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An Introduction to Freshwater Fishes as Biological Indicators

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An Introduction to Freshwater Fishes as Biological Indicators

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Introduction

The freshwaters of North America are populated by a rich tapestry of native fishes, some of which possess enough charisma and color to rival their marine and tropical counterparts. While names such as trout and bass are well-embedded into the American vernacular, the less familiar monikers of darter, madtom, and dace remain relatively unknown. However, it is more often these lesser known groups that function as valuable indicators of biological integrity, thereby providing important information to scientists regarding the health of our nation's waterways.

This guide is intended to act as a reference for environmental and fisheries professionals, naturalists, and educators on the use of fishes as biological indicators. The species described herein were not chosen for their familiarity, commercial, or recreational value, but rather their distribution and utility as bioindicators. In addition, an effort was made to provide clear, concise species descriptions to assist investigators in both the identification of fishes and their indicator value.

The Conservation of Fishes

Over 1,000 species of freshwater fishes occur in the surface waters of North America (Williams et al. 1989). This extraordinary component of our natural history is punctuated by the fishes of the southeastern United States (Photos 1-4), a fauna possessing remarkable diversity and a high degree of endemism. Recently, there has been an emerging awareness among biologists that a significant proportion of these fishes have become threatened or endangered due to the activities of humans. Williams et al. (1989) reviewed the conservation status of North American fishes and estimated approximately 21.3 % of the 1,042 extant species were "imperiled." More recently, Jelks et al. (2008) found that since that 1989 review, there was a 92% increase in the number of imperiled taxa from 364 to 700. Over the past 100 years, a total of 28 species have gone extinct (Boschung and Mayden 2004). In the United States, 139 species are currently listed as threatened or endangered (USFWS 2008).

Photo 1: Spring Cavefish (*Forbesichthys agassizii*).

Photo 2: Tangerine Darter (*Percina aurantiaca*).

Photo 3: Greenfin Darter (*Etheostoma chlorobranchium*).

Photo 4: Mobile Logperch (*Percina kathae*).

Any discussion on the reduction, extirpation, or extinction of a species inevitably requires a diagnosis of the causal factors of decline. Extirpations and extinctions of fishes have been attributed to habitat and landscape alterations such as channelization, impoundment, wetland destruction, and deforestation (Angermeier 1995). The intersection of species traits incompatible with various stressors and habitat alterations has unfortunately spelled doom for some fishes. For example, the combination of a restricted range and habitat destruction were likely responsible for the extinction of the Whiteline Topminnow (*Fundulus albolineatus*). Originally collected in Spring Creek (Huntsville, AL) in 1891, the natural channel where the Whiteline Topminnow once occurred is now an impounded, concrete lined canal in downtown Huntsville (Boschung and Mayden 2004). Many authors and experts have called for an ecological approach to aquatic species conservation, fisheries management, and water quality goals (Cook et al. 1972; Karr and Dudley 1981).

This philosophy advocates a holistic management methodology that recognizes the matrix of interdependencies that exist in nature. These relationships may exist between closely or distantly related taxa. A prime example of such a relationship exists between the fishes and native freshwater mussels of North America. Because the freshwater mussel life cycle possesses an obligate parasitic phase that requires a fish host, the composition of fish communities is important in maintaining mussel communities. Both game and non-game fishes (e.g. darters, daces, madtoms, and suckers) have been confirmed by laboratory analysis to function as hosts for numerous mussel species. Freshwater mussels are important members of aquatic ecosystems - filtering particulate matter, biodepositing nutrients, stabilizing substrates, and mixing sediments (Vaughn and Hakencamp 2001). Perturbations or management philosophies that alter fish communities are likely to adversely impact mussel communities, thereby altering nutrient and sediment dynamics.

Basic Fish Anatomy

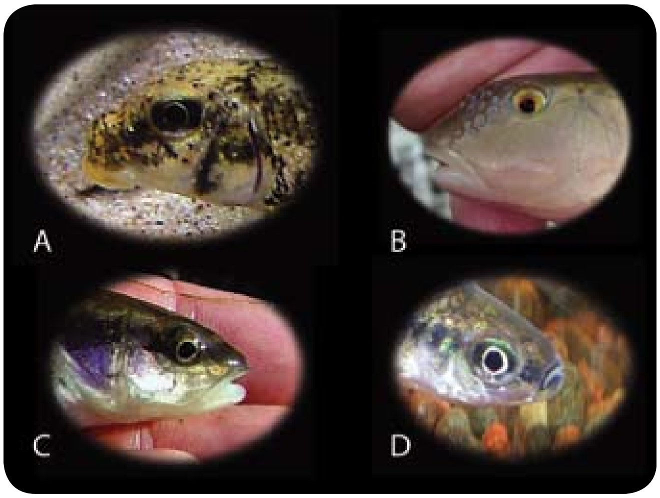


Figure 1. Mouth orientations. (A) Inferior (B) Subterminal (C) Terminal (D) Superior.

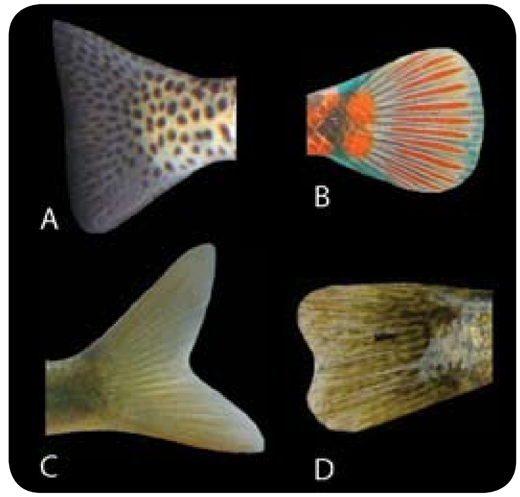


Figure 2. Caudal fin shapes. (A) Truncate (B) Rounded (C) Forked (D) Emarginate.

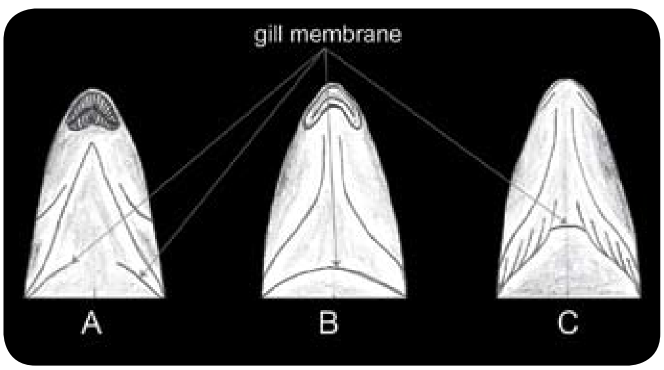


Figure 3. Branchiostegal membranes. (A) Bound to isthmus (B) Gill membranes broadly joined and not bound to isthmus (C) Gill membranes moderately joined and not bound to isthmus

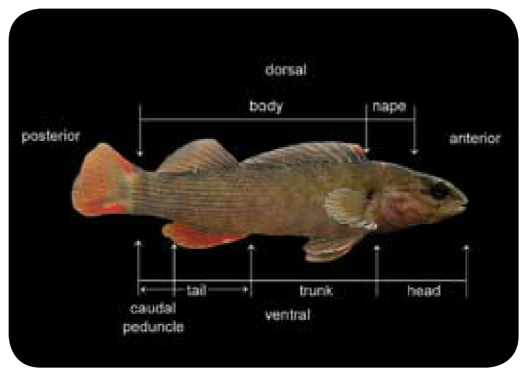


Figure 4. Basic body regions.

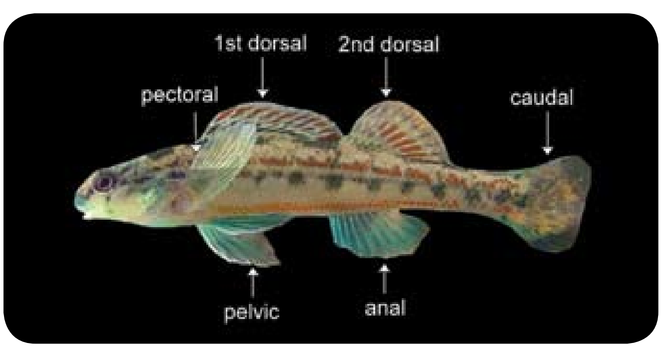


Figure 5. Basic fin anatomy.

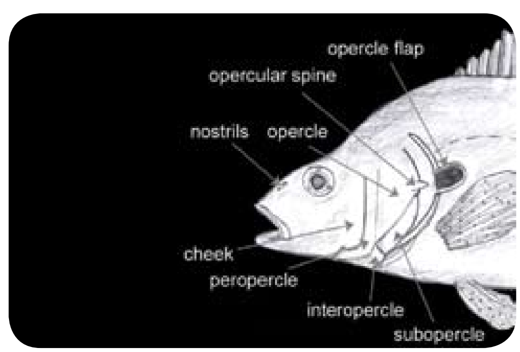


Figure 6. Basic head anatomy.

FISH AS BIOLOGICAL INDICATORS

Photo 5: Cacapon River, WV.

The use of fish as biological indicators has been historically alluded to by several investigators (Ortmann 1909; Forbes and Richardson 1913; Brinley 1942; Trautman 1957). More recently, with the systematic sampling of fish populations to evaluate biological integrity, scientists have described the specific advantages and disadvantages of fish as indicator organisms. What follows is a list based largely on Karr (1981) and Hocutt (1981):

Advantages

1. Long-lived: some families possess long lifespans.
2. Ubiquitous: fishes occur in a wide variety of habitats.
3. Extensively studied; there is a large amount of published information regarding the occurrence, habits, and habitats of fishes.
4. Diversity: North American fishes exhibit a wide range of feeding habits, reproductive traits, and tolerances to environmental perturbations.
5. Easily identified: relative to other groups of aquatic biota, fishes are among the easier groups to identify to the species level.
6. Well-known: many fish species are familiar to the general public and provide recreational opportunities.
7. Toxicity trends: presence/absence, growth, and recruitment data analysis may detect acute and sublethal effects.

Disadvantages

1. Manpower: with most sampling equipment, a three person crew is required to effectively and safely sample fish communities.
2. Migratory: the movement of fishes may provide misleading data.
3. Sampling bias: each sampling method (electroshocking, seining, etc.) has associated biases.

Commonly used terms

It is helpful to recognize commonly used terms for using freshwater fish as indicators of ecological health as well as the trophic classification of fish which is a critical attribute using in most fish indices.

Biological Indicator: A numerical value(s) derived from actual measurements, has known statistical properties, and conveys useful information for environmental decision making. It can be a measure, an index of measures, or a model that characterizes an ecosystem or one of its critical components (USEPA 2008).

Biological Integrity: The capability of supporting and maintaining a balanced, integrated, adapted community of organisms having a species composition, diversity, and functional organization comparable to the natural habitats of the region (Karr and Dudley 1981, adapted from Frey 1975).

Indicator Organism: An organism whose characteristics are used to point out the presence or absence of environmental conditions which cannot be feasibly measured from other taxa or the environment as a whole (slightly modified from Landres et al. 1988).

Ecological Health: A biological system can be considered healthy when its inherent potential is realized, its condition is stable, its capacity for self-repair when perturbed is preserved, and minimal external support for management is needed (Karr et al. 1986).

Trophic Classification of Fish

Trophic classifications of fish can be quite useful in bioassessments. For instance, the predominance of one type of feeding group over another may be a sign of decreased food supply or the potential harmful effects of pollutants. Typical trophic designations for fish include:

Piscivores
Feed on other fish (e.g., Rock Bass, Northern Pike, Largemouth Bass).

Herbivores
Feed on plant material (e.g., Chiselmouth, Grass Carp, Eastern Silvery Minnow).

Omnivores
Feed on anything available (e.g., Fathead Minnow, White Sucker).

Insectivores
Feed on insects (e.g., Lake Chub, Spotfin Shiner).

Filter feeders
Feed on zooplankton by straining the water through the gill rakers (e.g., Alewife, Paddlefish, Blueback Herring).

Invertivores
Feed on insects, mollusks, and crustaceans (e.g., Lake Sturgeon, American Shad).

Generalists
Known to feed on fish and macroinvertebrates (e.g., Fallfish, Blacknose Dace).

Index of Biotic Integrity (IBI)

Originally developed by Dr. James Karr, the Index of Biotic Integrity (IBI) (see Karr 1981) has been instrumental in evaluating the integrity of surface waters nationwide since the early 1980s. While initially developed to assess wadeable Midwestern streams, the index has since been adapted and calibrated for use in numerous regions and habitat types (e.g. Ohio EPA 1987; Simon and Emery 1995). Today, it remains an effective and adaptable tool, capable of detecting changes in the biological integrity of surface waters.

In general, the index is designed to evaluate changes in fish assemblages, using an integrated, multimetric approach. Karr (1981) advocated a method based on two fundamental community characteristics: species composition and richness and ecological factors. These two characteristics can be further broken down into seven overarching community traits: species richness and composition, presence of indicator species, trophic function, fish abundance, reproductive function,

Table 1. Original IBI Metrics (Karr 1981; Karr et al. 1986).

1.	**Total number of species** - A measure of the total number of species weighted to biogeographic region, stream size, and season.
2.	**Number of darter species** - Benthic fishes intolerant of environmental perturbations.
3.	**Number of sunfish species** - Quiet water inhabitants sensitive to changes in pool habitat; excludes black basses.
4.	**Number of sucker species** - A long-lived taxa sensitive to environmental perturbations.
5.	**Number of intolerant species** - Species sensitive to various environmental perturbations.
6.	**Percentage of Green Sunfish** - A species tolerant to changes in habitat and water quality.
7.	**Percentage omnivores** - Omnivores increase as specialist feeders decrease.
8.	**Percentage insectivorous cyprinids** - Specialist feeders that indicate the presence of a sufficient invertebrate food source.
9.	**Percentage top carnivores** - Top predators occur in balanced, trophically diverse ecosystems.
10.	**Number of individuals** - An overall measure of production; low catch per unit efforts may suggest toxic stressors.
11.	**Percentage hybrids** - Habitat degradation often decreases reproductive separation.
12.	**Percentage disease, tumors, fin damage, and skeletal anomalies** - Associated with toxic pollutants and biological contaminants.

and condition. The community traits are measured by twelve metrics, which may vary according to habitat type (e.g. wadeable stream vs. large river). The original IBI metrics proposed by Karr (1981) and Karr et al. (1986) are presented in Table 1. A modification of the original IBI metrics proposed by Simon and Emery (1995) for use in great rivers may be found in Table 2.

Once a study site is sampled, the results are compared to a baseline community or reference condition which represents a relatively undisturbed or "least impaired" state (Stoddard et al. 2006). Each individual metric is then assigned a numerical value by a qualified biologist in relation to the reference condition (Fore et al. 2003).

Table 2. Great River IBI Metrics (Simon and Emery 1995).

1.	**Total number of species** - A measure of species relative to including exotic species.
2.	**Proportion of round-bodied sucker species** - A long-lived taxa sensitive to environmental perturbations.
3.	**Proportion of large river faunal group** - A group of typical large river inhabitants (Pflieger 1971) that declines in proportion with habitat degradation.
4.	**Number of centrarchid species** - Quiet water inhabitants sensitive to changes in pool habitat; includes black basses.
5.	**Number of sensitive species** - Species sensitive to various environmental perturbations.
6.	**Number of tolerant species** - Species tolerant of various environmental perturbations.
7.	**Percentage simple lithophilous spawning fish** - Reduced with degraded habitat.
8.	**Percentage insectivores** - Insectivores are generally associated with higher quality systems.
9.	**Percentage carnivores** - Top predators occur in balanced, trophically diverse ecosystems.
10.	**Percentage omnivores** - Omnivores increase as specialist feeders decrease; an indicator of stream degradation.
11.	**Catch per unit effort** - An overall measure of production; low catch per unit efforts may suggest toxic stressors.
12.	**Percentage of individuals with disease, eroded fins, lesions and tumors** - Associated with toxic pollutants and biological contaminants.

Sampling Fish Populations

Photo 6: A sampler using a backpack electroshocker.

A wide array of procedures and protocols have been developed to sample inland fish populations. Electroshocking techniques (Photo 6) remain the most common approach to capture fishes, although seines (Photo 7) are also employed. Sampling designs and techniques are often based on several considerations, including desired standardization, sampling objectives, target population, the resources available, and time constraints.

Photo 7: A pair using a seine to capture various darters.

The site selection process depends heavily on the objectives of the study. Basin-wide studies may include multiple sites selected systematically or randomly to reduce bias, or consist of sites sampled historically. Watercourse access is also an important consideration, as private property often requires landowner permission and may impact logistical planning (boat access, etc.).

When sampling with the intent of performing a bioassessment of an individual study site, a representative stream reach is chosen, away from the influence of tributaries and bridges (Barbour et al. 1999). Sampling is conducted from a downstream barrier (photo 8) or riffle and proceeds in an upstream direction. U.S. EPA protocol calls for a minimum of two samplers to conduct one sweep of the sample area. Fishes are held in live wells before being identified, measured (if needed), and enumerated. Dubious specimens are preserved for laboratory identification. Voucher collections are made with the purpose of having all identifications confirmed by a second experienced taxonomist.

Electrofishing and seining techniques possess their own advantages and disadvantages. In order to understand how a sample may be biased, it's important to recognize the shortcomings of an individual methodology or technique. The following is paraphrased from Barbour et al. (1999):

Advantages/Disadvantages of electroshocking:

1. Time efficient
2. Appropriate for a wide array of habitats
3. Easily standardized
4. Selective of large fishes

Advantages/Disadvantages of seining:

1. Inexpensive and easy to maintain
2. Minimal impact on fish populations
3. Generally less effective for large fishes
4. Standardization is difficult

Photo 8: A downstream sampling blockade.

Fish Habitats

The fishes of North America occupy a variety of habitats, ranging from narrow roadside ditches to large rivers and lakes. The factors that may dictate the distribution of a particular species include climate, physiography, hydrology, stream size, biogeography, geochemistry, and human disturbance. The last factor has become increasingly important as a growing human population increases its demands on the natural environment.

While some fish species may be well distributed throughout a watershed, others may possess a more restricted range. For example, on a watershed scale, a species list made at point A (Fig. 7) and point D would likely be quite different. However, seasonal spawning migrations may place the species commonly found at point D at point A. Many species use these headwater habitats as nurseries for their young, including well-known game fishes such as Northern Pike (*Esox lucius*). Humans often fragment such pathways by constructing dams or altering swamp-like headwaters by ditching and draining. When this occurs, the reproductive success of highly migratory species becomes precarious if alternative waters cannot be found.

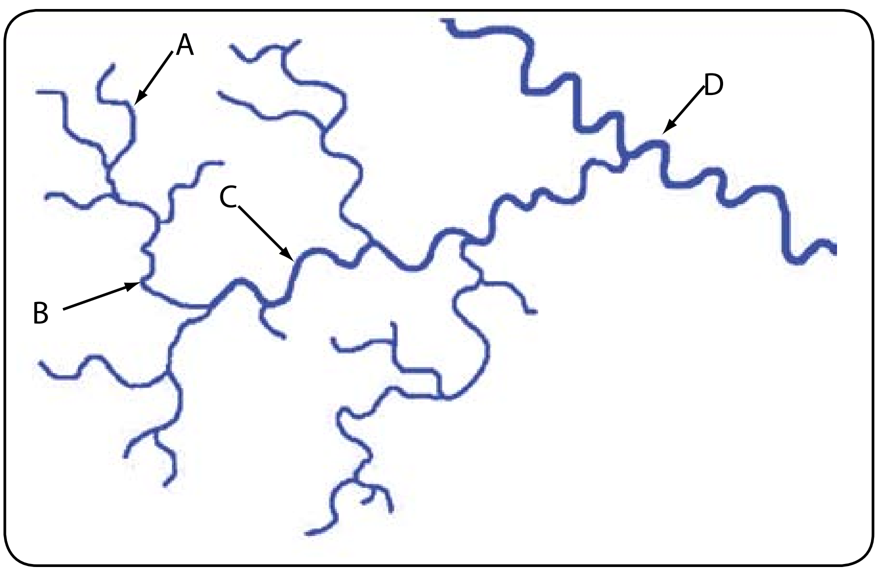


Figure 7: A hypothetical watershed. (A) Headwater, (B) Creek, (C) Small river, (D) Large river.

An interesting and often asked question is: "Why does species X occur in river system Y but not Z?" The answer may be related to available habitat or "biogeography." Biogeography is the study and interpretation of the past to explain present distributional patterns. It can greatly affect the expected species in a waterway or even the pollution tolerance of a species. For instance, Fausch et al. (1984) showed that the number of fish species will increase in proportion to the size of a watershed. When assigning pollution tolerance, some fish species at the edge of their range may be classified as intolerant since they are rare, so pollution tolerance throughout their entire range should be considered. So to answer the question above, biogeographers may look at historical connections between drainages, disturbance events (e.g. ice ages), and/or geology.

Photo 9: Floodplain during spring. The backwater channels and pools of floodplains are often breeding sites for a number of migratory fish species.

Photo 10: An agricultural headwater channel in a low-gradient region of the Midwest. Such channels are often highly modified and dominated by turbid flow regimes.

Family and Species Accounts

In North America, scientists have identified 1,151 extant fish species belonging to 37 taxonomic families (Jelks et al. 2008). This section details over 60 common freshwater species and subspecies and are organized within 11 families, with information on identification, habitat, pollution tolerance, and IBI use. The families include:

Lampreys (Petromyzontidae)

The lampreys are an ancient family of fishes, with fossils dating back to at least 280 million years ago. They are among the most distinctive fishes, lacking hinged lower jaws, paired fins, and possessing crudely developed skeletons. Some species are parasitic, while others, termed “brook lampreys,” spend the majority of their life filter-feeding from the water column while in the larval “ammocoete” stage.

Adult Chestnut Lamprey
(Ichthyomyzon castaneus)

Family Level Identifiers: Jaws and paired fins absent. Seven gill openings present on each side of fish. Body long, slender, and “snake-like.”

Habitat: The Petromyzontidae occur primarily in the Northern Hemisphere (Etnier and Starnes 1993), with approximately 20 species found in North America. They occupy a wide range of habitats, from headwater creeks to large glacial lakes. While probably most abundant in sand and gravel substrates, ammocoetes often burrow into organic sands. Ammocoetes and adults may significantly differ in habitat requirements.

Pollution Tolerance: In general, the lampreys are considered “intermediate” to “intolerant” of pollution and habitat disturbance (Barbour et al. 1999). Ammocoetes generally require clear water, permanent flow, and stable beds of fine textured substrates mixed with organic matter (Pflieger 1997). Trautman (1981) reported the sensitivity of a number of lamprey species to disturbance and siltation, including the Silver Lamprey (*Ichthyomyzon unicuspis*), Mountain Brook Lamprey (*Ichthymyzon greeleyi*), and Least Brook Lamprey (*Lamptera aepyptera*). Jenkins and Burkhead (1994) suggested that *I. bdellium* functions an “indicator of good water and substrate quality”. Rice and Michael (2001) noted that the decline of the Ohio Lamprey (*Ichthyomyzon bdellium*) was likely a result of the systematic damming of the Ohio River.

Table 3. Overview of Pollution Tolerance for Family Petromyzontidae.*

(Review by Barbour et al. 1999)		
Tolerant	**Intermediate**	**Intolerant**
0%	37%	63%

*8 species rated

Ammocoetes

The Petromyzontidae have a unique life cycle, where a significant period of time is spent as an "ammocoete," or larval lamprey. Ammocoetes are quite different than adult lamprey, lacking teeth, the disc-like mouth, and functional eyes. They feed by burrowing into fine substrates and filtering microorganisms and detritus until metamorphosis occurs.

Use in IBI: The Petromyzontidae are not evaluated by a single metric, but may be accounted for under general metrics such as *Metric 1: Total number of fish species* and *Metric 10: Number of individuals.* If alternative metrics that account for exotic species are utilized, the Sea Lamprey (*Petromyzon marinus*) (photo left) may be enumerated under such a metric if collected outside its native range. In addition, due to a number of lamprey being intolerant species, the Petromyzontidae may also be included under *Metric 5: Number of intolerant species*.

Table 4. Tolerance designations for selected petromyzontids.

Common Name	Scientific Name	Ohio EPA 1987	Jester et al. 1992		Lyons 1992	Whittier and Hughes 1998	Barbour et al. 1999	Halliwell et al. 1999	Pirhalla 2004
			WQ	Habitat				Habitat	
Ohio Lamprey	*Ichthyomyzon bdellium*	S	-	-	-	-	I	M	-
Chestnut Lamprey	*Ichthyomyzon castaneus*	-	MI	I	-	-	M	-	-
Northern Brook Lamprey	*Ichthyomyzon fossor*	R	-	-	-	-	I	I	-
Southern Brook Lamprey	*Ichthyomyzon gagei*	-	I	I	-	-	I	-	-
Mountain Brook Lamprey	*Ichthyomyzon greeleyi*	S	-	-	-	-	I	I	-
Silver Lamprey	*Ichthyomyzon unicuspis*	-	-	-	-	-	M	I	-
Least Brook Lamprey	*Lamptera aepyptera*	-	-	-	-	-	M	-	T
American Brook Lamprey	*Lamptera appendix*	R	-	-	-	-	I	I	-
Sea Lamprey	*Petromyzon marinus*	-	-	-	-	-	M	M	MI

I = intolerant M = intermediate MI = moderately intolerant MT = moderately tolerant
P = moderately tolerant R = rare intolerant S = special intolerant T = tolerant

Chestnut Lamprey
(*Ichthyomyzon castaneus*)

Identification: Adult parasitic. *Adults* (A): Body long and cylindrical, with a low dorsal fin separated by a small notch. Coloration brown to brownish-olive dorsally; belly lighter in color. Sides may be mottled. *Ammocoetes* (B): Coloration generally paler than adults (Boschung and Mayden 2004).

General Distribution/Habitat: Distributed throughout the Mississippi River basin, Lake Michigan basin, Red River (of the North) basin, and a few Gulf drainages. Adults occur in rivers and reservoirs, while ammocoetes and breeding adults are found in small, headwater streams. Adults are generally found in current over sand and gravel, whereas ammocoetes are often more abundant in low-gradient headwaters in organic sand, muck, and silty substrates.

Indicator Use/IBI (1, 10): The Chestnut Lamprey is vulnerable to river and stream modifications that fragment its habitat and disconnect historical spawning sites. State and regional tolerance classifications rank *I. castaneus* as both an "intermediate" (Barbour et al. 1999) and "intolerant" species (Jester et al. 1992). The Chestnut Lamprey scores under IBI metrics 1 and 10. If considered a sensitive species, the Chestnut Lamprey also scores under metric 5.

American Brook Lamprey
(*Lamptera appendix*)

Identification: Adult non-parasitic. *Adults:* Body long and cylindrical, with "2" dorsal fins separated by a deep notch. Coloration gray to grayish-olive dorsally; belly white; fins may have a yellowish tinge. *Ammocoetes:* Dorsal fins may be separate (Jenkins and Burkhead 1994). Coloration generally brown dorsally; belly white.

General Distribution/Habitat: Widely but somewhat disjunctly distributed throughout the Mississippi River basin, Great Lakes-St. Lawrence basin, and Atlantic slope. Generally found in large creeks and small rivers. Adults occur over sand and gravel substrates, whereas ammocoetes may be more common in organic sand or organic sand and fine gravel substrates.

Indicator Use/IBI (1, 5, 10): The American Brook Lamprey is generally considered sensitive to pollution, turbidity, siltation, and migrational barriers such as dams (Eddy and Underhill 1974; Becker 1983). State and regional tolerance classifications rank *L. appendix* as an "intolerant" species (Ohio EPA 1987; Halliwell et al. 1999). As a sensitive species, the American Brook Lamprey scores under IBI metrics 1, 5, and 11.

STURGEONS (ACIPENSERIDAE)

In the freshwater systems of North America, there are few creatures as large, primitive, and enigmatic as the sturgeon. Unfortunately, populations of these magnificent fishes have been declining since the turn of the century, a result of large river impoundment, siltation, and the overharvesting of females for caviar. The U.S. Fish and Wildlife Service currently lists four species of sturgeon as federally endangered.

Family Level Identifiers: Body robust. Several rows of longitudinal plates. Dorsal and anal fin set posteriorly. Four barbels underneath snout. Sturgeon are among the largest fish found in the freshwater systems of North America.

Habitat: Most sturgeon species inhabit large rivers, lakes, and marine environments. It should be noted that some species are chiefly marine, and migrate to freshwaters only to spawn (anadromous). Preferred substrates include clean sand and gravel, where they feed on snails, small mussels, and a variety of benthic organisms.

Pollution Tolerance: Pollution tolerance among the sturgeons varies from species to species. River modifications, mainly dams, have perhaps had the greatest impact on this family, severely limiting the ability of many species to access historic spawning waters and silting formerly suitable habitats (Trautman 1981). Trautman (1981) commented on the decline of Lake Sturgeon in Lake Erie and its tributaries: “The decline in sturgeon abundance appears to have been chiefly caused by the inability of the fish to reach its spawning grounds because of dams; by having the former spawning habitat destroyed by silting, pollution, or drainage; and by destruction of the great quantities of mussels and gastropods in both the streams and Lake Erie.” Jenkins and Burkhead (1994) commented that the Acipenseridae may also be particularly susceptible to overfishing due to their long lifespans.

Shovelnose Sturgeon
(Scaphirhynchus platorynchus)

Table 5. Overview of Pollution Tolerance for Family Acipenseridae.*

(Review by Barbour et al. 1999)		
Tolerant	**Intermediate**	**Intolerant**
0%	50%	50%

*4 species rated

Evolution, Diversity, and Distribution

The sturgeons are among the most ancient fishes found in North America, with fossils dating back to at least the upper Cretaceous period (70 million years ago). At present 25 species have been identified worldwide, with the majority of species found in central and eastern Europe. In North America, eight species belonging to two genera occur, with diversity maximized in the waters of the southern United States.

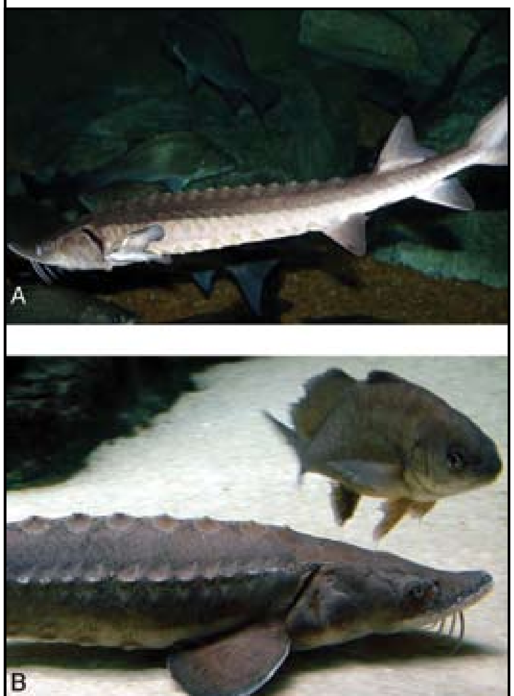
Use in IBI: Karr's (1981) IBI does not include a metric for the sturgeon family. When appropriate, intolerant sturgeon species might be included in *Metric 5: Number of intolerant species.* Otherwise, their presence is recorded under general metrics such as *Metric 1: Total number of fish species* and *Metric 10: Number of individuals*.

Table 6. Tolerance designations for selected acipenserids.

Common Name	Scientific Name	Ohio EPA 1987	Jester et al. 1992		Lyons 1992	Whittier and Hughes 1998	Barbour et al. 1999	Halliwell et al. 1999	Pirhalla 2004
			WQ	Habitat				Habitat	
Shortnose Sturgeon	*Acipenser brevirostrum*	-	-	-	-	-	I	-	-
Lake Sturgeon	*Acipenser fulvescens*	-	-	-	-	-	M	-	-
Green Sturgeon	*Acipenser medirostris*	-	-	-	-	-	-	-	-
Atlantic Sturgeon	*Acipenser oxyrhynchus*	-	-	-	-	-	I	-	-
White Sturgeon	*Acipenser transmontanus*	-	-	-	-	-	-	-	-
Pallid Sturgeon	*Scaphirhynchus albus*	-	-	-	-	-	-	-	-
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*	-	MI	I	-	-	M	-	-

I = intolerant M = intermediate MI = moderately intolerant MT = moderately tolerant
P = moderately tolerant R = rare intolerant S = special intolerant T = tolerant

Lake Sturgeon
(Acipenser fulvescens)



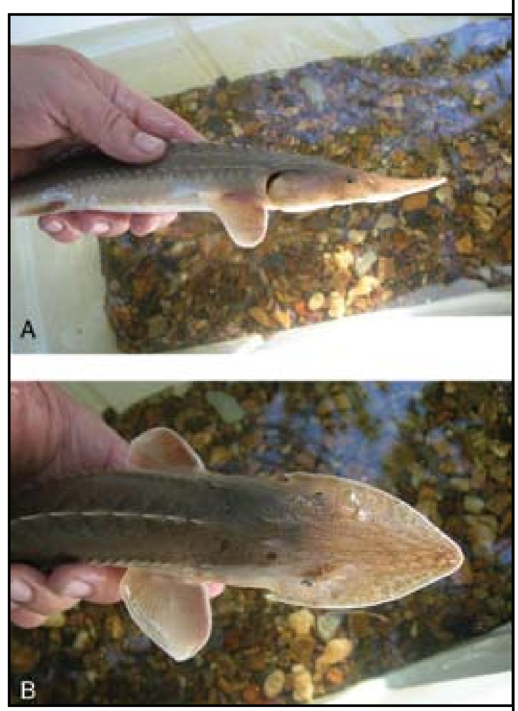
Identification: Body elongate and robust, with a short, pointed, conical snout (B). Caudal peduncle partially plated. Barbels on lower snout 4, smooth in texture. Coloration dusky gray dorsally; sides gray; belly grayish white to white. Dorsal plates 9-17; dorsal fin rays 35-40; anal fin rays 25-30. Caudal fin forked and without a filament.

General Distribution/Habitat: Distributed in the upper Mississippi River basin, Great Lakes-St. Lawrence basin, and Hudson Bay basin. Generally rare throughout is range. Occurs in large rivers and lakes. Often found over coarse substrates where mollusks, crustaceans, and insects are abundant.

Indicator Use/IBI (1, 10): A highly migratory species, the decline of the Lake Sturgeon has been attributed to the widespread damming of rivers, pollution, siltation, and overfishing (Trautman 1981; Boschung and Mayden 2004). In a review of state and regional tolerance classifications, Barbour et al. (1999) reported an “intermediate” ranking for *A. fulvescens*. The Lake Sturgeon scores under IBI metrics 1 and 10, although may also score under metric 5 if considered an “intolerant” species.

Shovelnose Sturgeon
(Scaphirhynchus platorynchus)

Identification: Body elongate and robust, with a long, wide, pointed, and flattened snout (B). Tail tapering and slender; caudal peduncle completely plated. Barbels on lower snout 4, coarsely fringed. Dorsal plates 13-19; dorsal fin rays 29-36; anal fin rays 18-24. Caudal fin asymmetrically forked and often with a long filament.



General Distribution/Habitat: Widely distributed throughout Mississippi River basin and historically from the Rio Grande River (Etnier and Starnes 1993). Occurs mainly in rivers where the current is moderate to swift. Most abundant over clean-swept, coarse substrates.

Indicator Use/IBI (1, 10): The Shovelnose Sturgeon has experienced declines throughout its range due to the impoundment of large rivers, which inhibit access to historical spawning grounds and reduce current (Helms 1974; Robison and Buchanan 1988; Etnier and Starnes 1993). It has been reported to tolerate turbid waters (Robison and Buchanan 1988). Regional and state tolerance classifications range from “intermediate” (Barbour et al. 1999) to “intolerant” (Jester et al. 1992). The Shovelnose Sturgeon scores under IBI metrics 1 and 10, although may also score under metric 5 if considered an “intolerant” species.

Minnows (Cyprinidae)

Cyprinidae represents the most diverse family of fishes in all the world. Presently, over 2000 species and 210 genera have been described (Boschung and Mayden 2004). Of the 2000 identified species, nearly 300 are found in North America, with the greatest diversity occurring in the waters of the southern United States. While often thought of as small, silvery fish, members of the minnow family often possess elegant characters and magnificent coloration.

Family Level Identifiers: Body often elongate (with exceptions). Dorsal rays 9 or fewer. Fins generally soft and flexible.

Habitat: Minnows occupy nearly every freshwater habitat found in North America, including headwater streams, creeks, rivers, ponds, lakes, swamps, and marshes. They are well-known for their tendency to form large schools, which they may utilize for protection, spawning, or enhanced foraging (Morgan and Colgan 1987; Freeman and Grossman 1992; Pitcher 1993).

Pollution Tolerance: Pollution tolerance among the cyprinids varies from species to species. To illustrate this, consider the following: two geographically ubiquitous minnows, the Bluntnose Minnow (*Pimephales notatus*) and Spotfin Shiner (*Cyprinella spiloptera*) have exhibited tolerance to turbidity, disturbance, and pollution (Trautman 1981). Another cyprinid with a more restricted distribution, the Streamline Chub (*Erimystax dissimilis*), is only found in pristine large creeks and rivers (Etnier and Starnes 1993), and serves as an excellent indicator of high quality habitat. Interspecific disparities like these and the intolerance of some species to all but near pristine habitats promote the use of the Cyprinidae as sensitive indicators of waterway integrity (Jenkins and Burkhead 1994).

Table 7. Overview of Pollution Tolerance for Family Cyprinidae.*

(Review by Barbour et al. 1999)		
Tolerant	**Intermediate**	**Intolerant**
17%	47%	36%

*76 species rated

Bluenose Shiner (*Pteronotropis welaka*)

Tricolor Shiner (*Cyprinella trichroistia*)

Nest Builders

Among the nest building behaviors exhibited by the Cyprinidae, the expertise of the genus *Nocomis* may be unmatched. While some minnow species excavate simple pits, the *Nocomis* chubs have been known to assemble nests consisting of several thousand stones (Reighard 1943). Nest construction such as this may take 20 to 30 hours (Jenkins and Burkhead 1994) while the male transports stones with his mouth.

Use in IBI: Cyprinids are an integral part of IBI scoring in most regions. For example, *Metric 8: Percentage insectivorous cyprinids*, utilizes specialist minnow species who feed chiefly on insects. Alternatively, *Metric 7: Percentage omnivores* accounts for cyprinids that are generalist feeders, an indicator of stream degradation (i.e. specialists vs. generalists). Cyprinids such as the Creek Chub and some dace species are often substituted for Green Sunfish in *Metric 6: Percent Green Sunfish*. Additionally, pollution intolerant cyprinids would be accounted for in *Metric 5: Number of intolerant species.*

Table 8. Tolerance designations for selected cyprinids.

Common Name	Scientific Name	Ohio EPA 1987	Jester et al. 1992		Lyons 1992	Whittier and Hughes 1998	Barbour et al. 1999	Halliwell et al. 1999	Pirhalla 2004
			WQ	Habitat				Habitat	
Stoneroller Minnow	*Campostoma anomalum*	-	MI	MI	-	-	M	T	MI
Redside Dace	*Clinostomus elongatus*	I	-	-	-	-	I	I	-
Rosyside Dace	*Clinostomus funduloides*	S	-	-	-	-	I	-	MI
Spotfin Shiner	*Cyprinella spiloptera*	-	I	I	-	-	M	T	MI
Tricolor Shiner	*Cyprinella trichroistia*	-	-	-	-	-	-	-	-
Common Carp	*Cyprinus carpio*	T	T	T	T	T	T	T	-
Streamline Chub	*Erimystax dissimilis*	R	-	-	-	-	I	I	-
Gravel Chub	*Erimystax x-punctatus*	M	I	I	-	-	M	I	-
Crescent Shiner	*Luxilus cerasinus*	-	-	-	-	-	-	-	-
Striped Shiner	*Luxilus chrysocephalus*	-	MI	MI	-	-	M	T	-
Common Shiner	*Luxilus cornutus*	-	-	-	-	M	M	M	I
Pearl Dace	*Margariscus margarita*	-	-	-	-	-	M	M	-
Hornyhead Chub	*Nocomis biguttatus*	I	-	-	-	-	I	M	-
River Chub	*Nocomis micropogon*	I	-	-	-	-	I	M	I
Bigeye Chub	*Notropis amblops*	I	I	I	-	-	I	M	-
Bigeye Shiner	*Notropis boops*	R	MI	I	-	-	I	-	-
Silverjaw Minnow	*Notropis buccatus*	-	-	-	-	-	M	T	I
Rosyface Shiner	*Notropis rubellus*	I	I	I	I	-	I	I	I
Pugnose Minnow	*Opsopoeodus emiliae*	R	-	-	-	-	I	-	-
Southern Redbelly Dace	*Phoxinus erythrogaster*	-	I	I	-	-	M	-	-
Bluntnose Minnow	*Pimephales notatus*	T	MT	MT	T	-	T	T	MI
Fathead Minnow	*Pimephales promelas*	T	T	T	T	I	T	T	T
Blacknose Dace	*Rhinichthys atratulus*	T	-	-	T	-	T	T	T
Longnose Dace	*Rhinichthys cataractae*	R	-	-	-	-	I	M	MI
Creek Chub	*Semotilus atromaculatus*	T	MI	MI	T	M	T	T	T
Fallfish	*Semotilus corporalis*	-	-	-	-	M	M	M	MI

I = intolerant M = intermediate MI = moderately intolerant MT = moderately tolerant
P = moderately tolerant R = rare intolerant S = special intolerant T = tolerant

Stoneroller Minnow
(Campostoma anomalum)

A

B

Identification: Body somewhat cylindrical and robust anteriorly; becoming quite deep in older individuals. Coloration olive-brown dorsally with brassy and brown sides; belly white. Breeding males often covered with tubercles; also with dark medial bands present on the dorsal and anal fin. Mouth subterminal to slightly inferior, with cartilaginous edge on lower lip. Dorsal fin rays 8; anal fin rays 7; pectoral fin rays 15; pelvic fin rays 8. All fins somewhat small.

General Distribution/Habitat: Well distributed throughout the Mississippi River basin, Great Lakes basin, western Gulf slope, and mid-Atlantic region. Occurs in flowing sections of creeks and rivers, less common in lakes and impoundments (Becker 1983). Most abundant over coarse substrates.

Indicator Use/IBI (1, 10): The Central Stoneroller may be best described as an "intermediate" species, capable of spawning under various conditions (Becker 1983) and tolerant of moderate turbidity (Trautman 1981; Becker 1983). Regional and state tolerance classifications have ranked the Central Stoneroller as "tolerant" (Halliwell et al. 1999) as well "moderately intolerant" (Jester et al. 1992; Pirhalla 2004). *C. anomalum* under metrics that evaluate community diversity and abundance.

Redside Dace
(Clinostomus elongatus)

Identification: Body slender, moderately deep, and laterally compressed. Coloration generally olive dorsally and silvery, with a conspicuous red streak or smudge posterior of opercle. Breeding males with small, irregularly spaced tubercles. Mouth terminal, large, with a projecting lower jaw. Dorsal fin rays 8; anal fin rays 9; pectoral fin rays 14-16; pelvic fin rays 8. Caudal fin emarginate to forked.

A

B

General Distribution/Habitat: Disjunctly distributed throughout the upper Mississippi basin, Great Lakes basin, and upper Susquehanna River basin. Generally confined to small, headwater streams and creeks. Thrives in flowing pools where the water is cool and clear. Most abundant over clean substrates of gravel and sand.

Indicator Use/IBI (1, 5, 8, 10): With somewhat narrow habitat requirements, the Redside Dace is a sensitive headwater species confined to relatively undisturbed habitats. It is reportedly sensitive to turbidity, thermal stress, and channel modification (Scott and Crossman 1973; Trautman 1981; Becker 1983). State and regional tolerance classifications generally rank *C. elongatus* as an "intolerant" species (Ohio EPA 1987; Halliwell et al. 1999). As a sensitive insectivorous cyprinid, the Redside Dace scores under numerous IBI metrics, including metrics 1, 5, 8, and 10.

Common Carp (Mirror variety)
(Cyprinus carpio)

Identification: Body robust, deep, with a "humped" profile anterior of the dorsal fin. Coloration dark olive to smoky brown; color fading on belly to yellow-white. Mouth subterminal, with two barbels present on each side of mouth. Breeding males with fine tubercles. Dorsal fin with 1 spinous ray and 15-23 soft rays; anal fin with 1 spinous ray and 4-6 soft rays; pectoral fin rays 14-17; pelvic fin rays 8-9. Caudal fin emarginate to forked.

General Distribution/Habitat: Widespread throughout the United States. A habitat generalist, the carp is found in creeks, rivers, lakes, and marshes. It is most abundant in shallow, warmwater habitats where the current is sluggish. The carp may be found over coarse or soft substrates.

Indicator Use/IBI: A tolerant exotic species introduced into North America during the 1800s, the Asian Carp is capable of tolerating low dissolved oxygen levels, thermal stress, turbidity, and pollution (McKay 1963; Becker 1983). Several state and regional tolerance classifications rank the carp as a "tolerant" species (Ohio EPA 1987; Jester et al. 1992; Halliwell et al. 1999; Whittier 1999). As an exotic species, the Asian Carp may or may not be included in general community diversity and abundance metrics. If exotic species are included in the IBI, Asian Carp may be enumerated under *Metric 7: Percent Omnivores*.

Streamline Chub
(Erimystax dissimilis)

Identification: Body slender, elongate, and terete. Coloration olive dorsally with a silvery belly; several lateral blotches present extending from the opercle to caudal peduncle. Mouth small and horizontal. Breeding males with very small tubercles. Dorsal fin rays 8; anal fin rays 7; pectoral fin rays 16-19; pelvic fin rays 8. Caudal fin forked.

General Distribution/Habitat: Disjunctly distributed throughout the Ohio River basin. Typically found in large creeks and rivers in relatively shallow water (<1.5 m) and moderate current. Most abundant over substrates of clean sand, gravel, and rubble.

Indicator Use/IBI (1, 5, 8, 10): The Streamline Chub occurs in clear, relatively pristine large creeks and rivers (Etnier and Starnes 1993). Trautman (1981) noted the disappearance of *E. dissimilis* from several silted riffles and shoals throughout Ohio. The return of the Streamline Chub to historically disturbed or polluted creeks and rivers may indicate progress towards recovery. State and regional tolerance classifications generally rank the Streamline Chub as an "intolerant" species (Ohio EPA 1987; Halliwell et al. 1999). As a sensitive insectivorous cyprinid, the Streamline Chub scores under numerous IBI metrics, including metrics 1, 5, 8, and 10.

Gravel Chub
(Erimystax x-punctatus)

Identification: Body slender, elongate, and terete. Coloration generally olive dorsally with a silvery belly and conspicuous mid-lateral "X" or "Y" markings (B). Mouth small and horizontal. Breeding males with very small tubercles. Dorsal fin rays 8; anal fin rays 7; pectoral fin rays 13-16; pelvic fin rays 8. Caudal fin forked.


A


B

General Distribution/Habitat: Distributed throughout the Mississippi River basin. Occurs in large creeks and rivers in moderately shallow water (<2 m) and slow to swift current. Generally most abundant over substrates of clean sand, gravel, and rubble. Trautman (1981) noted that the Gravel Chub may utilize habitats deeper and slower than the Streamline Chub (*E. dissimilis*).

Indicator Use/IBI (1, 8, 10): Like its close relative the Streamline Chub, the Gravel Chub is found mainly in pristine large creeks and rivers. It is considered sensitive to turbidity, siltation, impoundment, and pollution (Trautman 1981; Becker 1983; Robison and Buchanan 1988). Regional and state tolerance classifications have conferred both an "intermediate" (Ohio EPA 1987) and "intolerant" status (Jester et al. 1992; Halliwell 1999) to this species. As an insectivorous cyprinid, the Gravel Chub generally scores under IBI metrics 1, 8, and 10.

Crescent Shiner
(Luxilus cerasinus)


A


B

Identification: Body deep and laterally compressed; often with darkened and distinctive "crescents." Body coloration silvery; olive dorsally. Fins often with red edges. Breeding males with brilliant cherry red fins, lips, and body; moderate sized tubercles. Mouth terminal. Dorsal fin rays 8; anal fin rays 9; pectoral fin rays 14-17; pelvic fin rays 8. Caudal fin forked.

General Distribution/Habitat: Restricted to the mid-Atlantic slope, perhaps most abundant in the Roanoke drainage (Jenkins and Burkhead 1994) (B). Occurs in creeks and small rivers in flowing pools, runs, and riffles. Generally found in moderate to high-gradient stream sections (Jenkins and Burkhead 1994). May be found over both coarse and soft substrates.

Indicator Use/IBI (1, 8, 10): Although the Crescent Shiner may be sensitive to sharp decreases in temperature and dissolved oxygen, *L. cerasinus* has been reported as tolerant of turbidity (Matthews and Styron 1981; Jenkins and Burkhead 1994). Due to its relatively restricted range, tolerance rankings have not been developed for *L. cerasinus*. As an insectivorous cyprinid, the Crescent Shiner scores under IBI metrics 1, 8, and 10.

Striped Shiner
(Luxilus chrysocephalus)

Identification: Body somewhat robust and moderately compressed. Coloration olive-gray dorsally with silvery sides; may have a metallic sheen. Mouth terminal. Breeding males (A-B) with a brassy sheen, pinkish-red fin margins, and moderate to large tubercles (B). Dorsal fin rays 8; anal fin rays 9; pectoral fin rays 14-16; pelvic fin rays 8. Caudal fin forked.

General Distribution/Habitat: Widespread throughout the Mississippi River basin, Great Lakes basin, and Gulf slope. Most common in small and large creeks, although it may be found in rivers. Usually occurs in flowing pools where the current is moderate. Generally found over both coarse and fine substrates.

Indicator Use/IBI (1, 8, 10): In Ohio, Trautman commented that the Striped Shiner seemed to adapt better to warmer and turbid water than the Common Shiner (*Luxilus cornutus).* Interestingly, Pflieger (1971) observed that the Common Shiner was more common in turbid, prairie streams while the striped shiner was abundant in cool, clear, upland streams. State and regional tolerance classifications range from “moderately intolerant” (Jester et al. 1992) to “tolerant” (Halliwell et al. 1999). As an insectivorous cyprinid, the Striped Shiner scores under IBI metrics 1, 8, and 10.

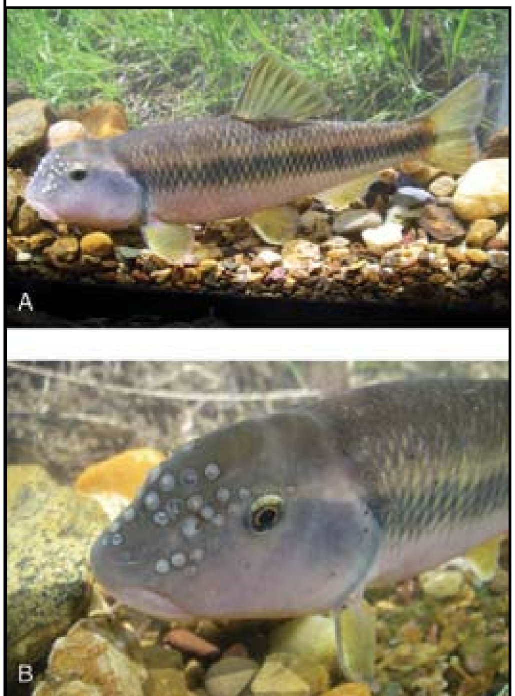
Common Shiner
(Luxilus cornutus)

Identification: Body somewhat deep and moderately compressed. Coloration olive-blue or olive-gray dorsally with silvery sides; may have a metallic sheen. Scales crowded anterior of dorsal fin. Mouth terminal. Breeding males (A) with a brassy sheen, pinkish-red fin margins, and moderate to large tubercles. Dorsal fin rays 8; anal fin rays 9; pectoral fin rays 15-17; pelvic fin rays 8. Caudal fin forked.

General Distribution/Habitat: Widely distributed in the upper Mississippi River basin, Great Lakes basin, and northern Atlantic slope. Typically occurs in creeks (B) and rivers, although *L. cornutus* may also be found in lakes (Becker 1983). Most abundant in sluggish or moderate current over coarse and fine substrates.

Indicator Use/IBI (1, 8, 10): In Ohio, Trautman (1981) considered the Common Shiner more sensitive to silt and turbid waters than the Striped Shiner (*L. chrysocephalus*). Becker (1983) noted that the “common shiner in nature adjusts to a wide range of average temperatures”. State and regional tolerance classifications for *L. cornutus* range from “intermediate” (Halliwell et al. 1999; Whittier 1999) to “intolerant” (Pirhalla 2004). As an insectivorous cyprinid, the Common Shiner scores under IBI metrics 1, 8, and 10.

River Chub
(Nocomis micropogon)



Identification: Body robust with small eye. Coloration dark olive to yellow dorsally, often with a faint rosy hue present on the belly and head (especially breeding males). Breeding males with conspicuous tubercles on snout (B). Mouth subterminal. Dorsal fin rays 8; anal fin rays 7; pectoral fin rays 15-19; pelvic fin rays 8. Caudal fin emarginate to slightly forked.

General Distribution/Habitat: Distributed throughout the eastern Mississippi River basin, Great Lakes basin, and Atlantic slope. Occurs in creeks and rivers in shallow water where the current is moderate to strong. Generally found over coarse substrates such as gravel, cobble, boulder, and bedrock rubble.

Indicator Use/IBI (1, 5, 8, 10): The River Chub is an inhabitant of high quality stream reaches of clear water and good current. Excessive turbidity and siltation often results in rapid population declines or outright extirpation (Trautman 1981). State and regional tolerance classifications rank *N. micropogon* as both an “intermediate” (Halliwell 1999) and “intolerant” species (Ohio EPA 1987; Halliwell et al. 1999; Pirhalla 2004). As a sensitive insectivorous cyprinid, the river chub scores under numerous IBI metrics, including metrics 1, 5, 8, and 10.

Silverjaw Minnow
(Notropis buccatus)

Identification: Body elongate and head dorsally depressed. Large “chambers” occur on the cheek and jaw (B, see arrow). Coloration olive or yellowish dorsally; side silvery with a dark lateral line. Breeding males with minute tubercles. Mouth subterminal. Dorsal fin rays 8; anal fin rays 8; pectoral fin rays 14-16; pelvic fin rays 8. Caudal fin forked.

General Distribution/Habitat: Generally (and disjunctly) distributed throughout the eastern Mississippi River basin, Great Lakes basin, mid-Atlantic slope, and Gulf slope. Occurs in creek and rivers in sluggish to moderate current. Often most abundant in sandy pools, although may occur over a variety of substrates.

Indicator Use/IBI (1, 8, 10): The Silverjaw Minnow is moderately tolerant of turbidity, industrial pollutants, and has been documented to persist in streams impacted by coal mining waste (Trautman 1981; Jenkins and Burkhead 1994). However, Trautman (1981) noted that it may be sensitive to excessive siltation. State and regional tolerance classifications rank *N. buccatus* as both “tolerant” (Halliwell 1999) and “intolerant” (Pirhalla 2004). As an insectivorous cyprinid, the Silverjaw Minnow scores under IBI metrics 1, 8, and 10.

Rosyface Shiner
(Notropis rubellus)

Identification: Body elongate and laterally compressed. Coloration olive-gray dorsally with a silvery side; lateral stripe often faint. Breeding males with a brilliant rose colored snout and cheek (B); small tubercles may also be present. Mouth terminal. Dorsal fin rays 8; anal fin rays 10; pectoral fin rays 12-14; pelvic fin rays 8. Caudal fin forked.

General Distribution/Habitat: Widely distributed throughout the Mississippi River basin, Great Lakes-St. Lawrence basin, Red River (of the North) basin, and Atlantic slope. Most common in creeks and rivers where the water is shallow and the current moderate. Generally found over sand, gravel, cobble, and boulder substrates.

Indicator Use/IBI (1, 5, 8, 10): The Rosyface Shiner is intolerant of turbidity and siltation, with marked declines occurring where such conditions predominate (Trautman 1981; Robison and Buchanan 1988). Interestingly, Becker (1983) noted the development of a turbidity resistant strain in the Pecatonica and Sugar River basins of southwestern Wisconsin. State and regional tolerance classifications consistently rank the Rosyface Shiner as an “intolerant” species (Ohio EPA 1987; Jester et al. 1992; Halliwell et al. 1999; Jennings et al. 1999; Pirhalla 2004). As a sensitive insectivorous cyprinid, *N. rubellus* scores under IBI metrics 1, 5, 8, and 10.

Pugnose Minnow
(Opsopoeodus emiliae)

Identification: Body slender and somewhat compressed laterally. Coloration brownish-yellow to greenish dorsally; silvery sides, with a distinctive lateral stripe. Breeding males with tubercles around snout; anal and caudal fins may have a pinkish-red hue. Mouth distinctive, small, and superior (B, see arrow). Dorsal fin rays 9; anal fin rays 8; pectoral fin rays 15; pelvic fin rays 8. Caudal fin forked.

General Distribution/Habitat: Widely distributed in the Mississippi River basin, Gulf slope, southern Atlantic slope, Lake Michigan drainage, and Lake Erie drainage. Most abundant in large creeks and rivers where the current is sluggish to absent. May also occur in lakes. Often found near stream vegetation over both fine and coarse substrates.

Indicator Use/IBI (1, 5, 8, 10): The Pugnose Minnow has been considered intolerant of siltation and turbidity (Smith 1979; Trautman 1981). Becker (1983) noted that populations were being reduced or extirpated throughout its northerly distribution. State and regional tolerance classifications have ranked the Pugnose Minnow as an “intolerant” species (Ohio EPA 1987). As a sensitive insectivorous cyprinid, the Pugnose Minnow scores under IBI metrics 1, 5, 8, and 10.

Bluntnose Minnow
(Pimephales notatus)

Identification: Body cylindrical and somewhat compressed. Coloration olive-gray dorsally with silvery sides; often with a prominent lateral stripe. A wedge-shaped blotch on the caudal peduncle may be present. Breeding males with moderately-sized tubercles on snout (B). Mouth subterminal. Dorsal fin rays 8; anal fin rays 7; pectoral fin rays 15-16; pelvic fin rays 8. Caudal fin forked.

General Distribution/Habitat: Widely distributed throughout the Mississippi River basin, Great Lakes-St. Lawrence basin, northern and mid-Atlantic slope, Gulf slope, and Red River (of the North) drainage. Occurs in headwater streams, creeks, river, impoundments, and glacial lakes. May be found in sluggish or moderate current over both coarse and fine substrates.

Indicator Use/IBI (1, 7, 10): A habitat generalist, the Bluntnose Minnow is one of the most successful fishes in the United States (Trautman 1981; Becker 1983). It has been reported to tolerate disturbance, turbidity, and siltation (Trautman 1981; Becker 1983; Boschung and Mayden 2004). State and regional tolerance classifications rank *P. notatus* as "moderately intolerant" (Pirhalla 2004) to "tolerant" (Ohio EPA 1987; Halliwell et al. 1999). As an omnivorous cyprinid, *P. notatus* scores under IBI metrics 1, 7, and 10.

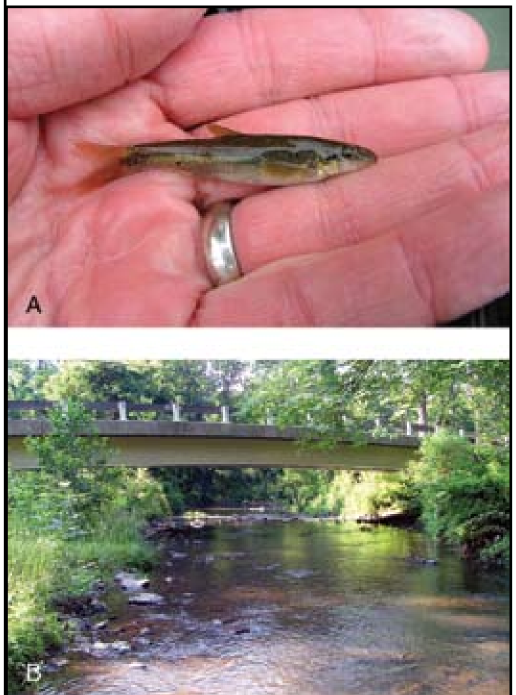
Blacknose Dace
(Rhinichthys atratulus)

Identification: Body elongate and somewhat robust. Coloration brown-gray dorsally; side yellowish-white or silvery, often with a prominent dark brown or black lateral stripe. Breeding males characterized by bright red fins and rusty colored lateral band (A). Mouth subterminal. Dorsal fin rays 8; anal fin rays 7; pectoral fin rays 13-16; pelvic fin rays 8. Caudal fin forked.

General Distribution/Habitat: Widely distributed throughout the upper Mississippi River basin, Great Lakes-St. Lawrence basin, Red River of the North drainage, and northern to mid-Atlantic slope. Generally confined to headwater streams and creeks (B) where the water is cool to warm and the current moderate to strong. Occurs over both coarse and fine substrates.

Indicator Use (1, 7, 10): In Ohio, Trautman (1981) observed that *R. atratulus* was susceptible to habitat alterations that modify headwater streams. However, regional and state tolerance classifications generally confer a "tolerant" ranking to *R. atratulus* (Ohio EPA 1987; Halliwell 1999; Pirhalla 2004). The use of the Blacknose Dace as an indicator species is somewhat precarious due to its propensity for being abundant in both high quality and marginal habitats. The Blacknose Dace scores under IBI metrics 1, 7, and 10.

Longnose Dace
(Rhinichthys cataractae)



Identification: Body elongate and somewhat compressed; snout long and overhanging. Body with charcoal-gray coloration and a dusky, faint lateral stripe. Breeding males with red lips and fins. Dorsal fin rays 8; anal fin rays 7; pectoral fin rays 13-15; pelvic fin rays 8. Caudal fin moderately forked.

General Distribution/Habitat: Sporadically distributed throughout Canada, the upper Mississippi River basin, Great Lakes-St. Lawrence basin, the northern and mid-Atlantic slope, and the northwestern United States south to Mexico. Occurs in mainly in creeks (B) and rivers, although may be found in lakes. Most abundant in shallow water where the current is moderate to swift. Generally found over sand, gravel, cobble, and boulder substrates.

Indicator Use/IBI (1, 8, 10): Becker (1983) reported that the Longnose Dace may tolerate abrupt environmental changes (e.g. low D.O., high temperatures, and turbidity) for short periods of time. State and regional tolerance classifications have ranked the Longnose Dace as both an "intermediate" (Halliwell 1999) and "moderately intolerant" species (Pirhalla 2004). As an insectivorous cyprinid, the Longnose Dace scores under IBI metrics 1, 8, and 10.

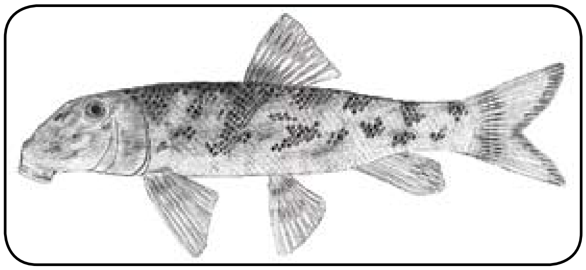
Creek Chub
(Semotilus atromaculatus)

Identification: Body elongate and cylindrical; head large. Large individuals often robust. Coloration dark olive dorsally with iridescent blue overtones; belly white. Prominent dusky lateral line. Breeding male with tubercles and rose colored fins. Mouth large and terminal (B). Anterior base of dorsal fin with black blotch. Dorsal fin rays 8; anal fin rays 8; pectoral fin rays 16-17; pelvic fin rays 8. Caudal fin emarginate to forked.

General Distribution/Habitat: Widespread east of the Rocky Mountains. Generally found in small headwater streams and creeks, less common in rivers and lakes. May be abundant in moderate or sluggish current. Occurs over both fine and coarse substrates.

Indicator Use/IBI (1, 7, 10): An adaptable species, the Creek Chub is tolerant of disturbance, pollution, and moderate levels of silt (Smith 1979; Trautman 1981; Becker 1983). Becker (1983) wrote that *S. atromaculatus* possessed the "tenacity of a weed" while Trautman and Gartman (1974) noted its increased abundance following stream channelization. State and regional tolerance classifications have ranked *S. atromaculatus* as both "tolerant" (Ohio EPA 1987; Pirhalla 2004) and "moderately intolerant" (Jester et al. 1992). The Creek Chub scores under IBI metrics 1, 7, 10.

Suckers (Catostomidae)



Northern Hog Sucker (*Hypentilium nigricans*)

The relatively large family of Catostomidae contains roughly 70 species, the vast majority of which are native to North America. Catostomids can serve as excellent indicators of habitat and water quality as they are primarily benthic or epibenthic in nature. Small groups are often seen in foraging for food in clear, gravelly runs of creeks and rivers.

Family Level Identifiers: Abdominal pelvic fin. Cycloid scales. Dorsal fin with ten or more rays. Many species have fleshy, downturned lips that are either plicate or papillose.

Habitat: Suckers are found in a variety of habitats, including ditches, streams, rivers, and glacial lakes. They often account for the majority of the fish biomass in healthy large creeks and rivers. As a group, they prefer clear water and clean, coarse substrates such as sand, gravel, and cobble.

Pollution Tolerance: The suckers of North America are, for the most part, sensitive to pollution and habitat degradation (see table 10, Karr 1981; Trautman 1981; Becker 1983). Because they are a long-lived taxon, commonly reaching 10-20 years old, they are ideal long-term biomonitors. Etnier (1997) noted that sucker imperilment is most often attributed to stream alterations and nonpoint source pollution.

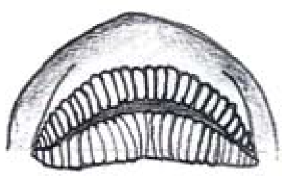
Table 9. Overview of Pollution Tolerance for Family Catostomidae.*

(Review by Barbour et al. 1999)		
Tolerant	**Intermediate**	**Intolerant**
22%	43%	35%

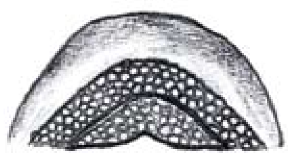
*23 species rated

Identifying Suckers - Lips

A helpful tip in identifying the various sucker species is to examine the texture, form, and dissection of the lip(s). Generally, the lip(s) are either described as papillose or plicate, with some species exhibiting an intermediate form between the two. See the individual species descriptions for detail on lip morphology.



Plicate



Papillose

White Sucker
(*Catostomus commersoni*)

Blacktail Redhorse
(*Moxostoma poecilurum*)

Use in IBI: Metrics that directly evaluate the presence and diversity of the sucker family include *Metric 4: Number of sucker species*. Ohio EPA substitutes % round-bodied suckers for *Metric 2: Number of darter species* in large streams and rivers (boat sampling sites). When appropriate, pollution intolerant suckers would be used in *Metric 5: Number of intolerant species*. Due to the pollution tolerance of the White Sucker, this species is sometimes utilized as an alternative to *Metric 6: Percent Green Sunfish*. On a generic level, suckers would also be used in a few other metrics, such as *Metric 1: Total number of species* and *Metric 10: Number of individuals.*

Table 10. Tolerance designations for selected catostomids.

Common Name	Scientific Name	Ohio EPA 1987	Jester et al. 1992		Lyons 1992	Whittier and Hughes 1998	Barbour et al. 1999	Halliwell et al. 1999	Pirhalla 2004
			WQ	Habitat				Habitat	
River Carpsucker	*Capiodes carpio*	x	T	T	x	x	M	-	x
Quillback Carpsucker	*Carpiodes cyprinus*	x	MT	MT	x	x	M	T	x
Highfin Carpsucker	*Carpiodes velifer*	x	MT	MT	x	x	I	-	x
White Sucker	*Catostomus commersoni*	T	MI	I	T	MT	T	T	MI
Blue Sucker	*Cycleptus elongatus*	R	MI	I	x	x	I	-	x
Creek Chubsucker	*Erimyzon oblongus*	x	MI	I	x	M	M	I	T
Lake Chubsucker	*Erimyzon sucetta*	x	MI	MI	x	x	M	-	x
Northern Hog Sucker	*Hypentilium nigricans*	I	I	I	I	x	I	M	I
Smallmouth Buffalo	*Ictiobus bubalus*	x	MT	MT	x	x	M	-	x
Bigmouth Buffalo	*Ictiobus cyprinellus*	x	MT	MT	x	x	M	-	x
Spotted Sucker	*Minytrema melanops*	x	MI	I	x	x	M	-	x
Silver Redhorse	*Moxostoma anisurum*	M	x	x	x	x	M	M	x
River Redhorse	*Moxostoma carinatum*	I	I	MI	x	x	I	I	x
Black Redhorse	*Moxostoma cervinum*	I	MI	MI	x	x	I	I	x
Golden Redhorse	*Moxostoma erythrurum*	M	MI	MI	x	x	M	I	x
Greater Jumprock	*Moxostoma lachneri*	x	x	x	x	x	I	-	x
Shorthead Redhorse	*Moxostoma macrolepidotum*	M	I	I	x	x	M	M	x
Greater Redhorse	*Moxostoma valenciennesi*	R	x	x	I	x	I	I	x

I = intolerant   M = intermediate   MI = moderately intolerant   MT = moderately tolerant
P = moderately tolerant   R = rare intolerant   S = special intolerant   T = tolerant

Quillback
(Carpiodes cyprinus)

Identification: Body deep, stout, and somewhat compressed. Dorsal fin long, with elongated anterior rays. Coloration olive-gray to brassy dorsally; sides silvery; belly white. Fins dusky. Mouth inferior with thin lips (B). Dorsal fin rays 22-30; anal fin rays 7-8; pectoral fin rays 15-17; pelvic fin rays 8-10. Caudal fin forked.

General Distribution/Habitat: Widely distributed throughout the Mississippi River basin, Great Lakes-St. Lawrence basin, mid-Atlantic slope, and eastern Gulf slope. Known mainly from rivers, lakes, and impoundments. It generally occurs in quiet waters over coarse and fine substrates.

Indicator Use/IBI (1, 4, 10): The Quillback is reportedly tolerant of turbidity, although less so than a close relative, the River Carpsucker (*C. carpio*) (Etnier and Starnes 1993). In some regions, the Quillback has apparently expanded its range and increased in abundance since the turn of the 20th century (Smith 1979). State and regional tolerance classifications for *C. cyprinus* range from "intermediate" (Barbour et al. 1999) to "tolerant" (Jester et al. 1992; Simon and Emery 1995). The Quillback scores under IBI metrics 1, 4, and 10.

White Sucker
(Catostomus commersoni)

Identification: Body tubular with a rounded snout. Coloration olive-gray dorsally with dark mottles; sides often with patches of dark gray or black (especially in young individuals [A]); belly white. Fins dull yellow or orange. Mouth inferior with fleshy, papillose lips (B). Dorsal fin rays 9-14; anal fin rays 7-8; pectoral fin rays 16-19; pelvic fin rays 9-11. Caudal fin forked.

General Distribution/Habitat: Widely distributed throughout the Mississippi River basin, Great Lakes-St. Lawrence basin, Atlantic slope, and north into Canada. Known from creeks, small rivers, and lakes. Highly migratory; may be found in very small or ephemeral habitats when spawning. Occurs over coarse and fine substrates.

Indicator Use/IBI (1, 4, 10): The White Sucker is a wide-ranging species apparently tolerant of low oxygen levels, siltation, and organic and inorganic pollutants (Trautman 1981). Saint-Jacques et al. (2000) found the White Sucker to be a flexible feeder adaptable to changing environmental conditions. State and regional tolerance classifications for *C. commersoni* range from "tolerant" (Ohio EPA 1987; Lyons 1992; Halliwell et al. 1999) to "moderately intolerant" (Jester et al. 1992; Pirhalla 2004). The White Sucker scores under IBI metrics 1, 4, and 10, and may be substituted for metric 6.

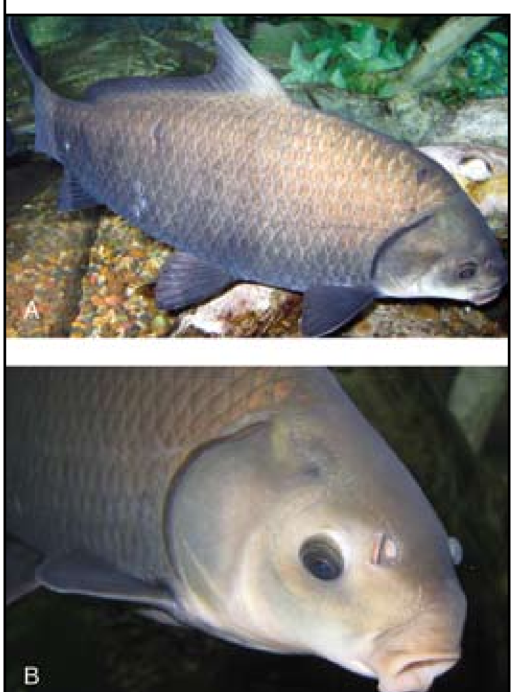
Northern Hog Sucker
(Hypentilium nigricans)

Identification: Body thick and robust anteriorly; tapering posteriorly. Head concave between eyes. Coloration light brown, olive-green or bronze, with dark saddles and mottles; belly white. Mouth inferior with fleshy, papillose lips. Pectoral fins broad and large. Dorsal fin rays 10-12; anal fin rays 7; pectoral fin rays 15-18; pelvic fin rays 10. Caudal forked.

General Distribution/Habitat: Widespread in the Mississippi River basin, Great Lakes basin, and sporadically occurring throughout the Atlantic slope. Disjunctly distributed on the Gulf slope. Occurs in creeks and rivers in flowing glides, runs, and riffles. Generally most abundant over clean sand, gravel, and cobble substrates.

Indicator Use/IBI (1, 4, 5, 10): Sensitive to heavy siltation, pollution, and channel modification, the Northern Hog Sucker is most abundant in clean streams with good current (Smith 1979; Trautman 1981; Boschung and Mayden 2004). State and regional tolerance classifications for *H. nigricans* range from "intermediate" (Halliwell et al. 1999) to "intolerant" (Ohio EPA 1987; Jester et al. 1992; Lyons 1992; Pirhalla 2004). As a sensitive benthic inhabitant, the Northern Hog Sucker scores under IBI metrics 1, 4, 5, and 10. In addition, *"% round-bodied suckers"* (which includes *H. nigricans*) may replace *Metric 2: Number of darter species* at boat sites.

Smallmouth Buffalo
(Ictiobus bubalus)



Identification: Body deep and compressed with large scales. Coloration dusky brown, olive-brown, or gray dorsally; sides light gray, often with a coppery or bronze cast; belly white. Fins dusky to dark gray. Mouth small and inferior, with a thick upper lip. Dorsal fin rays 26-31; anal fin rays 9; pelvic fin rays 9-11. Caudal fin widely forked.

General Distribution/Habitat: Distributed throughout the Mississippi River basin and Gulf Slope. Typically found in large rivers where the current is moderate, although may adapt to impounded conditions (Boschung and Mayden 2004). Occurs over both coarse and fine substrates.

Indicator Use/IBI (1, 4, 10): Trautman (1981) and Etnier and Starnes (1993) noted that the Smallmouth Buffalo is less tolerant of turbidity and more common in swift current than its congeners. Becker (1983) reported the Smallmouth Buffalo as a species that "prefers clean, clear water". State and regional tolerance classifications for *I. bubalus* range from "tolerant" (Simon and Emery 1995) to "intermediate" (Barbour et al. 1999). The Smallmouth Buffalo scores under IBI metrics 1, 4, and 10. The genus *Ictiobus* may be excluded from metric 4 under some IBI interpretations.

Spotted Sucker
(Minytrema melanops)

Identification: Body somewhat cylindrical, slender, and elongate. Lateral line incomplete to absent. Coloration olive-brown to bronze with numerous dark spots (A); belly silvery-white. Mouth inferior with thin, plicate lips (B). Dorsal fin rays 11-12; anal fin rays 7; pectoral fin rays 16-18; pelvic fin rays 9-10. Caudal fin widely forked.

General Distribution/Habitat: Well-distributed throughout the Mississippi River basin, lower Great Lakes, southern Atlantic slope, and Gulf slope. Occurs in creeks, rivers, lakes, and reservoirs. Typically found in lowland habitats where the current is sluggish to moderate. May be found over both coarse and fine substrates.

Indicator Use/IBI (1, 4, 10): The Spotted Sucker is reportedly intolerant of industrial pollutants, siltation, and turbidity (Smith 1979; Trautman 1981). White and Haag (1977) suggested that "changes in range and abundance of *Minytrema* may be related to stream alterations that alter its food supply and feeding habits". Regional and state tolerance classifications range from "intermediate" (Barbour et a. 1999) to "intolerant" (Jester et al. 1992). The Spotted Sucker scores under IBI metrics 1, 4, and 10. In addition, *"% round-bodied suckers"* (which includes *Minytrema*) may replace *Metric 2: Number of darter species* at boat sites.

Golden Redhorse
(Moxostoma erythrurum)

Identification: Body elongate and somewhat robust. Lateral line generally 40-43 scales. Coloration brassy or gold; belly white. Fins dusky gray or reddish-orange. Mouth inferior with plicate lips that form a U-shape posteriorly. Breeding males with conspicuous tubercles on the snout, cheek, anal, and caudal fins. Dorsal fin rays 12-14; pectoral fin rays 17-18; anal fin rays 7; pelvic fin rays 9. Caudal fin forked.

General Distribution/Habitat: Distributed throughout the Mississippi River basin, the lower Great Lakes, Red River (of the North) drainage, Mobile basin, and a few mid-Atlantic drainages. Typically found in creeks and rivers, less common in lakes and impoundments. Most abundant in sluggish to moderate current where clean substrates of sand, gravel, cobble, and bedrock are present.

Indicator Use/IBI (1, 4, 10): The Golden Redhorse is intolerant of domestic and organic pollutants, continuous turbidity, and heavy siltation (Trautman 1981; Becker 1983). Becker (1983) noted that it is intolerant of cold and warm water, preferring instead to find an intermediate temperature. Regional and state tolerance classifications range from "intermediate" (Ohio EPA 1987) to "intolerant" (Halliwell et al. 1999). The Golden Redhorse scores under IBI metrics 1, 4, and 10.

Shorthead Redhorse
(Moxostoma macrolepidotum)

Identification: Body elongate and somewhat robust. Coloration brown-olive dorsally; sides silver with olive-yellow overtones; belly white. Fins reddish-orange to silvery translucent. Mouth inferior and somewhat small; lips plicate; lower lip much deeper than upper lip (B). Breeding males with minute tubercles. Dorsal fin rays 12-14; anal fin rays 7; pectoral fin rays 16-17; pelvic rays 9. Caudal fin forked.

General Distribution/Habitat: Widespread in the Mississippi River basin, Great Lakes-St. Lawrence basin, Atlantic slope, and Hudson Bay basin. Typically found in small to large rivers, although may be found in lakes and impoundments. Occurs in sluggish to moderate current over both coarse and fine substrates.

Indicator Use/IBI (1, 4, 10): In Arkansas, Robison and Buchanan (1988) reported *M. macrolepidotum* as the most tolerant *Moxostoma* sucker to turbidity. It has also been documented as intolerant of heavy siltation and pollution (Trautman 1981; Sule and Skelly 1985). Regional and state tolerance classifications for *M. macrolepidotum* range from "intermediate" (Ohio EPA 1987; Halliwell et al. 1999) to "intolerant" (Jester et al. 1992). The Shorthead Redhorse scores under metrics 1, 4, and 10. In studies where *% round bodied suckers* replace *Metric 3: Number of darter species*, the Shorthead would be included in this substitute metric.

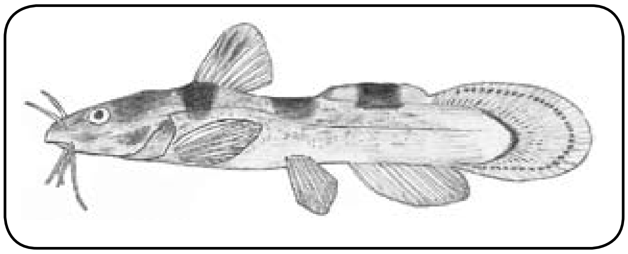
Black Jumprock
(Scartomyzon cervinum)

Identification: Body cylindrical, slender, and elongate. Coloration greenish-yellow to brassy, with irregular dark blotches or mottles; belly white. Dorsal and caudal fin with distinctive dark edges. Mouth inferior and small; lips plicate. Dorsal fin rays 10-12; anal fin rays 7; pectoral fin rays 14-16; pelvic fin rays 9. Caudal fin forked.

General Distribution/Habitat: Restricted to several Atlantic slope drainages in Virginia and North Carolina. Occurs in creeks and small rivers (B, upper Roanoke River). Most abundant in moderate current where the streambed is comprised of coarse, clean substrates. Juveniles may be found in silty and detritus laden pools or backwaters (Jenkins and Burkhead 1994).

Indicator Use/IBI (1, 4, 10): Perhaps due to its limited distribution, there is little information available on the tolerance of *S. cerinum* to environmental changes. Likewise, tolerance classifications have not been developed for *S. cervinum*. By default, the Black Jumprock would score under IBI metrics 1, 4, and 10.

Catfishes (Ictaluridae)



Brindled Madtom (*Noturus miurus*)

With their barbels and scaleless bodies, ictalurids are among the most distinctive fishes in North America. Some might also be surprised to learn that Ictaluridae is the largest family of fishes indigenous to North America (Burr and Mayden 1992). Most of this diversity is found in the genus *Noturus*, a taxon of small, cryptic catfish known commonly as madtoms.

Family Level Identifiers: Head either depressed or moderately depressed. Body scaleless. Dorsal fin short and usually with 1 spine. Mouth with 8 barbels. Adipose fin present.

Habitat: Catfish occupy a variety of freshwater habitats, from wetlands and lakes to rivers and small streams. Most of the physically larger species occupy medium to large river habitats, in addition to lakes and reservoirs. The smaller species (*Noturus* genus) vary to such a degree that it is difficult to make general statements regarding habitat preference.

Pollution Tolerance: Generally, catfishes of the *Ameirus*, *Ictalurus*, and *Pylodictis* genera are "intermediate species" in terms of pollution tolerance. The pollution intolerant ictalurids are primarily from the *Noturus* genus (madtoms). The madtoms also account for the majority of the imperiled catfish species, which Etnier (1997) attributes to pollution, altered stream flows, and small ranges. Of the 25 described madtom species, five are federally listed as endangered or threatened (Burr and Stoeckel 1999).

Table 11. Overview of Pollution Tolerance for Family Ictaluridae.*

(Review by Barbour et al. 1999)		
Tolerant	**Intermediate**	**Intolerant**
12%	53%	35%

*17 species rated

Madtoms. The common name "madtom" refers to the genus *Noturus*, currently represented by 25 species (Sabaj et al. 2006). Due to their small size, cryptic coloring, and reclusive behavior, these small catfishes have gone largely unnoticed by the general public and may even be overlooked during fish surveys. They are also among the most sensitive aquatic taxa to disturbance and pollution. In fact, Boschung and Mayden (2004) commented that madtoms are the ultimate "ecological canary" and are often "the first to disappear as a result of ecological downturns".

Tadpole Madtom (*Noturus gyrinus*)

Mountain Madtom (*Noturus eleutherus*)

Use in IBI: While there is not a specific metric that measures ictalurids, there are circumstances when they are used in conjunction with other benthic species. The genus *Noturus* (madtoms), for example, might be used in conjunction with darters or other benthic insectivores in *Metric 2: Number and darter species*. Many madtoms are also considered intolerant species, and therefore would be used under *Metric 5: Number of intolerant species*. It should also be noted that where alternative insectivore metrics are used, madtoms might also be included in this grouping, as many smaller species feed primarily on aquatic insects.

Table 12. Tolerance designations for selected ictalurids.

Common Name	Scientific Name	Ohio EPA 1987	Jester et al. 1992		Lyons 1992	Whittier and Hughes 1998	Barbour et al. 1999	Halliwell et al. 1999	Pirhalla 2004
			WQ	Habitat				Habitat	
White Catfish	*Ameiurus catus*	x	T	MT	x	M	M	M	x
Black Bullhead	*Ameiurus melas*	P	T	T	x	x	M	x	x
Yellow Bullhead	*Ameiurus natalis*	T	T	MT	T	MT	T	T	T
Brown Bullhead	*Ameiurus nebulosus*	T	MT	MI	x	T	T	T	T
Blue Catfish	*Ictalurus furcatus*	x	x	x	x	x	M	x	x
Channel Catfish	*Ictalurus punctatus*	x	MT	MT	x	M	M	M	x
Elegant Madtom	*Noturus elegans*	x	x	x	x	x	x	x	x
Mountain Madtom	*Noturus eleutherus*	R	I	I	x	x	I	x	x
Slender Madtom	*Noturus exilis*	x	MI	I	x	x	I	x	x
Yellowfin Madtom	*Noturus flavipinnis*	x	x	x	x	x	x	x	x
Stonecat Madtom	*Noturus flavus*	I	I	I	x	x	I	M	x
Tadpole Madtom	*Noturus gyrinus*	x	MI	I	x	MI	M	M	T
Margined Madtom	*Noturus insignis*	x	x	x	x	x	M	M	MI
Speckled Madtom	*Noturus leptacanthus*	x	x	x	x	x	x	x	x
Brindled Madtom	*Noturus miurus*	I	I	I	x	x	I	M	x
Freckled Madtom	*Noturus nocturnus*	x	MI	MI	x	x	M	x	x
Northern Madtom	*Noturus stigmosus*	R	x	x	x	x	I	x	x
Scioto Madtom	*Noturus trautmani*	S	x	x	x	x	I	x	x
Flathead Catfish	*Pylodictis olivaris*	x	MT	MT	x	x	M	x	x

I = intolerant   M = intermediate   MI = moderately intolerant   MT = moderately tolerant
P = moderately tolerant   R = rare intolerant   S = special intolerant   T = tolerant

Channel Catfish
(Ictalurus punctatus)

Identification: Body elongate, slender, and scaleless; head small. Older individuals often robust. Coloration brownish-olive dorsally; sides with irregularly spaced dark spots; belly white. Mouth large and subterminal. Dorsal fin rays 6; anal fin rays 24-29; pectoral fin rays 9; pelvic fin rays 8. Caudal fin forked.

General Distribution/Habitat: Widespread throughout the United States; except for discrete areas in the Atlantic drainage and the western United States. Occurs in small and large rivers, reservoirs, lakes, and ponds. Often occupies deep runs and pools during the day, frequents shoals to feed at night. Typically found over sand, gravel, cobble, bedrock, and rubble substrates.

Indicator Use/IBI (1, 10): An adaptable and wide-ranging species, the Channel Catfish is capable of maintaining populations in turbid streams where the rate of silt deposition is not too severe (Trautman 1981; Robison and Buchanan 1988). State and regional tolerance classifications for *I. punctatus* range from "intermediate" (Whittier and Hughes 1998; Halliwell et al. 1999) to "tolerant" (Simon and Emery 1995). The Channel Catfish scores under IBI metrics 1 and 10. In great rivers, the Channel Catfish scores as a tolerant (6) and great river species (3) (Simon and Emery 1995).

Stonecat Madtom
(Noturus flavus)

Identification: Body elongate, slender posteriorly and scaleless; head depressed. Adipose fin joined to caudal with a notch present between the two Coloration olive-brown or gray dorsally, becoming grayish-white or yellowish-white ventrally. Mouth subterminal. Dorsal fin rays 6; anal fin rays 15-18; pectoral fin rays 9-11; pelvic fin rays 8-10. Caudal fin truncate to slightly rounded.

General Distribution/Habitat: Distributed in the Mississippi River basin, Great Lakes-St. Lawrence basin, and Red River (of the North) drainage. Typically occurs in creeks and small rivers where the current is moderate to rapid. Most abundant over gravel, cobble, boulder, or bedrock rubble substrates.

Indicator Use/IBI (1, 10): Of the madtoms found in the *Noturus* genus, the Stonecat Madtom may be among the more adaptable species (Cross 1967). Becker (1983) commented that the Stonecat tolerates "pollution and oxygen depletion which few other fish can survive". Regional and state tolerance classifications for *N. flavus* range from "intermediate" (Halliwell et al. 1999) to "intolerant" (Ohio EPA 1987; Jester et al. 1992). The Stonecat Madtom scores under IBI metrics 1 and 10.

Tadpole Madtom
(Noturus gyrinus)

Identification: Head and trunk stout before posterior base of dorsal fin; tail thin. Coloration brown, brownish-yellow or brownish-gray; usually with a conspicuous lateral stripe on body. Mouth terminal and moderately large for size. Adipose fin joined to caudal fin; small notch present between the two. Dorsal fin rays 6; anal fin rays 14-16; pectoral fin rays 7; pelvic fin rays 8. Caudal fin rounded to slightly emarginate.

General Distribution/Habitat: Occurs in the Mississippi River basin, Great Lakes-St. Lawrence basin, Atlantic slope, and Gulf slope. Typically found in creeks, rivers, lakes, marshes, backwaters, and ditches. Prefers sluggish or lentic habitats where the substrate is comprised of mud, sand, or organic matter.

Indicator Use/IBI (1, 10): From Ohio to Alabama, experts have reported the extirpation of Tadpole Madtom populations due to ditching, draining, turbidity, and siltation (Trautman 1981; Boschung and Mayden 2004). Regional and state tolerance classifications for *N. gyrinus* range from “tolerant” (Pirhalla 2004) to “intolerant” (Jester et al. 1992). The Tadpole Madtom scores under IBI metrics 1 and 10.

Brindled Madtom
(Noturus miurus)

Identification: Head and trunk moderately robust before posterior base of dorsal fin. Coloration light yellowish-tan with numerous dark mottles and speckles. Distinctive dark blotch on anterior/distal edge of dorsal fin (see drawing on page 29). Black band continuous over adipose fin. Mouth subterminal. Dorsal fin rays 6; anal fin rays 13-17; pectoral fin rays 8; pelvic fin rays 9. Caudal fin truncate to slightly rounded.

General Distribution/Habitat: Distributed throughout the Mississippi River basin and lower Great Lakes. Typically occurs in creeks and small rivers where the current is sluggish to moderate. Most abundant in lightly silted sand and gravel substrates. Often found underneath organic debris or freshwater mussel shells (A-B).

Indicator Use/IBI (1, 5, 10): The Brindled Madtom has been described as relatively intolerant of siltation and industrial pollutants (Trautman 1981; Parker 1987). State and regional tolerance classifications for *N. miurus* range from “intermediate” (Halliwell et al. 1999) to “intolerant” (Ohio EPA 1987; Jester et al. 1992). The Brindled Madtom scores under IBI metrics 1, 5, and 10.

Trouts (Salmonidae)

There are few families as attractive to fisherman as the salmonids. No other taxa has been so extensively stocked, introduced, researched, and genetically altered as this group (Boschung and Mayden 2004). In fact, trout species have been so widely stocked that most do not realize their status as an "exotic." The Brown Trout (*Salmo trutta*), for example, is native to Europe, while the Rainbow Trout (*Oncorhynchus mykiss*) is indigenous to the Pacific Northwest.

Family Level Identifiers: Scales very small. Head missing scales. Adipose fin present. Fins do not have spines.

Habitat: Salmonids occupy a variety of habitats, but most require clean, cool water where food is plentiful and dissolved oxygen is high. Many stockings have failed due to water temperatures exceeding 70° F in the summer months. While some salmonids are primarily marine dwelling species (e.g. Pacific Salmon), all reproduce in freshwater.

Pollution Tolerance: Like other families, salmonids vary in pollution tolerance. Many species, as previously mentioned, are temperature sensitive. Etnier and Starnes (1993) commented that Brook Trout (*salvelinus fontinalis*) do not tolerate maximum water temperatures much higher than 61° F. Consequently, native Brook Trout populations are confined to streams fed by groundwater, and are likely susceptible to stressors such as siltation, urbanization and riparian destruction, all of which are known to raise stream temperatures. Another indirect stressor to native trout populations involves the introduction of exotic species, such as the Rainbow and Brown Trout in Tennessee and Northern Georgia, where success of these exotic species has been to the detriment of the native Brook Trout (Etnier and Starnes 1993). Finally, although some dams have been made "fish friendly" (fish ladders, etc.), many of these structures still impede highly migratory (and anadromous) salmonids from carrying out essential life migrations.

Table 13. Overview of Pollution Tolerance for Family Salmonidae.*

(Review by Barbour et al. 1999)		
Tolerant	**Intermediate**	**Intolerant**
0%	76%	24%

*21 species rated

Rainbow Trout (*Oncorhynchus mykiss*)

Brook Trout (*Salvelinus foutinalis*)

Lake Trout (*Salvelinus namaycush*)

Use in IBI: While a specific metric does not evaluate the presence and diversity of the Salmonidae, they are often substituted into numerous metrics throughout the United States. For example, salmonids may be substituted for, or used in conjunction with, sunfish in *Metric 3: Number of sunfish species*. Salmonid diversity and abundance may also be substituted for intolerant species in *Metric 5: Number of intolerant species*. The salmonids are also evaluated under *Metric 9: Percent top carnivores* and general metrics such as *Metric 1: Total number of species* and *Metric 10: Total number of individuals*.

Table 14. Tolerance designations for selected salmonids.

Common Name	Scientific Name	Ohio EPA 1987	Jester et al. 1992		Lyons 1992	Whittier and Hughes 1998	Barbour et al. 1999	Halliwell et al. 1999	Pirhalla 2004
			WQ	Habitat				Habitat	
Lake Herring	*Coregonus artedi*	x	x	x	x	x	M	I	x
Cutthroat Trout	*Oncorhynchus clarki*	x	x	x	x	x	I	x	x
Pink Salmon	*Oncorhynchus gorbuscha*	x	x	x	x	x	M	x	x
Coho Salmon	*Oncorhynchus kisutch*	x	x	x	x	x	M	x	x
Rainbow Trout	*Oncorhynchus mykiss*	x	I	I	x	MI	M	I	MI
Chinook Salmon	*Oncorhynchus tshawytscha*	x	x	x	x	x	M	x	x
Atlantic Salmon	*Salmo salar*	x	x	x	x	I	M	I	x
Brown Trout	*Salmo trutta*	x	I	I	x	MI	M	I	MI
Brook Trout	*Salvelinus malma*	x	x	x	I	MI	M	I	MI
Lake Trout	*Salvelinus namaycush*	x	x	x	I	MI	M	I	x

I = intolerant   M = intermediate   MI = moderately intolerant   MT = moderately tolerant
P = moderately tolerant   R = rare intolerant   S = special intolerant   T = tolerant

Rainbow Trout
(Orcorhynchus mykiss)

Identification: Body elongate and slender. Coloration silvery to olive dorsally with numerous dark spots; sides with many to few dark spots and a pinkish-red streak (A-B); belly silvery to white. Caudal, adipose, and dorsal fin with dark spots. Mouth moderate to large and terminal. Dorsal fin rays 10-13; anal fin rays 10-13; pectoral fin rays 11-17; pelvic fin rays 9-10. Caudal fin truncate to slightly emarginate.

General Distribution/Habitat: Native to Asia and the Pacific coast. Extensively stocked and now disjunctly distributed throughout the United States and Canada. Generally occurs in cool creeks and rivers where the flow is moderate to swift (Becker 1983). Reportedly thrives in the cool tailwaters of dams (Robison and Buchanan 1988).

Indicator Use/IBI (1, 10): Of the trout species, the Rainbow is considered the most tolerant of high temperatures (Becker 1983). State and regional tolerance classifications for *O. mykiss* range from intermediate (Barbour et al. 1999) to intolerant (Jester et al. 1992; Halliwell et al. 1999). The Rainbow Trout generally scores under IBI metrics 1 and 10. When appropriate, it may be considered a top carnivore under metric 9. In addition, in some regions, *O. mykiss* may score as an intolerant species (metric 5).

Brown Trout
(Salmo trutta)

Identification: Body elongate and slender. Coloration tannish-olive to brown dorsally with dark sports, usually with a pale outline; sides with numerous red spots possessing a pale outline; belly yellowish. Caudal fin without dark spots. Mouth moderate to large and terminal. Dorsal fin rays 12-14; anal fin rays 10-12; pectoral fin rays 13-14; pelvic fin rays 9-10. Caudal fin truncate to forked.

General Distribution/Habitat: Native to Asia and Europe. Extensively stocked and now disjunctly distributed throughout the United States and Canada. May occupy a wide range of habitats, including cool creeks, rivers, lakes, and ponds. Occurs in sluggish to swift current and over both fine and coarse substrates.

Indicator Use/IBI (1, 10): Like the Rainbow Trout, the Brown Trout is more tolerant of higher temperatures than many of its relatives (Etnier and Starnes 1993). Becker (1983) considered the Brown Trout tolerant to episodic turbidity, persisting in areas intolerable to the Brook Trout. State and regional tolerance classifications for *S. trutta* range from “intermediate” (Barbour et al. 1999) to “intolerant” (Jester et al. 1992; Halliwell et al. 1999). If exotic species are included, the Brown Trout scores under IBI metrics 1 and 10. It may also be considered a top predator by some programs.

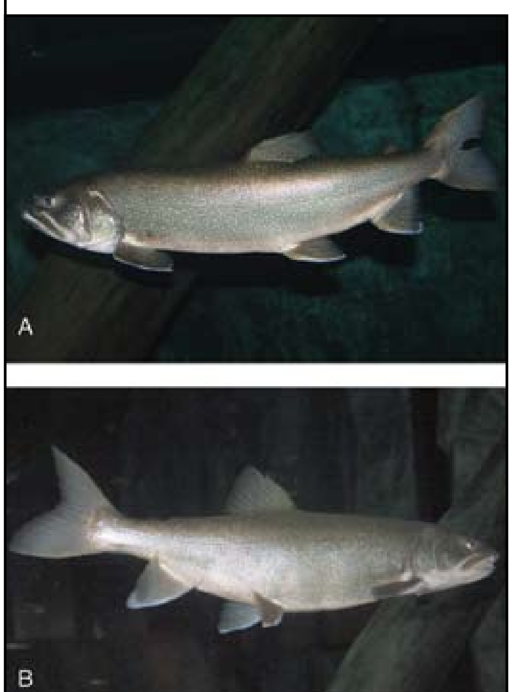
Brook Trout
(Salvelinus fontinalis)

Identification: Body elongate, slender, and laterally compressed. Coloration smoky olive to brassy dorsally with numerous small vermiculations; sides with dark vertical bars and red spots; belly red, yellowish, or white. Caudal, adipose, and dorsal fin with dark spots or blotches. Mouth large and terminal. Dorsal fin rays 10-14; anal fin rays 9-13; pectoral fin rays 11-14; pelvic fin rays 8-10. Caudal fin emarginate.

General Distribution/Habitat: Widespread throughout eastern North America. It has also been widely introduced outside of its native range (Jenkins and Burkhead 1994). Typically occurs in cool, well-shaded sections of headwater streams and creeks that possess considerable influxes of groundwater. Generally found over both fine and coarse substrates.

Indicator Use/IBI (1, 5, 10): An intolerant native salmonid species, the Brook Trout is more sensitive to changing environmental conditions and higher temperatures than the exotic Rainbow Trout and Brown Trout (Etnier and Starnes 1993). The formerly mentioned species may complicate matters by competing with native Brook Trout (Kelly et al. 1979; Etnier and Starnes 1993). State and regional tolerance classifications for *S. fontinalis* range from “moderately intolerant” (Pirhalla 2004) to “intolerant” (Lyons 1992).

Lake Trout
(Salvelinus namaycush)

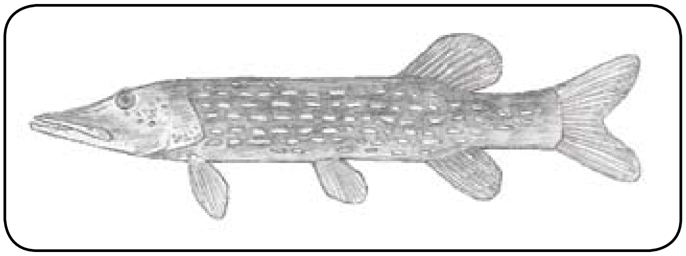


Identification: Body slender and laterally compressed. Coloration grayish-olive dorsally with numerous irregular, pale spots; may have a rosy tinge subdorsally (A); sides also with numerous spots; belly white. Mouth large and terminal. Dorsal fin rays 8-10; anal fin rays 8-10; pectoral fin rays 12-17; pelvic fin rays 8-11. Caudal fin forked.

General Distribution/Habitat: Widely distributed throughout the northern United States and Canada. It has also been extensively introduced. Typically occurs in lakes at depths of up to 300 feet (Becker 1983). May be found over fine or coarse substrates.

Indicator Use/IBI (1, 5, 9, 10): The Lake Trout is a species adapted to cruising deep, cold waters while searching for food. At the southern boundary of its range, this species has apparently severely declined as a result of Sea Lamprey predation and overfishing (Trautman 1981; Becker 1983). Becker (1983) noted that reproducing populations no longer occur in Lake Michigan and stocked populations have limited reproductive success. State and regional tolerance classifications generally for *S. namaycush* range from “moderately intolerant” (Whittier and Hughes 1998) to “intolerant” (Lyons 1992; Halliwell et al. 1999). The Lake Trout scores under IBI metrics 1, 5, 9, and 10.

PIKES (ESOCIDAE)



Northern Pike (*Esox lucius*)

Family Esocidae contains some of the most popular sport fishes in North America, including the well known Northern Pike and Muskellunge. Diversity among the family is limited to just one genus, with four species native to areas east of the Rocky Mountains. Stocking has occurred throughout the United States, however, as the "Northern" and "Muskey" continue to be fisherman favorites.

Family Level Identifiers: Body elongate. Dorsal fin and anal fin set posteriorly. Abdominal pelvic fins. Mouth often described as "duckbill-like." Cycloid scales.

Habitat: The pike family occurs in both lotic and lentic habitats where an abundance of aquatic vegetation, woody debris, or other cover is present. During breeding season, esocids may be found in small channels or even ephemeral habitats, including ditches, wet prairies, backwaters, and marshes.

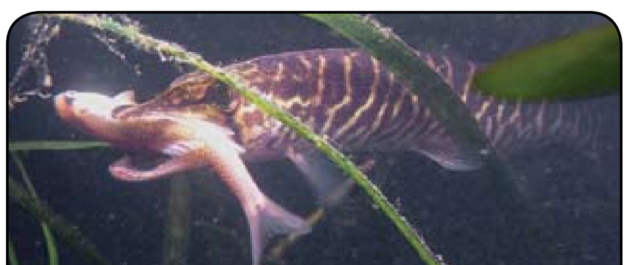
Pollution Tolerance: In general terms, family Esocidae is moderately tolerant of pollution and habitat disturbance. It should be noted, however, that pikes are susceptible to channel and backwater modification (ditching, dredging and draining) due to their habitat and spawning requirements. For example, White et al. (1975) found that Northern Pike populations in Lake Erie and its tributaries have continued to decline since 1885 where dredging and draining were extensive. Several experts have also suggested that members of this family are sensitive to excessive turbidity (Trautman 1981; Robison and Buchanan 1988; Etnier and Starnes 1993).

Table 15. Overview of Pollution Tolerance for Family Esocidae.*

(Review by Barbour et al. 1999)		
Tolerant	**Intermediate**	**Intolerant**
0%	100%	0%

*5 species rated

Northern Pike
(*Esox lucius*)



Grass Pickerel
(*Esox americanus vermiculatus*)

Ambush Predators

With nicknames like "water wolf," "perch killers," and "slew sharks," members of family Esocidae are clearly fearsome predators beloved by fishermen. The hunting strategy of an esocid is pretty straightforward; lie-in-wait for unsuspecting prey and strike with lightning-quick acceleration and razor sharp teeth. Pikes use this stealthy technique to feed on a wide assortment of prey, including aquatic insects, fish, crayfish, turtles, frogs, and even muskrats and ducks!

Use in IBI: Family Esocidae contains top-tier predators that are reported under *Metric 9: Percent top carnivores*. In addition, the general presence of this family is accounted for in several other metrics, such as *Metric 1: Total number of fish species* and *Metric 10: Total number of individuals*.

Notes/Comments: The pike family is holartic in distribution, with the Amur Pike (*Esox reicherti*) endemic to the Amur River of Siberia and the Northern Pike occurring in North America, Europe, and Asia. The remaining species are only found in North America.

Table 16. Tolerance designations for selected esocids.

Common Name	Scientific Name	Ohio EPA 1987	Jester et al. 1992		Lyons 1992	Whittier and Hughes 1998	Barbour et al. 1999	Halliwell et al. 1999	Pirhalla 2004
			WQ	Habitat				Habitat	
Redfin Pickerel	*Esox americanus americanus*	x	x	x	x	x	M	M	T
Grass Pickerel	*Esox americanus vermiculatus*	P	MI	MI	x	x	M	M	x
Northern Pike	*Esox lucius*	x	MI	MI	x	M	I	M	x
Muskellunge	*Esox masquinongy*	x	x	x	x	x	I	M	x
Chain Pickerel	*Esox niger*	x	MT	I	x	M	M	M	T

I = intolerant M = intermediate MI = moderately intolerant MT = moderately tolerant
P = moderately tolerant R = rare intolerant S = special intolerant T = tolerant

Grass Pickerel
(Esox americanus vermiculatus)

Identification: Body elongate and tubular, with a duckbill-like snout. Coloration usually dark green, brown, or yellow with whitish-yellow vermiculations; belly white. Distinctive tear-drop marking below eye. Cheek and opercle scaled. Teeth conspicuous. Dorsal fin rays 12-13; anal fin rays 11-12; pectoral fin rays 14-15; pelvic fin rays 9-10. Caudal fin moderately forked.

General Distribution/Habitat: Distributed throughout the Mississippi River basin and southern Great Lakes. Typically inhabits ditches and small creeks where the current is sluggish or absent. May also occur in marshes and inland lakes. Generally found near cover; may be found over both fine and coarse substrates.

Indicator Use/IBI (1, 10): This small pike species requires in-stream cover and clear to moderately turbid water to thrive. In agricultural or urban areas where stream or ditch vegetation is routinely removed, *E.a. vermiculatus* may be reduced in numbers or eliminated (Trautman 1981). It has been documented to tolerate elevated temperatures and low dissolved oxygen levels (Scott and Crossman 1973). State and regional classifications range from “intermediate” (Barbour et al. 1999) to “moderately intolerant” (Jester et al. 1992). The Grass Pickerel scores under metrics 1 and 10.

Northern Pike
(Esox lucius)

Identification: Body tubular and robust, with a large, duckbill-like snout (A). Coloration dark olive-green dorsally; sides with numerous, irregular spots; belly white. All fins with dark blotches except pectorals. Cheek fully scaled; opercle scaled on the upper half. Dorsal fin rays 15-19; anal fin rays 12-15; pectoral fin rays 14-17; pelvic fin rays 10-11. Caudal fin moderately forked.

General Distribution/Habitat: The Northern Pike is distributed throughout the Mississippi River basin and Great Lakes basin all the way north into the Arctic. It has also been widely introduced. Typically found in creeks, rivers, lakes, impoundment, and marshes. It may move into small, ephemeral habitats during the breeding season, including ditches and wetlands. Occurs over both fine and coarse substrates.

Indicator Use/IBI (1, 9, 10): The Northern Pike is vulnerable to habitat alterations that modify backwater and swamp-like spawning grounds including dredging and draining activities (Trautman 1981). This large predator may tolerate low dissolved oxygen levels, but is sensitive to elevated temperatures (Casselman 1978; Becker 1983). Regional and state tolerance classifications range from “intermediate” (Whittier and Hughes 1998) to “intolerant” (Halliwell et al. 1999). The Northern Pike scores under IBI metrics 1, 9, and 10.

Topminnnows and Killifishes (Fundulidae)

The Fundulidae are an attractive and rather unfamiliar group of native fishes widely distributed throughout North America. The family contains 4 genera, with *Fundulus* being the largest and most prevalent group in the United States. Fundulids possess interesting adaptations that enhance surface feeding capabilities and allow them to dwell in hypoxic environments.

Family Level Identifiers: Overall body size small; often with a flattened head. Fins without spines; dorsal fin often set posteriorly; pelvic fin abdominal. Mouth small and terminal to superior. Often strongly sexually dimorphic.

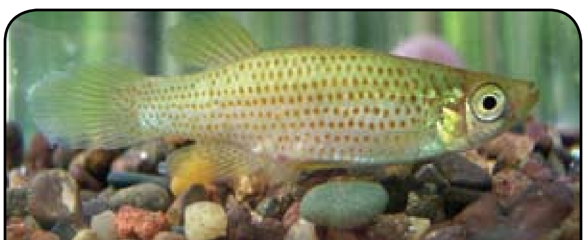
Habitat: Topminnows and killifishes occur in small headwaters, creeks, rivers, lakes, and wetlands. They are generally most abundant where the current is sluggish or absent; occurring in both open water or near aquatic vegetation. They are found over coarse or fine substrates.

Pollution Tolerance: The killifishes and topminnows of North America are, like many other families, variable in their tolerance to pollution and habitat disturbance. Some, such as the Western Banded Killifish (*Fundulus diaphanus menona*), inhabitat clear, vegetated waters where substrates are free of silts (Trautman 1981). Etnier and Starnes (1993) noted that channelization had eliminated the swamp habitat needed to support Northern Starhead Topminnow (*Fundulus dispar*) populations in western Tennessee. Interestingly, fundulids may be found in hypoxic environments due to morphological adaptations that allow them to utilize the oxygen-rich surface layer of the water column (Lewis 1970; Killgore and Hoover 2001).

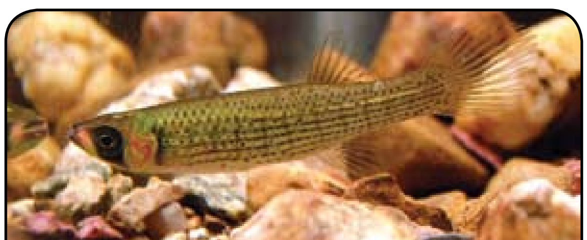
Table 17. Overview of Pollution Tolerance for Family Fundulidae.*

(Review by Barbour et al. 1999)		
Tolerant	**Intermediate**	**Intolerant**
17%	50%	33%

*6 species rated



Russetfin Topminnow
(*Fundulus escambiae*)



Lined Topminnow
(*Fundulus lineolatus*)

Longnose Killifish
(*Fundulus similis*)

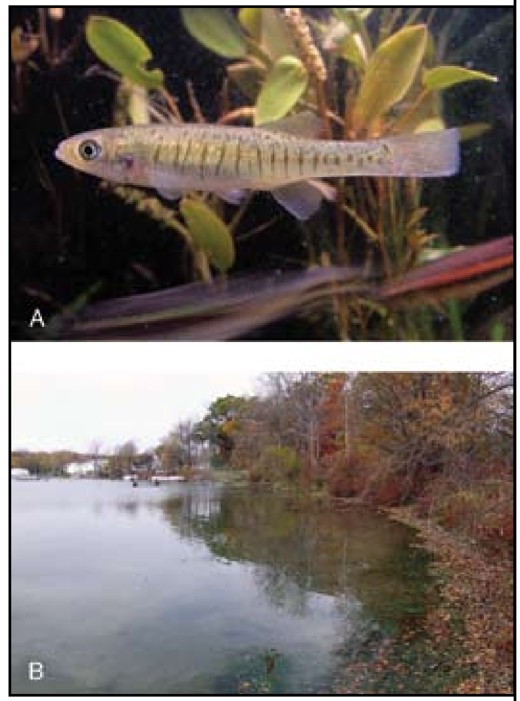
Use in IBI: As originally proposed by Karr (1981), fundulids are not directly evaluated under a specific IBI metric. However, the presence and abundance of the Fundulidae may be included under general metrics such as *Metric 1: Total number of fish species* and *Metric 10: Total number of individuals*. Alternative metrics to *Metric 8: Percent insectivorous cyprinids* may enumerate all insectivorous species, which would include most of the Fundulidae. Pollution intolerant topminnows and killifishes would be enumerated under *Metric 5: Number of intolerant species.*

Table 18. Tolerance designations for selected fundulids.

Common Name	Scientific Name	Ohio EPA 1987	Jester et al. 1992		Lyons 1992	Whittier and Hughes 1998	Barbour et al. 1999	Halliwell et al. 1999	Pirhalla 2004
			WQ	Habitat				Habitat	
Blair's Starhead Topminnow	*Fundulus blairae*	-	T	I	-	-	-	-	-
Northern Studfish	*Fundulus catenatus*	-	MI	I	-	-	I	-	-
Golden Topminnow	*Fundulus chrysotus*	-	MT	I	-	-	-	-	-
Banded Killifish	*Fundulus diaphanus*	-	-	-	-	M	T	T	T
Starhead Topminnow	*Fundulus dispar*	-	-	-	-	-	I	-	-
Mummichog	*Fundulus heteroclitus*	-	-	-	-	T	M	T	T
Blackstripe Topminnow	*Fundulus notatus*	-	MT	MI	-	-	M	-	-
Blackspotted Topminnow	*Fundulus olivaceus*	-	MT	MI	-	-	M	-	-
Plains Topminnow	*Fundulus sciadicus*	-	MT	MI	-	-	-	-	-
Plains Killifish	*Fundulus zebrinus*	-	MT	MT	-	-	-	-	-

I = intolerant   M = intermediate   MI = moderately intolerant   MT = moderately tolerant
P = moderately tolerant   R = rare intolerant   S = special intolerant   T = tolerant

Western Banded Killifish
(Fundulus diaphanus menona)

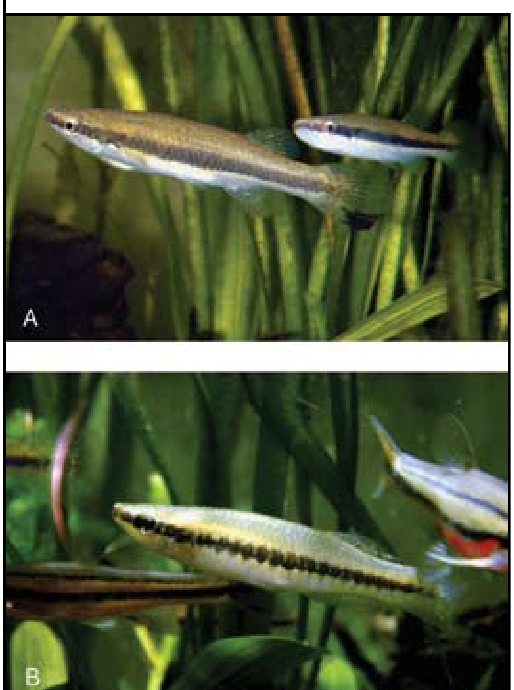


Identification: Body elongate and noticeably wider anteriorly than posteriorly; head flattened. Coloration light olive-yellow dorsally, often with dark speckles; sides lighter with irregular, narrow vertical bars; belly pale yellow-white. Mouth terminal and small to moderate in size. Males generally with large dorsal and anal fins. Dorsal fin rays 12-13; anal fin rays 9-11; pectoral fin rays 16-17; pelvic fin rays 6. Cadual fin rounded to truncate.

General Distribution/Habitat: Distributed in the upper Mississippi River basin and lower Great Lakes basin. Typically found in lakes (B) and sluggish sections of creeks and rivers.

Indicator Use/IBI (1, 10): The Western Banded Killifish is generally most abundant in clear, quite waters. In Ohio, *F.d. menona* has reportedly undergone population reductions due to loss of habitat and siltation (Trautman 1981). However, small populations still persist in streams degraded by channelization, siltation, and agricultural runoff (Poly and Miltner 1995). Most regional and state tolerance classifications do not separate between the two subspecies - the Western Banded and Eastern Banded Killifish (*F.d. diaphanus*). The Western Banded Killifish scores under IBI metrics 1 and 10.

Blackstripe Topminnow
(Fundulus notatus)



Identification: Body elongate and moderately robust; head flattened. Coloration olive-yellow dorsally; sides with a distinctive longitudinal stripe that extends from the snout to caudal peduncle (diamond shaped accented with vertical bars in males [B]); belly silvery-white. Mouth oblique and small. Dorsal fin rays 9-10; anal fin rays 12; pectoral fin rays 14-15; pelvic fin rays 6. Cadual fin rounded.

General Distribution/Habitat: Widely distributed throughout the Mississippi River basin, lower Great Lakes basin, and several Gulf slope drainages. Occurs in small creeks to rivers, lakes, and impoundments. Typically present where the current is sluggish or absent. Found over both fine and coarse substrates.

Indicator Use/IBI (1, 10): The Blackstripe Topminnow is reportedly tolerant of low dissolved oxygen and turbidity (Trautman 1981; Boschung and Mayden 2004). This adaptative topminnow appears to have recently expanded its range and invaded new habitats where it was not previously recorded (Trautman 1981; Becker 1983; Poly and Miltner 1995). State and regional tolerance classifications generally rank *F. notatus* as an "intermediate" species (Jester et al. 1992; Barbour et al. 1999). The Blackstripe Topminnow scores under IBI metrics 1 and 10.

Sculpins (Cottidae)

Family Cottidae is largely marine in distribution, with the northern Pacific Ocean maintaining the majority of the species. In the freshwater systems of North America, two genera and less than 30 species have been identified. Much like the darters (*Ammocrypta*, *Crystallaria*, *Etheostoma,* and *Percina*), sculpins are primarily benthic-dwelling fishes lacking a swim bladder. They are aggressive predators, feeding chiefly on macroinvertebrates, crayfish, and smaller fishes.

Family Level Identifiers: Head and mouth large. Body dorsally depressed. Often scaleless, although a few ctenoid scales may be present. Pectoral fins large. Pelvic fin with one spine and two to five rays.

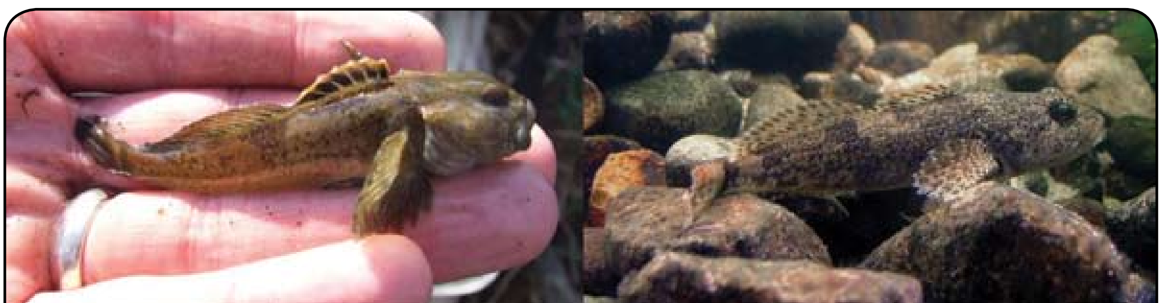
Habitat: Most sculpin species dwell in of areas swift current and considerable groundwater influence (cool water streams). Although they are often more common in small to medium-sized streams, they are also found in rivers and lakes. Favored substrates include gravel, cobble, and boulders.

Pollution Tolerance: Pollution tolerance varies among this cool water-dwelling family. In general, sculpins are intolerant to moderately tolerant of polluted conditions. Trautman (1981) found that Mottled Sculpin (*Cottus bairdi*) populations decreased in the presence of silts, pollution, and disturbance, while flourishing populations occurred in the clearest and cleanest brooks of higher gradients.

Table 19. Overview of Pollution Tolerance for Family Cottidae.*

(Review by Barbour et al. 1999)		
Tolerant	**Intermediate**	**Intolerant**
0%	60%	40%

*5 species rated



Mottled Sculpin (*Cottus bairdi*)

Headwater habitat of the
Banded Sculpin (*Cottus carolinae*)

Use in IBI: Family Cottidae is sometimes used as an alternative taxa to *Metric 2: Number and identity of darter species* or in conjunction with other benthic taxa such as madtoms or darters. These taxa are generally more vulnerable to stream degradation because they feed and reproduce in benthic habitats (Kuehne and Barbour 1983, Ohio EPA 1987). Cottids that are intolerant of pollution are included in Metric *5: Number and identity of intolerant species*. The general presence and abundance of sculpin is enumerated under *Metric 1: Total number of fish species* and *Metric 10: Total number of individuals.*

Table 20. Tolerance designations for selected cottids.

Common Name	Scientific Name	Ohio EPA 1987	Jester et al. 1992		Lyons 1992	Whittier and Hughes 1998	Barbour et al. 1999	Halliwell et al. 1999	Pirhalla 2004
			WQ	Habitat				Habitat	
Prickly Sculpin	*Cottus asper*	x	x	x	x	x	M	x	x
Mottled Sculpin	*Cottus bairdi*	I	x	x	I	x	I	I	MI
Paiute Sculpin	*Cotus beldingi*	x	x	x	x	x	I	x	x
Banded Sculpin	*Cottus carolinae*	x	I	I	x	x	M	x	x
Slimy Sculpin	*Cottus cognatus*	x	x	x	x	x	M	x	x

I = intolerant M = intermediate MI = moderately intolerant MT = moderately tolerant
P = moderately tolerant R = rare intolerant S = special intolerant T = tolerant

Mottled Sculpin
(Cottus bairdi)


A


B

Identification: Body robust and dorsally depressed. Coloration cryptic; body grayish-brown with patchy dark speckles and black saddles. Breeding males often with brilliant orange bands on the first dorsal fin. Mouth very large and terminal. Pectoral fins large. First dorsal fin spines 6-9; second dorsal rays 15-18; anal fin rays 12-14; pectoral fin rays 14-17. Caudal fin rounded.

General Distribution/Habitat: Widely and disjunctly distributed in the Mississippi River basin, Great Lakes-St. Lawrence basin, Atlantic slope, the western United States, and north into Canada. Occurs in cool water creeks and rivers. Found over coarse substrates such as gravel, cobble, boulder, and bedrock rubble.

Indicator Use/IBI (1, 5, 10): Mottled Sculpin require clear, cool, oxygenated water that is relatively free of clayey silts and pollutants (Trautman 1981). Due to their propensity for small cool water streams, they are vulnerable to thermal stress resulting from riparian corridor destruction or groundwater lowering. Regional and state tolerance classifications for *C. bairdi* range from "moderately intolerant" (Pirhalla 2004) to "intolerant" (Ohio EPA 1987; Lyons 1992; Halliwell et al. 1999). The Mottled Sculpin scores under IBI metrics 1, 5, and 10.

Banded Sculpin
(Cottus carolinae)


A


B

Identification: Body robust and dorsally depressed. Coloration cryptic; body often reddish-brown with 4 dark saddles. First dorsal fin with a reddish-orange band. Chin mottled. Mouth very large and terminal. Pectoral fins large. First dorsal fin spines 6-9; second dorsal rays 14-18; anal fin rays 11-15; pectoral fin rays 12-18; pelvic fin rays 3-4. Caudal fin rounded.

General Distribution/Habitat: Distributed throughout the Mississippi River basin and Mobile basin. Occurs in small creeks (B) to rivers where the current is moderate to swift. Most abundant over clean sand, gravel, cobble, and rubble substrates.

Indicator Use/IBI (1, 5, 10): Generally widespread and common throughout its range, the Banded Sculpin inhabits clear, cool to coldwater habitats. However, Pflieger (1975) observed that *C. carolinae* may be more tolerant of warmer waters than its congeners. Regional and state tolerance classifications for *C. carolinae* range from "intermediate" (Barbour et al. 1999) to "intolerant" (Jester et al. 1992). The Banded Sculpin scores under IBI metrics 1 and 10. As benthic inhabitants, the Cottidae may also be substituted for *Metric 2: Number of darter species* in certain regions.

SUNFISHES (CENTRARCHIDAE)

Beloved by anglers, this well-known family contains about 30 species, including popular fishes such as the Smallmouth Bass, Largemouth Bass, Black Crappie, and Bluegill Sunfish. The term "panfish" often refers to the tasty, smaller fish species of the sunfish family. The sunfish are among the most notorious of the hybridizing fishes, especially species belonging to the genus *Lepomis*.

Family Level Identifiers: A spinous dorsal fin with 6-13 spines followed by a soft dorsal fin. Three or more anal fin spines. Scales ctenoid.

Habitat: Most sunfish species inhabit quiet waters, such as sluggish stream and river reaches, pools, wetlands, and lakes. Many favor the cover of macrophytes and woody debris.

Pollution Tolerance: Generally, the sunfish family is moderately tolerant of pollution and habitat alterations. As pool inhabitants, centrarchids are vulnerable to pool degradation and the loss of adequate midwater and benthic food items (Ohio EPA 1987). Intolerant species are represented by fishes such as the Blackbanded Sunfish (*Enneacanthus chaetodon*) and Longear Sunfish (*Lepomis megalotis*). Well known sunfishes, such as the Green Sunfish (*Lepomis cyanellus*) and Bluegill Sunfish (*Lepomis macrochirus*), are among the more hardy tolerant North American fishes, reportedly tolerant of low dissolved oxygen and habitat disturbance (Baker 1983; Matthews 1987; Killgore and Hoover 2001).

Table 21. Overview of Pollution Tolerance for Family Centrarchidae.*

(Review by Barbour et al. 1999)		
Tolerant	**Intermediate**	**Intolerant**
5%	86%	9%

*22 species rated

Dollar Sunfish (*Lepomis marginatus*)

Spotted Bass (*Micropterus punctulatus*)

Smallmouth Bass (*Micropterus dolomieu*)

Orangespotted Sunfish (*Lepomis humilis*)

Use in IBI: The sunfish family is an integral part of IBI scoring. Metrics that evaluate the family directly include *Metric 3: Number of sunfish species*. Hybrid sunfishes are often excluded from this metric. *Metric 6: Percent Green Sunfish* measures the quality of headwater fish communities by calculating the abundance of Green Sunfish versus other fish species. In addition to these metrics, sunfishes are speciated and enumerated for a number of other metrics that evaluate the fish community as a whole (e.g. *Metric 1: Total number of species and Metric 5: Total number of intolerant species*). Due to the extensive hybridization observed in this family, the sunfish may also be a large part of *Metric 11: Percentage hybrids*.

Table 22. Tolerance designations for selected centrarchids.

Common Name	Scientific Name	Ohio EPA 1987	Jester et al. 1992		Lyons 1992	Whittier and Hughes 1998	Barbour et al. 1999	Halliwell et al. 1999	Pirhalla 2004
			WQ	Habitat				Habitat	
Mud Sunfish	*Acantharchus pomotis*	-	-	-	-	-	M	M	-
Rock Bass	*Ambloplites rupestris*	-	MI	I	I	M	M	M	MI
Flier	*Centrarchus macropterus*	-	I	I	-	-	M	-	-
Banded Pygmy Sunfish	*Elassoma zonatum*	-	I	I	-	-	M	-	-
Blackbanded Sunfish	*Enneacanthus chaetodon*	-	-	-	-	-	I	I	-
Bluespotted Sunfish	*Enneacanthus gloriosus*	-	-	-	-	-	M	I	T
Banded Sunfish	*Enneacanthus obesus*	-	-	-	-	M	M	I	T
Redbreast Sunfish	*Lepomis auritus*	-	MT	MT	-	M	M	M	MI
Green Sunfish	*Lepomis cyanellus*	T	T	T	T	-	T	T	MI
Pumpkinseed Sunfish	*Lepomis gibbosus*	MT	-	-	-	T	M	M	T
Warmouth Sunfish	*Lepomis gulosus*	-	MT	MT	-	-	M	-	-
Orangespotted Sunfish	*Lepomis humilis*	-	T	MT	-	-	M	-	-
Bluegill Sunfish	*Lepomis macrochirus*	MT	MT	MT	-	T	M	T	T
Dollar Sunfish	*Lepomis marginatus*	-	MT	MI	-	-	-	-	-
Longear Sunfish	*Lepomis megalotis*	MI	MT	MT	-	-	I	-	-
Redear Sunfish	*Lepomis microlophus*	-	MT	MT	-	-	M	-	-
Spotted Sunfish	*Lepomis punctatus*	-	MT	I	-	-	M	-	-
Smallmouth Bass	*Micropterus dolomieu*	MI	I	I	I	M	M	M	MI
Spotted Bass	*Micropterus punctulatus*	-	MI	MI	-	-	M	-	-
Largemouth Bass	*Micropterus salmoides*	-	MT	MT	-	T	M	M	T
White Crappie	*Pomoxis annularis*	-	T	MT	-	-	M	T	-
Black Crappie	*Pomoxis nigromaculatus*	-	MT	MT	-	T	M	M	-

I = intolerant M = intermediate MI = moderately intolerant MT = moderately tolerant
P = moderately tolerant R = rare intolerant S = special intolerant T = tolerant

Rock Bass
(Ambloplites rupestris)


A


B

Identification: Body deep and somewhat robust. Coloration olive or brown dorsally; sides lighter with dark patches and spots; belly white. Eye red. Mouth terminal to slightly oblique and large. Dorsal fin spines 10-12; second dorsal fin rays 10-12 ; anal fin spines 5-7 and 9-11 soft rays; pectoral fin rays 13-15; pelvic fin rays 1 spine and 5 rays. Caudal fin emarginate.

General Distribution/Habitat: Well-distributed throughout the upper Mississippi River basin, Great Lakes-St. Lawrence basin, Hudson River basin, Red River (of the North) drainage, and Atlantic slope. Occurs in creeks, rivers, glacial lakes, and impoundments. Most abundant in sluggish current or still water where plenty of cover is present. Found over both coarse and fine substrates.

Indicator Use/IBI (1, 3, 10): The Rock Bass is reportedly intolerant of high turbidity, siltation, and low dissolved oxygen levels (Bouck 1972; Robison and Buchanan 1988; Jenkins and Burkhead 1994). Regional and state tolerance classifications range from "intermediate" (Whittier and Hughes 1998; Halliwell et al. 1999) to "intolerant" (Lyons 1992). The Rock Bass scores under IBI metrics 1, 3, and 10. It may also be considered a top carnivore.

Bluespotted Sunfish
(Enneacanthus gloriosus)


A


B

Identification: Body deep and laterally compressed. Coloration somewhat olive-gray and dusky; numerous light blue, light green or gold spots irregularly scattered on body and fins. Males with enlarged second dorsal and anal fin. Mouth terminal and moderate in size. Dorsal fin spines 8-9; second dorsal fin rays 10-12; anal fin spines 3 and 9-10 soft rays; pectoral fin rays 12-13. Caudal fin rounded to slightly emarginate.

General Distribution/Habitat: Distributed along the Atlantic slope and Gulf slope. Generally confined to lowland and circumneutral or acidic streams, rivers, swamps, and oxbow backwaters (Peterson and VanderKooy 1997). Most abundant in heavily vegetated habitats in sluggish current or still water. Found over both coarse and fine substrates.

Indicator Use/IBI (1, 3, 10): An inhabitant of silt-free, vegetated backwaters, the habitat of the Bluespotted Sunfish may be compromised where coastal development has occurred (Boschung and Mayden 2004). Regional and state tolerance classifications for *E. gloriosus* range from "intolerant" (Halliwell et al. 1999) to "tolerant" (Pirhalla 2004). The Bluespotted Sunfish scores under IBI metrics 1, 3, and 10.

Redbreast Sunfish
(Lepomis auritus)

Identification: Body deep and laterally compressed. Opercle flap dark, long, and thin (A). Often less distinctive in younger individuals (B). Coloration dark olive dorsally; sides with orange and blue mottling; cheek with blue-green mottles. Breeding males with a bright red-orange breast. Mouth terminal and somewhat small to moderate in size. Dorsal spines 10-11; dorsal fin rays 11-12; anal spines 3; anal fin rays 9-10; pectoral rays 14-15. Caudal fin emarginate.

General Distribution/Habitat: Widely distributed on the Atlantic slope and sporadically occurring throughout the Gulf slope. It has also been introduced to a number of drainages. Occurs chiefly in creeks and rivers in flowing pools, although it may be found in lakes and impoundments.

Indicator Use/IBI (1, 3, 10): The Redbreast Sunfish has exhibited considerable tolerance to thermal stress, occurring in waters up to 39° C (102.2° F) (Saecker and Wolcott 1988). State and regional tolerance classifications for *L. auritus* range from "moderately intolerant" (Pirhalla 2004) to "moderately tolerant" (Jester et al. 1992). The Redbreast Sunfish scores under IBI metrics 1, 3, and 10.

Green Sunfish
(Lepomis cyanellus)

Identification: Body somewhat elongate for *Lepomis* genus; robust. Coloration dark olive dorsally; with blue-green flecks and yellow-orange belly. Snout and cheek with blue-green mottles. Conspicuous black blotch present near posterior base of dorsal fin. Mouth terminal and large. Dorsal spines 9-11; dorsal fin rays 10-11; anal spines 3; anal fin rays 9-10; pectoral fin rays 13-14. Caudal fin emarginate.

General Distribution/Habitat: Widely distributed throughout the Mississippi River basin, Great Lakes basin, and Gulf slope. Introduced elsewhere throughout the United States (Jenkins and Burkhead 1994). Found in small streams, ditches (B), creeks, lakes, ponds, and marshes. Usually most abundant in shallow water where the current is sluggish or absent. Found over both coarse and fine substrates.

Indicator Use/IBI (1, 3, 6, 10): An adaptive species, the Green Sunfish is known to tolerate turbidity, siltation, and elevated temperatures (Sigler and Miller 1963; Trautman 1981; Becker 1983). State and regional tolerance classifications for *L. cyanellus* range from "moderately intolerant" (Pirhalla 2004) to "tolerant" (Ohio EPA 1987; Jester et al. 1992; Lyons 1992; Halliwell et al. 1999). The Green Sunfish scores under IBI metrics 1, 3, 6, and 10.

Pumpkinseed Sunfish
(Lepomis gibbosus)

Identification: Body deep and laterally compressed. Coloration dark olive dorsally; sides with blue-green and orange-yellow mottling; belly orange-yellow. Ear flap with a pale margin; with or without red spot on posterior end. Mouth terminal and small. Dorsal fin spines 10; dorsal fin rays 11-12; anal fin spines 4; anal fin rays 9-10; pectoral fin rays 12-13. Caudal fin emarginate.

General Distribution/Habitat: Well-distributed throughout the upper Mississippi River basin, Great Lakes-St. Lawrence Basin, and Atlantic slope. It has been modestly introduced elsewhere (Jenkins and Burkhead 1994). Occurs in creeks, rivers, ponds, lakes, and reservoirs. Most abundant where the current is sluggish or absent. May be found over both coarse and fine substrates.

Indicator Use/IBI (1, 3, 10): The Pumpkinseed is often most abundant in clear, vegetated waters (Trautman 1981; Becker 1983). It has demonstrated some tolerance to acidic waters and high temperatures (Becker 1983; Graham and Hastings 1984). Regional and state tolerance classifications range from "tolerant" (Pirhalla 2004) to "intermediate" (Halliwell et al. 1999). The Pumpkinseed scores under IBI metrics 1, 3, and 10.

Warmouth Sunfish
(Lepomis gulosus)

Identification: Body deep and laterally compressed. Coloration dusky dorsally; sides brownish or brassy with a greenish sheen; belly greenish-yellow. Distinctive dark bands radiate from eye. Mouth terminal to oblique and somewhat large. Dorsal fin spines 10; dorsal fin rays 9-10; anal fin spines 3; anal fin rays 8-10; pectoral fin rays 12-13. Caudal fin emarginate.

General Distribution/Habitat: Widely distributed throughout the Mississippi River basin, Atlantic slope, Gulf slope, and lower Great Lakes Basin. Occurs in creeks, ponds, lakes (B), impoundments, and swamps. Most abundant where the current is sluggish or absent and profuse vegetation is present. May be found over both coarse and fine substrates.

Indicator Use/IBI (1, 3, 10): The Warmouth has been associated with silt-free, clear water conditions (Trautman 1981) as well as turbid, muddy habitats (Becker 1983). Matthews (1987) and Killgore and Hoover (2001) have documented *L. golosus* to occur in hypoxic (D.O. <1 mg/L) environments. Regional and state tolerance classifications range from "moderately tolerant" (Jester et al. 1992) to "intermediate" (Barbour et al. 1999). The Warmouth scores under IBI metrics 1, 3, and 10.

Orangespotted Sunfish
(Lepomis humilis)

Identification: Body deep and laterally compressed. Coloration olive-gray dorsally; side, cheek, and opercle with large orange spots; belly orange. Breeding males display magnificent colors and possess a metallic sheen (B). Ear flap elongate; often with a strong white margin (A-B). Mouth terminal and small. Dorsal fin spines 10-11; dorsal fin rays 10; anal fin spines 3; anal fin rays 8-9; pectoral fin rays 14-15. Caudal fin emarginate.

General Distribution/Habitat: Widely distributed throughout the Mississippi River basin, Gulf Slope, and lower Great Lakes basin. Occurs in creeks, rivers, lakes, and impoundments. Most abundant in sluggish current or still water. Found over both coarse and fine substrates.

Indicator Use/IBI (1, 3, 10): Becker (1983) reported the Orangespotted Sunfish as the most tolerant centrarchid to turbidity. Boschung and Mayden (2004) considered *L. humilis* tolerant to low flow conditions, warm water, and silt. It has also demonstrated tolerance to hypoxia (Gould and Irwin 1962). State and regional tolerance classifications generally range from "tolerant" (Jester et al. 1992) to "intermediate" (Barbour et a. 1999). The Orangespotted Sunfish scores under IBI metrics 1, 3, and 10.

Bluegill Sunfish
(Lepomis macrochirus)

Identification: Body moderately deep and laterally compressed. Coloration variable; olive to olive-brown dorsally; sides often a patchy matrix of blue, brown, and green; belly white to orange. Dark, chain-like vertical bars often visible in younger individuals (B). Mouth terminal to oblique and small to moderate in size. Dorsal spines 10; dorsal fin rays 10-12; anal spines 3; anal fin rays 10-12; pectoral fin rays 13-14. Caudal fin emarginate.

General Distribution/Habitat: Widely distributed throughout the Mississippi River basin, Great Lakes-St. Lawrence basin, southern Atlantic slope, and Gulf slope. Widely introduced. Found in creeks, rivers, lakes, ponds, and impoundments. Often most abundant in still water or sluggish current. Found over both coarse and fine substrates.

Indicator Use/IBI (1, 3, 10): An adaptive species, the Bluegill Sunfish is known to tolerate turbidity, moderate variations in pH, and low dissolved oxygen (Becker 1983; Graham and Hastings 1984; Matthews 1987; Killgore and Hoover 2001). State and regional tolerance classifications for *L. macrochirus* range from "tolerant" (Whittier and Hughes 1998; Halliwell et al. 1999; Pirhalla 2004) to "intermediate" (Barbour et al. 1999). The Bluegill Sunfish scores under IBI metrics 1, 3, and 10.

Dollar Sunfish
(Lepomis marginatus)

Identification: Body deep and laterally compressed. Coloration variable; olive-brown to olive-blue dorsally; sides blue-green, red, orange, and olive-brown; belly orange or red with blue-green flecks. Ear flap elongate and expanded, with a well-defined pale margin. Breeding males often with a brilliant, blood red cast (B). Mouth terminal and small. Dorsal fin spines 10; dorsal fin rays 10-11; anal fin spines 3; anal fin rays 9-10; pectoral fin rays 12. Caudal fin emarginate.

General Distribution/Habitat: Distributed throughout the southern Atlantic slope and Gulf slope. Occurs in creeks, backwaters, lakes, and swamps. Most abundant where the current is sluggish or absent and profuse vegetation is present. Generally found over fine substrates and detritus.

Indicator Use/IBI (1, 3, 10): The Dollar Sunfish is most abundant in higher quality backwater habitats. Etnier and Starnes (1993) reported that *L. marginatus* was likely more abundant historically in western Tennessee, which they attributed to stream channelization. Jester et al. (1992) ranked the Dollar Sunfish as "moderately tolerant" of water quality degradation and "moderately intolerant" of habitat degradation. The Dollar Sunfish scores under IBI metrics 1, 3, and 10.

Longear Sunfish
(Lepomis megalotis)

Identification: Body deep and laterally compressed. Coloration generally olive-brown dorsally; sides grading to light olive with dull blue-green mottling (A); belly yellowish. Fins often with longitudinal red bands. Breeding males magnificently colored (B); sides of contrasting blue-green, olive, and orange; fins blood red or brown-red; belly orange. Mouth terminal to oblique and small to moderate in size. Dorsal fin spines 10; dorsal fin rays 10-11; anal fin spines 3; anal fin rays 9-10; pectoral fin rays 13-15. Caudal fin emarginate.

General Distribution/Habitat: Widely distributed throughout Mississippi River basin, Great Lakes basin, and Gulf Slope. Occurs in creeks, rivers, ponds, lakes, and impoundments. Most abundant where the current is sluggish or absent and profuse vegetation is present. May be found over both coarse and fine substrates.

Indicator Use/IBI (1, 3 10): Populations of Longear Sunfish have reportedly been extirpated by soil erosion and siltation in Wisconsin (Becker 1983). In Ohio, Trautman (1981) correlated Longear population reductions with increases in turbidity and siltation. Regional and state tolerance classifications range from "moderately tolerant" (Jester et al. 1992) to "moderately intolerant" (Ohio EPA 1987). The Longear Sunfish scores under IBI metrics 1, 3, and 10.

Spotted Sunfish
(Lepomis punctatus)

Identification: Body small, deep, and laterally compressed. Coloration olive-brown or dark blue dorsally; sides olive with a brassy or metallic blue-green cast; belly greenish yellow, yellow, or white. Sides, cheek, opercle, and fins may have dark spots. Ear flap short and dark; often with a narrow, pale margin. Mouth terminal and small. Dorsal fin spines 10; dorsal fin rays 10-11; anal fin spines 3; anal fin rays 10; pectoral fin rays 13. Caudal fin emarginate.

General Distribution/Habitat: Widely distributed throughout the Mississippi River basin, southern Atlantic slope, and several Gulf slope drainages. Occurs in creeks, rivers, swamps, and estuaries. Most abundant where the current is sluggish or absent and vegetation is present. May be found over both fine and coarse substrates.

Indicator Use/IBI (1, 3, 10): While it may occur in moderately turbid waters (Robison and Buchanan 1988), the Spotted Sunfish is generally considered a species of higher quality lowland streams and backwaters. State and regional tolerance classifications have designated *L. punctatus* as both "intermediate" (Barbour et a. 1999) and "intolerant" (Jester et al. 1992). The Spotted Sunfish scores under IBI metrics 1, 3, and 10.

Smallmouth Bass
(Micropterus dolomieu)

Identification: Body elongate and robust. Coloration olive to brown dorsally; sides with several chain-like vertical bars (often more distinctive in young individuals); belly yellowish white to white. Eye often red. Mouth terminal to slightly obliquely and large. Dorsal fin spines 10; dorsal fin rays 13-15; anal fin spines 3; anal fin rays 10-11; pectoral fin rays 16-18; Caudal fin emarginate to moderately forked.

General Distribution/Habitat: Widely distributed throughout the Mississippi River basin, Great Lakes-St. Lawrence basin, Red River (of the North drainage), and northern to mid-Atlantic drainage. Experts have had trouble deducing the native range of *M. dolomieu* due to extensive stocking throughout the United States (Jenkins and Burkhead 1994). Most abundant in creeks, rivers, lakes, and impoundments in flowing or quiet pools. May be found over both coarse and fine substrates.

Indicator Use/IBI (1, 3, 9, 10): The Smallmouth Bass is generally considered more sensitive to turbidity and siltation than other black basses (Robison and Buchanan 1988). State and regional tolerance classifications for *M. dolomieu* range from "intermediate" (Whittier and Hughes 1998; Halliwell et al. 1999) to "intolerant" (Jester et al. 1992; Lyons 1992). The Smallmouth scores under IBI metrics 1, 3, 9, and 10.

Largemouth Bass
(Micropterus salmoides)

Identification: Body elongate and moderately robust. Coloration green to olive-brown dorsally; sides lighter, with a distinctive longitudinal stripe, often present as a series of irregular blotches in younger individuals (B); belly white. Mouth terminal to slightly oblique and large; upper jaw extends to (at least) the posterior edge of eye. Dorsal fin spines 10; dorsal fin rays 12-14; anal fin spines 3; anal fin rays 10-12; pectoral fin rays 14-15. Caudal fin emarginate to slight forked.

General Distribution/Habitat: Widespread throughout the United States and into parts of southern Canada. Occurs in creeks, rivers, lakes, ponds, and impoundments. Most abundant in quiet water or flowing pools where cover is present. May be found over both coarse and fine substrates.

Indicator Use/IBI (1, 3, 9, 10): The Largemouth Bass is reportedly more tolerant of turbidity than the other basses of the genus *Micropterus* (Etnier and Starnes 1993), especially in waters where food is abundant (Miller 1975). State and regional tolerance classifications for *M. salmoides* range from "intermediate" (Halliwell et al. 1999) to "tolerant" (Whittier and Hughes 1998; Pirhalla 2004). As a top predator, the Largemouth Bass scores under IBI metrics 1, 3, 9, and 10.

Black Crappie
(Pomoxis nigromaculatus)

Identification: Body deep and laterally compressed. Coloration dusky dorsally; sides with irregular, dark mottles (A-B); belly white. Fins darkly pigmented and mottled. Mouth oblique and moderate to large in size. Dorsal fin spines 7-8; dorsal fin rays 15-16; anal fin spines 6-7; anal fin rays 16-19; pectoral fin rays 13-15. Caudal fin emarginate.

General Distribution/Habitat: Distributed throughout the Mississippi River basin, Great Lakes-St. Lawrence basin, Gulf slope, and southern Atlantic slope. Widely introduced through its native range and elsewhere (Jenkins and Burkhead 1994). Occurs in rivers, ponds, lakes, and impoundments. Most abundant in quiet waters where cover is present. May be found over both coarse and fine substrates.

Indicator Use/IBI (1, 3, 10): The Black Crappie is often considered less tolerant of turbidity, siltation, and eutrophication than the White Crappie (*Pomoxis annularis*) (Robison and Buchanan 1988; Etnier and Starnes 1993). During a fish kill in Wisconsin, Woodbury (1941) reported the Black Crappie as the most sensitive species to waters supersaturated with oxygen resulting from an algal bloom. Regional and state tolerance classifications for *P. nigromaculatus* range from "tolerant" (Whittier and Hughes 1988) to "intermediate" (Halliwell et al. 1999). The Black Crappie scores under metrics 1, 3, and 10.

Perches (Percidae)

With roughly 200 species, Percidae is one of the most diverse fish families in North America. The majority of the species belong to two genera, *Etheostoma* and *Percina*, commonly called "darters," which are colorful, benthic dwelling fishes. Also found in this family are popular sport fishes such as Walleye, Sauger, and Yellow Perch.

Family Level Identifiers: Two dorsal fins that are separated or narrowly joined. Anal spines 1 or 2. Pelvic fins with 1 spine and 4 rays. Branchiostegal membranes not bound to isthmus. Scales ctenoid. Male darters often display bright colors and/or different patterning than females.

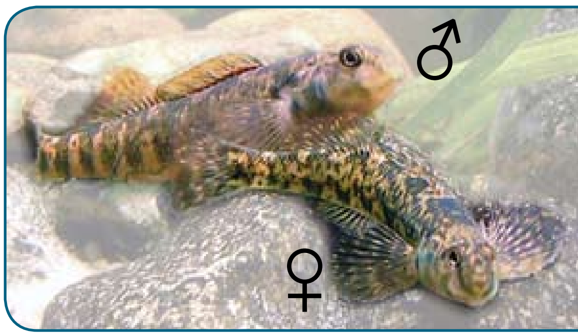
Habitat: The perch family may be found in nearly every type of freshwater habitat east of the Rocky Mountains. The larger family members, including such fishes as the Yellow Perch, Walleye, and Sauger, are more common to lakes, reservoirs, and rivers. The smaller members (darters) inhabit streams of all sizes, in addition to lakes and wetlands.

Pollution Tolerance: Many darter species are intolerant of siltation, pollutants, and habitat disturbance. Like the sculpin and madtoms, these small fishes are generally more vulnerable to stream degradation because they feed and reproduce in benthic habitats (Kuehne and Barbour 1983; Ohio EPA 1987). It should be noted that Percids, and more specifically the darters, are the most imperiled group of North American fishes, with one-third of all darters in some degree of decline (Boschung and Mayden 2004).

Table 23. Overview of Pollution Tolerance for Family Percidae.*

(Review by Barbour et al. 1999)		
Tolerant	**Intermediate**	**Intolerant**
0%	59%	41%

*39 species rated



Sexual Dimorphism: Many percids are sexually dimorphic, or have characteristics that differentiate male from female. Most of the darter (*Etheostoma* and *Percina*) males have spectacular color during the breeding season, while female coloring is somewhat mottled and dull.

Bloodfin Darter (*Etheostoma sanguifluum*)

Redline Darter (*Etheostoma ruflinineatum*)

Use in IBI: Darter presence and identity is measured directly by *Metric 2: Number of darter species* and, when appropriate, *Metric 5: Number of intolerant species*. When evaluating large river habitats, darters are often replaced by alternative metrics such as *Percentage round bodied suckers* or *Percentage large river faunal group* (Ohio EPA 1987; Simon and Emery 1995). However, in large river habitats, darters may still be accounted for under various metrics, including *Percentage large river faunal group* and *Percentage insectivores*. Walleye and Sauger populations are enumerated under *Metric 9: Proportion of individuals as top carnivores*. The general presence of family Percidae is accounted for in several other metrics, such as *Metric 1: Total number of fish species* and *Metric 10: Total number of individuals*.

Table 24. Tolerance designations for selected percids.

Common Name	Scientific Name	Ohio EPA 1987	Jester et al. 1992		Lyons 1992	Whittier and Hughes 1998	Barbour et al. 1999	Halliwell et al. 1999	Pirhalla 2004
			WQ	Habitat				Habitat	
Eastern Sand Darter	*Ammocrypta pellucida*	RI	x	x	x	x	I	I	x
Greenside Darter	*Etheostoma blennioides*	MI	I	I	x	x	M	I	MI
Rainbow Darter	*Etheostoma caeruleum*	MI	x	x	I	x	M	I	x
Bluebreast Darter	*Etheostoma camurum*	RI	x	x	x	x	I	I	x
Iowa Darter	*Etheostoma exile*	x	x	x	I	x	M	M	x
Fantail Darter	*Etheostoma flabellare*	x	MI	I	x	x	M	M	MI
Swamp Darter	*Etheostoma fusiforme*	x	MI	I	x	M	M	I	T
Harlequin Darter	*Etheostoma histrio*	x	I	I	x	x	I	x	x
Greenbreast Darter	*Etheostoma jordani*	x	x	x	x	x	x	x	x
Redband Darter	*Etheostoma luteovinctum*	x	x	x	x	x	x	x	x
Spotted Darter	*Etheostoma maculatum*	RI	x	x	x	x	I	I	x
Johnny Darter	*Etheostoma nigrum*	x	MI	I	x	x	M	M	x
Orangethroat Darter	*Etheostoma spectabile*	x	MI	MI	x	x	M	x	x
Speckled Darter	*Etheostoma stigmaeum*	x	MI	MI	x	x	x	x	x
Tippecanoe Darter	*Etheostoma tippecanoe*	x	x	x	x	x	I	x	x
Variegate Darter	*Etheostoma variatum*	CI	x	x	x	x	I	M	x
Banded Darter	*Etheostoma zonale*	CI	I	I	I	x	I	I	x
Yellow Perch	*Perca flavescens*	x	T	MT	x	MT	M	M	T
Logperch	*Percina caprodes*	MI	MI	MI	x	x	M	M	x
Gilt Darter	*Percina evides*	SI	x	x	x	x	I	I	x
Blackside Darter	*Percina maculata*	x	MI	I	x	x	M	M	x
Slenderhead Darter	*Percina phoxocephala*	RI	MI	MI	x	x	I	x	x
Dusky Darter	*Percina sciera*	MI	MI	MI	x	x	M	x	x
River Darter	*Percina shumardi*	x	MI	I	x	x	M	x	x
Sauger	*Stizostedion canadense*	x	MT	MI	x	x	M	x	x
Walleye	*Stizostedion vitreum*	x	MT	MI	x	x	M	M	x

I = intolerant   M = intermediate   MI = moderately intolerant   MT = moderately tolerant
P = moderately tolerant   R = rare intolerant   S = special intolerant   T = tolerant

Eastern Sand Darter
(Ammocrypta pellucida)

Identification: Body terete. Coloration translucent; yellowish-olive dorsally with 12-16 dark spots; sides with a series of 12-16 longitudinal dark blotches or spots; belly pale yellowish-green. No opercular spine. First dorsal fin spines 9-11; second dorsal fin rays 8-11; anal spine 1; anal fin rays 8-10. Caudal fin emarginate.

General Distribution/Habitat: Distributed in parts of the Great Lakes-St. Lawrence basin and upper Ohio River drainage (B). Typically an inhabitant of creeks, rivers, and lakes. In lotic habitats, it is most abundant where the current is sluggish to moderate and substrates comprised of clean, fine to medium-grained sand.

Indicator Use/IBI (1, 2, 5, 10): The Eastern Sand Darter is known to burrow into sandy substrates leaving only the eyes and forehead exposed (Jordan and Copeland 1877). The Eastern Sand Darter is sensitive to siltation (Trautman 1981; Kuehne and Barbour 2003), and it has been suggested that siltation may interfere with its burrowing tendencies (Spreitzer 1979). Regional and state tolerance classifications rank *A. pellucida* as "intolerant" (Ohio EPA 1987; Halliwell et al. 1999). The Eastern Sand Darter scores under IBI metrics 1, 2, 5, and 10.

Greenside Darter
(Etheostoma blennioides)

Identification: Body elongate and moderately robust. Breeding males with darkened bodies, brilliant blue-green pelvic and anal fins, and vertical green bars posteriorly. Females with mottled coloration consisting of various shades of green (B, near). Blunt snout overhangs small, terminal mouth. First dorsal fin spines 13-14; dorsal fin rays 12-14; anal fin spines 2; anal fin rays 7-9; pectoral fin rays 14-16. Caudal fin slightly emarginate.

General Distribution/Habitat: Occurs in the Mississippi River basin, lower Great Lakes basin, and parts of the mid-Atlantic drainage. Most abundant in creeks and rivers where the current is moderate to swift. Often found over coarse substrates comprised of sand, gravel, cobble, and rubble. Apparently favors areas of rooted aquatic vegetation, algae, or mosses. Studies have shown this vegetative affinity is due to olfactory stimuli (McCormick and Aspinwall 1983).

Indicator Use/ IBI (1, 2, 10): The Greenside Darter is often abundant in clear or slightly turbid waters where the current is moderate to swift. Regional and state tolerance classifications for *E. blennioides* range from "moderately intolerant" (Ohio EPA 1987; Pirhalla 2004) to "intolerant" (Jester et al. 1992). The Greenside Darter scores under IBI metrics 1, 2, and 10.

Rainbow Darter
(Etheostoma caeruleum)

Identification: Body somewhat deep and moderately robust. Breeding males with intense electric blue and orange coloration (A). Females generally yellow-brown with dark, irregular mottles (B). Both sexes with several dark dorsal saddles, with 2-3 often more conspicuous than the rest. First dorsal fin spines 9-11; dorsal fin rays 12-14; anal fin spines 2; anal fin rays 6-8; pectoral fin rays 13. Caudal fin rounded.

General Distribution/Habitat: Widely distributed in the Mississippi River drainage and Great Lakes basin. Occurs in small creeks to small rivers where the current is moderate to swift. Most abundant over sand, gravel, and cobble substrates. Juveniles often favor the shallow margins of runs and riffles.

Indicator Use/IBI (1, 2, 10): The Rainbow Darter is reportedly sensitive to siltation and impoundment (Robison and Buchanan 1988; Boschung and Mayden 2004). Trautman (1981) considered the Rainbow Darter less tolerant of pollutants than the Johnny Darter (*Etheostoma nigrum*) but more so than the Bluebreast Darter (*Etheostoma camurum*) or Variegate Darter (*Etheostoma variatum*). State and regional tolerance classifications for *E. caeruleum* range from "moderately intolerant" (Ohio EPA 1987) to "intolerant" (Lyons 1992; Halliwell et al. 1999). The Rainbow Darter scores under IBI metrics 1, 2, and 10.

Bluebreast Darter
(Etheostoma camurum)

Identification: Body robust and elongate; snout short. Coloration smoky olive dorsally; sides checkered; belly light olive, blue-green, or yellow. Males with irregular red spots on body (bright in breeding males [A]). Females with duller coloration, spots grayish-brown (B). Mouth small and terminal. First dorsal fin spines 10-13; second dorsal fin rays 11-13; anal fin spines 2; anal fin rays 7-9; pectoral fin rays 13-15. Caudal fin round to truncate.

General Distribution/Habitat: Disjunctly distributed throughout the Ohio River basin. Occurs in large creeks and rivers where the current is moderate to swift. Prefers riffles where the water is clear, deep, and swift. Most abundant over substrates of gravel, cobble, and boulders.

Indicator Use/IBI (1, 2, 5, 10): The Bluebreast Darter requires high quality, undisturbed habitats free of silts and pollutants. Stream impoundment and siltation have likely extirpated numerous populations throughout the eastern United States (Etnier and Starnes, 1993). This percid is an excellent indicator of high quality water resources. Regional and state tolerance classifications rank *E. camurum* as "intolerant" (Ohio EPA 1987; Halliwell et al. 1999). The Bluebreast Darter scores under IBI metrics 1, 2, 5, and 10.

Fantail Darter
(Etheostoma flabellare)

Identification: Body elongate and shallow. Coloration dark olive to light tan with dusky vertical bars that fade ventrally (A). Breeding males characterized by a charcoal colored head and large orange-yellow dorsal spine knobs (A). Mouth terminal. First dorsal fin spines 7-8; dorsal fin rays 13-15; anal fin spines 2; anal fin rays 8-9; pectoral fin rays 11-13. Caudal fin broadly rounded.

General Distribution/Habitat: Occurs in the Mississippi River basin, lower Great Lakes-St. Lawrence basin, and parts of the mid-Atlantic drainage. Typically found in small to large creeks and rivers where the current is moderate to swift. Most abundant over substrates of gravel, cobble, and rubble. This small, wiry darter often seeks refuge in narrow crevices or voids.

Indicator Use/IBI (1, 2, 10): The Fantail Darter is tolerant to moderate turbidity and intermittent hypoxia (Jenkins and Burkhead 1994; Matthews and Styron 1981). The adhesive eggs of this species are attached to the undersides of flat stones, likely reducing its sensitivity to siltation. Regional and state tolerance classifications for *E. flabellare* range from "intermediate" (Halliwell et al. 1999) to "moderately intolerant" (Jester et al. 1992; Pirhalla 2004). The Fantail Darter scores under IBI metrics 1, 2, and 10.

Redband Darter
(Etheostoma luteovinctum)

Identification: Body moderately deep. Males (A) with alternating, red-orange vertical bars located on the breast, belly, and caudal region. Breeding males with bold, blue-green ventral coloration (B). Females mottled olive-brown with dark lateral blotches. Snout somewhat blunt and short. First dorsal fin spines 9-11; second dorsal fin rays 12-14; anal fin spines 2; anal fin rays 7-8; pectoral fin rays 12-13. Caudal fin slightly emarginate.

Habitat: Geographically restricted to the Duck and Cumberland River drainages where it may be locally abundant (Etnier and Starnes, 1993). Occurs in small to medium-sized creeks (B) where the current is sluggish to moderate. Typically found over gravel and rubble with a shallow layer of silt.

Indicator Use (1, 2, 10): Perhaps due to its restricted distribution, the use of the Redband Darter as an indicator species has not been assessed. Regional and state tolerance classifications have not evaluated the sensitivity of *E. luteovinctum* to environmental perturbations. By default, the Redband Darter scores under IBI metrics 1, 2, and 10.

Spotted Darter
(Etheostoma maculatum)

Identification: Body elongate and robust. Males (A) dark olive dorsally; sides lighter with darkly margined red spots; fins dusky with or without whitish border; breast blue-green. Females olive with dusky, less distinctive spots or mottles; breast dusky white. Pectoral fins generally short. Snout sharp with a terminal mouth. First dorsal fin spines 11-13; anal fin spines 2. Caudal fin rounded.

General Distribution/Habitat: Disjunctly distributed in the Ohio River drainage. Found in large creeks and rivers where the current is moderate to strong. Most common over sand, gravel, cobble, and boulder substrates (A-B, Green River [KY], in-situ photos).

Indicator Use/IBI (1, 2, 5, 10): The Spotted Darter is essentially an obligate inhabitant of shallow, swiftly flowing sections of large creeks and rivers. Clean, heterogeneous mixtures of gravel and cobble are apparently important to the life history of *E. maculatum* (Kessler and Thorp 1993). A recent range-wide assessment of Spotted Darter populations suggested that this small percid is sensitive to siltation, impoundment, stream flow alteration, and adverse changes in water quality (Mayasich et al. 2004). State and regional tolerance classifications rank *E. maculatum* as “intolerant” (Ohio EPA 1987; Halliwell et al. 1999).

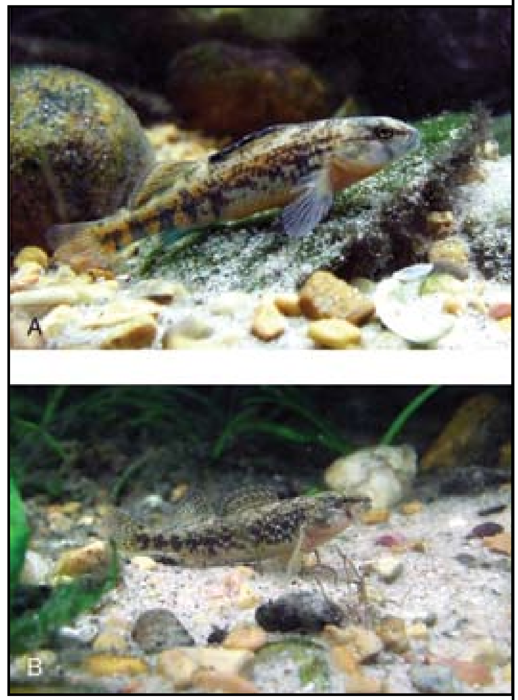
Redline Darter
(Etheostoma rufilineatum)

Identification: Body moderately deep and robust. Males (A) with a blue-green breast and checkered red-brown body. Soft dorsal, anal, and caudal fins often with narrow red band and white-gray margin. Females olive-brown without bright red fins or body coloration; usually with dark spots on fins. First dorsal fin spines 11-13; second dorsal fin rays 11-12; anal fin spines 2; anal fin rays 7-9; pectoral fin rays 12-15. Caudal fin rounded or slightly emarginate.

General Distribution/Habitat: Geographically restricted to the Cumberland and Tennessee drainages. Occurs in creeks and rivers where the current is moderate to swift. Most abundant over sand, gravel, cobble, and boulder substrates (B, Powell River [TN], in-situ photo). Unlike other species of the subgenus *Nothonotus*, the redline may be found in 2nd or 3rd order streams (Etnier and Starnes, 1993).

Indicator Use/IBI (1, 2, 10): Generally abundant throughout its restricted range, the Redline Darter inhabits clear, swiftly flowing waters. It has been reported as intolerant of hypoxic conditions (Ultsch et al. 1978). Perhaps owing to its restricted range, regional and state tolerance classifications have not evaluated the sensitivity of *E. rufilineatum* to environmental perturbations. By default, the Redline Darter scores under IBI metrics 1, 2, and 10.

Orangethroat Darter
(Etheostoma spectabile)

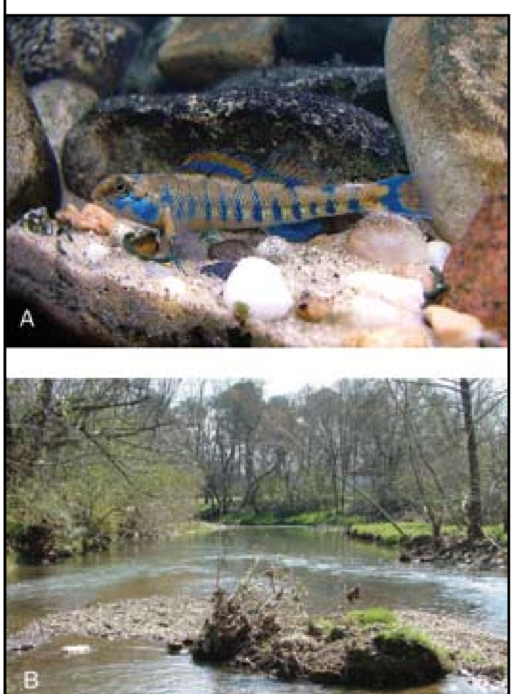


Identification: Body moderately robust and deepest just before first dorsal fin. Males (A) with alternating blue and brick red vertical bars; usually more distinctive posteriorly. Females (B) generally olive-brown with dark mottles. Fins often clear or with brownish coloration. First dorsal fin spines 9-11; second dorsal fin rays 12-13; anal fin spines 2; anal fin rays 5-7; pectoral fin rays 11-12. Caudal fin rounded to slightly emarginate.

General Distribution/Habitat: Fairly widespread in the Mississippi River basin (especially the western drainages) and lower Great Lakes. Occurs in ditches and headwater creeks where the current is sluggish to moderate. Often found over substrates of sand, gravel, cobble, and bedrock rubble.

Indicator Use/IBI (1, 2, 10): The Orangethroat Darter has exhibited tolerance to moderate levels of turbidity and silt (Pflieger 1975; Trautman 1981). However, Orangethroat numbers are often reduced when siltation and turbidity become excessive, or channelization increases stream discharge (Trautman, 1981). Regional and state tolerance classifications for *E. spectabile* range from "intermediate" (Barbour et al. 1991) to "moderately intolerant" (Jester et al. 1992). The Orangethroat scores under metrics 1, 2, and 10.

Speckled Darter
(Etheostoma stigmaeum)



Identification: Body elongate and terete. Males (A) with electric blue vertical bars from the posterior edge of opercle to caudal peduncle. Spinous dorsal banded with orange and blue. Females generally light brownish with dark lateral blotches or mottles. Snout rather blunt. First dorsal fin spines 11-13; second dorsal fin rays 10-13; anal fin spines 2; anal fin rays 7-9; pectoral fin rays 12-15. Caudal fin slightly emarginate.

General Distribution/Habitat: Distributed in the mid to lower Mississippi River basin and several Gulf slope drainages. Occurs in creeks (B) and small rivers where the current is sluggish to moderate. Most abundant in sand and gravel substrates.

Indicator Use/IBI (1, 2, 10): A species of good quality streams, the Speckled Darter may be more sensitive to habitat alterations than other common darter species (Etnier 1972; Etniesr and Starnes 1993). In Arkansas, Robison and Buchanan (1988) noted that the Speckled Darter was likely more common historically in streams altered by channelization activities. Regional and state tolerance classifications have not been developed for *E. stigmaeum*. By default, the Speckled Darter would score under IBI metrics 1, 2, and 10.

Variegate Darter
(Etheostoma variatum)

Identification: Body elongate and robust. Males with bright blue vertical bars and irregular red blotches. Females with duller colors and less distinctive bands, bars, and spots. Mouth terminal and nearly horizontal. Snout blunt. Pectoral fins large. First dorsal spines 12-13; second dorsal fin rays 13-14; anal fin spines 2; anal fin rays 9-10; pectoral fin rays 15. Caudal fin truncate to slightly emarginate.

General Distribution/Habitat: Distributed throughout the upper Ohio River drainage. Occurs in large creeks and rivers where the current is moderate to swift. Generally most abundant over substrates of sand, gravel, cobble and boulders.

Indicator Use/IBI (1, 2, 5, 10): The Variegate Darter is reportedly susceptible to siltation, mine wastes, and other pollutants (Trautman 1981). Jenkins and Burkhead (1994) considered *E. variatum* "a canary of the health of rivers of the coal region." Because much of their life history is carried out on riffles (May 1969), they are vulnerable to stream alterations that homogenize channel dynamics such as impoundment and channelization. Regional and state tolerance classifications for *E. variatum* range from "intermediate" (Halliwell et al. 1999) to "intolerant" (Ohio EPA 1987). The Variegate scores under metrics 1, 2, 5, and 10.

Banded Darter
(Etheostoma zonale)

Identification: Body elongate, somewhat robust, and laterally compressed. Males (A-B) yellowish-white and mottled dorsally; sides with vertical bright green bars; first and second dorsal fin with a red longitudinal stripe; breast and head green. Females intensely colored; sides with dusky mottles or blotches; breast white. Pectoral fins large. First dorsal fin spines 10-12; second dorsal fin rays 11-13; anal fin spines 2; anal fin rays 7-9; pectoral fin rays 13-15. Caudal fin truncate to slightly emarginate.

General Distribution/Habitat: Distributed throughout the Mississippi River basin, Lake Michigan drainage, Susquehanna drainage, and Savannah drainage. Typically found in creeks and small rivers where the current is moderate to swift. Most abundant over clean sand, gravel, and cobble substrates.

Indicator Use/IBI (1, 2, 5, 10): The Banded Darter has reportedly declined in parts of Indiana and Illinois where heavy siltation has occurred (Etnier and Starnes 1993). Trautman (1981) noted the Banded Darter as tolerant of organic pollutants. Regional and state tolerance classifications rank *E. zonale* as "intolerant" (Ohio EPA 1987; Jester et al. 1992; Lyons 1992; Halliwell et al. 1999). The Banded Darter scores under IBI metrics 1, 2, 5, and 10.

Yellow Perch
(Perca flavescens)

Identification: A moderately deep and laterally compressed percid. Body coloration olive-yellow dorsally with several dark saddles; saddles extending ventrally; dark blotch on posterior of first dorsal fin; belly white. Mouth large, terminal, and with small teeth. First dorsal fin spines 13-15; second dorsal fin spines 1-2; second dorsal fin rays 12-15; anal fin spines 2; anal fin rays 6-8; pectoral fin rays 13-16. Caudal fin moderately forked.

General Distribution/Habitat: Well-distributed in the Mississippi River basin, Great Lakes-St. Lawrence basin, Hudson Bay basin, Atlantic slope, and north into Canada. Widely introduced historically (Boschung and Mayden 2004). Occurs in large creeks, rivers, backwaters, and lakes (B). Often most abundant in quiet waters over both fine and coarse substrates.

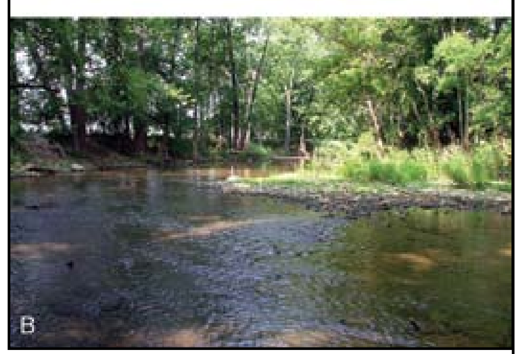
Indicator Use/IBI (1, 10): The Yellow Perch is capable of adapting to a wide range of habitat types and is relatively tolerant of low dissolved oxygen levels (Becker 1983; Jenkins and Burkhead 1994). Regional and state tolerance classifications for *P. flavescens* range from “tolerant” (Jester et al. 1992; Pirhalla 2004) to “intermediate” (Halliwell et al. 1999). The Yellow Perch scores under IBI metrics 1 and 10.

Logperch
(Percina caprodes)

Identification: Body elongate and robust; snout long and pointed. Coloration greenish-yellow with numerous thin, dark, dorsal saddles extending ventrally; belly whitish-yellow. First dorsal fin spines 14-16; second dorsal fin rays 15-17; anal spines 2; anal fin rays 10-11; pectoral fin rays 14-15. Caudal fin truncate to slightly emarginated.

General Distribution/Habitat: Distributed in the Mississippi River basin, Great Lakes-St Lawrence basin, Hudson Bay drainage, and Potomac drainage. Occurs in creeks (B) and rivers where the current is moderate. May also be found in lakes. Generally most abundant over clean sand, gravel, and cobble substrates.

Indicator Use/IBI (1, 2, 10): The Logperch is sensitive to river impoundment and heavy siltation, which has contributed to population reductions in several Ohio rivers, including the Ohio River (Trautman 1981). In Virginia, Jenkins and Burkhead (1994) associated population reductions in the upper Big Sandy drainage and North Fork Holston River with siltation and pollutants, respectively. Regional and state tolerance classifications for *P. caprodes* range from “intermediate” (Halliwell et al. 1999) to “moderately intolerant” (Ohio EPA 1987; Jester et al. 1992). The Logperch scores under IBI metrics 1, 2, and 10.



Channel Darter
(Percina copelandi)

Identification: Body elongate and moderately slender; snout somewhat blunt. Coloration light brown or yellowish dorsally with dark mottles; sides with irregularly spaced, small lateral blotches. Dorsal fin spines 11-13; dorsal fin rays 12; anal fin spines 2; anal fin rays 8-9; pectoral fin rays 13-15. Caudal fin emarginate.

General Distribution/Habitat: Distributed throughout the Mississippi River basin and Great Lakes-St. Lawrence basin. Occurs in rivers and large creeks where the current is moderate to swift. Most abundant in runs and riffles comprised of clean sand, gravel, and cobble substrates. However, the habitat preference of *P. copelandi* may vary depending on season (Etnier and Starnes 1993).

Indicator Use/IBI (1, 2, 5, 10): The Channel Darter is generally most abundant in silt free habitats (Trautman 1981; Robison and Buchanan 1988; Pflieger 1997). Regional and state tolerance classifications for *P. copelandi* range from “moderately intolerant” (Jester et al. 1992) to “intolerant” (Ohio EPA 1987). The Channel Darter scores under IBI metrics 1, 2, 5, and 10.

Gilt Darter
(Percina evides)

Identification: Body elongate and robust. Males light tannish-yellow to olive dorsally; sides with thick, oval blotches below dorsal saddles. Breeding males may possess brilliant red or goldish-orange coloration. Females brown to olive dorsally with blotches and saddles; lacking brilliant colors. First dorsal fin spines 11-13; second dorsal fin rays 12-13; anal spines 2; anal fin rays 10; pectoral fin rays 13-15. Caudal fin emarginate.

General Distribution/Habitat: Disjunctly distributed throughout the Mississippi River basin and lower Great Lakes basin. Occurs in large creeks and rivers (B) where the current is moderate to swift. Most abundant over sand, gravel, cobble, and rubble substrates.

Indicator Use/IBI (1, 2, 10): The Gilt Darter inhabits high quality, flowing reaches of large creeks and rivers where the streambed is free of silt (Becker 1983; Etnier and Starnes 1993). It has apparently been extirpated from numerous localities across the Midwest (Trautman 1981; Becker 1983). Regional and state tolerance classifications rank *P. evides* as “intolerant” (Ohio EPA 1987). The Gilt Darter scores under IBI metrics 1, 2, 5, and 10.

Slenderhead Darter
(Percina phoxocephala)

Identification: Body elongate and laterally compressed; snout long and pointed. Coloration olive or yellowish dorsally with dark mottles; sides with lateral blotches; belly white to yellow. First dorsal fin with a yellow or orange band. Mouth subterminal and small. Dorsal fin spines 11-14; dorsal fin rays 11-15; anal fin spines 2; anal fin rays 7-10; pectoral fin rays 13-15. Caudal fin truncate to rounded.

General Distribution/Habitat: Fairly widespread in the Mississippi River basin. Occurs in large creeks and rivers where the current is moderate to swift. Most abundant over clean sand, gravel, and cobble substrates.

Indicator Use/IBI (1, 2, 10): In Wisconsin, Becker (1983) noted that the Slenderhead Darter is often found in slightly turbid to turbid waters. Trautman (1981) attributed decreases of *P. phoxocephala* in Ohio to siltation of sand and gravel habitats. Boschung and Mayden (2004) commented that the Slenderhead is "tolerant of turbidity but intolerant of siltation". Regional and state tolerance classifications for *P. phoxocephala* range from "moderately intolerant" (Jester et al. 1992) to "intolerant" (Ohio EPA 1987). The Slenderhead Darter scores under IBI metrics 1, 2, and 10.

Roanoke Darter
(Percina roanoka)

Identification: Body elongate and moderately robust; snout short and blunt. Males (A-B) light tannish-yellow to olive dorsally; sides with thick, vertical bars to oval blotches; belly orange. Females brown to olive dorsally; sides with mid-lateral stripe; belly tannish-yellow to olive. First dorsal fin spines 10-11; second dorsal fin rays 10-11; anal spines 2; anal fin rays 8-9; pectoral fin rays 13-14. Caudal fin slightly emarginate.

General Distribution/Habitat: Distributed throughout several mid to southern Atlantic drainages. Occurs in creeks and rivers where the current is moderate to swift. Most abundant over sand, gravel, cobble, and rubble substrates.

Indicator Use/IBI (1, 2, 10): The Roanoke Darter inhabits well-oxygenated, flowing habitats and has demonstrated sensitivity to low dissolved oxygen levels under laboratory conditions (Matthews and Styron 1981). In Virginia, the Roanoke Darter is apparently expanding its range. Jenkins and Burkhead (1994) noted that *P. roanoke* may outcompete native darter species when invading new drainages. Regional and state tolerance classifications have not been developed for *E. roanoka*. The Roanoke Darter scores under IBI metrics 1, 2, and 10.

Dusky Darter
(Percina sciera)

Identification: Body elongate and laterally compressed; moderately deep; snout short to moderate. Coloration olive dorsally with dark mottles; sides with lateral blotches; belly white to yellow. Mouth small and terminal. First dorsal fin spines 12-13; second dorsal fin rays 12-14; anal fin spines 2; anal fin rays 9-10; pectoral fin rays 13-15. Cadual fin truncate to slightly emarginate.


A


B

General Distribution/Habitat: Well distributed throughout the Mississippi River basin and Gulf slope. Occurs in large creeks and rivers where the current is sluggish to moderate. Often associated with woody debris. Most abundant over substrates of clean sand and gravel.

Indicator Use/IBI (1, 2, 10): Extirpations of Dusky Darter populations in Arkansas have been attributed to "channelization, agricultural practices, and other habitat-altering activities" (Robison and Buchanan 1988). This species may be vulnerable to "stream maintenance" activities that remove woody debris or aquatic vegetation. Regional and state tolerance classifications generally rank *P. sciera* as "moderately intolerant" (Ohio EPA 1987; Jester et al. 1992). The Dusky Darter scores under IBI metrics 1, 2, and 10.

Walleye
(Stizostedion vitreus)


A


B

Identification: Body elongate and slightly compressed. Coloration brown to greenish-yellow dorsally; sides with irregular mottles and speckles; belly white. First dorsal fin with a dark blotch on posterior. Mouth large, terminal, and with sharp teeth (B). First dorsal fin spines 13-14; second dorsal fin rays 19-22; anal fin spines 2; anal fin rays 12-14; pectoral fin rays 13-16. Caudal fin emarginate.

Distribution/Habitat: Widespread throughout the United States and north into Canada. Occurs in rivers and lakes; generally less successful in impoundments. Found over both coarse and fine substrates. In lotic habitats, the Walleye is frequently associated with deeper, darker water during the day and shoals during the evening hours (Becker 1983).

Indicator Use/IBI (1, 9, 10): Population reductions of the highly migratory *S. vitreum* have been associated with the damming of rivers, excessive siltation, and turbidity (Smith 1979; Trautman 1981). Rohde et al. (1994) noted that the Walleye is intolerant of pollution and siltation. Regional and state tolerance classifications rank the Walleye as "intermediate" (Halliwell et al. 1999) to "moderately intolerant" (Jester et al. 1992). As a top carnivore, the Walleye scores under IBI metrics 1, 9, and 10.

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