.–Continued.

Lenawee County continued

Deerfield Township
- Adams & Lane
- Baxer Ave. & Schwab
- Brenot
- Burton & White Joint County
- Camp
- Cannon
- Carpenter & Davis
- Cook Joint County
- Diver
- Dusseau
- Floodwood Creek
- Forche
- Forsyth
- Fry
- Hall & Munson
- Isley
- Keller & Riga Outlet
- Knapp, John I.
- Lamley
- Leonard
- Little Raisin Jt. Co., S. Br. of
- Macon Jt. Co., South Branch
- Rouget, Charles
- Schwab & Schwab Extension
- Seidel
- Springbrook
- Swamp Raisin Joint County

Dover Township
- Anderson, John C.
- Ayers & Town #2
- Baker
- Baker & Buchanan
- Baker Tile
- Bear Creek
- Benfield Tile
- Benner
- Big Swamp
- Big Swamp, Branch of
- Big Swamp Extension
- Bird Tile
- Bovee
- Bovee & Hubbell
- Brazee Tile
- Bryant, E. J.
- Bryant & Russell

Dover Township (continued)
- Burkhart Tile
- Cadmus Open
- Cadmus, South
- Cadmus Tile
- Carpenter
- Clayton Tile
- Collins & Loonam
- Complex
- Compton
- Culhane
- Deline
- Deline & Extension
- Dickerson
- Douglass
- Dutcher
- Farmer, James A.
- Furman Tile
- Harrison
- Harrison, Br. 1 & S. Br. of Br. 1
- Hathaway Tile
- Hill, H. M.
- Horning Tile
- Hudson & Dover
- Kerr & Clemenson
- Lord & Rorick
- Lowery
- Mason Tile
- Miller Tile
- Nash
- No. 46 & Extension
- No. 46 & Extension, Branch of
- Perkins
- Raisin River, South Branch
- Raisin River, Upper End, South Br.
- Rice Lake
- Rome Sec. 26
- Shaw
- Stoney Creek
- Stoney Creek, South Branch
- Thompson # 44
- Town Line
- Townsend
- Tuttle Tile
- Voorhees Tile
- Warren
- Warren, Branch of (South)

Table 19.–Continued.

Lenawee County continued

Dover Township (continued)
- Warren, North Branch of
- Whaley
- Winslow

Fairfield Township
- Abbott
- Aldrich Tile
- Allen Tile
- Anderson, B. H. Tile
- Baker, Bennett C.
- Baker & May
- Brown # 1
- Bryant & Russell
- Burgess & Ayers
- Carpenter & Green
- Chandler
- Day Tile
- Deland, Martin
- Dunbar
- Foote
- Force & Rathbun
- Fuller Tile
- Griffith
- Hall
- Hillard
- Hoadley, Art
- Hoadley Tile
- Holly Tile
- Holmes
- Horton, G. B. Extension
- Hough
- Jacobs Open
- Jasper
- Jasper, West Branch of
- Knapp & Extension
- Knox Tile
- Lord Tile
- Morse
- Nelson Extension
- Nelson Tile
- Nile
- Nile Extension
- Peavey
- Pitcher & Livesay
- Raymond
- Raymond & Witt

Fairfield Township (continued)
- Ross & Smith
- Scharer
- Smith & Kellogg
- Stoney Creek
- Stoney Creek, South Branch
- Sturtevant & Bovee
- Swich
- Ulrich
- Walker & Morse
- Welch
- Weston
- Whitehead
- Witt

Franklin Township
- Black Creek
- Bowen
- Boyd Tile
- Brugger
- Burns
- Burns Extension
- Coleman Tile
- Cooley Joint County
- Cox Tile
- Derby, Peter
- Driscoll Tile
- Elliott
- Evans Creek
- Evans Creek, Extension of
- Evans Lake Park
- Fisk
- Hunter Tile
- Keeney
- Keeney Extension
- Kemp, Sec. 34
- Kemp Tile
- Kerr Tile
- Lamkin Tile
- Lewis
- Lewis Extension
- Love
- Munger & Extension
- Munger Tile
- Norcross
- Norcros, North Branch
- Payne

Table 19.–Continued.

Lenawee County continued

Franklin Township continued
- Peters
- Powell Tile
- Preston Tile
- Slater
- Slater, North Branch
- Sloan
- Smith
- Stoner
- Tallman
- Tallman, West Branch
- Taylor Tile
- Thielan
- Tipton Tile
- Tripp
- Vanderpool & Rexford
- VanValkenburg
- Vollmer Tile
- Whelan Tile
- Wilson & Bowen
- Wilson Tile
- Wisner Extension
- Wisner Tile

Hudson Township
- Bear Creek
- Bear Creek Extension
- Benfield Tile
- Bird Tile
- Camp & Extension
- Clayton Tile
- Dowling Tile
- Elston
- Henning Tile
- Hudson & Dover
- J. B.
- Miller Tile
- Milliken
- McCarty
- Raisin River, Upper End, South Br.
- Rice Lake
- Rooney
- Tucker
- Vedder

Macon Township
- Bear Swamp Joint County
- Clark
- Coats
- Craig
- Downing-Steele
- Foote Tile
- Ford-Macon
- Frayer Tile
- Gibson
- Gibson, Alec
- Gould Tile
- Harrington Tile
- Hatch
- Hendershot Tile
- Karcher
- Lake Ridge
- Lenawee & Washtenaw Jt. Co.
- Little Raisin
- Little Raisin, Ext. of North End
- Little Raisin, North End of
- Little Raisin, West Br. of N. End
- Macon # 2
- Macon # 2 Joint County, Middle Br.
- Macon # 7
- Macon # 21
- Macon Central
- Macon & Clinton Extension Jt. Co.
- Macon Joint County
- Macon Joint County, Middle Branch
- Macon Joint County, South Branch
- Macon, New # 8 & Extension
- Macon, Old # 8
- Milan # 4 Joint County
- Murphy
- Patterson & Extension
- Paul Tile
- Pennington
- Rendell Joint County
- Rendell Joint County
- Richardson Joint County
- Richmond
- Riley Joint County
- Saline & Macon Joint County
- Schroeder Brook
- Squires Tile
- Steele

Table 19.–Continued.

Lenawee County continued

Macon Township continued
- Steele Joint County
- Suydam Tile
- Swick
- Vandeventer Joint County
- Watson Tile & Extension
- Wilson Springbrook

Madison Township
- Adrian-Madison-Beecher
- Baker & May
- Big Meadow
- Bixby
- Bryant & Russell
- Cadoo Tile
- Daniels Swamp
- Stoney Creek, South Branch
- Titus Tile
- Waltermire Tile
- Dutcher
- Fike & Frayer
- Hoadley Tile
- Home Acres
- Holmes
- Jordan Tile
- King Tile
- Knox Tile
- Marvin
- Mitchell
- Palmyra # 70
- Pitcher & Livesay
- Porter, L. A.
- Savage
- Stoney Creek
- West Tile

Ogden Township
- Baker, Bennett C.
- Baluss & West Branch
- Bay
- Bell & Extension
- Big Briney Outllet
- Bruce
- Burk
- Carpenter & Green
- Clement
- Foote

Ogden Township continued
- Hahn
- Hahn, Extension of
- Hambrook & King
- Hazzard
- Hoadley, Art
- Hodges
- Johnson
- Malburg
- Ogden
- Ogden Outlet
- Ovenshire
- Ovenshire & S. Br. of Ovenshire
- Ovenshire, South Branch
- Peavey
- Pence Tile
- Rau
- Rinehart
- Rockwood
- Sebring, Clough & Corbin
- Swick
- Uloth
- Underwood
- Walker Brook
- Wickter
- Wilt

Palmyra Township
- Bailey, J.
- Big Meadow
- Bixby
- Brenot
- Camp
- Clapp Tile
- Colvin
- Crandall # 71
- DeBar
- Demlow Tile
- Driggs
- Gaffney
- Goodrich & Bowerman
- Graham Tile
- Grinnell
- Hambrook & King
- Harsh, L. A. & Extension
- Hartley
- Hill or No. 7

Table 19.–Continued.

Lenawee County continued

Palmyra Township continued
- Isley
- Keeber
- Leonard, F. W.
- Little Raisin, Jt. Co., S. Br. of
- Nichols
- Palmyra # 70
- Palmyra # 70, Branch of
- Palmyra Tile # 2
- Palmyra Township # 1
- Pease
- Palmyra # 1 Tile
- Palmyra # 1 Tile, Branch of
- Pifer, G. A.
- Pifer, G. A. Extension
- Pope, R. D.
- Ricker
- Robb
- Rogers, Dwight
- Stafford & Rogers
- Swamp Raisin Joint County
- VanFleet
- VanFleet, Branch of
- Westgate
- Westgate, South Branch
- Whitmarsh
- Wiley
- Wooster Tile

Raisin Township
- Ash
- Baxter Ave. & Schwab
- Boyd Tile
- Champlain Brook Extension
- Clapp Tile
- Cook
- Cook Drain & Extension
- Crommer Tile
- Demlow Tile
- Dibble, Chauncey
- Farrah Tile
- Gateview # 3
- Harkness
- Harkness, Branch of
- Hathaway
- Hedrick Tile
- Kelley, Ben

Raisin Township continued
- Kelley, Ben Extension of
- Little Raisin
- Macon Joint County, S. Br.
- Marks
- Miller, Van R.
- Moore Tile
- Neuman
- Nichols
- Pine Grove Tile
- Pleasant Acre Farm
- Raisin # 32
- Riley Tile
- Scholzen
- Schwab & Schwab Extension
- Seminary & Extension
- Slater
- Slater, North Branch
- Spalding
- Springbrook
- Springbrook Extension
- Sutton
- Swamp Raisin Joint County
- Tallman
- Wade Tile
- Walker Brook
- Westgate
- Westgate Extension
- Westgate, South Branch
- Woodruff Brook, West Branch
- Palmer

Ridgeway Township
- Ackley
- Andrews Tile
- Baxter Ave & Schwab
- Britton Tile
- Clement & Osterhout
- Coats
- Craig
- Dibble, Chauncey
- Downing-Steele
- Exelby
- Gibson, Alec
- Gittus Tile
- Hansen Tile
- Hathaway

Table 19.–Continued.

Lenawee County continued

Ridgeway Township continued
- Hecksteadt Tile
- Iveson
- Kelley, Ben Extension of
- Kelley, Ben
- Hoagland
- Libstaff & Lenawee Co. Special Joint Co.
- Linn
- Little Raisin
- Macon # 2 Jt. Co., Middle Branch
- Macon Extension, Middle Branch
- Macon Jt. Co., Middle Branch
- Macon Joint County, South Branch
- Oliver
- Osgood Tile
- Ousterhout & Rixom
- Packard Joint County
- Palmer
- Ransom
- Richardson Joint County
- Ridgeway Village
- Riley Tile
- Scholzen
- Schroeder Brook
- Schwab & Schwab Extension
- Spalding
- Springbrook
- Steele
- Steele Joint County
- Sutton
- Suydam Tile
- Swamp Raisin Joint County
- Wahoo Prairie Joint County
- Wilson & Extension
- Wilson Springbrook
- Wilson Springbrook, West Branch
- Witt Tile

Riga Township
- Beagle
- Blissfield & Riga
- Burton & White Joint Co.
- Clement
- Eddy Extension
- Floodwood Creek
- Foster
- East Riga

Riga Township continued
- Gary & Pat Smith
- Goll
- Hazzard
- Keller & Riga Outlet
- Knapp, John I.
- Lamley
- Pollard
- Riga Ditch
- Rosewinkle
- Smith, Patrick

Rollin Township
- Hazen Creek
- Hudson, Floyd
- Ketcham Tile
- Rooney

Rome Township
- Atwood Tile
- Barrus
- Billings Tile
- Curtis Tile
- Douglass
- Dowling Tile
- Driscoll Tile
- Fauty
- Fleming & Extension
- Gilbert
- Gregg Tile
- Harris & North Branch
- Harrison
- Hawley Tile
- Hazen Creek
- Hood
- Hudson, Floyd
- Hunt Tile
- Kobneck Tile
- Lowery
- Lowery, North End
- Mann Tile
- Meyers Tile, Ed
- McDonald
- Nash
- Penrod Tile
- Pickford & Extension
- Pickford Tile

Table 19.–Continued.

Lenawee County continued

Rome Township continued

- Rome Sec. 26
- Ryan & Extension
- Schnerlia
- Smead
- Stoddard
- Torry Extension
- Wallace

Seneca Township

- Bear Creek
- Big Swamp
- Big Swamp Extension
- Bryant, E. J.
- Bryant & Russell
- Burch Tile
- Chandler
- Clement Tile
- Complex
- Complex Branch
- Day Tile
- Deline # 14
- Deline #14, Branch #2
- Drainage District #1
- Ennis Tile
- Furman Tile
- Horton, G. B. Extension
- Lord & Rorick
- Meister
- Metcalf
- Metcalf, South Branch
- Milliken
- Morrison
- Morris Tile
- Nile
- Nile Extension
- Plate Tile
- Potter, M. S.
- Smith, Potter
- Stoney Creek
- Stoney Creek, South Branch
- Town Line
- Tufts, C. L.
- Tuggle, S. F.
- Welch
- Williams

Tecumseh Township

- Boyd Tile
- Champlain Brook Extension
- Cook
- Cook Drain & Extension
- Cook Extension
- Evans Creek, Extension of
- Goheen
- Gove Tile
- Hatch
- Little Raisin
- Little Raisin, Extension of N. End
- Little Raisin, North End of
- Little Raisin, West Br. Of N. End
- Macon Joint County, S. Branch
- Payne
- Rector Tile
- Slater
- Stone
- Sutton
- Tallman
- Tallman, South Branch
- Tallman, West Branch
- VanValkenburg
- Westhaven

Woodstock Township

- Briggs Lake
- Burk
- Moyer & Bedell
- Plumb Brook Joint County
- Shiner Lake
- Tompkins Tile
- Woodstock & Somerset Joint Co.

Table 19.–Continued.

Monroe County

Dundee Township
- Bunce Drain, N. & S. Div.
- Burnett Drain
- Carney and Wilson Drain
- Cassidy Drain
- Curtis Drain
- Curtis and Rowley Drain
- Dundee and Milan No. 3 Drain
- Dunlap Drain
- Dunlap Drain, E. Div.
- George Day Drain
- Graham Tile Drain
- Hagen Drain
- Hunt and Stowell Drain
- Janney Drain
- Johnes Drain
- Kent and Suydam Drain
- Knoll Drain
- Koster Drain
- Lafler Drain
- Lenawee County Special Drain
- Lipstaff Drain
- Macon Drain
- Martin and Marine Drain
- Middle Branch Drain
- Morrison Drain
- Neiman Drain
- North Macon Drain
- Plumadore Drain
- Roe Drain
- Roskeda Drain
- Smith and Morse Drain
- Smith and Roe Drain
- South Branch Macon River Drain
- South Little River Raisin Drain
- Stowell School Drain
- Swamp Raisin Creek Crain
- Toten Drain
- Wahoo Prairie Drain
- Woodruff Drain

Frenchtown Township
- Bates Drain
- Brost Drain
- Dr. Laboe Drain
- Jarbo Drain
- Mason Run Drain

Frenchtown Township continued
- Moore Drain
- Southworth Drain
- Zimmerman Drain

London Township
- Barnes Drain
- Bear Creek Drain
- Beaver Meadow Drain
- Carmel Drain
- Davis Drain
- Ingraham Drain
- Lewis Wann Drain
- Master Drain
- Stevens Drain
- Spiecker Drain
- Sugar Run Drain
- Wanty Drain
- Wilson Drain

Milan Township
- Albert Johnson Drain
- Bear Creek Drain
- Bear Swamp Drain
- Campbell Swamp Drain
- Comfort Drain
- Crowe Drain
- Dibble Drain
- Ellis Drain
- Hall and Hanlon Drain
- Hall and Reevs Drain
- Hoag and Auten Drain
- Holcomb Drain
- Howe Drain
- John Cone Drain
- J. Rice Drain
- Kehow Drain
- Lee and Fulcher Drain
- Leet and Weidner Drain
- Leppleman Drain
- Macon Drain
- Macon and Milan Drain
- Maltby-Murry Drain
- Mary Drain
- Milan Center Ditch
- Milan No. 1 Drain
- Milan No. 3 Drain

Table 19.–Continued.

Monroe County continued

Milan Township continued
- Milan No. 4 Drain
- Mooney Drain
- Nolan and Engle Drain
- N. Macon Creek Drain
- Philips Drain
- Pilbeamand Hazen Tile Drain
- Pullen Drain
- Rendell Tile Drain
- Richardson Drain
- Roskeda Drain
- Sherman and Wilson Drain
- Smith & Allen Drain
- Steele Drain
- Thayer Drain
- Vanderventer Drain
- VanSchoich Drain
- Warren Lewis Drain
- Zeloff Drain

Raisinville Township
- Ansel Drain
- Barnaby Drain
- Baum Drain
- Brost Drain
- Brown Drain
- Burdeau Drain
- Karn Drain
- Mason Run Drain
- Middle Branch Willow Run Drain
- Moore Drain
- North Branch Willow Run Drain
- Nosar and Scheitz Drain
- Porth Drain
- Rath Drain
- Seitz Drain
- Smock Drain
- South Branch Willow Run Drain
- Sullivan Drain
- Wakefield Tile Drain

Summerfield Township
- Ball Drain
- Bennett and Archer Drain
- Beverly Drain
- Burnham Drain
- Burton and White Drain
- Dernier and Towner Drain
- Goodrich Drain
- Hall Drain
- Miller Drain No. 4
- Montri Drain
- Perry Drain
- Roe Drain
- Russell Drain
- Shaler Drain
- Stacy Drain
- Thompson and Martin Drain
- Thompson and Tyler Drain
- Veits Drain
- West Branch Southwell Drain
- West Division Dunlap Drain

City of Monroe
- Ives Drain
- Mason Run Cutoff
- Rye Drain
- Southworth Drain

Table 20.–Boat access sites in the River Raisin watershed. Data from: Michigan Department of Natural Resources, Parks and Recreation Division. Access key: 1=concrete ramp, 2=gravel ramp, 3=informal access, 4=carry-in access, 5=fee access, 6=access from adjoining waters with public access, 7=Hellenberg Field, access to Lake Erie. Dashes indicate number of parking spaces unknown or access from adjoining waters.

Body of water	County	TRS	Access type	Parking spaces	Water (acres)
Goose Lake	Hillsdale	T5S R1W Sec. 17	2	4	69
Lombard Lake	Hillsdale	T5S R1W Sec. 15	4	6	281
Moon Lake	Hillsdale	T5S R1W Sec. 15	4	4	32
Clark Lake	Jackson	T4S R1E Sec. 16	2	4	580
Vineyard Lake	Jackson	T4S R2E Sec. 28	1	30	505
Norvell lake	Jackson	T4S R2E Sec. 04	3	3	154
Mud lake	Jackson	T4S R2E Sec. 36	5	-	119
Goose Lake	Lenawee	T5S R1E Sec. 08	5	-	200
One Mile Lake	Lenawee	T5S R1E Sec. 12	4	10	29
Cleveland Lake	Lenawee	T5S R1E Sec. 12	4	4	14
Grassy Lake	Lenawee	T5S R2E Sec. 18	3	4	54
Deep Lake	Lenawee	T5S R2E Sec. 18	2	10	65
Allens Lake	Lenawee	T5S R2E Sec. 03	1	15	63
Wolf Lake	Lenawee	T5S R2E Sec. 09	6	-	69
Meadow Lake	Lenawee	T5S R2E Sec. 10	6	-	26
Kellys Lake	Lenawee	T5S R2E Sec. 11	6	-	43
Killarney Lake	Lenawee	T5S R2E Sec. 10	5&6	-	19
Lake Adrian	Lenawee	T6S R3E Sec. 26	4	-	86
Iron Lake	Lenawee	T5S R2E Sec. 02	3	6	78
Sand Lake	Lenawee	T5S R2E Sec. 12	1	24	440
Evans Lake	Lenawee	T5S R3E Sec. 06	5	-	201
Wamplers Lake	Len/Jac	T5S R2E Sec. 02	1	150	780
Round Lake	Len/Jac/Was	T5S R3E Sec. 06	2&6	10	67
Lake Hudson	Lenawee	T7S R1E Sec. 25	1	30	500
Demings Lake	Lenawee	T7S R2E Sec. 26	3	3	29
Globe Mill Pond	Lenawee	T5S R4E Sec. 27	2	10	38
Standish Mill Pond	Lenawee	T5S R4E Sec. 27	1	10	13
Saline Pond	Washtenaw	T4S R5E Sec. 01	3	-	28
Milan Pond	Washtenaw	T4S R6E Sec. 35	2	-	20
River Raisin	Monroe	T7S R9E Sec. 05	7	50	Lake Erie

Table 21.–Dams in the River Raisin watershed. Data from: Michigan Department of Environmental Quality, Land and Water Management Division. Major dams (see Figure 21) are bolded. Lk-Lvl Contol Str.=lake-level control structure.

Dam name	River	Twp.	Range	Section
Hillsdale				
Lake Somerset Dam	Goose Creek	5S	1W	01
Lombard Lake Dam	Trib. Goose Creek	5S	1W	15
Jackson				
Sharonville SGA Pond 2	Unnamed swamp	3S	2E	36
Sharonville SGA Pond 1	Trib. River Raisin	3S	2E	36
Clark Lake Dam	Goose Creek	4S	1E	15
Lake Columbia Dam	Goose Creek	4S	1E	22
Sweezy Lk-Lvl Control Str.	Trib. River Raisin	4S	2E	02
Norvell Dam	River Raisin	4S	2E	03
Vineyard Lk-Lvl Control Str.	River Raisin	4S	2E	29
Brooklyn Dam	River Raisin	4S	2E	19
Lenawee				
Juniper Hills Dam	Brigg’s Lake Creek	5S	1E	01
South Lake Dam	South Lake	5S	1E	14
Goose Lk-Lvl Control Str.	Goose Creek	5S	1E	08
Pratt Dam	Wolf Creek	5S	2E	14
Springville Mill Dam	Wolf Creek	5S	2E	11
Dewey Lk-LvlControl Str.	Trib. Wolf Creek	5S	2E	17
Springville Dam	Trib. Wolf Creek	5S	2E	14
Loch Erin Dam	Wolf Creek	5S	3E	25
Evans Lk-Lvl Control Str.	Evans Creek	5S	3E	07
Standish Dam	River Raisin	5S	4E	27
Red Millpond Dam	River Raisin	5S	4E	27
Globe Mill Dam	River Raisin	5S	4E	34
Atles Mill Dam	River Raisin	5S	4E	05
Satterthwaite Dam	Trib. River Raisin	5S	4E	27
O’Neal Dam	Macon Creek	5S	5E	08
Sparrow Dam	Hazen Creek	6S	1E	25
Fry Lake Dam	Squaw Creek	6S	2E	03
Squaw Creek Dam	Trib. Squaw Creek	6S	2E	03
Lake Adrian Dam	Wolf Creek	6S	3E	35
Ruesink Dam	Trib. Beaver Creek	6S	3E	16
Lake Hudson Dam	Bear Creek	7S	1E	35
Raisin Dam	Trib. S. Br. Raisin R.	7S	2E	27
Adrian City Rec. Pond Dam	Trib. S. Br. R. Raisin	7S	3E	03
McCoy’s Pond Dam	Trib. River Raisin	7S	4E	07
Blissfield Dam	River Raisin	7S	5E	29
River Raisin Weir	River Raisin	7S	5E	12

Table 21.–Continued.

Dam name	River	Twp.	Range	Section
Monroe				
Milan Dam	Saline River	5S	6E	02
Dundee Cement Co. Dam	N. Br. Macon Creek	6S	6E	01
Dundee Mill Dam	River Raisin	6S	6E	13
Murciak Dam	River Raisin	6S	7E	13
Waterloo Dam	River Raisin	6S	8E	36
West of Sisters Island	River Raisin	6S	9E	31
East of Sisters Island	River Raisin	6S	9E	31
West of Monroe Street	River Raisin	6S	9E	31
West of Macomb Street	River Raisin	6S	9E	32
City Filtration Plant	River Raisin	7S	9E	05
Hellenberg Field	River Raisin	7S	9E	05
Washtenaw				
Sharon Mills Dam	River Raisin	3S	3E	29
Deppmann Dam	Trib. Saline River	3S	5E	32
Warner Drain Dam	Koch Warner Drain	3S	6E	34
Kirk Dam	Trib. Iron Creek	4S	3E	22
Par 3 Ranch Dam	Trib. River Raisin	4S	3E	03
Manchester Mill Dam	River Raisin	4S	3E	02
Iron Lake Dam	Iron Creek	4S	3E	28
Broucek Dam	Trib. River Raisin	4S	3E	11
Curtiss Park Dam	Saline River	4S	5E	01
Saline River Dam	Saline River	4S	5E	01
Spring Brook Dam	Koch & Warner Dr.	4S	5E	12
Ella Lee Lake Dam	Trib. Saline River	4S	6E	18
Ford Manchester Dam	River Raisin	4S	6E	01

Table 22.–Numbers of major fish species impinged at the Detroit Edison Monroe Power Plant from May, 1985 through April, 1986. Data from: A. Nuhfer, Michigan Department of Natural Resources, Fisheries Division, personal communication.

	Month												
Species	May	June	July	August	Sept	October	November	December	January	Feb	March	April	Totals
Gizzard shad	2,944	3,417	4,057	396,217	114,484	3,272,676	1,704,038	3,233,888	555,285	11,473	7,296	4,248	9,310,023
White perch	7,884	10,074	5,044	41,071	169,234	94,769	28,917	12,757	84,114	2,813	343	4,248	461,268
Trout-perch	10,727	9,225	528	609	2,135	1,450	649	21	18,709	6,882	54,632	32,287	137,854
White bass	615	900	4,177	33,352	40,684	9,393	7,084	2,135	7,121	0	493	328	106,282
Freshwater drum	4,526	5,991	2,020	12,834	15,899	32,535	15,125	431	2,495	616	1,037	3,338	96,847
Yellow perch	20,401	15,326	11,040	6,661	6,445	6,859	2,010	676	2,928	153	3,160	2,587	78,246
Emerald shiner	1,151	3,174	3,700	632	1,313	2,332	4,676	4,022	4,959	374	552	2,573	29,458
Spottail shiner	1,441	2,451	1,526	508	1,091	927	551	49	173	165	1,144	1,007	11,033
Walleye	288	533	1,854	902	321	536	467	141	1,874	48	152	258	7,374
Smelt	228	1,328	407	28	865	1,543	1,251	64	307	57	26	117	6,221
Other species	1,217	2,147	1,001	917	2,617	3,314	3,689	3,240	3,086	597	1,570	1,422	24,817
TOTAL	51,422	54,566	35,354	493,731	355,088	3,426,334	1,768,457	3,257,424	681,051	23,178	70,405	52,413	10,269,423

Table 23.–Estimated numbers of fish larvae entrained February 13, 1982 through February 12, 1983 at Detroit Edison's Monroe Power Plant located at the mouth of the River Raisin. In the following months no larvae were collected: February 1982, October 1982 - February 1983. Data from: Jude et al. 1983.

				Month					% of
Species	March	April	May	June	July	August	Sept	Total	total
Gizzard shad	0	17,300,000	853,000,000	3,020,000,000	184,000,000	3,040,000	41,200	4,080,000,000	86.80
Freshwater drum	0	0	0	129,000,000	29,400,000	58,900	0	158,000,000	3.37
White bass and white perch	0	0	11,500,000	127,000,000	17,600,000	197,000	0	156,000,000	3.32
Yellow perch	0	0	103,000,000	23,300,000	933,000	93,600	0	128,000,000	2.72
Common carp	0	50,300,000	16,500,000	10,900,000	1,840,000	43,200	0	79,700,000	1.70
Damaged larvae	0	214,000	14,400,000	21,200,000	2,400,000	122,000	0	38,300,000	0.81
Emerald shiner	0	0	1,480,000	12,100,000	2,820,000	5,440,000	756,000	22,600,000	0.48
Rainbow smelt	0	0	0	9,360,000	914,000	717,000	0	11,000,000	0.23
Spottail shiner	0	0	3,420,000	1,050,000	0	238,000	309,000	5,020,000	0.11
Quillback	0	3,080,000	1,340,000	457,000	0	0	0	4,870,000	0.10
Channel catfish	0	0	804,000	2,040,000	1,210,000	93,600	0	4,160,000	0.09
Unidentified cyprinidae	0	0	2,490,000	233,000	17,400	58,900	0	2,800,000	0.06
Burbot	0	239,000	2,530,000	0	0	0	0	2,770,000	0.06
Trout-perch	0	2,130	2,340,000	34,600	0	0	0	2,380,000	0.05
Walleye	0	29,800	2,050,000	0	0	0	0	2,080,000	0.04
White sucker	103,000	0	664,000	448,000	0	0	0	1,210,000	0.03
Lepomis spp.	0	0	77,800	28,800	388,000	428,000	0	923,000	0.02
Logperch	0	0	46,700	0	50,900	473,000	33,000	603,000	0.01
Largemouth bass	0	0	435,000	164,000	0	0	0	599,000	0.01
Pomoxis spp	0	0	580,000	0	0	0	0	580,000	0.01
Unidentified coregoninae	0	14,900	175,000	0	0	0	0	190,000	0.00
Northern hog sucker	124,000	0	0	0	0	0	0	124,000	0.00
TOTALS	227,000	71,300,000	1,020,000,000	3,360,000,000	242,000,000	11,000,000	1,140,000	4,700,000,000	

Table 24.–National Pollution Discharge Elimination System permits issued in the River Raisin watershed by Michigan Department of Environmental Quality, Surface Water Quality Division. In addition, there are 60 industrial site and 18 construction site storm water permits.

Facility	Location	Waste	Receiving water
Adrian WWTP	Adrian	Sanitary	S. Br. River Raisin
Aget Mfg. Co.	Adrian	Non-contact cooling water	River Raisin
Amoco Oil Co.	Napoleon	Process water	Stoney Lake Drain
Big M Paperboard	Palmyra	Process water	River Raisin
Blissfield Mfg. Co.	Blissfield	Cooling, runoff	River Raisin
Blissfield WWTP	Blissfield	Sanitary, runoff	River Raisin
Boysville of Mi., Inc.	Clinton	Sanitary	S. Macon Creek
Brooklyn WTP	Brooklyn	Process Water	River Raisin
Brooklyn WWSL	Brooklyn	Sanitary	Goose Creek
Clayton WWSL	Clayton	Sanitary	S. Br. River Raisin
Clinton WWTP	Clinton	Sanitary	River Raisin
Deerfield WWTP	Deerfield	Sanitary	River Raisin
Diehl, Inc.	Adrian	Non-contact cooling water	S. Br. River Raisin
Dundee WWTP	Dundee	Sanitary, process water	River Raisin
Fairfield Twp.-Jasper WWSL	Weston	Sanitary	Black Creek
Ford Motor Co.	Monroe	Non-contact cooling water	River Raisin
Holnam, Inc.	Dundee	Runoff, process water, sanitary, non-contact cooling water	Macon Creek
Jude Stone Quarry	Napoleon	Process water	Austin No. 1 Dr.
Laidlaw Landfill	Adrian	Process water, stormwater runoff	River Raisin
Wamplers Lake WWSL	Franklin Twp.	Sanitary	Evans Creek
Lake Loch Erin WWTP	Onsted	Sanitary	Wolf Creek
Lenawee Farm Bureau Oil-Co-op	Adrian	Process water	River Raisin
Manchester WWTP	Manchester	Sanitary	River Raisin
Marco Products, Inc.	Adrian	Runoff, process water	East Side Dr.
Lake Hudson WWSL	Clayton	Sanitary	Bear Creek
Milan WWTP	Milan	Sanitary, Process water	Saline River
NSK Bearing Corp.	Saline	Process water, sanitary, cooling, runoff	Saline River
Onsted WWSL	Onsted	Sanitary	Wolf Creek
Orbital Engine Co.	Tecumseh	Non-contact cooling water	Cook Drain
Orchard Grove MHP	Saline	Sanitary	Saline River
Orchard Grove WWTP	Saline	Sanitary	Rouse Drain
Petersburg WWTP	Petersburg	Sanitary	River Raisin
PPG Industries, Inc.	Adrian	Non-contact cooling water, cooling water, runoff	Savage Drain
Saline WWTP	Saline	Sanitary, process water	Saline River
Tecumseh Products Co.	Tecumseh	Non-contact cooling water	River Raisin
Tecumseh WWTP	Tecumseh	Sanitary, process water	River Raisin
Union Camp Corp	Monroe	Process water, cooling water	River Raisin
Wacker Silicones Corp.	Adrian	Sanitary, cooling, runoff, process	River Raisin
Wickes Mfg. Co.	Adrian	Non-contact cooling water	S. Br. River Raisin

Table 25.–Maximum-minimum July water temperatures for several locations in the River Raisin watershed. Data from: Michigan Department of Natural Resources, Fisheries Division. Site refers to locations on Figure 4.

					Temperature (°F)		
Stream and Location	Twp.	Range	Section	Site	Max.	Min.	Median
River Raisin							
Austin Road	4S	3E	12	3	79	68	73
Allen Road	4S	4E	29	4	79	65	72
Russell Road	5S	4E	34	5	80	66	73
E. Gorman Road	7S	4E	34	7	78	66	72
Dundee	6S	6E	13	9	80	71	76
Ida-Maybee Road	6S	7E	13	10	82	73	77
Raisinville Road	6S	8E	27	11	81	69	75
Saline River							
Sherman Road	5S	7E	07	a	78	68	73
S. Br. River Raisin							
Heritage Park	6S	4E	30	c	73	64	68
N. Br. Macon Creek							
Day Road	5S	6E	36	g	79	64	71

Table 26.–Organizations with interest in the River Raisin watershed.

Organization
Brest Bay Sportsmens Club
Canvasback Club
Carleton Sportsmens Club
Ducks Unlimited-Adrian Chapter
Ducks Unlimited-Brooklyn Chapter
Ducks Unlimited-Monroe Chapter
Grass Lake Sportsmens Club
Heart of the Lakes Sportsmens Club (Brooklyn)
Hillsdale County Conservation Club
Irish Hills Rod & Gun Club
Jackson County Outdoor Club
Johnson's Sporting Goods (Adrian)
Knutson's Reccreational Sales (Brooklyn)
Lenawee County Conservation League
Manchester Sportsmens Club
Maybee Sportsmens Club
Michigan Salmon & Steelheaders Association-Jackson Chapter
Michigan United Conservation Clubs Districts 2 & 3
Monroe County Rod & Gun Club
National Wild Turkey Federation - Monroe Chapter
National Wild Turkey Federation-Waterloo Long Beards Chapter
Pheasants Forever - Adrian Chapter
Pheasants Forever - Jackson Chapter
Pheasants Forever - Monroe Chapter
Pheasants Forever - Washtenaw Chapter
River Raisin Land Trust
River Raisin Sportsmens Club (Blissfield)
River Raisin Watershed Council
Tri-County Sportsmens League
Trout Unlimited - Adrian Chapter
Whitetails Unlimited - Adrian Chapter
Whitetails Unlimited - Monroe Chapter
Michigan Lakes and Streams Association
Lake Columbia Property Owners Association
Lake Loch Erin Association
Lake Somerset Association
Norvell Lake Association
Sand Lake Association
Wamplers Lake Association

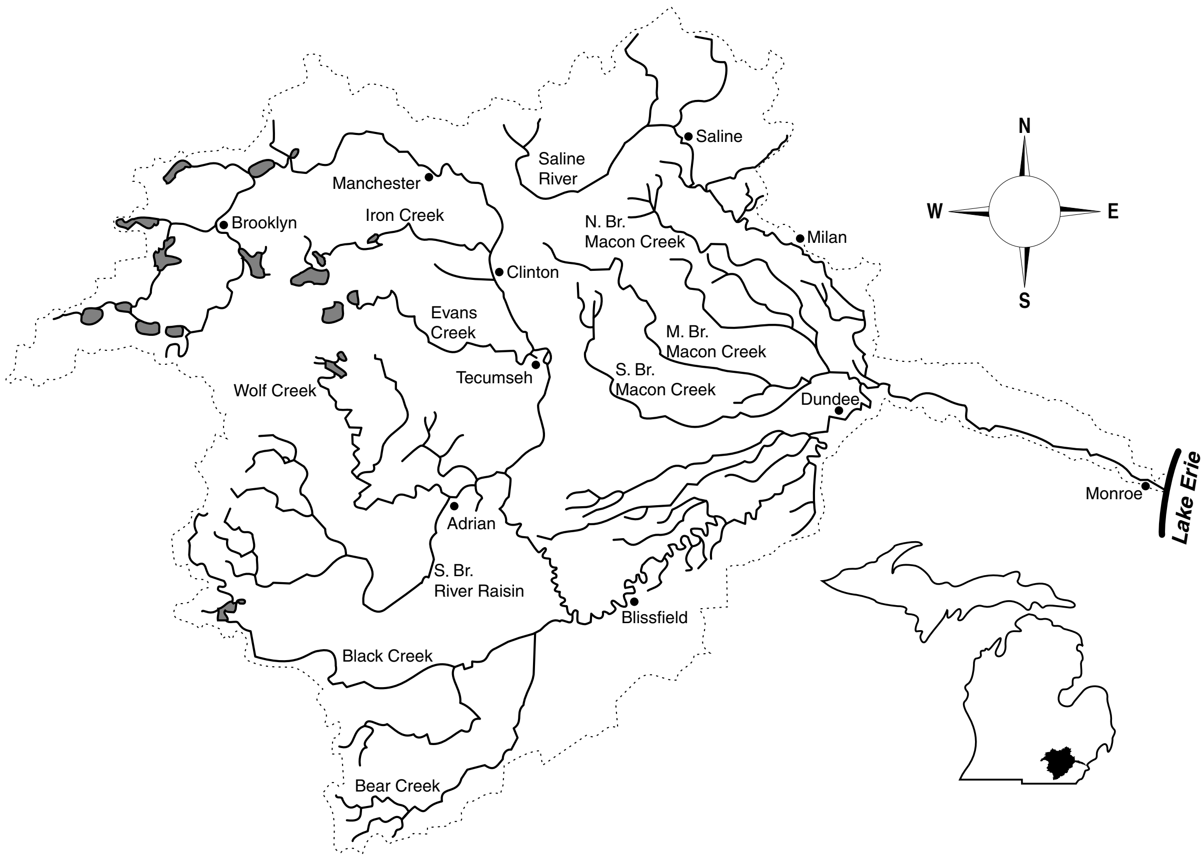

Figure 1.–The River Raisin watershed in southeastern Michigan showing major tributaries and towns.

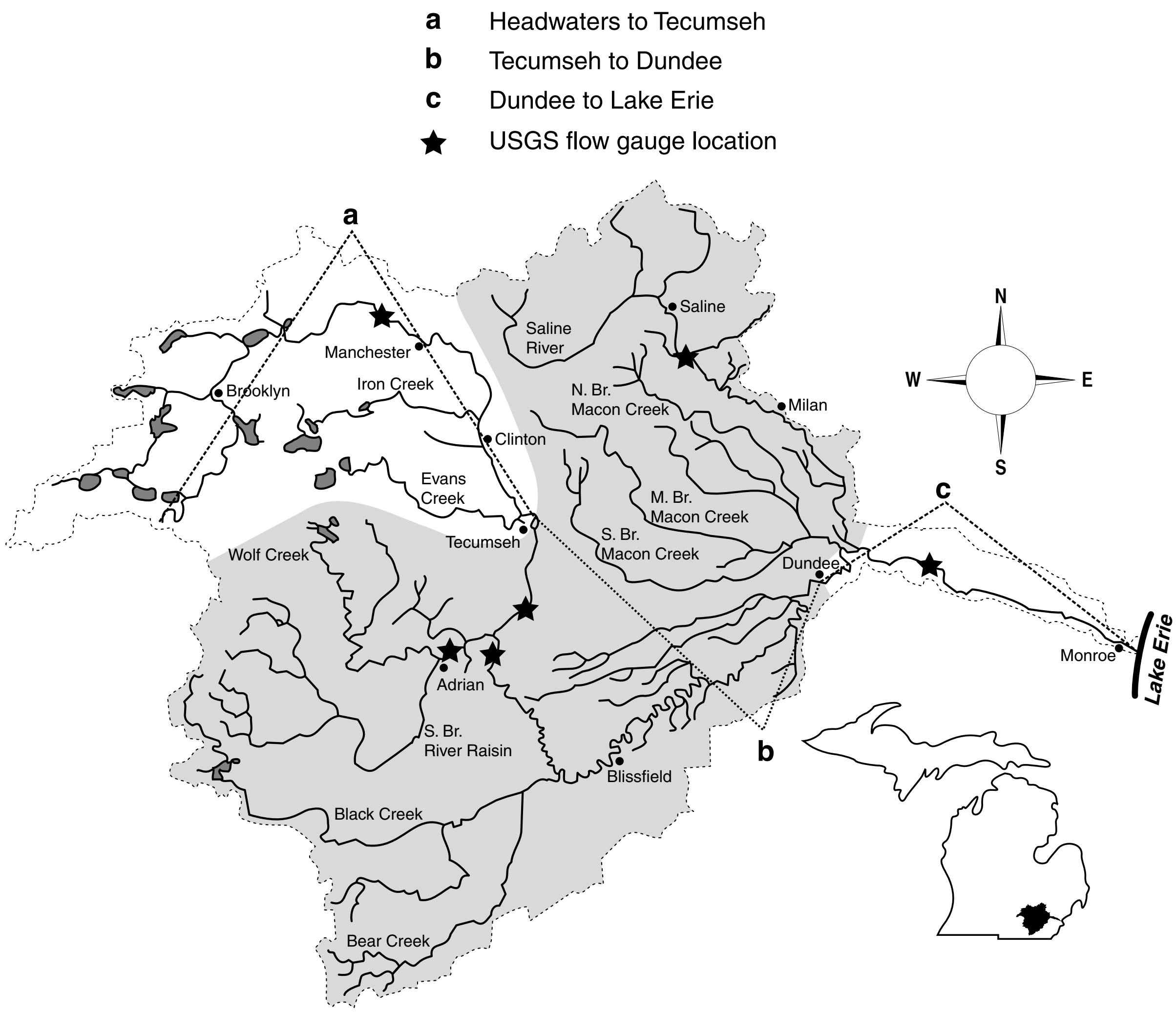

Figure 2.–Location of United States Geological Survey flow gauge stations and mainstem river segments in River Raisin watershed.

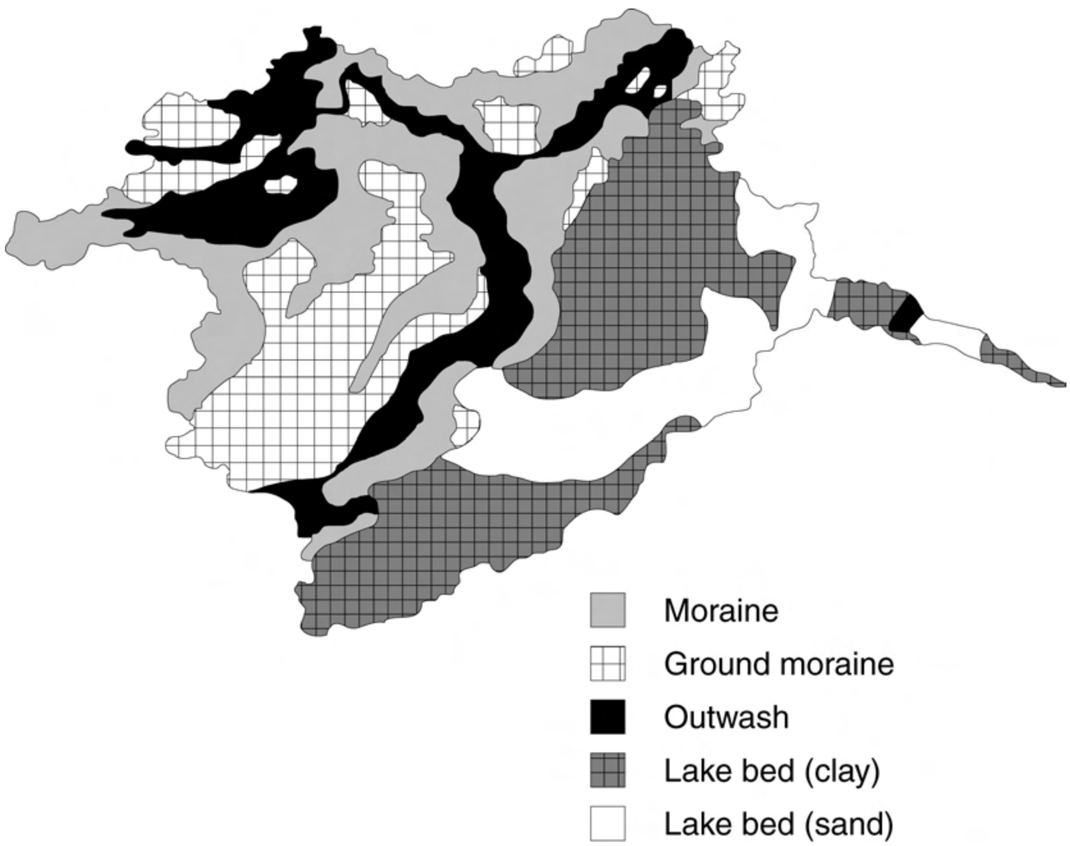

Figure 3.–Surficial geology map of the River Raisin watershed. Data from: Roth 1994.

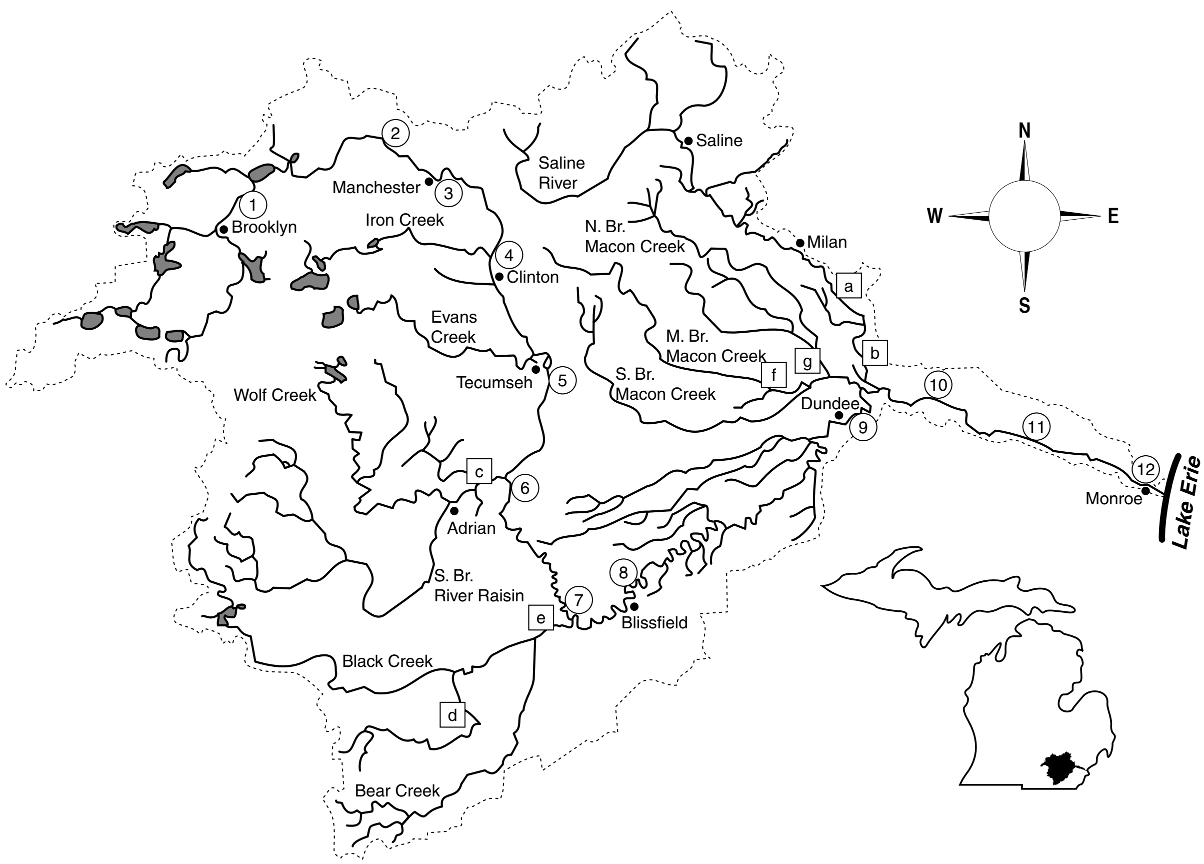

Figure 4.–ERDAS database locations for sites in the River Raisin watershed (See Tables 2, 3, and 4). Data from: P. Seelbach, Michigan Department of Natural Resources, Fisheries Division, personal communication. Circles indicate mainstem sites and squares indicate tributary sites.

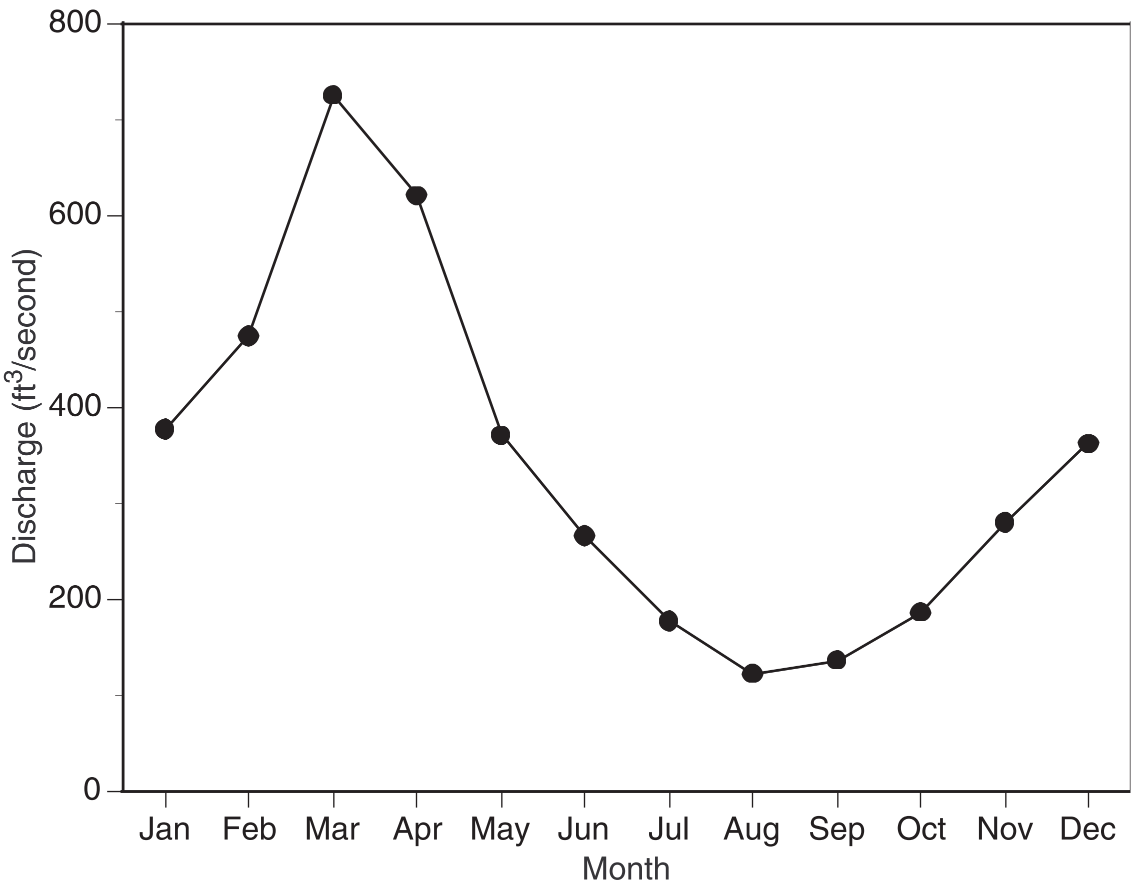

Figure 5.–Mean monthly discharge (cfs) for River Raisin mainstem east of Adrian for the period of record 1954-94. Data from: United States Geological Survey gauge records.

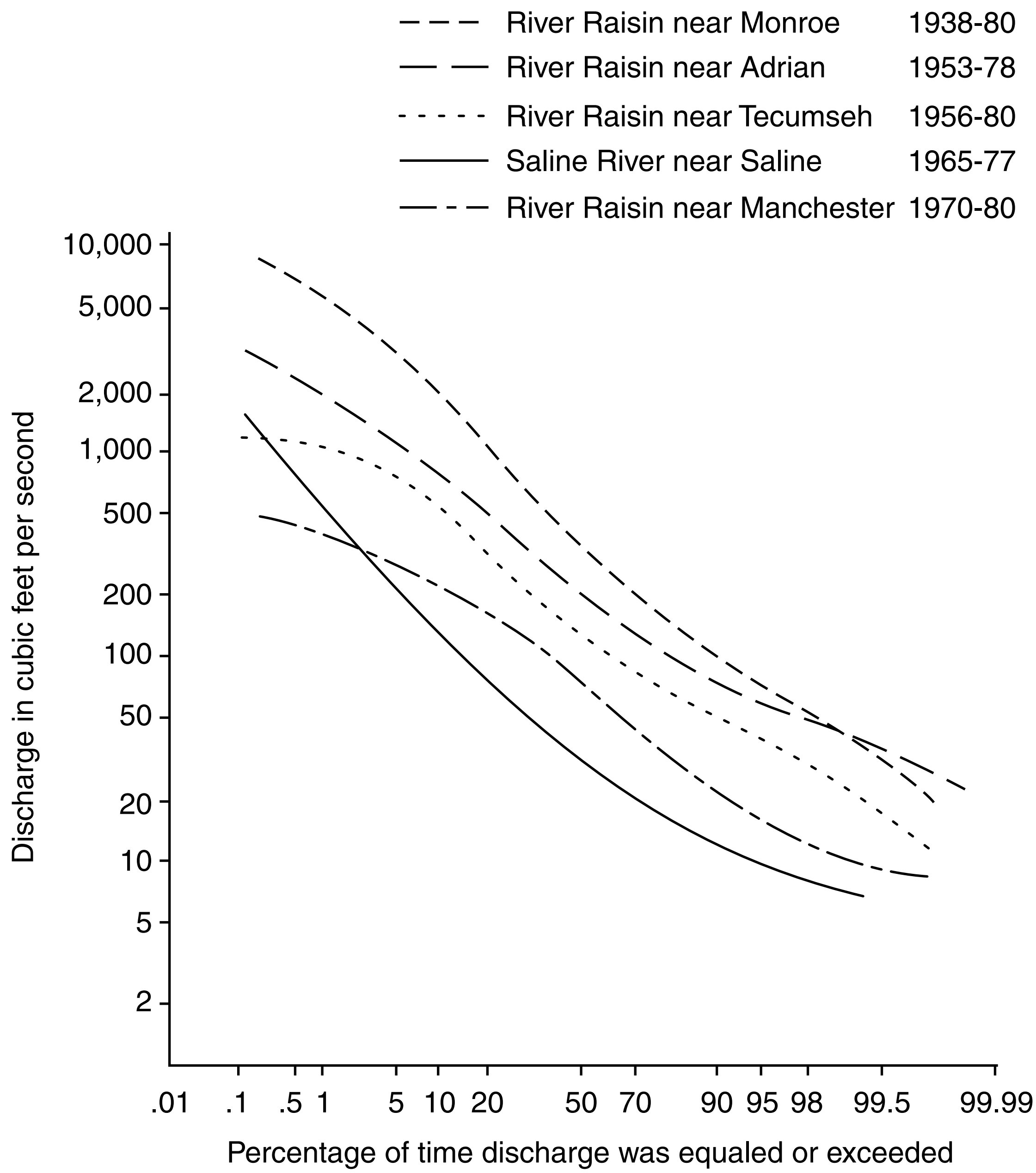

Figure 6.–Flow duration curves for United States Geological Survey gauging stations on River Raisin mainstem and Saline River. See Figure 4 for precise gauge locations. Data from: Fulcher et al. 1986.

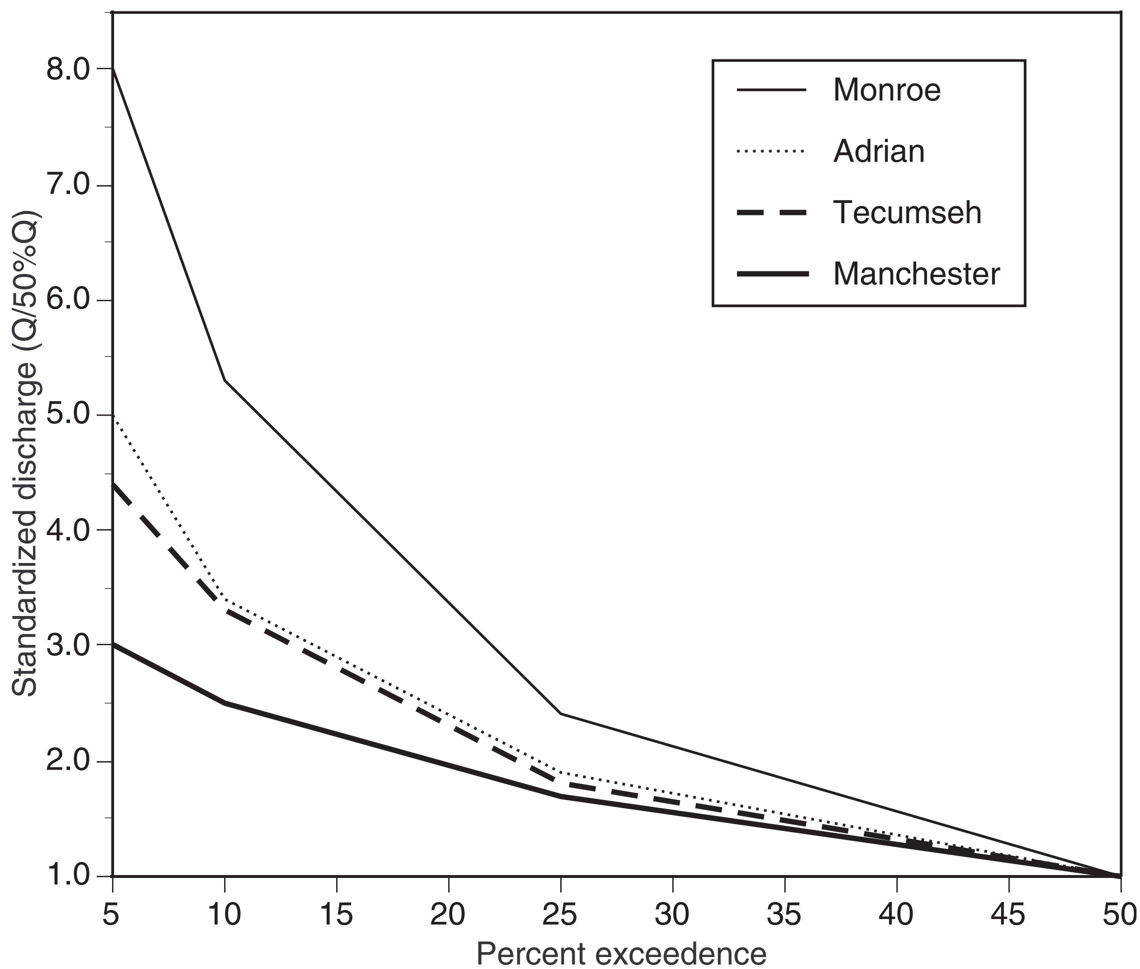

Figure 7.–Standardized high flow exceedence curves for four United States Geological Survey gauge stations on the River Raisin. Data from: United States Geological Survey gauge data for period of record. Standardized discharge is the discharge(Q)/median(50%Q) discharge.

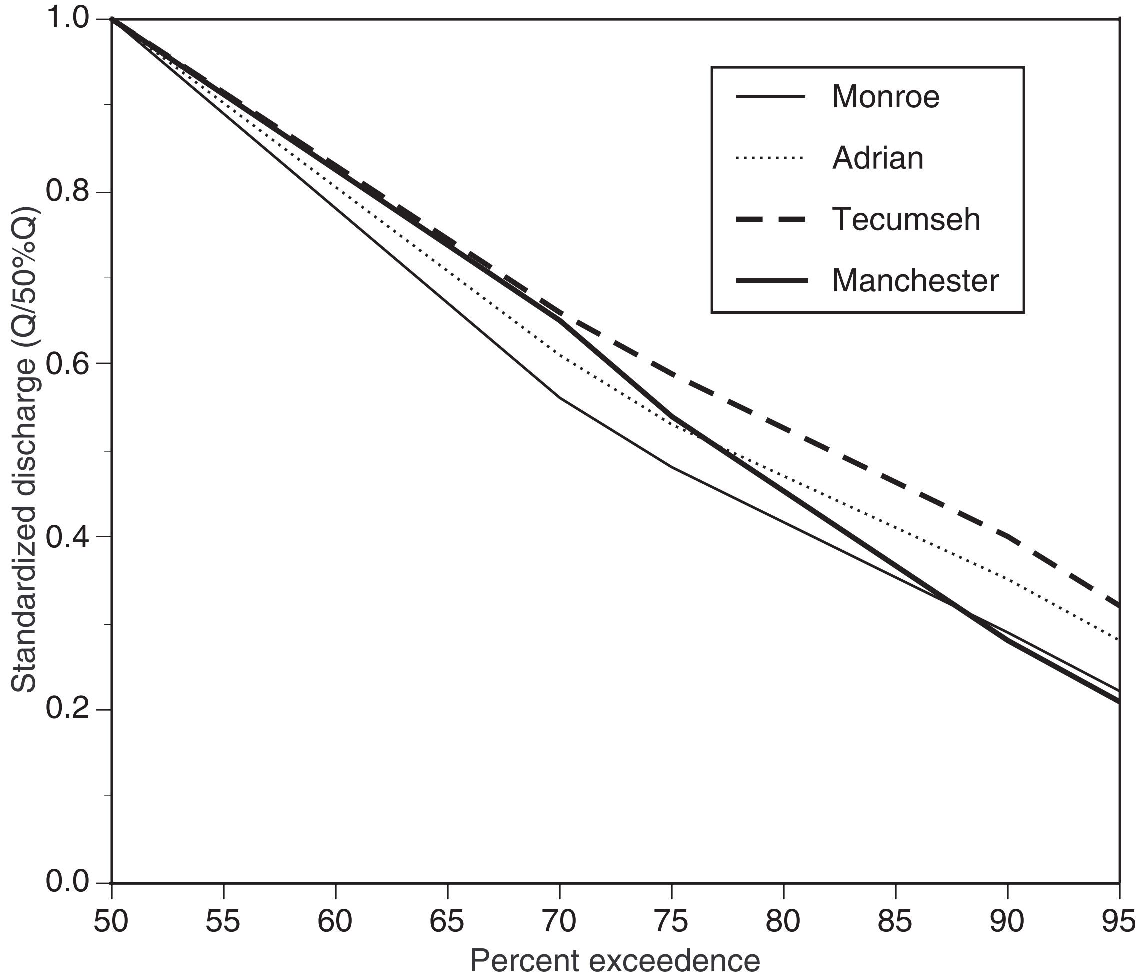

Figure 8.–Standardized low flow exceedence curves for four United States Geological Survey gauge stations on the River Raisin. Data from: United States Geological Survey gauge data for period of record. Standardized discharge is the discharge(Q)/median(50%Q) discharge.

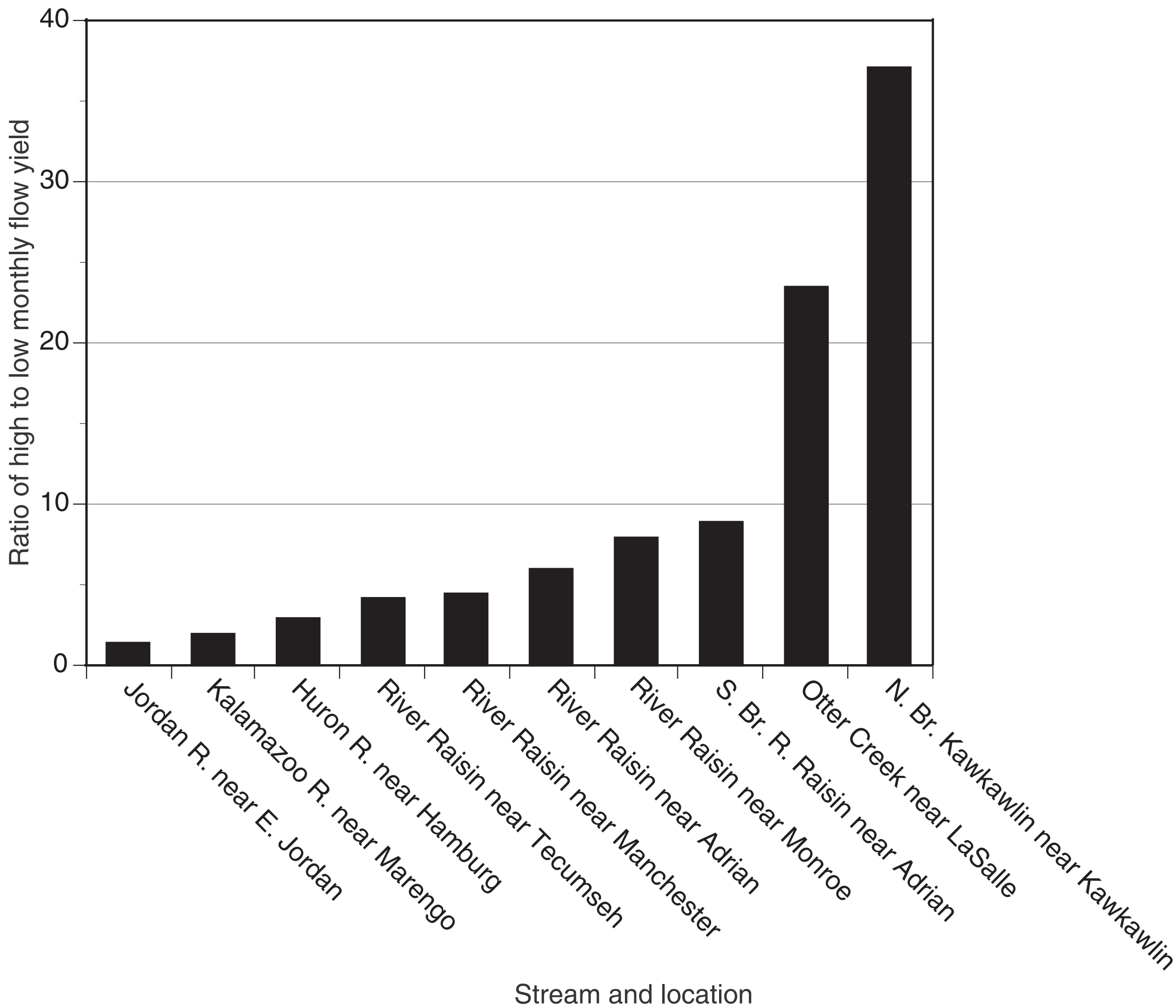

Figure 9.–Ratio of high to low monthly flow yields for sites on selected Michigan streams. Data from: United States Geological Survey gauge records.

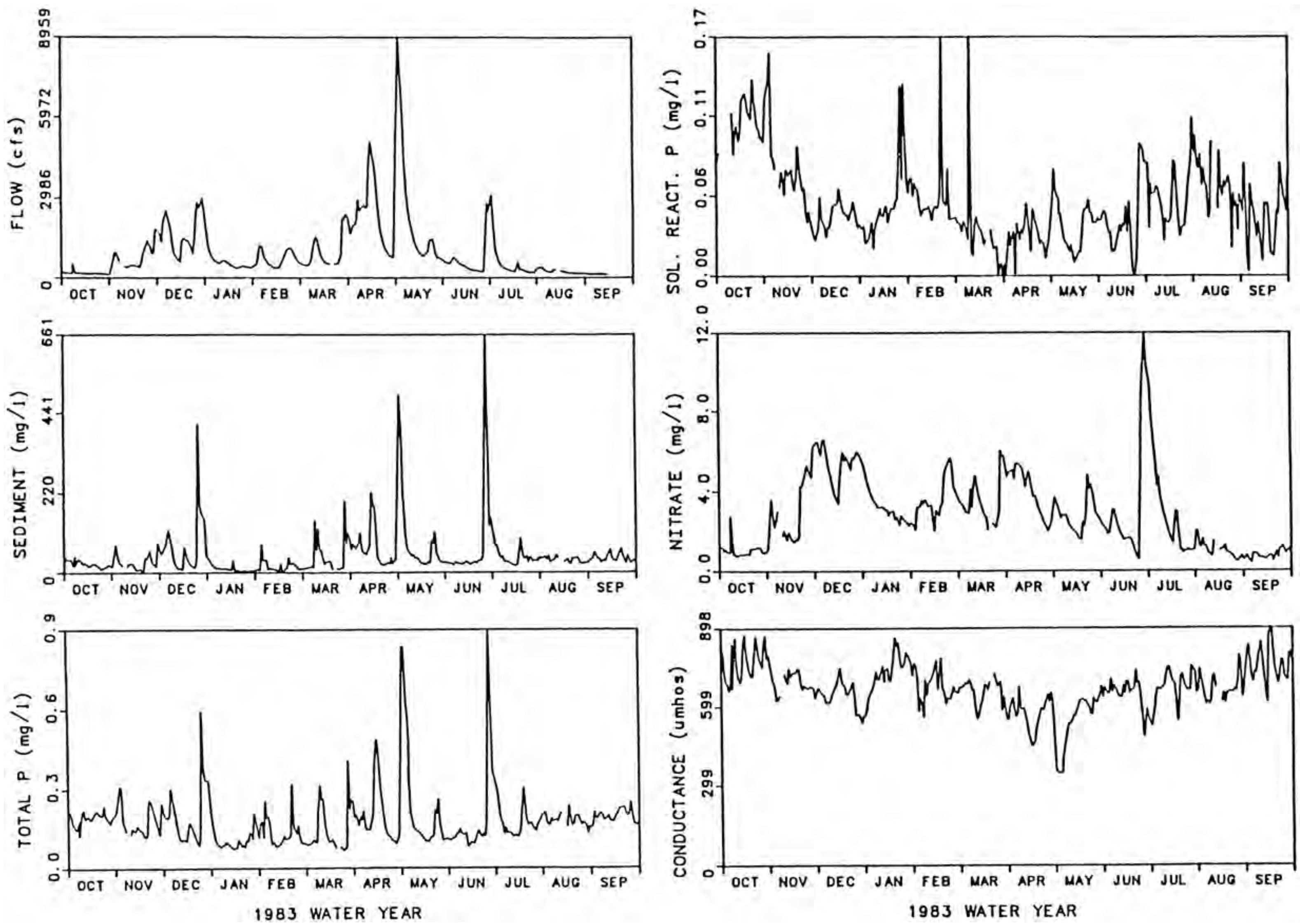

Figure 10.–Annual hydrograph, sedigraph, and nutrient chemograph ttfor the River Rasin at Ida-Maybee Road. Data from: Baker 1988.

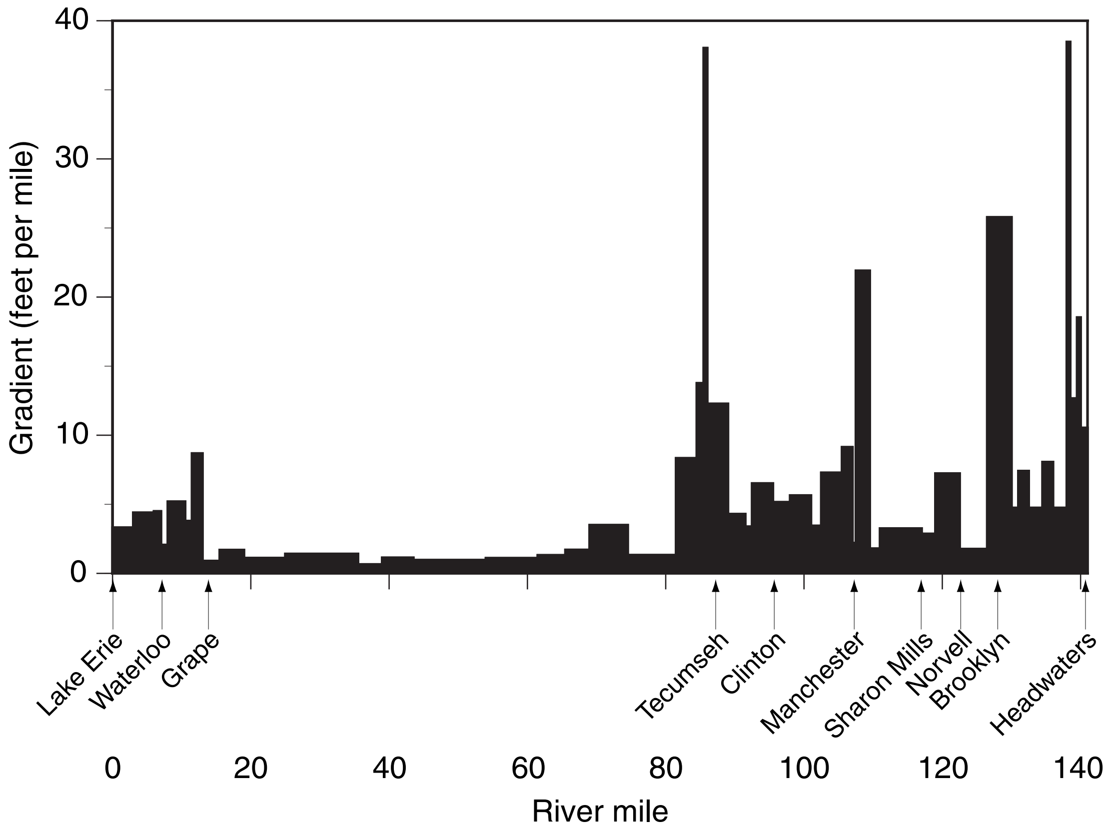

Figure 11a.–Gradient (elevation change in feet per mile) of the mainstem River Raisin from the mouth at Lake Erie to the headwaters. Data from: P. Seelbach and G. Whelan, Michigan Department of Natural Resources, Fisheries Division, personal communication.

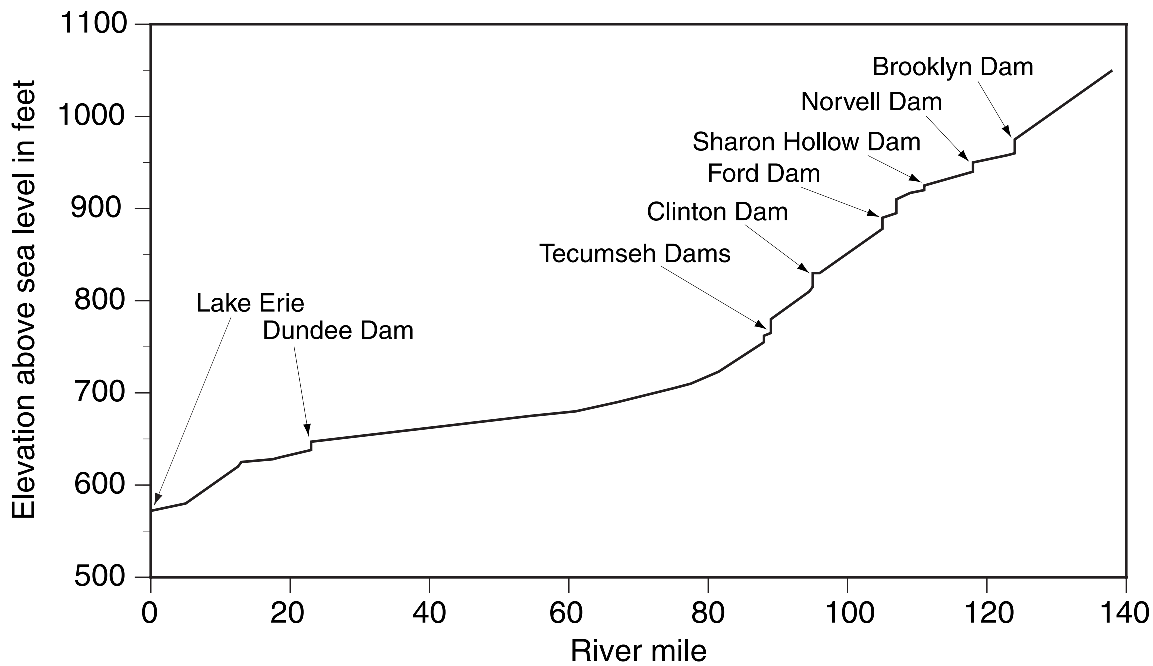

Figure 11b.–Elevation changes by river mile from the mouth to the headwaters of the River Raisin mainstem. Selected major dam locations are noted. Data from: Knutilla and Allen 1975.

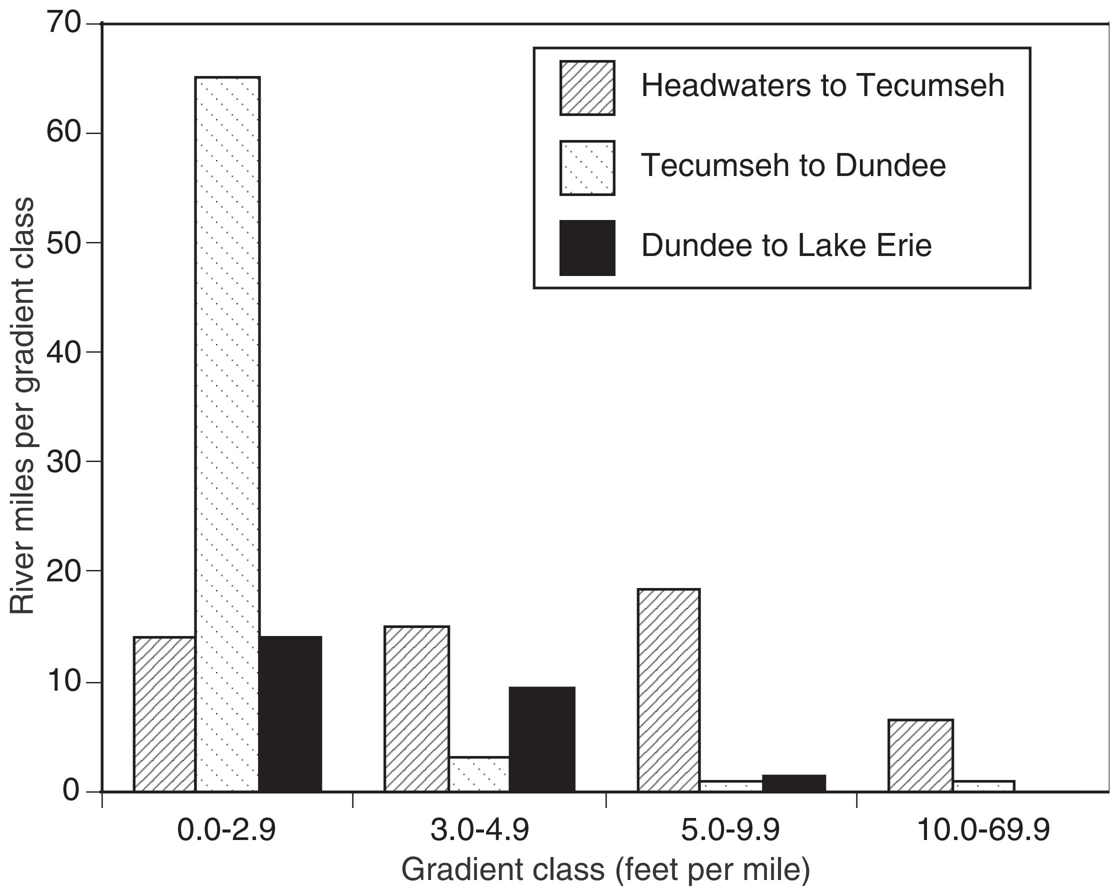

Figure 12.–Gradient classes and length of river in each for three sections of the River Raisin mainstem. Data from: P. Seelbach and G. Whelan, Michigan Department of Natural Resources, Fisheries Division, personal communication.

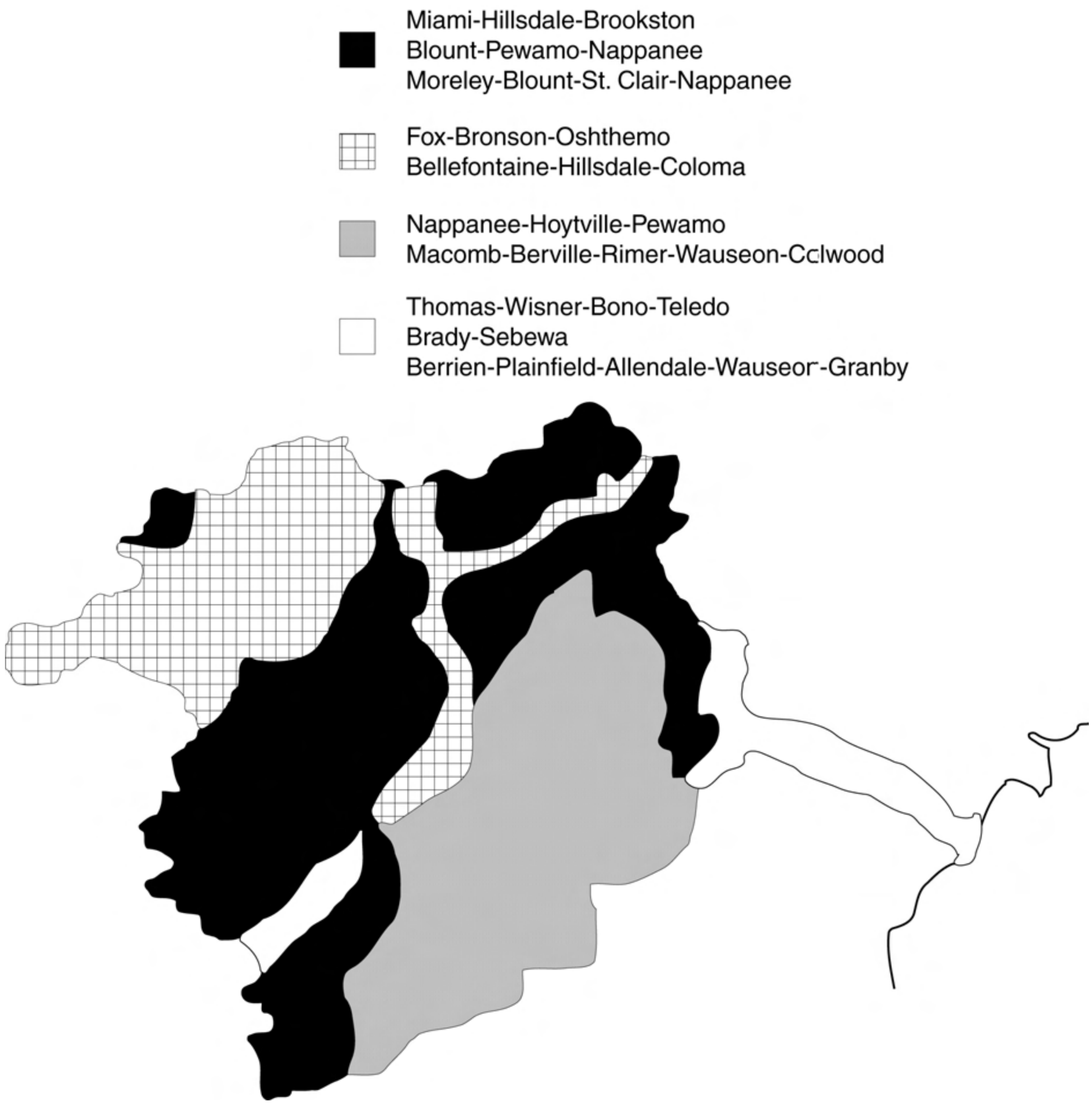

Figure 13.–Soil associations in the River Raisin watershed. Data from: Michigan Water Resources Commission 1965.

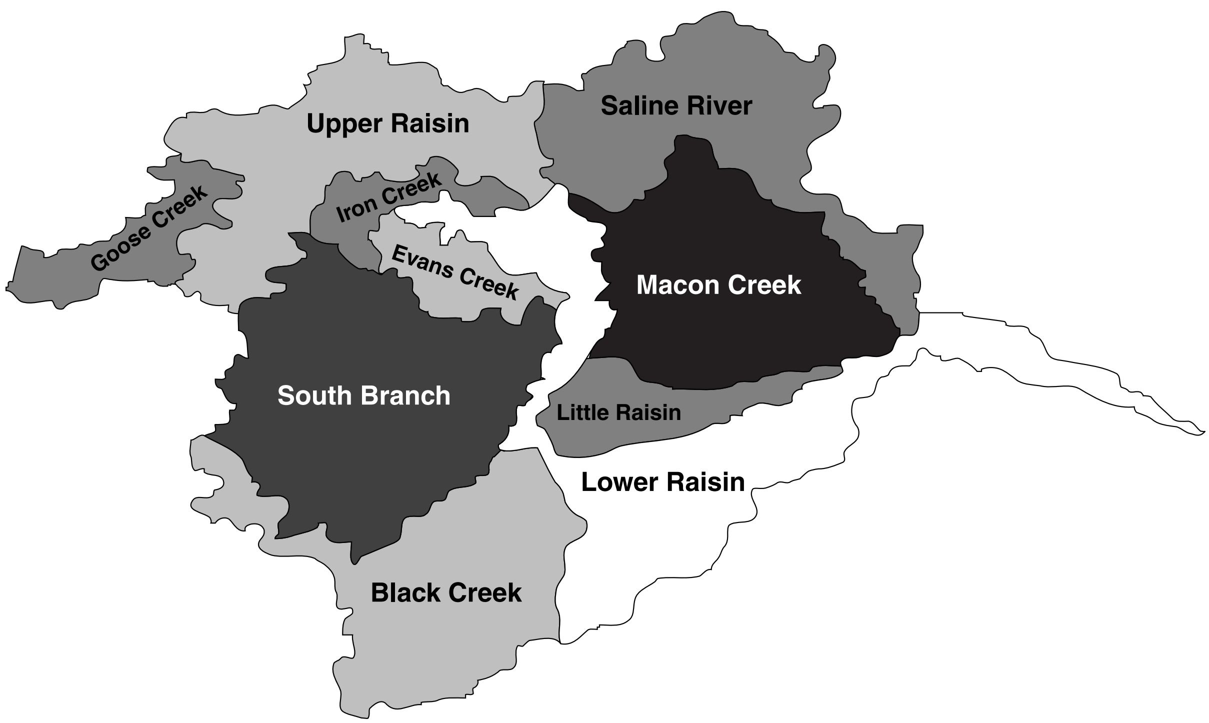

Figure 14.–Major sub-basins of the River Raisin watershed. Data from: Roth 1994.

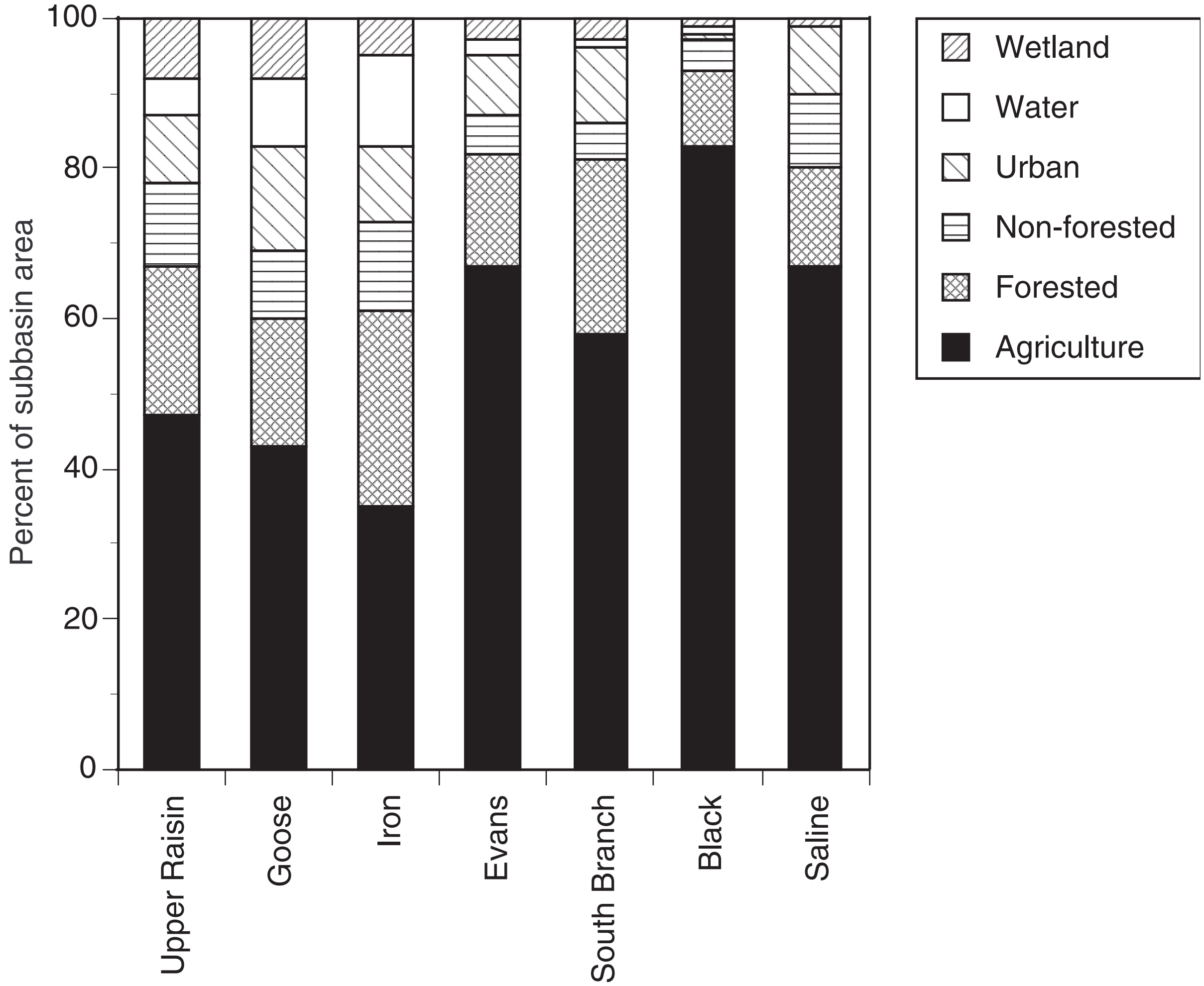

Figure 15.–Land uses in seven major sub-basins of the River Raisin watershed. Land uses are given as the percentage of land area. Data from: Roth 1994.

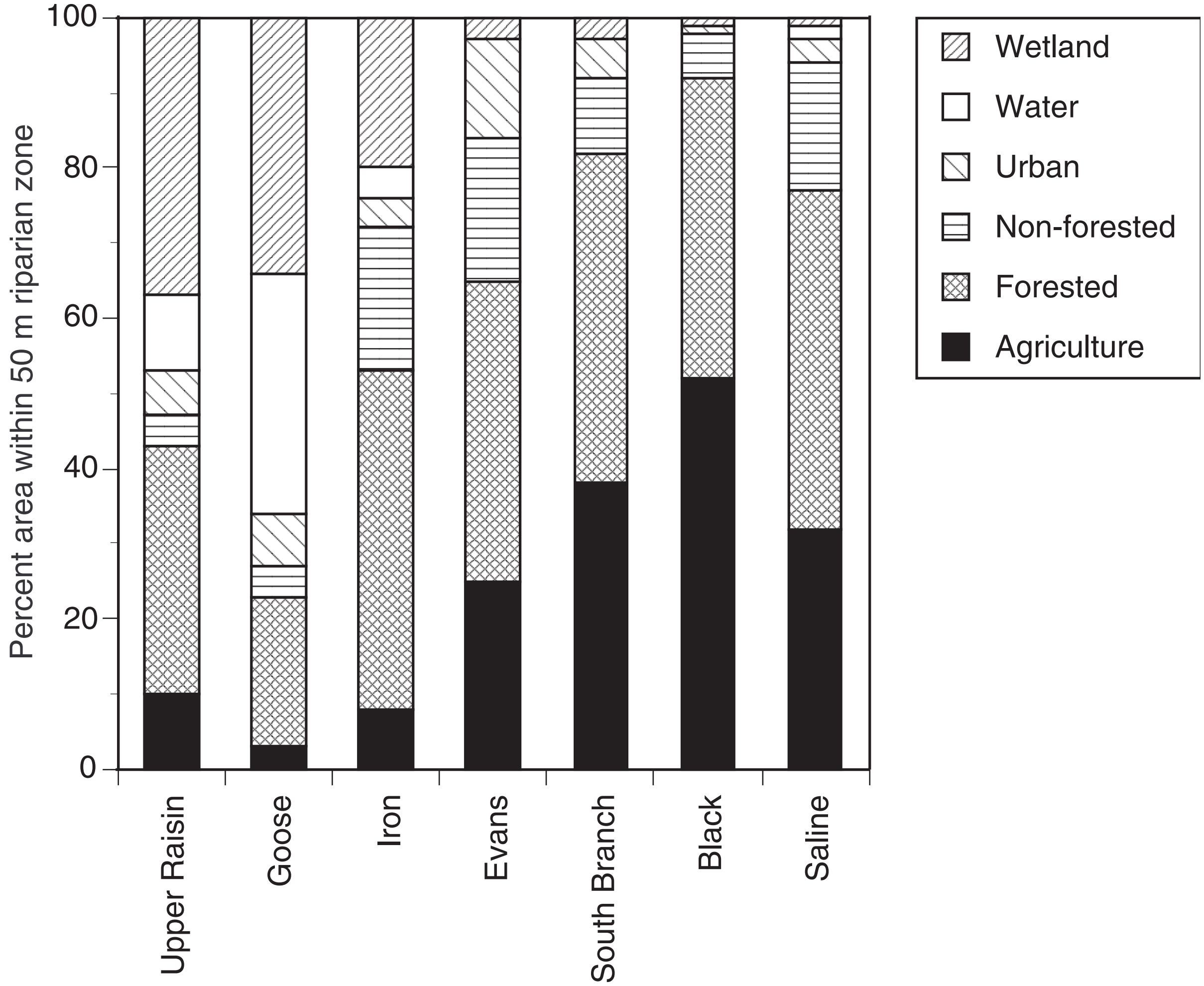

Figure 16.–Land uses in a 50 meter riparian zone (50 m each bank, 100 m total width) for seven major sub-basins of the River Raisin watershed. Land uses are given as the percentage of land area in 50 m of the stream, for the entire stream length. Data from: Roth 1994.

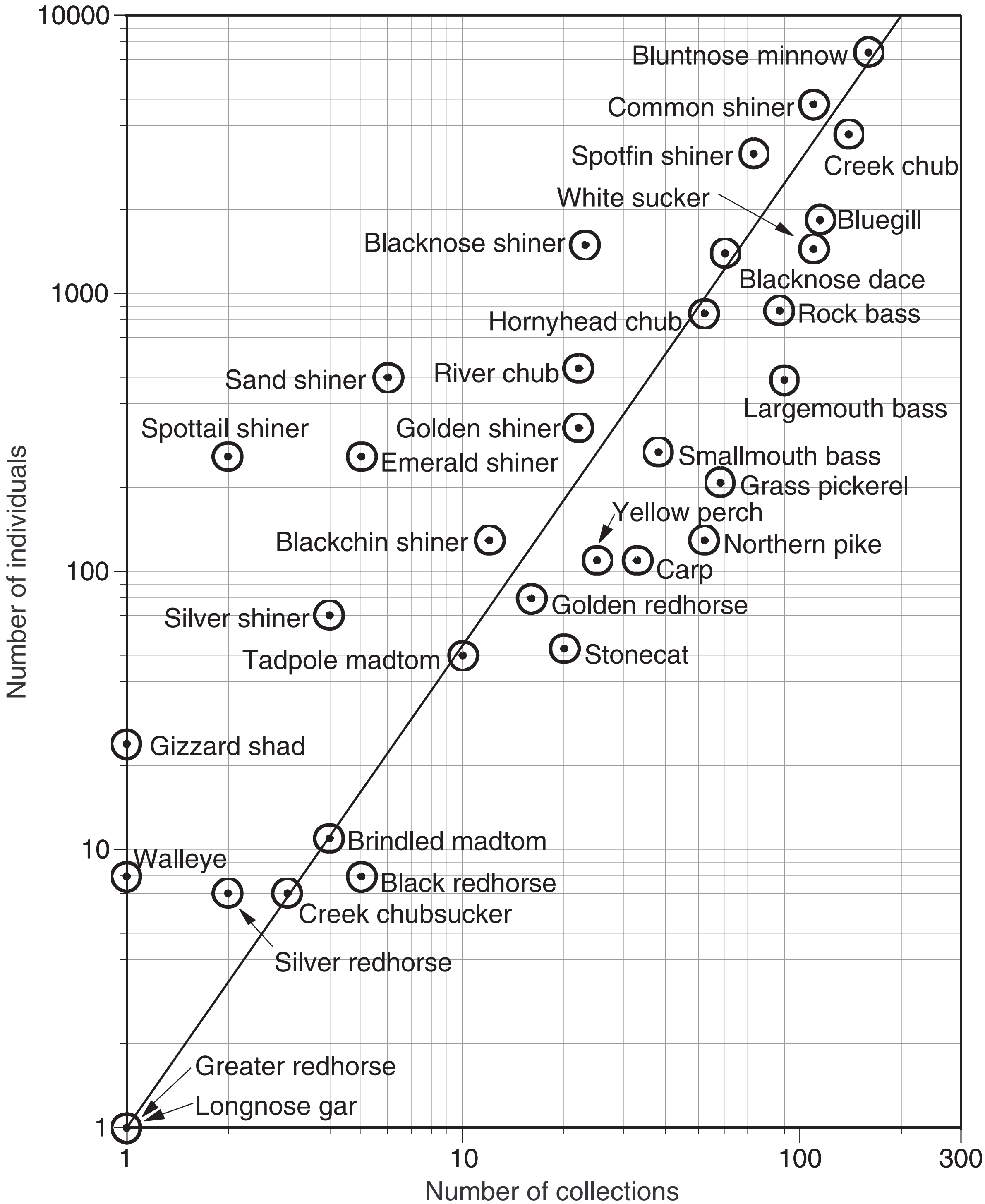

Figure 17.–Numerical abundance (vertical axis) and breadth of representation in ecological samples (horizontal axis) of River Raisin fishes. Data from: Smith et al. 1981.

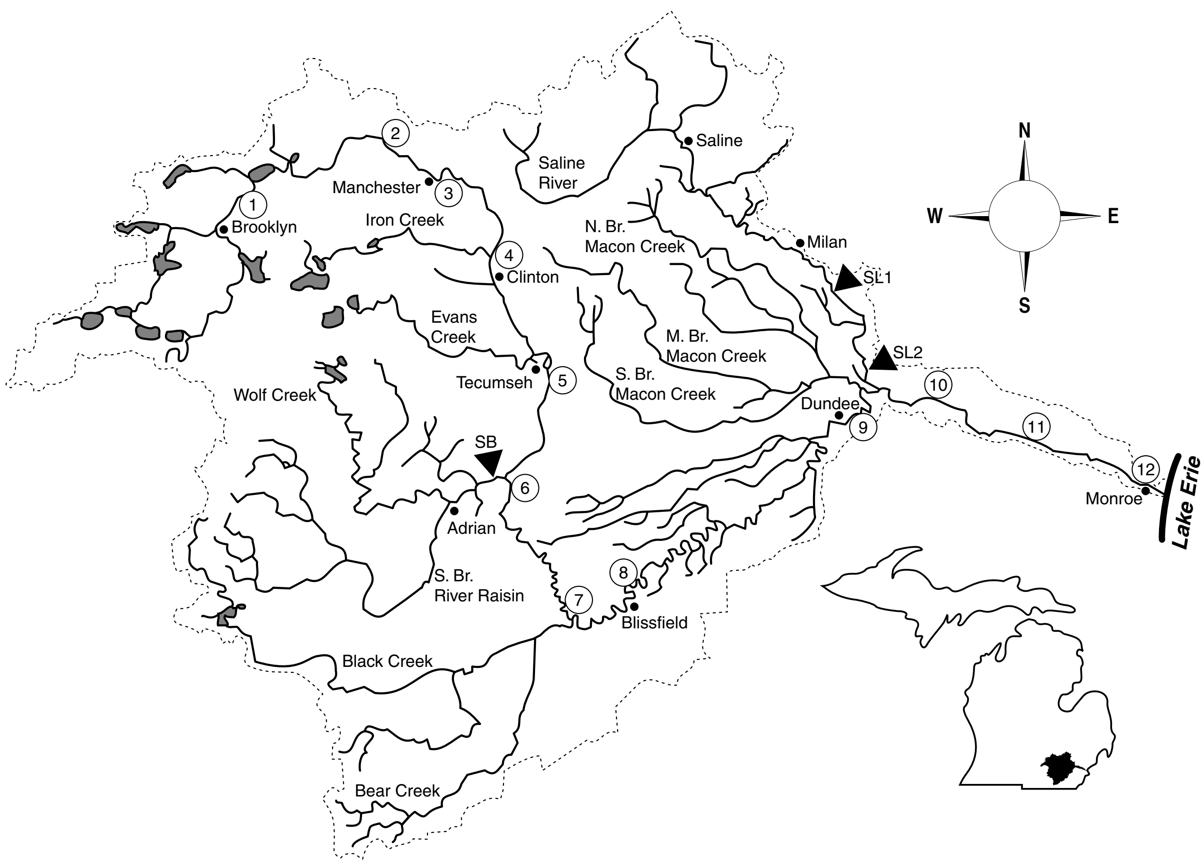

Figure 18.–Location of sampling stations during 1984 Michigan Department of Natural Resources, Fisheries Division River Raisin rotenone survey. Circles indicate mainstem sites and triangles indicate tributary sites. Data from: Towns 1985.

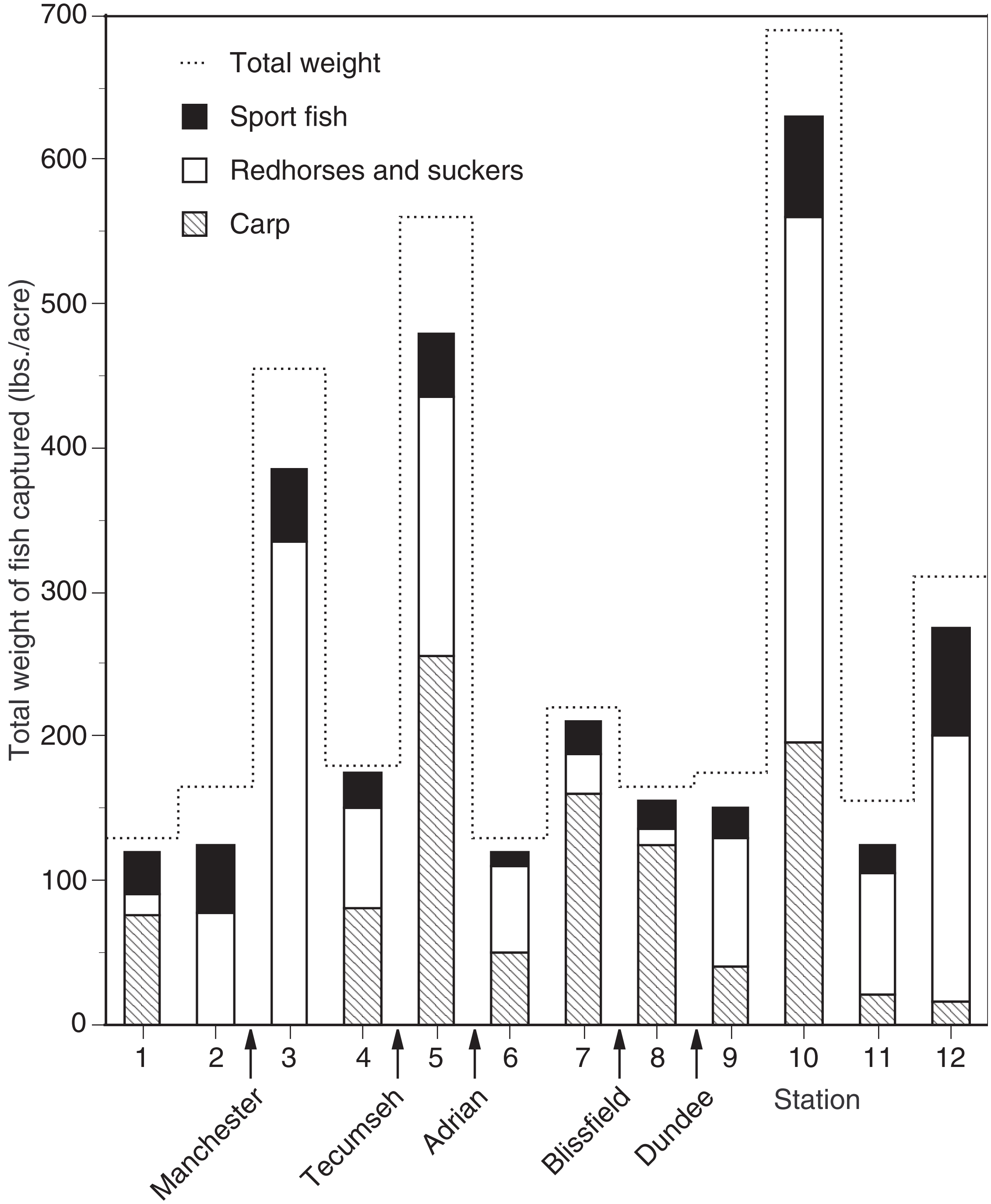

Figure 19.–The weight of sport fish (includes smallmouth bass, largemouth bass, rock bass, bluegill, northern pike, bullhead spp., channel catfish, and walleye), redhorses and suckers (includes northern hog sucker, white sucker, and all redhorse spp.), and carp captured at each mainstem station during the 1984 Michigan Department of Natural Resources, Fisheries Division River Raisin rotenone survey. The dotted line represents the weight of all fish captured. Data from: Towns 1985.

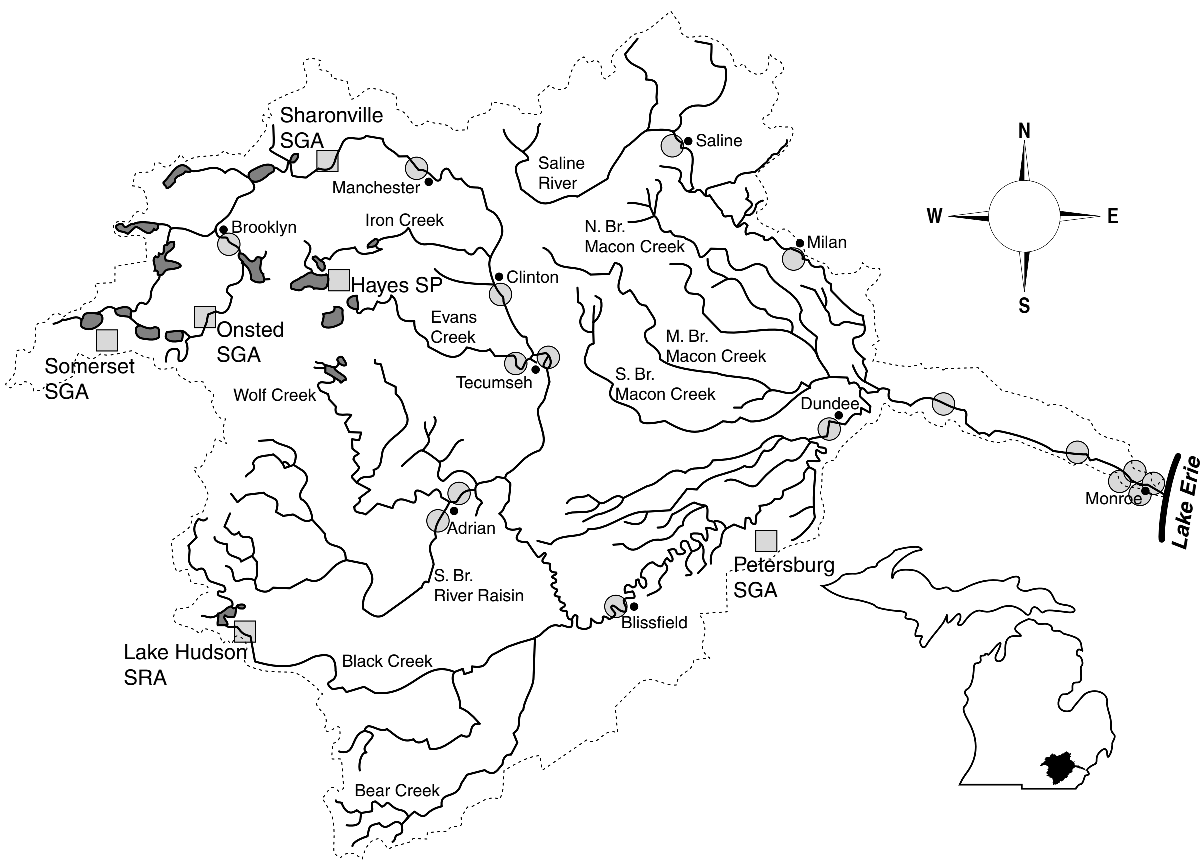

Figure 20.–State game areas, State recreational areas, State parks, and municipal parks in the River Raisin watershed. Open square = State facility and open circle = city, village or township facility.

1. Lake Somerset (Goose Creek)
2. Lake Columbia (Goose Creek)
3. Brooklyn
4. Norvell Lake
5. Sharon Hollow
6. Manchester Mill
7. Ford Manchester
8. Altas Mill (Clinton)
9. Red Mill (Tecumseh)
10. Standish Mill (Tecumseh)
11. Globe Mill (Tecumseh)
12. Blissfield
13. Deerfield
14. Dundee
15. Murciak (Grape)
16. Waterloo
17. Lake Loch Erin (Wolf Creek)
18. Lake Adrian (Wolf Creek)
19. Lake Hudson (Bear Creek)
20. Saline (Saline River)
21. Milan (Saline River)

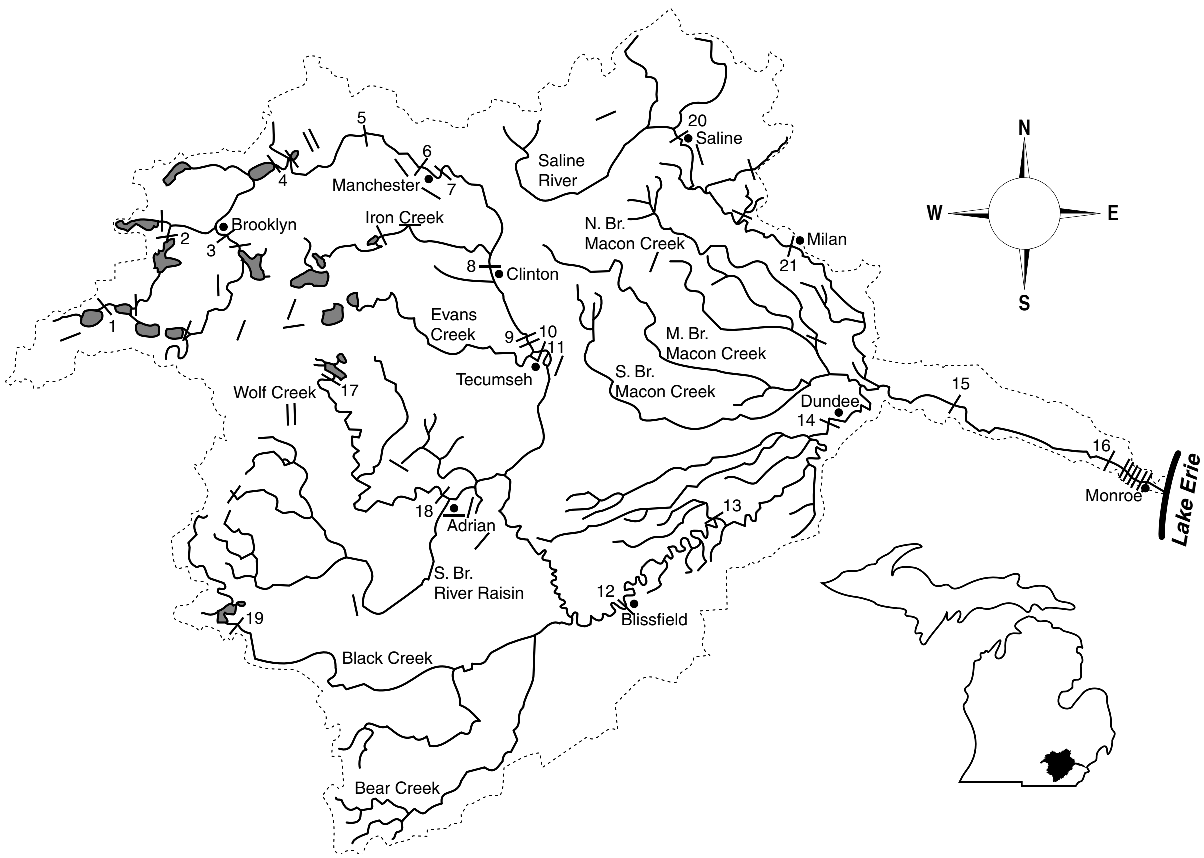

Figure 21.–Approximate location of dams in the River Raisin watershed. Major dams are numbered. Data from: Michigan Department of Environmental Quality, Land and Water Management Division, Dam Safety Section.

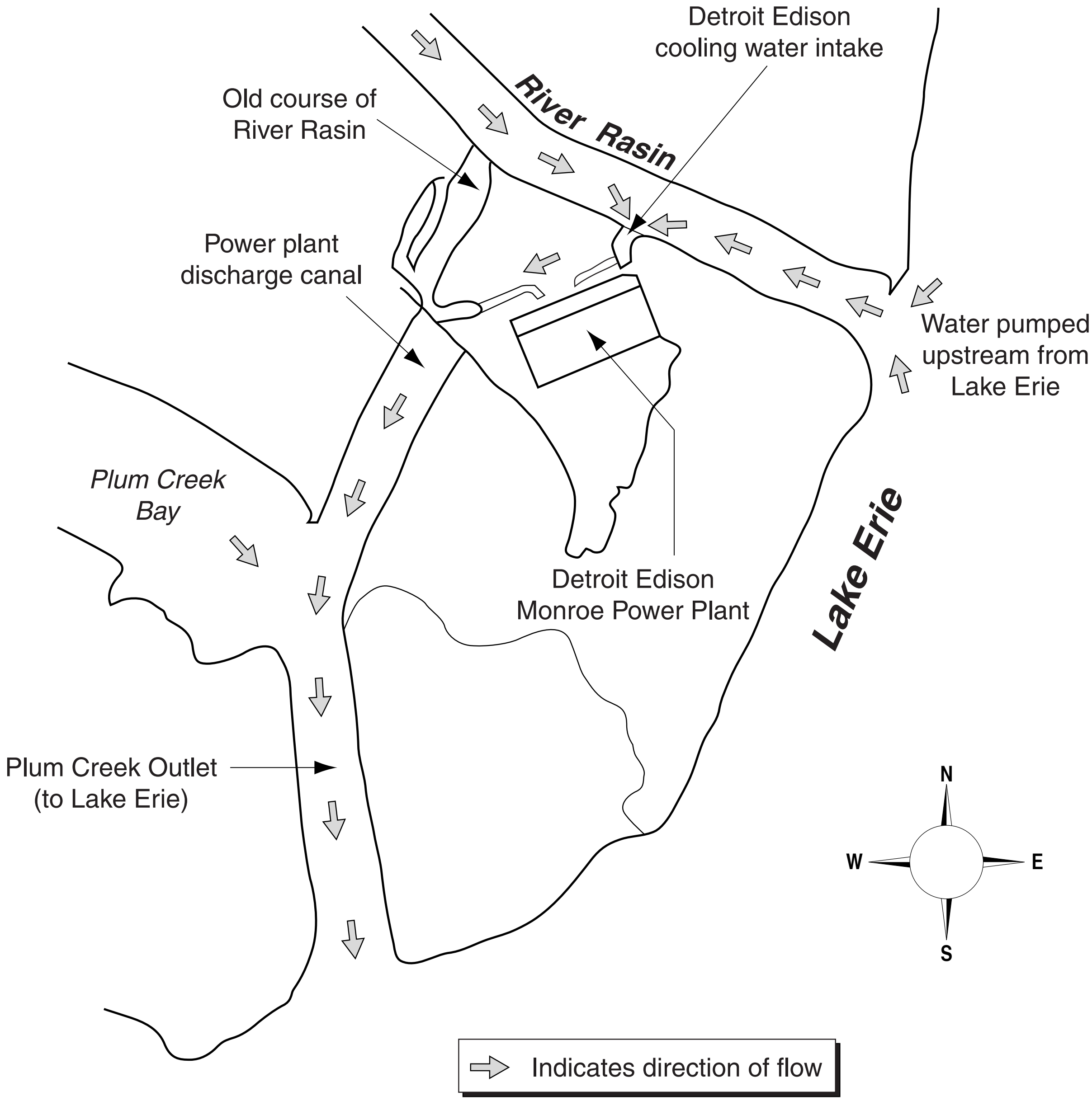

Figure 22.–Detroit Edison Monroe Power Plant cooling water flow configuration. Data from: aerial photograph, Engineering Department, City of Monroe.

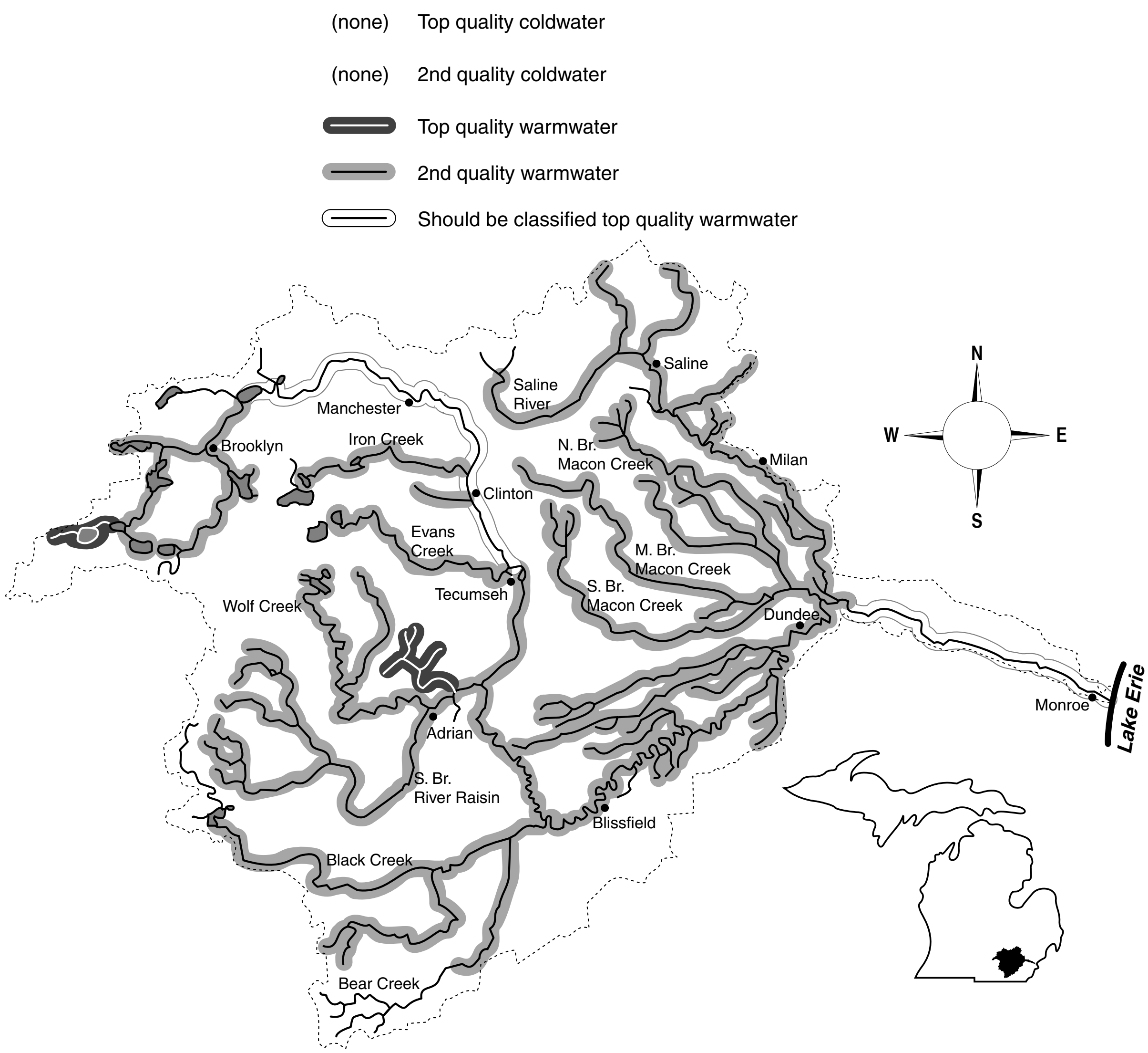

Figure 23.–Michigan Department of Natural Resources, Fisheries Division stream classification map, 1964. The mainstem from Norvell Dam to Tecumseh and from the confluence with the Saline River to Lake Erie should be classified top quality warmwater.

Michigan DNR

STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES

Number 23 October 1998

River Raisin Assessment Appendix

Kenneth E. Dodge

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FISHERIES DIVISION
SPECIAL REPORT

MICHIGAN DEPARTMENT OF NATURAL RESOURCES
FISHERIES DIVISION

Fisheries Special Report 23
October 1998

River Raisin Assessment
Appendix

Kenneth E. Dodge

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Appendix

This appendix contains maps of known past and present fish distributions within the Raisin River watershed. Historic fish distributions were compiled from records located at the University of Michigan, Museums Fisheries Library and from historic anecdotal records. Historic distributions (black bars) are noted only when they are significantly different from more recent distributions. Fish species may have been present historically in areas designated as present distribution. Present fish distributions (gray shaded) were compiled from seining survey records (Smith et al. 1981), rotenone survey records (Towns 1985), and survey files located at the Michigan Department of Natural Resources offices at the Institute for Fisheries Research and Jackson District Headquarters. Fish distribution maps prepared by J. N. Taylor (Smith et al. 1981) were particularly helpful. Personal communications from G. Smith, U of M Ruthven Museum; R. Haas, MDNR, Lake St. Clair Research Station; C. Latta, Institute for Fisheries Research; and L. Goedde, Ohio Division of Wildlife yielded valuable information.

Scientific names and phylogenic order follow Robins et al. 1991. For species that are listed under Michigan's Endangered Species Act (Section 36505 (1a) Part 324 of Act 451, 1994), their status follows their scientific name.

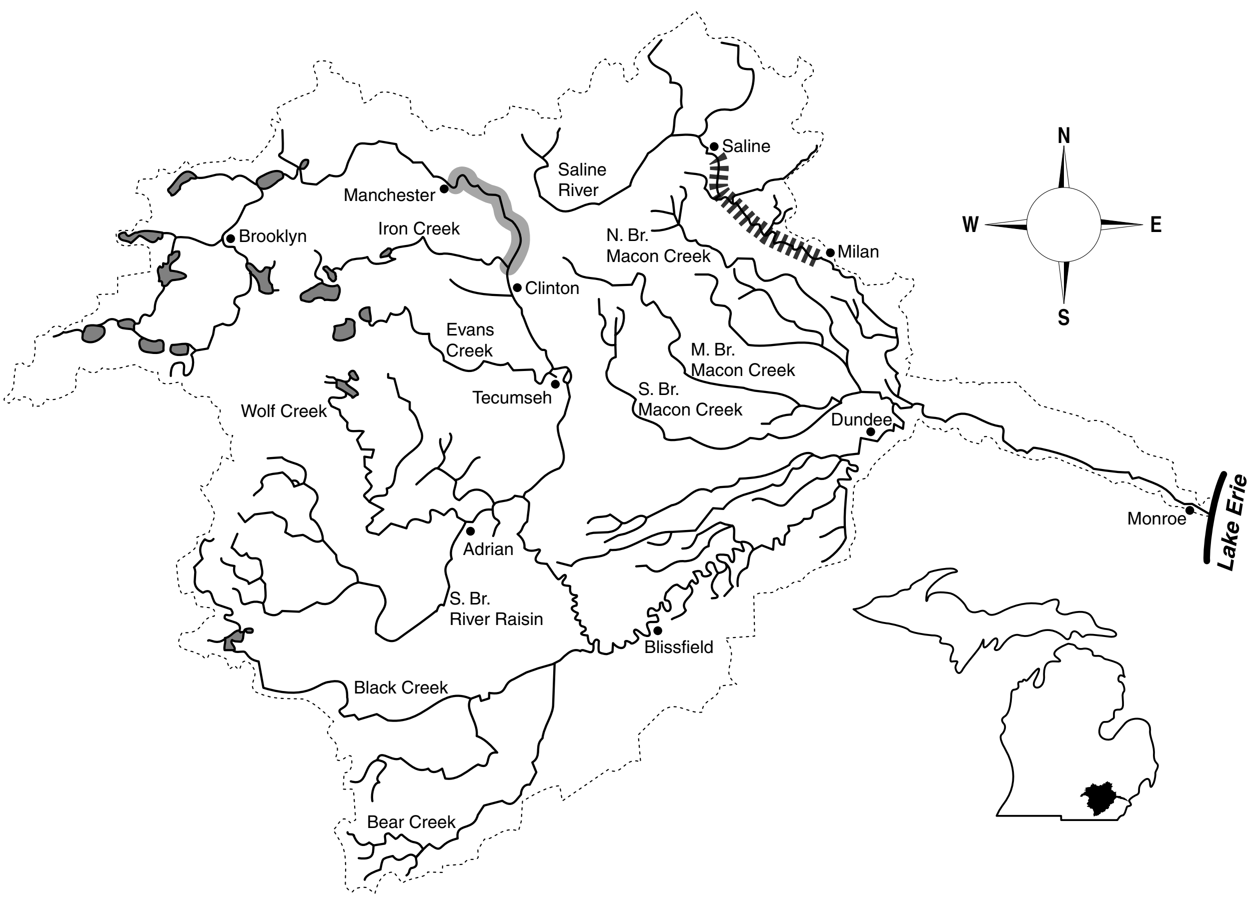
The habitat descriptions were compiled from Fisheries of the Great Lakes Region (Hubbs and Lagler 1947), Freshwater Fishes of Canada (Scott and Crossman 1973), Fishes of Missouri (Pflieger 1975), The Fishes of Ohio (Trautman 1982), and Fishes of Wisconsin (Becker 1983).

Northern brook lamprey (*Ichthyomyzon fossor*) - rare

Habitat:

feeding - young: low gradient, substrate with bars and beds of mixed sand and organic debris
- moderately warm water

spawning - clear, high gradient streams (<15 feet wide)
- riffles with sand or gravel substrate



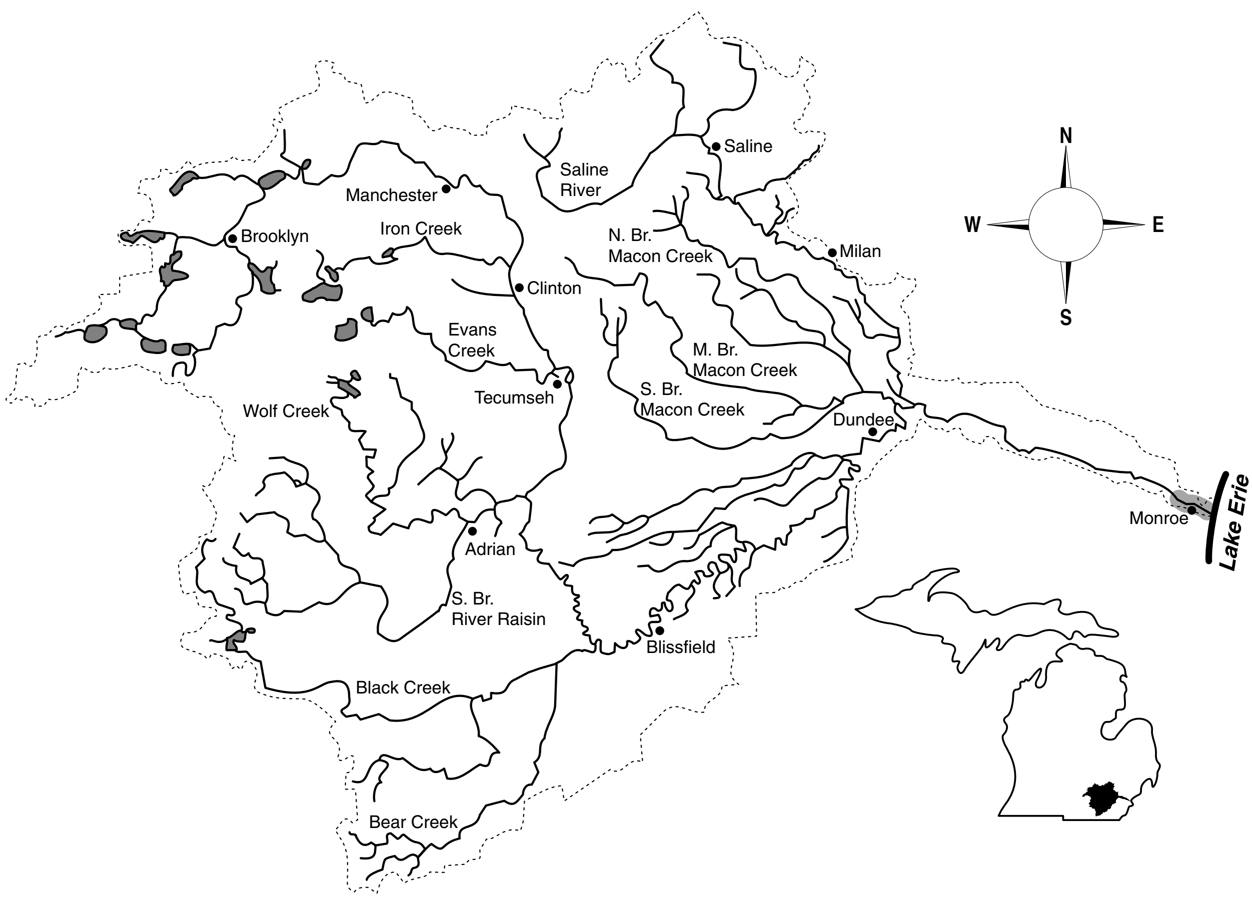
Silver lamprey (*Ichthyomyzon unicuspis*)

Habitat:

feeding - young: sand, muck, or organic debris substrate
- adults: clear river water with prey species

spawning - gravel and sand substrate
- moderate gradient
- moderate size stream
- cannot tolerate silt
- no dams

winter refuge - amnocetes burrow for 4 to 7 years in mud and silt at river margins



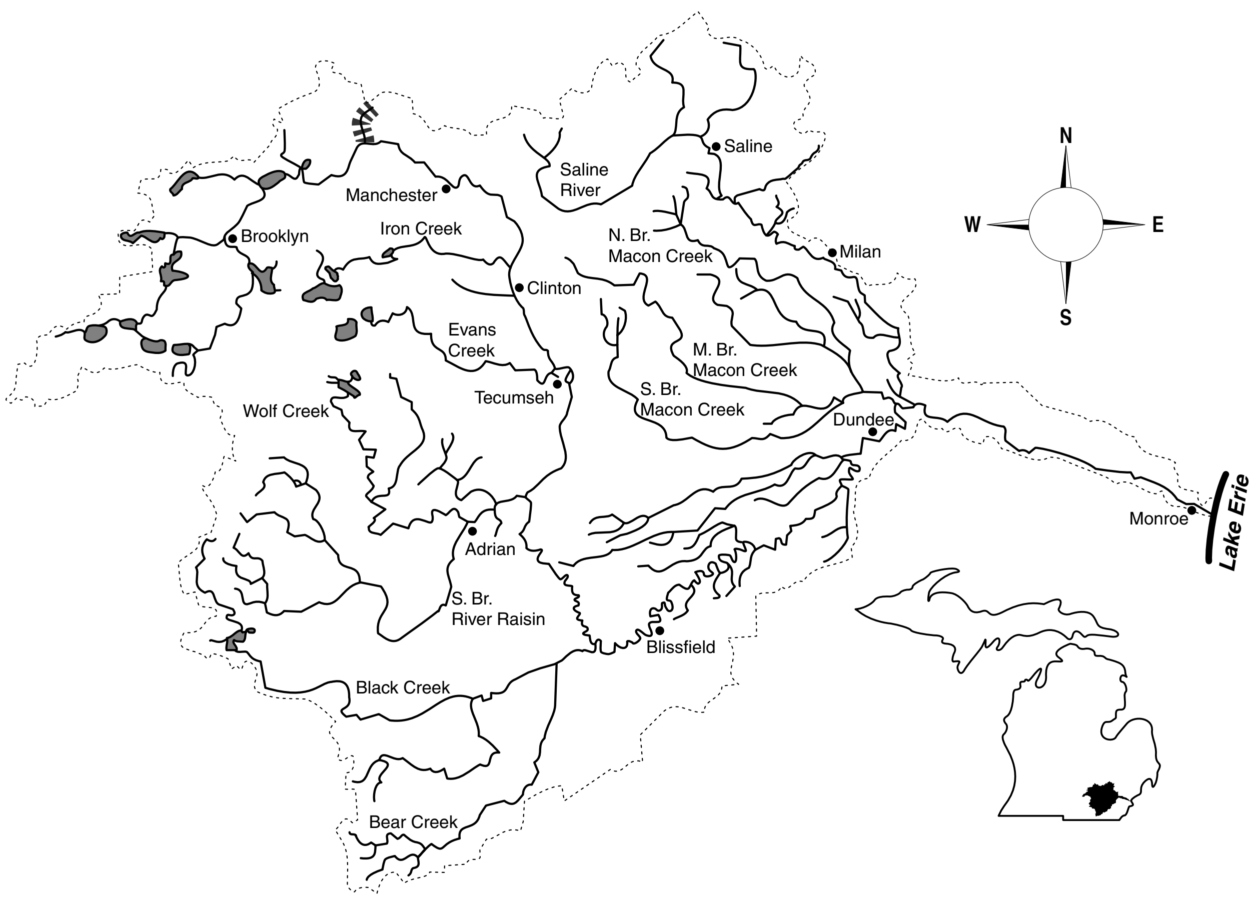
American brook lamprey (*Lampetra appendix*) - rare

Habitat:

feeding - young: low gradient, substrate with bars and beds of mixed sand and organic debris
- clear cool stream water, sensitive to turbidity

spawning - clear, high gradient streams (>15 feet wide)
- cold water
- gravel substrate

winter refuge - sand or silt substrate for amnocoetes

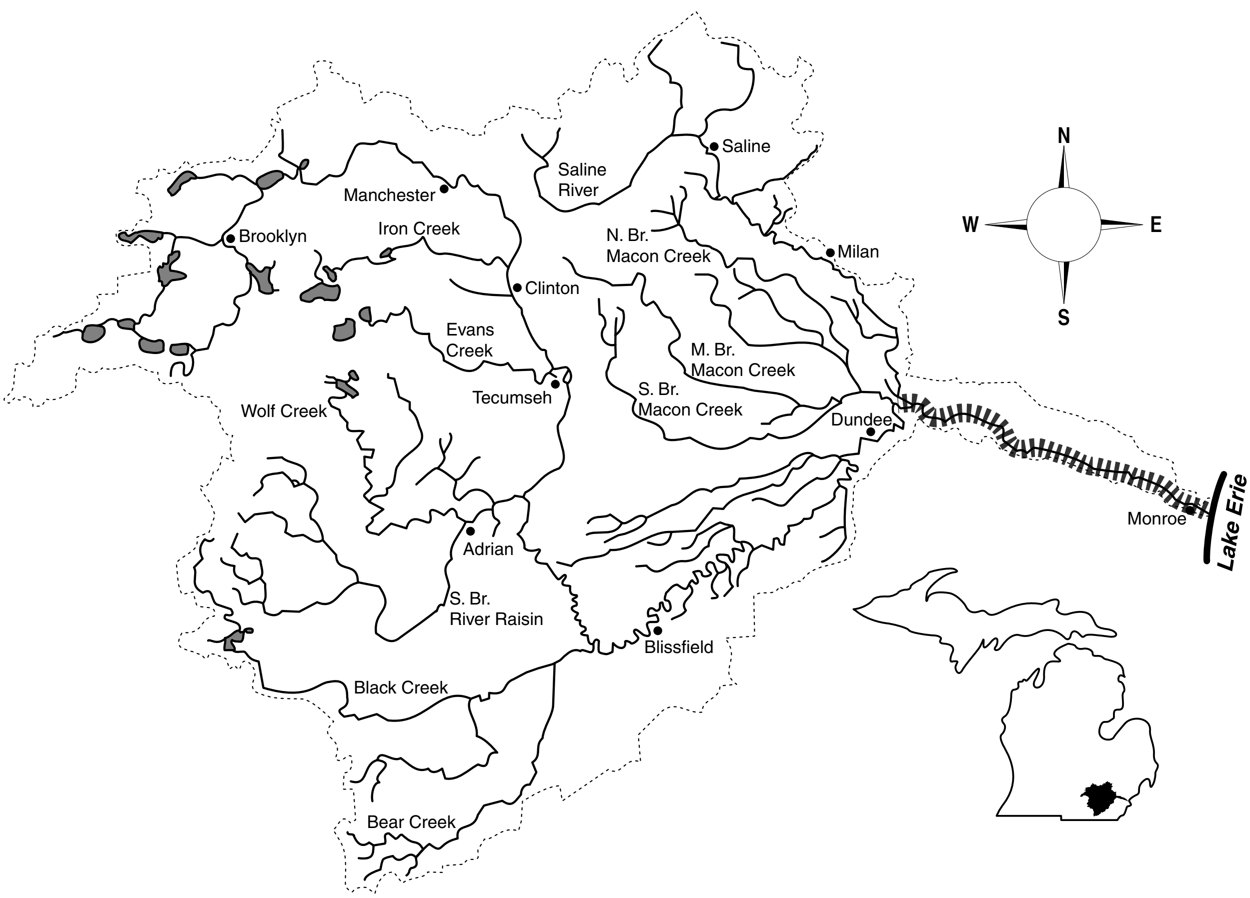


Lake sturgeon (*Acipenser fulvescens*) - threatened

Habitat:

feeding - shoal areas of large rivers, lakes, and impoundments
- gravel, sand, rock substrates

spawning - in or before rapids, at the base of dams in rivers
- in 2-15 feet of water
- swift current
- rocky ledges or around rocky islands in Great Lakes

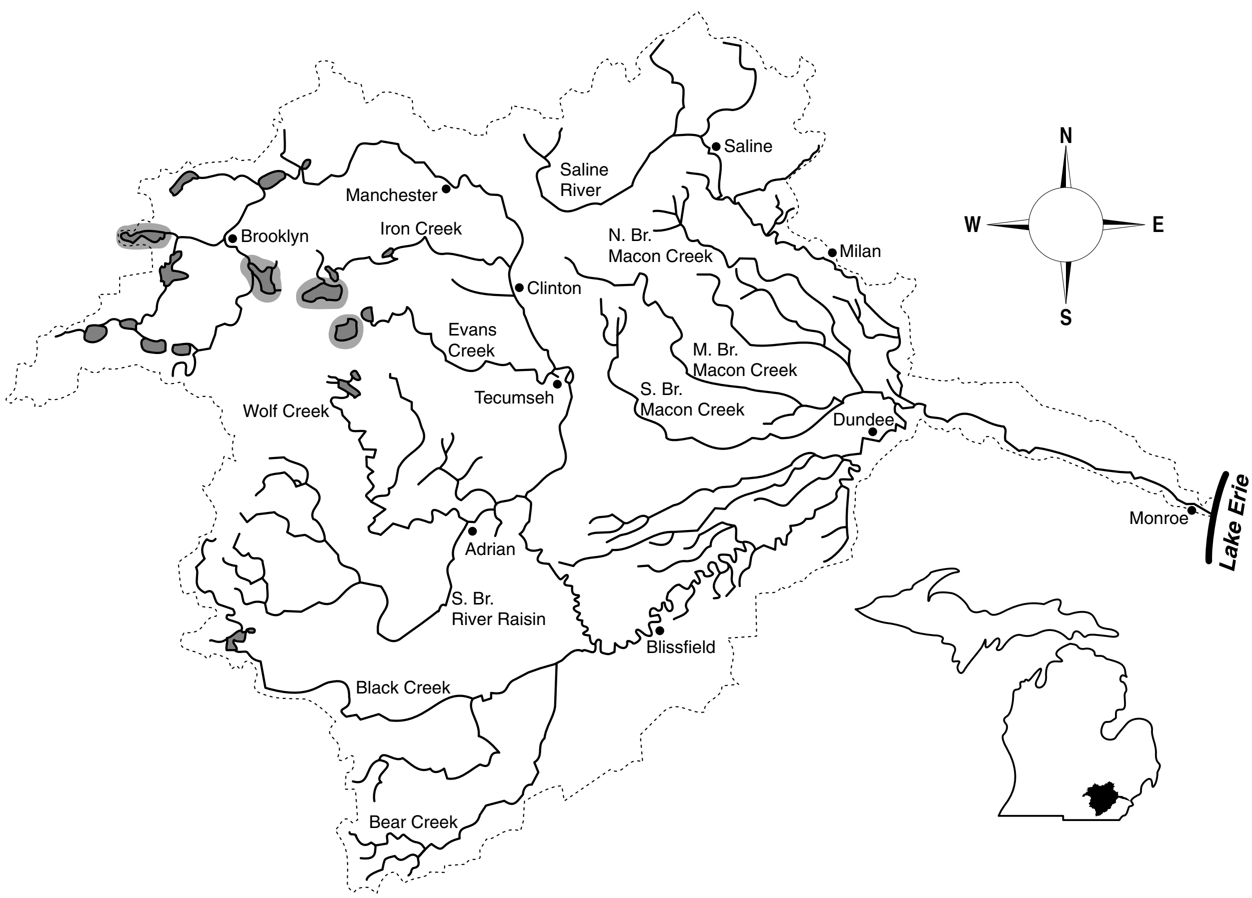


Longnose gar (*Lepisosteus osseus*)

Habitat:

feeding
- adults: in deeper water
- young: in shallows
- clear water, low-gradient streams, lakes, and impoundments
- will feed in moderate current
- aquatic vegetation preferred, but not necessary
- open water fish

spawning
- warm shallow water of lakes or streams over vegetation



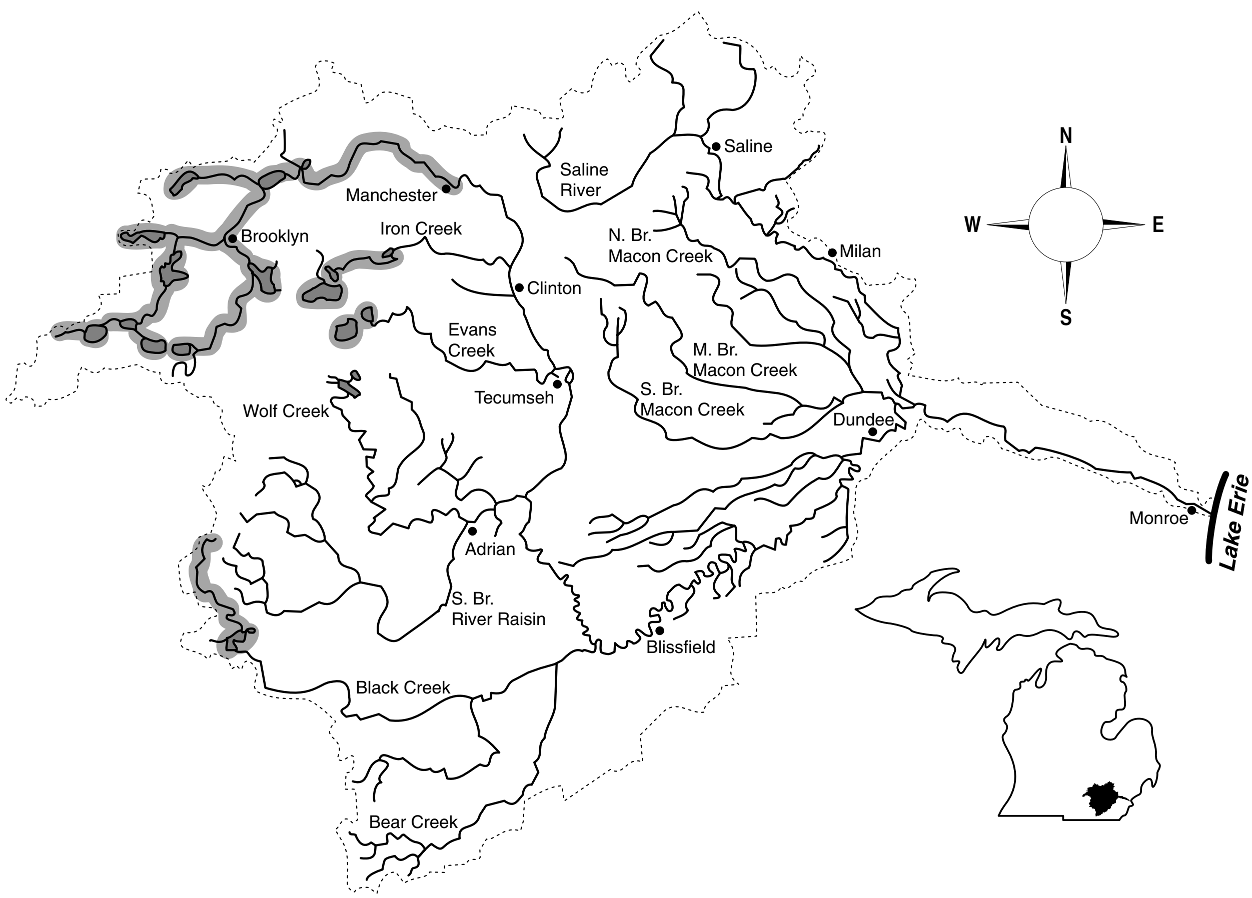
Bowfin (*Amia calva*)

Habitat:

feeding - clear water
- abundant rooted aquatic vegetation
- low gradient streams, lakes, and impoundments
- tolerate only small amount of silt

spawning - need vegetated water, 1 to 2 feet deep
- can spawn under logs, stumps, or bushes

winter refuge - gravelly pockets among aquatic vegetation

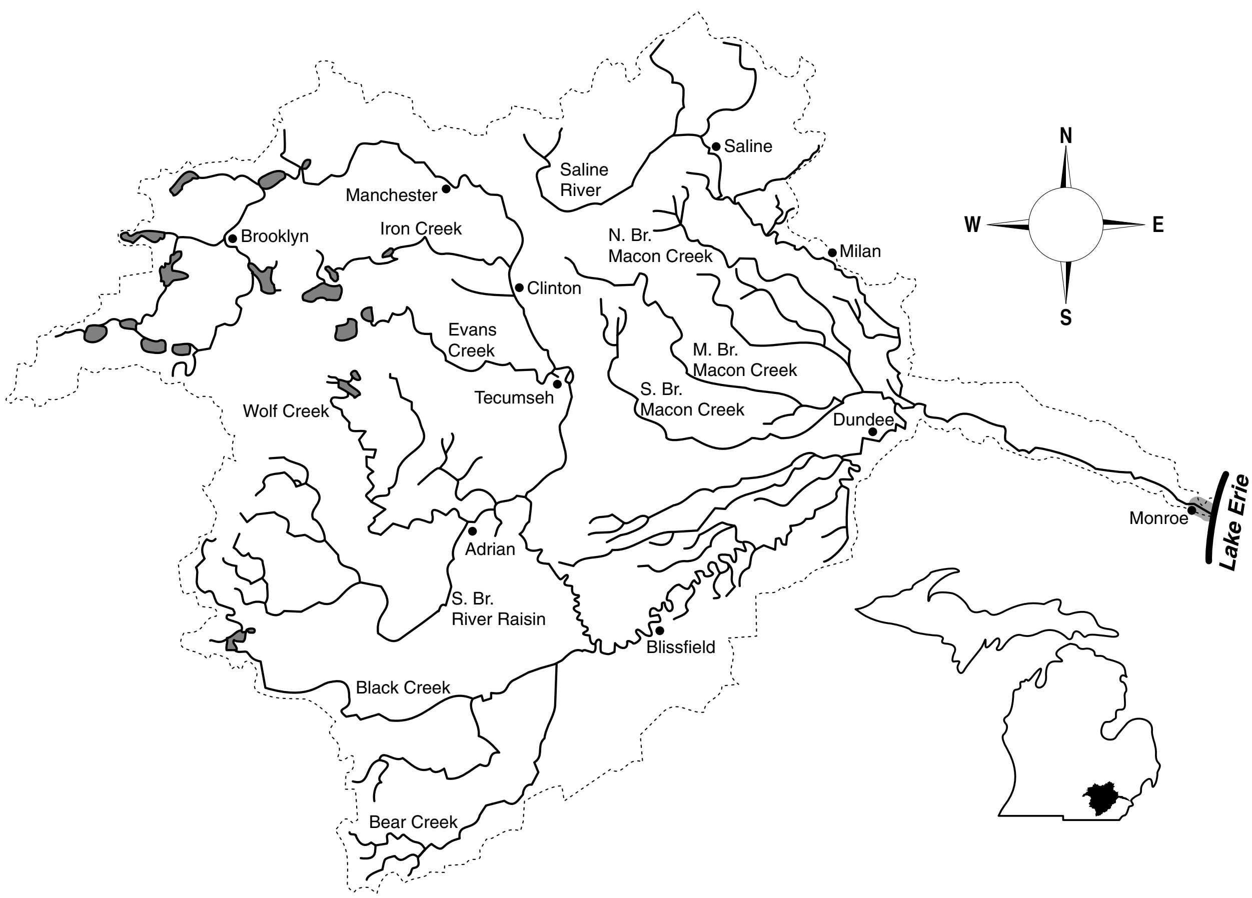


Mooneye (*Hiodon tergisus*) - threatened

Habitat:

feeding - swift waters to feed at or near water surface
- cannot tolerate silted habitats nor turbidity
- lives in largest rivers and their interconnecting lakes; larger pools of streams and open reservoirs

spawning - large, clear streams



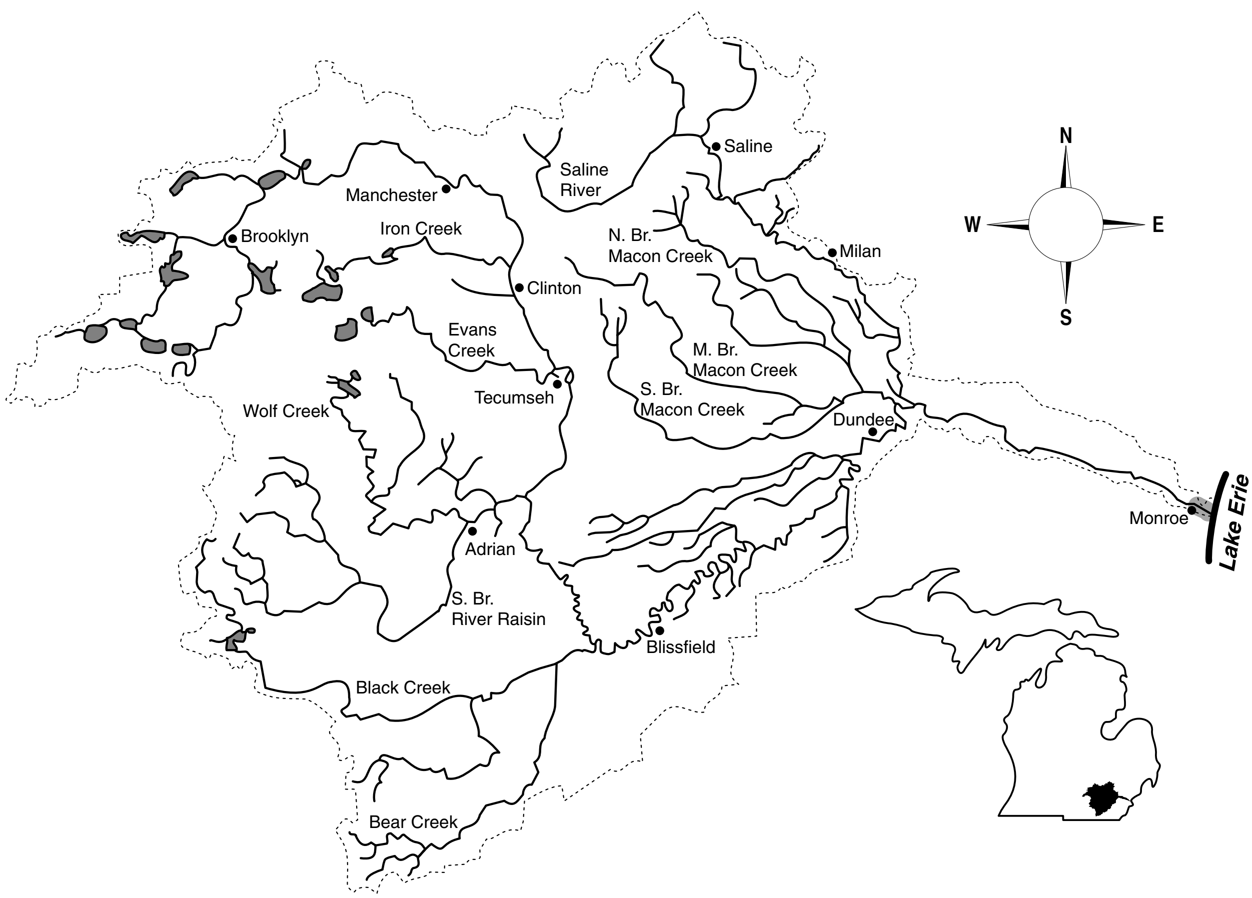
American eel (*Anguilla rostrata*) - rare

Habitat:

feeding - medium to large rivers and Lake Erie
- must have current
- moderately clear water
- avoid cool spring-fed streams

spawning - catadromous
- occurs in the SW portion of the North Atlantic called the Sargasso Sea

winter refuge - buried in muddy or silty substrate



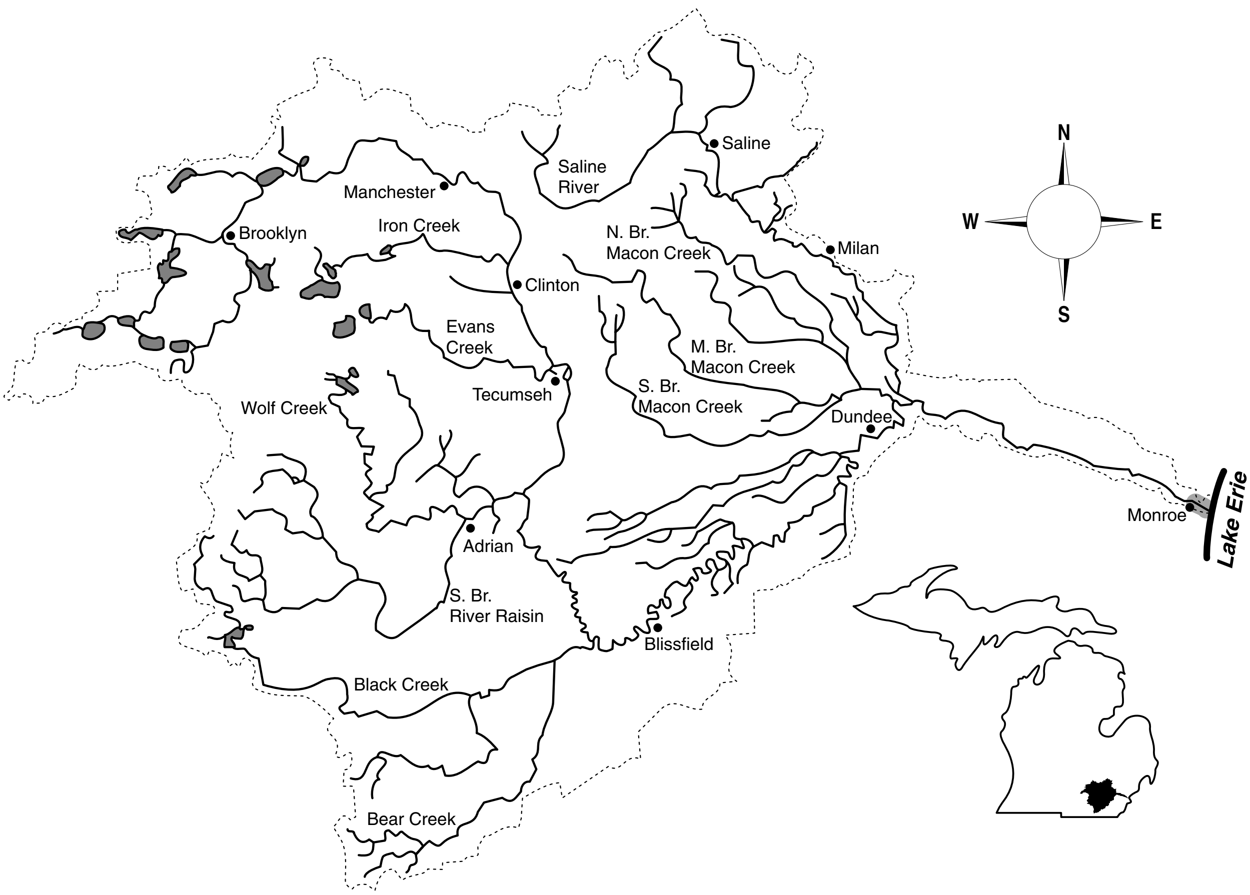
Alewife (*Alosa pseudoharengus*)

Habitat:

feeding - adults: deep water of Lake Erie
- young: shallow water of Lake Erie
- prefers warmer waters

spawning - streams or shallow beaches of lake
- sand or gravelly substrate

winter refuge - deep water

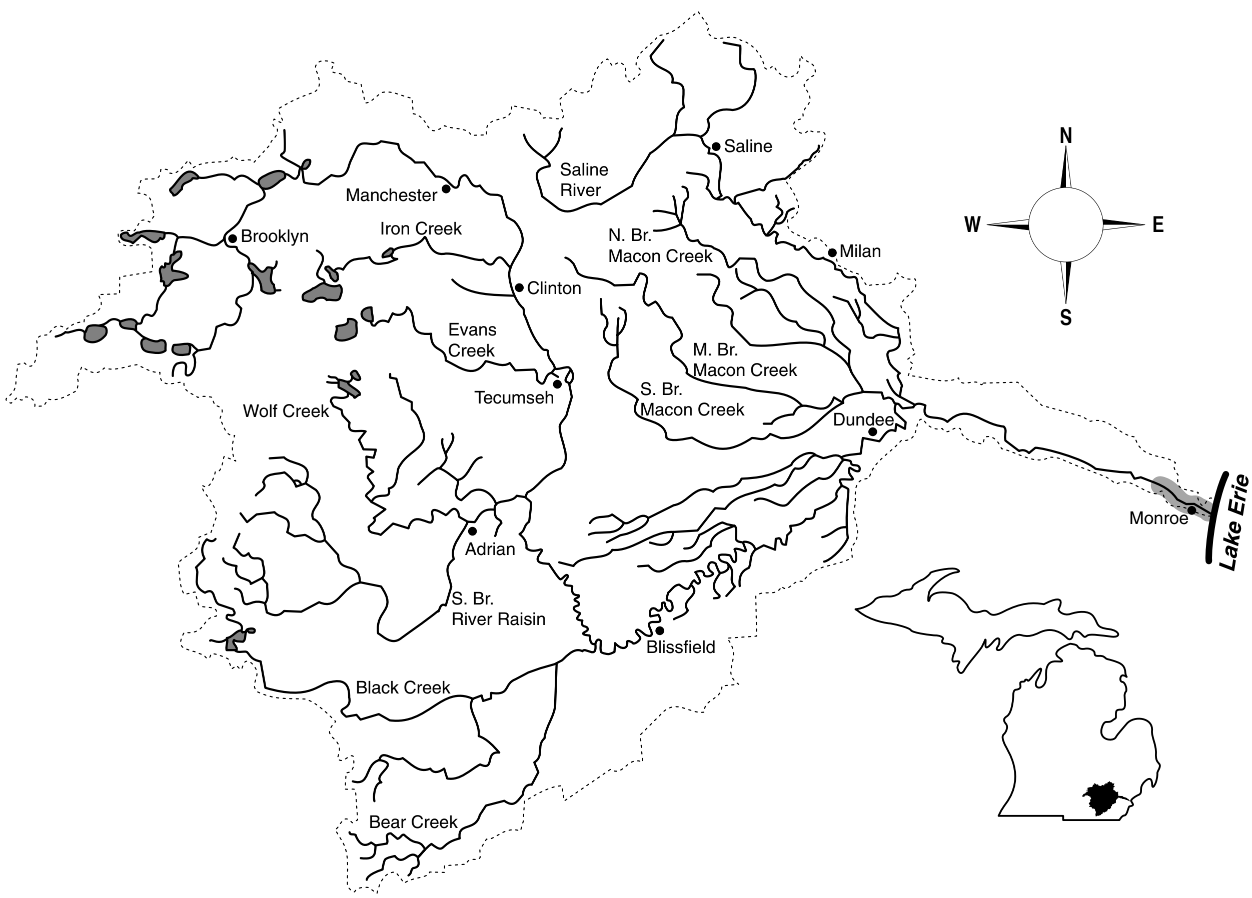


Gizzard shad (*Dorosoma cepedianum*)

Habitat:

feeding - large streams with low gradient, impoundments, and Lake Erie
- tolerant of clear and turbid water

spawning - shallow areas of ponds, lakes, and large rivers
- low gradient

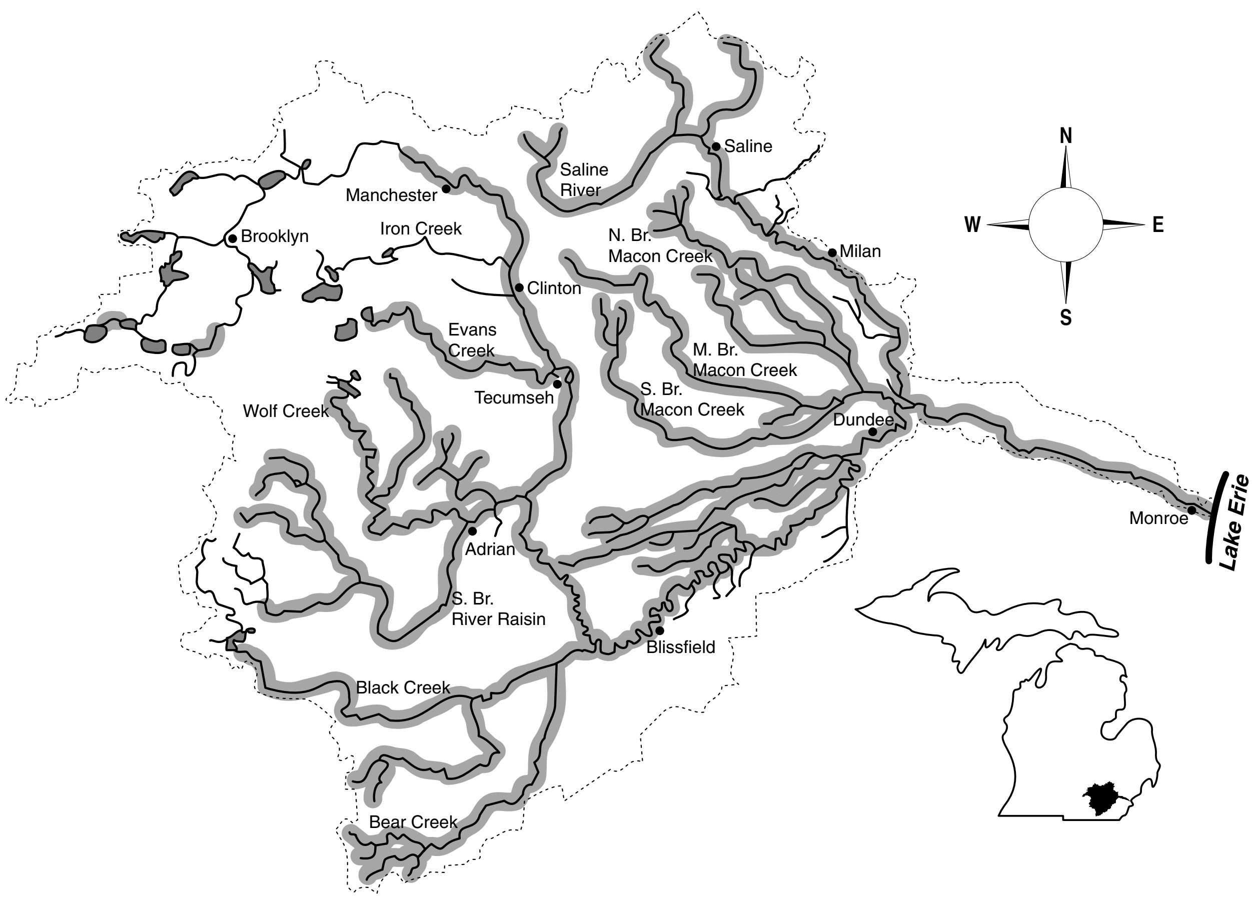


Central stoneroller (*Campostoma anomalum*)

Habitat:

feeding - moderate to high gradients
- rocky riffles
- somewhat tolerant of turbidity
- riffles and adjacent pools of warm, clear, shallow streams
- gravel or cobble substrate

spawning - riffles

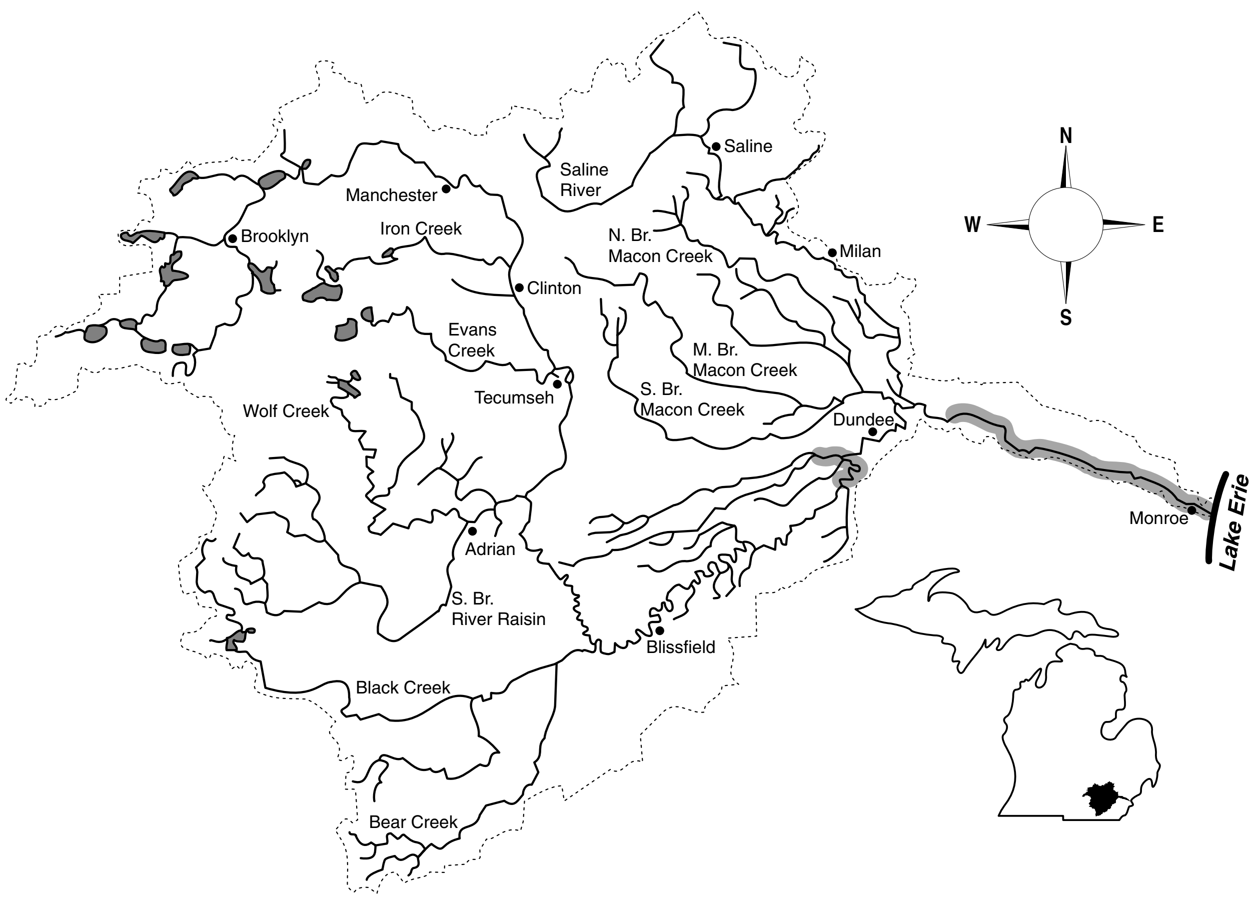


Goldfish (*Carassius auratus*)

Habitat:

feeding - vegetation
- low gradient, shallow, warm water streams, rivers, lakes, and impoundments
- tolerates some turbidity and siltation

spawning - warm, weedy shallows

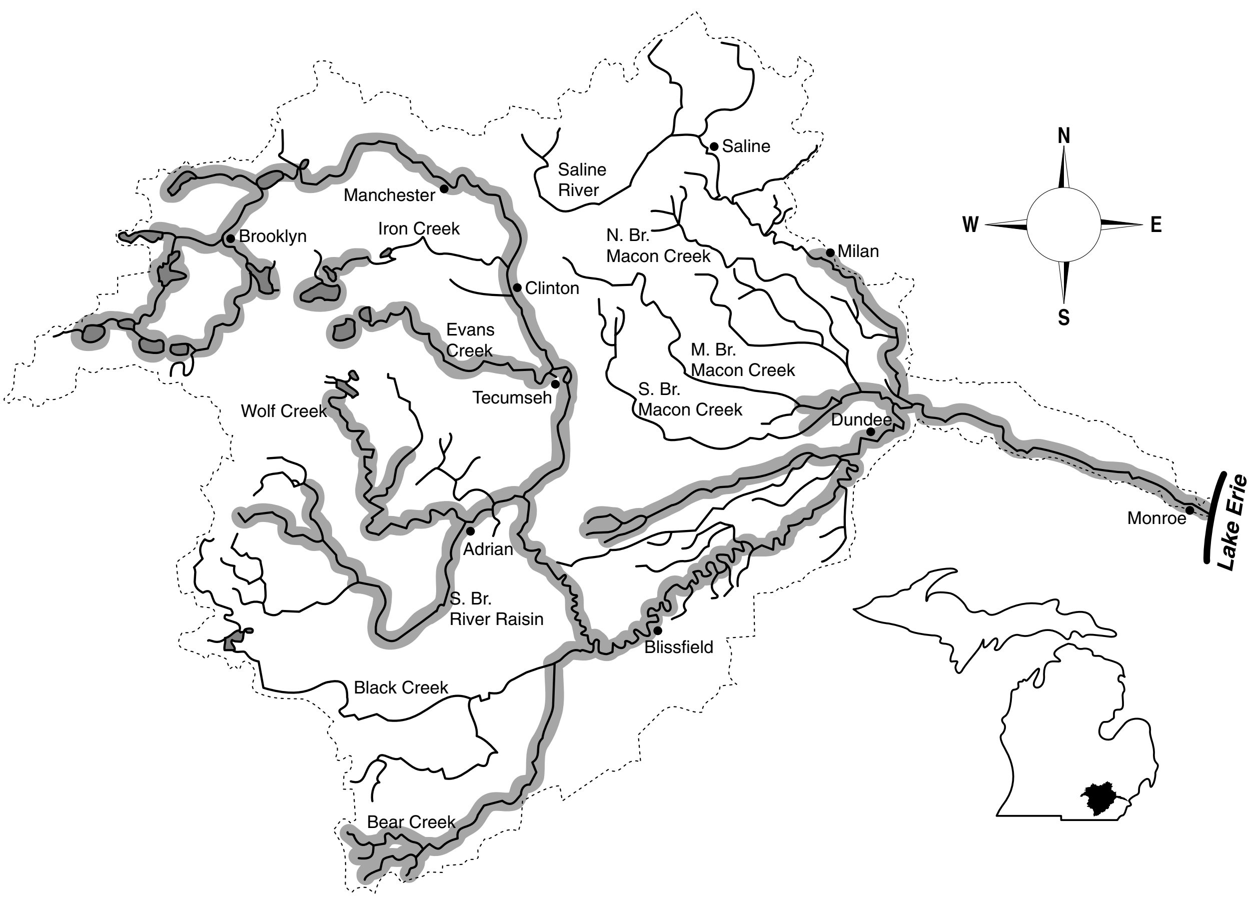


Spotfin shiner (*Cyprinella spiloptera*)

Habitat:

feeding - clear water tolerant of turbidity and siltation
- some current
- shallow depths
- medium sized streams, lakes, and impoundments
- clear sand or gravel substrate

spawning - swift current
- crevice spawner or on underside of submerged logs and roots

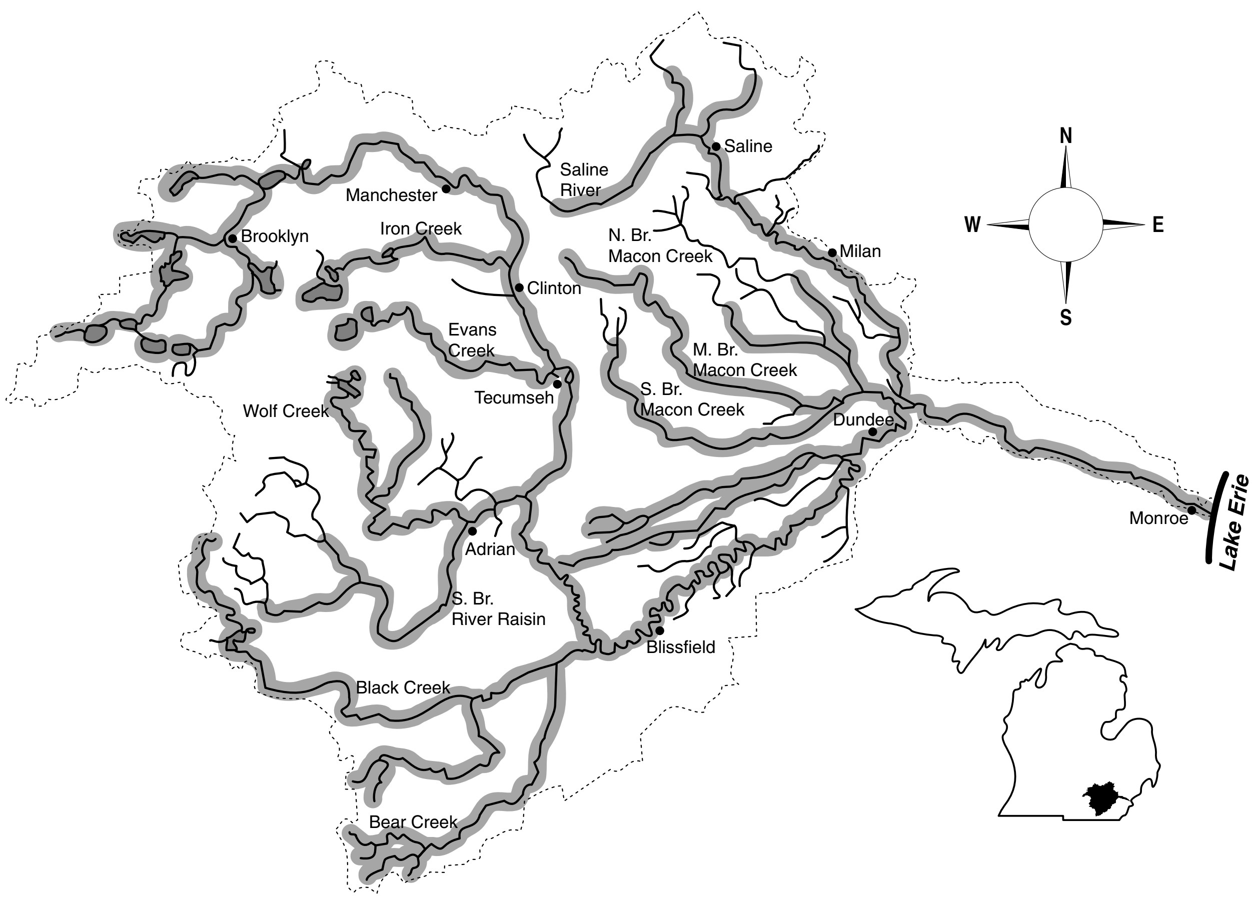


Common carp (*Cyprinus carpio*)

Habitat:

feeding - low gradient fertile streams, rivers, lakes, and impoundments
- abundance of aquatic vegetation or organic matter
- tolerant of all substrates and clear to turbid water

spawning - weedy or grassy shallows



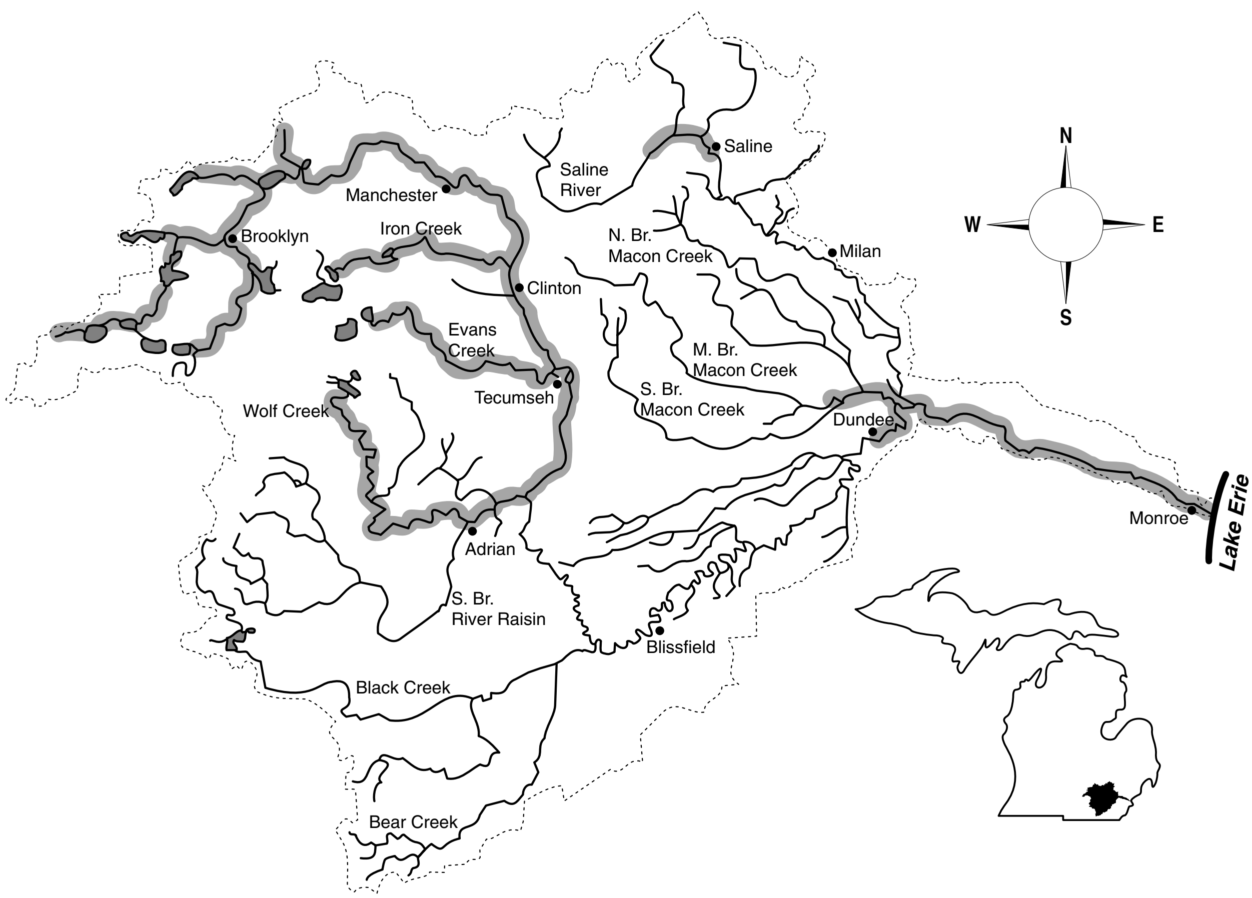
Striped shiner (*Luxilus chrysocephalus*)

Habitat:

feeding - clear to slightly turbid streams and rivers
- gravel substrate
- low gradient

spawning - gravel, boulder, bedrock, or sand substrate
- clear water in small streams with moderate to high gradient

winter refuge - in large deep pools of low gradient rivers

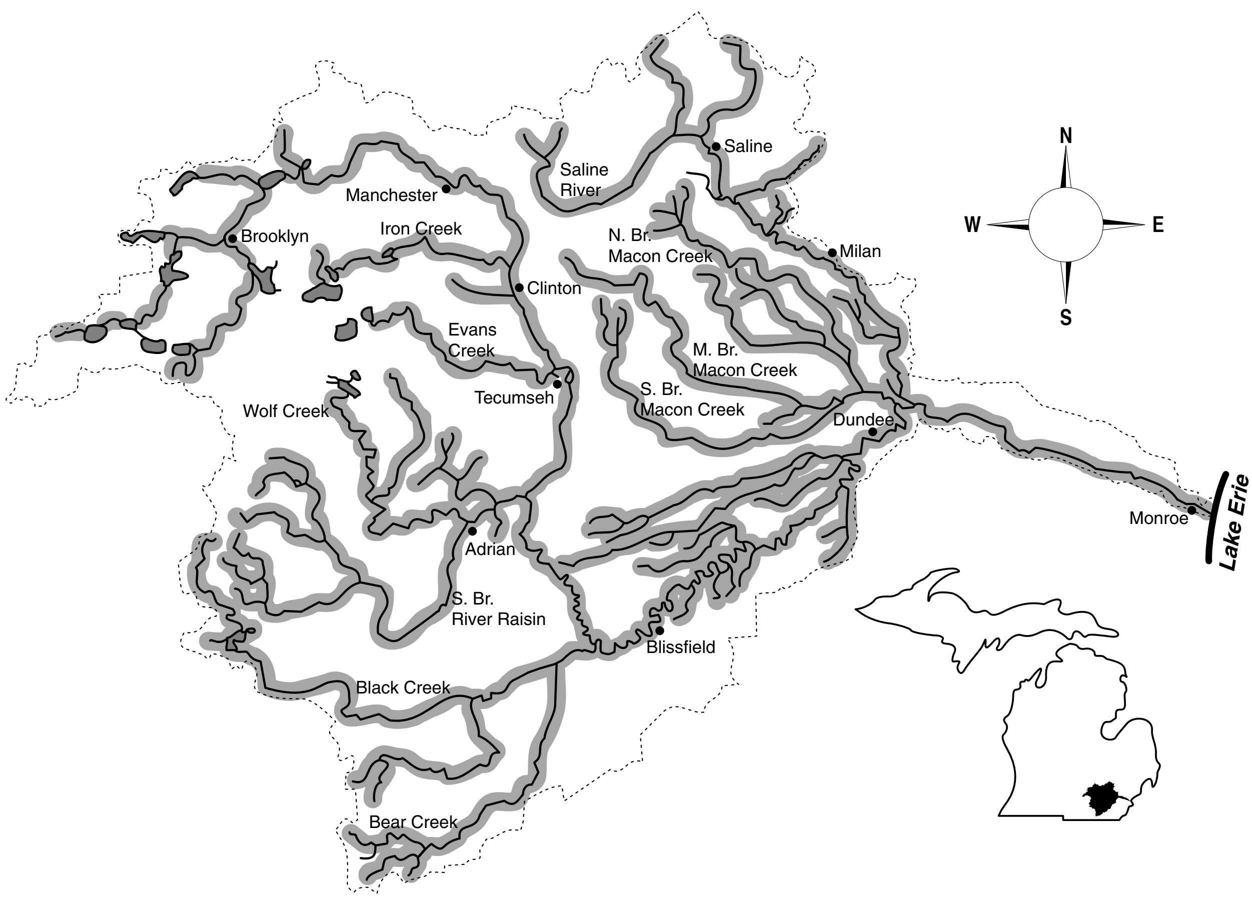


Common shiner (*Luxilus cornutus*)

Habitat:

feeding - small, clear, high-gradient streams and rivers, or shores of clear water lakes and impoundments
- gravel substrate
- can tolerate some submerged aquatic vegetation
- not very tolerant of turbidity or silted waters

spawning - gravel nests of other fish, especially those at the head of a riffle

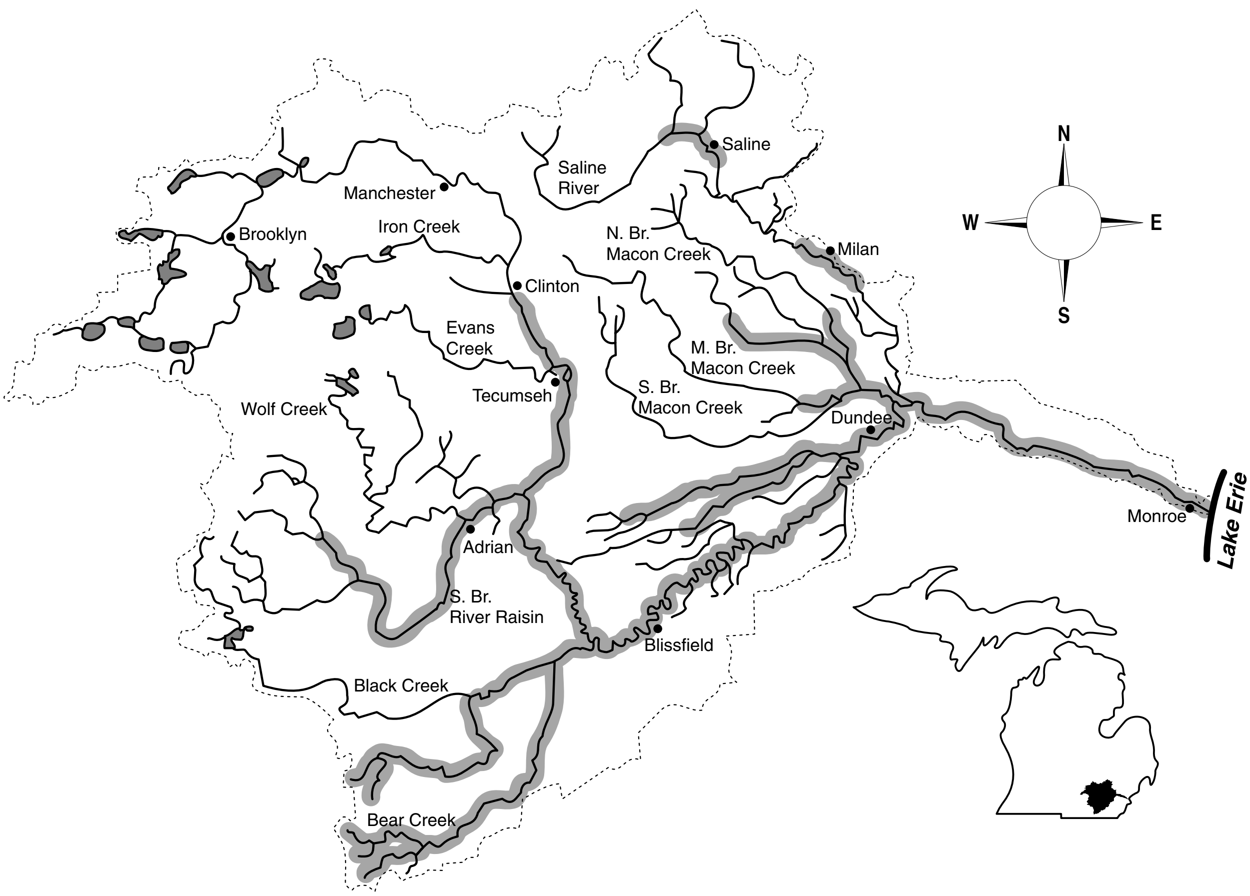


Redfin shiner (*Lythrurus umbratilis*)

Habitat:

feeding
- clear, quiet warm rivers in weedy pools
- little to no current
- abundant submerged and emergent vegetation

spawning
- over sand and gravel substrate in slow moving sections of streams

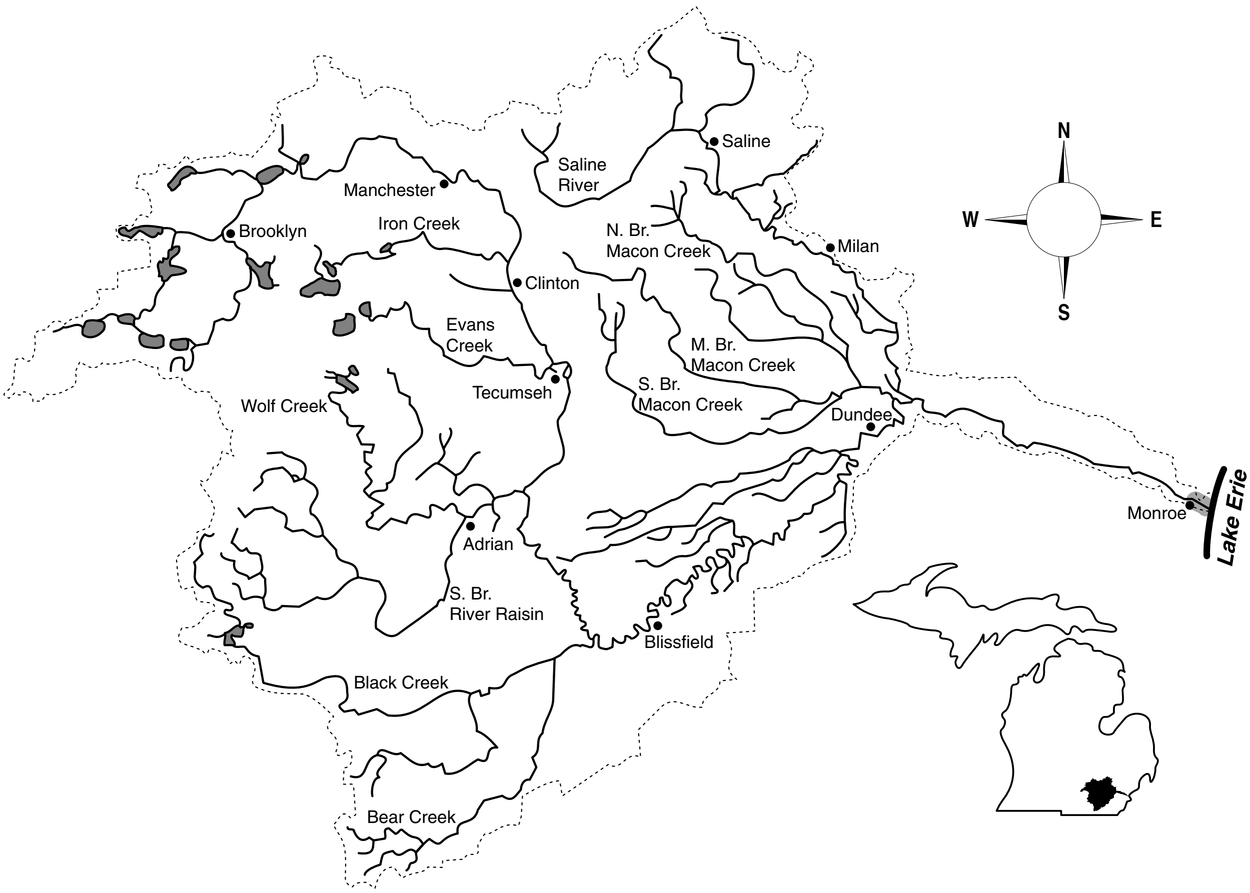


Silver chub (*Macrhybopsis storeriana*) - special concern

Habitat:

feeding - large deep rivers with low gradient
- clean gravel or sand substrate
- cannot tolerate turbidity or silt

spawning - thought to occur in open water

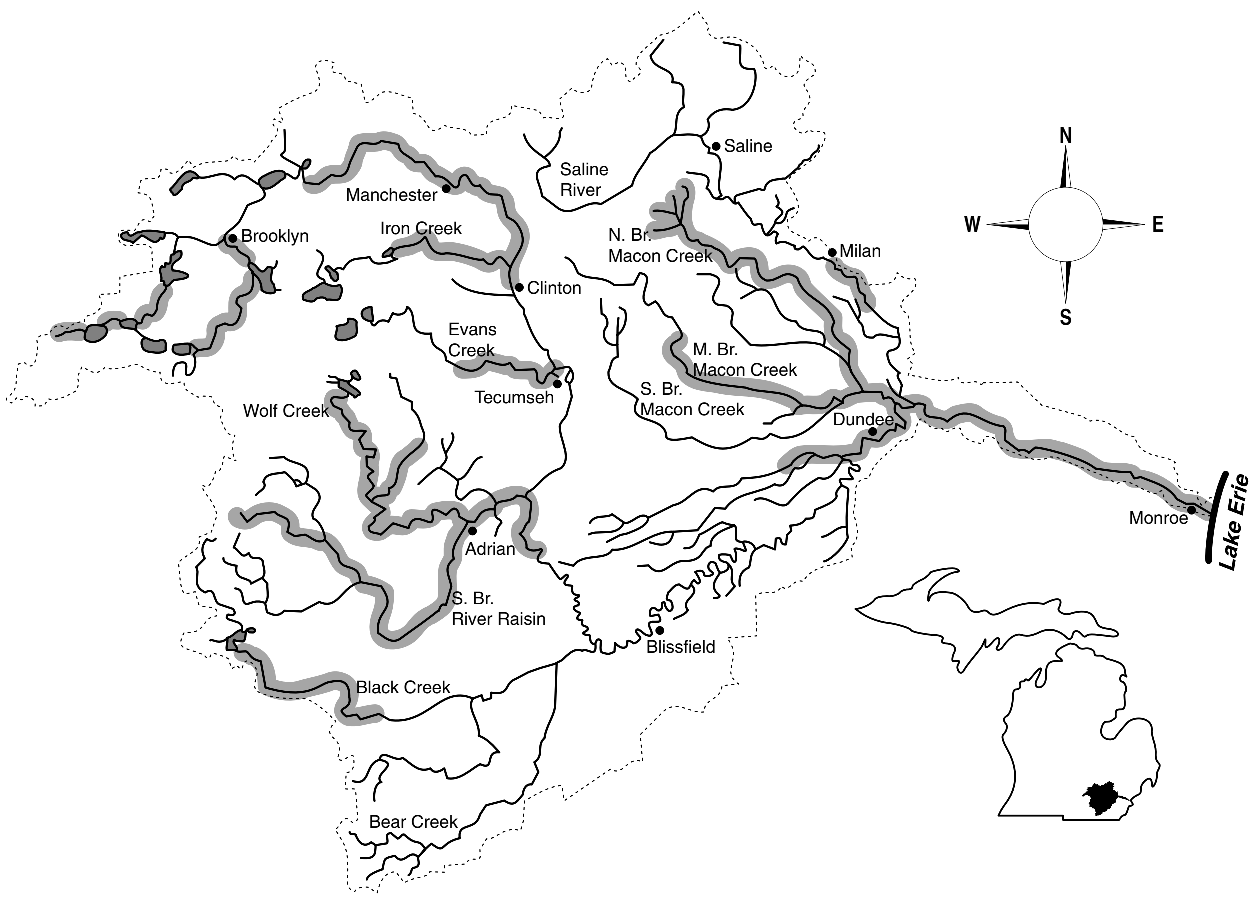


Hornyhead chub (*Nocomis biguttatus*)

Habitat:

feeding
- adults: near riffles
- young: near vegetation
- clear water, does not tolerate turbidity
- gravel substrate
- low gradient streams that are tributaries to large streams

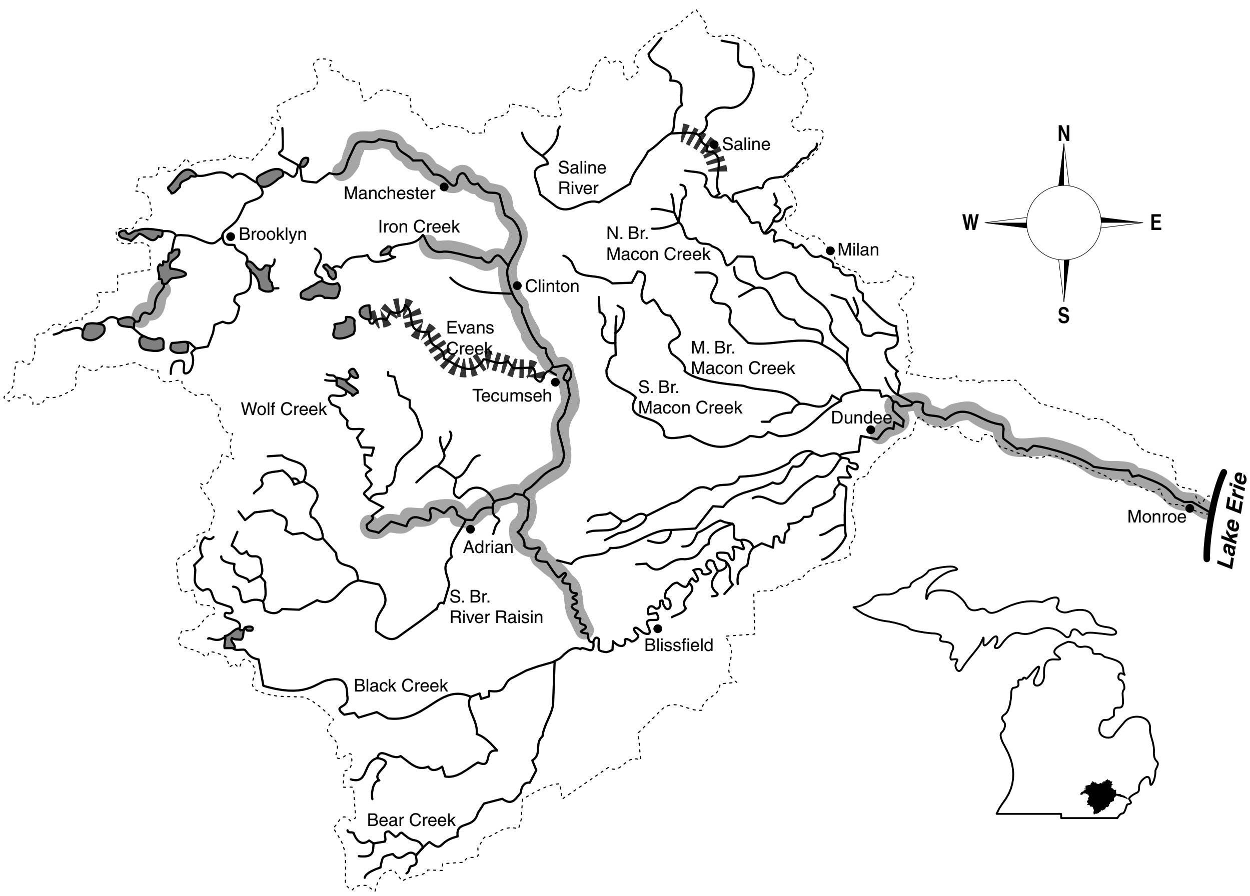
spawning
- large stones and pebbles present
- often below a riffle in shallow water
- gravel substrate



River chub (*Nocomis micropogon*)

Habitat:

feeding - moderate to large streams
- moderate to high gradient
- gravel, boulder, or bedrock substrate
- little to no aquatic vegetation
- cannot tolerate turbidity or siltation

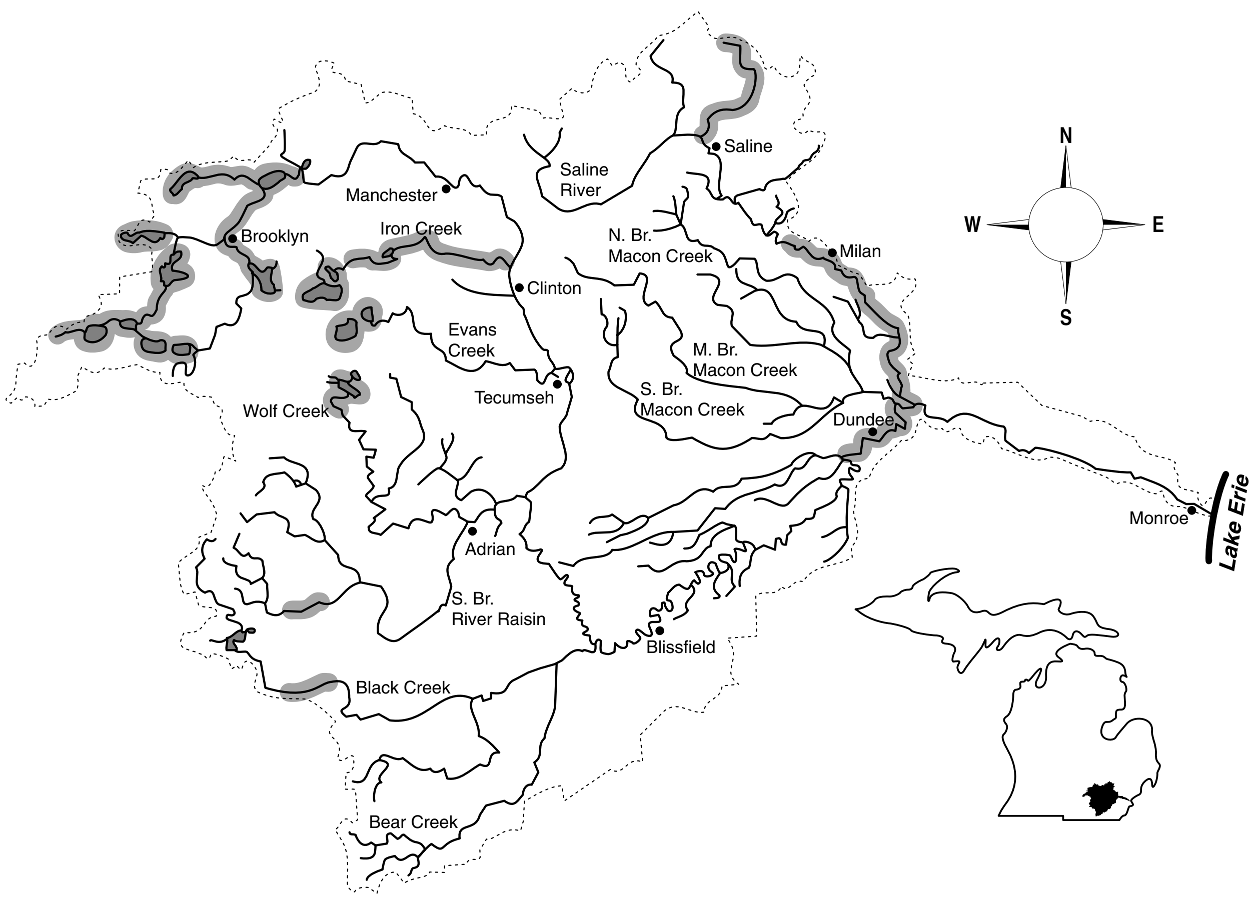


Golden shiner (*Notemigonus crysoleucas*)

Habitat:

feeding - lakes and impoundments and quiet pools of low gradient streams
- clear shallow water
- heavy vegetation

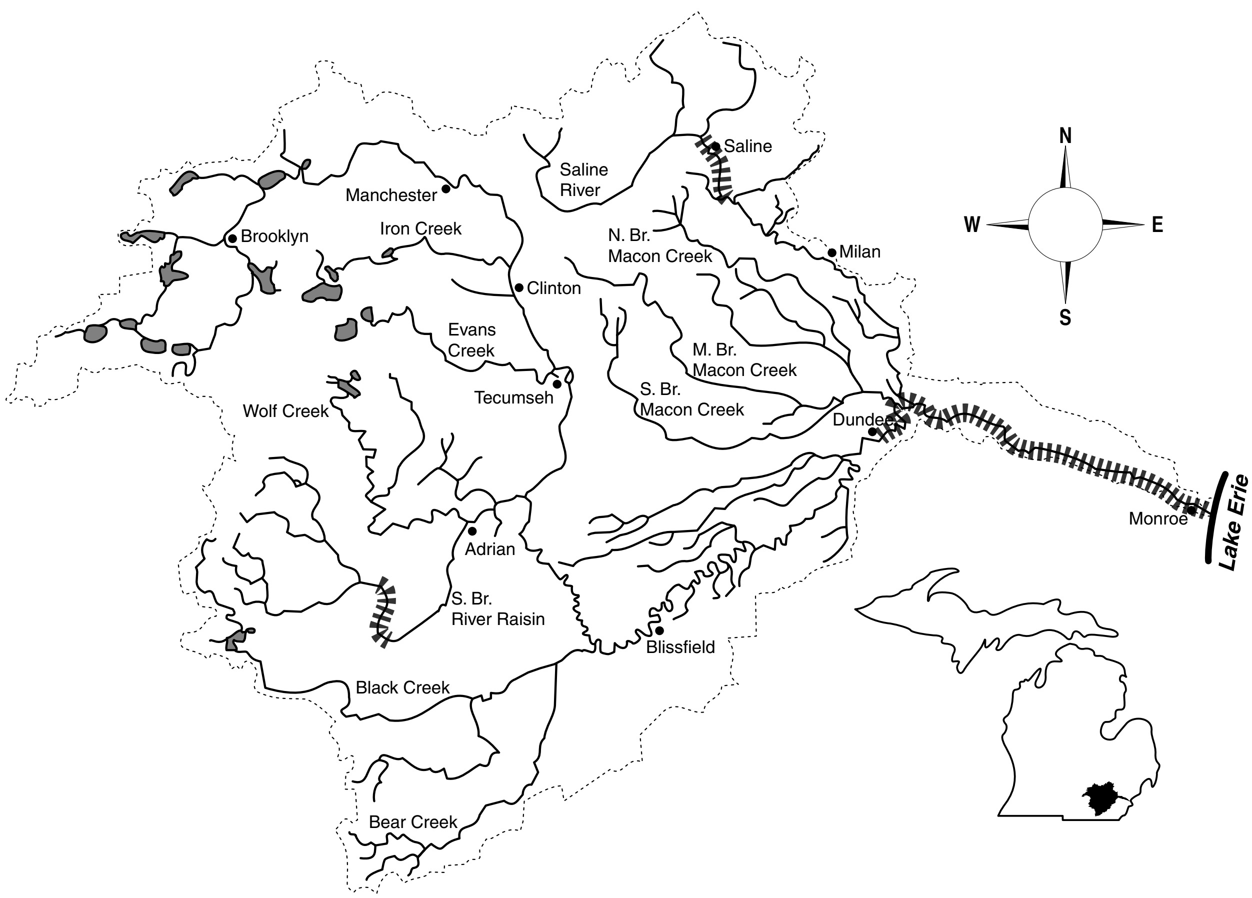
spawning - vegetation



Bigeye chub (*Notropis amblops*) - endangered

Habitat:

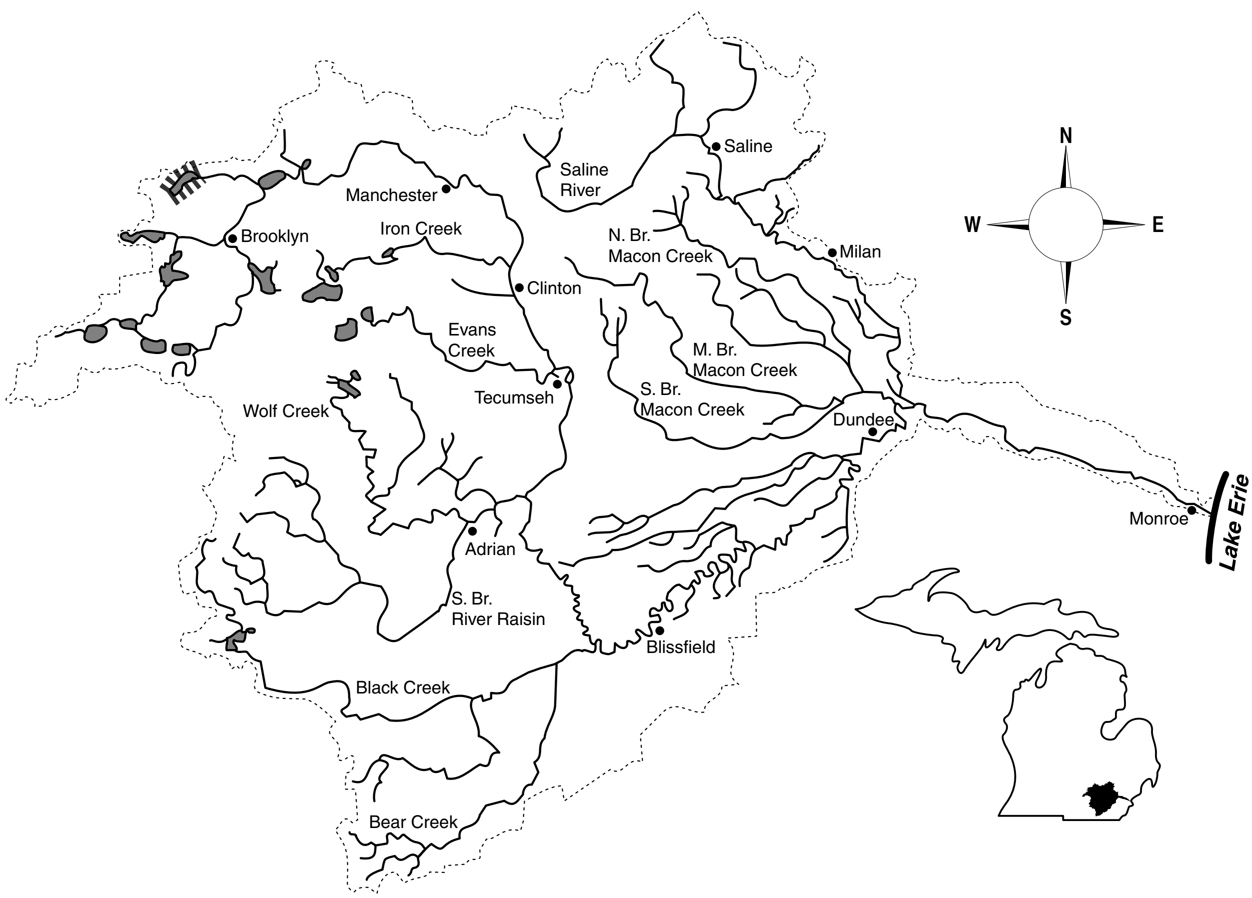
feeding - clear streams
- silt-free, gravelly or rocky substrates
- near riffles, but not in main current also in quiet pools



Pugnose shiner (*Notropis anogenus*) - special concern

Habitat:

feeding - very clear water of lakes, impoundments, and low-gradient streams
- aquatic vegetation
- clean sand, marl, or organic debris substrate
- extremely intolerant of turbidity

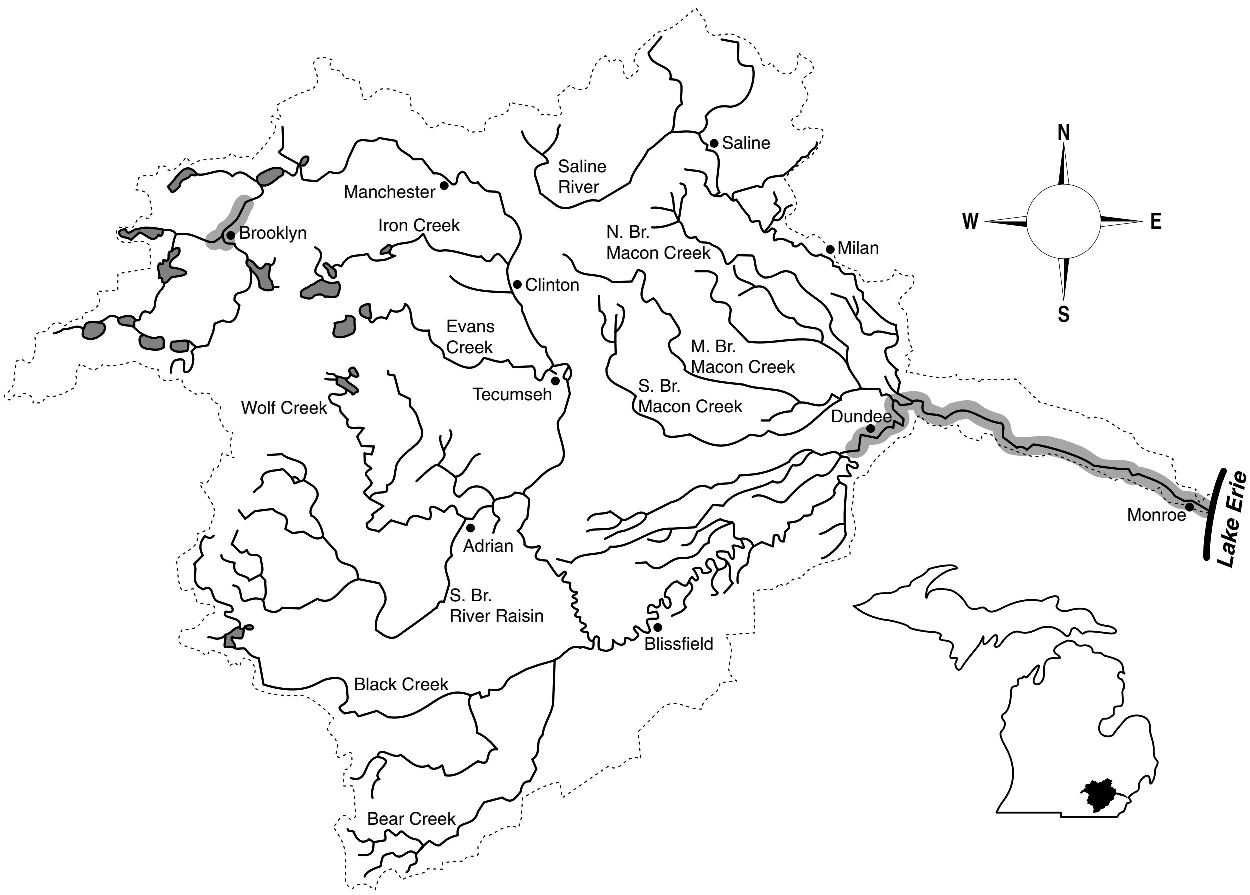


Emerald shiner (*Notropis atherinoides*)

Habitat:

feeding
- open-large stream channels
- low to moderate gradient
- range of turbidites and bottom types
- midwater or surface preferred, substrate of little importance
- avoids rooted vegetation

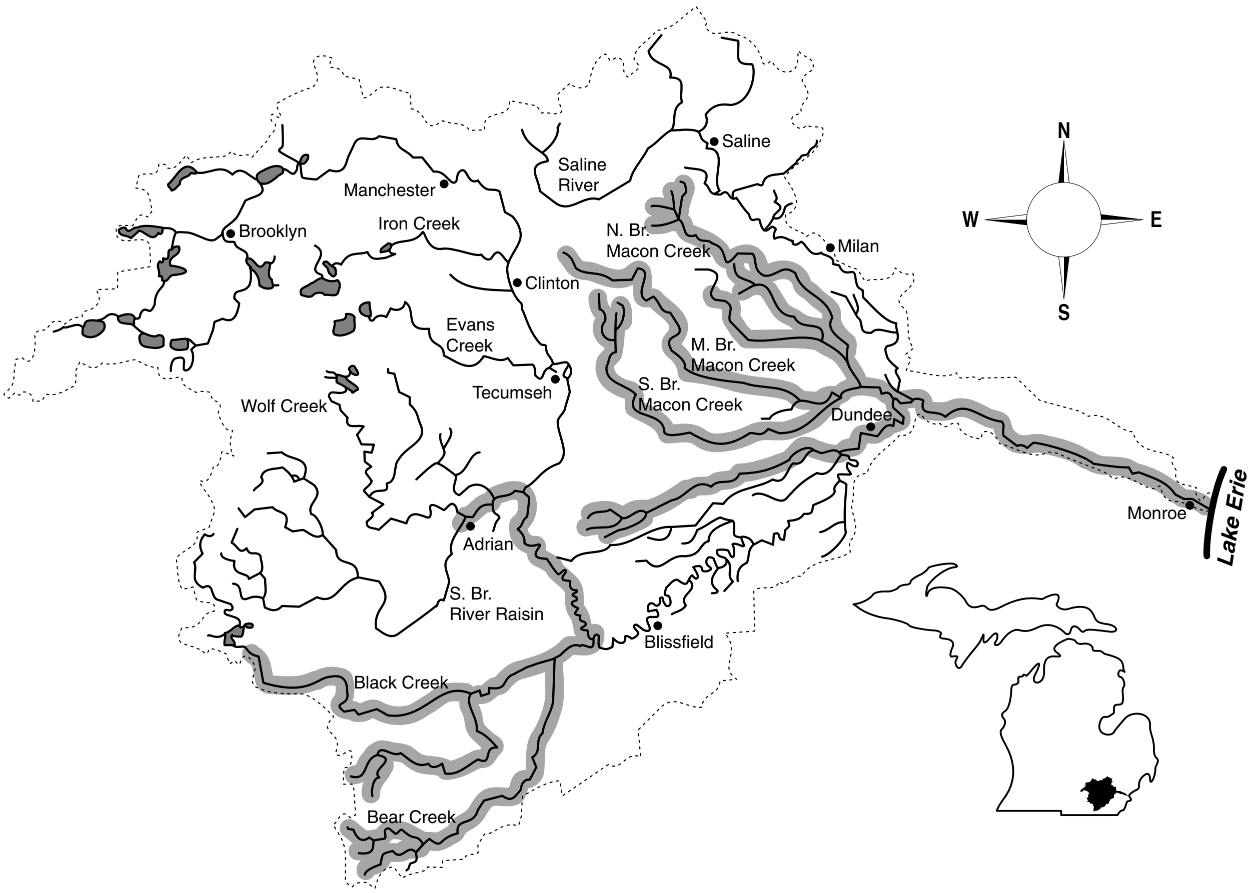
spawning
- sand or firm mud substrate or gravel shoals



Silverjaw minnow (*Notropis buccatus*)

Habitat:

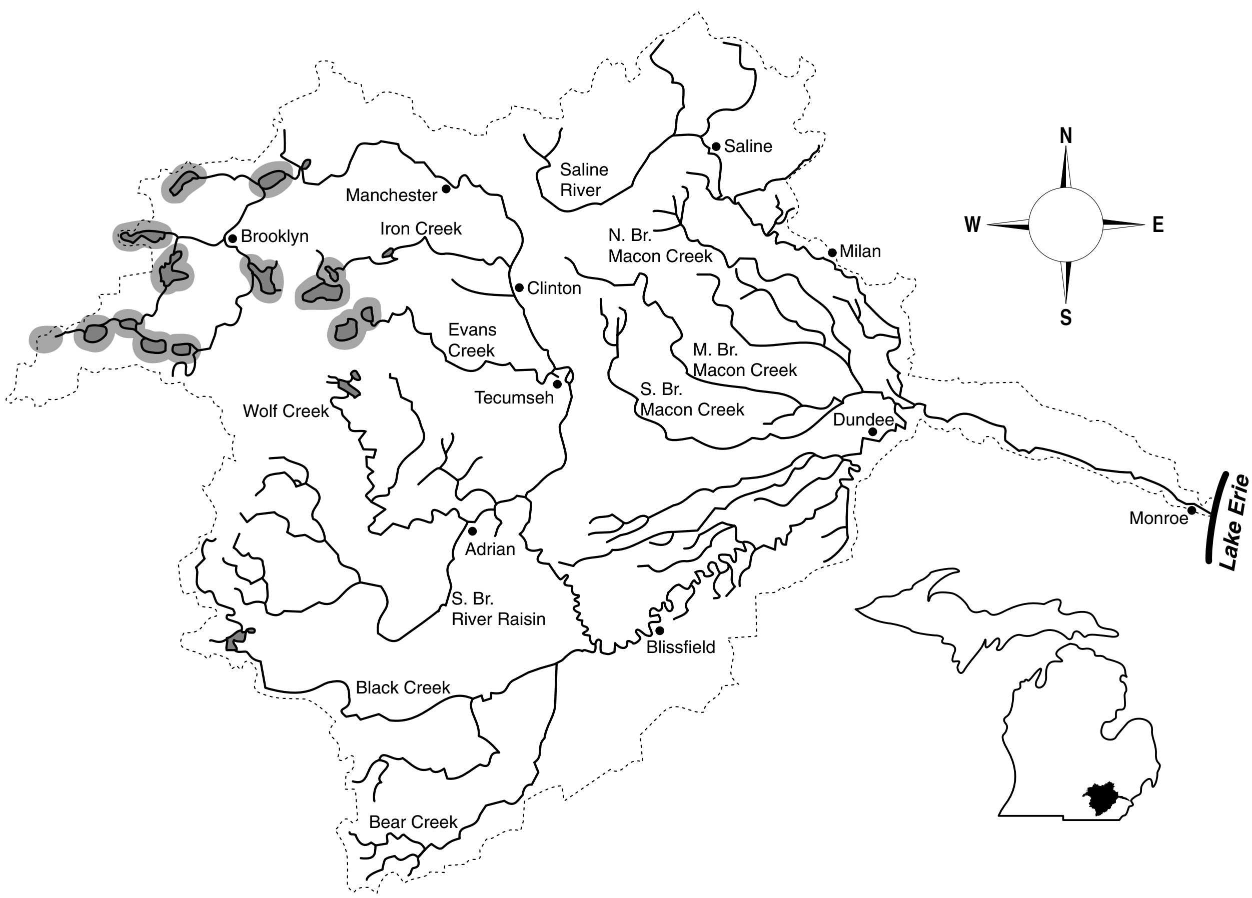
feeding
- small, clear, shallow streams
- sand substrate
- moderate gradient
- high tolerance to turbidity and domestic and industrial pollutants



Blackchin shiner (*Notropis heterodon*)

Habitat:

feeding
- lakes, impoundments, and quiet pools in streams and rivers
- clear water
- clean sand, gravel, or organic debris substrate
- dense beds of submerged aquatic vegetation
- cannot tolerate turbidity, silt, or loss of aquatic vegetation

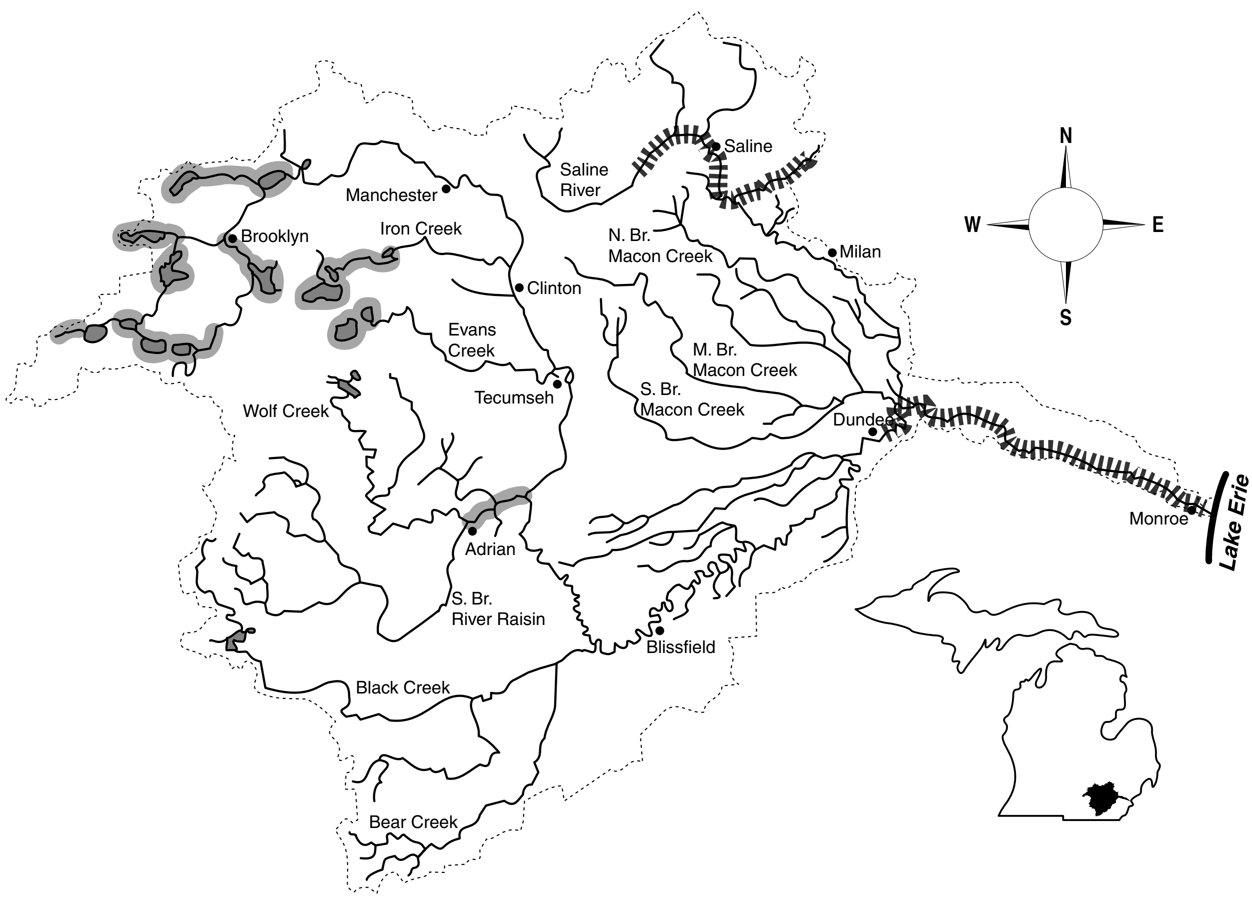


Blacknose shiner (*Notropis heterolepis*)

Habitat:

feeding
- clear lakes, impoundments, and pools of small, clear, low gradient streams
- aquatic vegetation
- clean sand, gravel, marl, muck, peat, or organic debris substrate
- cannot tolerate much turbidity, much siltation, or loss of aquatic vegetation

spawning
- sandy substrate

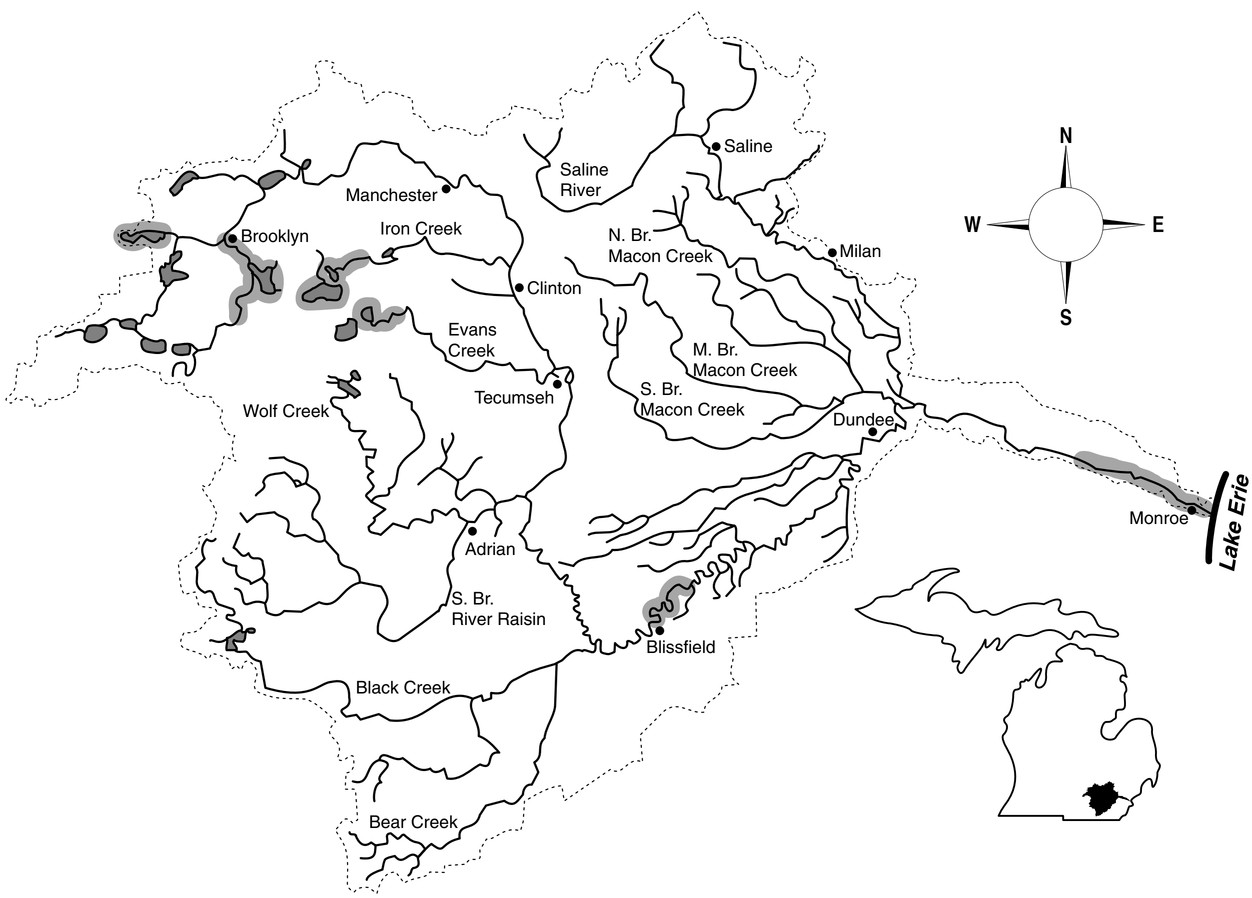


Spottail shiner (*Notropis hudsonius*)

Habitat:

feeding - large rivers, lakes, and impoundments
- firm sand and gravel substrate
- low current
- sparse to moderate vegetation
- avoids turbidity

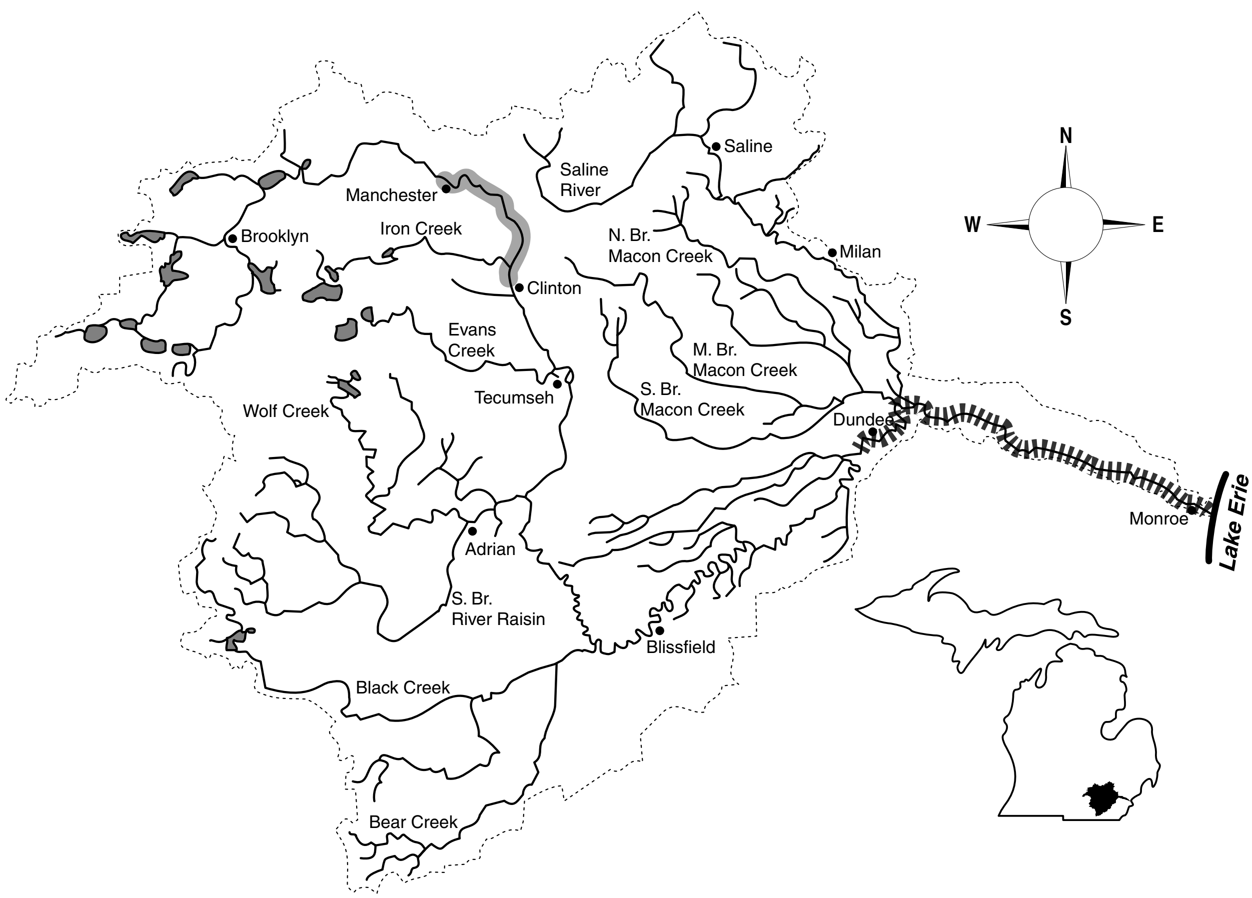
spawning - over sandy shoals or gravelly riffles
- near the mouths of small streams



Silver shiner (*Notropis photogenis*) - endangered

Habitat:

feeding
- moderate to large sized streams
- clear water with moderate to high gradients
- gravel and boulder substrate
- riffles and swifter eddies and currents of pools
- does not like silt substrate or rooted aquatic vegetation

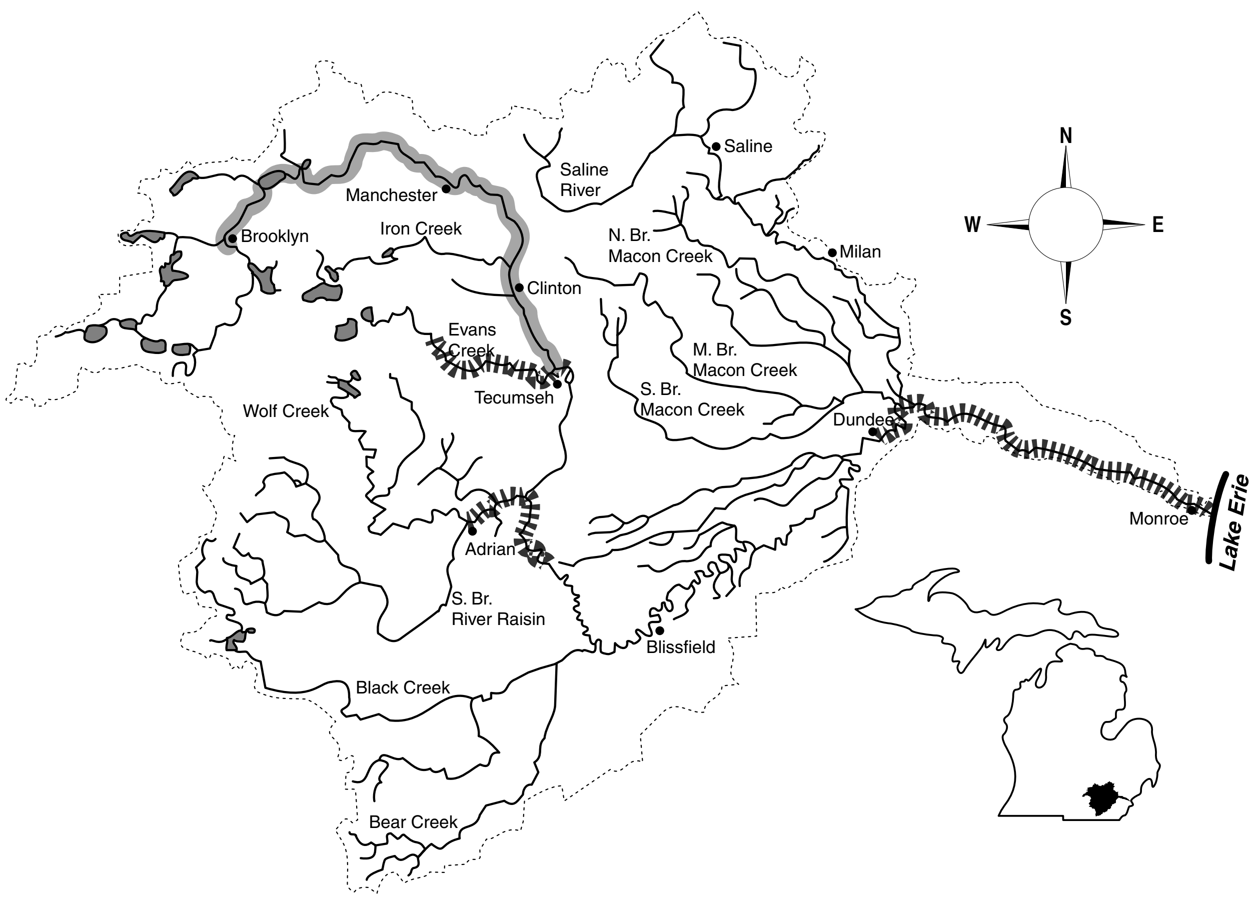


Rosyface shiner (*Notropis rubellus*)

Habitat:

feeding
- moderate sized streams
- moderate to high gradient
- gravel or sand substrate; intolerant of silt substrate
- clear water; intolerant of turbidity

spawning
- on nests of horneyhead chub, chesnut lamprey, and redhorses
- sandy-gravel, gravel or bedrock substrate
- shallow high gradient water

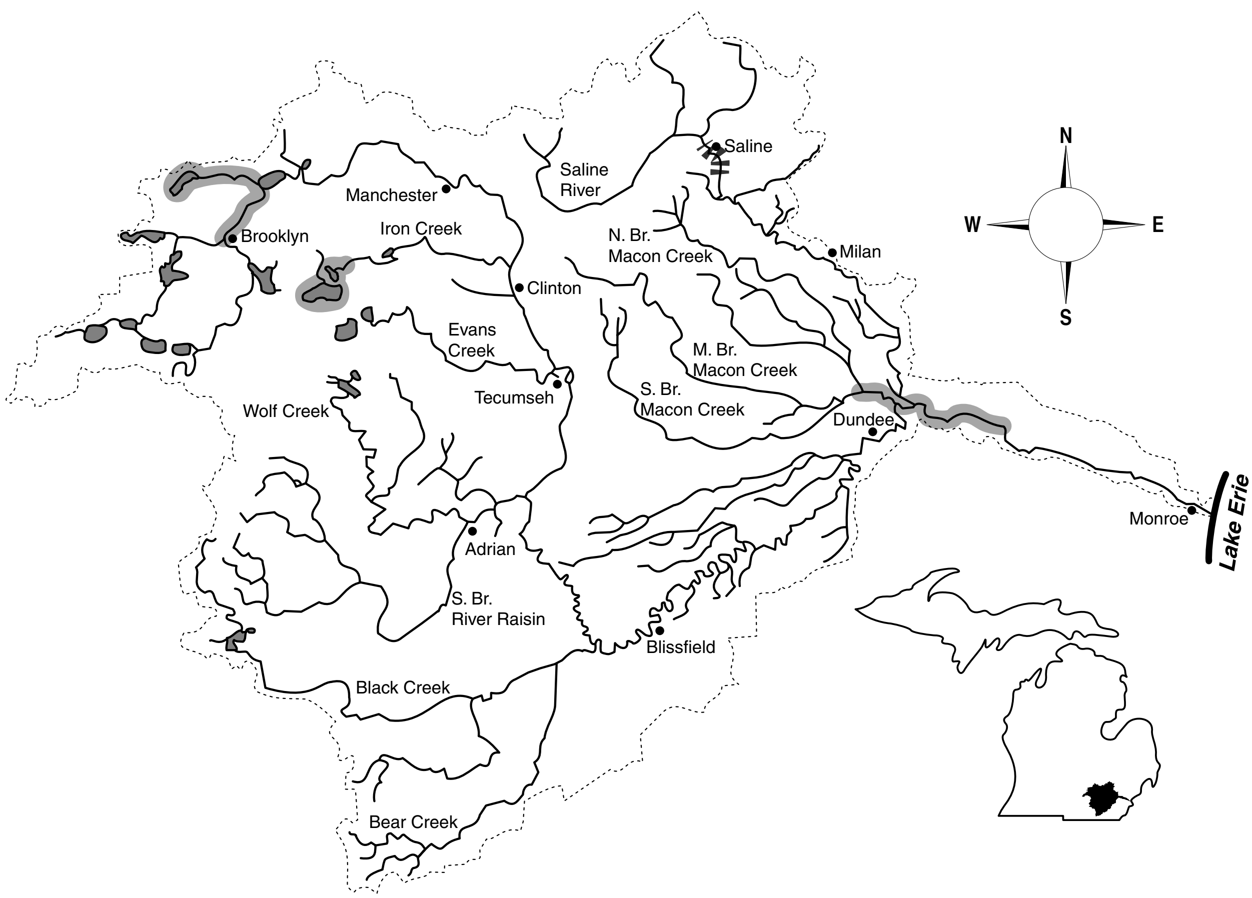


Sand shiner (*Notropis stramineus*)

Habitat:

feeding
- sand and gravel substrate
- shallow pools in medium size streams, lakes, and impoundments
- clear water and low gradient
- rooted aquatic vegetation preferred
- tolerant of some inorganic pollutants provided substrate is not covered

spawning
- clean gravel or sand substrate

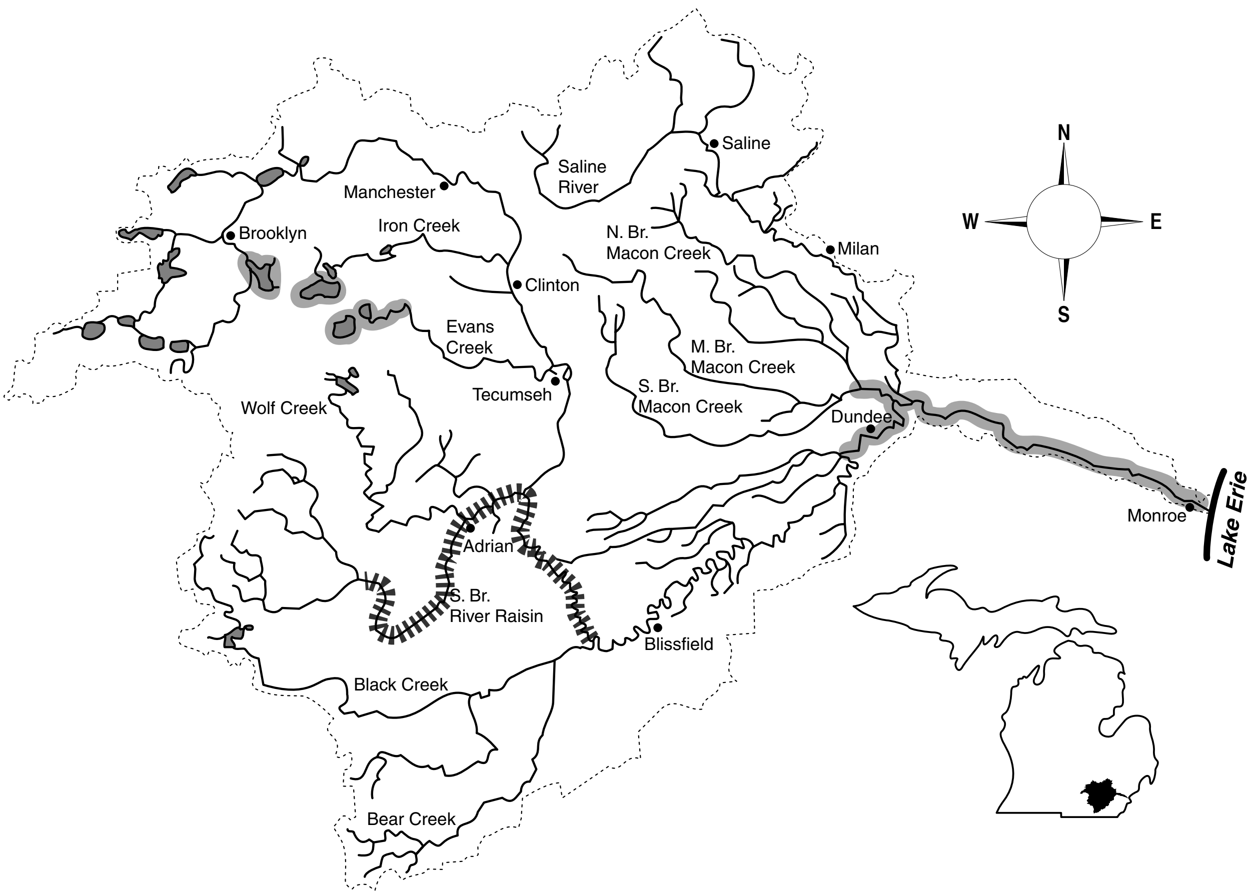


Mimic shiner (*Notropis volucellus*)

Habitat:

feeding - pools and backwater of streams, moderately weedy lakes and impoundments
- quiet or still water
- clear shallow water

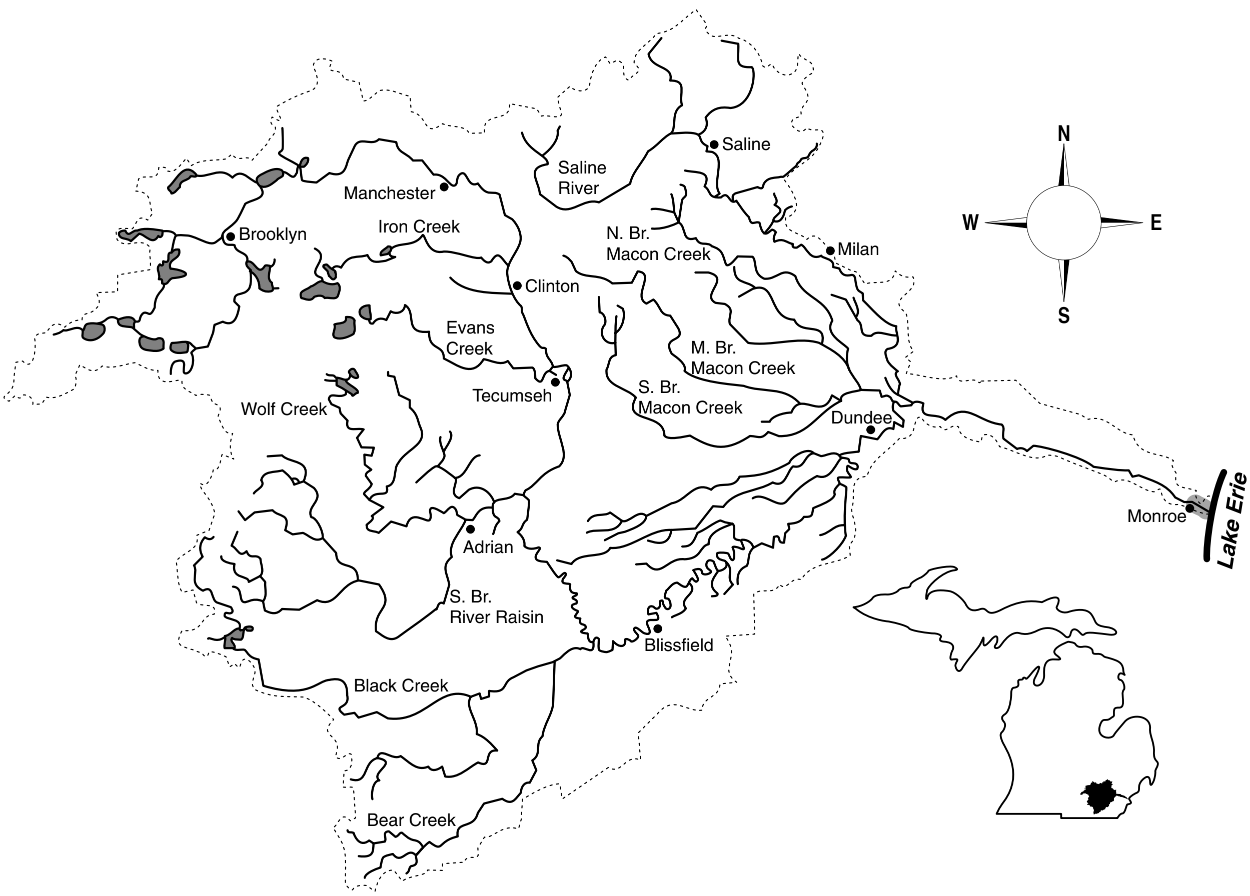
spawning - aquatic vegetation necessary



Pugnose minnow (*Opsopoeodus emiliae*) - threatened

Habitat:

feeding
- clear vegetated rivers
- low current
- sand or mud substrates
- intolerant of turbidity

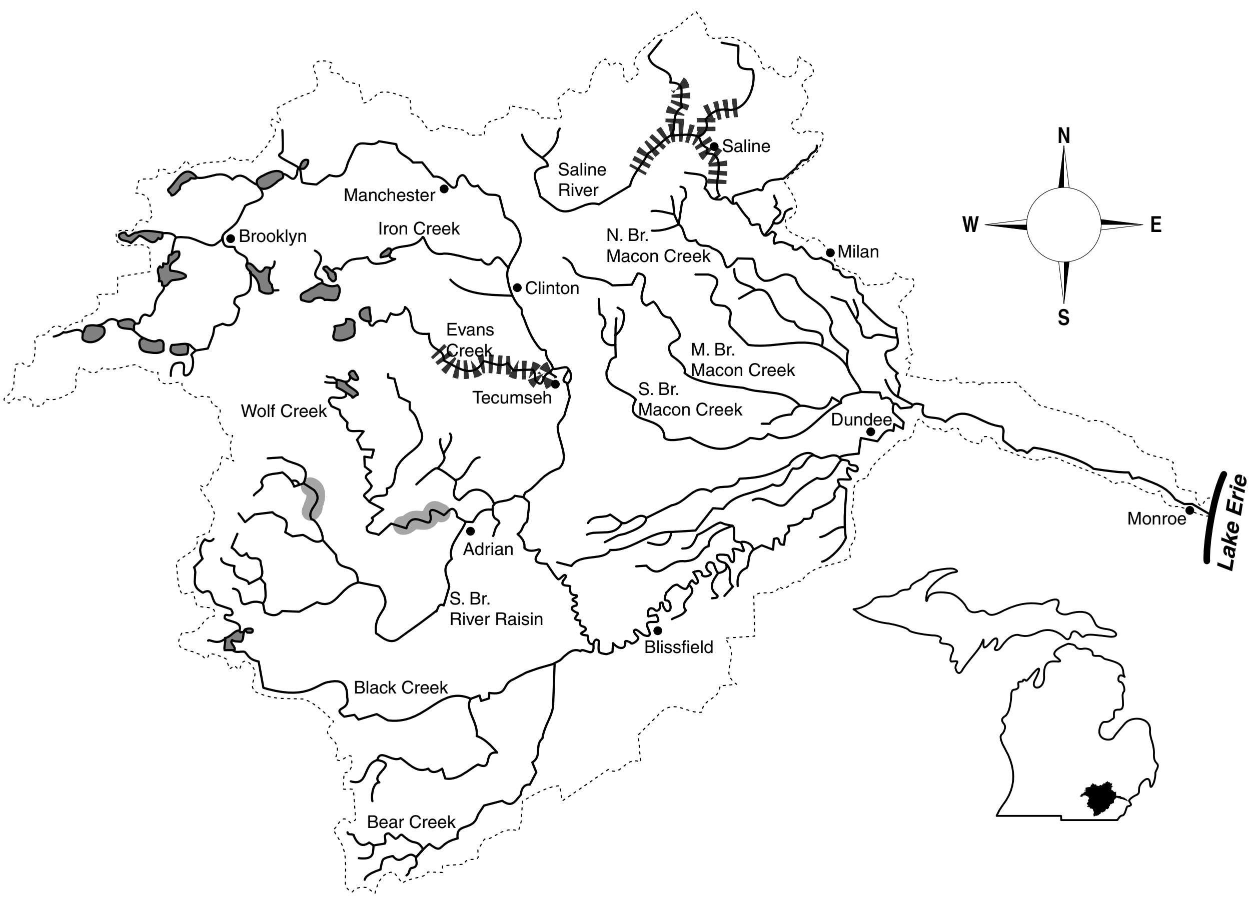


Southern redbelly dace (*Phoxinus erythrogaster*) - threatened, may be extirpated

Habitat:

feeding - cool, clear, silt-free small to medium streams
- gravel substrate
- cut banks overhung by vegetation
- instream aquatic vegetation rare or absent

spawning - gravelly riffles
- eggs scattered in crevices and in other species nests

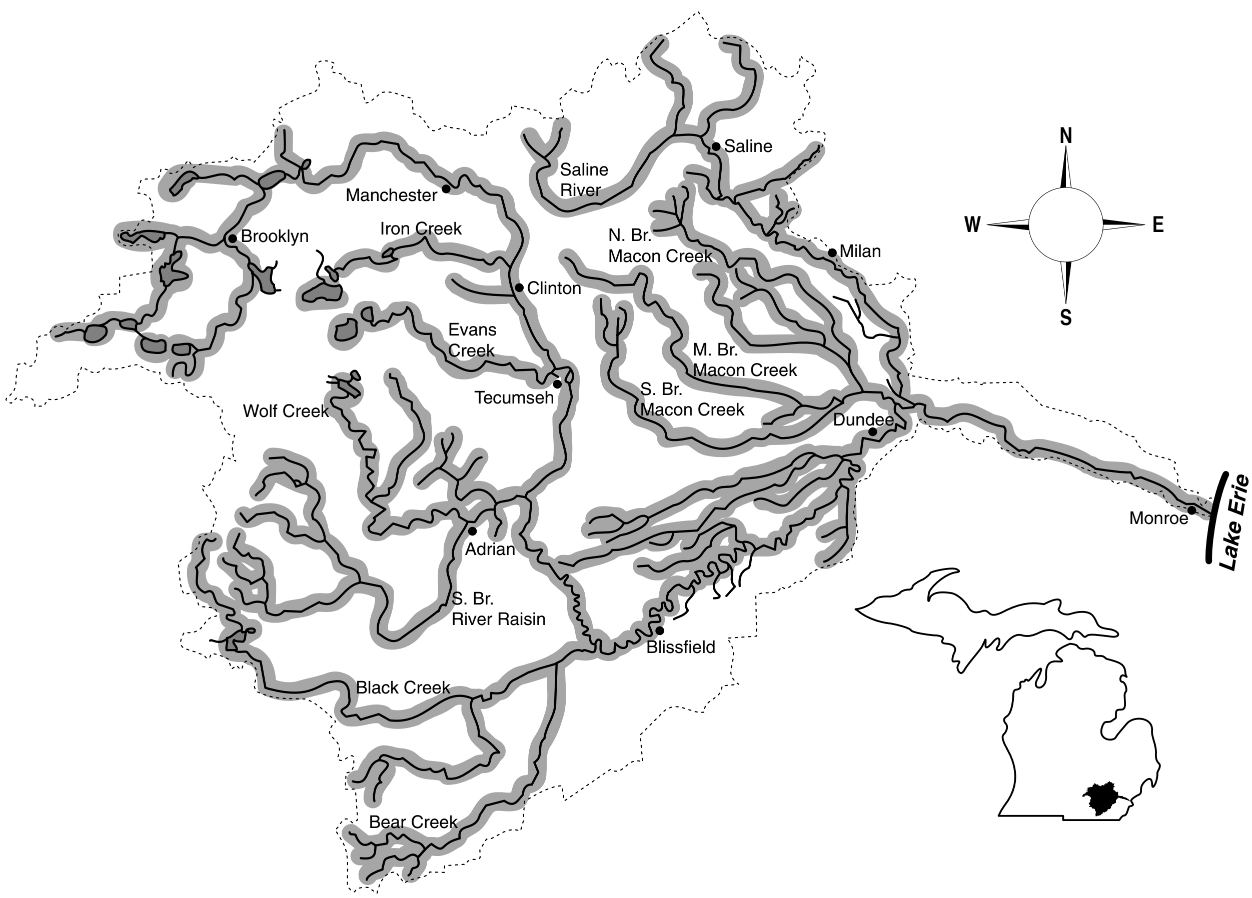


Bluntnose minnow (*Pimephales notatus*)

Habitat:

feeding
- quiet pools and backwaters of medium to large streams, lakes, and impoundments
- clear warm water
- some aquatic vegetation
- firm substrates
- tolerates all gradients, turbidity, organic and inorganic pollutants

spawning
- eggs deposited on the underside of flat stones or objects
- nests in sand or gravel substrate

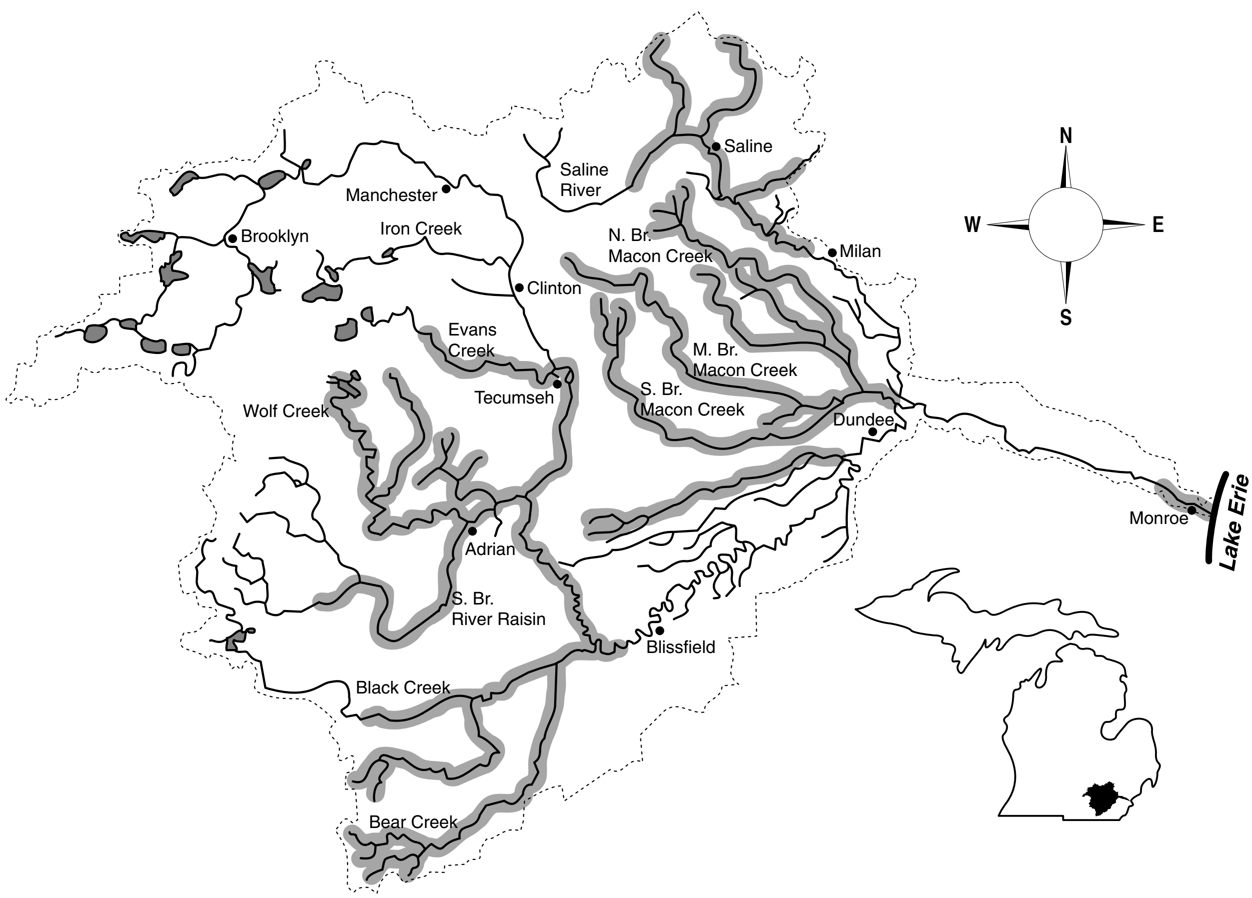


Fathead minnow (*Pimephales promelas*)

Habitat:

feeding - pools of small streams, lakes, and impoundments
- tolerant of turbidity, high temperatures, and low oxygen

spawning - on underside of objects in water 2 to 3 feet deep
- prefer sand, marl, or gravel substrate



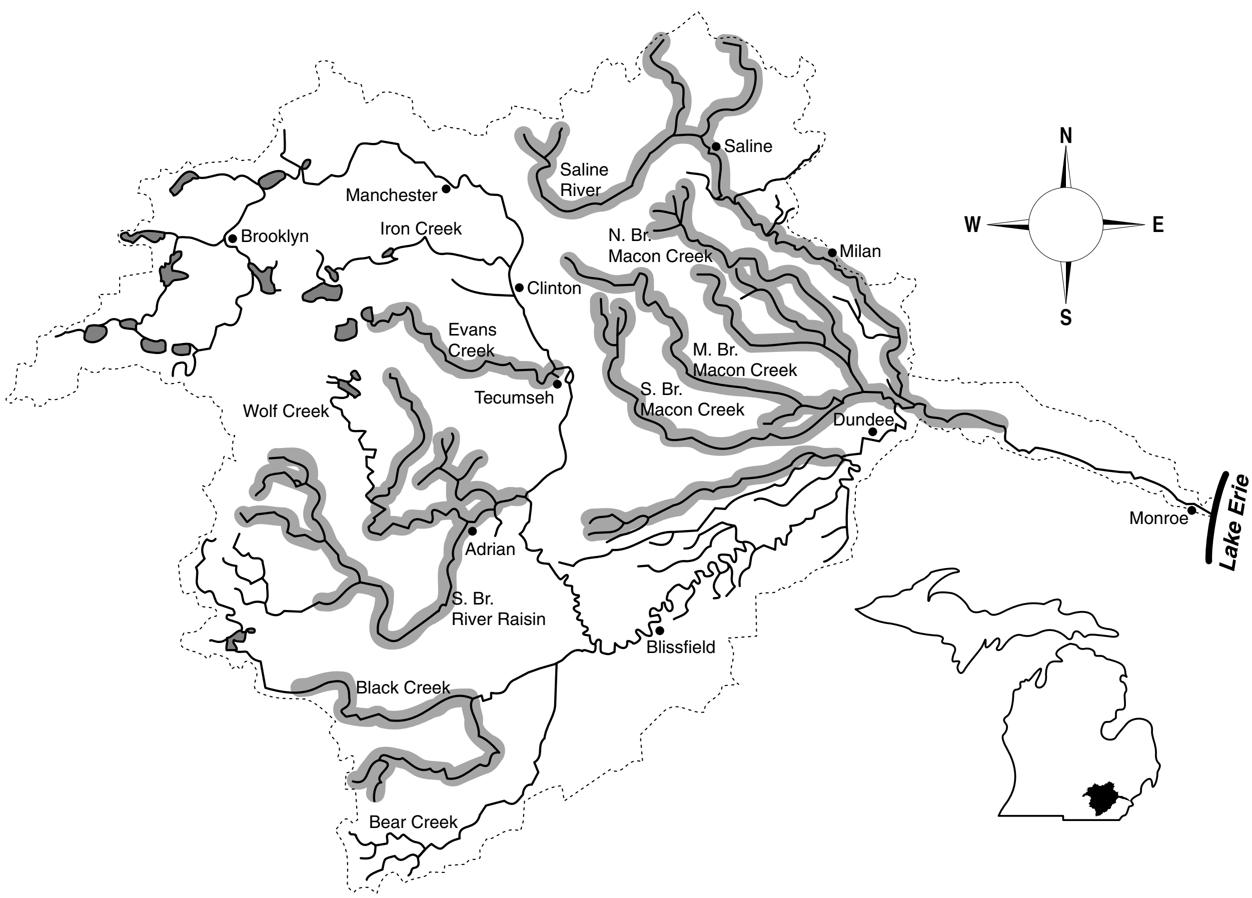
Blacknose dace (*Rhinichthys atratulus*)

Habitat:

feeding - moderate to high gradient streams
- sand and gravel substrate
- clear cool water in pools with deep holes and undercut banks
- does not tolerate turbidity and silt well

spawning - riffles with gravel substrate and fast current

winter refuge - larger waters



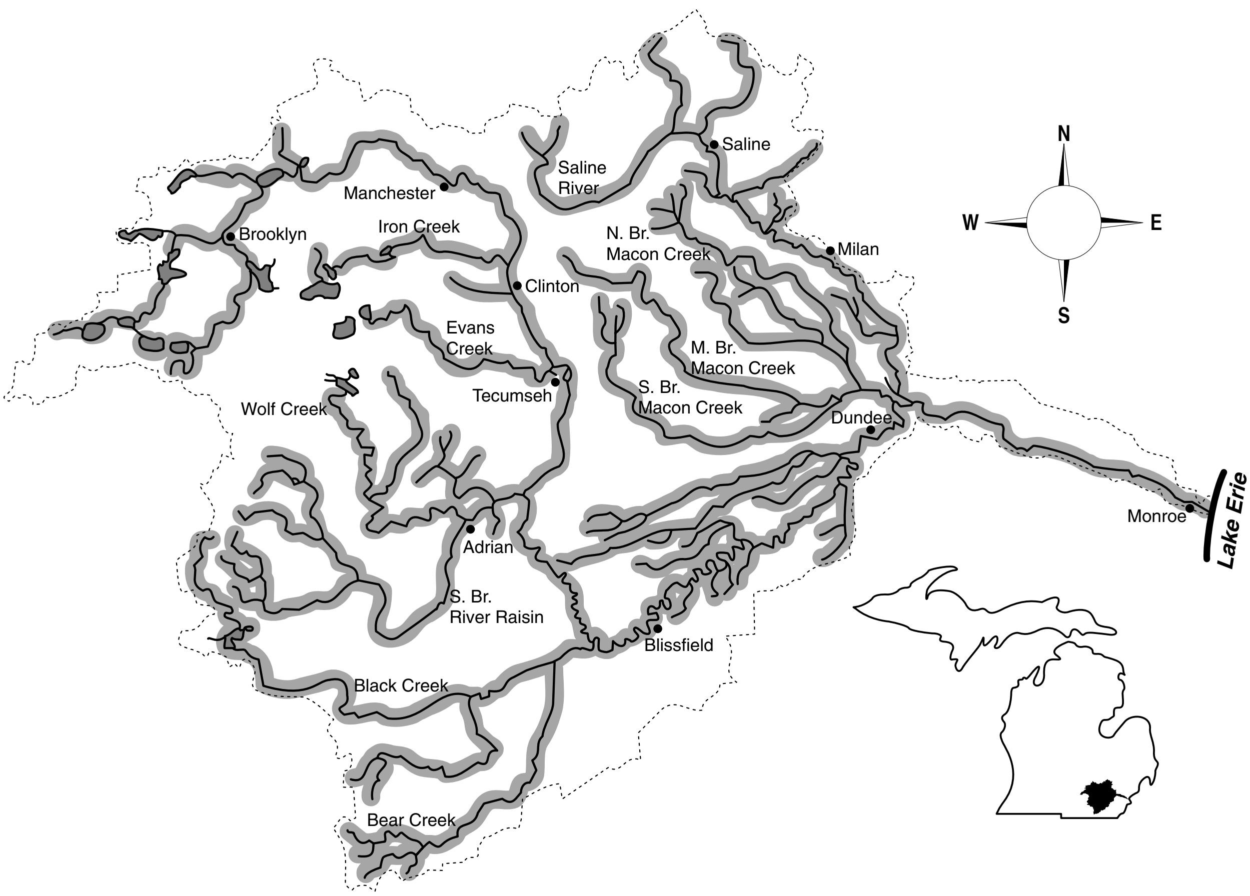
Creek chub (*Semotilus atromaculatus*)

Habitat:

feeding - streams, rivers, or shore waters of lakes and impoundments
- can tolerate intermittent flows
- tolerates moderate turbidity

spawning - gravel nests
- low current

winter refuge - deeper pools and runs

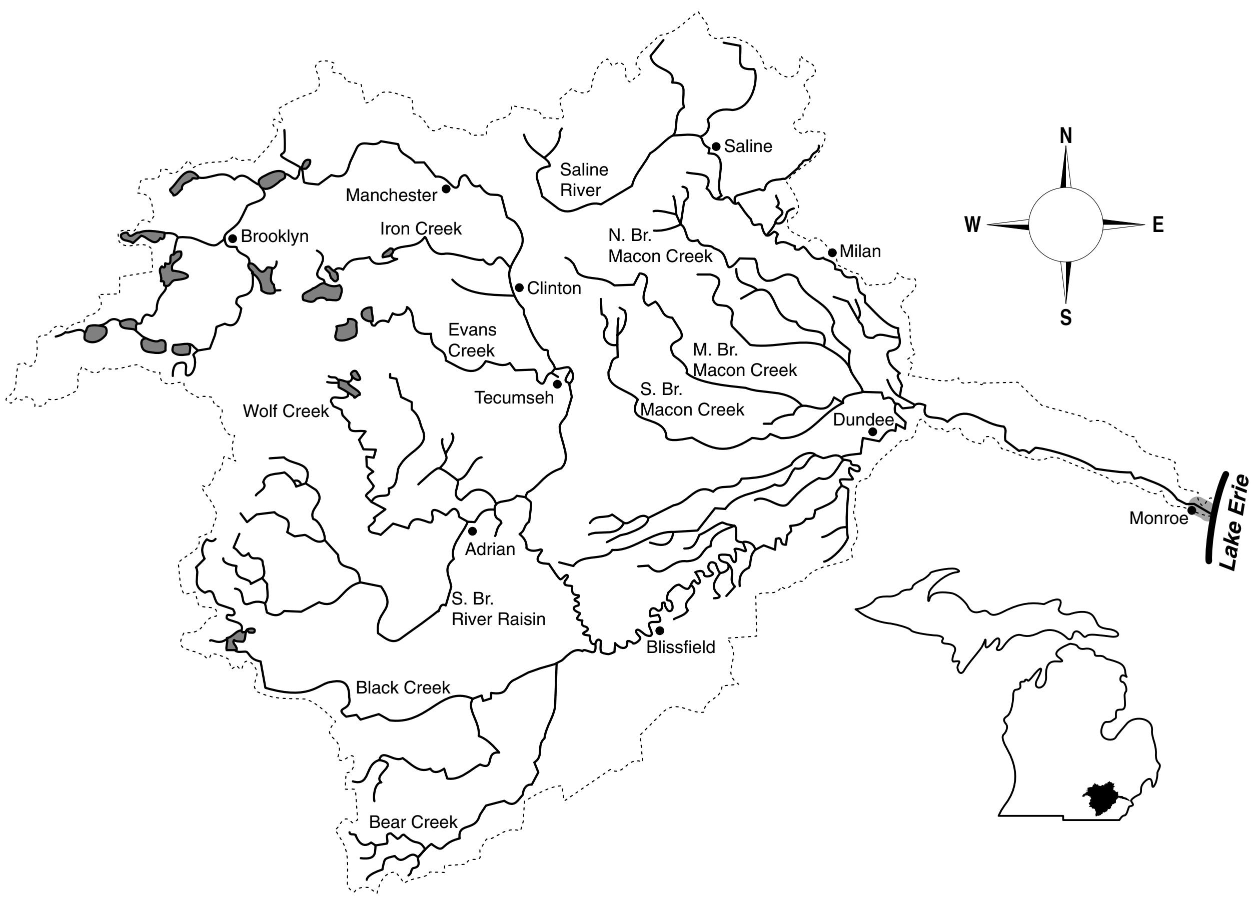


Quillback (*Carpoides cyprinus*)

Habitat:

feeding - clear to turbid water
- sand, sandy gravel, sandy silt, or clay-silt substrate
- medium- to low-gradient rivers and streams; also lakes and sloughs

spawning - streams or overflow areas of bends of rivers or bays of lakes
- scatter eggs over sand or mud substrate

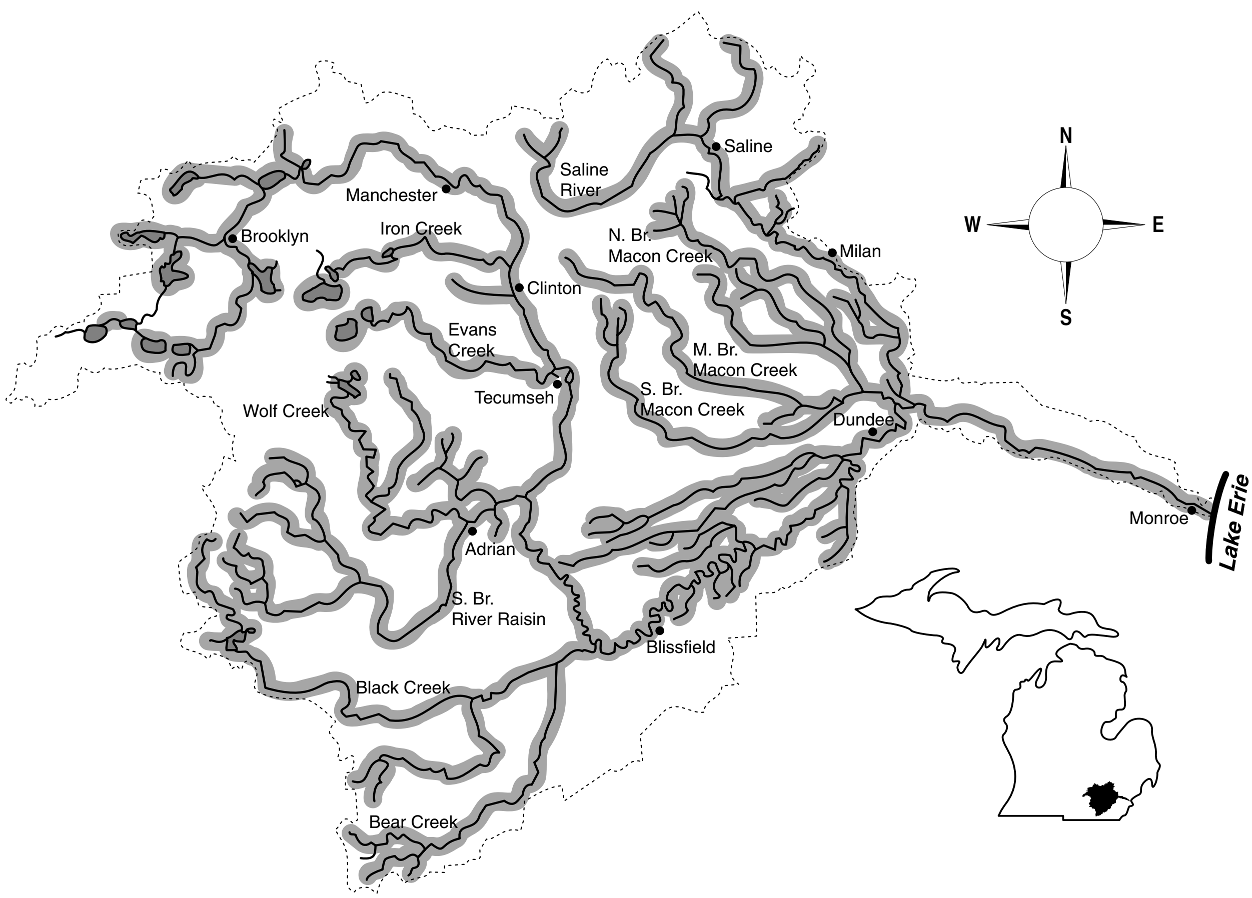


White sucker (*Catostomus commersoni*)

Habitat:

feeding - streams, rivers, lakes, and impoundments
- can inhabit highly turbid and polluted waters

spawning - quiet gravelly shallow areas of streams



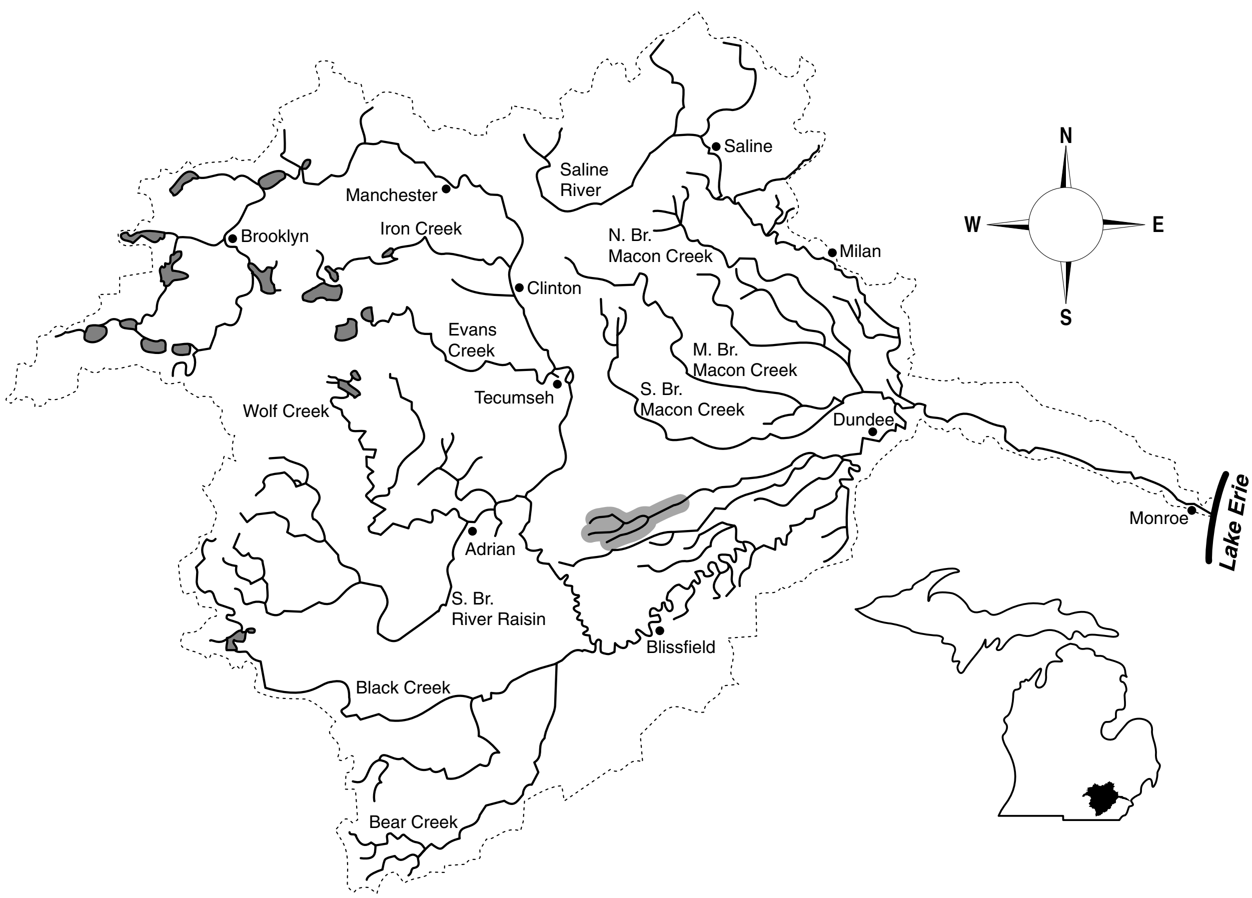
Creek chubsucker (*Erimyzon oblongus*) - threatened

Habitat:

feeding - clear quiet waters with thick submergent vegetation
- sand, gravel, or silt mixed with organic debris substrate
- in deeper more sluggish pools, protected inlets, and overflow ponds
- moderate and high gradient

spawning - gravelly shoals of streams, riffles, or lake outlets

winter refuge - larger creeks

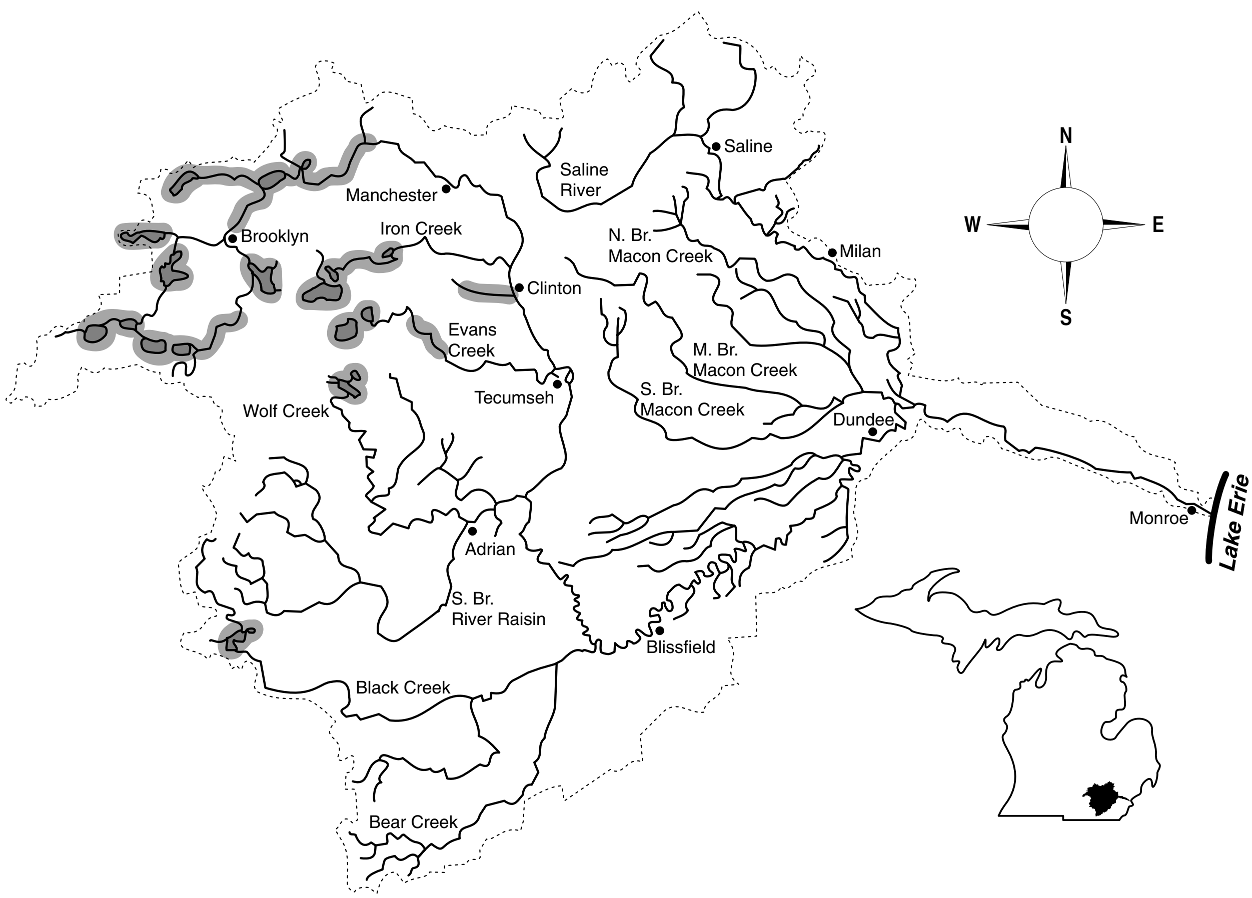


Lake chubsucker (*Erimyzon sucetta*)

Habitat:

feeding - larger clear streams, rivers, lakes, and impoundments
- cannot tolerate turbid water
- low gradient
- prefers dense vegetation over substrate of sand or silt mixed with organic debris

spawning - small clear streams with moderate to high gradient
- sand or gravel substrate; no clayey silt



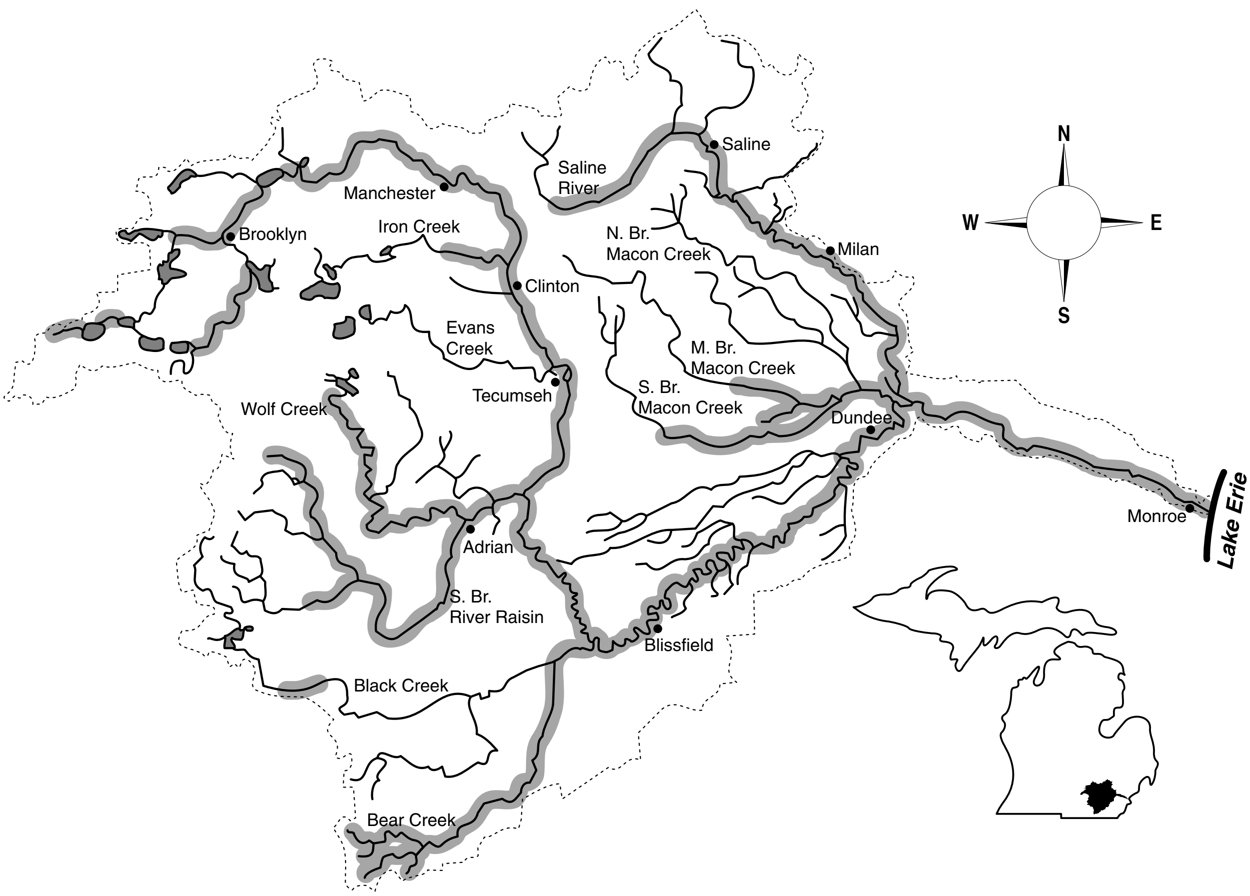
Northern hog sucker (*Hypentelium nigricans*)

Habitat:

feeding
- gravel or rubble substrate
- riffles and adjacent pools of warm shallow streams
- clear water
- doesn't like turbidity or siltation
- avoids profuse amounts of aquatic vegetation

spawning
- riffles
- shallow gravel substrate
- high gradient

winter refuge
- deeper quieter pools

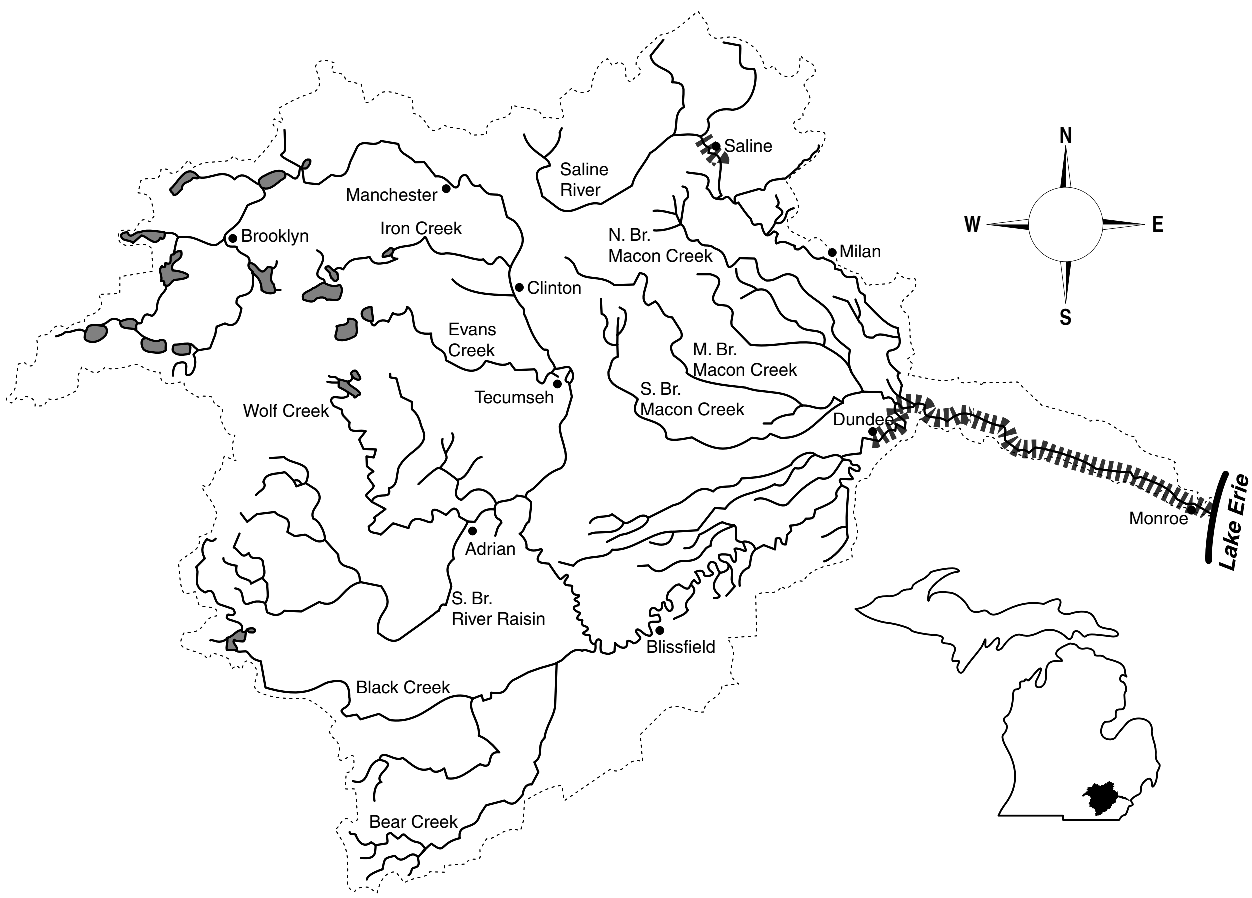


Spotted sucker (*Minytrema melanops*) - rare

Habitat:

feeding - clear warm rivers (pools, backwaters) with little current
- abundant vegetation
- soft substrate with organic debris
- intolerant of turbidity

spawning - riffles

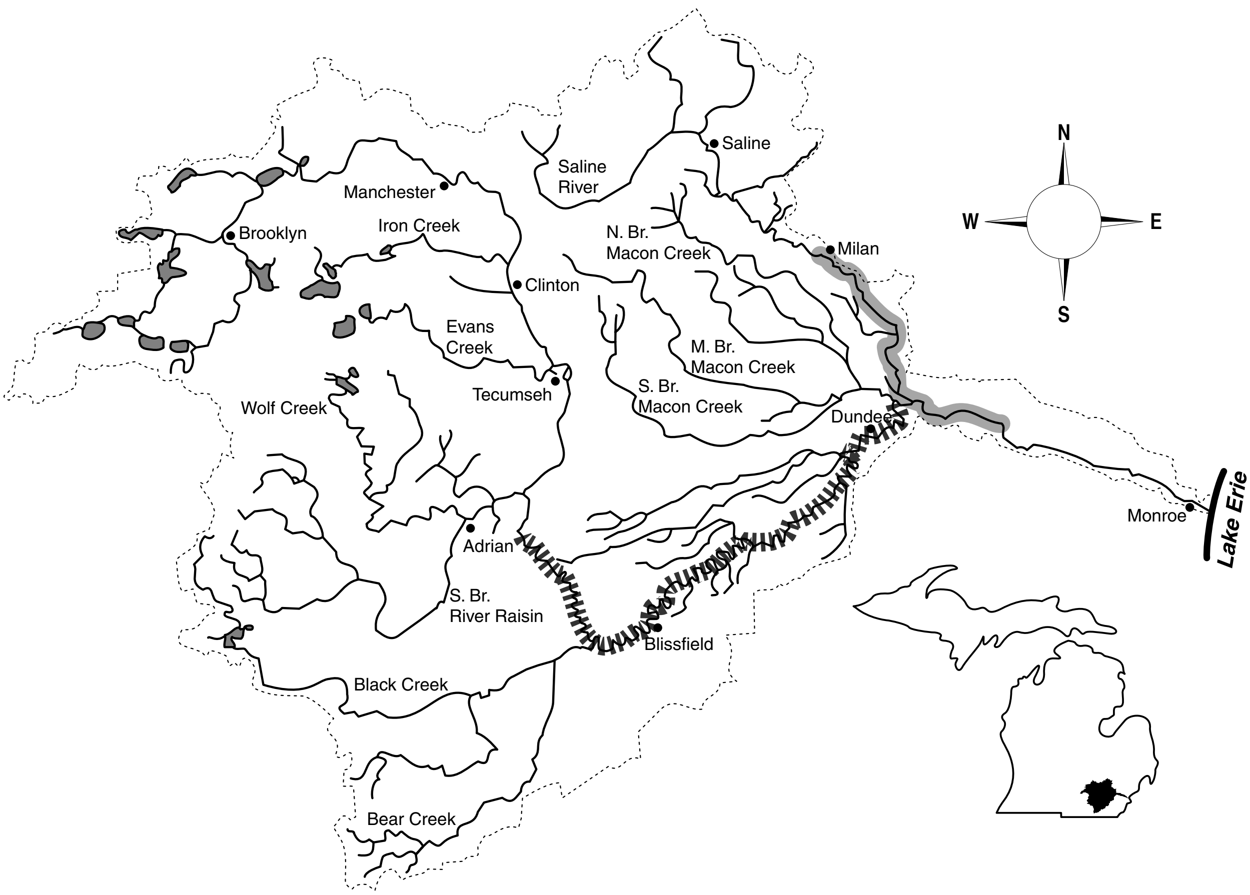


Silver redhorse (*Moxostoma anisurum*)

Habitat:

feeding
- streams, rivers, lakes, and impoundments
- low current
- pollution and turbidity intolerant

spawning
- swift current in rivers, do not spawn in tributaries
- males territorial
- gravel to rubble substrate



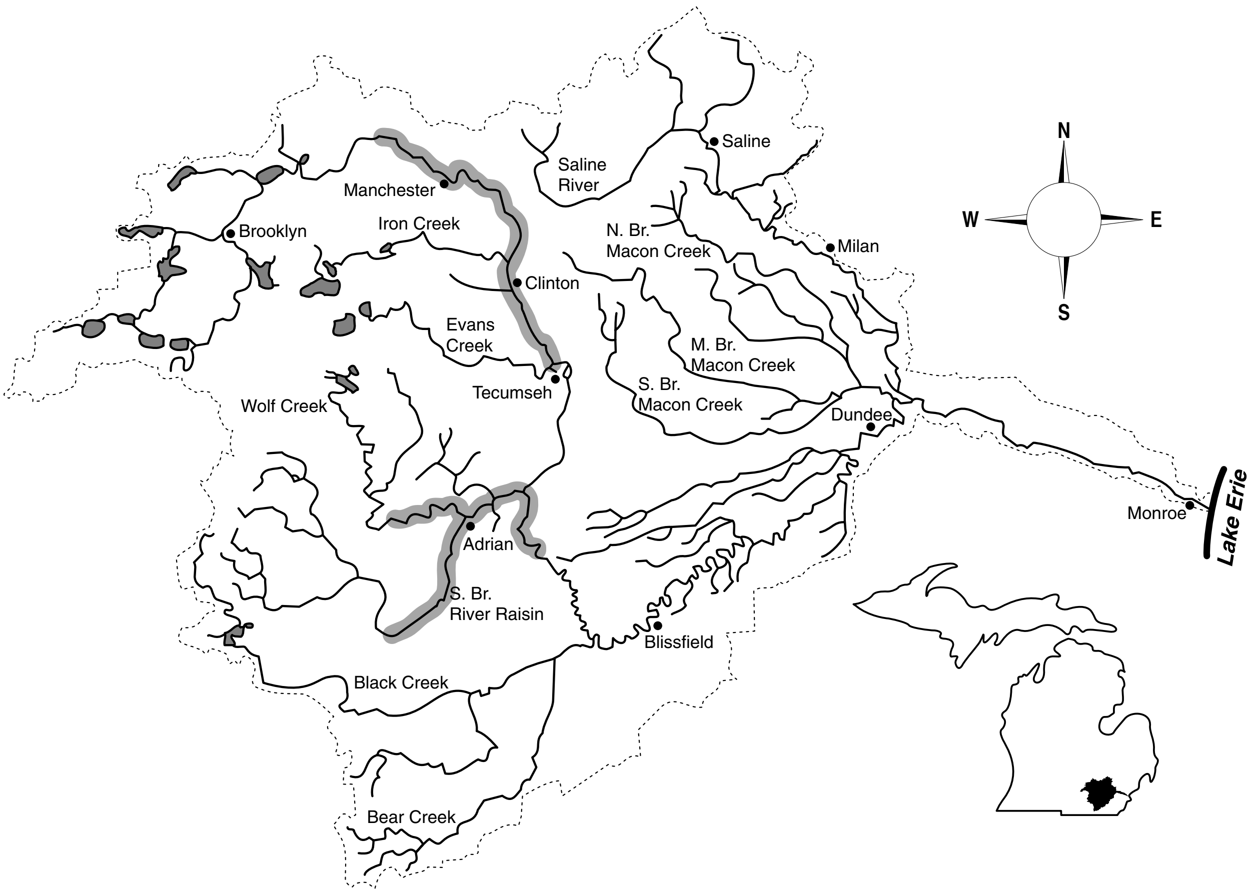
Black redhorse (*Moxostoma duquesnei*) - special concern

Habitat:

feeding - gravel substrate
- clear water, intolerant of siltation, turbidity, and low gradients
- medium size streams
- cooler swifter streams and short rocky pools with current

spawning - gravelly riffles

winter refuge - deeper holes



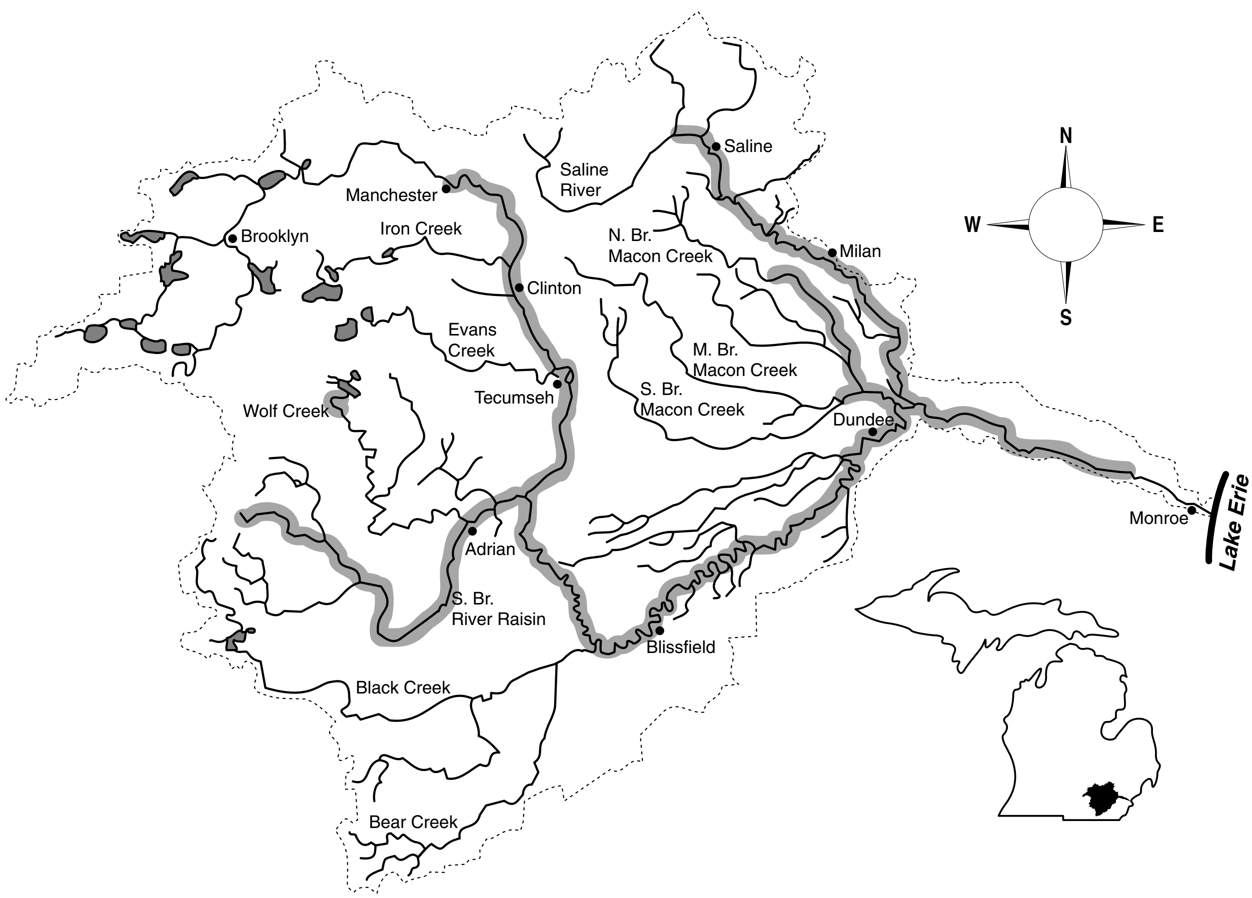
Golden redhorse (*Moxostoma erythrurum*)

Habitat:

feeding - warm medium gradient streams and rivers
- clear riffly streams
- medium size streams and rivers
- tolerates some turbidity and silt

spawning - shallow gravelly riffles

winter refuge - larger streams

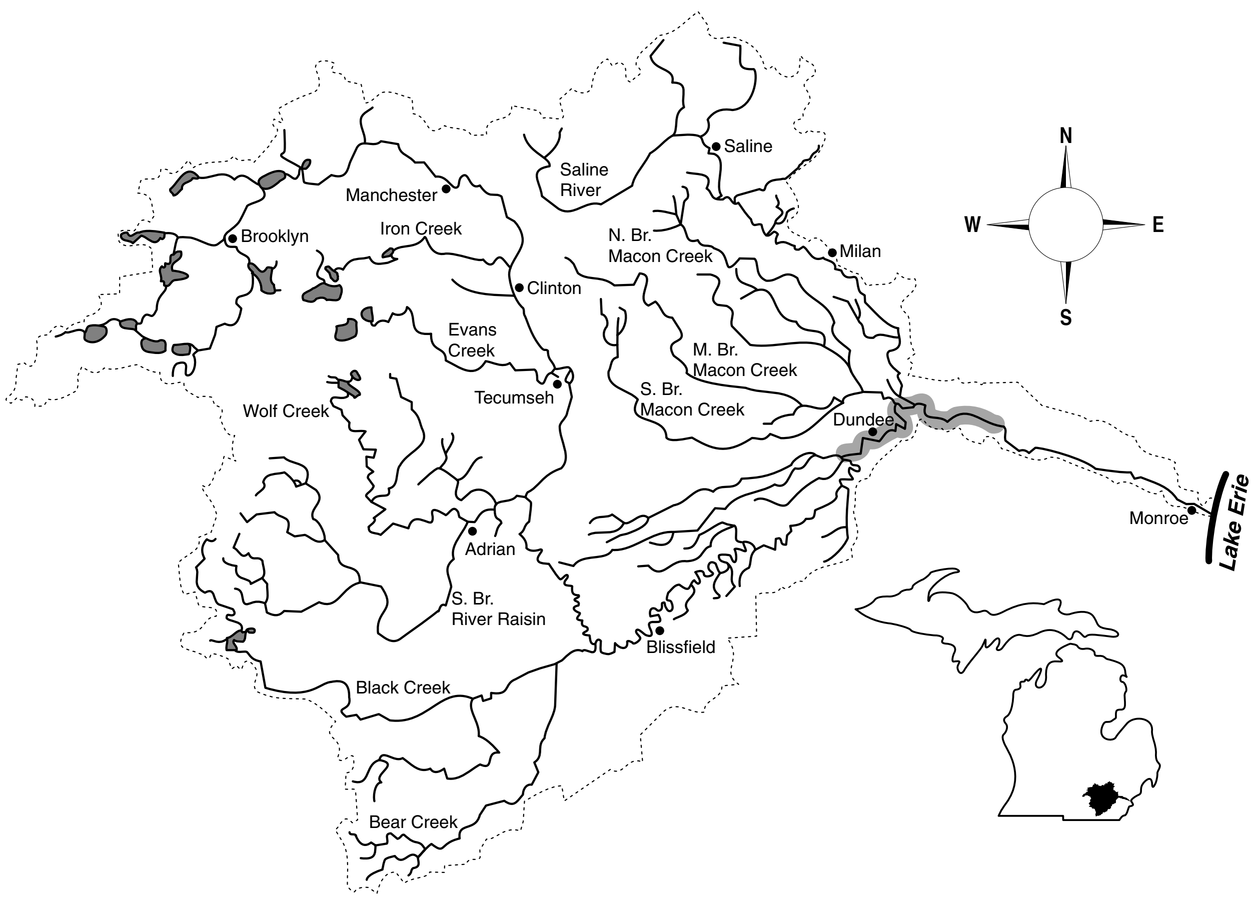


Shorthead redhorse (*Moxostoma macrolepidotum*)

Habitat:

feeding - downstream sections of large rivers, lakes, and impoundments
- rocky substrates
- swift water near riffles
- clear to slightly turbid water

spawning - gravelly riffles in smaller feeder streams

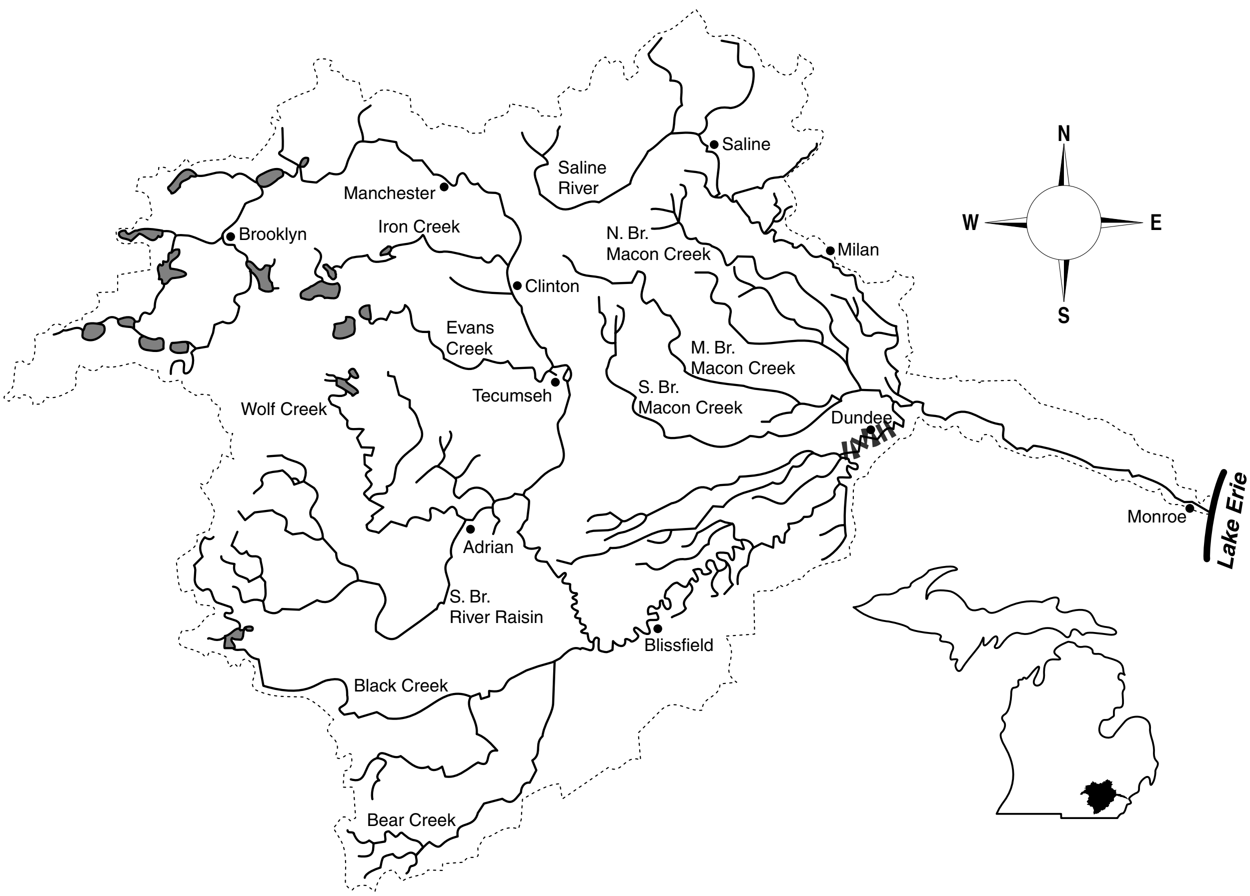


Greater redhorse (*Moxostoma valenciennesi*) - locally extirpated

Habitat:

feeding - large clear streams
- clean sand, gravel, or boulder substrate
- intolerant of excessive turbidity and chemical pollutants

spawning - moderately rapid current

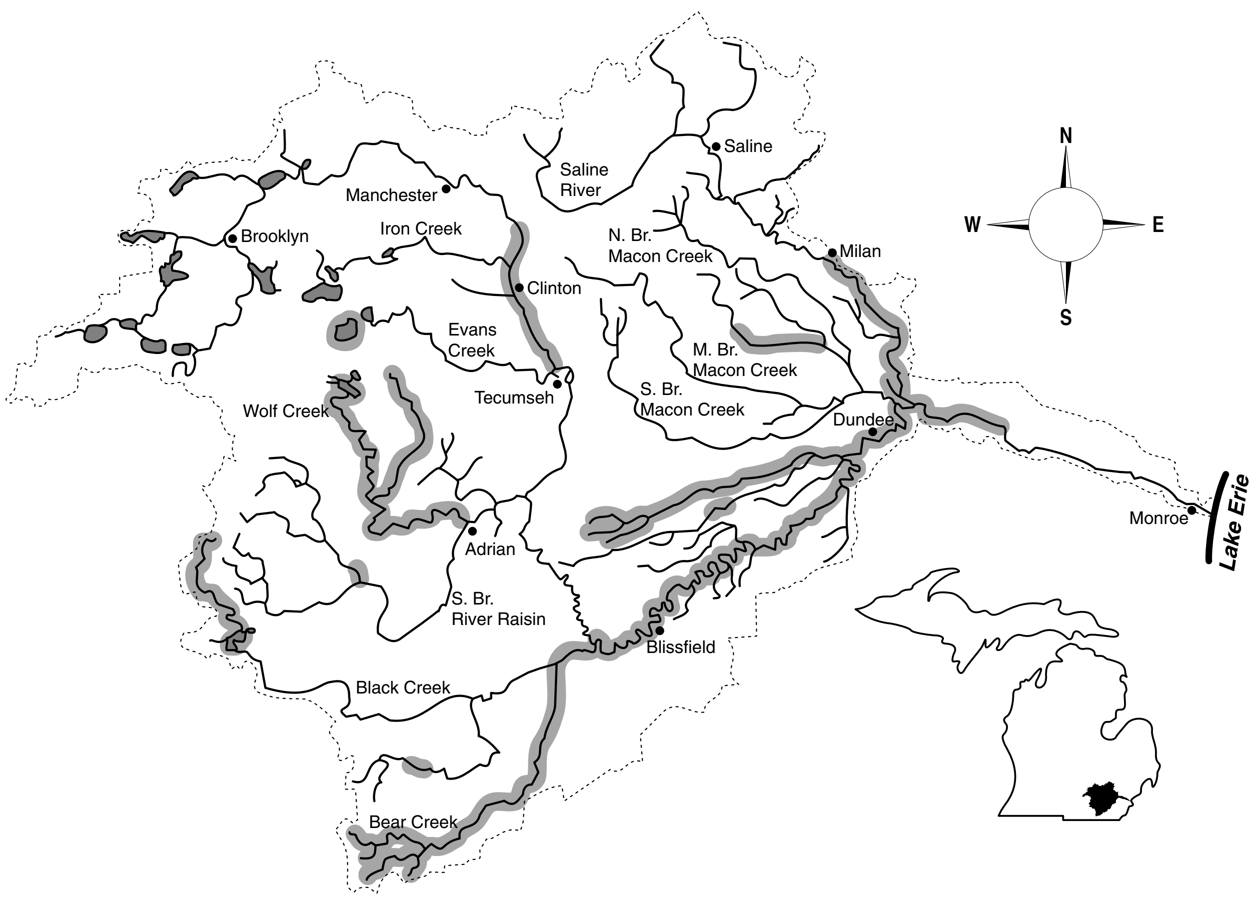


Black bullhead (*Ameiurus melas*)

Habitat:

feeding - turbid water
- silt bottom
- low gradient small to medium streams, pools, and headwaters of large rivers; also in lakes and impoundments
- can tolerate very warm water and very low dissolved oxygen

spawning - nest in moderate to heavy vegetation or woody debris and under overhanging banks

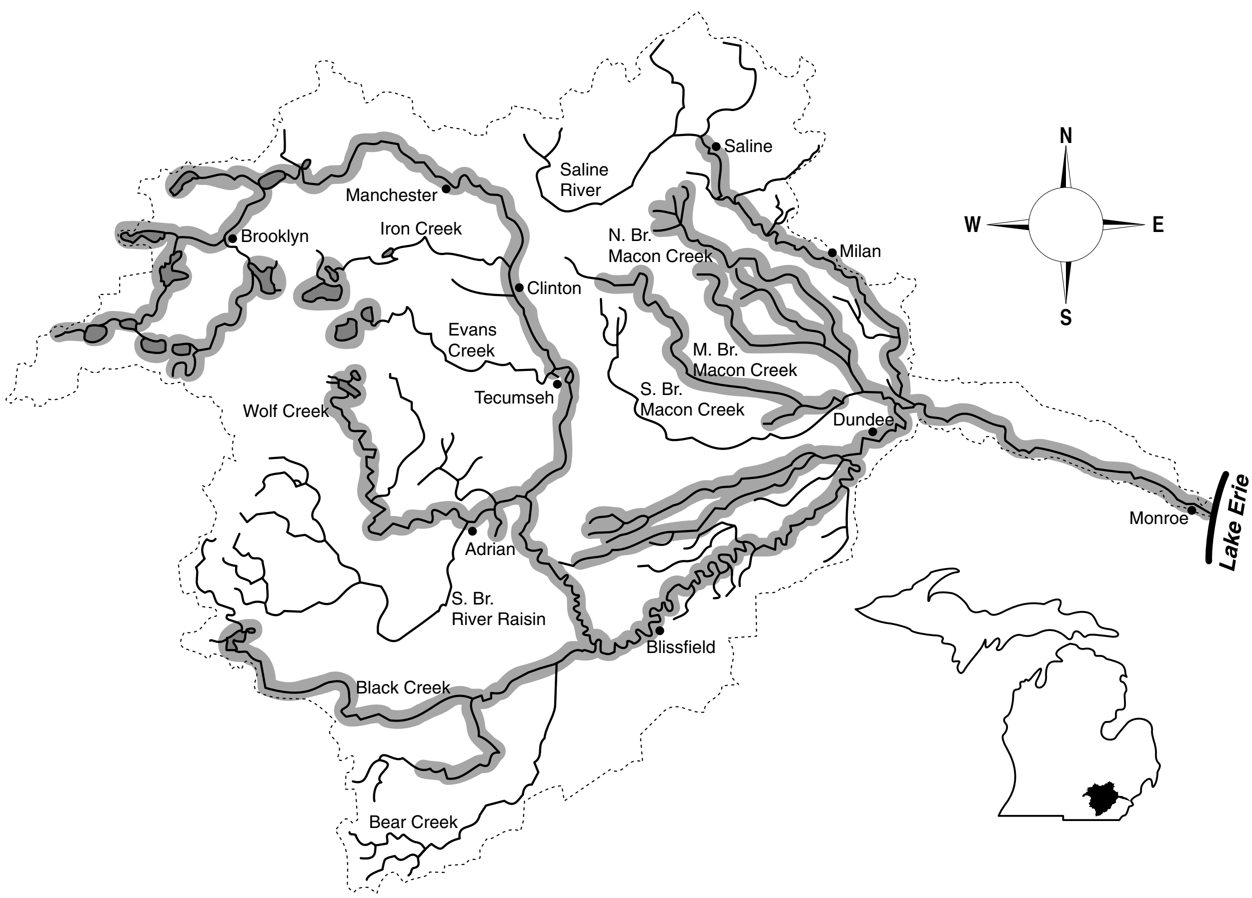


Yellow bullhead (*Ameiurus natalis*)

Habitat:

feeding - clear flowing water
- heavy vegetation
- low gradient streams, lakes, and impoundments
- tolerant of low oxygen

spawning - nest under a stream bank or near stones or stumps



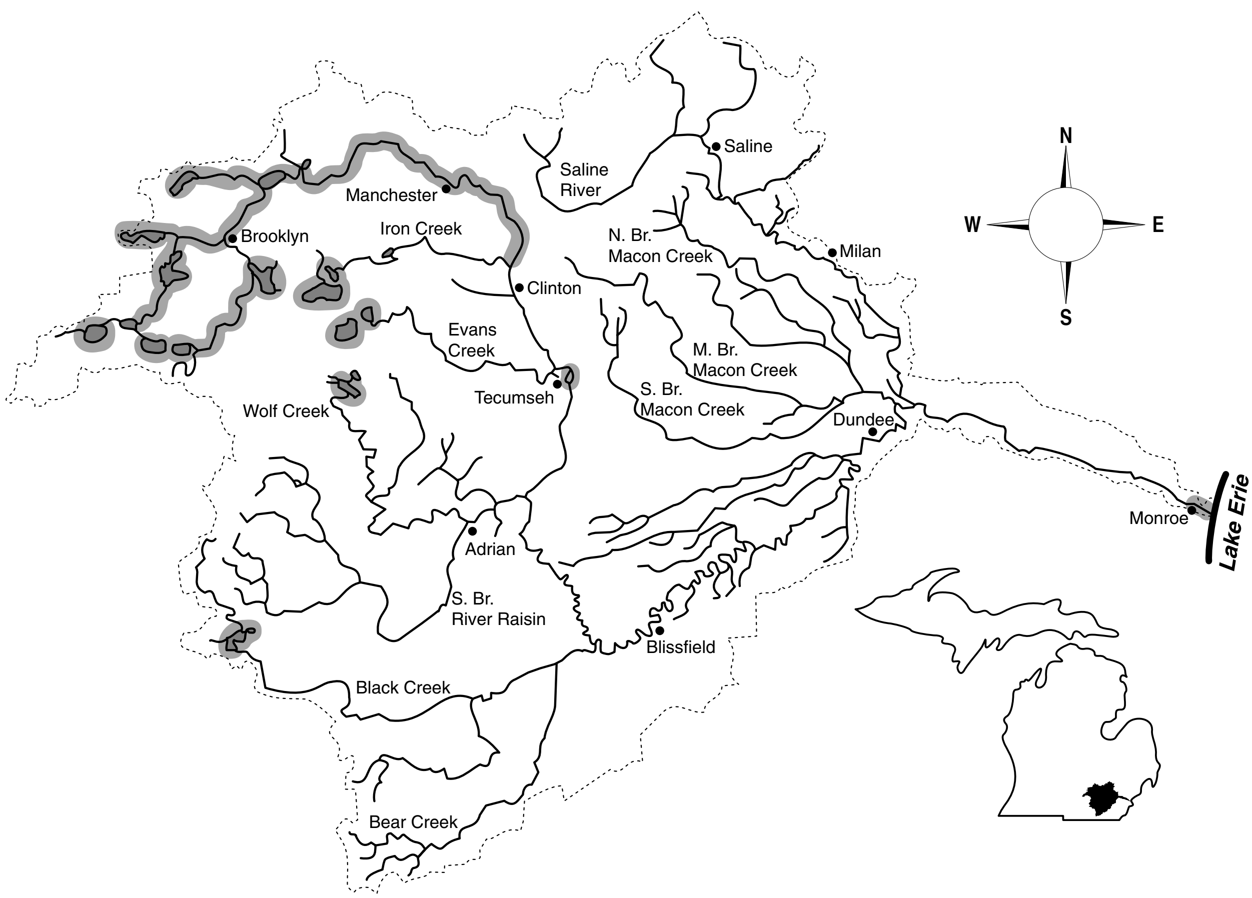
Brown bullhead (*Ameiurus nebulosus*)

Habitat:

feeding - larger streams and rivers, lakes and impoundments
- clear cool water with little clayey silt
- moderate amounts of aquatic vegetation
- sand, gravel, or muck substrate
- not tolerant of turbid water
- tolerant of warm water and low oxygen

spawning - nest in mud or sand substrate among rooted aquatic vegetation usually near a stump, tree, or rock

winter refuge - in muddy bottoms

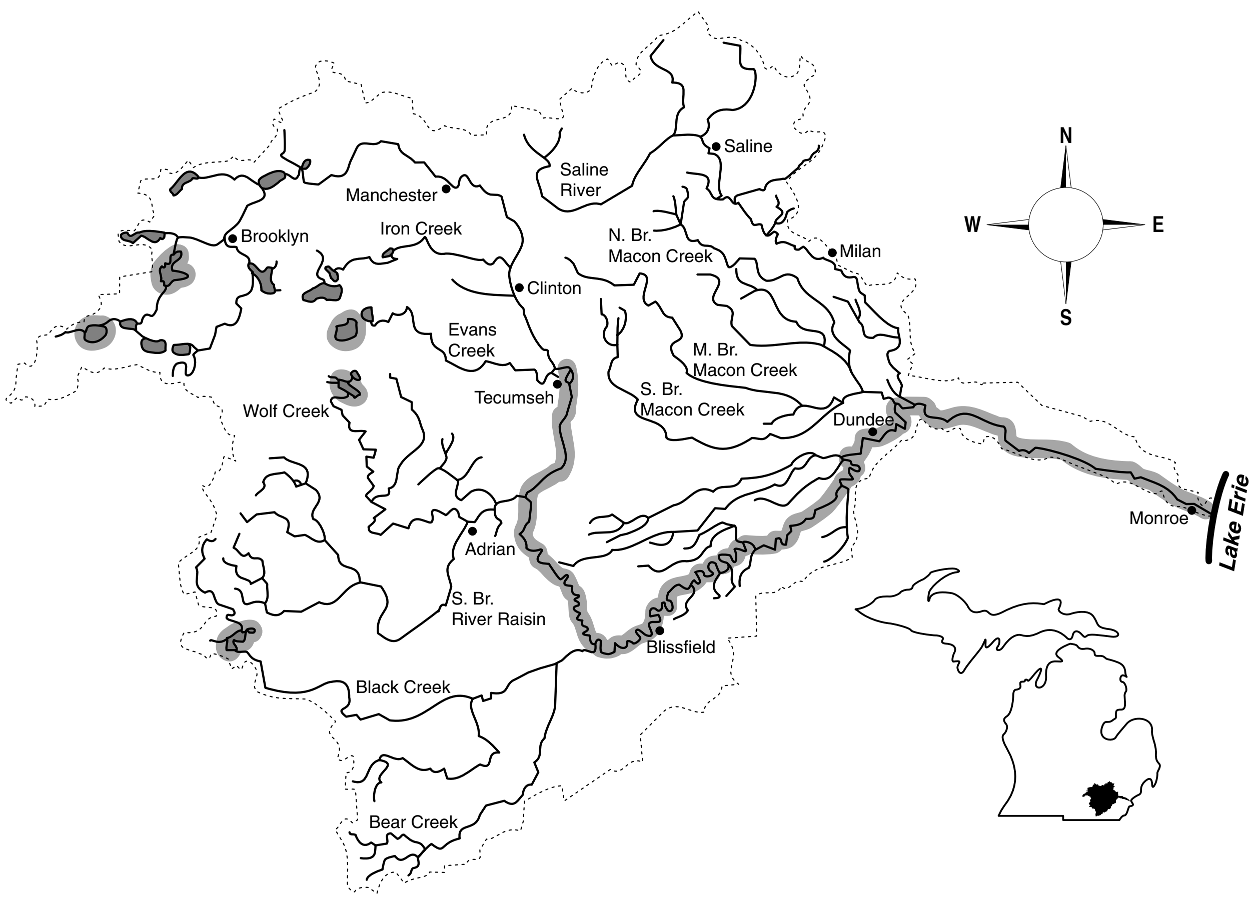


Channel catfish (*Ictalurus punctatus*)

Habitat:

feeding - moderately-clear, deeper waters of rivers, lakes, and impoundments
- sand, gravel, or rubble substrate
- low to moderate gradient

spawning - secluded semi-dark areas such as holes, under banks, log jams, or rocks

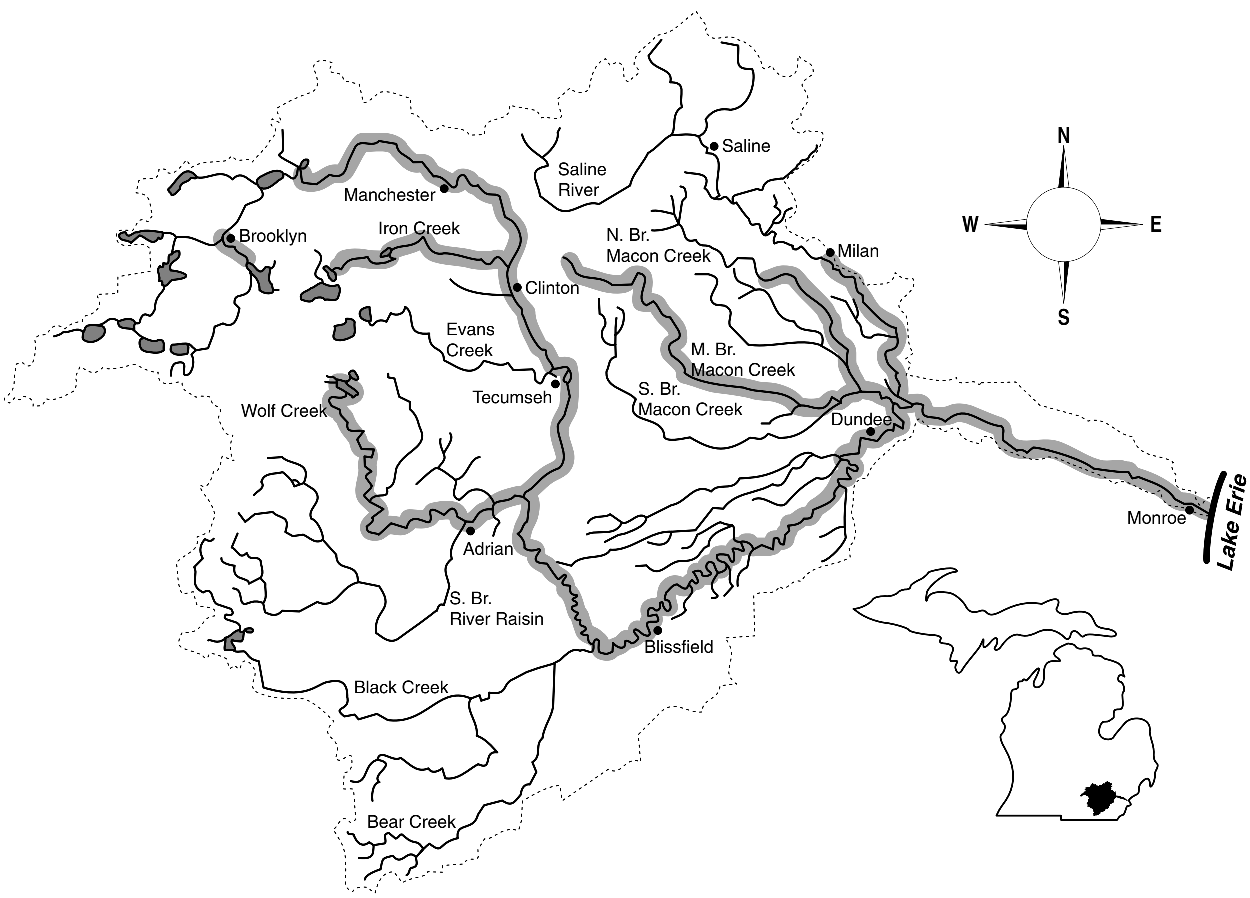


Stonecat (*Noturus flavus*)

Habitat:

feeding
- consistent low to moderate gradient flowing water
- rocky riffles of larger streams and smaller rivers
- not tolerant of silt
- tolerant of low oxygen and pollution

spawning
- eggs deposited beneath stones
- shallow rocky areas of streams or lakes

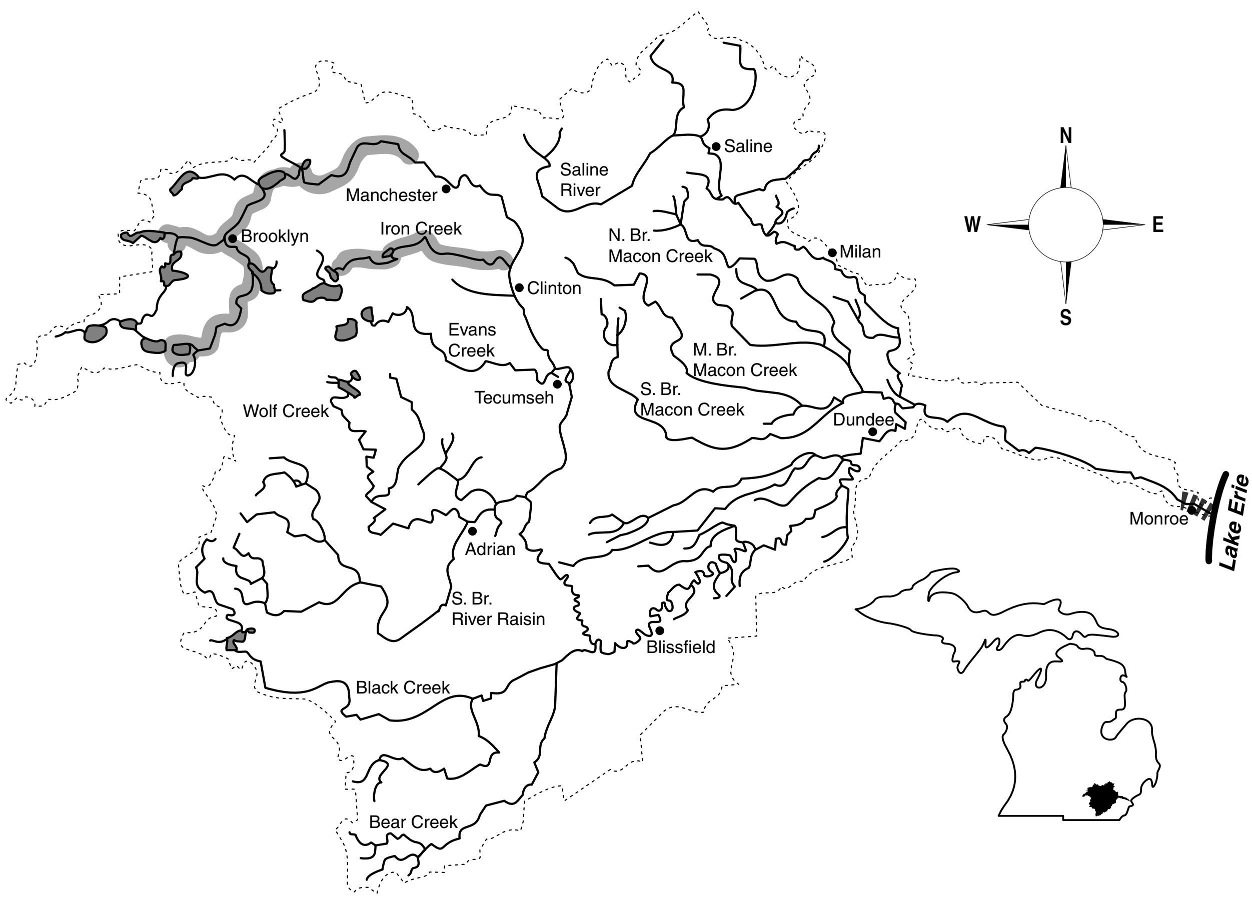


Tadpole madtom (*Noturus gyrinus*)

Habitat:

feeding - vegetative cover in low-moderate current waters
- muddy substrate with extensive vegetation
- clear waters of streams, rivers, and lakes

spawning - mostly in rivers, sometimes shallows of lakes
- nests in dark cavities (ex: beneath boards, logs, crayfish burrows)

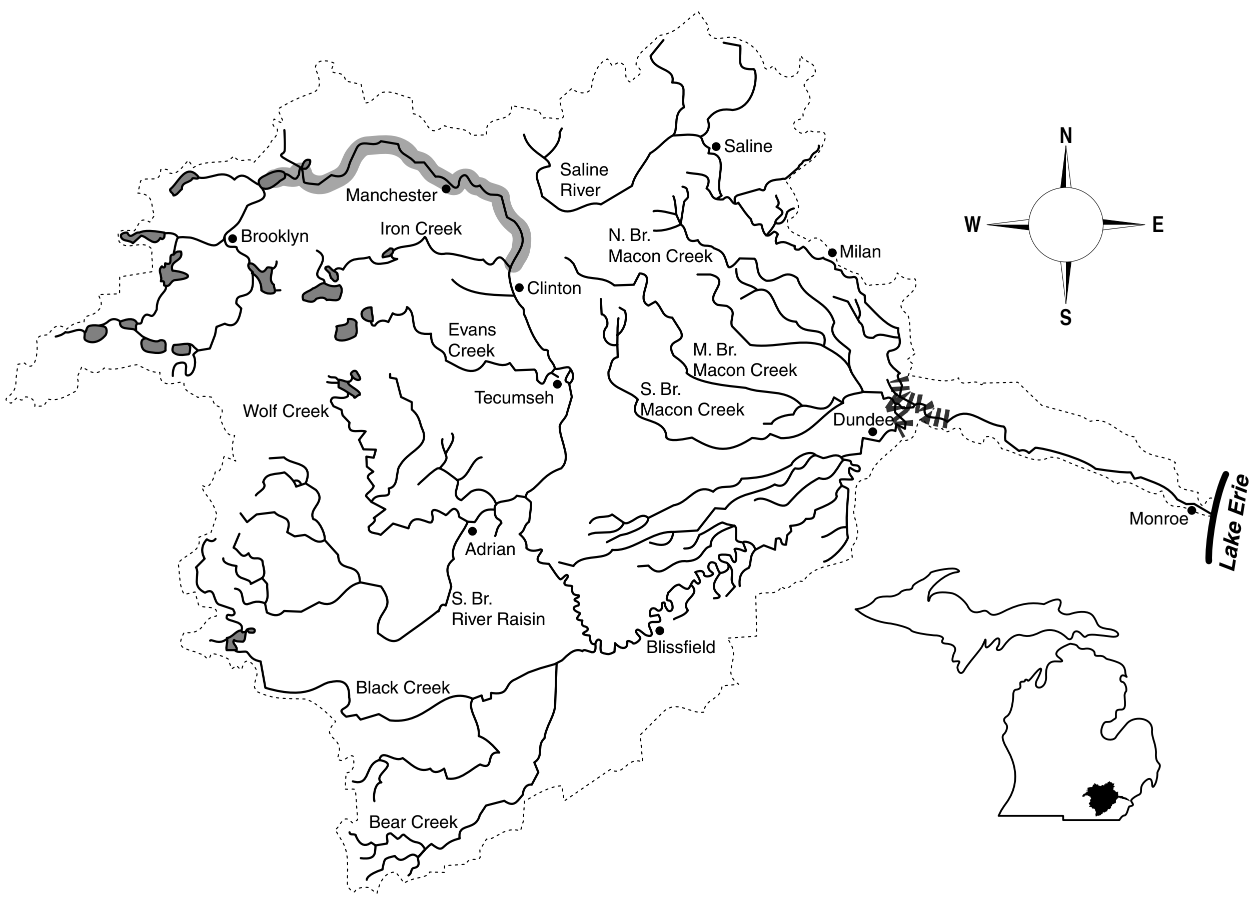


Brindled madtom (*Noturus miurus*) - special concern

Habitat:

feeding - low gradient streams or pools of higher gradient reaches
- sand or organic debris substrate - no clayey silts
- in riffles of sluggish or moderate flow if sand is present

spawning - silt or mud substrate
- emergent vegetation

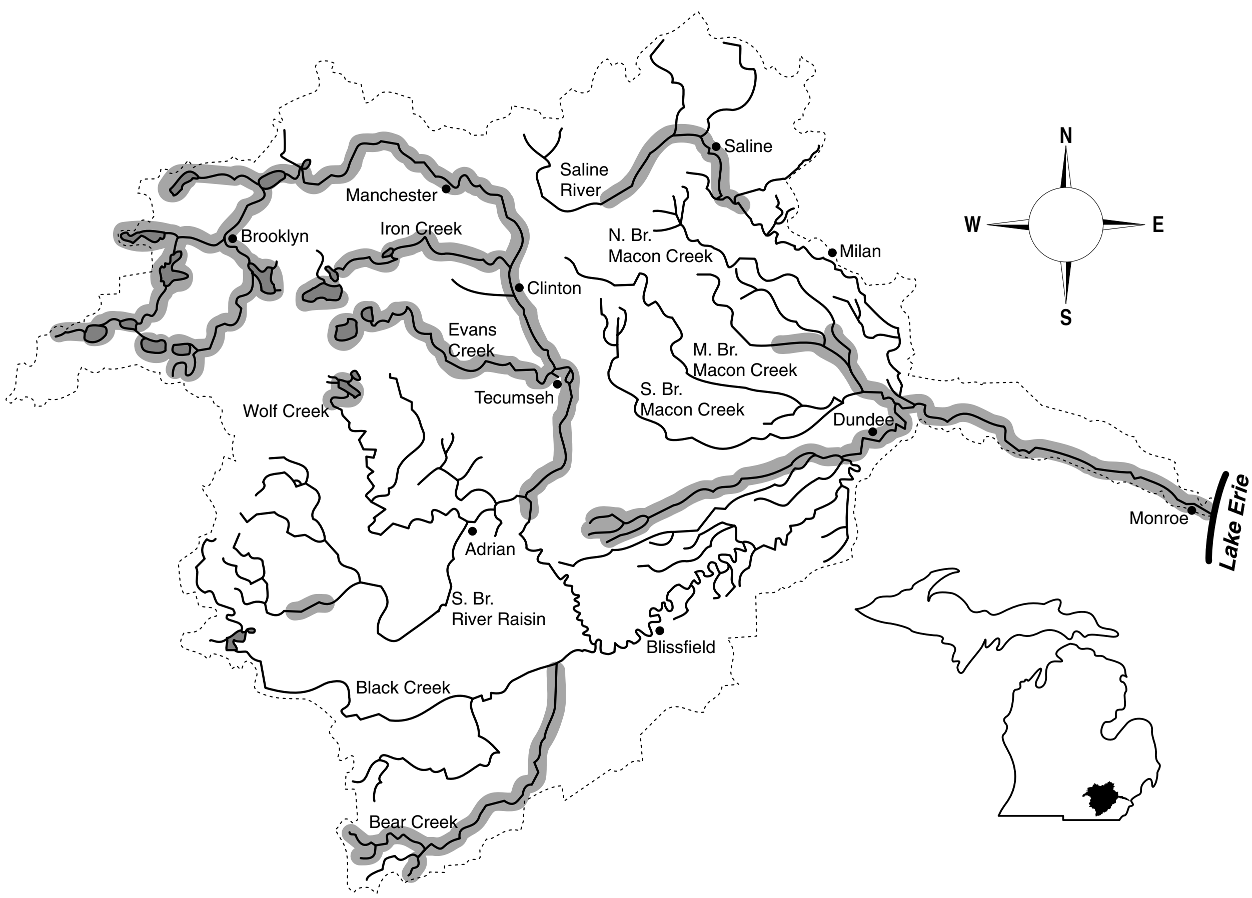


Grass pickerel (*Esox americanus vermiculatus*)

Habitat:

feeding
- juveniles: along shore
- adults: in deeper portions of streams, rivers, lakes, and impoundments
- clear water, little current, dense vegetation
- tolerates low oxygen concentrations

spawning
- broadcast spawner over submerged vegetation

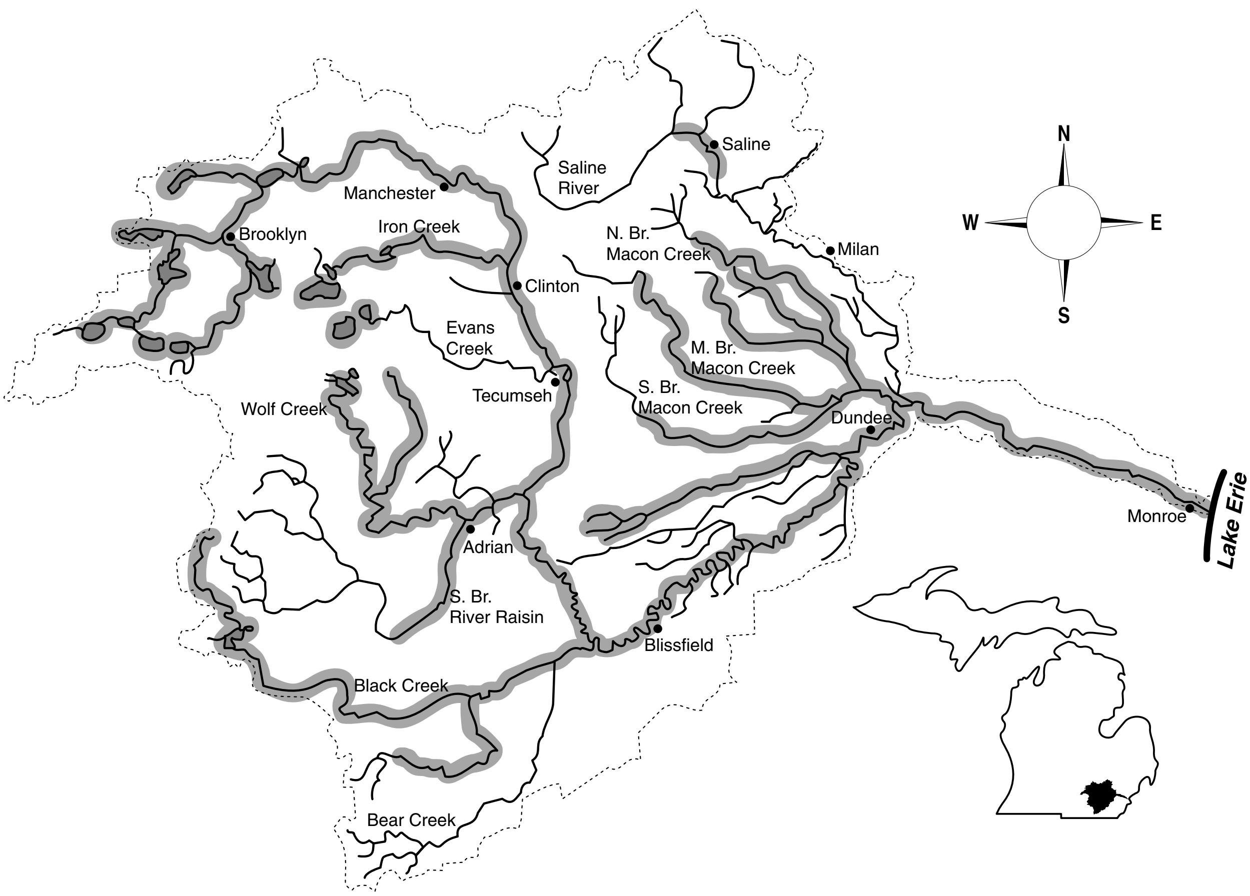


Northern pike (*Esox lucius*)

Habitat:

feeding - cool to moderately warm streams, rivers, lakes, and impoundments
- vegetation in slow to moderate current

spawning - submerged vegetation with slow current in shallow water

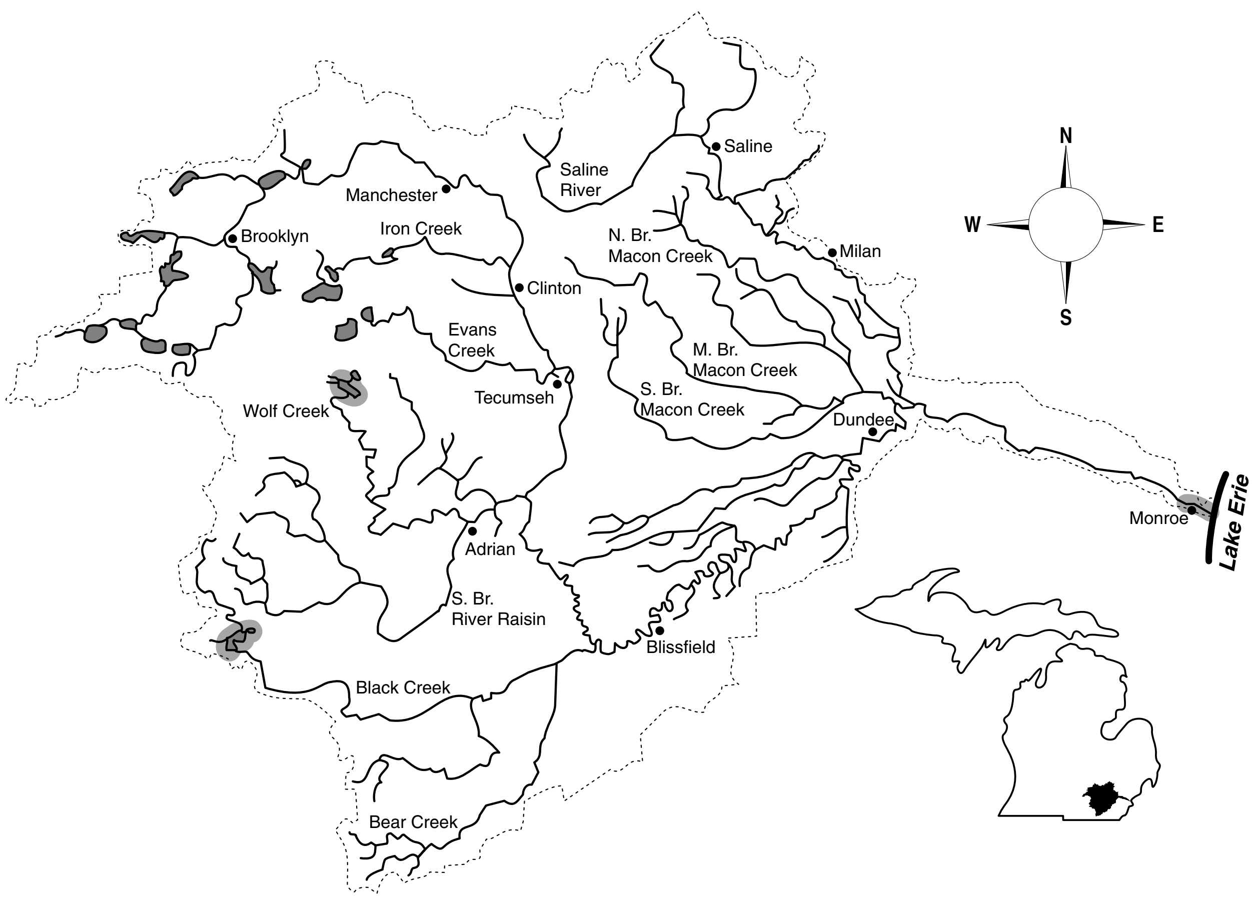


Muskellunge (*Esox masquinongy*)

Habitat:

feeding - warm, heavily vegetated lakes, stumpy weedy bays, and slow heavily vegetated medium to large rivers
- shallow cool water
- tolerant of low oxygen

spawning - clear shallow waters (15-20") in heavily vegetated areas

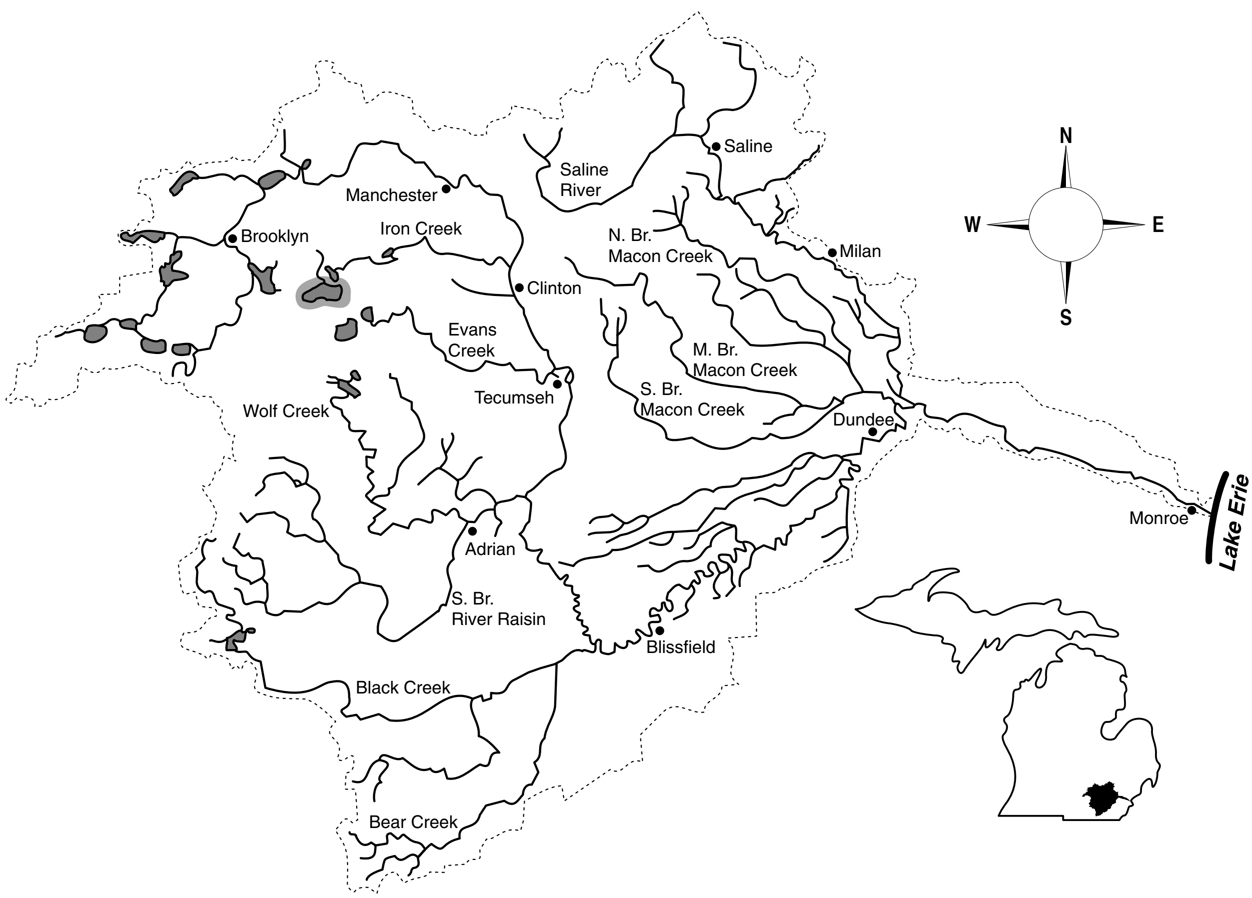


Tiger muskellunge (*Esox masquinongy* x *E. lucius*) - rare

Habitat:

feeding - intermediate between muskellunge and northern pike

spawning - hybrid species; muskellunge x northern pike
- occasionally produced in wild, but most often from hatcheries
- males are sterile, females may be fertile

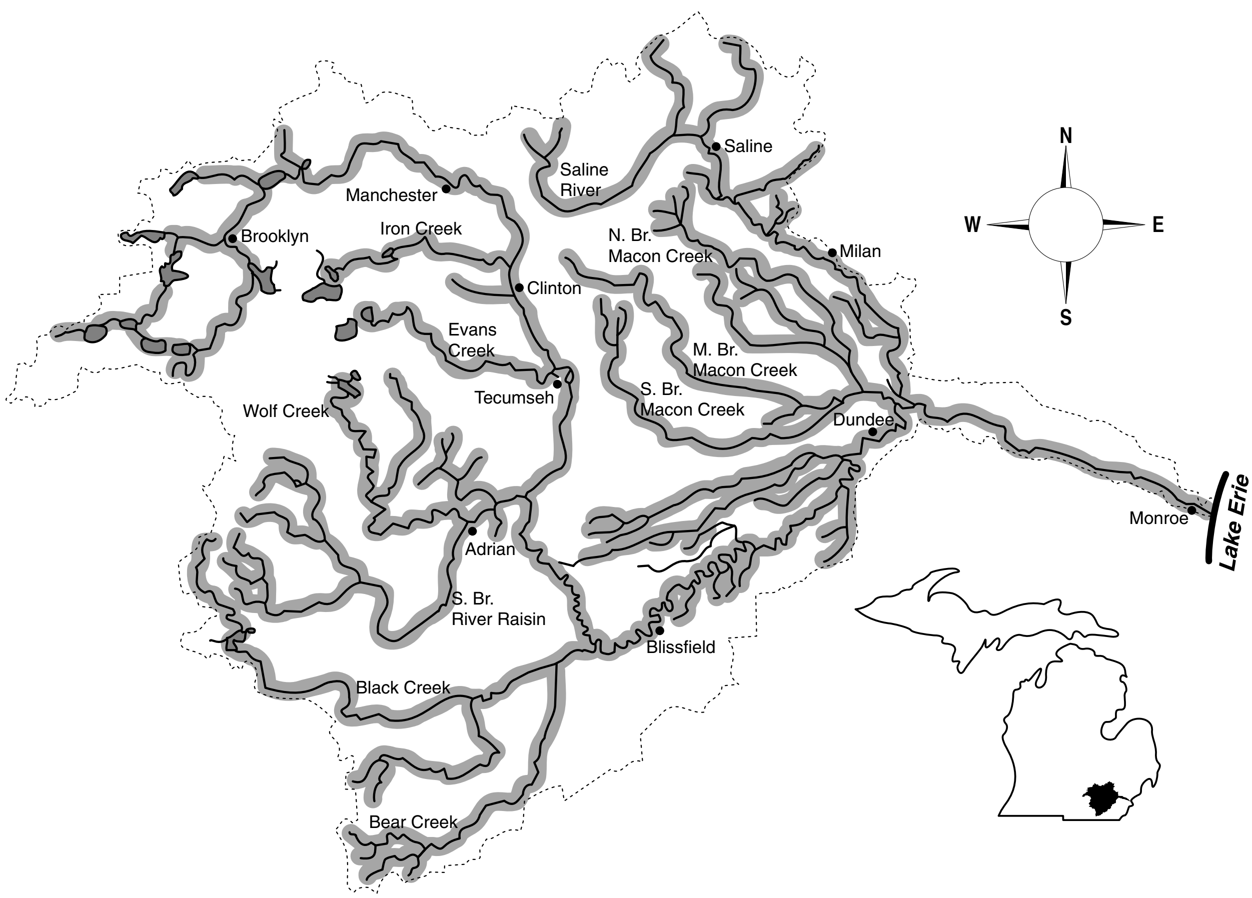


Central mudminnow (*Umbra limi*)

Habitat:

feeding - undisturbed clear, low-gradient streams or rivers and lakes and impoundments
- organic debris, muck, or peat substrates
- aquatic vegetation

spawning - floodplain areas, on vegetation

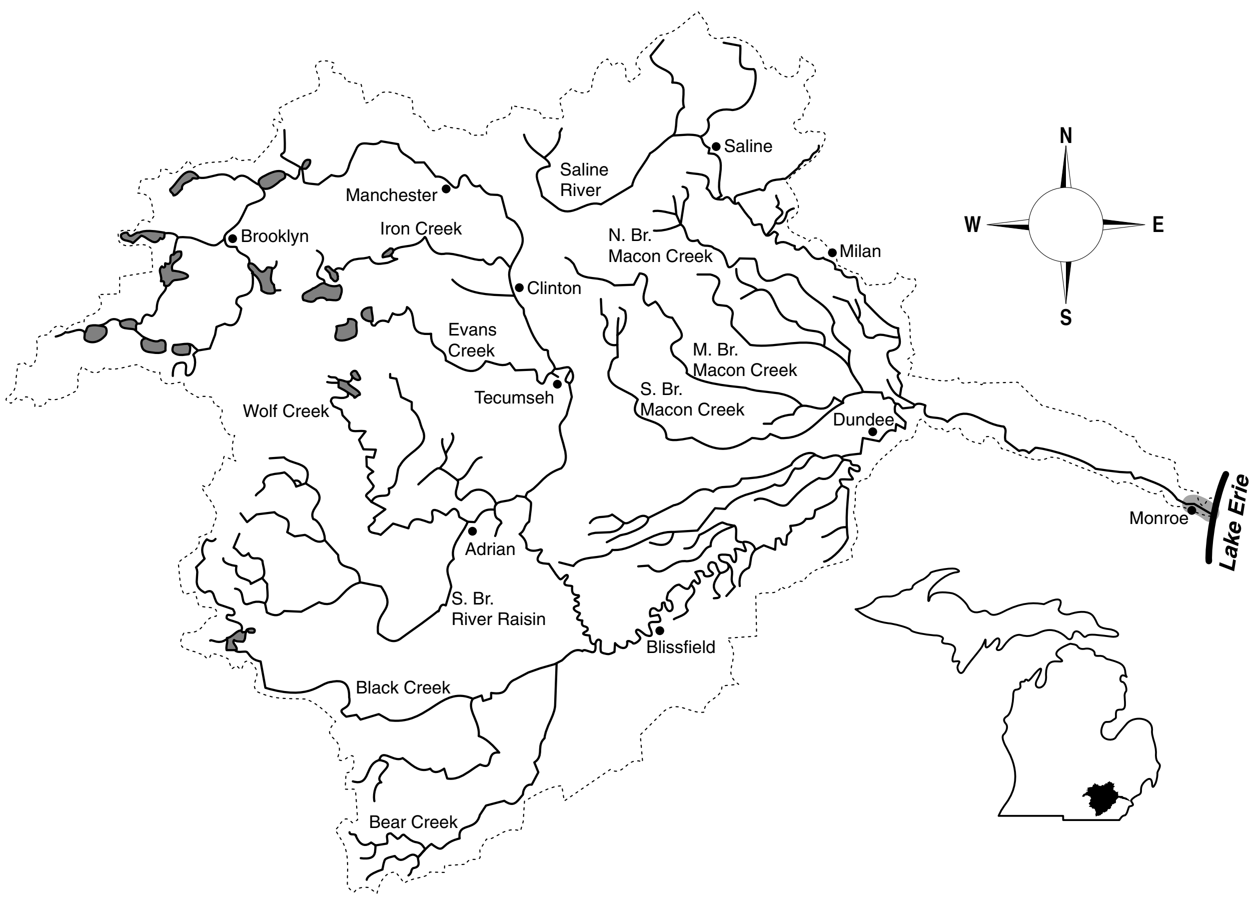


Rainbow Smelt (*Osmerus mordax*)

Habitat:

feeding - midwater of lakes; 42-192 ft. in Lake Erie

spawning - in streams or off-shore shoals in Lake Erie
- gravel substrate
- swift current

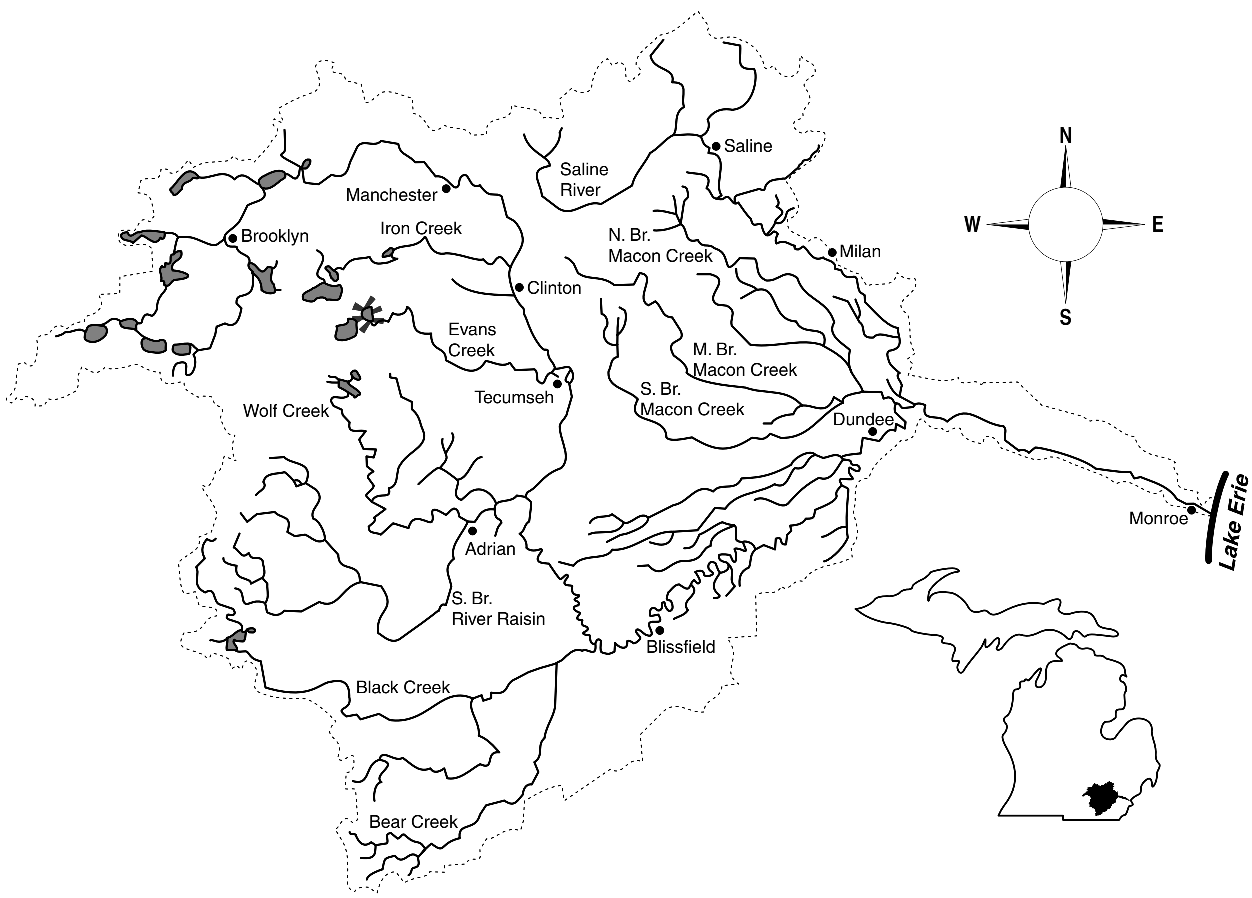


Cisco {Lake herring} (*Coregonus artedi*) - special concern

Habitat:

feeding - deep cool lakes, preferably oligotrophic

spawning - usually in lakes
- 3 to 6 feet of water with no vegetation
- often over gravel or stony substrate

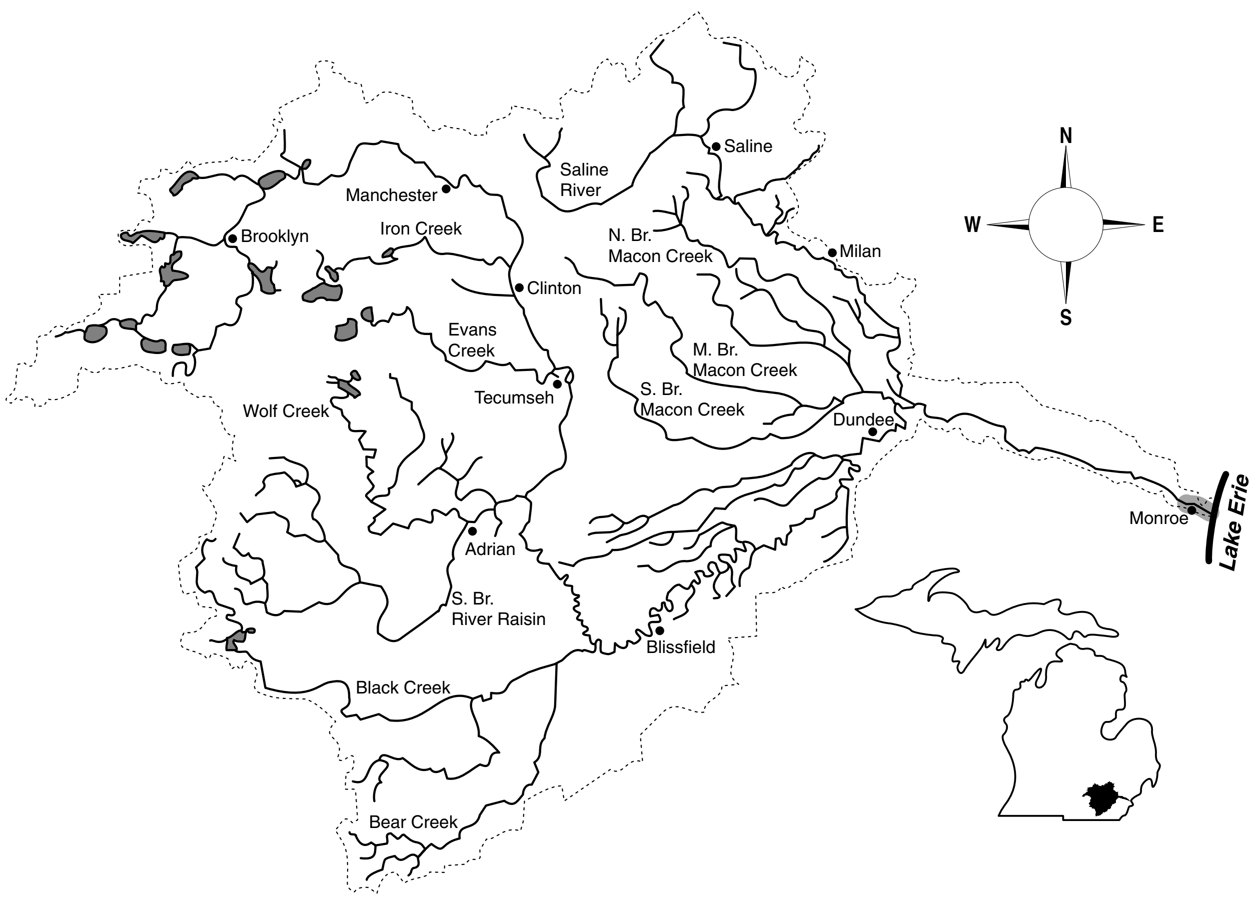


Lake whitefish (*Coregonus dupeaformis*)

Habitat:

feeding - cold deep lakes; Lake Erie

spawning - shallow water (<25 feet)
- hard or stony substrate

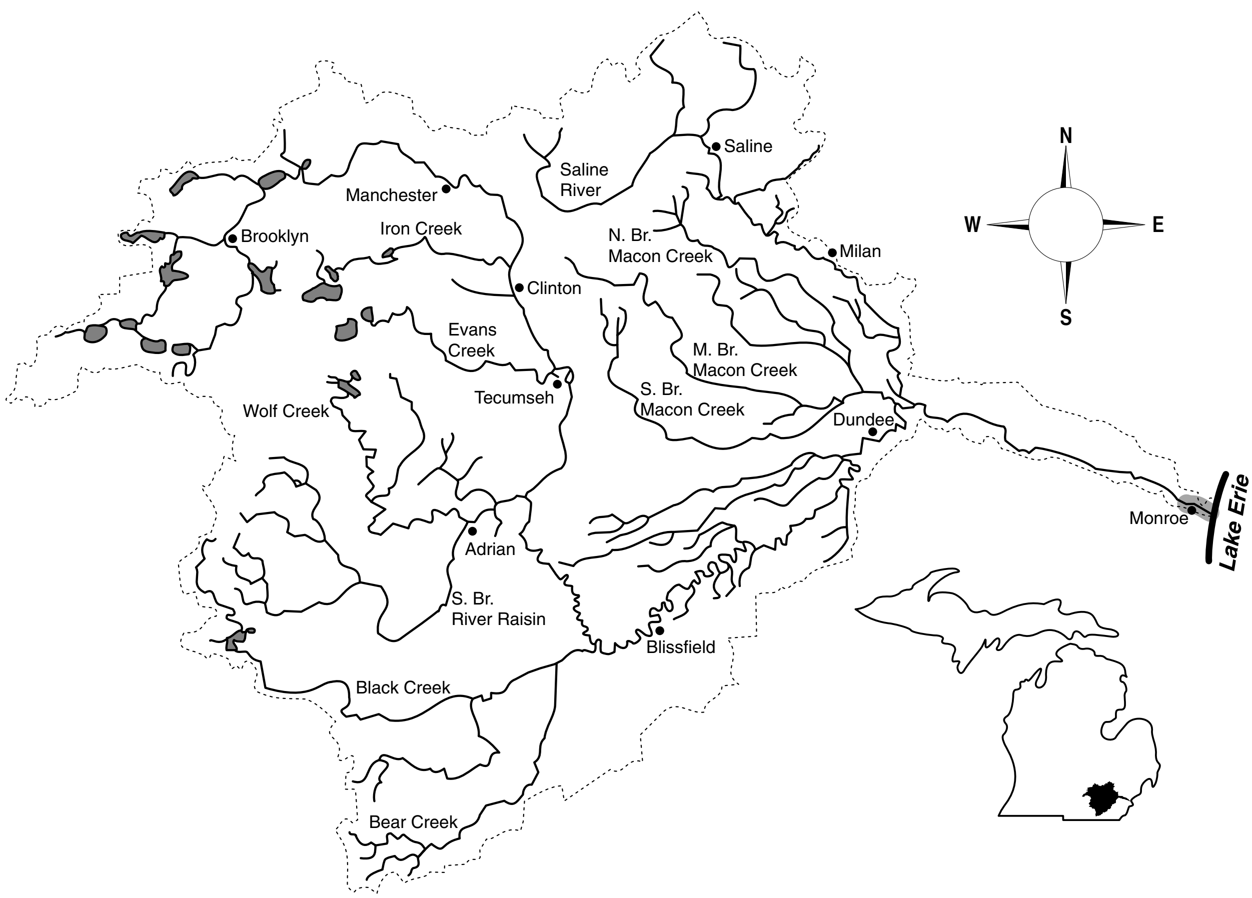


Coho salmon (*Oncorhynchus kisutch*)

Habitat:

feeding - adults: Lake Erie
- young: shallow gravel substrate in cold streams, later into pools

spawning - cold streams and rivers
- swifter water of shallow gravelly substrate

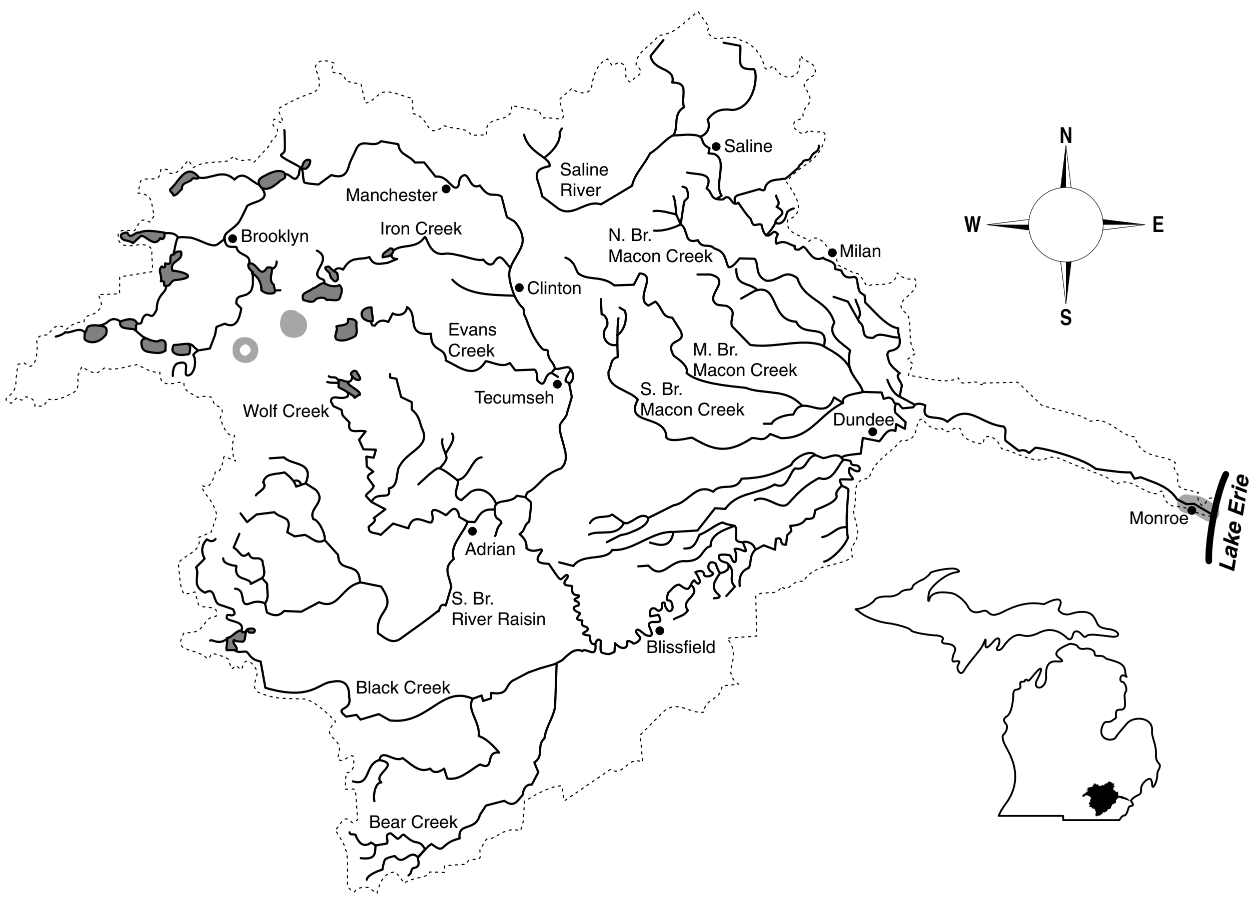


Rainbow trout (*Oncorhynchus mykiss*)

Habitat:

feeding - cold clear water of rivers and Lake Erie
- moderate current

spawning - gravelly riffles above a pool
- smaller tributaries

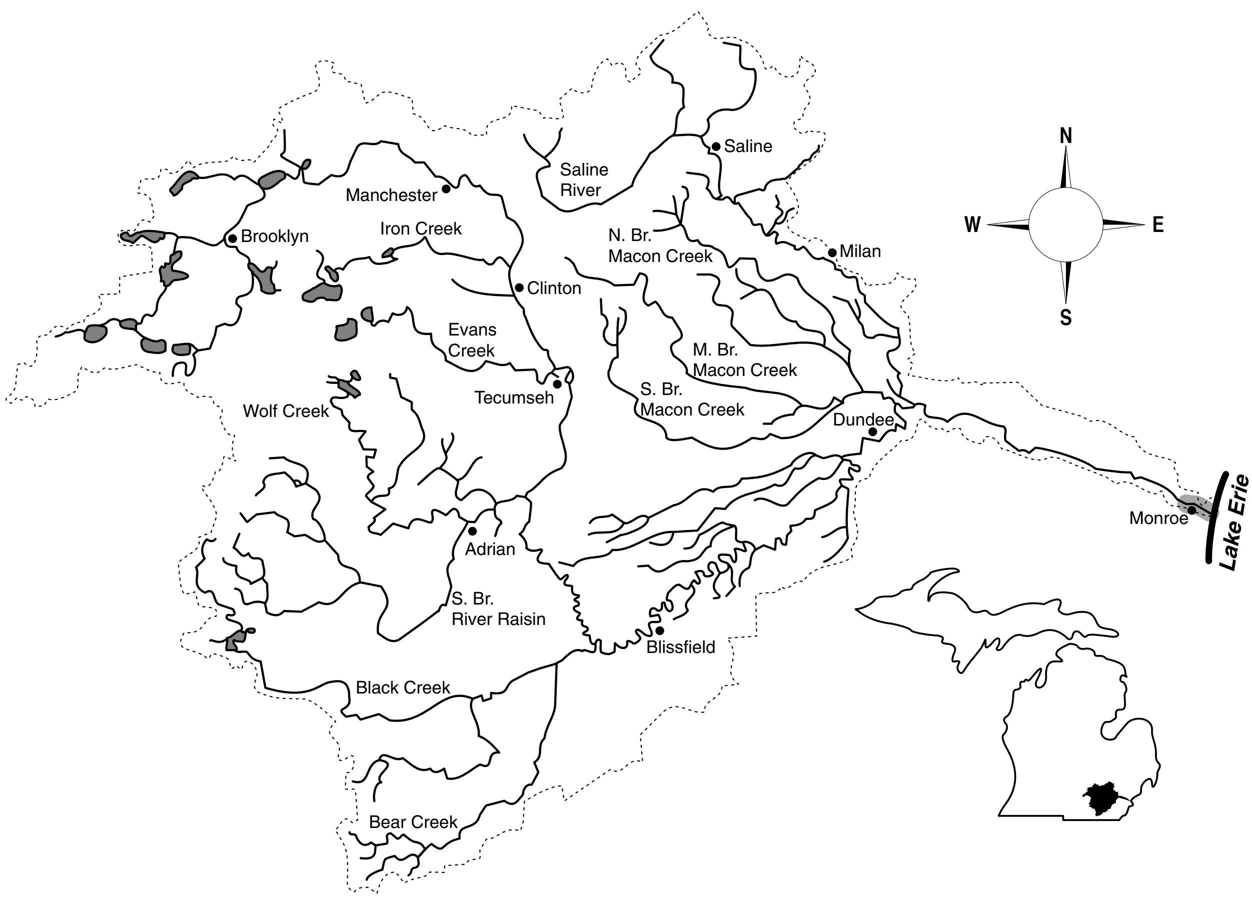


Chinook salmon (*Oncorhynchus tshawyscha*)

Habitat:

feeding - adults: Lake Erie
- young: shallow gravel substrate in cool streams, later into pools

spawning - gravelly substrate in cool streams

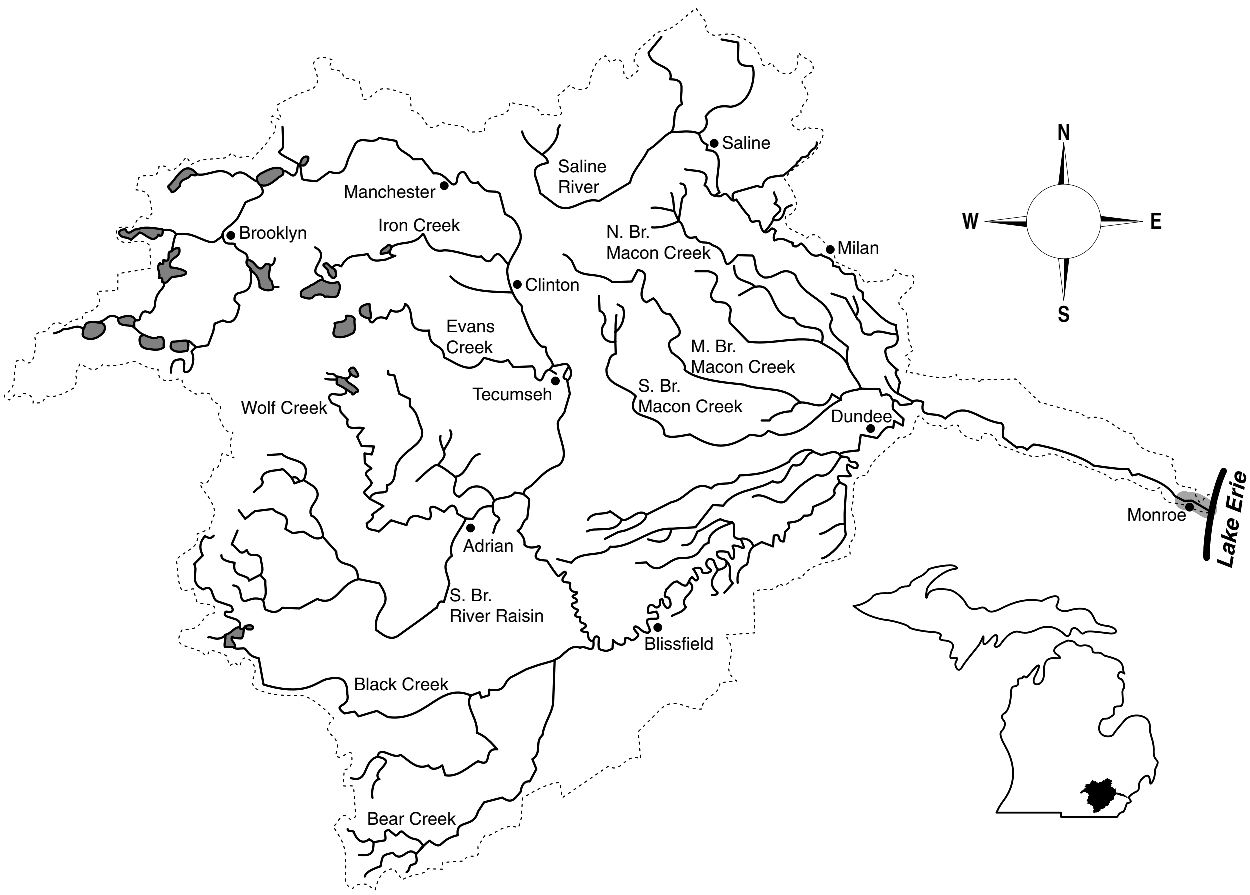


Brown trout (*Salmo trutta*)

Habitat:

feeding - cold, clear streams, rivers, and lakes (not >70˚F)
- medium to swift current in streams
- does not tolerate silt well
- prefers few individuals and species around
- abundance of aquatic and land insects

spawning - gravelly riffles; shallow headwater areas

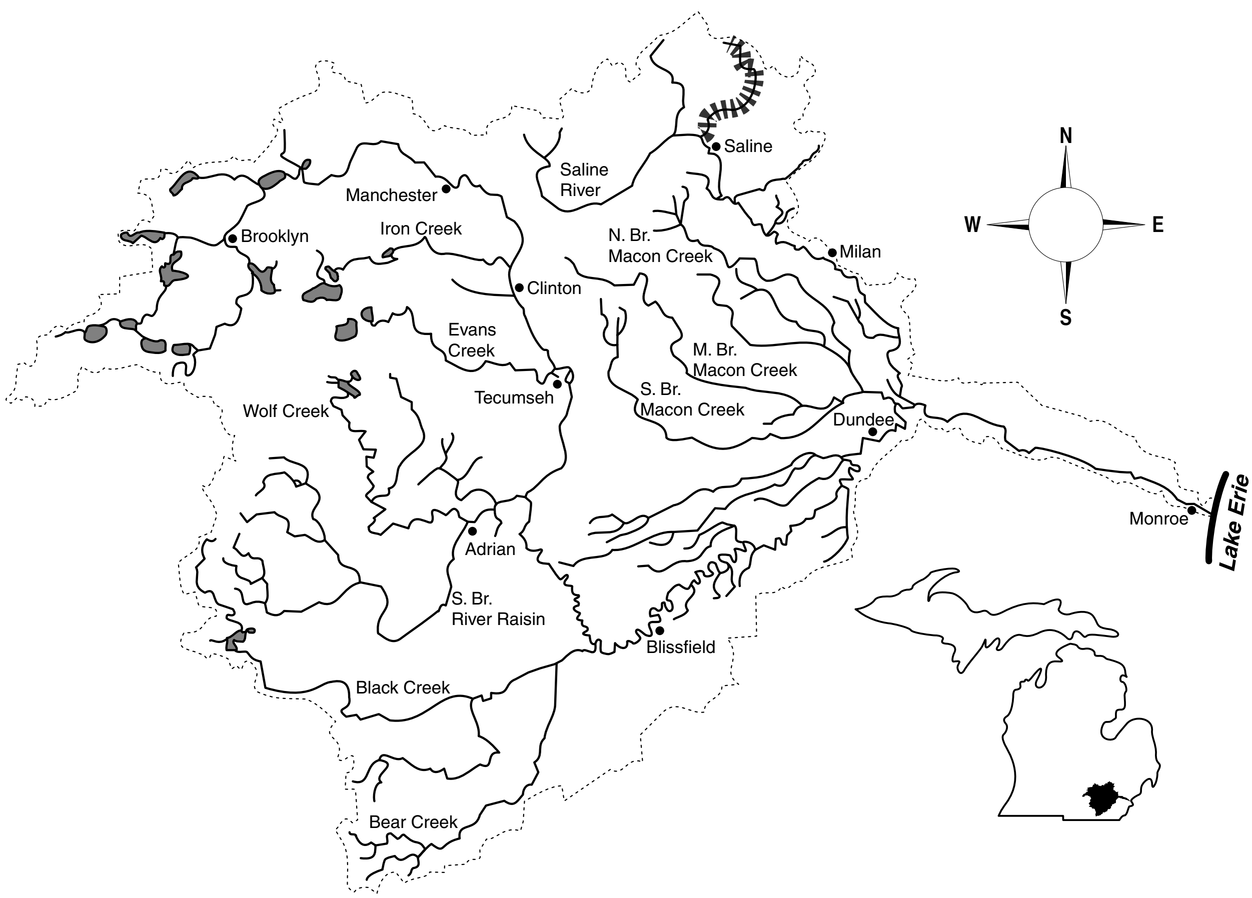


Brook trout (*Salvelinus fontinalis*) - locally extirpated

Habitat:

feeding - cold, clear streams, rivers, and lakes (not >65˚F)
- low current
- well oxygenated water

spawning - gravelly riffles; shallow or headwater streams

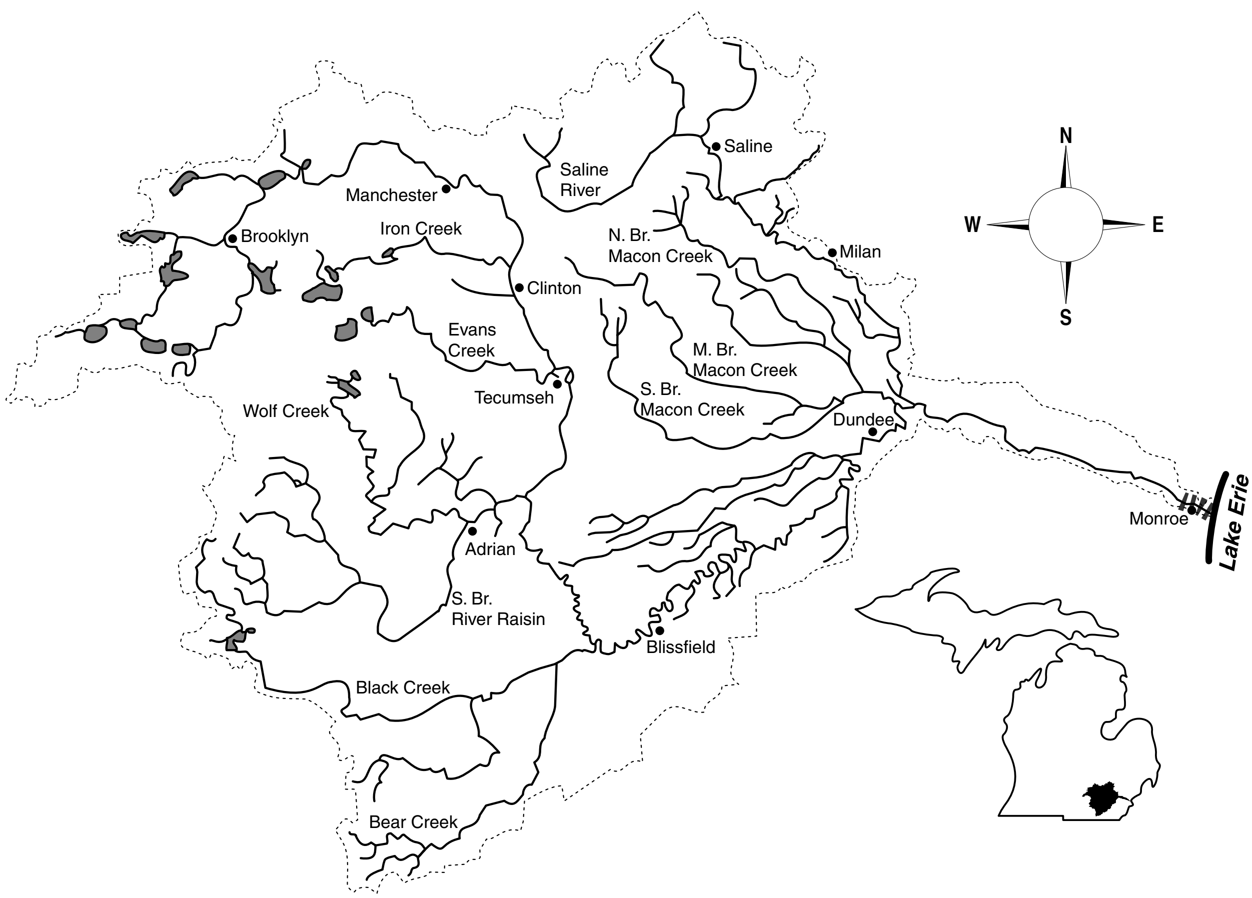


Lake trout (*Salvelinus namaycush*)

Habitat:

feeding - cold lakes and rivers

spawning - large boulder or rubble substrate
- shallow water of lakes and rivers

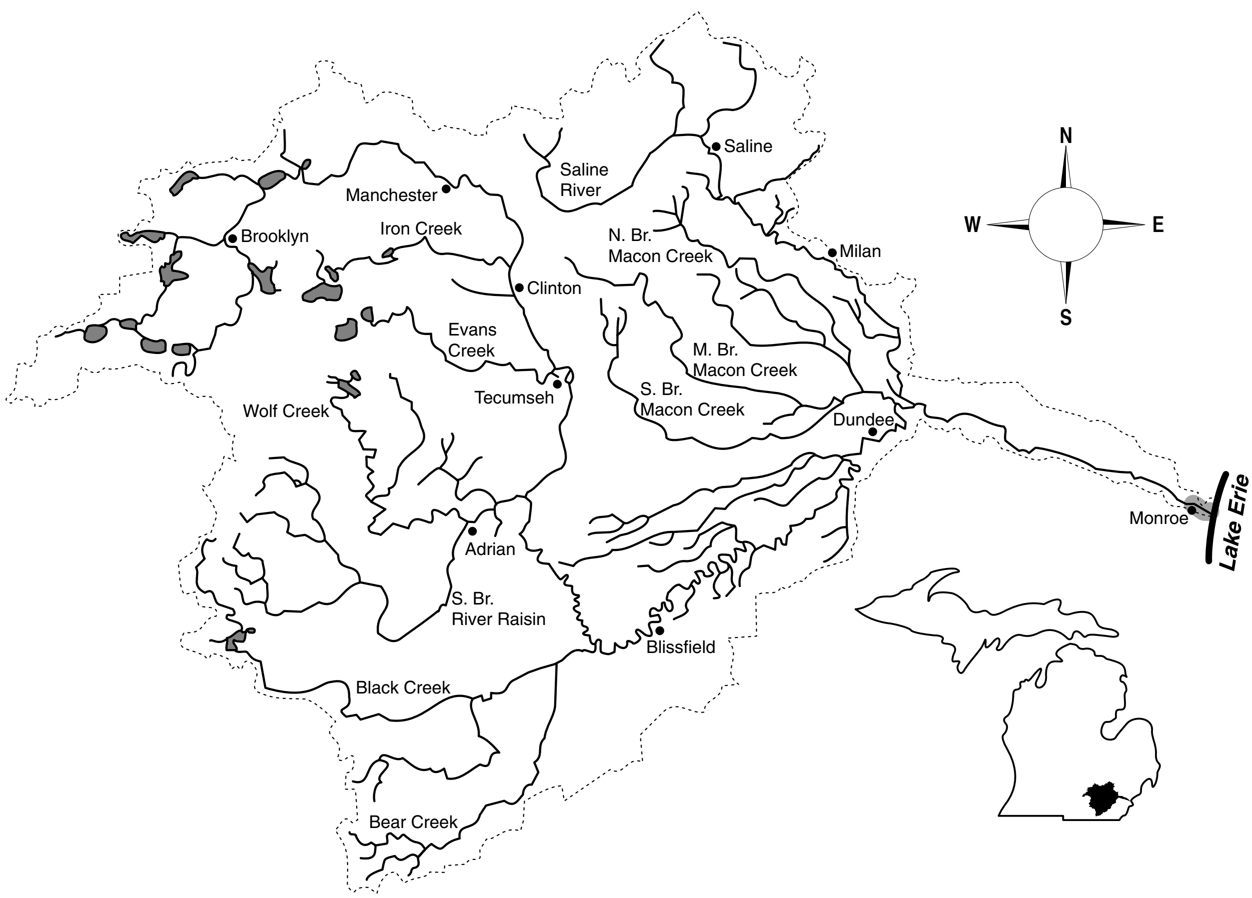


Trout-perch (*Percopsis omiscomaycus*)

Habitat:

feeding
- clean sand or fine gravel substrate
- long deep pools in low gradient streams and Lake Erie
- highly intolerant of clayey silts
- avoids rooted aquatic vegetation

spawning
- over rocks in shallows
- over sand and gravel substrates in Lake Erie

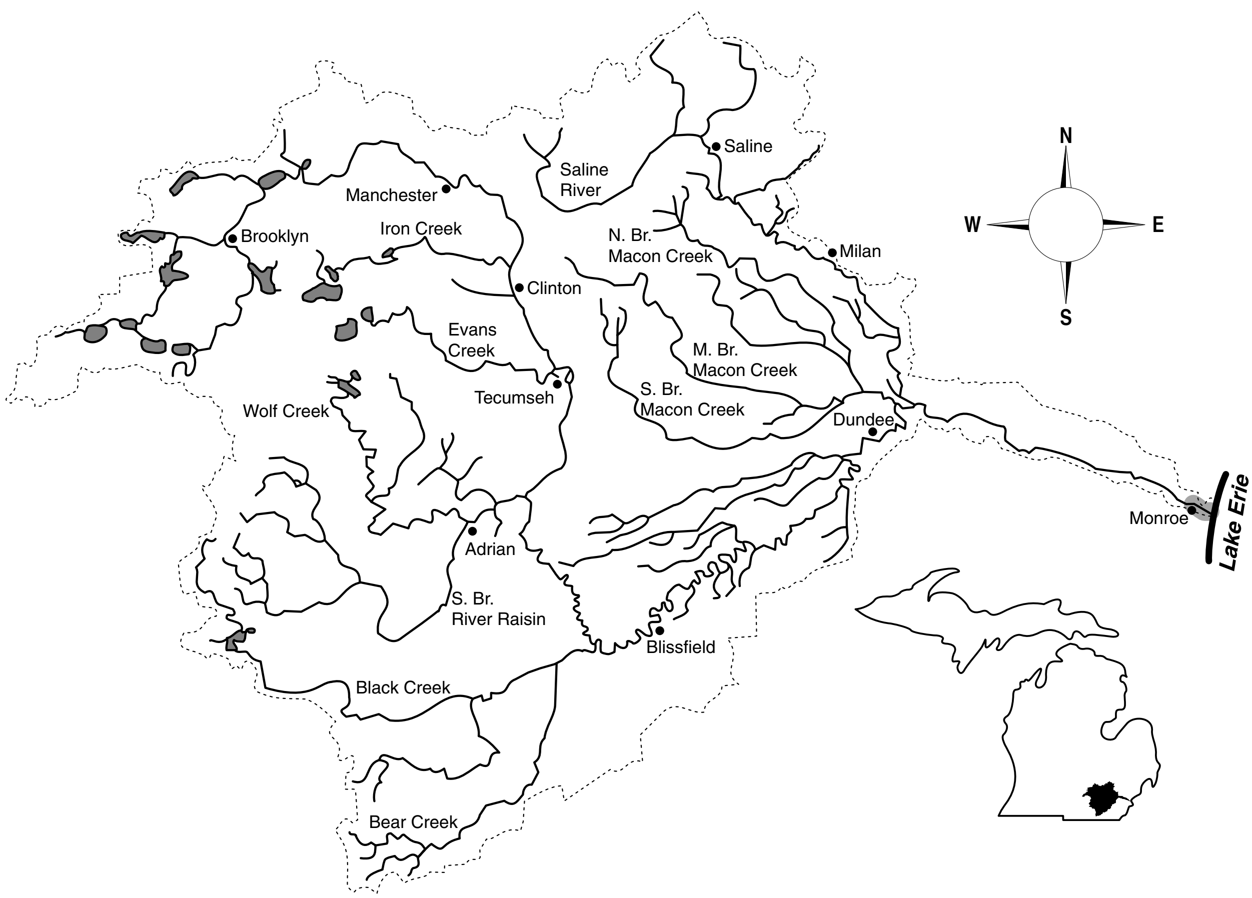


Burbot (*Lota lota*)

Habitat:

feeding - deep cold lakes and large cool rivers
- mud, sand, rubble, boulder, silt, and gravel substrates

spawning - in 1 to 4 feet of water in shallow bays or on shoals 5-10 feet deep usually in lakes, sometimes rivers
- over sand or gravel substrate
- under ice

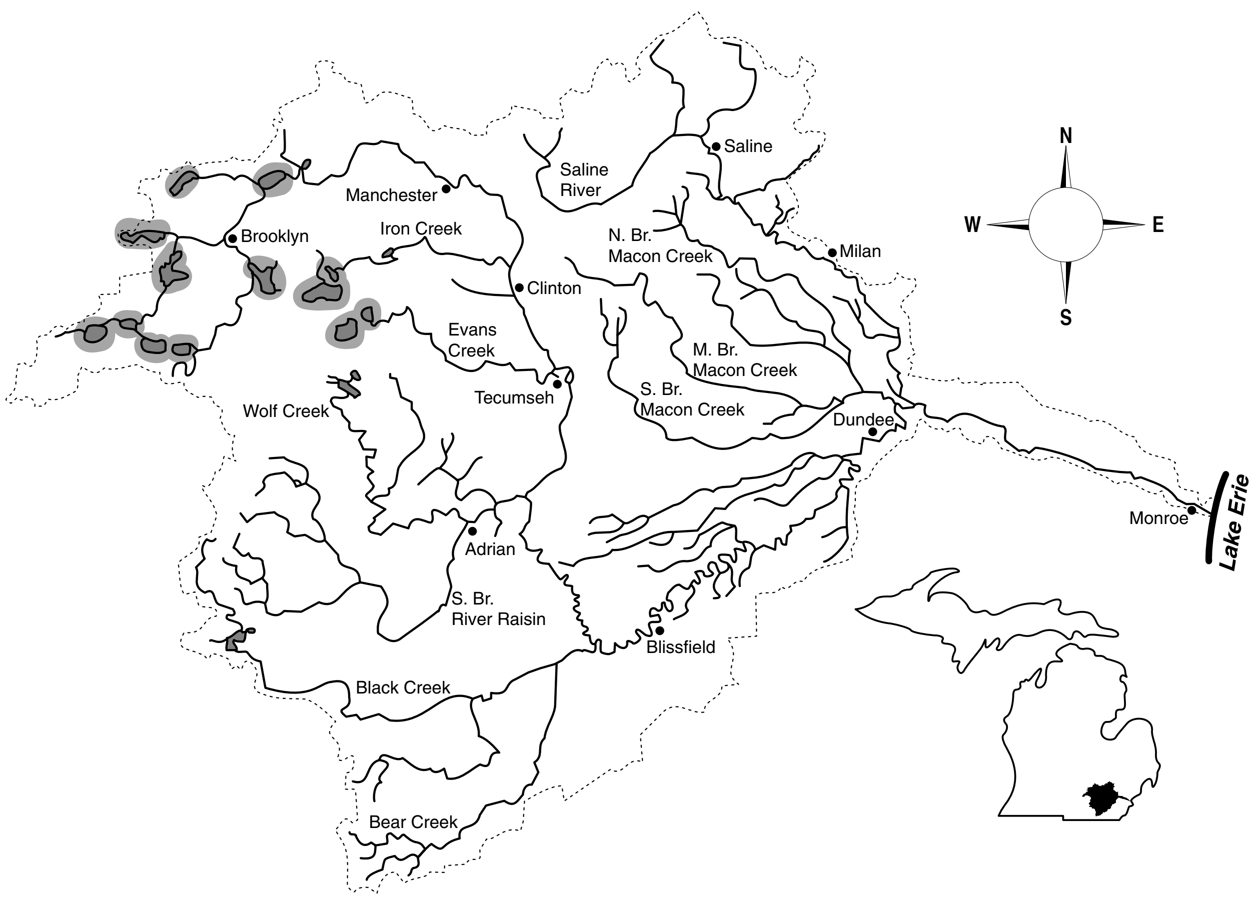


Banded killifish (*Fundulus diaphanus*)

Habitat:

feeding - quiet backwaters at the mouths of streams and lakes
- substrate of sand, gravel, and a few boulders
- also found over detritus substrate where patches of submerged aquatic vegetation are present

spawning - quiet areas of weedy pools



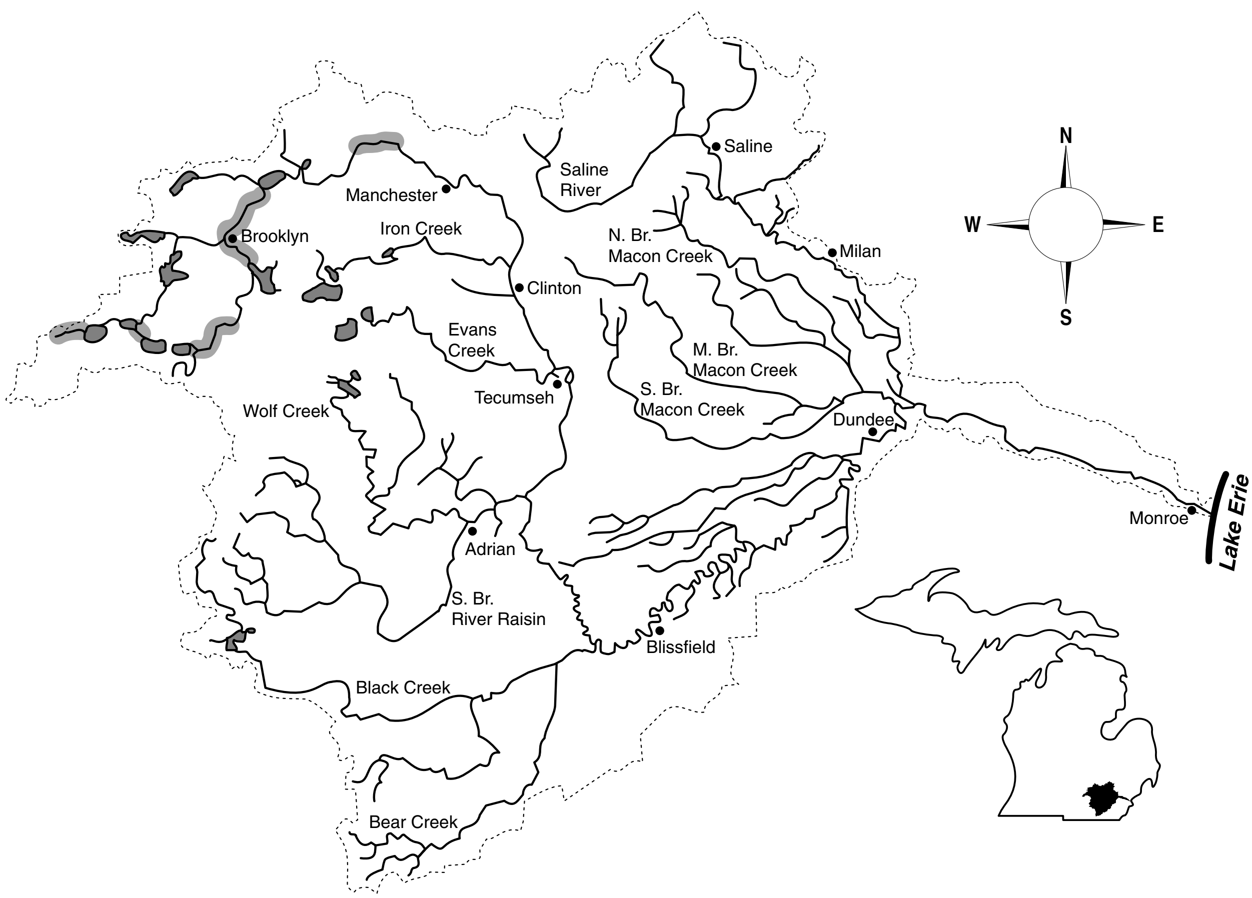
Blackstripe topminnow (*Fundulus notatus*)

Habitat:

feeding - clear waters of lakes, impoundments and in low-gradient streams
- aquatic or submerged land vegetation
- somewhat tolerant of turbid water

spawning - in vegetation or algae

winter refuge - in deeper water with bottom vegetation

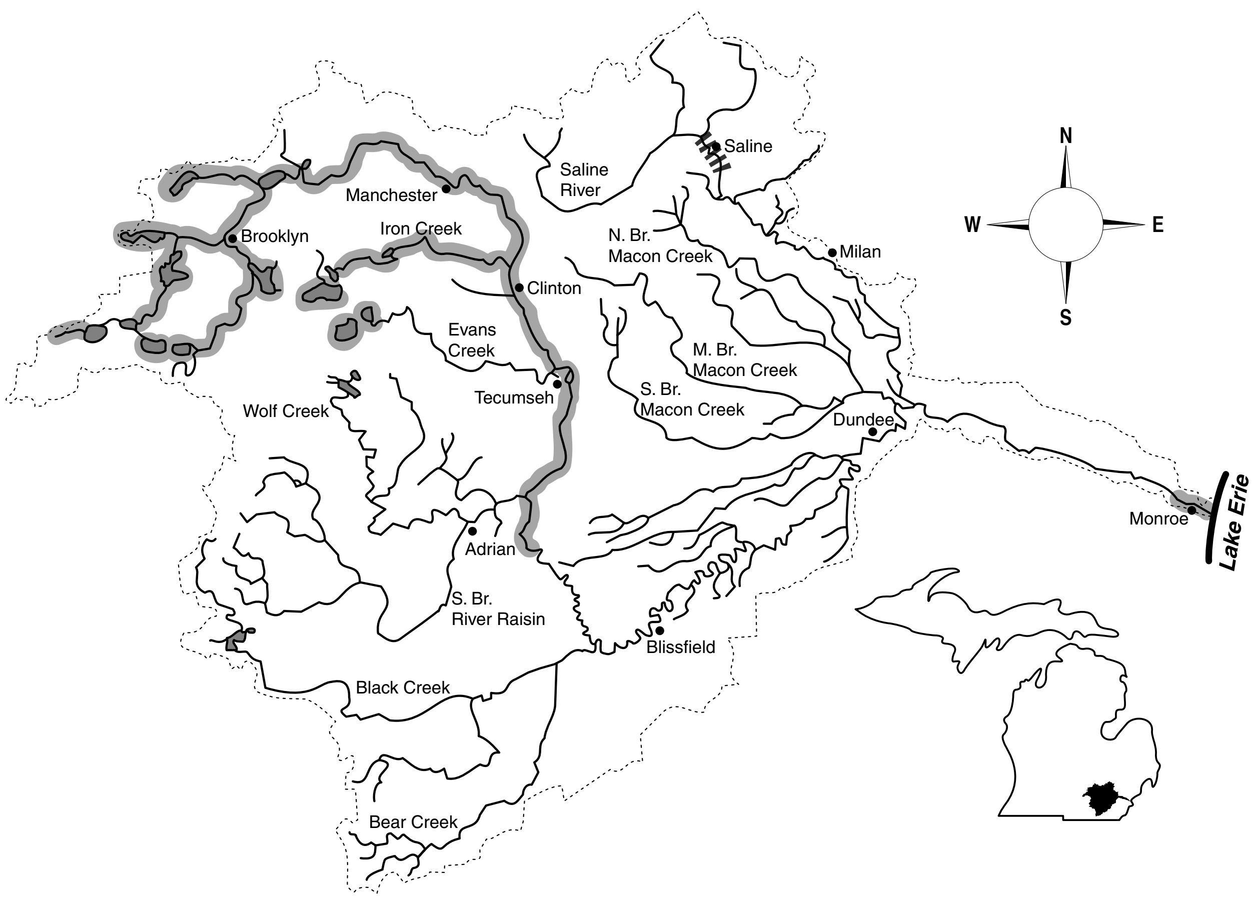


Brook silverside (*Labidesthes sicculus*)

Habitat:

feeding - clear, warm pools in streams and rivers; also lakes
- does not tolerate turbidity
- most frequently at surface

spawning - in and around aquatic vegetation or over gravel substrate with a moderate current

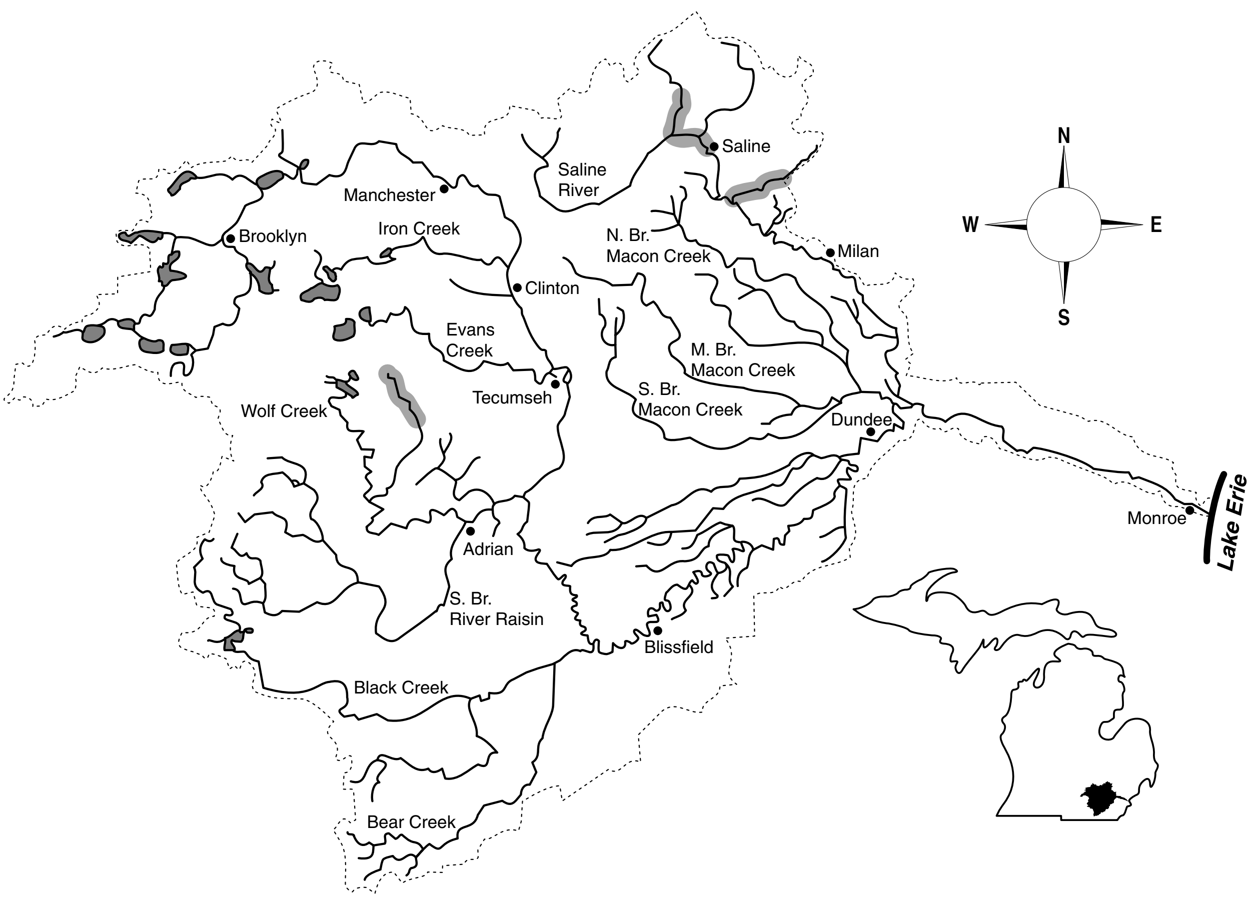


Brook stickleback (*Cluaea inconstans*)

Habitat:

feeding
- clear, cold, densely vegetated streams, and swampy margins of lakes
- low gradient
- muck, peat, or marl substrate
- not tolerant of turbidity

spawning
- shallow cool (<66˚F) water
- aquatic reeds or grasses necessary

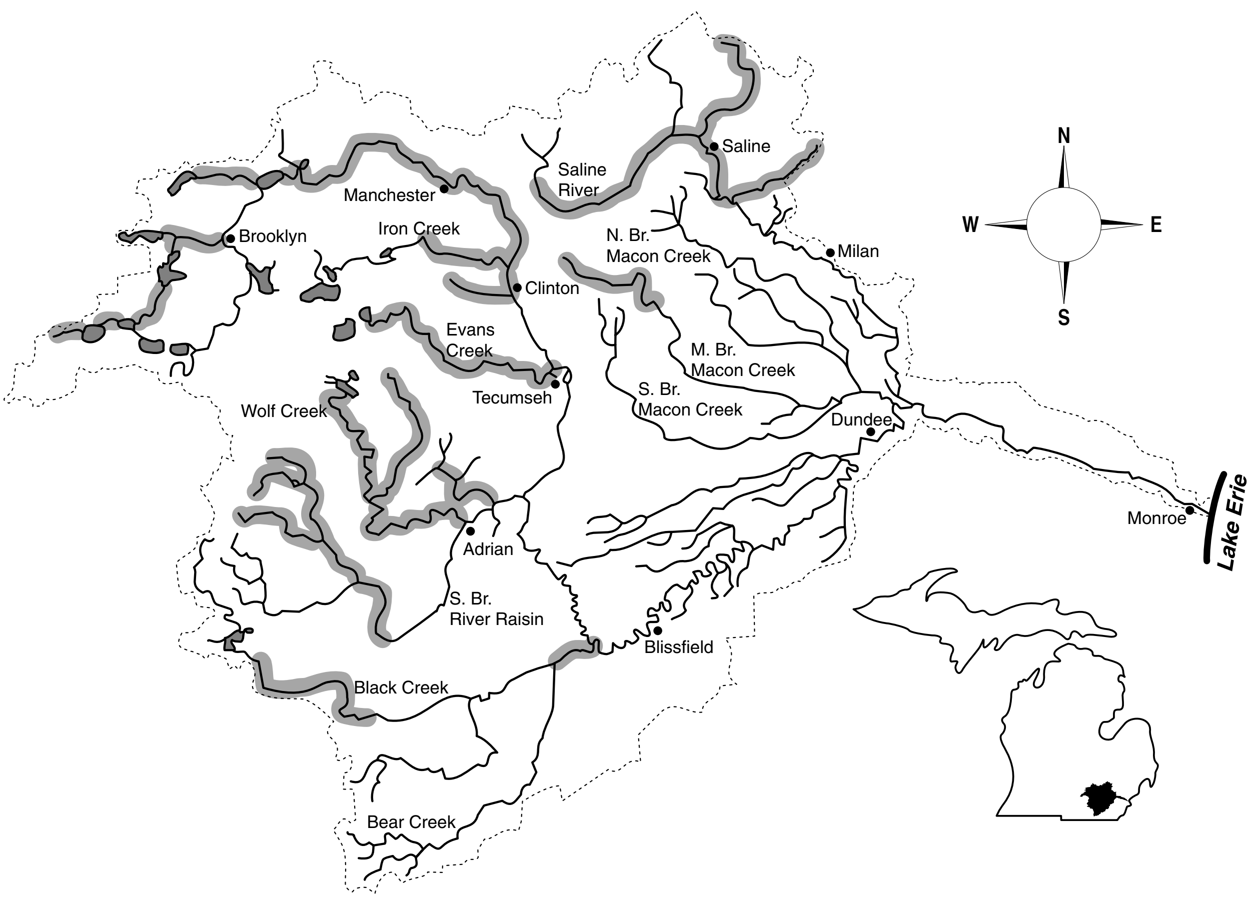


Mottled sculpin (*Cottus bairdi*)

Habitat:

feeding - cool to cold streams
- riffle and rock substrates preferred
- clear to slightly turbid shallow water

spawning - nests under logs or rock

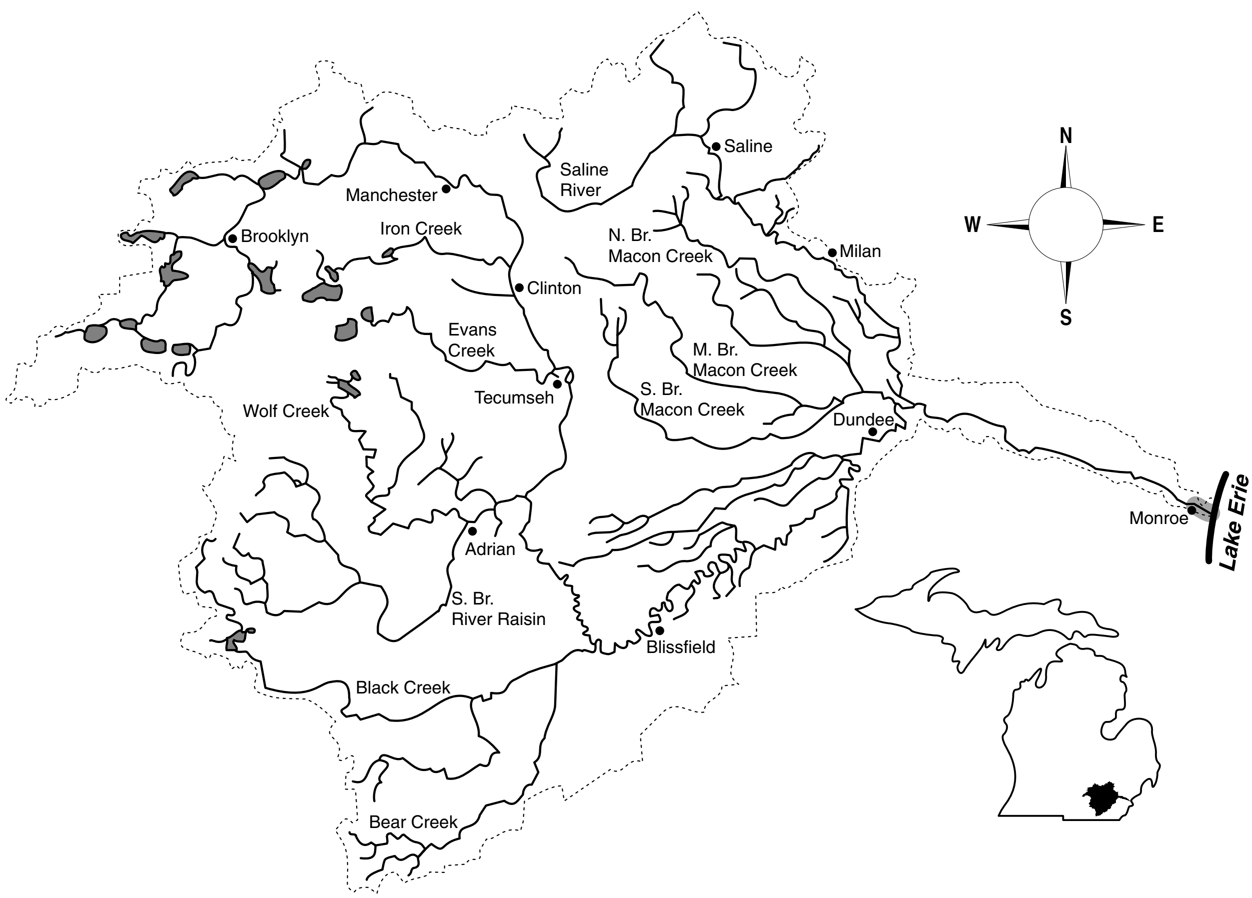


White perch (*Morone americana*)

Habitat:

feeding - clear, warm water of low-gradient streams, lakes, and impoundments

spawning - shallow water over firm substrate

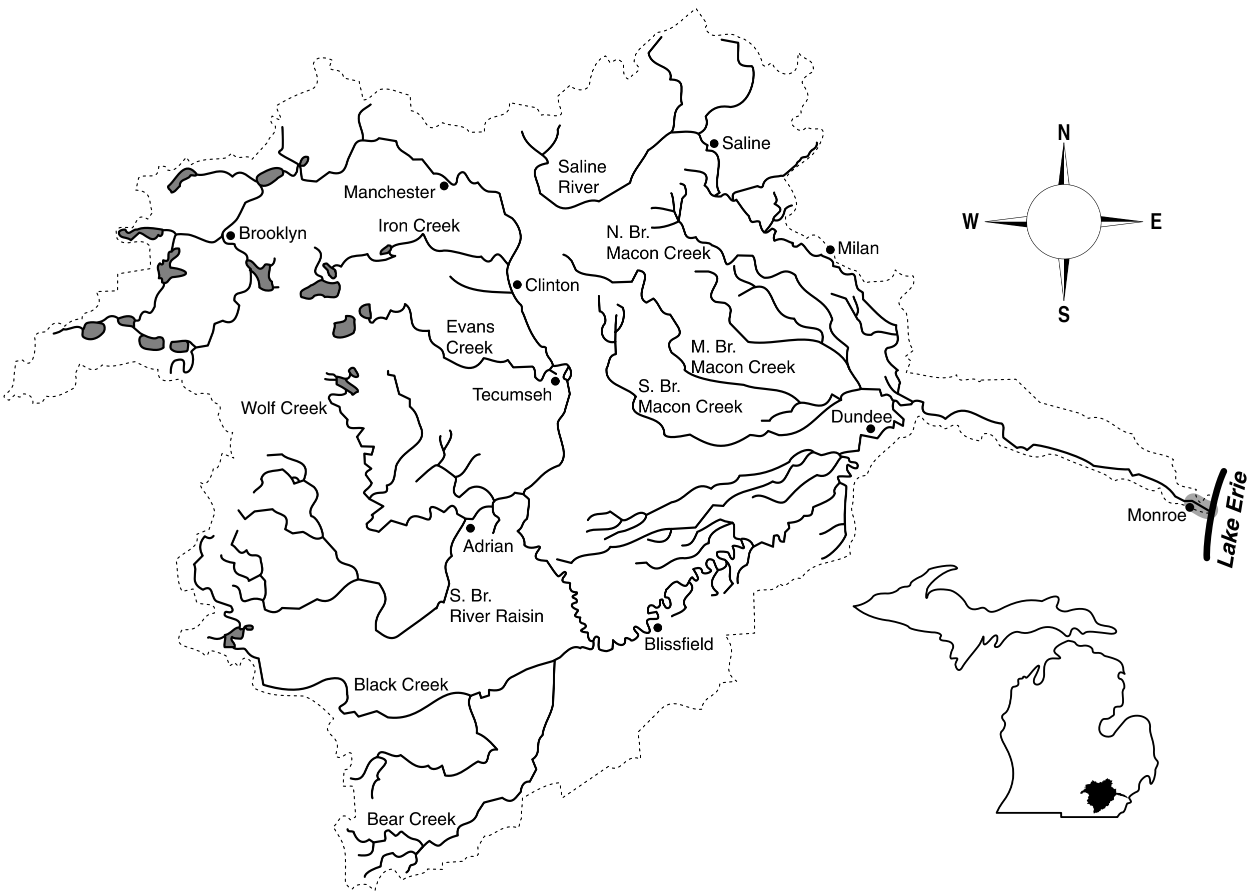


White bass (*Morone chrysops*)

Habitat:

feeding - large lakes, impoundments, and Lake Erie
- clear water of 30 feet or less depth
- firm substrate

spawning - tributary streams or shallow water of lakes
- over firm substrate



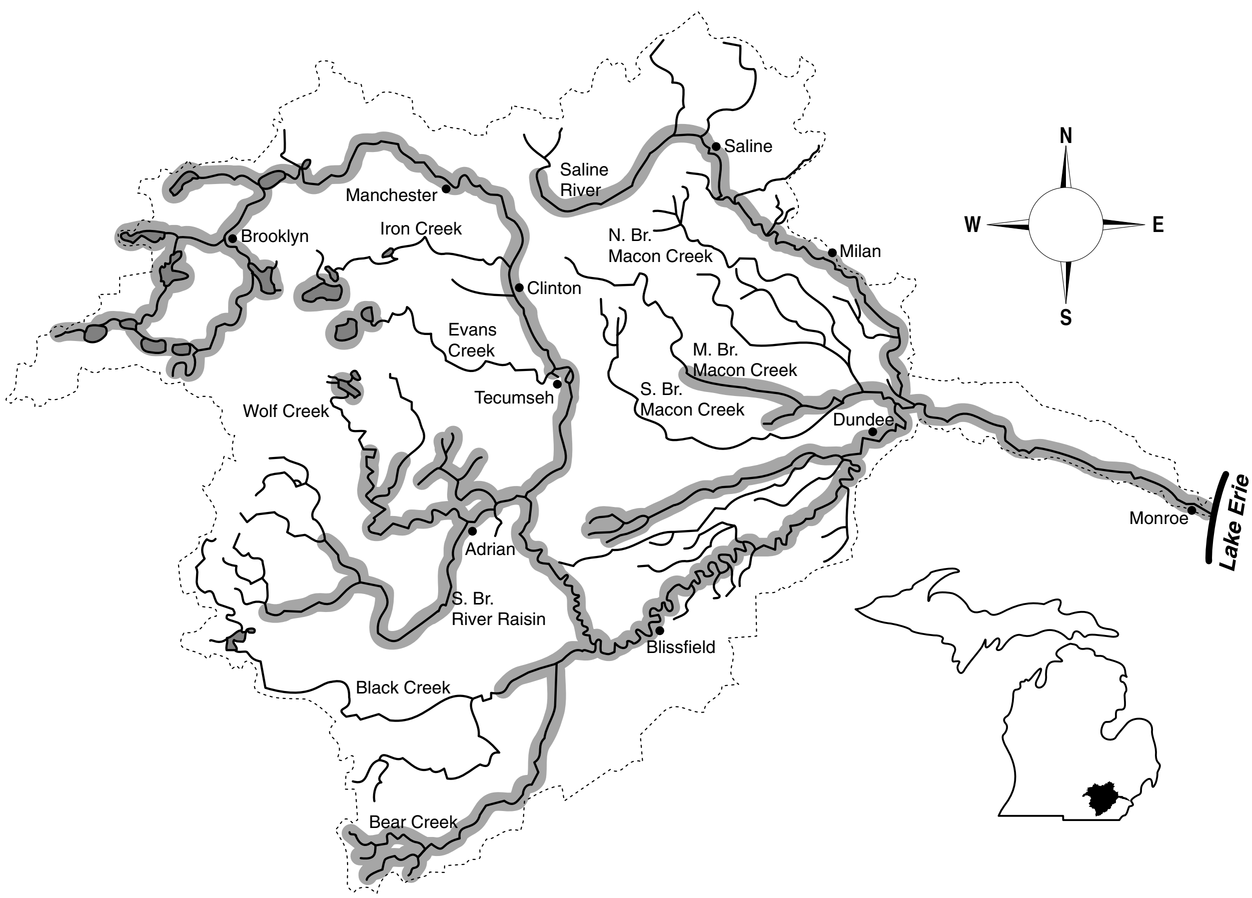
Rock bass (*Ambloplites rupestris*)

Habitat:

feeding - clear, cool streams, rivers, and lakes
- rocky to sand substrate
- woody or vegetative cover

spawning - sand or gravel nests
- shallow water

winter refuge - deep water

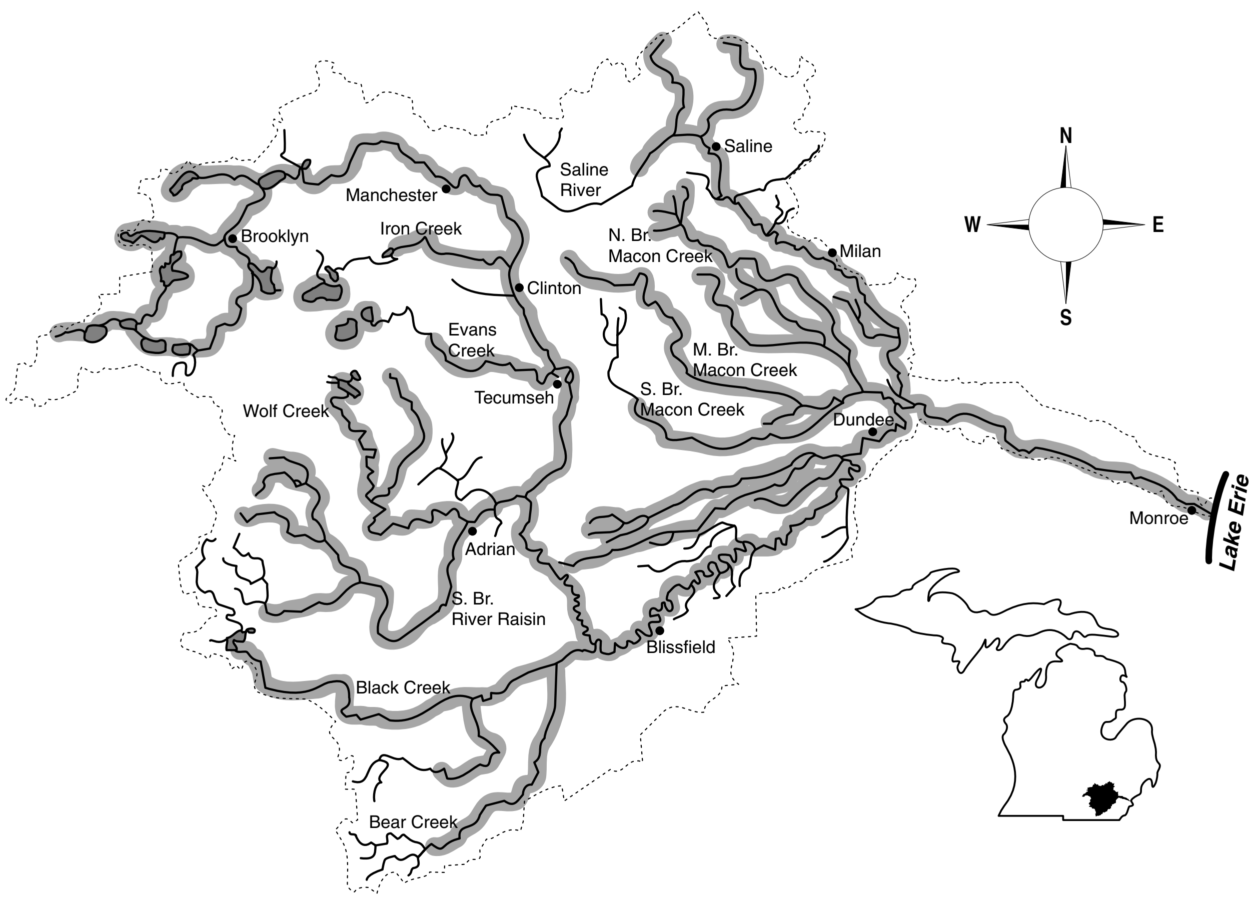


Green sunfish (*Lepomis cyanellus*)

Habitat:

feeding - impoundments and lakes, and low-current streams and rivers
- no substrate preference

spawning - nests in shallow areas sheltered by rocks, logs, or aquatic vegetation

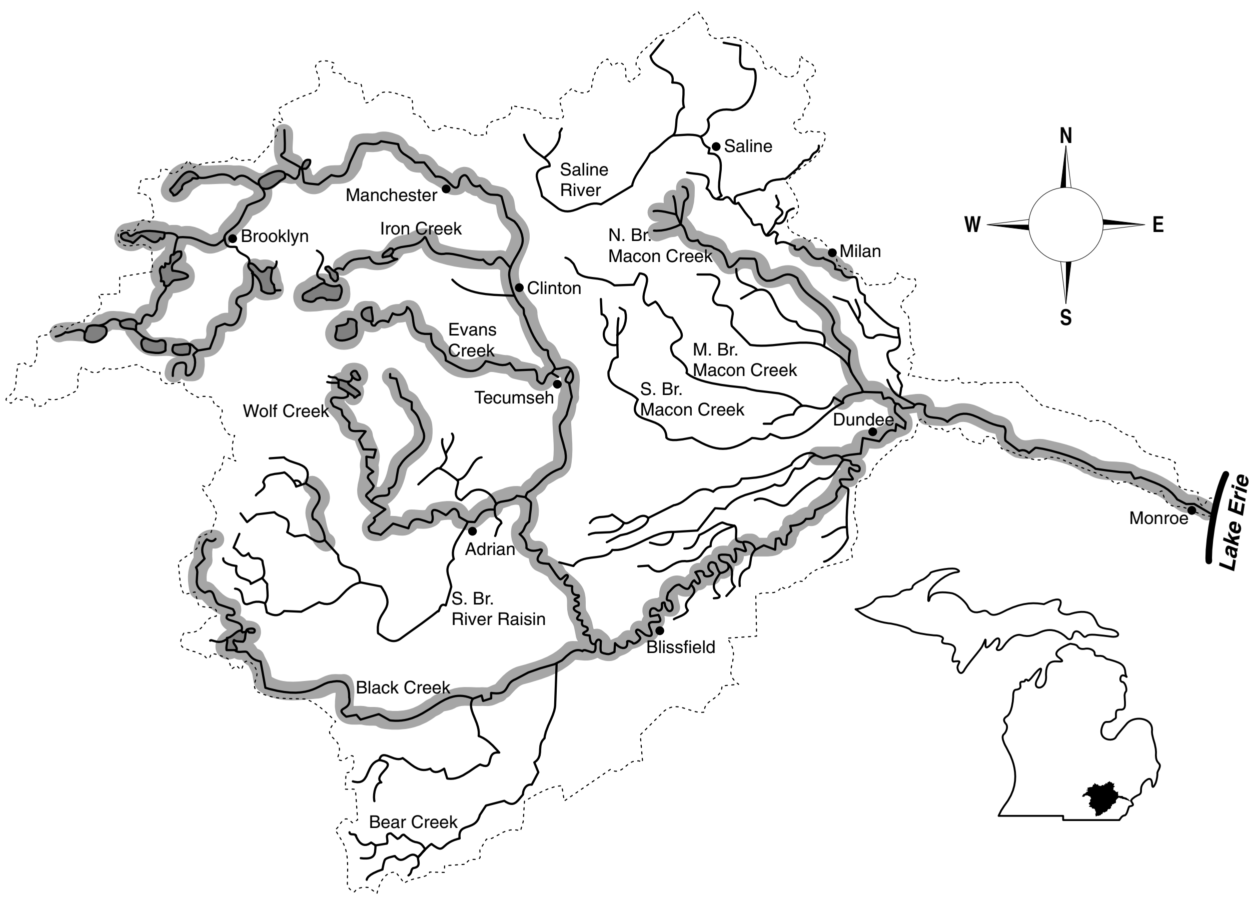


Pumpkinseed sunfish (*Lepomis gibbosus*)

Habitat:

feeding
- non-flowing clear water in streams and rivers; also lakes and impoundments
- muck or sand partly covered with organic debris substrate
- dense beds of submerged aquatic vegetation

spawning
- nest in sand, gravel, or rock substrate
- in shallow water near submerged vegetation

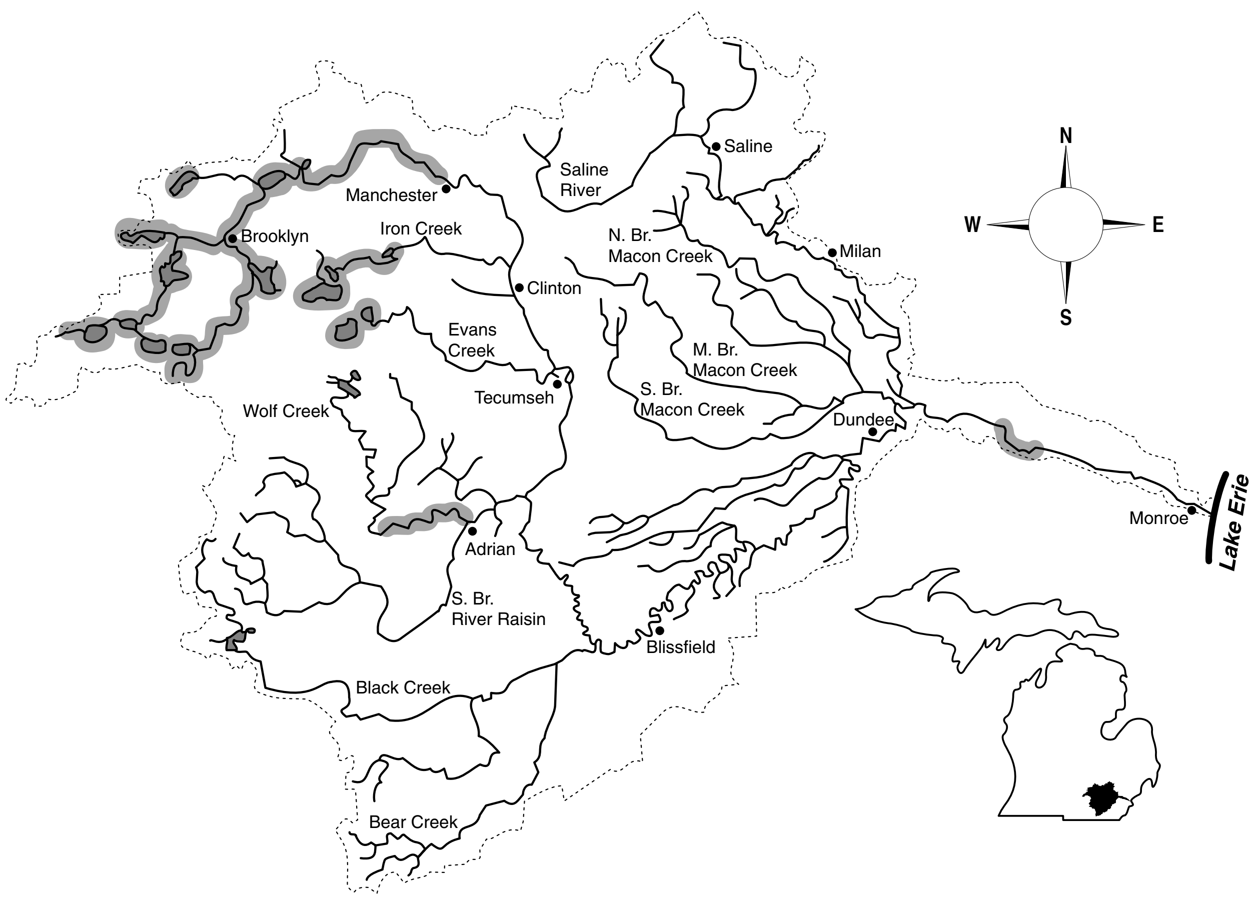


Warmouth (*Lepomis gulosus*)

Habitat:

feeding - clear lakes and impoundments and very low-gradient streams
- abundant aquatic vegetation
- silt-free water
- mucky substrate often covered with organic debris

spawning - nesting sites in loose silt, sand with silt, or rubble over silt near stumps, roots, or vegetation

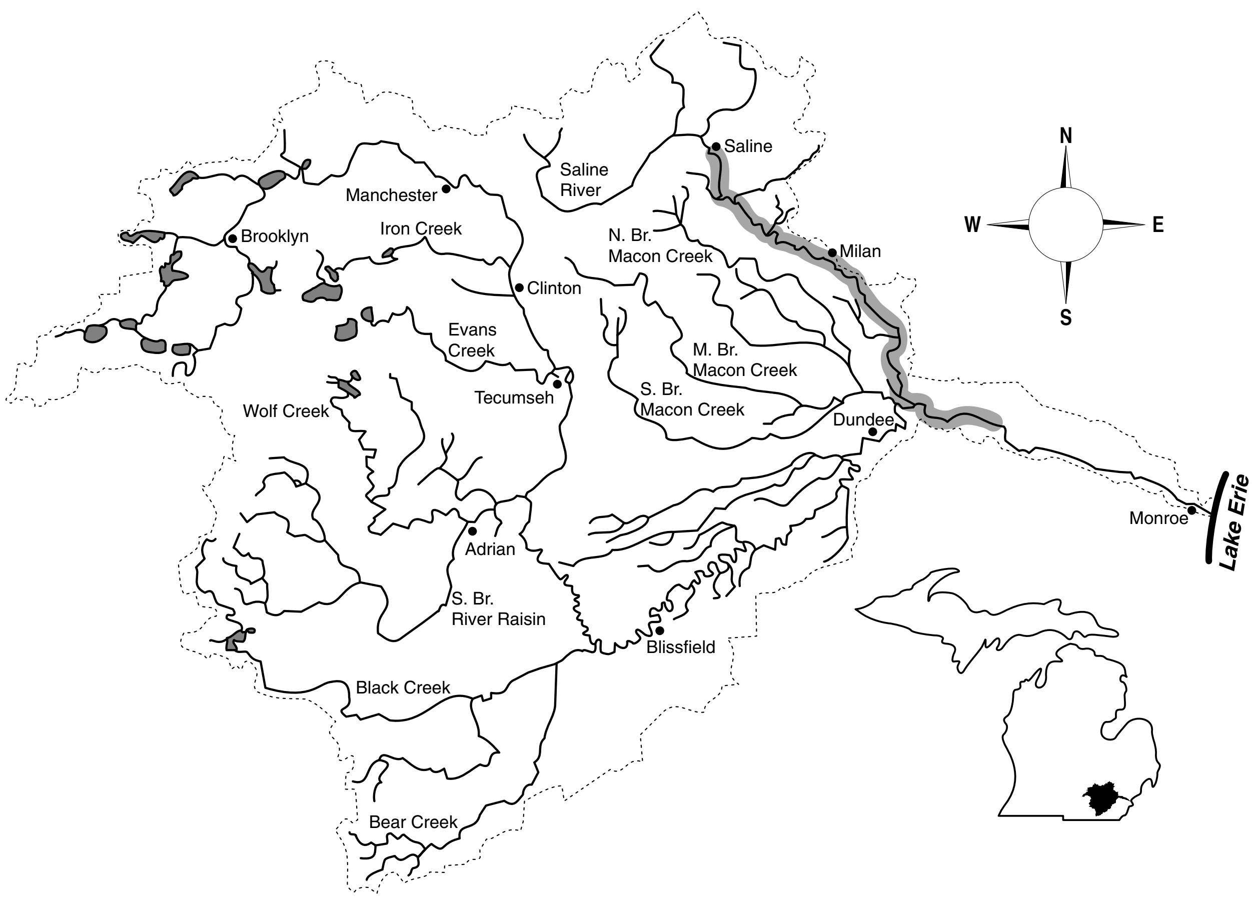


Orangespotted sunfish (*Lepomis humilis*) - non-native species

Habitat:

feeding
- soft bottomed pools, sloughs, backwater lakes, and sluggish streams >15ft. wide
- tolerant of silt, turbidity, and some pollution mainly over mud, gravel, clay, and sand substrates
- prefers scanty to moderate amounts of vegetation
- can withstand low oxygen concentrations
- low to no gradient
- not in cool water

spawning
- shallow water
- gravel, sand, or mud substrate



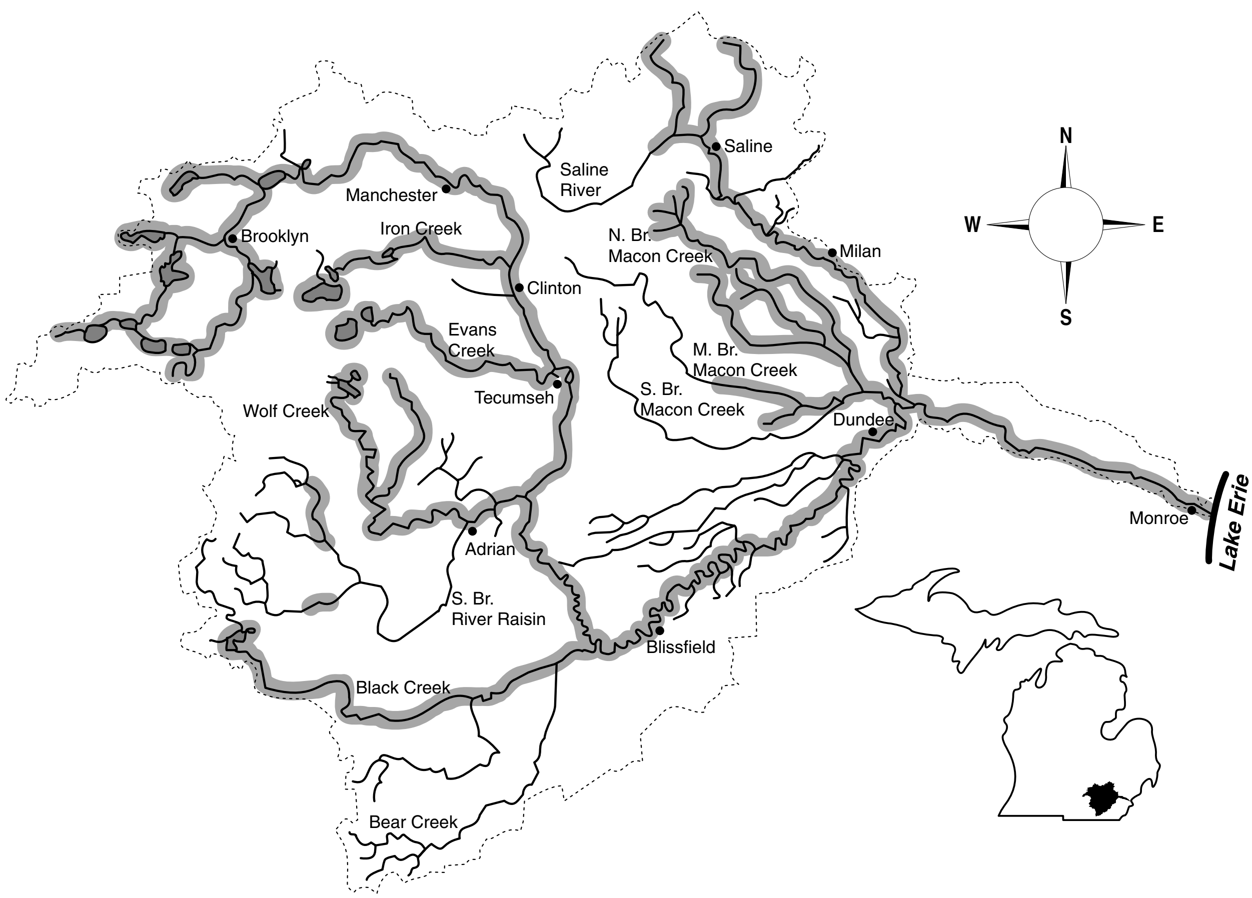
Bluegill (*Lepomis macochrius*)

Habitat:

feeding - non-flowing clear streams and rivers; also lakes and impoundments
- sand, gravel, or muck containing organic debris substrate
- scattered beds of aquatic vegetation
- cannot tolerate low oxygen or continuous high turbidity and siltation

spawning - nests in firm substrate of gravel, sand, or mud

winter refuge - deep water

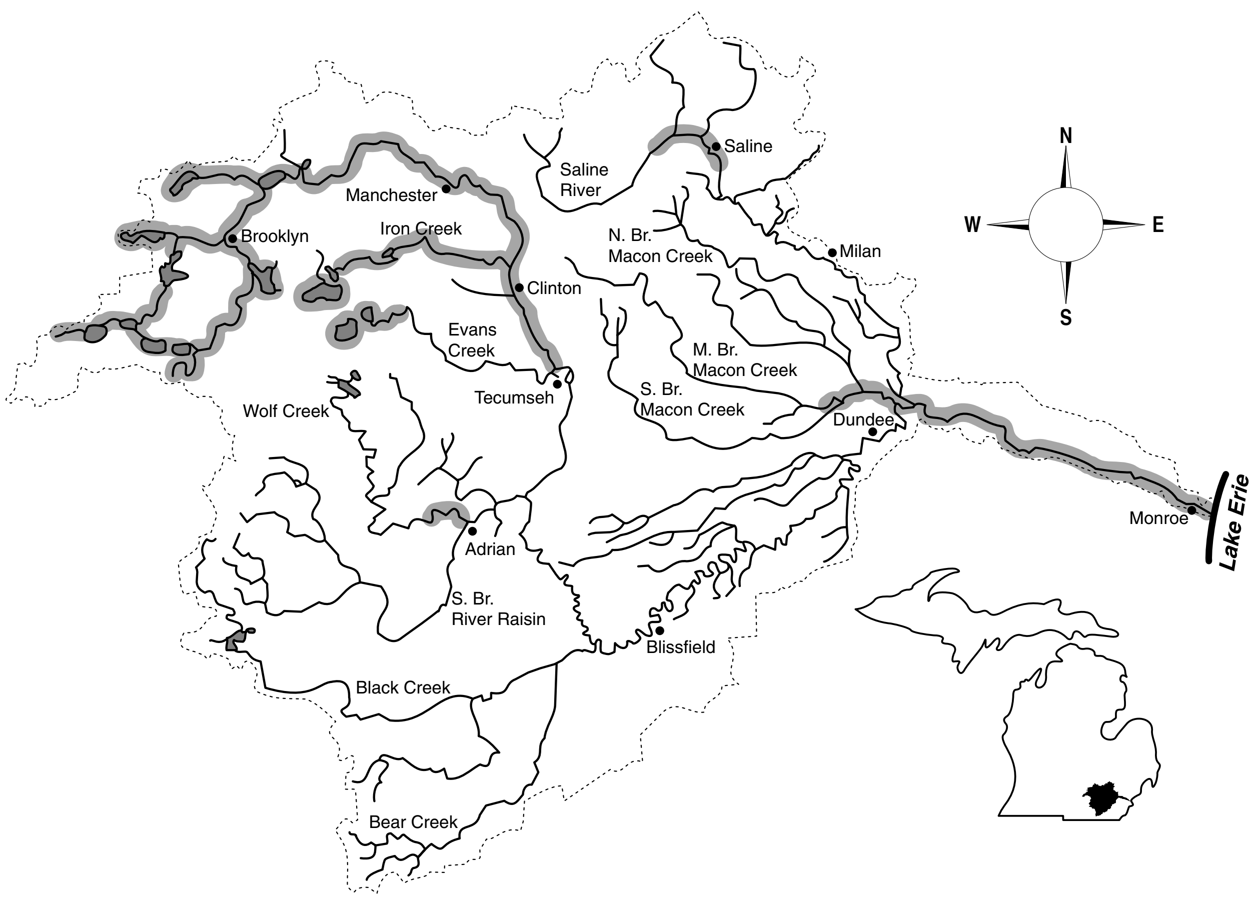


Longear sunfish (*Lepomis megalotis*)

Habitat:

feeding - clear moderate-sized shallow streams with moderate vegetation
- rocky substrates
- little to no current

spawning - nests in gravel, sand, or hard rock substrate

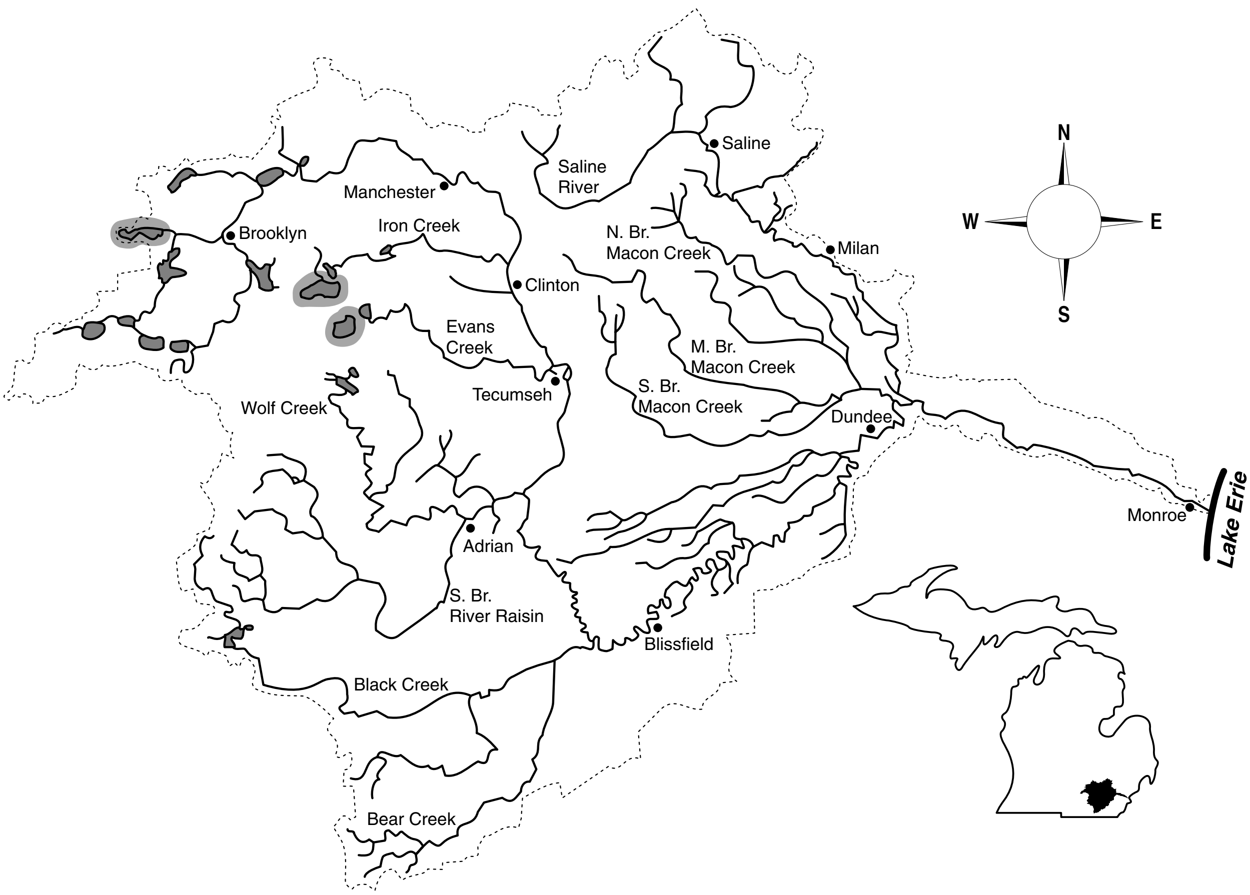


Redear sunfish (*Lepomis microlophus*)

Habitat:

feeding - non-flowing clear waters of streams and lakes
- some aquatic vegetation

spawning - nest in silt or gravel substrate



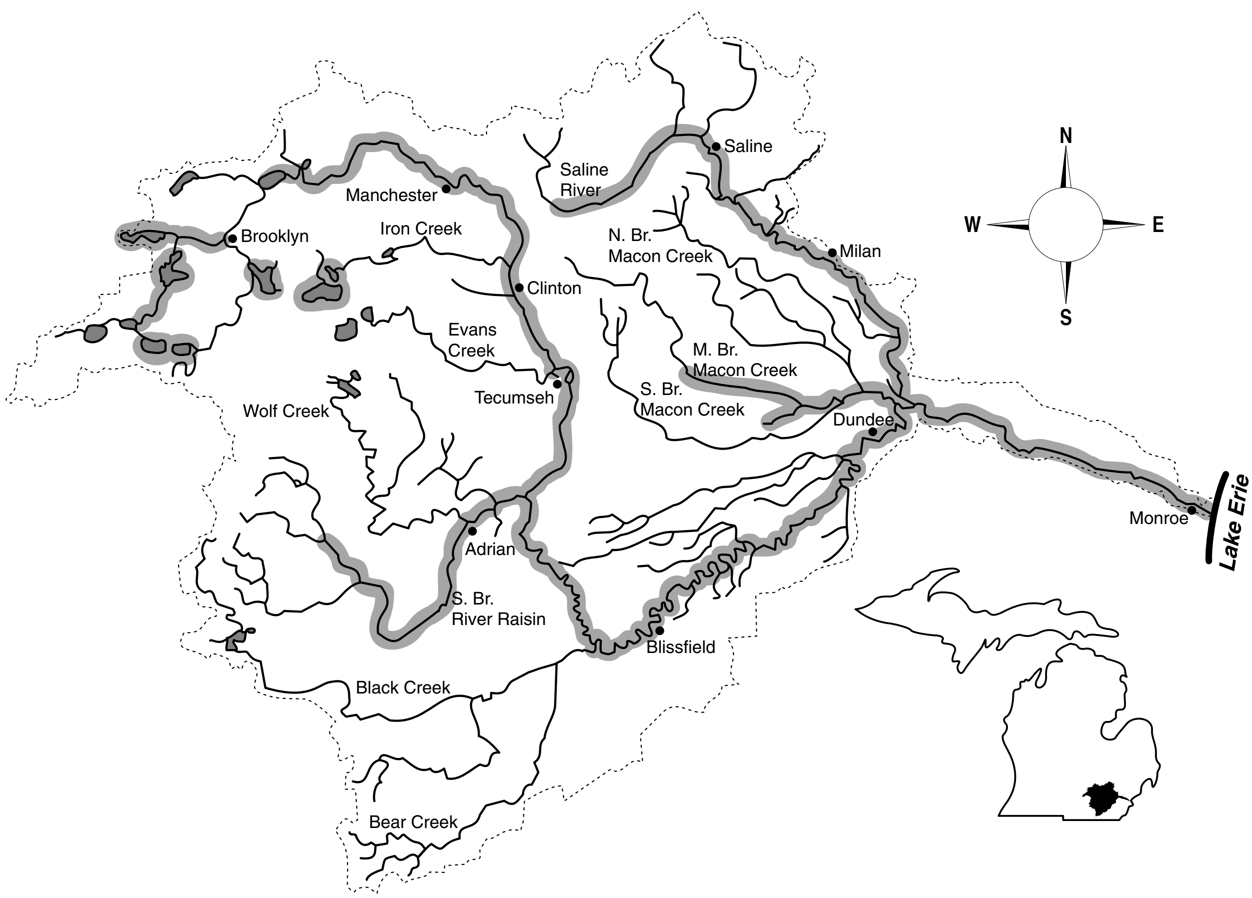
Smallmouth bass (*Micropterus dolomieu*)

Habitat:

feeding - clear, cool, deep lakes and rivers
- streams where 40% consists of riffles over clean gravel, boulder, or bedrock substrate
- in pools with a current and >4 feet of depth
- gradients between 4 and 25 feet per mile

spawning - nest in sandy, gravel, or rocky substrate
- gradients 7 to 25 feet per mile
- streams 20 to 100 feet wide

winter refuge - larger deeper waters with gradients between 3 to 7 feet per mile

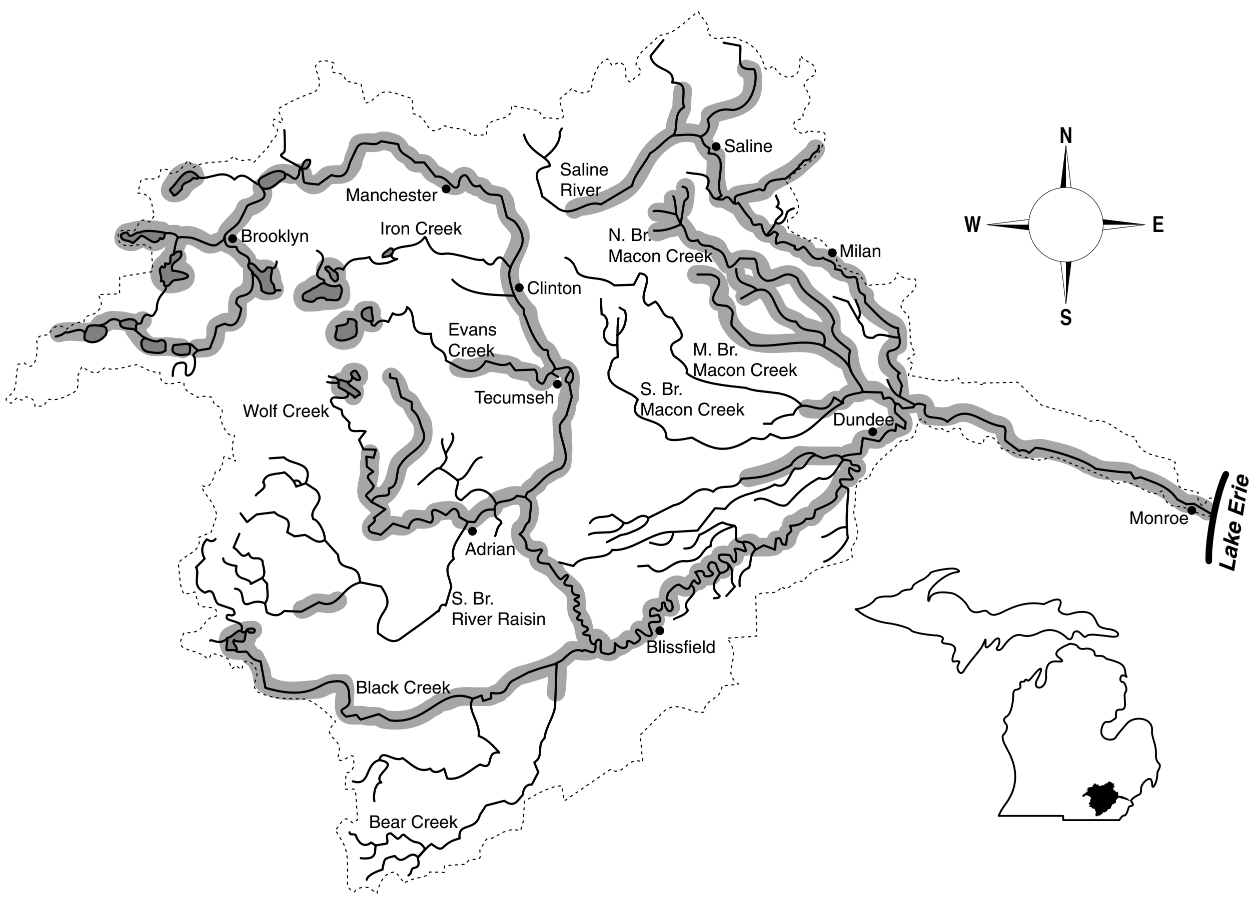


Largemouth bass (*Micropterus salmoides*)

Habitat:

feeding
- non-flowing clear waters - lakes, impoundments, and pools of streams
- abundant aquatic vegetation
- soft muck, organic debris, gravel, sand, and hard non-flocculent clay substrates

spawning
- nest in gravelly sand to marl and soft mud substrates
- emergent vegetation
- quiet shallow bays; no current

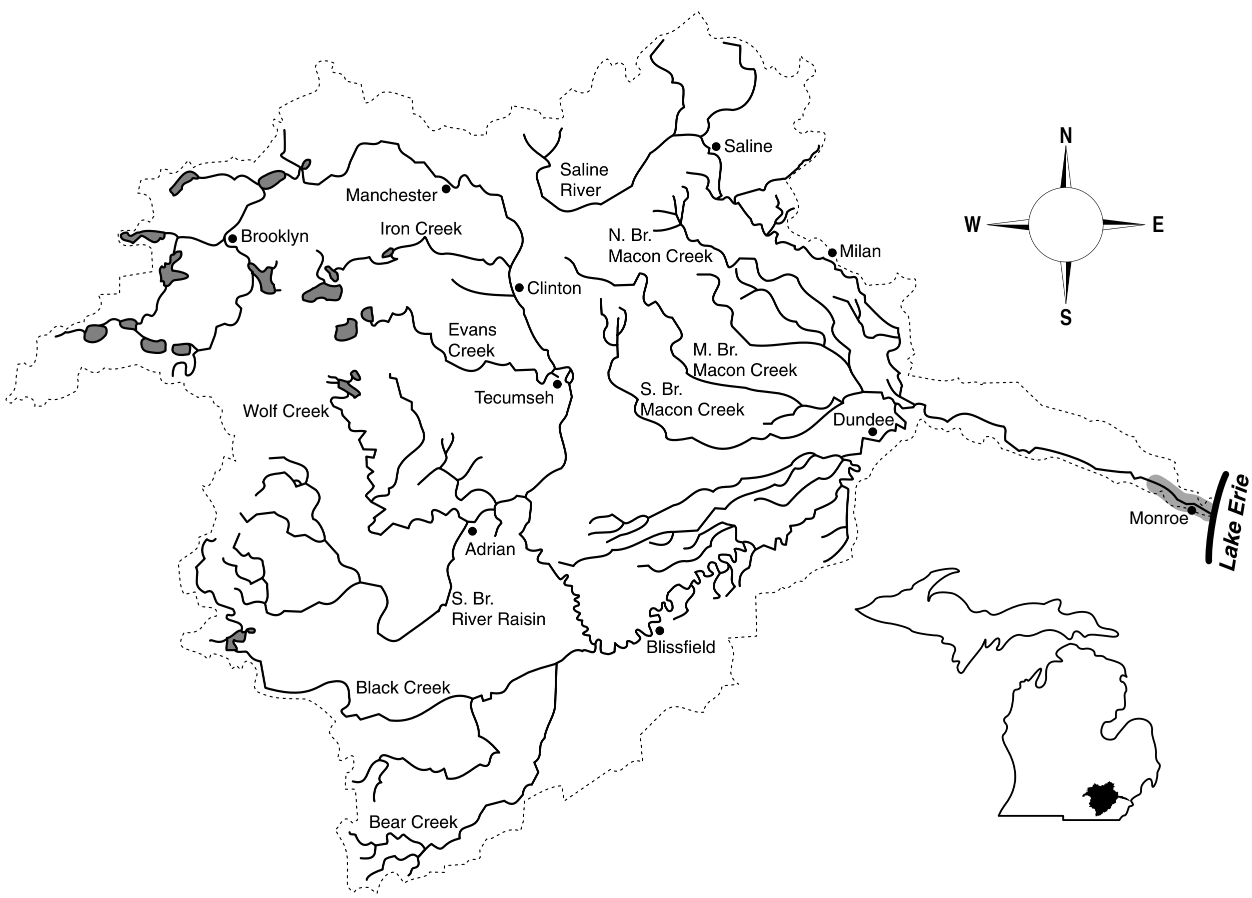


White crappie (*Pomoxis annularis*)

Habitat:

feeding
- lakes and impoundments >5 acres
- sluggish pools of moderate to large low-gradient rivers
- no substrate preference
- can tolerate severe turbidity and rapid siltation

spawning
- various substrates usually beside rooted aquatic vegetation
- sometimes under banks

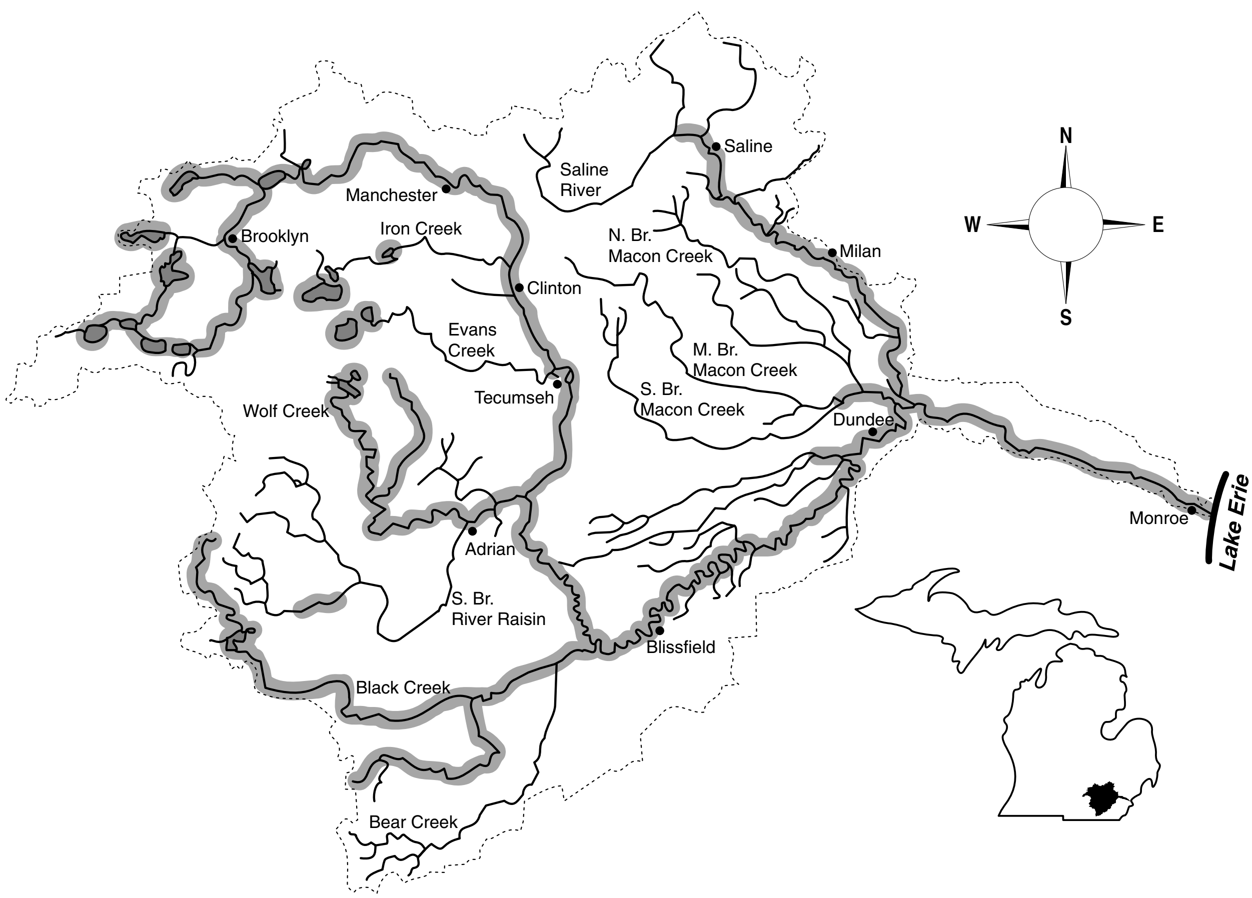


Black crappie (*Pomoxis nigromaculatus*)

Habitat:

feeding - larger clear non-silty low-gradient rivers; also in lakes and impoundments
- clean hard sand or muck substrate
- associated with submerged aquatic vegetation
- does not tolerate silt or turbidity well

spawning - nests in gravel, sand, or mud substrate
- some vegetation must be present
- sometimes nests under banks

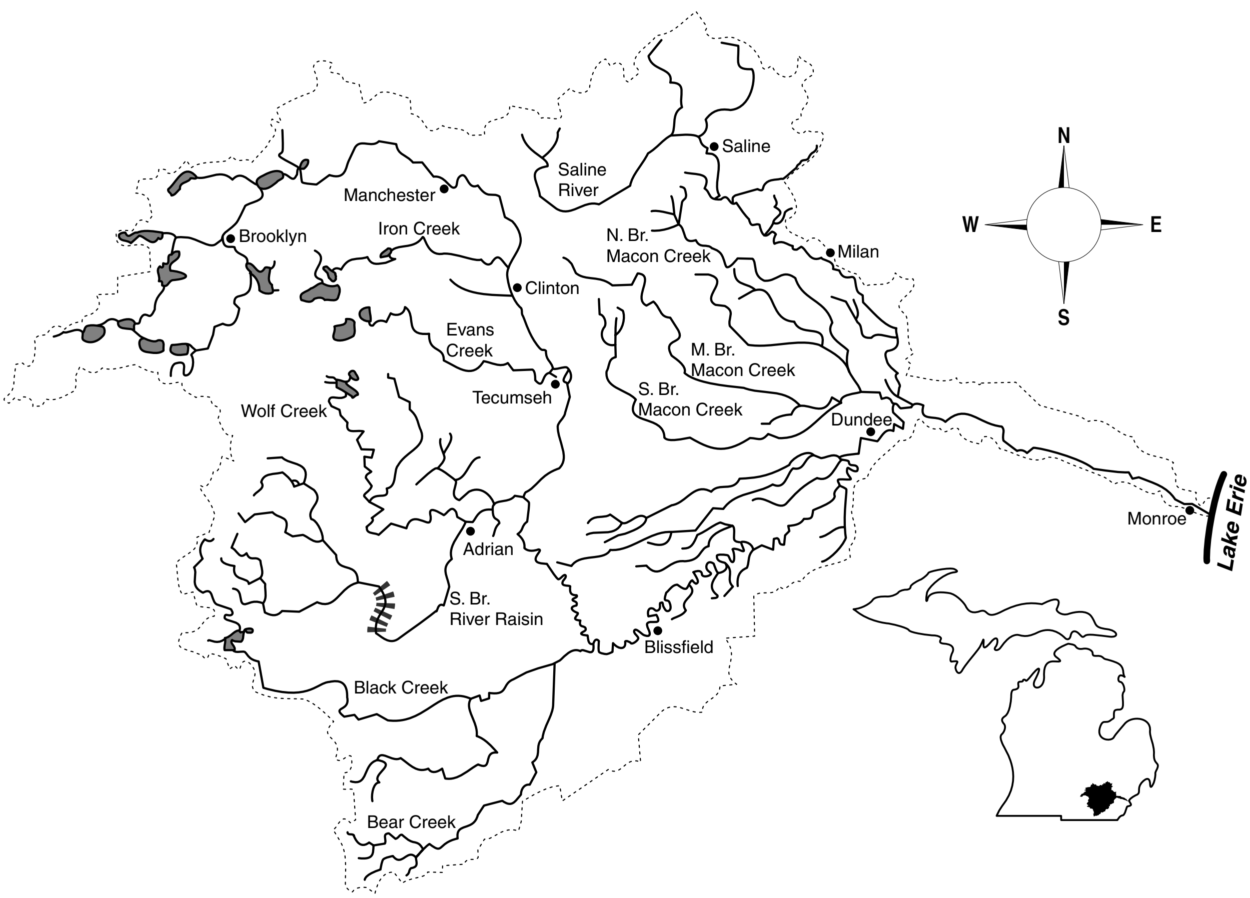


Eastern sand darter (*Ammocrypta pellucida*) - threatened, may be locally extirpated

Habitat:

feeding - sandy substrate in clear streams and lakes
- does not tolerate silt well

spawning - sandy substrate

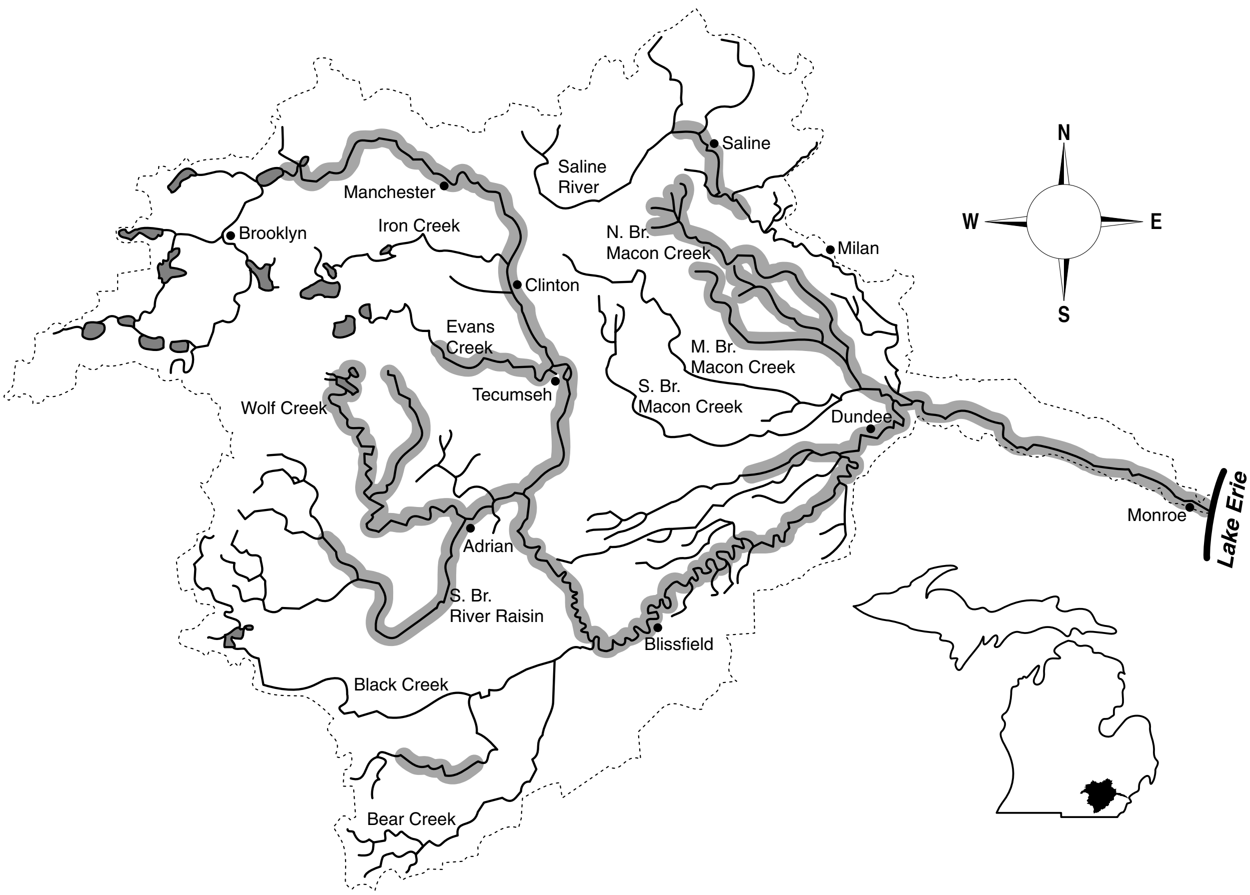


Greenside darter (*Etheostoma blennioides*)

Habitat:

feeding - young: in quiet water
- swift gravelly riffles or pools with current of streams and rivers

spawning - filamentous algae necessary for egg deposition

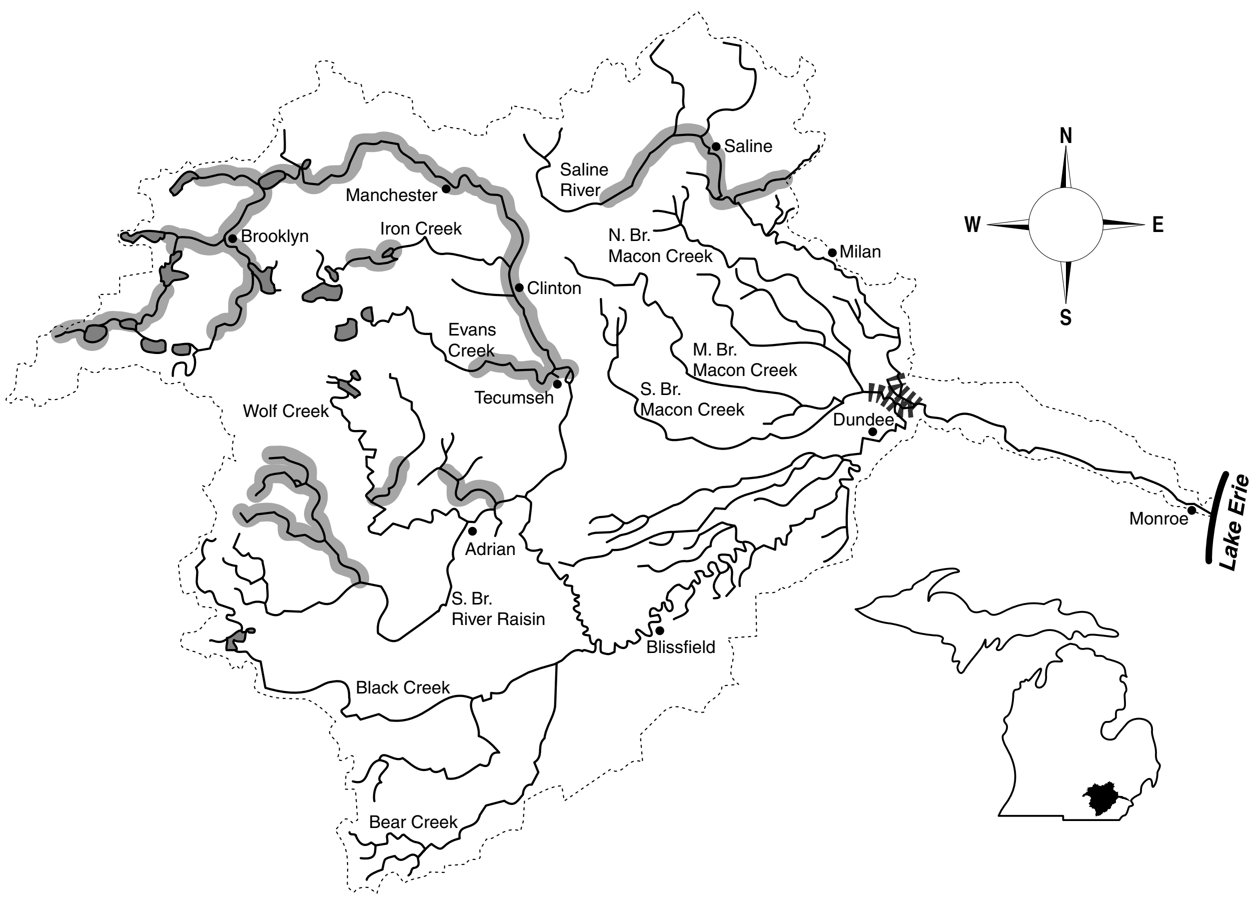


Rainbow darter (*Etheostoma caeruleum*)

Habitat:

feeding - gravelly high gradient riffles
- clear, moderate to large streams
- in shallows (average 1 foot)

spawning - gravel or rubble riffles

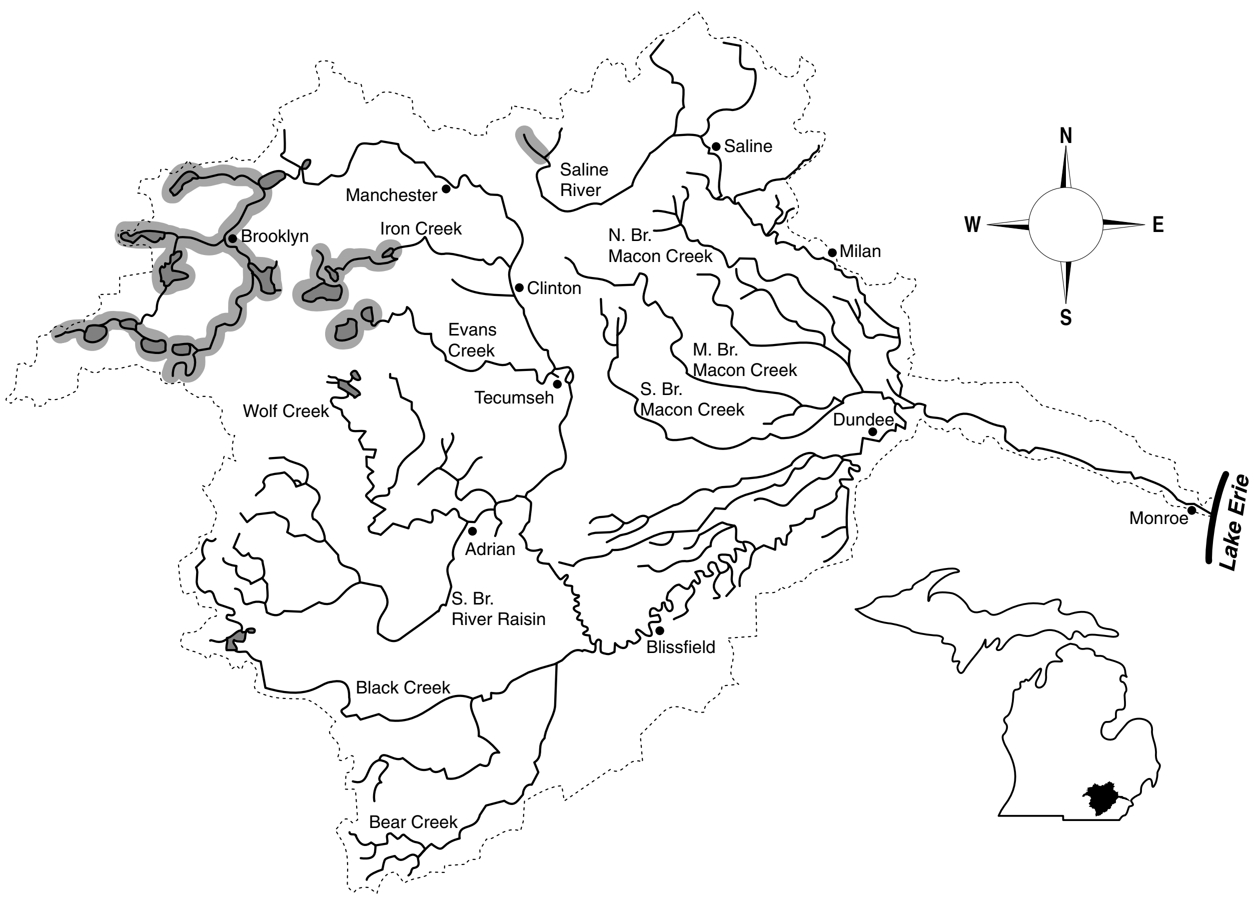


Iowa darter (*Etheostoma exile*)

Habitat:

feeding
- clear, slow moving streams and lakes
- sandy to muddy substrates
- intolerant of turbid water
- lives in rooted aquatic vegetation

spawning
- in pond-like extensions of streams on organic matter or roots
- in shallows



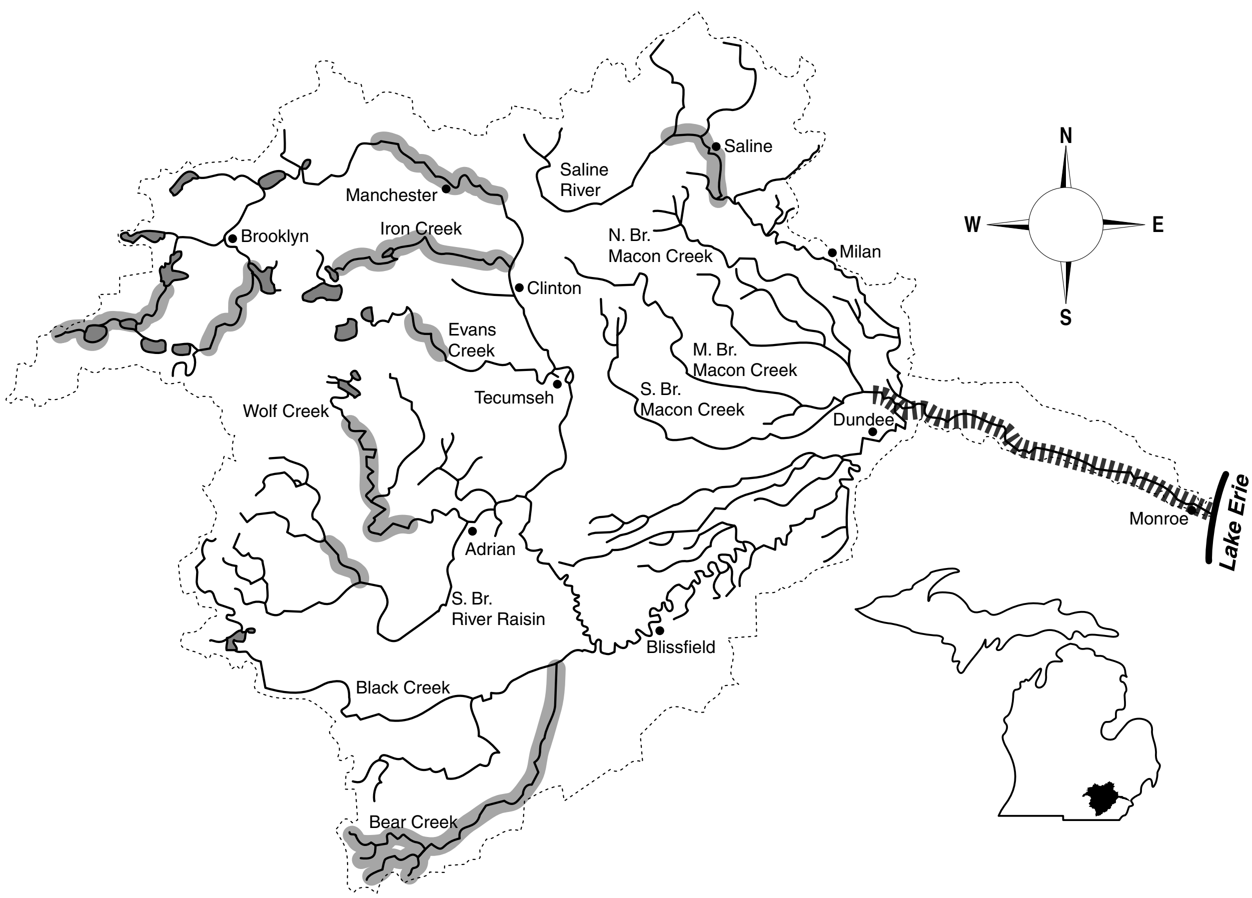
Fantail darter (*Etheostoma flabellare*)

Habitat:

feeding - small, shallow (<18 inches) streams
- some tolerance of turbidity and siltation
- clear warm waters
- slow to moderate current
- gravel and boulder substrate

spawning - gravel in slower water
- lays eggs on underside of rocks, male guards and fans them

winter refuge - moves downstream to larger and deeper waters

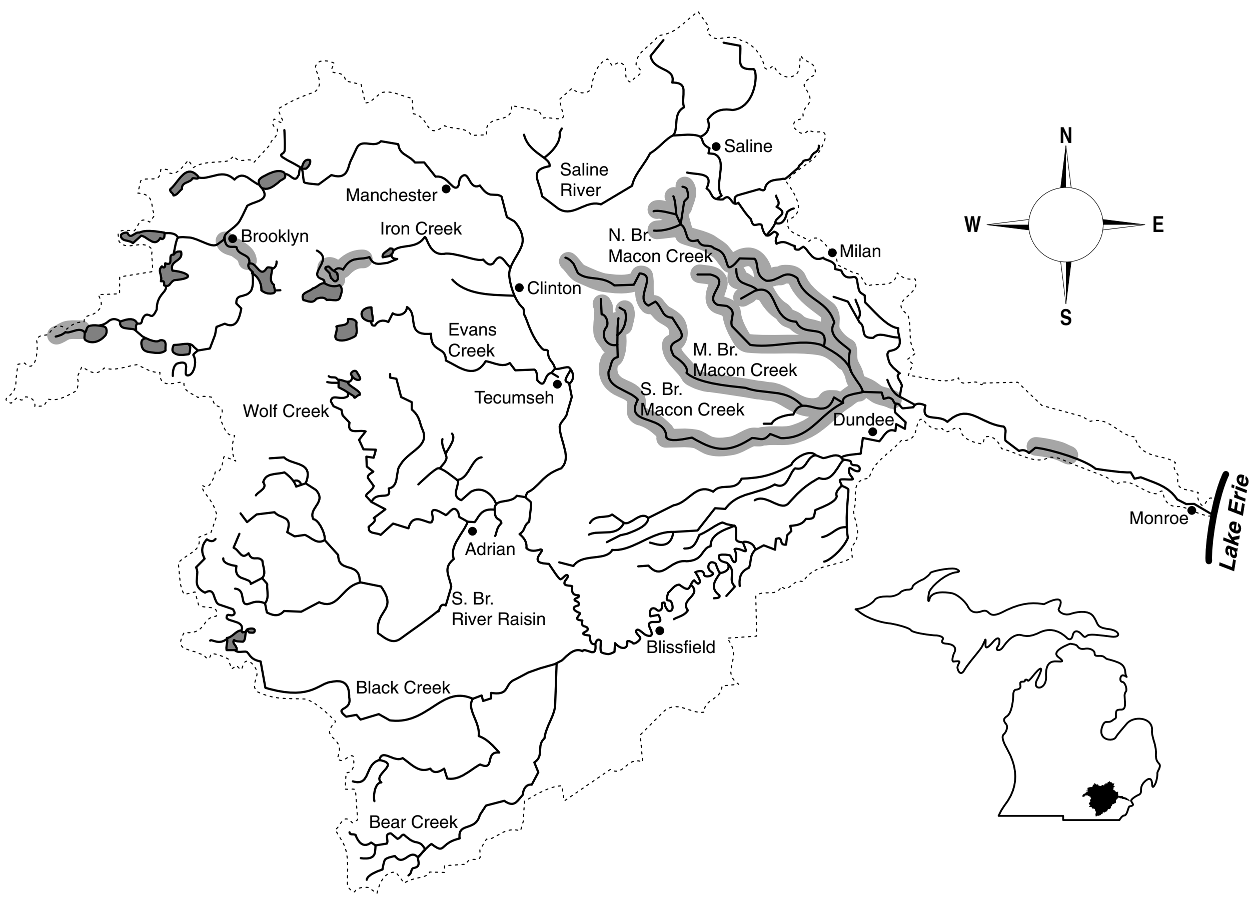


Least darter (*Etheostoma microperca*)

Habitat:

feeding - moderate to warm temperature
- clear quiet low-gradient vegetated streams (wetlands, floodplains)
- soft substrate

spawning - spawning occurs on stems of plants
- male guards a territory in a vegetated area

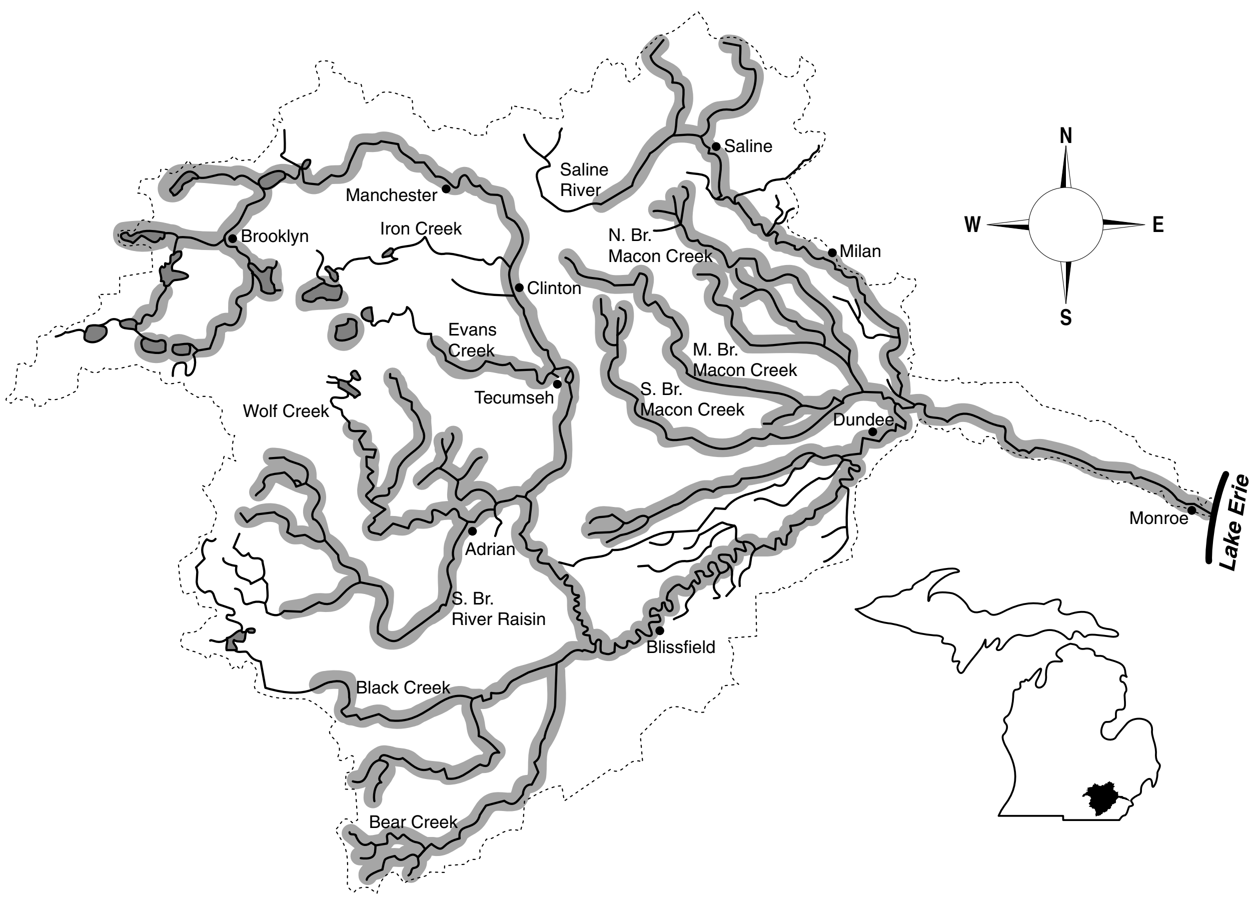


Johnny darter (*Etheostoma nigrum*)

Habitat:

feeding
- sand and silt substrate
- little to moderate current
- shallow areas of streams, rivers, lakes, and impoundments
- tolerant of many organic and inorganic pollutants and turbidity

spawning
- underneath rocks
- in stream pools or protected shallows of lakes

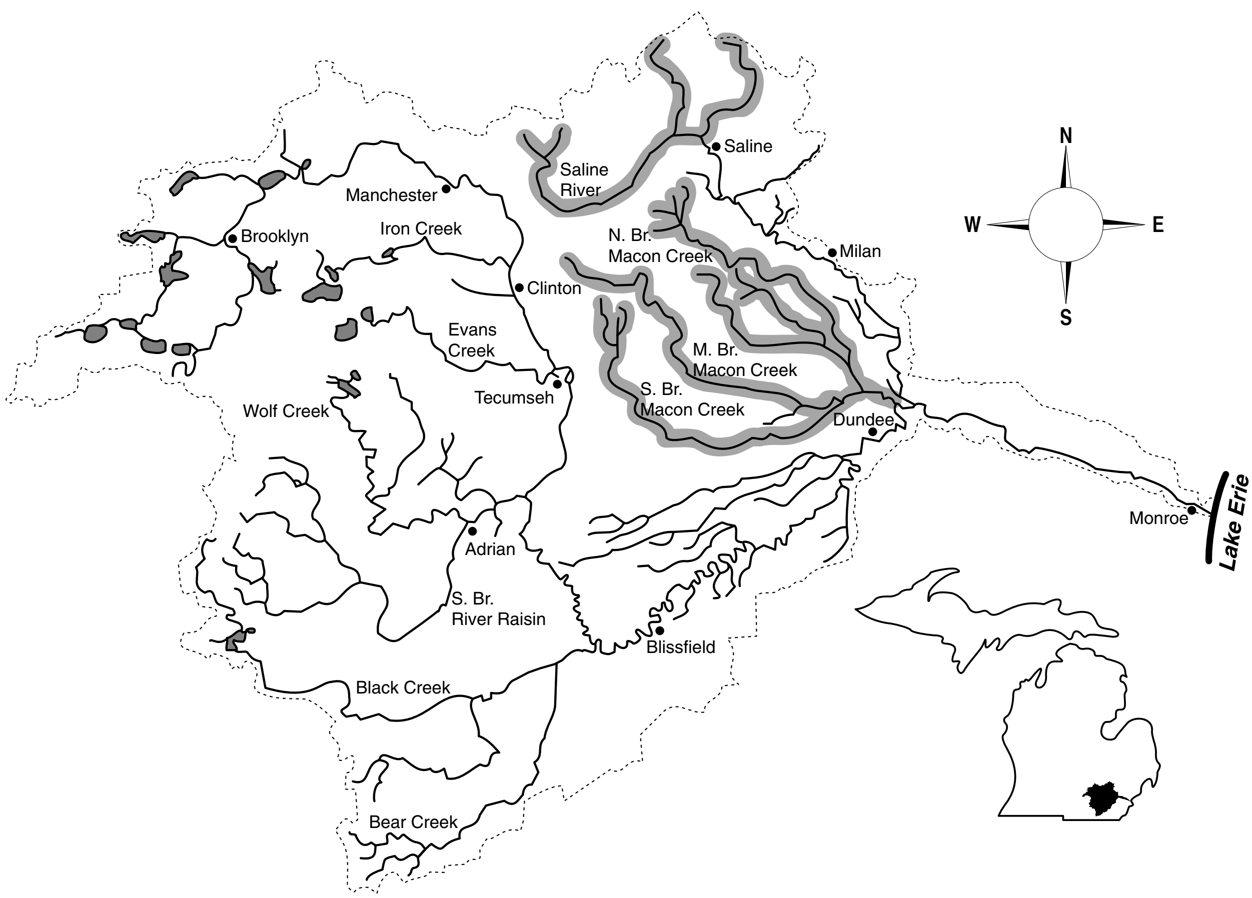


Orangethroat darter (*Etheostoma spectabile*)

Habitat:

feeding
- small-moderate size creeks and spring branches
- sand, gravel, or rock substrate in sluggish riffles or in pools with sufficient current to prevent siltation
- prefers clear streams but tolerant of turbidity
- low to moderate gradient

spawning
- gravel riffles
- slow current

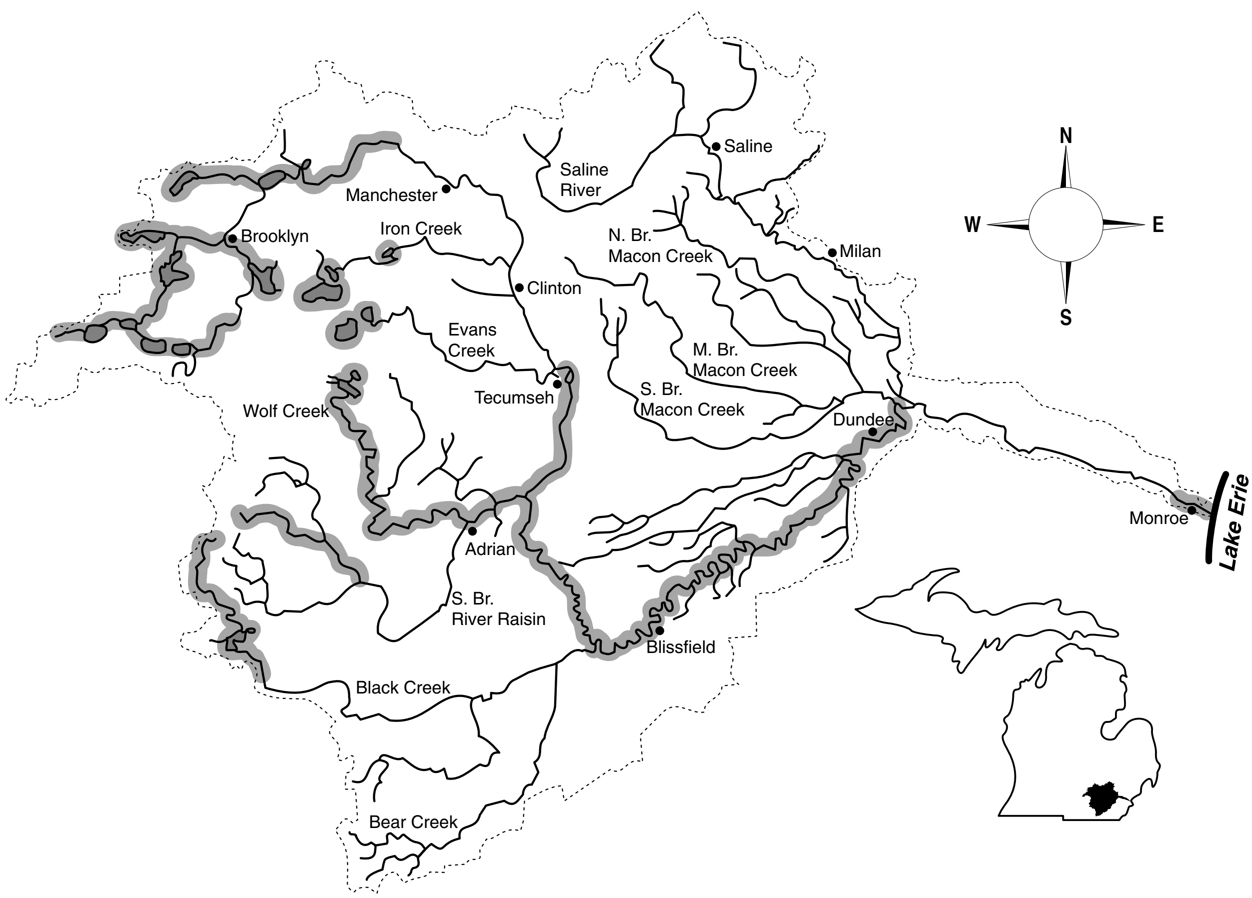


Yellow perch (*Perca flavescens*)

Habitat:

feeding
- clear lakes and impoundments; also Lake Erie
- low gradient rivers
- abundance of rooted aquatics
- muck, organic debris, sand, or gravel substrate
- does not tolerate turbidity and siltation

spawning
- shallows of lakes, tributaries of streams
- occurs over rooted vegetation, submerged brush, fallen trees
- may occur over sand or gravel

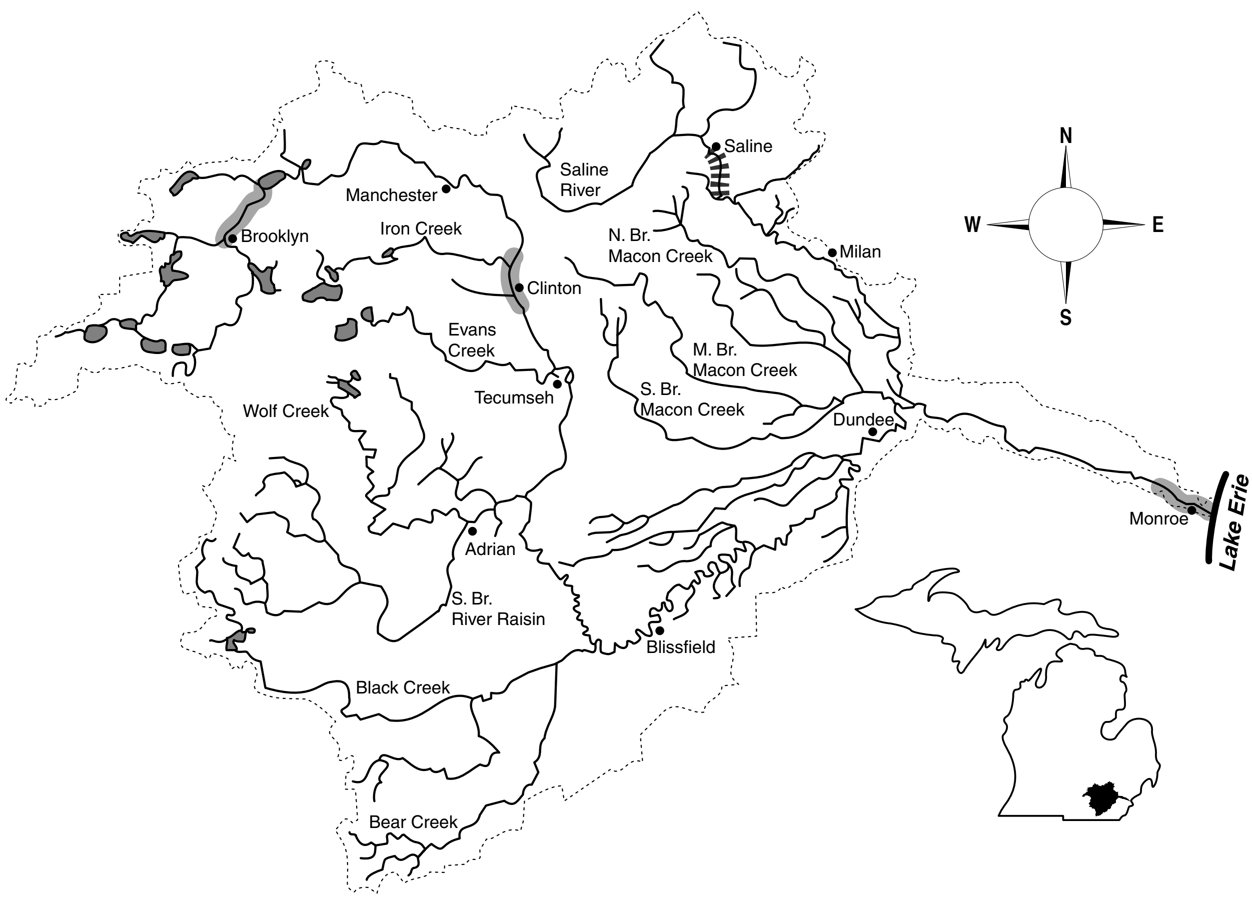


Logperch (*Percina caprodes*)

Habitat:

feeding - gravel riffles, deeper slower sections of rivers
- medium size streams; also lakes, impoundments, and Lake Erie
- sand, gravel, or rock substrate
- avoids turbidity and silt

spawning - riffles or sandy in-shore shallows

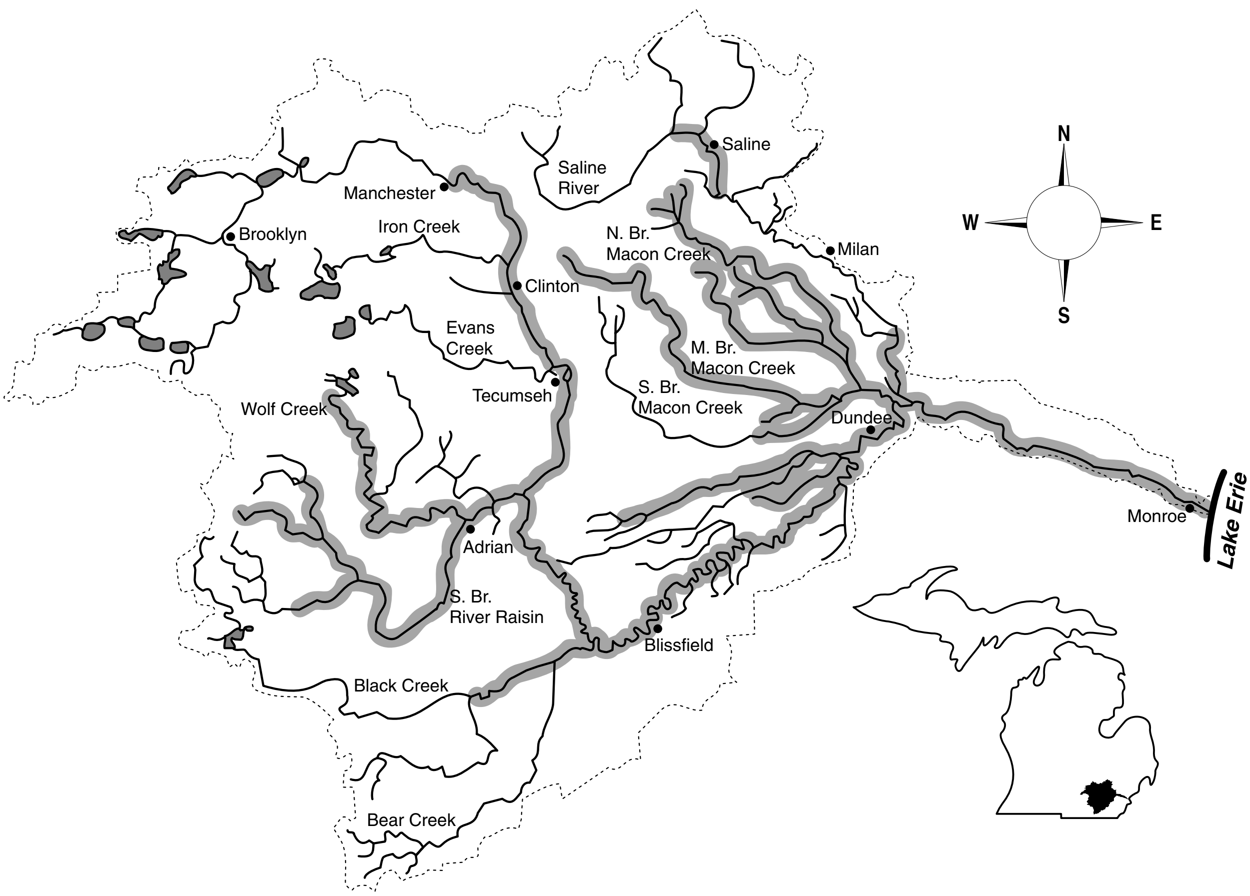


Blackside darter (*Percina maculata*)

Habitat:

feeding - small to medium streams
- low to medium gradient
- gravel and sand substrate
- tolerate some turbidity

spawning - gravel and sand substrate

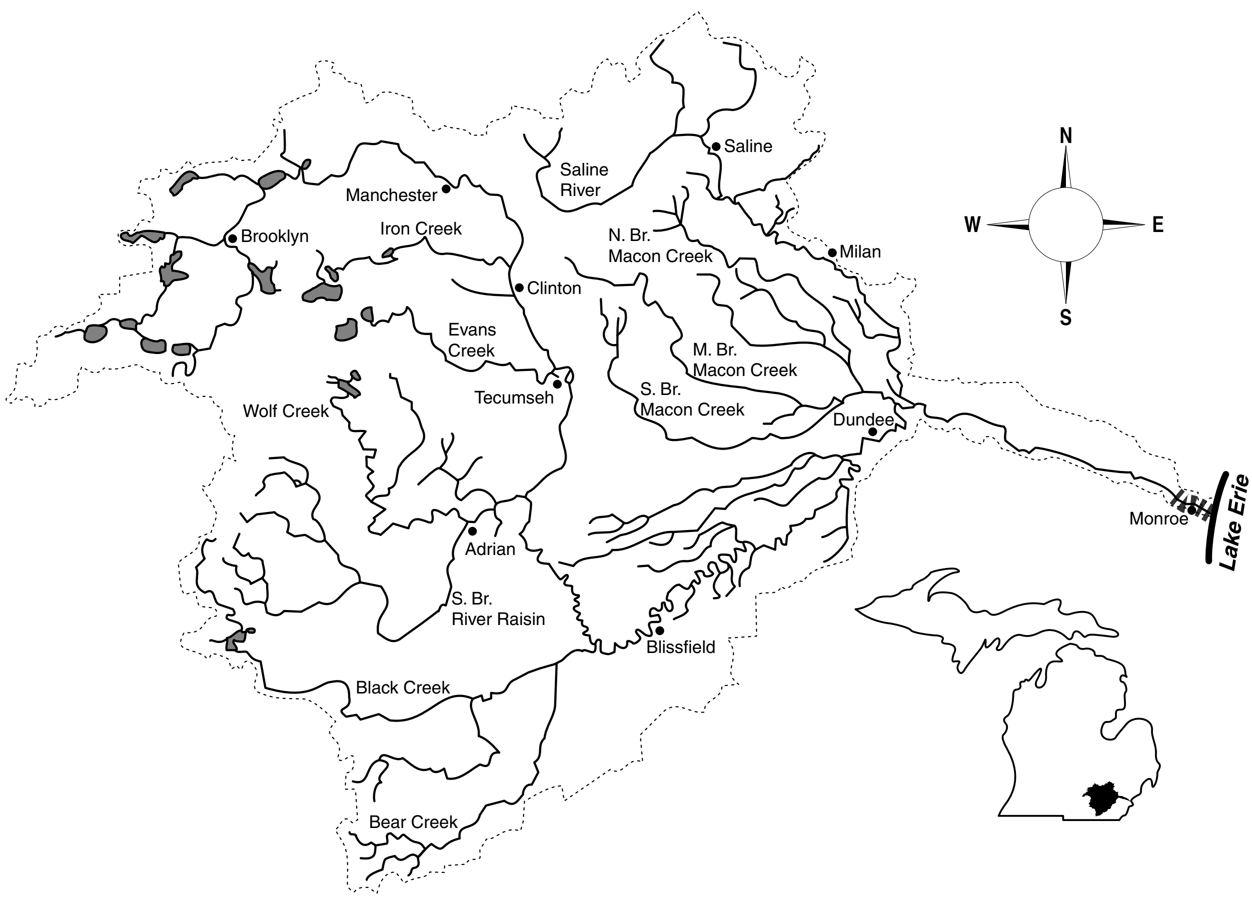


Sauger (*Stizostedion canadense*) - threatened

Habitat:

feeding - larger, deeper, low gradient rivers; turbid lakes and impoundments; also Lake Erie
- not tolerant of high gradient
- tolerant of silted substrate
- more tolerant of turbid water than walleye
- young may be in shallows or flats

spawning - shoals of gravel and rubble



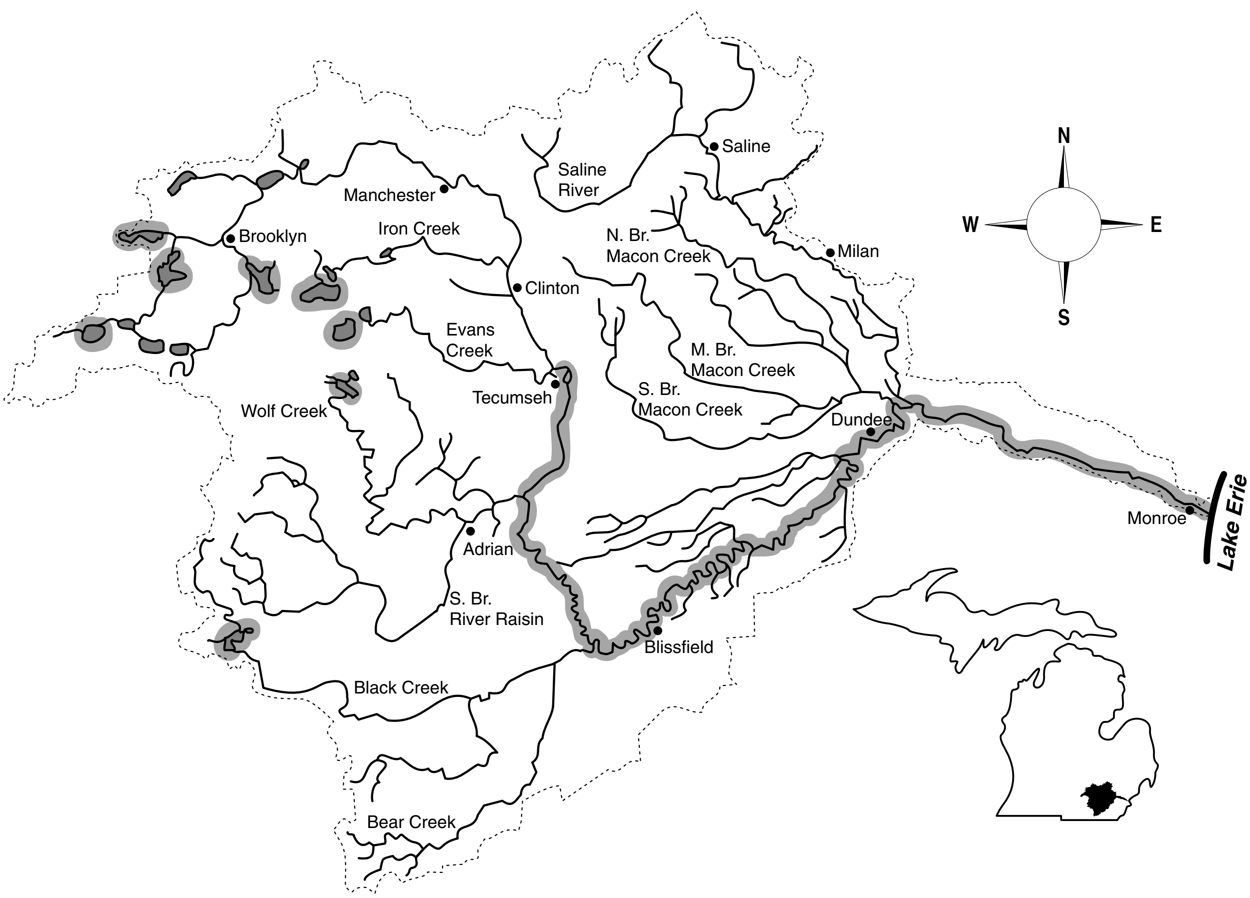
Walleye (*Stizostedion vitreum*)

Habitat:

feeding - larger, deeper streams and in large, shallow, turbid lakes and impoundments; also Lake Erie
- gravel, bedrock, and firm substrates preferred
- does not tolerate a lot of turbidity or low oxygen

spawning - rocky substrates in high gradient water in rivers
- boulder to coarse gravel shoals in lakes

winter refuge - avoids strong currents

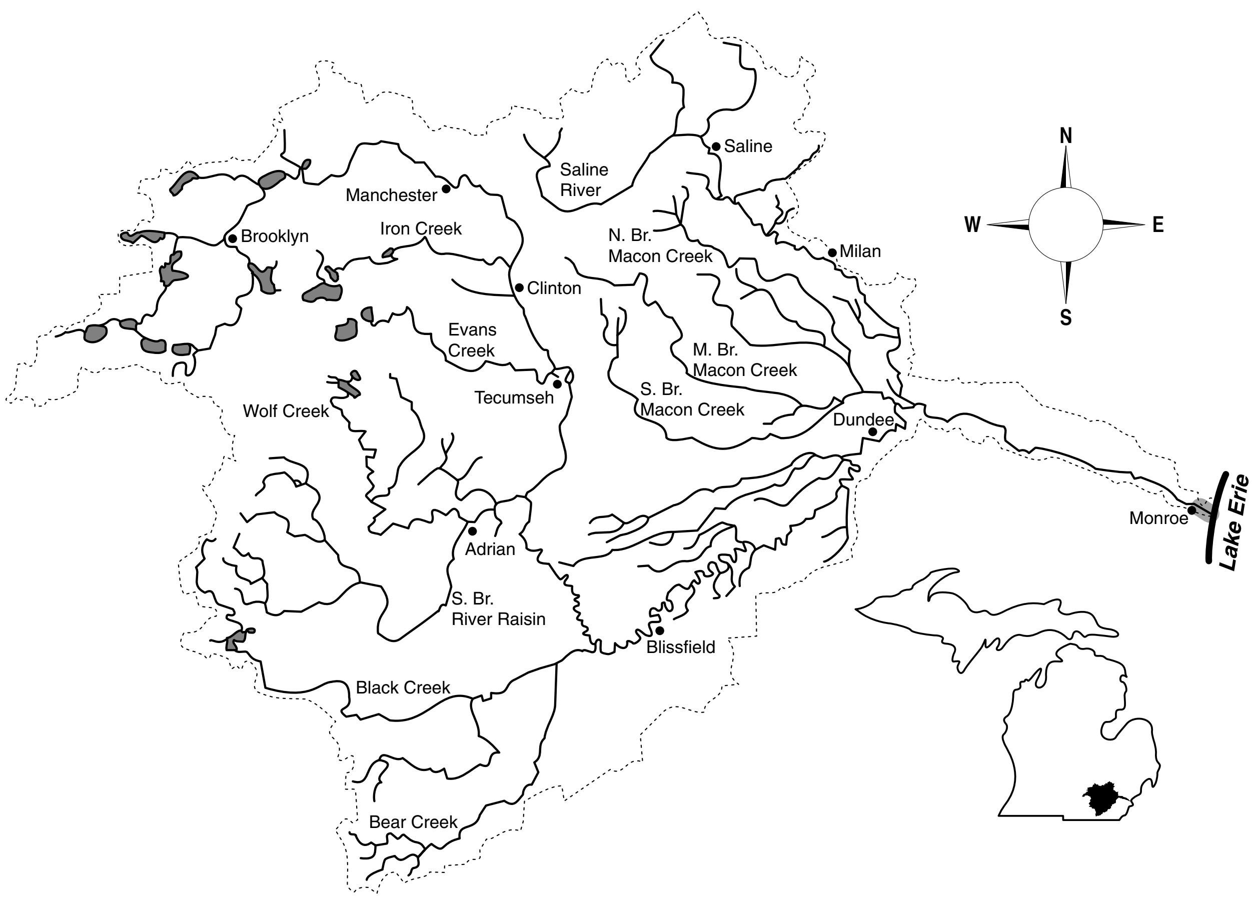


Freshwater drum (*Aplodinotus grunniens*)

Habitat:

feeding - deeper pools of rivers
- in shallows
- prefers clear waters and clean substrates
- can adapt to high turbidity levels

spawning - pelagically, in open water, over sand or mud substrate
- occurs in bays or lower portions of marshes



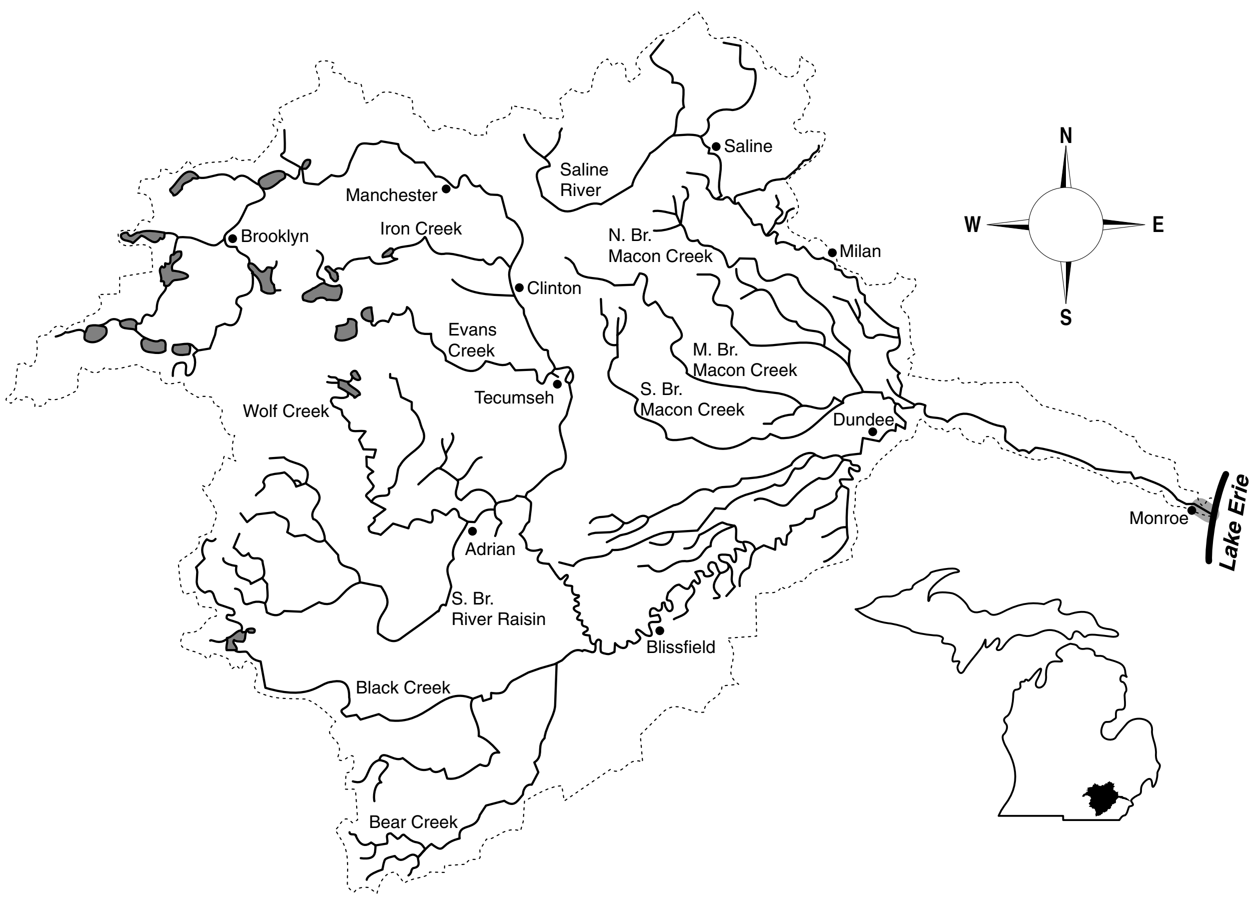
Round goby (*Neogobius melanostomus*) - non-native species

Habitat:

feeding - rock, cobble, riprap, and vegetate areas of rivers and lakes
- young found over sand substrate

spawning - rocky substrate with large interstitial spaces

winter refuge - rocky substrate with large interstitial spaces
- deep water



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